



Cisco Crosswork Optimization Engine 6.0 User Guide

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CHAPTER 1

About Cisco Crosswork Optimization Engine

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- [Overview of Cisco Crosswork Optimization Engine, on page 1](#)
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- [Bandwidth Feature Packs, on page 3](#)
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Audience

This guide is for experienced network administrators who want to use Cisco Crosswork Optimization Engine in their network. This guide assumes that you are experienced and familiar with using the following technologies:

- Networking technologies and protocols (BGP-LS, IGP (OSPF and IS-IS), PCEP, model-driven telemetry, and so on)
- Traffic Engineering (TE) tunnels:
 - RSVP-TE tunnel provisioning
 - Segment Routing Traffic Engineering (SR-TE) policy provisioning
- Cisco Segment Routing Path Computation Element (SR-PCE)
- Point to Multi Point Tree (Tree-SID)
- Flexible Algorithms

Overview of Cisco Crosswork Optimization Engine

Cisco Crosswork Optimization Engine is part of the Cisco Crosswork Network Automation suite of products and provides the ability to preserve network intent with proactive network monitoring, network visualization, and closed loop automation. It also provides real-time network optimization allowing operators to effectively maximize network utilization and increase service velocity.

Crosswork Optimization Engine is offered as an individual application and is also a component of Cisco Crosswork Network Controller (see [Crosswork Network Controller Solution and Crosswork Optimization Engine, on page 2](#)).

Crosswork Optimization Engine provides the following:

- A topology map that gives valuable real-time network visualization of the following:
 - devices
 - links and link utilization
 - SR-TE policies
 - SR-MPLS and SRv6
 - Tree-SID
 - Flexible Algorithms
 - Circuit-Style Segment Routing (CS-SR) policies
 - RSVP-TE tunnels
- A UI that allows the network operator to perform the following tasks:
 - Provision SR policies and RSVP-TE tunnels and modify or remove them using an intuitive workflow
 - Preview an SR policy or RSVP-TE tunnel before deploying it to the network
 - Continuously track SR policy dynamic path computations to maintain SLA objectives (with correct licensing)
 - Provision static Point to Multi Point (Tree-SID) policies.
 - Provision circuit Style SR-TE policies.
- APIs that extend Crosswork Optimization Engine functions to other Crosswork applications and third party applications.

This guide covers all the Crosswork Optimization Engine capabilities. However, either due to licensing or the configuration of the role that is associated with your user account, you may not be able to access the features and functions. For licensing and ordering information, work with your Cisco Partner or Cisco account representative.

Crosswork Network Controller Solution and Crosswork Optimization Engine

Cisco Crosswork Network Controller is a turnkey network automation solution for deploying and operating IP transport networks that delivers increased service agility, cost efficiency, and optimization for faster time-to-customer value and lower operating cost. The solution combines intent-based network automation to deliver critical capabilities for service orchestration and fulfillment, network optimization, service path computation, device deployment and management, and anomaly detection and automatic remediation. For more information, see [Cisco Crosswork Network Controller](#).

Cisco Crosswork Optimization Engine is offered as an individual application and is also a component of Cisco Crosswork Network Controller where its functionality is integrated into Cisco Crosswork Network Controller's UI.

Throughout this document, when using the Crosswork Optimization Engine as part of the Crosswork Network Controller solution, some options are not available or are slightly different. For example, to navigate to the Traffic Engineering UI, instead of **Traffic Engineering > Traffic Engineering**, the navigation within the Crosswork Network Controller solution is **Services & Traffic Engineering > Traffic Engineering**.

Bandwidth Feature Packs

Crosswork Optimization Engine feature packs (available with certain licensing) are tools that tackle congestion mitigation and the management of SR-TE policies to find and maintain intent based bandwidth requirements. Users can define the optimization intent and the tools implement the intent, while continuously monitoring, tracking, and reacting to maintain the original intent. To learn more about these feature packs, see the following topics:

- [Local Congestion Mitigation \(LCM\)](#), on page 83
- [SR Circuit Style Manager \(CSM\)](#), on page 61
- [Bandwidth on Demand \(BWoD\)](#), on page 105

Crosswork Optimization Engine APIs

Advanced users can integrate other Crosswork applications and third-party applications with Crosswork Optimization Engine functions by using application programming interfaces (APIs) delivering new capabilities into their network operations.

For more information, see the [Cisco Crosswork Network Automation API Documentation on Cisco DevNet](#).



CHAPTER 2

Traffic Engineering in Cisco Crosswork Optimization Engine

Traffic engineering (TE) is a method of optimizing and steering traffic in a network to achieve an operational goal or provide custom services, such as using guaranteed bandwidth routes for prioritized traffic. TE improves network performance by forcing traffic to take predetermined routes and by using available resources effectively.

One of the biggest advantages of using Crosswork is the ability to visualize SR-TE policies and RSVP-TE tunnels on a topology map. By visually examining your network, the complexity of provisioning and managing these SR-TE policies is significantly reduced.

The following table lists what Traffic Engineering SR policies and RSVP tunnels can be visualized and provisioned through the Crosswork UI.

For a list of known limitations, important notes, and what networking technologies are supported, see the [Cisco Crosswork Optimization Engine Release Notes](#).

Table 1: Supported TE Technologies

| TE Technology | Crosswork Optimization Engine | |
|---------------------|-------------------------------|----------------|
| | Visualize | Provision |
| SR-MPLS | ✓ | ✓ |
| SRv6 | ✓ | ✗ |
| RSVP | ✓ | ✓ |
| Flexible Algorithms | ✓ | ✗ ¹ |
| Tree-SID | ✓ | ✓ ² |
| Circuit Style | ✓ | ✓ |

¹ When provisioning SR-TE policies, you can use segment lists with SIDs that are part of a Flexible Algorithm.

² Only static Tree-SID policies are supported. Dynamic Tree-SID policies can be provisioned manually on the device or via an API.



Note Users must be assigned admin roles or have certain Device Access Group permissions to provision and access some features. For more information on Role-based Access Control (RBAC) and user roles, see the "[Cisco Crosswork Network Controller Administration Guide](#)".

- [Segment Routing Path Computation Element \(SR-PCE\)](#), on page 6
- [What is Segment Routing?](#), on page 6
- [SR-TE Policy PCC and PCE Configuration Sources](#), on page 8
- [What is Resource Reservation Protocol \(RSVP\)?](#), on page 9
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- [Resolve SR-TE Policies and RSVP-TE Tunnels](#), on page 17

Segment Routing Path Computation Element (SR-PCE)

Cisco Crosswork uses the combination of telemetry and data that are collected from the Cisco Segment Routing Path Computation Element (SR-PCE) to analyze and compute optimal TE tunnels.

Cisco SR-PCE (formerly Cisco XR Traffic Controller (XTC)) runs on the Cisco IOS XR operating system. SR-PCE provides stateful PCE functionality that helps control and reroute TE tunnels to optimize the network. PCE describes a set of procedures by which a Path Computation Client (PCC) can report and delegate control of headend tunnels that are sourced from the PCC to a PCE peer. The PCC and PCE establish a Path Computation Element Communication Protocol (PCEP) connection that SR-PCE uses to push updates to the network.

Crosswork discovers all devices that are part of the IGP domain including those that do not establish PCEP peering with SR-PCE. However, PCEP peering is required to deploy TE tunnels to the device.



Note Features may not work as expected if the SR-PCE version is not supported. It is important to refer to the [Crosswork Optimization Engine Release Notes](#) for SR-PCE version support and compatibility.

For SR-PCE and HA configuration, see the "Prepare Infrastructure for Device Management: Manage Providers" section in the [Cisco Crosswork Network Controller Administration Guide](#).

What is Segment Routing?

Segment routing for traffic engineering takes place through a tunnel between a source and destination pair. Segment routing for traffic engineering uses the concept of source routing, where the source calculates the path and encodes it in the packet header as a segment. Segments are an identifier for any type of instruction. For example, topology segments identify the next hop toward a destination. Each segment is identified by the segment ID (SID) consisting of a unsigned 32-bit integer. Each segment is an end-to-end path from the source

to the destination, and instructs the routers in the provider core network to follow the specified path instead of the shortest path calculated by the IGP. The destination is unaware of the presence of the tunnel.

Segments

Interior gateway protocol (IGP) distributes two types of segments: prefix segments and adjacency segments. Each router (node) and each link (adjacency) has an associated segment identifier (SID).

- A prefix SID is associated with an IP prefix. The prefix SID is manually configured from the segment routing global block (SRGB) range of labels, and is distributed by IS-IS or OSPF. The prefix segment steers the traffic along the shortest path to its destination. A node SID is a special type of prefix SID that identifies a specific node. It is configured under the loopback interface with the loopback address of the node as the prefix.

A prefix segment is a global segment, so a prefix SID is globally unique within the segment routing domain.

- An adjacency segment is identified by a label called an adjacency SID, which represents a specific adjacency, such as egress interface, to a neighboring router. The adjacency SID is distributed by IS-IS or OSPF. The adjacency segment steers the traffic to a specific adjacency.

An adjacency segment is a local segment, so the adjacency SID is locally unique relative to a specific router.

By combining prefix (node) and adjacency segment IDs in an ordered list, any path within a network can be constructed. At each hop, the top segment is used to identify the next hop. Segments are stacked in order at the top of the packet header. When the top segment contains the identity of another node, the receiving node uses equal cost multipaths (ECMP) to move the packet to the next hop. When the identity is that of the receiving node, the node pops the top segment and performs the task required by the next segment.

Segment Routing Policies

Segment routing for traffic engineering uses a “policy” to steer traffic through the network. An SR policy path is expressed as a list of segments that specifies the path, called a segment ID (SID) list. Each segment is an end-to-end path from the source to the destination, and instructs the routers in the network to follow the specified path instead of the shortest path calculated by the IGP. If a packet is steered into an SR policy, the SID list is pushed on the packet by the head-end. The rest of the network executes the instructions embedded in the SID list.

Crosswork supports the visualization (and some provisioning) of the following SR-related policies:

- [SR-MPLS and SRv6](#), on page 19
- [Flexible Algorithms](#), on page 43
- [Tree Segment Identifier \(Tree-SID\) Multicast Traffic Engineering](#), on page 49



Note Crosswork discovers existing SR policies when devices are imported, but cannot manage them. SR policies can be managed only if they were provisioned using the UI.

There are two types of SR policies: dynamic and explicit.

Dynamic SR Policy

A dynamic path is based on an optimization objective and a set of constraints. The head-end computes a solution, resulting in a SID list or a set of SID lists. When the topology changes, a new path is computed. If the head-end does not have enough information about the topology, the head-end might delegate the computation to a path computation engine (PCE).

Explicit SR Policy

When you configure an explicit policy, you specify an explicit path which consists of a list of prefix or adjacency SIDs, each representing a node or link along on the path.

Disjointness

Crosswork uses the disjoint policy to compute two lists of segments that steer traffic from two source nodes to two destination nodes along disjoint paths. The disjoint paths can originate from the same head-end or different head-ends. Disjoint level refers to the type of resources that should not be shared by the two computed paths. The following disjoint path computations are supported:

- **Link** – Specifies that links are not shared on the computed paths.
- **Node** – Specifies that nodes are not shared on the computed paths.
- **SRLG** – Specifies that links with the same Share Risk Link Group (SRLG) value are not shared on the computed paths.
- **SRLG-node** – Specifies that SRLG and nodes are not shared on the computed paths.

When the first request is received with a given disjoint-group ID, a list of segments is computed, encoding the shortest path from the first source to the first destination. When the second request is received with the same disjoint-group ID, information received in both requests is used to compute two disjoint paths: one path from the first source to the first destination, and another path from the second source to the second destination. Both paths are computed at the same time. The shortest lists of segments is calculated to steer traffic on the computed paths.



Note

- Disjointness is supported for two policies with the same disjoint ID.
- Configuring affinity and disjointness at the same time is not supported.

SR-TE Policy PCC and PCE Configuration Sources

SR-TE policies discovered and reported by Crosswork may have been configured from the following sources:

- Path Computation Client (PCC) initiated—Policies configured on a PCC (see [PCC-Initiated SR-TE Policy Example, on page 9](#)). This policy type displays as **Unknown** in the UI.
- Path Computation Element (PCE) initiated—Policies configured on a PCE or created dynamically by Crosswork. PCE Initiated policy types can be one of the following:
 - **Dynamic**
 - **Explicit**
 - **Circuit-Style**

- **Bandwidth on Demand**
- **Local Congestion Mitigation**



Note SR policies that are configured using the UI are the only types of SR-TE policies that you can modify or delete in Crosswork.

PCC-Initiated SR-TE Policy Example

The following example shows a configuration of an SR-TE policy at the headend router. The policy has a dynamic path with affinity constraints computed by the headend router. See SR configuration documentation for your specific device to view descriptions and supported configuration commands (for example: [Segment Routing Configuration Guide for Cisco ASR 9000 Series Routers](#)).

```
segment-routing
traffic-eng
policy foo
color 100 end-point ipv4 1.1.1.2
candidate-paths
preference 100
dynamic
metric
type te
!
!
constraints
affinity
exclude-any
name RED
!
!
!
!
```

What is Resource Reservation Protocol (RSVP)?

Resource Reservation Protocol (RSVP) is a signaling protocol that enables systems to request resource reservations from the network. RSVP processes protocol messages from other systems, processes resource requests from local clients, and generates protocol messages. As a result, resources are reserved for data flows on behalf of local and remote clients. RSVP creates, maintains, and deletes these resource reservations.

The RSVP-TE process contains the following functionalities:

- Endpoint control, which is associated with establishing and managing TE tunnels at the headend and tail end.
- Link-management, which manages link resources to do resource-aware routing of TE Label-Switched Path (LSP) and to program MPLS labels.
- Fast Reroute (FRR), which manages the LSPs that need protection and assigns backup tunnel information to these LSPs.

The interactions between TE and RSVP assume the existence of the endpoint control, link-management, and FRR functionality within TE.

RSVP-TE Explicit Routing (Strict, Loose)

RSVP-TE explicit routes are particular paths in the network topology that you can specify as abstract nodes, which could be a sequence of IP prefixes or a sequence of autonomous systems, in the Explicit Route Object (ERO). The explicit path can be administratively specified, or automatically computed using an algorithm such as constrained shortest path first (CSPF).

The explicit path that is specified in the ERO could be a strict path or a loose path.

A strict path means that a network node and its preceding node in the ERO must be adjacent and directly connected.

A loose hop means that a network node specified in the ERO must be in the path but is not required to be directly connected to its preceding node. If a loose hop is encountered during ERO processing, the node that processes the loose hop can update the ERO with one or more nodes along the path from itself to the next node in the ERO. The advantage of a loose path is that the entire path does not need to be specified or known when creating the ERO. The disadvantage of a loose path is that it can result in forwarding loops during transients in the underlying routing protocol.



Note RSVP-TE tunnels cannot be configured with loose hops when provisioning within the UI.

RSVP FRR

When a router's link or neighboring device fails, the router often detects this failure by receiving an interface-down notification. When a router notices that an interface has gone down, it switches LSPs going out that interface onto their respective backup tunnels (if any).

The FRR object is used in the PATH message and contains a flag that identifies the backup method to be used as facility-backup. The FRR object specifies setup and hold priorities, which are included in a set of attribute filters and bandwidth requirements to be used in the selection of the backup path.

The Record Route Object (RRO) reports in the RESV message the availability or use of local protection on an LSP, and whether bandwidth and node protection are available for that LSP.

The signaling of the FRR requirements is initiated at the TE tunnel headend. Points of Local Repair (PLR) along the path act on the FRR requirements based on the backup tunnel availability at the PLR, and signal the backup tunnel selection information to the headend. When an FRR event is triggered, the PLR sends PATH messages through the backup tunnel to the merge point (MP) where the backup tunnel rejoins the original LSP. The MP also sends RESV messages to the PLR using the RSVP-Hop object that is included by the PLR in its PATH message. This process prevents the original LSP from being torn down by the MP. Also, the PLR signals the tunnel headend with a PATH-ERROR message to indicate the failure along the LSP and that FRR is in active use for that LSP. This information is used by the headend to signal a new LSP for the TE tunnel, and to tear down the existing failed path after the new LSP is set up through make-before-break techniques.

RSVP-TE Tunnel PCC and PCE Configuration Sources

RSVP-TE tunnels discovered and reported by Crosswork may have been configured from the following sources:

- Path Computation Client (PCC) initiated—RSVP-TE tunnels configured on a PCC (see [PCC-Initiated RSVP-TE Tunnel Example, on page 11](#)).
- Path Computation Element (PCE) or PCC initiated dynamically.

PCC-Initiated RSVP-TE Tunnel Example

The following is a sample device configuration for a PCC-initiated RSVP-TE tunnel. See the appropriate documentation to view descriptions and supported RSVP-TE tunnel configuration commands for your particular device (for example: *MPLS Command Reference for Cisco NCS 5500 Series, Cisco NCS 540 Series, and Cisco NCS 560 Series Routers*).

```
interface tunnel-te777
  ipv4 unnumbered Loopback0
  destination 192.168.0.8
  path-option 10 dynamic
  pce
  delegation
!
```

Get a Quick View of Traffic Engineering Services

The TE Dashboard provides a high-level summary of RSVP-TE tunnel, SR-MPLS, SRv6, and Tree-SID policy information.

To get to the TE Dashboard, choose **Traffic Engineering > TE Dashboard**.

Get a Quick View of Traffic Engineering Services

TE Dashboard © Last Update: 07-Aug-2023 04:55:52 PM PDT | ↕

SR-MPLS

15

Total Policy Count

Policy State

Oper Down: 4, Admin Down: 0, Oper Up: 11

Policy Type & Metric Type

- BWsd: 1, LCM: 4, Regular: 9, Circuit Style1: 1
- IGP: 0, TE: 4, LATENCY: 1, HOPCOUNT: 0, UNKNOWN: 10

SRv6

0

Total Policy Count

Policy State

Oper Down: 0, Admin Down: 0, Oper Up: 0

Metric Type

- IGP: 0, TE: 0, LATENCY: 0, HOPCOUNT: 0, UNKNOWN: 0

Tree-SID

2

Total Policy Count

Policy State

Oper Down: 0, Admin Down: 0, Oper Up: 2

Metric Type

- IGP: 1, TE: 1, LATENCY: 0, HOPCOUNT: 0, UNKNOWN: 0

RSVP-TE

2

Total Tunnel Count

Policy State

Oper Down: 1, Admin Down: 0, Oper Up: 1

Metric Type

- IGP: 1, TE: 1, LATENCY: 0, HOPCOUNT: 0, UNKNOWN: 0

Fast Re-Route

0 Policies with FRR enabled

Fast Re-Route

0 Policies with FRR enabled

2 → Policies and Tunnels Under Traffic Threshold Range 0 to 1000 Kbps 📅 06-Aug-2023 16:55 to 07-Aug-2023 16:55 1M 1W 1D 1H | Reset

3 → Policy / Tunnel Type: All SR-MPLS RSVP-TE Total 17

| Headend | Endpoint | Color / ID | Policy / Tunnel Type | Metric Type | Traffic Rate (Kbps) | Actions |
|----------|----------|------------|----------------------|-------------|---------------------|---------|
| cw-xrv57 | cw-xrv58 | 4007 | SR-MPLS | Unknown | 0 | ... |
| cw-xrv51 | cw-xrv52 | 3333 | SR-MPLS | TE | 0 | ... |
| cw-xrv51 | cw-xrv54 | 10 | RSVP-TE | TE | 0 | ... |
| cw-xrv51 | cw-xrv55 | 32321 | RSVP-TE | IGP | 0 | ... |
| cw-xrv59 | cw-xrv61 | 312 | SR-MPLS | LATENCY | 0 | ... |
| cw-xrv50 | cw-xrv54 | 16 | SR-CS | TE | 0 | ... |
| cw-xrv50 | cw-xrv52 | 2022 | SR-MPLS | TE | 0 | ... |
| cw-xrv50 | cw-xrv52 | 2222 | SR-MPLS | TE | 0 | ... |

4 → Policy and Tunnel Change Events 📅 06-Aug-2023 16:55 to 07-Aug-2023 16:55 1M 1W 1D 1H | Reset


Policy / Tunnel Type: All SR-MPLS SRv6 Tree-SID RSVP-TE Total 7

| Headend | Endpoint | Color / ID | Policy / Tunnel Type | Metric Type | Events | | | Actions |
|----------|----------|------------|----------------------|-------------|---------|-------------------|--------|---------|
| | | | | | Total ↓ | Operational State | Change | |
| cw-xrv57 | cw-xrv58 | 4005 | SR-MPLS | Unknown | 6 | 5 | 1 | ... |
| cw-xrv57 | cw-xrv58 | 4006 | SR-MPLS | Unknown | 4 | 3 | 1 | ... |
| cw-xrv57 | cw-xrv58 | 4007 | SR-MPLS | Unknown | 4 | 3 | 1 | ... |
| cw-xrv57 | cw-xrv58 | 4004 | SR-MPLS | Unknown | 2 | 1 | 1 | ... |
| cw-xrv59 | cw-xrv61 | 312 | SR-MPLS | LATENCY | 2 | 1 | 1 | ... |
| cw-xrv57 | cw-xrv58 | 4003 | SR-MPLS | Unknown | 1 | 0 | 1 | ... |
| cw-xrv50 | cw-xrv52 | 2022 | SR-MPLS | TE | 1 | 0 | 1 | ... |

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Note If you are viewing the HTML version of this guide, click the images to view them in full-size.

| Callout No. | Description |
|-------------|---|
| 1 | <p>Traffic Engineering Dashlet: Displays the total policy count and count of policies according to the policy state.</p> <p>It also displays the number of all TE policies and the number of policies/tunnel according to the metric types for all TE services.</p> <p>To drill down for more information, click on a value. The topology map and TE table appear displaying only the filtered data that you clicked on.</p> |
| 2 | <p>Policies and Tunnels Under Traffic Threshold:</p> <p>Displays RSVP-TE tunnels and SR-MPLS policies that have traffic below the defined threshold in the selected time period. This information may be used to find and filter the unused policies or tunnels. Click  to update the underutilized LSP threshold value.</p> <p>Note Traffic utilization is not captured for SRv6 and Tree-SID policies.</p> |
| 3 | <p>Allows you to filter the data on the dashlet based on the time range you want to view (date, 1 month, 1 week, 1 day, and 1 hour).</p> |
| 4 | <p>Policy and Tunnel Change Events: Displays all the policies and tunnels that have had a path or state change event ordered by the event count, within the selected time range. This information helps identify the unstable policies and tunnels.</p> <p>Note The addition or deletion of leaf nodes for Tree-SID policies is captured as events.</p> |



Note For a list of known limitations, see the [Cisco Crosswork Optimization Engine Release Notes](#)

View TE Event and Utilization History

The historical data captures the traffic rate and change events for a policy or tunnel. To view the historical data:



Note Traffic Rate is not captured for SRv6 and Tree-SID policies.

Step 1 From the main menu, choose **Traffic Engineering > Traffic Engineering** .

Step 2 From the **Actions** column of the Traffic Engineering table, click **...** > **View Details** > **History** tab for a policy or tunnel. The tab displays associated historical data for that device. Click on the event to see the path or state change event

SR Policy Details

Current **History**

06-Aug-2023 16:30 to 07-Aug-2023 16:30 1M 1W **1D** 1H | Reset

No Traffic Rate Data

Selected

100 Mbps
50 Mbps
0 Mbps

17:00 19:00 21:00 23:00 01:00 03:00 05:00 07:00 09:00 11:00 13:00 15:00

● Traffic Rate ● Events

Selected Time: 07-Aug-2023 07:28:41 AM PDT

Admin State ↑ Up
Oper State ↑ Up

Candidate Path

[Expand All](#)

| Path Name | Preference | Path Type | State |
|------------------------------|------------|---|--------------------------------------|
| <input type="checkbox"/> 234 | 100 | Explicit ↑ | ↑ |

| S... | Seg... | L... | Algo | IP | N... | Inte... | S... |
|------|---|------|------|---------|-------|---------|------|
| 0 | ● IG... | 2... | 0 | 10.0... | xr... | | |

Path Name 234
Oper State ↑ Up
Metric Type UNKNOWN
Disjoint Group ID:
Association Source: -
Type: -
PCE Initiated true
Affinity Exclude-Any: -
Include-Any: -
Include-All: -

information.

View Traffic Engineering Device Details

To view Traffic Engineering Device details (SR-MPLS, SRv6, RSVP-TE, and Flexible Algorithm information), do the following:

- Step 1** From the main menu, choose **Traffic Engineering > Traffic Engineering**.
- Step 2** From the Traffic Engineering topology map, click on a device.
- Step 3** From the **Traffic Engineering** tab, click on the policy type you are interested in. Each tab displays associated data for that device. From the browser, you can copy the URL and share with others.

The following example shows the Tree-SID information details for the selected device.

Note If you are viewing the HTML version of this guide, click on the image to view it in full-size.

Device Details

Details Links Traffic Engineering

General SR-MPLS SRv6 Tree-SID RSVP-TE Flex Algo

Selected 0 / Total 9

| | Root Name | Root IP | Name | Tree ID | Label | Type | Programming St... | Fast Reroute | PCE Address | Admin Status | Oper Status | Actions |
|--------------------------|-----------|-------------|---------------------|---------|-------|--------|-------------------|--------------|----------------|--------------|-------------|---------|
| <input type="checkbox"/> | xrv9k-13 | 192.168.0.3 | DAY_0_TREE_SID | - | 35 | Static | None | Enable | 172.27.226.118 | | | ... |
| <input type="checkbox"/> | xrv9k-17 | 192.168.0.7 | MY_FIRST_TRR_SID | - | 15200 | Static | None | Enable | 172.27.226.118 | | | ... |
| <input type="checkbox"/> | xrv9k-13 | 192.168.0.3 | R4_TREE_SID | - | 22 | Static | None | Enable | 172.27.226.118 | | | ... |
| <input type="checkbox"/> | xrv9k-13 | 192.168.0.3 | TREE_SID_ERROR... | - | 3233 | Static | None | Disable | 172.27.226.118 | | | ... |
| <input type="checkbox"/> | xrv9k-13 | 192.168.0.3 | TREE_SID_MULTIL... | - | 220 | Static | None | Disable | 172.27.226.118 | | | ... |
| <input type="checkbox"/> | xrv9k-17 | 192.168.0.7 | Test-TS1 | - | 1234 | Static | None | Disable | 172.27.226.118 | | | ... |
| <input type="checkbox"/> | xrv9k-17 | 192.168.0.7 | Test-TS3 | - | 8989 | Static | None | Disable | 172.27.226.118 | | | ... |
| <input type="checkbox"/> | xrv9k-13 | 192.168.0.3 | netflix | - | 15202 | Static | None | Enable | 172.27.226.118 | | | ... |
| <input type="checkbox"/> | xrv9k-14 | 192.168.0.4 | tree-sid-oper-error | - | 4578 | Static | None | Disable | 172.27.226.118 | | | ... |

Configure Traffic Engineering Settings

Configure TE Timeout Settings

To configure timeout settings for the provisioning and retrieval of data for SR-TE policies, RSVP-TE tunnels, Bandwidth on Demand and IGP paths, select **Administration > Settings > System Settings > Traffic Engineering > General Settings** under the Advance Settings section. Enter the timeout duration options. For more information, click



Note Timeouts change the response time of each of the actions if SR-PCE is slow in responding. You can modify the settings for a large scale topology or to address slow SR-PCE response due to latency or load.

Configure How Device Groups Are Displayed for Traffic Engineering

You can configure what is shown on the topology map when a device group is selected and a device in the selected SR policy, service, or RSVP-TE tunnel does not belong in the group. To set the behavior, choose **Administration > Settings > User Settings** tab > **Switch Device Group** and select one of the behavior options.

By default, the user is asked each time to choose the device group view.

Configure Historical Data Settings

To configure the TE Dashboard (and Historical Data) settings for the collection of policy and tunnel metrics, state changes, path changes, data retention interval, and the utilization threshold for underutilized LSPs, select **Administration > Settings > System Settings** tab > **Performance Monitoring & Analytics > Historical Data**.

The screenshot displays the 'System Settings' page with the 'User Settings' tab selected. The left sidebar contains a list of settings categories, with 'Historical Data' highlighted in blue. The main content area shows the 'Historical Data Settings' section, which includes three toggle switches for 'LSP Traffic Rate', 'LSP State Change', and 'LSP Path Change', all of which are turned 'On'. Below these is a 'Retention Interval' field with a value of '2' and a range of '1 to 30 days'.

| Setting | Value |
|--------------------|-------------------------|
| LSP Traffic Rate | On |
| LSP State Change | On |
| LSP Path Change | On |
| Retention Interval | 2 (Range: 1 to 30 days) |

Table 2: Available Historical Data Setting Options

| Historical Data Settings | Description |
|--------------------------|---|
| LSP Traffic Rate | Turn on this field to capture the metric data in the TE Dashboard. |
| LSP State Change | Turn on this field to capture the state change details in the TE Dashboard. |
| LSP Path Change | Turn on this field to capture the path change details in the TE Dashboard. |
| Retention Interval | <p>The interval for which the historical data is collected and retained before being deleted. The default retention interval is set to two days.</p> <p>Note If the Retention Interval is reduced, all data older than the new retention interval is lost. For example, if the retention interval is set to 30 days and later it is reduced to 7 days, all the data older than 7 days will be deleted.</p> |

Resolve SR-TE Policies and RSVP-TE Tunnels

Orphaned TE policies are any PCE initiated SR-TE policies (SRv6, SR-MPLS, and Tree-SID) or RSVP-TE tunnels that were created within Crosswork and *after* the last cluster data synchronization. After a switchover in a High Availability setup, Crosswork automatically checks for any orphaned TE policies. Orphaned policies/tunnels may also happen after a backup/restore operation. You will be able to view policy details, but not modify them since they were not included as part of the last data synchronization. Crosswork will display an alarm when it finds orphan TE policies (**Administration > Alarms**).

Crosswork provides APIs to help clear these orphans. To get a list of orphan SR-TE policies or RSVP-TE tunnels use `cisco-crosswork-optimization-engine-sr-policy-operations:sr-datalist-oper` or `cisco-crosswork-optimization-engine-rsvp-te-tunnel-operations:rsvp-te-datalist-oper` where `is-orphan=True` and default action is GET. To make the orphans manageable again, use a SAVE action for the corresponding URL per policy type. For more information see [API documentation on Devnet \(Crosswork Optimization Engine APIs > 6.0 Release APIs\)](#).



CHAPTER 3

SR-MPLS and SRv6

This section describes the SR-MPLS and SRv6 policy features that Crosswork supports. For a list of known limitations and important notes, see the [Cisco Crosswork Optimization Engine Release Notes](#) .

- [View SR-MPLS and SRv6 Policies on the Topology Map, on page 19](#)
- [View SR-MPLS and SRv6 Policy Details, on page 21](#)
- [Visualize IGP Path and Metrics, on page 23](#)
- [Find Multiple Candidate Paths \(MCPs\), on page 24](#)
- [Visualize Underlying Paths Associated with a Defined Binding-Segment ID \(B-SID\) Label, on page 27](#)
- [Visualize Native SR Paths, on page 28](#)
- [Configure TE Link Affinities, on page 32](#)
- [Create Explicit SR-MPLS Policies, on page 33](#)
- [Create Dynamic SR-MPLS Policies Based on Optimization Intent, on page 34](#)
- [Modify SR-MPLS Policies, on page 35](#)

View SR-MPLS and SRv6 Policies on the Topology Map

To get to the Traffic Engineering topology map, choose **Traffic Engineering** > **Traffic Engineering**.

From the Traffic Engineering table, click the checkbox of each SR-MPLS or SRv6 policy you want to view on the map. You can select up to 10 policies that will appear as separate colored links.

Figure 1: Traffic Engineering UI : SR-MPLS and SRv6 Policies

The screenshot shows the Traffic Engineering UI. On the left, a network topology map displays several nodes (xrv9k-12 to xrv9k-17) connected by colored lines representing SR-TE policies. Callouts 1-5 point to specific UI elements on the map. On the right, the SR Policy table is displayed, showing a list of policies with columns for Headend, Endpoint, Color, Admin Status, and Open. Callouts 6-9 point to specific UI elements in the table and dashboard area.

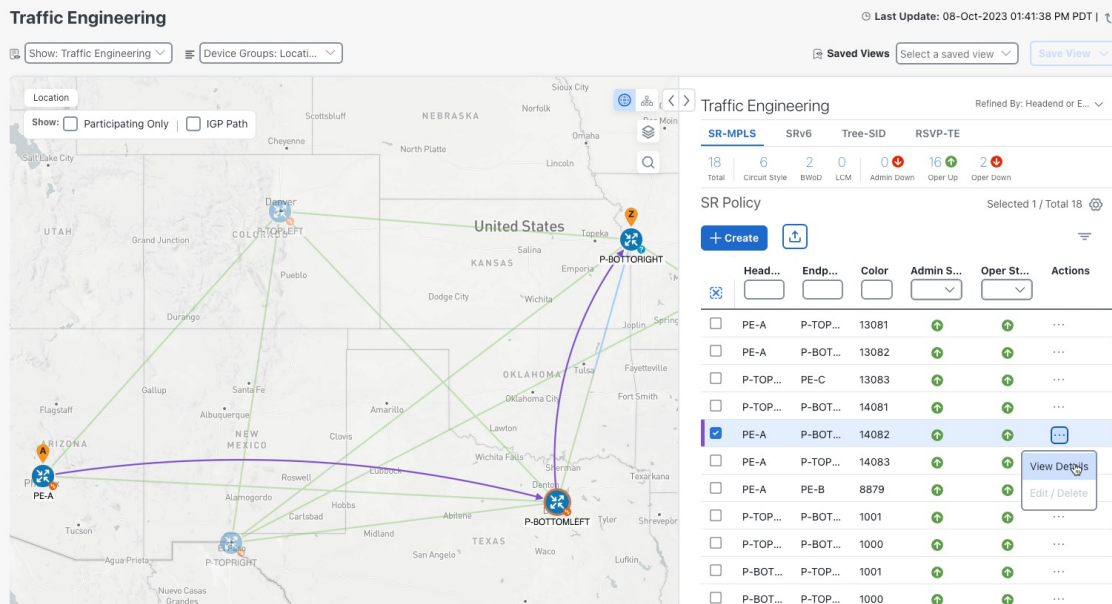
| Callout No. | Description |
|-------------|---|
| 1 | A device with an orange (🔴) outline indicates there is a node SID associated with that device or a device in the cluster. |
| 2 | Click the appropriate check box to enable the following options: <ul style="list-style-type: none"> • Show IGP Path—Displays the IGP path for the selected SR-TE policy. • Show Participating Only—Displays only links that belong to selected SR-TE policy. All other links and devices disappear. |
| 3 | When SR-TE policies are selected in the SR-MPLS or SRv6 tables, they show as colored directional lines on the map indicating source and destination. An adjacency segment ID (SID) is shown as an orange circle on a link along the path (🔴). |
| 4 | SR-MPLS and SRv6 Policy Origin and Destination: If both A and Z are displayed in a device cluster, at least one node in the cluster is a source and another is a destination. The A+ denotes that there is more than one SR-TE policy that originates from a node. The Z+ denotes that the node is a destination for more than one SR policy. |
| 5 | The content of this window depends on what has been selected or filtered. In this example, the SR-MPLS tab is selected and the SR Policy table is displayed. |
| 6 | Click on either the SR-MPLS or SRv6 tabs to view the respective list of SR-TE policies. |
| 7 | The Mini Dashboard provides a summary of the operational SR-MPLS or SRv6 policy status. If filters are applied, the Mini Dashboard is updated to reflect what is displayed in the SR Policy and SRv6 Policy tables. In addition to the policy status, the SR-MPLS Mini Dashboard table displays the number of PCC and PCE initiated tunnels that are <i>currently</i> listed in the SR Policy table. |

| Callout No. | Description |
|-------------|---|
| 8 | <p>This option allows you to choose how the group filter (when in use) should be applied on the table data. For example, if Headend only was selected, then it would only display policies where the headend device of the policy is in the selected group. This filter allows you to see specific configurations and is useful when you have a large network.</p> <p>Filter options:</p> <ul style="list-style-type: none"> • Headend or Endpoint—Show policies with either the headend or endpoint device in the selected group. • Headend and Endpoint—Show policies if both the headend and endpoint are in the group. • Headend only—Show policies if the headend device of the policy is in the selected group. • Endpoint only—Show policies if endpoint device of the policy is in the selected group. |
| 9 | Exports <i>all</i> data into a CSV file. You cannot export selected or filtered data. |

View SR-MPLS and SRv6 Policy Details

View SR-MPLS or SRv6 TE policy level details as well segment lists and any path computation constraints configured on a per-candidate path basis.

Step 1 From the **Actions** column, click  > **View Details** for one of the SR-MPLS or SRv6 policies.



The screenshot displays the Traffic Engineering dashboard. On the left, a map of the United States shows network paths between various cities. On the right, a table lists SR Policies. The table has columns: Headend, Endp..., Color, Admin S..., and Oper St... The policy with ID 14082 is selected, and a 'View Details' button is visible in the Actions column.

| SR-MPLS | SRv6 | Tree-SID | RSVP-TE |
|---------|---------------|------------|---------|
| 18 | 6 | 2 | 0 |
| Total | Circuit Style | BWob | LCM |
| | | Admin Down | Oper Up |
| | | Oper Down | |

| Head... | Endp... | Color | Admin S... | Oper St... | Actions |
|-------------------------------------|----------|----------|------------|--------------------------------------|--------------------------------------|
| <input type="checkbox"/> | PE-A | P-TOP... | 13081 | ● | ● |
| <input type="checkbox"/> | PE-A | P-BOT... | 13082 | ● | ● |
| <input type="checkbox"/> | P-TOP... | PE-C | 13083 | ● | ● |
| <input type="checkbox"/> | P-TOP... | P-BOT... | 14081 | ● | ● |
| <input checked="" type="checkbox"/> | PE-A | P-BOT... | 14082 | ● | ● |
| <input type="checkbox"/> | PE-A | P-TOP... | 14083 | ● | ● |
| <input type="checkbox"/> | PE-A | PE-B | 8879 | ● | ● |
| <input type="checkbox"/> | P-TOP... | P-BOT... | 1001 | ● | ● |
| <input type="checkbox"/> | P-TOP... | P-BOT... | 1000 | ● | ● |
| <input type="checkbox"/> | P-BOT... | P-TOP... | 1001 | ● | ● |
| <input type="checkbox"/> | P-BOT... | P-TOP... | 1000 | ● | ● |

Step 2 View SR-MPLS or SRv6 policy details. From the browser, you can copy the URL and share with others.

Note The Delay value is calculated for all policies every 10 minutes. Hover your mouse over the "i" icon (next to the Delay value) to view the last time the value was updated.

Figure 2: SR Policy Details - Headend, Endpoint, and Summary

SR Policy Details ... ✕ Clear

Current History

Headend A PE-A | Source IP: 100.100.100.5
TE RID: 100.100.100.5
PCC IP: 100.100.100.5

Endpoint Z P-BOTTORIGHT | Dest IP: 100.100.100.4
TE RID: 100.100.100.4

Color 14082

Summary ^

Admin State ↑ Up

Oper State ↑ Up

Binding SID 24027

Policy Type Regular

Profile ID -

Description -

Traffic Rate 0 Mbps

Unused True i

Delay 2 i

Accumulated Metric 0

Delegated PCE 172.20.118.119

Non-delegated PCEs 172.20.118.63

PCE Computed Time 01-Jan-2023 09:02:46 PM PDT

Last Update 05-Oct-2023 01:21:08 PM PDT

[See less](#) ^

Figure 3: SR Policy Details - Candidate Path

The screenshot displays the 'Candidate Path' configuration page. At the top, there is a 'Collapse All' button. Below it is a table with columns: Path Name, Preference, Path Type, and State. The selected path is 'bwod_name_101236' with a preference of 100 and path type 'Explicit'. Below the table, there is a detailed view of the path configuration:


| S... | Seg... | L... | Algo | IP | N... | Inte... | S... |
|------|--------|------|------|----------|-------|---------|------|
| 0 | No... | 1... | 0 | 192.1... | xr... | | Reg |

Below the table, the detailed configuration for the selected path is shown:

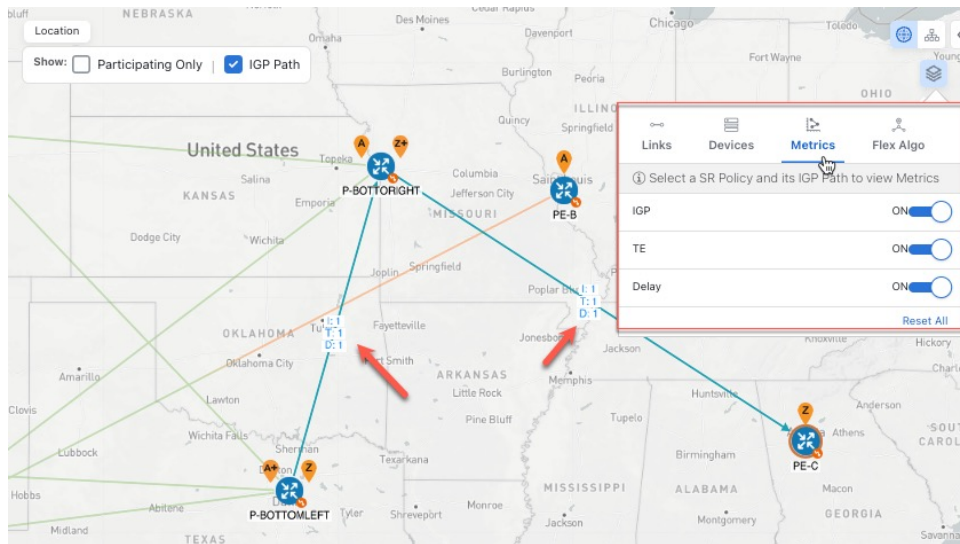
- Path Name:** bwod_name_101236
- Oper State:** Up | Active
- Metric Type:** UNKNOWN
- Bandwidth:** Requested: 0 Mbps, Reserved: 0 Mbps
- Disjoint Group:** ID: -, Association Source: -, Type: -
- PCE Initiated:** true
- Affinity:** Exclude-Any: -, Include-Any: -, Include-All: -
- Segment Type:** Protected
- SID Algorithm:** -

Visualize IGP Path and Metrics

View the physical path and metrics between the endpoints of the selected SR-MPLS policies.

- Step 1** From the **SR Policy** table, check the check box next to the SR-TE (SR-MPLS and SRv6) policies you are interested in.
- Step 2** Check the **Show IGP Path** check box. The IGP paths for the selected SR-MPLS policies are displayed, with straight lines, instead of the segment hops. In a dual stack topology, the **Participating Only** checkbox must also be checked to view metrics on participating links.
- Step 3** Click  > **Metrics** tab.
- Step 4** Toggle applicable metrics to **ON**.
- Note** You must check the **Show IGP Path** check box in order to view metrics.

Find Multiple Candidate Paths (MCPs)



Find Multiple Candidate Paths (MCPs)

Visualizing MCPs gives you insight into which paths might be a better alternative to the currently active one. If you determine to do so, you can then manually configure the device and change which path becomes active.

Important Notes

- Only PCC-initialized SR-TE policies with MCPs are supported.
- Crosswork Optimization Engine does not distinguish dynamic paths versus explicit paths. The Policy Type field value displays as 'Unknown'.
- You can view active explicit paths, but not inactive candidate explicit paths in the UI.

Before you begin

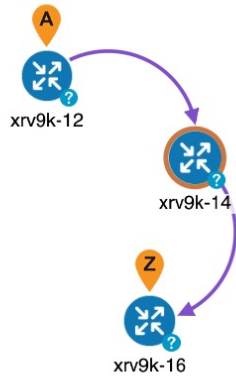
A policy must be configured with MCPs on devices before visualizing them on the Traffic Engineering topology map. This configuration can be done manually or within Crosswork Network Controller.

Step 1 From the main menu, choose **Traffic Engineering > Traffic Engineering > SR-MPLS or SRv6** tab.

Step 2 Navigate to the active SR-TE policy that has MCPs configured and view it on the topology map.

- Check the check box next to the SR-TE policy that has MCPs configured.
- View the SR-TE policy that is highlighted on the topology map.

In this example, you see that the active path is going from **xrv9k-12 > xrv9k-14 > xrv9k-16**.



Step 3 View the list of candidate paths.

- a) From the SR-TE Policy table **Actions** column, click > **View Details**. A list of candidate paths appear along with policy details in the **SR Policy Details** window. The green A in the state column indicates the active path.

Find Multiple Candidate Paths (MCPs)

SR Policy Details ... | X

Current **History**

Headend A xrv9k-12 | Source IP: 192.168.0.2
TE RID: 192.168.0.2 | IPv6 RID: 2001:192:168::2
PCC IP: 192.168.0.2

Endpoint Z xrv9k-16 | Dest IP: 192.168.0.6
TE RID: 192.168.0.6 | IPv6 RID: 2001:192:168::6

Color 2023

Summary

Admin State Up

Oper State Up

Binding SID 24012

Policy Type Regular

Profile ID -

Description -

Traffic Rate 0 Mbps

Unused True ⓘ

[See more](#) ▾

Candidate Path

[Collapse All](#)

| Path Name | Preference | Path Type | State |
|--|------------|-----------|--|
| <input checked="" type="checkbox"/> cfg_sr2023_discr_100 | 100 | Unknown | Up A |
| <input type="checkbox"/> cfg_sr2023_discr_50 | 50 | Unknown | Down |
| <input type="checkbox"/> cfg_sr2023_discr_25 | 25 | Unknown | Down |

Path Name cfg_sr2023_discr_25

Oper State Down

Metric Type TE

Bandwidth -

Disjoint Group ID: -
Association Source: -
Type: -

PCE Initiated false

Affinity Exclude-Any: -
Include-Any: -
Include-All: -

Segment Type Unprotected

SID Algorithm -

Step 4 You can expand individual paths or click **Expand All** to view details of each path.

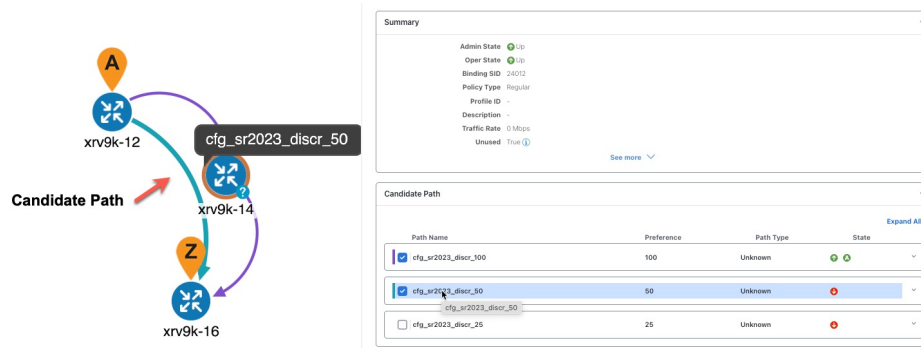
Step 5 Visualize the candidate path on the topology map.

- a) Check the check box next to any candidate path.

Note You will not be able to select or view explicit candidate paths.

- b) From the **Candidate Path** area, hover your mouse over the candidate path name. The candidate path is highlighted on the topology map.

In this example, you see that the alternate path goes directly from **xrv9k-12** > **xrv-16**.



Summary

Admin State: Up
Oper State: Up
Binding SID: 24012
Policy Type: Regular
Profile ID: -
Description: -
Traffic Rate: 0 Mbps
Unused: True

See more

Candidate Path

| Path Name | Preference | Path Type | State |
|----------------------|------------|-----------|-------|
| cfg_sr2023_discr_100 | 100 | Unknown | Up |
| cfg_sr2023_discr_50 | 50 | Unknown | Down |
| cfg_sr2023_discr_25 | 25 | Unknown | Down |

Visualize Underlying Paths Associated with a Defined Binding-Segment ID (B-SID) Label

Cisco Crosswork allows you to visualize the underlying path of a B-SID hop that you have manually configured on a device or configured using Crosswork Network Controller. In this example, we have assigned **15700** as a B-SID label on an SR-MPLS policy hop.

To view the B-SID underlying path for an SR-MPLS or SRv6 policy, do the following:

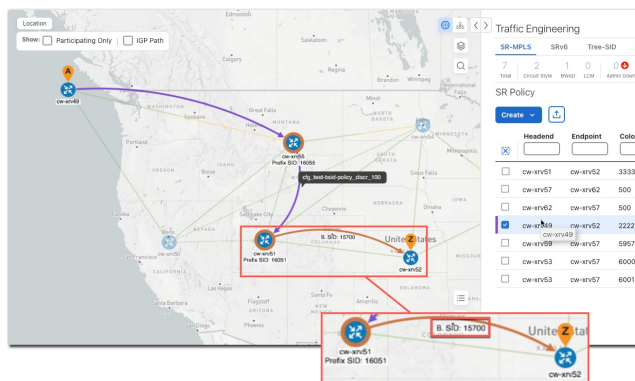
Step 1

From the main menu, choose **Traffic Engineering > Traffic Engineering > SR-MPLS**.

Step 2

From the SR Policy table, check the check box next to the policy that has a hop assigned with a B-SID label. Hover your mouse over any part of the SR-MPLS row to see the B-SID name. The B-SID path is highlighted in **orange** on the topology map.

In this example, you see that the B-SID path is going from **cw-xrv51** to **cw-xrv52**.



Step 3

From the **Actions** column, click **...** > **View Details**.

Step 4

From the **SR Policy Details** window, expand the active path name to view more information. In this example, the underlying path actually goes from **cw-xrv51 > cw-xrv54 > cw-xrv53 > cw-xrv52**.

SR Policy Details

Current | History

Headend cw-xrv51 | Source IP: 3.3.3.51
TE RID: 3.3.3.51 | IPv6 RID: fe00:3:3:51
PCC IP: 3.3.3.51

Endpoint cw-xrv52 | Dest IP: 3.3.3.52
TE RID: 3.3.3.52 | IPv6 RID: fe00:3:3:52

Color: 3333

Summary

- Admin State: Up
- Oper State: Up
- Binding SID: 15700
- Policy Type: Regular
- Profile ID: -
- Description: -
- Traffic Rate: 0 Mbps
- Unused: True

Candidate Path

| Path Name | Preference | Path Type | State |
|--|------------|-----------|---|
| <input checked="" type="checkbox"/> cfg_bsid-51-52_discr_100 | 100 | Unknown | ✔ ✔ |

| Segment | Segment Type | Label | Algo | IP | Node | Interface | SID Type |
|---------|--------------|-------|------|----------|----------|-----------|----------|
| 0 | Node SID | 16054 | 0 | 3.3.3.54 | cw-xrv54 | | Reg |
| 1 | Node SID | 16053 | 0 | 3.3.3.53 | cw-xrv53 | | Reg |
| 2 | Node SID | 16052 | 0 | 3.3.3.52 | cw-xrv52 | | Reg |

Path Name: cfg_bsid-51-52_discr_100

Oper State: Up | Active

Metric Type: TE

Bandwidth: -

Disjoint Group ID: Association Source: -
Type: -

PCE Initiated: false

Affinity: Exclude-Any: -
Include-Any: -
Include-All: -

Segment Type: Unprotected

SID Algorithm: -

Visualize Native SR Paths

Visualizing the native path will help you in OAM (Operations, Administration and Maintenance) activities to monitor label-switched paths (LSPs) and quickly isolate forwarding problems to assist with fault detection and troubleshooting in the network. Since this feature uses multipaths, all ECMP paths are shown between the source and destination. You can visualize only native SR IGP paths.

Before you begin

Confirm that device requirements are met. See [Visualize Native Path Device Prerequisites, on page 30](#).

To create a path query, do the following:

- Step 1** From the main menu, choose **Traffic Engineering > Path Query**. The Path Query dashboard appears.
- Step 2** On the Path Query dashboard, click **New Query**.
- Step 3** Enter the device information in the required fields to find available Native SR IGP Paths.
- Step 4** Click **Get Paths**. The Running Query ID pop-up appears.

Note Path queries may take a moment to complete. When the Running Query ID pop-up appears, you can also select **View Past Queries** to return to the Path Query Dashboard. If you already had path queries in the list, you can view existing details as the new query continues to run in the background, which is indicated by the blue Running icon in the Query State column. When the new query state turn green, completed, it can be viewed.

Step 5 Click **View Result** when it becomes available on the Running Query ID pop-up. The Path Details panel appears with corresponding available paths details while the defined topology map appears with the available Native SR IGP Paths on the left.

Example:

In the below example, you can view the available paths : **Path 0**

Figure 4: Path Details

The screenshot displays the Path Query interface. On the left, a map of the United States shows a network topology with nodes labeled PE-A, PE-B, PE-C, TOP-LEFT, TOP-RIGHT, and BOTTOM-LEFT. On the right, a 'New Path Query' dialog box is open, featuring a search bar for 'Device Groups: Locat...', a 'Select Service' dropdown, a 'Select Instance' dropdown, and input fields for 'Headend' and 'Endpoint'. The dialog also includes 'Get Paths' and 'Cancel' buttons. The top right corner of the interface shows the last update time: '© Last Update: 09-Nov-2023 06:02:31 PM IST | ↻'.

Step 6 From the main menu, choose **Traffic Engineering > Path Query**. to return to the Path Query dashboard.

Step 7 From the **Actions** column, click **View Details**.

If you have not provided the longitude and latitude information for your devices, the path is visualized in the logical view.

Step 8 From the available paths, click **Path 0** to expand and view the active path.

Example:

Figure 5: Path Details

Path Details

Select Service: L3vpn-Service | NSS-L3-Shared-540-internal

Headend: PE-C (100.100.10.7)

Endpoint: PE-B (100.100.10.8)

Available Paths

Path 0

Status: Found

Output: GigabitEthernet0/0/0/0

Nexthop: 20.20.20.30

Source: 100.100.10.7

Destination: 127.0.0.0

Hop Details [What is ret code/char?](#)

Hop Index:0 | Hop Origin IP:100.100.10.7 | Hop Destination IP:20.20.20.30 | MRU:1500 | Labels:[16006] | ret code:0 | multipaths:0

Hop Index:1 | Hop Origin IP:20.20.20.30 | Hop Destination IP:20.20.20.21 | MRU:1500 | Labels:[16006] | ret code:8 | return char:L | multipaths:1

Hop Index:2 | Hop Origin IP:20.20.20.21 | Hop Destination IP:20.20.20.26 | MRU:1500 | Labels:[implicit-null] | ret code:8 | return char:L | multipaths:1

Hop Index:3 | Hop Origin IP:20.20.20.26 | MRU:0 | ret code:3 | return char:I | multipaths:0

Visualize Native Path Device Prerequisites

Confirm the following device software and configurations are met prior to visualizing native paths.

1. Devices should be running Cisco IOS XR 7.3.2 or higher. Run `show version` command to verify it.
2. Devices should have GRPC enabled.
 - a. Run `show grpc` to confirm GRPC configuration. You should see something similar to this:

```


tpa
vrf default
address-family ipv4
default-route mgmt
!
address-family ipv6
default-route mgmt
!
!
!
or

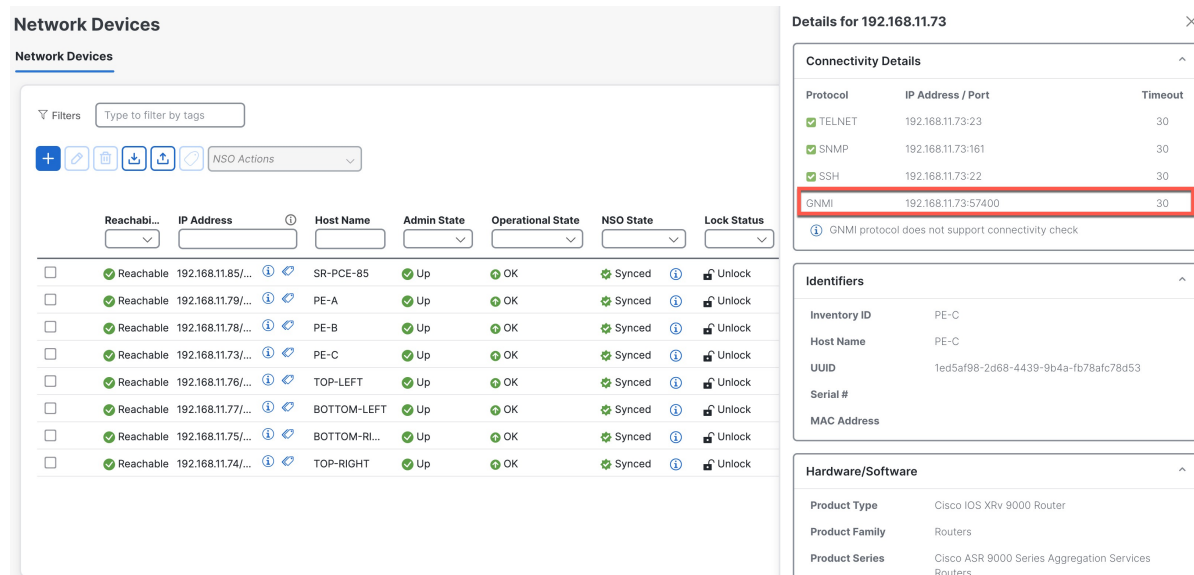
linux networking
vrf default
address-family ipv4
default-route software-forwarding
!
address-family ipv6
default-route software-forwarding
!
!
!
```

**Note**

- `address-family` is only required in an IPv4 topology.
- To enable GRPC with a secure connection, you must upload security certificates to connect to the device.

3. Devices should have GNMI capability enabled and configured.

- From Device Management > Network Devices, click  icon for the device you are interested.
- Confirm that GNMI is listed under Connectivity Details.



The screenshot shows the 'Network Devices' management interface. On the left, a table lists several devices with columns for Reachability, IP Address, Host Name, Admin State, Operational State, NSO State, and Lock Status. On the right, a 'Details for 192.168.11.73' panel is open, showing 'Connectivity Details' with a table of protocols and their configurations. The GNMI entry is highlighted with a red box.

| Protocol | IP Address / Port | Timeout |
|----------|---------------------|---------|
| TELNET | 192.168.11.73-23 | 30 |
| SNMP | 192.168.11.73-161 | 30 |
| SSH | 192.168.11.73-22 | 30 |
| GNMI | 192.168.11.73-57400 | 30 |

Below the connectivity table, a note states: "GNMI protocol does not support connectivity check".

The 'Identifiers' section shows: Inventory ID: PE-C, Host Name: PE-C, UUID: 1ed5af98-2d68-4439-9b4a-fb78afc78d53, Serial #: , MAC Address: .

The 'Hardware/Software' section shows: Product Type: Cisco IOS XRv 9000 Router, Product Family: Routers, Product Series: Cisco ASR 9000 Series Aggregation Services Routers.

**Note**

Based on the type of devices, the following device encoding type are available:

- JSON
- BYTES
- PROTO
- ASCII
- JSON IETF

4. Devices should have the CDG router static address. Static route should be added from the device to the southbound CDG IP address. For example:

```
RP/0/RP0/CPU0:xrvr-7.3.2#config
```

```
RP/0/RP0/CPU0:xrvr-7.3.2(config)#router static
```

```
RP/0/RP0/CPU0:xrvr-7.3.2(config-static)#address-family ipv4 unicast <CDG Southbound interface IP: eg. 172.24.97.110> <Device Gateway eg: 172.29.105.1>
```

```
RP/0/RP0/CPU0:xrivr-7.3.2(config-static)#commit
```

Configure TE Link Affinities

If you have any affinities you wish to account for when provisioning an SR policy, Tree-SID, or RSVP-TE tunnel, then you can optionally define affinity mapping on the Cisco Crosswork UI for consistency with affinity names in device configurations. Cisco Crosswork will only send bit information to SR-PCE during provisioning. If an affinity mapping is not defined in the UI, then the affinity name is displayed as "UNKNOWN". If you want to configure affinity mappings in Cisco Crosswork for visualization purposes, you should collect affinities on the device, then define affinity mapping in the Cisco Crosswork UI with the same name and bits that are used on the device.

The affinity configuration on interfaces simply turns on some bits. It is a 32-bit value, with each bit position (0–31) representing a link attribute. Affinity mappings can be colors representing a certain type of service profile (for example: low delay, high bandwidth, and so on). This makes it easier to refer to link attributes.

See SR, Tree-SID, or RSVP-TE configuration documentation for your specific device to view descriptions and supported configuration commands (for example: [Segment Routing Configuration Guide for Cisco ASR 9000 Series Router](#))

The following example shows the affinity configuration (`affinity-map`) on a device:

```
RP/0/RP0/CPU0:c12#sh running-config segment-routing traffic-eng affinity-map
Wed Jul 27 12:14:50.027 PDT
segment-routing
 traffic-eng
  affinity-map
   name red bit-position 1
   name blue bit-position 5
   name green bit-position 4
  !
 !
 !
```

Step 1 From the main menu, choose **Administration > Settings > System Settings tab > Traffic Engineering > Affinity > TE Link Affinities**. You can also define affinities while creating an SR-TE policy, Tree-SID, or RSVP-TE tunnel by clicking **Manage Mapping**.

Step 2 To add a new affinity mapping, click **+ Create**.

Step 3 Enter the name and the bit it will be assigned. For example (using the above configuration):

Example:

| TE Link Affinities | | Flex-Algo Affinities |
|--|-----------------------|---|
| <div style="display: flex; justify-content: space-between; align-items: center;"> + Create ☰ </div> | | |
| Name ⓘ | Bit Position (0-31) ⓘ | Actions |
| <input type="text"/> | <input type="text"/> | |
| green | 4 | <div style="display: flex; gap: 5px;"> Edit Delete </div> |
| blue | 5 | <div style="display: flex; gap: 5px;"> Edit Delete </div> |
| red | 1 | <div style="display: flex; gap: 5px;"> Edit Delete </div> |

Step 4 Click **Save** to save the mapping.

Note You should remove the TE tunnel before removing the affinity to avoid orphan TE tunnels. If you have removed an affinity associated to a TE tunnel, the affinity is shown as "UNKNOWN" in the **SR Policy / RSVP-TE Tunnel Details** window.

Create Explicit SR-MPLS Policies


This task creates SR-MPLS policies using an explicit (fixed) path consisting of a list of prefix or adjacency Segment IDs (SID list), each representing a node or link along on the path.



Tip If you plan to use affinities, collect affinity information from your devices, and then map them in Cisco Crosswork before creating an explicit SR-MPLS policy. For more information, see [Configure TE Link Affinities, on page 32](#).

Step 1 From the main menu, choose **Traffic Engineering > Traffic Engineering > SR-MPLS** tab.

Step 2 From the **SR Policies** table, click + **Create**.

Step 3 Enter or select the required SR-MPLS policy values. Hover the mouse pointer over the  to view a description of the field.

Tip If you have set up device groups, you can select the device group from the **Device Groups** drop-down list. Then navigate and zoom in on the topology map to click the device for headend or endpoint selection.

Step 4 Under Policy Path, click **Explicit Path** and enter a path name.

Step 5 Add segments that will be part of the SR-MPLS policy path.


Step 6 Click **Preview** and confirm that the policy you created matched your intent.

Step 7 If you want to commit the policy path, click **Provision** to activate the policy on the network or exit to abort the configuration process.

Step 8 Validate the SR-MPLS policy creation:

a. Confirm that the new SR-MPLS policy appears in the SR Policy table. You can also click the check box next to the policy to see it highlighted in the map.

Note The newly provisioned SR-TE policy may take some time, depending on the network size and performance, to appear in the **SR Policy** table. The **SR Policy** table is refreshed every 30 seconds.

b. View and confirm the new SR-MPLS policy details. From the **SR Policy** table, click the  and select **View**.

Note On a setup with high node, policy, or interface counts, a timeout may occur during policy deployment. To configure timeout options, see [Configure TE Timeout Settings, on page 15](#).

Create Dynamic SR-MPLS Policies Based on Optimization Intent


This task creates an SR-MPLS policy with a dynamic path. SR-PCE computes a path for the policy based on metrics and path constraints (affinities or disjointness) defined by the user. A user can select from three available metrics to minimize in path computation: IGP, TE, or latency. The SR-PCE will automatically re-optimize the path as necessary based on topology changes. In the event of a link or interface failing, the network will find an alternate path that meets all the criteria specified in the policy and raise an alarm. The alarm is also raised in case no path is found, the packets are then dropped.



Tip For visualization purposes, you can optionally collect affinity information from your devices and then map them in Cisco Crosswork before creating a dynamic SR-MPLS policy. For more information, see [Configure TE Link Affinities, on page 32](#) or [Configure Flexible Algorithm Affinities, on page 43](#).

Step 1 From the main menu, choose **Traffic Engineering > Traffic Engineering > SR-MPLS** tab.

Step 2 From the **SR Policy** table, click + **Create**.

Step 3 Under **Policy Details**, enter or select the required SR-MPLS policy values. Hover the mouse pointer over  to view a description of each field.

Tip If you have set up device groups, you can select the device group from the **Device Groups** drop-down menu. Then navigate and zoom in on the topology map to click the device for headend or endpoint selection.

Step 4 Under **Policy Path**, click **Dynamic Path** and enter a path name.

Step 5 Under **Optimization Objective**, select the metric you want to minimize.

Step 6 Define any applicable constraints and disjointness.

Note

- Affinity constraints and disjointness cannot be configured on the same SR-MPLS policy. Also, there cannot be more than two SR-MPLS policies in the same disjoint group or subgroup. The configuration will not be allowed during Preview.
- If there are existing SR-MPLS policies belonging to a disjoint group that you define here, all SR-MPLS policies that belong to that same disjoint group are shown during Preview.

Step 7 Under **Segments**, select whether or not protected segments should be used when available.

Step 8 If applicable, enter a SID constraint in the **SID Algorithm** field. Cisco Crosswork will try to find a path with this SID. If a path with the SID constraint cannot be found, the provisioned policy will remain operationally down until the conditions are met.

Note

- Flexible Algorithm: The values correspond to the Flexible Algorithm that are defined on the device and the 128-255 range is enforced by Cisco IOS XR.
- Algorithm 0: This is a Shortest Path First (SPF) algorithm based on link metric. This shortest path algorithm is computed by the Interior gateway protocol (IGP).
- Algorithm 1: This is a Strict Shortest Path First (SSPF) algorithm based on link metric. The algorithm 1 is identical to algorithm 0 but requires that all nodes along the path honor the SPF routing decision. Local policy does not alter the forwarding decision. For example, a packet is not forwarded through locally engineered path.

Step 9 Click **Preview**. The path is highlighted on the map.

Step 10 If you want to commit the policy path, click **Provision**.

Step 11 Validate the SR-MPLS policy creation:

- a. Confirm that the new SR-MPLS policy appears in the SR Policy table. You can also click the check box next to the policy to see it highlighted in the map.

Note The newly provisioned SR-MPLS policy may take some time, depending on the network size and performance, to appear in the **SR Policy** table. The **SR Policy** table is refreshed every 30 seconds.

- b. View and confirm the new SR-MPLS policy details. From the **SR Policy** table, click and select **View**.

Note On a scaled setup with high node, policy, or interface counts, a timeout may occur during policy deployment. To configure timeout options, see [Configure TE Timeout Settings, on page 15](#).

Modify SR-MPLS Policies

To view, modify, or delete an SR-MPLS policy, do the following:

Step 1 From the main menu, choose **Traffic Engineering > Traffic Engineering > SR-MPLS** tab.

Step 2 From the SR Policy table, locate the SR-MPLS policy you are interested in and click .

Step 3 Choose **View** or **Edit/Delete**.

- Note**
- You can only modify or delete SR-MPLS policies that have been created with the UI.
 - After updating the SR-MPLS policy details, you can preview the changes on the map before saving it.
-



CHAPTER 4

Resource Reservation Protocol (RSVP)

This section describes the RSVP-TE tunnel features that Crosswork Optimization Engine supports. For a list of known limitations and important notes, see the [Cisco Crosswork Optimization Engine Release Notes](#).

- [View RSVP-TE Tunnels on the Topology Map](#), on page 37
- [View RSVP-TE Tunnel Details](#), on page 39
- [Create Explicit RSVP-TE Tunnels](#), on page 40
- [Create Dynamic RSVP-TE Tunnels Based on Optimization Intent](#), on page 41
- [Modify RSVP-TE Tunnels](#), on page 42



View RSVP-TE Tunnels on the Topology Map

To get to the Traffic Engineering topology map for RSVP-TE visualization, choose **Traffic Engineering > Traffic Engineering > RSVP-TE** tab.

Figure 6: Traffic Engineering UI - RSVP-TE Tunnels

| Tunnel ID | Headend | Endpoint | Admin Sta... | Oper Status | Actions |
|-------------------------------------|---------|----------|--------------|-------------|---------|
| <input checked="" type="checkbox"/> | 3345 | xrv9k-15 | xrv9k-17 | 🟢 | ⋮ |
| <input checked="" type="checkbox"/> | 6000 | xrv9k-16 | xrv9k-14 | 🟢 | ⋮ |
| <input checked="" type="checkbox"/> | 10111 | xrv9k-14 | xrv9k-16 | 🟢 | ⋮ |
| <input checked="" type="checkbox"/> | 10112 | xrv9k-15 | xrv9k-17 | 🟢 | ⋮ |
| <input type="checkbox"/> | 10122 | xrv9k-13 | xrv9k-15 | 🟢 | ⋮ |
| <input type="checkbox"/> | 113 | xrv9k-14 | xrv9k-13 | 🟢 | ⋮ |
| <input checked="" type="checkbox"/> | 105 | xrv9k-14 | xrv9k-13 | 🟢 | ⋮ |
| <input checked="" type="checkbox"/> | 117 | xrv9k-14 | xrv9k-13 | 🟢 | ⋮ |
| <input checked="" type="checkbox"/> | 115 | xrv9k-14 | xrv9k-13 | 🟢 | ⋮ |
| <input checked="" type="checkbox"/> | 101 | xrv9k-14 | xrv9k-13 | 🟢 | ⋮ |

476165

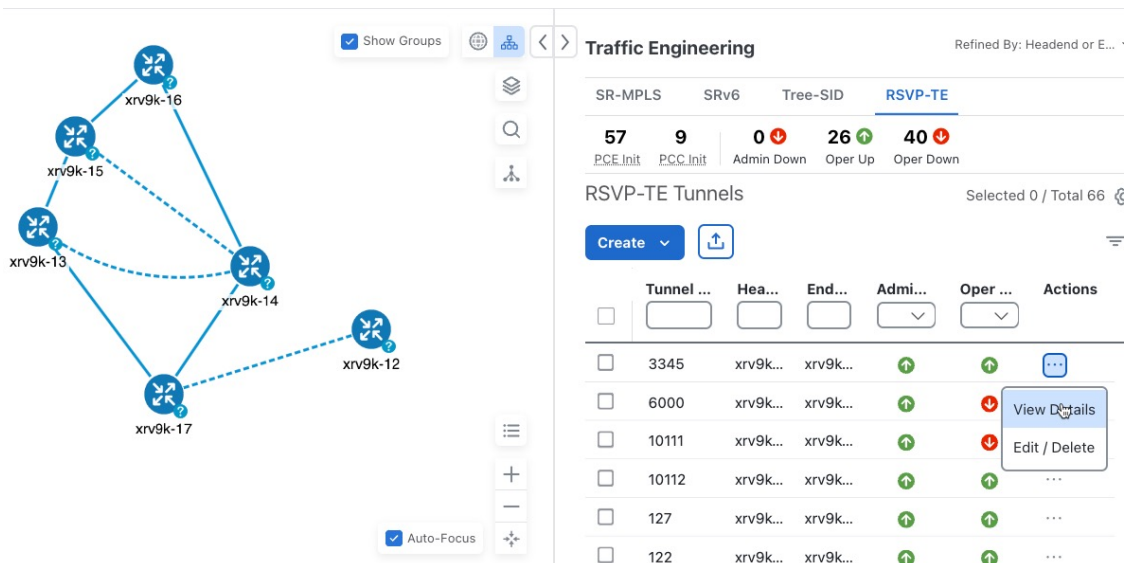
| Callout No. | Description |
|-------------|--|
| 1 | Click Show Participating Only to display links that only belong to the selected RSVP-TE tunnels. All other links and devices disappear. |
| 2 | <p>A device with a solid orange outline () indicates that it is a strict hop. A dashed orange outline indicates that a loose hop was discovered.</p> <p>Note RSVP-TE tunnels cannot be configured with loose hops when provisioning in the UI.</p> |
| 3 | <p>When RSVP-TE tunnels are selected in the RSVP-TE Tunnel table, they show as colored directional lines on the map indicating source and destination.</p> <ul style="list-style-type: none"> Record Route Object (RRO) paths are shown as straight lines. Explicit Route Object (ERO) paths are shown as curved lines. <p>Note If both RRO and ERO paths are available, the RRO path is displayed by default.</p> <ul style="list-style-type: none"> An adjacency segment ID (SID) is shown as a green dot on a link along the path () <p>If both A and Z are displayed in a device cluster, at least one node in the cluster is a source and another is a destination. The A+ denotes that there is more than one RSVP-TE tunnel that originates from a node. The Z+ denotes that the node is a destination for more than one RSVP-TE tunnel.</p> |
| 4 | <p>SR-MPLS and SRv6 Policy Origin and Destination: If both A and Z are displayed in a device cluster, at least one node in the cluster is a source and another is a destination. The A+ denotes that there is more than one SR-TE policy that originates from a node. The Z+ denotes that the node is a destination for more than one SR policy.</p> |
| 5 | <p>The content of this window depends on what has been selected or filtered. In this example, the RSVP-TE tab is selected and the RSVP-TE Tunnels table is displayed. Depending on what is selected on the topology map, or whether you are in the process of viewing and managing RSVP-TE tunnels, you can do the following:</p> <ul style="list-style-type: none"> Create Dynamic RSVP-TE Tunnels Based on Optimization Intent, on page 41 Create Explicit RSVP-TE Tunnels, on page 40 Modify RSVP-TE Tunnels, on page 42 View RSVP-TE Tunnel Details, on page 39 |
| 6 | Click the RSVP-TE tab. |
| 7 | The Mini Dashboard provides a summary of the operational RSVP-TE tunnel status and the number of PCC and PCE initiated tunnels that are <i>currently</i> listed in the RSVP-TE tables. If filters are applied, the Mini Dashboard is updated to reflect what is displayed in the RSVP-TE table. |

| Callout No. | Description |
|-------------|---|
| 8 | <p>This option allows you to choose how the group filter (when in use) should be applied on the table data. For example, if Headend only was selected, then it would only display policies where the headend device of the policy is in the selected group. This filter allows you to see specific configurations and is useful when you have a large network.</p> <p>Filter options:</p> <ul style="list-style-type: none"> • Headend or Endpoint—Show policies with either the headend or endpoint device in the selected group. • Headend and Endpoint—Show policies if both the headend and endpoint are in the group. • Headend only—Show policies if the headend device of the policy is in the selected group. • Endpoint only—Show policies if endpoint device of the policy is in the selected group. |
| 9 | Exports <i>all</i> data into a CSV file. You cannot export selected or filtered data. |

View RSVP-TE Tunnel Details

View RSVP-TE tunnel details such as binding label, delegated PCE, metric type, ERO/RRO, delay, and so on.

Step 1 From the **Actions** column, click  > **View Details** for one of the RSVP-TE tunnels.



The screenshot displays the 'Traffic Engineering' section of the Cisco Crosswork Optimization Engine 6.0 interface. On the left, a network diagram shows nodes xrv9k-12 through xrv9k-17 connected by solid and dashed lines. On the right, a table lists RSVP-TE tunnels. The table has columns for Tunnel ID, Headend, End, Admin, Oper, and Actions. A 'View Details' button is highlighted in the 'Actions' column for the tunnel with ID 6000.

| Tunnel ... | Hea... | End... | Admi... | Oper ... | Actions |
|------------|----------|----------|---------|----------|---------------|
| 3345 | xrv9k... | xrv9k... | ↑ | ↑ | ... |
| 6000 | xrv9k... | xrv9k... | ↑ | ↓ | View Details |
| 10111 | xrv9k... | xrv9k... | ↑ | ↓ | Edit / Delete |
| 10112 | xrv9k... | xrv9k... | ↑ | ↑ | ... |
| 127 | xrv9k... | xrv9k... | ↑ | ↑ | ... |
| 122 | xrv9k... | xrv9k... | ↑ | ↑ | ... |

Step 2 View RSVP-TE tunnel details. From the browser, you can copy the URL and share with others.

Note

- For end-to-end delays on RSVP-TE tunnels, inter-domain RSVP-TE tunnels must all be explicit (every interface along that path is specified as an adjacency hop).
- If applicable, the Delay value is calculated for all policies every 10 minutes. Hover your mouse over the "i" icon (next to the Delay value) to view the last time the value was updated.

> RSVP-TE Tunnel Details
⋮ | ✕

Headend A xrv9k-6 (192.168.0.6)
Endpoint B xrv9k-7 (192.168.0.7)
Tunnel ID 33000

✓ Summary

| | |
|-----------------------|--|
| Description | - |
| Path Name | 60701-rsvp |
| LSP ID | 6 |
| Path Type | Unknown |
| Admin State | ↑ Up |
| Oper State | ↑ Up |
| Utilization | 0 Mbps |
| Delay | 109 i |
| Signaled Bandwidth | 0 Mbps |
| Setup / Hold Priority | 7 / 7 |
| Metric Type | IGP |
| Fast Re-route (FRR) | Disable |
| Binding Label | 24012 |
| Accumulated Metric | 20 |
| Disjoint Group ID: | - |
| Association Source: | - |
| Type: | - |
| PCE Initiated | true |
| Delegated PCE | 2001:420:28f:2011:250:56ff:fe85:a025 |
| Non-delegated PCEs | - |
| Affinity Exclude-Any: | - |
| Include-Any: | - |
| Include-All: | - |
| PCE Computed Time | 27-Oct-2021 12:33:03 PM PDT |
| Last Update | 27-Oct-2021 12:39:58 PM PDT |


Last Updated ✕
 27-Oct-2021 06:41:22 PM PDT

Explicit Route Object (ERO)

| Hop | Node | IP | Interface Name | Type |
|-----|---------|-----------|------------------------|--------|
| 0 | xrv9k-3 | 10.0.0.29 | GigabitEthernet0/0/0/4 | Strict |
| 1 | xrv9k-7 | 10.0.0.42 | GigabitEthernet0/0/0/1 | Strict |

Create Explicit RSVP-TE Tunnels

This task creates RSVP-TE tunnels using an explicit (fixed) path consisting of a list of prefix or adjacency Segment IDs (SID list), each representing a node or link along on the path.

-
- Step 1** From the main menu, choose **Traffic Engineering > Traffic Engineering**.
- Step 2** From the right window, click **RSVP-TE**.
- Step 3** Under **RSVP-TE Tunnels**, click + **Create**.
- Step 4** Enter the required RSVP-TE Tunnel values. Hover the mouse pointer over  to view a description of each field.
- Tip** If you have set up device groups, you can select the device group from the **Device Groups** drop-down menu. Then navigate and zoom in on the topology map to click the device for headend or endpoint selection.
- Step 5** Under Tunnel Path, click **Explicit Path** and enter a path name.
- Step 6** Add segments that will be part of the RSVP-TE path.
- Step 7** Click **Preview**. The path is highlighted on the map.
- Step 8** If you want to commit the tunnel path, click **Provision**.
- Step 9** Validate the RSVP-TE tunnel creation:
- Confirm that the new RSVP-TE tunnel appears in the RSVP-TE Tunnels table. You can also click the check box next to the policy to see it highlighted in the map.

Note The newly provisioned RSVP-TE tunnel may take some time, depending on the network size and performance, to appear in the **RSVP-TE Tunnels** table. The **RSVP-TE Tunnels** table is refreshed every 30 seconds.
 - View and confirm the new RSVP-TE tunnel details. From the **RSVP-TE** table, click *** (in the same row as the RSVP-TE tunnel), and select **View**.
- Note** On a scaled setup with high node, policy, or interface counts, a timeout may occur during policy deployment. Please contact a Cisco representative to fine tune the timers involved.
-

Create Dynamic RSVP-TE Tunnels Based on Optimization Intent

This task creates an RSVP-TE tunnel with a dynamic path. SR-PCE computes a path for the tunnel that is based on metrics and path constraints (affinity or disjointness) defined by you. You can select from three available metrics to minimize in path computation: IGP, TE, or delay. SR-PCE will also automatically re-optimize the path as necessary based on topology changes.



Tip If you plan to use affinities, collect affinity information from your devices and then map them in Cisco Crosswork before creating a dynamic RSVP-TE tunnel. For more information, see [Configure TE Link Affinities, on page 32](#).

-
- Step 1** From the main menu, choose **Traffic Engineering > Traffic Engineering**.
- Step 2** From the right window, click **RSVP-TE**.
- Step 3** Under **RSVP-TE Tunnels**, click + **Create**.

- Step 4** Enter the required RSVP-TE Tunnel values. Hover the mouse pointer over ⓘ to view a description of each field.
- Tip** If you have set up device groups, you can select the device group from the **Device Groups** drop-down menu. Then navigate and zoom in on the topology map to click the device for headend or endpoint selection.
- Step 5** Under **Tunnel Path**, click **Dynamic Path** and enter the Path Name.
- Step 6** Under **Optimization Objective**, select the metric you want to minimize.
- Step 7** Define any applicable constraints and disjointness.
- Note** Affinity constraints and disjointness cannot be configured on the same RSVP-TE tunnel. Also, there cannot be more than two RSVP-TE tunnels in the same disjoint group or subgroup. If there are existing RSVP-TE tunnels belonging to a disjoint group that you define here, all RSVP-TE tunnels that belong to that same disjoint group are shown during Preview.
- Step 8** Click **Preview**. The path is highlighted on the map.
- Step 9** If you want to commit the tunnel path, click **Provision**.
- Step 10** Validate the RSVP-TE tunnel creation:
- Confirm that the new RSVP-TE tunnel appears in the RSVP-TE Tunnels table. You can also click the check box next to the policy to see it highlighted in the map.

Note The newly provisioned RSVP-TE tunnel may take some time, depending on the network size and performance, to appear in the **RSVP-TE Tunnels** table. The **RSVP-TE Tunnels** table is refreshed every 30 seconds.
 - View and confirm the new RSVP-TE tunnel details. From the **RSVP-TE** table, click ☰ and select **View**.

Note On a scaled setup with high node, policy, or interface counts, a timeout may occur during policy deployment. Please contact a Cisco representative to fine tune the timers involved.
-

Modify RSVP-TE Tunnels

To view, modify, or delete an RSVP-TE tunnel, do the following:

- Step 1** From the main menu, choose **Traffic Engineering > Traffic Engineering**.
- Step 2** From the **Traffic Engineering** window select the **RSVP-TE** tab.
- Step 3** Locate the RSVP-TE tunnel you are interested in and click ☰.
- Step 4** Choose **View** or **Edit/Delete**.
- Note**
- You can only modify or delete RSVP-TE tunnels that have been created with the UI or API.
 - After updating the RSVP-TE tunnel details, you can preview the changes on the map before saving it.
-



CHAPTER 5

Flexible Algorithms

Flexible Algorithm allows operators to customize and compute the IGP shortest path according to their own needs and constraints (specific metrics and link properties). Many possible constraints can be used to compute a path over a network. For example, Flexible Algorithm can confine the path to a particular plane for networks with multiple logical planes. Since the meaning of the algorithm is not defined by any standard, but is defined by the user, it is called a Flexible Algorithm.

Crosswork enables you to filter the IGP topology based on Flexible Algorithm and visualize the subset of the network that is capable of providing a specific set of transport characteristics. The ability to visualize Flexible Algorithm topologies provides an important tool to help you deploy, maintain, and verify that the configured Flexible Algorithm intent is realized in your network. For example, to improve service availability, you may use Flexible Algorithm to define disjoint logical topologies to increase resiliency to network failures. Crosswork allows you to visualize both Flexible Algorithm topologies simultaneously and verify they have no common nodes or links. Or if they do, help you determine the common network elements so that you can update Flexible Algorithm configurations.

This section contains the following topics:

- [Configure Flexible Algorithm Affinities, on page 43](#)
- [Visualize Flexible Algorithm Topologies, on page 44](#)
- [View Flexible Algorithm Details , on page 45](#)

Configure Flexible Algorithm Affinities

Flexible Algorithm affinity names that are defined on devices are not collected by Crosswork. You can optionally define affinity mapping on the Cisco Crosswork UI for consistency with Flexible Algorithm affinity names in device configurations. Cisco Crosswork will only send bit information to SR-PCE during provisioning. If an affinity mapping is not defined in the UI, then the affinity name is displayed as "UNKNOWN". If you want to configure affinity mappings in Cisco Crosswork for visualization purposes, you should collect affinities on the device, then define affinity mapping in the Cisco Crosswork UI with the same name and bits that are used on the device.

See SR configuration documentation for your specific device to view descriptions and supported configuration commands (for example: [Segment Routing Configuration Guide for Cisco ASR 9000 Series Routers](#))

The following example shows the Flexible Algorithm affinity configuration (`affinity-map`) on a device:

```
router isis CORE
 is-type level-2-only
 net 49.0001.0000.0000.0002.00
 log adjacency changes
```

```

affinity-map b33 bit-position 33
affinity-map red bit-position 1
affinity-map blue bit-position 5
flex-algo 128
  priority 228
  advertise-definition
  affinity exclude-any blue indigo violet black
!
```

For visualization purposes, you must map the affinity names to the bits using the following procedure:

- Step 1** From the main menu, select **Administration > Settings > System Settings > Traffic Engineering > Affinity > Flex-Algorithm Affinities** tab.
- Step 2** To add a new Flexible Algorithm affinity mapping, click **+ Create**.
- Step 3** Enter the name and the bit it will be assigned. For example (using the above configuration):

Example:

| Name ? | Bit Position (0-255) ? | Actions |
|----------------------|------------------------|---|
| <input type="text"/> | <input type="text"/> | |
| b33 | 33 | Edit Delete |
| red | 1 | Edit Delete |
| blue | 5 | Edit Delete |

- Step 4** Click **Save** to save the mapping. To view all Flexible Algorithm affinities for a link, see [View Flexible Algorithm Details](#), on page 45.

Visualize Flexible Algorithm Topologies

Crosswork allows you to visualize Flexible Algorithm nodes and links on the topology map that have been manually configured or dynamically provisioned using the UI in your network.




Note To apply a Flexible Algorithm constraint when dynamically provisioning an SR-MPLS policy, see [Create Dynamic SR-MPLS Policies Based on Optimization Intent](#), on page 34.

Before you begin

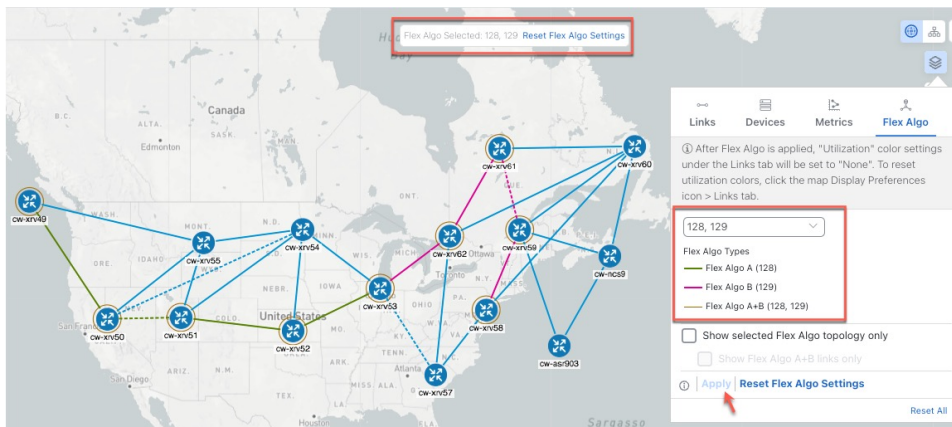
You must understand and configure Flexible Algorithms in your network. See the SR Flexible Algorithm configuration documentation for your specific device to view descriptions and supported configuration commands (for example: [Segment Routing Configuration Guide for Cisco NCS 540 Series Routers](#)).



Note You cannot visualize Flexible Algorithms if a Flexible Algorithm ID is the same across different domains.

- Step 1** From the main menu, select **Traffic Engineering > Traffic Engineering**.
- Step 2** From the topology map, click .
- Step 3** Click the **Flex Algo** tab.
- Step 4** From the drop-down list, select up to two Flexible Algorithm IDs.
- Step 5** View the Flexible Algorithm Types and confirm that the selection is correct. Also, note the color assignments for each Flexible Algorithm.
- Step 6** (Optional) Check the **Show selected Flex Algo topology only** check box to isolate the Flexible Algorithms on the topology map. When this option is enabled, SR policy selection is disabled.
- a) Check the **Show Flex Algo A+B links only** to show only those links and nodes that participate in both Flexible Algorithms.
- Step 7** Click **Apply**. You must click **Apply** for any additional changes to Flexible Algorithm selections to see the update on the topology map.

Example:



Note If a selected Flexible Algorithm is defined with criteria but there are no link and node combinations that match it (for example, a defined affinity to include all nodes or links with the color blue), then the topology map will be blank. If a selected Flexible Algorithm is not configured on a node or link, then the default blue link or node color appears.

- Step 8** (Option) Click **Save View** to save the topology view and Flexible Algorithm selections.

View Flexible Algorithm Details

To view device or link Flex Algorithm details, do the following:

Step 1 From the main menu, choose **Traffic Engineering > Traffic Engineering**.

Step 2 To view device Flexible Algorithm details:

- From the topology map, click on a device.
- In the **Device Details** window, navigate to the **Traffic Engineering > Flex-Algo** tab. For example:

The screenshot shows the 'Device Details' window with the 'Traffic Engineering' tab selected. Under the 'Flex Algo' sub-tab, the configuration for 'Algo 128' is displayed. The configuration includes:

- IGP: Domain ID: 300, ISIS System ID: 0000.0000.0062, Level: 2
- Participating: Yes
- Elected Definition: Metric Type: LATENCY
 - Exclude-Any Affinity:
 - Include-Any Affinity:
 - Include-All Affinity:
- Advertised: Yes
 - Priority: 128
 - Definition Equal to Local: Yes

Below the configuration for Algo 128, there are expandable sections for Algo 129, Algo 130, and Algo 131.

Note If the device is not a member, then you will only see IGP domain and OSPF ID information.

Step 3 To view whether a link is part of a Flexible Algorithm topology:

- From the topology map, click on a link.
- Click the **Traffic Engineering** tab. If the link is a member, then the **FA Topologies** row displays what Flexible Algorithm each source and destination device belong to.

The screenshot shows the 'Link Details' window with the 'Traffic Engineering' tab selected. The 'Summary' section is active, and the 'General' sub-tab is selected. The following table displays the Flexible Algorithm topology information for the link:

| | A Side | Z Side |
|-----------------|------------------------|------------------------|
| Node | cw-xrv61 | cw-xrv62 |
| IF Name | GigabitEthernet0/0/0/3 | GigabitEthernet0/0/0/3 |
| FA Affinities | | |
| FA TE Metric | 1 | 23 |
| FA Delay Metric | | |
| FA Topologies | 128, 129, 130, 131 | 128, 129, 130, 131 |

Note

- Application-Specific Link Attribute (ASLA) is supported on PCC and core routers that are Cisco IOS XR 7.4.1 or later versions.
 - Cisco Crosswork only supports strict ASLA handling for Flexible Algorithm topologies.
 - For Flexible Algorithms defined with Traffic Engineering (TE) or Delay metric types, only nodes advertising OSPF or IS-IS ASLA TE and ASLA Delay link metrics will be included in the corresponding Flexible Algorithm topology.
-



CHAPTER 6

Tree Segment Identifier (Tree-SID) Multicast Traffic Engineering

Tree-SID is a method of implementing tree-like multicast flows over a segmented routing network. Using Tree-SID, an SDN controller (a device running SR-PCE using PCEP), calculates the tree. Each node (device) in the tree has a specific role in routing the multicast data through the tree. These roles include Ingress for the root or headend node, Transit or Bud for midpoint nodes that are not leaf nodes, and Egress for destination leaf nodes. The tree itself is assigned a single SID label, which represents all of the tree segments and devices in it. The SDN controller is highly flexible, as it understands the segmentation and can construct routing paths using any kind of constraints that network architects can specify.

The most interesting use case for constraint-based Tree-SID use is where routers are configured to deliver two P2MP streams with the same content over different paths. Here, the multicast flow is forwarded twice through the network, each copy following a unique path. The two copies never use the same node or link to reach the destination, reducing packet loss due to network failures on any one of the paths.

For detailed information on Tree-SID, see the Segment Routing Tree-SID configuration documentation for your specific device (for example: [Segment Routing Configuration Guide for Cisco NCS 540 Series Routers](#)).

This section contains the following topics.

- [Visualize Tree-SID Policies, on page 49](#)
- [View a Point-to-Multipoint Tree on the Topology Map, on page 50](#)
- [Create Static Tree-SID Policies, on page 54](#)
- [Modify a Tree-SID Policy, on page 57](#)

Visualize Tree-SID Policies

Crosswork UI provides the ability to view details of the Tree-SID root, transit, leaf nodes and bud nodes in the UI and allows you to easily confirm that Tree-SID is implemented correctly in your network (see [View a Point-to-Multipoint Tree on the Topology Map, on page 50](#)).

The Tree-SID policy has the following nodes:

- Root node—Encapsulates the multicast traffic, replicates it, and forwards it to the transit nodes.
- Transit node—Acts as a leaf (egress) node as well as a mid-point (transit) node toward the downstream sub-tree.
- Leaf node—Decapsulates the multicast traffic and forward it to the multicast receivers.

- Bud Node—Has a separate leaf node path and is displayed separately in the topology map.

You can visualize the following Tree-SID policies:

- **Static:** A Static Tree-SID policy is configured via SR-PCE, either directly using SR-PCE CLI or from the Crosswork UI. You can refer to the Tree-SID configuration documentation for your specific device to find out more information and examples of the supported configuration commands. (for example: [Segment Routing Configuration Guide for Cisco ASR 9000 Series Routers](#))
- **Dynamic:** A Dynamic Tree-SID policy is not explicitly configured, it is configured as part of a L3VPN/mVPN service.



Note Static and Dynamic Tree-SID policies support fast reroute (FRR).

View a Point-to-Multipoint Tree on the Topology Map

Crosswork allows you to visualize Tree-SID policies configured in your network.

The following example shows a representation of a Tree-SID policy in the Crosswork topology map. The root node (R) and leaf nodes (L) are clearly marked, and the arrows denote the path through the transit nodes from the root to the leaf nodes.

You can drill down on the nodes and the links to see more details about the Tree-SID policy and validate the configuration.

Traffic Engineering Last Update: 13-Nov-2023 04:10:20 PM PST |

Show: Traffic Engineering Device Groups: Locati... Saved Views Select a saved view Save View

Location Show: Participating Only

Tree-SID Policy Details

Current History

Leaf Node Name Leaf Node IP Collapse All

xrv9k-27 192.168.0.27

| Node | | Egress Link | | |
|---------|----------|--------------|-----------|-----------|
| Role | Name | IP | Local IP | Remote IP |
| Root | xrv9k-26 | 192.168.0.26 | 10.0.0.30 | 10.0.0.29 |
| Transit | xrv9k-23 | 192.168.0.23 | 10.0.0.41 | 10.0.0.42 |
| Leaf | xrv9k-27 | 192.168.0.27 | - | - |

xrv9k-24 192.168.0.24

| Node | | Egress Link | | |
|---------|----------|--------------|-----------|-----------|
| Role | Name | IP | Local IP | Remote IP |
| Root | xrv9k-26 | 192.168.0.26 | 10.0.0.30 | 10.0.0.29 |
| Transit | xrv9k-23 | 192.168.0.23 | 10.0.0.41 | 10.0.0.42 |
| Bud | xrv9k-27 | 192.168.0.27 | 10.0.0.46 | 10.0.0.45 |
| Leaf | xrv9k-24 | 192.168.0.24 | - | - |

Before you begin

To visualize a multicast tree in the topology map, Tree-SID policies must be configured in your network. For more information, see the SR Tree-SID configuration documentation for your specific device (for example: [Segment Routing Configuration Guide for Cisco NCS 540 Series Routers](#)).

Step 1 From the main menu, select **Traffic Engineering** > **Traffic Engineering** > **Tree-SID** tab.

Step 2 Select the Tree-SID policies you want to view on the topology map.

Note You can view a maximum of two policies on the topology map at the same time.

The screenshot displays the Cisco Traffic Engineering interface. On the left, a map shows a network topology with nodes and links. On the right, a panel titled 'Traffic Engineering' shows a summary of policies and a table of selected Tree-SID policies.

Traffic Engineering Summary:

| SR-MPLS | SRV6 | Tree-SID | RSVP-TE |
|---------|---------|----------|------------|
| 2 | 0 | 2 | 0 |
| Total | Dynamic | Static | Admin Down |
| | | Oper Up | Oper Down |

Tree-SID Policy Table:

| Roos... | Roos... | Name | Tre... | Label | Admi... | Oper ... | Action |
|-------------------------------------|----------|----------|---------|-------|---------|--------------------------------------|--------------------------------------|
| <input checked="" type="checkbox"/> | xrv9k... | 192.1... | Disney | - | 152001 | + | + |
| <input checked="" type="checkbox"/> | xrv9k... | 192.1... | MY_F... | - | 15200 | + | + |

Note Any change in end-points is captured as an event in the historical data tab. For information on Tree-SID Historical Data see, [View TE Event and Utilization History, on page 13](#)

Step 3 To view the Tree-SID Details, from the **Actions** column, click > **View Details** for one of the Tree-SID policies.


View a Point-to-Multipoint Tree on the Topology Map

Traffic Engineering Last Update: 13-Nov-2023 04:13:51 PM PST | ↕


Show: Traffic Engineering | Device Groups: Locat... | Saved Views | Select a saved view | Save View

Tree-SID Policy Details


Current | History


Root  xrv9k-26 | Root IP: 192.168.0.26
TE RID: 192.168.0.26 | IPv6 RID: 2001:192:168::26

Name: Disney


Tree ID: - 

Summary

Admin State  Up

Oper Status  Up

Label: 152001

Type: Static 

Programming State: None




Metric Type: TE

Constraints: Exclude-Any: -
Include-Any: -
Include-All: -

FRR Protected: Disable

[See more](#) ↓

Tree-SID path

| Leaf Node Name | Leaf Node IP | | | |
|---|--------------|------------------------------|-----------------|------------------|
| <input checked="" type="checkbox"/> xrv9k-27 | 192.168.0.27 | Collapse All | | |
| Node | | | | |
| Egress Link | | | | |
| Role | Name | IP | Local IP | Remote IP |
|  Root | xrv9k-26 | 192.168.0.26 | 10.0.0.30 | 10.0.0.29 |
|  Transit | xrv9k-23 | 192.168.0.23 | 10.0.0.41 | 10.0.0.42 |
|  Leaf | xrv9k-27 | 192.168.0.27 | - | - |

xrv9k-24 | 192.168.0.24

Step 4 You can view the Tree-SID details and verify the path and node details to ensure that Tree-SID is correctly configured.

Note When viewing Tree-SID Policy Details, if a Source Node is not available, a warning icon and message appear next to the Oper Status field (hover your mouse over the warning icon), detailing where the connection issue resides.

The screenshot displays the 'Tree-SID Policy Details' window. At the top, there are tabs for 'Current' and 'History'. Below the tabs, the following information is shown:

- Root:** xrv9k-12 | Root IP: 192.168.0.2
TE RID: 192.168.0.2 | IPv6 RID: 2001:192:168::2
- Name:** Test-TS2
- Tree ID:** - ⓘ

The 'Summary' section contains the following details:

- Admin State:** Up (green arrow icon)
- Oper Status:** Down (red arrow icon) - A tooltip points to this status, stating: 'source node 192.168.0.2 not connected via PCEP'
- Label:** 9999
- Type:** Static ⓘ
- Programming State:** None
- Metric Type:** TE
- Constraints:** Exclude-Any: -
Include-Any: -
Include-All: -
- FRR Protected:** Disable

At the bottom of the summary section, there is a 'See more' link with a downward arrow.

Note A (Compute) label, next to the SR-PCE field, details the SR-PCE used to create the policies.

Tree-SID Policy Details

Current History

Summary

Admin State ● Up

Oper Status ● Down ⚠

Label 9999

Type Static i

Programming State None

Metric Type TE

Constraints Exclude-Any: -
Include-Any: -
Include-All: -

FRR Protected Disable

Node Count Leaf: 3 | Bud: 0 | Transit: 0

Path Compute Elements (SR-PCEs) 172.27.226.118(Compute)

Last Update 01-Aug-2023 07:23:41 PM CDT

[See less](#) ^

Create Static Tree-SID Policies

This task will explain how to create a static Tree-SID policy each representing a leaf or a root node.

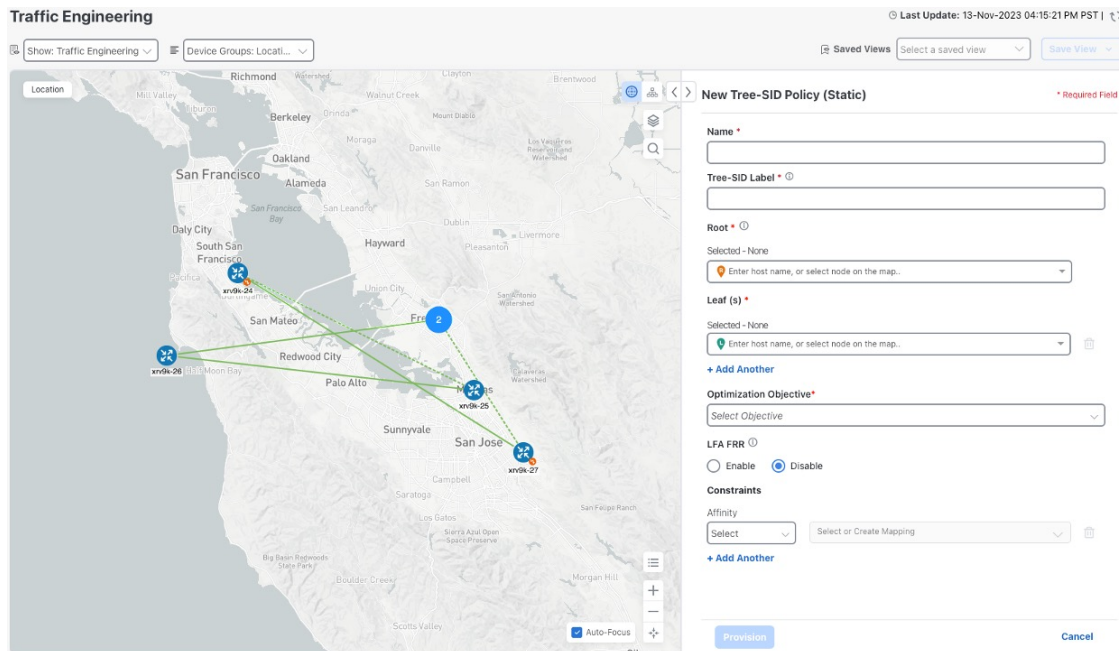


Tip If you plan to use affinities, collect affinity information from your devices and then map them in Cisco Crosswork before creating a static Tree-SID policy. For more information, see [Configure TE Link Affinities, on page 32](#).

Step 1 From the main menu, choose **Traffic Engineering > Traffic Engineering > Tree-SID** tab and click **Create**.

Step 2 Enter or select the required Tree-SID policy values. Hover the mouse pointer over i to view a description of the field.

Note You can only add PCC nodes with a PCEP session to PCE as root nodes.



Step 3 Add leaf nodes that will be part of the Tree-SID policy.

Step 4 Under **Affinity**, define any applicable affinities. For more information on Affinities, see [Configure TE Link Affinities, on page 32](#)

Step 5 To commit the policy, click **Provision**.

Step 6 Validate the Tree-SID policy creation:

- a. Confirm that the new Tree-SID policy appears in the Tree-SID table. You can also click the check box next to the policy to see it highlighted in the map.

Note The newly provisioned Tree-SID policy may take some time to appear in the Tree-SID table, depending on the network size and performance. The **Tree-SID** table is refreshed every 30 seconds.

- b. View and confirm the new Tree-SID policy details. From the topology map click **Tree-SID**, click **⋮** and select **View**.

Static Tree-SID Policy Configuration Example through Crosswork UI

The output below shows the static Tree-SID policy, configured from Crosswork UI, on the compute SR-PCE.

```
RP/0/RP0/CPU0:cw-xrv56#sh pce lsp p2mp
```

```
Tree: 50-52-54, Root: 3.3.3.50
PCC: 3.3.3.50
Label: 505254
Operational: up Admin: up Compute: Yes
Local LFA FRR: Disabled
Metric Type: IGP
Transition count: 1
Uptime: 00:01:45 (since Thu Apr 27 10:54:49 PDT 2023)
```

```

Destinations: 3.3.3.52, 3.3.3.54
Nodes:
Node[0]: 3.3.3.50 (cw-xrv50)
  Delegation: PCC
  PLSP-ID: 205
  Role: Ingress
  Hops:
    Incoming: 505254 CC-ID: 1
    Outgoing: 505254 CC-ID: 1 (11.1.28.54) [cw-xrv54]
    Outgoing: 505254 CC-ID: 1 (11.1.1.51) [cw-xrv51]
Node[1]: 3.3.3.54 (cw-xrv54)
  Delegation: PCC
  PLSP-ID: 148
  Role: Egress
  Hops:
    Incoming: 505254 CC-ID: 2
Node[2]: 3.3.3.51 (cw-xrv51)
  Delegation: PCC
  PLSP-ID: 187
  Role: Transit
  Hops:
    Incoming: 505254 CC-ID: 3
    Outgoing: 505254 CC-ID: 3 (11.1.2.52) [cw-xrv52]
Node[3]: 3.3.3.52 (cw-xrv52)
  Delegation: PCC
  PLSP-ID: 247
  Role: Egress
  Hops:
    Incoming: 505254 CC-ID: 4

```

The output below shows the same static Tree-SID policy on the High Availability (HA) peer SR-PCE.

```

RP/0/RP0/CPU0:cw-xrv63#sh pce lsp p2mp

Tree: 50-52-54, Root: 3.3.3.50
PCC: 3.3.3.50
Label: 505254
Operational: standby Admin: up Compute: No
Local LFA FRR: Disabled
Metric Type: IGP
Transition count: 0
Destinations: 3.3.3.52, 3.3.3.54
Nodes:
Node[0]: 3.3.3.54 (cw-xrv54)
  Delegation: PCE (3.3.3.56)
  PLSP-ID: 148
  Role: Egress
  Hops:
    Incoming: 505254 CC-ID: 2
Node[1]: 3.3.3.52 (cw-xrv52)
  Delegation: PCE (3.3.3.56)
  PLSP-ID: 247
  Role: Egress
  Hops:
    Incoming: 505254 CC-ID: 4
Node[2]: 3.3.3.51 (cw-xrv51)
  Delegation: PCE (3.3.3.56)
  PLSP-ID: 187
  Role: Transit
  Hops:
    Incoming: 505254 CC-ID: 3
    Outgoing: 505254 CC-ID: 3 (11.1.2.52)
Node[3]: 3.3.3.50 (cw-xrv50)
  Delegation: PCE (3.3.3.56)

```

```

PLSP-ID: 205
Role: Ingress
Hops:
  Incoming: 505254 CC-ID: 1
  Outgoing: 505254 CC-ID: 1 (11.1.28.54)
  Outgoing: 505254 CC-ID: 1 (11.1.1.51)

```

Modify a Tree-SID Policy


To modify a Tree-SID policy, do the following:



Note You cannot modify the name, label and root of a Tree-SID policy.

Step 1 From the main menu, choose **Traffic Engineering > Traffic Engineering**.

Step 2 From the **Traffic Engineering** window, click the **Tree-SID** tab.

Step 3 Locate the Tree-SID policy you are interested in and click .

Step 4 Choose **Edit**.

- Note**
- You can only modify or delete a static Tree-SID policy that is created using the Crosswork UI or API as opposed to one created using SR-PCE CLI
 - After updating the Tree-SID policy details, you can preview the changes on the map before saving it.
-

Tree-SID Important Notes

Limitation

- Tree-SID policies are only supported on devices running Cisco IOS XR software.
- PCE high-availability (HA) is supported for static Tree-SID policies configured via the Cisco Crosswork UI, but not supported if configured directly on the SR-PCE CLI.
- Tree-SID policy details based on SRv6 are not supported.
- If a single instance of SR-PCE is used, and the SR-PCE restarts, all static Tree-SID policies that were configured from the Crosswork UI are deleted.
- IPV4 unnumbered interfaces are not supported.

Visualization of Tree-SID Paths with Missing Nodes

Missing Tree-SID nodes can cause the following to happen:

A node on a Tree-SID policy path may not be available in the Crosswork topology information for various reasons. For example, the node is not added to the Crosswork device inventory. This affects how the Tree-SID policy path is displayed on the topology map. The unavailable node will cause one or more root-to-leaf paths

to look broken on the map, as shown in the figure below. However, the path details in the right panel will still show the full path.

The screenshot shows a network management interface with a map on the left and a detailed path view on the right. The map shows several nodes connected by lines, with one path highlighted in purple. The right panel, titled 'Tree-SID path', shows a list of nodes and their roles. A red box highlights a specific row in the table.

| Leaf Node Name | Leaf Node IP | Egress Link | | |
|----------------|---------------|-------------|------------|------------|
| Role | Name | IP | Local IP | Remote IP |
| Root | xrv9k-VM3-... | 192.168.4.3 | 10.0.2.25 | 10.0.2.26 |
| Bud | xrv9k-VM5-... | 192.168.4.5 | 20.10.0.14 | 20.10.0.15 |
| Transit | xrv9k-VM8 | 192.168.4.9 | 20.10.0.17 | 20.10.0.16 |
| Bud | xrv9k-VM7-... | 192.168.4.6 | 10.0.3.42 | 10.0.3.41 |



PART I

Bandwidth Feature Packs

- [SR Circuit Style Manager \(CSM\)](#), on page 61
- [Local Congestion Mitigation \(LCM\)](#), on page 83
- [Bandwidth on Demand \(BWoD\)](#), on page 105



CHAPTER 7

SR Circuit Style Manager (CSM)

The SR Circuit Style Manager (CSM) feature pack provides a bandwidth-aware Path Computation Element (PCE) to compute Circuit Style SR-TE policy paths that you can visualize in your network. Circuit Style enables segment routed transport tailored for circuit-oriented services over a packet based network through the use of bi-directional, co-routed, path protected SR-TE policies. Circuit Style SR-TE policies are typically used for high priority services, such as crucial monetary transactions or important live video feed, which *require committed bandwidth with fast and fail-safe connections*. The CSM feature pack ensures dynamic Circuit Style SR-TE policies are provisioned along paths that meet strict bandwidth requirements while at the same time respecting any additional user configured constraints such as latency minimization and disjointness.

Centralized bandwidth accounting in the CSM feature pack allows the user to monitor resource reservation levels and quickly identify hot spots where available bandwidth in the circuit style bandwidth pool is low. The ability to visualize Circuit Style SR-TE policies in your network topology enables easy verification of Circuit Style SR-TE policy configurations, details, and path states. With a few clicks you can view Active and Protect paths, operational status, reserved bandwidth pool size and monitor path failover behavior for individual Circuit Style SR-TE policies.



Note Functionality described within this section is only available with certain licensing options.

This section contains the following topics:

- [Circuit Style SR-TE Important Notes, on page 62](#)
- [Workflow for Setting Up CS SR-TE Policy Visualization, on page 67](#)
- [Enable SR Circuit Style Manager, on page 68](#)
- [Configure Circuit Style SR Policies, on page 69](#)
- [Review Circuit Style SR-TE Policy Bandwidth Utilization , on page 71](#)
- [View Circuit Style SR-TE Policies, on page 72](#)
- [Trigger CSM to Recalculate a Circuit Style SR-TE Policy, on page 76](#)
- [What Happens When Bandwidth Reservation Settings are Exceeded?, on page 76](#)
- [How Does CSM Handle Path Failures?, on page 80](#)

Circuit Style SR-TE Important Notes

This topic outlines the scope of Crosswork's support for Circuit Style SR-TE policies, including requirements and constraints on the policy attribute values set in each Circuit Style SR-TE policy, and the processing logic followed during path reversions.



Note Role-based Access Control (RBAC) and task permissions have been introduced in this release. To provision a Circuit Style SR-TE policy you must have write-access to the head-end device based on Device Access Groups and assigned roles. Only Circuit Style SR-TE admin users can modify Circuit Style SR-TE configuration settings. For more information on RBAC and user roles, see the "[Cisco Crosswork Network Controller Administration Guide](#)".

Policy Attribute Constraints

You set policy attribute values when you create a Circuit Style SR-TE policy, using either the device's command line interface or Cisco Crosswork Network Controller. You can also change them later.

The table below describes the requirements for each attribute, and how changes affect them. It is important to understand that all the attributes that are described in the table below act as constraints. Each of them corresponds to elements of the configuration that Cisco Crosswork uses to govern how Circuit-Style path hops are computed. Each value is effectively a path computation or optimization constraint, since they either specify a required property of a path or exclude possible choices for that path.

Table 3: Circuit Style SR-TE Policy Attribute Values and Constraints

| Attribute | Description |
|------------------------|--|
| Policy Path Protection | The path protection constraint is required for both sides of a Circuit Style SR-TE policy. |

| Attribute | Description |
|---------------------------|---|
| Bandwidth Constraint | <p>The bandwidth constraint is required and must be the same on both sides of a Circuit Style SR-TE policy. Bandwidth changes can be made to existing policies, with these effects:</p> <ul style="list-style-type: none"> • Once you configure the new bandwidth on both sides, Crosswork will evaluate the path. This <u>will not</u> result in a recomputed path • If the new bandwidth is higher, Crosswork checks the existing path to ensure sufficient resources. If all currently delegated paths can accommodate the new bandwidth, Crosswork returns the same path with the new bandwidth value, indicating to the path computation client (PCC) that it was successful. If any of the current paths cannot accommodate the new bandwidth, it returns the old bandwidth value indicating that it was unsuccessful. This evaluation will not be retried unless the bandwidth is changed again. • If the bandwidth is lower, Crosswork returns the same path with the new bandwidth value to indicate to the PCC that it was successful. <p>The user interface shows both the requested and reserved bandwidth under each candidate path when you view the policy details. These values can differ if the requested bandwidth is increased but there is insufficient available CS pool bandwidth along one or more of the paths.</p> |
| Candidate Paths and Roles | <p>The Working path is defined as the highest preference Candidate Path (CP).</p> <p>The Protect path is defined as the CP of the second highest preference.</p> <p>The Restore path is defined as the lowest preference CP. The headend must have <code>backup-ineligible</code> configured.</p> <p>CPs of the same role in each direction must have the same CP preference.</p> |
| Bi-Directional | <p>All paths must be configured as co-routed.</p> <p>Paths of the same role on both sides must have the same globally unique bi-directional association ID.</p> |

| Attribute | Description |
|----------------------------|---|
| Disjointness | <p>Working and Protect paths on the same PCC must be configured with a disjointness constraint using the same disjoint association ID and disjointness type.</p> <p>The disjointness association ID for a Working and Protect path pair in one direction must be unique when compared with the corresponding pair in the opposite direction.</p> <p>Only the Node and Link disjoint types are supported. The disjoint type used must be the same in both directions of the same policy.</p> <p>The Restore path must not have a disjointness constraint set.</p> <p>Crosswork follows strict fallback behavior for all Working and Protect path disjointness computations. This means that, if node type disjointness is configured but no path is available, Crosswork makes no automatic attempt to compute a less restrictive link type disjoint path.</p> |
| Metric Type | <p>Only the TE, IGP, Hop count, and Latency metric types are supported. The metric type used must match across Working, Protect and Restore paths in both directions.</p> |
| Segment Constraints | <p>All Working, Protect and Restore paths must have the following segment constraints:</p> <ul style="list-style-type: none"> • protection unprotected-only • adjacency-sid-only <p>To ensure persistency through link failures, configure static adjacency SIDs on all interfaces that might be used by Circuit Style policies.</p> |
| Unsupported Configurations | <p>The following configurations are not supported:</p> <ul style="list-style-type: none"> • Metric-bounds • SID-Algo constraints • Partial recovery is not supported 7.8.x. • State-sync configuration between PCEs of a high-availability pair. These are not required with Circuit Style SR-TE policies. Use of this feature may result in degraded performance. • Multiple Circuit Style SR-TE policies between the same nodes with the same color but different endpoint IPs. |

| Attribute | Description |
|----------------------------|---|
| Supported Policy Changes | <p>The following constraints may be changed for an operationally "up" Circuit Style SR-TE policy that has been previously delegated:</p> <ul style="list-style-type: none"> • Metric type • Disjoint type • MSD • Affinities <p>Once configuration changes are made in a consistent manner across all CPs and both PCCs (for example: the new metric type is the same for all CPs and both sides), Crosswork will initiate a recompute, which can result in new Working, Protect and Restore paths.</p> <p>During any transitory period in which configurations are not in sync between paths on the same PCC or between PCCs, no path updates are sent to the PCCs.</p> |
| Unsupported Policy Changes | <p>The following configuration changes to a previously delegated and operationally "up" Circuit Style SR-TE policy are not supported:</p> <ul style="list-style-type: none"> • CP preference • Disjoint Association ID • Bi-directional Association ID <p>To change these configurations for an existing policy, you must first shut down the policy on both sides, make the change (complying with restrictions as detailed above in terms of consistency) and then "no shut" the policy.</p> |
| Path Computation | <p>Crosswork computes paths for circuit style policies only after a complete bi-directional, path-protected set of candidate paths has been delegated, including Working and Protect paths on both sides. In cases where there is insufficient bandwidth and a path cannot be found, SR Circuit Style Manager will continue to retry after 30 minutes until a solution is found, or if Circuit Style SR-TE is disabled.</p> <p>Crosswork computes the Restore path only after the Working and Protect paths are down. The SR Circuit Style Manager feature pack configuration interface provides a configurable delay timer to control how long after Restore paths are delegated from both sides to wait before the path is computed. This delay allows topology and SR policy state changes to fully propagate to Crosswork, in cases where these changes triggered the Restore path delegation.</p> <p>Automatic re-optimization is not supported for any paths based on changes in topology, LSP state, or any periodic event. Path computation is supported for Intra/Inter area/level and Intra/Inter IGP Domain (same AS) Not supported path computation Inter-AS.</p> |

| Attribute | Description |
|--------------------|---|
| Reversion Behavior | <p>Reversion behavior is controlled by the configuration of the WTR lock timer option under the Protect and Revert paths (it is not relevant for the Working path):</p> <ul style="list-style-type: none"> • No lock configuration: Revert after a default 5-minute lock • Lock with no duration specified: No reversion • Lock duration <value>: Revert after the specified number of seconds |

Reversion Logic

Path reversion depends on the initial state of the Working, Protect, and Restore paths and the events affecting each path. The scenarios in the following table provide examples of typical reversion behavior.

Table 4: Path Reversion Scenarios

| Initial State | Events | Behavior |
|---|---|--|
| Working path is down, Protect path is up/active | Working path comes back up | <ol style="list-style-type: none"> 1. Working path recovers to up/standby state. 2. Each PCC moves the Working path to active after the WTR timer expires. 3. Protect path moves to up/standby. |
| Working path is down, Protect path is down, Restore path is up/active | Working path comes back up, then Protect path comes back up | <ol style="list-style-type: none"> 1. Working path recovers and goes to up/active state 2. Restore path is removed 3. Protect path recovers and goes to up/standby |

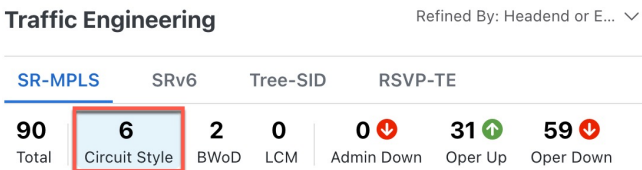
| Initial State | Events | Behavior |
|---|---|---|
| Working path is down, Protect path is down, Restore path is up/active | Protect path comes back up, then Working path comes back up | <p>On side A: The Working path failure is local (the first Adj SID in the SegList is invalid):</p> <ol style="list-style-type: none"> 1. Protect path recovers and goes to up/active. 2. Restore path is removed. 3. Working path recovers and goes to up/standby. 4. Each PCC moves the Working path to active after the WTR timer expires, Protect path goes to up/standby. <p>On side Z: Working path failure is remote (first Adj SID in SegList is valid):</p> <ol style="list-style-type: none"> 1. Protect path recovers but is not brought up, Restore path remains up/active. 2. Working path recovers and goes up/active. 3. Restore path is removed. 4. Protect path goes to up/standby. |

Workflow for Setting Up CS SR-TE Policy Visualization

The following tasks are necessary to start visualizing Circuit Style SR-TE policies in the topology map:

Table 5: Tasks to Complete to Start Visualizing Circuit Style SR-TE Policies

| Step | Action |
|---|---|
| 1. Enable the SR Circuit Style Manager (CSM) feature pack. | <p>From the main menu, choose Services & Traffic Engineering > Traffic Engineering > Circuit Style SR-TE > Configuration.</p> <p>Follow the steps in Enable SR Circuit Style Manager, on page 68.</p> |
| <p>2. Configure CS SR policies on the devices.</p> <p>Note If you do this step before enabling the Circuit Style SR-TE feature pack, then the CS SR policies will appear operationally down.</p> | <p>You can configure CS SR policies using one of the following methods:</p> <ul style="list-style-type: none"> • Configure CS SR policies manually on the device using the CLI. For more information, see Configure Circuit Style SR Policies, on page 69. • If you are using Crosswork Optimization Engine within Crosswork Network Controller, you can configure CS SR policies using the UI. For more information, see the Cisco Crosswork Network Controller Solution Workflow Guide. |

| Step | Action |
|--|--|
| 3. Verify that the CS SR policies appear in the SR Policy table. | <p>From the main menu, select Traffic Engineering > Traffic Engineering > SR-MPLS > Circuit Style.</p>  <p>The SR Policy table now shows a filtered list containing only CS SR policies.</p> |
| 4. Verify that the reserved bandwidth pool settings you defined in Step 1 are configured properly. | <p>Click on a CS SR node or policy and navigate to the Link Details > Traffic Engineering page (see Review Circuit Style SR-TE Policy Bandwidth Utilization, on page 71). From the Circuit Style section, view the reserved bandwidth pool size. You can also view current Circuit Style SR-TE bandwidth utilization and how much is still available for use.</p> |

Enable SR Circuit Style Manager

In order to manage and visualize Circuit Style SR-TE policies on the topology map, you must first enable SR Circuit Style Manager (CSM) and set bandwidth reservation settings.

When CSM is enabled, it computes the best failover bidirectional paths with the requested bandwidth and other constraints defined in the Circuit Style SR policy configuration between two nodes.

- Step 1** From the main menu, choose **Traffic Engineering > Circuit Style SR-TE > Configuration**.
- Step 2** Toggle the **Enable** switch to **True**.
- Step 3** Enter the required bandwidth pool size and threshold information. The following list describes additional field information. See also [What Happens When Bandwidth Reservation Settings are Exceeded?](#), on page 76.

| Field | Description |
|--------------------------|--|
| Basic | |
| Link CS BW Pool Size | The percentage of each link's bandwidth reservable for Circuit Style SR-TE policies. |
| Link CS BW Min Threshold | The Link CS BW Pool utilization percentage beyond which a threshold crossing event notification will be generated. |
| Advanced | |
| Validation Interval | This is the interval that CSM policy will wait before the bandwidth that is reserved for an undelegated policy is returned to the Circuit Style SR-TE policy bandwidth Pool. |
| Timeout | The duration until which CSM will wait for the delegation request, to generate a notification. |

| Field | Description |
|--------------------------|--|
| Restore Delegation Delay | The duration until which CSM will pause before processing a restore path delegation. |

- Step 4** Click **Commit Changes** to save the configuration. After enabling CSM, you must create Circuit Style SR policy configurations either manually on the device (see [Configure Circuit Style SR Policies, on page 69](#)) or through Cisco Crosswork Network Controller .

Configure Circuit Style SR Policies

A Circuit Style SR policy configuration must include the destination endpoint, the amount of requested bandwidth, and the bidirectional attribute (see [Circuit Style SR-TE Important Notes, on page 62](#) for additional requirements or notable constraints). The configuration should also include a Performance Measurement Liveness (PM) profile. A PM profile enables proper detection of candidate path liveness and effective path protection. PCCs do not validate past the first SID, so without PM, the path protection will not occur if the failure in the Circuit Style SR policy candidate path is not the first hop in the segment list. For more information, see [Configuring SR Policy Liveness Monitoring](#).

This section provides *guidance* on how to manually configure a Circuit Style SR policy and a Performance Measurement Liveness (PM) profile on a device.

- Step 1** If applicable, enable the hardware module on the device for PM configuration.

Example:

```
hw-module profile offload 4
reload location all
```

- Step 2** Configure the PM profile.

Example:

```
performance-measurement
liveness-profile sr-policy name CS-active-path
probe
tx-interval 3300
!
npu-offload enable    !! Required for hardware Offload only
!
!
liveness-profile sr-policy name CS-protect-path
probe
tx-interval 3300
!
!
npu-offload enable    !! Required for hardware Offload only
!
!
!
```

Step 3 Configure the Circuit Style SR policy with the PM profile. All configurations shown in the example are required in order for CSM to manage the Circuit Style SR-TE policy. Entries that are defined by the user are italicized. See [Circuit Style SR-TE Important Notes, on page 62](#) for additional requirements or notable constraints.

Example:


```

segment-routing
 traffic-eng
  policy cs1-cs4

    performance-measurement
      liveness-detection
        liveness-profile backup name CS-protect      !! Name must match liveness profile defined for
Protect path
        liveness-profile name CS-active             !! Name must match liveness profile defined for
Active path
      !
      !
      bandwidth 10000
      color 1000 end-point ipv4 192.168.20.4
      path-protection
      !
      candidate-paths
        preference 10
        dynamic
          pcep
          !
          metric
            type igp
          !
          !
          backup-ineligible
          !

      constraints
        segments
          protection unprotected-only
          adjacency-sid-only
          !
          !
        bidirectional
          co-routed
          association-id 1010
          !
          !
        preference 50
        dynamic
          pcep
          !
          metric
            type igp
          !
          !
        constraints
          segments
            protection unprotected-only
            adjacency-sid-only
            !
            disjoint-path group-id 3 type node
            !
          bidirectional
            co-routed
            association-id 1050
            !

```


Link Details 

Summary **Traffic Engineering**

General SR-MPLS SRv6 Tree-SID RSVP-TE

| | A Side | Z Side |
|------------------------|-------------------------|----------------------------|
| Node | NCS-3 | NCS1 |
| IF Name | GigabitEthernet0/0/0/2 | GigabitEthernet0/0/0/0 |
| FA Affinities | | |
| FA TE Metric | | |
| FA Delay Metric | | |
| FA Topologies | 128, 129, 130, 131, 132 | 128, 129, 130, 131, 132... |

Circuit Style Bandwidth Pool

| | A Side | Z Side |
|------------------|----------|----------|
| Pool Size | 800 Mbps | 800 Mbps |
| Used | 4 Mbps | 4 Mbps |
| Available | 796 Mbps | 796 Mbps |

View Circuit Style SR-TE Policies

View Circuit Style SR-TE policy details such as the endpoints, bandwidth constraints, IGP metrics, and candidate (Working and Protect) paths.

Step 1 From the main menu, choose **Traffic Engineering** > **Traffic Engineering** > **SR-MPLS** and click **Circuit Style**.

Traffic Engineering Refined By: Headend or E... ▾

SR-MPLS SRv6 Tree-SID RSVP-TE

| | | | | | | |
|-----------|---------------|----------|----------|------------|-------------|-------------|
| 90 | 6 | 2 | 0 | 0 ↓ | 31 ↑ | 59 ↓ |
| Total | Circuit Style | BWoD | LCM | Admin Down | Oper Up | Oper Down |

The **SR Policy** table lists all Circuit Style SR-TE policies.

Step 2 From the **Actions** column, click  > **View Details** for one of the Circuit Style SR-TE policies.

Note You cannot edit or remove Circuit Style SR-TE policy configurations that have been created directly on the device.

The screenshot shows the Traffic Engineering interface. On the left is a topology map of the San Francisco Bay Area with nodes labeled xrv9k-14, xrv9k-16, xrv9k-15, xrv9k-12, and xrv9k-17. A path is highlighted between xrv9k-16 and xrv9k-15. On the right is the 'Traffic Engineering' panel with a summary table and a list of SR Policies.

| SR-MPLS | SRv6 | Tree-SID | RSVP-TE |
|------------|---------------|----------|---------|
| 90 | 6 | 2 | 0 |
| Total | Circuit Style | BWd | LCM |
| 0 | 0 | 0 | 0 |
| Admin Down | Oper Up | 31 | 59 |
| | Oper Down | | |

| Head... | Endp... | Color | Admin... | Oper St... | Actions |
|-------------------------------------|-----------|-----------|----------|------------|---------|
| <input checked="" type="checkbox"/> | xrv9k-16 | xrv9k-15 | 11056 | + | + |
| <input type="checkbox"/> | xrv9k-15 | xrv9k-16 | 11056 | + | + |
| <input type="checkbox"/> | xrv9k-16 | xrv9k-15 | 4294... | + | + |
| <input checked="" type="checkbox"/> | xrv9k-15 | xrv9k-16 | 4294... | + | + |
| <input checked="" type="checkbox"/> | xrv9k-... | xrv9k-12 | 5600 | + | + |
| <input checked="" type="checkbox"/> | xrv9k-12 | xrv9k-... | 5600 | + | + |

The **Circuit Style Policy Details** window is displayed in the side panel. By default, the Active path is displayed in the topology map and shows the bidirectional paths (Bi-Dir Path checkbox is checked) on the topology map. The Candidate Path list displays the Active (path that currently takes traffic) and Protected paths.

The screenshot shows the Circuit Style Policy Details window. On the left is a topology map of the Fremont area with nodes labeled xrv9k-23 and xrv9k-25. A path is highlighted between them. On the right is the 'Circuit Style Policy Details' panel with a summary table and a list of candidate paths.

| Current | History |
|----------|--|
| Headend | xrv9k-25 TE RID: 192.168.0.15 PCC IP: 192.168.0.15 |
| Endpoint | xrv9k-23 TE RID: 192.168.0.15 |
| Color | 6905 |

| Path Name | Pref | Role | State |
|--|------|------|-------|
| <input checked="" type="checkbox"/> cfg_srte_c_6905_ep_192.16... | 100 | + | A |
| <input type="checkbox"/> cfg_srte_c_6905_ep_192.16... | 50 | + | + |

Note The Bandwidth Constraint value can differ from the bandwidth you requested if the value was increased and insufficient resources existed to satisfy demand on all Active and Protected candidate paths.

Step 3 View Candidate path configuration details.

- The **Circuit Style Policy Details** window allows you to drill down to view more information about the candidate paths. You can also copy the URL and share this information with others.

The operational (Oper State Up) candidate path with the highest preference will always be the Active path (see [How Does CSM Handle Path Failures?](#), on page 80). In this example, the Protected path (with preference 50) is currently the Active path and is displayed on the topology map. Notice that it is designated with a green "A" icon under State to clearly indicate it is currently the operational Active path. Click **Expand All** to view more information about both paths.

View Circuit Style SR-TE Policies

The screenshot shows the 'Circuit Style Policy Details' window. The left pane is a map of the San Jose area with three paths highlighted: a purple path (highest preference), a blue path (second preference), and a pink path (third preference). The right pane shows the configuration details for the selected path, including Path Name, Oper State, Metric Type, Bandwidth, Bi-Dir Association ID, Disjoint Group, PCE Initiated, Affinity, Segment Type, and SID Algorithm.

| Path Name | Pref | Role | State |
|--|------|------|--------------------------------------|
| <input type="checkbox"/> cfg_srte_c_6905_ep_192.168.0.23... | 100 | | ● |
| <input checked="" type="checkbox"/> cfg_srte_c_6905_ep_192.168.0.23... | 90 | | ● |
| <input type="checkbox"/> cfg_srte_c_6905_ep_192.168.0.23... | 50 | | ● |

- Note**
- First preference paths are shown as purple links.
 - Second preference paths are shown as blue links.
 - Third preference paths are shown as pink links.

If the Circuit Style SR-TE policy configuration was done through Cisco Crosswork Network Controller, you have the option to view the Circuit Style SR-TE policy configuration. To see the configuration, click the link next to **Config ID**. For example:

Circuit Style Policy Details ... | X

Current History

| Path Name | Pref | Role | State |
|--|------|------|---|
| <input checked="" type="checkbox"/> cfg_srte_c_6905_ep_192.168.... | 100 | | ↑ A ^ |

Path Name cfg_srte_c_6905_ep_192.168.0.25_disc

Oper State ↑ Up | A Active

Metric Type IGP

Bandwidth Requested: 9.006 Mbps
Reserved: 0 Mbps

Bi-Dir Association ID 5906

Config ID [CS-CS-SR-WP-601-head-end-internal](#)

Disjoint Group ID: [567](#)
Association Source: 0.0.0.0
Type: Node-disjoint


PCE Initiated false

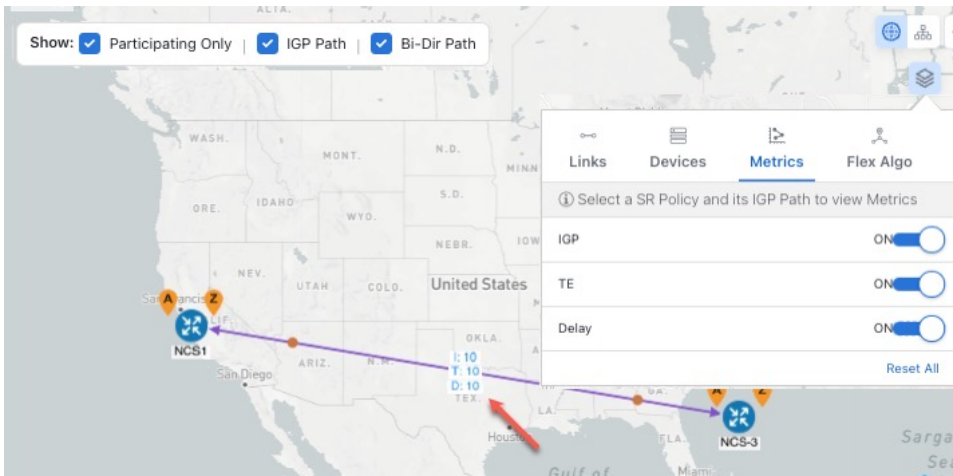
Affinity Exclude-Any: -
Include-Any: -
Include-All: -

Segment Type Unprotected

SID Algorithm -

Here is a sample of a Circuit Style policy configuration. For more information, see [Configure Circuit Style SR Policies, on page 69](#).

- Step 4** To view the physical path and metrics between endpoints of the selected Circuit Style SR-TE policies, click  to turn applicable metrics on and check the **IGP Path** checkbox.





Trigger CSM to Recalculate a Circuit Style SR-TE Policy

Circuit Style SR-TE policies are static in nature, meaning once the paths are computed, they will not be automatically re-optimized based on topology or operational status changes that may affect their paths. You can manually trigger CSM to recalculate a CS-SR policy after the policy's operational status went from down to up or if bandwidth size and requirement changes have been configured.



Note You can only reoptimize an Active and Protect path. It will not work for a Restore path.

- Step 1** From the main menu, choose **Traffic Engineering** > **Traffic Engineering** > **SR-MPLS** and click **Circuit Style**. The **SR Policy** table lists all Circuit Style SR-TE policies.
- Step 2** From the **Actions** column, click  > **View Details** for the Circuit Style SR-TE policies you want CSM to recalculate a path for again.
- Step 3** From the top-right corner, click  > **Reoptimize**.

What Happens When Bandwidth Reservation Settings are Exceeded?

CSM discovers and updates the available and reservable bandwidth in the network. CSM maintains an accounting of all bandwidth reservations provided for CS SR policies to ensure that the total reserved bandwidth on all interfaces remains at or below the network-wide resource pool (bandwidth pool size).


This topic provides examples of how CSM handles policies that exceed either the bandwidth pool size or bandwidth alarm threshold that were set in the CSM Configuration page.

Example: Bandwidth Utilization Surpasses Defined Threshold

- Link CS Bandwidth Pool Size: 10%
- Link CS Bandwidth Minimum Threshold: 10%

In this example, the bandwidth pool size for the 10 Gbps ethernet interfaces is 1Gbps and the alarm threshold is set for 100 Mbps (10% of pool size).

1. A Circuit Style SR-TE policy from node 5501-02 to node 5501-01 (r02 - r01) is created with a bandwidth of 100 Mbps.

Link Details 

Summary **Traffic Engineering**


General SR-MPLS SRv6 Tree-SID RSVP-TE

| | A Side | Z Side |
|------------------------|-------------------------|----------------------------|
| Node | xrv9k-15 | xrv9k-16 |
| IF Name | TenGigE0/0/0/0 | TenGigE0/0/0/0 |
| FA Affinities | | |
| FA TE Metric | | |
| FA Delay Metric | | |
| FA Topologies | 128, 129, 130, 131, 132 | 128, 129, 130, 131, 132... |

Circuit Style Bandwidth Pool

| | A Side | Z Side |
|------------------|-------------|-------------|
| Pool Size | 100.00 Mbps | 100.00 Mbps |
| Used | 0 Mbps | 0 Mbps |
| Available | 100.00 Mbps | 100.00 Mbps |

2. Later, the requested bandwidth configured for the policy is increased to 500 Mbps. CSM determines the additional bandwidth along the existing path is available and reserves it.

Link Details 

Summary **Traffic Engineering**

General SR-MPLS SRv6 Tree-SID RSVP-TE

| | A Side | Z Side |
|------------------------|-------------------------|----------------------------|
| Node | 5501-02 | 5501-01 |
| IF Name | TenGigE0/0/0/0 | TenGigE0/0/0/0 |
| FA Affinities | | |
| FA TE Metric | | |
| FA Delay Metric | | |
| FA Topologies | 128, 129, 130, 131, 132 | 128, 129, 130, 131, 132... |

Circuit Style Bandwidth Pool

| | A Side | Z Side |
|------------------|-----------|-----------|
| Pool Size | 1000 Mbps | 1000 Mbps |
| Used | 500 Mbps | 500 Mbps |
| Available | 500 Mbps | 500 Mbps |

- Since the bandwidth utilization (500 Mbps) with the updated policy is above the configured pool utilization threshold (100 Mbps), an event is triggered.

| | | |
|----------------|---|--|
| Optima CSM App |  Warning | Bandwidth pool allocation (500.000) exceeds pool threshold (100.00) for frankenrouter-02 TenGigE0/0/0/21 |
| Optima CSM App |  Warning | Bandwidth pool allocation (500.000) exceeds pool threshold (100.00) for frankenrouter-02 TenGigE0/0/0/20 |
| Optima CSM App |  Warning | Bandwidth pool allocation (500.000) exceeds pool threshold (100.00) for 5501-02 TenGigE0/0/0/2 |
| Optima CSM App |  Warning | Bandwidth pool allocation (500.000) exceeds pool threshold (100.00) for 5501-02 TenGigE0/0/0/0 |
| Optima CSM App |  Warning | Bandwidth pool allocation (500.000) exceeds pool threshold (100.00) for 5501-01 TenGigE0/0/1/0/1 |
| Optima CSM App |  Warning | Bandwidth pool allocation (500.000) exceeds pool threshold (100.00) for 5501-01 TenGigE0/0/0/0 |

Example: Bandwidth Pool Size and Utilization Exceeded

- Link CS Bandwidth Pool Size: 10%
- Link CS Bandwidth Minimum Threshold: 90%

In this example, the bandwidth pool size for the 10 Gbps ethernet interfaces is 1Gbps and the alarm threshold is set for 900 Mbps.

- An existing Circuit Style SR-TE policy from node 5501-02 to node 5501-01 (*r02 - r01*) uses a bandwidth of 500 Mbps.
- Later, a new policy requiring a bandwidth of 750 Mbps with a path from node 5501-02 to node 5501-01 to 5501-2 (*r02 - r01 - r2*) is requested. The only paths available between these 2 nodes are the paths computed for the first CS policy.
 - CSM cannot compute a path for the new Circuit Style SR-TE policy *r02 - r01 - r2* and therefore remains operationally down. CSM will try again, every 30 minutes, to find a path that meets the bandwidth requirements.

Summary

Admin State ↑ Up

Oper State ↓ Down

Binding SID 0

Policy Type Circuit-Style

Profile ID -

Description -

Traffic Rate 0 Mbps

Unused True ⓘ

[See more](#) ▾

Candidate Path

[Expand All](#)

| Path Name | Pref | Role | State |
|---|------|------|---|
| <input checked="" type="checkbox"/> cfg_r1-r2-2_discr_100 | 100 | | ↑ A ▾ |
| <input checked="" type="checkbox"/> cfg_r1-r2-2_discr_50 | 50 | | ↑ ▾ |

- Alerts are triggered.

| Source | Severity | Description |
|---------------------------------------|---|--|
| Optima CSM App | ⚡ Warning | Unable to compute path for 10.10.10.1 <-> 10.255.255.2 color 2000 due to CsmUpdateStatus.NO_PATH |
| SR Policy [10.255.255.2#10.255.255.2] | ⚡ Warning | Policy 'srte_c_2000_ep_10.10.10.1' has operational status as DOWN. |
| SR Policy [10.255.255.1#10.255.255.2] | ⚡ Warning | Policy 'srte_c_2000_ep_10.10.10.2' has operational status as DOWN. |

3. Later, the Circuit Style SR-TE policy *r02 - r01 - r2* is updated and only requires 10 Mbps. The following behaviors occur:

- Since the total bandwidth required for the two polices (10 Mbps + 500 Mbps = 510 Mbps) now requires less than the bandwidth pool size (1Gbps), Circuit Style SR-TE policy *r02 - r01 - r2* receives a path computed by CSM and becomes operationally up.

Summary

Admin State ↑ Up

Oper State ↓ Down

Binding SID 0

Policy Type Circuit-Style

Profile ID -

Description -

Traffic Rate 0 Mbps

Unused True ⓘ

[See more](#) ▾

Candidate Path

[Expand All](#)

| Path Name | Pref | Role | State |
|---|------|------|---|
| <input checked="" type="checkbox"/> cfg_r1-r2-2_discr_100 | 100 | | ↑ A ▾ |
| <input checked="" type="checkbox"/> cfg_r1-r2-2_discr_50 | 50 | | ↑ ▾ |

- Since the second Circuit Style SR-TE policy with the reduced bandwidth is now provided a path by CSM, alerts are cleared.

| Source | Severity | Description |
|-------------------------------------|----------|--|
| SR Policy [10.10.10.1#10.255.255.1] | Clear | Policy 'srte_c_2000_ep_10.10.10.1#10.255.255.1' has operational status back to UP. |
| SR Policy [10.10.10.2#10.255.255.2] | Clear | Policy 'srte_c_2000_ep_10.10.10.2#10.255.255.2' has operational status back to UP. |

How Does CSM Handle Path Failures?

Cisco Crosswork computes paths for Circuit Style SR-TE policies only after a complete bidirectional, path-protected set of candidate paths has been delegated. There are three types of candidate paths that are used during path failures:

- **Working**—This is the path with the highest preference candidate path.
- **Protect**—This path is defined as the second highest preference candidate path. If the Working path goes down, the Protected path (with the lower preference value) is activated. After the Working path recovers, the Protected path remains active until the default lock duration expires.
- **Restore**—This path is defined as the lowest preference candidate path. Crosswork computes the Restore path only after the Working and Protect paths are down. You can control how long after Restore paths are delegated from both sides to wait before the path is computed (see [Enable SR Circuit Style Manager, on page 68](#)). This delay allows topology and policy state changes to fully propagate to Crosswork, in cases where these changes triggered the Restore path delegation.

To address path failures effectively and switchover from working path to protect path, you can configure Performance Measurement (PM). For more information, see [Configure Circuit Style SR Policies, on page 69](#).

Examples



Note Illustrations are for demonstration purposes only and may not always reflect the exact UI or data described within the workflow content. If you are viewing the HTML version of this guide, click the images to view them in full-size.

The following image shows that the Working and Protected paths of the Circuit Style SR-TE policy are operational. The *active* path is indicated by the "A" icon.

Endpoint 5501-01 | TE RID: 10.255.255.1
Color 1000

Summary

- Admin State Up
- Oper State Up
- Binding SID 24016
- Policy Type Circuit-Style
- Profile ID -
- Description -
- Traffic Rate 0 Mbps
- Unused True ?

Candidate Path

| Path Name | Pref | RoleState |
|-----------------------|------|---|
| > cfg_r1-r2_discr_100 | 100 | Up Up |
| > cfg_r1-r2_discr_50 | 50 | Up |

When the Active path goes down, the Protected path immediately becomes "active". When the Active path goes back up, then the Protected path takes the role of "protected" again and the Active path (with preference 100) becomes active.

Endpoint 5501-01 | TE RID: 10.255.255.1
Color 1000

Summary

- Admin State Up
- Oper State Up
- Binding SID 24016
- Policy Type Circuit-Style
- Profile ID -
- Description -
- Traffic Rate 0 Mbps
- Unused True ?

Candidate Path

| Path Name | Pref | RoleState |
|-----------------------|------|---|
| > cfg_r1-r2_discr_50 | 50 | Up Up |
| > cfg_r1-r2_discr_100 | 100 | Down |

In the case where both Working and Protected paths go down, CSM calculates a Restore path and it becomes the active path. Note that the Restore path has the lowest preference value of 10. The Restore path only appears in this particular case. If either the Working or Protected paths become operational again, the Restore path disappears from the topology map and from the Candidate Path list.

How Does CSM Handle Path Failures?

Traffic Engineering / Traffic Engineering Last Refresh: 13-Oct-2022 03:33:54 PM GMT+11

Show Traffic Engineering Device Groups Unassigned... Saved Views Select a saved view Save View

All Locations / Unassigned Devices

Show: Participating Only KSP Path Bi-Dir Path Show Groups Color: 1000

Summary

- Admin State Up
- Oper State Up
- Binding SID 24007
- Policy Type Circuit-Style
- Profile ID -
- Description -
- Traffic Rate 0 Mbps
- Unused True (i)
- [See more](#)

Candidate Path Expand All

| Path Name | Pref | RoleState |
|--|------|--|
| <input checked="" type="checkbox"/> > cfg_r1-r2_discr_10 | 10 | + A |
| <input type="checkbox"/> > cfg_r1-r2_discr_50 | 50 | + |
| <input type="checkbox"/> > cfg_r1-r2_discr_100 | 100 | + |

Auto-Focus



CHAPTER 8

Local Congestion Mitigation (LCM)

- [Local Congestion Mitigation Overview, on page 83](#)
- [LCM Important Notes, on page 84](#)
- [LCM Calculation Workflow, on page 87](#)
- [Workflow Example: Mitigate Congestion on Local Interfaces, on page 89](#)
- [Configure LCM, on page 96](#)
- [Add Individual Interface Thresholds, on page 99](#)
- [Monitor LCM Operations, on page 100](#)
- [Temporarily Exclude an Interface from LCM, on page 103](#)

Local Congestion Mitigation Overview

Local Congestion Mitigation (LCM) searches for congestion on a configurable cadence (as opposed to a triggered event) and provides localized mitigation recommendations in surrounding interfaces (local interface-level optimization) within a domain. LCM computes the shortest paths for one or more tactical policies to divert the minimal amount of traffic on a congested interface to alternate paths with sufficient bandwidth. It attempts to keep as much of the traffic on the original IGP path. With LCM, you are able to do the following:

- Monitor congestion as defined by the interface thresholds you specify.
- Visually preview LCM recommendations on your network before you decide whether to commit the Tactical Traffic Engineering (TTE) SR policy deployment.
- Enable LCM to delete any down, failed or uncommitted LCM TTE policies when there is an imminent risk of network failures based on LCM solution configurations. For more information, see the advanced configuration options (**Auto Repair Solution** and **Adjacency Hop Type**) in [Configure LCM, on page 96](#).

LCM allows for a wider applicability of the solution in various network topologies such as that involving multiple IGP areas due to its simpler path computation and limitation to specific network elements. Focusing on the problem locally within a domain eliminates the need for simulating edge-to-edge traffic flows in the network through a full traffic matrix and allows for better scaling of large networks. Also, LCM performs the collection of TTE SR policy and interface counters via SNMP and does not require the use of SR-TM.



Note Take a look at the [Workflow Example: Mitigate Congestion on Local Interfaces, on page 89](#) to see how to use LCM in your network.

LCM Important Notes

Consider the following information when using LCM:

- You must have the Advanced RTM license package to use LCM.
- Role-based Access Control (RBAC) and task permissions have been introduced in this release. LCM-specific Device Access Groups are automatically added to each domain that is identified as the network is discovered. Confirm that appropriate users are assigned to these Device Access Groups so that they will be able to view LCM recommendations and take the appropriate action. Admin users that have access to LCM Device Access Groups for one or more domains may modify LCM configurations. However, removing LCM Device Access Groups have to be done manually. For more information on RBAC and user roles, see the "[Cisco Crosswork Network Controller Administration Guide](#)".
- LCM does not support LDP-labeled traffic. LDP-labeled traffic *must not* be steered into LCM autoroute TTE SR policies.
- The use of LCM is not recommended on networks with Tree SID policies. Initial calculations are skewed because full traffic measurements are unavailable.
- LCM supports domains with up to 2000 devices. A *domain* is an identifier that is assigned to an IGP process. Domains are learned from the network. The domain ID is taken from the PCC router configuration (`link-state instance-id`) that you use to advertise IGP with BGP-LS.
- LCM recommended solutions use the resources within a single domain only.
- LCM evaluates network utilization on a regular, configurable cadence of 1 minute or more. The cadence is typically set to be greater than or equal to the SNMP traffic polling interval but can be set lower to improve responsiveness. The default cadence is 10 minutes.
- The traffic statistics collection interval affects how quickly LCM can respond to topology changes and LSP deployments that affect interface and LSP traffic measurements. It can take up to twice the traffic statistics collection interval plus the LCM evaluation interval for LCM recommendations to fully reflect these changes. During this period, LCM recommendations may evolve as the traffic measurements are updated and eventually fully converge in Crosswork.
- LCM leverages ECMP across parallel TTE SR policies and assumes roughly equal splitting of traffic. The degree to which actual ECMP splitting adheres to this assumption depends on the presence of large elephant flows and the level of traffic aggregation.

You can configure LCM to detect excessive uneven ECMP splitting among parallel TTE SR policies and issue an event to notify. To mitigate the effects of uneven ECMP, the overprovisioning factor is used in LCM. For more information, see [Configure LCM](#).
- LCM assumes traffic in an *existing* SR-TE policy is ineligible for optimization and should not be steered into LCM TTE SR policies. To enforce this assumption, any existing non-LCM SR-TE policies should not use regular Algo-0 prefix SIDs. Any combination of Algo-1 Strict, Flexible Algorithm, or adjacency SIDs is recommended to prevent this traffic from being steered into LCM TTE SR policies.

- When domain interfaces and links are removed (intentionally or unintentionally), the following occurs:
 - If all links in a domain go down (LINK_DOWN state), LCM configuration and the Domain UI card (see [Configure LCM, on page 96](#)) will remain available until the links are aged out (after 4 hours). This behavior is intentional as it gives you time to recover domain interfaces and links if this was done by mistake.
 - If you want to force domain removal before links age out, then you can remove links manually from the UI. The domain will remain in a "ready for deletion" status until the last link is removed.
- After an HA switchover, you can manually add missing interfaces that were previously monitored or update domain configuration options after the system is stable. Missing interfaces and other configuration options occur if they were added after the last cluster data synchronization.

LCM Platform Requirements

The following is a non-exhaustive list of high-level requirements for proper LCM operation:

Congestion Evaluation Requirements

LCM requires traffic statistics from the following:

- Interface traffic measurements
- Headend SR-TE policy traffic measurements

To ensure LCM is receiving these traffic statistics:

- Enable SNMP on the devices whose traffic you want to monitor, including the headend device. For more on this task, see [Configuring SNMP Support](#). Note that gNMI is also an option for collecting traffic measurements.
- Ensure that the SNMP-enabled devices are all reachable from the Crosswork Data Gateway. For more on this task, see [Check Connectivity to the Destination](#).

Congestion Mitigation Requirements

The headend device must support PCE-initiated SR-TE policies with autoroute steering. However, LCM will not work if the headend is a Cisco NCS device and there is L2VPN traffic in the network.

Devices should be configured with `force-sr-include` to enable traffic steering into SR-TE policies with autoroute. For example:

```
segment-routing traffic-eng pcc profile ID autoroute force-sr-include
```

The `ID` parameter in this command identifies the PCC profile associated with the SR-TE policy that PCE has provisioned. The ID value can be any integer from 1 to 65535, but it must match the profile ID that PCE uses to instantiate the policy. If not, the policy will not be activated. For example, if PCE provisions a policy with profile ID 10, you must configure `segment-routing traffic-eng pcc profile 10 autoroute force-sr-include` on the headend router to enable autoroute announcement for that policy. For more information, see the *Segment Routing Configuration Guide, Cisco IOS XE 17 (Cisco ASR 920 Series)*, [COE-PCE Initiated SR Policy with OSPF and IS-IS SR-TE Autoroute Announce](#).



Note The ID that is configured under the PCC profile, must match the Profile ID option set in the LCM Configuration page.

The headend device must support Equal Cost Multi-Path (ECMP) across multiple parallel SR-TE policies. To verify that a device can support SR-TE policies using ECMP, check that the device has the following:

- Segment Routing is enabled and configured, with a Segment Routing Global Block (SRGB) that matches the SRGB of the SR-TE policy headend and tailend routers. Use the `show segment-routing mpls state` command to verify the SRGB configuration on the device.
- BGP-LS is enabled and configured to advertise and receive link-state information from the SR-TE policy headend and tailend routers. Use the `show bgp link-state link-state` command to verify the BGP-LS status and the `show bgp link-state link-state database` command to verify the link-state information on the device.
- ECMP is enabled and configured to load-balance traffic across multiple equal-cost paths based on flows. Use the `show ip route` command to verify the ECMP routes and the `show ip cef` command to verify the ECMP load-balancing algorithm on the device.

If all these conditions are met, then the device can support an SR-TE policy using ECMP.

BGP-LS Speaker Placement for Multiple AS Networks with a Dedicated IGP Instance Between ASBRs

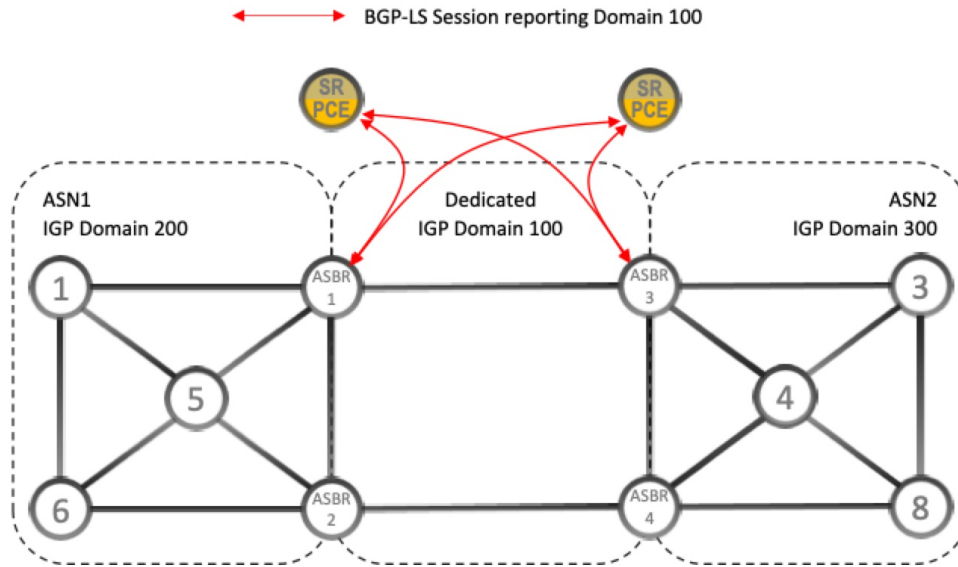
To support interdomain latency-optimized SR policy path computation by an SR-PCE (or other use cases where egress peer engineering (EPE) is not supported), a dedicated IGP instance may be configured between autonomous system border routers (ASBRs) in different ASNs. In these cases, it is important to identify which ASBRs report the topology via BGP-LS for proper topology discovery.

In the following example, at least one ASBR in each AS participating in the dedicated inter-AS IGP (Domain 100) must have BGP-LS enabled to report the IGP between each ASBR. Each ASBR must report the domain with the same BGP-LS identifier.



Note More than one ASBR per AS reporting the BGP-LS topology is also supported.

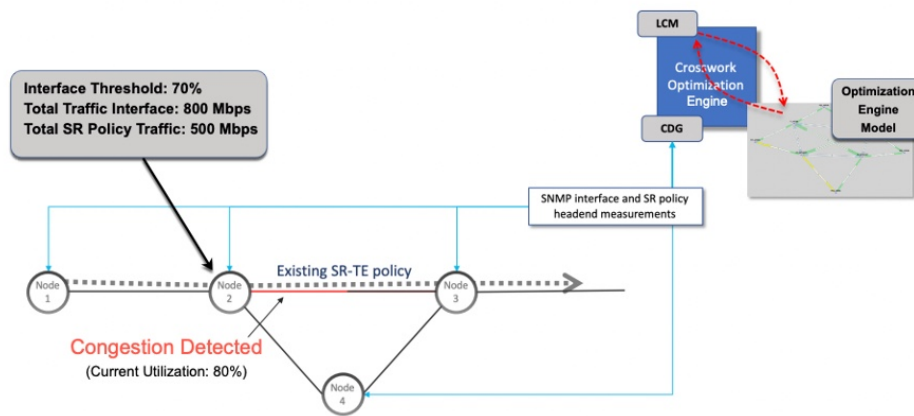
Figure 7: BGP-LS Session Reporting Domain 100



LCM Calculation Workflow

This example walks you from congestion detection to the calculations LCM performs prior to recommending tactical tunnel deployment. These calculations are done on a per domain basis which allows better scalability and faster calculation for larger networks.

Figure 8: LCM Configuration Workflow Example



- Step 1** LCM first analyzes the Optimization Engine Model (a realtime topology and traffic representation of the physical network) on a regular cadence.
- Step 2** In this example, after a congestion check interval, LCM detects congestion when Node 2 utilization goes above the 70% utilization threshold.
- Step 3** LCM calculates how much traffic is eligible to divert.

LCM only diverts traffic that is not already routed on an existing SR policy or RSVP-TE tunnel (for example: unlabeled, IGP routed, or carried via FlexAlgo-0 SIDs). The traffic within an SR-TE policy will not be included in LCM calculation and will continue to travel over the original programmed path.

Eligible traffic is computed by taking the interface traffic statistics that account for all traffic on the interface and subtracting the sum of traffic statistics for all SR-TE policies that flow over the interface.

Total interface traffic – SR policy traffic and RSVP-TE tunnels = Eligible traffic that can be optimized

This process must account for any ECMP splitting of SR policies to ensure the proper accounting of SR policy traffic. In this example, the total traffic on congested Node 2 is 800 Mbps. The total traffic of all SR policies routed over Node 2 is 500 Mbps.

The total traffic that LCM can divert in this example is 300 Mbps: 800 Mbps – 500 Mbps = 300 Mbps

Step 4 LCM calculates the amount that must be sent over alternate paths by subtracting the threshold equivalent traffic from the total traffic on the interface. In this example, the amount to be diverted is 100Mbps:

800 Mbps – 700 Mbps (70% threshold) = 100 Mbps

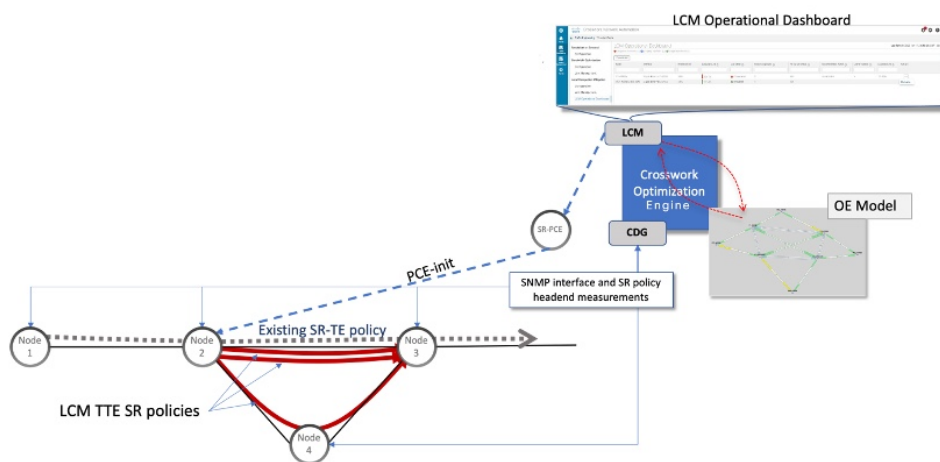
LCM must route 100 Mbps of 300 Mbps (eligible traffic) to another path. Note that if the Over-provisioning Factor (OPF) percentage is set to 10, then LCM must route 110 (100 Mbps x 1.10) of the eligible traffic. The OPF can be set in the Advanced tab within the LCM Configuration window. For more information, see [Configure LCM, on page 96](#).

Step 5 LCM determines how many TTE SR policies are needed and their paths. The ratio of how much LCM eligible traffic can stay on the shortest path to the amount that must be detoured, will determine the number of TTE SR policies that are needed on the shortest versus alternate paths, respectively.

In this example, LCM must divert one-third of the total eligible traffic (100Mbps out of 300Mbps) away from the congested link. Assuming a perfect ECMP, LCM estimates that three tactical SR-TE policies are required to create this traffic split: one tactical SR-TE policy will take the diversion path and two tactical SR-TE policies will take the original path. There is sufficient capacity in the path between Node 2 and Node 4. Therefore, LCM recommends three TTE SR policies (each expected to route approximately 100Mbps) to be deployed from Node 2 to Node 3 via SR-PCE:

- 2 TTE SR policies to take a direct path to Node 3 (200 Mbps)
- 1 TTE SR policy takes hop via Node 4 (100 Mbps)

These recommendations will be listed in the **LCM Operational Dashboard**.



- Step 6** Assuming you deploy these TTE SR policies, LCM continues to monitor the deployed TTE policies and will recommend modifications or deletions as needed in the LCM **Operational Dashboard**. TTE SR policy removal recommendations will occur if the mitigated interface would not be congested if these policies were removed (minus a hold margin). This helps to avoid unnecessary TTE SR policy churn throughout the LCM operation.
-

Workflow Example: Mitigate Congestion on Local Interfaces



Note If you are viewing the HTML version of this guide, click on the images to view them in full-size.

In this example, we will enable LCM and observe the congestion mitigation recommendations to deploy TTE SR policies when utilization on a device's interface surpasses a defined utilization threshold. We will preview the recommended TTE SR policies before committing them to mitigate the congestion. The example goes through the following steps:

1. View uncongested topology.
 2. Set utilization thresholds for individual interfaces.
 3. Enable and configure LCM in Manual mode. Manual mode allows you to view recommended TTE policies prior and decide whether or not to deploy them.
 4. After LCM detects congestion, view LCM recommendations on the Operational Dashboard.
 5. Preview the recommended LCM TTE policies to deploy visually on the topology map.
 6. Commit and deploy all LCM TTE policy recommendations to mitigate the congestion.
 7. Verify that the LCM TTE policies have been deployed.
-

- Step 1** View initial topology and utilization prior to LCM configuration.
- a) In this example, note that the node cw-xrv60 has a utilization of 7.17%.

Figure 9: Initial Utilization

Workflow Example: Mitigate Congestion on Local Interfaces

The screenshot displays a network map on the left with several routers (cw-xrv01 to cw-xrv07) connected. On the right, the 'Link Details' window is open, showing the configuration for the link between cw-xrv60 and cw-xrv62. The 'Summary' tab is active, and the 'Utilization' field is highlighted in yellow, indicating 7.17% (71.73Mbps/1Gbps). A red box highlights the 'Utilization' field in the main table and a detailed view of the 'A Side' configuration below it.

| | A Side | Z Side |
|----------------|-------------------------|--------------------------|
| Node | cw-xrv60 | cw-xrv62 |
| TE Router ID | 3.3.3.60 | 3.3.3.62 |
| IPv6 Router ID | bb:bb:bb:3:3::60 | bb:bb:bb:3:3::62 |
| IF Name | GigabitEthernet0/0/0/1 | GigabitEthernet0/0/0/1 |
| IF Description | | GigabitEthernet0/0/0/1 |
| IF Alias | | *** connect to xrv60 *** |
| Type | | ETHERNETCSMADC |
| Local IF ID | 3.3.3.60 (0) | 3.3.3.62 (7) |
| Utilization | 7.17% (71.73Mbps/1Gbps) | 0% (1.44kbps/1Gbps) |

| | A Side |
|----------------|-------------------------|
| Node | cw-xrv60 |
| TE Router ID | 3.3.3.60 |
| IPv6 Router ID | bb:bb:bb:3:3::60 |
| IF Name | GigabitEthernet0/0/0/1 |
| IF Description | |
| IF Alias | |
| Type | |
| Local IF ID | 3.3.3.60 (0) |
| Utilization | 7.17% (71.73Mbps/1Gbps) |

Step 2 Define any individual interface thresholds.

LCM allows you to configure a *global* utilization threshold that can be used for all interfaces. When traffic utilization surpasses the threshold, LCM will try to find bypass policies to remediate the congestion. You set the global utilization threshold in the **LCM Configuration** page. However, if you want to define different thresholds for individual interfaces, we recommend that you define them in the **Customized Interface Threshold** page *prior* to enabling LCM.

- In this example, we will define an individual interface threshold. Go to the **Customized Interface Thresholds** page (**Traffic Engineering > Local Congestion Mitigation > Domain-ID > ... > Interface Thresholds**). You can add interfaces individually or upload a CSV file with a list of nodes and interfaces with custom utilization thresholds. For more information, see [Add Individual Interface Thresholds, on page 99](#).

See the following example and note the defined threshold for cw-xrv60 with interface GigabitEthernet0/0/0/1 is 16%.

Note The utilization thresholds used in this example are extremely low and are best used for lab environments.

Figure 10: Customized Interface Thresholds

Customized Interface Thresholds

Interfaces to Monitor: Selected Interfaces - LCM monitors only the interfaces with custom thresholds.

+ Create | Edit Mode: OFF

| Node | Interface | Threshold (%) | Select for |
|----------|------------------------|---------------|--------------------------|
| cw-xrv60 | GigabitEthernet0/0/0/1 | 16 | <input type="checkbox"/> |

Note By default, LCM monitors all interfaces. This includes any individual thresholds that are imported to this page. The rest of the interfaces will be monitored using the global **Utilization Threshold** defined in the **LCM Configuration** page (see **Step 3**).

b) After adding interfaces and defining thresholds, click **Save**.

Step 3 Enable LCM and configure the global utilization thresholds.

a) From the main menu, choose **Traffic Engineering > Local Congestion Mitigation > Domain-ID** and click **Configuration**. Toggle the **Enable** switch to **True** and configure other LCM options. In this example, the global threshold is set at 80%, the **Interfaces to Monitor > All Interfaces** option is selected.

Figure 11: LCM Configuration Page

Configuration

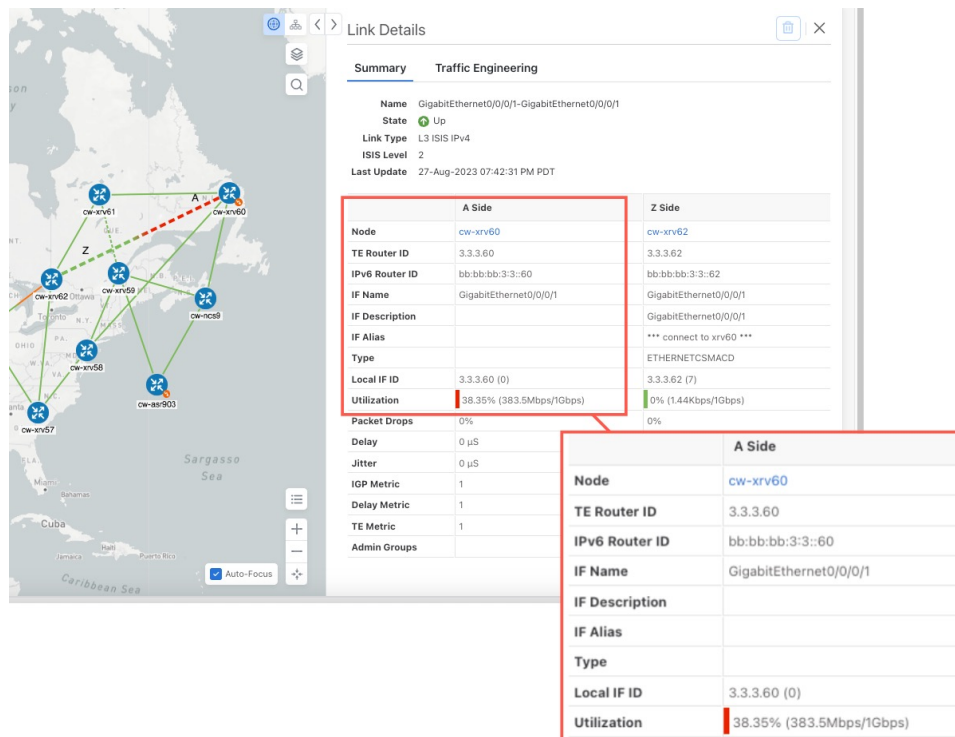
Basic Advanced

| | | |
|--|--|---|
| Enable ⓘ False <input checked="" type="checkbox"/> True | Color ⓘ 2000 <small>Range: 1 to 4294967295</small> | Utilization Threshold ⓘ 80 <small>Range: 0 to 100</small> |
| Utilization Hold Margin ⓘ 5 <small>Range: 0 to Utilization Threshold</small> | Delete Tactical SR Policies when Disabled ⓘ False <input checked="" type="checkbox"/> True | Profile ID ⓘ 1981 <small>Range: 0 to 65535</small> |
| Congestion Check Interval ⓘ 300 seconds <small>Range: 60 to 86400 seconds</small> | Max LCM Policies per Set ⓘ 8 <small>Range: 1 to 8</small> | Interfaces to Monitor ⓘ <input type="radio"/> Selected Interfaces <input checked="" type="radio"/> All Interfaces |
| Description ⓘ LCM Startup Config | | |

b) Click **Commit Changes** to save your configuration. After committing the configuration changes, LCM will display *recommendations* on the **LCM Operational Dashboard** if congestion occurs on any monitored interfaces. Later, you will be able to preview the recommended TTE policies and decide whether or not to commit and deploy them onto your network.

Step 4 After some time, congestion occurs surpassing the custom LCM threshold defined at 16% for node cw-xrv60 with interface GigabitEthernet0/0/0/1.

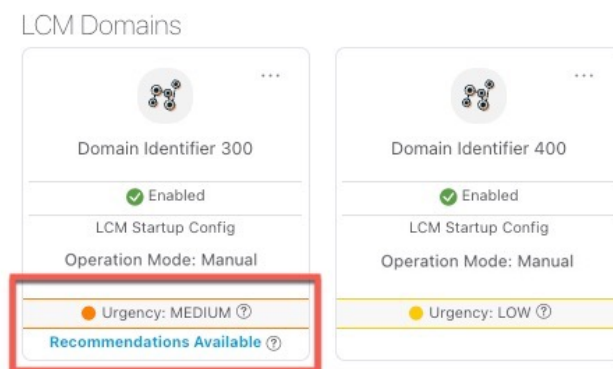
Figure 12: Observed Congestion



Step 5 View TTE SR policy recommendations in the LCM Operational Dashboard.

- Navigate to **Traffic Engineering > Local Congestion Mitigation**. When congestion is detected, the domain displays the urgency type and recommendations that are available. Click the question mark icons to display more information about the urgency type and when the most recent recommendation was given.

Figure 13: Congested Detected and LCM Recommendations



- (Optional) View LCM events.

From the top-right corner of the Crosswork UI, click  > **Events** tab to view LCM events. You can also monitor this window to view LCM events as they occur. You should see events for LCM recommendations, commit actions, and any exceptions.

- c) Open the **Operational Dashboard (Traffic Engineering > Local Congestion Mitigation > Domain-ID > ... > Operational Dashboard)**.

The dashboard shows that cw-xrv60 utilization has surpassed 16% and is now at 38.5%. In the **Recommended Action** column, LCM recommends the deployment of TTE policy solution sets (**Recommended Action - Update Set**) to address the congestion on the interface. For more information, see [Monitor LCM Operations, on page 100](#).

Figure 14: LCM Operational Dashboard

| Node | Interface | Threshold Ut... | Evaluation ... | LCM State | Policies De... | Policy Set ... | Recommend... | Commit ... | Expected Util... | Solution Update... |
|----------|-----------------|-----------------|----------------|-----------|----------------|----------------|--------------|------------|------------------|--------------------|
| cw-xrv60 | GigabitEther... | 16% | 38.35% | Congested | 4 | DEGRADED | Update Set | None | 14% | 29-Aug-2023 04:... |

Note If LCM cannot find a solution (**Recommended Action - No Solution**), it may be due to constraints enabled when configuring LCM ([Configure LCM, on page 96](#)).

- d) Before committing TTE policies, you can preview the deployment of each TTE policy solution set. Click **...** in the **Actions** column and choose **Preview Solution**.

Figure 15: Preview Solution

| Node | Interface | Threshold Ut... | Evaluation ... | LCM State | Policies | Solution Update... | Action |
|----------|-----------------|-----------------|----------------|-----------|----------|--------------------|---|
| cw-xrv60 | GigabitEther... | 16% | 38.35% | Congested | 4 | 29-Aug-2023 04:... | <ul style="list-style-type: none"> Preview Solution View Deployed Policies Pause |

The resulting window displays the node, interface, and the recommended action for each TTE policy. From the **Preview** window, you can select the individual TTE policies, and view different aspects and information as you would normally do in the topology map. You can expand each policy to view individual segments. After reviewing the potential implications on your network, you can decide whether or not to deploy the bypass policies that LCM recommends.

The following figure shows the recommended TTE policies for node cw-xrv60.

Figure 16: LCM TTE Deployment Preview

Workflow Example: Mitigate Congestion on Local Interfaces

- e) After you are done viewing the recommended TTE policies on the map, go back to the **Operational Dashboard** and click **Commit All**. The LCM State column changes to **Mitigating**.

Figure 17: Mitigating State

Note All LCM recommendations per domain must be committed in order to mitigate congestion and produce the expected utilization as shown in the **Operational Dashboard**. The mitigating solution is based on *all* LCM recommendations being committed because of dependencies between solution sets.

Step 6 Validate TTE SR policy deployments.

- a) Click  > **Events** tab. Note which LCM events are listed in the **Events** window.

Note Crosswork will report network events that are detected based on the policies and features you have enabled. For example, if a link drop causes an SR-TE policy to go down or if LCM detects congestion an event is displayed. These alerts are reported in the UI and, if desired, can be forwarded to third party alerting/monitoring tools.

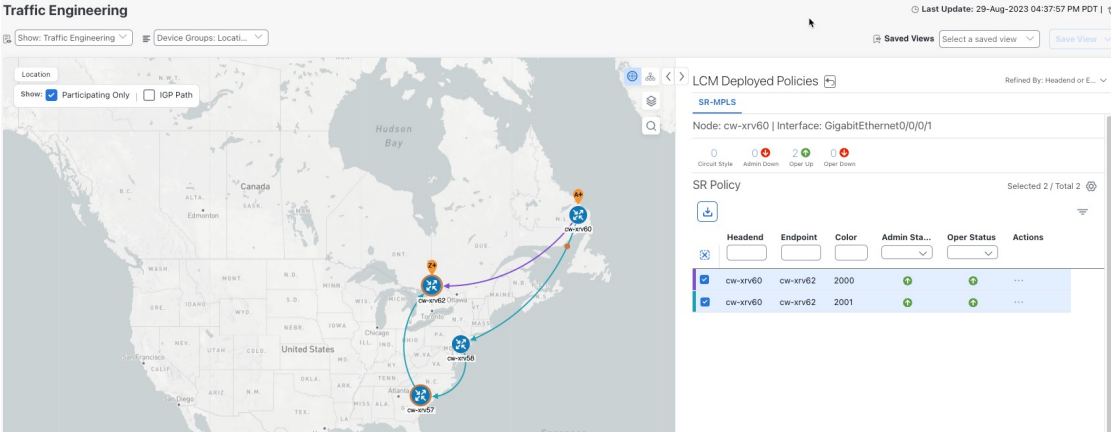
- b) Return to the **Operational Dashboard** to see that the LCM state changes to **Mitigated** for all TTE policy solution sets.

Note The LCM state change will take up to 2 times longer than the SNMP cadence.

- c) Confirm the TTE policy deployment by viewing the topology map.

Click  in the **Actions** column and choose **View Deployed Policies**. The deployed policies are displayed in focus within the topology map.

Figure 18: View TTE Deployment Policies on Topology Map



The screenshot displays the Traffic Engineering interface. On the left, a map of the United States shows a network topology with nodes labeled cw-xrv60, cw-xrv62, and cw-xrv67. On the right, the 'LCM Deployed Policies' panel is open, showing details for SR-MPLS. The node is cw-xrv60 and the interface is GigabitEthernet0/0/0/1. Below this, there is a table of SR Policies.

| Headend | Endpoint | Color | Admin Sta... | Oper Status | Actions |
|-------------------------------------|----------|----------|--------------|--------------------------------------|---------|
| <input checked="" type="checkbox"/> | cw-xrv60 | cw-xrv62 | 2000 | ● | ... |
| <input checked="" type="checkbox"/> | cw-xrv60 | cw-xrv62 | 2001 | ● | ... |

d) View SR policy details.


From the **Actions** column of one of the deployed policies click  and choose **View Details**. Note that the **Policy Type** is **Local Congestion Mitigation**.

Figure 19: SR Policy Details

The screenshot displays the 'SR Policy Details' window. It has two tabs: 'Current' (selected) and 'History'. Under the 'Current' tab, the following information is shown:

- TE RID: 3.3.3.60 | IPv6 RID: bb:bb:bb:3::60
- PCC IP: 3.3.3.60
- Endpoint: cw-xrv62 | Dest IP: 3.3.3.62
- TE RID: 3.3.3.62 | IPv6 RID: bb:bb:bb:3::62
- Color: 2000

Below this is a 'Summary' section with the following details:

- Admin State: Up (green up arrow)
- Oper State: Up (green up arrow)
- Binding SID: 24013
- Policy Type: Local Congestion Mitigation
- Profile ID: 2021
- Description: -
- Traffic Rate: 198.93 Mbps
- Unused: False (info icon)
- Delay: 1 (info icon)
- Accumulated Metric: 0
- Delegated PCE: 10.194.132.94
- Non-delegated PCEs: 10.194.132.93
- PCE Computed Time: 28-Aug-2023 04:59:16 PM PDT
- Last Update: 28-Aug-2023 04:59:19 PM PDT

At the bottom of the summary section, there is a 'See less' link with an upward arrow.

Step 7 Remove the TTE SR policies upon LCM recommendation.

- After some time, the deployed TTE SR policies may no longer be needed. This occurs if the utilization will continue to stay under the threshold without the LCM-initiated TTE tunnels. If this is the case, LCM generates new recommended actions to delete the TTE SR policy sets.
- Click **Commit All** to remove the previously deployed TTE SR policies.
- Confirm the removal by viewing the topology map and SR Policy table.

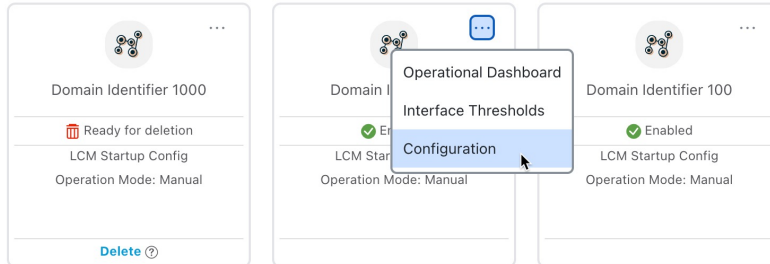
In this scenario we observed how to leverage LCM to alleviate traffic congestion in the network. LCM takes the manual tracking and calculation out of your hands but at the same time gives you control as to whether to implement the congestion mitigation recommendations, or not. You can preview the recommendations and see how the potential deployment will take effect in your network before you deploy them. As traffic changes, LCM tracks the deployed TTE SR-TE policies and decides whether or not they are still needed. If not, LCM recommends deleting them.

Configure LCM

To enable and configure LCM:

Step 1 From the main menu, choose **Traffic Engineering > Local Congestion Mitigation > Domain-ID-card** and click *****> Configuration**.

LCM Domains



Step 2 Toggle the **Enable** switch to **True**.

Step 3 Enter the required information. Hover the mouse pointer over **i** to view a description of each field.

Note If LCM is enabled, but cannot find a solution (**Recommended Action - No Solution**), it may be due to constraints enabled in this page.

The following list describes additional **Basic** field information not described in hover text:

- **Utilization Threshold**—Set the utilization percent at which LCM will consider an interface to be congested. This value applies to all interfaces, unless you specify thresholds to individual interfaces in the **Customized Interface Thresholds** page.
- **Profile ID**—This is a required configuration to enable traffic steering onto LCM policies. Autoroute (steers traffic into the tactical SR-TE policies LCM creates) is applied to SR-TE policies through the proper **Profile ID** option that is set here to align with the configuration on the PCC associating that Profile ID with autoroute feature.
- **Congestion Check Interval** (seconds)—This value determines the interval at which LCM will evaluate the network for congestion. Under a steady state, when there are no recommendation commits, it uses this interval to re-evaluate the network to determine if changes are required to recommendations. For example, if the interval is set to 600 seconds (10 minutes), LCM will evaluate the network every 10 minutes for new congestion and determine whether a new recommendation or modifications to existing recommendations are needed. Examples of modifications can include removal or updates to individual policies that were previously recommended. This option is typically set to greater than or equal to the SNMP polling cadence but can be set as low as 60 sec to improve responsiveness within the bounds imposed by the traffic collection interval.
- **Interfaces to Monitor**—By default, this is set to **Selected Interfaces** and you will need to add thresholds to individual interfaces by importing a CSV file in the **Customized Interface Thresholds** page (**Traffic Engineering > Local Congestion Mitigation > Domain-ID > *** > Customized Interface Thresholds**). Only interfaces defined in the **Customized Interface Thresholds** page will be monitored. If set to **All Interfaces**, LCM will monitor the interfaces with custom thresholds that are uploaded in the **Customized Interface Thresholds** page and the rest of the interfaces using the **Utilization Threshold** value configured on this page.

The following list describes additional **Advanced** field information not described in hover text:

- **Advanced > Congestion Check Suspension Interval** (seconds)—This interval determines the time to wait (after a **Commit All** is performed) before resuming congestion detection and mitigation. Since this interval should allow time for network model convergence, set the interval to no less than twice the SNMP collection cadence.

- **Advanced > Auto Repair Solution**—If set to **True**, LCM will automatically delete any down, failed, or uncommitted LCM TTE policies. This option is mainly to address a failure in a policy.

If this option is disabled, and the **Urgency** status of the recommendation shown in the LCM Operational Dashboard is **High**, then the recommended solution is a candidate for the **Auto Repair Solution**. This means that a network failure will most likely occur if the solution is not deployed.

- **Advanced > Adjacency Hop Type**—If set to **Protected**, LCM will create SR policies using protected adjacency SIDs. This allows for Topology-Independent Loop-Free Alternate (TI-LFA) to compute a path for any adjacency failures.

Note This option should only be set to **Protected** if all nodes in the same IGP area as LCM is operating are strict SPF SID capable.

- **Advanced > Optimization Objective**—LCM calculates tactical SR policies based on the metric type chosen to minimize.
- **Advanced > Deployment Timeout**—Enter the maximum amount of seconds allowed to confirm deployment of tactical SR policies.
- **Advanced > Over-provisioning Factor (OPF)**—This option helps address unequal ECMP traffic distribution (elephant flows). This value determines the percentage of how much extra traffic should be accounted for when computing a path for a by-pass policy. If LCM needs to divert x amount of traffic due to congestion, then it will search for a path that can support $x * (1 + OPF)$ traffic. For more information, see [LCM Calculation Workflow, on page 87](#). The default value is 0.
- **Advanced > Maximum Segment Hops**—When calculating bypass TTE policies, LCM uses the effective Maximum SID Depth (MSD) value (as entered here) for specified device tags. You can assign up to five device tags with specific MSD values.

Note A **0** value will not result in a solution. Setting a **0** value is equivalent to LCM monitoring and indicating when there is congestion in the network without providing a recommendation.

Crosswork learns from SR-PCE the MSD for each platform advertising the hardware limit in the IGP and BGP-LS. It represents the hardware limit that can be imposed exclusive of any service/transport/special labels. Therefore, you may want to use this new option to assign less than the advertised MSD value that LCM can use for bypass TTE policy calculation. To view the MSD value for a device, navigate to the **Traffic Engineering** topology map and click on the device. From the **Device Details** page, and click **SR-MPLS > Prefixes** tab > **Expand All**.

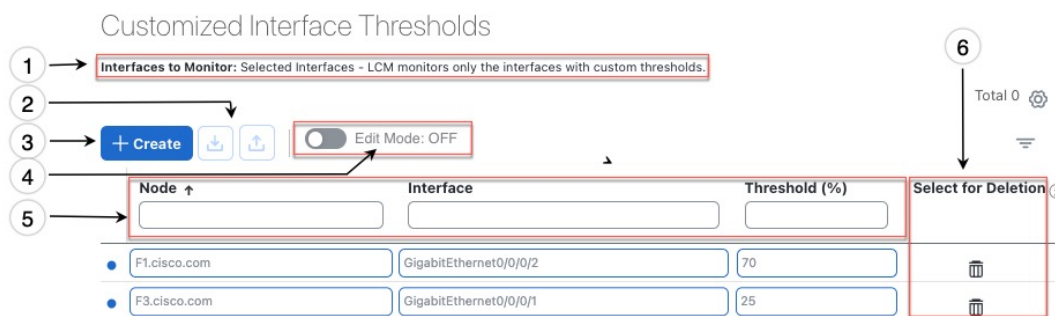
Note Prior to using this option, you must create device tag groups that you want to assign certain MSD values to. For information on creating tags and assigning them to devices, see the [Cisco Crosswork Network Controller Administration Guide](#)


- **Step 4** To save your configuration, click **Commit Changes**. If congestion occurs on any monitored interfaces, LCM will display *recommendations* (LCM will *not* automatically commit or deploy new TTE policies) on the **LCM Operational Dashboard**. You can then preview the recommended TTE policies and decide whether or not to commit and deploy them onto your network.

Add Individual Interface Thresholds

Networks have many different links (10G, 40G, 100G) that require different thresholds to be set. The **Customized Interface Thresholds** page allows you to manage and assign individual thresholds to nodes and interfaces.

Figure 20: Customized Interface Thresholds



| Callout No. | Description |
|-------------|---|
| 1 | Interfaces to Monitor: Displays the option that is currently configured in the Configure LCM page. |
| 2 | Import CSV File: All interfaces currently in the table will be replaced with the data in the CSV file you import. Export CSV File: All interfaces are exported to a CSV file. You cannot filter data for export. |
| 3 | + Create: Click this button to add new interface threshold rows. |
| 4 | Edit Mode: When Edit Mode is ON , you can edit multiple fields in one session, then click Save . |
| 5 | Filter: By default, this row is available for you to enter text in which to filter content. |
| 6 | Select for Deletion: Click  to delete the row. When Edit Mode is ON , you can check multiple rows to delete, then click Save . |

To assign specific threshold values for individual interfaces when using LCM, do the following:

- Step 1** From the main menu, choose **Traffic Engineering > Local Congestion Mitigation > Domain-ID > ... > Interface Thresholds** and click one of the following:
- **Import CSV File**—Edit a CSV file to include a list of interfaces and thresholds, then later import the file into LCM.
 - **Add New Interface**—Manually add individual interfaces and thresholds.
- Step 2** If you import a CSV file:
- a) Click the **Download sample configuration file** link.

- b) Click **Cancel**.
- c) Open and edit the configuration file (LCMLinkManagementTemplate.csv) you just downloaded. Replace the sample text with your specific node, interface, and threshold information.
- d) Rename and save the file.
- e) Navigate back to the **Customized Interface Thresholds** page.
- f) Click **Import .CSV File** and navigate to the CSV file you just edited.
- g) Click **Import**.

- Step 3** If you manually add individual interfaces:
- a) Click the first empty row and enter the appropriate node, interface, and threshold values.

Figure 21: Add First Interface

| Node | Interface | Threshold (%) | Select for Deletion |
|----------------------|----------------------|----------------------|--------------------------|
| <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="checkbox"/> |
| <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="checkbox"/> |

- b) Click + **Create** to add more interfaces.

- Step 4** Confirm that the information appears correctly in the **Customized Interface Thresholds** page.

Note To update the table, you can either turn on Edit Mode or import a CSV file that replaces all current data in the table.

Monitor LCM Operations

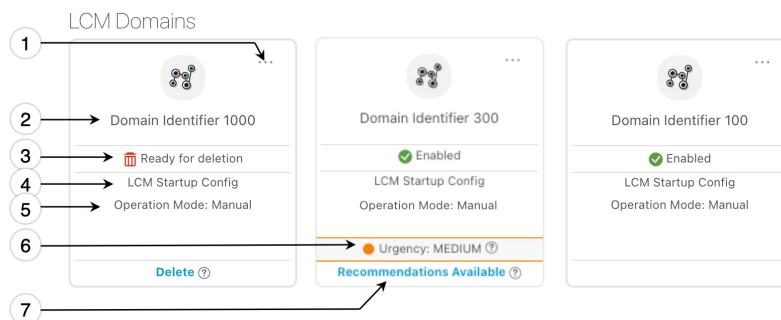


Note This topic describes how to use and configure the LCM Domain Dashboard and the LCM Operational Dashboard to monitor LCM operations. For information on how to use LCM in your network, see the [Workflow Example: Mitigate Congestion on Local Interfaces, on page 89](#) topic.

LCM Domains Dashboard

The LCM Domain Dashboard (**Traffic Engineering > Local Congestion Mitigation**) displays all the domains discovered by Crosswork. A *domain* is an identifier assigned to an IGP process.

Figure 22: LCM Domains Dashboard



| Callout No. | Description |
|-------------|--|
| 1 | <p>Main Menu: Allows you to navigate to the following pages:</p> <ul style="list-style-type: none"> Operational Dashboard Add Individual Interface Thresholds Configure LCM |
| 2 | <p>Domain Identifier: The domain ID is taken from the router configuration (<code>link-state instance-id</code>) that you use to advertise IGP with BGP-LS.</p> |
| 3 | <p>LCM Status: Indicates whether LCM has been enabled for the domain or can be deleted. Also</p> |
| 4 | <p>LCM Configuration Description: The description is defined in the Configure LCM page. The default description is "LCM Startup Config".</p> |
| 5 | <p>Operation Mode: Manual—This option requires a user to view the LCM Operational Dashboard and decide whether to commit TE tunnel recommendations.</p> |
| 6 | <p>Urgency: Indicates the importance of the recommendation deployment or action. Urgency values can be one of the following:</p> <ul style="list-style-type: none"> Low—Indicates that LCM instantiated policies can be removed because they are no longer needed or that no changes are required. Medium—Indicates new or modified recommendations. High—Indicates network failures and recommendations should be deployed. This is a candidate that can be addressed automatically if the Auto Repair Solution advanced option was enabled. See Configure LCM, on page 96. |
| 7 | <p>Configure: This link appears if LCM has not yet been configured. Click Configure to go to the Configure LCM page.</p> <p>Recommendations Available: This link appears if LCM has detected congestion and has TTE policy recommendations. To view LCM recommendations, click the link to go to the LCM Operational Dashboard.</p> <p>Delete: Indicates that the domain card can be removed from LCM monitoring.</p> |

LCM Operational Dashboard

The LCM Operational Dashboard (**Traffic Engineering > Local Congestion Mitigation > Domain-ID > ... > Operational Dashboard**) shows congested interfaces as defined by the configured utilization threshold.

For each interface, it lists details such as current utilization, recommended action, status, expected utilization after committing recommendations, and so on. Hover the mouse pointer over ⓘ to view a description of what type of information each column provides.

From the Actions column, you can do the following:

- Preview TTE policies prior to deployment (⋮ > **Preview Solution**)
- Verify deployment (⋮ > **View Deployed Policies**)
- Pause or resume an interface (⋮ > **Resume / Pause**)

To gain a better understanding of what information the LCM Operational Dashboard provides, see the following example:



Note If you are viewing the HTML version of this guide, click on the image to view it in full-size.

Figure 23: LCM Operational Dashboard

| Node | Interface | Threshold Util... | Evaluation Util... | LCM State | Policies Deplo... | Policy Set St... | Recommended ... | Commit St... | Expected Utiliz... | Solution Up... | Actions |
|--------------|------------------|-------------------|--------------------|-----------|-------------------|------------------|-----------------|--------------|--------------------|----------------|---------|
| L2-NCSS5... | GigabitEthern... | 30% | 25.85% | Mitigated | 2 | DEGRADED | Delete Set | None | 12.92% | 14-Nov-2023... | ⋮ |
| L5-8201-L... | FortyGigE0/0/... | 8% | 15.78% | Congested | 0 | - | Create Set | None | 7.89% | 14-Nov-2023... | ⋮ |

In this example, the following information is conveyed:

- The first row is an interface that is currently in a Mitigated state. It shows that two policies have been deployed (**Policies Deployed - 2**) to mitigate a previous congestion. However, the current recommendation (**Recommended Action - Delete Set**) is to delete the policies since they are no longer needed (congestion should not occur even if the previously deployed policies are removed). Since the current recommendation has not been committed, the current Commit Status is None.
- The second row is an interface that is currently in a Congested state. LCM detects congestion and suggests to deploy policies to remediate the congestion (**Recommended Action - Create Set**). You can choose to preview the solution (⋮ > **Preview Solution**).



Note If LCM cannot find a solution (**Recommended Action - No Solution**), it may be due to constraints enabled in the **LCM Configuration** page. For more information, see [Configure LCM, on page 96](#).

Recommendations are listed as part of a set, and if deployed, all changes are committed. You must click **Commit All**.

Temporarily Exclude an Interface from LCM



You can temporarily pause LCM from including an interface for mitigations. When an interface is paused it will no longer be considered as part of a recommendation and any existing solutions that the interface participates in will be removed. Pausing operations may be necessary in many use cases such as the following:

- Where deployed solutions do not result in the intended resolution
- When there is uneven ECMP traffic
- When there are policies that are not carrying traffic
- When an interface is continuously throttling between different solutions

LCM Function Pack may automatically pause an interface when certain anomalies are detected, for example, when there is:

- No LCM SR policy traffic
- Excessive LCM Policy Traffic Imbalance
- Excessive LCM Oscillations/removals per hour

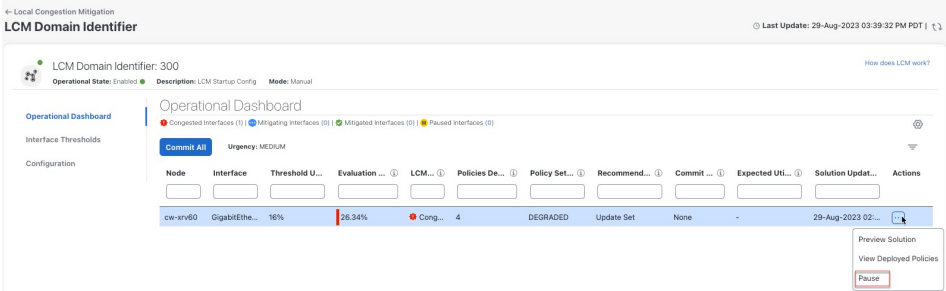
In these circumstances, the user may perform a corrective action, and manually Unpause the interface.

From the Actions column of the LCM Operational Dashboard, click  > **Pause** for the interface you would like to exclude from LCM calculations. To include the interface in LCM calculations again, click  > **Resume**.



Note Pausing multiple interfaces at the same time may result in requests timing out. However, each request will be queued and displayed on the dashboard.

Figure 24: Pause Interface



The screenshot shows the LCM Operational Dashboard for LCM Domain Identifier 300. The dashboard displays a table of interfaces with columns for Node, Interface, Threshold, Evaluation, LCM, Policies, Policy Set, Recommendation, Commit, Expected Uptime, Solution Update, and Actions. The interface 'GigabitEthernet0/20' is highlighted in blue, and a 'Pause' button is visible in the Actions column.

| Node | Interface | Threshold U... | Evaluation ... | LCM... | Policies De... | Policy Set... | Recommend... | Commit ... | Expected Uti... | Solution Updat... | Actions |
|----------|----------------|----------------|----------------|---------|----------------|---------------|--------------|------------|-----------------|--------------------|--|
| sw-er060 | GigabitEthe... | 10% | 26.34% | Cong... | 4 | DEGRADED | Update Set | None | - | 29-Aug-2023 02:... | Preview Solution View Deployed Policies Pause |



CHAPTER 9

Bandwidth on Demand (BWoD)

Bandwidth on Demand (BWoD) provides a bandwidth-aware Path Computation Element (PCE) in conjunction with SR-PCE for segment routing policies (SR policies). BWoD policies can be PCC-initiated (PCE-delegated), or PCE-initiated. BWoD is designed for the delivery of soft bandwidth guarantee services over SR policies. BWoD monitors network conditions and re-optimizes BWoD paths to prevent total BWoD traffic on any interface from exceeding the configured threshold percent.

BWoD does not track total interface utilization, and therefore, interfaces can still be congested if the combined BWoD traffic and non-BWoD traffic exceed the interface capacity. In addition, BWoD does not enforce the total amount of traffic entering BWoD SR policy. BWoD policies may traverse Equal Cost Multi-Path (ECMP) and assume even traffic distribution over these paths. However, actual ECMP distribution can be uneven, especially when there are large flows.



Note Functionality described within this section is only available with certain licensing options.

This section contains the following topics:

- [BWoD Important Notes, on page 105](#)
- [PCC-Initiated BWoD SR-TE Policies, on page 106](#)
- [Provision an SR-TE Policy to Maintain Intent-Based Bandwidth Requirements Example, on page 108](#)
- [Configure Bandwidth on Demand, on page 109](#)
- [Troubleshoot BWoD, on page 110](#)

BWoD Important Notes

Consider the following information when using BWoD:

- You must have the Advanced RTM license package to use BWoD.
- Role-based Access Control (RBAC) and task permissions have been introduced in this release. To provision a BWoD policy, you must have write-access to the head-end device based on Device Access Groups and assigned roles. Only BWoD admin users can modify BWoD configuration settings. For more information on RBAC and user roles, see the [Cisco Crosswork Network Controller Administration Guide](#).
- If BWoD cannot find a path for a policy that guarantees its requested bandwidth, BWoD will attempt to find a *best effort* path if this option is enabled.

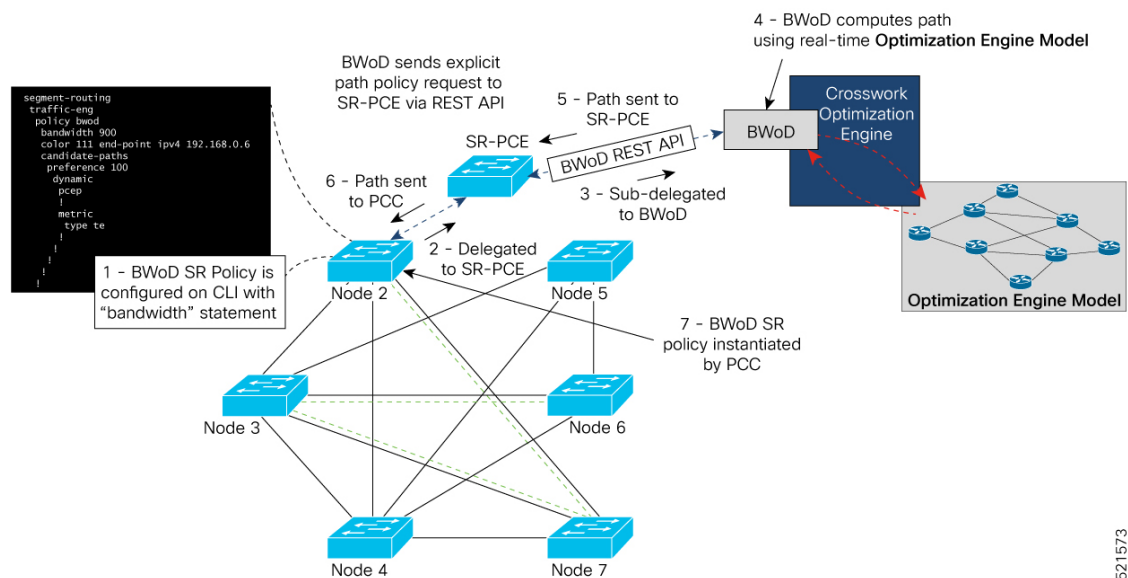
- BWoD will disable itself when an unexpected error is encountered to avoid network disruption.
- BWoD temporarily pauses operation whenever the Optimization Engine model is unavailable due to an Optimization Engine restart or a rebuild of the topology from Topology Services. Any requests to BWoD during this time are rejected. When the model becomes available and BWoD receives 2 traffic updates from the Optimization Engine, BWoD will resume normal operation.
- If the Policy Violation advanced field is set to **Strict**, then the SR Policy Traffic option should be set to **Max Measured Requested**.
- After a switchover in a High Availability setup, BWoD policies created after the last cluster data synchronization will not be manageable and are considered orphaned TE policies. Crosswork will display an alarm when it finds orphan TE policies (**Administration > Alarms**). You can use APIs to help clear these orphan policies so that they are manageable. For more information, see [API documentation on Devnet](#).

PCC-Initiated BWoD SR-TE Policies

When enabled, BWoD automatically connects to all SR-PCE providers configured in Crosswork. The persistent connection is made to the SR-PCE BWoD Rest API, registering it as a PCE for bandwidth constrained SR-TE policies.

The following figure shows the PCC-initiated workflow for BWoD:

Figure 25: PCC-Initiated BWoD SR-TE Policies

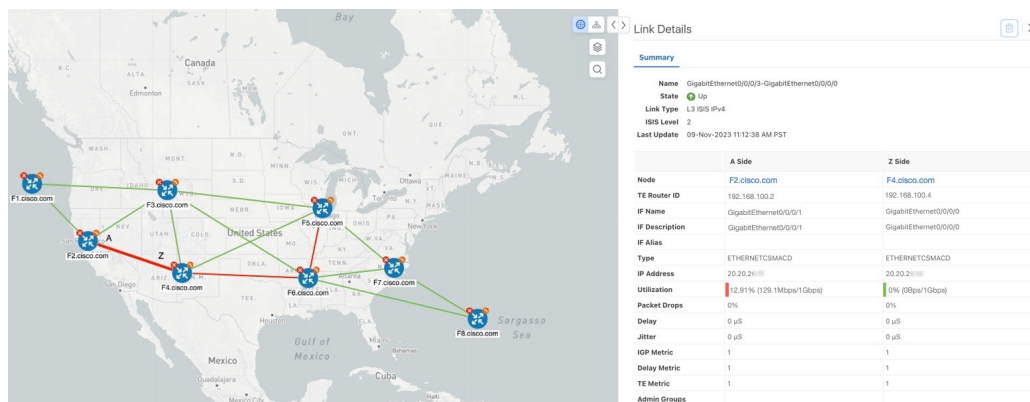


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| Callout No. | Description |
|-------------|--|
| 1 | <p>A BWoD policy is configured on a PCC via the CLI. For example:</p> <pre> segment-routing traffic-eng policy bwod bandwidth 900 color 100 end-point ipv4 1.1.1.2 candidate-paths preference 100 dynamic pcep ! metric type te ! ! constraints affinity exclude-any name RED ! ! ! ! ! </pre> |
| 2 | <p>The bandwidth statement is added to a PCE delegated SR policy to create a BWoD policy. Once committed, the PCC delegates the path compute to SR-PCE.</p> |
| 3, 4 | <p>SR-PCE then sub-delegates the policy to BWoD which attempts to compute a path that meets the bandwidth constraint.</p> |
| 5, 6 | <p>If a bandwidth-compliant path is found, the segment list is returned to SR-PCE which forwards it over PCEP to the PCC and the PCC instantiates it. If BWoD is unable to compute a bw-compliant path for the policy or doing so will force an existing BWoD policy to not have a bw-compliant path, best effort paths may be computed by BWoD which attempt to minimize violations. This occurrence will also trigger BWoD to issue an event to the COE events UI indicating which BWoD policies are now on best effort paths.</p> |
| 7 | <p>A BWoD SR-TE policy is instantiated.</p> |


Provision an SR-TE Policy to Maintain Intent-Based Bandwidth Requirements Example

Figure 26: Initial BWoD Topology Example



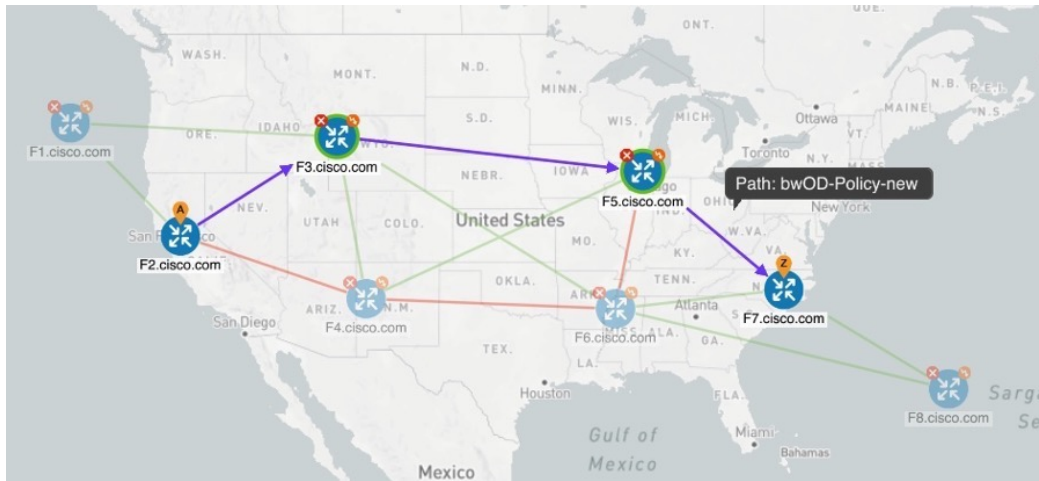
In this scenario we are using the above topology. The goal is to create a path from F2.cisco.com to F7.cisco.com that can accommodate 920 Mbps of traffic while keeping the utilization at 80%. The above example highlights the utilization on nodes F2.cisco.com and node F4.cisco.com to show that the link is being utilized and has a capacity of 1 Gbps. BWoD will initially try to find a single path that does not include this link since the addition of the requested bandwidth would exceed the utilization threshold.

Step 1 Enable and Configure BWoD.

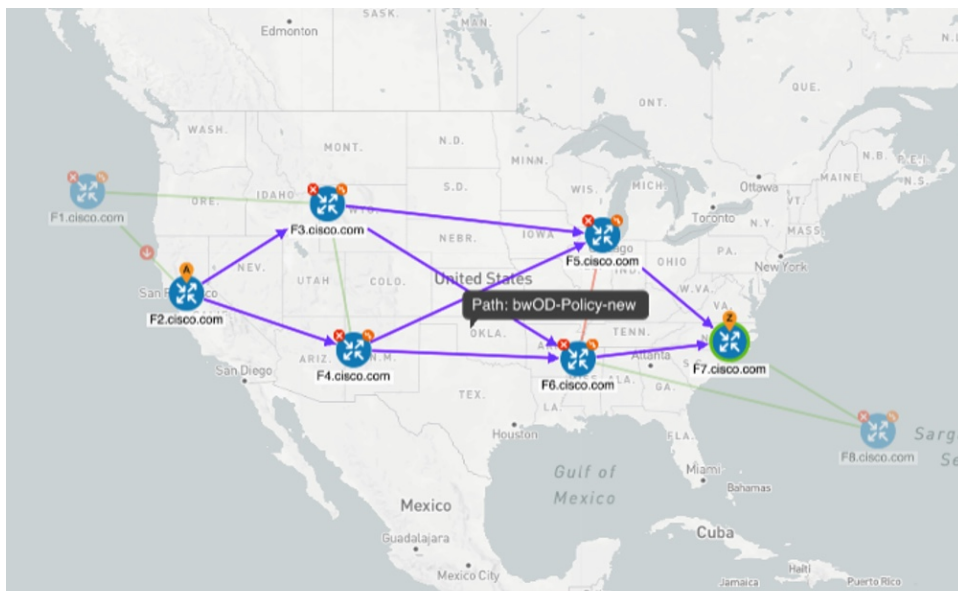
- a) From the main menu, choose **Traffic Engineering** > **Bandwidth on Demand** > **Configuration**.
- b) Toggle the Enable switch to **True** and enter **80** to set the utilization threshold percentage. To find descriptions of other options, simply hover the mouse over .
- c) Click **Commit Changes**.

Step 2 Create a PCE-initiated BWoD SR-TE Policy.

- a) From the main menu, choose **Traffic Engineering** > **SR-TE** tab and click **+Create**.
- b) Enter the required SR-TE policy details.
- c) In the **Policy Path** field, click **Bandwidth on Demand** and enter a unique name for the BWoD path. In this case, **bwOD-Policy-new**.
- d) From the **Optimization Objective** drop-down list, select **Traffic Engineering (TE) Metric**.
- e) In the **Bandwidth** field enter the requested bandwidth. In this case, we are requesting **920** Mbps.
- f) Click **Preview**.



In the below example, the BWoD SR policy uses the existing ECMP paths on the network without explicitly splitting the traffic to avoid congestion. The traffic may be distributed by ECMP, but BWoD does not influence that. It is only aware of it and takes it into consideration if it occurs on the path computed.



g) If you are satisfied with the proposed SR-TE policy deployment, click **Provision**.

Step 3


Verify that the new BWoD SR-TE policy has been created.

- a) From the main menu, choose **Traffic Engineering** > **SR-TE**.
- b) Select the new BWoD SR-TE policy and view the SR policy details (click and choose **View**). Note that the Policy Type is **Bandwidth on Demand**.

Configure Bandwidth on Demand

There are two parts to configure Bandwidth on Demand (BWoD):

1. Enable and configure BWoD options.
2. Create BWoD SR policies. As long as BWoD is enabled, you can create multiple BWoD SR policies.

-
- Step 1** From the main menu, choose **Traffic Engineering > Bandwidth on Demand > Configuration**.
- Step 2** Toggle the **Enable** switch to **True**.
- Step 3** Configure additional options. Hover the mouse pointer over  to view a description of each field.
- Step 4** Click **Commit Changes** to save the configuration.
- Step 5** To create BWoD SR policies, navigate to **Traffic Engineering > Traffic Engineering**.
- Step 6** From the SR Policy table, click **Create > PCE Init**.
- Step 7** In addition to entering the required SR policy details, click the **Bandwidth on Demand** option and enter the required bandwidth.
- Step 8** Click **Preview** to view the proposed SR policy.
- Step 9** Click **Provision** to commit the SR policy.
-

Troubleshoot BWoD

The following are some of the most common error conditions for BWoD and some possible corrective actions that may fix the issue.

Table 6: Errors

| Error Event Message | Possible Causes and Recommended Corrective Action |
|---|--|
| OptimaModelError | <p>The network model used by BWoD from the Optimization Engine is corrupt or is missing key data that is needed to properly support BWoD. Possible causes include network discovery issues or synchronization problems between the Optimization Engine and Topology Services. Try restarting the Optimization Engine pod to rebuild the model.</p> <p>This error can also occur if the time required to discover a policy and add it to the model after it has been deployed exceeds the Deployment Timeout option set for BWoD. The default is 30 seconds which should suffice for small to medium sized networks. However, larger networks may require additional time.</p> |
| NATSTimedOutError | <p>The deployment of a bandwidth policy through SR-PCE exceeds the Deployment Timeout option set for BWoD. Increase the Deployment Timeout option to allow for additional time for deployments in larger networks.</p> |
| Traceback or other errors found in the log file | Please contact your Cisco service representative. |

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