Prepare Infrastructure for Device Management

This chapter provides an overview of key setup concepts—such as credential profiles, providers, and tags—and directs you to the relevant tasks and reference material needed to prepare your environment for comprehensive device management.

Manage credential profiles

A credential profile is a collection that

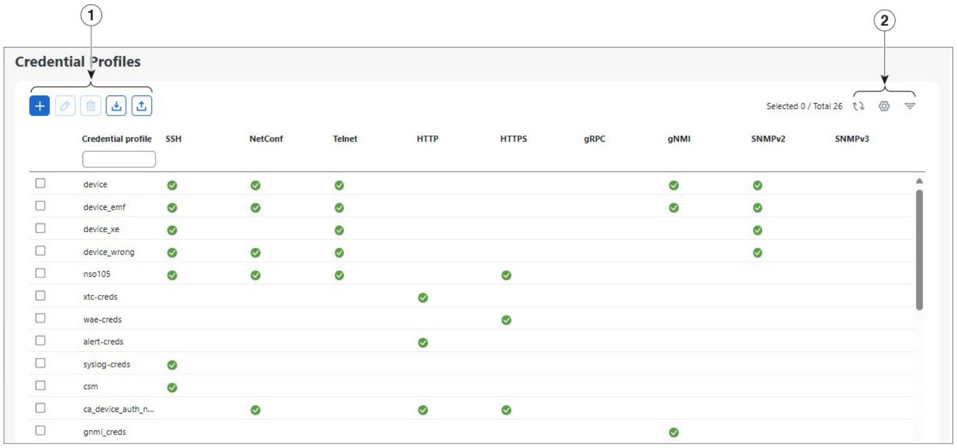
- stores credentials for various network protocols (such as SNMP, Telnet, SSH, and HTTP) set at the device level,
- enables consistent application of credentials when adding devices or providers, and
- automates device configuration changes, streamlines monitoring, and facilitates communication with providers.

Credential profiles may include as many protocols and their corresponding credentials as needed within a single profile. They must contain credentials that match those configured on devices.

Credential profiles page

From the **Credential profiles** page, you can create a new credential profile, update the settings configured for an existing profile, or delete a profile. To open this page, choose **Device Management** > **Credential profiles**.

Figure 1: Credentials profile page



Credential Profiles

	Credential profile	SSH	NetConf	Telnet	HTTP	HTTPS	gRPC	gNMI	SNMPv2	SNMPv3
□	device	✓	✓	✓				✓	✓	
□	device_emf	✓	✓	✓				✓	✓	
□	device_xe	✓		✓					✓	
□	device_wrong	✓	✓	✓					✓	
□	nso105	✓	✓	✓		✓				
□	xtc-creds				✓					
□	wae-creds					✓				
□	alert-creds				✓					
□	syslog-creds	✓								
□	csm	✓								
□	ca_device_auth_n...		✓		✓	✓				
□	gnmi_creds							✓		

Table 1: Credentials profile page items

Item	Description
1	Click + to add a credential profile. See Create credential profiles, on page 2.
	Click ✎ to edit the settings for the selected credential profile. See Edit credential profiles, on page 6.
	Click 🗑 to delete the selected credential profile. See Delete credential profiles, on page 7.
	Click ⭳ to import new credential profiles from a CSV file. You can also download a CSV file template by clicking this icon. The template includes sample data that you can use as a guide for building your own CSV file. See Import credential profiles using a CSV file, on page 3.
	Click ⭱ to export credential profiles to a CSV file. See Export credential profiles, on page 7.
2	Click ⟳ to refresh the **Credential Profiles** window.
	Click ⚙ to choose the columns to make visible in the **Credential Profiles** window.
	Click ☰ to set filter criteria on one or more columns in the **Credential Profiles** window.
	To clear a filter, click the corresponding [X] in the Filters menu.

Create credential profiles

This section explains how to create a new credential profile using the Crosswork Network Controller UI.

Note If you have many credential profiles to import, you may find it more efficient to put the information in a CSV file and import the file. Refer to Import credential profiles using a CSV file for instructions.

To create a new credential profile, complete these steps:

Procedure

Step 1 Choose **Device Management** > **Credential Profiles** > +.

Step 2 Enter a descriptive profile name to ensure it is easily distinguishable from other credential profiles. The name can contain a maximum of 128 alphanumeric characters. You can use letters, numbers, dots (.), underscores (_), and hyphens (-).

Step 3 Select a protocol from the **Connectivity type** drop-down list. Confirm what connection types must be configured in a credential profile for specific providers. Refer to Provider families, on page 9 for a list of supported provider families.

Step 4 Complete the applicable credentials and ensure they match what is already on the device.

Step 5 To add more protocols, click **+ Add Another** and repeat the previous steps.

Step 6 Click **Save**.

Import credential profiles using a CSV file

If you need to add many credential profiles, add the information to a CSV file and import it. Importing credential profiles from a CSV file adds the profiles to the database. Any duplicate profiles that already exist are overwritten.

Additional security

To maintain network security, use asterisks instead of real passwords and community strings in any CSV file you plan to import. After the import, follow the steps in Edit credential profiles, on page 6 to replace the asterisks with actual passwords and community strings.

Considerations when replacing an existing CSV file

When you re-import a credential profile CSV file that you have exported and edited, all passwords and community strings in the exported file are replaced with asterisks (*). You cannot re-import an exported credential profile CSV file with blank passwords.

To import credential profiles using a CSV file, complete these steps:

Procedure

Step 1 Choose **Device Management** > **Credential Profiles** > ⤓.

Step 2 If you have not already created a credential profile CSV file to import:

a) Click the **Download sample 'Credential template (*.csv)' file** link and save the CSV file template to your local drive.

b) Open the template using your preferred tool and edit one row for each credential profile. See Credential profile template guidelines, on page 4.

c) When you are finished, save the new CSV file.

Step 3 Click **Browse** to navigate and open the CSV file.

Step 4 With the CSV file selected, click **Import**.

The credential profiles you imported should now be displayed in the **Credential Profiles** window.

Credential profile template guidelines

Use these guidelines when editing the credential template:

- Use a semicolon to separate multiple entries in the same field. Use two semicolons with no space between them to indicate that you are leaving the field blank. The order in which you enter values in each field is important because it determines how fields are mapped to each other. For example, if you enter **SSH**;**NETCONF**;**TELNET** in the **Connectivity Type** field and you enter **UserTom**;**UserDick**;**UserHarry**; in the **User Name** field, the entries are mapped in order.
  - SSH: UserTom
  - NETCONF: UserDick
  - TELNET: UserHarry
- Enter SNMP community string information exactly as currently entered on your devices. Failure to do so will result in loss of device connectivity, and inability to collect certain KPI data or execute configured Playbooks on devices associated with the credential profile.
- Password and community string information associated with a user ID are stored in plain text in the CSV file you prepare. Review the security implications of storing credentials and apply appropriate safeguards.
- Delete the sample data rows before saving the file. If you keep the sample rows, the imported data will include both sample and intended information. Column header rows are always ignored during import.
- Each row defines a credential profile. This table helps you populate each credential profile.

Table 2: Credential profile template guidelines

Field	Entries	Required or Optional
Credential Profile	The name of the credential profile. For example, **nso** or **srpce**.	Required

Field	Entries	Required or Optional
Connectivity Type	Valid values are SSH, SNMPv2, NETCONF, TELNET, HTTP, HTTPS, GNMI, SNMPv3, or TL1.	Required • Devices—SNMP and SSH are required to avoid operational errors due to clock synchronization checks. • SR-PCE—Since SR-PCE is considered a provider and a device, SSH, and HTTP are required. • NSO—NETCONF is required. **Note** SSH and SNMP credentials are mandatory for onboarding devices and synchronizing with the NSO provider.
User Name	For example, NSOUser	Required if **Connectivity Type** is **SSH**, **NETCONF**, **TELNET**, **HTTP**, **HTTPS**, **SNMPv3**, or **GRPC**.
Password	The password for the specified **User Name**.	Required
Enable Password	Use an Enable password. Valid values are: **`ENABLE`**, **`DISABLE`**, or leave blank (unselected)	Required if **Connectivity Type** is **SSH** or **TELNET**. Otherwise leave the field blank.
Enable Password Value	Specify the Enable password to use.	Required if **Connectivity Type** is **SSH** or **TELNET**, and **Enable Password** is set to **`ENABLE`**. Otherwise leave blank.
SNMPV2 Read Community	For example: **`readprivate`**	Required if **Connectivity Type** is **SNMPv2**
SNMPV2 Write Community	For example: **`writeprivate`**	Required if **Connectivity Type** is **SNMPv2**
SNMPV3 User Name	For example: **`DemoUser`**	Required if **Connectivity Type** is **SNMPv3**
SNMPV3 Security Level	Valid values are **`noAuthNoPriv`**, **`AuthNoPriv`** or **`AuthPriv`**	Required if **Connectivity Type** is **SNMPv3**

Field	Entries	Required or Optional
SNMPV3 Auth Type	Valid values are • HMAC_SHA2-512 • HMAC_SHA2_384 • HMAC_SHA2_256 • HMAC_SHA2_224 • HMAC_MD5 • HMAC_SHA	Required if **Connectivity Type** is **SNMPv3** and **SnmpV3 Security Level** is **AuthNoPriv** or **AuthPriv**
SNMPV3 Auth Password	The password for this authorization type.	Required if **Connectivity Type** is **SNMPv3** and **SnmpV3 Security Level** is **AuthNoPriv** or **AuthPriv**
SNMPV3 Priv Type	These SNMPv3 Privacy Types are supported: • CFB_AES_128 • CBC_DES_56 • AES-192 • AES-256 • 3-DES	Required if **Connectivity Type** is **SNMPv3** and **SnmpV3 Security Level** is **AuthPriv**
SNMPV3 Priv Password	The password for this privilege type.	Required if **Connectivity Type** is **SNMPv3** and **SnmpV3 Security Level** is **AuthPriv**

Edit credential profiles

To edit credential profiles, complete these steps.

Warning If you change the settings in a credential profile without first changing the settings on the associated device, you might lose connectivity, be unable to collect some KPI data, or be unable to execute configured playbooks on devices associated with the modified profile. For example, if the SNMP community string on the device does not match the value in the credential profile, SNMP-based KPIs will not function.

Before you begin

- Export a CSV backup of the profiles you want to change. Refer to Export credential profiles for instructions.
- Change settings on any associated devices.

Procedure

Step 1 Choose **Device Management** > **Credentials**.

Step 2 Select the profile check box for the profile you want to update. Click ✎.

Step 3 Make the necessary changes and then click **Save**.

Note
If the device is not updated within 30 seconds after you modify connectivity or credential profile information, move the device state to DOWN and then UP. This action triggers CLI reachability, and the updated values are displayed.

Export credential profiles

When you export credential profiles, the system saves the selected profiles in a CSV file. You can use this CSV file to quickly create backup copies of your credential profiles. You can edit the CSV file as needed and re-import it to add new credential profiles or modify existing data.

The exported credential profiles CSV file does not contain real passwords or community strings. All the characters in the password and community string entries are replaced with asterisks. If you plan to modify and re-import the CSV file, use asterisks instead of actual passwords or community strings. To replace the asterisks with actual values after importing, see Edit credential profiles, on page 6 for instructions.

Procedure

Step 1 Choose **Device Management** > **Credential Profiles**.

Step 2 (Optional) In the **Credential Profiles** page, filter the credential profile list as needed.

Step 3 Select the profile check boxes for the profiles you want to export.

Step 4 Click ⇪. Depending on your browser, you will be prompted to select a path and file name for saving the CSV file, or to open the file immediately.

Delete credential profiles

To delete a credential profile, complete these steps:

Note You cannot delete a credential profile that is associated with one or more devices or providers.

Procedure

Step 1 Export a backup CSV file that contains the credential profile you plan to delete. For instructions, refer to Export credential profiles, on page 7.

Step 2 Check whether any devices or providers are using the credential profile you plan to delete. To do this, filter on the **Credential Profile** column. This column is available in the **Devices** window (choose **Device Management** > **Credential Profiles**) and in the Providers window (choose **Administration** > **Manage Provider Access**).

Step 3 Reassign the devices or providers to a different credential profile. For instructions, see Change the credential profile for multiple network devices, on page 8 and Edit provider settings, on page 51.

Step 4 After all devices and providers have had their credential profiles reassigned, from the main menu, choose **Device Management** > **Credential Profiles**.

Step 5 In the **Credential Profiles** window, choose the profile that you want to delete and then click 🗑.

Change the credential profile for multiple network devices

If you want to change the credential profile for many network devices, it is often more efficient to edit device information in a CSV file. The process includes these steps:

1. Export a CSV file containing the devices whose credential profiles you want to change. Refer to Export device information to a CSV file for instructions.
2. Edit the CSV file, changing the credential profile for each device (this credential profile must already exist).
3. Save the edited file.

The credential profile linked to these devices must include the authorization credentials for each protocol configured during onboarding. If any protocol-specific credentials are missing or incorrect in the profile, the CSV import will succeed, but reachability checks for these devices will fail.

Before you begin

Ensure that the credential profile you intend to switch to already exists; otherwise, the CSV import will fail. If you haven't created the necessary credential profile, do so before proceeding.

Procedure

Step 1 From the main menu, choose **Device Management** > **Devices**. The **Network Devices** tab is displayed by default.

Step 2 Choose the devices whose credential profiles you want to change. Your options are:

- Click ⬆ to include all devices.
- Filter the device list by entering text in the **Search** field or by filtering specific columns. Then click ⬆ to include only the filtered list of devices.
- Check the boxes next to the device records you want to change. Then click ⬆ to include only the devices that have been checked.

Step 3 Edit and save the new CSV file using the tool of your choice. Be sure to enter the correct credential profile name in the **Credential Profile** field for each device.

Step 4 Click ⤓.

Step 5 In the **Import** dialog box, click **Browse**, choose the new CSV file, and click **Import**.

Providers

Crosswork Network Controller components depend on external services, such as Cisco Crosswork Network Services Orchestrator (NSO) and Segment Routing Path Computation Element (SR-PCE), to perform operations like configuration modifications and segment routing path calculations. To manage access and facilitate information sharing among Crosswork Network Controller components, each external service must have a configured provider that belongs to a specific provider family (for example, NSO or SR-PCE).

A provider family is a service grouping that

- specifies the type of external service offered to the Crosswork Network Controller, and
- defines the parameters unique to the service type.

The system stores provider connectivity details and makes this information available to applications interacting with those external platforms.

For more information, refer to Providers in the *Before you begin* section of the **Get Up and Running (Post-Installation) chapter** of the guide.

Provider families

Crosswork Network Controller supports different types, or families, of providers. Each provider family supplies its own mix of special services, and each comes with unique requirements and options.

Table 3: Supported provider families

Provider family	Description
NSO	Instances of Cisco Network Services Orchestrator (Cisco NSO), used to configure network devices. See Add a Cisco NSO provider, on page 19.
SR-PCE	Instances of Cisco Segment Routing Path Computation Elements (Cisco SR-PCE) containing the configuration information needed to allow Cisco Crosswork applications to communicate with and retrieve segment routing information for the network. See Add SR-PCE providers, on page 29.
WAE	Instances of Cisco WAN Automation Engine (Cisco WAE) provide "what if" analysis used to evaluate network changes. See Add Cisco WAE providers, on page 45 .

Provider family	Description
Syslog Storage	Instances of storage servers (remote or on the Cisco Crosswork application VM itself) where you want to store syslogs and other data retrieved from devices by KPIs and playbooks. See Add syslog storage providers, on page 46.
Alert	Instances of providers (such as Cisco Crosswork Situation Manager) to which alerts collected during KPI monitoring are to be forwarded. See Add an alert provider, on page 47
Proxy	Instances of proxy providers. See Add proxy providers, on page 48
Accedian (ACCEDIAN_PROXY)	Instances of Accedian Skylight providers. See Add Accedian Skylight as provider for more details.

Provider dependency

This section explains the provider configurations required for each system component.

Table 4: Provider dependency matrix

Cisco Crosswork Network Controller Component	Provider Type					
	NSO	SR-PCE	WAE	Syslog Storage	Alert	Proxy
Element Management Functions	Optional	Optional	Optional	Optional	Optional	Optional
Optimization Engine	Optional	Mandatory Required protocol is HTTP.	Optional	Optional	Optional	Optional
Active Topology	Mandatory Required protocols are HTTPS and SSH (for NSO backup)	Mandatory Required protocol is HTTP.	Optional	Optional	Optional	Optional
Service Health	Mandatory Required protocols are HTTPS and SSH (for NSO backup)	Mandatory Required protocol is HTTP.	Optional	Optional	Optional	Optional
Change Automation	Mandatory Required protocols are HTTPS and SSH (for NSO backup)	Optional	Optional	Optional	Optional	Optional

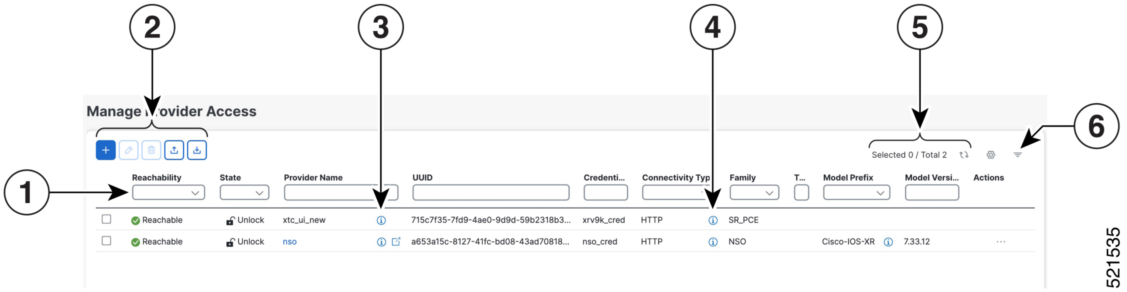
Cisco Crosswork Network Controller Component	Provider Type					
	NSO	SR-PCE	WAE	Syslog Storage	Alert	Proxy
Health Insights	Mandatory Required protocols are HTTPS and SSH (for NSO backup)	Optional	Optional	Optional	Optional	Optional

Note Configuring a syslog storage provider with Change Automation and an alert provider with Health Insights is beneficial but not mandatory.

Manage Provider Access

The **Manage Provider Access** page allows you to easily access tasks to create and manage providers. To navigate to this page, choose **Administration** > **Manage Provider Access**.

Figure 2: Manage provider access page



Manage Provider Access

Selected 0 / Total 2

	Reachability	State	Provider Name		UUID	Credenti...	Connectivity Typ		Family	T...	Model Prefix		Model Versi...	Actions
□	✓ Reachable	Unlock	xtc_ui_new	ⓘ	715c7f35-7fd9-4ae0-9d9d-59b2318b3...	xrv9k_cred	HTTP	ⓘ	SR_PCE					
□	✓ Reachable	Unlock	nso	ⓘ	a653a15c-8127-41fc-bd08-43ad70818...	nso_cred	HTTP	ⓘ	NSO		Cisco-IOS-XR	ⓘ	7.33.12	···

Table 5: Manage provider access page items

Item	Description
1	The icon shown next to the provider in this column indicates the provider's **Reachability**.

Item	Description
2	Click ⊞ to add a provider. See Add a provider, on page 12.
	Click ✎ to edit the settings for the selected provider. See Edit provider settings, on page 51.
	Click 🗑 to delete the selected provider. See Delete providers, on page 52.
	Click ⤓ to import new providers or update existing providers from a CSV file. You can also download a CSV file template by clicking this icon. The template includes sample data that you can use as a guide for building your own CSV file. See Import providers, on page 15.
	Click ⤒ to export a provider to a CSV file. See Export providers, on page 52.
3	Click ⓘ next to the provider in the **Provider Name** column to open the **Properties** pop-up window, showing the details of any startup session key/value pairs for the provider.
4	Click ⓘ next to the provider in the **Connectivity Type** column to open the **Connectivity Details** pop-up window, showing the protocol, IP, and other connection information for the provider.
5	Click ⟳ to refresh the **Providers** window.
	Click ⚙ to choose which columns are visible in the Providers window.
6	Click ☰ to set filter criteria on one or more columns in the **Providers** window.
	To clear a filter, click the corresponding [X] in the Filters menu.

Avoid topology sync issues during provider updates

Wait for the system to respond before making another provider update. For example, leave a pause between adding, deleting, or reading providers. If actions are performed too quickly, topology services may not reflect the changes. If you notice that topology is not synchronized, restart the topology service.

Add a provider

Before you begin

Review the configuration requirements for your provider family. For more information, see Provider families, on page 9.

Use this procedure to add a new external provider. Once you add the provider, you can map it to the managed devices.

To add a provider, complete these steps:

Procedure

Step 1 Choose **Administration** > **Manage Provider Access** > ⊞.

Step 2 Enter required provider details. For specific field definitions, see Add provider window fields, on page 13.

Step 3 Click **Save** to add the new provider.

Step 4 Repeat the steps to add more providers.

Add provider window fields

The table lists the Add Provider window fields and their descriptions.

Table 6: Fields in the Add Provider window (=Required)*

Field	Description
*** Provider Name**	The name for the provider that will be used to refer to it in the Cisco Crosswork application. For example: `Linux_Server`. The name can contain up to 128 alphanumeric characters, as well as dots (.), underscores ("_") or hyphens ("-"). No other special characters are allowed.
*** Credential profile**	Select the name of the credential profile that is used by the Cisco Crosswork application to connect to the provider.
*** Family**	Select the provider family.
Connection type(s)	
*** Protocol**	Select the principal protocol to be used to connect to the provider. For information on provider configurations required for each system component, see Provider dependency, on page 10 matrix. To add more connectivity protocols for this provider, click ⊕ at the end of the first row. To delete a protocol you have entered, click ⊗shown next to that row. You can enter multiple sets of connectivity details, including those for the same protocol.
*** Server details**	Select and provide one of these options: • IP Address (IPv4 or IPv6) and subnet mask of the provider's server. • FQDN (domain name and host name)
*** Port**	Enter the port number to use to connect to the provider's server. This is the port corresponding to the protocol being configured. For example, if the protocol used to communicate with the provider server is SSH, the port number is usually 22.
Timeout(sec)	Enter the amount of time (in seconds) to wait before the connection times out. The default is 30 seconds.

Field	Description
*** Encoding type**	Required if you are adding a Accedian_proxy provider. The available options are JSON, BYTES, PROTO, ASCII, and JSON IETF. Based on device capability, each device supports a single encoding format at a time.
Model prefix info **Note** The **Model** and **Version** fields do not apply to single VM deployments of Crosswork Network Controller.	
*** Model**	Required if you are adding a Cisco NSO provider: Select the model prefix that matches the NED CLI used by Cisco NSO. Valid values are: • `Cisco-IOS-XR` • `Cisco-NX-OS` • `Cisco-IOS-XE` For telemetry, only `Cisco-IOS-XR` is supported. To add more model prefix information for this Cisco NSO provider, click the ⊕ at the end of any row in the **Model Prefix Info** section. To delete a model prefix you have entered, click the ⊗ shown next to that row.
*** Version**	Required only if you are adding a Cisco NSO provider: Enter the Cisco NSO NED driver version used on the NSO server.
Provider properties	
Property key	Enter the name of the key for the special provider property you want to configure. Provider properties determine how the Cisco Crosswork Network Controller component interacts with each provider. The need for these properties and their types vary by provider family. Additional details are documented in topics dedicated to adding specific providers in this guide. The system does not validate provider properties. Ensure that you enter properties valid for the provider. **Note** In a two network interface configuration, the Cisco Crosswork applications default to communicating with providers using the Management Network Interface (`eth0`). You can change this behavior by adding **Property key** and **Property value** as `outgoing-internal` and `eth1` respectively. This is most often necessary when creating the SR-PCE provider, as its management interface may reside on the data network instead of the management network.
Property value	Enter the value to assign to the property key. To add more special properties for this provider, click ⊕ at the end of any key/value pair in the **Provider properties** section. To delete a key/value pair you have entered, click ⊗ shown next to that pair.

Import providers

Before you begin

Importing providers from a CSV file adds any providers not already in the database, and overwrites any existing providers with the same name. For this reason, export a backup of all your current providers before starting the import. For instructions, see Export providers, on page 52.

Use this task to quickly onboard several providers at once. To create a CSV file that specifies providers and then import it into the Crosswork Network Controller, complete these steps:

Procedure

Step 1 Choose **Administration** > **Manage Provider Access**.

Step 2 Click ⤓ to open the **Import providers** panel.

Step 3 If you have not already created a provider CSV file to import:

a) Click the **Download sample 'Provider template (*.csv)' file** link and save the CSV file template to a local storage resource.

b) Open the template using your preferred tool. Begin adding rows to the file, one row for each provider.

Use a semicolon to separate multiple entries in the same field. Use two semicolons (;;) with no space between them to indicate that you are leaving the field blank. When you separate entries with semicolons, the order in which you enter values is important. For example, if you enter `SSH;SNMP;NETCONF;TELNET` in the **connectivity_type** field and you enter `22;161;830;23` in the **connectivity_port** field, the order of entry determines the mapping between the two fields:

- SSH: port 22
- SNMP: port 161
- NETCONF: port 830
- Telnet: port 23

Delete any sample data rows before saving the file, or they will be imported along with the data you want. The column header row can stay, as it is ignored during import.

c) Save the completed CSV file.

Step 4 Click **Browse**, select your completed CSV file and click **Open**.

Step 5 With the CSV file selected, click **Import**.

The provider information you imported should now be displayed in the **Providers** window.

Step 6 Review the import results. Resolve any errors reported during the import and verify provider details to confirm connection.

Cisco NSO providers

Network Services Orchestrator (NSO) acts as the configuration engine enabling service and transport provisioning, including VPN services and segment routing policies. Crosswork Network Controller integrates

NSO providers to offer unified device lifecycle management, service orchestration, and visualization, providing a single pane of glass for network and service views. Cisco NSO providers in Crosswork Network Controller serve as a network management component that:

- enables Crosswork Network Controller to configure devices based on their expected functions,
- allows optional configuration of MDT sensor paths for data collection, and
- delivers essential device management, configuration, and maintenance services.

NSO function packs

The Cisco NSO sample function packs offer a starting point for VPN service provisioning functionality in Crosswork Network Controller. While some samples can be used "as is" in limited network configurations, they are intended to demonstrate the extensible design of Crosswork Network Controller.

- For answers to common questions, consult Cisco DevNet or Cisco Customer Experience representatives.
- Support for further customization of samples for your specific use cases can be arranged through your Cisco account team.
- See View Installed NSO Function Packs to monitor the state of the installed NSO function packs.
- The NSO Function Pack deployment via Crosswork Network Controller UI is supported for NSO system installation and as a root user. For detailed deployment information, see the *Cisco Crosswork Network Controller 7.1 Installation Guide*.

Requirements for adding NSO providers

Required configurations for adding NSO providers

Ensure these configuration requirements are met prior to adding an SR-PCE provider.

- Create a credential profile for the Cisco NSO provider. For instructions, see Create credential profiles, on page 2.
- Confirm Cisco NSO device configurations. For more information, see Configuration sample for Cisco NSO devices.

Required information for adding NSO providers

You must have this information when adding a SR-PCE provider.

- The name you want to assign to the Cisco NSO provider.
- The Cisco NSO NED device models and driver versions used in your topology. You can find the Cisco NSO version using the `version` command.
- The Cisco NSO server IP address or FQDN (Domain name and host name). When NSO is configured with HA, use the management VIP address as the IP address.
- The NSO cross launch feature is not available for user roles with read-only permissions.

NSO layered service architecture (LSA) deployment

Crosswork Network Controller supports the deployment of Cisco NSO Layered Service Architecture (LSA). An NSO layered service architecture is a network management framework that

- supports deployment of multiple device nodes for improved memory usage and provisioning throughput,
- organizes NSO providers into customer-facing (CFS) and resource-facing (RFS) roles for service management, and
- automates the identification and role assignment of each NSO provider to streamline operations and scalability.

In an LSA deployment, only one CFS provider is permitted. This provider encompasses all services, while RFS (resource-facing service) providers manage individual devices. On the **Manager Provider Access** page, the **Type** column identifies whether the NSO provider is CFS.

Key considerations for NSO LSA deployment

- Enable LSA settings before adding an NSO LSA provider. For details, see Enable layered service architecture (LSA), on page 17.
- If LSA settings are not enabled or provider property values are misconfigured, perform the recommended recovery steps mentioned in the NSO LSA setup recovery, on page 18 section.
- Ensure that RFS node IP addresses configured on the CFS match those shown in the user interface. A mismatch generates the error: "LSA cluster is missing RFS providers."
- For a CFS node, only the `forward` property key is used.

Enable layered service architecture (LSA)

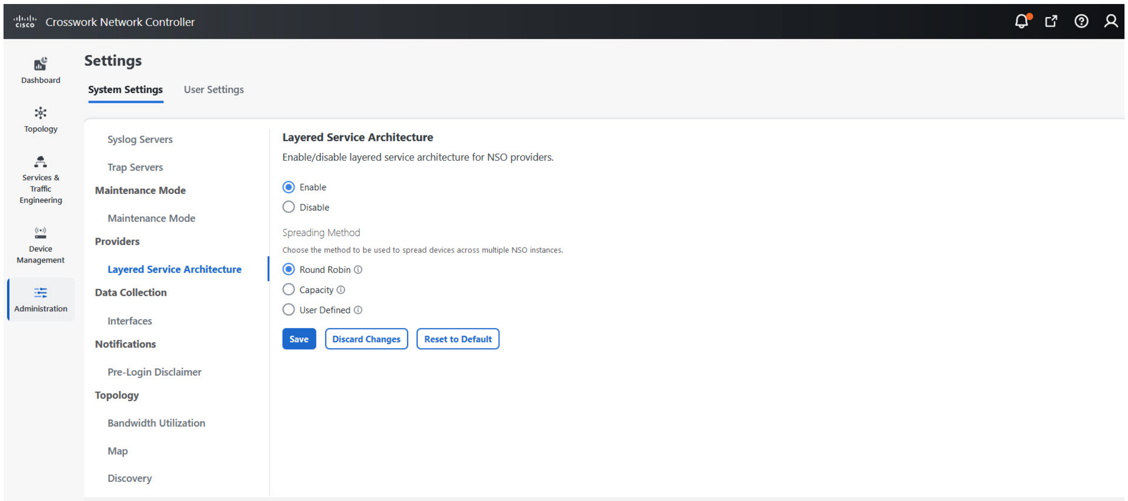
Use this procedure to configure LSA. This provides scalability by spreading network devices across multiple NSO instances, using your preferred distribution method.

To enable LSA, complete these steps.

Procedure

Step 1 Choose **Administration** > **Settings** > **System settings** > **Layered service architecture**.
The **Layered service architecture** page appears.

Figure 3: Layered service architecture page



Layered Service Architecture

Enable/disable layered service architecture for NSO providers.

● Enable
○ Disable

Spreading Method

Choose the method to be used to spread devices across multiple NSO instances.

● Round Robin ⓘ
○ Capacity ⓘ
○ User Defined ⓘ

Step 2 Select **Enable**.

Step 3 Select the method to distribute devices across multiple NSO instances:

- **Round Robin**: Evenly distributes devices to RFS nodes in a cyclical manner (for example, Device 1 to RFS1, Device 2 to RFS2, and so on).
- **Capacity**: Assigns devices to each RFS instance based on its available capacity.
- **User Defined**: Assigns devices to specific NSO providers as specified in the device settings. For more details, see Add devices individually through the UI.

Step 4 Click **Save**.

Note

After saving, you cannot disable LSA without first removing all NSO providers.

NSO LSA setup recovery

Use this procedure to recover a misconfigured NSO LSA setup.

To recover the LSA setup, complete these steps.

Procedure

Step 1 Remove the NSO providers and associated devices in Device Management.

Step 2 Clean up the associated services in the Cisco NSO application.

Step 3 Enable LSA settings and add the the NSO LSA provider with correct property values.

Step 4 Add the NSO providers and devices again to Crosswork Network Controller, and map them to the Crosswork Data Gateway.

Step 5 Perform the sync operation on the NSO nodes (RFS and CFS) to sync the devices correctly.

The NSO LSA functionality is recovered as expected.

Embedded NSO for single VM deployment

Crosswork Network Controller deployed on a single VM with the Advantage package, uses an embedded NSO instead of an external NSO. The embedded NSO comes bundled as part of the Crosswork Network Controller Advantage package and is automatically installed when the package is deployed on a single VM.

When the embedded NSO is installed on the Crosswork Network Controller:

- An NSO provider entry is automatically onboarded on the Providers page.
- An SSO service provider entry supporting NSO cross-launch is automatically added on the SSO page.
- The embedded NSO provider and the SSO service provider entries cannot be edited or deleted.

Add a Cisco NSO provider

Before you begin

- Ensure all Requirements for adding NSO providers, on page 16 are met.
- Create a credential profile for NSO if one does not already exist.

Use this procedure to when you need to enable device onboarding and management between Cisco NSO and Crosswork Network Controller.

⚠ **Attention** Crosswork Network Controller does **not** continuously scan NSO for device status changes. New device addition to NSO is discovered only when there is an explicit action in Crosswork Network Controller that interacts with NSO.

To onboard newly added devices from NSO to Crosswork Network Controller, perform an NSO action or update and save the NSO provider policy details.

- Perform any NSO action for a device (from **Device Management** > **Network Devices**.
- Edit and save the policy details of an existing NSO provider (select **Actions > Edit policy details** > set **Onboard from** to **TRUE** > **Save**) to trigger Crosswork Network Controller to rescan NSO.

To add a Cisco NSO provider, complete these steps:

Procedure

Step 1 Choose **Administration** > **Manage Provider Access** > ➕.

Step 2 Enter these provider field values:

a) **Provider name**: Enter a name for the provider.

b) **Credential profile**: Select the previously created Cisco NSO credential profile.

c) **Family**: Select **NSO**.

d) Configure connection properties:

- **Protocol**: Select **HTTPS** and/or **SSH**. For more information, see Provider dependency, on page 10 matrix.

  Note
  To use the **Backup NSO** option during backup, configure the SSH connectivity protocol in the NSO provider; otherwise, the backup will fail.

- **Server details**: Provide the IP address (IPv4 or IPv6) or FQDN (domain or host name) of the server.

  Important
  If you update the IP address or FQDN of the NSO provider, detach and reattach devices from the associated virtual data gateway. If you fail to do this, the provider changes will not be reflected in MDT collection jobs.

- **Server details**: Provide the IP address (IPv4 or IPv6) or FQDN (domain or host name) of the server.

- **Port**: Enter the appropriate port number. For HTTPS, enter the port that corresponds with what is configured on the NSO VM in etc/ncs/ncs.conf to access NSO using HTTPS. NSO uses **8888** as default port.

- **Timeout** (Optional): Enter the amount of time (in seconds) to wait before timing out the connection to the NSO server. The default is 30 seconds.

Note
If you set the **Site location** parameter in NSO, you can determine if geo-fencing is violated during testing when Crosswork Network Controller and the active NSO are not in the same site location. Crosswork Network Controller will also raise and clear alarms if a geo-fence violation is detected.

e) Configure the model prefix information:

- **Model**: Select Cisco-IOS-XR, Cisco-NX-OS, or Cisco-IOS-XE. Add a model for each type of device that will be used in the topology. If you have more than one, add another supported model.

- **Version**: Enter the NED software version installed for the device model in NSO.

f) For **Provider properties**, enter the key and value pairs as needed.

Property key	Value
forward	Set to **true** if you need to allow provisioning operations from the Crosswork Network Controller UI and enable the northbound interface to NSO through the Crosswork API gateway. **Note** The default value of **forward** is "false". If this is not changed, devices added to Crosswork Network Controller will not be added to NSO. This setting is used in conjuction with the **Edit Policy** option (see Edit the NSO provider policy, on page 22).

Property key	Value
nso_crosslaunch_url **Note** For NSO standalone providers only.	Enter the URL to enable cross-launching NSO application from the Crosswork Network Controller UI. Example format: **https://<NSO IP address/FQDN>: port number** Requires a valid protocol (**HTTP** or **HTTPS**), and the provider must be reachable. The cross launch icon (↗) is displayed in the **Provider Name** column. Alternately, you can cross launch the NSO application using the launch icon located at the top right corner of the window.
input_url_prefix **Note** For NSO LSA providers only.	Enter the RFS ID. Example format: **/rfc-x**, where **x** refers to the number of the RFS node. For RFS node 1: `input_url_prefix: /rfc-1`

Step 3 Click **Save**.

What to do next

(Optional) Configure the NSO site name, on page 21

Configure the NSO site name

You can configure the site name for NSO from the NCS backend. The site name appears as a read-only value on the NSO provider in the Crosswork Network Controller UI.

To configure the NSO site name, complete these steps.

Procedure

Step 1 Log in to ncs_cli in configuration mode.

Step 2 Set `hcc dns member master ip-address nso1-mgmt-IP location site1-location`

Step 3 Set `hcc dns member standby ip-address nso2-mgmt-IP location site2-location`

Step 4 Commit your changes.

View installed NSO function packs

Crosswork Network Controller allows you to monitor the operational status of installed NSO function packs.

To view installed NSO function packs, complete these steps.

Procedure

Step 1 Choose **Administration** > **Crosswork Manager**.

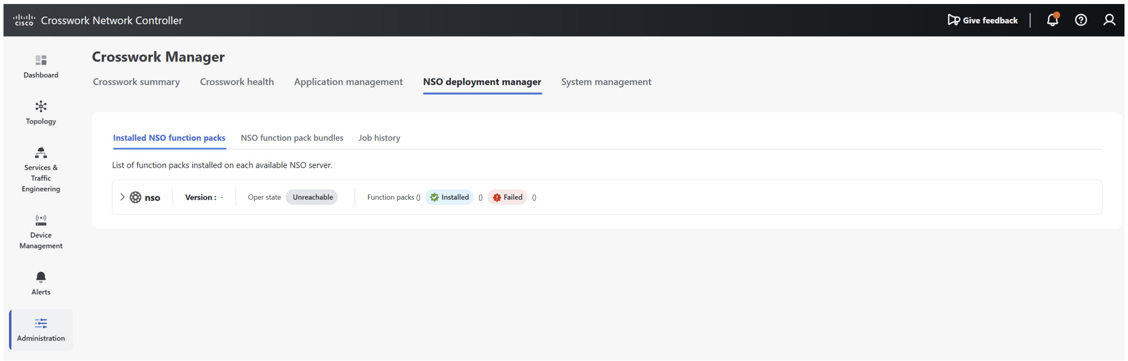
Step 2 On the **Crosswork Manager** window, select the **NSO deployment manager** tab.

The **Installed NSO function packs**, **NSO function pack bundles**, and **Job history** tabs are displayed.

Note
You can also access this view from NSO provider entries in the **Providers** page by choosing **Actions** > **View function packs**.

The **Installed NSO function packs** tab lists all NSO function pack bundles deployed on the NSO server.

Figure 4: Installed NSO function packs



Crosswork Manager

Crosswork summary | Crosswork health | Application management | NSO deployment manager | System management

Installed NSO function packs | NSO function pack bundles | Job history

List of function packs installed on each available NSO server.

nso | Version : - | Oper state Unreachable | Function packs () Installed () Failed ()

Step 3 Expand the bundles to view the number of function packs within each bundle, the function pack name, operational state (**Up** or **Down**), description, and version number.

Edit the NSO provider policy

Edit the NSO provider policy when you need to modify how devices are matched, onboarded, synchronized, or managed between Crosswork Network Controller and NSO.

To edit an NSO provider policy, complete these steps.

Procedure

Step 1 Choose **Administration** > **Manage Provider Access**.

Step 2 On a NSO provider, click **Actions** > **Edit policy details**.

The **Edit policy details** page for the selected NSO provider is displayed.

Step 3 Update the policy configuration fields to meet the specific requirements of your environment, ensuring the values align with your discovered devices. You can modify each criteria to define a targeted subset of devices and fine-tune the actions that DLM will perform.

For example, when a device's configuration is changed, DLM will attempt to sync with NSO and apply all relevant rules, such as MatchRule, OnboardToNSO, OnboardToRule.

The different attributes you can edit within the NSO policy are:

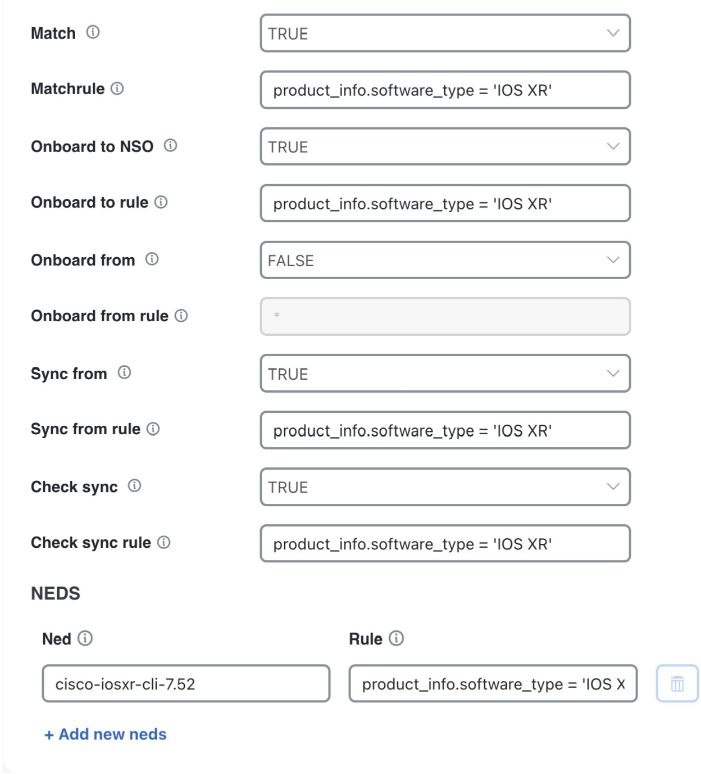
Table 7: Editable policy attributes

Attribute	Description
Match	Set to **True** to match Crosswork Network Controller devices with those in NSO based on their IP address.
MatchRule	Enter an expression defining the subset of devices.
Onboard To NSO	Set to **True** to add missing devices to NSO.
Onboard To Rule	Enter an expression for onboarding a subset of devices.
Onboard From	Set to **True** to onboard devices from NSO to Crosswork network Controler if they are missing.
Onboard From Rule	Enter an expression for onboarding devices from NSO.
Sync From	Set to **True** to sync-from the NSO device after onboarding.
Sync From Rule	Enter an expression defining the subset of devices for sync-from.
Check Sync	Set to **True** to check sync status of NSO devices.
Check Sync Rule	Enter an expression for the subset of devices for check-sync.
NED	Specify the Network Element Driver (NED) to be used. By default, the latest CLI NED on NSO is used.
Rule	Enter an expression to define which devices should use a specific NED.

Step 4 Review your changes and click **Save**. The NSO policy rules are applied every time DLM synchronizes with NSO.

Specifying a NED for IOS-XR devices

The following image shows the policy attributes that set the cisco-iosxr-cli-7.52 NED for IOS-XR devices with a software version 6.23.



Match ⓘ	TRUE
Matchrule ⓘ	product_info.software_type = 'IOS XR'
Onboard to NSO ⓘ	TRUE
Onboard to rule ⓘ	product_info.software_type = 'IOS XR'
Onboard from ⓘ	FALSE
Onboard from rule ⓘ	*
Sync from ⓘ	TRUE
Sync from rule ⓘ	product_info.software_type = 'IOS XR'
Check sync ⓘ	TRUE
Check sync rule ⓘ	product_info.software_type = 'IOS XR'

NEDS

Ned ⓘ	Rule ⓘ
cisco-iosxr-cli-7.52	product_info.software_type = 'IOS X

The entry for defining **Rule** is partially visible. Here is the complete text for your reference:

product_info.softwaretype='IOS XR' and product_info.softwareversion='6.23'

You can specify different criteria such as hostname, software type, and IP address and use operators like Eq (=), Neq (!=), GT (>), LT (<), GTEQ (>=), LTEQ (<=) and EqA (= =) to define the comparisons. Here are few more examples of expressions you can use to edit provider details:

- **Device information**
  - host_name = 'host1'
  - product_info.manufacturer = 'Cisco Systems'
  - profile!='simulators'
- **Software and product details**
  - product_info.software_type = 'IOS XR'
  - product_info.softwareversion = '6.23'
  - product_info.producttype = 'Cisco IOS XRv 9000 Router'
  - product_info.productfamily = 'Routers'
  - product_info.productseries = 'Cisco ASR 9000 Series Aggregation Services Routers'
- **Routing information**
  - routing_info.router_loopback.inet_addr = '10.10.10.10'

  - routing_info.te_router_id = '10.8.8.52'

- **Combining criteria**
  - Use the AND, OR commands to combine criteria. For example:

    product_info.software_type = 'IOS XR' OR product_info.software_type = 'IOS XE'

    product_info.software_type = 'IOS XR' AND product_info.software_version = '7.0.1'

- **Using wildcards**

  Use the * symbol as a wildcard. For example, to match any IOS device, you can use IOS*. If no wildcard expression is used, the system performs an exact match of the string.

  - **Exact match example**

    If product_info.software_type = 'IOS XR' is specified, DLM matches only the devices where the software_type is exactly 'IOS XR'.

  - **Wildcard example**

    If product_info.software_type = 'IOS XR*' is specified, DLM matches all devices where the software_type starts with 'IOS XR'. This includes values such as 'IOS XR 1', 'IOS XRv'.

Note For more information about editing NSO provider details and forming expressions using the attributes available in the Crosswork Inventory API, refer to the link DLM Inventory APIs.

Cisco SR-PCE providers

Cisco Segment Routing Path Computation Elements (Cisco SR-PCE) providers

- supply device discovery, management, configuration maintenance, and route calculation services to Cisco Crosswork Network Controller components,
- enable system access as part of SDN controllers in the management domain, and
- support multi-AS topology and path calculations.

Requirements and additional information

Multi-AS topology and path calculations are supported if the complete topology is accessible to both the Crosswork Network Controller and each PCE. A single PCE cannot view a specific AS topology while another PCE views a different topology. Each PCE must have access to the entire topology view.

To learn and discover SR policies, Layer 3 links, and devices, at least one SR-PCE provider is required. Additionally, a second SR-PCE can be configured as a backup.

Requirements before adding SR-PCE providers

Required configurations for adding SR-PCE providers

Before adding an SR-PCE provider, ensure these configuration requirements are met to guarantee successful integration and operation.

- **Device and software requirements**: Configure a device to act as the SR-PCE. Enable SR for IS-IS or OSPF protocols according to your device platform documentation, and configure an SR-PCE. For example, refer to the *Segment Routing Configuration Guide for Cisco NCS 540 Series Routers*.

Note SR-PCE is only supported on the Cisco IOS XRv 9000 platform.

- **Credential profiles**: Create a credential profile for the Cisco SR-PCE provider (see Create credential profiles) with these connection types:
  - gRPC: Required to discover topology, SR-MPLS, and SRv6 policies. See Sample PCE configuration for enabling gRPC API on XR for configuration examples.
  - Basic HTTP text-authentication: Required to process for RSVP, TreeSID and PCEP sessions. MD5 authentication is currently not supported.

    If the Cisco SR-PCE server you are adding does not require authentication, you must still provide a credential profile for the provider. Select a profile that does not use the HTTP protocol.
- **gRPC with TLS (Optional)**: If setting up gRPC with Transport Layer Security (TLS), a certificate must be generated and added with the **Provider gRPC communication** role. The certificate secures TLS communication between gRPC clients and the EMS server. The client should use ems.pem and ca.cert to initiate the TLS authentication. To update the certificate, copy the newly generated certificate to the required location and restart the server. For more details, refer to the *Manage Certificates* chapter in this guide..
- **High availability**: For high availability, set up two separate Cisco SR-PCE providers with unique names and IP addresses, but with matching configurations.

Required information for adding SR-PCE providers

You must have this information when adding a SR-PCE provider:

- The name you want to assign to the Cisco SR-PCE provider. This is usually the DNS hostname of the Cisco SR-PCE server.
- The Cisco SR-PCE server IP address.
- The interface you want to use to communicate between Cisco SR-PCE and the Crosswork Network Controller server.
- SSH credentials for the PCE device to enable gRPC communication. PCE API credentials are used exclusively for HTTP-based communication.
- Determine whether to auto-onboard devices that Cisco SR-PCE discovers and, if so, whether their management status should be set to **`off`**, **`managed`** or **`unmanaged`** when added.

Requirements for auto-onboarding managed devices

If you plan to auto-onboard devices that the Cisco SR-PCE provider discovers and set them to a managed state in the database:

- Assign an existing credential profile for communication with the new managed devices.
- Configure the credential profile with an SNMP protocol.

TLS configurations for SR-PCE

A TLS configuration is a network security feature that:

- provides encrypted communication between SR-PCE and Crosswork applications
- leverages existing gNMI certificates for simplified certificate management
- supports server authentication (client authentication planned for future release), and
- ensures compliance with network security requirements.

TLS is enabled by default in SR-PCE gRPC configurations. Upload valid certificates and configure the trust chain in Crosswork to ensure secure communication.

How TLS works with gRPC API

When TLS is enabled:

1. SR-PCE presents its certificate to connecting clients
2. Clients validate the certificate against the configured root CA
3. An encrypted channel is established for all gRPC communications
4. All API data transmission occurs over this secure channel

Configure TLS for gRPC API

Enable secure, encrypted communications for gRPC API in SR-PCE deployments using TLS, to protect data in transit and ensure compliance.

Configuring TLS for the SR-PCE gRPC API secures all API interactions using encryption. This process is essential in environments where data confidentiality and integrity are required, especially when using Crosswork Network Controller for device management.

Before you begin

Before configuring TLS for the SR-PCE gRPC API, make sure all prerequisites are met.

- SR-PCE access and readiness
  - SR-PCE is installed and operational
  - Administrative access to the SR-PCE CLI and file system is available.
- Certificates and keys
  - A Root CA certificate is available (used for gNMI collection).
  - Private key and certificate files are generated for SR-PCE.

Note Crosswork Network Controller supports only server authentication and not mutual authentication (client certificate validation).

Use these steps to configure TLS on SR-PCE for gRPC API:

Procedure

Step 1 Verify TLS configuration on SR-PCE.

TLS is enabled by default when gRPC is configured. Check your current settings.

a) Access the SR-PCE CLI.

b) Check the gRPC configuration:

```
show running-config grpc
```

c) Ensure that the gRPC has these configurations:

- `no-tls` is not configured under gRPC.
- `tls-mutual` is not enabled under gRPC (it is disabled by default).

gRPC configuration shows TLS enabled without mutual authentication.

Step 2 Prepare the certificates.

Before uploading certificates to SR-PCE, ensure you have the private key, certificate, and root CA certificate.

Important
The certificates must include the `basicConstraints` extension with `CA:False`, ensuring it cannot be used as a certificate authority or improperly delegated in a chain of trust.

Step 3 Upload certificates to SR-PCE.

a) Transfer the private key and certificate to SR-PCE using SCP or SFTP.

b) Copy files to the required locations:

```
cp your-private-key.pem /misc/config/grpc/ems.key
cp your-certificate.pem /misc/config/grpc/ems.pem
```

c) Verify that the file has read permissions:

```
ls -la /misc/config/grpc/
```

d) Restart the emsd process to load the new certificates:

```
process restart emsd
```

The process restarts successfully without errors.

Step 4 Configure the root CA certificate in Crosswork Network Controller UI.

If not already configured for gNMI collection:

a) Log in to Crosswork Network Controller UI.

b) Navigate to **Administration** > **Certificate Management**.

c) Click the + icon to add a new certificate.

d) Configure the certificate:

- Device Certificate Name: Enter a name for the certificate.
- Certificate Role: Select `Provider gRPC Communication`.
- Secure gRPC CA certificate trustchain: Upload your root CA .pem file.

e) Click **Save**.

Note

If a gNMI certificate already exists and multiple trust chains are needed, update the existing .pem file to include all required CA certificates.

After successful addition, the gNMI Certificate appears in the Certificates listed in **Certificate Management** > **Certificates**.

The gRPC configuration displays TLS enabled without mutual authentication.

What to do next

After configuration, verify that TLS is functioning correctly.

1. Check the emsd process status:

   ```
   show process emsd
   ```

2. Review gRPC service status:

   ```
   show grpc status
   ```

3. Check logs for TLS-related errors:

   ```
   show logging | include TLS
   show logging | include grpc
   ```

4. Test connectivity from a gRPC client using TLS.

Related Topics

Certificates

Add a new certificate

Add SR-PCE providers

Before you begin

Ensure the configuration requirements defined in Requirements before adding SR-PCE providers, on page 25 are met prior to adding an SR-PCE provider.

To add one or more Cisco SR-PCE providers, complete these steps:

Procedure

Step 1 Choose **Administration** > **Manage Provider Access** > +.

Step 2 Enter these SR-PCE provider field values:

a) **Provider**: Enter a name for the SR-PCE provider.

b) **Credential profile**: Select the credential profile you created for the SR-PCE provider.

c) **Family**: Select **`SR_PCE`**.

d) Configure connection properties.

- **Connection type(s) > Protocol**:
  - Select **HTTP** and enter required fields. HTTP is required to process RSVP, TreeSID and PCEP sessions. The default port is 8080.
  - Select **GRPC** or **GRPC_SECURE** (gRPC with Transport Layer Security (TLS)) and enter required fields. These settings are required to process topology, SR-MPLS, and SRv6 policies. Only one of these options can be used. If GRPC_SECURE is selected, you must provide the trusted certificate in the **Certificate profile** field.
- **Server details**: Enter the server IP address (IPv4 or IPv6) and subnet mask.
- **Port**: Enter the port number.
- **Timeout** (Optional): Enter the amount of time (in seconds) to wait before timing out the connection to the server. The default is 30 seconds.

e) **Provider properties**: Enter property keys and values:

Table 8: Property keys

When the property key is..	And the value is..	Then..
auto-onboard	off	when devices are discovered, the device data is recorded in the Cisco SR-PCE database, but is not registered in the Crosswork Network Controller Inventory Management database. **Note** Use this option if you plan to manually (via UI or CSV import) enter all of your network devices.
	unmanaged	all devices that Crosswork Network Controller discovers will be registered in the Crosswork Network Controller Inventory Management database, with their configured state set to **unmanaged**. SNMP polling will be disabled for these devices, and no management IP information will be included. To get these devices into the **managed** state later, you will need to either edit them via the UI or export them to a CSV, make modifications and then import the updated CSV. You can also assign credential profiles by adding them to the device CSV file before import (the credential profiles must already exist).
	managed	all devices that Cisco SR-PCE discovers will be registered in the Crosswork Network Controller Inventory Management database with their configured state set to **managed**. Typically suitable for an environment that has same device profiles, devices are managed by their TE router-ID, and all devices can be discovered by the Cisco SR-PCE. SNMP polling will be enabled for these devices, and Cisco SR-PCE will also report the management IP address (TE Router ID for IPv4, or IPv6 Router ID for IPv6 deployment). The devices will be added with the credential profile associated with the device-profile key in the SR-PCE provider configuration. Important considerations If you enable this option for IPv6 deployment, devices will still register as **unmanaged** in the inventory. When you delete an onboarded device that was added via SR-PCE discovery with auto-onboard set to **managed**, the topology service adds it again as **unmanaged**. This ensures that devices that have been removed are not automatically managed again unless they acquire a new TE-ID. To manage a rediscovered device, update its status manually.
device-profile	a credential profile name	if the **auto-onboard** is set to **managed** and there is no valid **device-profile** set, the device will instead be onboarded as **unmanaged**.

When the property key is..	And the value is..	Then..
outgoing-interface	eth1	this enables Crosswork Network Controller access to SR-PCE via the data network interface when using a two NIC configuration.
preferred-stack	ipv4	indicates a dual stack is present and IPv4 is preferred.
	ipv6	indicates dual stack is present and IPv6 is preferred.
	NOT SET	indicates no dual stack.
pce	off	discovery of RSVP-TE tunnels and PCEP sessions (required for all LSP provisioning) is disabled.
	on	discovery of RSVP-TE tunnels and PCEP sessions (required for all LSP provisioning) is enabled. This option is enabled by default.
topology	any value	there is no impact. This property key is deprecated and should be manually removed if it still appears as an option. This property key is ignored, regardless if it is configured.

Important considerations when using property keys:

- Topology can be visualized even with **auto-onboard** as **off** and a **device-profile** is not specified.
- If **managed** or **unmanaged** options are set and you want to delete a device later, you must either:
  - Reconfigure and remove the devices from the network before deleting the device from Crosswork Network Controller. This avoids Crosswork Network Controller from rediscovering and adding the device back.
  - Set **auto-onboard** to **off**, and then delete the device from Crosswork Network Controller. However, doing so will not allow Crosswork Network Controller to detect or auto-onboard any new devices in the network.
- If you want to upgrade a device, change its state to **unmanaged** before starting the upgrade. After completing the upgrade, return the device to the **UP** state.
- It is not recommended to modify **auto-onboard** options once set. If you need to modify them:
  1. Delete the provider and wait until deletion confirmation is displayed in the **Events** window.
  2. Add the provider again with the updated **auto-onboard** option.
  3. Confirm the provider has been added with the correct **auto-onboard** option in the **Events** window.

Step 3 Click **Save** to add the SR-PCE provider.

Step 4 Confirm that the SR-PCE provider shows a green Reachability status without any errors. You can also view the Events window to see if the provider has been configured correctly.

Step 5 Repeat this process for each SR-PCE provider.

What to do next

- If **auto-onboard** is set to **off**, start onboarding devices.
- If you opted to automatically onboard devices, choose **Device Management** > **Network Devices** to view the device list. To add more node information such as geographical location details, export the device list (.csv), update it, and import it back. If geographical location data is missing, you will only be able to see device topology using the logical map.

Cisco SR-PCE reachability issues

Use this procedure to resolve Cisco SR-PCE connectivity problems and restoring real-time topology status updates and notifications.

You can find SR-PCE reachability issues raised in the Events table and reachability status in the **Providers** page. Refer to Get provider details, on page 50 for details. If the SR-PCE goes down, the system displays all topology links in their last known state, and you stop receiving topology updates and notifications. When SR-PCE connectivity resumes, the Events table (⚑) shows a reconnection message and the topology is updated accordingly.

You can troubleshoot reachability in these ways:

Procedure

Step 1 Check device credentials.

Step 2 Ping the provider host to verify network connectivity.

Step 3 Attempt a connection using the protocols specified in the provider's connectivity settings. For an SR-PCE provider, it is typically HTTP and port 8080.

Step 4 Check firewall rules and network configurations to ensure they are not blocking required ports or services.

Step 5 Check for Access Control List (ACL) settings on the Cisco SR-PCE host or any intervening devices that might restrict access.

Step 6 If the SR-PCE remains unreachable for a long period, or the system is not syncing or updating, delete the SR-PCE and add it again when connectivity returns.

a) Execute the following command on the SR-PCE host to restart the process:

```
# process restart pce_server
```

b) Choose **Administration** > **Manage Provider Access** and delete the SR-PCE provider. On restoring connectivity, add the provider again.

Multiple Cisco SR-PCE HA pairs

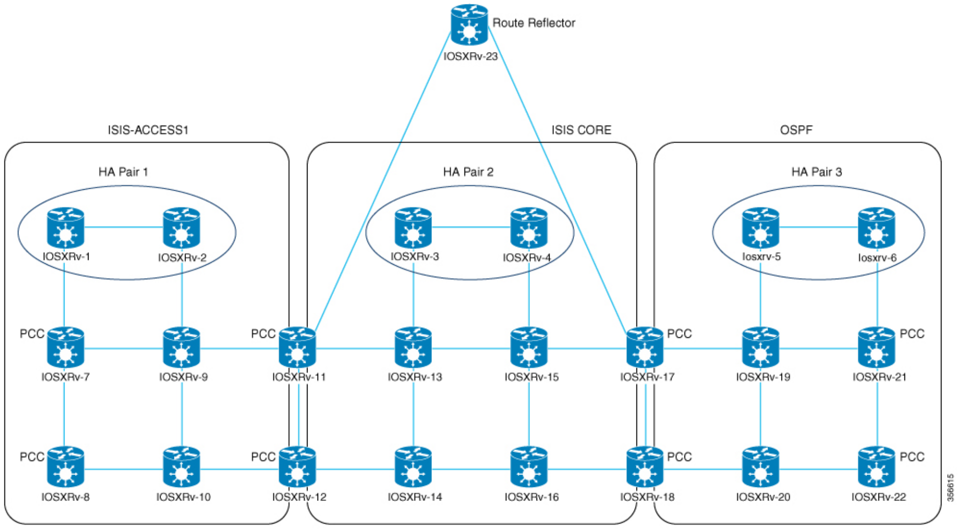
Multiple Cisco SR-PCE HA pairs allow network operators to deploy up to eight redundant SR-PCE pairs for greater overall system resilience and scalability. Each HA pair of Cisco SR-PCE providers must have matching configurations and must support the same network topology. If one SR-PCE in a pair becomes unreachable, the system uses the secondary SR-PCE to discover the network topology. If both fail, the next HA pair takes over and so forth. The network topology will continue to be updated correctly and you can view SR-PCE connectivity events in the Events table (⚑).

Multiple HA pair behavior

In the case of multiple SR-PCE HA pairs, each SR-PCE pair sees the same topology and manages only the tunnels created from its Path Computation Clients (PCCs). The figure shows a sample of a three SR-PCE HA pair topology.

- HA Pair 1—PCE iosxrv-1 and iosxrv-2 *only* provision and discover tunnels whose headends are iosxrv-7 and iosxrv-8. Note that iosxrv-9 and iosxrv-10 are not PCC routers.
- HA Pair 2—PCE iosxrv-3 and iosxrv-4 *only* provision and discover tunnels whose headends are iosxrv-11, iosxrv-12, iosxrv-17, and iosxrv-18. Note that iosxrv-13, iosxrv-14, iosxrv-15, and iosxrv-16 are not PCC routers.
- HA Pair 3—PCE iosxrv-5 and iosxrv-6 *only* provision and discover tunnels whose headends are iosxrv-21 and iosxrv-22. Note that iosxrv-19 and iosxrv-20 are not PCC routers.

Figure 5: Sample 3 HA pair topology



Note When multiple SR-PCE HA pairs are configured, the SR-PCE used for topology discovery is selected randomly based on which SR-PCE responds first. All SR-PCEs across all HA pairs must maintain the same complete network topology to ensure consistent network operations.

Configure HA

The following configurations must be done to enable each pair of HA Cisco SR-PCE providers to be added in Crosswork Network Controller.

Note There must be resilient IPv4 connectivity between both SR-PCEs to enable HA. The PCE IP address of the other SR-PCE should be reachable by the peer at all times.

Issue this commands on *each* Cisco SR-PCE device:

Enable the interface:

```
# interface <interface><slot>/<port>
ipv4 address <sync-link-interface-ip-address> <subnet-mask>
no shut
```

Enable HA:

```
# pce api sibling ipv4 <other-node-pce-address>
```

Establish a sync link between the two SR-PCEs:

```
# router static
address-family ipv4 unicast
<other-node-pce-ip-address>/<subnet-mask-length> <remote-sync-link-ip-address>
```

(Optional) `# pce segment-routing traffic-eng peer ipv4 <other-node-pce-ip-address>`

It should be entered for each PCC and not for other PCE nodes.

Enter this command on the PCC:

For SR Policies: `# segment-routing traffic-eng pcc redundancy pcc-centric`

For RSVP-TE Tunnels: `# mpls traffic-eng pce stateful-client redundancy pcc-centric`

Confirm sibling SR-PCE configuration

From the SR-PCE, enter the `show tcp brief` command to verify that synchronization between SR-PCEs in HA are intact:

```
#show tcp brief | include <remote-SR-PCE-router-id>
```

Confirm the information is correct:

Local address	Foreign address	State
`<local-SR-PCE-router-id>:8080`	`<remote-SR-PCE-router-id>:<any-port-id>`	ESTAB
`<local-SR-PCE-router-id>:<any-port-id>`	`<remote-SR-PCE-router-id>:8080`	ESTAB

For example:

```
RP/0/0/CPU0:iosxrv-1#sh tcp brief | i 192.168.0.2:
Mon Jun 22 18:43:09.044 UTC
0x153af340 0x60000000 0 0 192.168.0.1:47230 192.168.0.2:8080 ESTAB
0x153aaa6c 0x60000000 0 0 192.168.0.1:8080 192.168.0.2:16765 ESTAB
```

In this example, 192.168.0.2 is the remote SR-PCE IP.

SR-PCE delegation

Depending on where an SR-TE policy is created, the following SR-PCE delegation occurs:

- SR-PCE initiated—Policies configured on a PCE. SR-TE policies are delegated back to the source SR-PCE.

Note

- The policy can be PCE initiated even if it is created using the UI, but in that case it is not configured explicitly on SR-PCE.
- RSVP-TE tunnels cannot be configured directly on a PCE.

- PCC initiated—An SR-TE policy or RSVP-TE tunnel that is configured directly on a device. The SR-PCE configured with the lowest precedence is the delegated SR-PCE. If precedence is not set, then SR-PCE with the lowest PCE IP address is the delegated SR-PCE. The configuration example, shows that **10.0.0.1** is assigned a precedence value of 10 and will be the delegated SR-PCE.

```
segment-routing
  traffic-eng
    pcc
      source-address ipv4 10.0.0.2
      pce address ipv4 10.0.0.1
        precedence 10
       !
      pce address ipv4 10.0.0.8
        precedence 20
       !
       report-all
       redundancy pcc-centric
```

For RSVP-TE Tunnel:

```
mpls traffic-eng
interface GigabitEthernet0/0/0/0
!
interface GigabitEthernet0/0/0/1
!
interface GigabitEthernet0/0/0/2
!
pce
  peer source ipv4 192.168.0.02
  peer ipv4 192.168.0.9
    precedence 10
  !
  peer ipv4 192.168.0.10
    precedence 20
  !
  stateful-client
   instantiation
   report
   redundancy pcc-centric
   autoroute-announce
  !
!
auto-tunnel pcc
  tunnel-id min 1000 max 5000
```

- Crosswork Network Controller SR-PCE initiated—An SR-TE policy that is configured using Crosswork Network Controller. SR-PCE delegation is random per policy.

Note Only SR-TE policies or RSVP-TE tunnels created by Crosswork Network Controller can be modified or deleted by Crosswork Network Controller.

HA notes and limitations

- It is assumed that all PCCs are PCEP connected to both SR-PCEs.
- When an SR-PCE is disconnected only from Cisco Crosswork, the following occurs:
  - SR-PCE delegation assignments remain, but the SR-PCE that has been disconnected will not appear in Crosswork Network Controller.
  - You are not able to modify Cisco Crosswork SR-PCE initiated SR-TE policies if the disconnected SR-PCE is the delegated PCE.
- In some cases, when an SR-TE policy that was created via the UI is automatically deleted (intentional and expected) from Crosswork Network Controller, a warning message does not appear. For example, if the source PCC is reloaded, the UI created SR policy disappears and the user is not informed.
- In an extreme case where one SR-PCE fails on all links (to PCCs/topology devices) except the up-link to Crosswork Network Controller, topology information will not be accurate in Crosswork Network Controller. To resolve this, fix the connectivity issue or delete both SR-PCEs from the Provider page and re-add the reachable one.
- **PCE HA failover:** After a PCE HA failover, when Crosswork Network Controller connects to the next available PCE, the Topology Service could take up to **2 hours** to re-learn all L3 links and LSPs depending on the scale. During this time, newly created LSPs will remain in the queue and only appear in the UI after re-learning is complete.
- When an SR-PCE goes down, **Local Congestion Mitigation** (LCM) enters a dormant stage. To exit this state, all SR-PCEs must be connected, and their associated topologies fully synchronized with the topology service. LCM will remain dormant until these conditions are met. It is important to note that LCM does not have visibility into the state of the SR-PCE redundancy set.

SR-PCE configuration examples

The following configurations are *examples* to guide you in a multiple SR-PCE setup for HA. Please modify accordingly.

ISIS single topology configuration for dual-stack networks

Cisco Crosswork Network Controller supports ISIS Single Topology in addition to Multi-Topology. To utilize this, your XTC devices must be configured for ISIS Single Topology. For Single Topology configurations, only global IPv6 addressing is supported; support for link-local IPv6 addressing is not included.

Device-side configuration example

```
RP/0/RP0/CPU0:iosxrv-2(config)#router isis [NAME]
RP/0/RP0/CPU0:iosxrv-2(config-isis)#address-family ipv6 unicast
RP/0/RP0/CPU0:iosxrv-2(config-isis-af)#single-topology
```

Configuration requirements for deploying and reporting SR MSL policies to PCE

Enable gRPC on devices and for SR-TE policies

```
RP/0/RP0/CPU0:L1-NCS5501#sh running-config grpc
grpc
 segment-routing
  traffic-eng
   policy-service
  !
 !
 port 57400
 no-tls
```

Advertise all SR policies to BGP-LS peers

This configuration enables your router to report all configured SR MSL policies—both active and inactive—into the link-state database. As a result, these policies can be advertised via BGP-LS to controllers or peers, providing full visibility and supporting network orchestration.

```
RP/0/RP0/CPU0:L1-NCS5501#sh running-config segment-routing traffic-eng distribute link-state

segment-routing
 traffic-eng
  distribute link-state
   report-candidate-path-inactive
  !
 !
!
```

Prevent reporting MSL policies in PCEP

This configuration prevents SR MSL policies from being reported via PCEP. Since PCEP does not fully support MSL policies (it only advertises a single segment list, which can cause operational issues), it is recommended to remove the report-all command from the PCC configuration on the headend router.

```
RP/0/RP0/CPU0:L4-NCS560#sh running-config segment-routing traffic-eng pcc
segment-routing
 traffic-eng
  pcc
   source-address ipv4 192.100.0.4
   pce address ipv4 100.100.0.1
    precedence 25
   !
   pce address ipv4 100.100.0.2
    precedence 50
   !
   !  Remove the following line to prevent reporting MSL policies to PCE
   !  report-all
   redundancy pcc-centric
   profile 1981
    autoroute
     include ipv4 all
     force-sr-include
    !
   !
  !
 !
!
```

Advertise SR MSL policies in link-state to PCE neighbor via BGP-LS

This configuration enables your router to advertise SR MSL policies in the link-state address family to a PCE neighbor over BGP. By establishing a BGP session with the PCE and including the `address-family link-state link-state` configuration, the router ensures that SR MSL policies are advertised and can be learned by the PCE.

Note The link-state address family must be configured on both the headend and the PCE for successful exchange.

```
RP/0/RP0/CPU0:L1-NCS5501#sh running-config router bgp
router bgp 60
```

```
 neighbor <NEIGHBOR_IP>   ! PCE neighbor
  remote-as 60
  update-source Loopback0
  address-family ipv4 unicast
   next-hop-self
  !
  address-family ipv6 unicast
  !
  address-family link-state link-state. ! Enable BGP-LS for SR MSL policy advertisement
  !
 !
```

SRv6 data collection and traffic steering for DDM (Deterministic Demand Matrix) integration on Cisco IOS XR

Enable SRv6 locator accounting

This configuration enables the router to perform detailed accounting for IPv6 traffic specifically related to SRv6 locators. By tracking traffic on a per-prefix and per-nexthop basis, operators gain granular visibility into the usage and flow of SRv6-enabled services.

```
RP/0/RP0/CPU0:L1-NCS5501#sh running-config accounting
accounting
 prefixes
  ipv6
   mode per-prefix per-nexthop srv6-locators
  !
 !
!
```

Enable SRv6 accounting data to telemetry

This configuration sets up model-driven telemetry on the router to stream SRv6 accounting data to external collectors. By defining specific sensor paths, the router can push operational data related to SRv6 locator accounting, enabling real-time monitoring, analysis, and orchestration of SRv6 network performance and traffic patterns.

```
RP/0/RP0/CPU0:L1-NCS5501#sh running-config telemetry model-driven
telemetry model-driven
 sensor-group cisco_models
  sensor-path
Cisco-IOS-XR-infra-xtc-agent-oper:xtc/forwarding/policy-forwardings/policy-forwarding
  sensor-path
Cisco-IOS-XR-fib-common-oper:cef-accounting/vrfs/vrf[vrf-name='default']/afis/afi[afi-type=ipv6]/pfx/srv6locs/srv6loc

 !
!
```

Enable customer/VRF traffic steering to SRv6 locators via BGP

This configuration enables an edge router to steer customer or VRF (Virtual Routing and Forwarding) IPv4 and IPv6 traffic into specific SRv6 locators using BGP.

```
RP/0/RP0/CPU0:L1-NCS5501#sh running-config router bgp
router bgp 60
 bgp router-id <ROUTER_ID_IP>
 segment-routing srv6
  locator L1algo0
 !
 address-family ipv4 unicast
  network <ROUTER_ID_IP>/32
 !
 address-family vpnv4 unicast
  vrf all                ! If there are multiple VRF where traffic is ingressing, add srv6
 locator in vrf all.
   segment-routing srv6
    locator L1algo0
    alloc mode per-vrf
   !
  !
 !
 vrf ntt
  rd 200:200
  address-family ipv4 unicast
   segment-routing srv6   ! If there is only one VRF where traffic is ingressing, add srv6
 locator in this vrf alone, if there is no VRF, then add the locator in neighbor address
family
    locator L1algo0
    alloc mode per-vrf
   !
   redistribute connected
  !
  neighbor <NEIGHBOR_IP>
   remote-as 61
   update-source GigabitEthernet0/0/0/0
   address-family ipv4 unicast
    route-policy PASS_ALL in
    route-policy PASS_ALL out
   !
  !
 !
```

Verify SRv6 traffic steering via CEF accounting

This command is used to verify that IPv6 traffic is being steered into SRv6 locators, rather than MPLS labels, by inspecting the CEF accounting statistics. It provides granular visibility, showing packet and byte counts for specific IPv6 prefixes that are associated with SRv6 locators.

```
sh cef ipv6 accounting
fccc:cc3e:3::/48
Accounting: 0/0 packets/bytes output (per-prefix-per-path mode)
 via fe80::2/128, Bundle-Ether1201
  path-idx 0
  next hop fe80::2/128
  Accounting: 200000/58400000 packets/bytes output  <<< Traffic packets for prefix
fccc:cc3e:3::
```

Other sample SR-PCE configurations

Redundant SR-PCE configuration (on PCE with Cisco IOS-XR 7.x.x)

```
pce
 address ipv4 100.100.0.7
 state-sync ipv4 100.100.0.1
 api
  sibling ipv4 100.100.0.1
```

PCE configuration for enabling gRPC API on XR 25.2.1.x (IPv4 deployment)

```
conf t
  lslib-server
  !
  grpc
    port 57400
    no-tls
    address-family ipv4
    service-layer
    !
!
pce
  distribute link-state
  !
!
linux networking
  vrf default
    address-family ipv4
      default-route software-forwarding
    !
    address-family ipv6
      default-route software-forwarding
    !
  !
!
commit
```

Note For secure gRPC deployment, remove `no-tls`.

Configure distribute link-state on all PCEs to inject SR policies into BGP-LS.

Enable gRPC API on XR 25.2.1.x (IPv6 deployment)

```
conf t
  lslib-server
  !
  grpc
    port 57400
    no-tls
    address-family ipv6
    service-layer
    !
!
pce
  distribute link-state
  !
!
linux networking
  vrf default
    address-family ipv4
      default-route software-forwarding
    !
    address-family ipv6
      default-route software-forwarding
    !
  !
!
commit
```

Note For secure gRPC deployment, remove `no-tls`.

Configure distribute link-state on all PCEs to inject SR policies into BGP-LS.

Verify whether the topology is published in gRPC

```
sh lslib server topology-db
```

Verify the SR-MPLS LSP published in gRPC

```
show lslib server topology-db detail protocol sr
```

Redundant SR-PCE configuration (PCC)

```
segment-routing
 traffic-eng
  pcc
   source-address ipv4 100.0.0.1
   pce address ipv4 100.0.0.2
    precedence 200
   !
   pce address ipv4 100.0.0.3
    precedence 100
   !
   report-all
   redundancy pcc-centric
```

Redundant SR-PCE configuration (on PCC) for RSVP-TE

Note `Loopback0` represents the TE router ID.

```
ipv4 unnumbered mpls traffic-eng Loopback0
!
mpls traffic-eng
 pce
  peer source ipv4 200.100.200.1
  peer ipv4 209.165.0.6
   precedence 200
  !
  peer ipv4 100.100.0.0
   precedence 100
  !
  stateful-client
   instantiation
   report
   redundancy pcc-centric
   autoroute-announce
  !
 !
 auto-tunnel pcc
  tunnel-id min 1000 max 1999
 !
!
```

Sample Telemetry configuations

SR-TM configuation

```
telemetry model-driven
 destination-group crosswork
  address-family ipv4 5.5.5.5 port 9000
   encoding self-describing-gpb
   protocol tcp
  !
 !
 sensor-group SRTM
  sensor-path Cisco-IOS-XR-infra-tc-oper:traffic-collector/afs/af/counters/tunnels
  sensor-path
Cisco-IOS-XR-infra-tc-oper:traffic-collector/vrf-table/default-vrf/afs/af/counters/prefixes
```

```
 !
 subscription OE
  sensor-group-id SRTM sample-interval 60000
  destination-id crosswork
  source-interface Loopback0
!
traffic-collector
 interface GigabitEthernet0/0/0/3
 !
 statistics
  history-size 10
```

Note The destination address uses the southbound data interface (eth1) address of the Crosswork Data Gateway VM.

It is required to push sensor path on telemetry configuration via NSO to get prefix and tunnel counters. It is assumed that the Traffic Collector has been configured with all the traffic ingress interface. This configuration is needed for demands in the Bandwidth on Demand feature pack to work.

Telemetry sensor path

```
sensor-path Cisco-IOS-XR-infra-tc-oper:traffic-collector/afs/af/counters/tunnels/tunnel
sensor-path
Cisco-IOS-XR-infra-tc-oper:traffic-collector/vrf-table/default-vrf/afs/af/counters/prefixes/prefix
```

Telemetry configuration pushed by Crosswork Network Controller to all the headend routers via NSO

```
telemetry model-driven
  destination-group CW_43dc8a5ea99529715899b4f5218408a785e40fce
    vrf default
    address-family ipv4 5.5.5.5 port 30500
      encoding self-describing-gpb
      protocol tcp
    !
  !
destination-group CW_4b3c69a200668b0a8dc155caff295645c684a8f8
  vrf default
  address-family ipv4 5.5.5.5 port 30500
    encoding self-describing-gpb
    protocol tcp
  !
!
sensor-group CW_43dc8a5ea99529715899b4f5218408a785e40fce
  sensor-path Cisco-IOS-XR-infra-tc-oper:traffic-collector/afs/af/counters/tunnels/tunnel
!
sensor-group CW_4b3c69a200668b0a8dc155caff295645c684a8f8
  sensor-path
Cisco-IOS-XR-infra-tc-oper:traffic-collector/vrf-table/default-vrf/afs/af/counters/prefixes/prefix
!
subscription CW_43dc8a5ea99529715899b4f5218408a785e40fce
  sensor-group-id CW_43dc8a5ea99529715899b4f5218408a785e40fce sample-interval 300000
  destination-id CW_43dc8a5ea99529715899b4f5218408a785e40fce
!
subscription CW_4b3c69a200668b0a8dc155caff295645c684a8f8
  sensor-group-id CW_4b3c69a200668b%a8dc155caff295645c684a8f8 sample-interval 300000
  destination-id CW_463c69a200668b0a8dc155caff295645c684a8f8
  !
!
```

Traffic Collector configurations

Traffic Collector configurations (all Ingress traffic interface to be added below in the Traffic Collector)

```
RP/0/RSP0/CPU0:PE1-ASR9k#sh running-config traffic-collector
Fri May 22 01:14:35.845 PDT
traffic-collector
  interface GigabitEthernet0/0/0/0
  !
  statistics
    history-size 1
    collection-interval 1
    history-timeout 1
    history-minute-timeout
  !
!
```

Add BGP neighbor next-hop-self for all the prefix (to show TM rate counters)

```
bgp router-id 5.5.5.5
address-family ipv4 unicast
  network 5.5.5.5/32
  redistribute static
!
address-family link-state link-state
!
neighbor 1.1.1.1
  remote-as 65000
  update-source Loopback0
  address-family ipv4 unicast
   next-hop-self
  !
!
```

Traffic collector tunnel and prefix counters

```
RP/0/RSP0/CPU0:PE1-ASR9k#show traffic-collector ipv4 counters prefix
Fri May 22 01:13:51.458 PDT
Prefix              Label         Base rate         TM rate        State
                                  (Bytes/sec)       (Bytes/sec)
-----------------  -------------  ---------------  --------------  -----------------
1.1.1.1/32          650001         3                0              Active
2.2.2.2/32          650002         3                0              Active
3.3.3.3/32          650003         6                0              Active
4.4.4.4/32          650004         1                0              Active
6.6.6.6/32          650200         6326338          6326234        Active
7.7.7.7/32          650007         62763285         62764006       Active
8.8.8.8/32          650008         31129168         31130488       Active
9.9.9.9/32          650009         1                0              Active
10.10.10.10/32      650010         1                0              Active
RP/0/RSP0/CPU0:PE1-ASR9k#stt
RP/0/RSP0/CPU0:PE1-ASR9k#show traffic-collector ipv4 counters tunnel
Fri May 22 01:13:52.169 PDT
RP/0/RSP0/CPU0:PE1-ASR9k#]
```

Path computation client (PCC) support

A path computation client (PCC) is a network device that

- initiates path computation requests to an external path computation element (PCE),
- reports the status and attributes of label-switched paths (LSPs) such as RSVP-TE tunnels or SR policies, and

- establishes and manages Path Computation Element Protocol (PCEP) sessions with one or more PCEs for dynamic tunnel delegation and control.

Path computation clients (PCCs) can support delegation and reporting of multiple tunnel types, such as RSVP-TE tunnels and SR policies. For both functionalities to be supported on the same PCC, it is necessary to establish two separate PCEP connections with the PCEs. Each of these PCEP connections must use a unique source IP address, typically assigned to a loopback interface on the PCC.

Configuration example to set up PCEP connections for RSVP-TE tunnels on a Cisco IOS-XR

- The IP address 192.168.0.2 is the source IP for the PCEP session. This IP is assigned to a loopback interface on the router, ensuring stability and uniqueness.
- Two SR-PCEs are configured as peers for PCEP sessions. Each has a precedence value, with the lower precedence (10) indicating the preferred PCE for delegating RSVP-TE tunnels.
- An auto-tunnel PCC feature is configured with a range of tunnel IDs (from 10 to 1000). These IDs are assigned to RSVP-TE tunnels initiated by the PCE, such as those created by Cisco Crosswork Optimization Engine.

```
mpls traffic-eng
interface GigabitEthernet0/0/0/2
admin-weight 1
!
interface GigabitEthernet0/0/0/3
admin-weight 1
  pce
    peer source ipv4 192.168.0.2
    peer ipv4 192.168.0.1
      precedence 10
     !
    peer ipv4 192.168.0.8
      precedence 11
     !
    stateful-client
      instantiation
      report
     !
   !
   auto-tunnel pcc
    tunnel-id min 10 max 1000
   !
!
ipv4 unnumbered mpls traffic-eng Loopback0

rsvp
interface GigabitEthernet0/0/0/2
bandwidth 1000000
!
interface GigabitEthernet0/0/0/3
bandwidth 1000000
!
!
```

Add Cisco WAE providers

Before you begin

- Create a credential profile for the Cisco WAE provider. For instructions, see Create credential profiles, on page 2. This should be a basic HTTP/HTTPS text-authentication credential. MD5 authentication is not supported. If the Cisco WAE server you are adding does not require authentication, you must still supply a credential profile, but it can be any profile that does not use the HTTP/HTTPS protocol.

- Know the name you want to assign to the provider. This is usually the DNS hostname of the Cisco WAE server.
- Know the Cisco WAE server IP address and port. The connection protocol will be HTTP or HTTPS.

Cisco WAN Automation Engine (Cisco WAE) providers supply traffic and topology analysis to the Crosswork Network Controller components. The foundation software is Cisco WAE Planning, which provides a cross-sectional view of traffic, topology, and equipment state. It takes advantage of a predictive model that performs "what if" analysis of failure impacts.

To add one or more Cisco WAE providers using the Crosswork Network Controller UI, complete these steps. To add providers by importing CSV files, refer to the instructions in Import providers, on page 15.

Procedure

Step 1 Choose **Administration** > **Manage Provider Access** > +.

Step 2 Enter these provider field values:

a) **Provider name**: Enter a name for the Cisco WAE provider.
b) **Credential profile**: Select the credential profile you created.
c) **Family**: Select **`WAE`**.
d) Configure connection type properties:

- **Protocol**: Select **`HTTP`** or **`HTTPS`** as per the credential profile you are using.
- **Server details**: Enter the server IP address (IPv4 or IPv6) and subnet mask.
- **Port**: Enter the appropriate port number (usually `8080` for HTTP, and `8843` for HTTPS).
- **Timeout** (Optional): Enter the amount of time (in seconds) to wait before timing out the connection to the server. The default is 30 seconds.

Step 3 Click **Save** to add the provider.

Add syslog storage providers

Before you begin

- Create a credential profile for the storage provider. For instructions, see Create credential profiles, on page 2. This should be an SSH credential.
- Know the name you want to assign to the storage provider. This is usually the DNS hostname of the server.
- Know the storage provider's server IPv4 address and port. The connection protocol will be SSH.
- Know the destination directory on the storage provider's server. You will need to specify this using the **Provider properties** fields.

To add one or more storage providers using the Crosswork Network Controller UI, complete these steps. To add providers by importing CSV files, refer to the instructions in Import providers, on page 15.

Procedure

Step 1 Choose **Administration** > **Manage Provider Access** > ＋.

Step 2 Enter these provider field values:

a) **Provider name**: Enter a name for the storage provider.

b) **Credential profile**: Select the credential profile you created.

c) **Family**: Select `SYSLOG_STORAGE`.

d) Configure connection type properties:

- **Protocol**: Select `SSH` as the protocol to connect the provider.
- **Server details**: Enter the server IP address (IPv4 or IPv6) and subnet mask.
- **Port**: Enter the appropriate port number (usually `22` for SSH).
- **Timeout** (Optional): Enter the amount of time (in seconds) to wait before timing out the connection to the server. The default is 30 seconds.

e) To configure provider properties, enter this key/value pair:

Property key: `DestinationDirectory`

Property value: The absolute path where the collected data will be stored on the server. For example: `/root/cw-syslogs`

Step 3 Click **Save** to add the provider.

Add an alert provider

Before you begin

- Create a credential profile for the alert provider. For instructions, see Create credential profiles, on page 2. This should be a basic HTTP text-authentication credential. MD5 authentication is not supported. If the provider does not require authentication, you must still supply a credential profile. It can be any profile that does not use the HTTP protocol.
- Know the name you want to assign to the alert provider. This is usually the DNS hostname of the server.
- Know the alert provider's server IPv4 address and port. The connection protocol will be HTTP.
- Know the URL of the alert server endpoint. You will need to specify this using the **Provider properties** fields.

An Alert provider is a destination to which you want to forward alerts collected during KPI monitoring (such as Cisco Crosswork Situation Manager). An alert provider must be capable of receiving and processing incoming alert packages. Currently, only one alert provider is supported.

To add an alert provider using the Crosswork Network Controller UI, complete these steps. To add an alert provider by importing CSV files, refer to the instructions in Import providers, on page 15.

Procedure

Step 1 Choose **Administration** > **Manage Provider Access** > ⊞.

Step 2 Enter these provider field values:

a) **Provider name**: Enter a name for the alert provider.

b) **Credential profile**: Select the credential profile you created.

c) **Family**: Select **`ALERT`**.

d) Configure connection type properties:

- **Protocol**: **`HTTP`** is pre-selected as the protocol to connect the provider.
- **Server details**: Enter the server IP address (IPv4 or IPv6) and subnet mask.
- **Port**: Enter the port number (usually **`80`** for HTTP).
- **Timeout** (Optional): Enter the amount of time (in seconds) to wait before timing out the connection to the server. The default is 30 seconds.

e) For provider properties, the **`alertEndpointUrl`** **Property key** is pre-entered. In the **Property value** field, enter the alert server endpoint only. For example, if the complete path to the endpoint is **`http://aws.amazon.com:80/myendpoint/bar1/`**, you would enter **`/myendpoint/bar1/`** only.

Step 3 Click **Save** to add the provider.

Add proxy providers

Before you begin

- Create a credential profile for each proxy provider. For instructions, see Create credential profiles, on page 2. This should be a basic HTTP or HTTPS text-authentication credential.
- Know the Resource Facing Service (RFS) node name added to the Customer Facing Service (CFS) node in your LSA cluster.
- Know the name you want to assign to the provider. This is usually the DNS hostname of the proxy server.
- Know the proxy server IP address and port. The connection protocol will be HTTP or HTTPS.
- Ensure the Cisco NSO providers have been added. For more information, see Add a Cisco NSO provider, on page 19.
- For NSO proxy provider, create a credential profile with **HTTP/HTTPS** with **Basic Authentication**.
- For ONC 1.0 proxy provider, create a credential profile with **HTTPS** with **Basic Authentication**.

You add a proxy providers to enable service provisioning through the Crosswork Network Controller interface. Crosswork Network Controller supports adding Cisco NSO and Cisco Optical Network Controller (ONC) v1.0 proxy providers.

- NSO APIs are directly accessible if NSO is configured with an external IP address.
- If NSO is deployed within a private network, then it will be reachable only through the Crosswork Network Controller interface. Proxy providers enables you to use Crosswork interface to perform service provisioning with NSO.

To add proxy providers, complete these steps:

Procedure

Step 1 Choose **Administration** > **Manage Provider Access** > ➕.

Step 2 Enter these provider field values:

a) **Provider name**: Enter a name for the proxy provider.

b) **Credential profile**: Select the credential profile you created.

Note
For ONC provider, select the profile configured with ONC TAPI APIs, not the ONC UI credentials.

c) **Family**: Select `PROXY`.

d) Configure connection type properties:

- **Protocol**: Select `HTTP` or `HTTPS`.
- **Server details**: Enter the IP address (IPv4 or IPv6) and subnet mask of the NSO cluster or the ONC 1.0 cluster VIP.
- **Port**: Enter the appropriate port number (usually `30603` for HTTPS).
- **Timeout** (Optional): Enter the amount of time (in seconds) to wait before timing out the connection to the server. The default is 30 seconds.

e) Configure **Provider properties** with these key and value pairs:

Table 9: For NSO proxy provider

Property key	Property value
`forward`	`true`
`input_url_prefix` **Note** Required only in case of RFS nodes.	`/<rfs-node-name>` *<rfs-node-name>* refers to the name of the RFS node added to the CFS node in the LSA cluster.

Table 10: For ONC 1.0 proxy provider

Property key	Property value
`forward`	`true`
`input_url_prefix`	`/onc-tapi`

Property key	Property value
`output_url_prefix`	`/crosswork/onc-tapi`

Step 3 Click **Save** to add the provider.

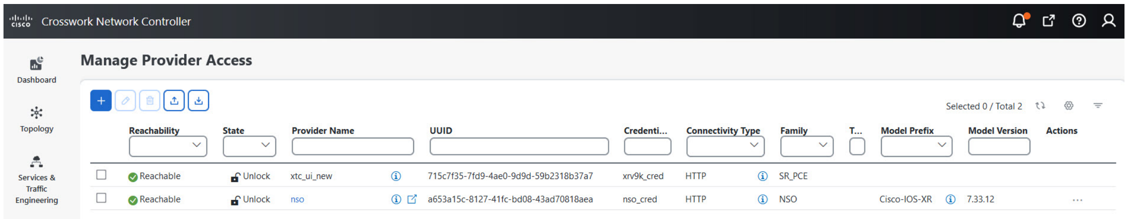
Get provider details

You can view details for each configured provider and check provider reachability in your Cisco Crosswork application. Use the **Providers** page to access information about each provider, including name, universally unique identifier (UUID), credential profile, and connectivity status. You can also view reachability status via different protocols.

Procedure

Step 1 Choose **Administration** > **Manage Provider Access**.
The **Providers** page displays all configured providers with details such as name, UUID, credential profile, and more.

Figure 6: Manage providers access



Manage Provider Access

Selected 0 / Total 2

	Reachability	State	Provider Name	UUID	Credenti...	Connectivity Type	Family	T...	Model Prefix	Model Version	Actions
□	Reachable	Unlock	xtc_ui_new	715c7f35-7fd9-4ae0-9d9d-59b2318b37a7	xrv9k_cred	HTTP	SR_PCE				
□	Reachable	Unlock	nso	a653a15c-8127-41fc-bd08-43ad70818aea	nso_cred	HTTP	NSO		Cisco-IOS-XR	7.33.12	...

Step 2 The icons in the **Reachability** column indicate whether a provider is reachable via the listed connectivity protocols.

Provider reachability is checked automatically after you add or modify a provider. For Change Automation and Health Insights, ongoing checks occur approximately every 5 minutes. For SR-PCE via the Optimization Engine, checks occur every 10 seconds.

Note
Change Automation events and **Health Insights** events apply only to cluster deployments of the Crosswork Network Controller. **Optimization Engine** events applies in all cases except single VM deployments of the Crosswork Network Controller Essentials tier.

Step 3 To view additional details for a provider:

a) In the **Provider Name** column, click ⓘ to view provider-specific key/value properties.

b) In the **Connectivity Type** column, click ⓘ to view detailed connectivity information for the provider. This information includes protocol, IP format, IP address, port, and timeout values.

c) In the **Model Prefix** column, click ⓘ to view the supported NED version(s) for a Cisco NSO provider's configured NED model prefix(es).

d) Click ✕ to exit the details window.

If you encounter SR-PCE reachability problems, ensure HTTP and port 8080 are set, and see Cisco SR-PCE reachability issues, on page 33.

For general provider reachability issues:

a. Ping the provider host.

b. Attempt a connection using the protocols specified in the provider's connectivity settings.

Use this CLI command to perform this check:

```
curl -v -H "X-Subscribe: stream" "http://<ip-address>:8080/
bwod/subscribe/json?keepalive-30&priority=5"
```

c. Check your firewall setting and network configuration.

d. Review Access Control List (ACL) settings on the provider host or intermediate devices that could restrict connectivity.

Edit provider settings

Before you begin

Export a CSV backup of the providers you want to change.

Use this procedure to update the settings for an existing provider. Provider changes can affect many devices in your network, potentially thousands in large environments.

Note

- Before editing any provider settings, make sure you understand the impact of your changes. If you are unsure about the potential risk of making a change, contact Cisco services for guidance.
- If modifying an SR-PCE provider, see related guidance in Add SR-PCE providers, on page 29 section; additional steps may be necessary.

To update an existing provider, complete these steps:

Procedure

Step 1 Choose **Administration** > **Manage Provider Access**.

Step 2 In the **Providers** window, select the provider to update and click ✎.

Step 3 Make necessary changes and click **Save**.

Step 4 Resolve errors and confirm provider reachability.

The provider settings are updated and propagated to mapped devices.

Delete providers

Use this procedure to remove providers that are no longer needed. Delete providers only when they are not actively associated with devices or credential profiles. The system alerts you if associations exist.

To delete providers, complete these steps:

Procedure

Step 1 Export a backup CSV file containing the provider you plan to delete. For instructions, see Export providers, on page 52.

Step 2 (Optional) Check whether any devices are mapped to the provider and change the provider before deletion.

a) Choose **Device Management** > **Network Devices**. The **Network Devices** tab is displayed by default.

b) In the **Network Devices** window, enter the obsolete provider name in the **Search** field.

c) Select the device that is mapped to the obsolete provider, and click ✎.

d) Choose a different provider from the **Provider** drop-down list.

e) Click **Save**.

Step 3 Choose **Administration** > **Manage Provider Access**.

Step 4 In the **Providers** window, select the provider(s) to delete.

Step 5 Click 🗑 and confirm when prompted.

The selected providers are deleted if they are not associated with any devices or credential profiles.

Export providers

You can export provider data to a CSV file. This is a handy way to keep backup copies of your provider information.

Note You cannot edit a CSV file and then re-import it to update existing providers.

Procedure

Step 1 Choose **Administration** > **Manage Provider Access**.

Step 2 (Optional) In the **Manage Provider Access** page, filter the provider list as needed.

Step 3 Select the check boxes for the providers you want to export. To select all the providers for export, use the check box at the top of the column.

Step 4 Click ⇪. Depending on your browser, you will be prompted to select a path and file name for saving the CSV file, or to open the file immediately.

The selected providers are exported to a CSV file.

Manage tags

A tag is a text identifier that you can attach to objects in the system. It helps

- group and categorize those objects, and
- enables users to identify, locate, and organize devices for varied purposes.

Crosswork Network Controller comes with a predefined set of tags (such as cli, mdt, reach-check, snmp, and clock-drift-check), which are automatically assigned to every device that is managed. These default tags cannot be selected, edited, deleted, or manually associated with any device.

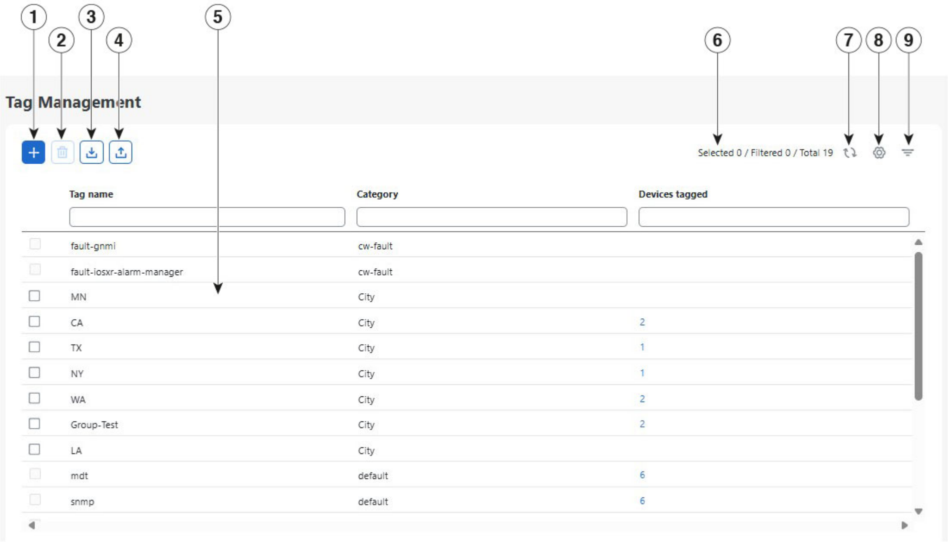
You can create custom tags to group devices by type, geographic location, their network role (for example, spine vs. leaf), or function (Provider vs. Provider Edge)

Tag management page

Tags can provide information such as the device’s physical location and its administrator’s email ID, and are used to group devices. Use the **Tag Management** page to easily create and manage them.

To navigate to this page, choose **Administration** > **Tag Management**.

Figure 7: Tag management page



Tag Management

Selected 0 / Filtered 0 / Total 19

	Tag name	Category	Devices tagged
□	fault-gnmi	cw-fault	
□	fault-iosxr-alarm-manager	cw-fault	
□	MN	City	
□	CA	City	2
□	TX	City	1
□	NY	City	1
□	WA	City	2
□	Group-Test	City	2
□	LA	City	
□	mdt	default	6
□	snmp	default	6

Table 11: Tag management page items

Item	Description
1	Click ＋ to create new device tags. For instructions, see Create tags, on page 54.
2	Click 🗑 to delete currently selected device tags. For instructions, see Delete tags, on page 56.

Item	Description
3	Click ⭳ to import the device tags defined in a CSV file into the Cisco Crosswork application. For instructions, see Import tags, on page 55. You can also download a CSV file template by clicking this icon. The template includes sample data that you can use as a guide for building your own CSV file.
4	Click ⭱ to export a CSV file that lists the tags that are currently configured and their attributes. You can update this file and import it back into the Cisco Crosswork application to quickly add or edit multiple tags. For instructions, see Export tags, on page 57.
5	Displays the tags and their attributes currently available in the Cisco Crosswork application.
6	Indicates the number of tags that are currently selected in the table.
7	Click ⟳ to refresh the **Tag Management** page.
8	Click ⚙ to choose the columns to make visible in the **Tag Management** page.
9	Click ≡ to set filter criteria on one or more columns in the **Tag Management** page.
	To clear a filter, click the corresponding [X] in the Filters menu.

Create tags

Creating tags makes it easier to organize, search, and filter managed objects. You can create up to 100 tags.

You can use a CSV file to efficiently import multiple tags. For instructions on importing multiple tags, see Import multiple tags using a CSV file.

Note Tag and tag category names are case-insensitive. They can contain up to 128 alphanumeric characters, as well as dots (.), underscores ("_"), or hyphens ("-"). No other special characters are allowed.

To create a tag, complete these steps:

Procedure

Step 1 Choose **Administration** > **Tag management** > +. This displays the **Add tags** pane.

Step 2 Choose the tag category from the **Select tag category** drop-down list or type a new category's name in the text field and click **Add**.

Step 3 In the **Add tags for <category name>**, type a name for the new tag and press Enter.

Step 4 Click **Save**.

Note

If you enter a duplicate tag, the **Save** button remains disabled.

Import tags

You can create a CSV file that lists the tags you want to apply to your devices, and then import it into the Cisco Crosswork applications. Importing multiple tags using a CSV file lets you efficiently create and update many tags and tag categories. This feature is valuable when you need to rapidly apply organizational tags to devices or make global tagging changes. The system automatically adds all new tags and tag categories from the CSV file to the database. It overwrites any existing tags with the same name. Consider exporting a backup of your current tags before starting the import.

Before you begin

Export a backup copy of your current tags. See Export tags, on page 57.

CSV file requirements

Your CSV file must include these fields:

Field	Description	Required or Optional
Tag Name	The name of the tag. For example: **`SanFrancisco`** or **`Spine/Leaf`**.	Required
Tag Category	The tag category. For example: **`City`** or **`Network Role`**.	Required

Note **Tag Name** and **Tag Category** fields are case-insensitive and can contain a maximum of 128 alphanumeric characters, plus dots (.), underscores ("_") or hyphens ("-"). No other special characters are permitted.

To import multiple tags using a CSV file, complete these steps:

Procedure

Step 1 From the main menu, choose **Administration** > **Tag Management** > ⤓.

Step 2 If you have not already created a CSV file:

a) Click the **Download sample 'Tags template (*.csv)' file** link and save the CSV file template to a local device.

b) Open the template in your preferred editor. Add a row for each tag, using a comma to separate fields and a semicolon for multiple entries in the same field.

c) Check that your file meets the formatting rules above.

Tip
Be sure to delete the sample data rows before saving the file, or they will be imported along with the data you want. The column header row can stay, as it is ignored during import.

d) Save the new CSV file.

Step 3 Click **Browse** and select your completed CSV file.

Step 4 Click **Import** to upload it.

The tags and tag categories appear in the **Tag Management** page.

What to do next

Assign imported tags to devices. See Apply or remove device tags, on page 56 for instructions.

Apply or remove device tags

Tags and their categories are your main tool for grouping devices. Once you have tagged a set of devices with the same tag, they are considered part of a group, and you can manage them more easily. You can apply a maximum of 15 tags to any one device.

In order to apply a tag to a device or group of devices, the tag must already exist. See Create tags for more information.

For efficiency, Cisco Crosswork automatically updates inventory data, including topology, for all the devices in a tagged group, as a single set of inventory collection jobs. But please note that tag-group membership is static for other functions. For example, if you add or remove a device from a tagged group after applying a KPI, the KPI will monitor only the original group members. If you change group membership and want the KPI to monitor all the members of the group, re-apply the KPI to the changed group.

To apply tags to a device or set of devices, complete these steps:

Procedure

Step 1 Choose **Device Management** > **Network Devices**. The **Network Devices** tab is displayed, showing the list of devices.

Step 2 (Optional) If the list is long, click ≡ to set one or more filters and narrow the list to only those devices you want to tag.

Step 3 Check the check box next to the device(s) you want to tag. If you select multiple devices, any changes you make will be applied to all the devices you selected.

Step 4 Click 🏷. The **Edit tags** window opens, showing the tags currently applied to the device(s) you selected.

Step 5 Click in the **Associate tag** field and type the name of the tag you want to apply.

Step 6 Click on tag in the search result list to associate it with the device. To delete an applied tag, click the X icon shown next to that tag.

Step 7 Click **Save**.

Delete tags

Tags are used to group devices. Deleting them can affect which KPIs are monitored and which Playbooks are run when using Change Automation. Carefully review tag associations before deleting any tags.

To delete tags, complete these steps:

Note If the tag is mapped to any devices, then the tag cannot be deleted.

Procedure

Step 1 Export a backup CSV file containing the tags you plan to delete. See Export tags, on page 57 for instructions.

Step 2 Choose **Administration** > **Tag Management**. The **Tag Management** page is displayed.

Step 3 Select the check box next to the tags you want to delete and click 🗑.

Step 4 Review the confirmation dialog box. It lists the number of devices currently using the tag(s).

Step 5 Click **Delete** to confirm deletion.

The selected tags are deleted if not mapped to devices.

Export tags

You can export tags and tag categories to a CSV file for backup and editing. This allows you to create backup copies or edit tags offline, then re-import to overwrite existing tags. Note that after re-importing, you may need to re-associate devices and tags.

Procedure

Step 1 Choose **Administration** > **Tag Management**.

Step 2 (Optional) In the **Tag Management** page, filter the tag list as needed.

Step 3 Select the check boxes for the tags you want to export. To select all tags, use the check box at the top of the column.

Step 4 Click 📤. Depending on your browser, you will be prompted to select a path and file name for saving the CSV file, or to open the file immediately.

The selected tags and tag categories are exported to a CSV file.