Validated Profile: Healthcare (Nonfabric) Vertical

Revised: December 20, 2023

Document Purpose and Usage

The purpose of this document is to outline the typical healthcare deployment profile that Cisco Systems recommends. It provides guidelines for a typical nonfabric deployment that uses Cisco DNA Center and also serves as a validation document you can refer to during the process. This document's theoretical sections should be used in conjunction with its practical sections to help a deployment engineer understand the service requirements. The document will also help the deployment engineer make the best decisions for their particular network during deployment and configuration.

Target Audience

The target audience for this healthcare profile is the technical staff that is responsible for engineering and operating the network, as well as the implementation teams.

Solution Overview

Healthcare network environments require a specialized set of demands that includes security, enhanced network services, efficient network management, seamless mobility, network high availability, and location services. The following topics describe the key considerations for a large, evolving healthcare network that needs to meet today's requirements.

Security

The healthcare system needs to protect the personal medical records and financial information of its patients. In the United States, hospitals and medical centers are required to have HIPAA-compliant wired and wireless networks that can provide complete and constant visibility into their network traffic. For these health care organizations, it is paramount to have security resilience to maintain their business continuity. In today’s complex IT environment, it has become a necessity to ensure that only trusted users are granted access to a network, to protect the integrity of the business amidst ever-evolving threats. Cisco Identity Service Engine (ISE) allows organizations to segment networks connecting trusted users and endpoints with trusted resources. Cisco ISE provides organizations the flexibility to deploy secure network access control to authorized users and network endpoints.

The rapid rise in encrypted traffic is changing the threat landscape. As more businesses become digital, a significant number of services and applications are using encryption as the primary method of securing information. Encryption technology has enabled much greater privacy and security for enterprises and individuals that use the internet to communicate and transact business. Traditional flow monitoring, as implemented in the Cisco Network as a Sensor (NaaS) solution and using NetFlow, provides a high-level view of network communications by reporting the addresses, ports, and byte and packet counts of a flow.

Cisco DNA Center's Rogue Management application detects and classifies threats, enabling network administrators, network operators, and security operators to monitor network threats. Cisco DNA Center helps to quickly identify the highest-priority threats, allowing you to monitor these threats in the Rogue Management dashboard found in Cisco DNA Assurance.

The Cisco Adaptive Wireless Intrusion Prevention System (aWIPS) is a wireless intrusion threat detection and mitigation mechanism that uses an advanced approach to detect threats and manage performance. When an access point detects a threat, Cisco aWIPS jumps into action. It combines network traffic analysis, network device and topology information, signature-based techniques, and anomaly detection to deliver highly accurate and complete wireless threat prevention.

Mobility

In today's healthcare environment, caregivers, patients, and equipment are constantly moving. Cisco wireless mobility solutions help healthcare services become more efficient. Caregivers can access information and order services from wherever they happen to be, using notebook computers, tablet PCs, wireless IP phones, and new dual-mode phones (which can connect over either the hospital’s WiFi network or cellular networks). Physicians on rounds can use their wireless laptops to update patient charts and provide dictation. These updates are immediately available to other staff members, helping to ensure that decisions are made based using the latest patient information. Dieticians, nurses, and therapists can check orders, keep track of special needs, and review test results using wireless tablets. Patients no longer need to wait in line to be registered. Instead, a roaming registration clerk can bring a wireless tablet to the patient in the lobby or emergency room. Patients who need immediate treatment can even be registered bedside after receiving critical care.

Network Management

Cisco DNA Center revolutionizes how you design, build, and manage your networks with faster, flexible deployment and simpler, centralized network management. This allows your systems to be up and running in days rather than months. Cisco DNA Center's infrastructure and solutions also provide a digital-ready foundation that facilitates greater patient engagement and smarter operations. Organizations could reap the following benefits:

- Use automation to lower complexity and costs: Roll out and update clinical, research, and factory networks faster and reduce day-to-day operational and network management costs with automation, management, and assurance.
- Faster innovation with actionable insights: Generate network-wide analytics to provide more relevant care and research experiences, increase clinician and staff productivity, and optimize space usage.
- Reduce risks with security everywhere: Keep critical patient data secure with continuous and faster threat detection and protection, with security embedded network-wide.

High Availability

This document covers the network foundation and architectures that enable advanced clinical applications and biomedical devices to operate in a protected, interactive, resilient, and responsive environment, which is based on the best practices of a robust healthcare environment.

Single points of failure are eliminated and rapid convergence architectures and technologies are used throughout the network. Advanced technologies are used to maximize uptime for mission-critical applications, such as Electronic Health Records (EHRs), Picture Archiving and Communications Systems (PACS), and biomedical devices. Ether Channel and/or SVL switching fabric can be replaced or upgraded without any interruption of service. Interior Gateway Protocol (IGP) helps ensure the highest level of resiliency during times of network convergence. Continuous uptime features include In-Service Software Upgrade (ISSU), Rolling AP upgrade (N+1), and Stateful Switch Over (SSO). These features reduce network downtime by allowing software upgrades to be performed while routers, switches, and wireless controllers are active.

Location Services

Intelligence on the location of mobile resources streamlines business and clinical processes and frees staff to deliver high-quality care. Now, leading healthcare organizations are adopting location solutions to improve their awareness of critical resources, including equipment and people. The Cisco Location-Aware Healthcare solution can help healthcare organizations monitor and optimize workflows and increase responsiveness, productivity, and efficiency. Location-aware health services have converged on three main solution areas: asset management, workflow optimization, and patient tracking. Most location-based solutions in the market today require proprietary, vendor-specific hardware and software. This limits the variety of use cases they can serve and creates management complexity. By contrast, Cisco Spaces is an open platform that sits at the nexus of a broad ecosystem of device and software partners, channel partners, and industry associations.

Here are the benefits that location services provide:

- Locate a Wi-Fi device by identifying the access point that's nearest to that device. This method provides less granular location accuracy than triangulation. However, it can be deployed in venues with fewer access points, or can extend Wi-Fi location analytics to outdoor access points.
- Locate connected and unconnected Wi-Fi devices, interferers, and active RFID tags using Cisco CleanAir ® technology and non-Wi-Fi interferers.
- Determine the precise location of connected Wi-Fi devices within 1 to 3 meters (depending on your deployment) using advanced angle-of-arrival (AoA) technology combined with FastLocate.
- Use hyperlocation to find connected Wi-Fi devices via the RSSI triangulation of probing signals, as well as network data packets, for faster refresh and greater location detail.
- Use analytics to generate insights into the Wi-Fi devices used by visitors at a venue, based on their location and movement patterns.

Traffic Optimization

Quality of Service (QoS) is a key component of traffic transmission efficiency in congested environments. QoS allows applications to be marked to reflect their importance for business operations. In a wired environment, these markings can be used to set different priority levels, as well as allocate bandwidth and control. In a wireless environment, these marking are also used to associate applications with one of eight user priority queues. Association with a queue is also used to differentiate the statistical frequency an application accesses the wireless medium. Proper marking at the infrastructure level results in optimized downstream traffic, where applications of higher business relevance can receive a statistical transmission advantage, and real-time applications can be prioritized over non-interactive applications. The same effect is applicable upstream when the client station marks QoS properly.

Guest Anchoring

An increasingly common medical application is guest access, which delivers internet access to individuals who are not directly under the control of the healthcare system's IT policy. To maintain the organization's needs, guest traffic should take lower precedence than medical applications. In addition to the classic guest user class, medical facilities also require a physician guest user class. These physicians need access beyond a simple internet connection and typically require access to resources within the facility's private network. Because these physicians are not necessarily employees, they are likely to use a variety of uncontrolled client devices. Additional security considerations are necessary to prevent the spread of viruses and the possibility of opening doors into the private network. Cisco DNA Center offers the guest anchoring solution for wireless guest users. The guest capability uses a secure tunnel from the controller within the network to a guest controller in the unsecured network area (a DMZ) to direct guest traffic outside of the enterprise network.

Healthcare Profile Summary

The following table highlights the key focus areas of the healthcare solution profile.

Key Deployment Areas	Features
Security	• Group-based Policy (also known as TrustSec software-defined segmentation) • Encrypted Traffic Analytics (ETA) • Peer-to-peer blocking • Rogue management and aWIPS

Key Deployment Areas	Features
Mobility	• 802.11r fast roaming • Intra-WLC and inter-WLC roaming
Network Management	Cisco DNA Center
High Availability	• AP SSO • N+1 SSO
Location Services	• Cisco Spaces • CMX
Traffic Optimization	• FastLane • MQOS
Guest Anchoring	• Wireless guest (Central Web-auth) • Wired guest

Hardware and Software Specifications

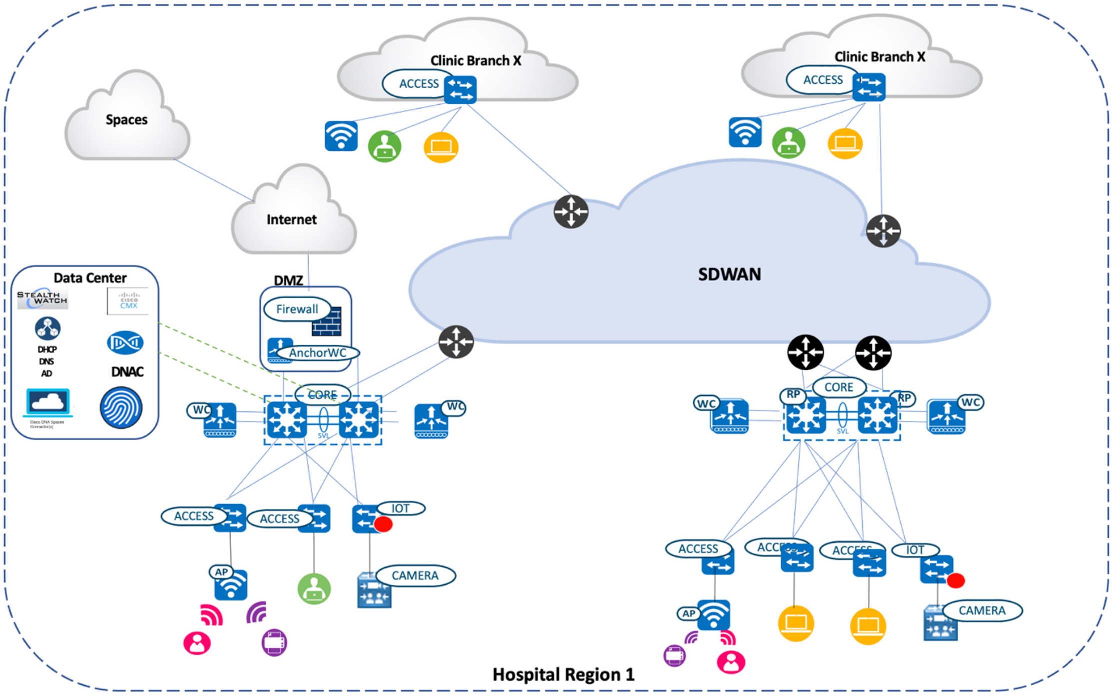
The solution is validated with the hardware and software listed in the following table.

Role	Model Name	Hardware Platform	Software Version	Software Version
Cisco DNA Center Controller	DN2-HW-APL-XL	Cisco DNA Center Appliance 3-Node Cluster	Cisco DNA Center 2.3.3.7	Cisco DNA Center 2.3.5.5
Identity Management, RADIUS Server	ISE-VM-K9	Cisco Identity Services Engine Virtual Appliance	Cisco Identity Services Engine 2.7 Patch 6, 3.1 Patch 4	Cisco Identity Services Engine 2.7 Patch 6, 3.1 Patch 4
Stealthwatch	SMCVE/FCVE	Stealthwatch Management Console/Stealthwatch Flow Collector	7.3.2	7.3.2

Role	Model Name	Hardware Platform	Software Version	Software Version
Cisco SD-WAN	vManage	Cisco vManage	20.6.3.1	20.6.3.1
	ASR1001-X/ASR1002-HX	Cisco ASR Series Aggregation Services Routers	17.6.5a	17.6.5a
	ISR-4351 ISR-4431	Cisco ISR Integrated Services Router	17.6.5a	17.6.5a
	8300	Cisco Edge Services Router	17.6.5a	17.6.5a
Cisco Collapsed Core Node	C9500-48Y4C C9600	Cisco Catalyst 9500 Series Switches Cisco Catalyst 9600 Series Switches Cisco Catalyst 6800 Series Switches	17.6.6a, 17.9.4a	17.6.6a, 17.9.4a
Cisco Access Node	C9300-48P C9300-24P C9407R C9200-48P 3850-48U	Cisco Catalyst 9300/3850 Series Switches	17.9.4a/16.12.10a	17.9.4a/16.12.10a
Cisco Wireless Controller	C9800-40-K9 C9800-L-K9	Cisco Catalyst 9800 Series Wireless Controller	17.9.4a	17.9.4a
Cisco IOT Node	IE-5000	Cisco Catalyst IE5000 Rugged Series	15.2(8)E1	15.2(8)E1
Cisco Access Points	9120-AXI 9130-AXI 2800 3700 3800	Cisco Catalyst/Cisco Aeronet Access Points	17.9.4a	17.9.4a
Wireless phones	Cisco Wireless IP Phone 8821, Apple iPhone 12, Xiaomi 11i	—	—	—
Wired Phones	Cisco Wired Phone	—	—	—
Wireless Laptops	Apple macOS (M1 Chip), Windows 10	—	—	—

Role	Model Name	Hardware Platform	Software Version	Software Version
Wired Laptops	Windows 10	—	—	—

Solution Topology



Solution Use Cases

Category	Functions	Use Case
Security	Intent-based networking	Cisco DNA Center – Cisco ISE Integration
		Site creation (under Network Hierarchy)
		Device discovery using the discovery tool and PnP
		Template Programmer
	Group-based policy microsegmentation	Communication between a nursing station and a doctor
		Accessing critical patient records
		Intersite security group tag (SGT) propagation using inline tagging
	P2P blocking with IPSK	Legacy devices which support wpa_supplicant
	Rogue and aWIPS	Threat detection and mitigation on a WLAN
	Encrypted traffic analytics	Threat detection on TLS communications between a wired workstation and the Emergency Health Records (EHR)
	AI endpoint analytics	Ad-hoc device plugged into the hospital network
Mobility	Wireless roaming	Physicians and nurses visiting patients and updating patient records
Traffic optimization	AutoQoS	Priority queuing for Apple clients using Fastlane
	MQoS	CVD-queuing profile using Cisco DNA Center application policy
Guest anchoring	Wireless guest access	Foreign guest on a campus site and anchor guest controllers on a DMZ servicing the guest clients
	Wired guest access	Wired medical endpoints which need internet access for maintenance,a software update, or a firmware update
Location services	Detect and locate in Cisco Spaces	Hospital staff tracking the location of medical devices (like fusion pumps or a health monitoring device) using wifi asset tags
High availability	AP/Client SSO	Network services for caregivers that are always available during unforeseen network outages or a planned maintenance window, aided by redundant and resilient networks both within a site and across sites
	N+1 SSO	
	ISSU/rolling AP upgrades	

Scale

Solution test verified the scale numbers listed in the following table. To view the scale numbers for the Cisco DNA Center appliance, see the *Cisco DNA Center Data Sheet*.

Category	Value
Device inventory	4000
Number of devices per site	100
Multiple Cisco DNA Center appliances	2
Number of buildings and floors	1000
Number of WLCs per site	2
Number of APs in inventory	6000
Number of endpoints	75,000 (50,000 wired, 25,000 wireless)
Number of SSIDs	5
Number of SGACLs	200
Number of SGTs	100
Assurance scale (number of Syslog messages and traps per second)	Customized by event type

Solution Keynotes

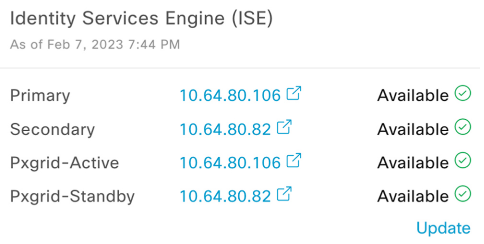
Security

In a healthcare environment, data security is essential for ensuring patient privacy and assuring availability. The system must be available to transport data at the performance levels required by caregivers to treat their patients effectively. High availability requires strict security measures to ensure that both accidental and intentional system misuse does not degrade system performance below acceptable service levels.

Intent-Based Networking Using Cisco DNA Center

An Administrator can design a network hierarchy that reflects multiple sites spread across multiple geographies. This hierarchy provides a consolidated view of the area, buildings, and floors which house nodes comprising of switches, routers, wireless controllers, IOT nodes, and access points. These nodes are discovered by Cisco DNA Center using the Discovery tool (which leverages automation). The administrator can then assign these nodes to the corresponding sites without needing to be physically present at any of these sites. Access points are added to the Cisco DNA Center inventory via the PnP workflow, which intelligently assigns them to the corresponding wireless controllers.

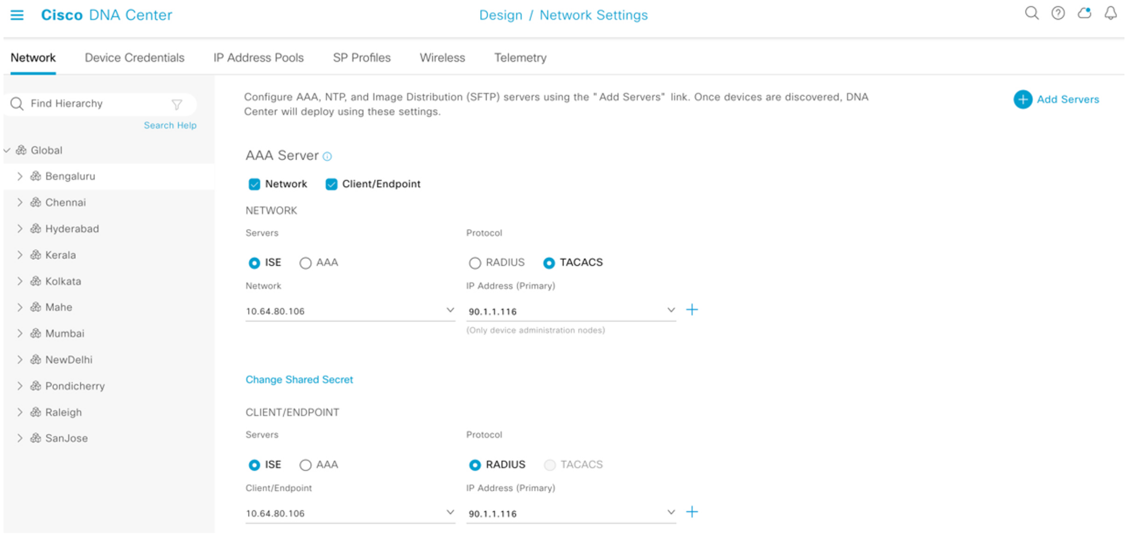
Cisco Identity Services Engine (ISE) is integrated with Cisco DNA Center through a PxGrid association. This association inherently gets to know the Cisco ISE clustered environment with Active/Standby pxGrid and PAN personas. The following figure illustrates the Cisco ISE persona information displayed by Cisco DNA Center on the **System 360** page.



Identity Services Engine (ISE)
As of Feb 7, 2023 7:44 PM

Primary	10.64.80.106	Available ✓
Secondary	10.64.80.82	Available ✓
Pxgrid-Active	10.64.80.106	Available ✓
Pxgrid-Standby	10.64.80.82	Available ✓

In Cisco DNA Center's **Network Settings** page, you can map multiple Policy Service Nodes (PSN) to the appropriate sites in order to efficiently manage and load balance the policy service requests propagating across different locations.



Configure AAA, NTP, and Image Distribution (SFTP) servers using the " Add Servers" link. Once devices are discovered, DNA Center will deploy using these settings.

AAA Server

☑ Network ☑ Client/Endpoint

NETWORK

Servers: ● ISE ○ AAA

Protocol: ○ RADIUS ● TACACS

Network: 10.64.80.106

IP Address (Primary): 90.1.1.116

(Only device administration nodes)

CLIENT/ENDPOINT

Servers: ● ISE ○ AAA

Protocol: ● RADIUS ○ TACACS

Client/Endpoint: 10.64.80.106

IP Address (Primary): 90.1.1.116

The network devices assigned to the site in this example create a Network Access Device entry for the equivalent devices in Cisco ISE.

The intent to be consumed has been designed in Cisco DNA Center until the previous step. The device provisioning workflow takes care of converting the intent into CLIs. The AAA/RADIUS configurations would then be provisioned on the corresponding network node, which completely binds the node in the RADIUS and Group-based Policy boundary for the **Access**, **Distribution**, and **Core/Router** device roles. Wireless controllers are brought into the Group-based Policy boundary with the help of Template Programmer.

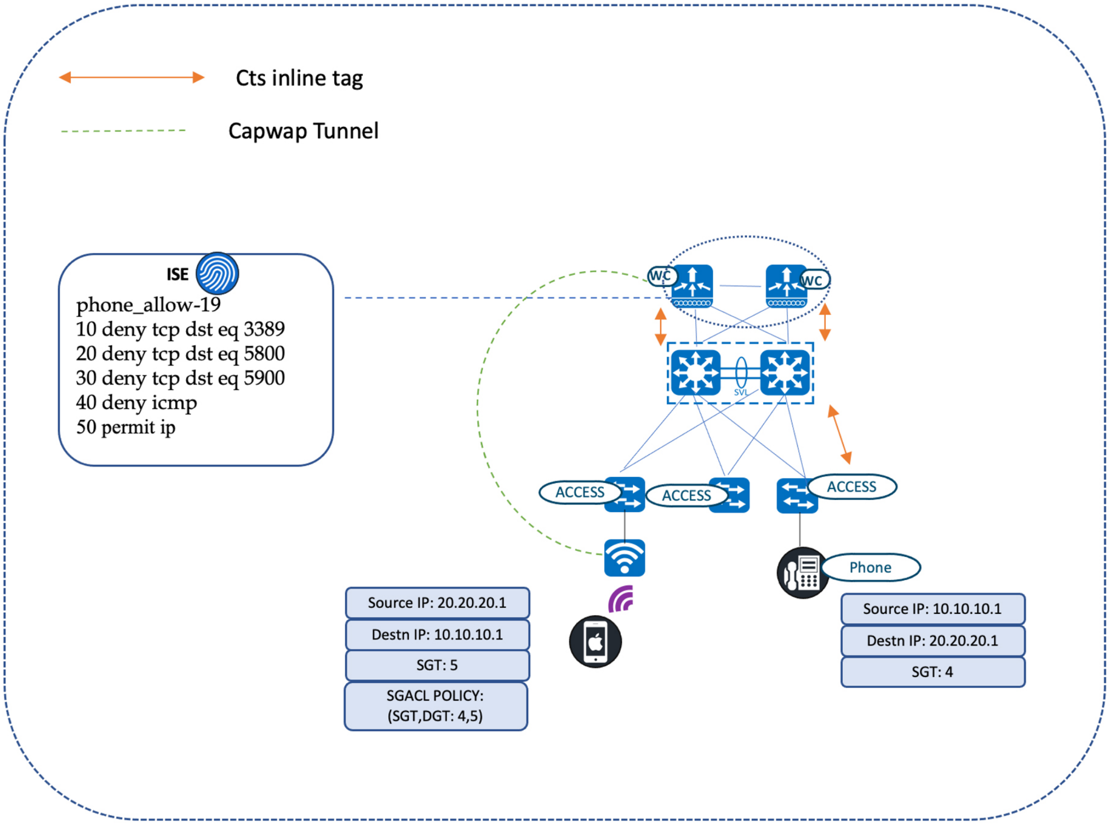
Group-Based Policy Microsegmentation

Administrators can segment users, guests, and IoT/medical devices into the appropriate logical network to limit the movement of threats around a network.

In this section, we'll describe an end-to-end use case that covers communication between hospital staff, who access critical patient records with CTS enforcement points being the wireless and wired segments. A basic knowledge of group-based policies is a prerequisite for understanding this use case.

Communication Between Nursing Station and Doctor

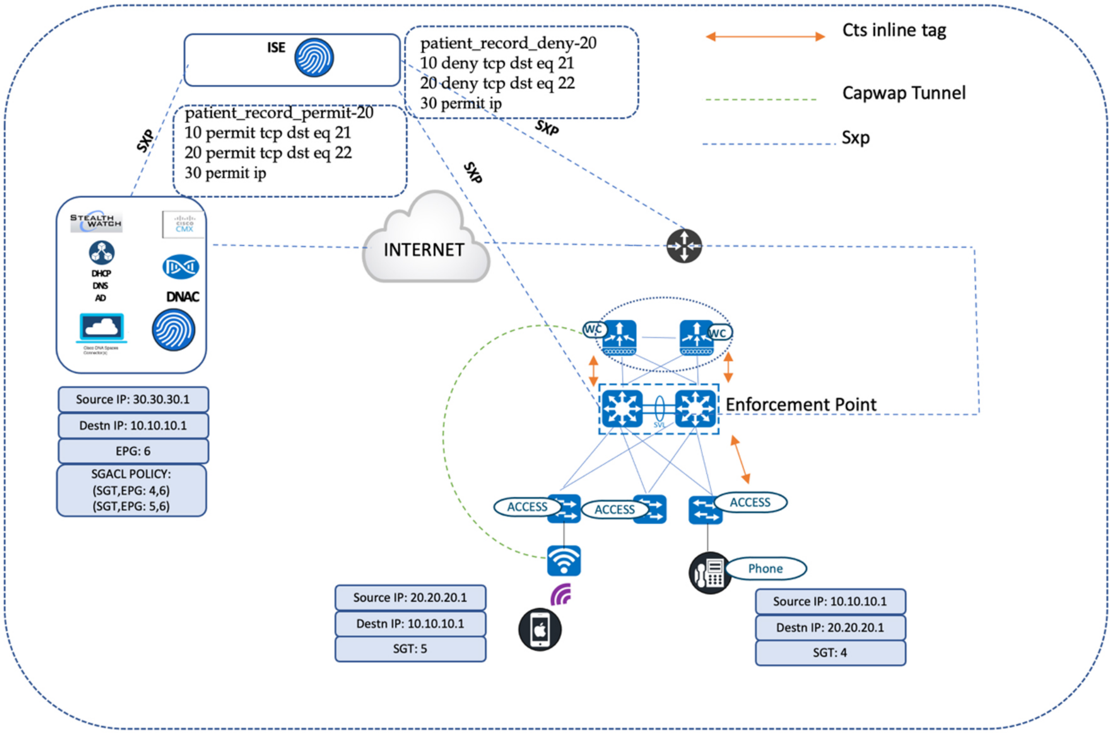
The healthcare network has both wired and wireless employees. In this example, we'll illustrate a phone call between a nurse on a wired phone in the nursing station and the doctor on a wireless phone. The wired phone connected to the access switch is MAB-authenticated, and the corresponding CTS tags for the phone are installed on the switch. The access switch propagates the CTS tags to the uplink SVL core networking node through the CTS manual configured on the directly connected links between the access switch and the core networking device. The wireless controllers, connected in split pair fashion to the SVL core, also has a CTS manually configured between them on the directly connected links. The wireless controllers have the SGACL policies downloaded for the corresponding Destination Group Tag (DGT), which is assigned to the doctor's wireless phone (which is attached to the local mode access point that's backhauling all of the traffic to the wireless controller servicing the clients in the central switching pattern). The most likely SGACL policy for any traffic directed to the doctor’s wireless phone is shown below.



```
9840-ha#show cts role-based permissions from 4 to 5
IPv4 Role-based permissions from group 4:NurseStation to group 5:Doctors:
 Phone_allow-19
RBACL Monitor All for Dynamic Policies: FALSE
RBACL Monitor All for Configured Policies: FALSE

Role-based IP access list phone_allow-19 (downloaded)
    10 deny tcp dst eq 3389
    20 deny tcp dst eq 5800
    30 deny tcp dst eq 5900
    40 deny icmp
    50 permit ip
```

Accessing Critical Patient Records

Critical patient records stored in data centers should be accessed by authorized personnel only. The core networking device at every site is the gateway for traffic entering and exiting from the enterprise domain. These core devices, which are in the critical data path, need to be aware of the group-based policy bindings to enforce the traffic that exits the network. The devices learn the policy bindings of the remote network through an SXP session with the Cisco ISE node. This applies to traffic originating from both wireless and wired users requesting access to patient records. The source CTS tags are carried inline until they reach the core node. The core device then inspects the received SGTs and searches the static policy for a match for the policy pair (source group tag (SGT) and destination group tag (DGT)). In this case, the DGT is the CTS tag for the patient records. Based on the authorization level of the requesting entity, access to patient records is either granted or denied at the core device. The traffic does not need to propagate until the record-maintaining servers to deny access to unauthorized users. In the following diagram, the nurse station cannot access critical patient records, whereas the doctors can.

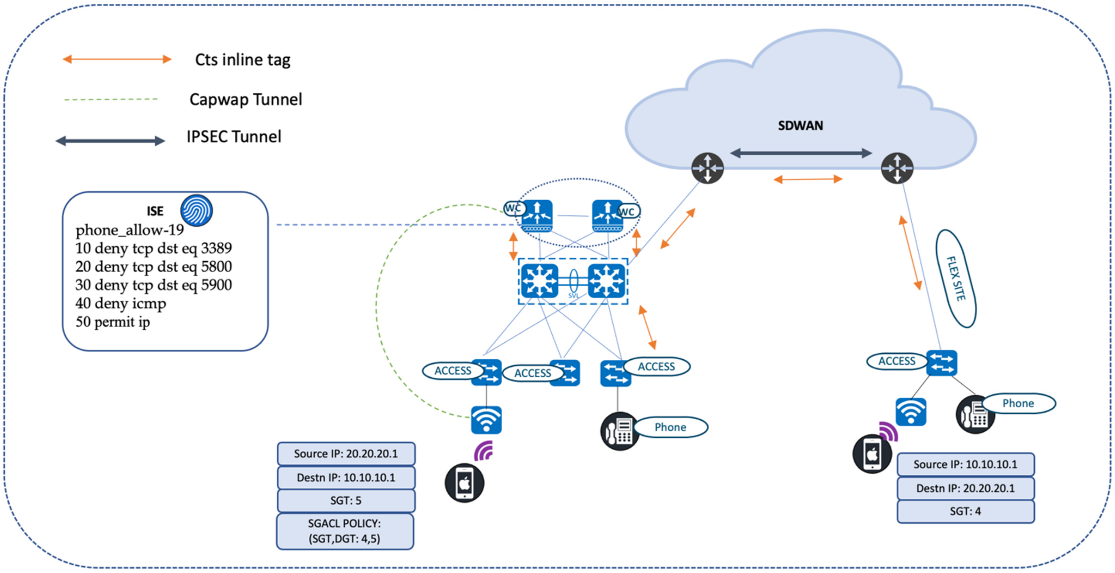


```
cts sxp enable
cts sxp default password 7 14141B180F0B293F37
cts sxp connection peer 90.1.1.117 source 192.169.50.31 password default mode local both

HCA-C3-CORE-9600-1#show cts sxp connections
 SXP              : Enabled
 Highest Version Supported: 4
 Default Password : Set
 Default Key-Chain: Not Set
 Default Key-Chain Name: Not Applicable
 Default Source IP: Not Set
Connection retry open period: 120 secs
Reconcile period: 120 secs
Retry open timer is not running
Peer-Sequence traverse limit for export: Not Set
Peer-Sequence traverse limit for import: Not Set
----------------------------------------------
Peer IP          : 90.1.1.117
Source IP        : 192.169.50.31
Conn status      : On (Speaker) :: On (Listener)
Conn version     : 4
Conn capability  : IPv4-IPv6-Subnet
Speaker Conn hold time    : 120 seconds
Listener Conn hold time    : 120 seconds
Local mode       : Both
Connection inst# : 1
TCP conn fd      : 1(Speaker) 2(Listener)
TCP conn password: default SXP password
Keepalive timer is running
Duration since last state change: 49:17:02:47 (dd:hr:mm:sec) :: 49:17:02:47 (dd:hr:mm:sec)
```

```
Total num of SXP Connections = 1

9600-SVL#show cts role-based permissions from 4 to 6
IPv4 Role-based permissions from group 4:NurseStation to group 6:record_room:
 patient_record_deny-20
9600-SVL#show cts role-based permissions from 5 to 6
IPv4 Role-based permissions from group 5:Doctors to group 6:record_room:
 patient_record_permit-20
```

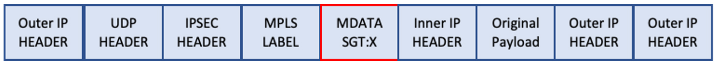
Remote Branch Clinic Accessing Critical Patient Records

The patient records are accessed from small branch clinics (also known as flex sites). The wireless controller at the main campus provides service to the flex access points in the branch clinics. The source CTS tags are carried inline until they reach the access node at the branch site. The access device inspects the received SGTs and searches the policy table to confirm if there is a match for the policy pair—the source group tag (SGT) and destination group tag (DGT). In this example, the DGT is the CTS tag for patient records.



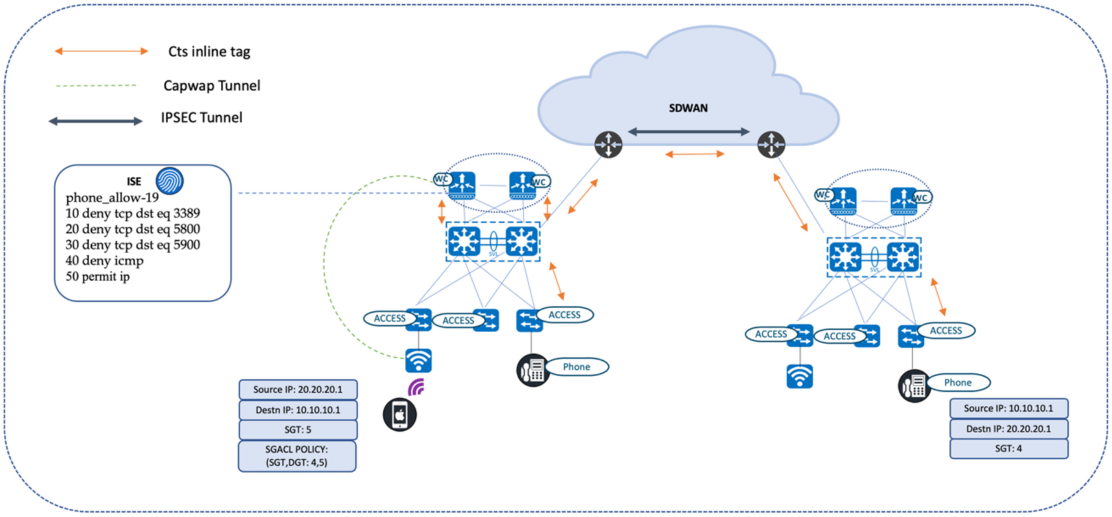
Intersite SGT Propagation Using Inline Tagging

The CTS tags for end users at hospitals located across different geographies are propagated using a CTS inline tag. CTS tags are carried across the site encapsulated in the IPSEC header.



Outer IP HEADER	UDP HEADER	IPSEC HEADER	MPLS LABEL	MDATA SGT:X	Inner IP HEADER	Original Payload	Outer IP HEADER	Outer IP HEADER

The following diagram illustrates a phone call between a nurse station and a doctor, who are located in different sites. Inline tagging is enabled on all egress interfaces, from the access switch (which the nurse station phones are connected to) to the wireless controller (which the doctor’s wireless phone is connected to). Inline tagging is also enabled on the egress interfaces of the intermediate nodes, such as the core device and SD-WAN edges. The IPSEC-enabled SD-WAN edges use the overlay to transport the CTS tags.

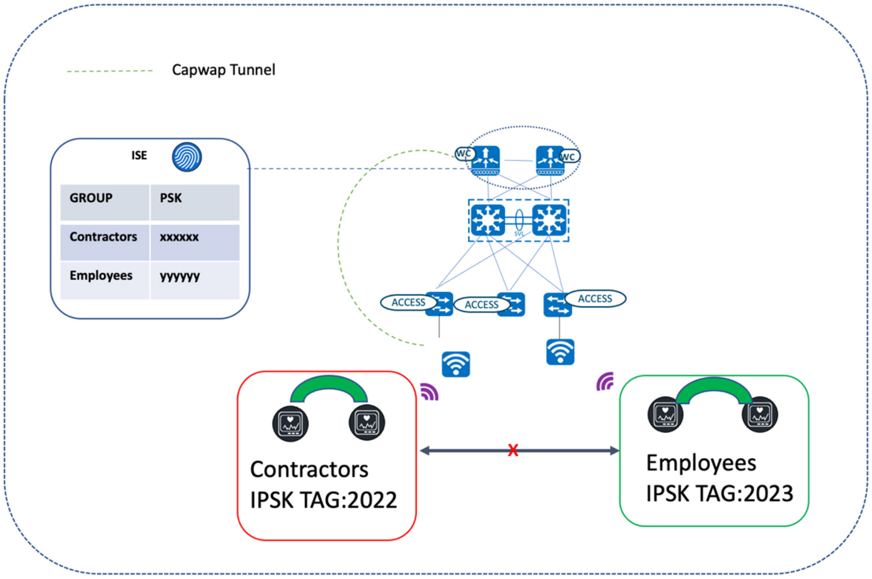


```
phone_allow-19
10 deny tcp dst eq 3389
20 deny tcp dst eq 5800
30 deny tcp dst eq 5900
40 deny icmp
50 permit ip
```

Peer-to-Peer Blocking with IPSK

Not all endpoints in a wireless network support the 802.1x supplicant for secure attachment. The endpoints that don't can use WPA-PSK instead. Since all users in the same WLAN using PSK share the same preshared key, it exposes the key to possible misuse, resulting in unauthorized access. To overcome this security gap, IPSK allows you to assign a unique preshared key to a particular user or user group. IPSK security can be further enhanced with peer-to-peer blocking when there is a requirement to disallow users with the same PSK (or users in the same or different WLANs) from interacting with each other.

The following diagram illustrates users connected to the same WLAN with the **allow-private-group** option enabled in the WLAN profile. In this scenario, the users which were authorized by the same authorization profile on Cisco ISE are able to communicate with each other (since they share the same IPSK tag). Users with different IPSK tags were authorized using unique Cisco ISE authorization profiles. As a result, these users will not be able to communicate with each other. For a description of how to enable peer-to-peer blocking, see the "Create a Model Config Design for Advanced SSID" topic in the *Cisco DNA Center User Guide*.



GROUP	PSK
Contractors	xxxxxx
Employees	yyyyyy

```
9840-ha#show wireless client summary ipsktag
Number of Clients: 5
```

```
MAC Address    AP Name                                       State           Ipsk Tag
----------------------------------------------------------------------------------------------
009a.d2f0.591a AP687D.B402.D02C                            Run              b0a8b704cbc54008
6887.c6f0.6176 AP687D.B402.D02C                             Run              7166848ee93a1c8f
98af.65a6.d966 AP7079.B333.8CD2                             Run              ea52373d6bfc33f0
b2aa.e402.9228 AP687D.B402.D02C                            Run              b0a8b704cbc54008
d037.45a7.f5f1 AP84F1.4782.1858                                Run              b0a8b704cbc54008
```

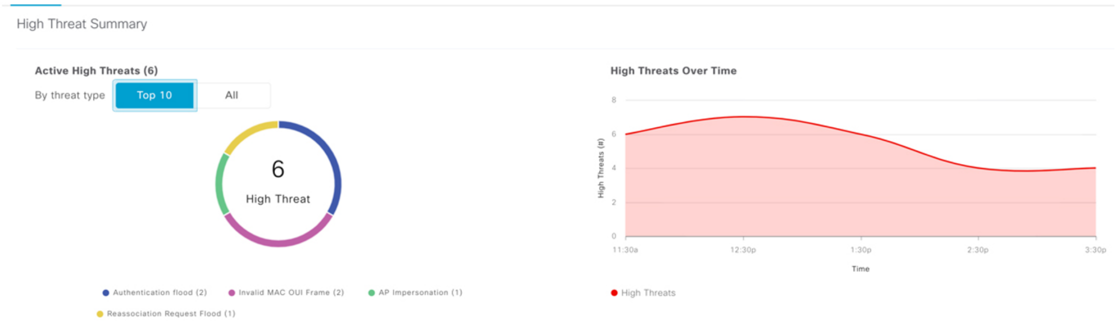
Rogue Management

Cisco DNA Center has a rogue management application which detects and classifies WLAN threats and enables the network administrator/operator to monitor them. Rogue APs are used to hack sensitive information in the WLAN. Consider a hacker transmitting a series of Clear to Send (CTS) frames, which mimic an AP instructing one client to transmit while instructing other clients to wait, which results in a disruption of service to the legitimate clients. A user could also plug in a rogue AP in the WLAN and build an ad-hoc network to intercept network traffic and hijack client sessions. Cisco DNA Center constantly monitors all nearby APs and automatically discovers and collects information about rogue APs. When Cisco DNA Center receives a rogue event from a managed AP, it responds in the following ways:

- If the unknown AP is not managed by Cisco DNA Center, Cisco DNA Center applies the rogue classification rules.
- If the unknown AP is not using the same SSID as your network, Cisco DNA Center verifies whether the AP is connected to the corporate wired network and extends to the wired network. If the rogue AP is physically connected to the corporate network's switch port , Cisco DNA Center classifies the AP as **Rogue on wire**. Cisco switches managed by Cisco DNA Center are required for the Rogue on wire feature to work.
- If the AP is unknown to Cisco DNA Center and is using the same SSID as your network, Cisco DNA Center classifies the AP as **Honeypot**.
- If the unknown AP is not using the same SSID as your network and is not connected to the corporate network, Cisco DNA Center verifies whether it is causing any interference. If it is, Cisco DNA Center classifies the AP as an **Interferer** and marks the rogue state as **Potential Threat**. The threshold level for classifying interferers on the network is greater than -75 dBm.
- If the unknown AP is not using the same SSID as your network, and is not connected to the corporate network, Cisco DNA Center verifies whether it is a neighbor. If it is, Cisco DNA Center classifies the AP as **Neighbor** and marks the rogue state as **Informational**. The threshold level for classifying the rogue AP as a neighbor AP is less than or equal to -75 dBm.

Adaptive Wireless Intrusion Prevention System

The Cisco Adaptive Wireless Intrusion Prevention System (aWIPS) is a wireless intrusion threat detection and mitigation app. With this fully infrastructure-integrated solution, you can continually monitor wireless traffic on both wired and wireless networks. Instead of waiting until damage or exposure has occurred, you can use this network intelligence to pinpoint attacks and proactively prevent new attacks. For more information on the Rogue Management and aWIPS apps, see the *Cisco DNA Center Rogue Management and aWIPS Application Quick Start Guide*.

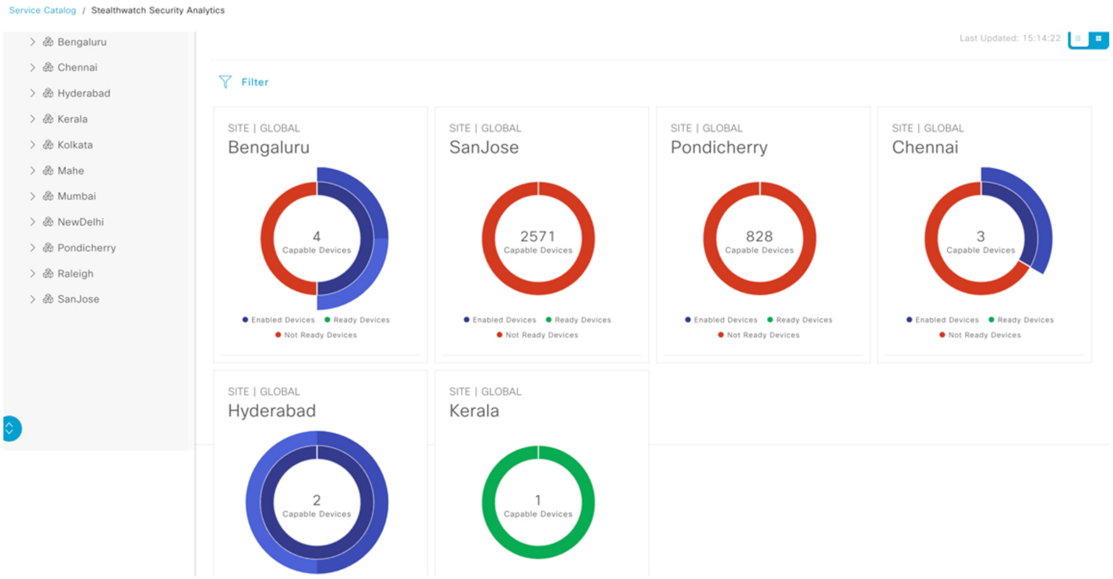


Cisco DNA Center supports the following standard signatures, which detect the various denial of service (DoS) attacks:

- authentication flood
- association flood
- CTS Flood
- RTS Flood
- broadcast Probe
- disassociation Flood
- disassociation Broadcast
- deauthentication flood
- deauthentication broadcast
- EAPOL logoff flood

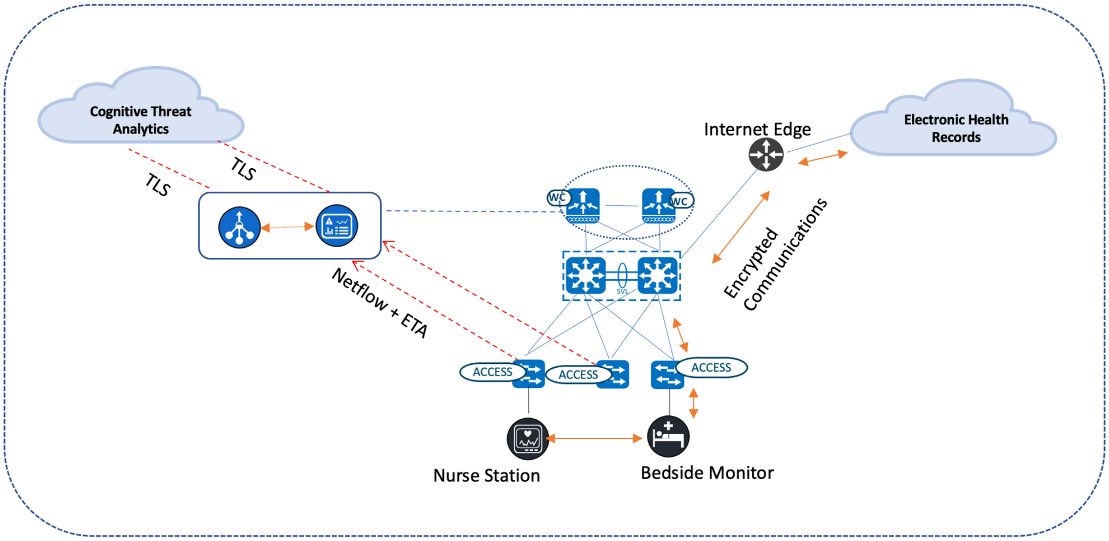
Encrypted Traffic Analytics

Cisco DNA Center's Stealthwatch Security Analytics (SSA) application can be used during the provisioning of Catalyst access switches to exercise ETA/NaaS use cases. Healthcare organizations must ensure that the most secure TLS libraries and cipher suites are used for communications between wired workstations throughout a medical facility and EHR systems, regardless of where the workstations and EHR systems are deployed. As access to EHR services in the cloud becomes more common (and in some cases, required), these communications need to be analyzed more closely for any signs of suspicious activity.



The intraflow metadata, or information about the events that occur inside of a flow, can be collected, stored, and analyzed within a flow monitoring framework. This data is especially valuable when traffic is encrypted because deep-packet inspection is no longer viable. This intraflow metadata, called Encrypted Traffic Analytics (ETA), is derived by using new data elements or telemetry that is independent of protocol details, such as the lengths and arrival times of packets within a flow. These data elements apply equally well to both encrypted and unencrypted flows. ETA extracts two main data elements: the initial data packet (IDP) and the sequence of packet length and time (SPLT). These elements are then communicated using a dedicated NetFlow template to Cisco Stealthwatch Enterprise.

When used in conjunction with Flexible NetFlow, a complete view of the flow's life is available, allowing you to identify malicious traffic as well as anomalous behavior and customizable policy violations in your network. When implementing ETA, in addition to cryptographic assessment, the metadata collected can be used to detect malware within the encrypted traffic without the need to decrypt the traffic when Cisco Stealthwatch is integrated with Cognitive Intelligence. When Flexible NetFlow and DNS information is combined with the ETA metadata found in the IDP, other ETA data elements (such as the sequence of packet length and times (SPLT)) provide a valuable way to identify malware through the detection of suspicious traffic. By default, only traffic (including DNS queries) that crosses the enterprise network perimeter outside of the enterprise address space (i.e. internet-bound traffic) is sent to the Cognitive Intelligence cloud for malware analysis. All traffic is monitored, and records are exported to the Cisco Stealthwatch flow collector. After processing, the flow collector sends only the metadata for this external traffic to the Cognitive Intelligence cloud in an encrypted TLS tunnel for further analysis. All other internal traffic is processed by the flow collector for conformance with the policies established in Cisco Stealthwatch, as well as for the cryptographic assessment based on ETA data. The following diagram depicts communication between a local medical server, a bedside monitor, and a nurse's workstation, as well as communications between these devices and a cloud-based EHR system. For more information about enabling SSA on access switches, see the *Stealthwatch Security Analytics Service on Cisco DNA Center User Guide*.



AI Endpoint Analytics

The Cisco AI Endpoint Analytics application provides next-generation endpoint visibility by pairing AI-driven analytics with network-driven deep-packet inspection. The majority of endpoints in the healthcare segment are Internet of Things (IoT)-based. This positions security as a major challenge for network administrators as they monitor these endpoints. Consider the case of a doctor plugged in to a patient’s health monitoring device, which is connected to the hospital's network. What if this device spread malware throughout the network, resulting in widespread issues? Cisco AI Endpoint Analytics comes to the rescue by minimizing the damage.

The first step in securing the endpoints is to identity the type of the devices, which is also known as endpoint profiling. Endpoint Analytics does its best to identify the maximum number of unknown endpoints in the enterprise network based on Deep Packet Inspection (DPI) and Machine Learning (ML). Endpoint profiling starts with aggregating and analyzing endpoint data from various data sources. Examples of these data sources include network devices or appliances supporting deep packet inspection and Cisco Identity Services Engine (ISE). Cisco AI Endpoint Analytics provides granular endpoint profiling details by defining the endpoint type, manufacturer, model, and operating system. The endpoints are profiled based on the combination of 400 available attributes.

The second step in securing the endpoints is to determine whether the profiled endpoint exhibits anomalous behavior, which ends up compromising network security. Trust Scores are assigned to the profiled endpoints, based on its trustworthiness in the network. The value ranges from 1 (low trust) to 10 (high trust). These Trust Scores are calculated using all of the available insights, such as endpoint authentication and compliance and endpoint anomaly detection. For more information about the the Cisco AI Endpoint Analytics application, see the *Cisco DNA Center User Guide*.

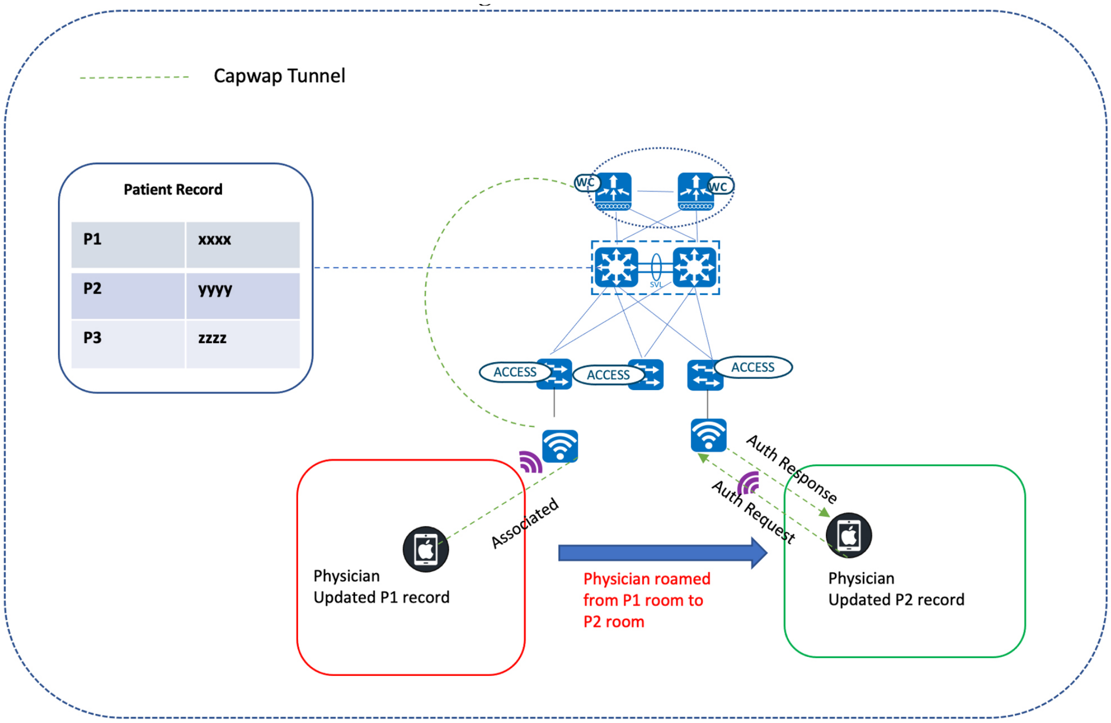
Mobility

Wireless Roaming

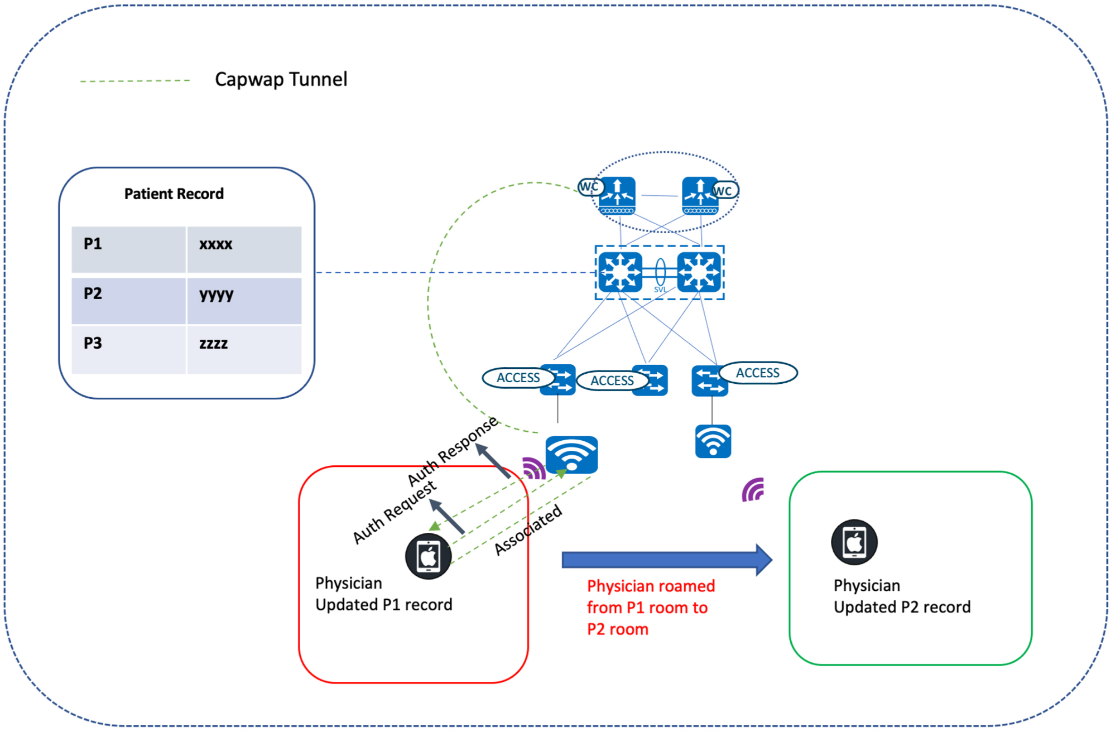
Cisco wireless mobility solutions aim to improve the efficiency of healthcare services. Physicians on rounds could use their wireless laptops to update patient charts, which helps other staff members stay up-to-date with the latest information. Dieticians and nurses could check for the latest orders and review test results using wireless tablets. Patients would no longer need to wait in an admission queue. The registration clerk, armed with a wireless tablet, could help a patient complete registration while they wait to be seen. Seamless mobility for a large number of clients is essential for supporting uninterrupted voice and data services. Fast roaming, such as CCKM and 802.11r/k/v, is enabled for this vertical. 802.11r, which is the IEEE standard for fast roaming, introduces a new roaming concept called Fast Transition (FT), where the initial handshake with the new AP is done even before the client roams to the target AP. The initial handshake allows the client and APs to do the Pairwise Transient Key (PTK) calculation in advance. These PTK keys are applied to the client and AP after the client sends a reassociation request or response exchange with the new target AP.

The FT key hierarchy is designed to allow clients to make fast BSS transitions between APs without requiring reauthentication at every AP. For a client to move from its current AP to a target AP using the FT protocols, the message exchanges are performed using one of the following two methods:

- **Over-the-Air**: The client communicates directly with the target AP using IEEE 802.11 authentication with the FT authentication algorithm.



- **Over-the-DS**: The client communicates with the target AP through the current AP. Client and target AP communication is carried in FT action frames between the client and the current AP, which are then sent through the controller.



Traffic Optimization

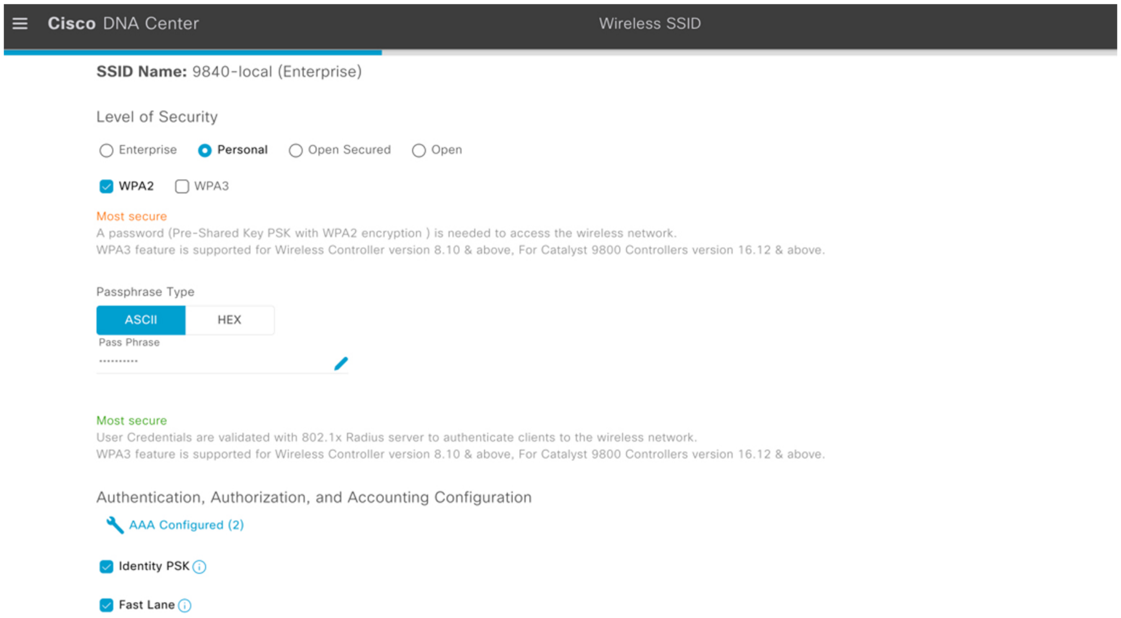
AutoQoS

As more and more interactive applications use wireless infrastructures, QoS becomes increasingly important. QoS allows network managers to establish SLAs with network users. It enables more efficient network resource sharing, expedites the handling of mission critical applications, and prioritizes time-sensitive multimedia and voice application traffic. QoS does this by:

- Reserving dedicated bandwidth for critical users and applications
- Controlling jitter and latency (required by real-time traffic)
- Managing and minimizing network congestion
- Shaping network traffic to smooth traffic flow
- Setting network traffic priorities

In a healthcare environment, QoS implementation is a policy decision and the applications used in different environments will dictate their QoS policy.

Cisco DNA Center enables the provision of the AutoQoS Fastlane during SSID creation for the prioritization of the traffic originating from Apple clients.



SSID Name: 9840-local (Enterprise)

Level of Security

○ Enterprise ● Personal ○ Open Secured ○ Open

☑ WPA2 □ WPA3

Most secure
A password (Pre-Shared Key PSK with WPA2 encryption) is needed to access the wireless network.
WPA3 feature is supported for Wireless Controller version 8.10 & above, For Catalyst 9800 Controllers version 16.12 & above.

Passphrase Type

ASCII | HEX

Pass Phrase: ....

Most secure
User Credentials are validated with 802.1x Radius server to authenticate clients to the wireless network.
WPA3 feature is supported for Wireless Controller version 8.10 & above, For Catalyst 9800 Controllers version 16.12 & above.

Authentication, Authorization, and Accounting Configuration

AAA Configured (2)

☑ Identity PSK

☑ Fast Lane

The following configurations are pushed to the wireless controller during WLC provisioning by Cisco DNA Center:

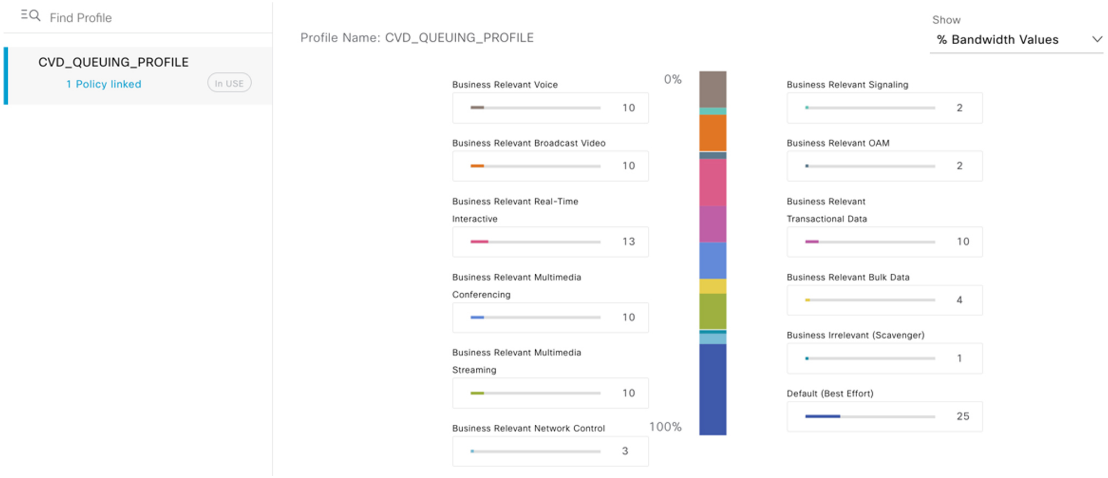
```
wireless profile policy 9840-local_Floor1_NF_5bfebcd0
 aaa-override
 accounting-list default
 autoqos mode fastlane
 cts inline-tagging
 cts role-based enforcement
 description 9840-local_Floor1_NF_5bfebcd0
 dhcp-tlv-caching
 exclusionlist timeout 180
 http-tlv-caching
 radius-profiling
 service-policy input platinum-up
 service-policy output platinum
 vlan Vlan510
```

Various built-in AutoQoS profiles are classified into different macros, based on the traffic characterization:

- Enterprise
- Voice
- Guest

MQoS

As part of the NBAR2-based Application QoS policy on IOS-XE based wireless controllers, Cisco DNA Center provisions the Cisco Validated Design Queuing profile.



CVD_QUEUING_PROFILE

1 Policy linked

Profile Name: CVD_QUEUING_PROFILE

Show % Bandwidth Values

Business Relevant Voice 10

Business Relevant Broadcast Video 10

Business Relevant Real-Time Interactive 13

Business Relevant Multimedia Conferencing 10

Business Relevant Multimedia Streaming 10

Business Relevant Network Control 3

Business Relevant Signaling 2

Business Relevant OAM 2

Business Relevant Transactional Data 10

Business Relevant Bulk Data 4

Business Irrelevant (Scavenger) 1

Default (Best Effort) 25

Cisco DNA Center bases its marking, queuing, and dropping treatments on IETF RFC 4594, as well as the business relevance category that you have assigned to the application. For more information, see the "Application Policies" topic in the *Cisco DNA Center User Guide*.

The following is a sample configuration:

```
9840-hca#show policy-map 9840-local_DNA-MARKING_0550e02f
  Policy Map 9840-local_DNA-MARKING_0550e02f
    Class 9840-local_VOICE_0550e02f
      set dscp ef
    Class 9840-local_TRANS_DATA_0550e02f
      set dscp af21
    Class 9840-local_SCAVENGER_0550e02f
      set dscp cs1
    Class 9840-local_REALTIME_0550e02f
      set dscp cs4
    Class 9840-local_MM_STREAM_0550e02f
      set dscp af31
    Class 9840-local_BROADCAST_0550e02f
      set dscp cs5
    Class 9840-local_OAM_0550e02f
      set dscp cs2
    Class 9840-local_SIGNALING_0550e02f
      set dscp cs3
    Class 9840-local_MM_CONF_0550e02f
      set dscp af41
    Class 9840-local_CONTROL_0550e02f
      set dscp cs6
    Class 9840-local_BULK_DATA_0550e02f
      set dscp af11
    Class class-default
      set dscp default
```

Guest Anchoring

Wireless Guest Access

Cisco DNA Center offers a wireless guest anchoring solution that does the following:

- Provisions the servicing wireless controllers as foreign controllers.
- Provisions the anchor controllers in the DMZ area (which acts as a gateway for guest users to reach the internet).

Guest traffic is tunnelled via CAPWAP all the way from the servicing APs attached to the foreign controller to the anchor controller in the DMZ.

Foreign Guest

```
wireless profile policy guest-camp_Global_GA_7ae528ce
 aaa-override
 accounting-list default
 description guest-camp_Global_GA_7ae528ce
 dhcp-tlv-caching
 exclusionlist timeout 180
 http-tlv-caching
 mobility anchor 90.1.1.7 priority 3
 mobility anchor 90.1.1.8 priority 3
 nac
 service-policy input silver-up
 service-policy output silver
 no shutdown
!
wlan guest-camp_Global_GA_7ae528ce 18 guest-campus2
 mac-filtering dnac-cts-guest-camp-1d1eb5df
 no security ft adaptive
 no security wpa
 no security wpa wpa2
 no security wpa wpa2 ciphers aes
 no security wpa akm dot1x
 no shutdown
```

Anchor Guest

```
wireless profile policy guest-camp_Global_GA_7ae528ce
 aaa-override
 accounting-list default
 description guest-camp_Global_GA_7ae528ce
 dhcp-tlv-caching
 exclusionlist timeout 180
 http-tlv-caching
 mobility anchor
 nac
 service-policy input silver-up
 service-policy output silver
 vlan Vlan91
 no shutdown
!
wlan guest-camp_Global_GA_7ae528ce 22 guest-campus2
 mac-filtering dnac-cts-guest-camp-1d1eb5df
 no security ft adaptive
 no security wpa
 no security wpa wpa2
 no security wpa wpa2 ciphers aes
 no security wpa akm dot1x
 no shutdown
```

Wired Guest Access

Wired guest access allows the wired port to connect to the manufacturer's or vendor's website for equipment maintenance, software, or firmware updates. Wired guest sessions are connected to the designated wired Ethernet ports and are completed using the configured authentication method (OPEN or Webauth). Wired guest sessions are terminated at the guest anchor controller in the DMZ through the CAPWAP tunnel originating from the guest foreign controller. Wired guest access is a two-controller solution with a guest anchor and a guest foreign controller. This type of deployment isolates the wired guest traffic from enterprise user traffic.

Foreign Guest

```
wireless profile policy PP_PGN-VIP-Wired
guest-lan enable-session-timeout
 mobility anchor 90.1.1.8 priority 3
 no shutdown
!
guest-lan profile-name PP_PGN-VIP-Wired 1 wired-vlan 515
 no security web-auth
 no shutdown
```

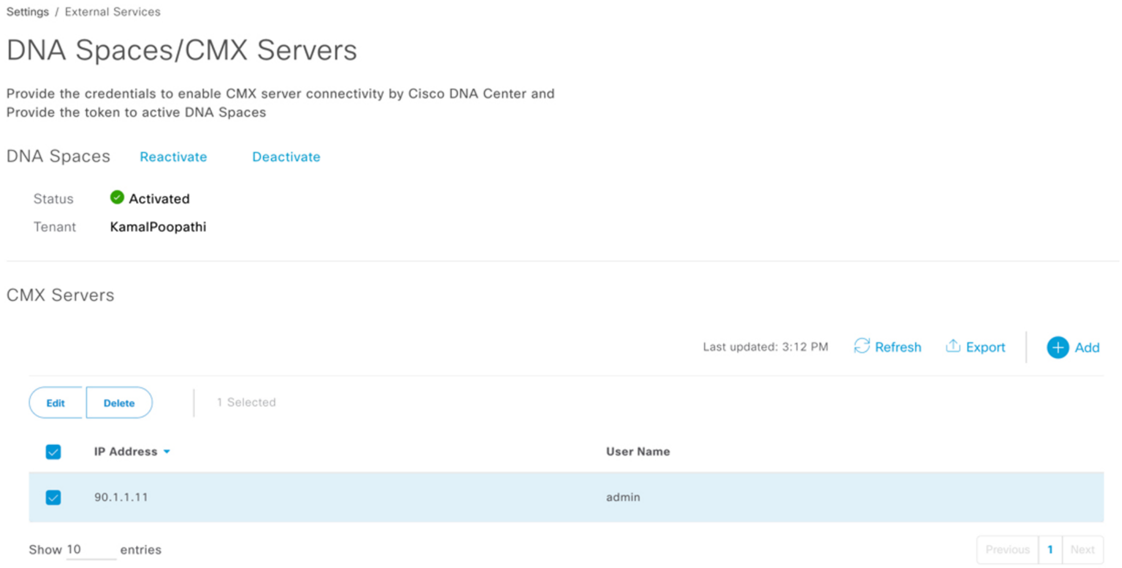
Anchor Guest

```
wireless profile policy PP_PGN-VIP-Wired
guest-lan enable-session-timeout
 mobility anchor
 vlan Vlan91
 no shutdown
!
guest-lan profile-name PP_PGN-VIP-Wired 1
 no security web-auth
 no shutdown
```

Location Services

CMX and Cisco Spaces

Patient and healthcare device mobility is essential for high-quality patient care. Cisco DNA Center addresses these use cases with the CMX and Cisco Spaces integration, which tracks the mobile assets such as wifi tags, laptops, and phones.



Settings / External Services

DNA Spaces/CMX Servers

Provide the credentials to enable CMX server connectivity by Cisco DNA Center and
Provide the token to active DNA Spaces

DNA Spaces

Status: Activated
Tenant: KamalPoopathi

CMX Servers

Last updated: 3:12 PM

1 Selected

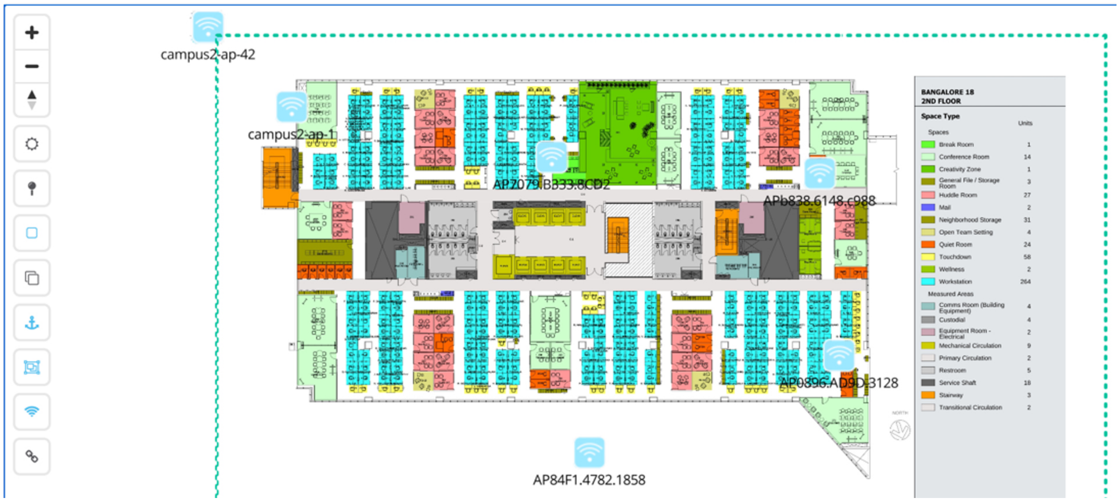
☑	IP Address	User Name
☑	90.1.1.11	admin

Show 10 entries

The Cisco Spaces connector is installed on premises, which establishes an NMSP connection with the wireless controllers. Via this connection, aggregated data is relayed from the controllers and access points to Cisco Spaces. For information on setting up the Cisco Spaces connector, see the "Prerequisites" chapter in the *Cisco Spaces: Connector Configuration Guide*.

The Cisco Spaces connector/CMX is then mapped to the corresponding site in Cisco DNA Center's **Wireless Network Settings** page and provision the wireless controller to push the NMSP mapping to the Cisco Spaces connector on the WLC.

The access points are placed under the corresponding floors in the wireless maps configured in Cisco DNA Center's Network Hierarchy page. The same positioning of the access points is reflected in Cisco Spaces (in the Detect and Locate application). This application also tracks the clients associated to access points, as well as Rogue APs, Rogue Clients, and Interferers. The medical assets that have wifi asset tags attached to them can also be tracked in Cisco Spaces.

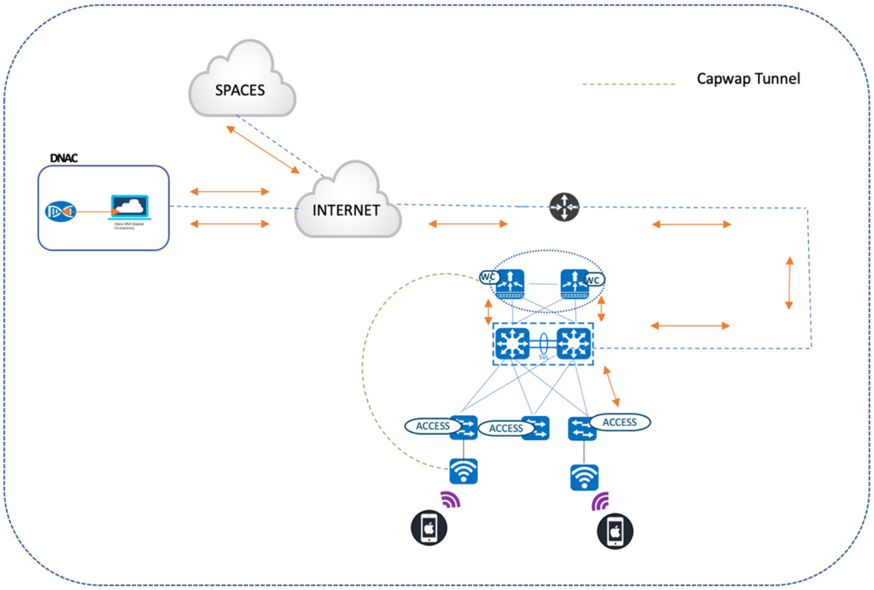


BANGALORE 18
2ND FLOOR

Space Type	Units
Spaces	
🟩 Break Room	1
🟩 Conference Room	14
🟩 Creativity Zone	1
🟫 General File / Storage Room	3
🟥 Huddle Room	27
🟦 Mail	2
🟫 Neighborhood Storage	31
🟨 Open Team Setting	4
🟧 Quiet Room	24
🟨 Touchdown	58
🟩 Wellness	2
🟦 Workstation	264
Measured Areas	
▨ Comms Room (Building Equipment)	4
▨ Custodial	4
▨ Equipment Room - Electrical	2
🟨 Mechanical Circulation	9
□ Primary Circulation	2
▨ Restroom	5
■ Service Shaft	18
🟧 Stairway	3
□ Transitional Circulation	2

The following topology depicts the logical flow of events and illustrates how Cisco Spaces and Cisco DNA Center are in sync:

- Cisco DNA Center is registered with Cisco Spaces.
- The WLC is registered with the Cisco Spaces connector.
- The Cisco Spaces connector forwards the aggregate details of APs and endpoints in the WLAN to Cisco Spaces.
- Cisco DNA Center's wireless maps are synced with Cisco Spaces.
- Cisco Space's Detect and Locate application forwards client map locations to the wireless maps maintained by Cisco DNA Center. For more information on Cisco DNA Center's integration with Cisco Spaces, see the "Cisco DNA Center Integration" chapter in the *Cisco Spaces Configuration Guide*.



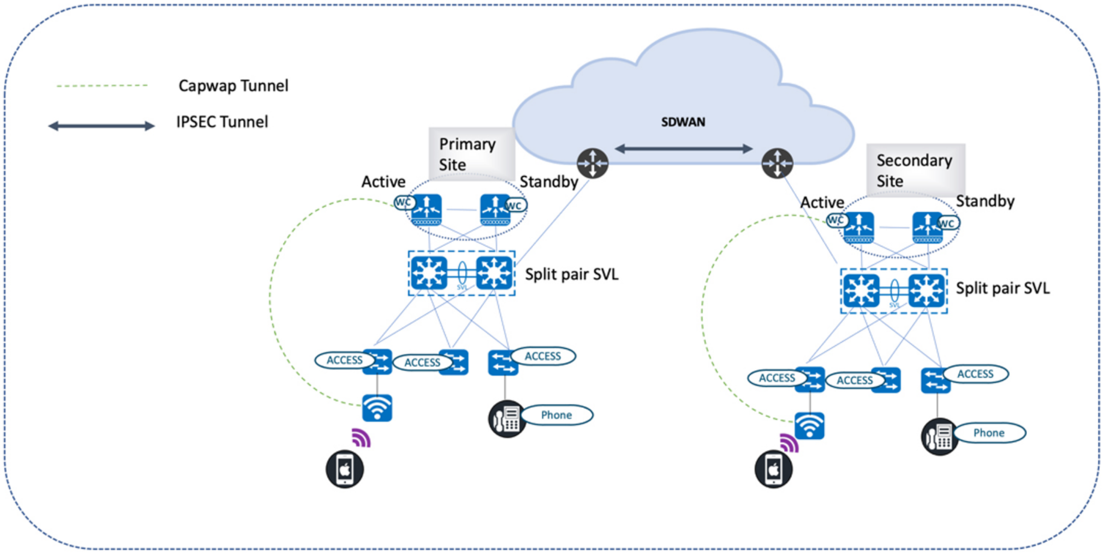
High Availability

AP/Client SSO

Healthcare networks need to be resilient enough to provide continuous service. The high availability feature (AP SSO/Client SSO) is especially important to achieve this goal. Cisco DNA Center allows you to form an RP+RMI HA setup, which involves connecting two physical wireless controllers to form an active and standby pair with a single control/data plane. At any given time, there is a single CAPWAP tunnel between an access point and the active WLC. Also, the AP database for both the active and standby WLCs are in sync. Whenever a failover occurs, the standby WLC becomes the new active WLC. And since it already has the details of the connected access point in its database, the APs never have to go down and reestablish the CAPWAP tunnel. It results in a seamless failover where the AP continues to stay up. Similarly, the wireless clients in the RUN state are synced between the active and standby WLCs. During a failover, clients do not have to reassociate and are able to maintain a continuous session.

N+1 SSO

Cisco DNA Center also provides N+1 HA functionality, offering controller redundancy of controllers across multiple geographies. Unlike the RP+RMI HA setup, AP SSO and Client SSO are not supported by N+1 setups. Whenever the primary controller fails, the APs disconnect from it and then join the secondary backup controller, which results in the restart of the CAPWAP state machine. After the primary controller resumes operation, the APs disconnect from the backup controller and rejoin the primary WLC. For more information, see the "Cisco DNA Center Configuration for N+1 High Availability" topic in the *Cisco Catalyst 9800 Wireless Controller N+1 High Availability White Paper*.



In-Service Software Upgrade

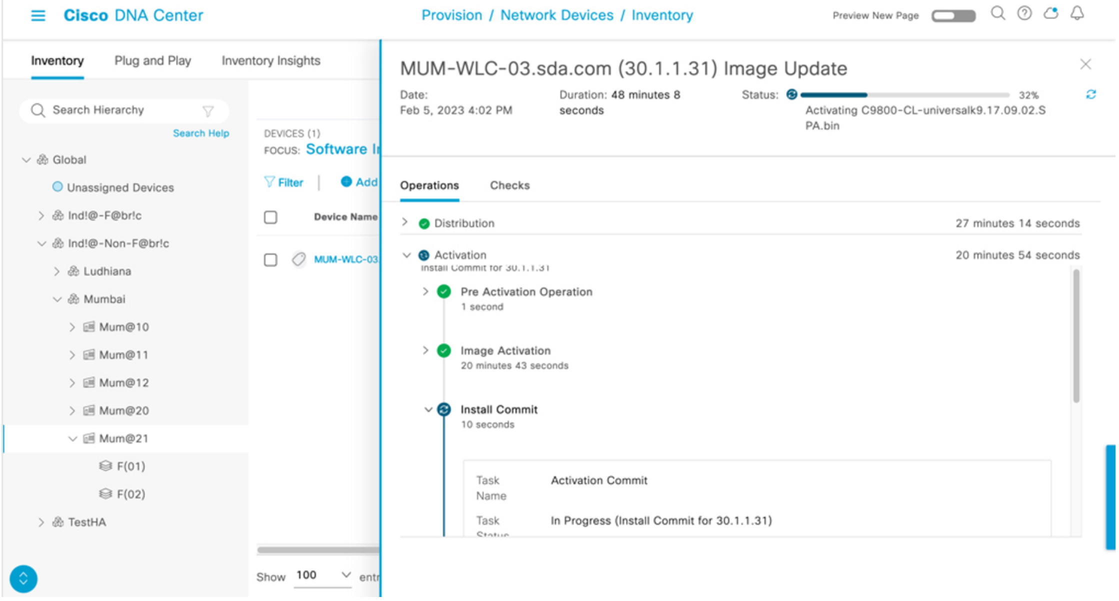
Cisco DNA Center offers the In-Service Software Upgrade (ISSU), which allows you to upgrade an HA-enabled wireless controller to a newer Cisco DNA Center version without disrupting data forwarding in your network. If you use the ISSU, note that you can only upgrade to a newer major version (in other words, you can't upgrade to a point or patch version).

You'll need to complete the following tasks when using an ISSU:

1. Onboard the controller's software image to flash memory.
2. Download the access point image to the relevant access point.
3. Install the controller's software image.

4. Commit your changes.

For more information about this feature, see the "Upgrade a Software Image with ISSU" topic in the *Cisco DNA Center User Guide*.



MUM-WLC-03.sda.com (30.1.1.31) Image Update

Date: Feb 5, 2023 4:02 PM

Duration: 48 minutes 8 seconds

Status: 32% Activating C9800-CL-universalk9.17.09.02.SPA.bin

Distribution 27 minutes 14 seconds

Activation 20 minutes 54 seconds
Install Commit for 30.1.1.31

Pre Activation Operation
1 second

Image Activation
20 minutes 43 seconds

Install Commit
10 seconds

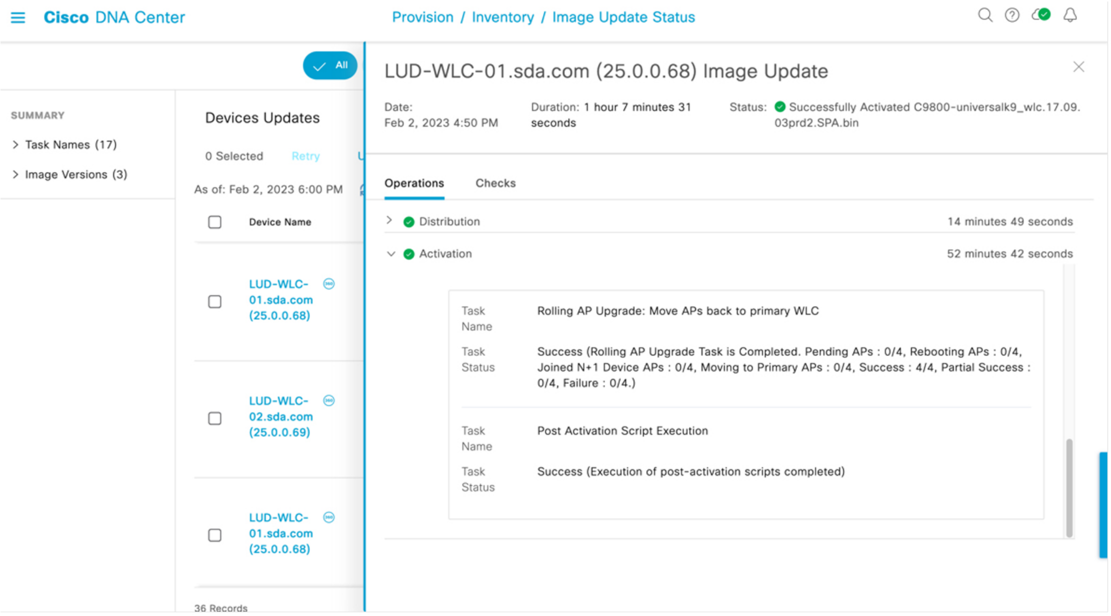
Task Name	Activation Commit
Task Status	In Progress (Install Commit for 30.1.1.31)

Rolling Access Point Upgrade

High availability (HA) isn't exclusive to wireless controllers. Cisco DNA Center also extends HA to access points, thanks to the rolling access point upgrade feature. When enabled, this feature provides the following benefits:

- Allows for staggered access point upgrades in an N+1 topology.
- Ensures that continuous service is available to users connected to the network while an upgrade is taking place.
- Automatically selects candidate access points using RRM-based neighbor information and the user-specified percentage for the upgrade: 5, 15 (default), or 25.

For more information about this feature, see the "About N+1 Rolling AP Upgrade" topic in the *Cisco DNA Center User Guide*.


Cisco DNA Center
Provision / Inventory / Image Update Status
All
SUMMARY
Task Names (17)
Image Versions (3)
Devices Updates
0 Selected
Retry
As of: Feb 2, 2023 6:00 PM
Device Name
LUD-WLC-01.sda.com (25.0.0.68)
LUD-WLC-02.sda.com (25.0.0.69)
LUD-WLC-01.sda.com (25.0.0.68)
36 Records
Operations
Checks

LUD-WLC-01.sda.com (25.0.0.68) Image Update

Date: Feb 2, 2023 4:50 PM

Duration: 1 hour 7 minutes 31 seconds

Status: Successfully Activated C9800-universalk9_wlc.17.09.03prd2.SPA.bin

Distribution 14 minutes 49 seconds

Activation 52 minutes 42 seconds

Task Name: Rolling AP Upgrade: Move APs back to primary WLC

Task Status: Success (Rolling AP Upgrade Task is Completed. Pending APs : 0/4, Rebooting APs : 0/4, Joined N+1 Device APs : 0/4, Moving to Primary APs : 0/4, Success : 4/4, Partial Success : 0/4, Failure : 0/4.)

Task Name: Post Activation Script Execution

Task Status: Success (Execution of post-activation scripts completed)

Telemetry-Based Assurance

Healthcare organizations have large-scale device sites with multiple endpoints. Administrators have indicated that managing, tracking, and monitoring these sites can be tedious. Cisco DNA Assurance simplifies these tasks by continually assessing the health of your network and its endpoints. The Telemetry Data Logger (TDL) collects streaming telemetry data from the devices managed by Cisco DNA Center, allowing network administrators to monitor network nodes and both wired and wireless clients in real-time. Armed with this data, administrators can troubleshoot any technical issues that arise.

AP Refresh

Advancing medical applications require medical assets to have high throughput and low latency wireless networks with efficient bandwidth transmission. As a result, there is a need to migrate to Wi-Fi6/Wi-Fi6E, the new generation of Wi-Fi standards. The migration or refresh task in the wireless domain requires meticulous planning at the following levels: hardware replacement, software upgrade, access point (AP) name changes, map update, etc. The devices are spread out across various locations, making the refresh task more tedious for administrators. To optimize the change tasks, Cisco DNA Center has an automated AP refresh workflow, which includes replacing Wi-Fi 5 (802.11ac - old generation) with Wi-Fi 6 (802.11ax - new generation). The workflow also chooses the APs, assigns names, maps locations, and copies the existing configurations to the new APs. The following tasks are involved in the workflow:

1. The network administrator creates a task for the AP refresh operation.

   The task can be edited multiple times.

2. The locations/sites are selected, meaning the AP refresh operation has begun.

   In the inventory, the older AP should be in the disconnected state.

3. The network administrator provides the AP hostname.

   The administrator usually retains the same hostname.

4. The new APs are plugged into the access switchports, and they are ready for Plug and Play (PnP) in the Cisco DNA Center inventory.

The serial number of the new PnP-ready AP is mapped to the new AP.

5. As a part of the bulk AP refresh, the network administrator provides a CSV input for the old and new AP mapping.
6. The network administrator submits the task and the AP host name change.

   The AP location and the older AP configurations are moved to the new AP.

Note The AP refresh creates a progress report of the task and the reason for failure (if any) with the retry option.

See the "AP Refresh Workflow" topic in the *Cisco DNA Center User Guide* for more information.

Technical References

- https://www.cisco.com/c/dam/en_us/solutions/industries/docs/healthcare/CLA_HealthcareSolution.pdf
- https://www.cisco.com/c/dam/en_us/solutions/industries/docs/retail/07cs1084-mobforhc_bro_aha_pdf_102307.pdf
- https://www.cisco.com/c/dam/en/us/solutions/collateral/enterprise-networks/mobility/wireless-design-guide-healthcare.pdf
- https://www.cisco.com/c/en/us/td/docs/cloud-systems-management/network-automation-and-management/dna-center/Cisco-Validated-Solution-Profiles/b_cisco_validated_solution_profile_healthcare_vertical.html
- https://www.cisco.com/c/en/us/solutions/collateral/enterprise-networks/software-defined-access/nb-06-ai-endpoint-analytics-wp-cte-en.html?oid=wpretr023097
- https://www.cisco.com/c/dam/en/us/td/docs/wireless/controller/9800/17-1/deployment-guide/c9800-ha-rau-apsp-apdp-issu-rel-17-1.pdf
- https://www.cisco.com/c/en/us/support/docs/wireless-mobility/wireless-lan-wlan/116493-technote-technology-00.html#anc24

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