Orchestrated Service Provisioning

This section explains the following topics:

Overview

By using the scenario workflows described in this section, we are providing examples of how to configure the system to deliver the operator’s intended configuration. These scenarios do not fully demonstrate all of the capabilities of Crosswork Network Controller. They are intended to demonstrate the flexibility of the platform. Additional customization is possible either by leveraging the resources available on Cisco DevNet or through engagement with Cisco Customer Experience.

Objective

Provision a set of VPN services with underlay transport policies that will meet and maintain service-level agreements (SLAs) between the service provider and the customer. An SLA defines the service-delivery expectations agreed upon between the service provider and the customer. The SLA details the products or services that the provider is to deliver to the customer, the provider's point of contact to which the customer will bring service issues, and the metrics the provider and customer both use to monitor compliance with the SLA.

Challenge

The service-provider network state changes continuously and so quickly that it is difficult to track and react to network problems fast enough to avoid congestion and maintain SLA compliance. In a typical lifecycle, there is a feedback loop that traditionally requires manual monitoring and intervention, which is time- and resource-intensive.

Solution

With network automation, the objective is to automate the feedback loop to enable quicker reaction to and remediation of network events. With Crosswork Network Controller, network operators can orchestrate L2VPN and L3VPN services across the transport network, via a programmable interface, in a very quick and efficient manner. Segment routing traffic engineering (SR-TE) polices can be configured to continuously track network changes and automatically react to optimize the network. These SR-TE polices can serve as the underlay configuration for the VPN services to automatically maintain the SLAs.

The services required for this solution can be created and managed using the Crosswork Network Controller UI. L2/L3 VPN Yang model-based service intents are implemented using the Cisco Network Services Orchestrator sample function packs, which provide sample service models that can be extended and fine-tuned to meet customer needs. Optionally, Service Health monitoring can be enabled to see which services are working as provisioned, if issues have been flagged, and what symptoms are detailed so to quickly address and fix.

Note The Network Services Orchestrator sample function packs are provided as a starting point for VPN service provisioning functionality in Crosswork Network Controller. While the samples can be used “as is” in some limited network configurations, they are intended to demonstrate the extensible design of Crosswork Network Controller. Answers to common questions can be found on Cisco Devnet and Cisco Customer Experience can provide answers to general questions about the samples. Support for customization of the samples for your specific use cases can be arranged through your Cisco account team.

Note Some scenario features and functions belonging to multiple components (such as Crosswork Optimization Engine, Crosswork Service Health, Crosswork Active Topology) will not be available as described unless all of the applications are successfully deployed.

How Does it Work?

1. User creates an SR-TE policy/On-Demand Next Hop (ODN) template with intent (e.g., bandwidth, latency) using the Cisco Crosswork Network Controller UI or APIs.
2. User creates a VPN service using the UI or APIs and specifies the following:
    - The endpoints participating in the VPN
    - Other required VPN parameters
    - The SR-TE policy/ODN template that is to be associated with the VPN service
3. During the provisioning process for the above steps, Cisco Network Services Orchestrator configures the SR-TE policy and the VPN service on the specified endpoints.
4. When the service is active, the network interacts with the SR-PCE to dynamically program the path that meets the intent in the configured SR-TE policy/ODN template. The headend device requests a path from the SR-PCE via PCEP (for dynamic SR-TE policies). If the request specifies bandwidth, the SR-PCE gets the path from Cisco Crosswork Optimization Engine.
5. The SR-PCE sends the path to the headend device via PCEP and updates the headend if path changes are required.

Usage Scenarios

We will walk you through the following usage scenarios that illustrate the execution of the orchestrated service provisioning use case using the Cisco Crosswork Network Controller UI:

- Scenario: Implement and Maintain SLA for an L3VPN Service for SR-MPLS (using ODN)
- Scenario: Implement and Maintain SLA for an L3VPN Service for SRv6 (using ODN)
- Scenario: Mandate a Static Path for an EVPN-VPWS Service using an Explicit MPLS SR-TE Policy
- Scenario: Provision an L2VPN Service over an RSVP-TE Tunnel with Reserved Bandwidth
- Scenario: Provision a Soft Bandwidth Guarantee with Optimization Constraints

Additional Resources

- For information about segment routing and segment routing policies, click here to see the Crosswork Optimization Engine User Guide.
- Cisco Network Services Orchestrator documentation is included in the latest Network Services Orchestrator image here.

Scenario: Implement and Maintain SLA for an L3VPN Service for SR-MPLS (using ODN)

This scenario walks you through the procedure for provisioning an L3VPN service with a specific SLA objective: all traffic for this service must take the lowest-latency path. The customer requires this low-latency path for this service, as all of this service's traffic is high priority. The customer also wants to use disjoint paths; that is, two unique paths that steer traffic from the same source but to two unique destinations, avoiding common links so that there is no single point of failure.

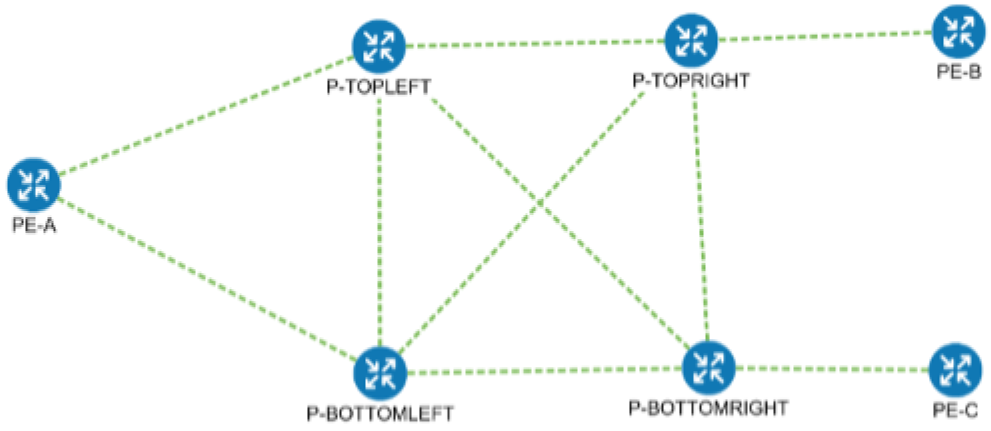
We'll achieve this using Segment Routing (SR) On-Demand Next Hop (ODN). SR ODN allows a service headend router to automatically instantiate an SR-TE policy to a BGP next-hop when required (on-demand). We configure the headend with an ODN template with a specific color that identifies the SLA. Crosswork will optimize the traffic path when it receives a prefix with that SLA-specific color. We define prefixes in a route policy that is associated with the L3VPN.

Crosswork Network Controller continues to monitor the network and will automatically optimize the network based on the defined SLA, in a closed loop.

Within this workflow, we also have the option to enable Crosswork's Service Health monitoring, and to use Flex-Algo as a constraint on how paths are computed and visualized. With Service Health monitoring, operators can gather quick insights into degraded and down services and then use these insights to visualize, inspect, and troubleshoot for improved network optimization.

With Flex-Algo, we can customize IGP shortest-path computations using algorithms we define. IGP will compute paths based on a user-defined combination of metric types and constraints, and present a filtered topology view based on our specific Flex-Algo definitions.

The following topology provides the base for this scenario:



In this scenario, we will:

- Create a segment routing ODN template with a specific color on the endpoints to ensure that traffic is transported within an LSP (underlay) and that a best-path tunnel is created dynamically when a prefix with the specified color is received. The ODN template defines the SLA on which you want to optimize the path. In this case, we will optimize on latency.
- Specify that the computed paths be disjoint: they will not share the same link.
- Create a route policy on each endpoint to be used to bind the L3VPN to the ODN template. This route policy adds a color attribute to the customer prefixes and advertises via BGP to other endpoints. This color attribute is used to indicate the SLA required for these prefixes.
- Create an L3VPN service with 3 endpoints and enable Service Health monitoring.
- Visualize how this overlay/underlay configuration optimizes the traffic path and automatically maintains the SLA while monitoring your service's health.

Assumptions and Prerequisites

- To use ODN, BGP peering for the prefixes must be configured between the endpoints or PEs. Usually for L3VPN, this is the VPNv4 and VPNv6 address family peering.
- For Service Health enablement, Service Health must be installed. See the Crosswork Network Controller Installation Guide chapter, Install Crosswork Applications.
- Before using Service Health's Assurance Graph, ensure that topology map nodes have been fully configured and created with a profile associated to the service. If not, Subservice Details metrics will show that no value has yet to be reported. See the Crosswork Network Controller Service Health Guide for further details.
- L3VPN service monitoring supports XR devices and does not support XE devices. Thus, after an L3VPN service is created and Service Health monitoring is enabled, if a provider and devices are removed, and then added back, service monitoring remains in a degraded state with a METRIC_SCHEDULER error. To recover, service monitoring must be stopped and restarted.
- (Optional) Flexible Algorithms, and the IDs that are used, must be configured in your network.

Note Screen captures, showing services and data, are for example purposes only and may not always reflect the devices or data described in the workflow content.

Step 1 Create an ODN template to map color to an SLA objective and constraints

Disjointness constraints work by associating a disjoint group ID with the ODN template, and all tunnels with the same disjoint group ID will be disjoint, i.e., they will use different links, nodes and shared risk link groups depending on how the disjoint groups are configured.

We will create the following ODN templates:

- Headend PE-A, color 72, latency, disjoint path (link), group ID 16 - L3VPN_NM-SRTE-ODN_72-a
- Headend PE-A, color 71, latency, disjoint path (link), group ID 16 - L3VPN_NM-SRTE-ODN_71-a
- Headend PE-B and PE-C, color 70, latency - L3VPN_NM-SRTE-ODN_70
- Headend PE-B, color 72, latency - L3VPN_NM-SRTE-ODN_72-b
- Headend PE-C, color 71, latency - L3VPN_NM-SRTE-ODN_71-c

For example purposes, we will show how to create the first ODN template - L3VPN_NM-SRTE-ODN_72-a. The other ODN templates can be created using the same procedure.

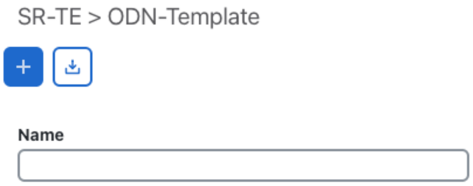
Before you begin

In this step, we will create an ODN template on each endpoint. The ODN template specifies the color and the intent; in this case, latency and disjointness. This ODN template will be used to dynamically create tunnels (on-demand) when prefixes with matching colors are received via BGP. Traffic to these prefixes will be automatically steered into the newly created tunnels, thereby meeting the SLA objective and constraints intended for these prefixes and signaled using colors in the BGP routes.

Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **SR-TE** > **ODN-Template**.

Step 2 Click + to create a new template and give it a unique name. In this case, the name is **L3VPN_NM-SRTE-ODN_72-a**. Click **Continue**.

You may also browse for an existing template on your system so to import the file. The information from the imported file is populated into the form.



Step 3 Choose the head-end device, **PE-A**, and specify the color **72**.

Step 4 Under dynamic, select **latency** as the metric-type. This is the SLA objective on which we are optimizing.

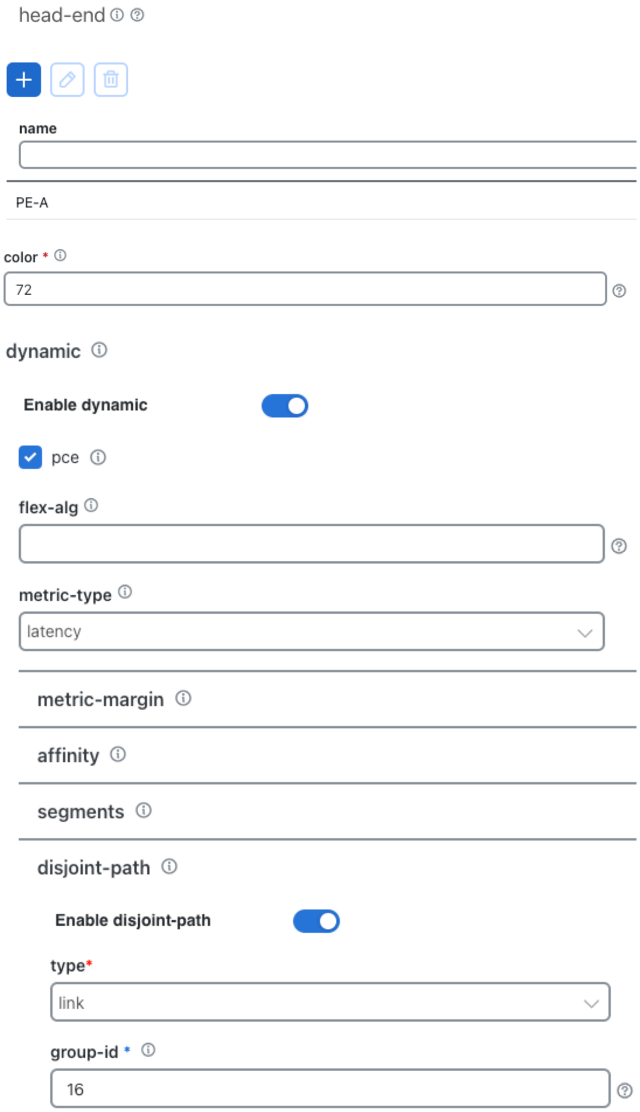
Step 5 Select the **pce** check box to specify that the path should be computed by the SR-PCE, not by the Path Computation Client (PCC).

Step 6 Define the required constraints. In this case, we want the computed paths to be disjoint in that they must not share a link.

Under disjoint-path, choose **link** as the type, and specify a numeric group ID, in this case, **16**, as the group-id.

Note You may choose the group ID. All paths requested with the same group-id will be disjoint from each other.

Note Optionally, you may configure Flex-Algo as a constraint.



head-end

name

PE-A

color * 72

dynamic

Enable dynamic: on

☑ pce

flex-alg

metric-type: latency

metric-margin

affinity

segments

disjoint-path

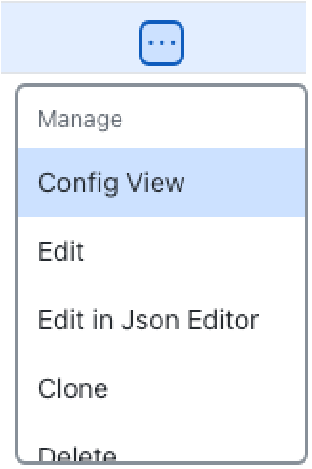
Enable disjoint-path: on

type*: link

group-id * 16

Step 7 Commit your changes or click **Dry Run** to check what will be configured on the devices before you commit.

Step 8 Check that the new ODN template appears in the table and its provisioning state is **Success**. Click ⋯ in the Actions column and choose **Config View** to see the Yang model-based service intent data that details the ODN template you created.



Step 9 Create the other ODN templates listed above in the same manner.

Note You can save some time by using the Clone function to build the other policies needed to complete this scenario. Simply select **Clone** from the ⋯ Actions column, provide a new name for the clone, edit the values, and then select **Commit**.

Step 2 Create an L3VPN Route Policy

In this step, we will create a route policy for each endpoint, and we will specify the same color as defined in the ODN template for that endpoint. The route policy defines the prefixes to which the SLA applies. When traffic from the specified network with a matching color is received, paths are computed based on the SLA defined in the ODN template. We will create the following route policies by first setting the routing policy tag and routing policy destination prefix. The routing policy prefixes should match with the subnet prefix configured on the PE devices in the service:

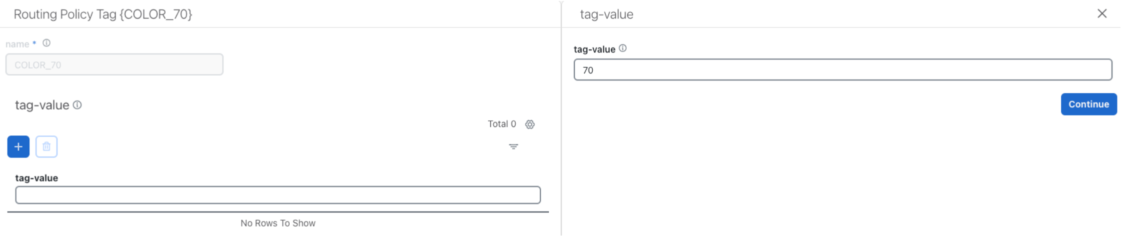
- Color 70, IPv4 prefix 70.70.70.0/30 - L3VPN_NM-SRTE-RP-PE-A-7
- Color 71, IPv4 prefix 70.70.71.0/30 - L3VPN_NM-SRTE-RP-PE-B-7
- Color 72, IPv4 prefix 70.70.72.0/30 - L3VPN_NM-SRTE-RP-PE-C-7

Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L3VPN** > **Routing Policy Tag**.

Step 2 Click + to create a new routing policy tag and type the name of the tag set: **COLOR_70**. Click **Continue**.

This is used as a label to reference the set in actions and conditions.

Step 3 Under tag-value, click + and type the tag-value: **70**.


Routing Policy Tag {COLOR_70}

name * : COLOR_70

tag-value

Total 0

tag-value

No Rows To Show

tag-value

tag-value: 70

The tag value may be a number between **1 – 4294967295** and should match to a color value.

Step 4 Click **Continue**. The new routing policy tag name with the new tag value is visible. Click **Commit changes**.

Create the other two routing policy tags (**COLOR_71** and **COLOR_72**) and tag values (**71** and **72**) by following the same steps above. Click **Continue**.

Now create the routing policy destination prefixes.

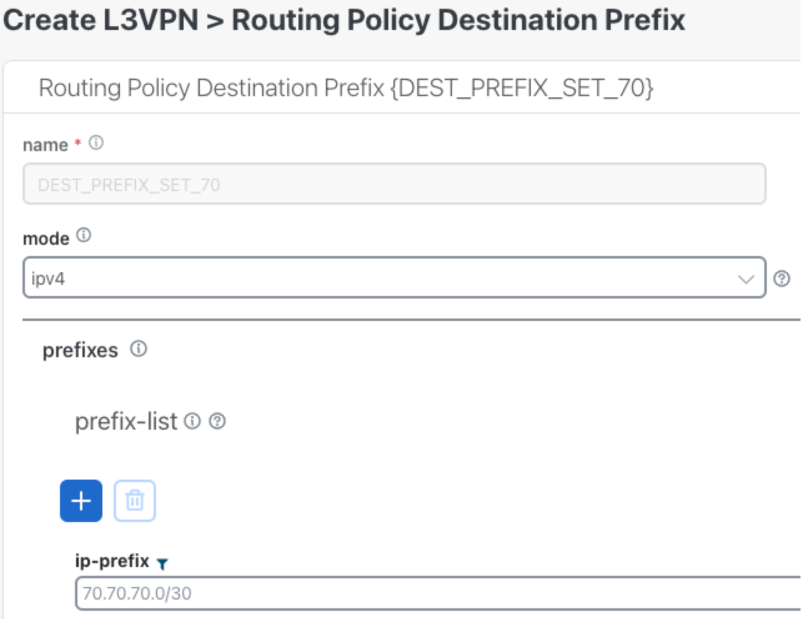
Step 5 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L3VPN** > **Routing Policy Destination Prefix.**

Step 6 Click + to create a new routing policy destination prefix and type the name: **DEST_PREFIX_SET_70**.

The name of the prefix set will reference the set in match conditions.

Step 7 For Mode, select **ipv4**.

Step 8 Expand prefixes and click + to add the ip-prefix to the prefix-list. Type **70.70.70.0/30** and click **Continue**.


Create L3VPN > Routing Policy Destination Prefix

Routing Policy Destination Prefix {DEST_PREFIX_SET_70}

name * : DEST_PREFIX_SET_70

mode: ipv4

prefixes

prefix-list

ip-prefix: 70.70.70.0/30

Step 9 Create the other two routing policy destination prefixes (**DEST_PREFIX_SET_71** and **DEST_PREFIX_SET_72**) by following the same steps.

Now we are ready to create the first route policy - L3VPN_NM-SRTE-RP-PE-A-7. The other route policies can be created using the same procedure.

Step 10 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L3vpn** > **Routing Policy**.

Step 11 Click + to create a new route policy and type a unique name for the top-level policy definition: **L3VPN_NM-SRTE-RP-PE-A-7**. Click **Continue**. The statements section appears.

Note The Route Policy statement defines the condition and action taken by the system.

Step 12 Expand statements and click + to add the name of the policy statement (such as **stmt1**) and click **Continue**. The statement{stmt1} panel appears showing **conditions** and **actions** sections.

Step 13 Expand conditions and then expand match-dest-prefix-set. In the prefix-set list, select or type the following: **DEST_PREFIX_SET_70**. This is what references a defined prefix set.

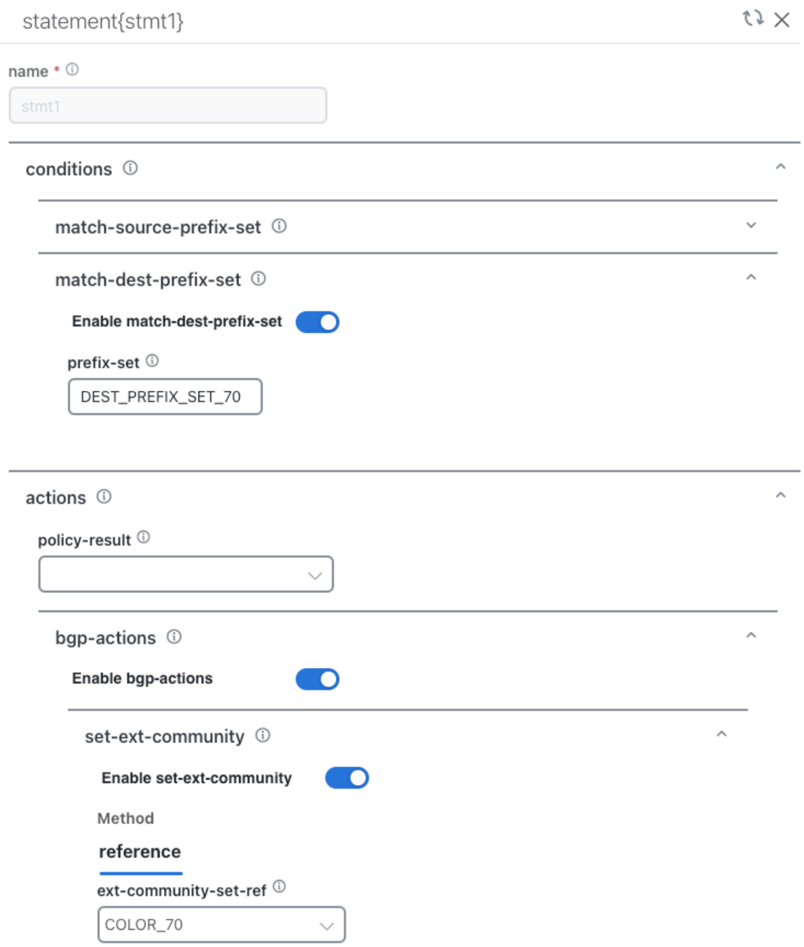
Note Once selected, the **Enable match-dest-prefix-set** toggle, which will match a referenced prefix-set according to the logic defined in the match-set-options list, switches on.

Step 14 Expand actions and then expand bgp-actions.

Step 15 For bgp-actions, slide the Enable bgp-actions toggle to the on position. By toggling bgp-actions on, it defines the top-level container for BGP-specific actions.

Step 16 Now expand set-ext-community. Slide the Enable-set-ext-community toggle to the on position. By toggling set-ext-community on, it sets the extended community attributes.

Step 17 For Method and reference, select the Ext-community-set-ref list and select **COLOR_70**. The Ext-community-set-ref references a defined extended community set by name.



statement{stmt1}

name * : stmt1

conditions

match-source-prefix-set

match-dest-prefix-set

Enable match-dest-prefix-set: on

prefix-set: DEST_PREFIX_SET_70

actions

policy-result:

bgp-actions

Enable bgp-actions: on

set-ext-community

Enable set-ext-community: on

Method: reference

ext-community-set-ref: COLOR_70

Step 18 Click **X** in the top-right corner to close the statement{stmnt1} panel and click **Commit changes**.

Step 19 Create the other route policies (**L3VPN_NM-SRTE-RP-PE-B-7** and **L3VPN_NM-SRTE-RP-PE-C-7**) in the same manner prior to creating the L3VPN service.

After creating the L3VPN route policies, create the VPN profile for each route policy and then create and provision the L3VPN service. The VPN profile will be referenced from the L3VPN service. This will bind the route policy to the L3VPN service.

Step 3 Create and provision the L3VPN service

In this step, we will create the L3VPN service with three endpoints: PE-A, PE-B, and PE-C. Each endpoint will be associated with a vpn-instance-profile, which in turn points to a VPN profile that contains the route policy with the same color as specified in the ODN template. In this way, traffic that matches the specified prefixes and color will be treated according to the SLA specifications.

First, we will create the VPN profiles. The newly created VPN profiles will have the same names as the L3VPN routing policy names.

Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L3VPN** > **VPN Profiles**.

Step 2 Click + to create a VPN profile to be referenced in the VPN service.

Step 3 Select the Id list and select **L3VPN_NM-SRTE-RP-PE-A-7**.

Now create and provision the L3VPN service.

Step 4 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L3vpn** > **L3vpn-Service**.

Step 5 Click + to create a new service and type a new vpn-id: **L3VPN_NM-SRTE-ODN-70**. Click **Continue**.

A VPN identifier uniquely identifies a VPN and has a local meaning (for example, within a service provider network).

Step 6 Create vpn-instance-profiles, which is a container that defines the route distinguisher (RD), route targets, and the export/import route policy. We will create vpn-instance-profiles for each endpoint, as follows:

- L3VPN_NM_SR_ODN-IE-PE-A-7 with route distinguisher 0:70:70
- L3VPN_NM_SR_ODN-IE-PE-B-7 with route distinguisher 0:70:71
- L3VPN_NM_SR_ODN-IE-PE-C-7 with route distinguisher 0:70:72

a. Expand vpn-instance-profiles and click + to create a new vpn-instance-profile profile-id: **L3VPN_NM_SR_ODN-I-PE-A-7**. Click **Continue**.

b. Enter the route distinguisher (rd) that will differentiate the IP prefixes and make them unique. For this scenario, we are using **0:70:70**.

c. For address-family, click + and select **ipv4** from the list. Click **Continue**.

d. Define the required VPN targets, including id, route-targets, and route-target-type (import/export/both).

e. Under vpn-policies, in the export-policy list, choose the relevant VPN profile (which contains the route policy: **L3VPN_NM-SRTE-RP-PE-A-7**). This forms the association between the VPN and the ODN template that defines the SLA.

f. Click **X** in the top-right corner when you are done.

g. Similarly, create the other vpn-instance-profiles.

Step 7 Define each VPN endpoint individually: PE-A, PE-B, and PE-C.

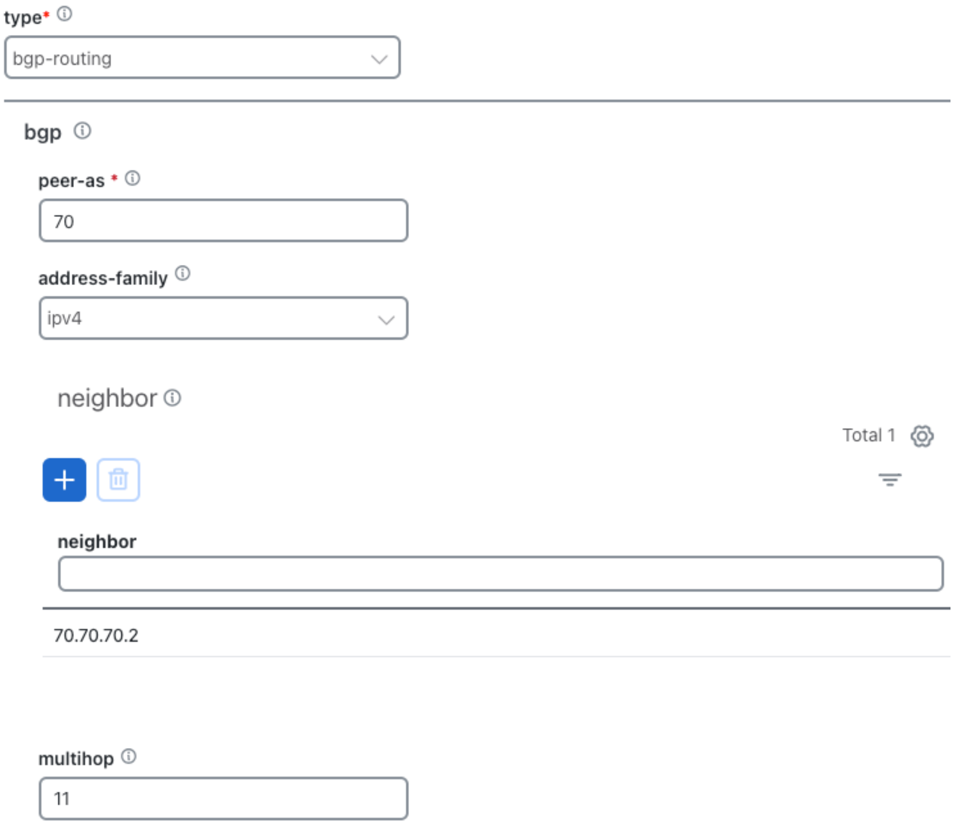
a) Expand vpn-nodes and click + to select the relevant device from the list: **PE-A**. Click **Continue**.

b) Enter the local-as number for network identification: **200**.

c) Expand active-vpn-instance-profiles and click + to select the profile-id you created in the previously: **L3VPN_NM-SRTE-RP-PE-A-7**. Click **Continue**.

d) Define the network access parameters for communication from the PE towards the CE:

- Under vpn-network-accesses, click + to create a new set of VPN access parameters and provide a unique ID. Click **Continue**.
- In the Interface-id field, type **Loopback70**. This is the identifier for the physical or logical interface. The identification of the sub-interface is provided at the connection level and/or the IP connection level.
- Expand ip-connection > ipv4 and enter a local-address (**70.70.70.1**) and then prefix-length (**30**).
- For routing-protocols, click + to create a unique id, set the type to bgp-routing, and then expand bgp to set the peer-as number (**70**), and the address-family (**ipv4**). In addition, set the bgp neighbor (**70.70.70.2**) and the multihop number (for example, **11**) that indicates the number of hops allowed between the bgp neighbor and the PE device.



type* ⓘ: bgp-routing

bgp ⓘ

peer-as * ⓘ: 70

address-family ⓘ: ipv4

neighbor ⓘ

Total 1

neighbor

70.70.70.2

multihop ⓘ: 11

- Click **X** in the top-right corner until you are back on the Create L3VPN screen.
- Similarly, create the other VPN nodes: **PE-B** and **PE-C**.

Step 8 Commit your changes or click **Dry Run** to check what will be configured on the devices before you commit.

Step 9 Check that the new L3VPN service appears in the table and its provisioning state is **Success**.

Step 4 Enable Service Health monitoring

After creating and provisioning the required L3VPN services, you can begin monitoring their health.

Before you begin

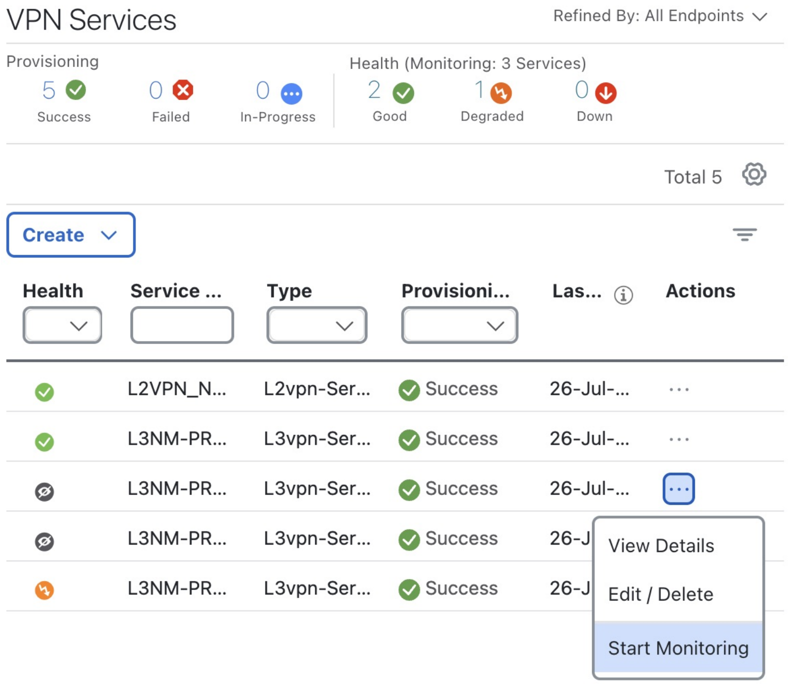
- (*Optional*) Ensure that Crosswork Service Health is installed. For details, see the "Install Crosswork Applications" chapter in the *Cisco Crosswork Network Controller Installation Guide*. For more information on Service Health, see the Cisco Crosswork Network Controller Service Health Guide.
- The Service Health related steps assume you have excess capacity available. Requirements (such as available resources, storage capacity, etc.) may be beyond the scope explained in this guide. See the Crosswork Network Controller Service Health Guide for further details.

Select the newly created, unmonitored, service which will have a gray health indicator:

Step 1 From the main menu, choose **Services & Traffic Engineering** > **VPN Services**. The map opens on the left side of the page and the table opens on the right side.

Step 2 In the Actions column, click ⋯ for the service you want to start monitoring the health.

Step 3 Click **Start Monitoring**.



VPN Services

Refined By: All Endpoints

Provisioning: 5 Success, 0 Failed, 0 In-Progress

Health (Monitoring: 3 Services): 2 Good, 1 Degraded, 0 Down

Total 5

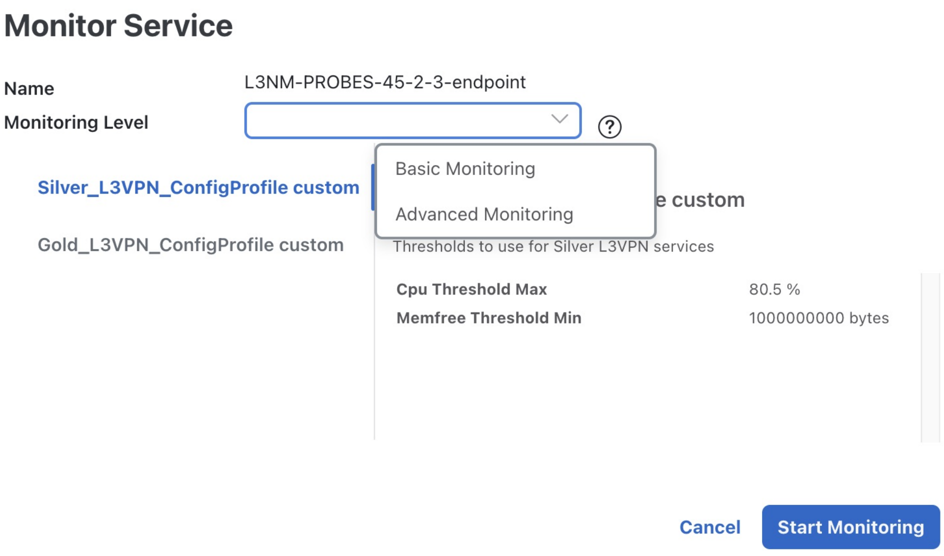
Create

Health	Service ...	Type	Provisioni...	Las...	Actions
✓	L2VPN_N...	L2vpn-Ser...	✓ Success	26-Jul-...	···
✓	L3NM-PR...	L3vpn-Ser...	✓ Success	26-Jul-...	···
⊘	L3NM-PR...	L3vpn-Ser...	✓ Success	26-Jul-...	···
⊘	L3NM-PR...	L3vpn-Ser...	✓ Success	26-J	
●	L3NM-PR...	L3vpn-Ser...	✓ Success	26-J	

Note The Health column color coding indicates the health of the service:

- Blue = Initiated
- Green = Good
- Orange = Degraded
- Red = Down
- Gray = Not Monitoring

Step 4 In the Monitor Service dialog box, select the Monitoring Level. For help with selecting the appropriate monitoring level for your needs, see the Cisco Crosswork Network Controller 6.0 Service Health Guide.



Monitor Service

Name: L3NM-PROBES-45-2-3-endpoint

Monitoring Level:

Silver_L3VPN_ConfigProfile custom

Gold_L3VPN_ConfigProfile custom

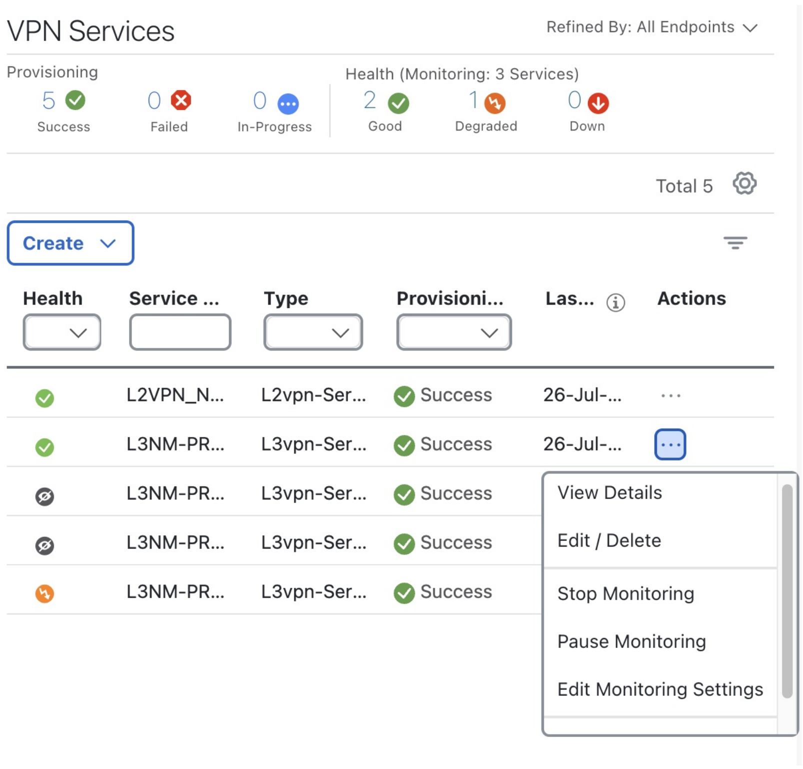
…e custom

Thresholds to use for Silver L3VPN services

Cpu Threshold Max	80.5 %
Memfree Threshold Min	1000000000 bytes

Step 5 Click **Start Monitoring**.

Note Once you have started monitoring the health of the service, in the Actions column, if you click ⋯ to view additional Service Health options, you will see: Stop Monitoring, Pause Monitoring, Edit Monitoring Settings, and Assurance Graph.



VPN Services

Refined By: All Endpoints

Provisioning: 5 Success, 0 Failed, 0 In-Progress

Health (Monitoring: 3 Services): 2 Good, 1 Degraded, 0 Down

Total 5

Health	Service ...	Type	Provisioni...	Las...	Actions
✓	L2VPN_N...	L2vpn-Ser...	✓ Success	26-Jul-...	⋯
✓	L3NM-PR...	L3vpn-Ser...	✓ Success	26-Jul-...	⋯
	L3NM-PR...	L3vpn-Ser...	✓ Success		
	L3NM-PR...	L3vpn-Ser...	✓ Success		
	L3NM-PR...	L3vpn-Ser...	✓ Success		

Step 6 Repeat these steps for each service that you wish to start health monitoring.

Step 5 Visualize the New VPN Service on the Map to See the Traffic Path

Step 1 In the L3VPN Service table, click on the service name or click ⋯ in the Actions column and choose **View Details** from the menu.

The map opens and the service details are shown to the right of the map.

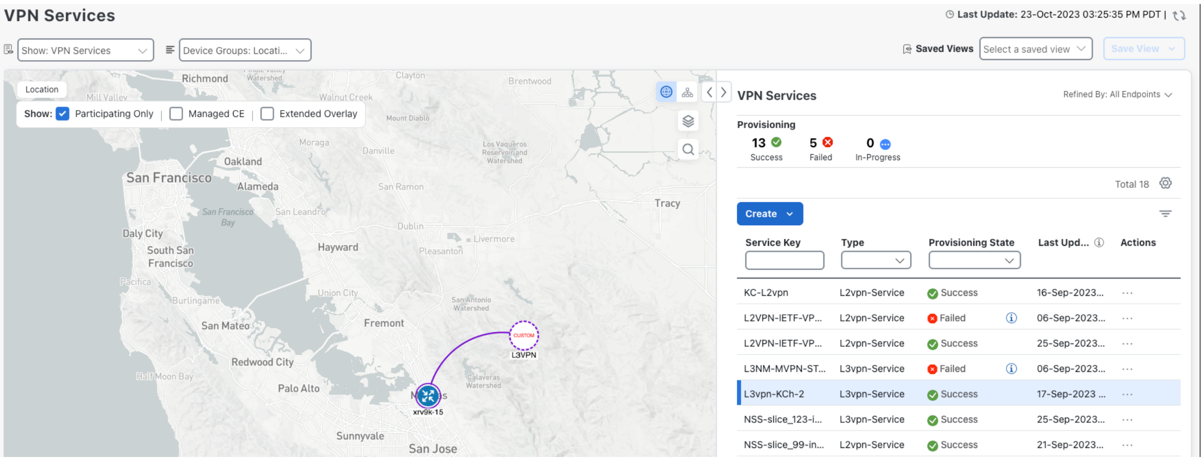
or

Go to **Services & Traffic Engineering** > **VPN Services**.

The map opens and a table of VPN services is displayed to the right of the map.

Click on the VPN in the Services table. If there are many services in the table, you can filter by name, type, or provisioning state to help locate the VPN.

In the map, you will see the VPN as an overlay on the topology. It shows a representation of the three endpoints and a dashed line that indicates that it is a virtual path.



VPN Services

Last Update: 23-Oct-2023 03:25:35 PM PDT |

Show: VPN Services

Device Groups: Locati...

Saved Views: Select a saved view

Location

Show: ☑ Participating Only | ☐ Managed CE | ☐ Extended Overlay

VPN Services

Refined By: All Endpoints

Provisioning

13 Success 5 Failed 0 In-Progress

Total 18

Service Key	Type	Provisioning State	Last Upd...	Actions
KC-L2vpn	L2vpn-Service	Success	16-Sep-2023...	⋯
L2VPN-IETF-VP...	L2vpn-Service	Failed	06-Sep-2023...	⋯
L2VPN-IETF-VP...	L2vpn-Service	Success	25-Sep-2023...	⋯
L3NM-MVPN-ST...	L3vpn-Service	Failed	06-Sep-2023...	⋯
L3vpn-KCh-2	L3vpn-Service	Success	17-Sep-2023 ...	⋯
NSS-slice_123-i...	L3vpn-Service	Success	25-Sep-2023...	⋯
NSS-slice_99-in...	L2vpn-Service	Success	21-Sep-2023...	⋯

Select the **Show Participating Only** check box if you do not want to see the devices that are not involved in the selected VPN.

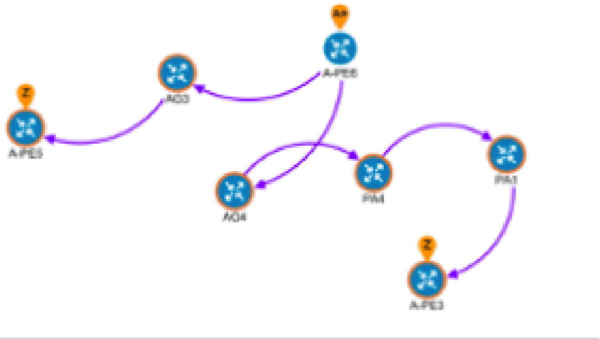
Step 2 In the Actions column, click

⋯

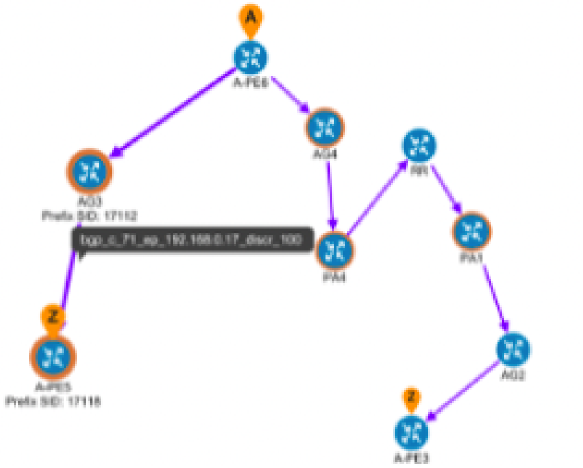
to drill down to a detailed view of the VPN service, including the device configurations and the computed transport paths.

Step 3 To see the computed paths for this VPN, click on the Transport tab in the Service Details pane. All the dynamically created SR-TE policies are listed in the Transport tab. Select one or more SR-TE policies to see the path from endpoint to endpoint on the map.

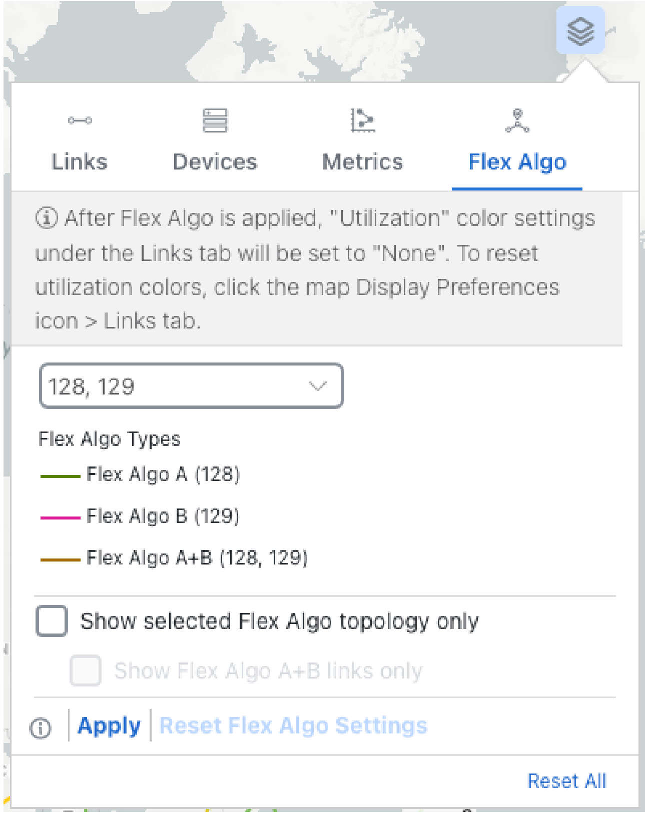
In this example, we are looking at the disjoint paths computed from PE-A to PE-B and from PE-A to PE-C.



Step 4 To see the physical path between the endpoints, select the **Show IGP Path** check box in the top-left corner of the map. Hover with your mouse over a selected policy in the table to highlight the path in the map and show prefix SID and routing information.



Step 5 To filter the topology to a specific Flex-Algo constraint and visualize nodes and links you have configured manually in your network, click the button at the top right of the map and do the following:



ⓘ After Flex Algo is applied, "Utilization" color settings under the Links tab will be set to "None". To reset utilization colors, click the map Display Preferences icon > Links tab.

128, 129

Flex Algo Types

- Flex Algo A (128)
- Flex Algo B (129)
- Flex Algo A+B (128, 129)

☐ Show selected Flex Algo topology only

☐ Show Flex Algo A+B links only

a) Click the **Flex Algo** tab.

b) From the drop-down list, choose up to 2 Flex-Algo IDs.

c) View the Flex-Algo Types and confirm that the selection is correct. Also, note the color assignments for each Flex-Algo ID.

d) (Optional) Check the **Show selected Flex Algo topology only** check box to isolate the Flex-Algo IDs on the topology map. When this option is enabled, SR policy selection is disabled.

e) Check the **Show Flex Algo A+B links only** to show only those links and nodes that participate in both Flex-Algos.

   If a selected Flexible Algorithm is defined with criteria but there are no links 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.

f) Click **Apply**. You must click **Apply** for any additional changes to your Flex-Algo selections to see the update on the topology map.

g) (Optional) Click **Save View** to save the topology view and Flexible Algorithm selections.

Step 6 Observe automatic network optimization

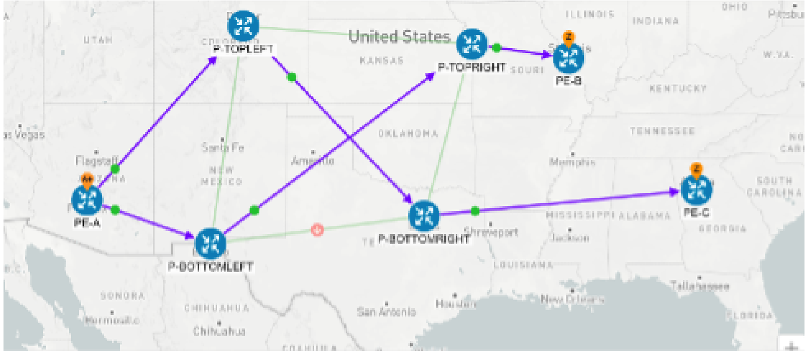
Observe automatic network optimization

The SR-PCE constantly monitors the network and automatically optimizes the traffic path based on the defined SLA. For illustration purposes, let’s look at what happens when one of the links goes down, in this case, the link between

P-BOTTOMLEFT and P-BOTTOMRIGHT. This means that the previous path from PE-A to PE-C is no longer viable. Therefore, the SR-PCE computes an alternative path, both from PE-A to PE-C and from PE-A to PE-B, to compensate for the link that is down and to maintain the disjoint paths.

Recomputed paths:

Source and Destination	Old path	New path
PE-A > PE-C	PE-A > P-BOTTOMLEFT > P-BOTTOMRIGHT > PE-C	PE-A > P-TOPLEFT > P-BOTTOMRIGHT > PE-C
PE-A > PE-B	PE-A > P-TOPLEFT > P-TOPRIGHT > PE-B	PE-A > P-BOTTOMLEFT > P-TOPRIGHT > PE-B



Step 7 Inspect a degraded service using Service Health to determine active symptoms

By analysing the root cause of reported active symptoms and impacted services, you can determine what issues must be addressed first to maintain a healthy setup and what requires further inspection and troubleshooting.

To view the active symptoms and root causes for a service degradation:

Before you begin

Ensure that service health monitoring is enabled for the service you want to inspect.

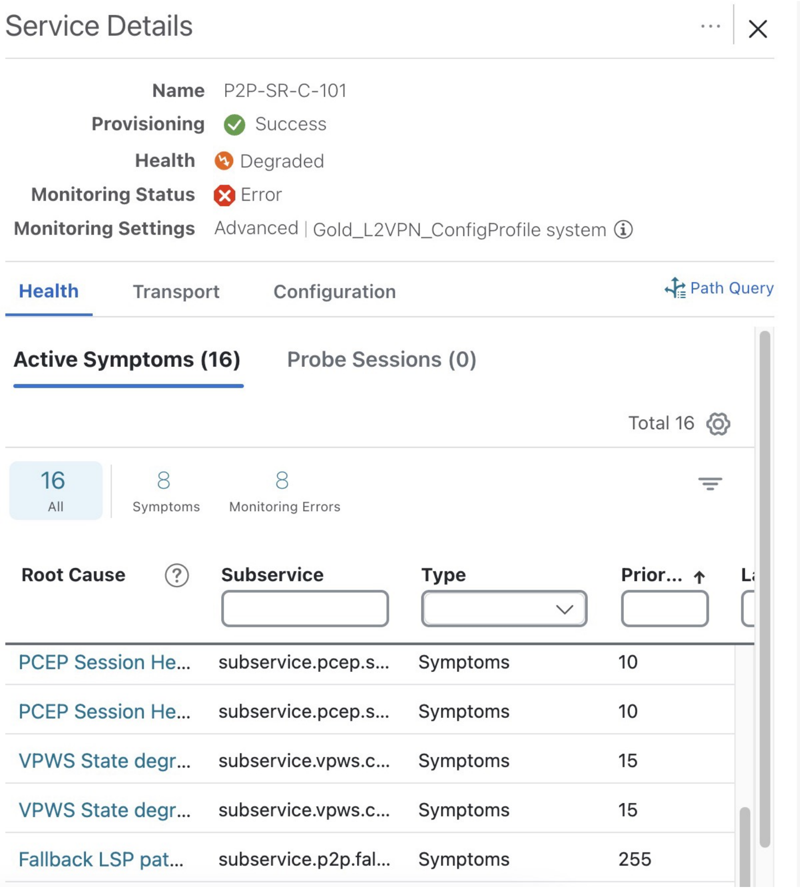
Note L3VPN service monitoring is supported on XR devices and not on XD devices. For an L3VPN service being monitored, if a provider and devices are deleted, and then added again, the monitoring status remain in the degraded state with a METRIC_SCHEDULER error. To recover from this error, stop and restart the service monitoring.

Step 1 From the main menu, choose **Services & Traffic Engineering** > **VPN Services**. The map opens on the left side of the page and the table opens on the right side.

Step 2 In the Actions column, click ⋯ and click **View Details**. The Service Details panel appears on the right side.

Step 3 Select the Health tab and click the **Active Symptoms** tab. The Active Symptoms table displays **Active Symptoms** and **Monitoring Errors** by default. To filter the table to show only the Active Symptoms, either click the **Symptoms** tab in the mini dashboard above the table or select **Symptoms** from the filter box under the **Type**. The table now shows a filtered list containing only the Active Symptoms.

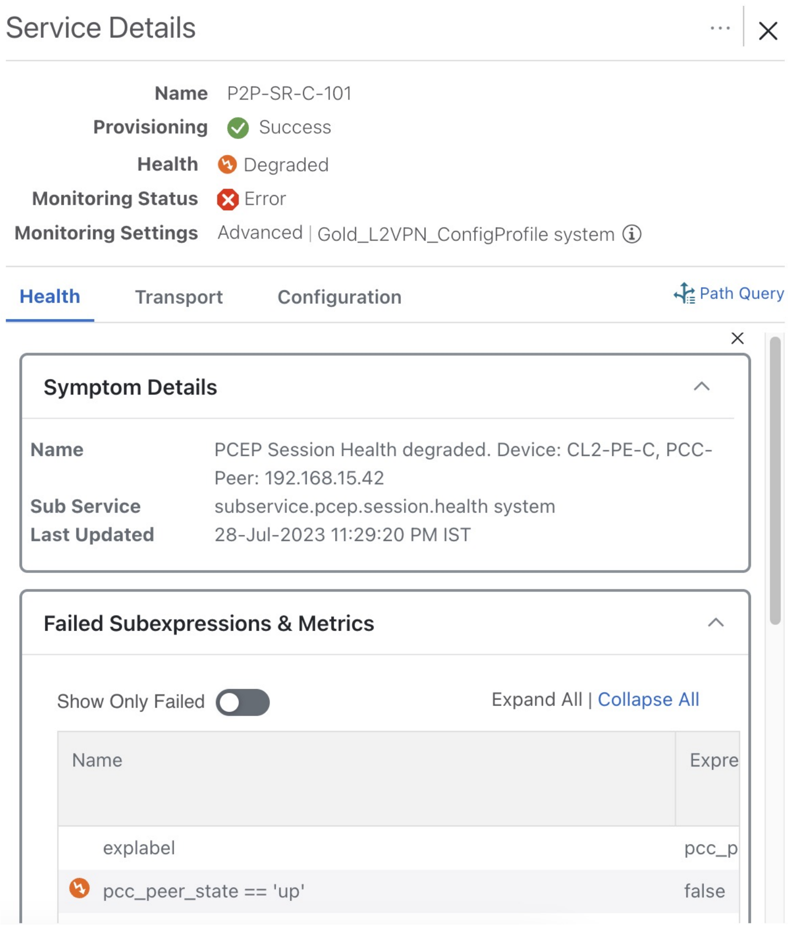
Review the Active Symptoms for the degraded service (including the Root Cause, Subservice, Type, Priority, and Last Updated details).



Name P2P-SR-C-101
Provisioning Success
Health Degraded
Monitoring Status Error
Monitoring Settings Advanced | Gold_L2VPN_ConfigProfile system

Root Cause	Subservice	Type	Prior...
PCEP Session He...	subservice.pcep.s...	Symptoms	10
PCEP Session He...	subservice.pcep.s...	Symptoms	10
VPWS State degr...	subservice.vpws.c...	Symptoms	15
VPWS State degr...	subservice.vpws.c...	Symptoms	15
Fallback LSP pat...	subservice.p2p.fal...	Symptoms	255

Step 4 Click on a Root Cause and view both the **Symptom Details** and the **Failed Subexpressions & Metrics** information. You can expand or collapse all of the symptoms listed in the tree, as required. In addition, use the **Show Only Failed** toggle to focus only on the failed expression values.



Service Details

Name P2P-SR-C-101
Provisioning ✓ Success
Health Degraded
Monitoring Status ✗ Error
Monitoring Settings Advanced | Gold_L2VPN_ConfigProfile system ⓘ

Symptom Details

Name PCEP Session Health degraded. Device: CL2-PE-C, PCC-Peer: 192.168.15.42
Sub Service subservice.pcep.session.health system
Last Updated 28-Jul-2023 11:29:20 PM IST

Failed Subexpressions & Metrics

Name	Expre
explabel	pcc_p
pcc_peer_state == 'up'	false

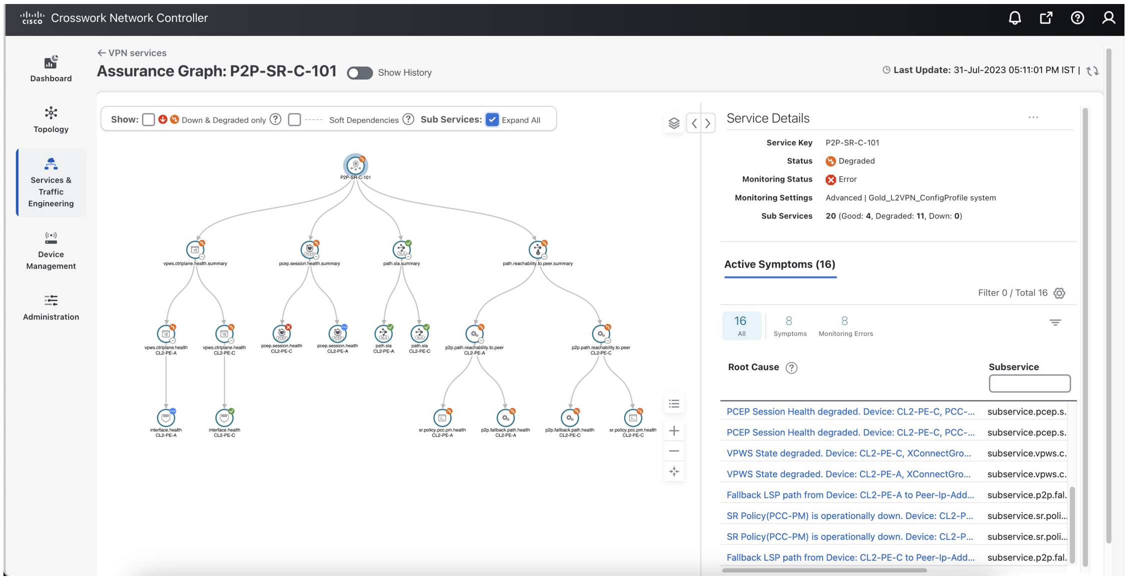
Step 5 Click the **Transport** and **Configuration** tabs and review the details provided.

Step 6 Click **X** in the top-right corner to return to the VPN Services list.

Step 7 In the Actions column, click ··· for the required degraded service and click **Assurance Graph**. The topology map of services and subservices appear with the Service Details panel showing Service Key, Status, Monitoring Status, Monitoring Settings, Sub Services, and Active Symptoms details.

This may take up to 5-10 minutes to update after a service has been enabled for monitoring.

Metrics such as Jitter-RT (Jitter Round Trip), Latency-RT (Latency Round Trip), PktLoss-DS (Packet Loss from Destination to Source), and PktLoss-SD (Packet Loss from Source to Destination) also appear (information collected using Y.1731 probes). Additionally, a table of Active Symptoms listing Root Cause, Subservice, Priority, and Last Updated details is populated.


Crosswork Network Controller
Dashboard
Topology
Services & Traffic Engineering
Device Management
Administration
← VPN services
Show History
Show: □ Down & Degraded only
□ Soft Dependencies
Sub Services: ☑ Expand All
P2P-SR-C-101
vpws.ctrlplane.health.summary
pcep.session.health.summary
path.sla.summary
path.reachability.to.peer.summary

Assurance Graph: P2P-SR-C-101

Last Update: 31-Jul-2023 05:11:01 PM IST |

Service Details

Service Key	P2P-SR-C-101
Status	Degraded
Monitoring Status	Error
Monitoring Settings	Advanced | Gold_L2VPN_ConfigProfile system
Sub Services	**20** (Good: **4**, Degraded: **11**, Down: **0**)

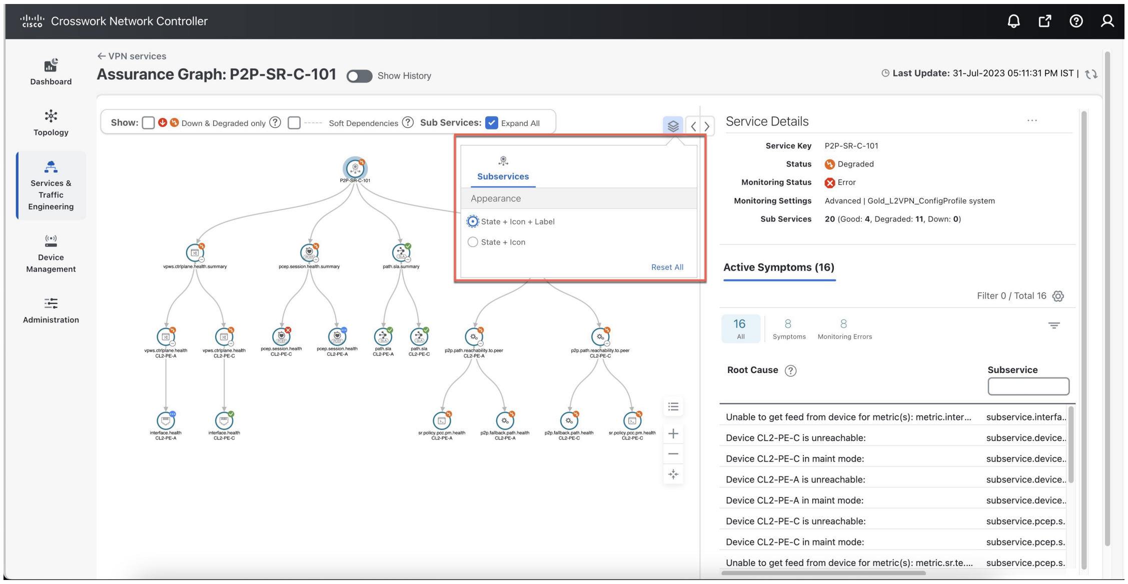
Active Symptoms (16)

Filter 0 / Total 16

16 All | 8 Symptoms | 8 Monitoring Errors

Root Cause	Subservice
PCEP Session Health degraded. Device: CL2-PE-C, PCC-...	subservice.pcep.s.
PCEP Session Health degraded. Device: CL2-PE-C, PCC-...	subservice.pcep.s.
VPWS State degraded. Device: CL2-PE-C, XConnectGro...	subservice.vpws.c.
VPWS State degraded. Device: CL2-PE-A, XConnectGro...	subservice.vpws.c.
Fallback LSP path from Device: CL2-PE-A to Peer-Ip-Add...	subservice.p2p.fal.
SR Policy(PCC-PM) is operationally down. Device: CL2-P...	subservice.sr.poli...
SR Policy(PCC-PM) is operationally down. Device: CL2-P...	subservice.sr.poli...
Fallback LSP path from Device: CL2-PE-C to Peer-Ip-Add...	subservice.p2p.fal.

At the top-right of the map, select the stack icon to select the appearance option for the Subservices: **State + Icon + Label** or **State + Icon**.



Assurance Graph: P2P-SR-C-101

Last Update: 31-Jul-2023 05:11:31 PM IST |

Service Details

Service Key	P2P-SR-C-101
Status	Degraded
Monitoring Status	Error
Monitoring Settings	Advanced | Gold_L2VPN_ConfigProfile system
Sub Services	**20** (Good: **4**, Degraded: **11**, Down: **0**)

Active Symptoms (16)

Filter 0 / Total 16

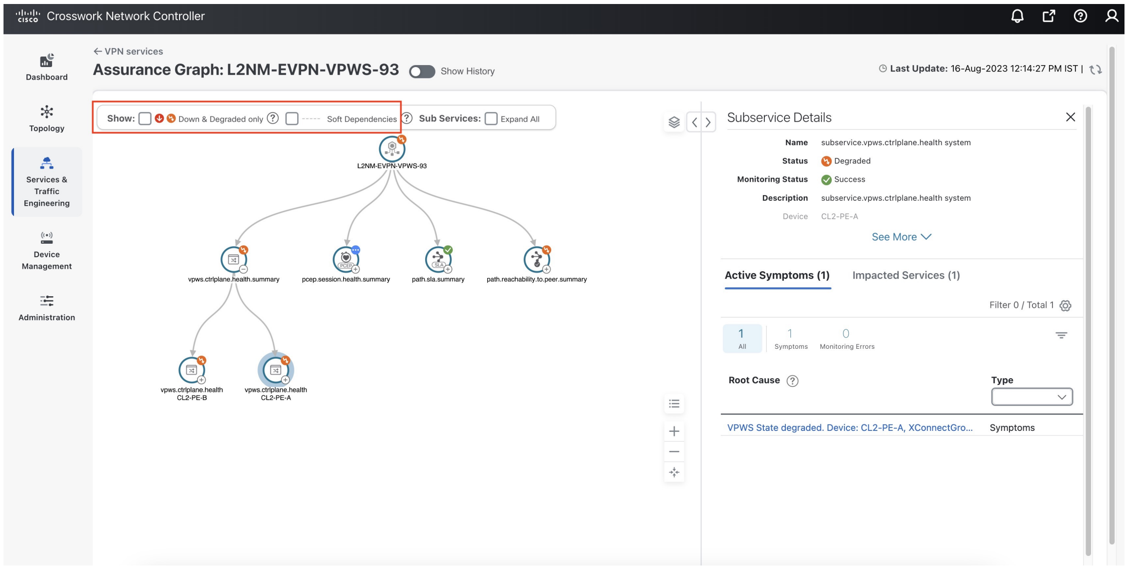
16 All | 8 Symptoms | 8 Monitoring Errors

Root Cause	Subservice
Unable to get feed from device for metric(s): metric.inter...	subservice.interfa..
Device CL2-PE-C is unreachable:	subservice.device..
Device CL2-PE-C in maint mode:	subservice.device..
Device CL2-PE-A is unreachable:	subservice.device..
Device CL2-PE-A in maint mode:	subservice.device..
Device CL2-PE-C is unreachable:	subservice.pcep.s.
Device CL2-PE-C in maint mode:	subservice.pcep.s.
Unable to get feed from device for metric(s): metric.sr.te....	subservice.pcep.s.

Step 8 By default, the Assurance Graph displays a concise view with only the service and the top level subservices (aggregator nodes). Click the + icon in the nodes to expand the graph and to view the dependent details. To expand all the nodes at once, click the **Subservices: Expand All** check box at the top.

Step 9 Select a degraded subservice in the Assurance Graph. The Subservice Details panel appears with subservice metrics, as well as subservice specific Active Symptoms and Impacted Services details.

- **Active Symptoms**: Provides symptom details for nodes actively being monitored.
- **Impacted Services**: Provides information for services that are impacted by issues based on historical monitoring of health status.


Crosswork Network Controller
Dashboard
Topology
Services & Traffic Engineering
Device Management
Administration
L2NM-EVPN-VPWS-93
vpws.ctrlplane.health.summary
pcep.session.health.summary
path.sla.summary
path.reachability.to.peer.summary
vpws.ctrlplane.health CL2-PE-B
vpws.ctrlplane.health CL2-PE-A
PCEP
SLA

← VPN services

Assurance Graph: L2NM-EVPN-VPWS-93 Show History

Last Update: 16-Aug-2023 12:14:27 PM IST |

Show: □ Down & Degraded only □ Soft Dependencies Sub Services: □ Expand All

Subservice Details

Name	subservice.vpws.ctrlplane.health system
Status	Degraded
Monitoring Status	Success
Description	subservice.vpws.ctrlplane.health system
Device	CL2-PE-A

See More

Active Symptoms (1) Impacted Services (1)

Filter 0 / Total 1

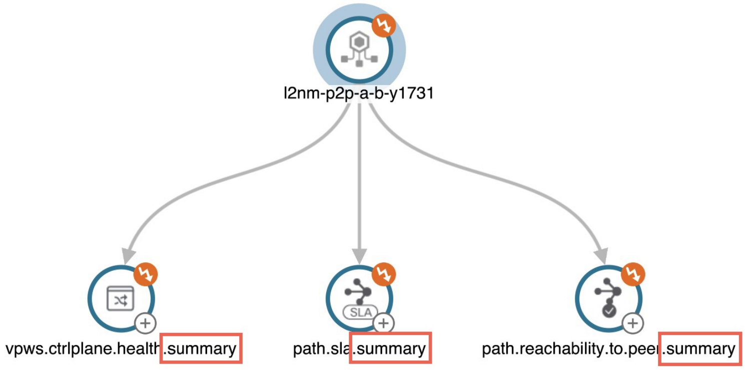
1 All 1 Symptoms 0 Monitoring Errors

Root Cause	Type
VPWS State degraded. Device: CL2-PE-A, XConnectGro...	Symptoms

Note At the top left of the map, check the **Down & Degraded only** or **Soft Dependencies** check boxes to further isolate the subservices. Soft Dependencies implies that a child subservice's health has a weak correlation to its parent's health. As a result, the degraded health of the child will not result in the parent's health degradation.

Note In some cases, the Summary node feature is available and summarizes the aggregated health status of child subservices and reports a consolidated health status to a service node. The Summary node feature is available in both L2VPN multipoint Basic and Advanced monitoring models.

- Basic monitoring subservices:
  - Device—Summarizes the health status of all underlying Devices participating in the given L2VPN service.
  - Bridge Domain—Summarizes the L2VPN service's Bridge Domain health status across all participating devices.
- Advanced monitoring subservices (in addition to what is also available with Basic monitoring):
  - EVPN—Summarizes the health status of all underlying subservices—BGP Neighbor Health and MacLearning Health across all participating PE endpoints and provides a consolidated overall EVPN health summary status.
  - Transport—Summarizes the health status of all underlying subservices—SR-ODN (dynamic), SR Policy (statically configured), and RSVP TE Tunnel, across all participating PE endpoints and provides a consolidated overall Transport health summary status.
  - SR-PCEP—Summarizes the health status of all the underlying subservices that are monitoring the PCEP sessions. Each underlying subservice monitors the PCEP session health on a particular device participating in the given VPN service.


l2nm-p2p-a-b-y1731
vpws.ctrlplane.health.summary
SLA
path.sla.summary
path.reachability.to.peer.summary

Step 10 Inspect the Active Symptoms and Impacted Services information, and the root causes associated with the degraded service to determine what issues may need to be addressed to maintain a healthy setup.

To further troubleshoot a service health issue (such as a device that is degraded due to not properly fetching data), continue with the following steps to examine if the issue is associated with a collection job.

Step 11 From the main menu, choose **Administration** > **Collection Jobs**.

The Collection Jobs page appears.

Step 12 Click the **Parameterized Jobs** tab.

Step 13 Review the Parameterized Jobs list to identify the devices that may have service health degradation issues. By reviewing Parameterized Jobs, you can identify and focus on gNMI, SNMP, and CLI-based jobs by their Context ID (protocol) for further troubleshooting purposes.

Step 14 In the Job Details panel, select the collection job you want to export and click ⤓ to download the status of collection jobs for further examination. The information provided is collected in a .csv file when the export is initiated.

Note When exporting the collection status, you must fill in the information each time an export is executed. In addition, make sure to review the **Steps to Decrypt Exported File** content available on the Export Collection Status dialog box to ensure you can access and view the exported information.

Step 15 Click **Export**.

Step 16 To check the status of the exported collection job data, click **View Export Status** at the top right of the Job Details panel. The Export Status Jobs panel appears providing the status of the export request.

Step 17 Review the exported .csv file for collection job details and the possible cause of the degraded device.

Summary and Conclusion

As we observed in this example, operators can use Cisco Crosswork Network Controller to orchestrate L3VPNs with SLAs and to maintain these SLAs using SR-TE policies that continuously track network conditions and automatically react to optimize the network. This automation increases efficiency and reduces human error that is generally unavoidable with manual tasks. Enabling Service Health to monitor provisioned services allows for more detailed symptoms, metrics, and analyzation of each service.

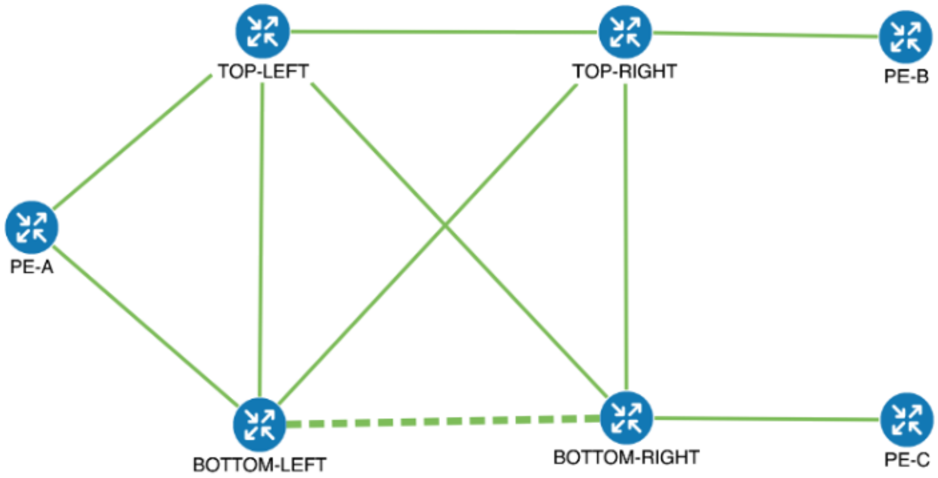
Scenario: Implement and Maintain SLA for an L3VPN Service for SRv6 (using ODN)

This scenario walks you through the procedure for provisioning an L3VPN service that requires a specific SLA objective. In this example, the lowest latency path is the SLA objective. The customer requires a low latency path for high priority traffic. The customer wants to use disjoint paths, i.e., two unique paths that steer traffic from the same source and to the same destination, avoiding common links so that there is no single point of failure. The customer also wants to enable SRv6, which utilizes the IPv6 protocol to handle packets with more efficiency, increase security and performance, allowing for a significantly larger number of possible addresses.

This is achieved using Segment Routing (SR) On-Demand Next Hop (ODN). ODN allows a service head-end router to automatically instantiate an SR-TE policy to a BGP next-hop when required (on-demand). The headend is configured with an ODN template with a specific color that defines the SLA upon which the traffic path will be optimized when a prefix with the specified color is received. Prefixes are defined in a route policy that is associated with the L3VPN.

Cisco Crosswork Network Controller continues to monitor the network and will automatically optimize the network based on the defined SLA, in a closed loop.

The following topology provides the base for this scenario:



In this scenario, we will:

- Create a segment routing ODN template with a specific color on the endpoints to ensure that traffic is transported within an LSP (underlay) and that a best-path tunnel is created dynamically when a prefix with the specified color is received. Enable SRv6 (IPv6) for service and link details. The ODN template defines the SLA on which you want to optimize the path. In this case, we will optimize on latency.
- Specify that the computed paths be disjoint: they will not share the same link.
- Create a route policy on each endpoint to be used to bind the L3VPN to the ODN template. This route policy adds a color attribute to the customer prefixes and advertises via BGP to other endpoints. This color attribute is used to indicate the SLA required for these prefixes.
- Create an L3VPN service with 3 endpoints: PE-A, PE-B, and PE-C. This is the overlay configuration.

- Visualize how this overlay/underlay configuration optimizes the traffic path and automatically maintains the SLA.

Assumptions and Prerequisites

- To use ODN with SRv6, BGP peering for the prefixes must be configured between the endpoints/PEs. Usually for L3VPN, this is the VPNv4 and VPNv6 address family peering, and this BGP peering is required to be over IPv6.

Procedure to Implement and Maintain SLA for an L3VPN Service for SRv6 Using ODN is detailed in this section.

Step 1 Create an ODN template to map color to an SLA objective and constraints

We will create the following ODN templates:

- Headend PE-A, color 72, latency, disjoint path (link), group ID 16 - L3VPN_NM-SRTE-ODN_72-a
- Headend PE-A, color 71, latency, disjoint path (link), group ID 16 - L3VPN_NM-SRTE-ODN_71-a
- Headend PE-B and PE-C, color 70, latency - L3VPN_NM-SRTE-ODN_70
    - With multiple headends in the SRv6 enabled ODN template, the same locator name should be configured on the headend routers. Otherwise, different ODN templates should be created for each headend.
- Headend PE-B, color 72, latency - L3VPN_NM-SRTE-ODN_72-b
- Headend PE-C, color 71, latency - L3VPN_NM-SRTE-ODN_71-c

For example purposes, we will show how to create the first ODN template - L3VPN_NM-SRTE-ODN_72-a. The other ODN templates can be created using the same procedure.

Before you begin

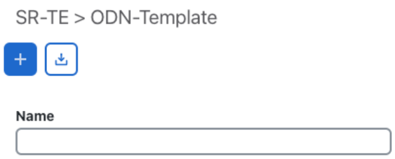
In this step, we will create an ODN template on each endpoint. The ODN template specifies the color and the intent; in this case, latency and disjointness. This ODN template will be used to dynamically create tunnels (on-demand) when prefixes with matching colors are received via BGP. Traffic to these prefixes will be automatically steered into the newly created tunnels, thereby meeting the SLA objective and constraints intended for these prefixes and signaled using colors in the BGP routes.

Disjointness constraints work by associating a disjoint group ID with the ODN template, and all tunnels with the same disjoint group ID will be disjoint, i.e., they will use different links, nodes and shared risk link groups depending on how the disjoint groups are configured.

Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **SR-TE** > **ODN-Template**.

Step 2 Click + to create a new template and give it a unique name.

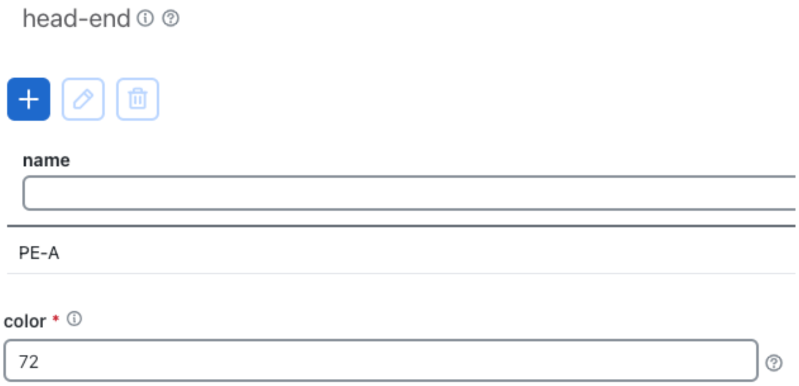
In this case, the name is **L3VPN_NM-SRTE-ODN_72-a**. Click **Continue**.



SR-TE > ODN-Template

Name

Step 3 Choose the headend device, **PE-A**, and specify the color **72**.



head-end

name

PE-A

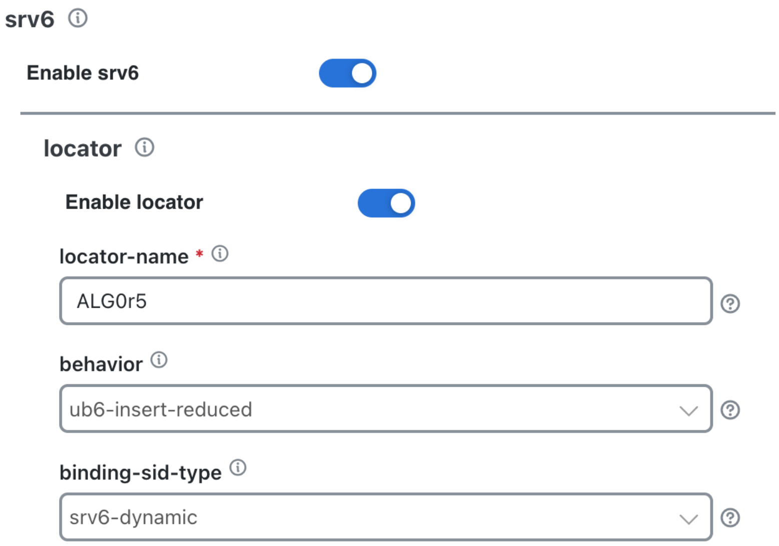
color *

72

Step 4 Under srv6, select the **Enable srv6** toggle.

Step 5 Under locator, enter the required SRv6 **locator-name**.

The locator name should match what is configured on the router.



srv6

Enable srv6

locator

Enable locator

locator-name *

ALG0r5

behavior

ub6-insert-reduced

binding-sid-type

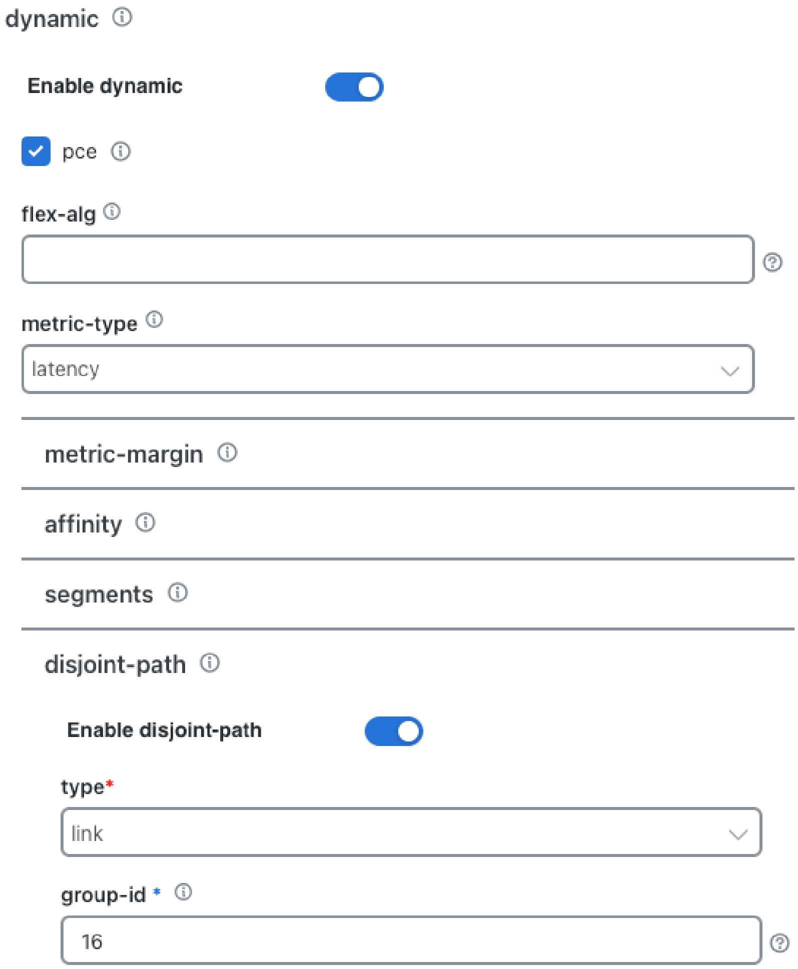
srv6-dynamic

Step 6 Under dynamic, select **latency** as the metric type. This is the SLA objective on which we are optimizing.

Step 7 Select the **pce** check box to specify that the path should be computed by the SR-PCE, not by the Path Computation Client (PCC).

Step 8 Define the required constraints. In this case, we want the computed paths to be disjoint in that they must not share a link.

Under disjoint-path, choose **link** as the type, and specify a numeric group ID, in this case, 16.



dynamic

Enable dynamic

☑ pce

flex-alg

metric-type: latency

metric-margin

affinity

segments

disjoint-path

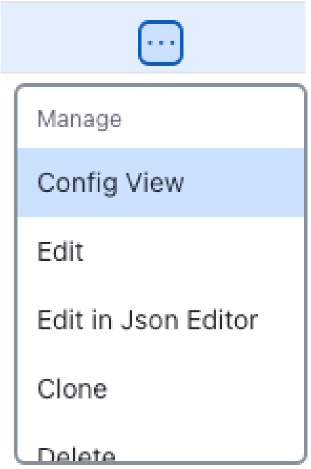
Enable disjoint-path

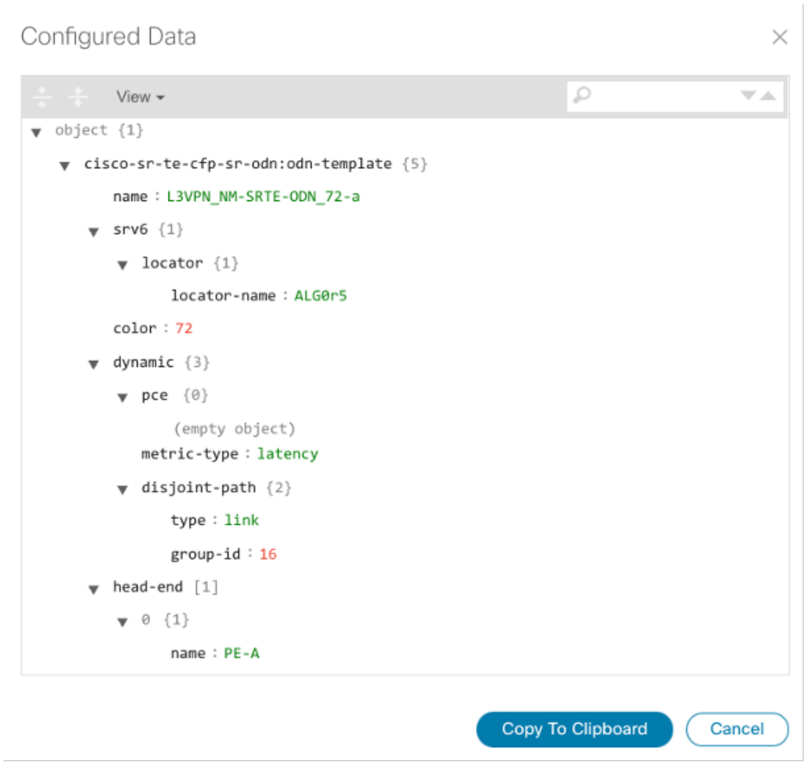
type*: link

group-id *: 16

Commit your changes or click **Dry Run** to check what will be configured on the devices before you commit.

Step 9 Check that the new ODN template appears in the table and its provisioning state is **Success**. Click ⋯ in the Actions column and choose **Config View** to see the Yang model-based service intent data that details the ODN template you created.





```
▼ object {1}
    ▼ cisco-sr-te-cfp-sr-odn:odn-template {5}
        name : L3VPN_NM-SRTE-ODN_72-a
        ▼ srv6 {1}
            ▼ locator {1}
                locator-name : ALG0r5
        color : 72
        ▼ dynamic {3}
            ▼ pce {0}
                (empty object)
            metric-type : latency
            ▼ disjoint-path {2}
                type : link
                group-id : 16
        ▼ head-end [1]
            ▼ 0 {1}
                name : PE-A
```

Step 10 Create the other ODN templates listed above in the same manner.

Step 2 Create an L3VPN Route Policy

In this step, we will create a route policy for each endpoint, and we will specify the same color as defined in the ODN template for that endpoint. The route policy defines the prefixes to which the SLA applies. When traffic from the specified network with a matching color is received, paths are computed based on the SLA defined in the ODN template. We will create the following route policies:

- Color 70, IPv6 prefix 70:70:70::0/64 - L3VPN_NM-SRTE-RP-PE-A-7
- Color 71, IPv6 prefix 70:70:71::0/64 - L3VPN_NM-SRTE-RP-PE-B-7
- Color 72, IPv6 prefix 70:70:72::0/64 - L3VPN_NM-SRTE-RP-PE-C-7

For example purposes, we will show how to create the first route policy - L3VPN_NM-SRTE-RP-PE-A-7. The other route policies can be created using the same procedure.

First, we will create the routing policy tag and routing policy destination prefix. The routing policy prefixes should match with the subnet prefix configured on the PE devices in the service.

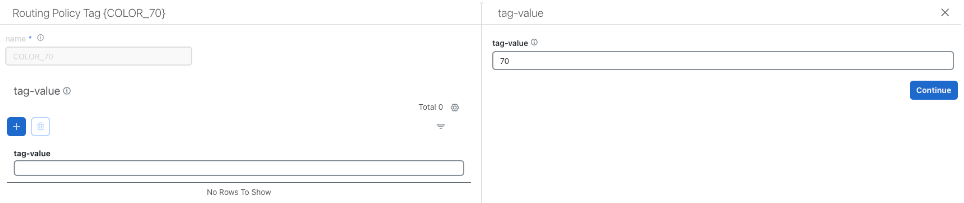
Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L3VPN** > **Routing Policy Tag**.

Step 2 Click + to create a new routing policy tag and type the name of the tag set: **COLOR_70**. Click **Continue**.

This is used as a label to reference the set in actions and conditions.

Step 3 Under tag-value, click + and type the Tag-value: **70**.

The tag value may be a number between **1 – 4294967295** and should match to a color value.



Routing Policy Tag {COLOR_70}

name * COLOR_70

tag-value

tag-value 70

Step 4 Click **Continue**. The new routing policy tag name with the new tag value is visible. Click **Commit changes**.

Create the other two routing policy tags (**COLOR_71** and **COLOR_72**) and tag values (**71** and **72**) by following the same steps above.

Now create the routing policy destination prefixes.

Step 5 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L3VPN** > **Routing Policy Destination Prefix**.

Step 6 Click + to create a new routing policy destination prefix and type the name: **DEST_PREFIX_SET_70**.

The name of the prefix set will reference the set in match conditions.

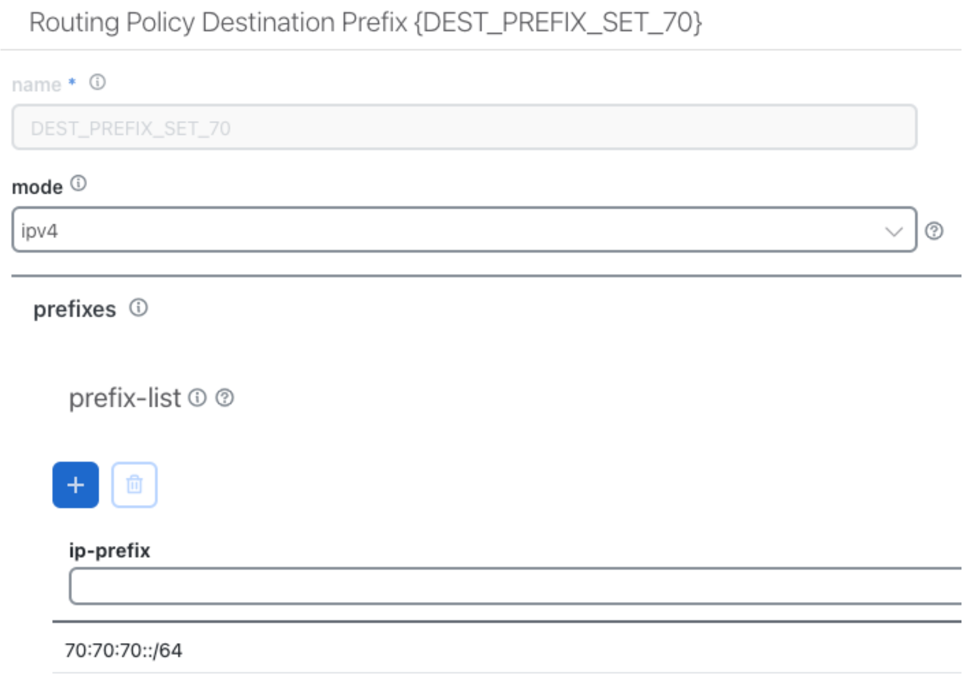
Step 7 For Mode, select **ipv6**.

Step 8 Expand prefixes and click + to add the ip-prefix to the prefix-list.

Step 9 For Ip-prefix, type **70:70:70::0/64** and click **Continue**.

Create the other two routing policy destination prefixes (**DEST_PREFIX_SET_71** and **DEST_PREFIX_SET_72**) by following the same steps. Click **Commit changes**.

Now we are ready to create the first route policy L3VPN_NM-SRTE-RP-PE-A-7. The other route policies can be created using the same procedure.



Routing Policy Destination Prefix {DEST_PREFIX_SET_70}

name * DEST_PREFIX_SET_70

mode: ipv4

prefixes

prefix-list

ip-prefix

70:70:70::/64

Step 10 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L3VPN** > **Routing Policy**.

Step 11 Click + to create a new route policy and type a unique name for the top-level policy definition: **L3VPN_NM-SRTE-RP-PE-A-7**. Click **Continue**. The statements section appears.

Note The Route Policy statement defines the condition and action taken by the system.

Step 12 Expand statements and click + to add the name of the policy statement (such as **stmt1**) and click **Continue**. The statement{stmt1} panel appears showing **conditions** and **actions** sections.

Step 13 Expand conditions and then expand match-dest-prefix-set before selecting the prefix-set list and select **DEST_PREFIX_SET_70**. This is what references a defined prefix set.

Note Once selected, the **Enable match-dest-prefix-set** toggle, which will match a referenced prefix-set according to the logic defined in the match-set-options list, switches on.

Step 14 Expand actions and then expand bgp-actions.

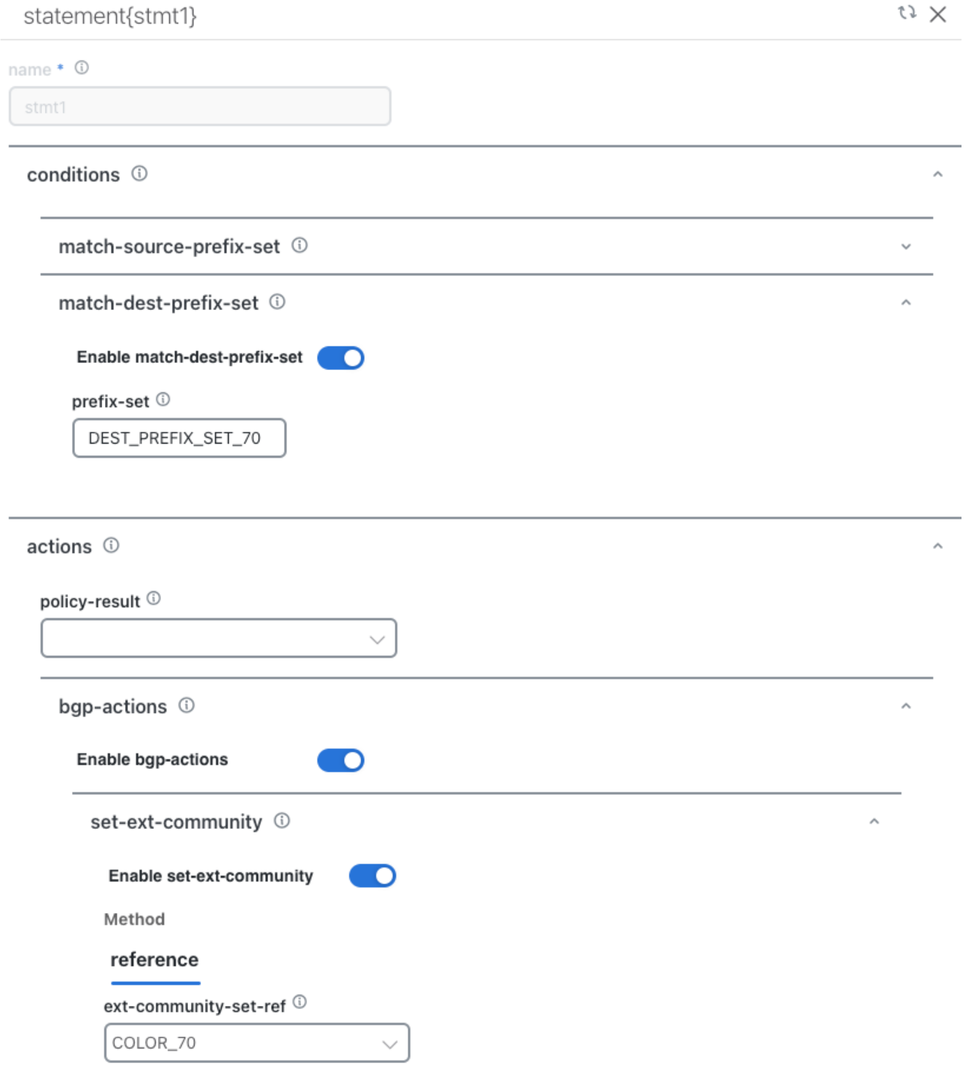
Step 15 For bgp-actions, slide the Enable bgp-actions toggle to the on position. By toggling bgp-actions on, it defines the top-level container for BGP-specific actions.

Step 16 Now expand set-ext-community. Slide the enable-set-ext-community toggle to the on position. By toggling set-ext-community on, it sets the extended community attributes.

Step 17 For Method and reference, select the ext-community-set-ref list and select **COLOR_70**. The Ext-community-set-ref references a defined extended community set by name.

Note Creating routing-policy tag-set is mandatory and needs to be mapped here.

Step 18 Click **X** in the top-right corner to close the statement{stmnt1} panel and click **Commit changes**.



statement{stmt1}

name * stmt1

conditions

match-source-prefix-set

match-dest-prefix-set

Enable match-dest-prefix-set

prefix-set: DEST_PREFIX_SET_70

actions

policy-result

bgp-actions

Enable bgp-actions

set-ext-community

Enable set-ext-community

Method: reference

ext-community-set-ref: COLOR_70

Step 19 Create the other route policies (L3VPN_NM-SRTE-RP-PE-B-7 and L3VPN_NM-SRTE-RP-PE-C-7) in the same manner.

After creating the L3VPN route policies, create the VPN profile for each route policy and then create and provision the L3VPN service. The VPN profile will be referenced from the L3VPN service. This will bind the route policy to the L3VPN service.

Step 3 Create and provision the L3VPN service

In this step, we will create the L3VPN service with three endpoints: PE-A, PE-B, and PE-C. Each endpoint will be associated with a vpn-instance-profile, which in turn points to a VPN profile that contains the route policy with the same color as specified in the ODN template. In this way, traffic that matches the specified prefixes and color will be treated according to the SLA specifications.

First, we will create the VPN profiles. The newly created VPN profiles will have the same names as the L3VPN routing policy names.

Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L3VPN** > **VPN Profiles**.

Step 2 Click + to create a valid VPN profile to be referenced in the VPN service.

Step 3 Select the Id list and select **L3VPN_NM-SRTE-RP-PE-A-7**.

Now create and provision the L3VPN service.

Step 4 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L3vpn** > **L3vpn-Service**..

Step 5 Click + to create a new service and type a new vpn-id: **L3VPN_NM-SRTE-ODN-70**.

A VPN identifier uniquely identifies a VPN and has a local meaning (for example, within a service provider network).

Step 6 Click **Continue**.

Step 7 Create vpn-instance-profiles, which is a container that defines the route distinguisher (RD), route targets, and the export/import route policy. We will create vpn-instance-profiles for each endpoint, as follows:

- L3VPN_NM_SR_ODN-IE-PE-A-7 with route distinguisher 0:70:70
- L3VPN_NM_SR_ODN-IE-PE-B-7 with route distinguisher 0:70:71
- L3VPN_NM_SR_ODN-IE-PE-C-7 with route distinguisher 0:70:72

a. Expand vpn-instance-profiles and click + to create a new vpn-instance-profile profile-id: **L3VPN_NM_SR_ODN-I-PE-A-7**. Click **Continue**.

b. Enter the route distinguisher (Rd) that will differentiate the IP prefixes and make them unique: **0:70:70**.

c. For address-family, click + and select **ipv6** from the list. Click **Continue**.

d. Define the required VPN targets, including route targets and route target types (import/export/both).

e. Under vpn-policies, in the Export-policy list, choose the relevant VPN profile (which contains the route policy: **L3VPN_NM-SRTE-RP-PE-A-7**). This forms the association between the VPN and the ODN template that defines the SLA.

f. Click **X** in the top-right corner when you are done.

g. Expand srv6 and slide the Enable srv6 toggle to the on position and then click + under address-family.

h. Select **ipv6** from address family list and click **Continue**.

i. For Locator-name, type **ALG0r5**. The SRv6 locator name should match locators configured at a node-global level on each router. Click **X** in the top-right corner until you are back on the Create L3VPN screen.

j. Similarly, create the other vpn-instance-profiles.

Step 8 Define each VPN endpoint individually: PE-A, PE-B, and PE-C.

a) Expand vpn-nodes and click + to select the relevant device from the list: **PE-A**. Click **Continue**.

b) Enter the local autonomous system number for network identification: **200**.

c) Expand active-vpn-instance-profiles and click + to select the Profile-id you created in the previously: **L3VPN_NM-SRTE-RP-PE-A-7**. Click **Continue**.

d) Define the network access parameters for communication from the PE towards the CE:

- Under vpn-network-accesses, click + to create a new set of VPN access parameters and provide a unique ID. Click **Continue**.
- In the Interface-id field, type **Loopback70**. This is the identifier for the physical or logical interface. The identification of the sub-interface is provided at the connection level and/or the IP connection level.
- Expand ip-connection > ipv6 and enter a Local-address (**70:70:70::1**) and the Prefix-length (**64**).
- Expand routing-protocols and click + before typing a unique identifier for the routing protocol: **EBGP**. Click **Continue**.
- From the routing protocol Type list, select **bgp-routing**.
- Expand bgp and for Peer-as, type **70**. This information indicates the customer's ASN when the customer requests BGP routing.
- From the Address-family list, select **ipv6**.
- Under neighbor, click + to create a neighbor IP address and type **70:70:70::2**. Click **Continue**.
- Type the Multihop number: **11**. This describes the number of IP hops allowed between a given BGP neighbor and the PE.
- For redistribute-connected, click + and select **ipv6** from the Address-family list. Click **Continue**.
- Click **X** in the top-right corner until you are back on the Create L3VPN screen.
- Similarly, create the other VPN nodes: **PE-B** and **PE-C**.

Step 9 Commit your changes or click **Dry Run** to check what will be configured on the devices before you commit.

Step 10 Check that the new L3VPN service appears in the table and its provisioning state is **Success**.

Step 4 Visualize the New VPN Service on the Map to See the Traffic Path

Step 1 In the L3VPN Service table, click on the service name or click ⋯ in the Actions column and choose **View Details** from the menu.

The map opens and the service details are shown to the right of the map.

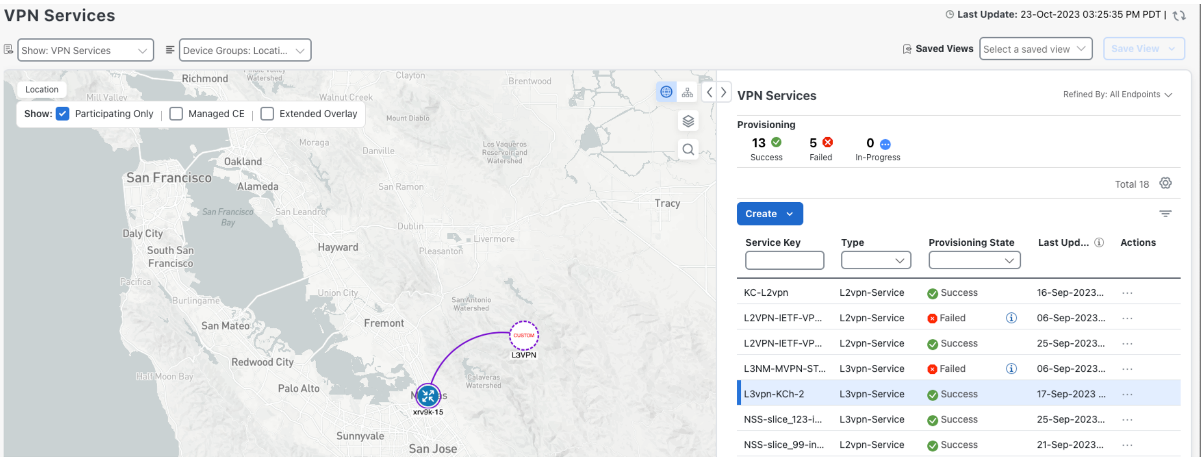
or

a) Go to **Services & Traffic Engineering** > **VPN Services**.

The map opens and a table of VPN services is displayed to the right of the map.

b) Click on the VPN in the Services table. If there are many services in the table, you can filter by name, type, or provisioning state to help locate the VPN.

In the map, you will see the VPN as an overlay on the topology. It shows a representation of the three endpoints and a dashed line that indicates that it is a virtual path.



VPN Services

Last Update: 23-Oct-2023 03:25:35 PM PDT |

Show: VPN Services | Device Groups: Locati... | Saved Views: Select a saved view | Save View

Show: ☑ Participating Only | □ Managed CE | □ Extended Overlay

VPN Services — Refined By: All Endpoints

Provisioning: 13 Success | 5 Failed | 0 In-Progress

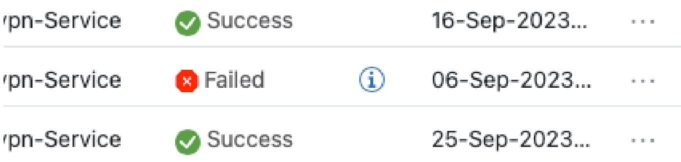
Total 18

Create

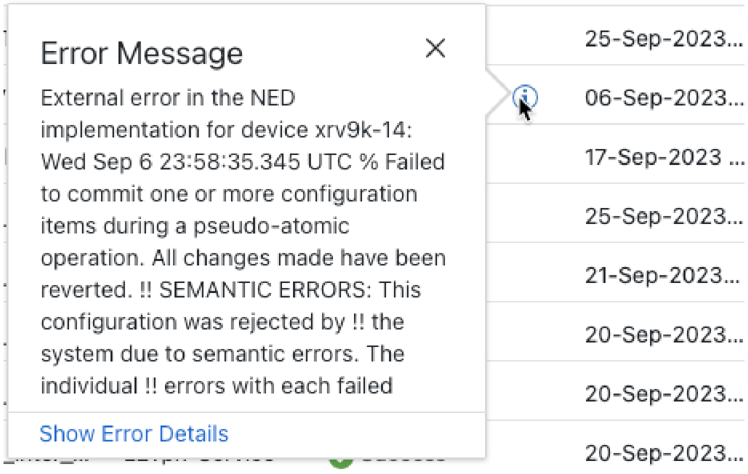
Service Key	Type	Provisioning State		Last Upd...	Actions
KC-L2vpn	L2vpn-Service	Success		16-Sep-2023...	···
L2VPN-IETF-VP...	L2vpn-Service	Failed	ⓘ	06-Sep-2023...	···
L2VPN-IETF-VP...	L2vpn-Service	Success		25-Sep-2023...	···
L3NM-MVPN-ST...	L3vpn-Service	Failed	ⓘ	06-Sep-2023...	···
L3vpn-KCh-2	L3vpn-Service	Success		17-Sep-2023 ...	···
NSS-slice_123-i...	L3vpn-Service	Success		25-Sep-2023...	···
NSS-slice_99-in...	L2vpn-Service	Success		21-Sep-2023...	···

Select the **Show Participating Only** check box if you do not want to see the devices that are not involved in the selected VPN.

Note When a Provision State shows a Failed state, an information icon appears. This is true whether you are on the VPN Services, Service Details, and many of the Provisioning screens that show a table of services and their Provisioning status. If you select the icon, Error Message details appear describing the failure. You can also click the **Show Error Details** link to view the Component Errors screen and take action to fix the error. Each failed source provides further error message details and recommendations. For example, in the Action column for the failed source on the component Errors screen, you may click ··· for different options (such as, **Check-Sync**, **Sync-To**, **Sync-From**, **Compare-Config**, **View Job Status**) that will assist in fixing the error. Service level actions are also available for additional options (such as, **Re-Deploy**, **Reactive-Re-deploy**, **Re-Deploy Reconcile**, **Clean-up**, etc.) that will assist in fixing the service level error. Use the information icons that appear next to these options, as well, for further fix details.

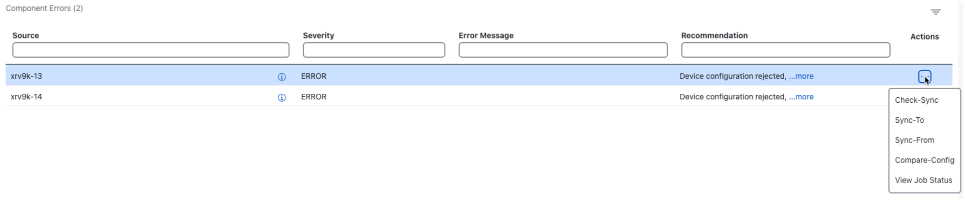


'pn-Service	Success		16-Sep-2023...	···
'pn-Service	Failed	ⓘ	06-Sep-2023...	···
'pn-Service	Success		25-Sep-2023...	···



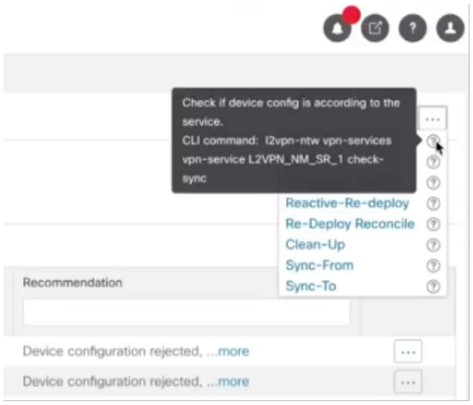
Error Message

External error in the NED implementation for device xrv9k-14: Wed Sep 6 23:58:35.345 UTC % Failed to commit one or more configuration items during a pseudo-atomic operation. All changes made have been reverted. !! SEMANTIC ERRORS: This configuration was rejected by !! the system due to semantic errors. The individual !! errors with each failed



Component Errors (2)

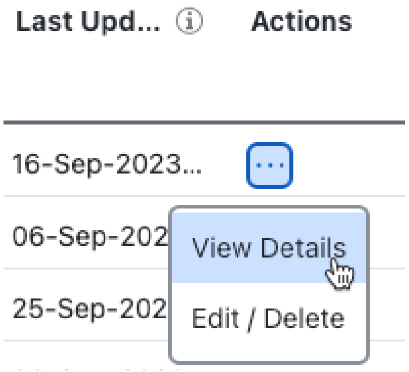
Source	Severity	Error Message	Recommendation	Actions
xrv9k-13	ERROR		Device configuration rejected, ...more	
xrv9k-14	ERROR		Device configuration rejected, ...more	



Check if device config is according to the service.
CLI command: l2vpn-ntw vpn-services vpn-service L2VPN_NM_SR_1 check-sync

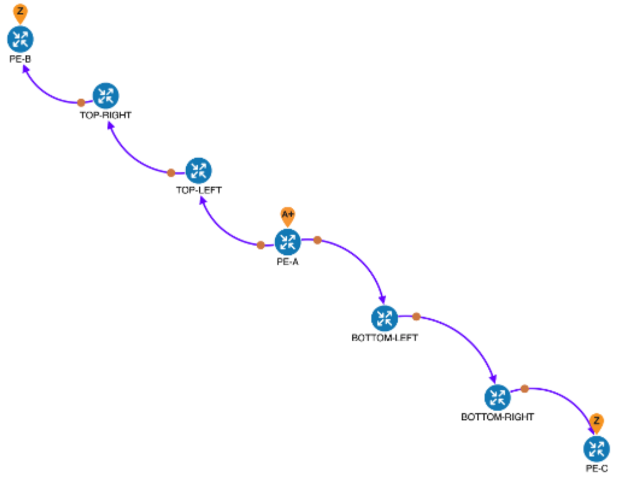
Recommendation
Device configuration rejected, ...more
Device configuration rejected, ...more

Step 2 In the Actions column, click ⋯ to drill down to a detailed view of the VPN service, including the device configurations and the computed transport paths.

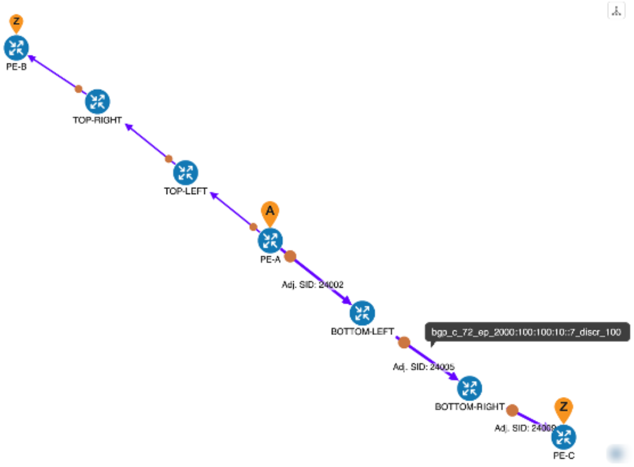


Step 3 To see the computed paths for this VPN, click on the Transport tab in the Service Details pane. All the dynamically created SR-TE policies are listed in the Transport tab. Select one or more SR-TE policies to see the path from endpoint to endpoint on the map.

In this example, we are looking at the disjoint paths computed from PE-A to PE-B and from PE-A to PE-C.



Step 4 To see the physical path between the endpoints, select the **Show IGP Path** check box in the top-left corner of the map. Hover with your mouse over a selected policy in the table to highlight the path in the map and show prefix SID and routing information.

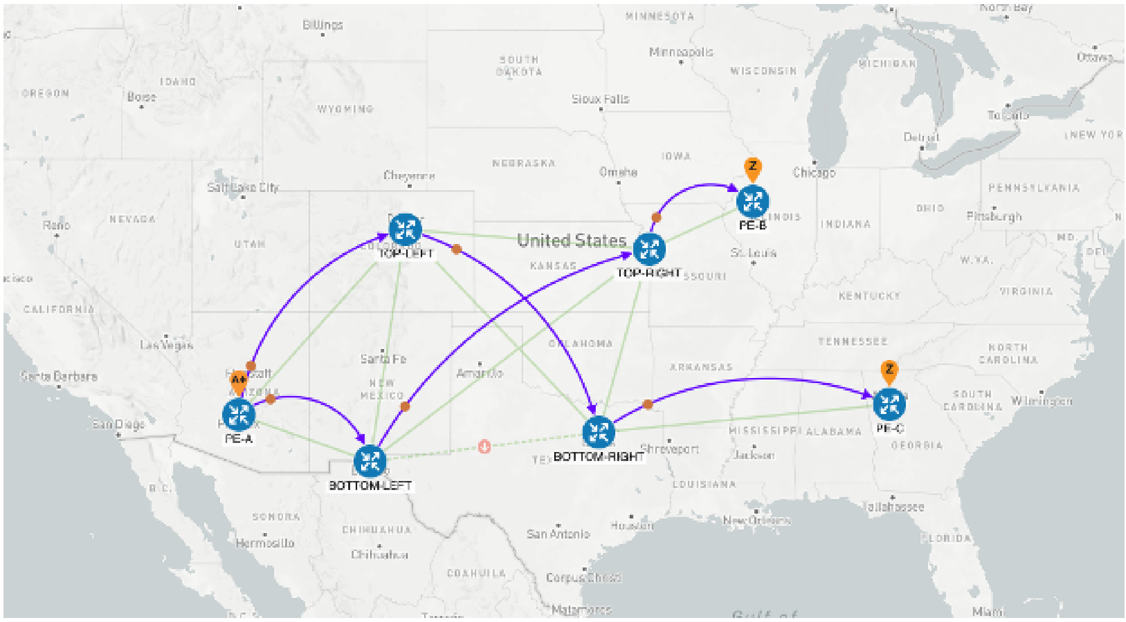


Step 5 Observe automatic network optimization

The SR-PCE constantly monitors the network and automatically optimizes the traffic path based on the defined SLA. For illustration purposes, let's take a look at what happens when one of the links goes down, in this case, the link between P-BOTTOMLEFT and P-BOTTOMRIGHT. This means that the previous path from PE-A to PE-C is no longer viable. Therefore, the SR-PCE computes an alternative path, both from PE-A to PE-C and from PE-A to PE-B, in order to compensate for the link that is down and to maintain the disjoint paths.

Recomputed paths:

Source and Destination	Old path	New path
PE-A > PE-C	PE-A > BOTTOM-LEFT > BOTTOM-RIGHT > PE-C	PE-A > TOP-LEFT > BOTTOM-RIGHT > PE-C
PE-A > PE-B	PE-A > TOP-LEFT > TOP-RIGHT > PE-B	PE-A > BOTTOM-LEFT > TOP-RIGHT > PE-B



Summary and Conclusion

As we observed in this example, operators can use Cisco Crosswork Network Controller to orchestrate L3VPNs for SRv6 with SLAs and to maintain these SLAs using SR-TE policies that continuously track network conditions and automatically react to optimize the network. This automation increases efficiency and reduces human error that is generally unavoidable with manual tasks.

Scenario: Mandate a Static Path for an EVPN-VPWS Service using an Explicit MPLS SR-TE Policy

To ensure that mission-critical traffic within a VPN traverses the higher capacity interfaces, rather than the lower capacity interfaces, we will create a point-to-point EVPN-VPWS service and associate a preferred path (explicit) MPLS SR-TE policy on both endpoints for service instantiation. In this way, we will mandate a static path for the mission-critical traffic.

In this scenario, we will see how quick and easy it is to create SR-TE policies and VPN services by uploading a file containing all the required configurations. We will download sample files (templates) from the provisioning UI, fill in the required data, and then import the file via the UI. Lastly, we will use the Service

Health functionality to review the health of the services and view the Assurance Graph and Last 24Hr Metrics to better analyze our service's health details.

Note In this scenario, reference to SR-TE specifically means SR-TE over MPLS.

In this scenario, we will:

- Create a SID list - a list of prefix or adjacency Segment IDs, each representing a device or link along the path.
- Provision an explicit SR-TE policy, which will reference the SID list, thus creating a predefined path into which the EVPN prefix will be routed.
- Provision a point-to-point EVPN-VPWS service from PE-A to PE-C and attach the explicit SR-TE policy.
- Visualize the path of the service and review the health of the services.

Assumptions and Prerequisites

- For transport mapping to L2VPN service, devices must be configured with the **l2vpn all** command.
- For Service Health enablement, Service Health must be installed. See the Crosswork Network Controller Installation Guide chapter, Install Crosswork Applications.
- (Optional) Service Health provides **Internal Storage** of monitoring data up to a maximum limit of 50 GB. This data is stored on your system. If you exceed the limit of the internal storage, historical data will be lost. If you choose to extend Service Health storage capacity, you can configure **External Storage** in the cloud using an Amazon Web Services (AWS) cloud account. By leveraging External Storage, all existing internal storage data will be automatically moved to the external cloud storage (see **Configuring Service Health External Storage Settings** for more details) and your internal storage will act locally as cache storage. Configuring External Storage for Service Health ensures you will not lose historical data for services that continue to monitor a service's health, and will retain service health data for any service you choose to stop monitoring when you select the option to retain historical monitoring service for the data. For more information on Internal and External Storage, and how to retain historical monitoring service data when stopped, see **Configuring Service Health External Storage Settings** and **Stopping Service Health monitoring**.
- Before using Service Health's Assurance Graph, ensure that topology map nodes have been fully configured and created with a profile associated to the service. If not, Subservice Details metrics will show that no value has yet to be reported.
- For Service Health, you must configure 2 buckets on the Y1731 profile associated with the device. If you have fewer than 2 buckets configured, Service Health cannot report the Y1731 probes/KPIs on the service details page.

Step 1 Prepare for Creating a SID List

Before you begin

The SID list consists of a series of prefix or adjacency SIDs, each representing a node or link along on the path. Each segment is an end-to-end path from the source to the destination, and it instructs the routers in the network to follow the specified path instead of the shortest path calculated by the IGP.

To build the SID list, you will need the MPLS labels of the desired traversing path. You can get these labels from the devices themselves or you can invoke the northbound Cisco Crosswork Optimization Engine API to retrieve this information.

Refer to Cisco Crosswork Network Automation API Documentation on Cisco Devnet for more information about the API.

Step 1 Prepare the input required to produce the SID list for the path from endpoint to endpoint. You will need the router ID of each endpoint, as follows:

```
{
  "input": {
    "head-end": "100.100.100.7",
    "end-point": "100.100.100.5",
    "sr-policy-path": {
      "path-optimization-objective": "igp-metric"
    }
  }
}'
```

Step 2 Invoke the API on the Cisco Crosswork Network Controller server by using the input prepared in the previous step. For example:

```
curl --location --request POST
'https://10.194.63.198:30603/crosswork/nbi/optima/v1/restconf/operations/cisco-crosswork-
optimization-engine-sr-policy-operations:sr-policy-dryrun' \
--header 'Content-Type: application/yang-data+json' \
--header 'Accept: application/yang-data+json' \
--header 'Authorization: Bearer
eyJhbGciOiJIUzUxMiJ9.eyJzdWIiOiJhZG1pbiIsImlzRnJvbU5ld0xvZ2luIjoidHJ1ZSIsInBvbGljeV9pZCI6ImFkb
WluIiwiYXV0aGVudGljYXRpb25EYXRlIjoiMjAyMS0wMy0yMlQxNjozODozNy43NDY2MTZaW0dNVF0iLCJzdWNjZXNzZnV
sQXV0aGVudGljYXRpb25IYW5kbGVycyI6IlF1ZXJ5RGF0YWJhc2VBdXRoZW50aWNhdGlvbkhhbmRsZXIiLCJpc3MiOiJod
HRwOlwvXC9sb2NhbGhvc3Q6NTQ4OVwvU1NPIiwibGFzdF9uYW1lIjoic21pdGgiLCJjcmVkZW50aWFsVHlwZSI6IlVzZXJ
uYW1lUGFzc3dvcmRDcmVkZW50aWFsIiwiYXVkIjoiaHR0cHM6XC9cLzEwLjE5NC42My4xOTg6MzA2MDNcL2FwcC1kYXNoY
m9hcmQiLCJhdXRoZW50aWNhdGlvbk1ldGhvZCI6IlF1ZXJ5RGF0YWJhc2VBdXRoZW50aWNhdGlvbkhhbmRsZXIiLCJsb25
nVGVybUF1dGhlbnRpY2F0aW9uUmVxdWVzdFRva2VuVXNlZCI6ImZhbHNlIiwiY2hhbmdlX3B3ZCI6ImZhbHNlIiwiZXhwI
joxNjE2NDU5OTIwLCJpYXQiOjE2MTY0MzExMjAsImZpcnN0X25hbWUiOiJqb2huIiwianRpIjoiU1QtODQtOFVlWXMybEt
3R2d1Z3RIYjl4MzVmTFlNTGVVRlp6OURyNGpoeFcxakhsV01VYXdXSWgxbUdTd01aRC1tOEk1S2Z0amI2ZmlWTUhlYnBYY
jBMMFZqRFc2WVppUFVUbHRpNFVpZnNUeG9aQ284WWpPWEc2VlFjS0Mwb29lWjJhc3BWanMzYnA3bHo5VkhySlBCTzl5TDN
GcFRIWXRPeWJtVi1jYXMtMSJ9.Vi4k0w8KsOv5M_O8zBqWochT3k9V9Pn2NjSn5ES9c5Pf-
4ds0o4kk6xuZx5_cggauiEICuUMnzmRzneST-oAuA' \
--data-raw '{
  "input": {
    "head-end": "100.100.100.5",
    "end-point": "100.100.100.7",
    "sr-policy-path": {
      "path-optimization-objective": "igp-metric"
    }
  }
}'
```

Step 3 Note the SID list ID in the API response. You will use this when creating the SID list in the next step. For example:

```
{
  "cisco-crosswork-optimization-engine-sr-policy-operations:output": {
    "segment-list-hops": [
      {
        "step": 0,
        "sid": 23002,
        "ip-address": "100.100.100.7",
        "type": "node-ipv4"
      }
    ],
    "igp-route": [
      {
        "node": "PE-A",
        "interface": "GigabitEthernet0/0/0/0"
      },
      {
        "node": "P-TOPLEFT",
        "interface": "GigabitEthernet0/0/0/2"
      },
      {
        "node": "P-BOTTOMRIGHT",
        "interface": "GigabitEthernet0/0/0/3"
      }
    ],
    "state": "success",
    "message": ""
  }
}
```

Step 2 Create the SID List in the Provisioning UI

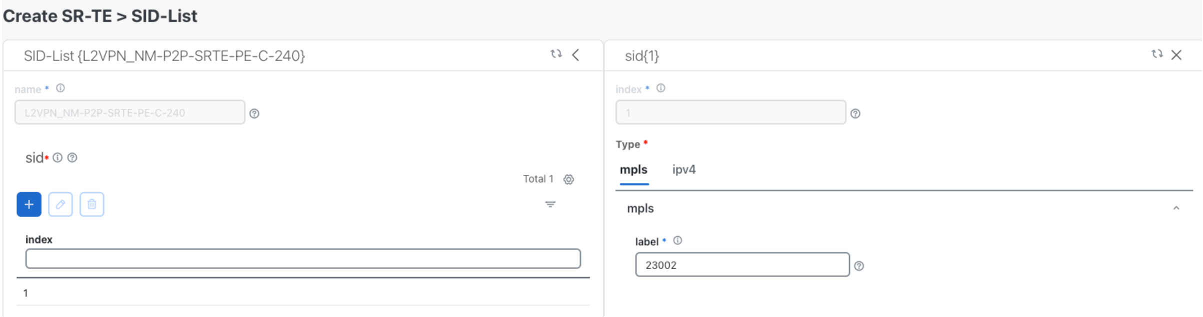
In this scenario, we will create a SID list for traffic from PE-C to PE-A and another SID list for traffic in the opposite direction.

Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **SR-TE** > **SID-List**.

Step 2 Click + to create a new SID list and give it a unique name. For this example, the SID list name is **L2VPN_NM-P2P-SRTE-PE-C-240**. Click **Continue**.

Step 3 Under sid, click + to create a new SID index and give it a numeric value. Click **Continue**.

Step 4 Under mpls, enter the SID ID that was received in the API response in Step 1.



Create SR-TE > SID-List

SID-List {L2VPN_NM-P2P-SRTE-PE-C-240}

name * : L2VPN_NM-P2P-SRTE-PE-C-240

sid{1}

index * : 1

Type * : mpls

label * : 23002

Step 5 Click **X** in the top-right corner to return to the SID list. Your new SID appears in the index table.

Step 6 Repeat these steps to create additional SID indexes, as required.

Step 7 Commit your changes.

Step 8 Check that the new SID list appears in the table.

Step 9 Create another SID list for the traffic from PE-A to PE-C. For this example, the SID list name is **L2VPN_NM-P2P-SRTE-PE-A-240**.

Step 3 Create an explicit SR-TE policy for each VPN endpoint by importing a file

In this step, we will provision two explicit SR-TE policies which will reference the SID lists created in Step 1.

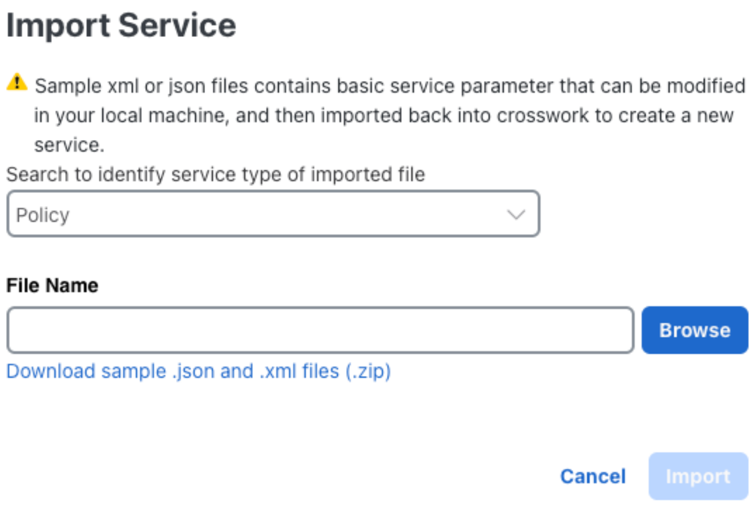
The first SR-TE policy specifies PE-C as the headend and provides the IP address of PE-A as the tail end. The second SR-TE policy specifies PE-A as the headend and provides the IP address of PE-C as the tail end.

Instead of manually filling in each field in the provisioning UI, we will import an xml file containing all the configurations required to create the SR-TE policy.

Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **SR-TE** > **Policy**.

Step 2 Click ⤓ to import.

Step 3 Download the sample .json or .xml file which will serve as a template for the required configuration. In the Import Service dialog, click the **Download sample .json and .xml files (.zip)** link



Import Service

⚠ Sample xml or json files contains basic service parameter that can be modified in your local machine, and then imported back into crosswork to create a new service.

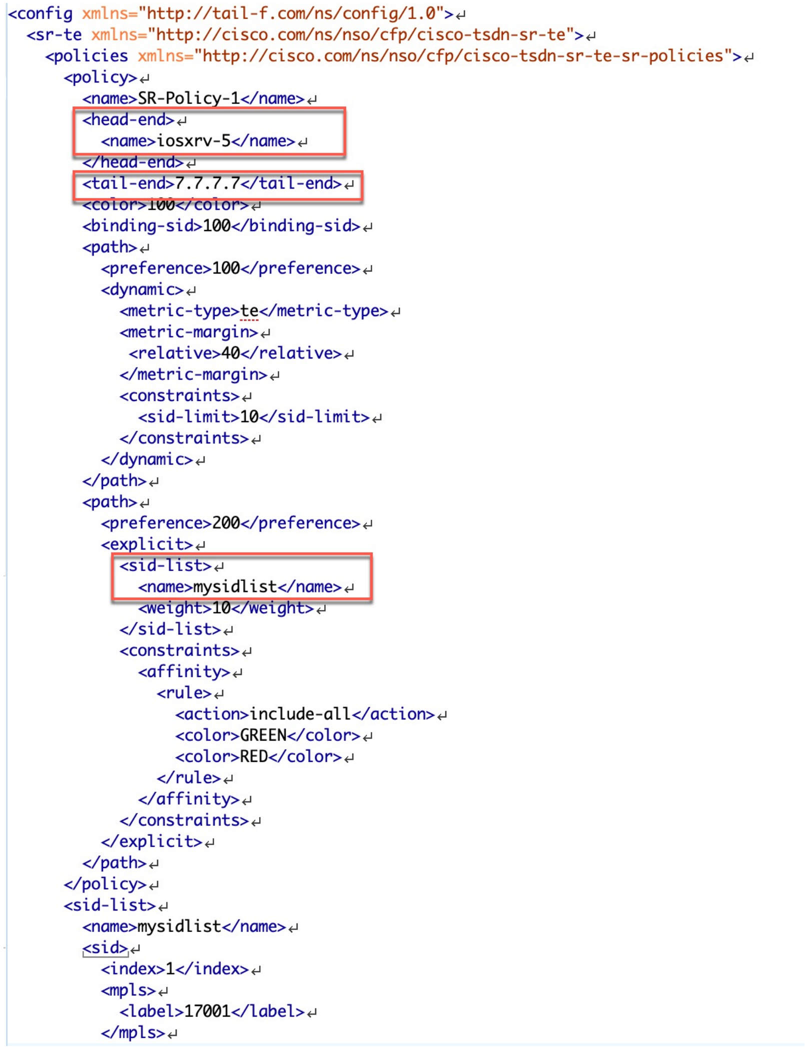
Search to identify service type of imported file

Policy

File Name

Step 4 Unzip the downloaded file and open sr-Policy.xml in an XML editor.

Step 5 Edit the xml file as required. Provide a name for the SR-TE policy, and specify the SID list to be associated with this policy. Save the xml file.



```
<config xmlns="http://tail-f.com/ns/config/1.0">
  <sr-te xmlns="http://cisco.com/ns/nso/cfp/cisco-tsdn-sr-te">
    <policies xmlns="http://cisco.com/ns/nso/cfp/cisco-tsdn-sr-te-sr-policies">
      <policy>
        <name>SR-Policy-1</name>
        <head-end>
          <name>iosxrv-5</name>
        </head-end>
        <tail-end>7.7.7.7</tail-end>
        <color>100</color>
        <binding-sid>100</binding-sid>
        <path>
          <preference>100</preference>
          <dynamic>
            <metric-type>te</metric-type>
            <metric-margin>
             <relative>40</relative>
            </metric-margin>
            <constraints>
              <sid-limit>10</sid-limit>
            </constraints>
          </dynamic>
        </path>
        <path>
          <preference>200</preference>
          <explicit>
            <sid-list>
              <name>mysidlist</name>
              <weight>10</weight>
            </sid-list>
            <constraints>
              <affinity>
                <rule>
                  <action>include-all</action>
                  <color>GREEN</color>
                  <color>RED</color>
                </rule>
              </affinity>
            </constraints>
          </explicit>
        </path>
      </policy>
      <sid-list>
        <name>mysidlist</name>
        <sid>
          <index>1</index>
          <mpls>
            <label>17001</label>
          </mpls>
```

Step 6 In the Import Service dialog, select **Policy** as the type of file to import, browse to the edited xml file, and click ⤓. If there are any errors in the file, you will be notified. If there are no errors, the file will be imported. The policy will be created and the devices will be configured accordingly.

Step 7 Check whether the new SR-TE policy appears in the Policy table and its Provisioning State is **Success**.

Step 8 Click ⋯ in the Actions column and choose **Config View** to see to see the Yang model-based service intent data that details the SR-TE policy you created. You can also check the devices themselves to make sure that they were provisioned correctly.

Step 4 Create and provision the L2VPN service

In this step, we will create and provision a P2P VPN service with PE-A and PE-C as the endpoints. The VPN service will reference the SR-TE policies we created in the previous step to ensure that the traffic traversing the VPN will follow the path defined in the SID lists.

As we did with the SR-TE policy, we will create the VPN service by importing an xml file containing all the required configurations. Once we have provisioned the VPN service, we will edit it in the provisioning UI in order to associate the SR-TE policies.

Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L2vpn** > **L2vpn-Service**.

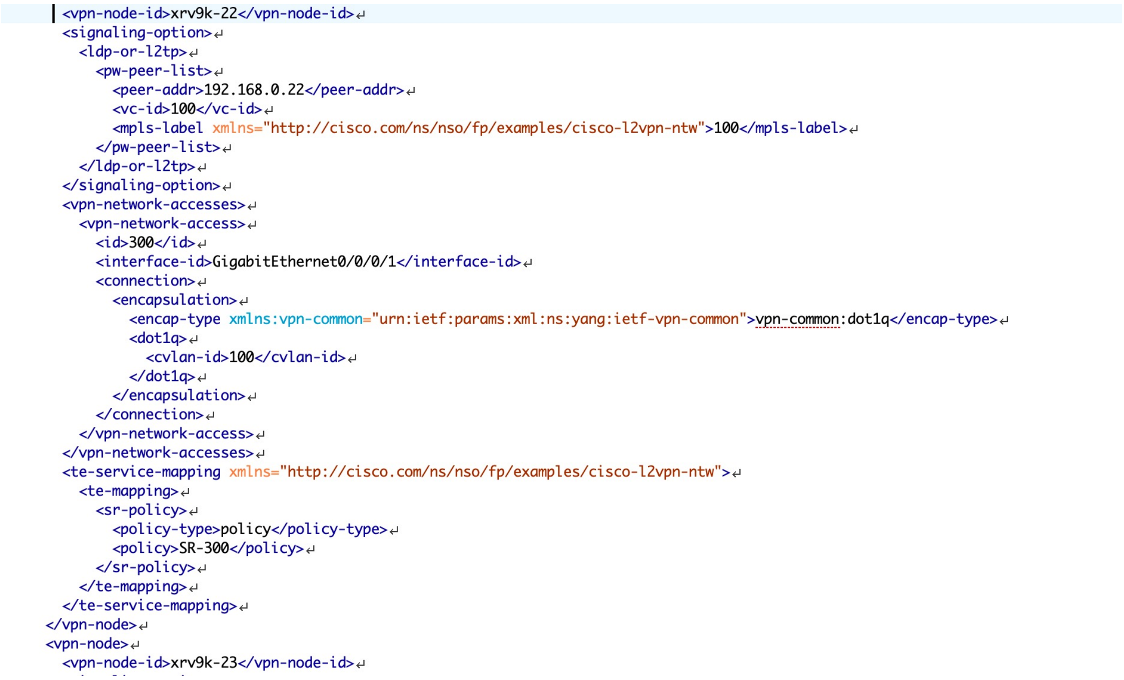
Step 2 Click ⤓ to import.

Step 3 If you did not download the sample .json or .xml files in Step 3, do so now.

Step 4 Open l2nm.xml in an XML editor.

Step 5 Edit the xml file as required. Provide a name for the L2VPN, configure each endpoint, and define the VPN parameters.

This is the configuration for PE-A in our example:



```
  <vpn-node-id>xrv9k-22</vpn-node-id>
  <signaling-option>
    <ldp-or-l2tp>
      <pw-peer-list>
        <peer-addr>192.168.0.22</peer-addr>
        <vc-id>100</vc-id>
        <mpls-label xmlns="http://cisco.com/ns/nso/fp/examples/cisco-l2vpn-ntw">100</mpls-label>
      </pw-peer-list>
    </ldp-or-l2tp>
  </signaling-option>
  <vpn-network-accesses>
    <vpn-network-access>
      <id>300</id>
      <interface-id>GigabitEthernet0/0/0/1</interface-id>
      <connection>
        <encapsulation>
          <encap-type xmlns:vpn-common="urn:ietf:params:xml:ns:yang:ietf-vpn-common">vpn-common:dot1q</encap-type>
          <dot1q>
            <cvlan-id>100</cvlan-id>
          </dot1q>
        </encapsulation>
      </connection>
    </vpn-network-access>
  </vpn-network-accesses>
  <te-service-mapping xmlns="http://cisco.com/ns/nso/fp/examples/cisco-l2vpn-ntw">
    <te-mapping>
      <sr-policy>
        <policy-type>policy</policy-type>
        <policy>SR-300</policy>
      </sr-policy>
    </te-mapping>
  </te-service-mapping>
</vpn-node>
<vpn-node>
  <vpn-node-id>xrv9k-23</vpn-node-id>
```

Step 6 Save the xml file.

Step 7 In the Import Service dialog, select **l2vpn service** as the type of file to import, browse to the edited xml file, and click ⤓. If there are any errors in the file, you will be notified. If there are no errors, the file will be imported. The service will be created and the devices will be configured accordingly.

Step 8 Check that the new L2VPN service appears in the L2VPN Service table and its Provisioning State is **Success**.

Step 9 Click ⋯ in the Actions column and choose **Config View** to see the Yang model-based service intent data that details the VPN service you created. You can also check the devices themselves to make sure that they were provisioned correctly.

Step 5 Attach the SR-TE policies to the L2VPN Service

At this stage, the provisioned L2VPN service you created does not have associated SR-TE policies that define the transport path. In this step, we will edit the L2VPN service in the provisioning GUI, attach the relevant SR-TE policies to each endpoint, and re-provision it.

Step 1 Locate the L2VPN in the VPN Service table.

Step 2 Click ⋯ in the Actions column and choose **Edit**.

Step 3 Under vpn-nodes, select **PE-A** and click the **Edit** button above the table.

Step 4 In the pane that opens on the right, open the **te-service-mapping > te-mapping** section.

Step 5 In the sr-policy tab, in the policy field, enter the name of the SR-TE policy created for PE-A:**L2VPN_NM-P2P-SRTE-PE-A-240**.

Step 6 Click **X** in the top-right corner to close the PE-A pane.

Step 7 Repeat the above steps for PE-C and attach the SR-TE policy: **L2VPN_NM-P2P-SRTE-PE-C-240**.

Step 8 Click **Commit Changes**.

Step 6 Enable Service Health monitoring

After creating and provisioning the required L2VPN services, you can begin monitoring their health.

Before you begin

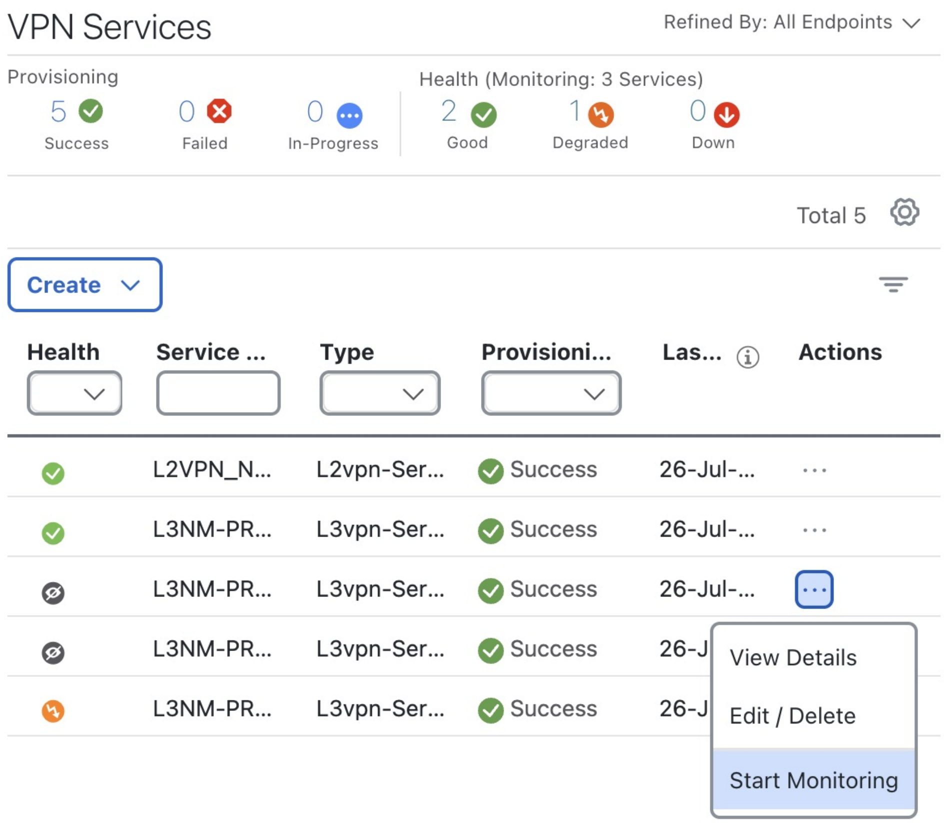
- Ensure that Crosswork Service Health is installed. For details, see the "Install Crosswork Applications" chapter in the *Cisco Crosswork Network Controller Installation Guide*.
- Ensure that the required L2VPN services are created and provisioned.

To enable service health monitoring, do the following:

Step 1 From the main menu, choose **Services & Traffic Engineering** > **VPN Services**. The map opens on the left side of the page and the table opens on the right side.

Step 2 In the Actions column, click ⋯ for the service you want to start monitoring the health.

Step 3 Click **Start Monitoring**.



VPN Services

Refined By: All Endpoints

Provisioning: 5 ✓ Success, 0 ✗ Failed, 0 ··· In-Progress

Health (Monitoring: 3 Services): 2 ✓ Good, 1 Degraded, 0 Down

Total 5

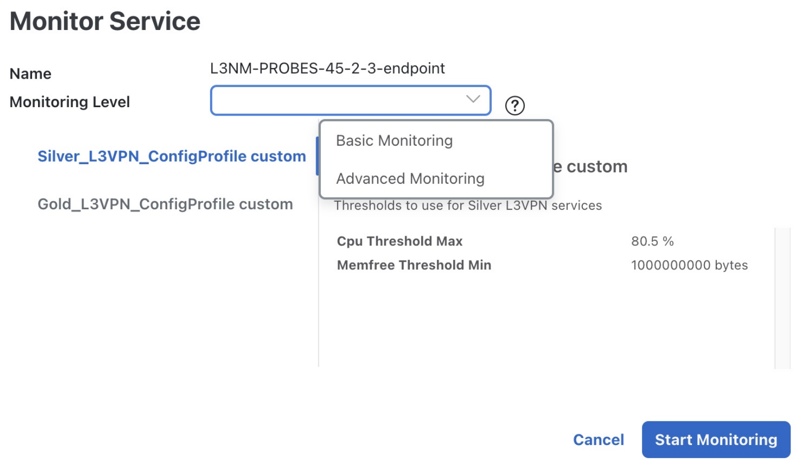
Create

Health	Service ...	Type	Provisioni...	Las... ⓘ	Actions
✓	L2VPN_N...	L2vpn-Ser...	✓ Success	26-Jul-...	···
✓	L3NM-PR...	L3vpn-Ser...	✓ Success	26-Jul-...	···
⌀	L3NM-PR...	L3vpn-Ser...	✓ Success	26-Jul-...	···
⌀	L3NM-PR...	L3vpn-Ser...	✓ Success	26-J	
●	L3NM-PR...	L3vpn-Ser...	✓ Success	26-J	

Note The Health column color coding indicates the health of the service:

- Blue = Initiated
- Green = Good
- Orange = Degraded
- Red = Down
- Gray = Not Monitoring

Step 4 In the Monitor Service dialog box, select the Monitoring Level. For help with selecting the appropriate monitoring level for your needs, see the **Cisco Crosswork Network Controller 6.0 Service Health Guide** > **Basic and Advanced Monitoring Rules** section.



Monitor Service

Name: L3NM-PROBES-45-2-3-endpoint

Monitoring Level:

Thresholds to use for Silver L3VPN services

Cpu Threshold Max	80.5 %
Memfree Threshold Min	1000000000 bytes

Once you have started monitoring the health of this service, if you select the Actions column and click to view additional Service Health options, you will see: **Stop Monitoring**, **Pause Monitoring**, **Edit Monitoring Settings**, **Assurance Graph.**

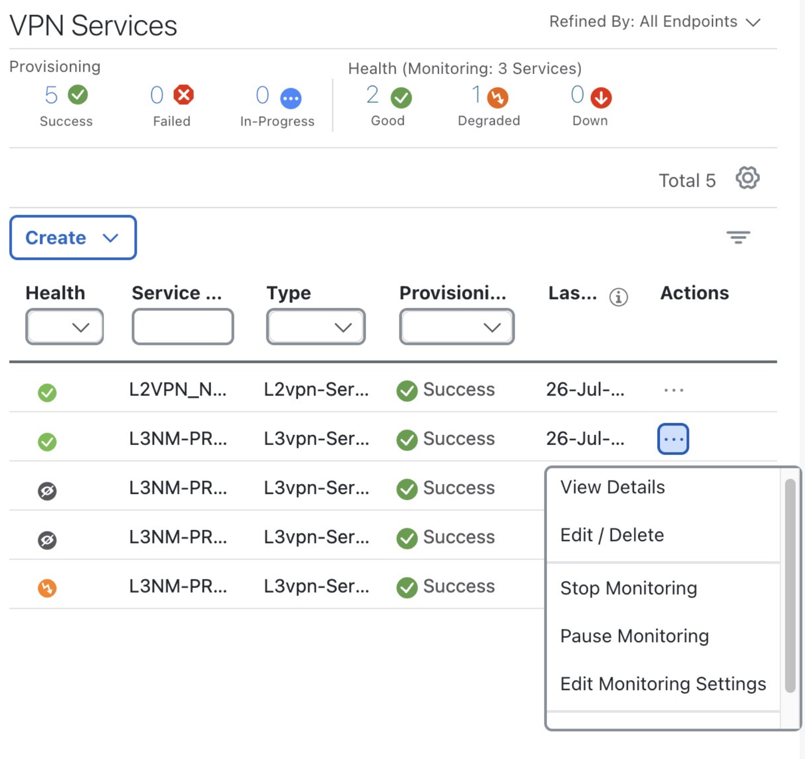
Note If you select **Edit Monitoring Settings**, you may update the Monitoring Level setting from Basic Monitoring to Advanced Monitoring, or from Advanced Monitoring to Basic Monitoring, at any time.

Note If you later decide to **Stop Monitoring** a service that has already been started, you have the option to retain the historical service data for that stopped service. See the **Cisco Crosswork Network Controller 6.0 Service Health Guide > Stop Service Health Monitoring** section for more detailed information.

Step 5 Click **Start Monitoring**.

Note

Once you have started monitoring the health of the service, in the Actions column, if you click ⋯ to view additional Service Health options, you will see: Stop Monitoring, Pause Monitoring, Edit Monitoring Settings, and Assurance Graph.



VPN Services

Refined By: All Endpoints

Provisioning			Health (Monitoring: 3 Services)		
5 ✓ Success	0 ✕ Failed	0 ⋯ In-Progress	2 ✓ Good	1 Degraded	0 Down

Total 5

Health	Service ...	Type	Provisioni...	Las...	Actions
✓	L2VPN_N...	L2vpn-Ser...	✓ Success	26-Jul-...	⋯
✓	L3NM-PR...	L3vpn-Ser...	✓ Success	26-Jul-...	⋯
⊘	L3NM-PR...	L3vpn-Ser...	✓ Success		
⊘	L3NM-PR...	L3vpn-Ser...	✓ Success		
●	L3NM-PR...	L3vpn-Ser...	✓ Success		

Step 6 Repeat these steps for each service that you wish to start health monitoring.

Step 7 Click **X** in the top-right corner when you are done.

Step 7 Visualize the L2VPN on the Map

In this step we will take a look at the representation of the L2VPN on the map, and we'll see the paths the traffic will take from PE-A to PE-C and vice versa, based on the explicit SR-TE policies we created.

Step 1 In the L2VPN Service table, in the Actions column for the new VPN, click ⋯ and choose **ViewDetails** from the menu. The map opens and the service details are shown to the right of the map.

or

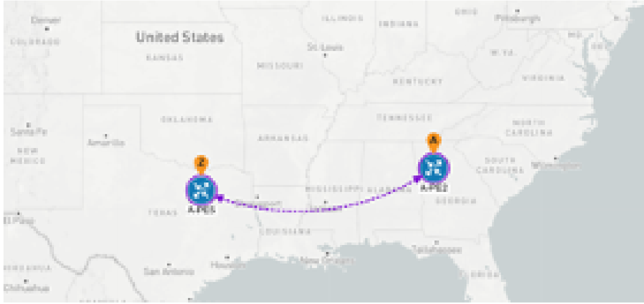
Go to **Services & Traffic Engineering** > **VPN Services**.

The map opens and a table of VPN services is displayed to the right of the map.

a) Click on the VPN in the Services table. If there are many services in the table, you can filter by name, type, or provisioning state to help locate the VPN.

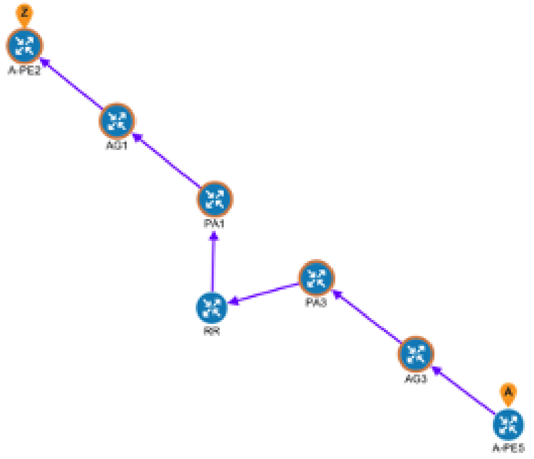
b) In the map, you will see the VPN as an overlay on the topology. It shows a representation of the endpoints and a solid line that indicates that it is a virtual path.

c) Select the **Show Participating Only** check box if you do not want to see the devices that are not involved in the selected VPN.



Step 2 Under the Actions column, click ⋯ and choose **View Details** to drill down to a detailed view of the VPN service, including the device configurations, the computed transport paths, and the health status for transport paths.

Step 3 In the Transport tab, select one or more SR-TE policies to see the path from endpoint to endpoint on the map. The image below shows the path for PE-C to PE-A. The **Show IGP Path** check box in the top left corner of the map is selected so the physical path is shown. The dashed line indicates that this link is being used to transport multiple services.



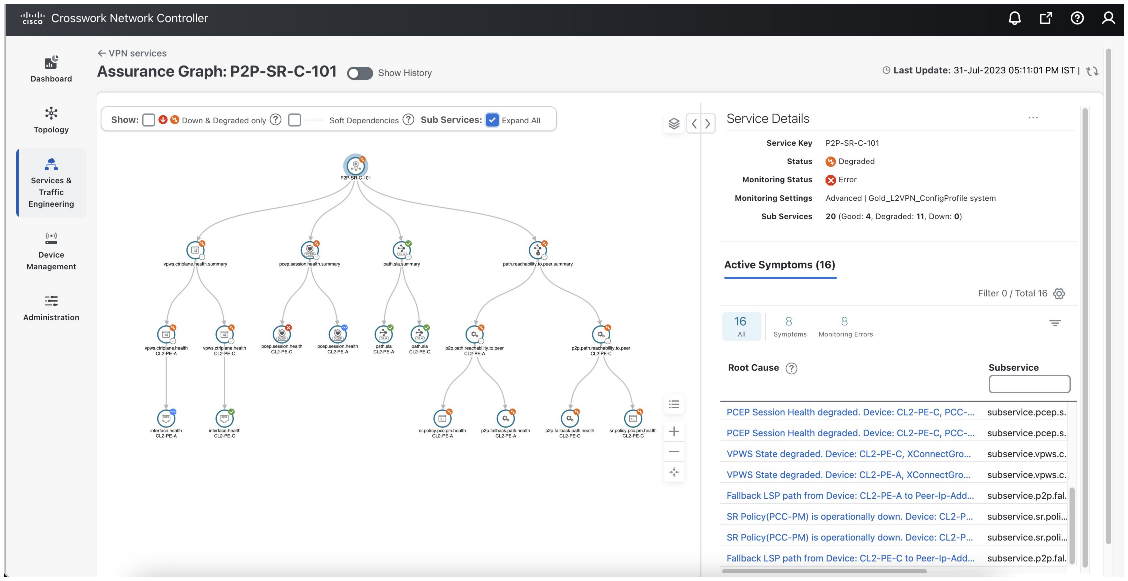
Step 8 Inspect a degraded service using Service Health and Last 24Hr Metrics to identify issues

In this step, you can utilize the Last 24Hr Metrics to identify the issues with the degraded services within a specific time range. By isolating the issues within a specific time range, you can drill down on the details that may have caused the degraded (or down) service that can lead to troubleshooting the service or the node to address detailed symptoms.

Step 1 Return to the VPN Services list.

Step 2 In the Actions column, click ⋯ for the degraded service and click **Assurance Graph**. The topology map of services and subservices appear with the Service Details panel showing Service Key, Status, Monitoring Status, Monitoring Settings, Sub Services, and Active Symptoms details.

Note This may take up to 5-10 minutes to update after a service has been enabled for monitoring.


Crosswork Network Controller
Dashboard
Topology
Services & Traffic Engineering
Device Management
Administration
← VPN services
Show: □ Down & Degraded only □ Soft Dependencies Sub Services: ☑ Expand All
Show History
P2P-SR-C-101

Assurance Graph: P2P-SR-C-101

Last Update: 31-Jul-2023 05:11:01 PM IST |

Service Details

Service Key	P2P-SR-C-101
Status	Degraded
Monitoring Status	Error
Monitoring Settings	Advanced | Gold_L2VPN_ConfigProfile system
Sub Services	**20** (Good: **4**, Degraded: **11**, Down: **0**)

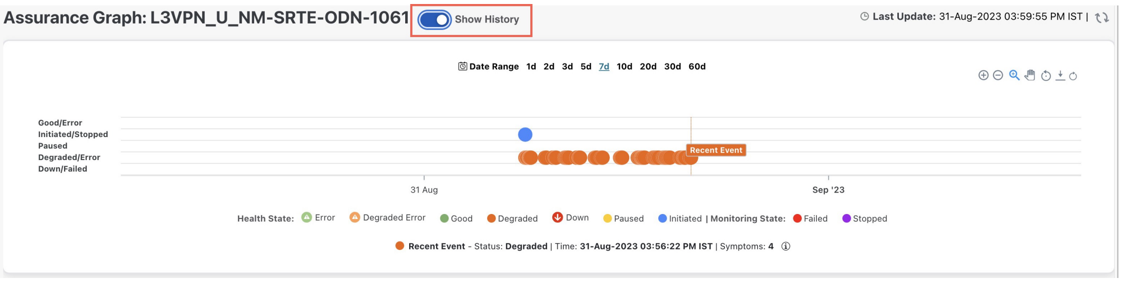
Active Symptoms (16)

Filter 0 / Total 16

16 All | 8 Symptoms | 8 Monitoring Errors

Root Cause	Subservice
PCEP Session Health degraded. Device: CL2-PE-C, PCC-...	subservice.pcep.s.
PCEP Session Health degraded. Device: CL2-PE-C, PCC-...	subservice.pcep.s.
VPWS State degraded. Device: CL2-PE-C, XConnectGro...	subservice.vpws.c.
VPWS State degraded. Device: CL2-PE-A, XConnectGro...	subservice.vpws.c.
Fallback LSP path from Device: CL2-PE-A to Peer-Ip-Add...	subservice.p2p.fal.
SR Policy(PCC-PM) is operationally down. Device: CL2-P...	subservice.sr.poli...
SR Policy(PCC-PM) is operationally down. Device: CL2-P...	subservice.sr.poli...
Fallback LSP path from Device: CL2-PE-C to Peer-Ip-Add...	subservice.p2p.fal.

Step 3 At the top of the page, click the **Show History** mode toggle. The historical Date Range graph appears. This graph shows different ranges of historical health service monitoring details from one day (1d) up to sixty days (60d). When you hover over an event on the Date Range graph, a tool tip with information about that event appears (such as date and time of the event, and number of symptoms).


Show History
Date Range 1d 2d 3d 5d 7d 10d 20d 30d 60d
Good/Error
Initiated/Stopped
Paused
Degraded/Error
Down/Failed
Recent Event
31 Aug
Sep '23
Health State: Error Degraded Error Good Degraded Down Paused Initiated | Monitoring State: Failed Stopped

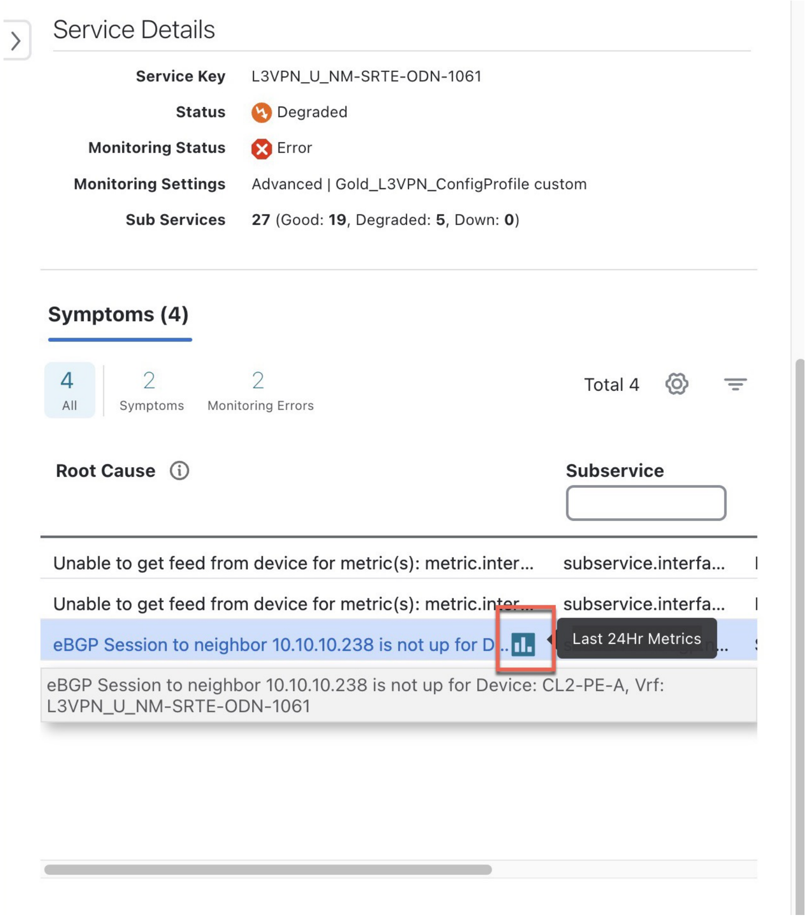
Assurance Graph: L3VPN_U_NM-SRTE-ODN-1061

Last Update: 31-Aug-2023 03:59:55 PM IST |

Recent Event - Status: **Degraded** | Time: **31-Aug-2023 03:56:22 PM IST** | Symptoms: **4**

Step 4 Review the Root Cause information by clicking a particular event in the graph. The Service Details panel reloads, showing the active symptoms and the root causes associated with the event. Columns can be resized using your mouse or you can select the gear icon to deselect or select columns you want to appear.

Note Once you enable **Show History** mode, Root Cause information in the Active Symptoms table will start to show the blue Last 24Hr Metrics icon. Data from the device will be initially delayed, however, and may take some time before **Last 24Hr Metrics** begins to populate with data. Until then, the value of zero is reported.



Service Details

Service Key	L3VPN_U_NM-SRTE-ODN-1061
Status	Degraded
Monitoring Status	Error
Monitoring Settings	Advanced | Gold_L3VPN_ConfigProfile custom
Sub Services	**27** (Good: **19**, Degraded: **5**, Down: **0**)

Symptoms (4)

4 All | 2 Symptoms | 2 Monitoring Errors

Total 4

Root Cause	Subservice
Unable to get feed from device for metric(s): metric.inter...	subservice.interfa...
Unable to get feed from device for metric(s): metric.inter...	subservice.interfa...
eBGP Session to neighbor 10.10.10.238 is not up for D...	...

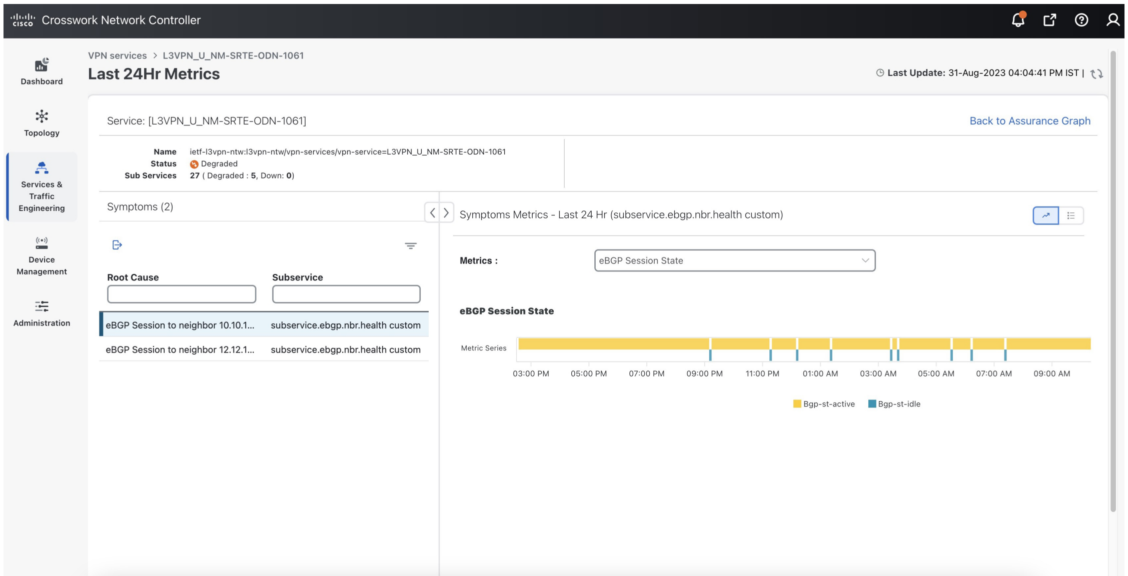
eBGP Session to neighbor 10.10.10.238 is not up for Device: CL2-PE-A, Vrf: L3VPN_U_NM-SRTE-ODN-1061

Step 5 To further isolate the possible issues and to utilize the **Last 24Hr Metrics**, perform the following steps:

a) In the Date Range graph, use your mouse to select the range of historical health service monitoring details from one day (1d) up to sixty days (60d).

Note At the top-right of the Date Range graph, select the appropriate icons to either zoom in or out, horizontally scroll through the date ranges, or refresh the graph to go back to the most recent event, for example. You can also use your mouse to draw a rectangle over events to further zoom in on the degraded devices. Events that are consecutive may appear as a line of white space.

b) Click on a degraded event in the graph. The Service Details panel reloads, showing any active symptoms and the root causes to be inspected. Expand the table and information as necessary for further details.



Last 24Hr Metrics

Last Update: 31-Aug-2023 04:04:41 PM IST |

Service: [L3VPN_U_NM-SRTE-ODN-1061]

Name: ietf-l3vpn-ntw:l3vpn-ntw/vpn-services/vpn-service=L3VPN_U_NM-SRTE-ODN-1061
Status: Degraded
Sub Services: 27 (Degraded : 5, Down: 0)

Symptoms (2)

Root Cause	Subservice
eBGP Session to neighbor 10.10.1...	subservice.ebgp.nbr.health custom
eBGP Session to neighbor 12.12.1...	subservice.ebgp.nbr.health custom

Symptoms Metrics - Last 24 Hr (subservice.ebgp.nbr.health custom)

Metrics : eBGP Session State

eBGP Session State

Step 6 Check the **Down & Degraded Only** check box at the top-left corner of the map to show only the Subservices which are degraded, along with other dependent but healthy subservices. Inspect the Service Details panel showing the active symptoms and their root cause. Uncheck the **Down & Degraded Only** check box and check the **Soft Dependencies** check box in the top-left corner of the map. Soft Dependencies implies that a child subservice's health has a weak correlation to its parent's health. As a result, the degraded health of the child will not result in the parent's health degradation.

Use the **+** or **–** symbols in the bottom-right corner of the map to zoom in or out on services mapped. Select the **?** to view the Link Color Legend that explains all of the icons, symbols, badges, and colors and their definitions.

Step 7 Select the degraded subservice in the map to show the subservice details.

Step 8 Click the **Symptoms** tab to show any root causes for the service health details that are displayed and then click the **Impacted Services** tab to view the impacted services.

Step 9 Click **X** in the top-right corner to return to the VPN Services list and in the Actions column, click ⋯ for the degraded service in the list and click **Assurance Graph** to show the Service Details panel.

Step 10 Again, select the **Show History** toggle in the top-right corner of the Service Details panel before selecting the blue metrics icon in one of the Root Cause rows. The Symptoms Metrics – Last 24 Hr bar chart appears. This chart provides details of the metric patterns for different sessions states (such as active, idle, failed) for individual root cause symptoms with Status, Session, Start Time, and Duration information to assist in troubleshooting prevailing issues. Use your mouse to hover over the chart to view the different details.

Continue to troubleshoot a service health issue using Parameterized Jobs

To further troubleshoot a service health issue (such as a device that is degraded due to not properly fetching data), continue with the following steps to examine if the issue is associated with a collection job.

Step 11 From the main menu, choose **Administration** > **Collection Jobs**.

The Collection Jobs page appears.

Step 12 Click the **Parameterized Jobs** tab.

Step 13 Review the Parameterized Jobs list to identify the devices that may have service health degradation issues. By reviewing Parameterized Jobs, you can identify and focus on gNMI, SNMP, and CLI-based jobs by their Context ID (protocol) for further troubleshooting purposes.

Step 14 In the Job Details panel, select the collection job you want to export and download the status of collection jobs for further examination. The information provided is collected in a .csv file when the export is initiated.

Note When exporting the collection status, you must fill in the information each time an export is executed. In addition, make sure to review the **Steps to Decrypt Exported File** content available on the Export Collection Status dialog box to ensure you can access and view the exported information.

Step 15 Click **Export**.

Step 16 To check the status of the exported collection job data, click **View Export Status** at the top right of the Job Details panel. The Export Status Jobs panel appears providing the status of the export request.

Step 17 Review the exported .csv file for collection job details and the possible cause of the degraded device.

Summary and Conclusion

In this scenario, we observed how simple it is to create explicit SR-TE policies and attach them to a L2VPN service in order mandate a static path for the mission-critical traffic. We saw how editing a pre-defined template and then importing it into the system enables quick and easy provisioning of services and SR-TE policies. We were then able to visualize the actual traffic paths on the map. Lastly, we used Service Health to monitor the health of the new service using the Assurance Graph, Last 24hr Metrics, and SubExpressions metrics to view when service may have been up, degraded, or down, and what the root causes were identified.

Scenario: Provision an L2VPN Service over an RSVP-TE Tunnel with Reserved Bandwidth

For the continuous stream transmission required for rich data media types, such as video and audio, bandwidth reservation is often required to provide higher quality of service. Cisco Crosswork Network Controller supports the creation and management of RSVP-TE tunnels to reserve guaranteed bandwidth for an individual flow. RSVP is a per-flow protocol that requests a bandwidth reservation from every node in the path of the flow. The endpoints, or other network devices on behalf of the endpoints, send unicast signaling messages to establish the reservation before the flow is allowed. If the total bandwidth reservation exceeds the available bandwidth for a particular LSP segment, the LSP is rerouted through another LSR. If no segments can support the bandwidth reservation, LSP setup fails and the RSVP session is not established.

In this scenario we will:

- Create RSVP-TE tunnels with reserved bandwidth.
- Enable Bandwidth on Demand functionality.
- Provision a VPN service from PE-A to PE-B and attach the RSVP-TE tunnels as underlay configuration.
- Visualize the path of the traffic when link utilization is below the bandwidth threshold. This path would change if the bandwidth utilization on the link crossed the specified threshold.

Assumptions and Prerequisites

Scenario 4 to provision an L2VPN service over an RSVP TE Tunnel with reserved bandwidth the following are the assumptions and prerequisites.

- For transport mapping to L2VPN service, devices must be configured with the **l2vpn all** command.
- For Service Health enablement and usage to monitor a services health, Service Health must be installed.
- For steps to enable Service Health during this scenario, see Scenario 3, Step 6 Enable Service Health monitoring. For additional Service Health related details, see Scenario: Implement and Maintain SLA for an L3VPN Service for SR-MPLS (using ODN), Scenario: Mandate a Static Path for an EVPN-VPWS Service using an Explicit MPLS SR-TE Policy.
- (Optional) Service Health provides **Internal Storage** of monitoring data up to a maximum limit of 50 GB. This data is stored on your system. If you exceed the limit of the internal storage, the least recently used historical data will be lost. If you choose to extend Service Health storage capacity, you can configure **External Storage** in the cloud using an Amazon Web Services (AWS) cloud account. By leveraging External Storage, all existing internal storage data will be automatically moved to the external cloud storage (see **Configuring Service Health External Storage Settings** for more details) and your internal storage will act locally as cache storage. Configuring External Storage for Service Health ensures you will not lose historical data for services that continue to monitor a service's health, and will retain service health data for any service you choose to stop monitoring when you select the option to retain historical monitoring service for the data. For more information on Internal and External Storage, and how to retain historical monitoring service data when stopped, see **Configuring Service Health External Storage Settings** and **Stopping Service Health monitoring**.
- (Optional) For initializing a Heuristic Package to monitor health of a services, see **Initializing Heuristic Packages to monitor the health of a service** for detailed steps to be performed prior to starting monitoring.

Step 1 Create an RSVP-TE tunnel for both directions of the L2VPN

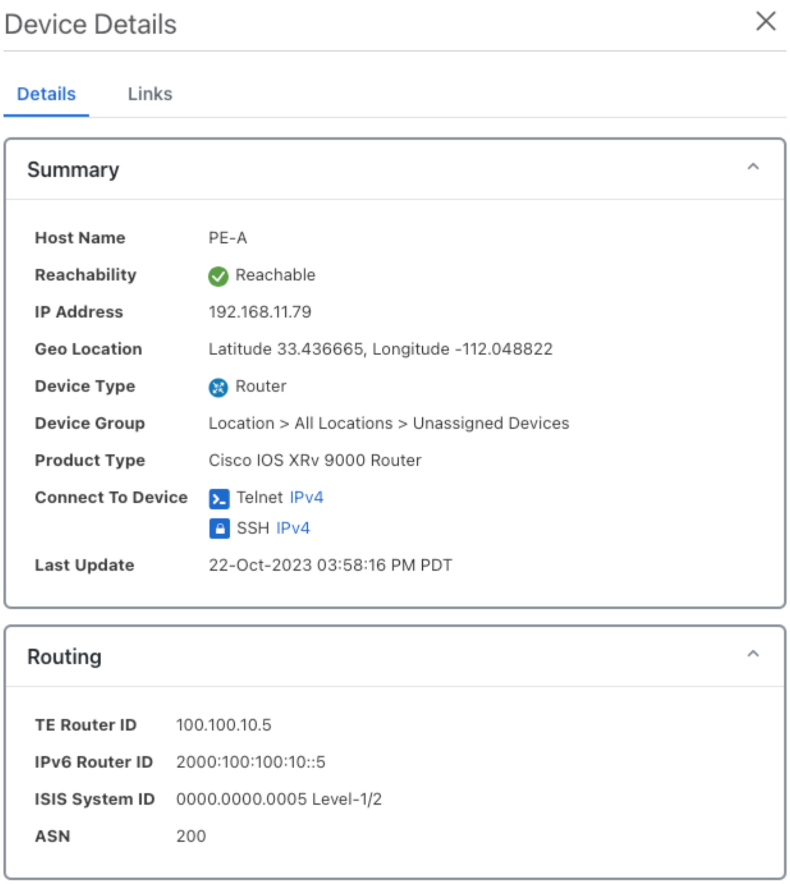
In this step, we will create an RSVP-TE tunnel from PE-A to PE-B and from PE-B to PE-A, and we'll reserve bandwidth of 1200 on the link.

Step 1 Go to Services & Traffic Engineering > Provisioning**(NSO) > RSVP-TE > Tunnel**.

Step 2 Click + to create a new RSVP-TE tunnel and give it a unique name. Click **Continue**.

Step 3 In the Identifier field, enter a numeric identifier for the tunnel. You will use this identifier later when you associate this RSVP-TE tunnel with the L2VPN service. For this example, the identifier is **2220**.

Step 4 In the source and destination fields, enter the loopback0 IP address of the source (PE-A) and the destination (PE-B) devices. This is the TE router ID. To find the TE router ID, go to Topology and click on a device in the map or in the list of devices. The Device Details pane opens and the TE router ID is shown under the Routing section.



Summary

Host Name	PE-A
Reachability	✓ Reachable
IP Address	192.168.11.79
Geo Location	Latitude 33.436665, Longitude -112.048822
Device Type	Router
Device Group	Location > All Locations > Unassigned Devices
Product Type	Cisco IOS XRv 9000 Router
Connect To Device	Telnet IPv4 SSH IPv4
Last Update	22-Oct-2023 03:58:16 PM PDT

Routing

TE Router ID	100.100.10.5
IPv6 Router ID	2000:100:100:10::5
ISIS System ID	0000.0000.0005 Level-1/2
ASN	200

Step 5 Define the endpoints:

a) Under head-end, select the headend device from the dropdown list.

b) Under tail-end, select the tailend device from the dropdown list.

Step 6 Reserve bandwidth on the link. Under te-bandwidth > generic, enter the bandwidth threshold for the link.

Step 7 Define the path of the RSVP-TE tunnel.

You have the option to define an explicit path or to have the path locally computed by the participating devices. Alternatively, you can have the SR-PCE compute a path dynamically. For this scenario we will have the path locally computed.

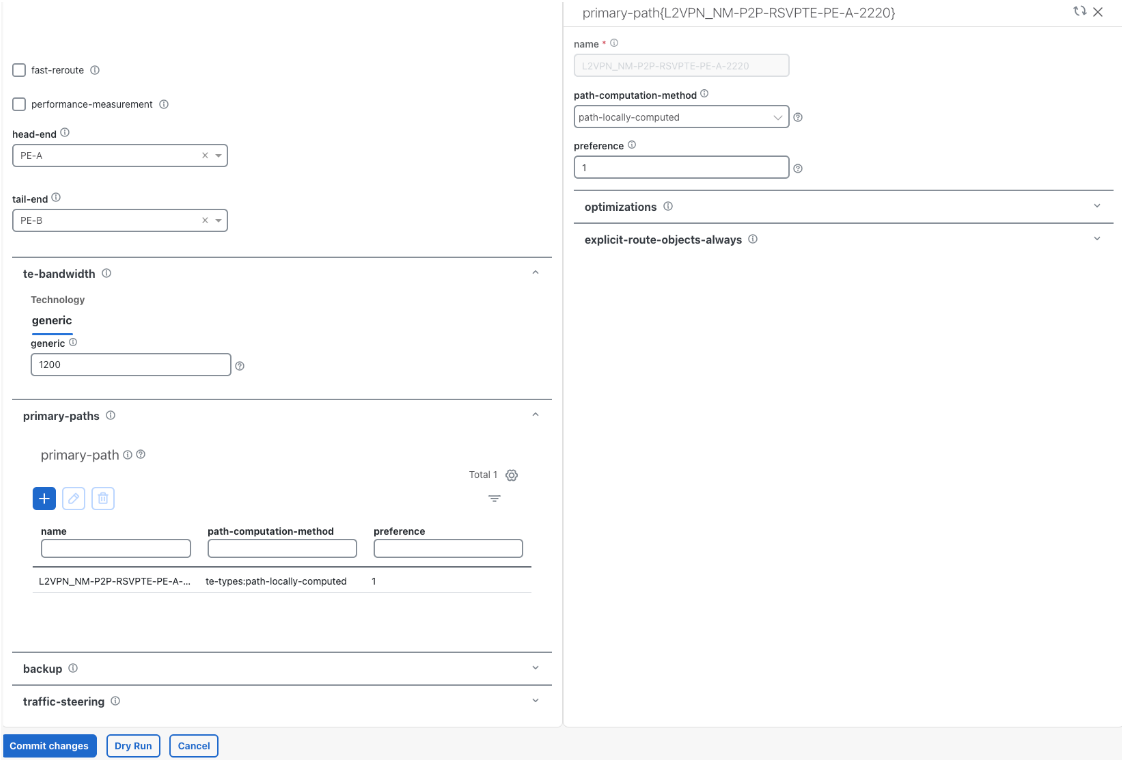
a) Under p2p-primary-paths, click + to create a new path.

b) In the pane that opens on the right, give the path a name.

c) Select the path computation method – **path-locally-computed**.

d) Specify a numeric preference for the path. The lower the number, the higher the preference.

e) Define the optimization metric, in this case, igp.



□ fast-reroute ⓘ

□ performance-measurement ⓘ

head-end ⓘ
PE-A

tail-end ⓘ
PE-B

te-bandwidth ⓘ

Technology
generic

generic ⓘ
1200

primary-paths ⓘ

primary-path ⓘ

Total 1

name	path-computation-method	preference
L2VPN_NM-P2P-RSVPTE-PE-A-...	te-types:path-locally-computed	1

backup ⓘ

traffic-steering ⓘ

primary-path{L2VPN_NM-P2P-RSVPTE-PE-A-2220}

name * ⓘ
L2VPN_NM-P2P-RSVPTE-PE-A-2220

path-computation-method ⓘ
path-locally-computed

preference ⓘ
1

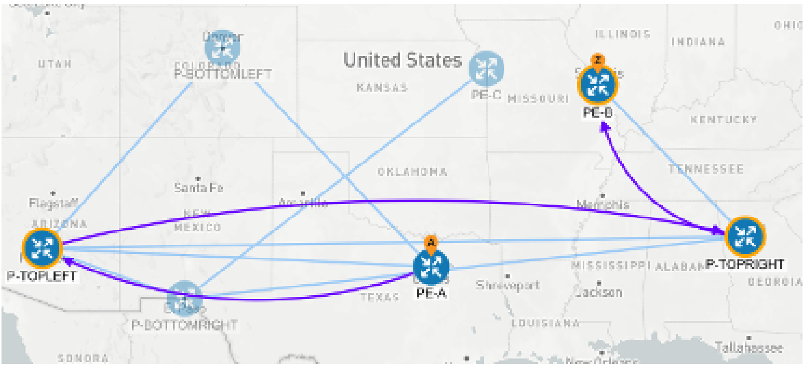
optimizations ⓘ

explicit-route-objects-always ⓘ

Step 8 Click **Commit Changes**.

Step 9 Verify that the RSVP-TE tunnel appears in the list of tunnels and its Provisioning State is **Success**.

Step 10 Click on the tunnel name to visualize the tunnel on the map and to see the tunnel details.



Step 2 Create the L2VPN service and attach the RSVP tunnel to the service

In this step, we will create a P2P L2VPN service using the provisioning GUI. If you want to create the service by importing a template, refer to Scenario 3—Mandate a static path for an EVPN-VPWS service using an explicit SR-TE policy

Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **L2VPN** > **L2vpn Service**.

Step 2 Click + to create a new service and give it a unique name. Click **Continue**.

Step 3 Choose the vpn-type field.

Step 4 Define each VPN endpoint individually – PE-A and PE-B.

a) Under vpn-nodes, click +.

b) Select the relevant device from the vpn-node-id and ned-id dropdown lists and click **Continue**.

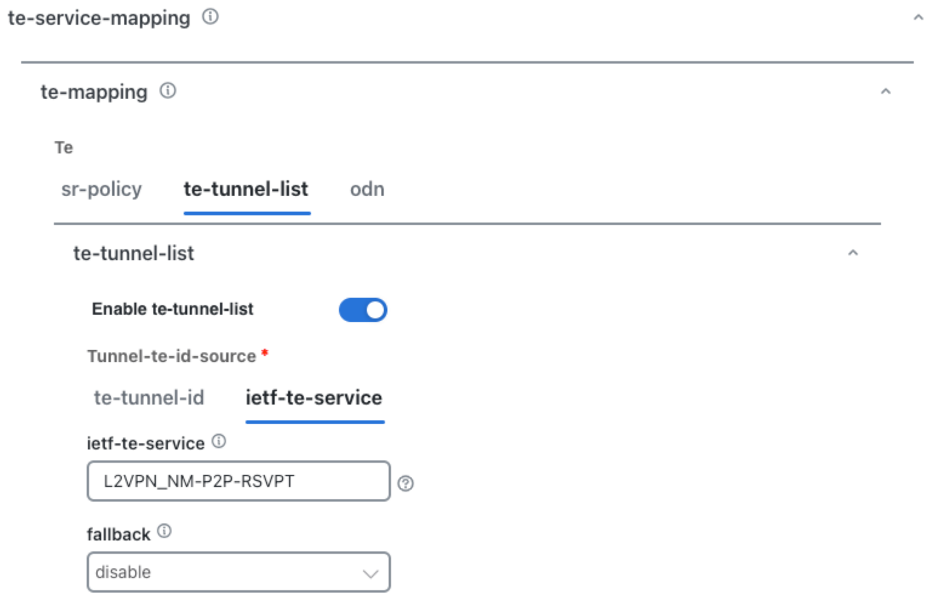
Step 5 Define the LDP signaling options by creating one or more pseudowires. In this case, specify the TE router ID of the peer device (PE-B), and provide a unique numeric label to identify the pseudowire.

Step 6 Attach the RSVP tunnel to the service:

a) Under te-service-mapping > te-mapping, click the te-tunnel-list tab.

b) Click the **ietf-te-service** tab.

c) Enter the name of the RSVP-TE tunnel you want to attach to this L2VPN service. The tunnel ID will be extracted from the tunnel configuration.



te-service-mapping ⓘ

te-mapping ⓘ

Te

sr-policy | **te-tunnel-list** | odn

te-tunnel-list

Enable te-tunnel-list: on

Tunnel-te-id-source *

te-tunnel-id | **ietf-te-service**

ietf-te-service ⓘ: L2VPN_NM-P2P-RSVPT

fallback ⓘ: disable

Note If you have an RSVP-TE tunnel on the device that was configured externally to Crosswork Network Controller, you can provide the tunnel ID under the te-tunnel-id tab.

Step 7 Define the VPN network access. In this case, we are using dot1q encapsulation and we have specified the physical interface (GigabitEthernet0/0/0/2) and the VLAN ID (2220).

Step 8 Follow the above steps for PE-B as well.

Step 9 Click **Commit Changes**. Verify that the L2VPN appears in the list of VPN services and that its Provisioning state is **Success**.

Step 3 Visualize the L2VPN service on the map

In this step we'll take a look at the representation of the L2VPN on the map and we'll see the paths the traffic will take from PE-A to PE-B and vice versa, based on the RSVP-TE tunnels we created.

Step 1 In the L2VPN Service table, click on the service name. The map opens and the service details are shown to the right of the map.

or

a) Go to **Services & Traffic Engineering > VPN Services**.

The map opens and a table of VPN services is displayed to the right of the map.

b) Click on the VPN in the Services table. When there are many services in the table, you can filter by name, type, or provisioning state to help locate the VPN.

In the map, you will see the VPN as an overlay on the topology. It shows a representation of the three endpoints and a dashed line that indicates that it is a virtual path.

Note The image below shows the VPN overlay in the geographical map. Use the buttons at the top right of the map to toggle between the logical and geographical maps.

Step 2 To see the hops in the route between PCC7_56 and PCC5_81, click the Transport tab and select one or more of the underlying TE tunnels to see the path from endpoint to endpoint on the map. The image below shows both RSVP-TE tunnels selected in the Transport tab and the route from PCC7_56 to PCC5_81 as shown on the logical map.

Step 3 As the RSVP-TE tunnels are configured with a reserved bandwidth, if the bandwidth utilization across the link exceeds the specified bandwidth, the path would be rerouted.

Summary and Conclusion

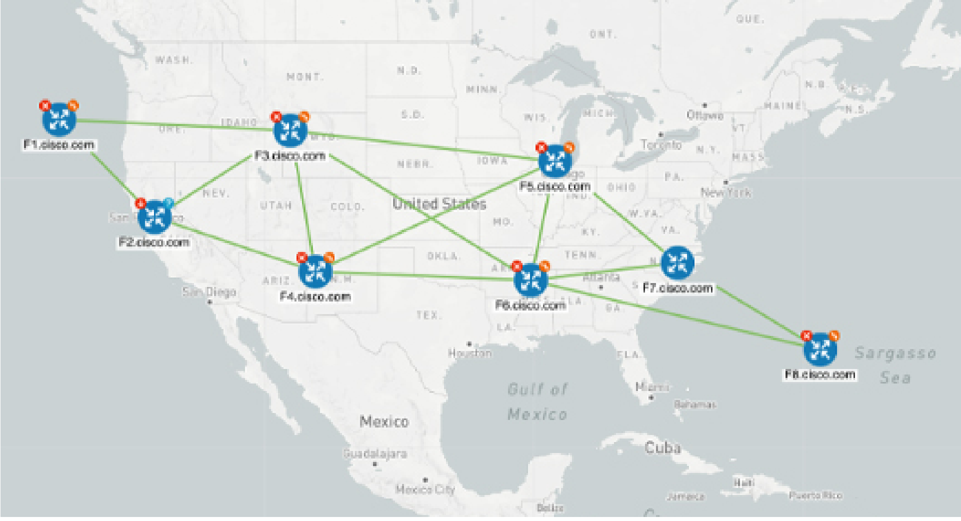
This scenario illustrated how to create RSVP-TE tunnels with reserved bandwidth and attach them to an L2VPN service to meet the high quality of service requirements for continuous streaming of rich data media. We observed the path on the map. This path would be recomputed if the bandwidth utilization on the link crossed the bandwidth reservation threshold.

Scenario: Provision a Soft Bandwidth Guarantee with Optimization Constraints

Service providers must be able to provide fast connections with the lowest latency possible to meet the needs of customers' peak traffic utilization times and to dynamically optimize services based on the customers' changing priorities throughout the day. For this purpose, the operator might need to reserve bandwidth on specific links to ensure a dedicated path that can handle a set amount of traffic with a specific optimization intent. The Bandwidth on Demand (BWoD) feature within Crosswork Network Controller enables this functionality. Paths with the requested bandwidth are computed when available. If a path that guarantees the requested bandwidth cannot be found, an attempt will be made to find a *best effort* path.

In this scenario, we will use BWoD to calculate the lowest TE metric path with a specified amount of available bandwidth between two endpoints.

This scenario uses the following topology as a base:



The goal is to create a path from F2.cisco.com to F7.cisco.com that can accommodate 250 Mbps of traffic while keeping the utilization at 80%. BWoD will initially try to find a single path to accommodate the requested bandwidth without exceeding the utilization threshold. If a single path cannot be found, BWoD may recommend splitting the path.

In this scenario we will:

- Orchestrate a new SR-TE policy with bandwidth and TE constraints.
- Configure and enable BWoD.
- Verify the state of the SR-TE policy and view the path on the map.

Step 1 Create a BWoD SR-TE Policy with the Requested Bandwidth and Optimization Intent

To create a BWoD SR-TE Policy with the Requested Bandwidth and Optimization Intent

Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)** > **SR-TE** > **Policy**.

Step 2 Click + to create a new SR-TE policy and give it a unique name. Click **Continue**.

Step 3 Define the endpoints:

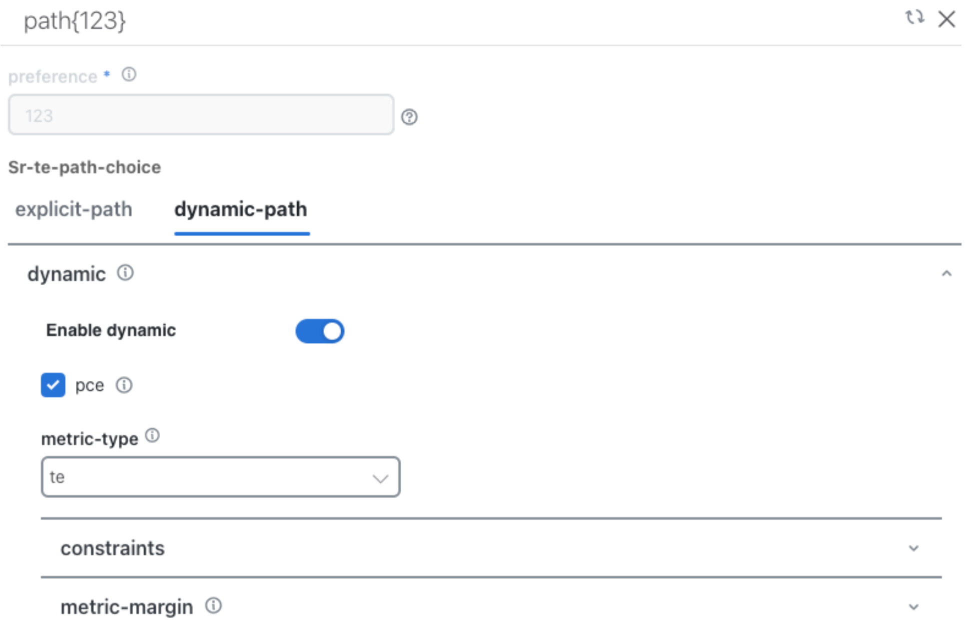
a) Under head-end, click + and select the headend device from the dropdown list and click **Continue**. Click **X** to close the Headend pane.
b) Enter the IP address of the tail-end device.
c) Enter a color to identify the traffic.

Step 4 Define the parameters on which the path will be computed:

a) Under path, click +.
b) Enter a path preference and click **Continue**.

c) In the dynamic-path tab, select **te** in the metric-type dropdown list as the optimization objective.

d) Select the **pce** check box to have the SR-PCE compute the paths for this policy.



path{123}

preference *

123

Sr-te-path-choice

explicit-path dynamic-path

dynamic

Enable dynamic

☑ pce

metric-type

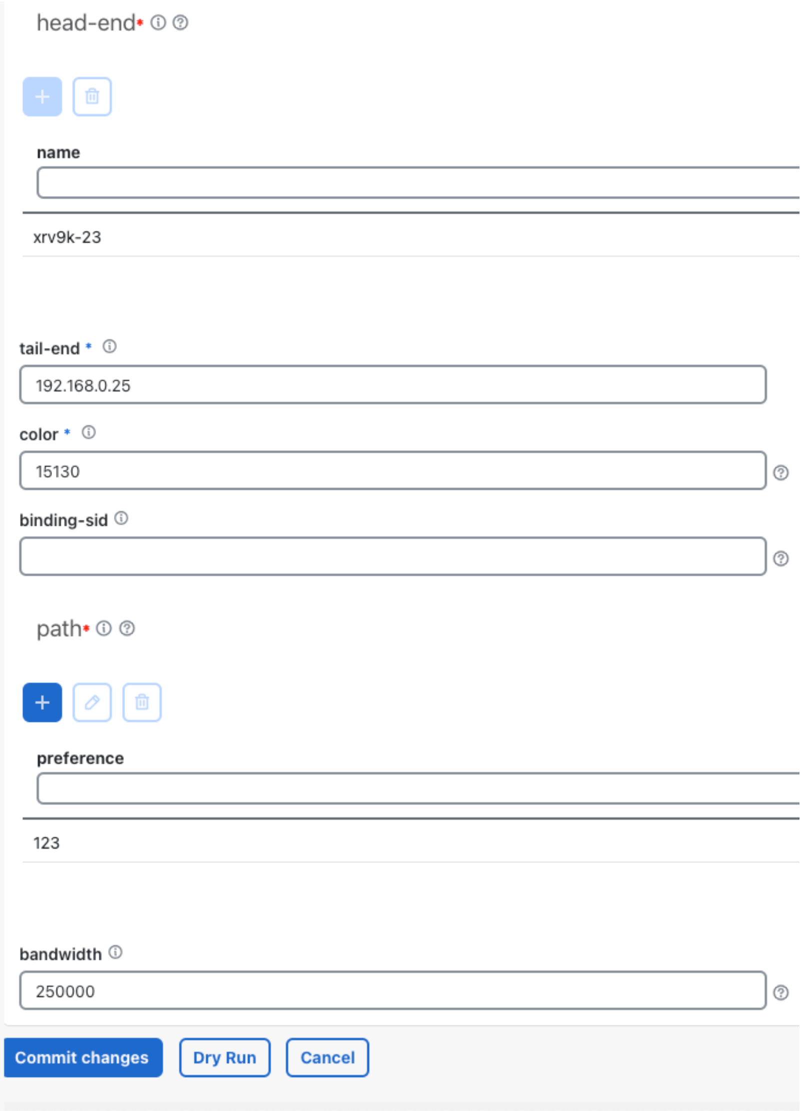
te

constraints

metric-margin

e) Click **X** to close the path pane.

Step 5 In the **Bandwidth** field enter the requested bandwidth in Kbps. In this case, we are requesting **250** Mbps or 250,000 Kbps.



head-end*

name

xrv9k-23

tail-end *

192.168.0.25

color *

15130

binding-sid

path*

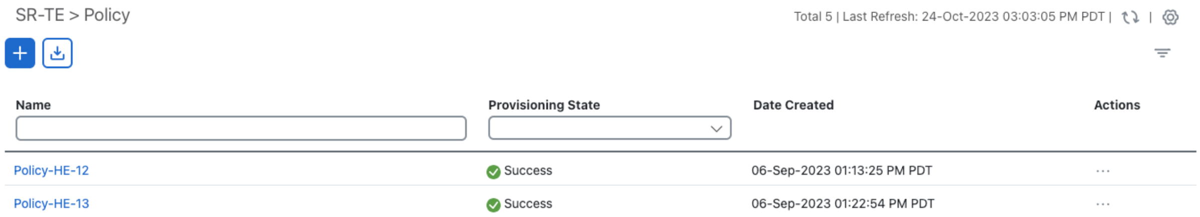
preference

123

bandwidth

250000

Step 6 Click **Commit Changes**. The new policy is created and appears in the list of SR-TE policies. The provisioning state should be **Success**.



SR-TE > Policy

Total 5 | Last Refresh: 24-Oct-2023 03:03:05 PM PDT |

Name	Provisioning State	Date Created	Actions
Policy-HE-12	✓ Success	06-Sep-2023 01:13:25 PM PDT	⋯
Policy-HE-13	✓ Success	06-Sep-2023 01:22:54 PM PDT	⋯

Step 7 Verify the new policy by viewing its details and its representation on the map:

a) Click ⋯ in the Actions column and choose **View**.

b) The map opens with the SR-TE policy details displayed to the right of the map.

Note The operational state of the policy is down because the SR-PCE alone is not able to address bandwidth computations before the BWoD functionality within Crosswork Network Controller is enabled.

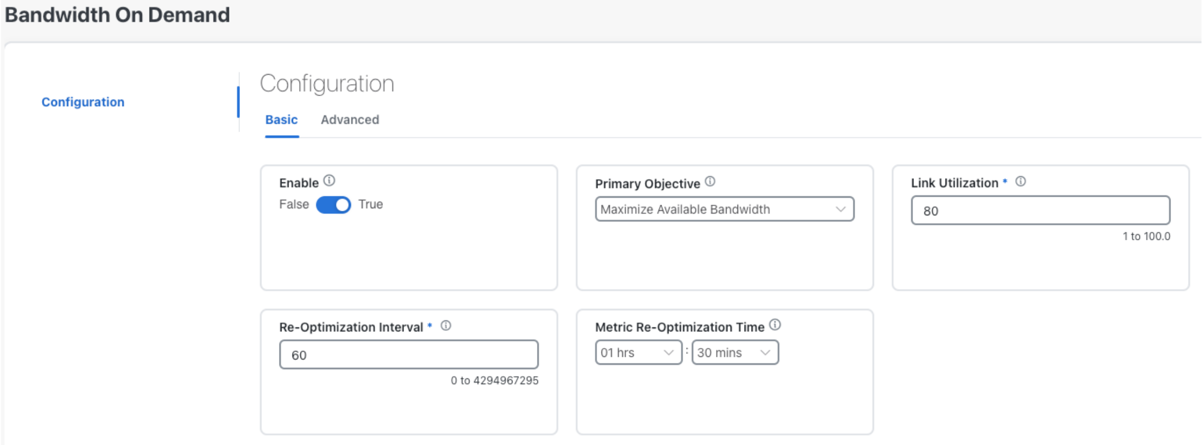
Step 2 Enable and Configure BWoD

Procedure to enable and configure BWoD

Step 1 Go to **Services & Traffic Engineering** > **Bandwidth on Demand**.

Step 2 Toggle the Enable switch to True, and enter 80 to set the utilization threshold percentage. To find descriptions of other options, hover the mouse over.

Step 3 Click **Commit Changes**.



Bandwidth On Demand

Configuration

Enable: False / True (True)

Primary Objective: Maximize Available Bandwidth

Link Utilization *: 80 (1 to 100.0)

Re-Optimization Interval *: 60 (0 to 4294967295)

Metric Re-Optimization Time: 01 hrs : 30 mins

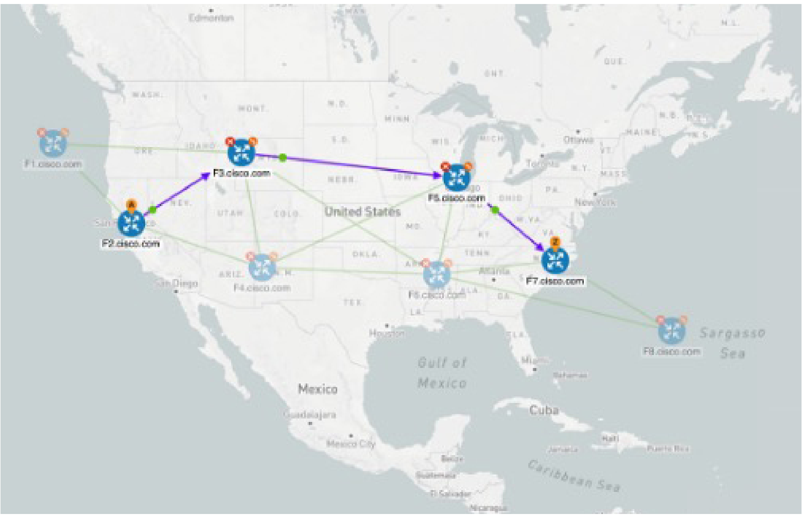
Step 3 Verify that the policy’s operational state is now Up and view the path on the map

Procedure to verify that the policy’s operational state is now Up and view the path on the map

Step 1 Go to **Services & Traffic Engineering** > **Provisioning (NSO)**.

Step 2 In the Policy table, locate and select the path computed for the endpoints.

Step 3 The path is shown as an overlay on the map. Select the **IGP Path** check box to see the physical path between the endpoints.



Summary and Conclusion

Operators can set and maintain bandwidth requirements based on optimization intent using the BWoD functionality provided in Cisco Crosswork Network Controller. This scenario illustrated how to provision an SR-TE policy with a specific bandwidth request. We saw how to enable BWoD functionality so that traffic is rerouted automatically to maintain bandwidth requirements. This automation alleviates the task of manually tracking and configuring paths to accommodate bandwidth requirements set by SLAs.