Extended Enterprise for SD-Access Deployments Implementation Guide

This *Extended Enterprise for SD-Access Deployments Implementation Guide* describes the implementation of the design defined in the *Extended Enterprise SD-Access Design Guide*. This guide incorporates a broad set of technologies, features, and applications for helping customers extend the enterprise Information Technology (IT) services to outdoor spaces.

Cisco Validated Designs (CVDs) provide the foundation for systems design and are based on common use cases or engineering system priorities. Each guide details the methodology for building solutions, and more importantly, the recommendations have been comprehensively tested by Cisco engineers to help ensure a faster, more reliable, and predictable deployment.

Extended Enterprise CVD

An enterprise has production, storage, distribution, and outdoor facilities. IT reach extends beyond the traditional carpeted space to non-carpeted spaces as well. IT can now extend network connectivity, security policy, and management to the outside, warehouses, and distribution centers with the same network operating systems and network management that offer automation, policy enforcement, and assurance. The Cisco Digital Network Architecture (Cisco DNA) is an architecture based on automation and analytics that provides comprehensive network visibility and end-to-end policy delivery at scale. Cisco DNA enables customers to capture business intent and activate it network wide in the campus and in non-carpeted spaces where the operations happen.

This CVD outlines the steps for both IT and operations teams to accomplish business goals by digitizing the operations in the outdoor spaces of an enterprise. It includes guidance for implementing Extended Enterprise use cases with the customer's existing Cisco DNA Center.

For More Information

To learn more about Extended Enterprise solutions, please visit:

- https://www.cisco.com/go/extendedenterprise
- https://www.cisco.com/go/iotcvd

Scope and Audience for this Document

This implementation document provides deployment guidance for an Extended Enterprise network design. It is a companion to the associated design and deployment guides for enterprise networks, which provide guidance in how to deploy the most common implementations of SD-Access. This guide discusses the extended enterprise implementation for SD-Access deployments.

This CVD discusses the Extended Enterprise implementation for Cisco Software-Defined Access (SD-Access) deployments. For the associated deployment guides, design guides, and white papers, refer to the following documents:

- Cisco Enterprise Networking design guides:
  - https://www.cisco.com/go/designzone

- Cisco IoT Solutions design guides:
  - https://www.cisco.com/go/iotcvd
- Cisco Extended Enterprise Solutions Overview:
  - https://www.cisco.com/go/extendedenterprise
- *Extended Enterprise Design Guide for non-fabric and SD-Access*:
  - https://www.cisco.com/c/en/us/td/docs/solutions/Verticals/EE/DG/ee-dg.html

What is in this Guide?

This document is organized in the following sections:

Implementation Overview, page 2	Discusses overall network topology and considerations.
Implementation Prerequisites, page 6	Check list with required SD-Access setup and configurations for Extended Enterprise fabric deployment
Design, page 6	Details Cisco DNA Center design options relevant to Extended Enterprise implementation for Cisco SD-Access deployments.
Creating Segmentation with Cisco DNA Center Policy Application, page 9	Explains segmentation options, how to add security policies and necessary configurations to provide micro segmentation.
Provisioning, page 35	Provides guidance to add Industrial Ethernet (IE) switches as extended nodes or policy extended nodes to the fabric, it also covers how to add access points (APs) and endpoints to the industrial switches.
Assurance, page 56	Gives an overview of Cisco DNA Center assurance capabilities for Extended Enterprise deployments.

This guide assumes that the user has already installed Cisco DNA Center, Cisco Identity Services Engine (ISE), and Wireless LAN Controller (WLC) in the enterprise network. For further information, refer to the *CVD Software-Defined Access & Cisco DNA Center Management Infrastructure* for implementation details:

- https://cs.co/sda-infra-pdg

Implementation Overview

The SD-Access for an Extended Enterprise deployment is based on the *Cisco Software-Defined Access Design Guide:* https://cs.co/sda-sdg. The design enables wired and wireless communications between devices in an outdoor or group of outdoor environments, as well as interconnection to the WAN and Internet edge at the network core.

References

- *CVD Software-Defined Access Medium and Large Site Fabric Provisioning* at the following URL:
  - https://cs.co/sda-fabric-pdg
- *CVD Software-Defined Access for Distributed Campus* at the following URL:
  - -https://cs.co/sda-distrib-pdg

This document provides implementation guidelines for a multi-site SD-Access deployment. The validation topology showcases an example of a deployment with three sites as described below.

Site 1 is the largest site in the deployment and is connected directly to the fusion devices by IP transit links. Its node roles are divided so that the Cisco Catalyst 9500s act as the combined fabric border and control nodes, and Cisco Catalyst 9300s in stacking configuration serve as the fabric edge nodes. Sites 2 and 3 are smaller deployments and have a stacked Catalyst 9300 serving as fabric border, control, and edge nodes, known as Fabric-in-a-Box (FiaB). Both Sites 2 and 3 connect back to the Catalyst 9500s in Site 1 which provides access to the Internet and to shared services. Site 1 has the WLC located on the shared services block in this implementation.

Site 2 is connected to Site 1 by SD-Access Transit with Catalyst 9500s serving as transit control plane nodes. This preserves fabric connectivity between the two sites and allows Scalable Group Tag (SGT) and virtual network information to be carried inline in the VXLAN header. The Site 2 WLC is embedded on the FiaB node (eWLC). Note that each fabric site requires a dedicated WLC when using SDA wireless.

For latency requirements from Cisco DNA Center to a fabric edge, refer to the Cisco DNA Center User Guide at the following URL:

https://www.cisco.com/c/en/us/support/cloud-systems-management/dna-center/products-user-guide-list.html

For network latency requirements from the AP to the WLC, refer to the latest Campus LAN and Wireless LAN Design Guide at Cisco Design Zone:

https://www.cisco.com/c/en/us/solutions/design-zone/networking-design-guides/campus-wired-wireless.html#~campus-guides

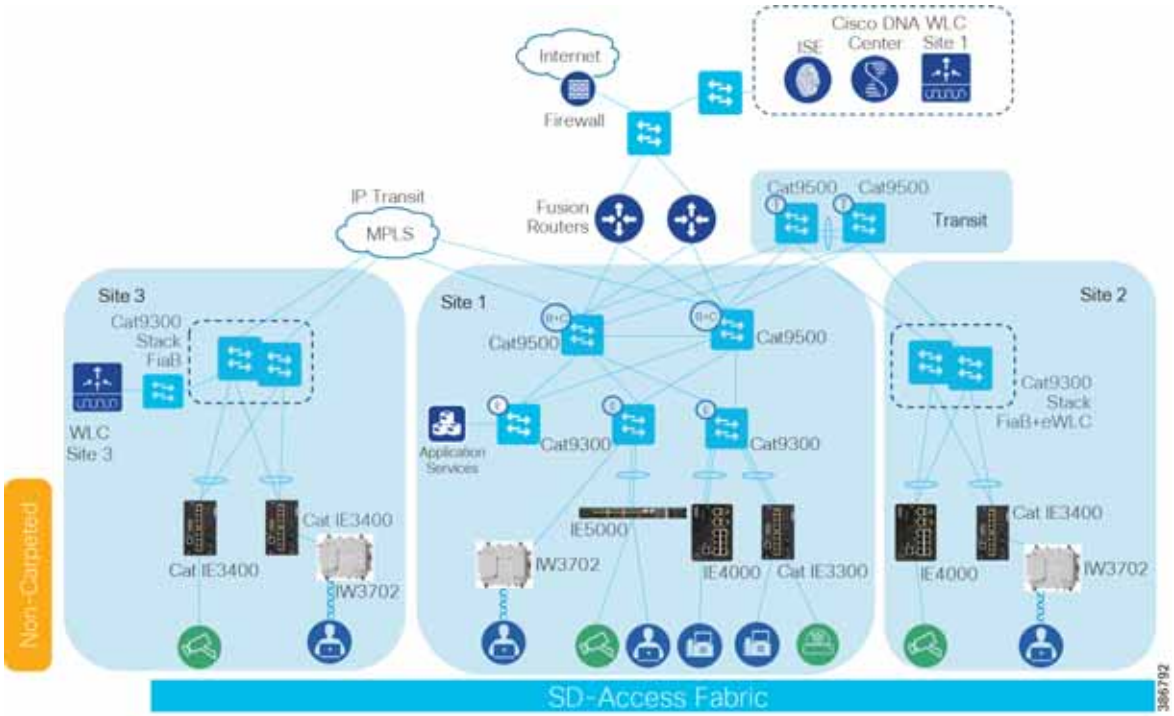
Site 3 is connected by IP transit over Multiprotocol Label Switching (MPLS) infrastructure so communication between the two fabric sites must exit the fabric at the border node and re-enter the fabric at the border node of the adjacent site. This does not allow virtual networks or SGTs to be carried inline and requires virtual routing and forwarding (VRF) and SGT Exchange Protocol (SXP) to maintain network segmentation. VRFs will maintain virtual network isolation while SXP will transmit IP-to-SGT mappings to each border node to re-tag traffic with the appropriate source tag upon re-entry to the Fabric. Site 3 has a dedicated WLC as required when using SD-Access wireless. To meet latency requirements, a non-fabric switch is connected to the border of Site 3 to allow IP connectivity with the fabric WLC.For more information on segmentation refer to the **Extended Enterprise Design Guide: for non-fabric and SD-Access** at the following URL:

https://www.cisco.com/c/en/us/td/docs/solutions/Verticals/EE/DG/ee-dg.html

Each site, building, floor, or geographic location has an enterprise access switch (for example, the Cisco Catalyst 9300) with at least two switches arranged in a stack. Ruggedized Cisco Industrial Ethernet (IE) switches are connected to the enterprise fabric edges as extended nodes or policy extended nodes and thus extend the enterprise network to the non-carpeted spaces.

Industrial switches are connected in a star topology with redundant links aggregated in an EtherChannel. Figure 1 shows the validation topology.

Figure 1 Validation Topology



Security policies are uniformly applied, which provides consistent treatment for a given service across the enterprise and Extended Enterprise networks. Controlled access is given to shared services and other internal networks by appropriate authorization profile assignments.

Application policies are applied to extended nodes using template functionality on Cisco DNA Center.

Validated Hardware/Software Matrix

Table 1 contains a list of the verified hardware and software components.

Table 1 Verified Hardware and Software Components

Role	Cisco Platforms	Version	Description	CVD Verified
Policy Extended Nodes	Catalyst IE3400/ Cisco Catalyst IE3400H series	IOS XE 17.3.1	Ruggedized full Gigabit Ethernet with a modular, expandable up to 26 ports. Up to 24 PoE/PoE+ ports.	Yes
Extended Nodes	Cisco Catalyst IE3300 / Cisco Catalyst IE3400 series	IOS XE 17.1.1s	Ruggedized full Gigabit Ethernet with a modular, expandable up to 26 ports. Up to 24 PoE/PoE+ ports.	Yes
	IE4000 series	IOS 15.2(7)E1a	Ruggedized DIN rail-mounted 40 GB Ethernet switch platform. IE4010 Series Switches with 28 GE interfaces and up to 24 PoE/PoE+ enabled ports.	Yes
	IE5000 series	IOS 15.2(7)E1a	Ruggedized One RU multi-10 GB aggregation switch with 24 Gigabit Ethernet ports plus 4 10-Gigabit ideal for the aggregation and/or backbones, 12 PoE/PoE+ enabled ports.	Yes

Table 1 Verified Hardware and Software Components (continued)

Role	Cisco Platforms	Version	Description	CVD Verified
Policy Extended Nodes	Catalyst IE3400/ Cisco Catalyst IE3400H series	IOS XE 17.3.1	Ruggedized full Gigabit Ethernet with a modular, expandable up to 26 ports. Up to 24 PoE/PoE+ ports.	Yes
APs	IW3702/IW6300	17.2.1/17.1.1	Rugged outdoor AP	Yes
Fabric Edge	Cat 9300	IOS XE 17.1.1s	480 Gbps stacking bandwidth. Sub-50-ms resiliency. UPOE and PoE+. 24-48 multigigabit ports. Up to 8 port fiber uplinks. AC environment.	Yes
Fabric Border and Control	Cat 9500	IOS XE 16.12.1s	Next generation of enterprise-class core and aggregation layer switches with 25, 40 and 100 Gigabit Ethernet fiber ports. AC environment.	Yes
Fusion Router	A router, L3 switch, or firewall with VRF support should be used. ASR1001 was used for validation	NA	NA	Yes
Cisco DNA Center Appliance	DN2-HW-APL	Not applicable	U - 44 core, L - 56 core (RET) 2x Two 10 Gbps Ethernet ports, One 1 Gbps management port	Yes
Cisco DNA Center	--	1.3.3.4	Single Pane of Glass	Yes
Cisco Identity Services Engine (ISE)	Cisco SNS-3515 and SNS-3595 Secure Network Server	ISE 2.6 Patch 5	Policy Engine	Yes
Wireless Controller	Cisco WLC 3504	AireOS 8.9.111.0	Wireless Controller	Yes
Wireless Controller	Cisco Catalyst 9800-L	IOS XE 17.2.1	Wireless Controller	Yes
Wireless Controller	Cisco Catalyst 9800 Embedded Wireless on C9300	IOS XE 17.1.1s	Wireless Controller	Yes

Notes:

- Devices that support extended nodes and policy extended nodes are Cisco Catalyst 9300, Cisco Catalyst 9400, and Cisco Catalyst 9500 series switches when configured as fabric edge.
- Cisco Catalyst 9200 series switches do not support extended nodes.

Implementation Prerequisites

This document is a companion of the CVDs: *Software-Defined Access & Cisco DNA Center Management Infrastructure*, *Software-Defined Access Medium and Large Site Fabric Provisioning*, and *Software-Defined Access for Distributed Campus*. This document assumes the user is already familiar with the prescribed implementation and the following tasks are completed:

1. Cisco DNA Center installation
2. ISE nodes installation
3. Integration of ISE with Cisco DNA Center
4. Discovery and provision of network infrastructure
5. Fabric domain creation
6. Fabric domain role provision for border, control, and edge nodes
7. WLC installation per fabric site
8. Configuration of fabric Service Set Identifier (SSID) and wireless profiles
9. Provisioning WLC with SSIDs and addition to the fabric

Tip: When implementing SD-Access wireless, one WLC is required per fabric site.

For further information, refer to the following documents for implementation details:

CVD Software-Defined Access & Cisco DNA Center Management Infrastructure

- https://cs.co/sda-infra-pdg

CVD Software-Defined Access Medium and Large Site Fabric Provisioning

- https://cs.co/sda-fabric-pdg

CVD Software-Defined Access for Distributed Campus

- https://cs.co/sda-distrib-pdg

Design

The Cisco DNA Center design area is used to create the structure and framework of your network within the Cisco DNA Center, including the physical topology, network settings, and device type profiles that you can apply to devices. As part of this design, you can design network hierarchy and settings, configure global wireless settings, create SSIDs, and manage the image repository. Most of these activities are completed as part of the *Software-Defined Access Medium and Large Site Fabric Provisioning*; however, additional specifications relevant to Extended Enterprise are explained here.

Create IP Address Pools

The Cisco DNA Center IP Address Management (IPAM) tool is used to create and reserve IP address pools for LAN and border automation, Enterprise Network Compute Systems (ENCS)/Network Functions Virtualization (NFV) workflows, and the binding of the subnet segment to a Virtual Network (VN) in host onboarding. IP address pools are defined at the global level and then reserved at the area, building, or floor level. Reserving an IP address pool holds the block of addresses, making them unavailable for use in other areas within Cisco DNA Center. For details on IP address pool creation, refer to the *CVD Software-Defined Access Medium and Large Site Fabric Provisioning*.

Creating an IP address pool for IE switches that will be added to the fabric to extend the network is required. Table 2-4 shows an example of IP addresses created and reserved on the fabric side on an Extended Enterprise deployment. The example showcases IP address pools for extended nodes, policy extended nodes, access points, and endpoints per fabric site. The example does not show network automation IP address pools.

Table 2 IP Pools Used in Site 1

IP Address Pool Name	Usage	IP Pool	Gateway	DHCP Server	DNS Server
Access-Point	Infrastructure	172.16.173.0/24	10.1.3.39	172.16.173.1	10.1.3.39
Badge-readers	Endpoints	10.102.116.0/24	10.1.3.39	10.102.116.1	10.1.3.39
Building-application	Endpoints	10.112.114.0/24	10.1.3.39	10.112.114.1	10.1.3.39
Building-Control	Endpoints	10.102.114.0/24	10.1.3.39	10.102.114.1	10.1.3.39
Employee-Data	Endpoints	10.101.114.0/24	10.1.3.39	10.101.114.1	10.1.3.39
Employee-Data-EN-AU	Endpoints	10.101.116.0/24	10.1.3.39	10.101.116.1	10.1.3.39
Employee-Phone	Endpoints	10.101.214.0/24	10.1.3.39	10.101.214.1	10.1.3.39
Extended-Pool	Infrastructure	172.16.175.0/24	10.1.3.1	172.16.175.1	10.1.3.39
Guest	Endpoints	10.103.114.0/24	10.1.3.39	10.103.114.1	10.1.3.39
Security-Contractors	Endpoints	10.102.115.0/24	10.1.3.39	10.102.115.1	10.1.3.39

Table 3 IP Pools Used in Site 2 (SD-Access Transit)

IP Address Pool Name	Usage	IP Pool	Gateway	DHCP Server	DNS Server
Access-Point-2	Infrastructure	172.16.178.0/24	10.1.3.39	172.16.178.1	10.1.3.39
Badge-readers-2	Endpoints	10.102.126.0/24	10.1.3.39	10.102.126.1	10.1.3.39
Building-Control-2	Endpoints	10.102.124.0/24	10.1.3.39	10.101.124.1	10.1.3.39
Employee-Data-2	Endpoints	10.101.124.0/24	10.1.3.39	10.101.124.1	10.1.3.39
Employee-Data-EN-AU-2	Endpoints	10.101.126.0/24	10.1.3.39	10.101.126.1	10.1.3.39
Employee-Phone-2	Endpoints	10.101.224.0/24	10.1.3.39	10.101.224.1	10.1.3.39
Extended-Pool-2	Infrastructure	172.16.176.0/24	10.1.3.1	172.16.176.1	10.1.3.39
Security-Contractors-2	Endpoints	10.102.125.0/24	10.1.3.39	10.102.125.1	10.1.3.39

Table 4 IP Pools Used in Site 3 (IP Transit)

IP Address Pool Name	Usage	IP Pool	Gateway	DHCP Server	DNS Server
Access-Point-3	Infrastructure	172.16.179.0/24	10.1.3.39	172.16.179.1	10.1.3.39
Badge-readers-3	Endpoints	10.102.136.0/24	10.1.3.39	10.102.136.1	10.1.3.39
Building-Control-3	Endpoints	10.102.134.0/24	10.1.3.39	10.102.134.1	10.1.3.39
Employee-Data-3	Endpoints	10.101.134.0/24	10.1.3.39	10.101.134.1	10.1.3.39
Employee-Data-EN-AU-3	Endpoints	10.101.136.0/24	10.1.3.39	10.101.136.1	10.1.3.39
Employee-Phone-3	Endpoints	10.101.234.0/24	10.1.3.39	10.101.234.1	10.1.3.39
Extended-Pool-3	Infrastructure	172.16.177.0/24	10.1.3.1	172.16.177.1	10.1.3.39
Security-Contractors-3	Endpoints	10.102.135.0/24	10.1.3.39	10.102.135.1	10.1.3.39

Design Considerations

In the overlay, IP subnets can be stretched across the fabric without flooding issues that can happen on large Layer 2 networks. Use fewer subnets and DHCP scopes for simpler IP addressing and DHCP scope management. Subnets are sized according to the services that they support, versus being constrained by the location of a gateway. Enabling the optional broadcast flooding (Layer 2 flooding) feature can limit the subnet size based on the additional bandwidth and endpoint processing requirements for the traffic mix within a specific deployment.

Different overlay networks can support overlapping address space, but be aware that most deployments require shared services across all VNs and some may use inter-VN communication. Avoid overlapping address space so that the additional operational complexity of adding a network address translation (NAT) device is not required for shared services communication.

Managing the Image Repository

The Cisco DNA Center stores all the unique software images according to image type and version. You can view, import, and delete software images.

Viewing Software Images

1. From the **Cisco DNA Center dashboard**, choose **Design > Image Repository**.

   Software images are displayed by device type. Virtual devices are not displayed by default.

2. Toggle the **Virtual** tab to view images for virtual devices.

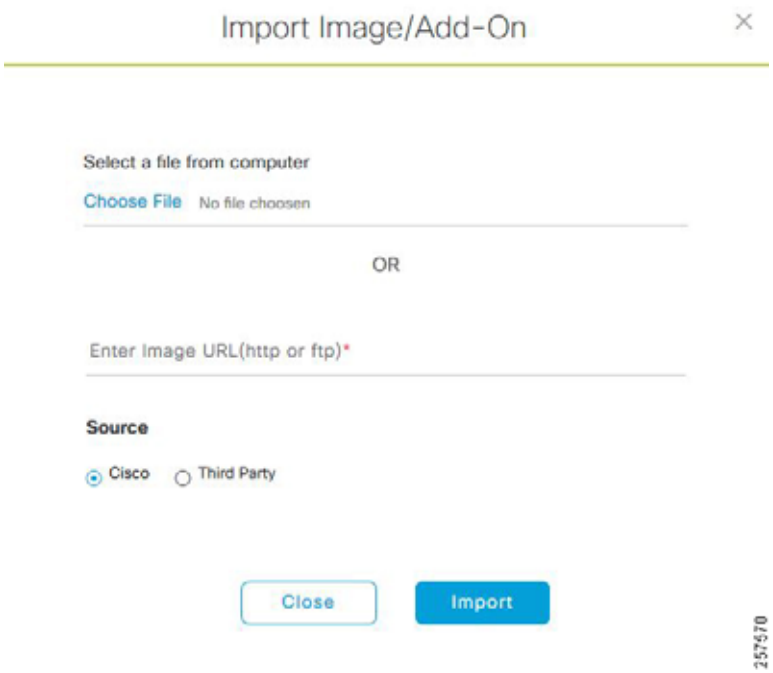
   As devices are discovered or manually added to the Cisco DNA Center, information about their software image is added to the image repository. During discovery:

   - If an image for a device does not appear under its family, the Cisco DNA Center will add an entry for that image under the correct platform.
   - If the image is already listed for that device family, the **Using Image** column will be incremented for the appropriate family.

Uploading an Image

1. From the **Cisco DNA Center dashboard**, choose **Design > Image Repository**.
2. Click **+ Import**.
3. In the pop-up window, click **Choose File** to navigate to a software image stored locally on your PC or specify an HTTP or FTP source where the image resides. For Cisco software images, ensure that the **Cisco** radio button beneath **Source** is selected. When finished, click **Import**.

Figure 2 Importing Image



4. Verify that the image was imported correctly. After successful import of an image, a notification is displayed at the bottom right of the screen. If an image is not imported directly from Cisco.com, the user will need to navigate to the Imported Images group and click the drop-down arrow to display all imported images. If the trash can icon to the far right of an image is blue, the image has been imported to Cisco DNA Center. If the trash can icon is gray and not selectable, the image has not been imported to Cisco DNA Center.

   Tip: If the image you just imported is not present in the list of imported images, click **Refresh** next to the **Filter** icon. The total number of images will increment by one and the image will be displayed in the list of imported images.

5. Assign the appropriate image to a platform by clicking **Assign** next to the image. A pop-up window will appear, on which the user can select device platforms for the image. When finished selecting platforms, click Assign.

Creating Segmentation with Cisco DNA Center Policy Application

This chapter will guide you through configurations needed on Cisco DNA Center and ISE to provide network segmentation and intent-based security policies as presented in the ***Extended Enterprise Design Guide for non-fabric and SD-Access***.

SD-Access supports two levels of segmentation: macro and micro. Macro-segmentation uses overlay networks with VRF instances. Micro-segmentation uses scalable group tags (SGTs) to apply policy to groups of users or devices. Segmentation using SGTs allows for simple-to-manage, group-based policies and enables granular data plane isolation between groups of endpoints within a virtualized network. Using SGTs also enables scalable deployment of policy without having to do cumbersome updates for these policies based on IP addresses.

Use virtual networks (macro-segmentation) when requirements dictate isolation at both the data plane and control plane. In general, if devices need to communicate with each other, they should be placed in the same virtual network. If communication is required between different virtual networks, use an external firewall or other device to enable inter-VN communication. A Virtual Network provides the same behavior and isolation as VRFs.

In the parking lot example provided in the *Extended Enterprise Design Guide for non-fabric and SD-Access*, two separate networks need to be completely isolated. One network provides employees access to the network and resources, and a separate network connects things such as security cameras, badge readers, and parking sensors. Those two networks are independent of each other and communication is never required between the two.

In this case, macro-segmentation is used to create two separate VNs: EMPLOYEE_VN and BUILDING_VN. Continuing with the example, IP cameras and security contractors may exist on the BUILDING_VN. Contractors should be able to access the cameras remotely for troubleshooting, but IP cameras should not be able to reach other IP cameras to protect the network from unauthorized access. In that scenario, we can apply a micro-segmentation policy using the policy application in the Cisco DNA Center, which leverages APIs to program the ISE TrustSec matrix.

The Cisco DNA Center policy application supports creating and managing VNs, policy administration and contracts, and SGT creation. The zero trust model and unified policy is at the heart of and the differentiator in the SD-Access solution. Therefore, deployments should set up their SD-Access policy (VNs and contracts) before doing any SD-Access provisioning.

In this chapter, the segmentation for the overlay network is defined. (Note that the overlay network will only be fully created until the host onboarding stage). This process virtualizes the overlay network into multiple self-contained virtual networks. After VN creation, the TrustSec policies are created to define which endpoints and groups within a VN can communicate.

Add an Enterprise Overlay Virtual Network for Macro Segmentation

VNs are created first and then group-based access control policies are used to enforce policy within the VN:

1. From the **Cisco DNA Center dashboard**, navigate to **POLICY > Virtual Network**.
2. Click the **+** to create a new virtual network.
3. Enter a virtual network name (example: **BUILDING**).
4. Drag scalable groups from the **Available Scalable Groups** pane into the **Groups** in the **Virtual Network** pane. This step needs to be revisited later after all needed scalable groups are created.
5. Click **Save**.
6. Verify that the VN with associated groups is defined and appears in the list on the left. These virtual network definitions are now available for provisioning the fabric in later steps.
7. Repeat this procedure for each overlay network.

   Tip: A common configuration convention is to use all caps for any user-defined elements. The VNs defined in the policy application are provisioned to the devices as a VRF definition. Using all caps to identify these user-defined variables can assist in troubleshooting and monitoring. This convention is a best practice recommendation.

Figure 3 Create a Virtual Network

Intent-Based Security Policy

Intent-based security gives the administrator the ability to express operational intent and automatically have the system select the appropriate IT-defined security policies without requiring network or security skills.

As part of the design decisions in advance of your network deployment, you decide network segmentation strategies for the organization. Micro-segmentation uses SGTs to apply policy to groups of users or device profiles. The desired outcomes of policy application using segmentation may be easily accommodated with group policies. In Cisco DNA Center, this is done by using group-based access control policies.

Group-Based Access Control Components

The Cisco SD-Access solution supports creation and provisioning of the following policy constructs:

- **Scalable groups**—Cisco TrustSec uses tags to represent logical group privilege. SGTs are used in access policies to control traffic flowing through switches, routers, and firewalls.
- **Security Group Access Control List (SGACL)**—An administrator uses policy enforcement to control the operations performed by the user based on the security group assignments and destination resources. Cisco DNA Center refers to these as "Group-Based Access Control policies" to express the intent of these constructs.
- **Access Contract**—An administrator uses policy enforcement to control the operations performed by the user based on destination port and protocol information. Cisco DNA Center has two predefined access contracts—permit and deny—which allow all traffic or deny all traffic between the selected groups, respectively.

Tip: Starting at Cisco DNA Center version 1.3.1, use of the Policy > Group-Based Access Control tab requires migration of policy information from ISE to Cisco DNA Center. Afterwards, Cisco DNA Center is considered the main policy information management point for TrustSec policy, and TrustSec information within ISE becomes read-only. After policy sync all changes should be made through Cisco DNA Center. Until policy migration is complete, the Policy > Group-Based Access Control tab is not available for use and TrustSec policy is managed through ISE.

For more information on synchronization of policy information between Cisco DNA Center and ISE, refer to the Cisco DNA Center User Guide at the following URL:
https://www.cisco.com/c/en/us/support/cloud-systems-management/dna-center/products-user-guide-list.html

Creating Security Group Tags

1. Navigate to **POLICY > Group-Based Access Control > Scalable Groups**.
2. Click **Create Scalable Group**.
3. In the Create Scalable Group pane, enter a name and description (optional) for the scalable group.

   The following characters are supported for the Name field:

   - alphanumeric characters
   - underscore (_)

   The scalable group name must start with an alphabetic character.
4. (Optional) If necessary, specify a Tag Value (Cisco DNA Center will generate a default value if not specified). The valid range for Tag Value is from 2 to 65519 and must not be in use by another scalable group.
5. Choose Virtual Networks for the tag.
6. From the **Virtual Networks** drop-down list choose the VNs to be associated with this scalable group. By default, the default virtual network (DEFAULT_VN) is chosen.
7. (Optional) Check the **Propagate to ACI** check box if you want the scalable group to be propagated to Cisco Application Centric Infrastructure (ACI).
8. Click **Save**.
9. Click **Deploy**.

Cisco DNA Center communicates to ISE through representational state transfer (REST) API calls; therefore, the newly created security tags are available to use in Cisco DNA Center when configuring policies. Click the **Scalable Group Name** link to view the details of a scalable group. Click **Edit** in the **View Scalable Group** window to update the scalable group details. When you click **Deploy**, Cisco DNA Center requests Cisco ISE to send notifications about the changes to the network devices. You can check the deployment status in the **Deploy** column.

Create a Micro-Segmentation Policy using SGTs

Micro-segmentation creates network segmentation that relies on the use of role- or group-based membership, regardless of IP addressing, in order to create policies that allow segmentation in the network.

Micro-segmentation policies are customized for an organization deployment. The following example shows a basic policy that can be used to deny IP cameras communication with other IP cameras.

Deployment considerations

- The TrustSec matrix uses an allowed list model by default; if a policy is not created traffic will be allowed. Change to a blocked list model has to be done with extreme caution. This model requires a detailed study of the control plane traffic as well as it has the potential to block ALL traffic, the moment it is enabled.
- Policy implementation is optimized by devices dynamically downloading SGACL policies only applicable to the assets they protect. When using the default allowed list model, explicit allow policies are redundant. Avoid configuring redundant policies to further optimize the number of policies downloaded to devices.

Create a Policy

1. Navigate to **POLICY > Group-Based Access Control > Policies**. Click **Create Policies**.
2. Click **Source to Destination(s)** to create an access control policy with a single source and multiple destination groups.

a. Click the radio button next to the source scalable group that you want to select. If the scalable group that you need does not exist, click the **Create Scalable Group** button to create a new scalable group.

b. Click **Next**.

c. Choose the destination scalable groups to which the selected source scalable group must be mapped. If necessary, you can view the scalable group details and edit the scalable groups. An orange triangle icon is displayed near a scalable group if a policy already exists between the source and destination.

d. Click **Next**.

e. Click the radio button next to the contract that you want to select. If necessary you can view and edit the contract details.If the contract that you need does not exist, click the **Create Contract** button to create a new contract. A contract defines a set of rules that allow or deny traffic based on protocols or ports.

Tip: You can only choose one contract for a policy.

f. Click **Next**. The Summary window lists the policies that are created based on the chosen scalable groups and contract.

g. Click **Save**.

h. Click **Deploy** to send notifications about the changes to the network devices.

3. Click **Destination to Source(s)** to create an access control policy with a single destination and multiple source groups.

a. Click the radio button next to the destination scalable group that you want to select. If the scalable group that you need does not exist, click **Create Scalable Group** to create a new scalable group.

b. Click the **Next** button.

c. Choose the source scalable groups to which the selected destination scalable group must be mapped. If necessary, you can view the scalable group details and edit the scalable groups. An orange triangle icon is displayed near a scalable group if a policy already exists between the source and destination.

d. Click the **Next** button.

e. Click the radio button next to the contract that you want to select. If necessary you can view and edit the contract details. If the contract that you need does not exist, click **Create Contract** to create a new contract. A contract defines a set of rules that allow or deny traffic based on protocols or ports.

Tip: You can choose only one contract for a policy.

f. Click the **Next** button. The **Summary** window lists the policies that are created based on the selected scalable groups and contract

g. Click the **Save** button.

h. Click **Deploy** to send notifications about the changes to the network devices.

Tip: You can toggle between the List view and the Drag and Drop view using the Toggle button displayed in the upper right corner of the Scalable Group listing area. The Drag and Drop view allows you to drag and drop the scalable groups to the Source and Destination fields while creating the access control policy. However, only the first 50 scalable groups are listed in the Drag and Drop view. It is recommended to use the List view if you have a larger number of scalable groups (more than 50) to view all the scalable groups.

Figure 4 Creating Security Policy

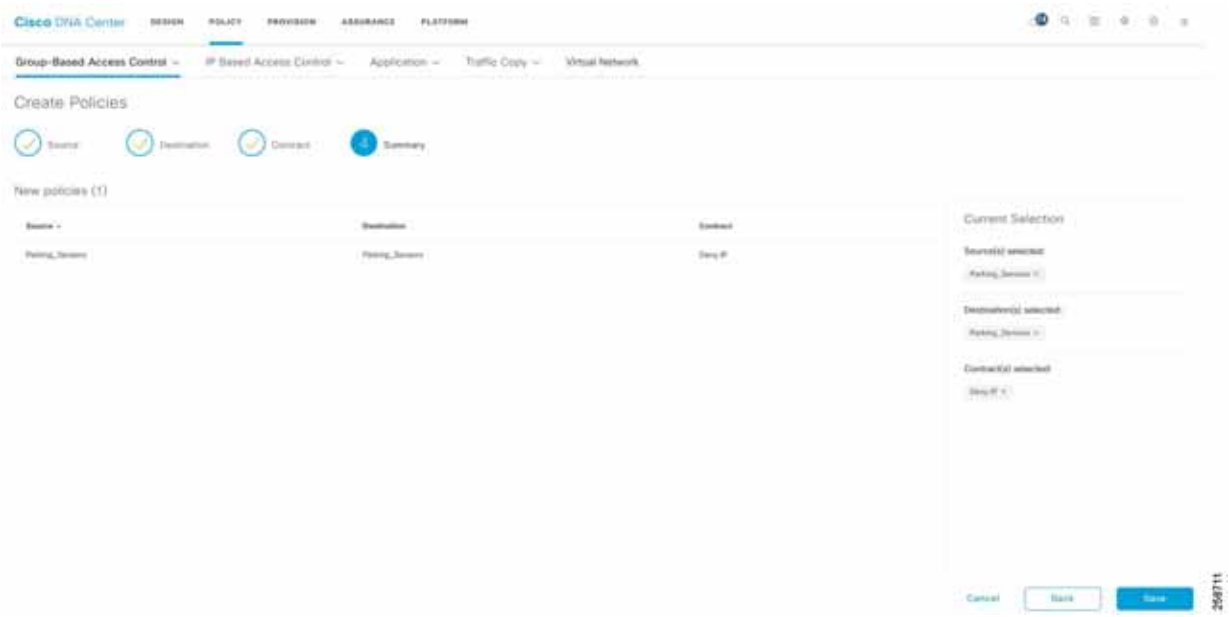


Figure 5 TrustSec Policy Matrix displaying BUILDING VN Tags

Creating Custom Contracts

The two default options for policy enforcement are permit and deny; however, it is possible to create custom contracts for more granularity. After creating a contract, it can be used in security policies.

1. Navigate to **Policy >Group-Based Access Control > Access Contracts.**
2. Click **Create Access Contract.**
3. In the Create Access Contract pane, enter a name and description for the contract.
4. Create the traffic filter rules:
   - From the Action drop-down list, choose **Deny or Permit**.
   - From the Application drop-down list, choose the application for which you want to apply that action. The port and protocol are automatically selected based on the application that you select. If you want to specify the transport protocol, source port, and destination port, choose the **Advanced** option in the Application drop-down list.

   You can create multiple rules. To create multiple rules to a contract, click the Plus symbol (**+**) and choose the settings for the Action and Application columns. The rules are checked in the order in which they are listed in the contract. Use the handle icon at the left end of a rule to drag and change the order of the rule.

   You can enable or disable logging for any traffic filter rule (including the default action) by clicking the **Logging** toggle. Logging is disabled by default. When logging is enabled, the network device sends a syslog message when the traffic filter rule is hit. This might be helpful in troubleshooting and initial testing of a policy. However, we recommend that you use this option sparingly because it might have resource and performance impacts on the network devices.

   Tip: Logging on contract rules is not supported on policy extended node.
5. From the Default Action drop-down list, choose **Deny** or **Permit**. You can enable logging for the default action, if required.
6. Click the **Save** button.
7. Click **Deploy** to send notifications about the changes to the network devices.

Figure 6 Custom Contracts

Role of Extended Nodes and Policy Extended Nodes on TrustSec

As explained in the Design Guide, TrustSec is defined in three activities: classification, propagation, and enforcement.

Classification

802.1x and MAB authentication is enabled on a policy extended node to communicate with Cisco ISE in order to download the VLAN and/or scalable group tag (SGT) attributes for the endpoints. The SGT is applied differently on extended nodes and policy extended nodes.

- For endpoints connected to extended nodes, VLAN-to-SGT mapping is used for classification. When the endpoint is authorized it is moved to the appropriate VLAN configured on ISE authorization policy. An entry for the endpoint is created on the closest fabric edge, linking the IP address to the VLAN SGT as configured on the host onboarding page. For more information on host onboarding configuration refer to Creating Extended Nodes Host Pool, page 37. For endpoints connected to policy extended nodes, the SGT is downloaded to the access port.
- For endpoints connected to policy extended nodes, the SGT is downloaded to the access port.

Tip: port-based authentication for extended nodes is available as of Cisco DNA center 1.3.3.0.

Propagation

- For endpoints connected to extended nodes, the SGT is added to the VXLAN header on the fabric edge. Consequently, the extended node is not aware of the tag and policies cannot be enforced for intra-VLAN traffic.
- For endpoints connected to policy extended nodes the SGT is propagated via inline tagging.

Tip: For SDA wireless endpoints, the SGT is carried on the VXLAN packet from the AP, even when connected to a policy extended node.

Enforcement

Traffic may be enforced on the fabric edge or policy extended node.

- Enforcement on the fabric edge: The fabric edge downloads policies applicable to endpoints connected directly or indirectly (via extended node, policy extended nodes, or APs). Fabric edges enforce traffic destined to endpoints on the SGT VLAN. Enforcement is always done at the fabric edge for endpoints connected to extended nodes.

- Enforcement on the policy extended node: The policy extended node downloads SGACL policies and enforces for endpoints directly connected to the switch. Policy extended node is desirable when intra-VLAN traffic enforcement is needed on the switch.

Tip: In deployments with a mix of extended and policy extended nodes, use a unique SGT per VLAN on the ISE authorization policy. Ensure this SGT is consistent with the SGT assigned on the host onboarding page. This practice will guarantee that enforcement is consistent regardless of enforcement point.

Scalable Group Assignment

Scalable groups can be assigned to endpoints dynamically or statically. Dynamic assignment is done by ISE after authenticating and authorizing the endpoint.

Static assignment may be used when port-based authentication is not possible such as when connecting a server using a trunk port. Detailed steps to configure static assignment are explained in Provisioning, page 35.

Dynamic assignment can be used after the endpoint authenticates with ISE.

- For endpoints connected to the fabric edge, policy extended node, or fabric APs, the SGT and VLAN is assigned as a result of authorization.
- For endpoints connected to extended nodes the VLAN is assigned as a result of authorization. The VLAN can be associated to an SGT in Cisco DNA Center as described in Provisioning, page 35 section.

ISE Configuration to Support Dynamic SGT Assignment

This section details the required configuration to support dynamic SGT assignment.

Authentication Policy

Authentication policies are used to define the protocols used by ISE to communicate with the endpoints and the identity sources to be used for authentication. ISE evaluates the policy conditions and, based on whether the result is true or false, applies the configured result. The authentication methods tested in this CVD are 802.1x and MAC.

Authentication Bypass (MAB). MAB uses the MAC address of a device to determine access privileges, and this method is used to authenticate end devices that do not support any supplicant software in them, such as 802.1X EAP-TLS, EAP-FAST, and so on.

For more information about MAB, refer to the following URL:

- https://www.cisco.com/c/en/us/products/collateral/ios-nx-os-software/identity-based-networking-services/config_guide_c17-663759.html

The authentication policy used in Cisco ISE for this CVD checks the protocol and the internal identity store for the endpoint MAC address. To configure the authentication policy in ISE, navigate to **Policy > Policy Sets > Default** and select the arrow on the right to configure the authentication policy.

Note: In this CVD, the default authentication policy set is used.

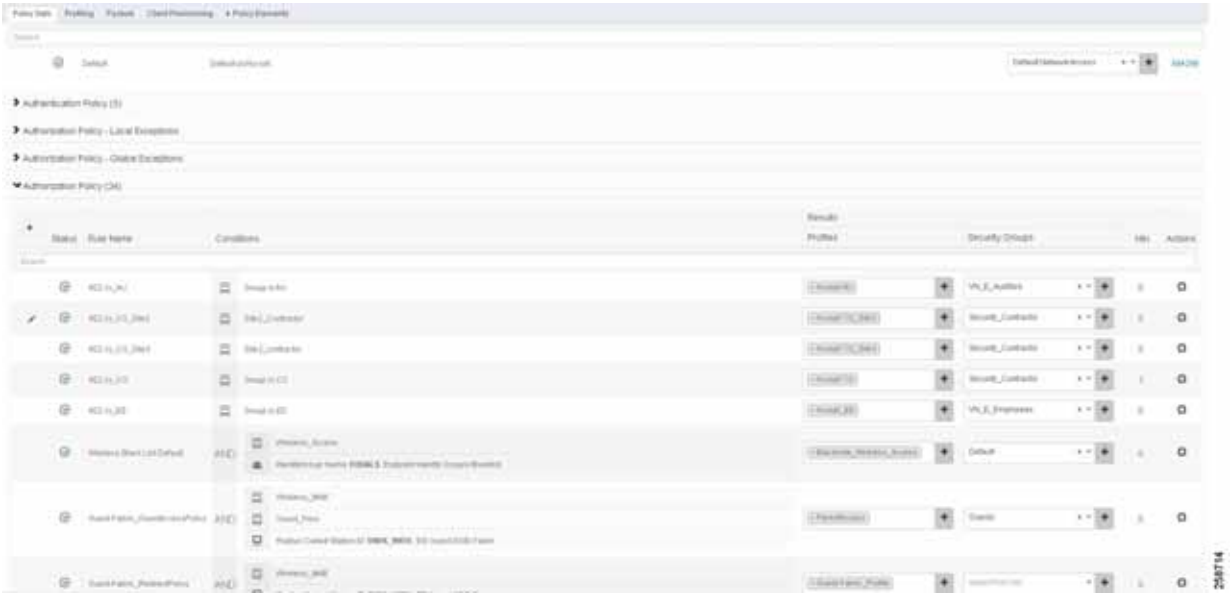
Authorization Policies

Authorization policies are critical for determining what the user or device should access within the network. Authorization policies are composed of authorization rules and can contain conditional requirements that combine one or more identity groups. The permissions granted to the user or device are defined in authorization profiles, which act as containers for specific permissions. Authorization policies may also assign an SGT for each authorization rule, as displayed in figure below. This CVD uses an SGT and VLAN to grant permissions to an IoT asset.

The VLAN assignment is configured on the authorization profile. After the appropriate authorization is granted and the VLAN and SGT are assigned, the TrustSec Policy Matrix determines the permissions associated with each device.

To configure the authorization policy in ISE, navigate to **Policy > Policy Sets > Default** and then select **Authorization Policy**.

Figure 7 Authorization Policies



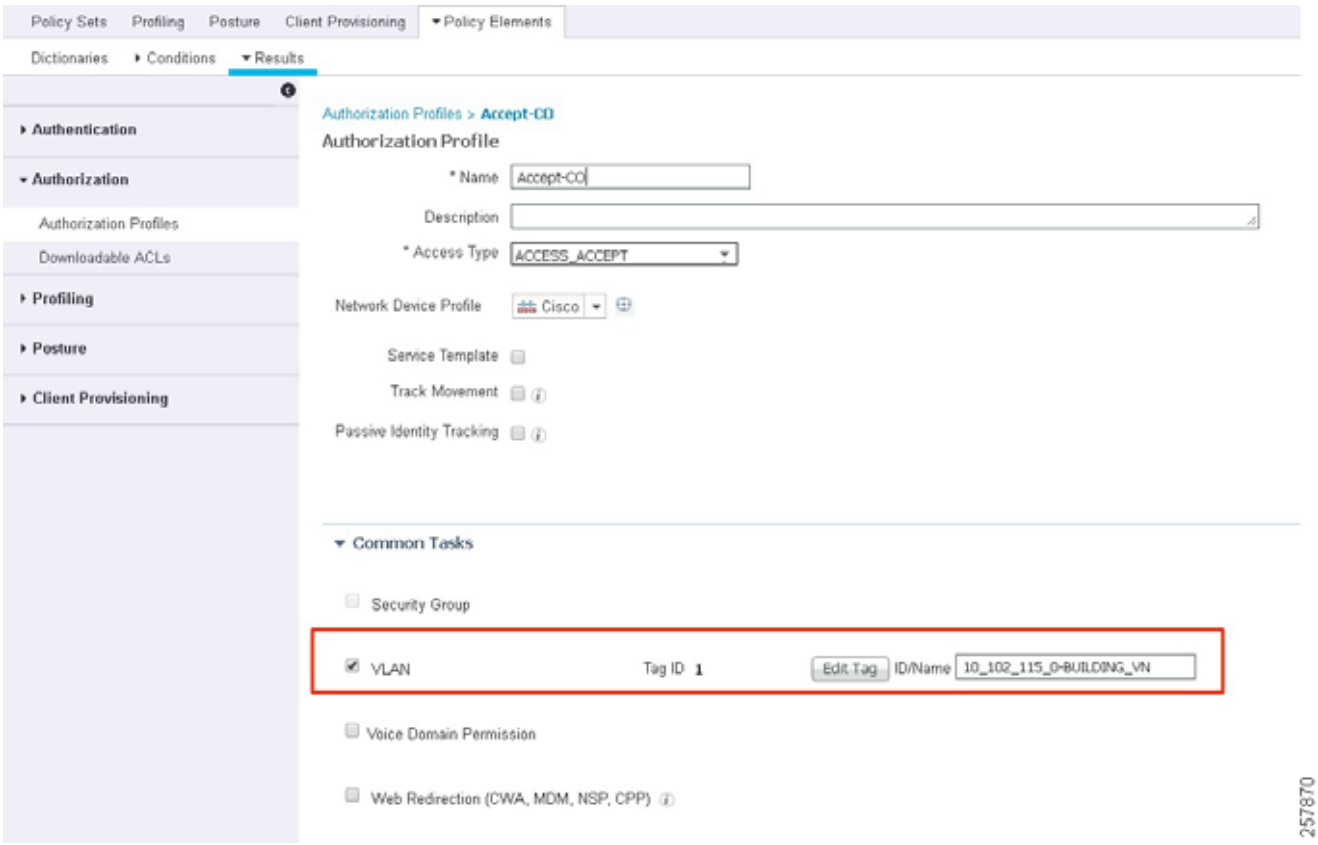
The default policy can be designed based on the organization's specific security requirements. One option is to assign a default SGT like DEFAULT_GENERIC for classifying devices that do not meet any of the authorization policy conditions.

Authorization Profile

An authorization profile can be used to move the user to a host pool as a result of authorization. Host pool creation is explained in Provisioning, page 35.

1. In **ISE**, navigate to **Policy > Policy Results**.
2. Click **Authorization** on the left panel and choose **Authorization Profiles**.
3. Click **Add** to add a new profile or choose an existing one to modify.
4. Provide a name and select **Access Type**. **ACCESS_ACCEPT** is selected by default.
5. Under **Common Tasks**, check the **VLAN** check box.
6. In **ID/Name** field enter ‘host pool subnet’ + ‘Virtual Network name’ in the following format: *10_102_115_0-BUILDING-VN*. As an alternative, a friendly name can be assigned to the VLAN in Cisco DNA Center to simplify policy deployment in ISE. This is especially useful on multi-site deployments where the same policy needs to be reused but the host pool subnet varies depending the fabric site. Details about configuring the Friendly name will be covered later in this document, refer to Creating Extended Nodes Host Pool, page 37.
7. Click **Submit**.

Figure 8 Authorization Profile



Tip: Cisco Catalyst 9800 Series Wireless Controllers support VLAN to VNID mapping as of IOS-XE version 17.2.1. This feature is required to dynamically assign the endpoint to the correct subnet using the VLAN field on the authorization profile.

Policy Enforcement over IP Transit

When the Cisco DNA Center provisions the SDA fabric, the Fabric Edge (FE) devices have enforcement enabled automatically using the **cts role-based enforcement** and **cts role-based enforcement vlan-list** *vlans* commands. However, enforcement is not enabled on the border. Flows between the FE devices and devices outside the fabric which traverse the border are not restricted by default.

Depending on the border device type, the best place to enforce Fabric to non-Fabric flows, if required, may be in the Fusion device. Device type, function, load and scale required need to be considered when deciding where best to enforce. In this implementation, there is no enforcement at the border.

Unlike the SD-Access Transit connection between sites where SGT information is carried in the VXLAN header, an IP Transit connection between sites is not guaranteed to carry inline tags. Devices external to the fabric that carry traffic between two sites connected via IP Transit may not have TrustSec enabled, may not be TrustSec capable, or may belong to the service provider. To maintain micro-segmentation, the border nodes need to re-apply the source tag lost in transit.

Although Cisco TrustSec inline tagging can be supported when VRF-Lite is used for network connectivity, it not supported in MPLS environments where both Label Distribution Protocol and Cisco TrustSec are required on the interface. This is not a configuration limitation but an architectural one, whereby the label Forwarding Information Base

(FIB) is used for next-hop processing, unlike the standard FIB, and hence the SGT and its IP association cannot be learned. In MPLS networks it is necessary to use SXP to "propagate" or communicate the IP-to-SGT mapping across the MPLS portion of the network.

In this implementation, ISE is used to share the IP-to-SGT mappings with the border nodes. This information is populated in ISE dynamically or statically. ISE has the IP-to-SGT mappings of endpoints that it has authenticated and authorized to share with the the border nodes.

In the case of statically assigned endpoints, this mapping needs to be manually configured in ISE. The border nodes on either end of the transit link must have the mappings used in the site on the opposite end, as well as any mappings for devices in the shared services subnet.

The IP-to-SGT mappings can be learned by the border using the following methods:

1. Use SXP to send the IP-to-SGT mapping from ISE to the border.
2. Use SXP to share statically added mappings from a network device to the border.
3. Use the CLI on the border to manually add mappings.

This document will focus on method 1 to keep user-configured IP-to-SGT static mappings in one central place along with any dynamic mappings learned from RADIUS sessions. The following table summarizes how IP-to-SGT mappings are added to ISE using method 1.

Table 5 IP-to-SGT Mapping by Endpoint Type

Endpoint Type	SGT Assignment	IP-to-SGT Mapping Required for IP Transit
Wireless Endpoint	By ISE after dynamic authorization	Automatically added in ISE during authorization
Authenticated wired endpoints	By ISE after dynamic authorization	Automatically added in ISE during authorization
Statically assigned endpoints	Manually assigned on the host onboarding page	IP pool is manually configured in ISE

Configuration to Support IP Transit SGT Propagation

This section details the required configuration to support SGT propagation when connecting fabric sites using IP transit.

Enabling SXP and Global Settings on ISE

This section assumes that policy has already been created in Cisco DNA Center.

1. During setup and sync of Cisco DNA Center and ISE, SXP should have been enabled. Verify that is has been enabled in ISE at **Administration > System > Deployment > (hostname of SXP node)**

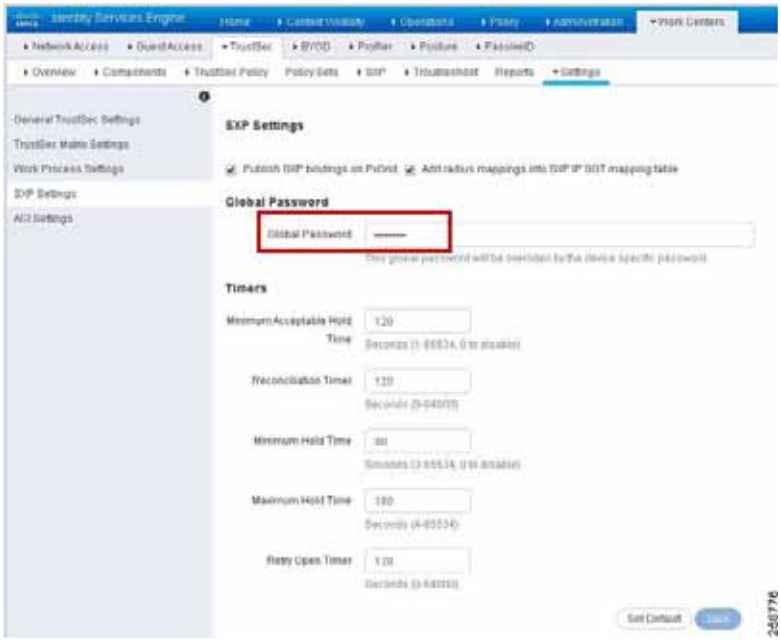
Figure 9 Enable SXP Service

Note: We recommend that you run the SXP service on a standalone node. In a distributed deployment, this would be a PSN node that handles SXP connections, and does not handle RADIUS authentications, sometimes referred to as an SXPSN.

Note the following points while using the SXP service:

- If the RADIUS accounting updates are too frequent (for example, around six to eight accounting updates in a few seconds), sometimes the accounting update packet might be dropped and SXP might not receive the IP-to-SGT binding.
- After upgrading from a previous version of ISE, SXP does not start automatically. After the upgrade, you must change the SXP password and restart the SXP process.
- Navigate to **Work Centers > TrustSec > Settings > SXP Settings** and enter a Global Password to be matched when adding the other end of the SXP connection on the border device.

Figure 10 SXP Settings



(Optional) Configuration of TrustSec Enforcement on Border Node

When the TrustSec device learns of a Scalable Group mapping, it will request policies from ISE associated with that SGT. It will only do this, however, if enforcement is enabled on the border. Cisco DNA Center does not enable this enforcement, but it can be added manually.

Note: In this implementation, there is no enforcement at the Fabric border, but this section was added for reference if the use case requires enforcing traffic leaving the fabric site.

For border routers, enter the global configuration command cts role-based enforcement on the border node to enable enforcement.

```
C9500-N15-1(config)#cts role-based enforcement
```

If the border is a switch, enforcement also needs to be enabled on the appropriate VLANs using the cts role-based enforcement vlan-list *vlan* command.

```
C9500-N15-1(config)#cts role-based enforcement

C9500-N15-1(config)#cts role-based enforcement vlan-list vlan
```

Tip: Even if enforcement is not enabled on the border node, IP-to-SGT mappings can still be used to re-tag incoming traffic with source SGTs to allow enforcement at another policy enforcement point if source tags were removed on the IP Transit link.

Using ISE and SXP to send IP-to-SGT mappings to the Fabric Border

Before proceeding with configuration of SXP, it is best to test connectivity between the IP-Transit connected sites. For this to occur you may need to redistribute routes between routing protocols and leak routes between the user created VNs/VRFs and the Global Routing Table (GRT). This is a manual configuration on the Fusion device.

Configuring ISE SXP devices with multiple Virtual Networks

Before the SXP Device is added, the IP address of the border node must be reachable from ISE and it must be in the VN/VRF where enforcement is needed. Therefore, if IP-to-SGT mappings are used for enforcement in the EMPLOYEE_VN and the BUILDING_VN, an IP from each of these Virtual Networks on the border node must be added as an SXP connection to ISE.

In the DEFAULT_VN, the management IP address of the device can be used for the SXP connection. If no policy enforcement is expected in the DEFAULT_VN, an SXP connection from that VRF is unnecessary. Within each user-created Virtual Network there are addresses that may also be used.

There are two IP addresses which could be used on the border node within a Virtual Network. One is the IP address towards the Fusion router, and the other is the Anycast IP address that Cisco DNA Center provisions into the Virtual Network when host pools are created. If you have multiple host pools in a Virtual Network or redundant Fusion routers, there will be more than one option. Either IP can be used if Route Leaking and Redistribution have been configured such that ISE can communicate with that IP address. Identify one IP address from each Virtual Network on the border node to use for the SXP connection to ISE.

Tip: Cisco ISE does not support multiple SXP session bindings with same IP address.

The configuration example below is trimmed for length.

```
C9500-N15-1#show run | sec interface
interface Loopback1039
   description Loopback Border
   vrf forwarding BUILDING_VN
   ip address 10.102.114.1 255.255.255.255
...
interface Vlan3004
   description vrf interface to External router
   vrf forwarding BUILDING_VN
   ip address 172.17.172.13 255.255.255.252
   no ip redirects
   ip route-cache same-interface
```

Before proceeding, ensure that the chosen IP address can contact ISE. Remember to source ICMP traffic from the VRF where the chosen source IP address resides.

```
C9500-N15-1#ping vrf BUILDING_VN 10.1.3.75 source 10.102.114.1
```

Adding SXP Domains

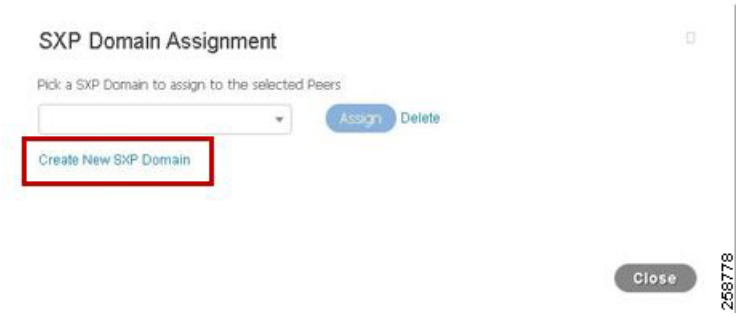
Before adding SXP Devices to ISE in an environment with multiple VRFs, SXP Domains need to be understood. An SXP Domain is a collection of SXP devices, and the administrator can direct a subset of IP-to-SGT mappings to each group. This can help enable a VRF awareness when distributing mappings by manually grouping SXP connections based on their VRF of origin into an SXP Domain and then assigning the appropriate IP-to-SGT mappings to the SXP Domain. This differs from deploying static IP-to-SGT mappings via SSH because that function cannot support distribution of mappings to multiple VRFs. Static IP-to-SGT mappings are assigned a domain when they are created. All IP-to-SGT mappings learned through RADIUS authentications are automatically added to the default domain but can be reassigned to a different domain using SXP Domain filters.

SXP connections from network devices with multiple VRFs will require a connection from an IP address in each Virtual Network back to ISE. We can use SXP Domains and SXP Domain filters to limit mappings sent from ISE to the network device to what is necessary for that Virtual Network. If not, the entire mapping table will be shared with each SXP connection peer from the network device.

To create an SXP domain in ISE:

1. Navigate to **Work Centers > TrustSec > SXP > SXP Devices.**
2. Click the **Assign SXP Domain link**, even if no SXP devices are present.
3. On the SXP Domain Assignment window, click the **Create New SXP Domain link**.

Figure 11 SXP Domain Assignment



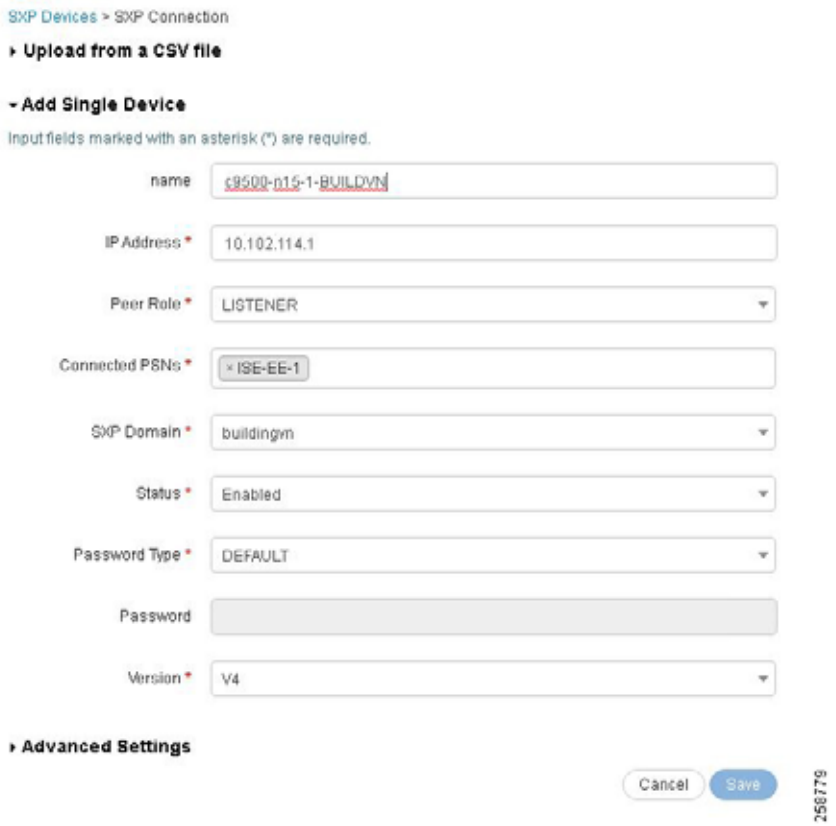
4. In the Enter VPN Name field that appears, enter a name for the new domain.
5. Click the **Create** button.

Create an SXP Domain for each Virtual Network where policy is enforced because we will group enforcement device SXP connections and mappings based on VN membership. These domains are selected when adding SXP Devices to ISE and can also be assigned or modified after the devices have been added.

Add an SXP Device on ISE

1. Choose **Work Centers > TrustSec > SXP > SXP Devices**.
2. Click the **Add** button.
3. Enter the device details:
   i. Click **Upload from a CSV file** link to add the SXP devices using a CSV file. Browse and select the CSV file, and then click the **Upload** button. You can also download the CSV template file, fill in the details of the devices that you want to add, and upload the CSV file.
   ii. Click the **Add Single Device link** to add the device details manually for each SXP device. Enter the name, IP address, SXP role (listener, speaker, or both), password type, SXP version, and connected PSNs for the peer device. You must also specify the SXP domain to which the peer device is connected.
4. (Optional) Click the **Advanced Settings** link and enter the following details:
   i. Minimum Acceptable Hold Time—Specify the time, in seconds, a speaker will send keep-alive messages for keeping the connection alive. The valid range is from 1 to 65534.
   ii. Keep-Alive Timer—Used by a speaker to trigger the dispatch of keep-alive messages during intervals when no other information is exported via update messages. The valid range is from 0 to 64000.
5. Click the **Save** button.

Figure 12 Add SXP Device



Configure SXP on the Border Node

1. On the border node, configure SXP. It must be added using the IP address chosen previously as the source address and the VRF/VN name must be specified using the ***vrf*** keyword

```
C9500-N15-1(config)#cts sxp enable

C9500-N15-1(config)#cts sxp default passwordmypass

C9500-N15-1(config)#cts sxp connection peer 10.1.3.75 source 10.102.114.1 password default
mode

local listener hold-time 0 0 vrf BUILDING_VN
```

2. Repeat these steps for an IP address in each VN for each enforcement device. If there are two Virtual Networks that require policy enforcement, then two SXP connections are made with ISE from the enforcement device.

Verify SXP Connection

Once the SXP device has been added to ISE in **Work Centers > TrustSec > SXP > SXP Devices** and the SXP configuration has been added to the border node by CLI, verify the status of the SXP connection.

To verify the SXP connection status, navigate to **Work Centers > TrustSec > SXP > SXP Devices** and review the Status column for the recently added device. The device status may be listed as PENDING_ON for several moments before moving to the ON state.

The connection status can also be verified on the CLI of the border node using the **show cts sxp connections** command. Remember to specify the VRF of the source IP address.

```
C9500-N15-1#show cts sxp connections vrfBUILDING_VN
```

The SXP entry at the top of the listing should be 'Enabled', and the Conn Status entry halfway down the output should be 'On'. This method is a quick way to verify the connection. See the Troubleshooting SXP Devices, page 31 section for example output.

Creating IP-to-SGT Static Mappings in ISE

Static IP-to-SGT mappings are necessary to enforce policies over IP Transit due to extended nodes not authenticating endpoints with ISE. The host onboarding settings of the port determine the host pool and SGT for the endpoint. Without authenticating the endpoint to ISE, ISE has no knowledge of the IP-to-SGT mapping. The switch also reapplies SGTs from its IP-to-SGT mappings that were removed when leaving the fabric on the IP Transit link.

Before you begin, ensure that the Scalable Group Tags needed for the mapping have been created.

To create a new static mapping:

1. Navigate to **Work Centers > TrustSec > Components > IP SGT Static Mapping**.
2. Click the **Add** button.
3. Enter the IP address or hostname for a single device or use CIDR notation for subnets.
4. The **Map to SGT individually** radio button is chosen by default.
   - Choose the SGT name in the **SGT** drop-down list.
   - Enter the SXP Domain name in the **Send to SXP Domain** field. If left blank, the default domain is used.
   - From the **Deploy to devices** drop-down list, select the grouping of devices to which the mapping should be deployed.

   The **Deploy to devices** field, if used, deploys mappings over SSH to the group of devices selected if CLI credentials have been entered during device creation under **Administration > Network Devices > (Device Name) > Advanced TrustSec Settings > Device Configuration Deployment**. This method of deploying IP-to-SGT mappings is not able to handle distribution to multiple VRFs.

   If the **Add to a mapping group** radio button is chosen, the IP address can be assigned to a mapping group which is a user-defined, named group with pre-selected options for the **SGT, Send to SXP Domain**, and **Deploy to devices** fields.
5. Click the **Save** button.

   Tip: Using SSH from ISE to push the mapping cannot be used for policy enforcement over Virtual Networks, because that ISE function is not VRF-aware. When creating the IP-to-SGT mapping, choosing a device name or device group from the Deploy to devices drop-down list indicates the user wants to push the static mapping via SSH to the device CLI.

Add an SXP Domain Filter

When static IP-to-SGT mappings are created, they are assigned an SXP domain and distributed to SXP devices or connections assigned to that domain. Unlike statically created mappings, all IP-to-SGT mappings ISE learns from RADIUS session information are placed in the default SXP domain. This becomes problematic when there are multiple SXP connections per enforcement device originating from different VNs/VRFs. IP-to-SGT mapping for an endpoint that is assigned to a Virtual Network during authentication need to be sent to the SXP connection on the enforcement device that resides in the same Virtual Network.

If traffic sourced from an endpoint in the BUILDING_VN leaves that fabric border and crosses the MPLS network and re-enters the border at the remote site, its IP-to-SGT mapping must be shared to the SXP connection within the same VN so it can be re-tagged with its source SGT information. If certain mappings, learned via RADIUS, should be moved to a different SXP domain, an SXP Domain Filter will need to be added.

Before creating Domain Filters, navigate to **Work Centers > TrustSec > Settings > SXP Settings**. Check the add radius mappings into SXP IP-to-SGT mapping table check box. This allows ISE to add IP-to-SGT mappings learned via RADIUS session to the SXP IP-to-SGT mapping table, otherwise only static mappings will be shared by SXP.

Tip: If static IP-to-SGT mappings have been created and shared via SXP that cover all host subnets in your network, then sharing RADIUS-learned IP-to-SGT mappings and creating SXP Domain Filters may be unnecessary because the static IP-to-SGT mapping will be enough to reapply source tags to traffic that matches the static mapping. You can view all the mappings known to ISE (including static mappings and session mappings) on the **Work Centers > TrustSec > SXP > All SXP Mappings** page.

By default, session mappings learned from the network devices are sent only to the default VPN group. You can create SXP domain filters to send the mappings to different SXP domains (VPNs). To add an SXP domain filter:

1. Navigate to **Work Centers > TrustSec > SXP > All SXP Mappings**.
2. Click the **Add SXP Domain Filter** button.
3. Do the following:
   - Enter the subnet details. The session mappings of the network devices with IP addresses from this subnet are sent to the SXP domain (VPN) that is selected in the **SXP Domain** field.
   - From the **SGT** drop-down list, choose an SGT. The SGT mappings will be sent to the SXP domain that is selected in the SXP Domain field.
   - If you have specified both Subnet and SGT, the session mappings that match this filter are sent to the SXP domain that you have selected in the **SXP Domain** field.
   - Choose the SXP domain to which the mappings must be sent.
4. Click the **Save** button.

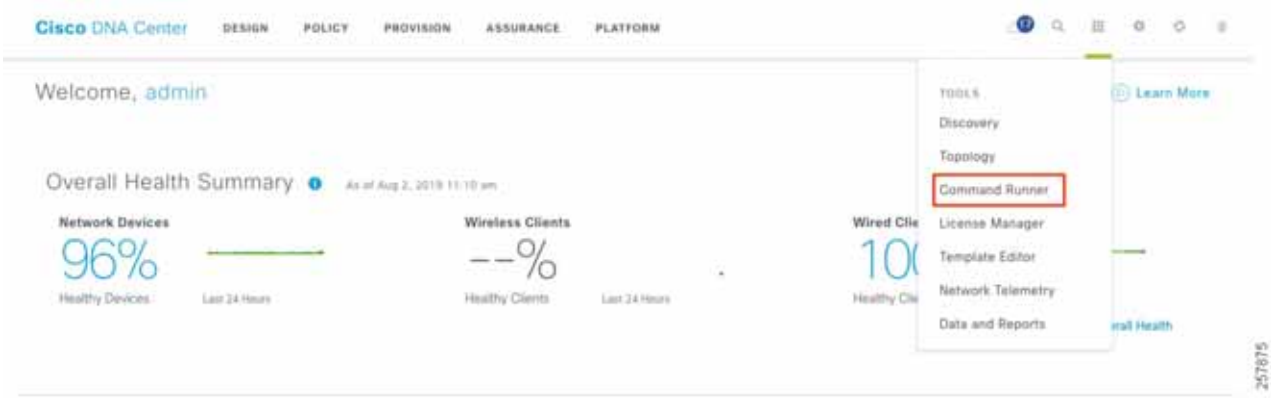
You can also update or delete the SXP domain filters. To update a filter, click the **Manage SXP Domain Filter** button, check the check box next to the filter that you want to update, and then click the **Edit** button. To delete a filter, check the check box next to the filter that you want to delete, and then click **Trash > Selected.**

Security Troubleshooting

This section uses the command runner functionality on Cisco DNA Center to get information in edge nodes. To use command runner, complete the following steps:

1. From the **Cisco DNA Center home page**, click **Command Runner** in **Tools**. The **Command Runner** window displays:

Figure 13 Launch Command Runner



2. On **Search by Device IP**, select the devices you want to run the commands on. A Device List with your selection displays.
3. Type the commands you want to run; you can type up to five commands.

Figure 14 Command Runner

4. Click **Run Command(s)**. If successful, a *Command(s) executed successfully* message displays.
5. Click the command displayed beneath the device name to view the command output. The complete command output is displayed in the Command Runner window.
6. If required, output can be exported to a file using the **Export CLI Output** option.

Figure 15 Command Runner Output

TrustSec Troubleshooting on Edge Switch and Policy Extended Node

This section contains a list of useful commands to troubleshoot TrustSec on the edge switches.

- **show cts environment-data**—Displays TrustSec environment data, useful for identifying scalable groups pushed to the device.

```
show cts environment-data
CTS Environment Data
====================
Current state = COMPLETE
Last status = Successful
Local Device SGT:
  SGT tag = 0-00:Unknown
Server List Info:
Installed list: CTSServerList1-0001, 1 server(s):
 *Server: 10.1.3.75, port 1812, A-ID BA5A4C740D22D66DB1C53EFAB7EA54FA
          Status = ALIVE
          auto-test = TRUE, keywrap-enable = FALSE, idle-time = 60 mins, deadtime = 20 secs
Security Group Name Table:
    0-00:Unknown
    2-00:TrustSec_Devices
    3-00:Network_Services
    4-00:VN_E_Employees
    5-00:Security_Contractor
    6-00:Guests
    7-00:Production_Users
    8-00:Developers
    9-00:VN_E_Auditors
    10-00:Point_of_Sale_Systems
    11-00:Production_Servers
    12-00:Development_Servers
    13-00:Test_Servers
    14-00:PCI_Servers
    15-00:BYOD
```

```
    16-00:Security_Cameras
    17-00:Default
    18-00:Parking_Sensors
    19-00:HVAC
    20-00:NotUsed
    21-00:Badge_Readers
    22-00:SecVideo_Server
    23-00:HVAC_Management
    24-00:PhysicalSec_Server
    25-00:VN_E_Unknown
    26-00:Unknown_Building_VN
    255-00:Quarantined_Systems
Environment Data Lifetime = 86400 secs
Last update time = 18:43:08 UTC Thu Aug 1 2019
Env-data expires in   0:03:08:43 (dd:hr:mm:sec)
Env-data refreshes in 0:03:08:43 (dd:hr:mm:sec)
Cache data applied           = NONE
State Machine is running
```

- **show cts role-based sgt-map vrf VIRTUAL_NETWORK all**—Shows IP to SGT mapping in the edge node. This command is useful on the edge node. It will display mappings for endpoints connected directly or through an AP or extended node.

```
sh cts role-based sgt-map vrf BUILDING_VN all
%IPv6 protocol is not enabled in VRF BUILDING_VN
Active IPv4-SGT Bindings Information

IP Address              SGT     Source
============================================
10.101.114.8            22      VLAN
10.102.114.1            16      VLAN
10.102.114.3            16      VLAN
10.102.114.4            16      VLAN
10.102.114.6            16      LOCAL
10.102.115.1            5       VLAN
10.102.115.101          5       VLAN
10.102.116.1            21      VLAN
10.112.114.1            22      VLAN

IP-SGT Active Bindings Summary
============================================
Total number of VLAN     bindings = 8
Total number of LOCAL    bindings = 1
Total number of active   bindings = 9
```

- **show cts role-based counters**—Provides information on the exit edge node about SGACL being applied. In the example, allowed packet counters are shown in green and denied packet counters are shown in red.

```
show cts role-based counters
From    To      SW-Denied  HW-Denied  SW-Permitt HW-Permitt SW-Monitor HW-Monitor
*       *       0          0          32965719   51066422   0          0
16      5       0          0          0          4          0          0
21      5       0          0          0          11         0          0
22      5       0          0          0          70         0          0
24      5       0          0          0          0          0          0
26      16      0          0          0          0          0          0
5       21      0          0          0          11         0          0
16      21      0          0          0          0          0          0
21      21      0          7          0          0          0          0
22      21      0          806        0          0          0          0
```

- **show cts role-based permissions**—Shows SGACL configured in ISE and pushed to the device.

```
show cts role-based permissions
IPv4 Role-based permissions default:
      Permit IP-00
IPv4 Role-based permissions from group 5:Security_Contractor to group 5:Security_Contractor:
      Deny IP-00
IPv4 Role-based permissions from group 16:Security_Cameras to group 5:Security_Contractor:
      Permit IP-00
IPv4 Role-based permissions from group 21:Badge_Readers to group 5:Security_Contractor:
      Permit IP-00
IPv4 Role-based permissions from group 22:SecVideo_Server to group 5:Security_Contractor:
      Permit IP-00
IPv4 Role-based permissions from group 24:PhysicalSec_Server to group 5:Security_Contractor:
      Permit IP-00
IPv4 Role-based permissions from group 5:Security_Contractor to group 16:Security_Cameras:
      Permit IP-00
IPv4 Role-based permissions from group 16:Security_Cameras to group 16:Security_Cameras:
      Deny IP-00
```

- **show cts rbacl**—Shows contracts downloaded to the device

```
show cts rbacl
CTS RBACL Policy
================
RBACL IP Version Supported: IPv4
  name   = Deny IP-00
  IP protocol version = IPV4
  refcnt = 26
  flag   = 0x41000000
  stale  = FALSE
  RBACL ACEs:
    deny ip

  name   = Permit IP-00
  IP protocol version = IPV4
  refcnt = 5
  flag   = 0x41000000
  stale  = FALSE
  RBACL ACEs:
    permit ip

  name   = https_http_only-15
  IP protocol version = IPV4
  refcnt = 2
  flag   = 0x41000000
  stale  = FALSE
  RBACL ACEs:
    permit tcp dst eq 443 log
    permit udp dst eq 443 log
    permit tcp dst eq 80 log
    permit tcp src eq 80 log
    permit tcp dst eq 22
    permit tcp src eq 22
    deny ip log
```

Troubleshooting SXP Devices

If an SXP device is added to ISE, it will remain in the “Pending_ON” state for a few minutes before moving to the “ON” state. This is the fastest method to confirm the SXP connection state.

show cts sxp connections—Shows SXP connection information including connection status, peer IP address, and source IP address. The vrf keyword must be used to see connection in any non-default VRFs.

If the connection remains in the “off” or “pending_on” state, check that the password and source IP address used for the connection matches the source IP address and password configured in ISE for the SXP device. Also check that SXP is enabled on the device with the cts sxp enable command.

```
C9500-N15-1#show cts sxp connections vrfBUILDING_VN
   SXP              : Enabled
   Highest Version Supported: 4
   Default Password : SetDefault
   Key-Chain: Not Set
   Default Key-Chain Name: Not Applicable
   Default Source IP: 10.4.14.3
Connection retry open period: 120 secs
Reconcile period: 120 secs
Retry open timer is not runningPeer-Sequence traverse limit for export: Not Set
Peer-Sequence traverse limit for import: Not Set
----------------------------------------------
Peer IP          : 10.1.3.75
Source IP        : 10.102.114.1
Conn status      : On
Conn version     : 4
Conn capability  : IPv4-IPv6-Subnet
Conn hold time   : 120 seconds
Local mode       : SXP Listener
Connection inst# : 2
TCP conn fd      : 3
TCP conn password: default SXP password
Hold timer is running
Duration since last state change: 25:04:07:19 (dd:hr:mm:sec)


Total num of SXP Connections = 1
```

Show cts sxp sgt-map—Shows IP-to-SGT mappings received via an SXP peer. If mappings are sent in a non-default SXP domain, use the vrf keyword to specify the appropriate VRF and display IP-to-SGT mappings. This command only shows IP-to-SGT mappings learned by the SXP connection, and any static mappings configured from the CLI will not be displayed here. For all IP-to-SGT map information on the device use the show cts role-based sgt-map all command as discussed in the previous section, remembering to specify VRF, if necessary.

```
C9500-N15-1#show cts sxp sgt-map vrfBUILDING_VN
SXP Node ID(generated):0xAC10AF01(172.16.175.1)
IP-SGT Mappings as follows:
IPv4,SGT: <10.102.114.0/24 , 16:Security_Cameras>
source  : SXP;
Peer IP : 10.1.3.75;
Ins Num : 2;
Status  : Active;
Seq Num : 201
Peer Seq: 0A01034B,
```

```
IPv4,SGT: <10.102.115.0/24 , 5:Security_Contractor>
source  : SXP;
Peer IP : 10.1.3.75;
Ins Num : 2;
Status  : Active;
Seq Num : 203
Peer Seq: 0A01034B,
IPv4,SGT: <10.102.116.0/24 , 21:Badge_Readers>
source  : SXP;
Peer IP : 10.1.3.75;
Ins Num : 2;
Status  : Active;
Seq Num : 191
Peer Seq: 0A01034B,IPv4,SGT: <10.102.124.0/24 , 16:Security_Cameras>source  : SXP;
Peer IP : 10.1.3.75;
Ins Num : 2;
Status  : Active;Seq Num : 205
Peer Seq: 0A01034B,
IPv4,SGT: <10.102.125.0/24 , 5:Security_Contractor>
source  : SXP;
Peer IP : 10.1.3.75;
Ins Num : 2;
Status  : Active;
Seq Num : 193
Peer Seq: 0A01034B,
IPv4,SGT: <10.102.126.0/24 , 21:Badge_Readers>
source  : SXP;
Peer IP : 10.1.3.75;
Ins Num : 2;
Status  : Active;
Seq Num : 187
Peer Seq: 0A01034B,
IPv4,SGT: <10.102.134.0/24 , 16:Security_Cameras>
source  : SXP;
Peer IP : 10.1.3.75;
Ins Num : 2;
Status  : Active;
Seq Num : 199
Peer Seq: 0A01034B,
IPv4,SGT: <10.102.135.0/24 , 5:Security_Contractor>
source  : SXP;
Peer IP : 10.1.3.75;
Ins Num : 2;
Status  : Active;
Seq Num : 189
Peer Seq: 0A01034B,
IPv4,SGT: <10.102.136.0/24 , 21:Badge_Readers>
source  : SXP;Peer IP : 10.1.3.75;
```

```
Ins Num : 2;
Status  : Active;
Seq Num : 195
Peer Seq: 0A01034B,
IPv4,SGT: <10.112.114.10 , 22:SecVideo_Server>
source  : SXP;
Peer IP : 10.1.3.75;
Ins Num : 2;
Status  : Active;
Seq Num : 197
Peer Seq: 0A01034B,
Total number of IP-SGT Mappings: 10
```

Dynamic SGT Classification Troubleshooting

To ensure that an endpoint has received the correct SGT from Cisco ISE, log in to the ISE primary Admin node:

1. Navigate to **Operations > Radius > Live Logs**. On the Live Logs page, filter for the endpoint in question. Live log entries for the endpoint should be visible. Under the Identity column, #CTSREQUEST# displays any time SGT information is downloaded to the switch.
2. Click the **Details** icon for the log entry under the Details column. Near the bottom of the page in the Results section of the output, there are several entries for cisco-av-pairs. The av-pair cts:security-group-tag=00-0000 contains the tag number issued to the endpoint.

On the Live Logs page, SGT information can also be found in the Authorization Profiles column. If the network device received SGT information along with the authorization profile for the endpoint, the name of the SGT will be displayed next to the Authorization Profile name.

On the policy extended nodes, details of the device session can be seen using command runner. The following command provides information on all access sessions of devices connected to the switch.

```
show access-session
Interface                MAC Address    Method  Domain  Status Fg  Session ID
-----------------------------------------------------------------------------------------
Gi1/7                    0022.bdfb.8cf9 mab     DATA    Auth        08AF10AC0000001795BCDFBF
Gi1/9                    0057.d2c0.df93 mab     VOICE   Auth        08AF10AC0000000D81D8183B
Gi1/1                    00c0.e40a.2748 mab     DATA    Auth        08AF10AC00000018A549416F
Gi1/5                    00ee.ab15.960c N/A     UNKNOWN Unauth      08AF10AC0000000E81D98D63
Ap1/1                    5254.dd23.b19a N/A     UNKNOWN Unauth      08AF10AC0000001081F20F97
Gi1/8                    8cae.4cff.364e N/A     UNKNOWN Unauth      08AF10AC0000001395A31103

Session count = 6
```

For a detailed view use the following command. It provides device details, assigned VLAN and assigned SGT.

```
show access-session interface gigabitEthernet 1/1 details
            Interface:  GigabitEthernet1/1
               IIF-ID:  0x1D65BB8C
          MAC Address:  00c0.e40a.2748
         IPv6 Address:  Unknown
         IPv4 Address:  10.103.100.4
            User-Name:  00-C0-E4-0A-27-48
          Device-type:  Un-Classified Device
          Device-name:  Unknown Device
               Status:  Authorized
               Domain:  DATA
```

```
          Oper host mode:  multi-auth
        Oper control dir:  both
         Session timeout:  N/A
  Acct update timeout:  172800s (local), Remaining: 171518s
    Common Session ID:  08AF10AC00000018A549416F
      Acct Session ID:  0x0000000b
               Handle:  0x1900000e
       Current Policy:  PMAP_DefaultWiredDot1xClosedAuth_1X_MAB
```

Local Policies:

Server Policies:

```
              Vlan Group:  Vlan: 1062
               SGT Value:  108


Method status list:
       Method           State
        dot1x           Stopped
          mab           Authc Success

SN-FOC2350V00A#
```

Provisioning

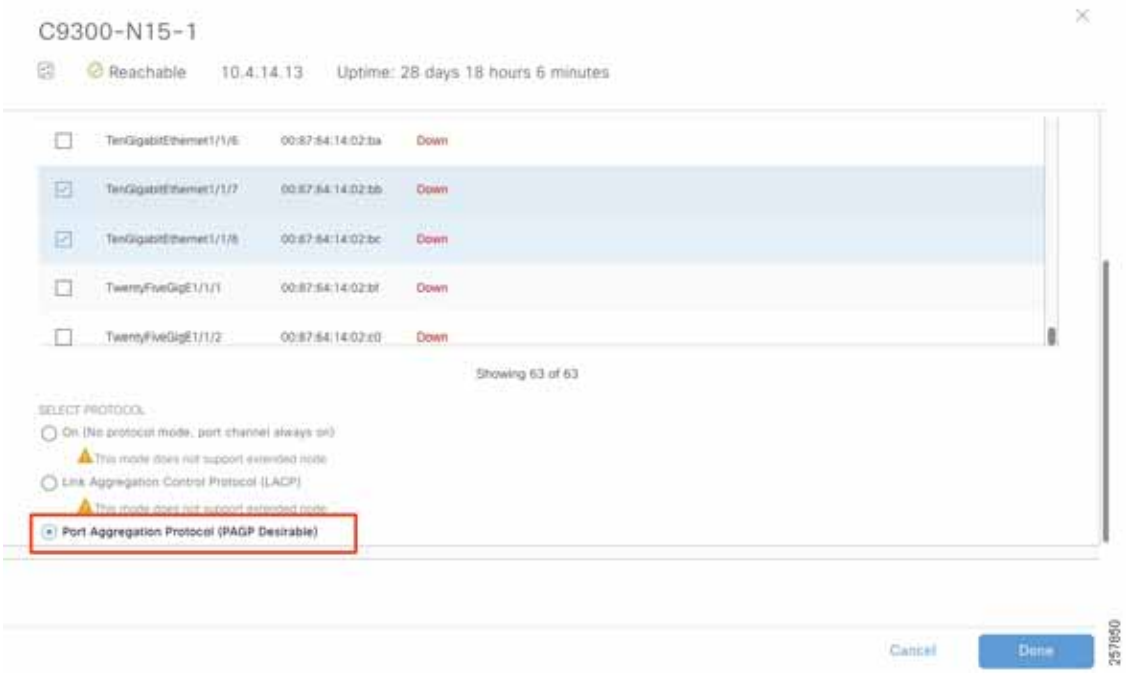
This chapter explains how to configure the fabric edge node and host onboarding page to support extended nodes and policy extended nodes. It also explains how to connect IE switches to the fabric network using the Cisco SD-Access Extension for IoT. Included are instructions to provision the network for endpoint onboarding.

Configure Fabric Edge

An extended node is connected to a fabric edge using EtherChannel. When using no authentication as the global setting for the fabric, the port channel gets created automatically once the industrial switch is connected to the network. If any other authentication template is selected, a port channel needs to be created manually. Authentication options are explained in Host Onboarding, page 36.

1. In the Cisco DNA Center dashboard, navigate to **PROVISION > Fabric**.
2. Select the **Fabric Domain**.
3. Choose the fabric site from the Fabric-Enabled Sites.
4. Click the **Fabric Infrastructure** tab and select the **fabric edge node**. A window with the device name as the title displays.
5. Select the **Port Channel** tab.
6. Click **+Create Port Channel**.
7. Select the interfaces to be used.
8. Under **Select Protocol**, click the PAGP radio button. PAGP is supported on IE3400 starting on IOS-XE version 17.1.1s.
9. Click **Done**.

Figure 16 Create Port-channel on Fabric Edge



Host Onboarding

The final required step to provision an SD-Access fabric is host onboarding. Although it is covered in the *Cisco Software-Defined Access Deployment Guide*, it requires special mention in this document because it enables extended node functionality.

Host onboarding comprises four distinct steps and is configured under the **Provision > Fabric > Host Onboarding** tab for a fabric site:

1. Define authentication template
2. Create host pools
3. Define SSID address pool
4. Assign Access Point ports

Define Authentication Template

The first step is to select the authentication template. These templates are predefined in the Cisco DNA Center and are pushed down to all devices that are operating as edge nodes within a site. It is mandatory to complete this step first, an authentication template must be defined before host pool creation.

Authentication templates deploy certain interface-level commands on the downstream (access) ports of all edge nodes. By default, access ports are considered all copper ports operating as switchports (as opposed to routed ports) on the edge nodes. These interface-level commands are port-based network access control configurations that validate a connected endpoint before it can connect to a network.

There are four supported authentication templates:

1. Closed Authentication
2. Open Authentication

3. Easy Connect
4. No Authentication

These templates are based on the AAA Phased Deployment Implementation Strategy of High Security mode, Low Impact mode, Monitor mode, and No Authentication mode. Hovering over each option in Cisco DNA Center provides information about the authentication template. To support dynamic authentication on access ports make sure an option other than **No authentication** is chosen.

https://www.cisco.com/c/en/us/td/docs/solutions/Enterprise/Security/TrustSec_1-99/Phased_Deploy/Phased_Dep_Guide.html#wp392247

To select an authentication template:

1. In the Cisco DNA Center dashboard, navigate to **PROVISION > Fabric**.
2. Select the **Fabric Domain**.
3. Select the fabric site from the **Fabric-Enabled Sites**.
4. Click the **Host Onboarding** tab.
5. Under Select Authentication Template, choose **Closed Authentication**.
6. Click **Save**.

Tip: An authentication template can be overwritten on a per-port basis. In this guide, we selected closed authentication because it provides a higher level of security for edge ports.

Create Host Pools

The second step is to bind the IP address pools to the VNs. Once bound, these components are referred to collectively as host pools. Multiple IP address pools can be associated with the same VN.

When a host pool is created, a subnet in the form of a reserved IP address pool is bound to a VN. From the perspective of device configuration, Cisco DNA Center creates the VRF definition on the fabric nodes, creates a switch virtual interface (SVI) or loopback interface (on switches and routers, respectively), defines these interfaces to forward for the VRF, and gives the IP address defined as the gateway for the reserved pool.

For the Extended Enterprise deployment, you create host pools for extended nodes, access points, and endpoints. In the security section we mentioned SGTs can be associated to a host pool. This is done when creating a host pool. Also, a friendly name for the host pool can be assigned during creation to be used on the VLAN field of ISE authorization profile.

Creating Extended Nodes Host Pool

Extended nodes and APs are special cases in the fabric. Extended Nodes and APs are connected to edge nodes like an endpoint, but they are part of the fabric infrastructure. Because of this, their traffic pattern is unique. Extended nodes receive a DHCP address via the overlay network. To accommodate this traffic flow, the extended node subnet, which is in the Global Routing Table (GRT), is associated with the overlay network. The Cisco DNA Center GUI calls this special overlay network associated with the GRT the INFRA_VN.

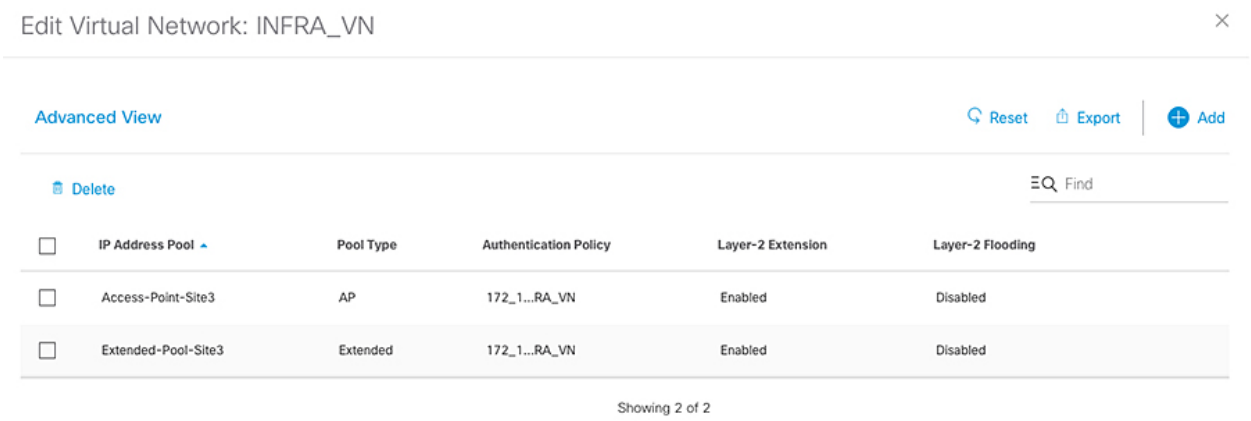
The Infrastructure Virtual Network (INFRA_VN) overlay is intended to represent devices that are part of the network infrastructure but associate and connect to the network in a similar method to endpoints: in other words, directly connected to the downstream ports of an edge node. Both APs and extended nodes (SD-Access extension for IoT) are part of the INFRA_VN.

Tip: INFRA_VN, while labeled as a VN in the GUI because it is part of the overlay network, is not provisioned as a VRF definition in the network. It is not truly a VRF and routes for the INFRA_VN are in the GRT.

Configuration Steps

1. Under the **Host Onboarding** tab, under **Virtual Networks**, select **INFRA_VN**.
2. In the **Edit Virtual Network: INFRA_VN** pane, click **+** to add a new pool.
3. From the **IP** drop-down menu, choose the IP pool name(s) to be associated to the VN. The drop-down menu shows IP pools reserved for the fabric site.
4. Under **Pool Type**, choose **Extended**.
5. Click **Update**.

Figure 17 Extended Node Host Pool



Creating AP Host Pool

AP host pools are also created in the INFRA_VN by performing the following steps:

1. Under the **Host Onboarding** tab, under **Virtual Networks**, select **INFRA_VN**.
2. In the **Edit Virtual Network: INFRA_VN** pane click **+** to add a new pool.
3. From the **IP** drop-down menu, choose the IP pool name(s) to be associated to the VN. The drop-down menu shows IP pools reserved for the fabric site.
4. Under **Pool Type**, choose **AP**.
5. Click **Update**.

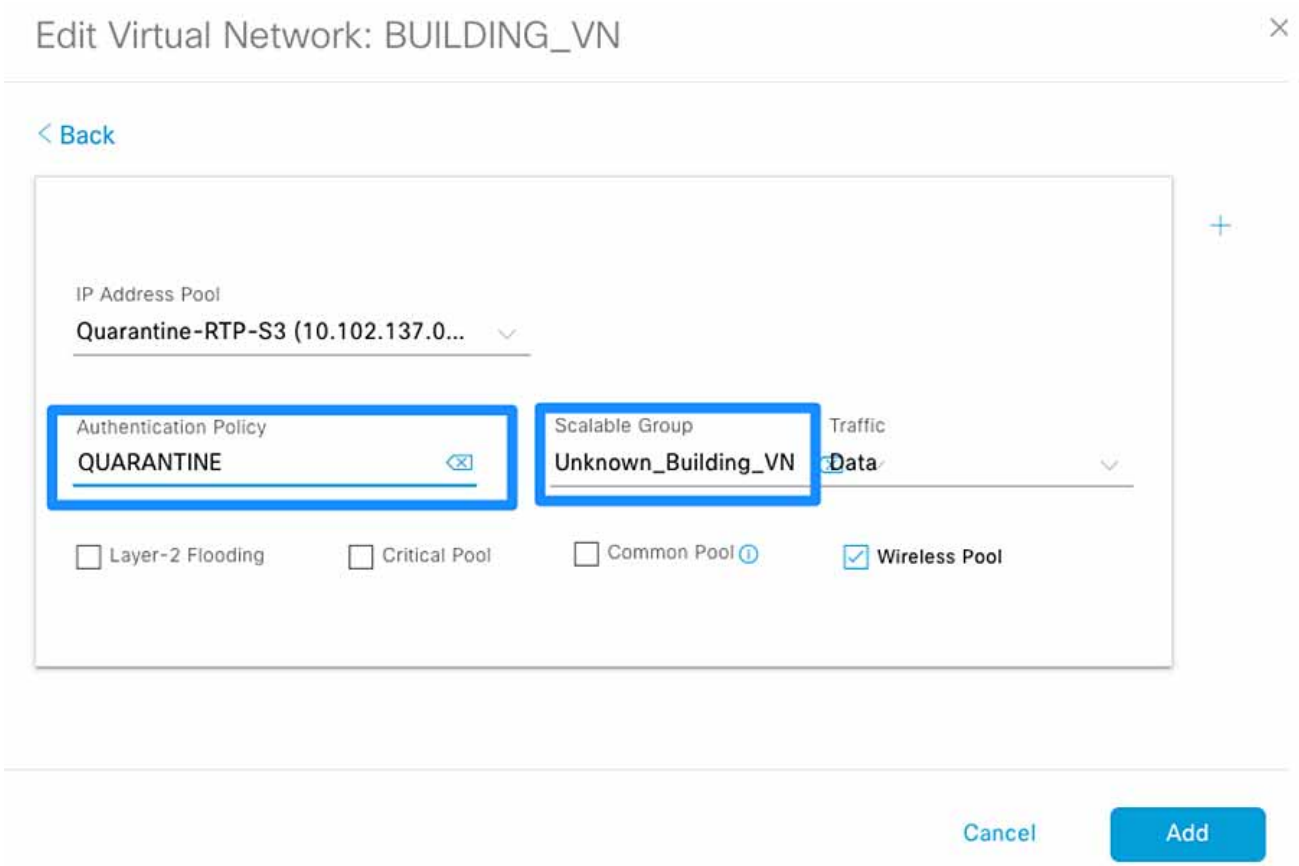
Creating Host Pools for Endpoint Onboarding

1. Under the **Host Onboarding** tab, choose the **VN** for the endpoints. In this CVD, one pool is used for building devices such as IP cameras and badge readers.
2. In the **Edit Virtual Network** pane, click **+** to add a new pool.
3. From the **IP** drop-down menu, choose the IP pool name(s) to be associated to the VN. The drop-down menu shows IP pools reserved for the fabric site.
4. (Optional) Assign a friendly name to the host pool on the **Authorization Policy** field as shown in the picture below. The friendly name can be used in ISE authorization profile to simplify policy creation workflow.

5. (Optional) From the **Scalable Group** drop-down list choose the **SGT** for the specific host pool. This step is needed for micro- segmentation because policy tagging is done at the edge using IP subnet to SGT mapping. The step is optional on deployments with policy extended nodes only but it is needed to enable micro-segmentations on deployments with extended nodes.
6. From the **Traffic** drop-down menu, choose **Data**.
7. Check the relevant options below. Make sure to check **Wireless Pool** if required by wireless endpoints.
8. Click **Update**.

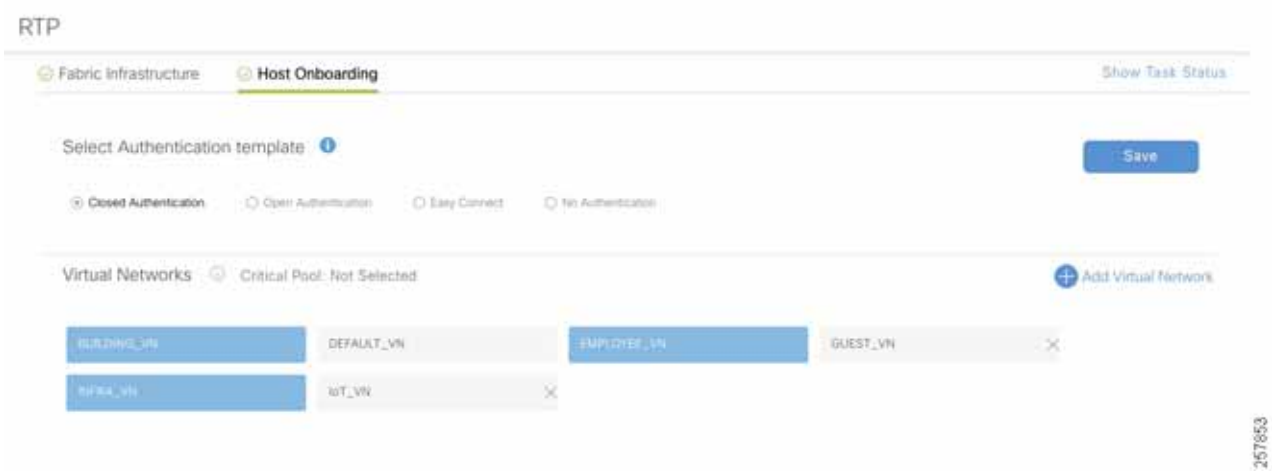
Tip: Authentication policy and Scalable group options cannot be modified once the pool is created.

Figure 18 Host Pool for Endpoints



Tip: After IP host pools are added to a VN, the VN background will change to blue as shown in Figure 19. Hovering over the VN will display how many pools are assigned.

Figure 19 Host Onboarding



Wireless SSID Configuration

This step binds an SSID to an IP address pool and is required for SD-Access in wireless scenarios. Each SSID for a fabric site must be assigned an IP address pool so that wireless hosts are associated with the correct subnet when connecting to the wireless network.

1. Click the **Host Onboarding** tab.
2. Under **Wireless SSIDs**, from the **Address Pool** drop-down menu, choose the IP address pool for the SSID.
3. (Optional) Under **Scalable Group**, choose an SGT. In this CVD, an unknown tag was used by default. The tag will be replaced by ISE after endpoint completes authorization process.
4. Repeat Steps 1 through 3 for every SSID.
5. Click **Save**.

Figure 20 Host Onboarding Wireless SSID

Select Port Assignment

The last step is to selectively overwrite default port configuration. This step is required in the following scenarios:

- Configuring a port for an AP if using closed authentication
- Configuring a port-channel for extended nodes if using closed authentication
- Configuring a server port

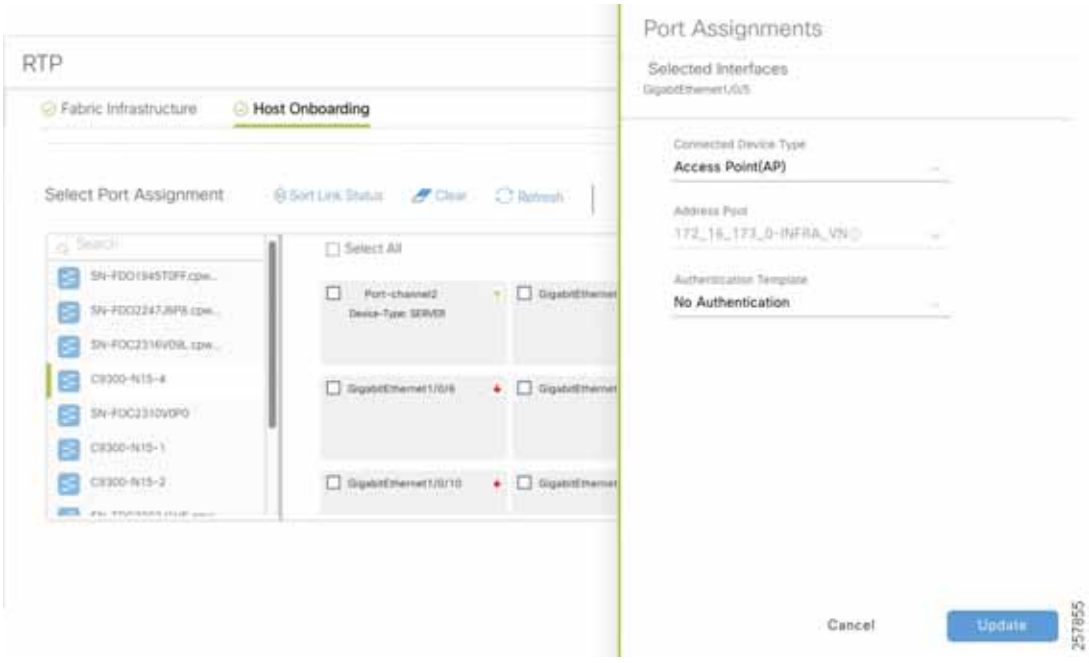
- Statically configuring a port for wired endpoints

Port Assignment for Access Points

Cisco DNA Center enables automatic onboarding of APs by provisioning a Cisco Discovery Protocol macro at the fabric edge nodes when the authentication template is set to **No Authentication**. If a different authentication template is used globally (for example, Closed Authentication), then the downstream switchport configurations on the edge nodes must be changed in the Cisco DNA Center.

1. Under the **Host Onboarding** tab, choose the switch where the access point will be connected.
2. Check the boxes for the appropriate ports to be used for APs.
3. Click **Assign**.
4. In the **Port Assignment** window, from the **Connected Device Type** drop-down menu, choose **Access Point (AP)**.
5. Leave the default address pool selection and, from the **Authentication Template** drop-down list, choose **No Authentication**. If adding an AP to an extended node, **No Authentication** is selected by default.
6. Click **Update**.
7. After all ports supporting APs have been chosen, under the **Host Onboarding** tab, click **Save**. Keep the default **Now** selection, and then click **Apply**.

Figure 21 AP Port Assignment



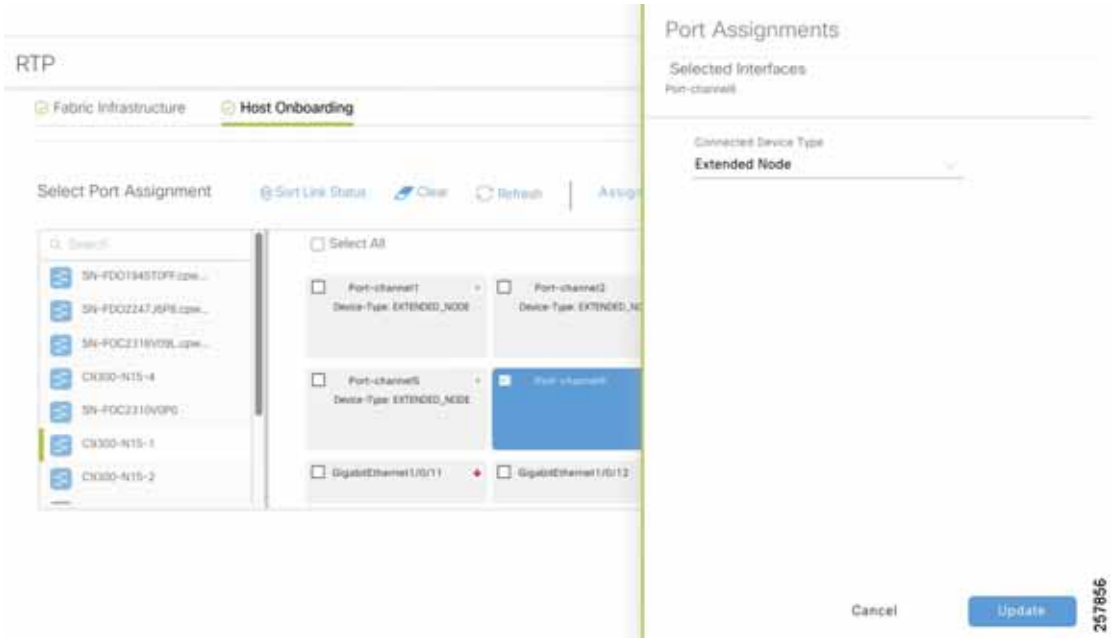
Tip: The configuration is not pushed to the switch until the configuration is saved.

Port Assignment for Extended Nodes Connected to Edge

Like APs, extended nodes are onboarded automatically when the authentication template is set to **No Authentication**. When a different authentication template is used globally (for example, **Closed Authentication**), then the downstream switchport configurations on the edge nodes must be changed in the Cisco DNA Center.

1. Under the **Host Onboarding** tab, choose the fabric edge switch (for example, **C9300**).
2. Check the box for the appropriate port channel to be used for extended nodes.
3. Click **Assign**.
4. In the **Port Assignment** window, from the **Connected Device Type** drop-down menu, choose **Extended Node**.
5. Click **Update**.
6. After all ports supporting extended nodes have been selected, under the **Host Onboarding** tab, click **Save**. Keep the default **Now** selection, and then click **Apply**.

Figure 22 Extended Node Assignment



Port Assignment for Server Ports

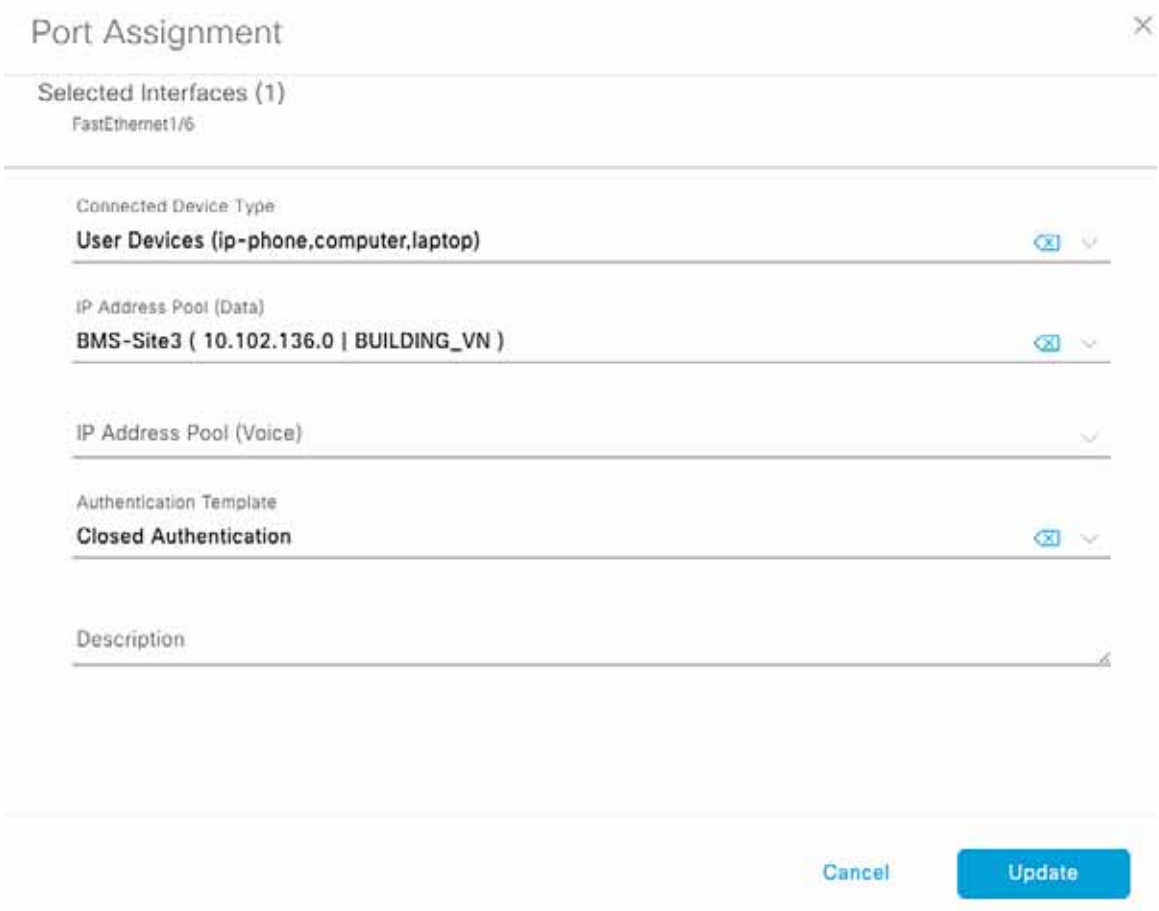
1. Under the **Host Onboarding** tab, choose a switch.
2. Check the box for the appropriate interface to be used for the server.
3. Click **Assign**.
4. On the **Port Assignment** window, from the **Connected Device Type** drop-down menu, choose **Server**.
5. Click **Update**.
6. Under the **Host Onboarding** tab, click **Save**. Keep the default **Now** selection, and then click **Apply**.

Port Assignment for Endpoints Requiring Static Configuration

1. Under the **Host Onboarding** tab, choose the extended node switch.

2. Check the box for the appropriate interface to be used for the wired endpoint.
3. Click **Assign**.
4. On the **Port Assignment** window, from the **Connected Device Type** drop-down menu, choose **User Devices**.
5. (Optional) From the **Address Pool** drop-down menu, choose the appropriate address pool. This option may be used for endpoints with static IP address.
6. (Optional) From the **Voice Pool** drop-down menu, choose the appropriate voice pool.
7. (Optional) Choose authentication option from the **Authentication Template** drop-down menu. This will overwrite global authentication template on the port.
8. Click **Update**.
9. Under the **Host Onboarding** tab, click **Save**. Keep the default **Now** selection, and then click **Apply**.

Figure 23 Endpoint Port Assignment



Adding an Extended Node to Cisco SD-Access Network

After the port channel has been created (if using closed authentication) and host onboarding has been configured as explained in the previous section, the extended node is deployed using zero-touch Plug and Play (PnP).

Cisco industrial switches running IOS or IOS-XE software have a PnP agent embedded in the software that communicates with the PnP deployment server. The PnP agent runs on a device if no startup configuration exists, such as when a device is powered on for the first time or reset to factory default. The PnP agent attempts to discover the PnP deployment server via DHCP or the Domain Name System (DNS). Cisco DNA Center serves as the PnP server for the Extended Enterprise deployment.

Adding a Policy Extended Node to Cisco SD-Access Network

Adding a policy extended node follows same process than an extended node. After the port channel has been created (if using closed authentication) and host onboarding has been configured as explained in the previous section, the policy extended node is deployed using zero-touch Plug and Play (PnP) if it meets the following requirements:

- Switch is a Catalyst IE3400 or IE3400H
- Switch has DNA Advance license
- Switch is running IOS-XE 17.1.1s or newer. Note that even if policy extended Node is provisioned on IOS-XE versions 17.1.1s and older, it is recommended you use IOS-XE version 17.3.1 because this version has critical fixes to guarantee TrustSec enforcement.

PnP Requirements for DHCP Discovery

- DHCP server with option 43 configured pointing to the Cisco DNA Center.
- DHCP server must accept the Cisco vendor-specific option 60 case-sensitive value **ciscopnp**.

Example of DHCP Configuration

DHCP option 43 consists of a string value that is configured as follows on a Cisco router CLI that is acting as a DHCP server:

```
ip dhcp pool pnp_device_pool<-- Name of DHCP pool
network 192.168.1.0 255.255.255.0<-- Range of IP addresses assigned to clients default-router
192.168.1.1<-- Gateway address
option 43 ascii "5A1N;B2;K4;I172.19.45.222;J80"<-- Option 43 string
```

The option 43 string has the following components, delimited by semi-colons:

- **5A1N;**—Specifies the DHCP sub-option for PnP, active operation, version 1, no debug information. It is not necessary to change this part of the string.
- **B2;**—IP address type, B2 stands for IPv4, B1 should be used for hostname.
- **Ixxx.xxx.xxx.xxx;**—IP address or hostname of the Cisco DNA Center controller (following a capital letter i). In this example, the IP address is 172.19.45.222.
- **Jxxxx**—Port number to use to connect to the Cisco DNA Center controller. In this example, the port number is 80. The default is port 80 for HTTP and port 443 for HTTPS.
- **K4;**—Transport protocol to be used between the device and the controller, use K4 for HTTP (default) or K5 for HTTPS.

For more information, refer to the *Cisco Digital Network Architecture Center User Guide*.

PnP Requirements for DNS Discovery

- Domain name option configured on DHCP server
- DNS server option configured on DHCP server
- PnP server (Cisco DNA Center) resolves to PnP deployment server IP in DNS

- IP helper address should be configured on the distribution switch

Bringing Up a Policy Extended Node or an Extended Node

Power on the device if it has no previous configuration. If the node device has configurations, use the ***write erase*** command to remove previous configuration and reload the extended node device. Cisco DNA Center adds the extended node device to the inventory and assigns the same site as the fabric edge. The device is then added to the fabric. Now the extended node device is onboarded and ready to be managed.

Once the configuration is complete, the node appears in the fabric topology with a tag (X) indicating that it is an extended node or policy extended node.

Figure 24 Extended Node or Policy Extended Node Added to the Fabric

Migrating an Extended Node to a Policy Extended Node

If your network has a Catalyst IE3400 with an older software version operating as extended node , upgrading the version won't enable policy extended node functionality. Node re-provision is required. Follow these steps.

1. Go to **Provision > Fabric** and choose the fabric site.
2. Choose the extended node and click **Remove From Fabric**. Confirm removal.
3. Click **Save** on the main page.
4. Once the device is removed from the fabric, go to **Provision > Devices > Inventory.**
5. Choose the device and click **Actions > Inventory > Delete Device**
6. Go to ISE and select **Administration > Network Resources > Network Devices**
7. Choose the device and click **Delete.** Confirm removal.
8. If a port channel was created on the fabric edge using other than PGAP option, it needs to be deleted. Follow steps 8-10 to delete and recreate the port channel.
9. Go to **Provision > Fabric** and choose the fabric site. Go to **Host Onboarding > Port Assignment**. Click the fabric edge and choose the port channel. Click **Clean**, then click **Save.**

10. Go to **Provision > Fabric** and choose the fabric site and fabric edge. Go to the **Port Channel** tab and delete the port channel.
11. Create the Port channel as described in Configure Fabric Edge.
12. From the device CLI, delete all configuration and reload.

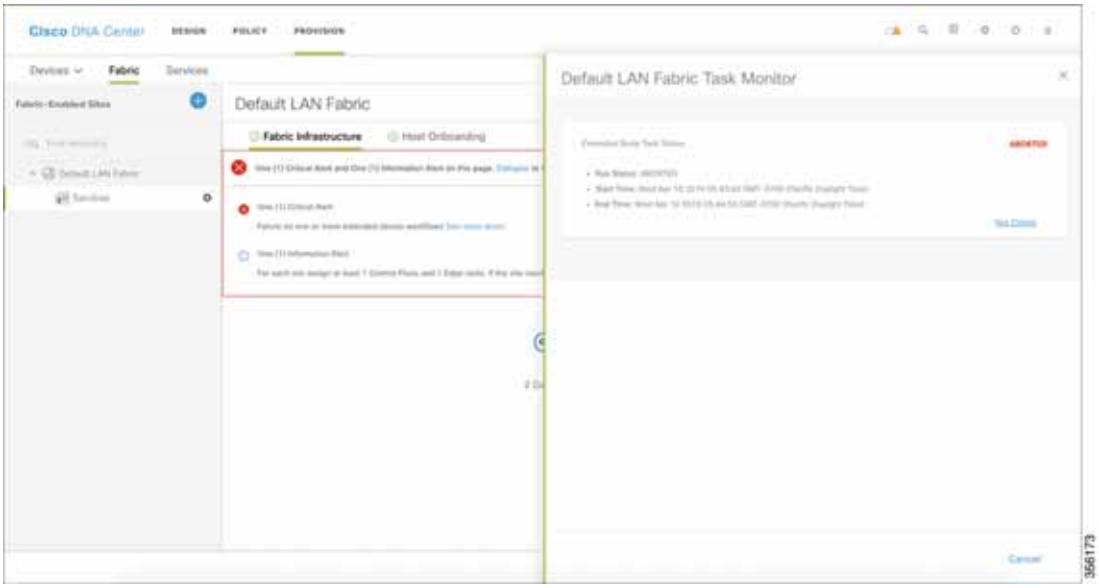
Extended Node or Policy Extended Node Troubleshooting

If errors in the workflow exist while configuring an extended node, an error notification is displayed as a banner on the topology window, as shown in Figure 25.

Figure 25 Extended Node Workflow Error

Click **See More Details** to view the error. The **Task Monitor** window displays the extended node task status. Click **See Details** to see the cause of error and possible solution, as shown in Figure 26.

Figure 26 Extended Node Workflow Error Details



The device console can also provide some helpful information. The following console output is provided as example of a successful flow. We have highlighted some important lines for reference.

```
Jul 17 19:04:50.534: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1043, changed state to up
//INFRA_VN vlan is up
Jul 17 19:04:50.852: %LINK-5-CHANGED: Interface Vlan1, changed state to administratively down
Jul 17 19:04:50.856: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1, changed state to down
Jul 17 19:04:55.540: DHCP: No configured hostname - not including Hostname option
Jul 17 19:05:00.549: %PNPA-DHCP Op-43 Msg: Process state = READY
Jul 17 19:05:00.549: %PNPA-DHCP Op-43 Msg: OK to process message
Jul 17 19:05:00.549: XML-UPDOWN: PNPA_DHCP_OP43 XML Interface(102) UP. PID=417
Jul 17 19:05:00.549: %PNPA-DHCP Op-43 Msg: _pdoon.1.ntf.don=417
Jul 17 19:05:00.552: %PNPA-DHCP Op-43 Msg: _pdoop.1.org=[A1D;B2;K4;I10.1.3.73;J80;]
```

```
Jul 17 19:05:00.552: %PNPA-DHCP Op-43 Msg: _pdgfa.1.inp=[B2;K4;I10.1.3.73;J80;]
Jul 17 19:05:00.552: %PNPA-DHCP Op-43 Msg: _pdgfa.1.B2.s12=[ ipv4 ]
Jul 17 19:05:00.552: %PNPA-DHCP Op-43 Msg: _pdgfa.1.K4.htp=[ transport http ]
Jul 17 19:05:00.552: %PNPA-DHCP Op-43 Msg: _pdgfa.1.Ix.srv.ip.rm=[ 10.1.3.73 ] //PnP server details
obtained
Jul 17 19:05:00.552: %PNPA-DHCP Op-43 Msg: _pdgfa.1.Jx.srv.rt.rm=[ port 80 ]
Jul 17 19:05:00.552: %PNPA-DHCP Op-43 Msg: _pdoop.1.ztp=[pnp-zero-touch] host=[] ipad=[10.1.3.73]
port=80
Jul 17 19:05:00.552: %PNPA-DHCP Op-43 Msg: _pors.done=1
Jul 17 19:05:00.552: %PNPA-DHCP Op-43 Msg: _pdokp.1.kil=[PNPA_DHCP_OP43] pid=417 idn=[Vlan1043]
Jul 17 19:05:00.552: XML-UPDOWN: Vlan1043 XML Interface(102) SHUTDOWN(101). PID=417
Jul 17 19:05:00.598: %DHCP-6-ADDRESS_ASSIGN: Interface Vlan1043 assigned DHCP address
172.16.175.86, mask 255.255.255.0, hostname // DHCP address assigned

Jul 17 19:05:06.456: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/5, changed
state to down
Jul 17 19:05:07.459: %LINK-3-UPDOWN: Interface GigabitEthernet1/5, changed state to down
Jul 17 19:05:09.822: %LINK-3-UPDOWN: Interface GigabitEthernet1/5, changed state to up
Jul 17 19:05:10.821: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/5, changed
state to up
Jul 17 19:05:17.274: AUTOINSTALL: Obtain siaddr 10.1.3.39 (as config server)
Jul 17 19:05:17.277: %PNP-6-HTTP_CONNECTING: PnP Discovery trying to connect to PnP server
http://10.1.3.73:80/pnp/HELLO
Jul 17 19:05:19.287: %PNP-6-HTTP_CONNECTED: PnP Discovery connected to PnP server
http://10.1.3.73:80/pnp/HELLO
Jul 17 19:05:20.297: %PNP-6-PROFILE_CONFIG: PnP Discovery profile pnp-zero-touch configured
Jul 17 19:05:48.709: %SYS-6-CLOCKUPDATE: System clock has been updated from 19:05:32 UTC Wed Jul 17
2019 to 19:05:48 UTC Wed Jul 17 2019, configured from console by console.
%Error opening tftp://10.1.3.39/network-confg (Timed out)
Jul 17 19:07:21.773: %PNP-6-PNP_DISCOVERY_DONE: PnP Discovery done successfully // PnP process
completed
000064: Jul 17 19:09:00.923: %SSH-5-ENABLED: SSH 1.99 has been enabled
```

Device Not Starting the Plug and Play Process

- Verify the device has no configuration. If the switch is a brownfield device, use the following commands to clear the switch configuration (spacing intentional for copy/paste):

```
del flash:private-config.text


del flash:config.text


del sdflash:config.text


del pnp.dat


delete /f /r flash:dc_profile_dir


del *pnp*

configure terminal

no pnp profile pnp-zero-touch

do delete /force nvram:*.cer

do delete /force flash:pnp-reset-config.cfg
```

```
crypto key zeroize

yes

no crypto pki certificate pool

yes

no crypto pki trustpoint pnplabel

yes

end
write erase
```

- Verify the PnP VLAN was created automatically on the switch. Before PnP starts, you should see a line for an interface VLAN pnp-VLAN created on the IE switch:

```
Jul 17 19:04:50.534: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan1043, changed state to up
```

- If that is not the case, verify that the EtherChannel is created on the fabric edge and IP Host Pool was created for extended nodes on INFRA_VN.
- If the switch gets a DHCP IP address, but the PnP process has not started, check that option 43 is configured on the DHCP server and that Option 60 is supported on the DHCP server.
- If a PnP timeout occurs while contacting Cisco DNA Center, verify that Cisco DNA Center is reachable from the PnP VLAN.

PnP Process Not Successful

Navigate to **Provision > Devices > Plug and Play** and click the device name. Under the **History** tab, review error details and click **Info** to get more information.

Provisioning Wireless Access Points

This guide assumes that the administrator already discovered, upgraded and configured redundancy on the WLC. For more information on those tasks, refer to the *CVD Software-Defined Access Medium and Large Site Fabric Provisioning*.

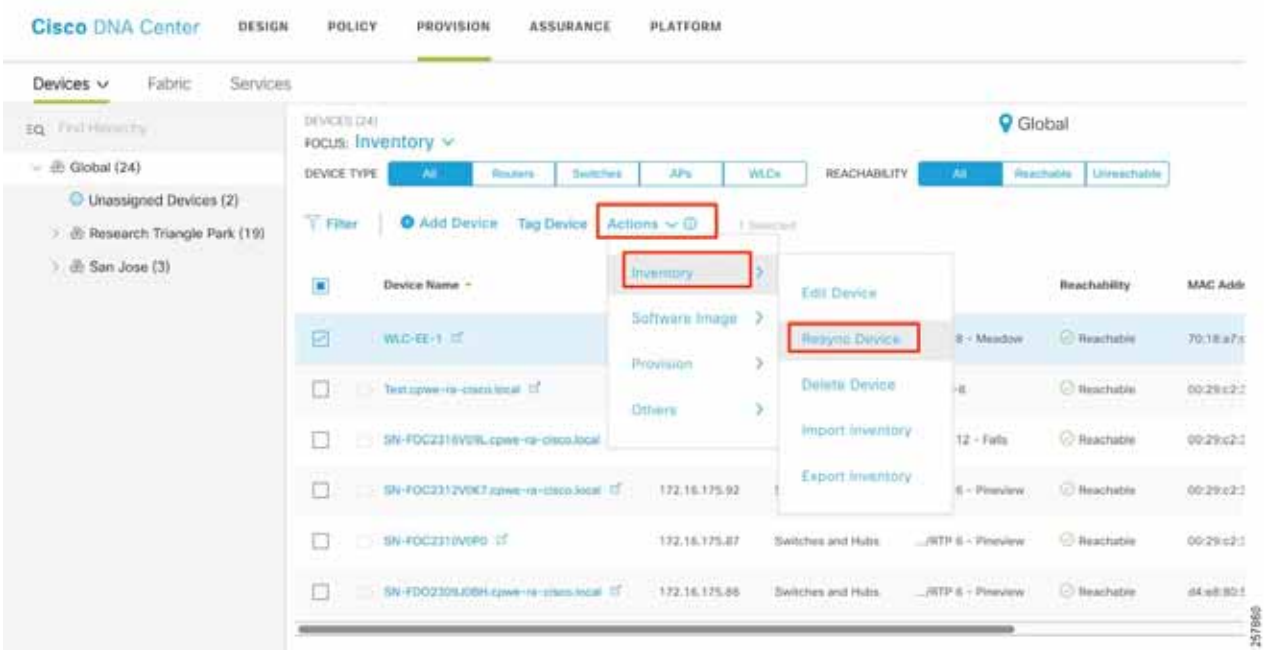
In order to add APs to the network, you must do the following:

- Add DHCP scope for APs with option 43 pointing to WLC.
- Make sure the IP address pool for APs was created in Cisco DNA Center with the correct DHCP server and associated to INFRA_VN in the host onboarding configuration.
- Ensure the AP is connected to the Power over Ethernet (PoE) port on an IE switch or a power injector.

Follow this procedure to provision an AP:

1. Navigate to the **Cisco DNA Center dashboard**. Under **PROVISION > Devices > Inventory**, choose the **WLC** and then in the **Actions > Inventory** drop-down menu, choose **Resync Device**. The APs associated with the WLC are added to the inventory without waiting for an inventory refresh.

Figure 27 Resync WLC for AP Provision



2. Navigate to **PROVISION > Devices > Inventory** and choose the APs being added. From the **Actions** drop-down menu, choose **Provision**.
3. On the **Provision Devices** page, assign the APs to a floor (the floor should be managed by a WLC), and then click **Next**. For **RF Profile**, choose **TYPICAL** and then click **Next**.
4. At the **Summary** page, click **Deploy**. In the slide-out panel, leave the default selection of **Now**, and then click **Apply** and acknowledge any warnings about reboots.

Endpoint Onboarding

At this point, the network is ready for endpoint onboarding, provided DHCP pools have been created for endpoints. You can connect endpoints to industrial switches or wirelessly to outdoor APs using the fabric SSID. The endpoint should receive the appropriate SGT and policies. If the endpoint is not able to connect, you can use **Client Health** page to diagnose issues.

Review the following required configurations to help diagnose endpoint onboarding issues:

- A DHCP scope for endpoints exists.
- The DHCP server is reachable from the host IP pool. If not, check the fusion router configuration.
- If the endpoint uses 802.1x authentication, the user should exist in the identity store configured in policy.
- For wireless endpoints, if the SSID is not available, verify the WLC and APs were provisioned successfully.
- For wired endpoints, confirm the extended node was configured with the correct host pool.

Provisioning a Software Image

The Cisco DNA Center allows you to push software images to the devices in your network. Prior to pushing the image, Cisco DNA Center checks the device for upgrade readiness, including device management status, SCP and HTTPS file transfer success, and disk space. If any pre-checks fail, you cannot perform the software image update. After the software image of the device is upgraded, the Cisco DNA Center checks the CPU usage, route summary, and so on, to ensure that the state of the network remains unchanged after the image upgrade.

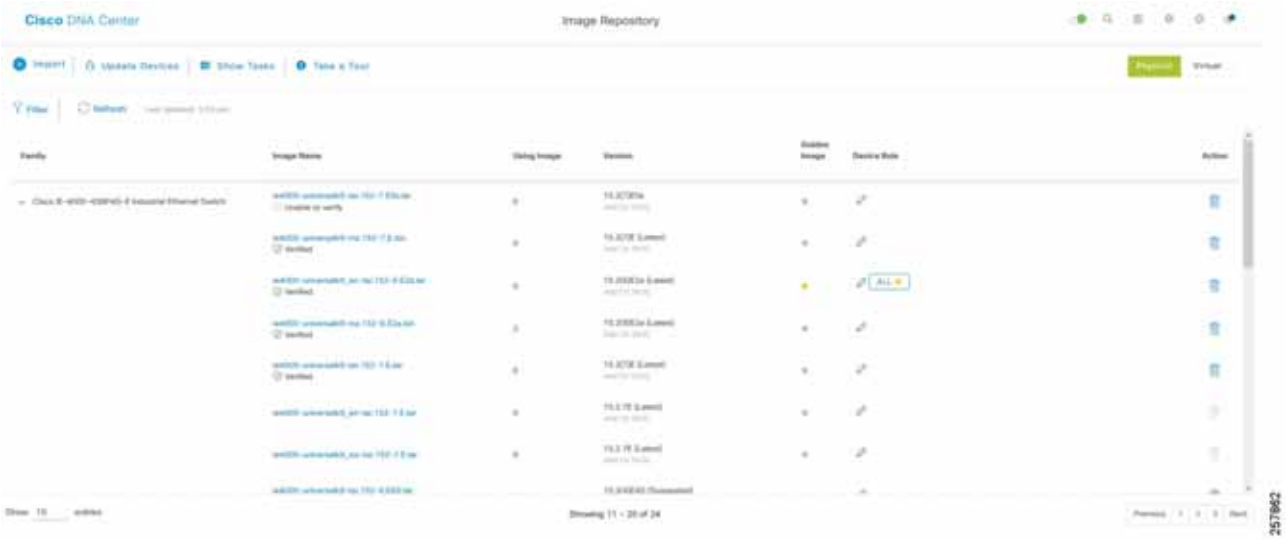
The Cisco DNA Center also compares each device software image with the image that you have designated as golden for that specific device type. If a difference exists between the software image of the device and the golden image, then the Cisco DNA Center specifies the software image of the device as outdated. The upgrade readiness pre-checks will be triggered for those devices. If all the pre-checks are cleared, you can distribute the new image to the device and activate it. The activation of the new image requires a reboot of the device. This might interrupt the current network activity; if downtime is not feasible, you can schedule the process to a later time. If you have not designated a golden image for the device type, then the device's image cannot be updated.

Designating an Image as Golden

To upgrade a device in the Cisco DNA Center, it must have a **golden** image for its platform. Devices can be assigned a golden image by **Family** and **Role**. When an image is marked as golden, it can be tagged so that it applies to a subset of devices by network role. The default is tag is **All**, but you can select from the following options: **Core**, **Distribution**, **Border Router**, **Unknown**, and **Access**.

1. Navigate to **Design > Image Repository**.
2. Navigate to the device family and then click the arrow next to the device family name to display a selection of images. Click the **gray star** under **Golden Image** to mark the image as golden.
   - If the software image is already imported to the Cisco DNA Center (indicated by a **blue trashcan** in the **Action** column), the process to mark it as golden is faster.
   - If the image is not imported (indicated by a **gray trashcan** in the **Action** column), the process will take longer because DNA attempts to import the image directly from Cisco.com.

Figure 28 Golden Image

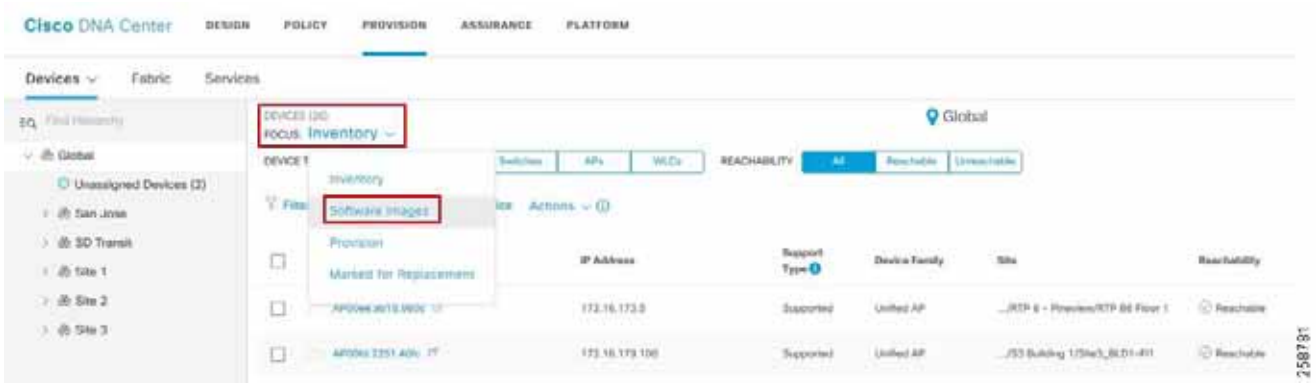


Upgrading Device to Golden Image

1. To check if a device needs upgrading, navigate to **Provision > Devices > Inventory**.

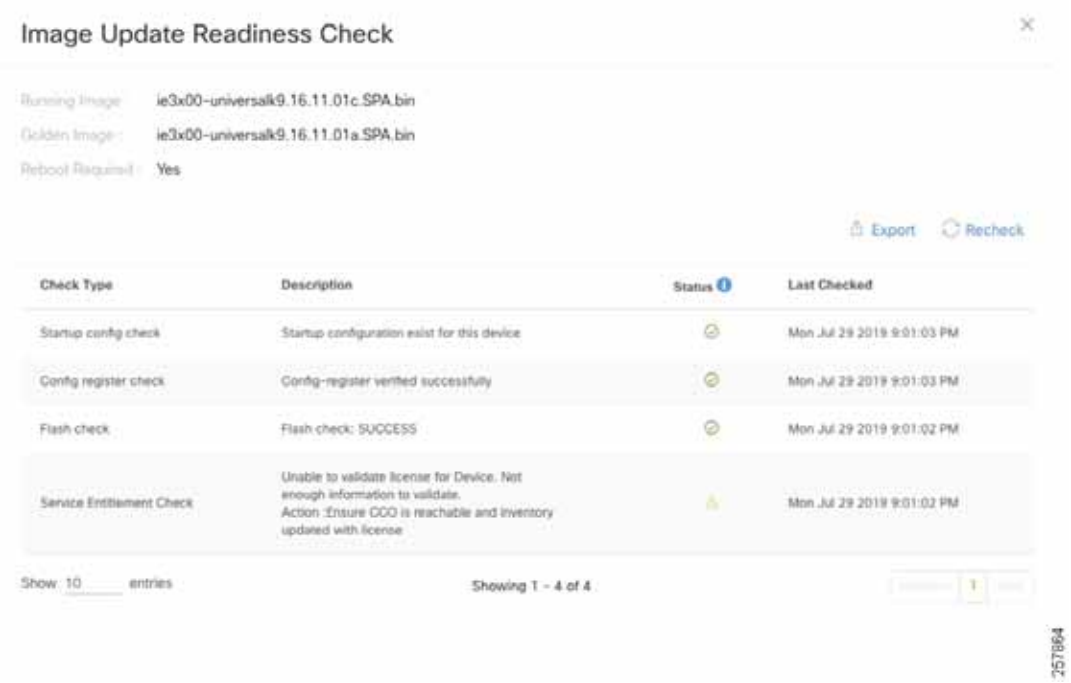
2. From the **Focus** drop-down menu, choose **Software Images**:

Figure 29 Change Focus to Software Images



- If a device shows as **Outdated** in the **Software Image** field, the device is not on the golden image and should be updated.
- If there is a **green check** next to **Outdated**, the device has passed upgrade readiness checks and can be updated.
- If there is a **red check** next to **Outdated**, the device has one or more issues in its readiness checks that must be resolved before the device can be updated.
- If **Outdated** is not displayed in the **OS Image** field for a device, it is either on the golden image or does not have a golden image specified in **Design > Image Repository**.

Figure 30 Upgrade Readiness



3. (Only if necessary) For more detail on a device image upgrade readiness check, click **Outdated**. The **Image Upgrade Readiness Check** window displays. Near the top of the page, the current running image and the golden image are displayed. The **Check Type** field lists the readiness check, and a brief description is shown. One or more failures will prevent provisioning of an image and need to be corrected before the image can be updated. Warning triangles in the **Status** field indicate an issue, but do not affect the ability to provision a software image to the device. Once issues are corrected, proceed to the next step.

   Tip: If you correct an issue on a device, click **Recheck**, and if the issue still displays a failing status, resync the device on the **Inventory** page using A**ctions > Resync** to update device details in the Cisco DNA Center. The change may be made on the device but might not have populated to the Cisco DNA Center.

4. To begin the image update process, check the box next to one or more devices that require an image update and that have passed image update pre-checks. Then click **Actions > Software Image > Update Image**. The **OS Update** window will display.

5. At the **Distribute** step, click the **Now** radio button to begin distribution of the image immediately or the **Later** radio button to schedule distribution for later. Click **Next** to continue to the **Activate** step. During device sync, the Cisco DNA Center checks files in the target device file system. If the golden image is found in the file system, the distribution step will be skipped.

6. At the **Activate** step, check the box next to **Schedule Activation** after **Distribution is Completed** to reload the device and boot to the new image immediately after distribution is complete. Leave the box unchecked to pre-stage the image on the device and schedule image activation and device reload for a later time. Click **Next** to continue to the **Confirm** step.

7. At the **Confirm** step, review details entered for image upgrade. Click **Confirm** to submit.

When an image upgrade begins, it is possible to check upgrade status by going to **Actions > Software Image > Image Update** status. Click the drop-down arrow to the far right of each entry in **Recent Tasks** to display more information about distribution and activation operations.

Click **Refresh** periodically to see the most up-to-date information on job status. When complete, both the distribution operation and activate operation are preceded by green tick marks and the top-level status is successful.

Figure 31 Successful Software Upgrade

Once upgraded to the golden image, **Outdated** no longer appears in the **Software Image** field for the device in Inventory.

Tip: If activation fails for any reason, you can retry by creating a new task. The Cisco DNA Center will find the image in the device already and distribution step will be skipped.

Template Provisioning

Some features such as NetFlow and QoS policies on extended nodes and policy extended nodes are not configured as part of network automation. In these cases, template provisioning can be used. This section provides an overview of template provisioning.

Creating a Project

Projects are logically grouped templates. Unlike templates grouped in the Onboarding Configuration project that are only available during the Plug and Play process, Day-N templates are available for use during provisioning of a device in the Cisco DNA Center inventory. To create a project, do the following:

1. From the **Cisco DNA Center** dashboard, choose **Tools > Template Editor**.
2. To create a new project, click **+** and then choose **Create Project**.
3. In the **Add New Project** window, enter a unique name for the project and then click **Add**. The new project will appear in the left window.

Creating a Regular Template

1. From the **Cisco DNA Center** dashboard, choose **Tools > Template Editor**.
2. Click **+** and choose **Create Template**.
3. In the **Add New Template** window, click **Regular Template**.
4. Enter a name for the template.
5. In the **Project Name** drop-down list, choose the correct project. Don't select **Onboarding Configuration** because those are not visible when applying configuration to an already provisioned device.
6. (Optional) Choose an existing **Tag** from the list or create a new one. This can be used to apply templates to a group of devices in a site.
7. In the **Select Device Type(s)** window, drill down to platforms or grouping of platforms.
   - If all selections below a parent grouping are selected, a blue check is displayed in the check box.
   - If some, but not all selections below a parent grouping are selected, a blue square is displayed.

   Choose all device platforms or groupings of platforms a template should apply to and click **Back to Add New Template** to return to the **Add New Template** window.
8. Under **Software Type**, choose the software type for the template. Any template assigned to IOS software will also be available to IOS-XE and IOS-XR software devices, but templates made for IOS-XE and IOS-XR software will not be available to other IOS software devices. Once complete, click **Add**.
9. Click **Add**.
10. After the template is created, click the template name in the left window to edit. In the **Template Editor** window, enter any content for the template. The Cisco DNA Center uses the Velocity Templating Language (VTL) to allow the use of variables and logic statements to generate a configuration from a template. Appendix B: Sample Template used in CVD Verification, page 50 includes some template examples.

    Note: In the Cisco DNA Center, configuration for devices is rendered via VTL. Velocity is a template programming language. In the Template Editor, configuration templates can be created using variables, macros, and loops that are then interpreted by Velocity to produce device configuration. All configurations are rendered on the Cisco DNA Center, and VTL does not have access to the current running configuration of the device.
11. Click **Actions** and then click **Save**. The Cisco DNA Center will check for VTL syntax errors in the template. If errors exist, the template will not be saved.
12. To configure variables use the **Form Editor** icon on the top right. This view allows you to configure variable properties. Click **Actions** and then click **Save.**

13. For the latest version of a template to be available in **Design > Network Profiles**, the template must be committed. Click **Actions** and then click **Commit**. In the **Commit** window, click **Commit**.

Creating a Composite Template

If you need to apply more than one template to the devices it is possible to use composite templates. Two or more regular templates are grouped together into a composite sequence template. You can create a composite sequential template for a set of templates, which are applied collectively to devices. The templates that you create can be added to a single composite template, which aggregates all the individual templates that you need. You must specify the order in which templates that are in the composite template are deployed to devices.

Furthermore, individual templates could contain a variable that could be changed if the template needs to be executed or not. For example, a composite template for an industrial switch could be created including a QoS template and a NetFlow template. A variable is used as flag in the template, when set to 1 the code in the template is executed. The administrator will be able to decide if configuring only one or two features. For this specific example check the Appendix section Appendix A Template Example.

Creating a Composite template is similar to the process described in Creating a Regular Template , page 53.

1. Create a template as described in Creating a Regular Template , page 53. Select **Composite** instead of **Regular** for template type.
2. After creating the template, click the composite template that you created in the tree view pane.
3. In the **Template Editor** window, drag and drop templates from the tree view pane to create a sequence. The templates are deployed based on the order in which they are sequenced. You can change the order of templates in the **Template Editor** window. By default, the **Applicable** option is chosen in the View filter and only the applicable templates that can be added to the composite template are shown in the **Template Editor** window. You can choose the **All** option in the **View** filter to view all the templates. In the **All** option view, the templates that match the chosen device types and software version are marked by a plus icon. You can drag and drop templates that have the same device type, software type, and software version as that of the composite template.
4. To abort the deployment process upon failure of the first template, select the first template in the **Template Editor** window and check the **Abort sequence on targets if deployment fails** check box.
5. From the **Actions** drop-down list, choose **Commit** to commit the template content.

Creating a Network Profile

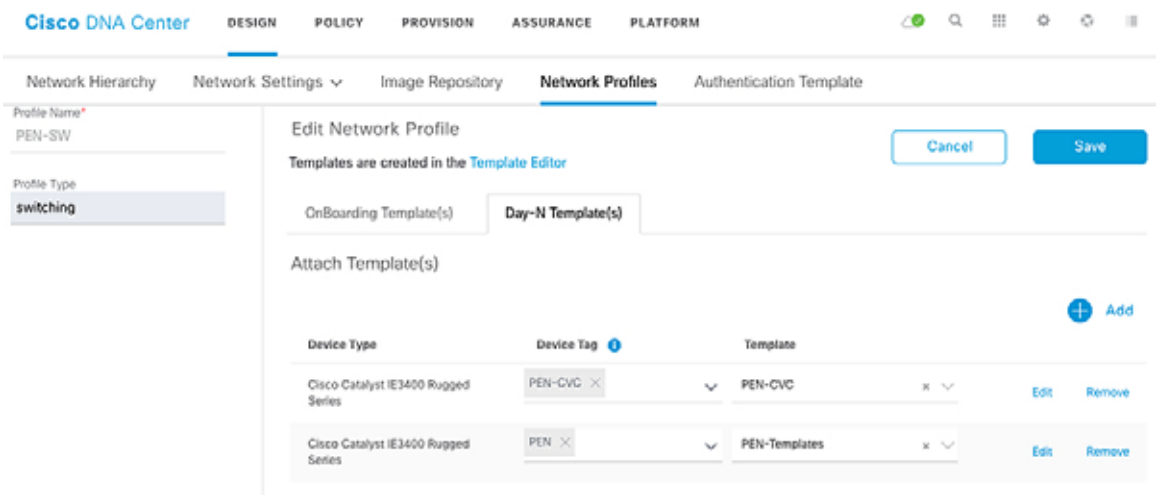
Before a device can be provisioned using a template, it must be associated with a network profile and the profile must be assigned to a site.

1. Navigate to **Design > Network Profiles**. Click **Add Profile**.
2. Choose **Switching** to create a switching network profile.
3. Enter a unique Profile Name. Choose **Day-N Template(s)** based on where the appropriate template is grouped.
4. To associate a template to the network profile, click **+Add**.
5. Under the **Device Type** column, drill down to a specific platform or group of devices. Only one platform type or one parent group of devices may be selected per field.
6. (Optional) Choose a **Device Tag** to allow templates to be applied to a subset of devices.
7. Under the **Template** column, choose the appropriate template.
8. (Optional) Click **+Add** to create another device type to template association within one network profile if needed.
9. Click **Save**.

Tip: If the expected template does not appear after choosing **Device Type** or **Device Role**, navigate back to **Template Editor** and ensure that the correct **Device Type** and **Role** have been added to the template. If changes have been made to the template and it still does not appear as a selection in **Design > Network Profiles**, ensure that the changes have been saved and committed.

The following figure shows a network profile with different templates applied to device with different tags.

Figure 32 Creating a Network Profile



Associating Network Profile to a Site

Once the network profile has been created and has templates associated, it must be assigned to a site. On the **Network Profiles** page, click **Assign Site**. Click a site or sites where the network profile should be assigned. If a network profile is assigned to a site, any device provisioned at the site with a device type and role that matches a template association within the profile will have a template available during the provisioning step.

Provisioning a Template on a Device

1. From the **Cisco DNA Center dashboard**, navigate to **Provision > Devices > Inventory**. The **Device Inventory** window displays.
2. Click the **Device Inventory** tab.
3. Click the check box adjacent to the device you want to provision.
4. From the **Action** drop-down list, choose **Provision > Provision Device**.
5. The **Assign Site** window displays. Click **Next.**
6. If any Day-N templates are available for the device, the templates associated with the site through the network profile appear in the advanced configuration. Choose the device in the left pane. In the right pane, choose values for the attributes that are bound to source. If you want the template to be pushed to the device even when it was pushed previously check **Push these templates even if its deployed before** check box.

   To export the template variables into a CSV file while deploying the template, click **Export** in the right pane. You can use the CSV file to make necessary changes in the variable configuration and import it into Cisco DNA Center by clicking **Import** in the right pane.

7. Click **Next** and then click **Deploy**.
8. Click **Now** or **Later**, then click **Apply.**
9. To see the deployment status, change to **Provision** view on the inventory page. The **Provision Status** column shows current status. Click a status for more details.

For more information in templates refer to https://www.cisco.com/c/en/us/td/docs/cloud-systems-management/network-automation-and-management/dna-center/1-3-3-0/user_guide/b_cisco_dna_center_ug_1_3_3_0/b_cisco_dna_center_ug_1_3_2_0_chapter_01000.html

Assurance

The Cisco DNA Center provides insights into enterprise networks by ingesting large amounts of data from network devices, clients, and sensors, and analyzing data. Many key performance metrics are measured and correlated to focus on highlighting issues and providing guided solutions.

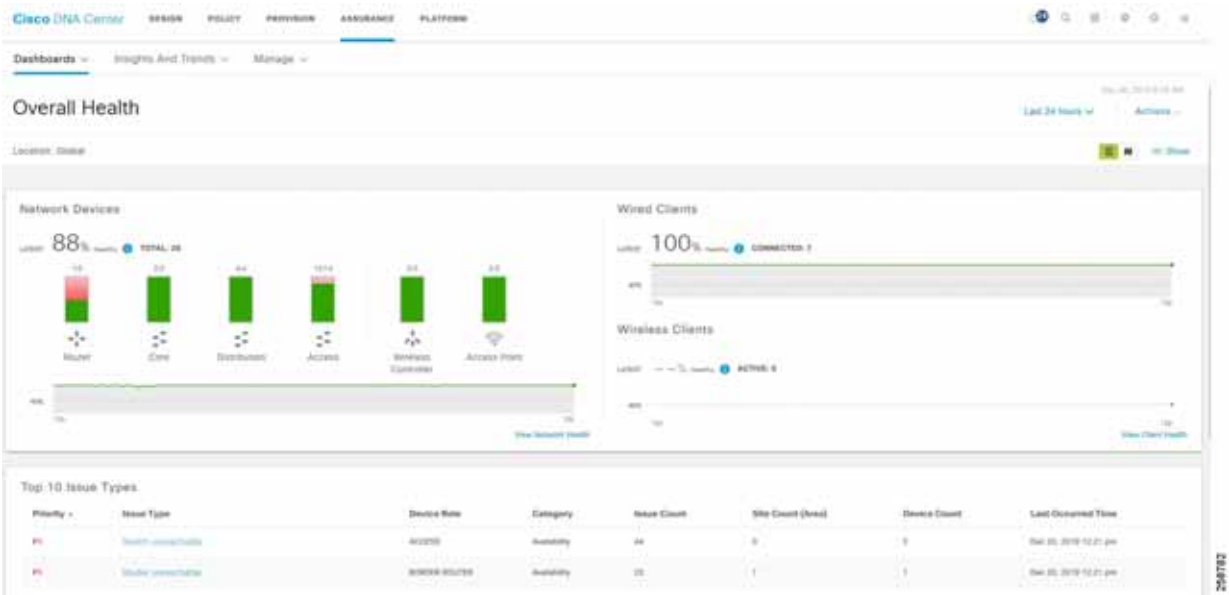
Network devices must be discovered, added to the inventory, and exist in a managed state before the performance metrics of devices and clients can be viewed. Optionally, Assurance can integrate with ISE to provide more detail about connected clients. Various telemetry profiles can also be distributed to network devices to configure syslog, SNMP, and NetFlow.

Overall Health

Navigate to **Assurance** from the **Cisco DNA Center dashboard**. **Assurance** displays the **Overall Health** page, which summarizes the health of the entire enterprise network using graphs to highlight network device and client health. The default view is 24 hours, but can be toggled between 3 hours, 24 hours, and 7 days using the **Last 24 hours** drop-down menu near the top right of the page.

The **Show** toggle above the graphs can be used to turn the location pane on or off. This allows for listing devices and health status by site hierarchy, building, or geographic views. The **Top 10 Issues** pane follows the graphs of network device and client health. This pane aggregates and sorts issues by severity, giving a concise list of issues affecting the network with an instance count per issue.

Figure 33 Assurance Dashboard



Network Health

View a summary of network health by clicking **Health > Network** on the **Overall Health** page or by clicking **View Network Health** at the bottom right of the **Network Devices** graph.

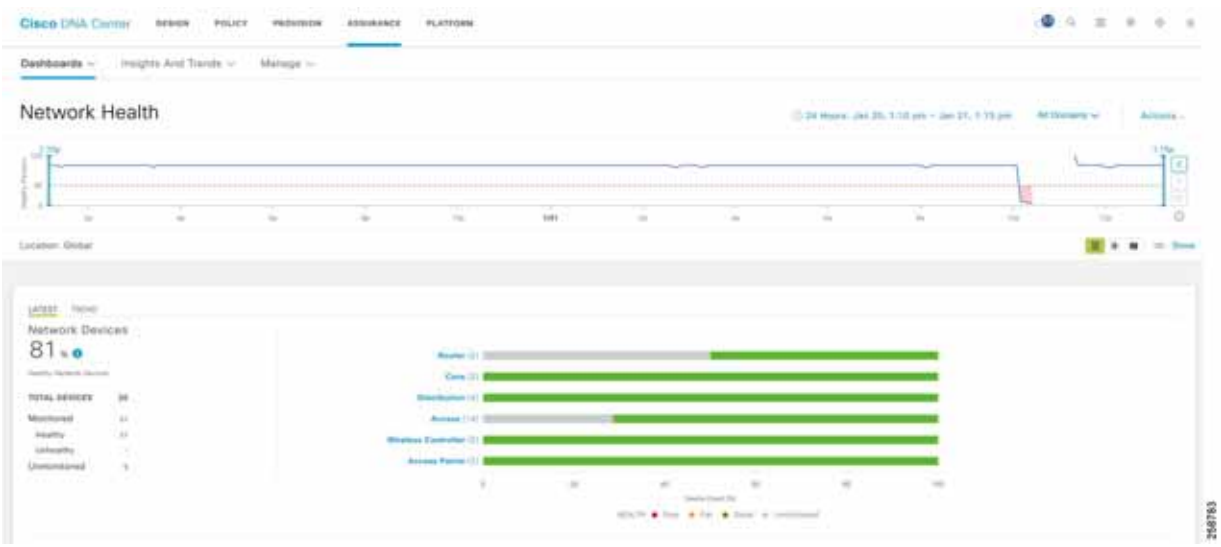
Near the top of the page, the network timeline is displayed. The slider bar can be adjusted to focus on a smaller slice of time. Using the **Last 24 Hours** drop-down list, up to 14 days of network health history are available.

In the **Network Devices** pane, devices are sorted by role and a summary of health score is indicated by color:

- **Red**—Critical issues. Health score range is 1 to 3.
- **Orange**—Warnings. Health score range is 4 to 7.
- **Green**—No errors or warning. Health score range is 8 to 10.
- **Gray**—No data available. Health score is 0.

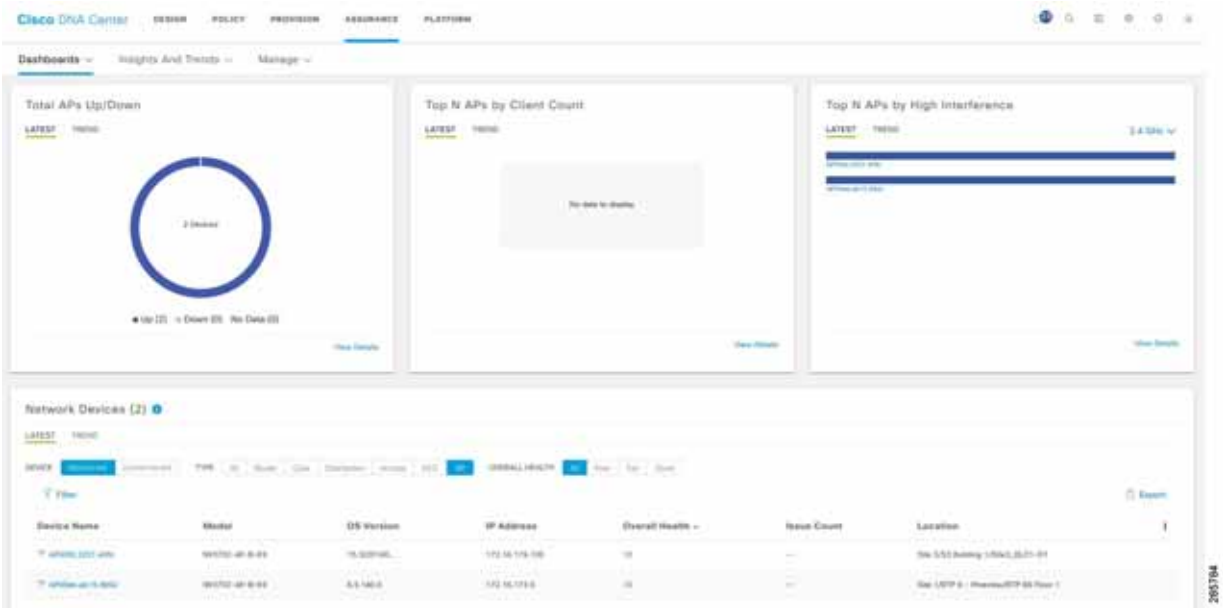
Like the **Overall Health** page, the **Location** pane can be toggled on or off by clicking **Show**. This pane lists devices and health status by site hierarchy, building, topology, or geographic views.

Figure 34 Network Health



Further down the **Network Health** page, panes display wireless AP information. Following the AP metrics is a **Network Devices** pane that lists all devices used to determine the network health metric.

Figure 35 Wireless AP Health



The list under **Network Devices** is filterable for quick identification of devices with outstanding issues. Hovering over the **Overall Health Score** for a given device will display the device health with health and percentage value of all KPI metrics. For more information about a device, click the device name to view complete information for the network device.

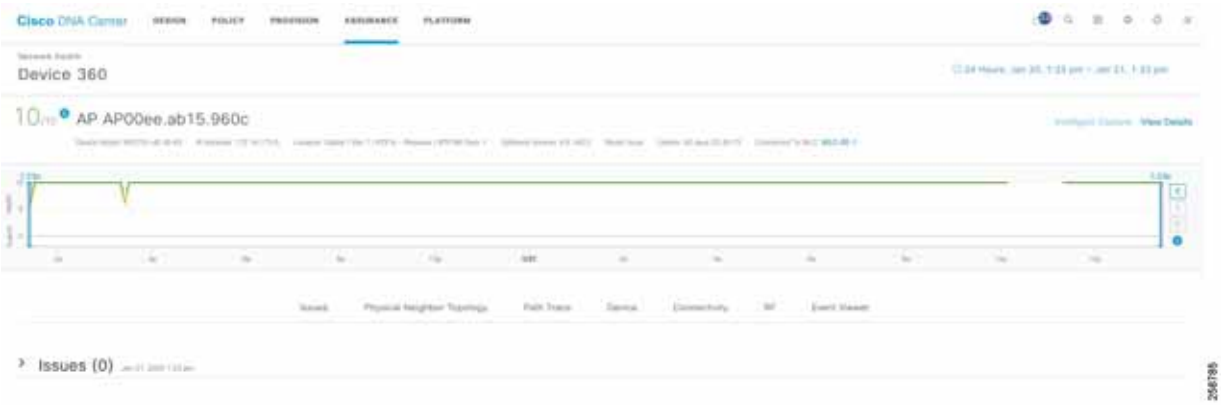
Device 360

The **Device 360** page provides detailed information about a network device for troubleshooting issues.

At the top of the page, the **Historical Health Graph** displays device health over the specified time window. Click **View Details** in the upper right of the **Device 360** window to view network information and rack location.

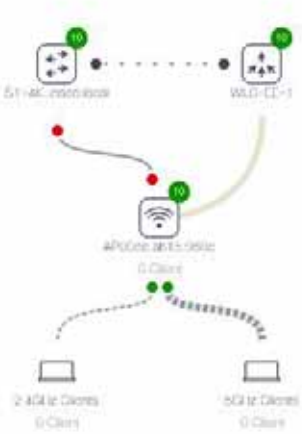
The **Issues** pane lists any issues detected by DNA that should be corrected. The most recent issue is listed first. Click an issue to view details. Any issue remains in the open state until the status is changed by clicking **Status** and selecting **Ignore** or **Resolve**.

Figure 36 Device 360



Following the **Issues** pane is the **Physical Neighbor Topology** pane. This shows connected devices and device and link health. Clicking a node brings up information about the target device. Hovering over a link displays details such as interface numbers, admin status, and mode.

Figure 37 Physical Network Topology



Following the **Physical Neighbor Topology** pane is the **Event Viewer** pane, which is for switches and routers, displays syslogs with a severity of an **Error** or above. Link status and device reachability events are recorded here. For APs, scenarios and sub-events are listed to help determine during which sub-event an issue occurred.

Warning: On the **Device 360** page, you will find a **Path Trace** section. Path trace functionality is not described in this guide since in the Cisco DNA Center 1.3 release, this feature does not recognize extended nodes. Therefore, if a topology contains extended nodes, you may get an error message.

Client Health

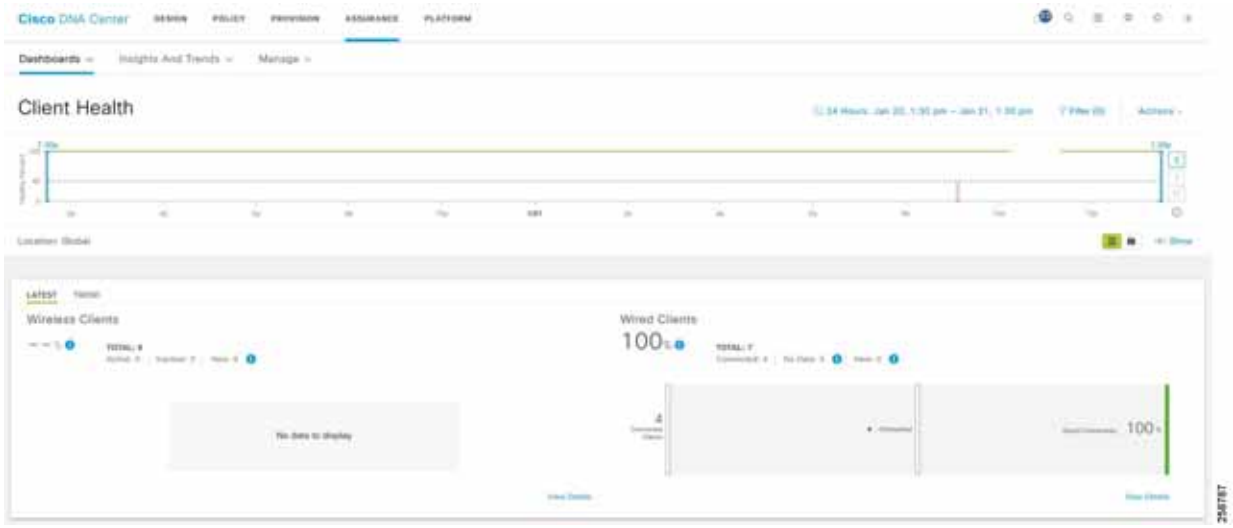
View a summary of client health by clicking **Health > Client** on the **Overall Health** screen or by clicking **View Client Health** at the bottom right of the **Wired and Wireless Clients** graph.

The client timeline is displayed near the top of the page. In the **Clients** pane, devices are sorted as **Wired** or **Wireless** clients, and a summary of health score is indicated by color.

- **Red**–Critical issues. Health score range is 1 to 3.
- **Orange**–Warnings. Health score range is 4 to 7.
- **Green**–No errors or warning. Health score range is 8 to 10.
- **Gray**–No data available. Health score is 0.

Like the **Overall Health** page, the **Location** pane can be toggled on or off by clicking **Show**. This pane lists client and health status by site hierarchy, building, topology, or geographic views.

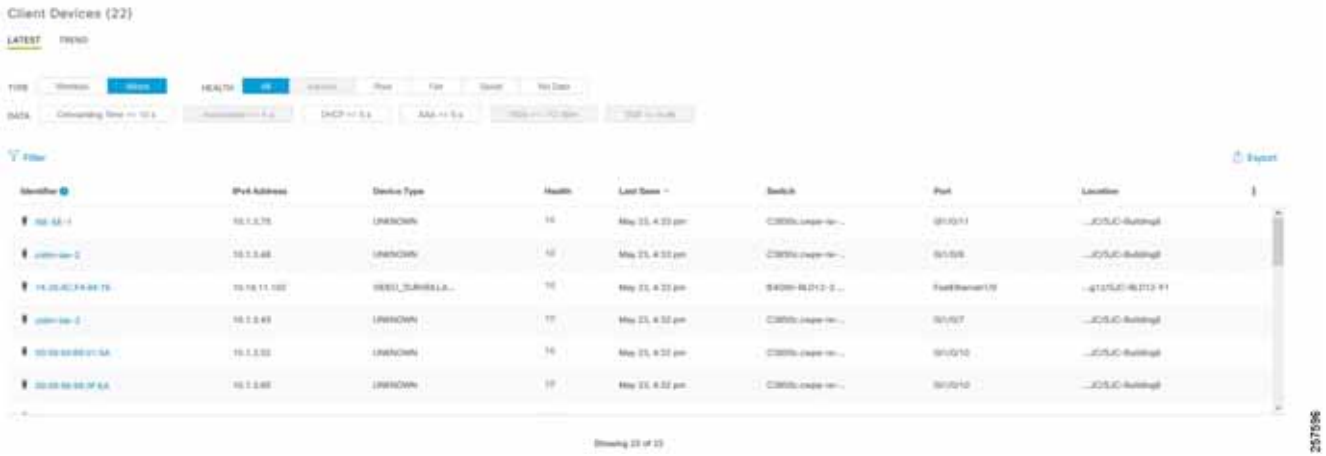
Figure 38 Client Health



Further down the **Client Health** page, information is provided about Received Signal Strength Indication (RSSI), Signal-to-Noise Ratio (SNR), Roaming Times, Clients per SSID, Physical Link Connectivity, and Onboarding Times.

The **Client Devices** list is filterable for quick identification of clients with outstanding issues. The **Client Health** field displays the client health score, which is the average of its onboarding and connected scores. Health scores are calculated every five minutes. For more information about a client, click the client name to view **Client 360** page for the device.

Figure 39 Client Device List



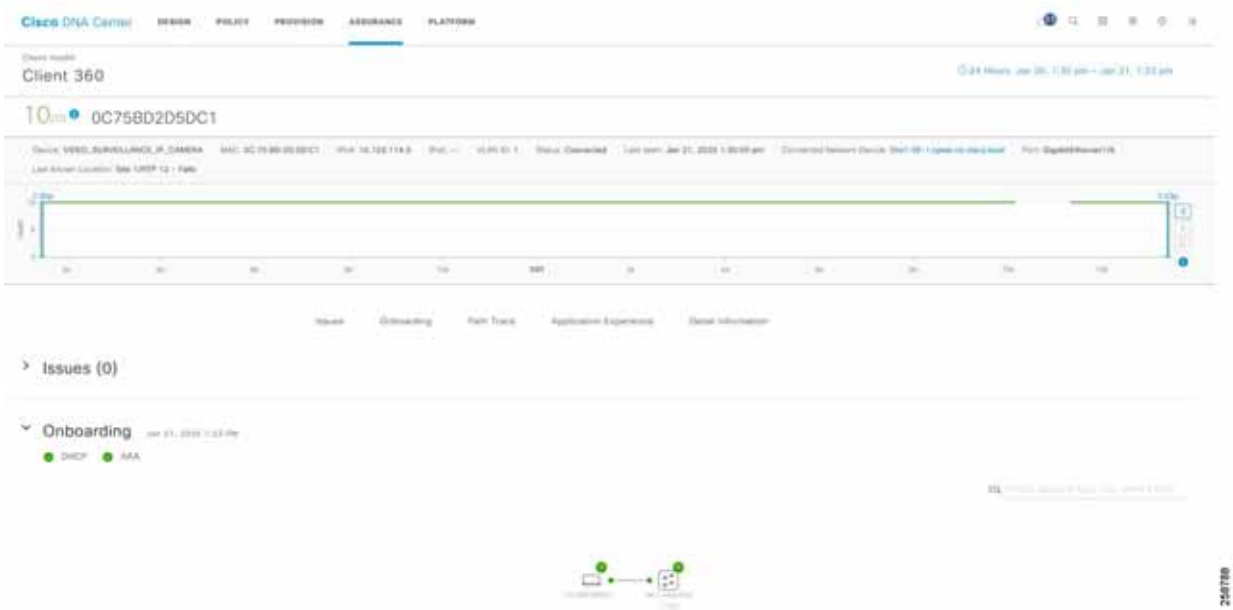
Client 360

Client 360 provides detailed information about a client for troubleshooting issues.

At the top of the page, the **Historical Health Graph** displays device health for the past 24 hours. Using the **Last 24 Hours** drop-down menu, this can be changed to 3 hours, 24 hours, or 7 days with a maximum history of 14 days.

The **Issues** pane lists any issues detected by the Cisco DNA Center that should be corrected. The most recent issue is listed first. Click an issue to view details. Any issue remains in the open state until status is changed by clicking **Status** and then selecting **Ignore** or **Resolve**.

Figure 40 Client 360



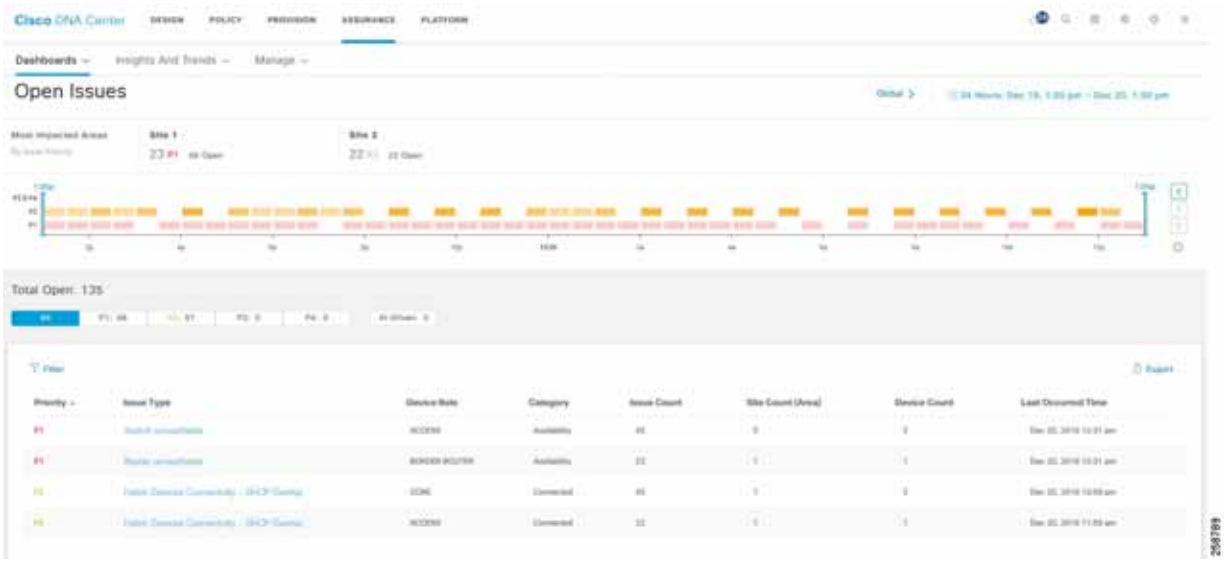
The **Onboarding** pane shows how the client connected to the network, information about onboarding services like DHCP and AAA, and device and link health. Clicking a node brings up information about the target device. Hovering over an endpoint displays details like interface numbers, admin status, and mode.

Figure 41 Device Onboarding

Issues

The **Dashboards > Issues > Open** displays a summary of all open network infrastructure with counters per issue, per site, and device count to help identify common or recurrent problems.

Figure 42 Open Issues



Appendix A Template Example

Example of template to configure NetFlow on 3400 switches.

```
#if ($apply_template == 1)
flow record SSA-FNF-REC
match ipv4 protocol
match ipv4 source address
match ipv4 destination address
match transport source-port
match transport destination-port
collect counter bytes long
collect counter packets long
flow exporter SSA-FNF-EXP
destination $collector
transport udp 2055
template data timeout 30
option interface-table
option application-table timeout 10
flow monitor eta-mon
ip flow-export destination $collector 2055
ip flow monitor SSA-FNF-MON input

interface $interface
ip flow monitor SSA-FNF-MON input
#end
```

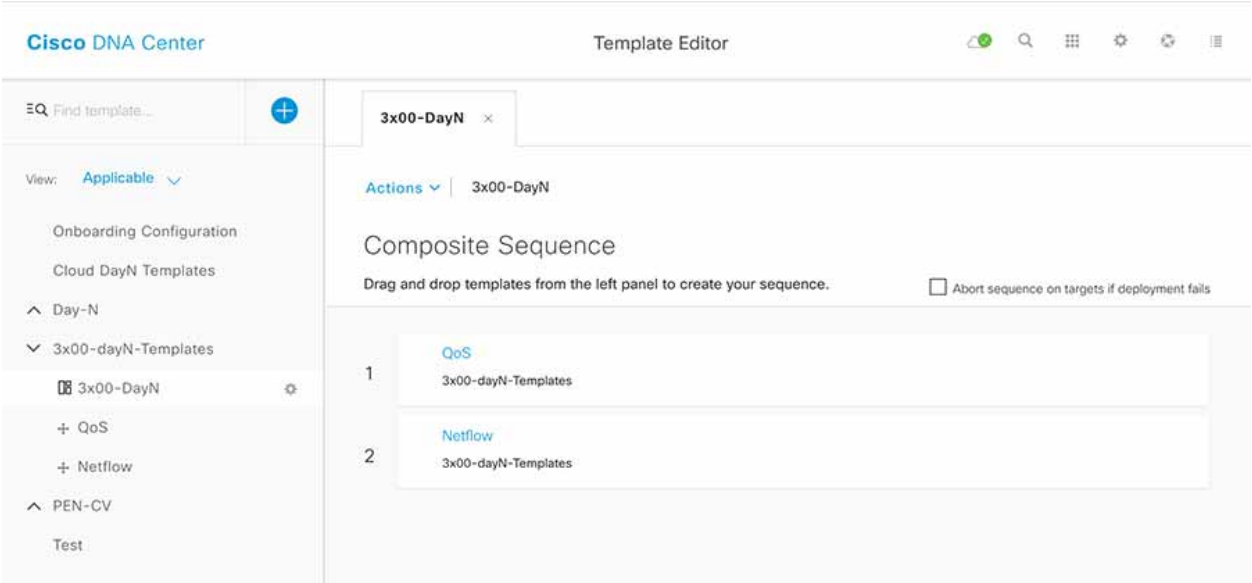
Example of template to configure QoS Scheduling on 3400 switches.

```
#if ($apply_template == 1)
class-map match-any VOICE_VIDEO_PQ_OUT
match ip dscp ef
match ip dscp cs5
class-map match-any NW_CONTROL_SIG_OAM_OUT
match ip dscp cs6
match ip dscp cs3
match ip dscp cs2
class-map match-any TRANSACTIONAL_DATA
match ip dscp af21
class-map match-any SCAVENGER
match ip dscp cs1


policy-map EE_QoS_Output_Policy
class VOICE_VIDEO_PQ_OUT
bandwidth percent 30
class NW_CONTROL_SIG_OAM_OUT
bandwidth percent 15
queue-limit 272 packets
queue-limit dscp cs3 128 packets
class TRANSACTIONAL_DATA
bandwidth percent 30
class class-default
bandwidth percent 25


interface $interface
service-policy output EE_QoS_Output_Policy
#end
```

Example of Composite Template

The following diagram shows an example of a composite template that includes the NetFlow template and QoS template created above.

Figure 43 Composite Template



When applying the composite template, choose each template on the left panel to fill in the variables. Note the apply_template variable on top is used to control when a template is provisioned. If template needs to be pushed even if it was before, make sure to check the **Push these templates even if its deployed before** check box

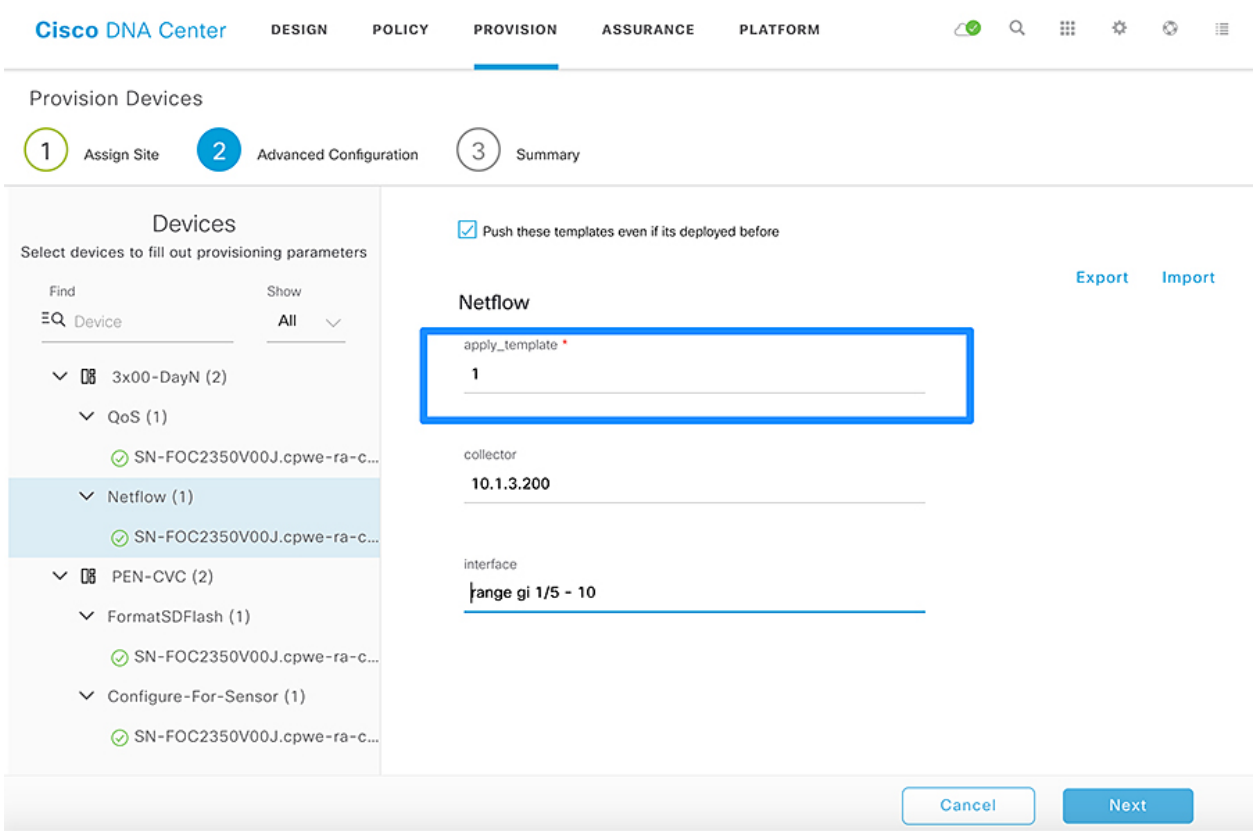



Figure 44 Provisioning Composite Template