Guide
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Cisco Cloud Campus LAN Design Guide (CVD)

August 2024

Contents

This document provides a pre-validated design and deployment guide for a Cisco Campus LAN with Catalyst® Switches and Access Points running in either Cloud Managed or Cloud Monitored mode alongside the various design guidelines, topologies, technologies, configurations, and other considerations relevant to the design of any highly available, full-service campus switching fabric. It is also intended to serve as a guide to direct readers to general design and best practices for Cloud-based Cisco Campus LAN.

Overview

The LAN is the networking infrastructure that provides access to network communication services and resources for end users and devices spread over a single floor or building. You create a campus network by interconnecting a group of LANs that are spread over a local geographic area. Campus network design concepts include small networks that use a single LAN switch, up to very large networks with thousands of connections.

The campus wired LAN enables communications between devices in a building or group of buildings, as well as interconnection to the WAN and Internet edge at the network core.

Specifically, this design provides a network foundation and services that enable:

- Tiered LAN connectivity
- Wired network access for employees
- IP Multicast for efficient data distribution
- Wireless and Wired infrastructure ready for multimedia services

Cisco's Campus LAN architecture offers customers a wide range of options. The Catalyst portfolio with Digital Network Architecture (a.k.a. Cisco Catalyst Center, previously known as Cisco DNA Center) provides a roadmap to digitization and a path to realizing immediate benefits of network automation, assurance and security with an on-prem operating model. The Catalyst portfolio with Meraki Dashboard enables customers to accelerate business evolution through easy-to-use cloud networking technologies that deliver secure customer experiences and simple deployment of network products with a cloud-first operating model.

The proposed architecture enables you to build secure, scalable, and robust enterprise networks. Since the design involves deploying Catalyst platforms in either Cloud Managed or Cloud Monitored modes, special attention should be given to proper planning and design to ensure interoperability and performance.

Introduction

Designing a LAN for the campus use case is not a one-design-fits-all proposition. The scale of campus LAN can be as simple as a single switch and wireless AP at a small remote site or a large, distributed, multi-building complex with high-density wired port and wireless requirements. The deployment may require very high availability for the services offered by the network, with a low tolerance for risk, or there may be tolerance for fix-on-failure approach with extended service outages for a limited number of users considered acceptable. Platform choices for these deployments are often driven by needs for network capacity, the device and network capabilities offered, and the need to meet any compliance requirements that are important to the organization.

This document provides a pre-validated design and deployment guide for a Cisco Campus LAN with Catalyst Switches and Access Points running in either Cloud Managed or Cloud Monitored mode alongside the various design guidelines, topologies, technologies, configurations, and other considerations relevant to the design of any highly available, full-service campus switching fabric. It is also intended to serve as a guide to direct readers to general design and best practices for Cloud-based Cisco Campus LAN.

Cloud management and monitoring for Cisco Catalyst

Cloud monitoring

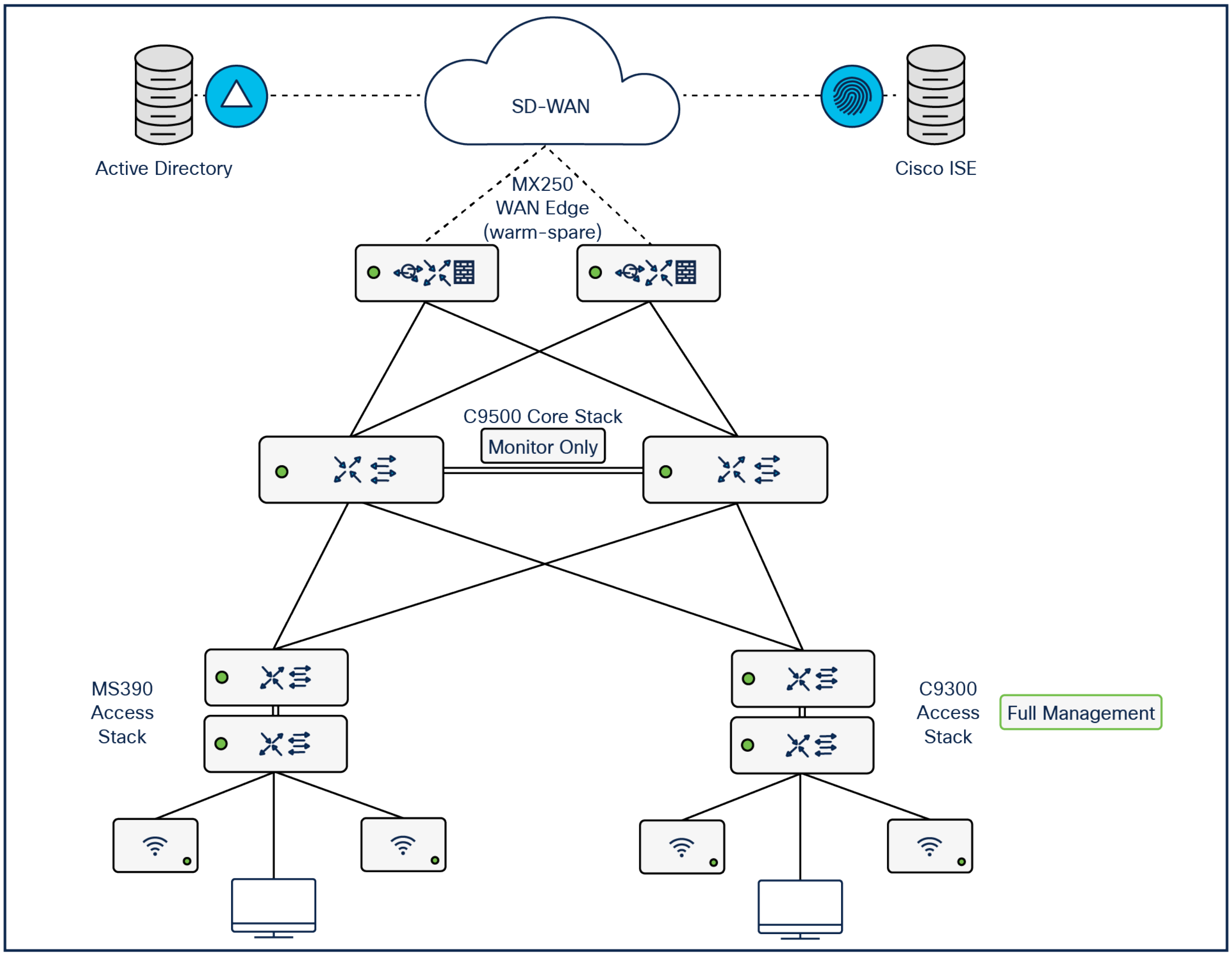
Selected Cisco Catalyst devices (9200, 9300, and 9500) are capable of connecting to the Meraki Dashboard for monitoring purposes. This offers dashboard monitoring and insights for Catalyst devices including visibility into some configuration items. However, please note that this does **not** offer full management in Meraki Dashboard. (i.e. No configuration changes in Meraki Dashboard). Please see the following snapshot of C9500 switches/stacks in the Meraki Dashboard:

#	Name	MAC address	Firmware version	Serial number
1	C9500SV-CORE-RIO [2] Monitor Only	a0:b4:39:77:64:40	IOS XE 17.3.4	Q2ZZ-ST
2	C9500SV-CORE-RIO [1] Monitor Only	a0:b4:39:77:38:80	IOS XE 17.3.4	Q2ZZ-58

For more information about Cloud Monitoring, please refer to this article.

Campus LAN architecture with Cloud management

Please refer to the following proposed architecture diagram as a reference for this CVD:



To achieve a robust, reliable, high speed and Future Proof Campus LAN, the following components are part of this architecture:

Component	SKU	Capabilities	Management Platform	Integrations
Wireless LAN	MR55-HW (Or MR56/57) with LIC-ADV And C9166-MR (1) with LIC-ADV	WiFi6 High-density Wireless Access points mGig uplinks Adaptive Policy	Meraki Dashboard	Cisco ISE (*Optional*) Azure Active Directory (*Optional*)
Access Switches	MS390-24P and LIC-MS390-24A And C9300-24P *M(1)* with C9300-NM-8X and LIC-MS390-24A	Physical Stacking with StackPower Up to 40G Uplinks Layer 3 capabilities	Meraki Dashboard	Cisco ISE (*Optional*)

Component	SKU	Capabilities	Management Platform	Integrations
Collapsed[2] Core Switches	C9500-24Y4C (*Monitor Only*)	Up to 100G Uplinks Secure segmentation with SD-Access MACSec 6.4 TB switching capacity	Meraki Dashboard (Monitor Only)	
WAN Edge and UTM	MX250 in warm-spare configuration (2) with LIC-MX250-SDW OR A Catalyst SD-WAN solution	10G SFP+ WAN 10G SFP+ LAN 1G SFP LAN Security (UTM) and SD-WAN 4 Gbps Firewall Throughput 2 Gbps SD-WAN Throughput	Meraki Dashboard	

(1) -M and -MR models are pre-shipped with Meraki management mode. If you have non-M devices, they can be transitioned to run in Cloud Managed mode (aka Meraki management mode). Please refer to documentation for further details.

(2) Warm-spare configuration requires only a **single** license for both MX appliances

Note: Catalyst -M and -MR SKUs are pre-shipped in Cloud Managed mode (aka Meraki management mode). However, you can transition existing compatible devices to Cloud Managed mode through CLI for switches OR the Wireless LAN Controller GUI for access points.

Logical architecture

This document will provide three options to design this campus architecture from a logical standpoint, which are outlined below (each with its own characteristics):

Layer 2 Access with Native VLAN 1

This option assumes that your Spanning Tree Protocol (STP) domain is extended all the way to your core layer. It offers great flexibility in terms of network segments as you can have your VLANs spanning over the different stacks/closets. However, the STP configuration and tuning is crucial since the Catalyst platforms can run different STP protocols than the Meraki MS390 switches.

Pros:

- Flexibility in your VLAN design
- Facilitates Wireless Roaming across the whole campus
- Easier to deploy and consistent configuration across the entire Campus LAN

Cons:

- Non-deterministic route failover
- Slow convergence
- Different STP protocol support on Cloud Monitored and Cloud Managed Catalyst Switches
- The possibility of VLAN hopping

Layer 2 access without Native VLAN 1

This option is similar to the above except that VLAN 1 does **not** exist and the *default* Native VLAN 1 is replaced with another non-trivial VLAN assignment which can be considered a more preferable option for customers as its separate from the Management VLAN

Pros:

- Flexibility in your VLAN design
- Facilitates Wireless Roaming across the whole campus
- Easier to deploy and consistent configuration across the entire Campus LAN
- Minimize the risk of VLAN hopping

Cons:

- Non-deterministic route failover
- Slow convergence
- Different STP protocol support on Cloud Monitored and Cloud Managed Catalyst Switches

> **Note:** Please note that the recommended Spanning Tree Protocol for Cloud-based Cisco Campus is Multiple Spanning Tree Protocol since it eliminates configuration and troubleshooting issues on the different platforms. As such, if you configure other protocols on (e.g. Per VLAN Spanning Tree [PVST]) on your network, then please note that VLAN 1 is going to be essential as backward compatible Bridge Protocol Data Units (BPDUs) only run in VLAN 1.

Layer 3 access

This option assumes that your Open Shortest Path First (OSPF) domain is extended all the way to your core layer and thus there is no need to rely on STP between your Access and Core for convergence. It offers fast convergence since it relies on Equal-cost multi-path routing (ECMP) rather than STP layer 2 paths. However, it doesn't offer great flexibility in your VLAN design as each VLAN cannot span between multiple stacks/closets.

Pros:

- Deterministic route failover
- Fast convergence
- Relies on either stacking or gateway redundancy at upper layers

Cons:

- VLANs cannot span multiple stacks/closets
- Your backbone area size can be unmanageable
- Layer 3 roaming is not possible **without** a concentrator

This CVD offers the design and configuration guidelines for **ALL** options above.

Campus LAN planning, design, and configuration

Planning

The following section provides information on planning your solution and ensuring that you have a successful deployment. This will include gathering the design requirements and planning for your Cloud-based Cisco Campus LAN architecture based on your own requirements.

Prior to proceeding to plan for your deployment, please refer to the Campus LAN Design Best Practices Guide which can be used to guide you through the planning phase of designing your Campus LAN.

Meraki cloud administration and management

If you don't have an account on the Meraki Dashboard, create one following these steps:

1. Generate an API Key for your account following these steps.
2. Claim your order(s) or serial number(s) into your Meraki Dashboard account.
3. Add your devices to existing networks or create new networks as required.
4. Configure firmware upgrades for your network(s) with latest Stable or RC releases for each device type (*Please check the firmware changelog for platform-specific details*).
5. Configure your network(s) with the correct time zone from **Network-wide > Configure > General** (*This is key for reporting and firmware upgrades*).
6. Configure your network(s) with the desired upgrade date and time.
7. Configure the MR upgrade behavior as desired.
8. Ensure that your Campus LAN has access to the internet for management purposes.
9. Ensure that Meraki Cloud is accessible and that all required ports are opened where applicable (information can be found in Dashboard).
10. Ensure that there is sufficient bandwidth for firmware upgrades as they tend to be large in size.
11. Ensure that only current administrators are added with the correct permissions on the Meraki dashboard (unless SAML is configured for Single Sign-on).
12. If using Single sign-on integration with Meraki dashboard, please ensure that login to dashboard is scoped such that administrators have the correct level of access where applicable (e.g. Per network, Per switch port, etc.). For more information about dashboard access roles, please refer to the following article.

13. In case of SAML SSO, it is still required to have one valid administrator account with full rights configured on the Meraki dashboard. However, it is recommended to have at least two accounts to avoid being locked out from dashboard.

14. Where applicable, ensure that the designated Management VLAN has access to Dynamic Host Configuration Protocol (DHCP) (at least during initial bootup before assigning a static IP address) and also to the internet.

Tech Tip: Please note that all switches within the same network will use the same Management VLAN unless changed statically on a per switch basis

Radius integration (e.g. Cisco ISE)

1. If using an external Radius server (e.g. Cisco ISE), then ensure that the network segment where ISE is hosted can access the Management VLAN configured on your network devices (or the Alternate Management Interface on MR and/or MS if configured and where applicable).

2. Ensure that all required ports are opened where applicable (e.g. 1812, 1813, etc.).

Tech Tip: It is recommended to access the Radius server via VPN as the Radius traffic sourced from Meraki devices is **not** encrypted.

Active directory integration

1. If using an external identity source (e.g. Active Directory), then ensure that the network segment where the AD is hosted can access the Management VLAN configured on your network devices (or the Alternate Management Interface on MR and/or MS if configured with Radius integration).

2. Ensure that all required ports are opened where applicable (e.g. 3268, 389, etc.).

Tech Tip: It is recommended to access the Active Directory server via VPN as the traffic is not encrypted (only port **3268** is supported).

Catalyst onboarding for cloud monitoring (C9200/9300/9500)

For ease of management, Customers can onboard Cisco C9200/9300/9500 switches/stacks for Cloud Monitoring such that they can be available in the Meraki Dashboard in Monitor only mode. This process enables dashboard monitoring on these switches/stacks and selected configuration parameters will be visible in the Meraki Dashboard. Please refer to the following article for the supported Catalyst 9000 series.

Pre-requisites

Please ensure the following prior to onboarding a switch/stack for Cloud Monitoring:

- It is a supported model (Please refer to this article)
- Running IOS-XE 17.3 – 17.10.1
- It must have an SVI or routed interface that has access to the Internet on port TCP 443

- It must have a valid DNS server
- It must have a valid DNA software subscription
- It must have Telnet for connectivity pre-check (Please refer to this article)
- A valid Dashboard account and API Key
- A computer with both access to internet on port 443 and access to the switch(es)

Tech Tips

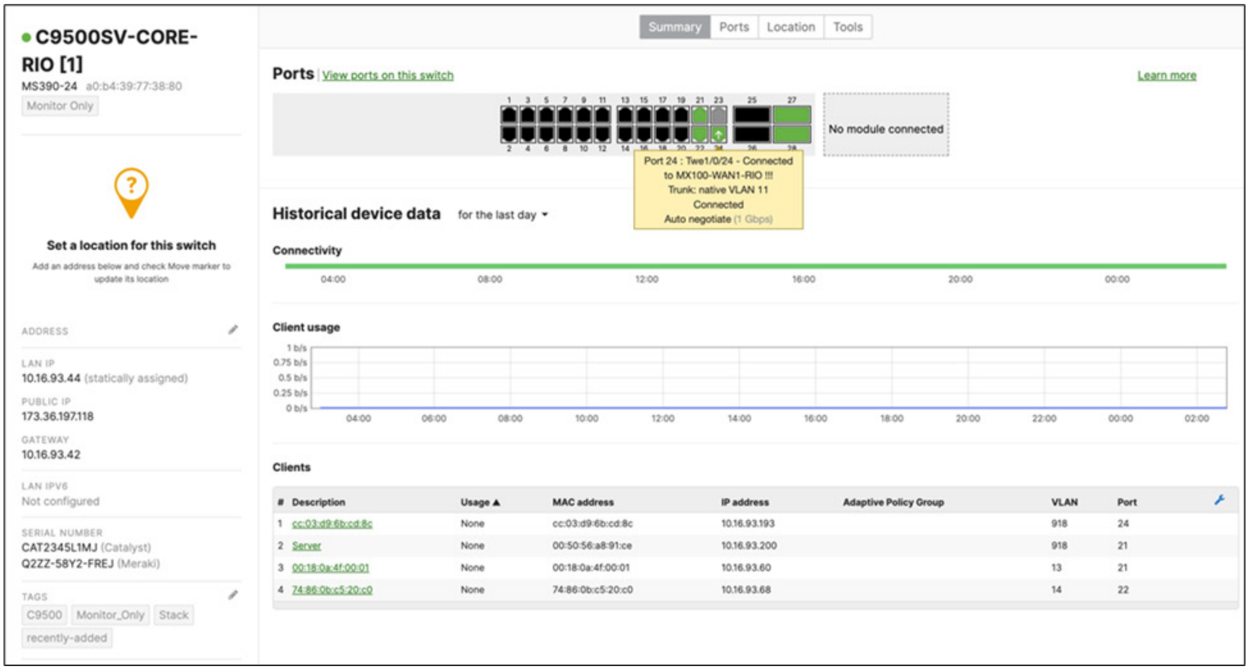
- HTTPS proxies to access the API endpoint and the TLS gateway are not currently supported. If necessary, ensure rules are in place to allow direct HTTPS connections to each.
- Connectivity must be via a front-panel port (not the management interface).
- Only the default VRF is supported.
- Ensure routes are in place to reach external addresses including a default route (use of ip default-gateway is not supported).
- IP routing (ip routing) must be enabled on the switch or will be enabled as part of onboarding.
- Ensure DNS is enabled on the switch (ip name-server {DNS server IP} configured).
- Ensure DNS lookup is enabled (ip domain lookup).
- NTP needs to be enabled on the switch (ntp server {address}), and the switch clock must reflect the correct time.
- AAA on the switch must be configured using aaa new model.
- RADIUS authentication is not currently supported.
- SSH access to the switch CLI must be enabled and accessible via the computer used for onboarding.
- The user account for onboarding must have privilege-15 level access on the switch.

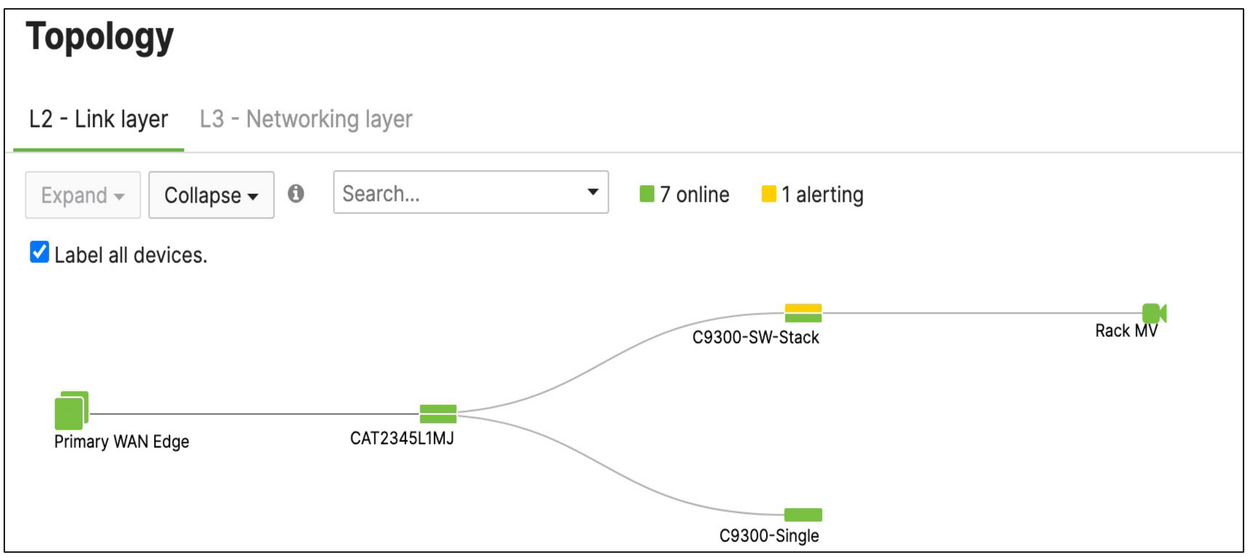
Onboarding catalyst devices for cloud monitoring

The onboarding process for the C9500 core switches is out of scope for the purposes of this CVD. Please refer to the following article for a step by step guide on onboarding Catalyst for Cloud Monitoring.

Switch Status on Meraki dashboard

Once the device has been onboarded for Meraki dashboard monitoring, it should come online on dashboard after several minutes and also the network topology will show all switches in Monitor Only mode.


C9500SV-CORE-RIO [1]
MS390-24 a0:b4:39:77:38:80
Monitor Only
Summary
Ports
Location
Tools
Ports
View ports on this switch
Learn more
No module connected
Port 24 : Twe1/0/24 - Connected to MX100-WAN1-RIO !!!
Trunk: native VLAN 11
Connected
Auto negotiate (1 Gbps)
Set a location for this switch
Add an address below and check Move marker to update its location
Historical device data
for the last day
Connectivity
Client usage
Clients
ADDRESS
LAN IP
10.16.93.44 (statically assigned)
PUBLIC IP
173.36.197.118
GATEWAY
10.16.93.42
LAN IPV6
Not configured
SERIAL NUMBER
CAT2345L1MJ (Catalyst)
Q2ZZ-58Y2-FREJ (Meraki)
TAGS
C9500
Monitor_Only
Stack
recently-added
Description Usage MAC address IP address Adaptive Policy Group VLAN Port
1 cc:03:d9:6b:cd:8c None cc:03:d9:6b:cd:8c 10.16.93.193 918 24
2 Server None 00:50:56:a8:91:ce 10.16.93.200 918 21
3 00:18:0a:4f:00:01 None 00:18:0a:4f:00:01 10.16.93.60 13 21
4 74:86:0b:c5:20:c0 None 74:86:0b:c5:20:c0 10.16.93.68 14 22


Topology
L2 - Link layer
L3 - Networking layer
Expand
Collapse
Search...
7 online
1 alerting
Label all devices.
C9300-SW-Stack
Rack MV
Primary WAN Edge
CAT2345L1MJ
C9300-Single

Design and configuration guidelines

Option 1: STP Based convergence with Native VLAN 1

Overview

This design option allows for flexibility in terms of VLAN and IP addressing across the Campus LAN such that the same VLAN can span across multiple access switches/stacks thanks to Spanning Tree that will ensure that you have a loop-free topology. However, this method of convergence is considered non- deterministic since the path of execution isn't fully determined (unlike Layer 3 routing protocols for example). As a result, convergence can be slow and STP must be tuned to provide best results.

This design is based on consistent STP protocols running in this campus deployment, as such **Multiple Spanning Tree Protocol (MST, aka 802.1s)** will be configured since it is supported on both the Meraki and Catalyst platforms.

> **Tech Tip:** It is recommended to run the **same** STP protocol across all switches (MST in this case). Running any other protocol on Catalyst (e.g. PVST) can introduce undesired behavior and can be more difficult to troubleshoot.

You should consider this option if you need a consistent VLAN assignment across all switching closets. Here are some things to consider about this design option:

Pros:

- Flexibility in your VLAN design
- Facilitates Wireless Roaming across the whole campus
- Easier to deploy and consistent configuration across the entire Campus LAN

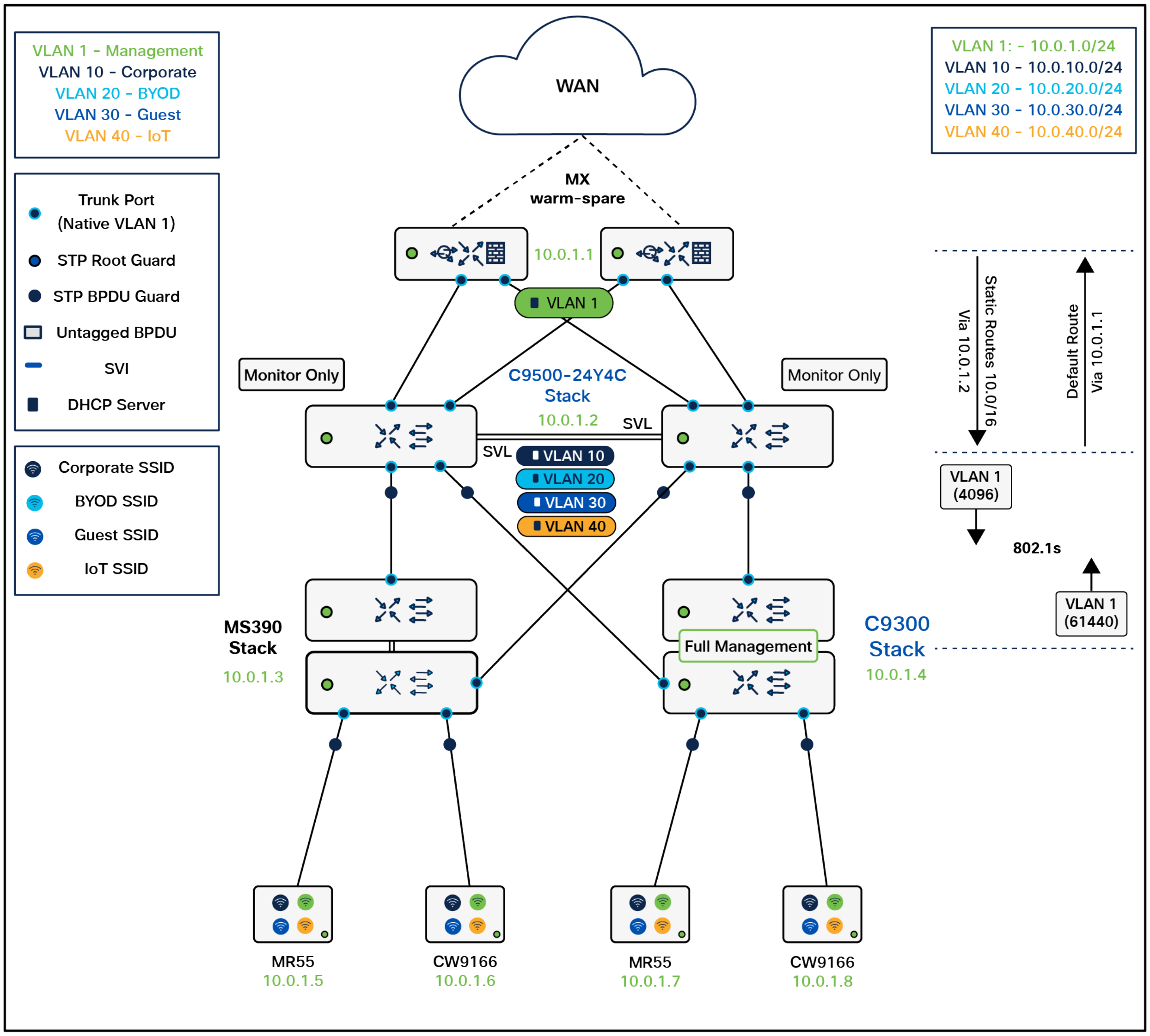
Cons:

- Non-deterministic route failover
- Slow convergence
- Different STP protocol support on Cloud Managed and Cloud Monitored Catalyst Switches

Since MST will be used as a loop prevention mechanism, all SVIs will be created on the collapsed core layer.

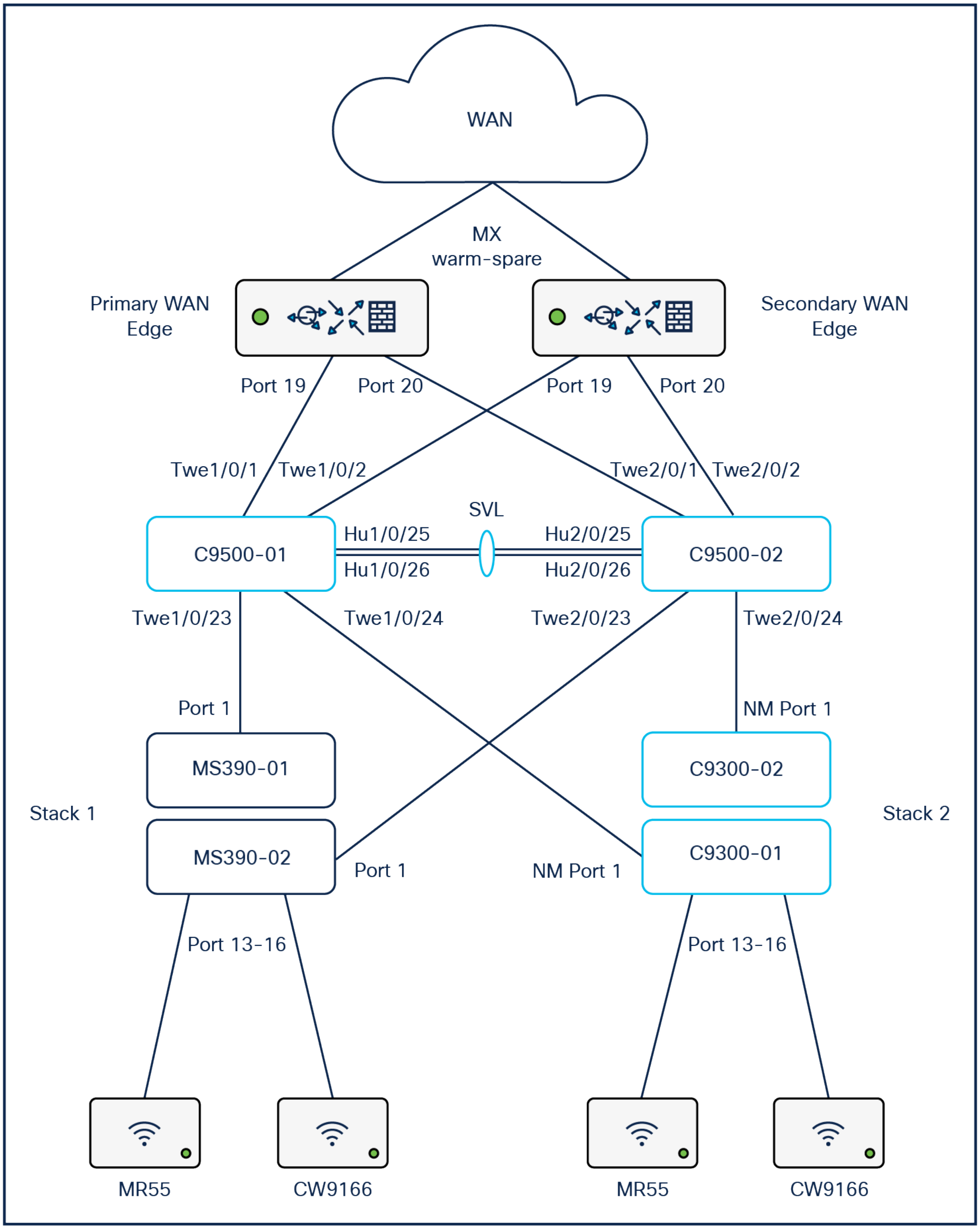
Logical architecture

The following diagram shows the logical architecture highlighting STP convergence within a campus LAN design leveraging Cloud Managed and Cloud Monitored Catalyst platforms:



Physical architecture

The following diagram shows the physical architecture and port list for this design:



Assumptions

The following assumptions have been considered:

- It is assumed that Wireless roaming is required **everywhere** in the Campus
- It is assumed that VLANs are **spanning** across multiple zones/closets
- **Corporate** SSID (*Broadcast in all zones/areas*) users are assigned VLAN **10** on all APs. CoA VLAN is VLAN **30** (via Cisco ISE)

- **BYOD** SSID (*Broadcast in all zones/areas*) users are assigned VLAN **20** on all APs. CoA VLAN is VLAN **30** (via Cisco ISE)
- **Guest** SSID (*Broadcast in all zones/areas*) users are assigned VLAN **30** on all APs
- **IoT** SSID (*Broadcast in all zones/areas*) users are assigned VLAN **40** on all APs
- Access Switches will be running in Layer 2 mode (*No SVIs or DHCP*)
- **MS390** Access Switches physically stacked together
- **C9300-M** (or compatible) Access Switches physically stacked together
- **C9500** Core Switches with Stackwise-virtual stacking using SVLs
- Access Switch uplinks are in **trunk mode** with native VLAN = VLAN 1 (Management VLAN*)
- STP root is at Distribution/Collapsed-core
- Distribution/Collapsed-core uplinks are in **Trunk mode** with Native VLAN = VLAN 1 (Management VLAN)
- All VLAN **SVIs** are hosted on the **core layer**
- Network devices will be assigned **fixed IPs** from the management VLAN DHCP pool. Default Gateway is **10.0.1.1**

Tech Tip: The client serving SVIs (offering DHCP services) were configured in this case on the C9500 Core Stack. However, it is also possible to configure them on the WAN Edge MX instead. In this case, please remember to configure the C9500 Core Stack uplinks **AND** the MX Downlinks with the appropriate VLANs in the Allowed VLAN list.

Tech Tip: While it is possible to configure a different Management VLAN than VLAN 1, the design and configuration guidelines in the coming section will assume that VLAN 1 is the Management VLAN. Please refer to this separate section should you wish to configure a different Management VLAN for your Campus LAN.

Network segments

Please check the following table for more information about the network segments (e.g. VLANs, SVIs, etc.) for this design:

Network Segment	VLAN ID	Subnet	Default Gateway	Notes
Management	1	10.0.1.0/24	10.0.1.1	SVI hosted on edge MX
Corporate Devices (Wireless and Wired)	10	10.0.10.0/24	10.0.10.1	SVI hosted on core switches
BYOD Wireless Devices	20	10.0.20.0/24	10.0.20.1	SVI hosted on core switches
Guest Wireless Devices	30	10.0.30.0/24	10.0.30.1	SVI hosted on core switches
IoT Wireless Devices	40	10.0.40.0/24	10.0.40.1	SVI hosted on core switches

Tech Tip: Please size your subnets based on your own requirements. The above table is for illustration purposes only

Tech Tip: In this example, the Management VLAN has been created on the Edge MX. Alternatively, you can create the SVI on the C9500 Core Stack.

Application	MR	Access switches	Core switches	MX Appliance
SIP (Voice)	EF DSCP 46 AC_Vo	Trust incoming values DSCP 46 CoS 5	Trust incoming values	EF DSCP 45 LLQ Unlimited
Webex and Skype	AF41 DSCP 34 AC_VI	Trust incoming values DSCP 34 CoS 4	Trust incoming values	Af41 DSCP 34 High Priority
All Video and Music	AF21 DSCP 18 AC_BE	Trust incoming values DSCP 18 CoS 2	Trust incoming values	AF21 DSCP 18 Medium Priority 5Mbps / Client
Software Updates	AF11 DSCP 10 AC_BK	Trust incoming values DSCP 10 CoS 1	Trust incoming values	AF11 DSCP 10

Device list

Device	Name	Management IP address	Notes
MX250	Primary WAN Edge	10.0.1.1	warm-spare
MX250	Spare WAN Edge		
C9500-24YCY	C9500-01	10.0.1.2	Stackwise Virtual (C9500-Core-Stack)
C9500-24CY	C9500-02		
MS390-24P	MS390-01	10.0.1.3	Physical Stacking (Stack1-MS390)
MS390-24P	MS390-02		
C9300-24P	C9300-01	100.1.4	

Device	Name	Management IP address	Notes
C9300-24P	C9300-02		Physical Stacking (Stack2-C9300)
MR55	AP1_Zone1	10.0.1.5	Tag = Zone1
C9166 (eq MR57)	AP2_Zone1	10.0.1.6	Tag = Zone1
MR55	AP3_Zone2	10.0.1.7	Tag = Zone2
C9166 (eq MR57)	AP4_Zone2	10.0.1.8	Tag = Zone2

Access policies

Access Policy Name	Purpose	Configuration	Notes
Wired-1x	802.1x Authentication via Cisco ISE for wired clients that support 802.1x	Authentication method = my Radius server Radius CoA = enabled Host mode = Single-Host Access Policy type = 802.1x Guest VLAN = 30 Failed Auth VLAN = 30 Critical Auth VLAN = 30 Suspend Port Bounce = Enabled Voice Clients = Bypass authentication Walled Garden = enabled	Cisco ISE authentication and posture checks

Access Policy Name	Purpose	Configuration	Notes
Wired-MAB	MAB Authentication via Cisco ISE for wired clients that do not support 802.1x	Authentication method = my Radius server Radius CoA = disabled Host mode = Single-Host Access Policy type = MAC authentication bypass Guest VLAN = 30 Failed Auth VLAN = 30 Critical Auth VLAN = 30 Suspect Port Bounce = Enabled Voice Clients = Bypass authentication Walled Garden = disabled	Cisco ISE authentication

Tech Tip: The above Access Policies are for illustration purposes only. Please configure your Access Policies as required.

Port list

Device name	Port	Far-end	Port details	Notes
Primary WAN Edge / Spare WAN Edge	1	WAN1		VIP1
Primary WAN Edge / Spare WAN Edge	2	WAN2		VIP2
Primary WAN Edge	19	9500-01 (Port Twe1/0/1)	Trunk (Native VLAN 1)	Downlink
	20	9500-02 (Port Twe2/0/1)	Trunk (Native VLAN 1)	Downlink
Spare WAN Edge	19	9500-01 (port Twe1/0/2)	Trunk (Native VLAN 1)	Downlink
	20	9500-02 (Port Twe2/0/2)	Trunk (Native VLAN 1)	Downlink

Device name	Port	Far-end	Port details	Notes
9500-01	Twe1/0/1	Primary WAN Edge (Port 19)	switchport access vlan 1 auto qos trust dscp policy static sgt 2 trusted	Uplink
	Twe1/0/2	Spare WAN Edge (Port 19)	switchport access vlan 1 auto qos trust dscp policy static sgt 2 trusted	Uplink
9500-02	Twe2/0/1	Primary WAN Edge (Port 20)	switchport access vlan 1 auto qos trust dscp policy static sgt 2 trusted	Uplink
	Twe2/0/2	Spare WAN Edge (Port 20)	switchport access vlan 1 auto qos trust dscp policy static sgt 2 trusted	Uplink
9500-01	Twe1/0/23	MS390-01 (Port 1)	switchport trunk native vlan 1 switchport trunk allowed vlans 1,10,20,30,40 channel-group 1 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	Downlink
	Twe1/0/24	C9300-01 (Port 1)	switchport trunk native vlan 1 switchport trunk allowed vlans 1,10,20,30,40 channel-group 2 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	Downlink

Device name	Port	Far-end	Port details	Notes
9500-02	Twe2/0/23	MS390-02 (Port 1)	switchport trunk native vlan 1 switchport trunk allowed vlans 1,10,20,30,40 channel-group 1 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	Downlink
	Twe2/0/24	C9300-02 (Port 1)	switchport trunk native vlan 1 switchport trunk allowed vlans 1,10,20,30,40 channel0group 2 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	Downlink
9500-01	Hu1/0/25	C9500-02 (Port Hu2/0/26)	stackwise-virtual link 1	Stackwise Virtual
	Hu1/0/26	C9500-02 (Port Hu2/0/25)	stackwise-virtual link 1	Stackwise Virtual
9500-02	Hu2/0/25	C9500-01 (Port Hu1/0/26)	stackwise-virtual link 1	Stackwise Virtual
	Hu2/0/26	C9500-01 (PortHu1/0/25)	stackwise-virtual link 1	Stackwise Virtual
MS390-01 **MS390-02** **C9300-01** **C9300-02**	5-8	Wired Clients	Access (Data VLAN 1) Access Policy = Wired-1x PoE Enabled STP BPDU Guard Tag = Wired Clients 802.1x AdP: Corp	For wired clients supporting 802.1x
MS390-01 **MS390-02**	9-12	Wired Clients	Access (Data VLAN 1) Access Policy = MAB	For wired clients that do not support 802.1x

Device name	Port	Far-end	Port details	Notes
C9300-01 **C9300-02**			PoE Enabled STP BPDU Guard Tag = Wired Clients MAB AdP: Corp	
MS390-01 **MS390-02** **C9300-01** **C9300-02**	13-16	MR	Trunk (Native VLAN 1) PoE Enabled STP BPDU Guard Tag = MR WLAN Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 1,10,20,30,40
MS390-01	1	9500-01 (Port Twe1/0/23)	Trunk (Native VLAN 1)PoE Disabled Name: Core 1 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 1,10,20,30,40
MS390-02	1	9500-02 (Port Twe2/0/23)	Trunk (Native VLAN 1) PoE Disabled Name: Core 2 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 1,10,20,30,40
C9300-01	C9300-01 / C9300-NM-8X / 1	9500-01 (Port Twe1/0/24)	Trunk (Native VLAN 1) PoE Disabled Name: Core 1 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 1,10,20,30,40
C9300-02	C9300-02 / C9300-NM-8X / 1	C9500-02 (Port Twe2/0/24)	Trunk (Native VLAN 1) PoE Disabled Name: Core 2 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 1,10,20,30,40

Wireless SSID list

SSID Name	Broadcast	Configuration	Notes	Firewall and Traffic Shaping
Acme Corp	All APs	Association = Enterprise with my Radius server Encryption = WPA2 only Splash Page = Cisco ISE Radius CoA = Enabled SSID mode = Bridge mode VLAN Tagging = 10 (ISE Override) AdP Group = 10:Corp Radius override = Enabled Mandatory DHCP = Enabled Layer 2 isolation = Disabled Allow Clients access LAN = Allow Traffic Shaping = Enabled with default settings	Cisco ISE Authentication and posture checks (172.31.16.32/1812)	Layer 2 Isolation = Disabled Allow Access to LAN = Enabled Per-Client Bandwidth Limit = 50Mbps Per-SSID Bandwidth Limit = Unlimited Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34) All Video and Music - AF21 (DSCP 18)
Acme BYOD	All APs	Association = Enterprise with my Radius server Encryption = WPA2 only 802.11w = Enabled Splash Page = Cisco ISE SSID mode = Bridge mode VLAN Tagging = 20 AdP Group = 20:BYOD Radius override = Disabled Mandatory DHCP = Enabled Layer 2 isolation = Disabled Allow Clients access LAN = Allow	Cisco ISE Authentication (via Azure AD) and posture checks. Dynamic GP assignment (Radius attribute = Airospace-ACLNAME)	Layer 2 Isolation = Disabled Allow Access to LAN = Enabled Per-Client Bandwidth Limit = 50Mbps Per-SSID Bandwidth Limit = Unlimited Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34) All Video and Music - AF21 (DSCP 18)

SSID Name	Broadcast	Configuration	Notes	Firewall and Traffic Shaping
		Traffic Shaping = Enabled with default settings		
Guest	All APs	802.11w = Enabled Splash Page = Click-Through SSID mode = Bridge mode VLAN Tagging = 30 AdP Group = 30:Guest Radius override = Disabled Mandatory DHCP = Enabled Layer 2 isolation = Enabled Allow Clients access LAN = Deny Per SSID limit = 100Mbps Traffic Shaping = Enabled with default settings	Meraki Authentication	Layer 2 Isolation = Enabled Allow Access to LAN = Disabled Per-Client Bandwidth Limit = 5Mbps Per-SSID Bandwidth Limit = 100Mbps Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34) All Video and Music - AF21 (DSCP 18)
Acme IoT	All APs	Association = identity PSK with Radius Encryption = WPA1 and WPA2 802.11r = Disabled 802.11w = Disabled Splash Page = None Radius CoA = Disabled SSID mode = Bridge mode VLAN Tagging = 40 AdP Group = 40:IoT Radius override = Disabled Mandatory DHCP = Enabled Allow Clients access LAN = Deny Per SSID limit = 10Mbps	Cisco ISE is queried at association time to obtain a passphrase for a device based on its MAC address. Dynamic GP assignment (Radius attribute Filter-Id)	Layer 2 Isolation = Disabled Allow Access to LAN = Enabled Per-Client Bandwidth Limit = 5Mbps Per-SSID Bandwidth Limit = Unlimited Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34) All Video and Music - AF21 (DSCP 18)

SSID Name	Broadcast	Configuration	Notes	Firewall and Traffic Shaping
		Traffic Shaping = Enabled with default settings		

Tech Tips:

- The above configuration is for illustration purposes only. Please configure your SSIDs based on your own requirements (mode, IP assignment, traffic shaping, etc.)
- Please note that Adaptive Policy on MR requires MR-ADV license. For more information about the requirements, please refer to this document.

Group policies

Group Policy Name	Purpose	Configuration	Notes
BYOD	For BYOD users to limit bandwidth per client and restrict access as desired. GP will be dynamically assigned based on Radius attribute	Name = BYOD Schedule = disabled Bandwidth = 10Mbps Firewall and Traffic Shaping = None Layer 3 FW = None Layer 7 FW = Block All Email VLAN = 20 Splash = N/A	

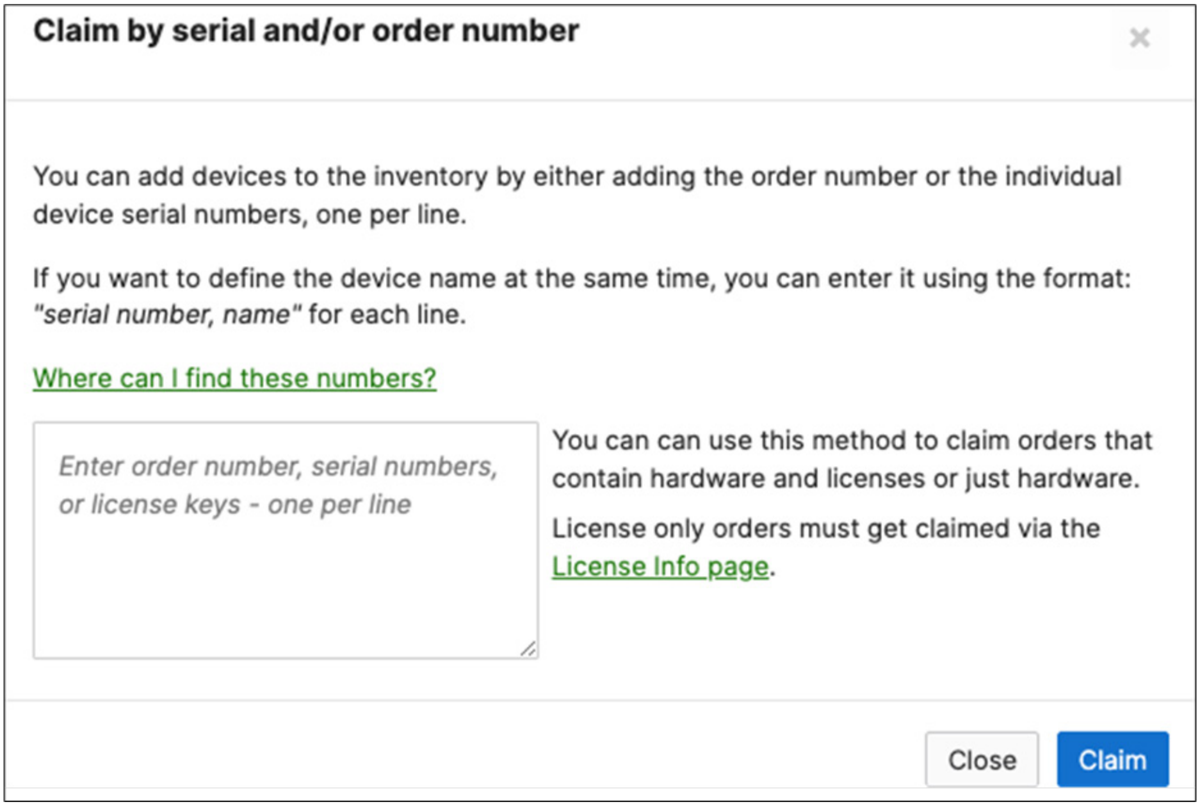
Tech Tip: The above Group Policies are for illustration purposes only. Please configure your Group Policies as required. To configure your Radius server to assign a dynamic Group Policy please refer to this article.

Configuration and implementation guidelines

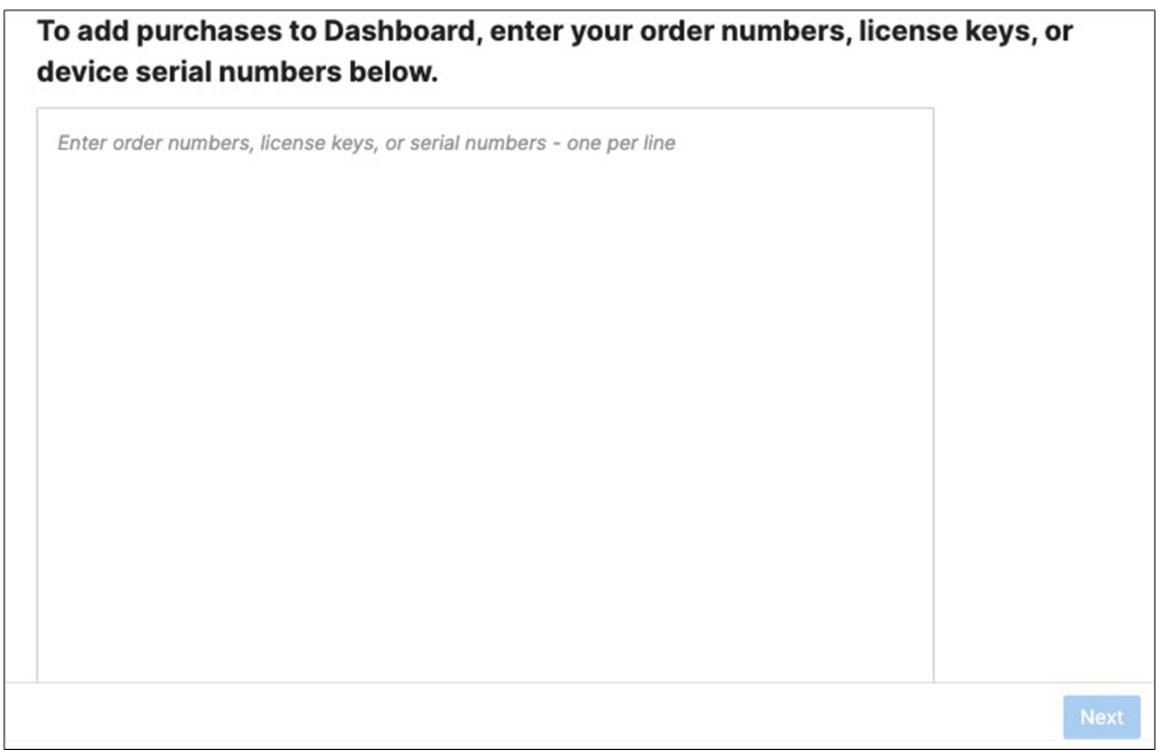
Notes:

- It is assumed that by this stage, Catalyst devices have been added to dashboard for either Monitoring (e.g. C9500) or Management (e.g. C9300). For more information, please refer to the above section.
- Before proceeding, please make sure that you have the appropriate licenses claimed into your dashboard account.

1. Login to your dashboard account (or create an account if you don't have one)
2. Navigate to **Organization > Configure > Inventory**
3. For Co-term license model, click on **Claim**. And for PDL, please click on **Add**



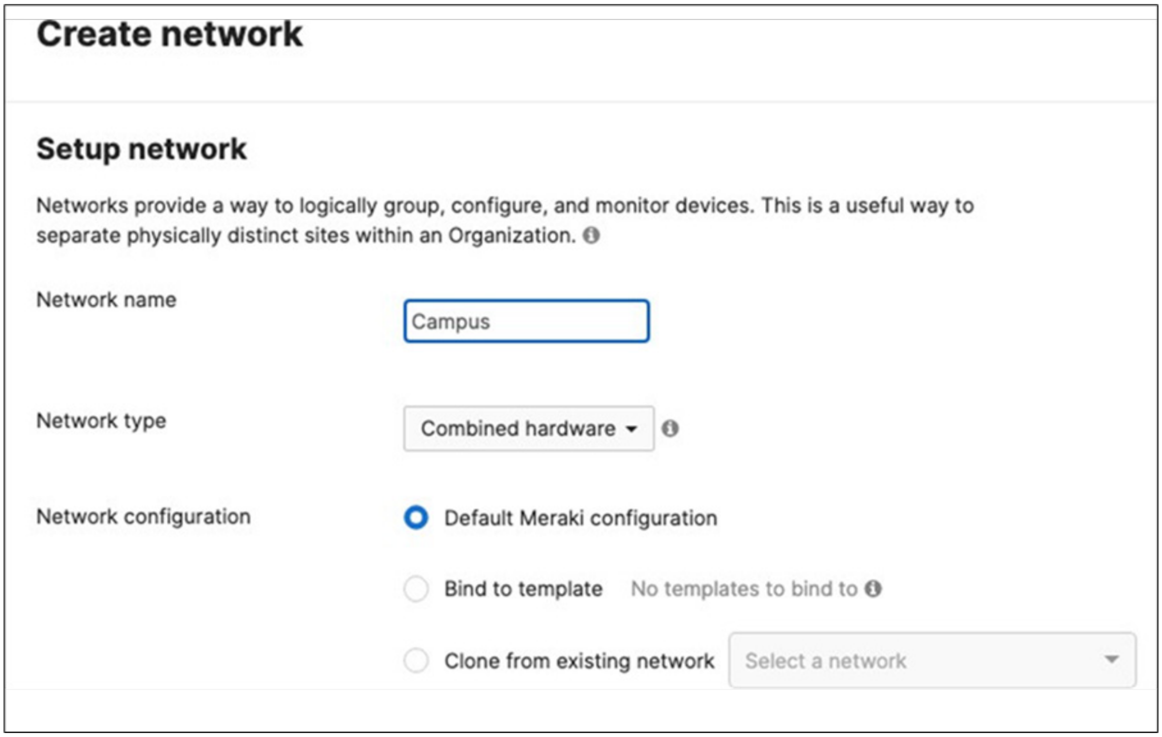
Claim by serial and/or order number
You can add devices to the inventory by either adding the order number or the individual device serial numbers, one per line.
If you want to define the device name at the same time, you can enter it using the format: "serial number, name" for each line.
Where can I find these numbers?
Enter order number, serial numbers, or license keys - one per line
You can can use this method to claim orders that contain hardware and licenses or just hardware.
License only orders must get claimed via the License Info page.
Close
Claim

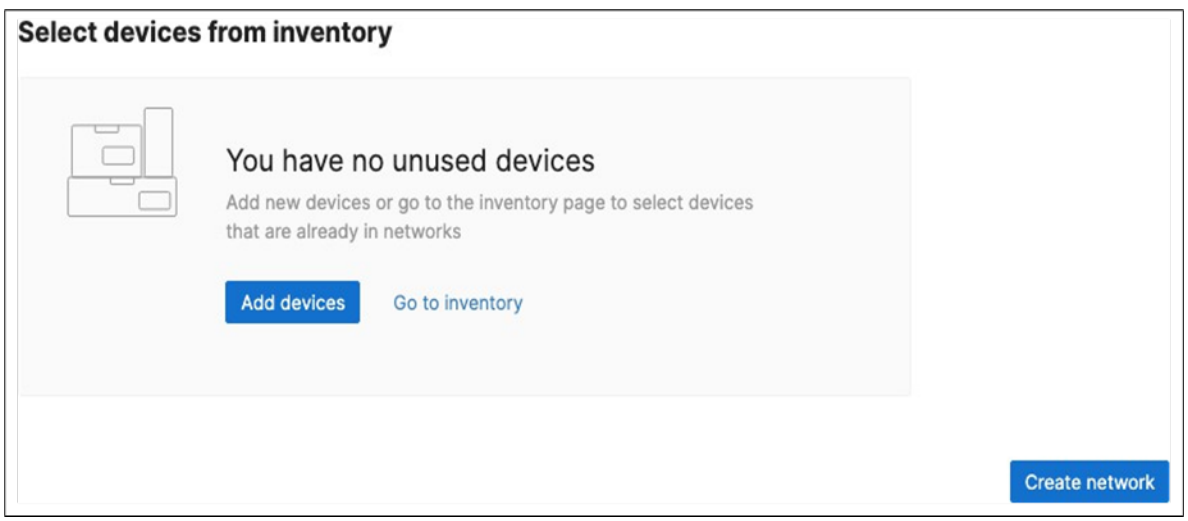


To add purchases to Dashboard, enter your order numbers, license keys, or device serial numbers below.
Enter order numbers, license keys, or serial numbers - one per line
Next

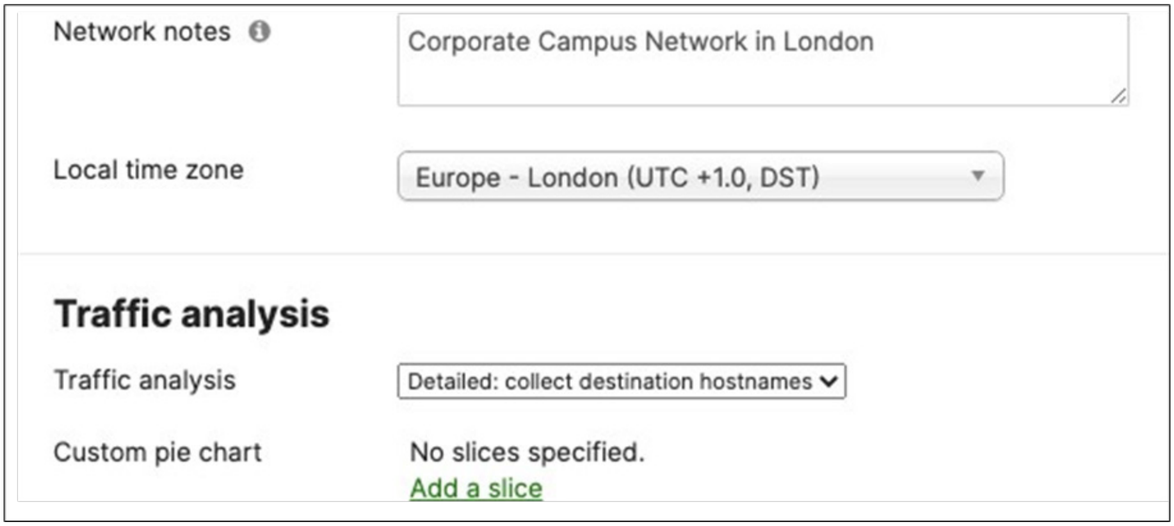
4. Enter the order and/or serial number(s) to claim the devices into your account. For PDL, click **Next** then please choose to add them to **Inventory** (Do not add them to a network)

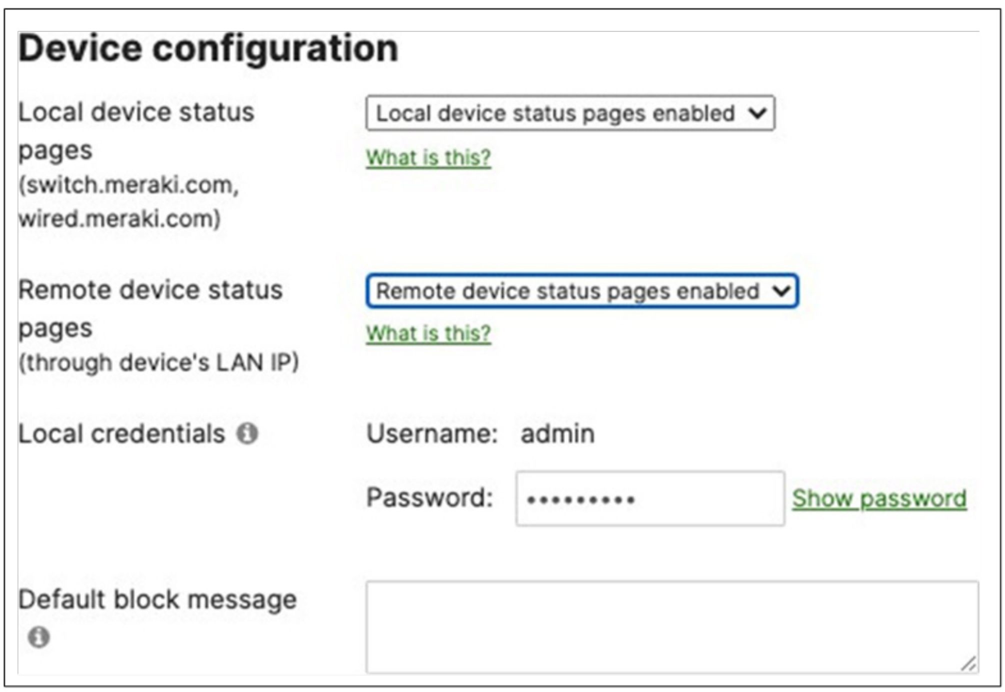
5. **Create a Dashboard Network**: Navigate to **Organization > Configure > Create network** to [create a network](#) for your Campus LAN (Or use an existing network if you already have one). If you are creating a new network, please choose "Combined" as this will facilitate a single topology diagram for your Campus LAN. Choose a name (e.g. Campus) and then click **Create network**

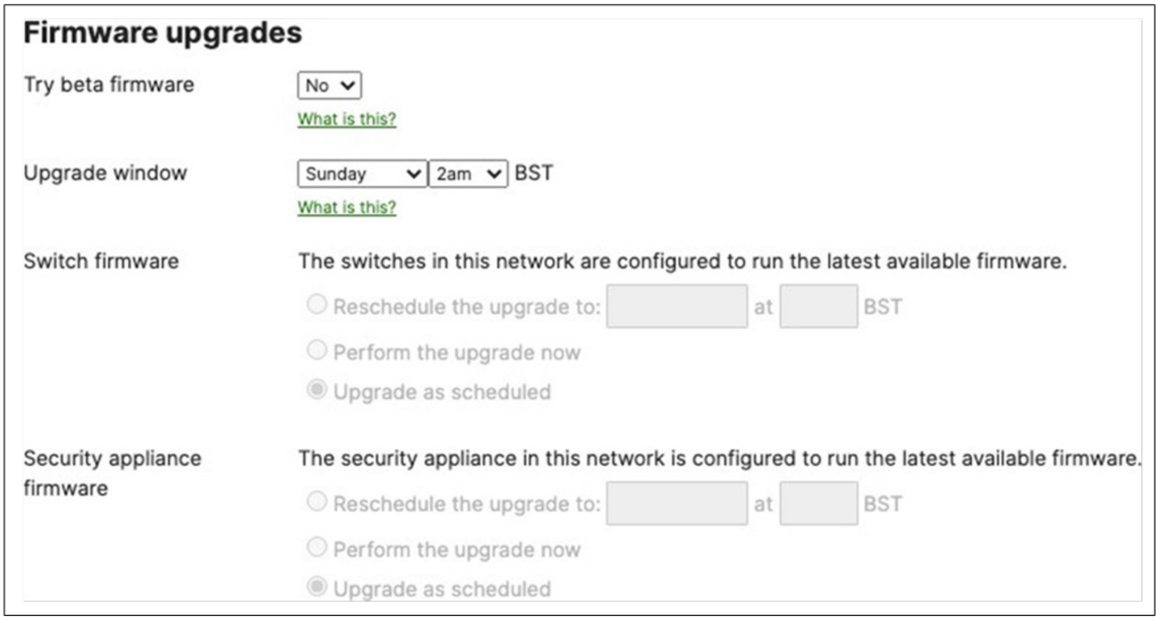




6. **Dashboard Network Settings:** Navigate to **Network-wide > Configure > General** and choose the settings for your network (e.g. Time zone, Traffic Analytics, firmware upgrade day/time, etc.)





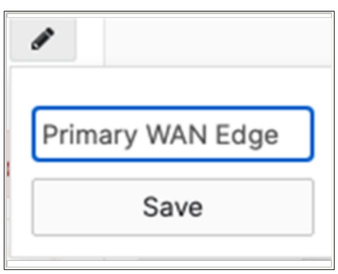


7. **Schedule Firmware Upgrade**: Navigate to **Organization > Monitor > Firmware upgrades** to select the [firmware settings] for your devices such that devices upgrade once they connect to dashboard. Select the device type then click on **Schedule upgrade.**

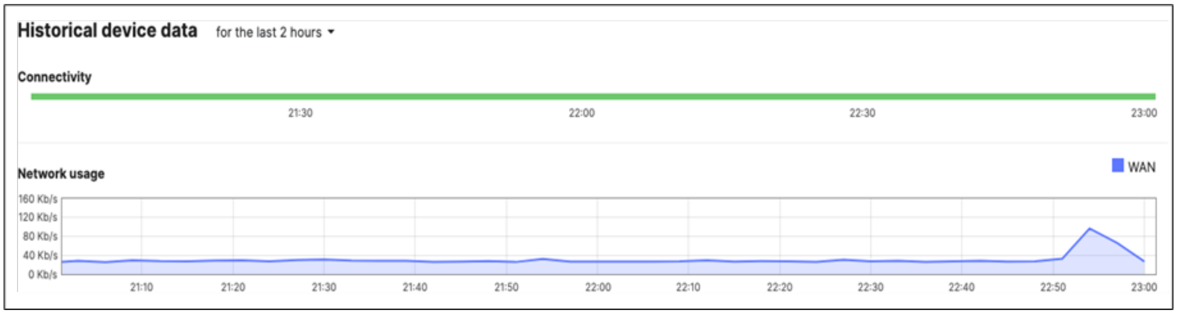
8. **Add Devices to a Dashboard Network**: Navigate to **Organization > Configure > Inventory**:

   - For Co-term licensing model, select the MS390 and C9300 switches and the Primary WAN Edge then click on **Add** then choose the Network Campus
   - For PDL licensing model, select the MS390 and C9300 switches and the Primary WAN Edge then click on **Change network assignment** and then choose the Network Campus
   - Please **DO NOT** add the Secondary WAN Edge device at this stage

9. **Rename MX Security Appliance**: Navigate to **Security and SD-WAN > Monitor > Appliance status** then click on the edit button to rename the MX to Primary WAN Edge then click on **Save.**



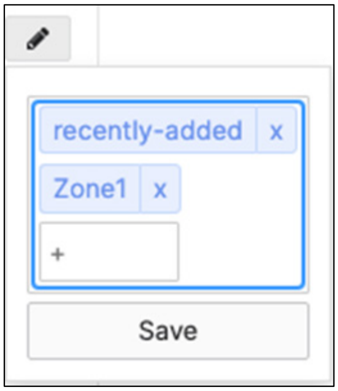
10. **MX Connectivity:** Plug in your WAN uplink(s) on the Primary WAN Edge MX then power it on and wait for it to come online on dashboard. This might take a few minutes as the MX will download its firmware and configuration. Navigate to **Security and SD-WAN > Monitor > Appliance status** and verify that the MX has come online and that its firmware and configuration is **up to date**.



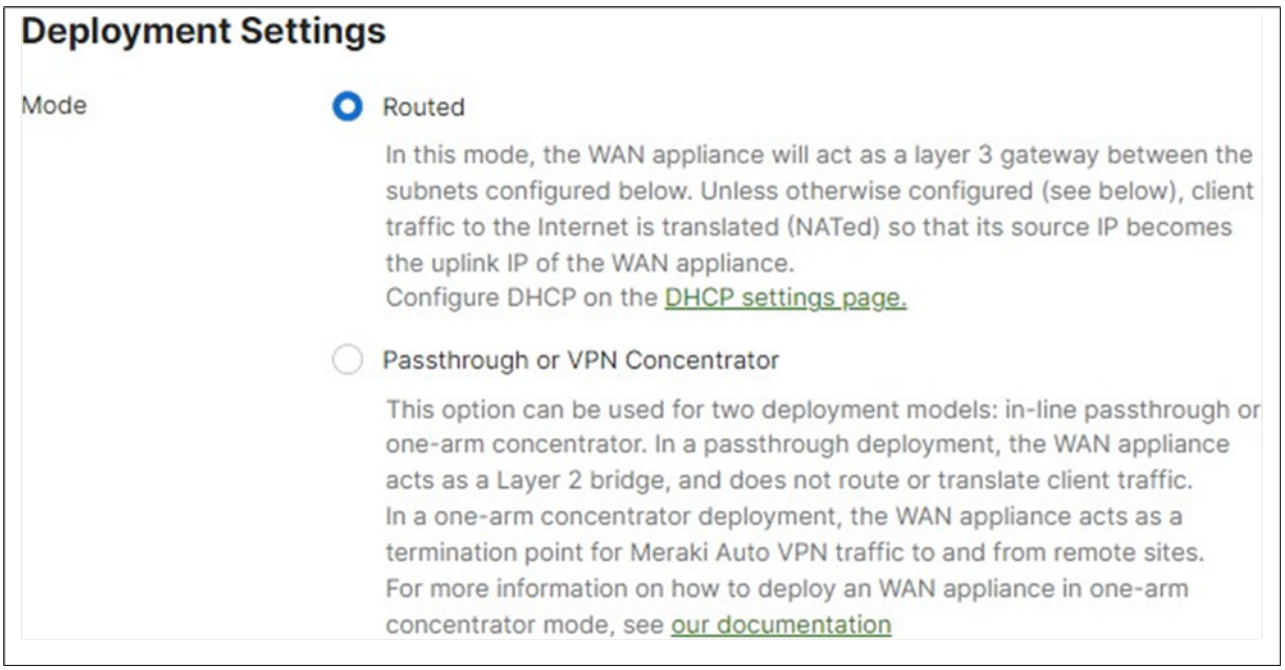
11. **Rename Access Switches:** Navigate to **Switching > Monitor > Switches** then click on each MS390 and C9300 switch and then click on the edit button on top of the page to rename it per the above table then click on **Save** such that all your switches have their designated names.

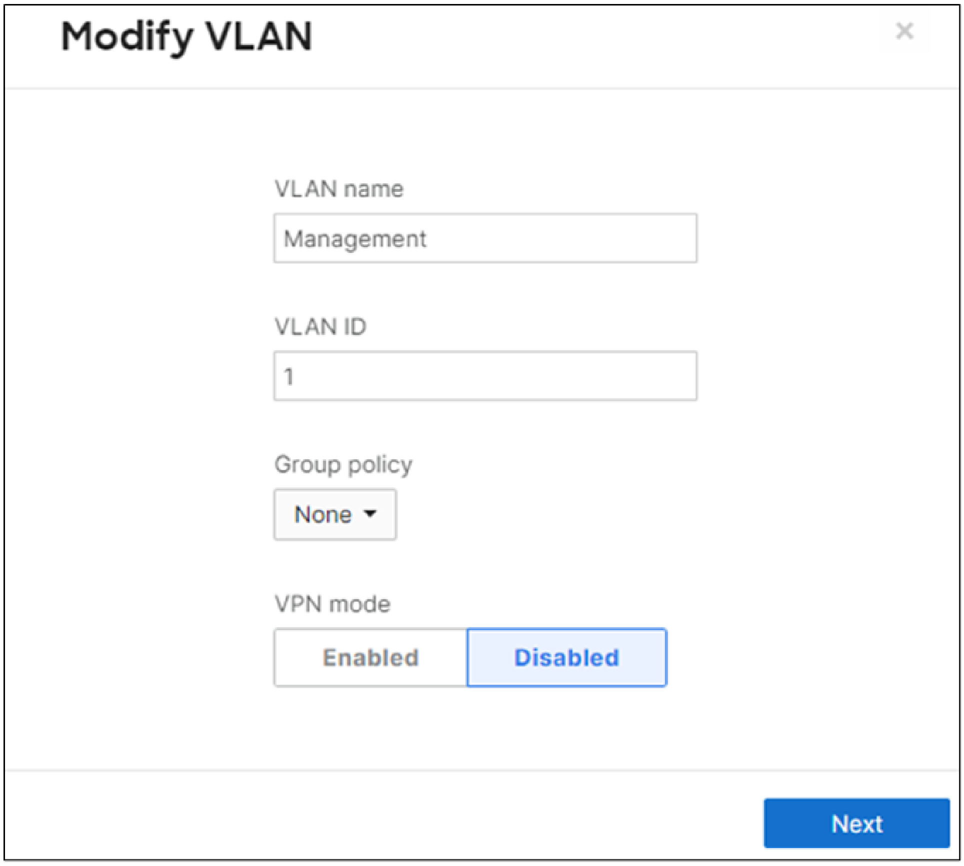
12. **Rename MR APs:** Navigate to **Wireless > Monitor > Access points** then click on each AP and then click on the edit button on top of the page to rename it per the above table then click on **Save** such that all your APs have their designated names.

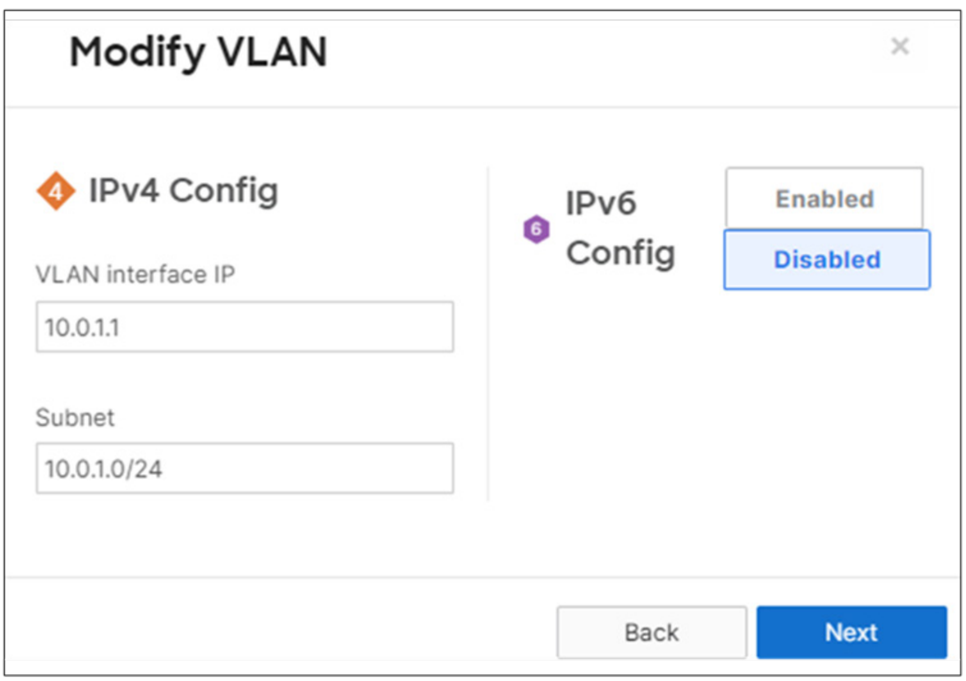
13. **MR AP Tags:** Navigate to **Wireless > Monitor >Access points** then click on each AP and then click on the edit button next to **TAGS** to add Tags to your AP per the above table then click on Save such that all your APs have their designated tags.

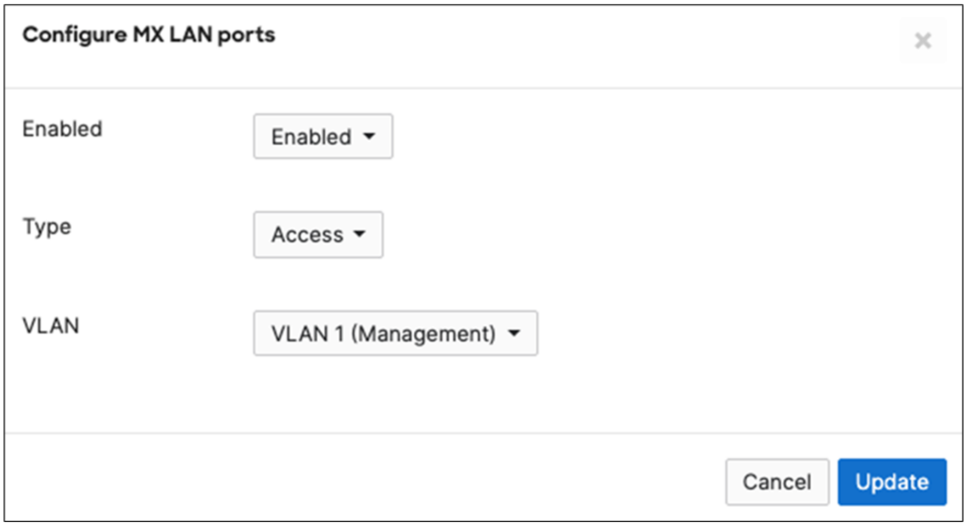


14. **MX Addressing and VLANs:** Navigate to **Security and SD-WAN > Configure > Addressing and VLANs**, and in the Deployment Settings menu select **Routed** mode. Further down the page on the Routing menu, click on **VLANs** then click on **Add VLAN** to add your management VLAN then click on **Create.** Then for the per-port VLAN settings, select your downlink ports (19 and 20) and click on **Edit** and configure them as access with VLAN 1 and click on **Update.** Finally, click on **Save** at the bottom of the page.

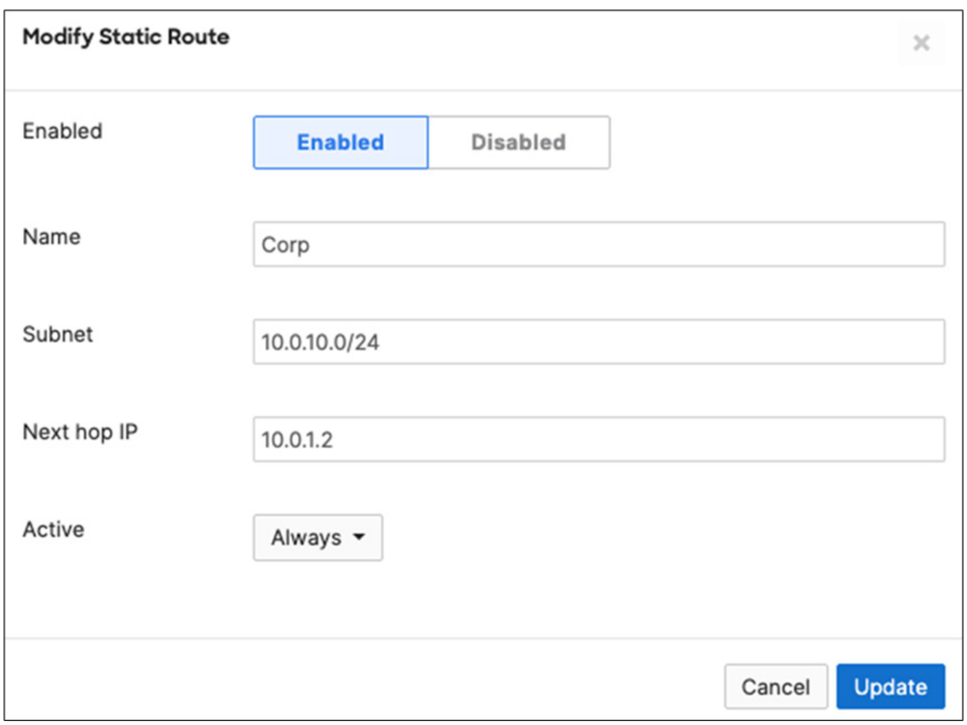



Modify VLAN
VLAN name
Management
VLAN ID
1
Group policy
None
VPN mode
Enabled
Disabled
Next


Modify VLAN
IPv4 Config
VLAN interface IP
10.0.1.1
Subnet
10.0.1.0/24
IPv6 Config
Enabled
Disabled
Back
Next



15. **Campus LAN Static Routes:** Create Static Routes for your Campus network by navigating further down the page to Static routes then click on **Add Static Route.** Start by adding your Corporate LAN subnet then click on **Update** and then add static routes to all other subnets (e.g. BYOD, Guest and IoT). Finally, click on **Save** at the bottom of the page. (*The Next hop IP that you have used here will be used to create a fixed assignment for the Core Stack later in DHCP settings*).

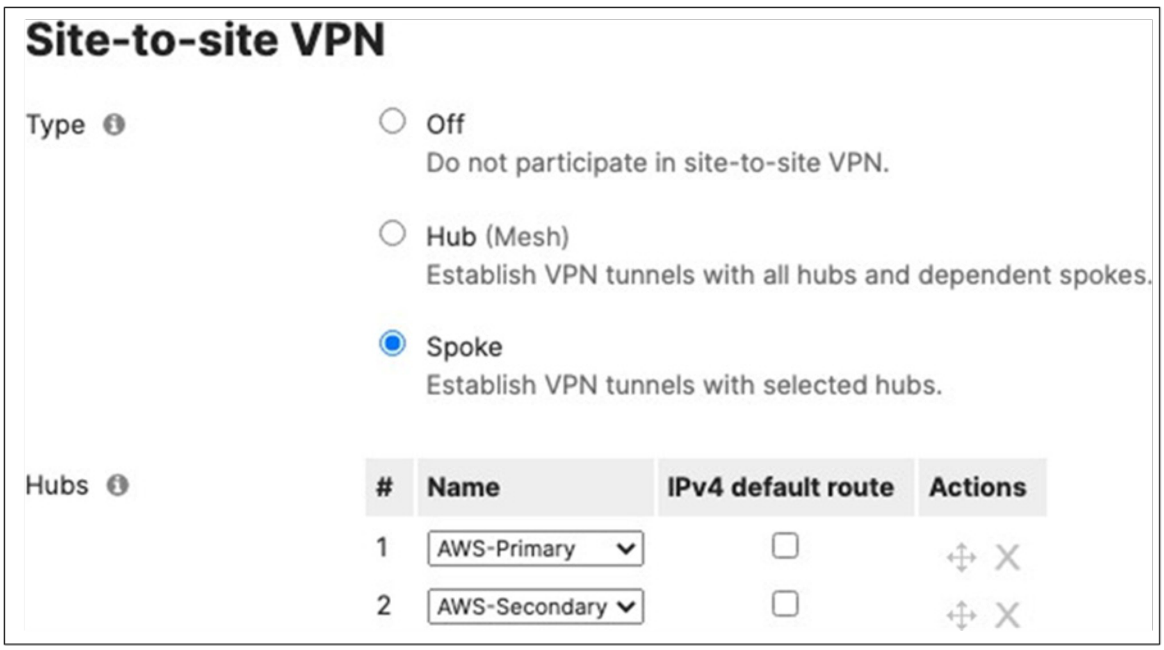


Delete | Add Static Route

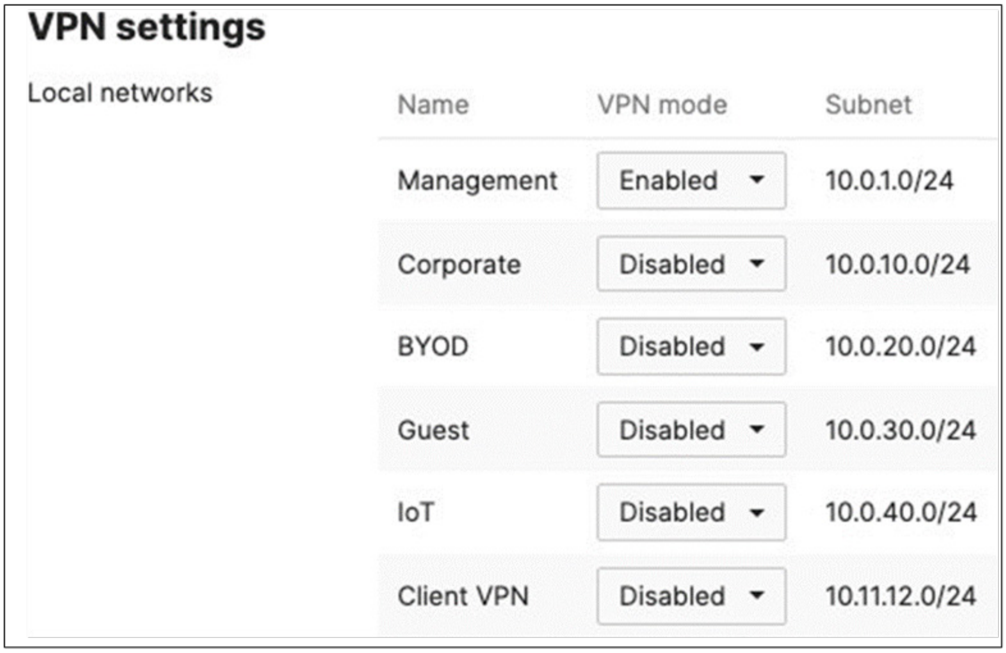
	Enabled	Name	Subnet ▲	Gateway IP	Conditions
☐	●	Corp	10.0.10.0/24	10.0.1.2	always
☐	●	BYOD	10.0.20.0/24	10.0.1.2	always
☐	●	Guest	10.0.30.0/24	10.0.1.2	always
☐	●	IoT	10.0.40.0/24	10.0.1.2	always

16. *Optional* - If you are accessing any resources over Meraki SD-WAN, please navigate to **Security and SD-WAN > Configure > Site-to-site VPN** and enable VPN based on your topology and traffic flow requirements. (In this case we will configure this Campus as **Spoke** with **Split Tunneling**)

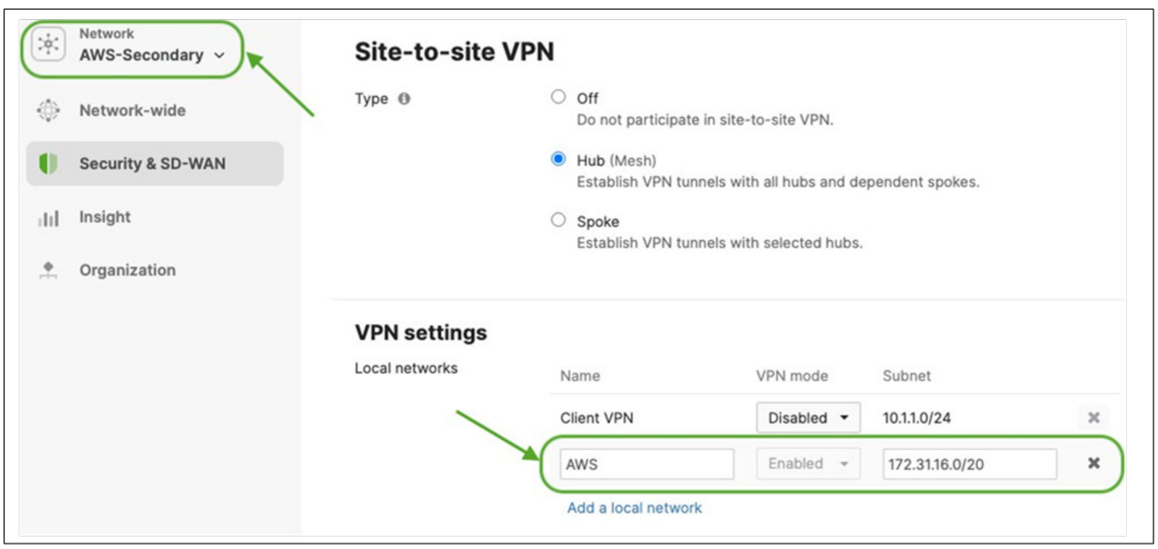
    - Choose Type: **Spoke** then click on **Add a hub** and select your hub site where you need access to resources via VPN. You can also add multiple hubs for resiliency. To choose Split Tunneling, please leave the box next to the Hub *unticked* as shown below.



    - Under **VPN Settings**, choose which subnet to be **Enabled** in VPN (*e.g. Management VLAN will be required for Radius authentication purposes as the MR/MS390/C9300 devices will reach out to Cisco ISE using their management IP*). Any Subnet that needs to access resources via VPN must be Enabled otherwise keep it as Disabled.



- Finally, click on **Save** at the bottom of the page
- On the Hub site, please make sure to advertise the subnets that are required to be reachable via VPN. Navigate to **Security and SD-WAN > Configure > Site-to-site VPN** then add a local network then click **Save** at the bottom of the page (*Please make sure that you are configuring this on the Hub's dashboard network*)



17. *Optional* - Verify that your VPN has come up by selecting your Campus LAN dashboard network from the Top-Left Network drop down list and then navigate to **Security and SD-WAN > Monitor >VPN status** then check the status of your VPN peers. Next, navigate to **Security and SD-WAN > Monitor > Route table** and check the status of your remote subnets that are reachable via VPN. You can also verify connectivity by pinging a remote subnet(e.g. 172.31.16.32 which is Cisco ISE) by navigating to **Security and SD-WAN > Monitor > Appliance status** then click on **Tools** and ping the specified IP address (*Please note that the MX will choose the highest IP participating in VPN by default as the source*).

2 site-to-site peers | 1 exported subnet | 0 Non-Meraki peers

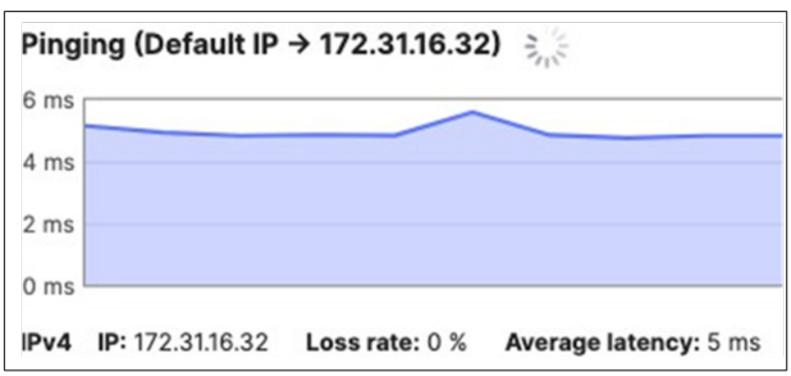
Status	Description	Usage	Latency (avg)	Connectivity ▲
●	AWS-Primary	None	4 ms	
●	AWS-Secondary	2.5 KB	4 ms	

2 total

Route table

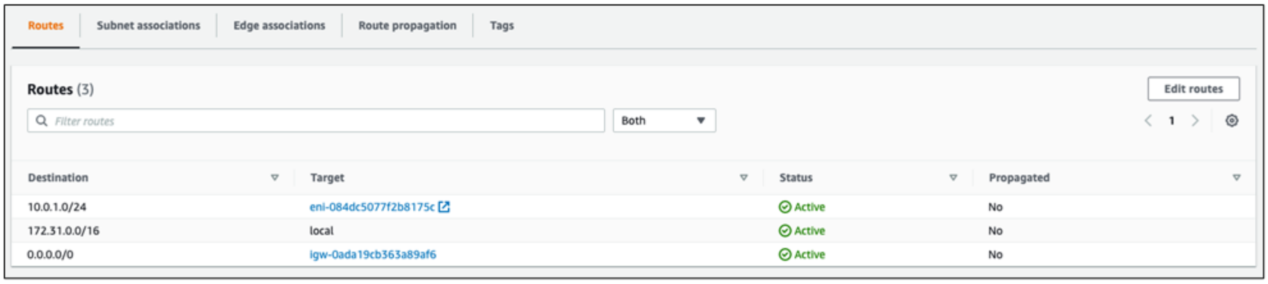
SUBNET: Search by subnet | NAME: Search by name | IP VERSION: All | TYPE: All | Show more filters

	Subnet/Prefix	Name	Version	Type	Next hop
●	10.0.1.0/24	Management	4	Local VLAN	—
●	10.0.40.0/24	IoT	4	Static Route	10.0.1.113
●	10.0.30.0/24	Guest	4	Static Route	10.0.1.113
●	10.0.20.0/24	BYOD	4	Static Route	10.0.1.113
●	10.0.10.0/24	Corporate	4	Static Route	10.0.1.113
●	172.31.16.0/20	AWS-Secondary: AWS	4	Meraki VPN: VLAN	Peer: AWS-Secondary
●	0.0.0.0/0	Default	4	Default WAN route	WAN uplink



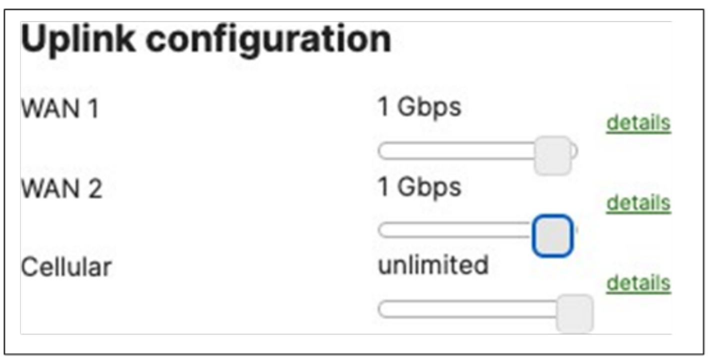
Please note that in order to ping a remote subnet, you must either have BGP enabled or have static routes at the far-end pointing back to the Campus LAN local subnets.

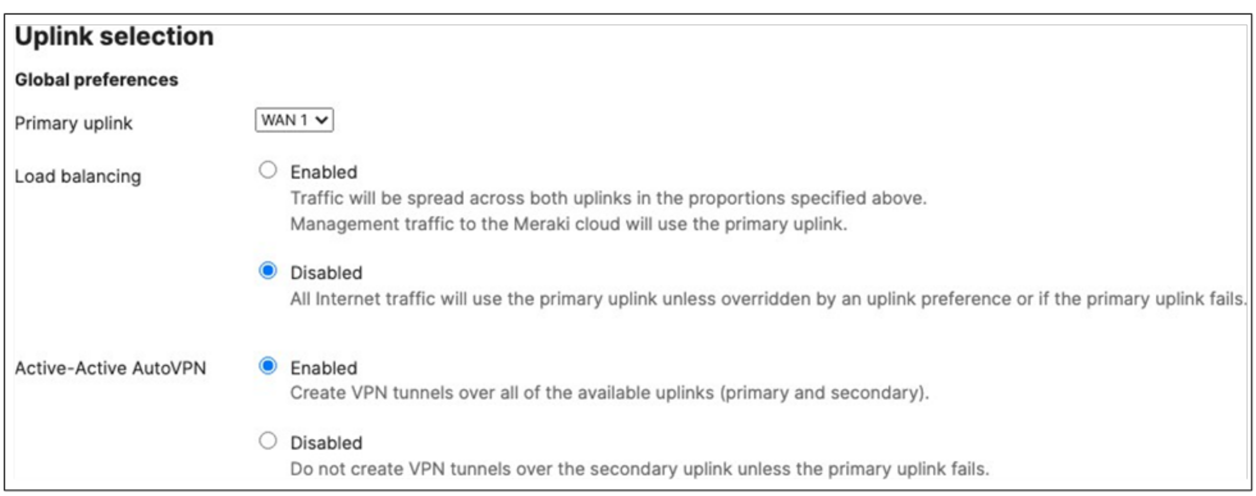
In this example, the VPC in AWS has been configured with a Route Entry to route 10.0.1.0/24 via the vMX deployed in AWS that has a VPN tunnel back to the Campus LAN site.

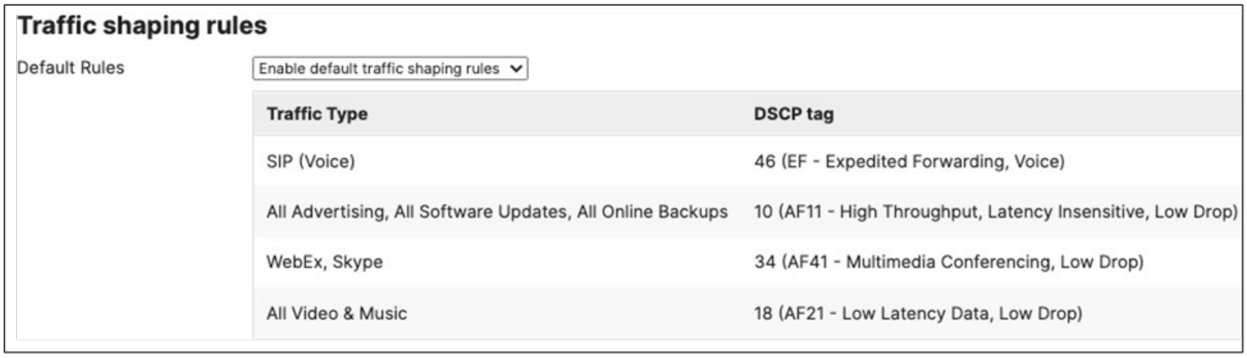


If the remote VPN peer (e.g. AWS) is configured in Routed mode, the static route is not required since traffic will always be NAT'd to a local reachable IP address.

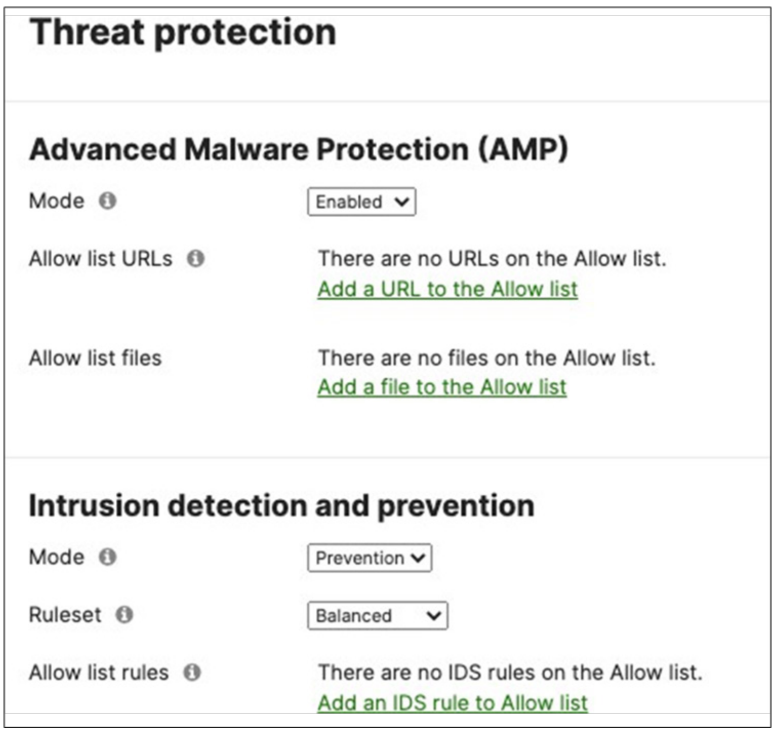
18. **SD-WAN and Traffic Shaping Configuration:** To configure Traffic Shaping settings for your Campus LAN site. Navigate to **Security and SD-WAN > Configure > SD-WAN and Traffic Shaping** to configure your preferred settings. For the purpose of this CVD, the **default traffic shaping rules** will be used to mark traffic with a DSCP tag without policing egress traffic (except for traffic marked with DSCP 46) or applying any traffic limits. (*Please adjust these settings based on your requirements such as traffic limits or priority queue values. For more information about traffic shaping settings on the MX devices, please refer to the following article*).





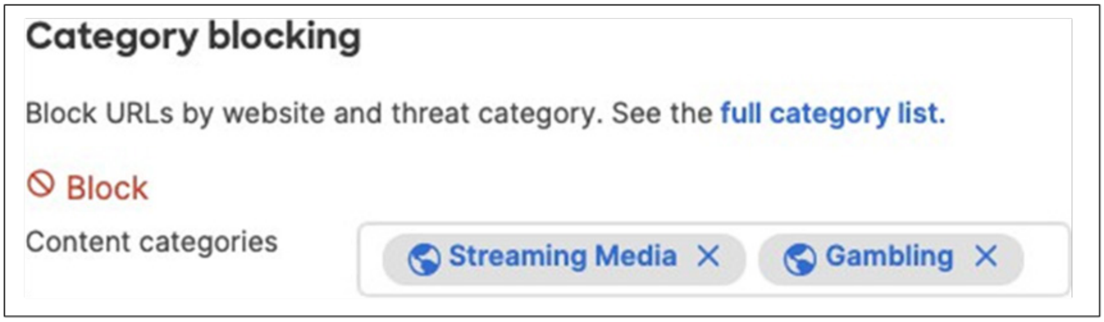


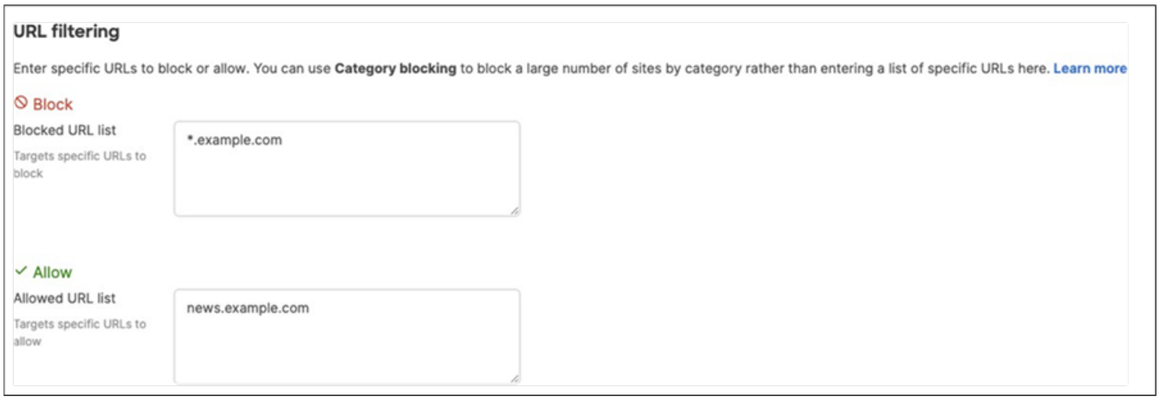
19. *Optional* - Configure [Threat Protection]() (Requires Advanced License or above) for your Campus LAN site. Navigate to **Security and SD-WAN > Configure > Threat Protection** and choose the settings that meet your site requirements. Please see the following configuration example:



20. Click on **Save** at the bottom of the page.

21. *Optional* - Configure [Content Filtering]() Settings (Requires Advanced License or above) for your Campus LAN site. Navigate to **Security and SD-WAN > Configure > Content filtering** and choose the settings that meet your site requirements. Please see the following configuration example:





22. Click on **Save** at the bottom of the page.

23. **Core Switch Uplinks:** On the Catalyst 9500 core switches, Connect their uplinks to the Primary WAN Edge MX and power them both on.

24. **Core Switch Network Access:** Connect to first C9500 switch via console and configure it with the following commands:

```
Switch>en
Switch#conft
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#hostname 9500-01
9500-01(config)#ip domain name meraki-cvd.local
9500-01(config)#cdp run
9500-01(config)#lldp run
9500-01(config)#stackwise
Please reload the switch for Stackwise Virtual configuration to take effect
Upon reboot, the config will be part of running config but not part of start-up
config. 9500-01(config-stackwise-virtual)#domain 1
9500-01(config)#exit
9500-01(config)#interface Twe1/0/1
9500-01(config-if)#switchport mode access
9500-01(config-if)#switchport access vlan 1
9500-01(config-if)#no shut
```

```
9500-01(config-if)#exit
9500-01(config)#interface Twe1/0/2
9500-01(config-if)#switchport mode access
9500-01(config-if)#switchport access vlan 1
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface vlan 1
9500-01(config-if)#ip address dhcp
9500-01(config-if)#no shut
9500-01(config-if)#end
9500-01#
9500-01#sh ip int brief
Interface             IP-Address   OK? Method Status      Protocol
Vlan1                 10.0.1.110   YES DHCP up            up
GigabitEthernet0/0    unassigned   YES NVRAM down         down
TwentyFiveGigE1/0/1   unassigned   YES unset              up
TwentyFiveGigE1/0/2   unassigned   YES unset              up
9500-01#ping 8.8.8.8
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 8.8.8.8, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/5 ms
9500-01#ping cisco.com
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 72.163.4.185, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 109/109/109 ms
9500-01#switch 1 renumber 1
9500-01#switch priority 5
9500-01#wr mem
Building configuration...
[OK]
```

25. **Core Switch Network Access:** Connect to the second C9500 switch via console and configure it with the following commands:

```
Switch>en
Switch#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#hostname 9500-02
9500-02(config)#ip domain name meraki-cvd.local
9500-01(config)#cdp run
9500-01(config)#lldp run
9500-02(config)#stackwise
Please reload the switch for Stackwise Virtual configuration to take effect
Upon reboot, the config will be part of running config but not part of start-up
config. 9500-02(config-stackwise-virtual)#domain 1
9500-02(config)#exit
9500-02(config)#interface Twe1/0/1
9500-01(config-if)#switchport mode access
9500-02(config-if)#switchport access vlan 1
9500-02(config-if)#no shut
9500-02(config-if)#exit
9500-02(config)#interface Twe1/0/2
9500-01(config-if)#switchport mode access
9500-02(config-if)#switchport access vlan 1
9500-02(config-if)#no shut
9500-02(config-if)#exit
9500-02(config)#interface vlan 1
9500-02(config-if)#ip address dhcp
9500-02(config-if)#no shut
9500-02(config-if)#end
9500-02#
9500-02#sh ip int brief
Interface              IP-Address      OK? Method Status      Protocol
Vlan1                  10.0.1.111    YES DHCP up              up
GigabitEthernet0/0     unassigned    YES NVRAM down           down
TwentyFiveGigE1/0/1    unassigned    YES unset up             up
TwentyFiveGigE1/0/2    unassigned    YES unset up             up
9500-02#ping 8.8.8.8
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 8.8.8.8, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/5 ms
9500-02#ping cisco.com
```

```
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 72.163.4.185, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 109/109/109 ms
9500-02#switch 1 renumber 2
9500-02#switch priority 1
9500-02#wr mem
Building configuration...
[OK]
```

26. **SVL Configuration**: Now that both C9500 switches have access to the network, proceed to configure the Stackwise Virtual Links per the port list provided above (*In this case with using two ports as part of the SVL providing a total stacking bandwidth of 80 Gbps*).

```
9500-01(config)#interface HundredGigE1/0/25
9500-01(config-if)#stackwise-virtual link 1
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface HundredGigE1/0/26
9500-01(config-if)#stackwise-virtual link 1
9500-01(config-if)#no shut
9500-01(config-if)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#reload
Proceed with reload? [confirm]
```

```
9500-02(config)#interface HundredGigE1/0/25
9500-02(config-if)#stackwise-virtual link 1
9500-02(config-if)#no shut
9500-02(config-if)#exit
9500-02(config)#interface HundredGigE1/0/26
9500-02(config-if)#stackwise-virtual link 1
9500-02(config-if)#no shut
9500-02(config-if)#end
9500-02#wr mem
Building configuration...
[OK]
9500-02#reload
Proceed with reload? [confirm]
```

27. **Connect Stacking Cables:** Whilst the C9500 switches are reloading, connect the stacking cables on both switches.

28. **Verify Stackwise Configuration:** Please wait for about **10 minutes** for the switches to come back up and initialize the stack. Then, connect to the 9500-01 (*Stack Master*) via console to verify that the stack is operational. The stackwise-virtual link should be **U** (Up) and **R** (Ready).

```
9500-01#show stackwise-virtual
Stackwise Virtual Configuration:
----------------------------
Stackwise Virtual : Enabled
Domain Number : 1

Switch Stackwise Virtual Link Ports
-----------------------------
1    1      HundredGigE1/0/25
           HundredGigE1/0/26
2    1      HundredGigE2/0/25
           HundredGigE2/0/26
9500-01#
9500-01#show stackwise-virtual link
Stackwise Virtual Link(SVL) Information:
-----------------------------
Flags:
-----
Link Status
-----------
U-Up D-Down
Protocol Status
-----------
S-Suspended P-Pending E-Error T-Timeout R-Ready
-----------------------------
Switch SVL Ports     Link-Status Protocol-Status
------------------------------------------------
1     1   HundredGigE1/0/25      U        R
          HundredGigE1/0/26      U        R
2     1   HundredGigE2/0/25      U        R
          HundredGigE2/0/26      U        R

9500-01#
9500-01#show stackwise-virtual bandwidth
```

```
Switch Bandwidth
----------------
1    80G
2    80G

9500-01#
9500-01#sh switch
Switch/Stack Mac Address : b0c5.3c60.fba0 - Local Mac Address
Mac persistency wait time: Indefinite
                         H/W Current
Switch#      Role       Mac Address      Priority      Version     State
*1          Active     b0c5.3c60.fba0      5            V02        Ready
2          Standby    40b5.c111.01e0       1             V02       Ready

9500-01#
```

29. *Optional* - Attach and configure stackwise-virtual dual-active-detection: DAD is a feature used to avoid a dual- active situation within a stack of switches. It will rely on a direct attachment link between the two switches to send hello packets and determine if the active switch is responding or not. Please note that DAD **cannot** be applied to any SVL links and has to be a dedicated interface. For the purpose of this CVD, interface HundredGigE1/0/27 and HundredGigE2/0/27 will be used for enabling DAD between the two C9500 switches.

```
9500-01#configure terminal
9500-01(config)#interface HundredGigE1/0/27
9500-01(config-if)#stackwise-virtual dual-active-detection
WARNING: All the extraneous configurations will be removed for HundredGigE1/0/27 on reboot.
INFO: Upon reboot, the config will be part of running config but not part of start-up config.
9500-01(config-if)#interface HundredGigE2/0/27
9500-01(config-if)#stackwise-virtual dual-active-detection
WARNING: All the extraneous configurations will be removed for HundredGigE1/0/27 on reboot.
INFO: Upon reboot, the config will be part of running config but not part of start-up config.
9500-01(config-if)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#reload
Reload command is being issued on Active unit, this will reload the whole stack
Proceed with reload? [confirm]Connection to 10.0.1.2 closed by remote host.
```

```
Connection to 10.0.1.2 closed.
>>
9500-01#sh stackwise-virtual dual-active-detection
In dual-active recovery mode: No
Recovery Reload: Enabled

Dual-Active-Detection Configuration:
-----------------------------------
Switch Dad port Status
-----------------------------------
1  HundredGigE1/0/27   up
2  HundredGigE2/0/27   up

9500-01#
```

30. Configure Multiple Spanning Tree Protocol (802.1s). Connect to the 9500-01 (*Stack Master*) via console and use the following commands:

```
9500-01(config)#spanning-tree mst configuration
9500-01(config-mst)#instance 0 vlan 1
9500-01(config-mst)#name region1
9500-01(config-mst)#revision 1
9500-01(config-mst)#exit
9500-01(config)#spanning-tree mode mst
9500-01(config)#spanning-tree mst 0 priority 4096
9500-01(config)#exit
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

31. Verify Spanning Tree Configuration (*Please note that interface Twe2/0/1 will be in STP blocking state due to the fact that both uplinks are connected to the same MX edge device at this stage*).

```
9500-01#show spanning-tree
MST0
Spanning tree enabled protocol mstp
Root ID     Priority     4096
            Address     b0c5.3c60.fba0
            This bridge is the root
            Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Bridge ID Priority      4096       (priority 4096 sys-id-ext 0)
         Address          b0c5.3c60.fba0
         Hello Time       2 sec Max Age 20 sec Forward Delay 15 sec

Interface    Role Sts Cost     Prio.Nbr Type
-----------------------------------------------------
Twe1/0/1     Desg FWD 2000     128.193 P2p
Twe2/0/1     Back BLK 2000     128.385 P2p

9500-01#
```

32. Configure STP Root Guard and UDLD on the Core Stack Downlinks:

```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#int Twe1/0/23
9500-01(config-if)#spanning-tree guard root
9500-01(config-if)#udld port aggressive
9500-01(config-if)#int Twe1/0/24
9500-01(config-if)#spanning-tree guard root
9500-01(config-if)#udld port aggressive
9500-01(config-if)#int Twe2/0/23
9500-01(config-if)#spanning-tree guard root
9500-01(config-if)#udld port aggressive
9500-01(config-if)#int Twe2/0/24
9500-01(config-if)#spanning-tree guard root
9500-01(config-if)#udld port aggressive
9500-01(config-if)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

33. *Optional* - **STP Hygiene:** It is recommended to configure **STP Root Guard** on all C9500 Core Stack downlinks to avoid any new introduced downstream switches from claiming root bridge status.

```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#define interface-range stp-protect TwentyFiveGigE1/0/3 - 22
9500-01(config)#interface range macro stp-protect
9500-01(config-if-range)#spanning-tree guard root
9500-01(config-if-range)#exit
9500-01(config)#define interface-range stp-protect2 TwentyFiveGigE2/0/3 - 22
9500-01(config)#interface range macro stp-protect2
9500-01(config-if-range)#spanning-tree guard root
9500-01(config-if)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

34. *Optional* - **STP Hygiene:** It is recommended to configure **STP Loop Guard** on all C9500 Core Stack **un-used stacking links**.

```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#interface HundredGigE1/0/27
9500-01(config-if)#spanning-tree guard loop
9500-01(config-if-range)#exit
9500-01(config)#interface HundredGigE1/0/28
9500-01(config-if)#spanning-tree guard loop
9500-01(config-if)#exit
9500-01(config)#interface HundredGigE2/0/27
9500-01(config-if)#spanning-tree guard loop
9500-01(config-if-range)#exit
9500-01(config)#interface HundredGigE2/0/28
9500-01(config-if)#spanning-tree guard loop
9500-01(config-if)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

35. Configure **SVIs** for your Campus LAN on the Core Stack:

```
9500-01(config)#interface vlan 10
9500-01(config-if)#ip address 10.0.10.1 255.255.255.0
9500-01(config-if)#no shut
9500-01(config-if)#interface vlan 20
9500-01(config-if)#ip address 10.0.20.1 255.255.255.0
9500-01(config-if)#no shut
9500-01(config-if)#interface vlan 30
9500-01(config-if)#ip address 10.0.30.1 255.255.255.0
9500-01(config-if)#no shut
9500-01(config-if)#interface vlan 40
9500-01(config-if)#ip address 10.0.40.1 255.255.255.0
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#ip dhcp pool vlan10
9500-01(dhcp-config)#network 10.0.10.0 /24
9500-01(dhcp-config)#default-router 10.0.10.1
9500-01(dhcp-config)#dns-server 208.67.222.222 208.67.220.220
9500-01(dhcp-config)#ip dhcp pool vlan20
9500-01(dhcp-config)#network 10.0.20.0 /24
9500-01(dhcp-config)#default-router 10.0.20.1
9500-01(dhcp-config)#dns-server 208.67.222.222 208.67.220.220
9500-01(dhcp-config)#ip dhcp pool vlan30
9500-01(dhcp-config)#network 10.0.30.0 /24
9500-01(dhcp-config)#default-router 10.0.30.1
9500-01(dhcp-config)#dns-server 208.67.222.222 208.67.220.220
9500-01(dhcp-config)#ip dhcp pool vlan40
9500-01(dhcp-config)#network 10.0.40.0 /24
9500-01(dhcp-config)#default-router 10.0.40.1
9500-01(dhcp-config)#dns-server 208.67.222.222 208.67.220.220
9500-01(dhcp-config)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

36. Verify your DHCP pool configuration:

```
9500-01#sh ip dhcp pool

Pool vlan10 :
Utilization mark (high/low) : 100 / 0
Subnet size (first/next)    : 0 / 0
Total addresses               254
Leased addresses                0
Excluded addresses              0
Pending event               : none
1 subnet is currently in the pool :
Current index    IP address range                    Leased/Excluded/Total
10.0.20.1         10.0.20.1          - 10.0.20.254   0 / 0 / 254

Pool vlan20 :
Utilization mark (high/low) : 100 / 0
Subnet size (first/next)    : 0 / 0
Total addresses                 254
Leased addresses                  0
Excluded addresses                0
Pending event               : none
1 subnet is currently in the pool :
Current index    IP address range                    Leased/Excluded/Total
10.0.20.1         10.0.20.1      - 10.0.20.254       0 / 0 / 254

Pool vlan30 :
Utilization mark (high/low) : 100 / 0
Subnet size (first/next)    : 0 / 0
Total addresses                 254
Leased addresses                  0
Excluded addresses                0
Pending event               : none
1 subnet is currently in the pool :
Current index    IP address range                    Leased/Excluded/Total
10.0.30.1         10.0.30.1 -     10.0.30.254        0 / 0 / 254

Pool vlan40 :
Utilization mark (high/low) : 100 / 0
Subnet size (first/next)    : 0 / 0
Total addresses                 254
Leased addresses                  0
```

```
Excluded addresses                0
Pending event                : none
1 subnet is currently in the pool :
Current index    IP address range                    Leased/Excluded/Total
10.0.40.1         10.0.40.1 - 10.0.40.254            0 / 0 / 254
9500-01#
```

37. Verify your SVI configuration:

```
9500-01#sh ip int brief | in Vlan
Vlan1      10.0.1.113       YES DHCP up       up
Vlan10     10.0.10.1        YES manual down   down
Vlan20     10.0.20.1        YES manual down   down
Vlan30     10.0.30.1        YES manual down   down
Vlan40     10.0.40.1        YES manual down   down
9500-01#
```

38. Configure **Layer 2 Switchports**, **SGTs** and **CST** (Cisco TrustSec) on your Core Stack interfaces. (*Please note that enforcement has been disabled on downlink ports allowing it to happen downstream*):

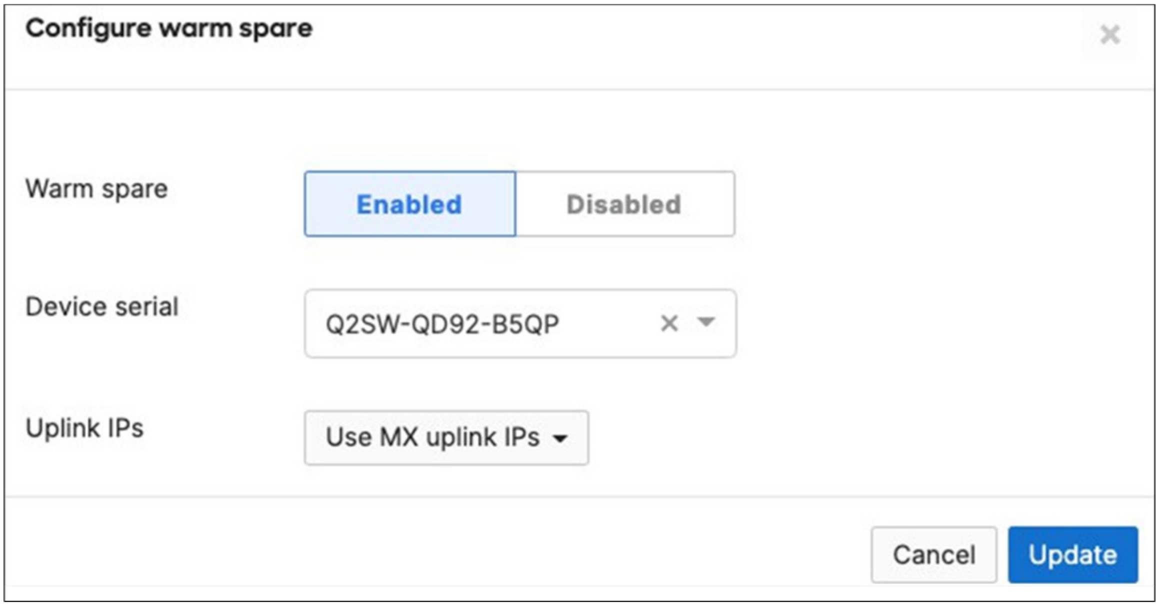
```
9500-01#conf t
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#cts sgt 2
9500-01(config)#cts role-based enforcement vlan-list 1,10,20,30,40
9500-01(config)#ip access-list role-based Allow_All
9500-01(config-rb-acl)#permit ip
9500-01(config-rb-acl)#exit
9500-01(config)#cts role-based permissions default Allow_All
9500-01(config)#interface TwentyFiveGigE1/0/23
9500-01(config-if)#switchport mode trunk
9500-01(config-if)#switchport trunk native vlan 1
9500-01(config-if)#switchport trunk allowed vlan 1,10,20,30,40
9500-01(config-if)#no cts role-based enforcement
9500-01(config-if)#cts manual
9500-01(config-if-cts-manual)#propagate sgt
9500-01(config-if-cts-manual)#policy static sgt 2 trusted
9500-01(config)#interface TwentyFiveGigE1/0/24
9500-01(config-if)#switchport mode trunk
9500-01(config-if)#switchport trunk native vlan 1
9500-01(config-if)#switchport trunk allowed vlan 1,10,20,30,40
9500-01(config-if)#no cts role-based enforcement
```

```
9500-01(config-if)#cts manual
9500-01(config-if-cts-manual)#propagate sgt
9500-01(config-if-cts-manual)#policy static sgt 2 trusted
9500-01(config)#interface TwentyFiveGigE2/0/23
9500-01(config-if)#switchport mode trunk
9500-01(config-if)#switchport trunk native vlan 1
9500-01(config-if)#switchport trunk allowed vlan 1,10,20,30,40
9500-01(config-if)#no cts role-based enforcement
9500-01(config-if)#cts manual
9500-01(config-if-cts-manual)#propagate sgt
9500-01(config-if-cts-manual)#policy static sgt 2 trusted
9500-01(config)#interface TwentyFiveGigE2/0/24
9500-01(config-if)#switchport mode trunk
9500-01(config-if)#switchport trunk native vlan 1
9500-01(config-if)#switchport trunk allowed vlan 1,10,20,30,40
9500-01(config-if)#no cts role-based enforcement
9500-01(config-if)#cts manual
9500-01(config-if-cts-manual)#propagate sgt
9500-01(config-if-cts-manual)#policy static sgt 2 trusted
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

39. **Spare WAN Edge Connectivity:** Follow these steps to create warm-spare with two MX appliances: (*Please note that this might result in a brief interruption of packet forwarding on the MX Appliance*):

- Navigate to **Security and SD-WAN > Monitor > Appliance status** and click on **Configure warm spare**

- Now click on Enabled then choose the Spare MX from the drop-down menu and then choose the Uplink IP option that suits your requirements (Please note that choosing Virtual IPs requires an additional IP address on the upstream network and a single broadcast domain between the two MXs) then click on **Update**



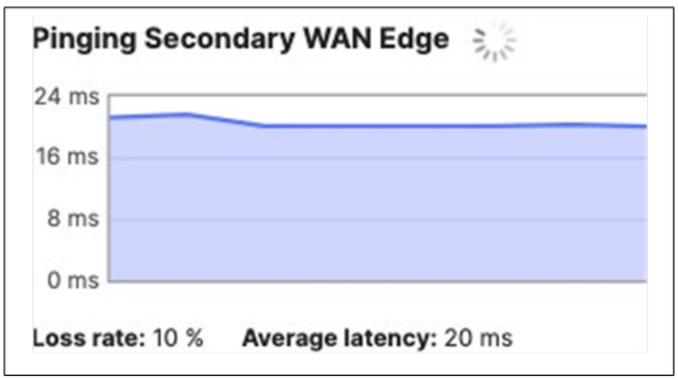
- Now click on **Spare** to access the Appliance status page of your Spare MX and click on the Edit button to rename the spare unit (e.g. Secondary WAN Edge)

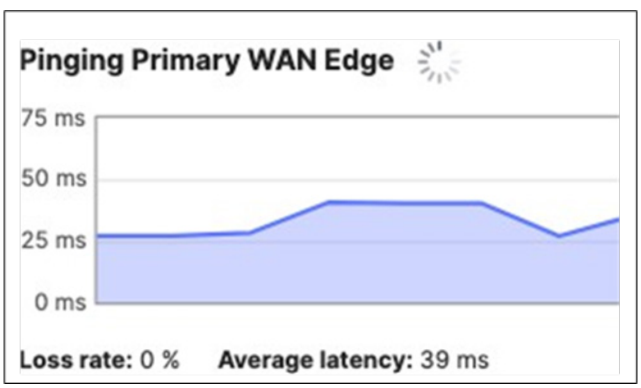
- Then configure the following on your C9500 Core Stack:

```
9500-01#configure terminal
9500-01(config)#interface Twe1/0/2
9500-01(config-if)#switchport mode access
9500-01(config-if)#switchport access vlan 1
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface Twe2/0/2
9500-01(config-if)#switchport mode access
9500-01(config-if)#switchport access vlan 1
9500-01(config-if)#no shut
9500-01(config-if)#end
9500-01#wr mem
Building configuration...
```

```
[OK]
```

- Then connect the Spare MX downlinks to your C9500 Core Stack (e.g. Spare MX port 19 to Twe1/0/2 and port 20 to Twe2/0/2)
- Then connect the Spare MX with its uplinks (*This must match the uplink configuration on your Primary WAN Edge*)
- Power on the Spare MX and wait for it to come online on dashboard

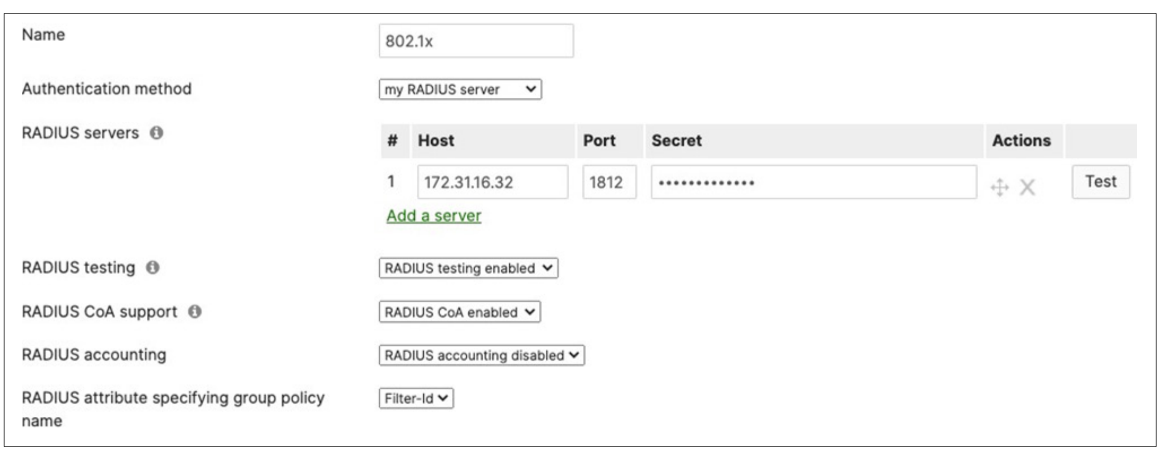




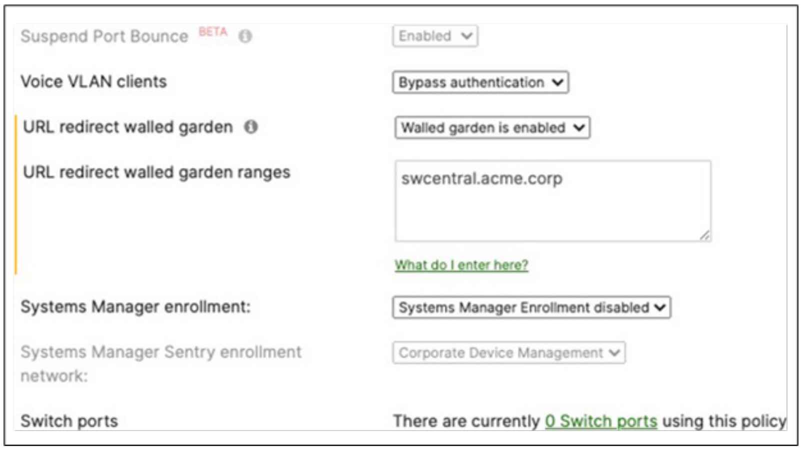
- You can also verify that your C9500 Core Stack interfaces to the Spare MX are up, and that the redundant uplinks are in STP BLK mode

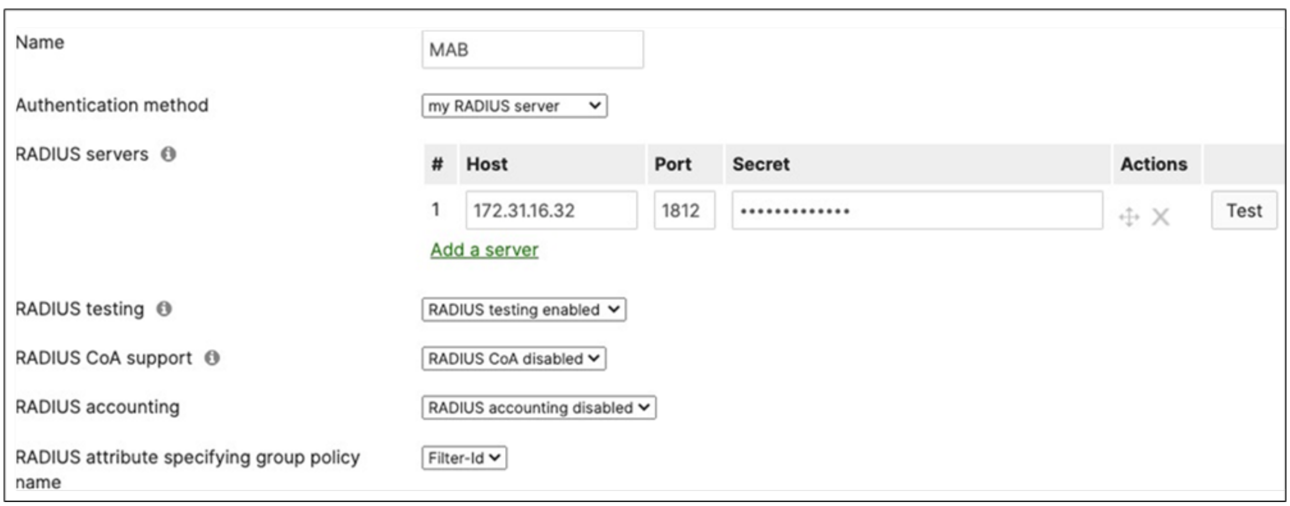
```
9500-01#sh ip interface brief
Interface              IP-Address OK?     Method Status     Protocol
TwentyFiveGigE1/0/2     unassigned        YES unset up      up
TwentyFiveGigE2/0/2     unassigned        YES unset up      up
9500-01#
9500-01#show spanning-tree
MST0
Spanning tree enabled protocol mstp
Root ID Priority 4096
     Address b0c5.3c60.fba0
     This bridge is the root
     Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Bridge ID Priority 4096 (priority 4096 sys-id-ext 0)
      Address    b0c5.3c60.fba0
      Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost      Prio.Nbr Type
Twe1/0/1       Desg FWD 2000      128.193 P2p
Twe1/0/2       Desg FWD 2000      128.194 P2p
Twe2/0/1       Back BLK 2000      128.385 P2p
Twe2/0/2       Back BLK 2000      128.386 P2p

9500-01#
```

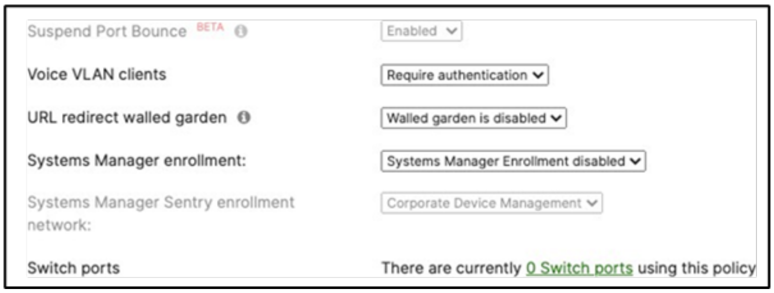
40. **Access Policy configuration:** When you're logged in dashboard, Navigate to **Switching > Configure > Access policies** to configure [Access Policies]() as required for your Campus LAN. Please see the following example for two Access Policies; **802.1x and MAB.**




Host Mode
Single-Host
Access policy type
802.1x
Guest VLAN
30
Failed Auth VLAN BETA
30
Re-authentication Interval BETA
Critical Auth VLAN BETA
Data
Voice

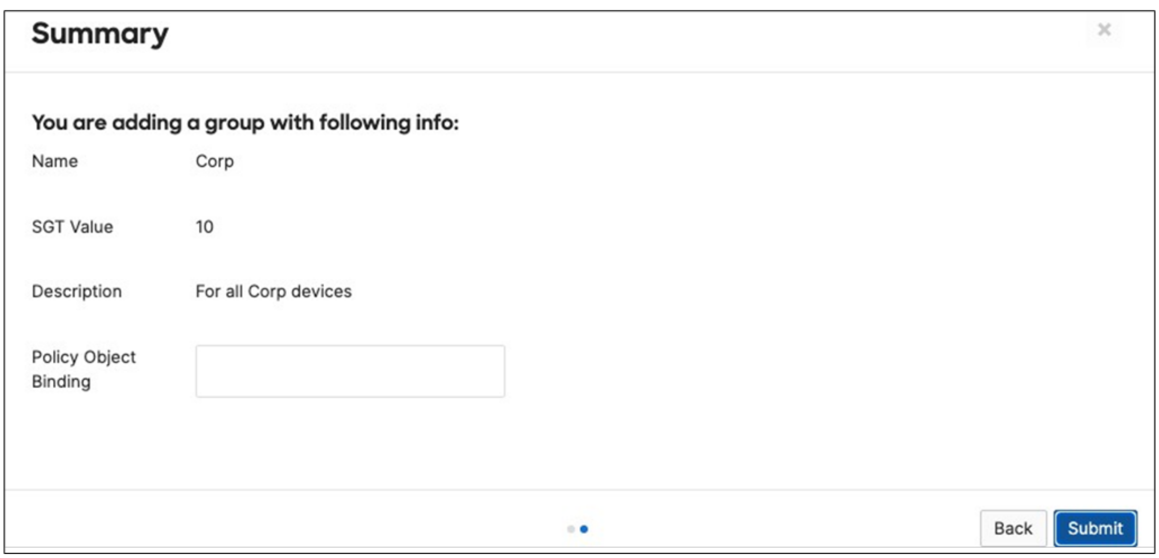

Suspend Port Bounce BETA
Enabled
Voice VLAN clients
Bypass authentication
URL redirect walled garden
Walled garden is enabled
URL redirect walled garden ranges
swcentral.acme.corp
What do I enter here?
Systems Manager enrollment:
Systems Manager Enrollment disabled
Systems Manager Sentry enrollment network:
Corporate Device Management
Switch ports
There are currently 0 Switch ports using this policy

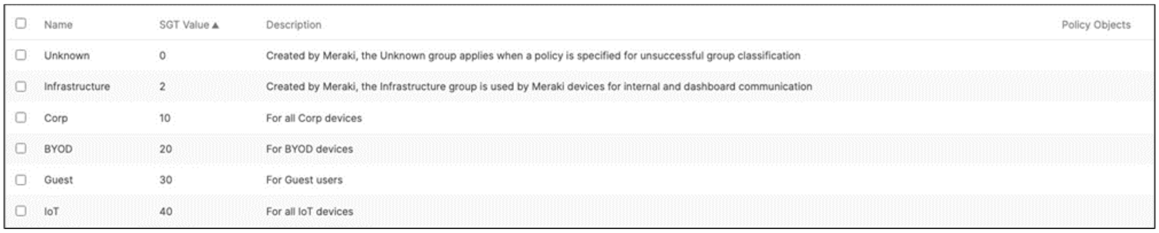

Name
MAB
Authentication method
my RADIUS server
RADIUS servers
Host Port Secret Actions
1 172.31.16.32 1812 ••••••••••••• Test
Add a server
RADIUS testing
RADIUS testing enabled
RADIUS CoA support
RADIUS CoA disabled
RADIUS accounting
RADIUS accounting disabled
RADIUS attribute specifying group policy name
Filter-Id



41. **Adaptive Policy Configuration**: Configure Adaptive Policy for your Campus LAN. When you're logged in dashboard, Navigate to **Organization > Configure > Adaptive Policy** then click on the **Groups** tab on the top.

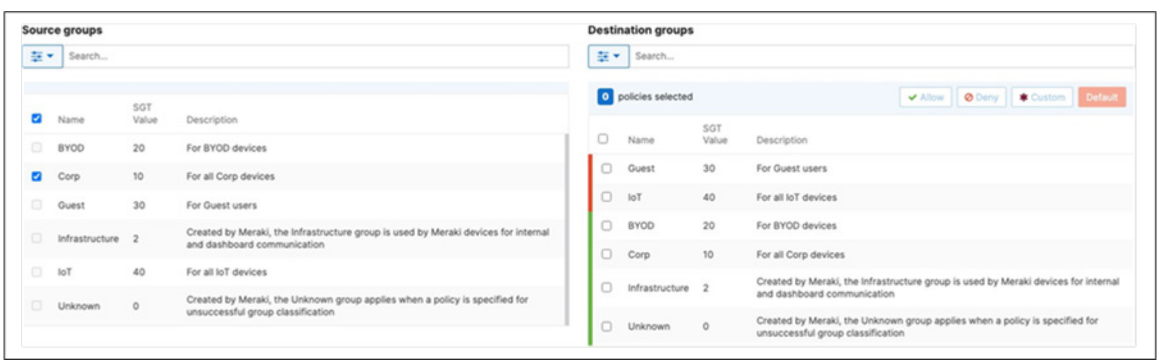
    There should be two groups (Unknown, Infrastructure) that are already available. Click on **Add group** to add *each* group required for your Campus LAN. You need to fill in the Name, the SGT value, and a description then click on **Review changes** then click on **Submit**. Please see the following examples:

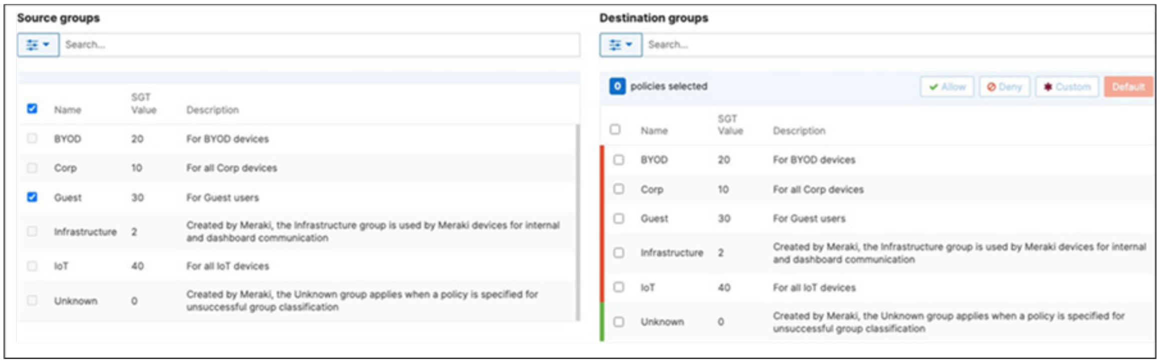


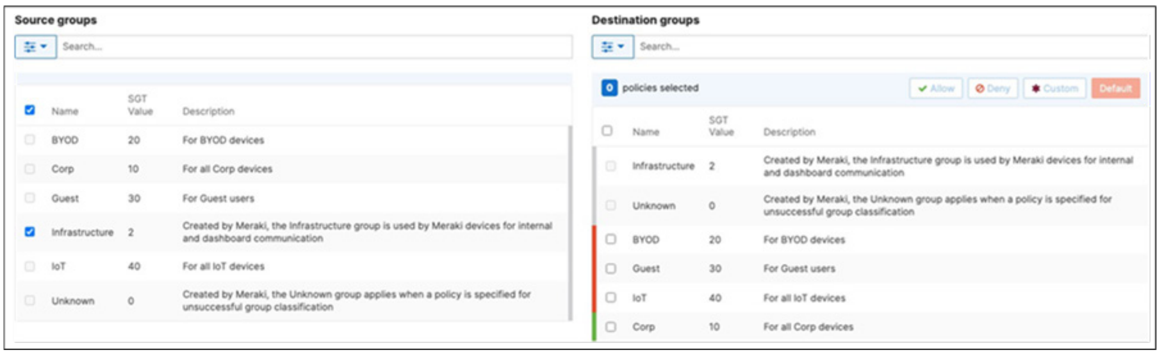


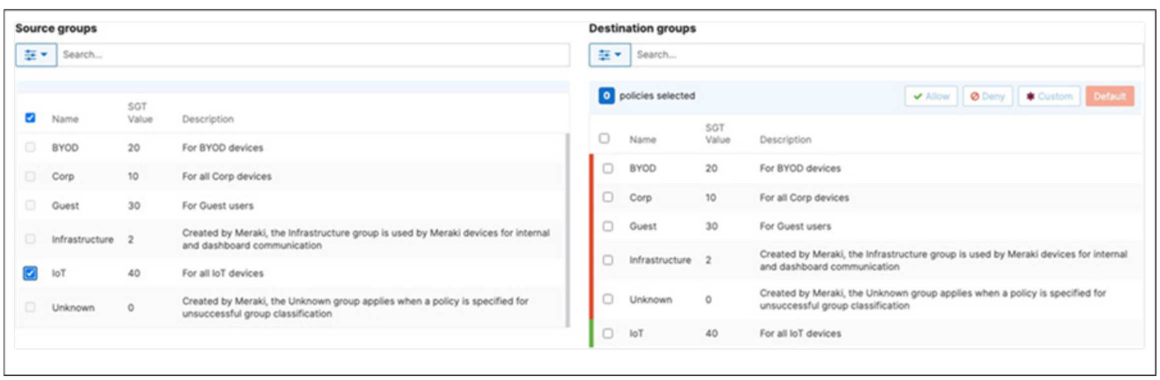
Name	SGT Value ▲	Description	Policy Objects
Unknown	0	Created by Meraki, the Unknown group applies when a policy is specified for unsuccessful group classification	
Infrastructure	2	Created by Meraki, the Infrastructure group is used by Meraki devices for internal and dashboard communication	
Corp	10	For all Corp devices	
BYOD	20	For BYOD devices	
Guest	30	For Guest users	
IoT	40	For all IoT devices	

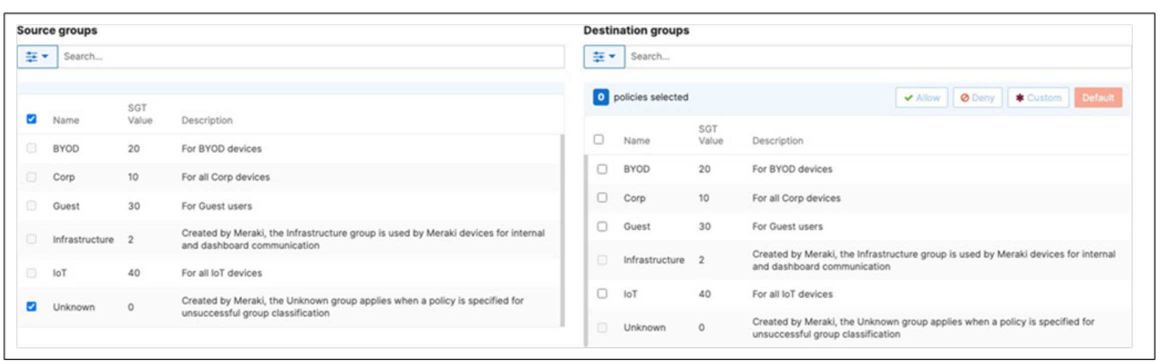
42. **Adaptive Policy Configuration:** Configure Adaptive Policy for your Campus LAN. When you're logged in dashboard, Navigate to **Organization > Configure > Adaptive Policy** then click on the **Policies** tab on the top. The source groups are on the left side, and the destination groups are on the right side. Select a source group from the left side then select all destination groups on the right side that should be allowed then click on **Allow** and click on **Save** at the bottom of the page. Next, select a source group from the left side then select all destination groups on the right side that should be denied (i.e. Blocked) then click on **Deny** and click on **Save** at the bottom of the page. After creating the policy for that specific source group, the allowed destination groups will be displayed with a green tab and the denied destination groups will be displayed with a red tab. Repeat this step for all policies required for all Groups (Allow and Deny).



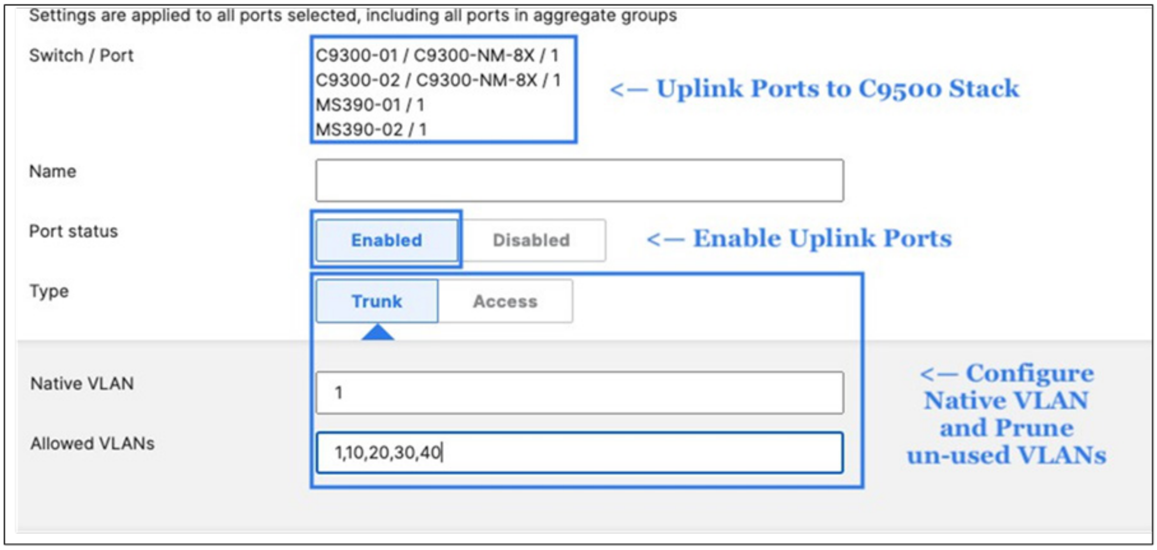

Source groups
Search...
Name SGT Value Description
BYOD 20 For BYOD devices
Corp 10 For all Corp devices
Guest 30 For Guest users
Infrastructure 2 Created by Meraki, the Infrastructure group is used by Meraki devices for internal and dashboard communication
IoT 40 For all IoT devices
Unknown 0 Created by Meraki, the Unknown group applies when a policy is specified for unsuccessful group classification
Destination groups
Search...
0 policies selected
Allow
Deny
Custom
Default
Name SGT Value Description
BYOD 20 For BYOD devices
Corp 10 For all Corp devices
Guest 30 For Guest users
Infrastructure 2 Created by Meraki, the Infrastructure group is used by Meraki devices for internal and dashboard communication
IoT 40 For all IoT devices
Unknown 0 Created by Meraki, the Unknown group applies when a policy is specified for unsuccessful group classification

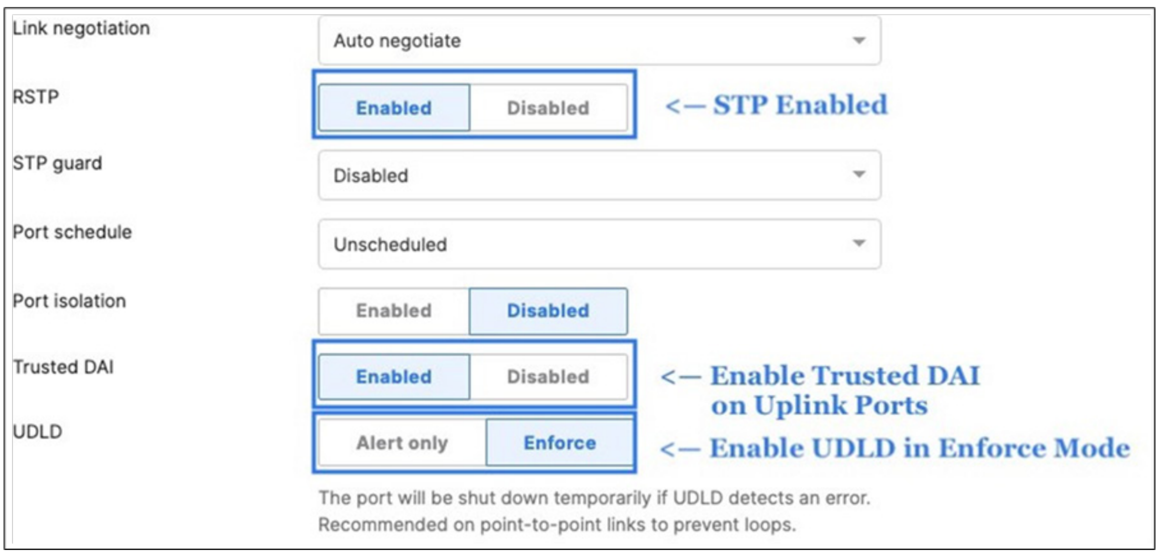

Source groups
Search...
Name SGT Value Description
BYOD 20 For BYOD devices
Corp 10 For all Corp devices
Guest 30 For Guest users
Infrastructure 2 Created by Meraki, the Infrastructure group is used by Meraki devices for internal and dashboard communication
IoT 40 For all IoT devices
Unknown 0 Created by Meraki, the Unknown group applies when a policy is specified for unsuccessful group classification
Destination groups
Search...
0 policies selected
Allow
Deny
Custom
Default
Name SGT Value Description
Infrastructure 2 Created by Meraki, the Infrastructure group is used by Meraki devices for internal and dashboard communication
Unknown 0 Created by Meraki, the Unknown group applies when a policy is specified for unsuccessful group classification
BYOD 20 For BYOD devices
Guest 30 For Guest users
IoT 40 For all IoT devices
Corp 10 For all Corp devices

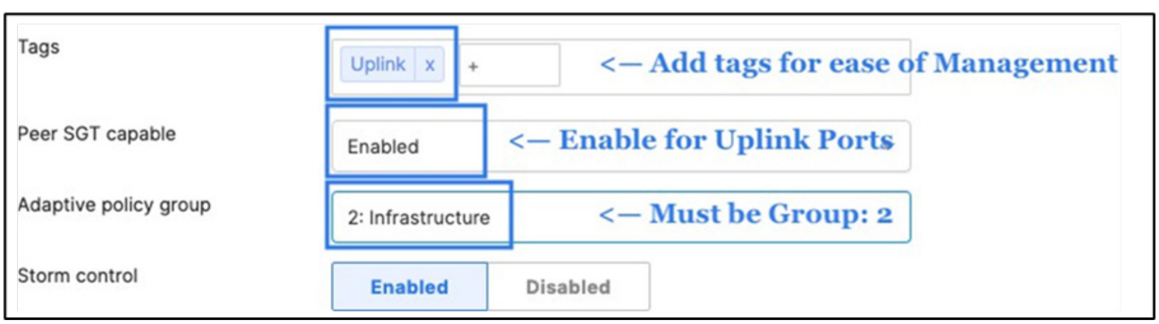

Source groups
Search...
Name SGT Value Description
BYOD 20 For BYOD devices
Corp 10 For all Corp devices
Guest 30 For Guest users
Infrastructure 2 Created by Meraki, the Infrastructure group is used by Meraki devices for internal and dashboard communication
IoT 40 For all IoT devices
Unknown 0 Created by Meraki, the Unknown group applies when a policy is specified for unsuccessful group classification
Destination groups
Search...
0 policies selected
Allow
Deny
Custom
Default
Name SGT Value Description
BYOD 20 For BYOD devices
Corp 10 For all Corp devices
Guest 30 For Guest users
Infrastructure 2 Created by Meraki, the Infrastructure group is used by Meraki devices for internal and dashboard communication
Unknown 0 Created by Meraki, the Unknown group applies when a policy is specified for unsuccessful group classification
IoT 40 For all IoT devices


Source groups
Search...
Name SGT Value Description
BYOD 20 For BYOD devices
Corp 10 For all Corp devices
Guest 30 For Guest users
Infrastructure 2 Created by Meraki, the Infrastructure group is used by Meraki devices for internal and dashboard communication
IoT 40 For all IoT devices
Unknown 0 Created by Meraki, the Unknown group applies when a policy is specified for unsuccessful group classification
Destination groups
Search...
0 policies selected
Allow
Deny
Custom
Default
Name SGT Value Description
BYOD 20 For BYOD devices
Corp 10 For all Corp devices
Guest 30 For Guest users
Infrastructure 2 Created by Meraki, the Infrastructure group is used by Meraki devices for internal and dashboard communication
IoT 40 For all IoT devices
Unknown 0 Created by Meraki, the Unknown group applies when a policy is specified for unsuccessful group classification

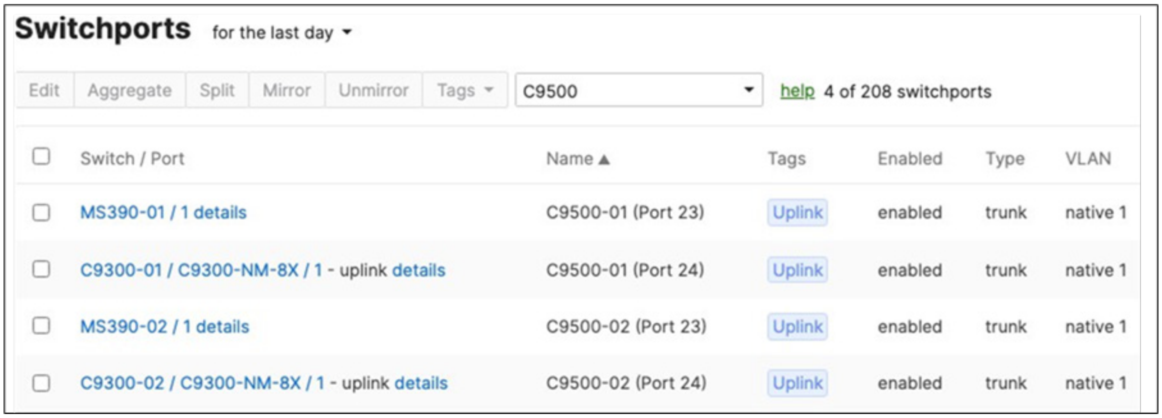
43. **Access Switch Ports Configuration:** Configure **Uplink Ports** on your Access Switches. When you're logged in dashboard, Navigate to **Switching > Monitor > Switch Ports**, then select your uplink ports and configure them as shown below. (Tip: You can filter for ports by using search terms in dashboard)



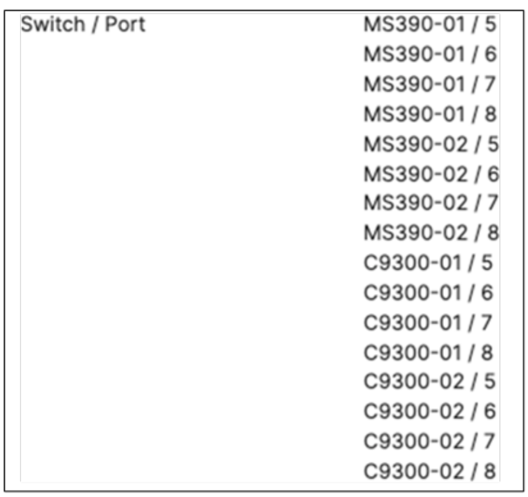


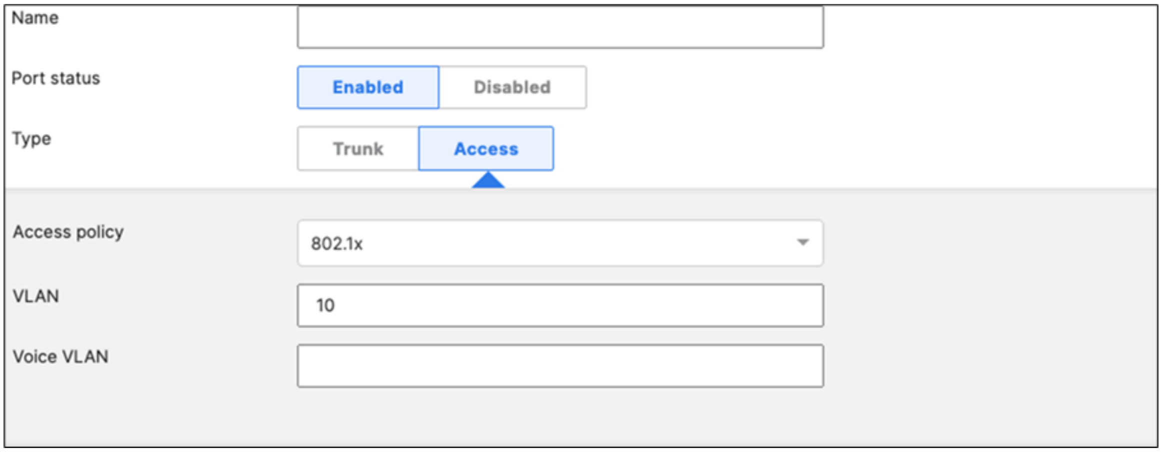


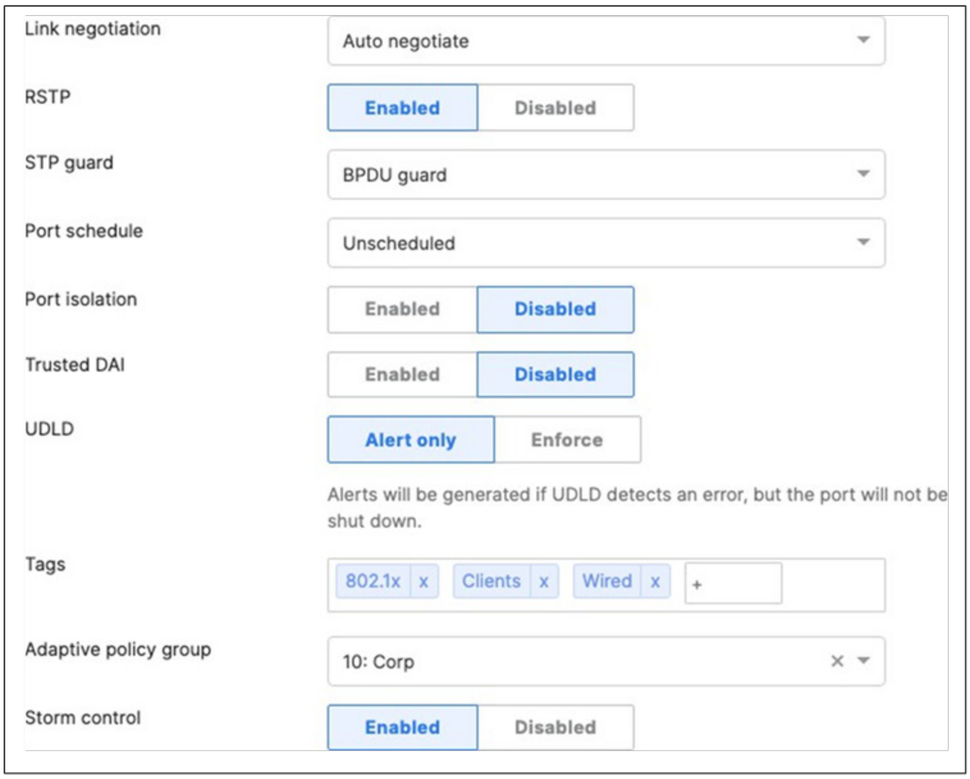
44. *Optional* – For ease of management, it is recommended that you rename the ports connecting to your Core switches with the actual switch name / Connecting port as shown below.



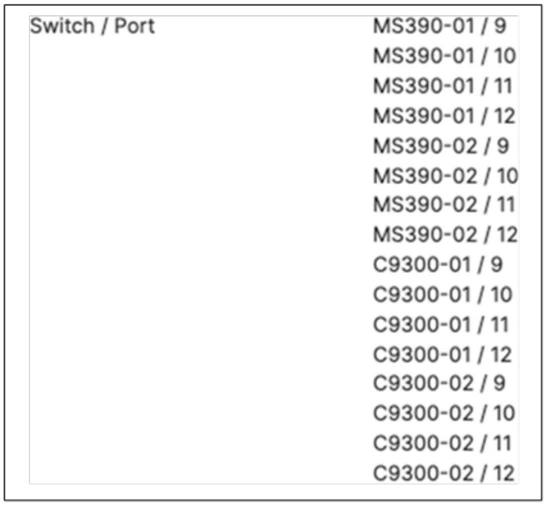
45. **Access Switch Ports Configuration:** Configure **Wired Client Ports (802.1x)** on your Access Switches. Navigate to or Refresh **Switching > Monitor > Switch Ports**, then select your Wired Client ports (5-8) and configure them as shown below. (Tip: You can filter for ports by using search terms in dashboard)

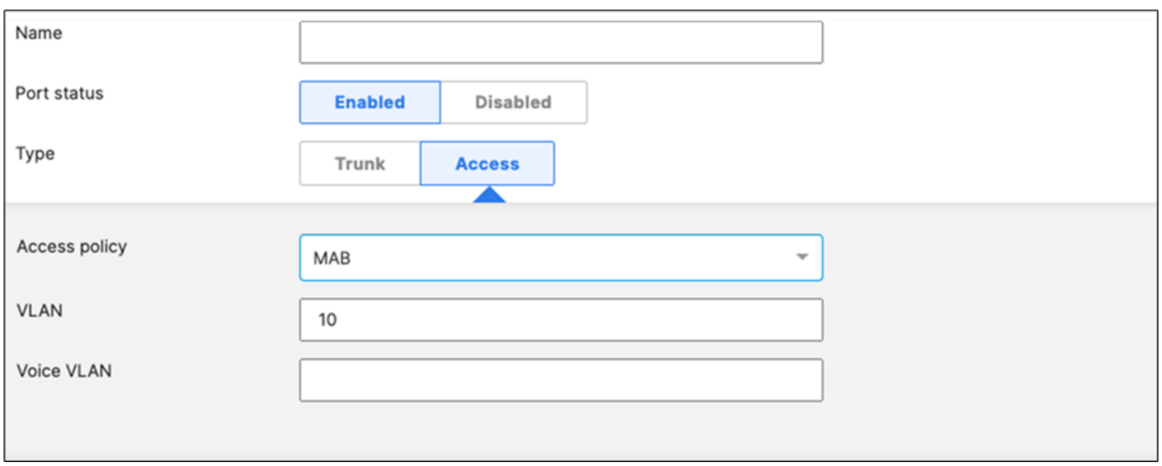


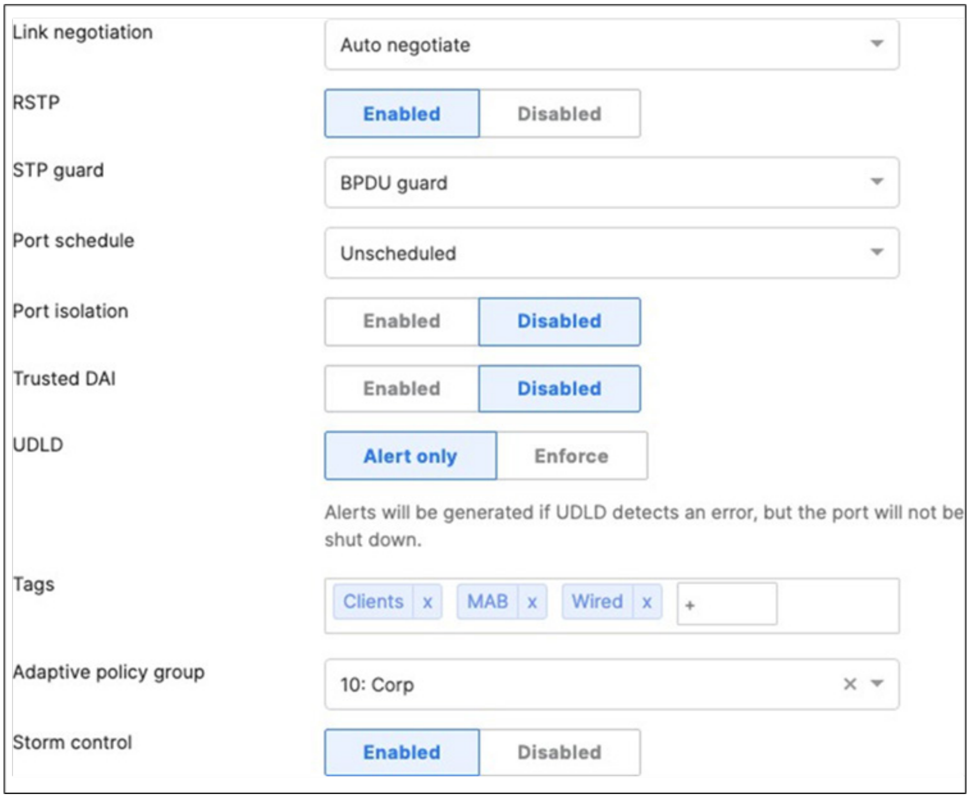

Name
Port status
Enabled
Disabled
Type
Trunk
Access
Access policy
802.1x
VLAN
10
Voice VLAN


Link negotiation
Auto negotiate
RSTP
Enabled
Disabled
STP guard
BPDU guard
Port schedule
Unscheduled
Port isolation
Enabled
Disabled
Trusted DAI
Enabled
Disabled
UDLD
Alert only
Enforce
Alerts will be generated if UDLD detects an error, but the port will not be shut down.
Tags
802.1x x
Clients x
Wired x
+
Adaptive policy group
10: Corp
Storm control
Enabled
Disabled

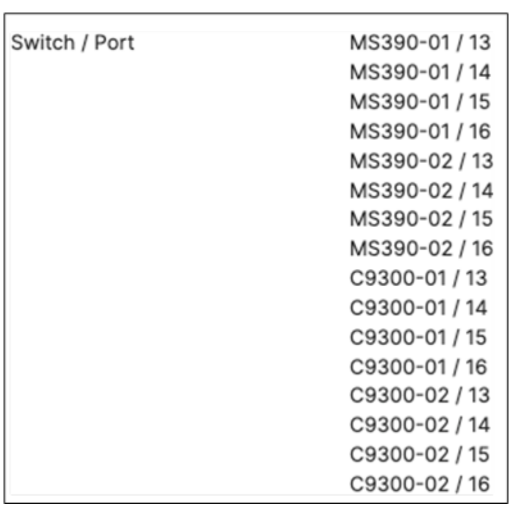
46. **Access Switch Ports Configuration:** Configure **Wired Client Ports (MAB)** on your Access Switches. Navigate to or Refresh **Switching > Monitor > Switch Ports**, then select your Wired Client ports (9-12) and configure them as shown below. (Tip: You can filter for ports by using search terms in dashboard)

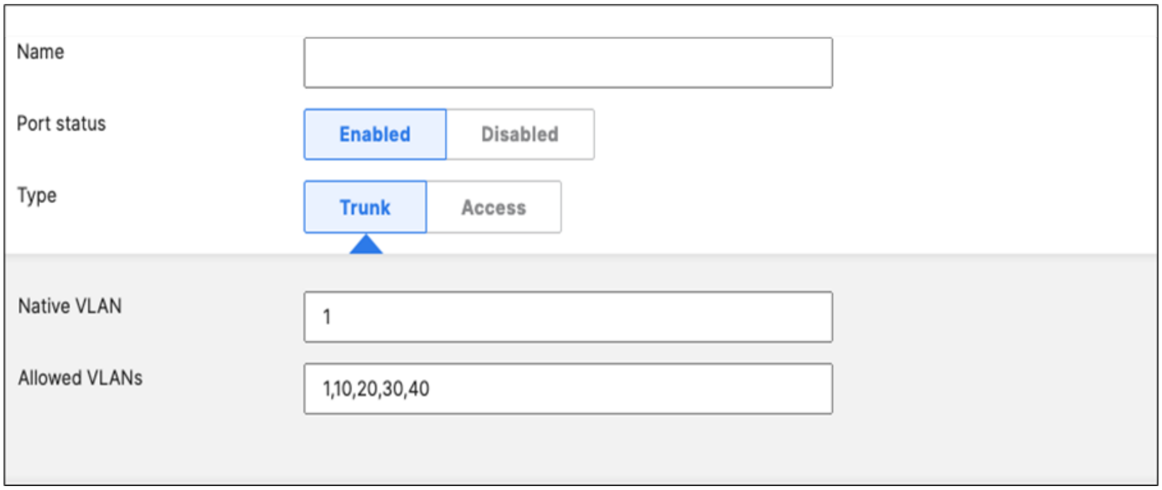




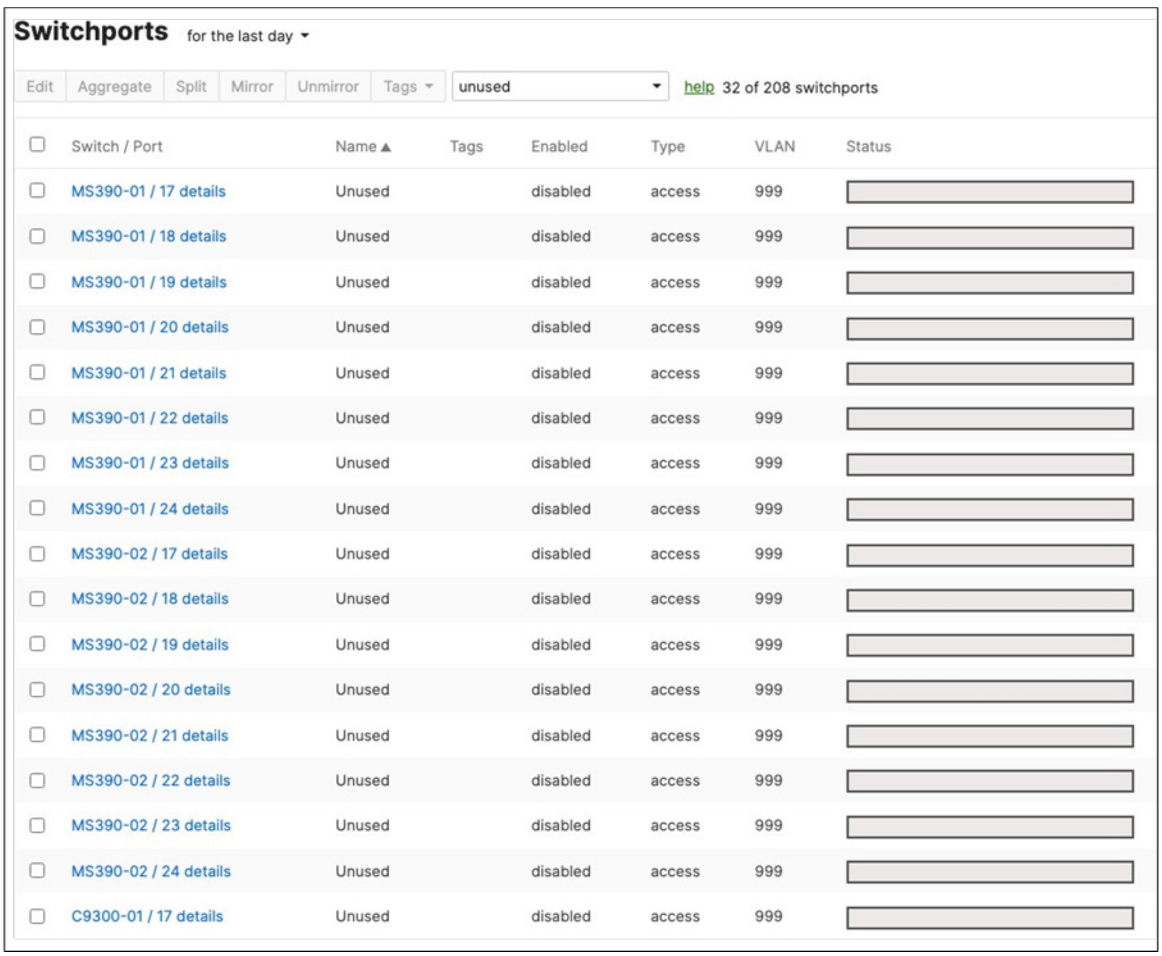


47. **Access Switch Ports Configuration:** Configure **MR Ports** on your Access Switches. Navigate to or Refresh **Switching > Monitor > Switch Ports**, then select your ports connecting to MR Access Points (13-16) and configure them as shown below. (Tip: You can filter for ports by using search terms in dashboard)





48. *Optional* - **Access Switch Ports Configuration:** Configure unused ports on your Access Switches such that they are disabled and mapped to an unrouted VLAN (*e.g. VLAN 999*). Navigate to **Switching > Configure > Switch Ports** and filter for any unused ports (e.g. 17-24) and configure them as shown below.



Switchports for the last day

Edit | Aggregate | Split | Mirror | Unmirror | Tags | unused | help 32 of 208 switchports

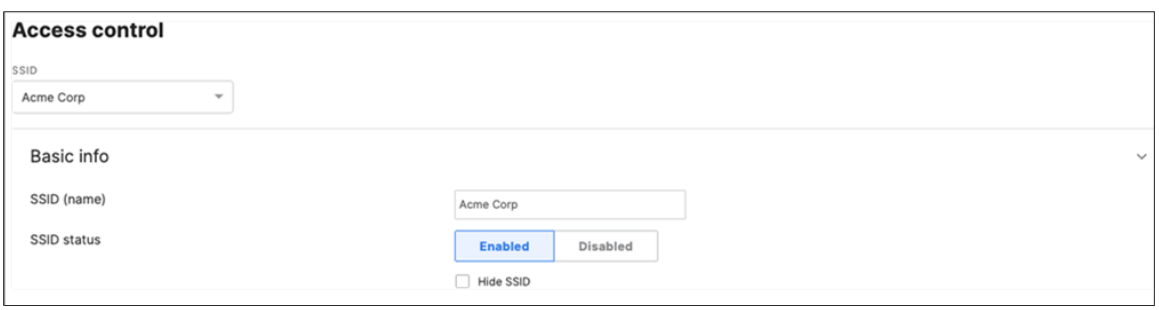
Switch / Port	Name ▲	Tags	Enabled	Type	VLAN	Status
MS390-01 / 17 details	Unused		disabled	access	999	
MS390-01 / 18 details	Unused		disabled	access	999	
MS390-01 / 19 details	Unused		disabled	access	999	
MS390-01 / 20 details	Unused		disabled	access	999	
MS390-01 / 21 details	Unused		disabled	access	999	
MS390-01 / 22 details	Unused		disabled	access	999	
MS390-01 / 23 details	Unused		disabled	access	999	
MS390-01 / 24 details	Unused		disabled	access	999	
MS390-02 / 17 details	Unused		disabled	access	999	
MS390-02 / 18 details	Unused		disabled	access	999	
MS390-02 / 19 details	Unused		disabled	access	999	
MS390-02 / 20 details	Unused		disabled	access	999	
MS390-02 / 21 details	Unused		disabled	access	999	
MS390-02 / 22 details	Unused		disabled	access	999	
MS390-02 / 23 details	Unused		disabled	access	999	
MS390-02 / 24 details	Unused		disabled	access	999	
C9300-01 / 17 details	Unused		disabled	access	999	

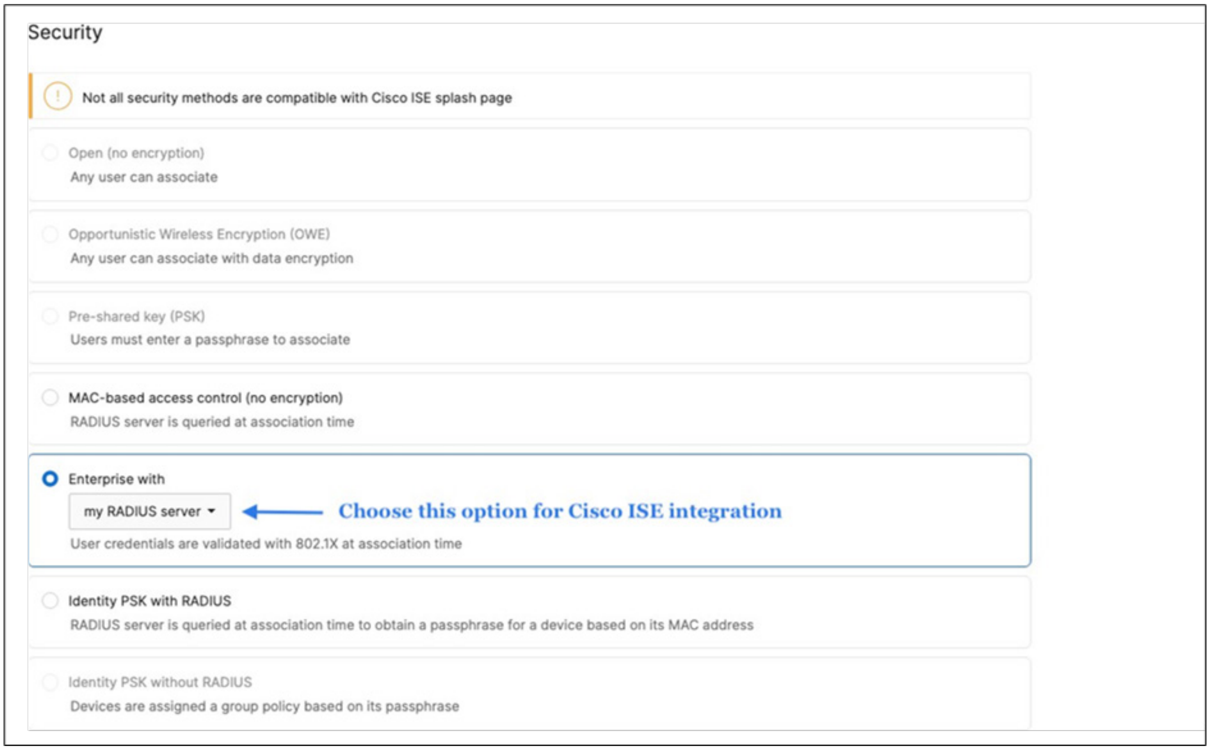
49. **Rename Wireless SSIDs:** To configure your SSIDs per the above table, first navigate to **Wireless > Configure SSIDs** then rename the SSIDs per your requirements (Refer to the above table for guidance).

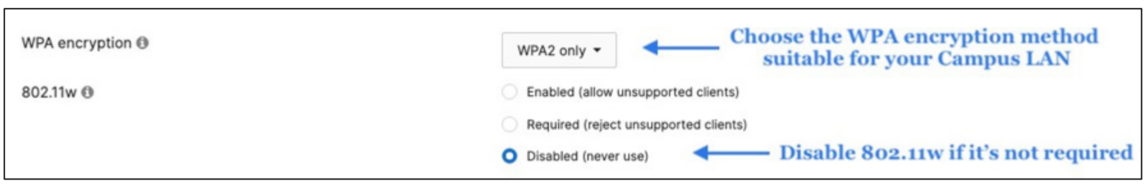
- **SSID#1** (First column, aka **vap:0, enabled** by default): Click on **rename** and change it to **Acme Corp**
- **SSID#2** (Second column, aka **vap:1**): Click on **rename** and change it to **Acme BYOD**, then click on the top drop-down menu to **enable** it
- **SSID#3** (Third column, aka **vap:2**): Click on **rename** and change it to **Guest**, then click on the top drop-down menu to **enable** it
- **SSID#4** (Fourth column, aka **vap:3**): Click on **rename** and change it to **Acme IoT**, then click on the top drop- down menu to **enable** it
- Click **Save** at the bottom of the page

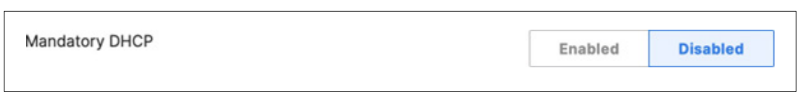
Acme Corp	Acme BYOD	Guest	Acme IoT
enabled	enabled	enabled	enabled
rename	rename	rename	rename
edit settings	edit settings	edit settings	edit settings
Open	Open	Open	Open
None	None	None	None
unlimited	unlimited	unlimited	unlimited
Meraki DHCP	Meraki DHCP	Meraki DHCP	Meraki DHCP
yes	no	no	no
no	no	no	no
n/a	n/a	n/a	n/a
Disabled	Disabled	Disabled	Disabled
no	no	no	no
n/a	n/a	n/a	n/a

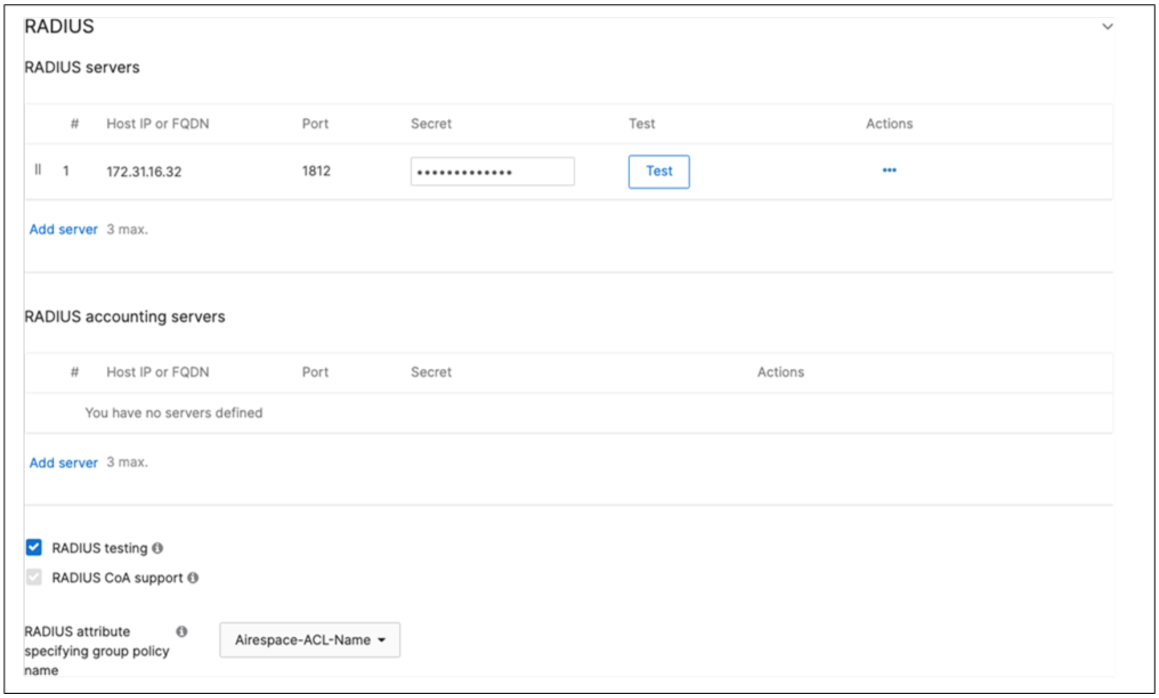
50. **Configure Access Control for Acme Corp**: Navigate to **Wireless > Configure > Access control** then from the top drop-down menu choose **Acme Corp.**

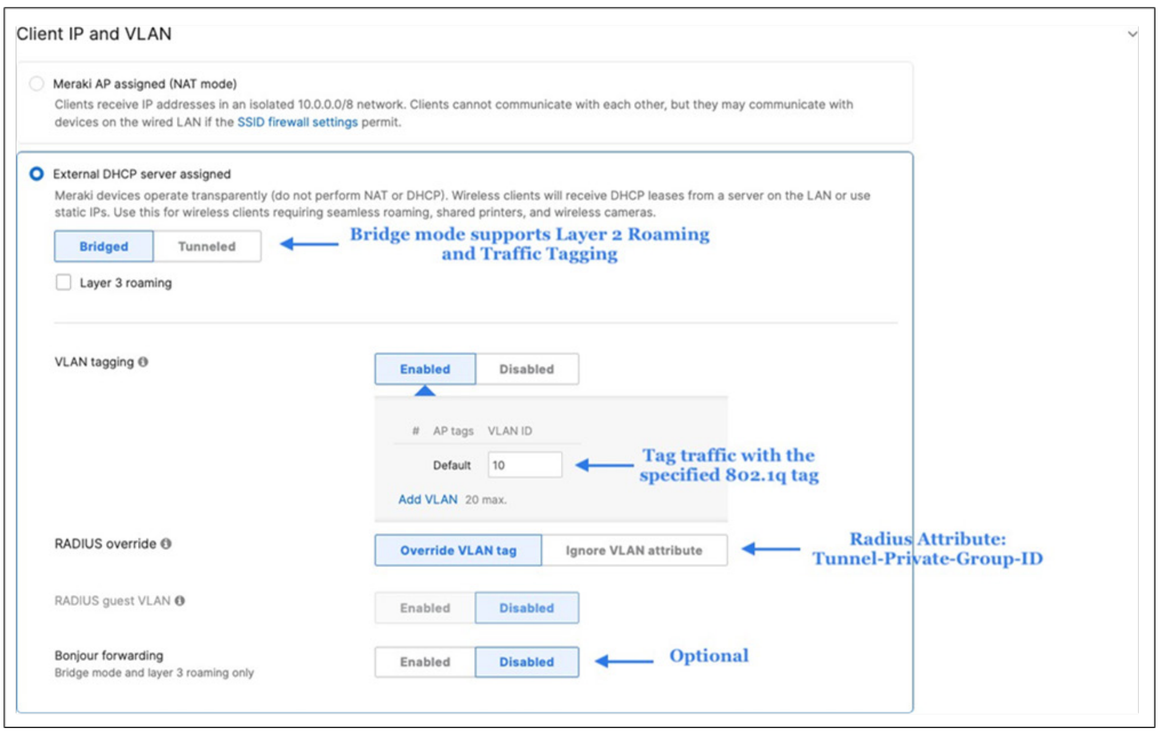



Security
Not all security methods are compatible with Cisco ISE splash page
Open (no encryption)
Any user can associate
Opportunistic Wireless Encryption (OWE)
Any user can associate with data encryption
Pre-shared key (PSK)
Users must enter a passphrase to associate
MAC-based access control (no encryption)
RADIUS server is queried at association time
Enterprise with
my RADIUS server
Choose this option for Cisco ISE integration
User credentials are validated with 802.1X at association time
Identity PSK with RADIUS
RADIUS server is queried at association time to obtain a passphrase for a device based on its MAC address
Identity PSK without RADIUS
Devices are assigned a group policy based on its passphrase

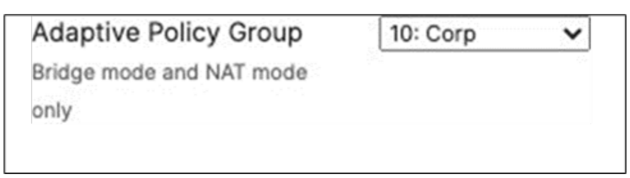

WPA encryption
WPA2 only
Choose the WPA encryption method suitable for your Campus LAN
802.11w
Enabled (allow unsupported clients)
Required (reject unsupported clients)
Disabled (never use)
Disable 802.11w if it's not required


Mandatory DHCP
Enabled
Disabled





- Click **Save** at the bottom of the page

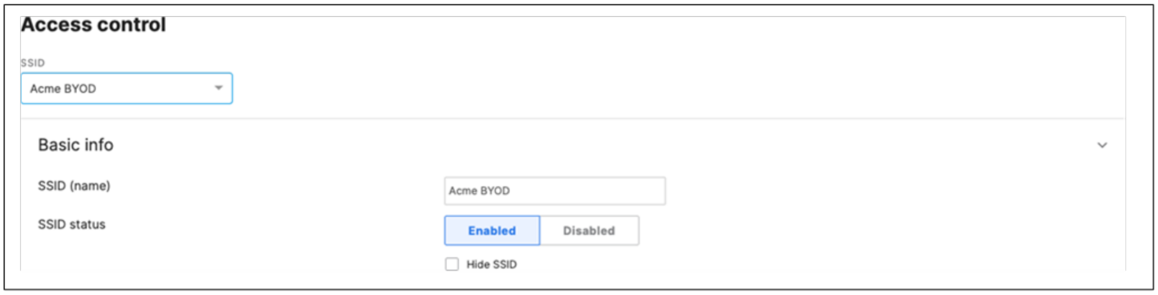


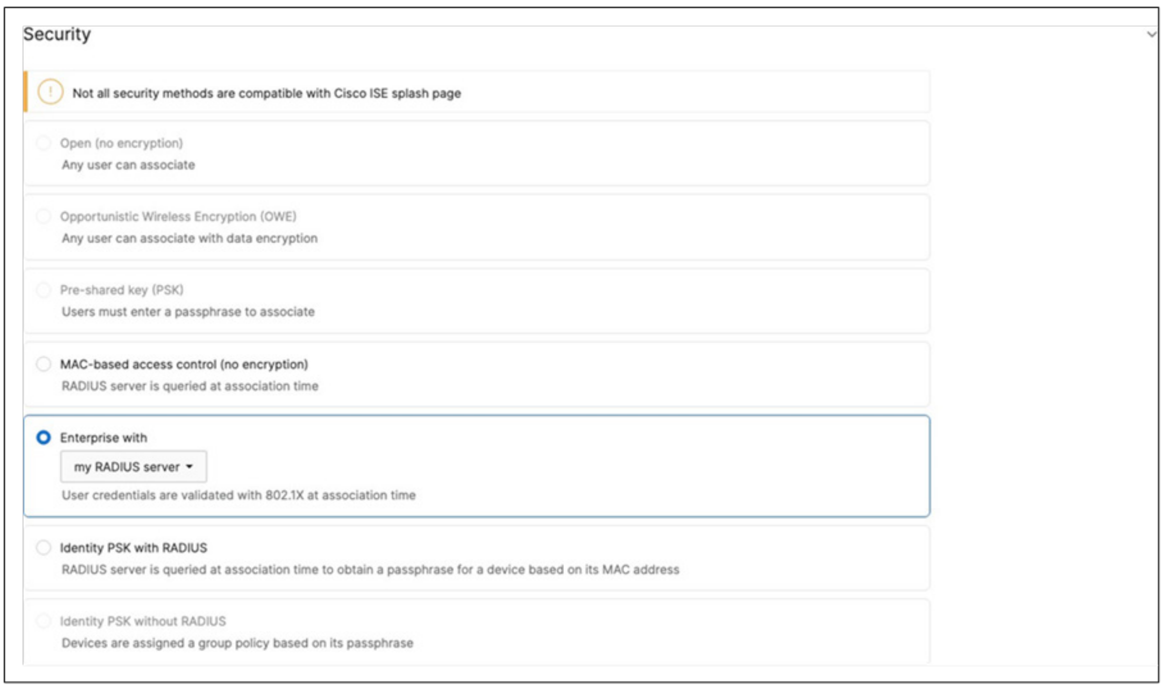
- Please Note: **Adaptive Policy Group** feature is **not** currently available in the New Version of the Access. You will need to click on **View old version**

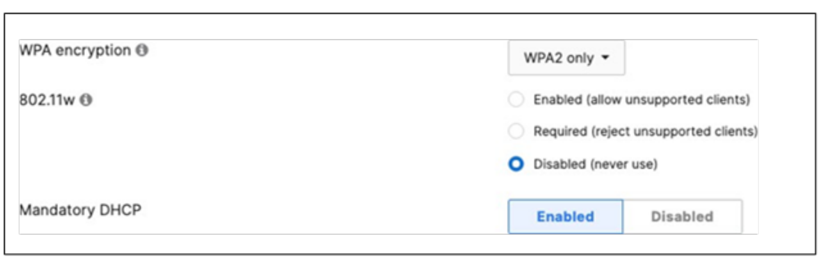
  View old version

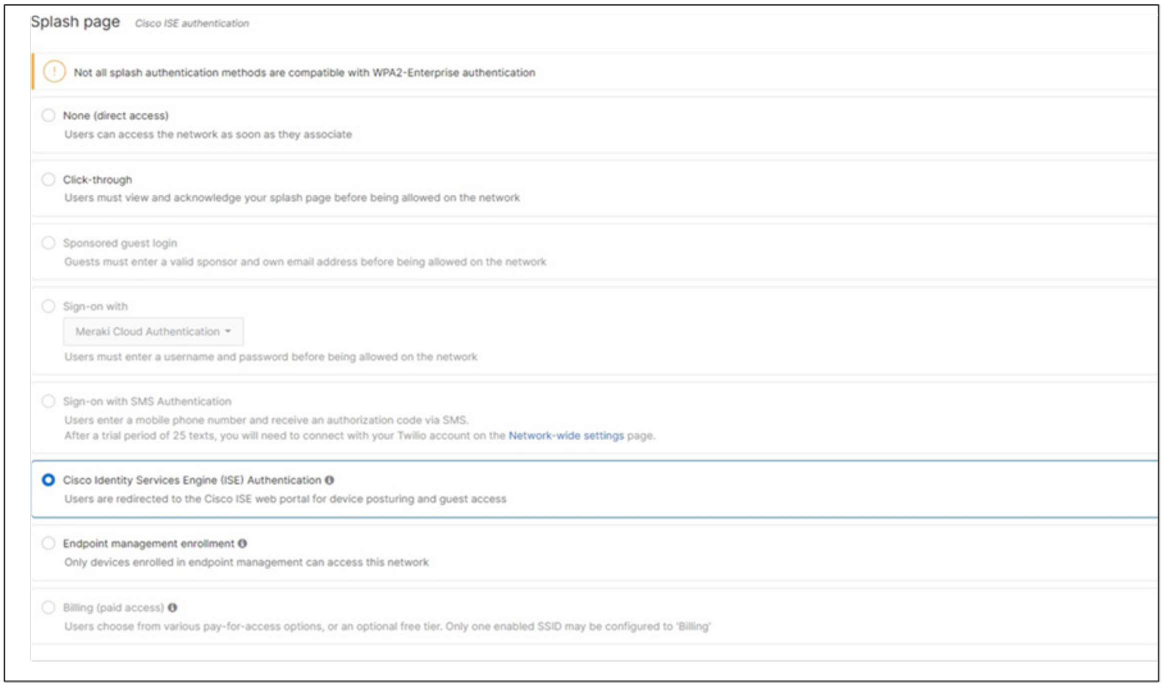
  which is available at the top right corner of the page to be able to access this and configure the Adaptive Policy Group (10: Corp). Then, please click **Save** at the bottom of the page

51. **Configure Access Control for Acme BYOD**: Navigate to **Wireless > Configure > Access control** then from the top drop-down menu choose **Acme BYOD.**



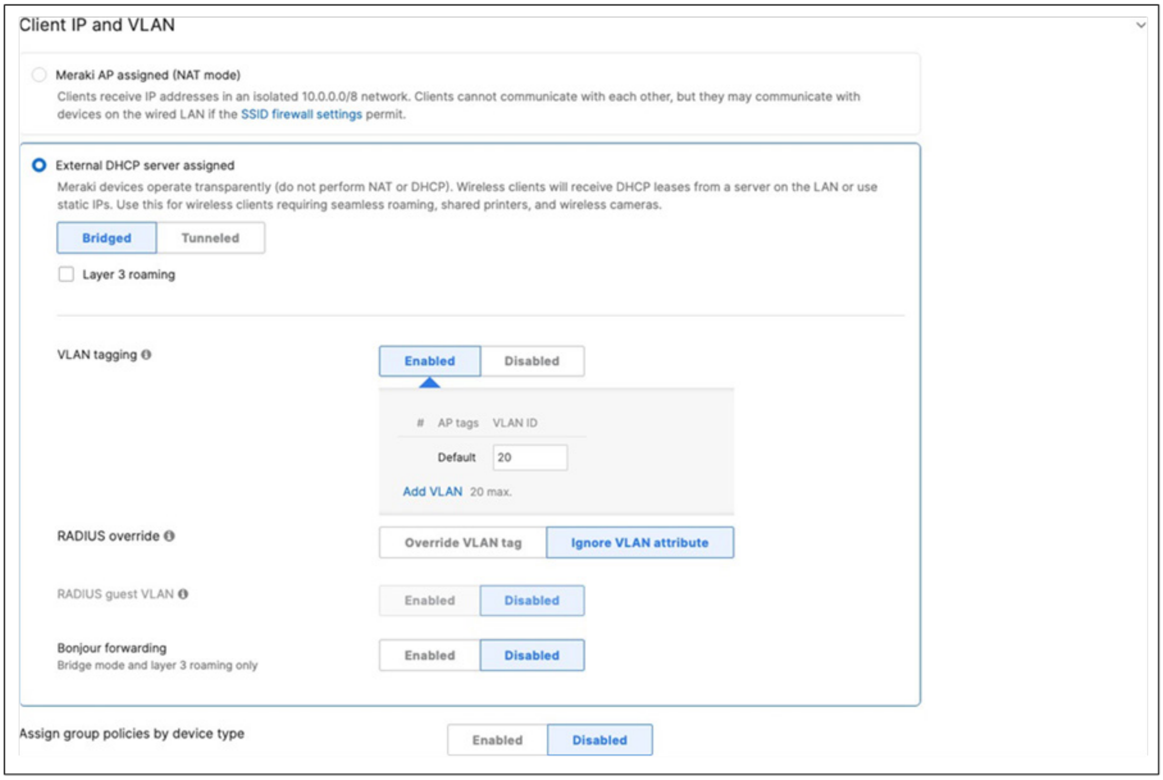





Splash page
Cisco ISE authentication
Not all splash authentication methods are compatible with WPA2-Enterprise authentication
None (direct access)
Users can access the network as soon as they associate
Click-through
Users must view and acknowledge your splash page before being allowed on the network
Sponsored guest login
Guests must enter a valid sponsor and own email address before being allowed on the network
Sign-on with
Meraki Cloud Authentication
Users must enter a username and password before being allowed on the network
Sign-on with SMS Authentication
Users enter a mobile phone number and receive an authorization code via SMS.
After a trial period of 25 texts, you will need to connect with your Twilio account on the Network-wide settings page.
Cisco Identity Services Engine (ISE) Authentication
Users are redirected to the Cisco ISE web portal for device posturing and guest access
Endpoint management enrollment
Only devices enrolled in endpoint management can access this network
Billing (paid access)
Users choose from various pay-for-access options, or an optional free tier. Only one enabled SSID may be configured to 'Billing'


RADIUS servers
#
Host IP or FQDN
Port
Secret
Test
Actions
1
172.31.16.32
1812
Test
Add server
3 max.

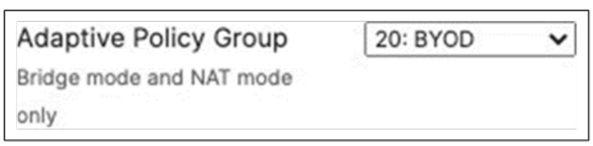

RADIUS testing
RADIUS CoA support
RADIUS attribute specifying group policy name
Airespace-ACL-Name



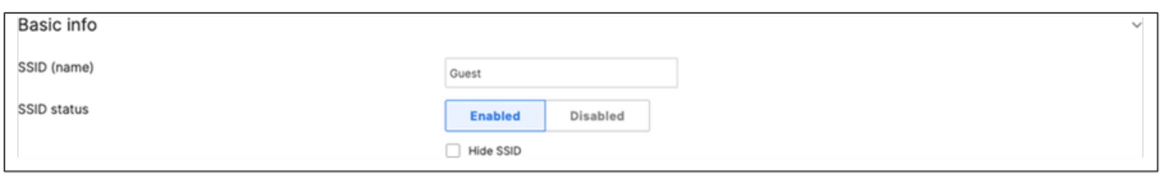
- Click on

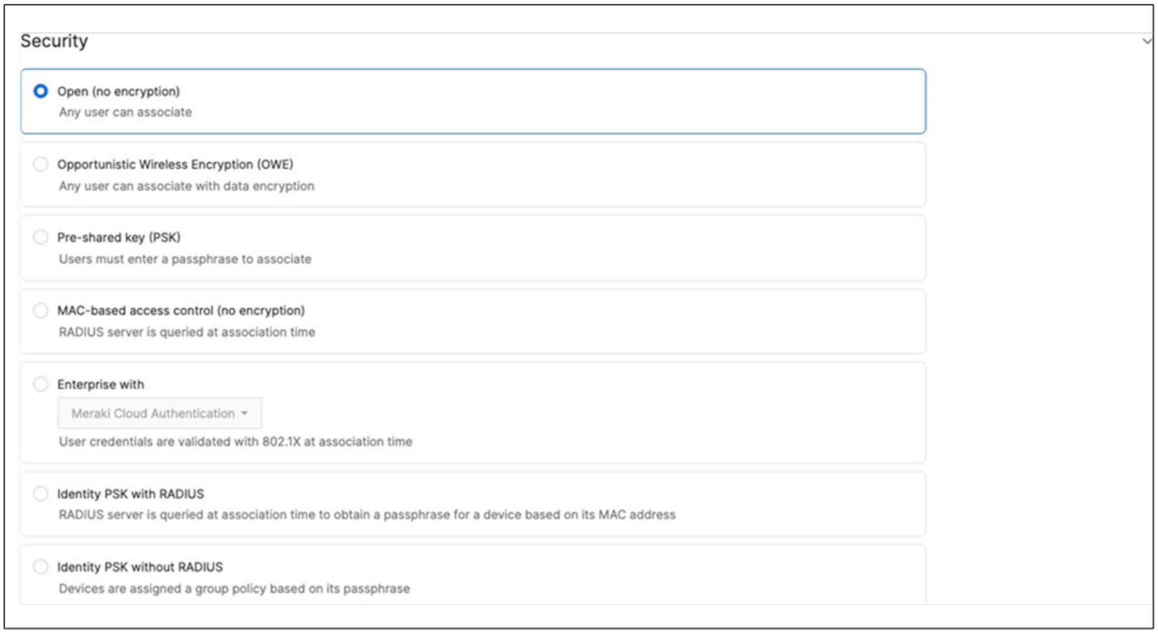
  View old Version

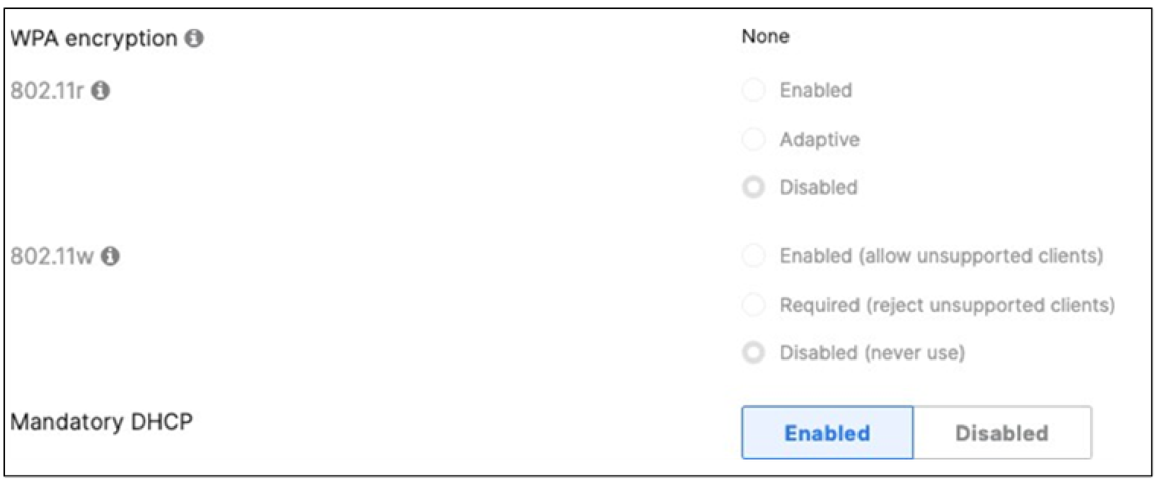
  which is available on the top right corner of the page, then choose the Adaptive Policy Group **20: BYOD** and then click on **Save** at the bottom of the page.

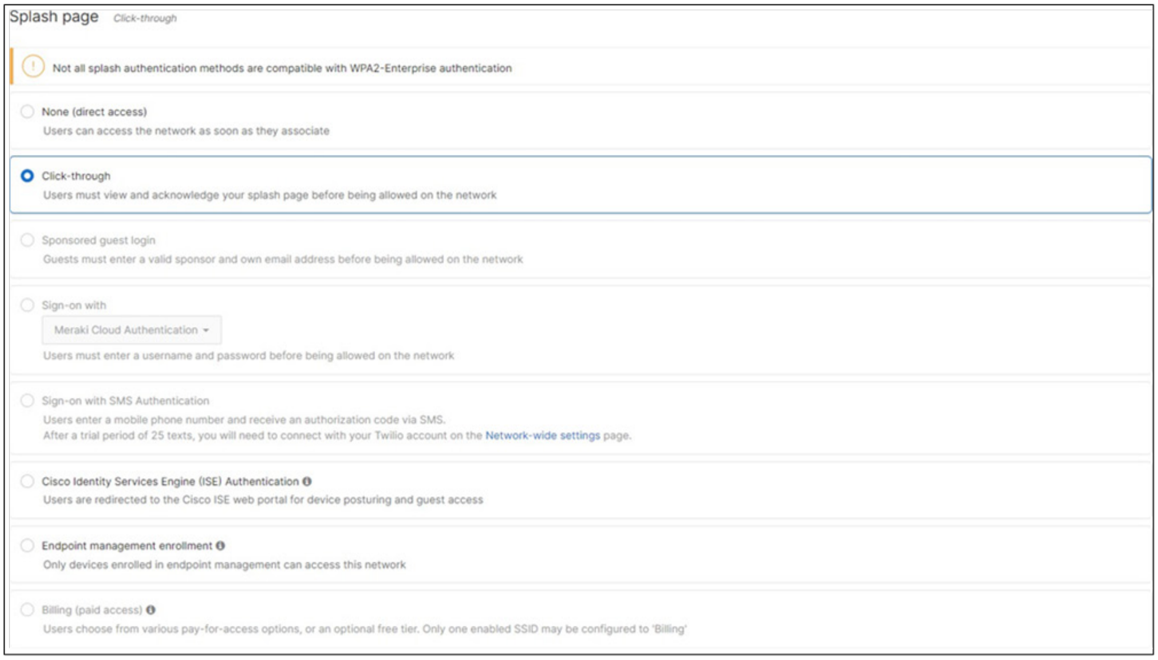


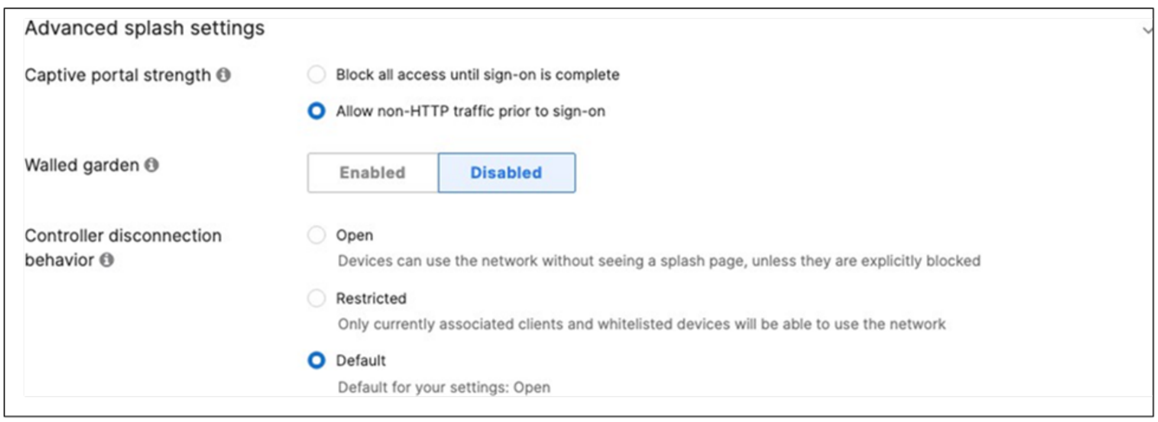
52. **Configure Access Control for Guest**: Navigate to **Wireless > Configure > Access control** then from the top drop-down menu choose **Guest.**

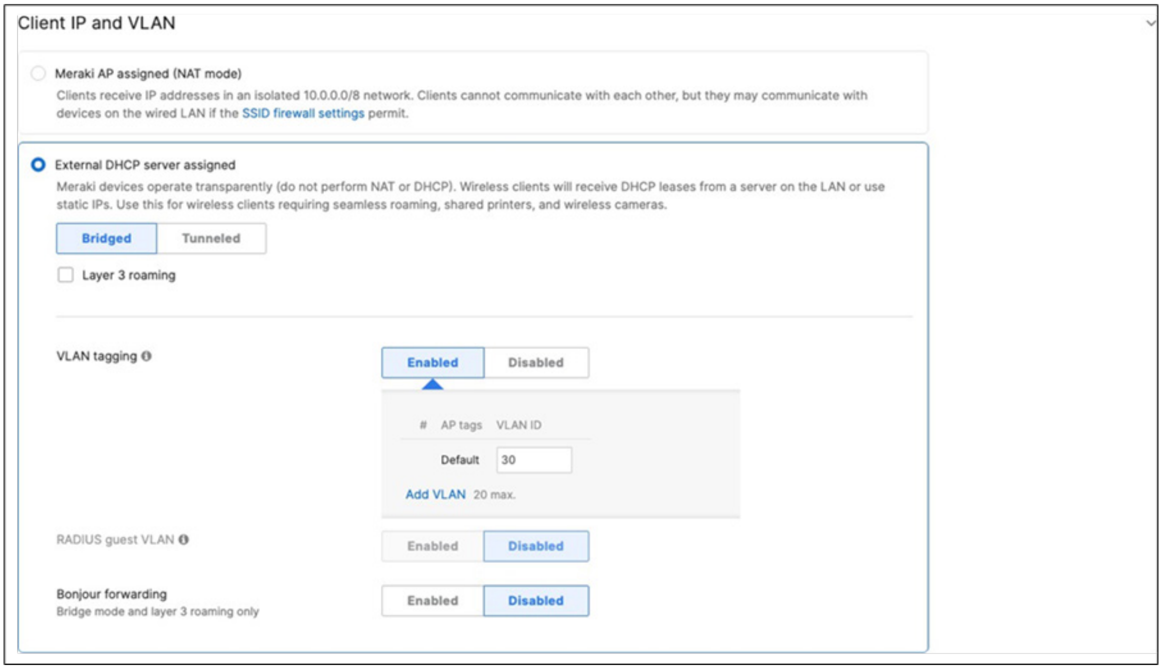



Security
Open (no encryption)
Any user can associate
Opportunistic Wireless Encryption (OWE)
Any user can associate with data encryption
Pre-shared key (PSK)
Users must enter a passphrase to associate
MAC-based access control (no encryption)
RADIUS server is queried at association time
Enterprise with
Meraki Cloud Authentication
User credentials are validated with 802.1X at association time
Identity PSK with RADIUS
RADIUS server is queried at association time to obtain a passphrase for a device based on its MAC address
Identity PSK without RADIUS
Devices are assigned a group policy based on its passphrase


WPA encryption
None
802.11r
Enabled
Adaptive
Disabled
802.11w
Enabled (allow unsupported clients)
Required (reject unsupported clients)
Disabled (never use)
Mandatory DHCP
Enabled
Disabled


Splash page Click-through
Not all splash authentication methods are compatible with WPA2-Enterprise authentication
None (direct access)
Users can access the network as soon as they associate
Click-through
Users must view and acknowledge your splash page before being allowed on the network
Sponsored guest login
Guests must enter a valid sponsor and own email address before being allowed on the network
Sign-on with
Meraki Cloud Authentication
Users must enter a username and password before being allowed on the network
Sign-on with SMS Authentication
Users enter a mobile phone number and receive an authorization code via SMS.
After a trial period of 25 texts, you will need to connect with your Twilio account on the Network-wide settings page.
Cisco Identity Services Engine (ISE) Authentication
Users are redirected to the Cisco ISE web portal for device posturing and guest access
Endpoint management enrollment
Only devices enrolled in endpoint management can access this network
Billing (paid access)
Users choose from various pay-for-access options, or an optional free tier. Only one enabled SSID may be configured to 'Billing'

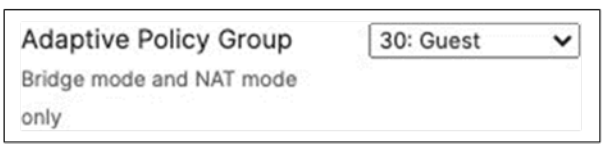

Advanced splash settings
Captive portal strength
Block all access until sign-on is complete
Allow non-HTTP traffic prior to sign-on
Walled garden
Enabled
Disabled
Controller disconnection behavior
Open
Devices can use the network without seeing a splash page, unless they are explicitly blocked
Restricted
Only currently associated clients and whitelisted devices will be able to use the network
Default
Default for your settings: Open



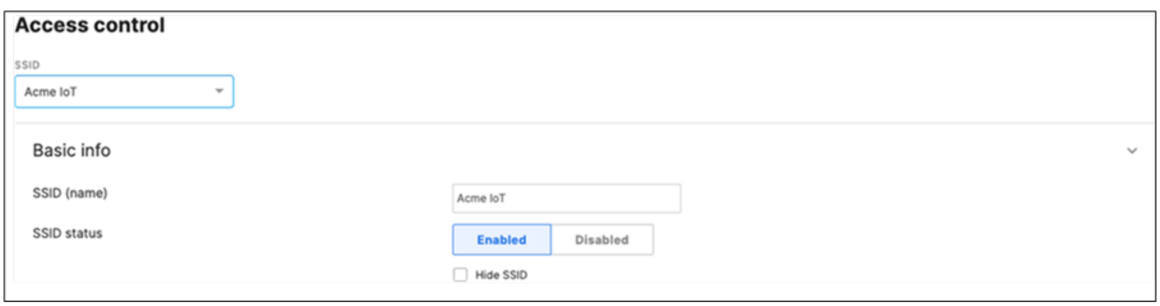
- Click on

  View old Version

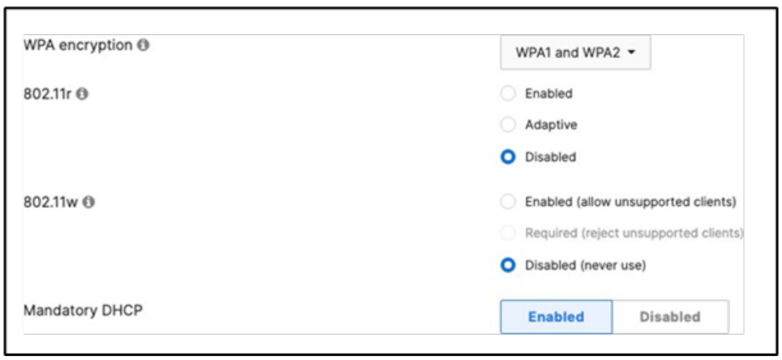
  at the top right corner of the page then choose the Adaptive Policy Group **30: Guest** then click on **Save** at the bottom of the page

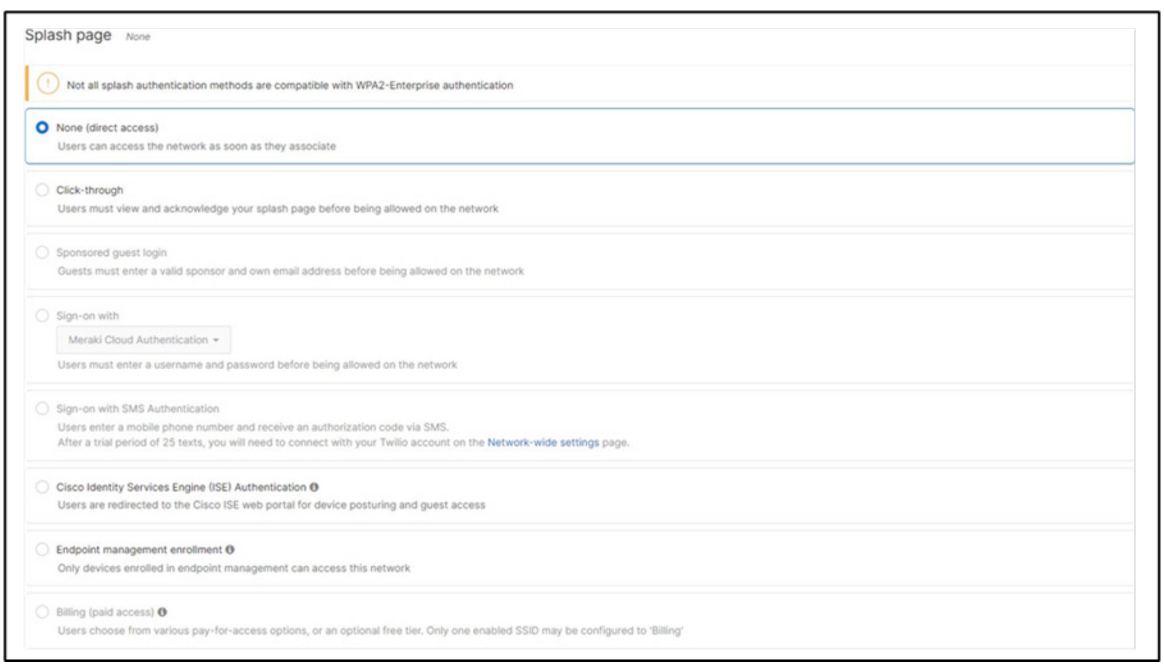


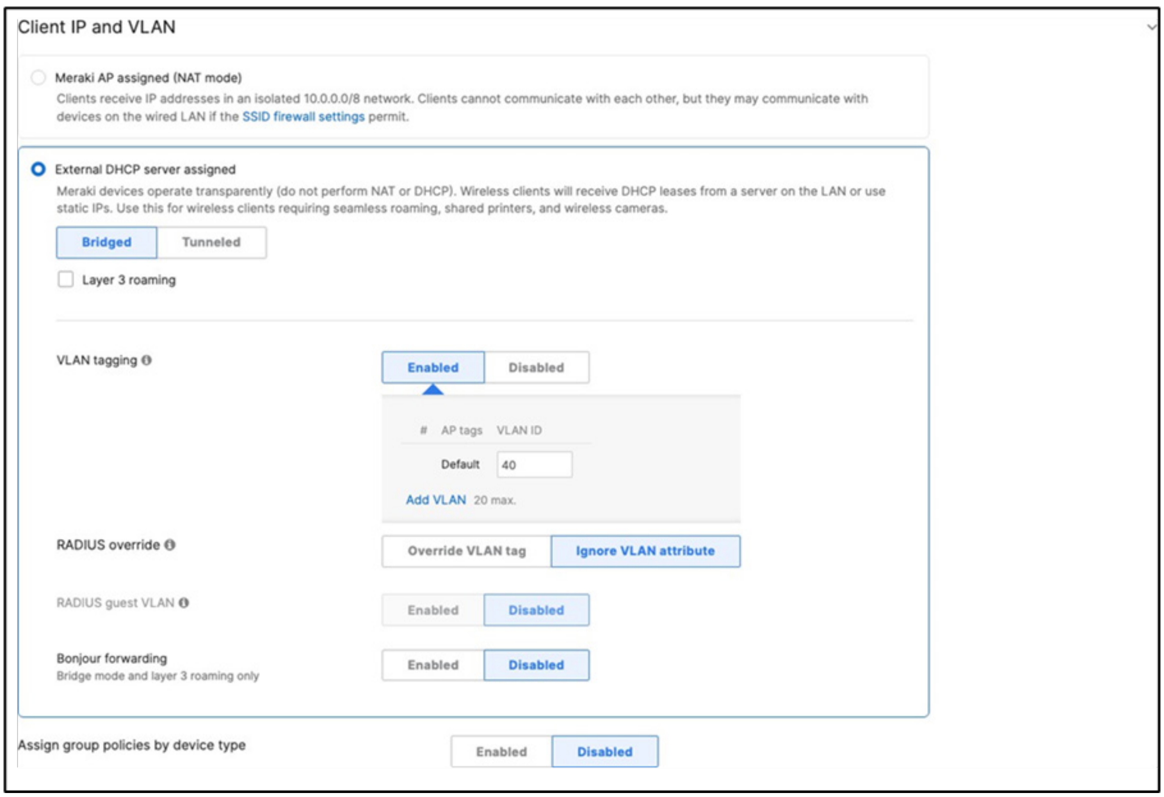
53. **Configure Access Control for Acme IoT**: Navigate to **Wireless > Configure > Access control** then from the top drop-down menu choose **Acme IoT.**




Security
Open (no encryption)
Any user can associate
Opportunistic Wireless Encryption (OWE)
Any user can associate with data encryption
Pre-shared key (PSK)
Users must enter a passphrase to associate
MAC-based access control (no encryption)
RADIUS server is queried at association time
Enterprise with
my RADIUS server
User credentials are validated with 802.1X at association time
Identity PSK with RADIUS
RADIUS server is queried at association time to obtain a passphrase for a device based on its MAC address
Identity PSK without RADIUS
Devices are assigned a group policy based on its passphrase


WPA encryption
WPA1 and WPA2
802.11r
Enabled
Adaptive
Disabled
802.11w
Enabled (allow unsupported clients)
Required (reject unsupported clients)
Disabled (never use)
Mandatory DHCP
Enabled
Disabled

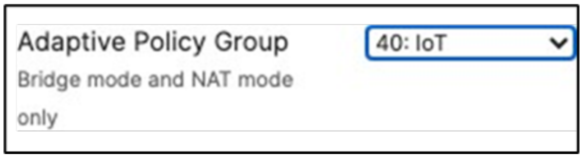

Splash page
None
Not all splash authentication methods are compatible with WPA2-Enterprise authentication
None (direct access)
Users can access the network as soon as they associate
Click-through
Users must view and acknowledge your splash page before being allowed on the network
Sponsored guest login
Guests must enter a valid sponsor and own email address before being allowed on the network
Sign-on with
Meraki Cloud Authentication
Users must enter a username and password before being allowed on the network
Sign-on with SMS Authentication
Users enter a mobile phone number and receive an authorization code via SMS.
After a trial period of 25 texts, you will need to connect with your Twilio account on the Network-wide settings page.
Cisco Identity Services Engine (ISE) Authentication
Users are redirected to the Cisco ISE web portal for device posturing and guest access
Endpoint management enrollment
Only devices enrolled in endpoint management can access this network
Billing (paid access)
Users choose from various pay-for-access options, or an optional free tier. Only one enabled SSID may be configured to 'Billing'



- Click on

  View old version

  at the top right corner of the page then choose the Adaptive Policy Group **40: IoT** then click on **Save** at the
- bottom of the page



54. Enabling **Stacking** on your MS390 and C9300 Switches in Meraki Dashboard; please follow these steps:

    A. Connect a **single** uplink to each switch (e.g. Port 1 on MS390-01 to Port TwentyFiveGigE1/0/23 on C9500)

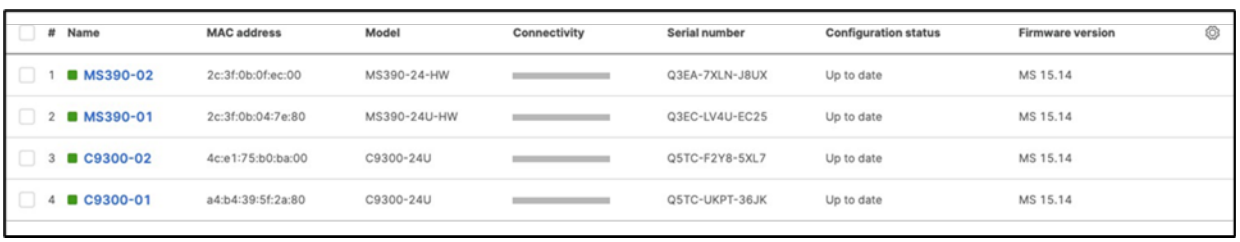
    B. Make sure all stacking cables are **unplugged** from all switches

    C. Power up all switches

    D. Verify that your C9500 Stack downlinks are up and not shutdown

```
9500-01#ship interface brief
Interface              IP-Address OK?    Method Status    Protocol
TwentyFiveGigE1/0/23   unassigned         YES unset up     up
TwentyFiveGigE1/0/24   unassigned         YES unset up     up
TwentyFiveGigE2/0/23   unassigned         YES unset up     up
TwentyFiveGigE2/0/24   unassigned         YES unset up     up
9500-01#
```

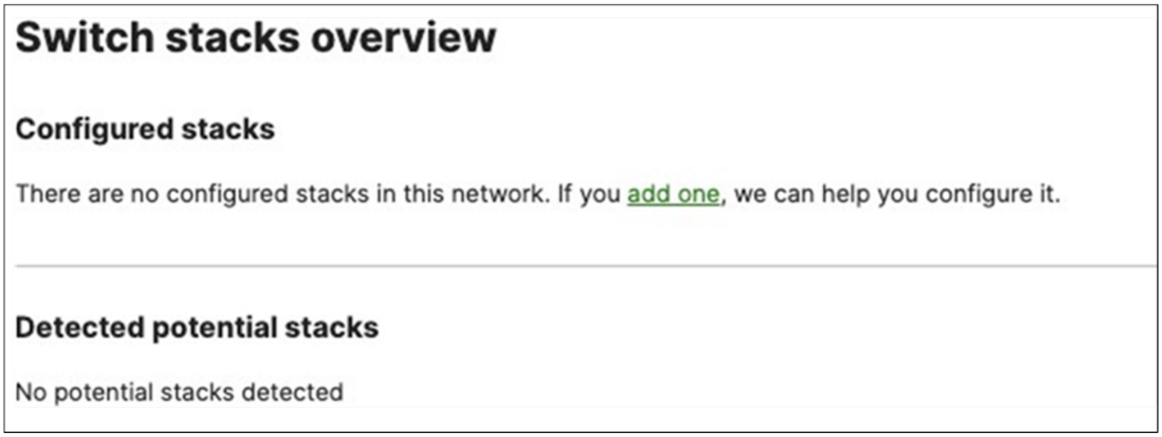
    E. Wait for them to come online on dashboard. Navigate to **Switching > Monitor > Switches** and check the status of your Access Switches



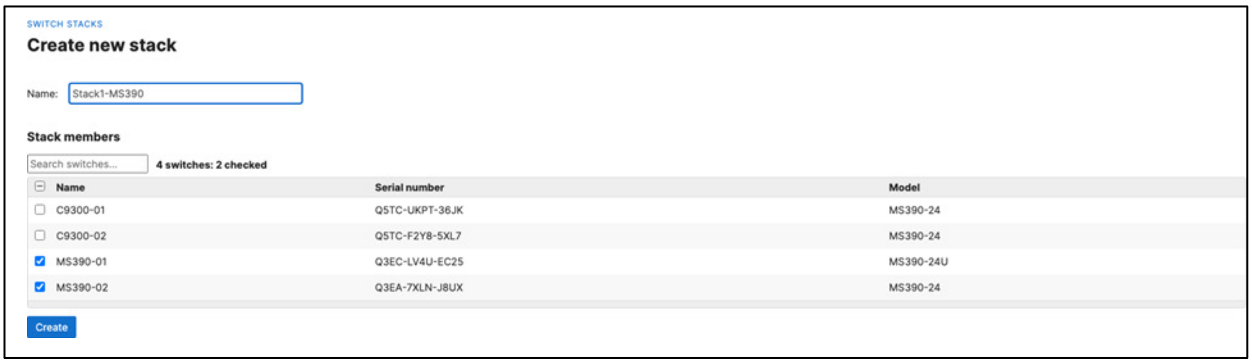
#	Name	MAC address	Model	Connectivity	Serial number	Configuration status	Firmware version
1	MS390-02	2c:3f:0b:0f:ec:00	MS390-24-HW		Q3EA-7XLN-J8UX	Up to date	MS 15.14
2	MS390-01	2c:3f:0b:04:7e:80	MS390-24U-HW		Q3EC-LV4U-EC25	Up to date	MS 15.14
3	C9300-02	4c:e1:75:b0:ba:00	C9300-24U		Q5TC-F2Y8-5XL7	Up to date	MS 15.14
4	C9300-01	a4:b4:39:5f:2a:80	C9300-24U		Q5TC-UKPT-36JK	Up to date	MS 15.14

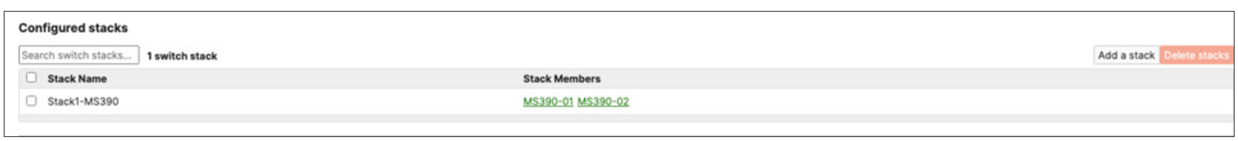
    F. After they come online and download their configuration and firmware (**Up to date**) you can proceed to the next step. You can see their Configuration status and Firmware version from **Switching > Monitor > Switches**

    G. Enable stacking in dashboard by Navigating to **Switching > Monitor > Switch stacks** then click on **add one**

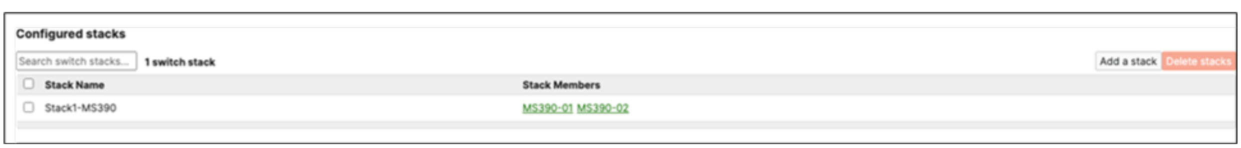


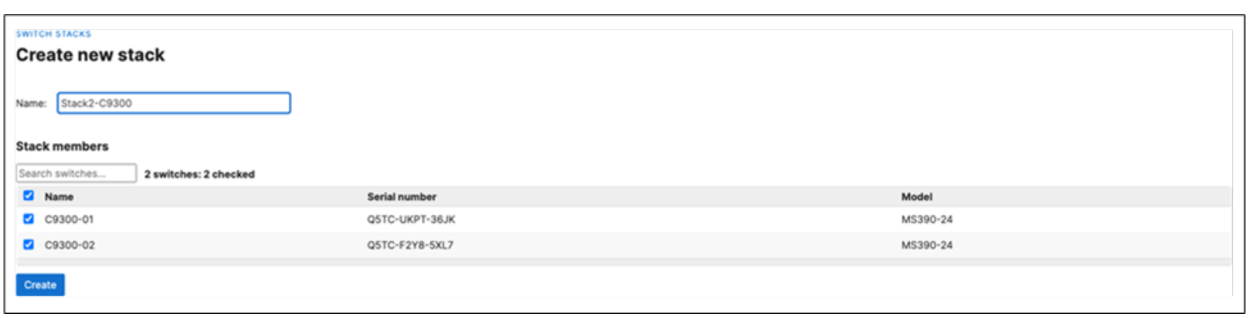
H. Then give your stack a **name** and select its **members** and click on **Create**

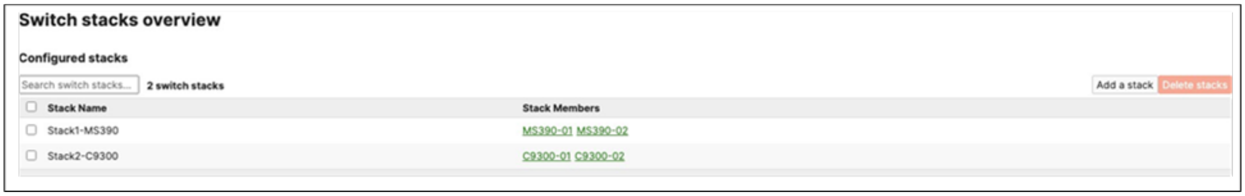




I. Now click on **Add a stack** to create all other stacks in your Campus LAN access layer by repeating the above steps







J. Power off **all** access switches

K. Disconnect **all** uplink cables from all switches

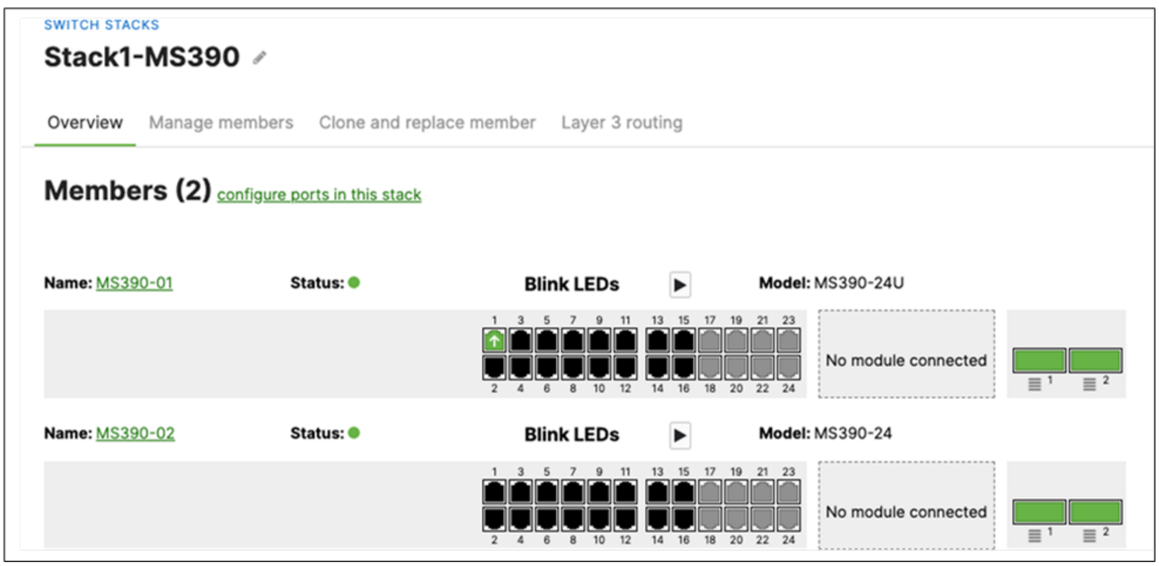
L. Nominate your master switch for each stack (e.g. MS390-01 for stack1 and C9300-01 for stack2)

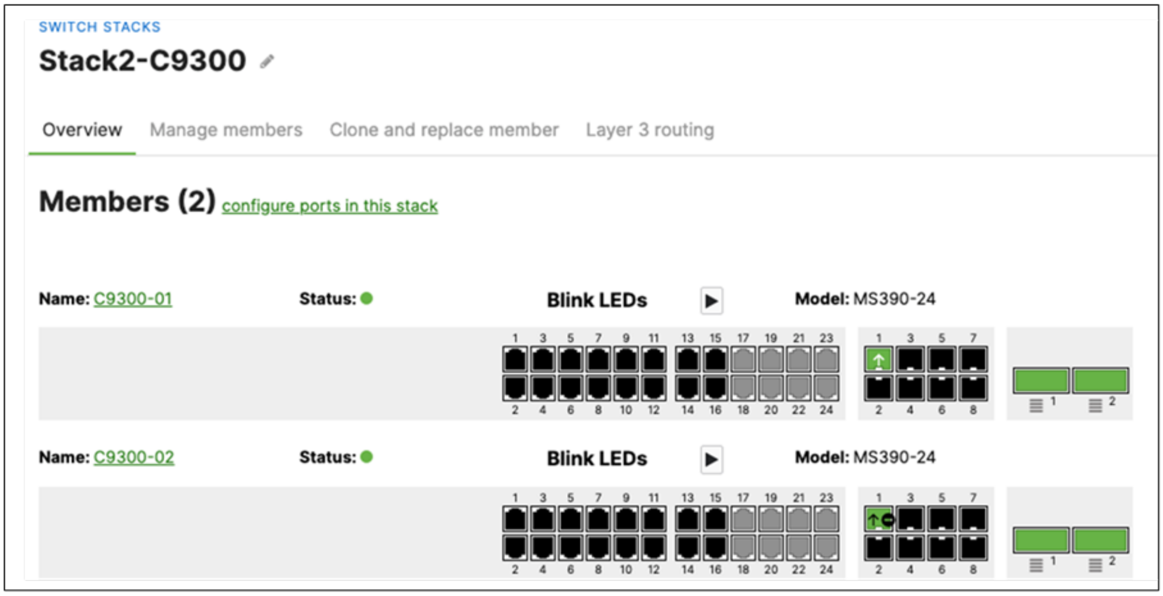
M. On the master switches, plug the uplink again

N. Plug stacking cables on all switches in each stack to form a **ring** topology and make sure that the Cisco logo is upright

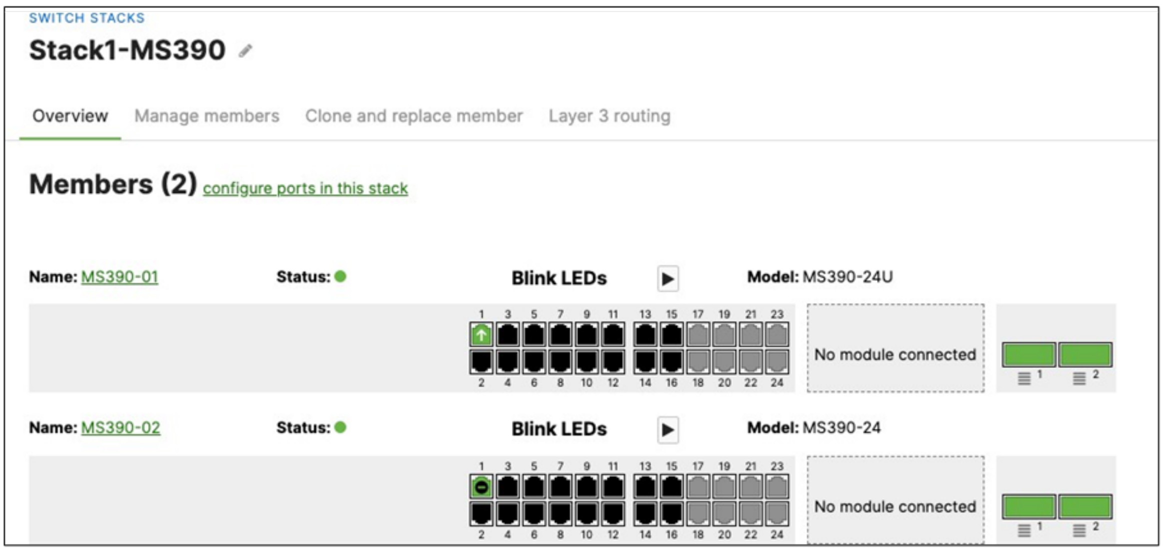
O. Power on your **master** switches **first**, then power other stack members

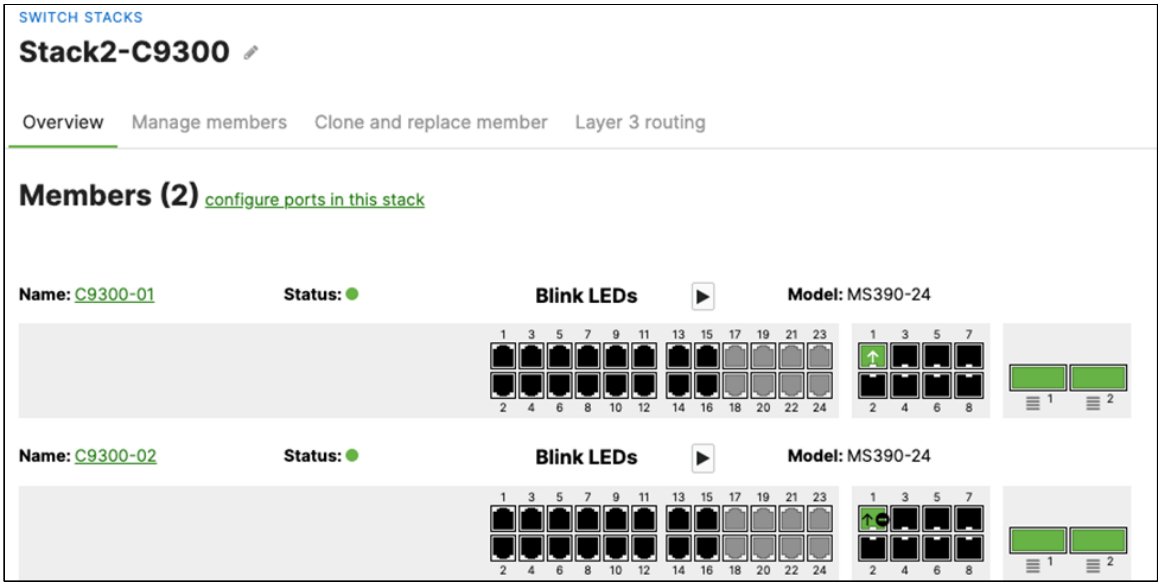
P. Wait for the stack to come online on dashboard. To check the status of your stack, Navigate to **Switching > Monitor > Switch stacks** and then click on each stack to verify that all members are online and that stacking cables show as connected



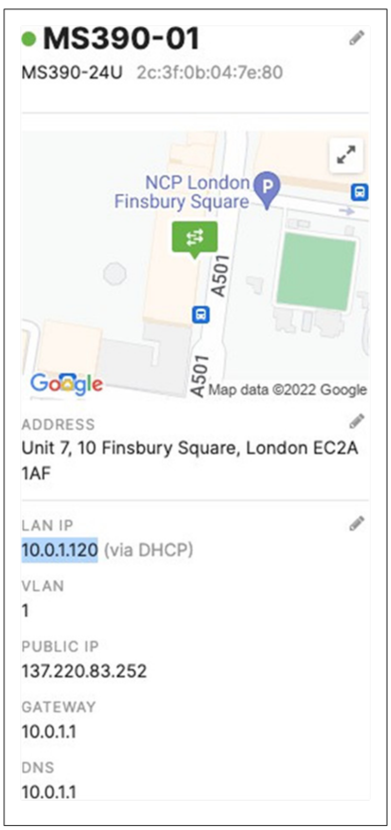


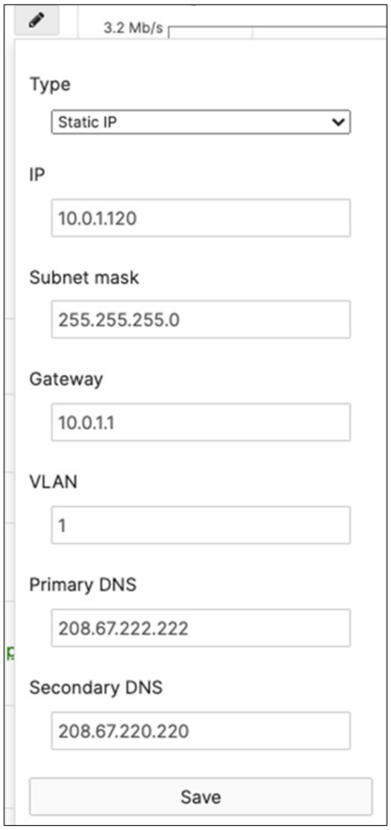
Q. Plug uplinks on all other non-master members and verify that the uplink is online in dashboard by navigating to **Switching > Monitor > Switch stacks** and then click on each stack to verify that all uplinks are showing as connected however they should be in **STP discarding mode**

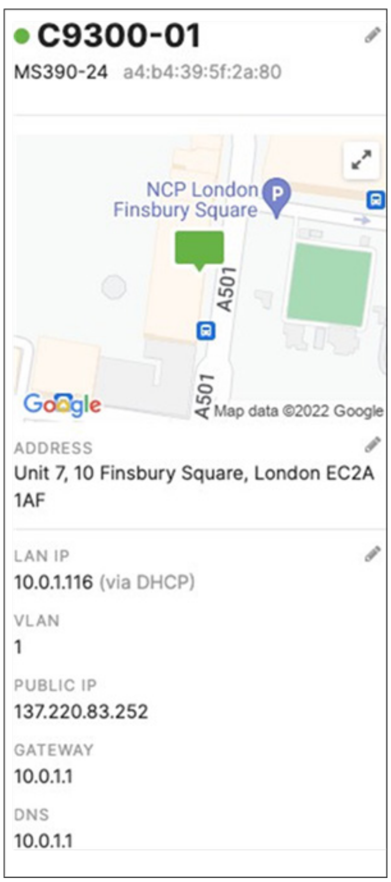


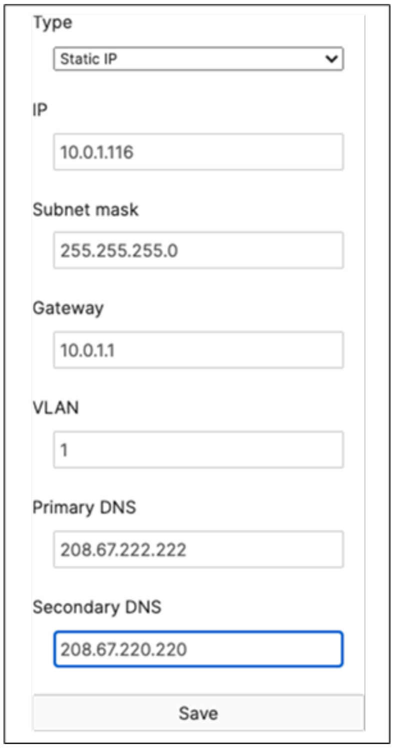


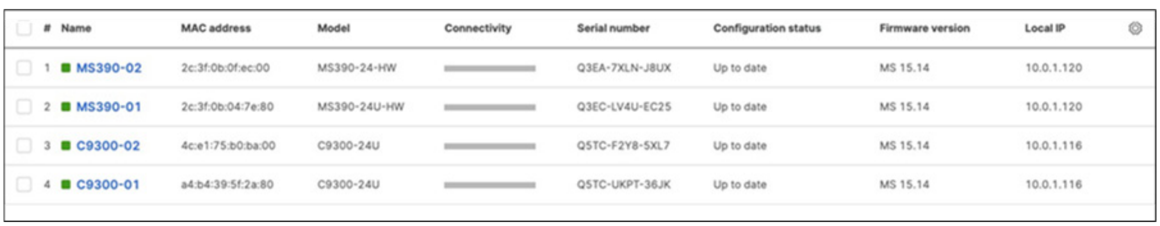
R. Configure the same Static IP for all members in each stack by navigating to **Switching > Monitor > Switches** then click on the master switch (e.g. MS390-01 for Stack1) and under LAN IP menu copy the IP address then click on the **edit** button to specify the Static IP address information (You can use the same IP address that was assigned using DHCP) then click **Save.** The same Static IP address information should now be copied for all members of the same stack. You can verify this by navigating to **Switch > Monitor > Switches** (Tip: Click on the configure button on the right-hand side of the table to add Local IP information display).




3.2 Mb/s
Type
Static IP
IP
10.0.1.120
Subnet mask
255.255.255.0
Gateway
10.0.1.1
VLAN
1
Primary DNS
208.67.222.222
Secondary DNS
208.67.220.220
Save

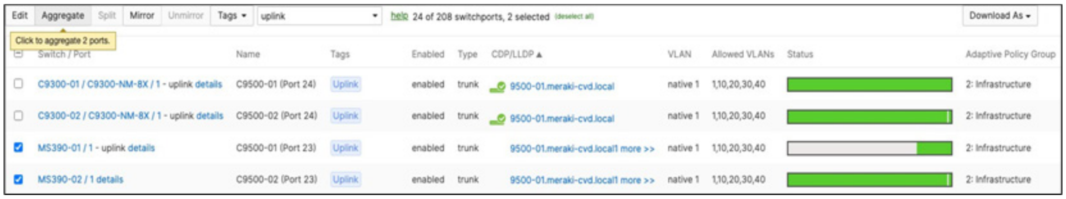

C9300-01
MS390-24 a4:b4:39:5f:2a:80
NCP London Finsbury Square
A501
A501
Google
Map data ©2022 Google
ADDRESS
Unit 7, 10 Finsbury Square, London EC2A 1AF
LAN IP
10.0.1.116 (via DHCP)
VLAN
1
PUBLIC IP
137.220.83.252
GATEWAY
10.0.1.1
DNS
10.0.1.1

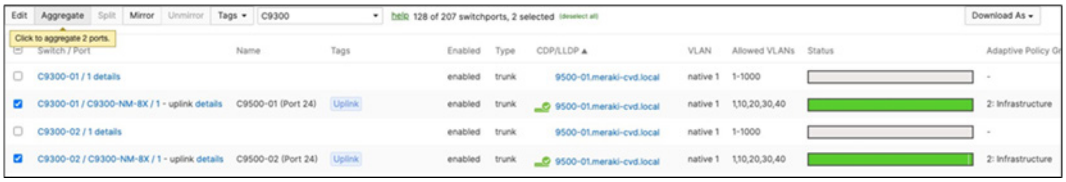


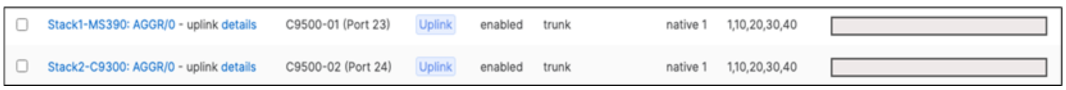


S. Finally, configure *etherchannels* on both your Access Switch Stacks and your Core Switch Stacks so that all uplinks can be operational (STP forwarding mode) at the same time. Follow these steps:

- First, disconnect the downlinks to non-master switches from your C9500 Core Stack (e.g. Port TwentyFiveGigE2/0/23 and TwentyFiveGigE2/0/24)
- Navigate to **Switching > Monitor > Switch ports** and search for **uplink** then select all uplinks in the same stack (in case you have tagged your ports otherwise search for them manually and select them all) then click on **Aggregate**. Please note that all port members of the same Ether Channel must have the **same** configuration otherwise Dashboard will not allow you to click the aggregate button.







- Please repeat above steps for **all** stacks in your network
- Please note that the above step will cause all members within the stack to go offline in Dashboard

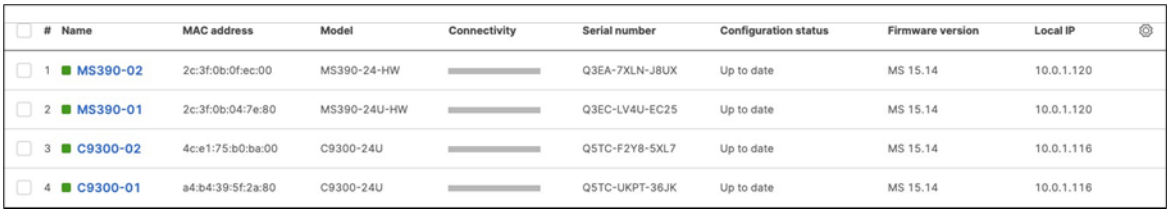
- On your C9500 Core Stack, please configure etherchannel Settings for your downlinks such that *each* Stack downlinks should be in a *separate* Port-channel and that the mode is **active**:

```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#interface TwentyFiveGigE1/0/23
9500-01(config-if)#channel-group 1 mode active
Creating a port-channel interface Port-channel 1

9500-01(config-if)#
9500-01(config-if)#interface TwentyFiveGigE2/0/23
9500-01(config-if)#channel-group 1 mode active
9500-01(config-if)#interface TwentyFiveGigE1/0/24
9500-01(config-if)#channel-group 2 mode active
Creating a port-channel interface Port-channel 2

9500-01(config-if)#interface TwentyFiveGigE2/0/24
9500-01(config-if)#channel-group 2 mode active
9500-01(config-if)#end
9500-01#
9500-01#show etherchannel 1 port-channel
Port-channels in the group:
------------------------
Port-channel: Po1 (Primary Aggregator)
---------------
```

```
Age of the Port-channel = 0d:01h:42m:43s
Logical slot/port = 9/1 Number of ports = 2
HotStandBy port = null
Port state = Port-channel Ag-Inuse
Protocol = LACP
Port security = Disabled
Fast-switchover = disabled
Fast-switchover Dampening = disabled
Ports in the Port-channel:

Index Load Port        EC state    No of bits
------+------+------+-------------+-----------
0    00   Twe1/0/23   Active        0
0    00   Twe2/0/23   Active        0

Time since last port bundled: 0d:01h:40m:21s     Twe2/0/23

9500-01#
9500-01#show etherchannel 2 port-channel
Port-channels in the group:
------------------

Port-channel: Po2 (Primary Aggregator)

-----------

Age of the Port-channel = 0d:01h:43m:56s
Logical slot/port = 9/2      Number of ports = 2
HotStandBy port = null
Port state = Port-channel Ag-Inuse
Protocol = LACP
Port security = Disabled
Fast-switchover = disabled
Fast-switchover Dampening = disabled
Ports in the Port-channel:
Index   Load    Port     EC state   No of bits
-------+------+------+-------------+-----------
0   00       Twe1/0/24    Active        0
0   00       Twe2/0/24    Active        0

Time since last port bundled: 0d:01h:42m:04s Twe2/0/24
9500-01#9500-01#wr mem
```

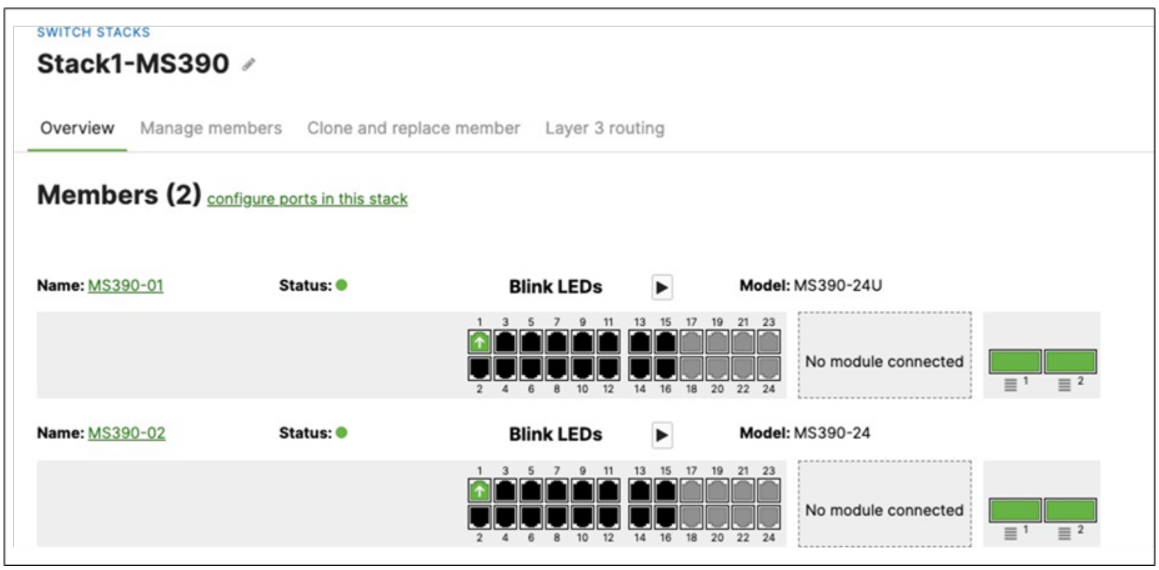
```
Building configuration...
[OK]
9500-01#
```

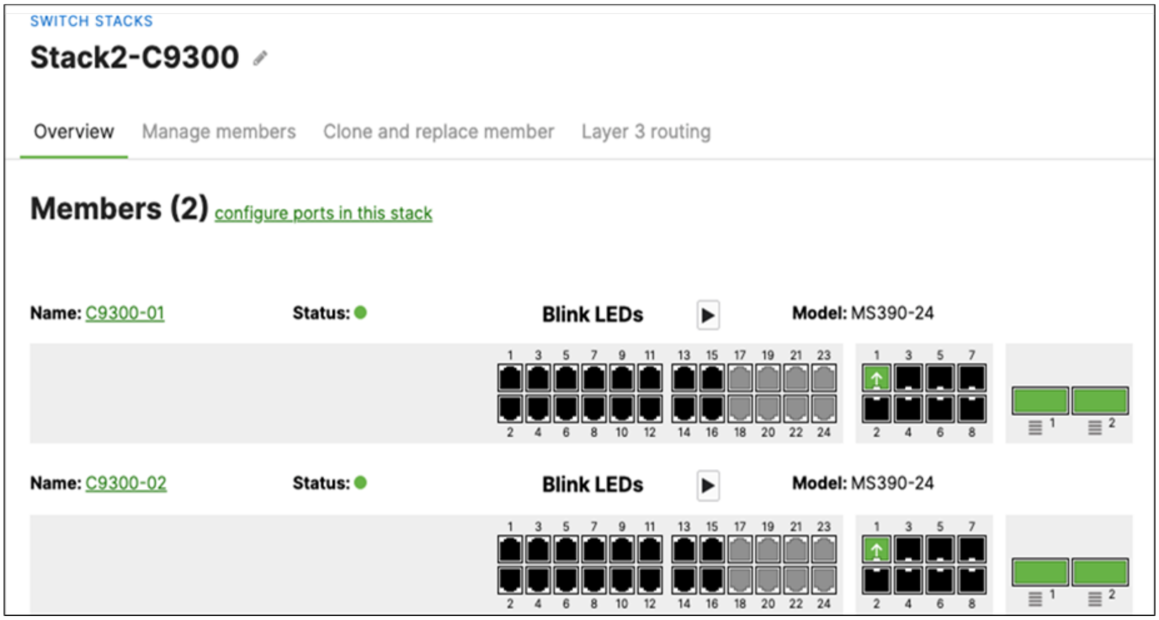
- Plug all uplinks to non-master switches
- Now all your switches should come back online on Dashboard



#	Name	MAC address	Model	Connectivity	Serial number	Configuration status	Firmware version	Local IP
1	MS390-02	2c:3f:0b:0f:ec:00	MS390-24-HW		Q3EA-7XLN-J8UX	Up to date	MS 15.14	10.0.1.120
2	MS390-01	2c:3f:0b:04:7e:80	MS390-24U-HW		Q3EC-LV4U-EC25	Up to date	MS 15.14	10.0.1.120
3	C9300-02	4c:e1:75:b0:ba:00	C9300-24U		Q5TC-F2Y8-5XL7	Up to date	MS 15.14	10.0.1.116
4	C9300-01	a4:b4:39:5f:2a:80	C9300-24U		Q5TC-UKPT-36JK	Up to date	MS 15.14	10.0.1.116

- And now all your uplinks from each stack should be in STP Forwarding mode, which you can verify on Dashboard by navigating to **Switching > Monitor > Switch stacks** and checking the uplink port status. Also, you can check that on your C9500 Core Stack:

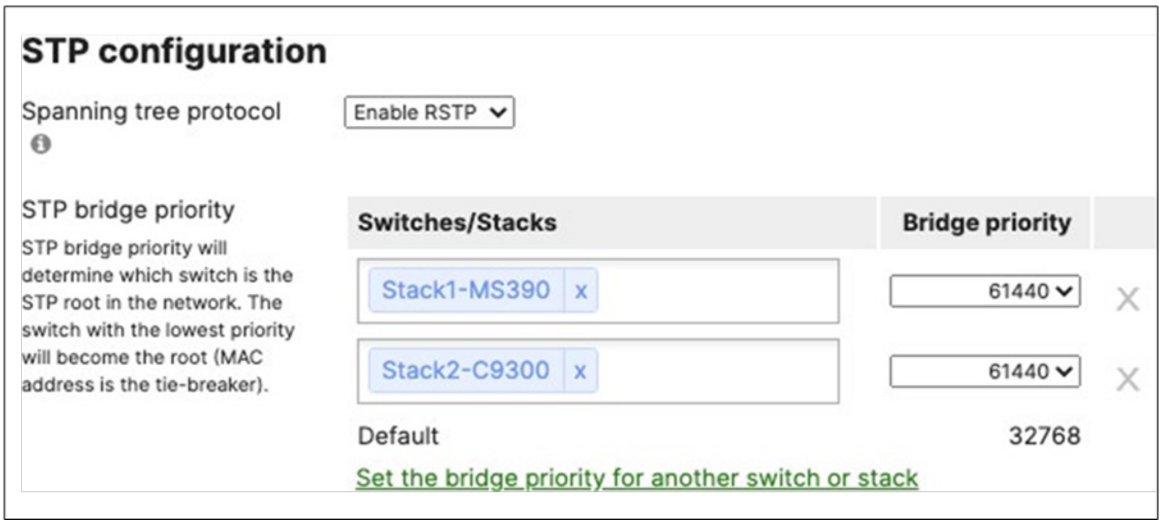





```
9500-01#show spanning-tree interface port-channel 1

Mst Instance        Role Sts Cost      Prio.Nbr Type
----------------------------------------------------
MST0               Desg FWD 10000     128.2089 P2p
9500-01#show spanning-tree interface port-channel 2

Mst Instance        Role Sts Cost      Prio.Nbr Type
----------------------------------------------------
MST0               Desg FWD 10000     128.2089 P2p
9500-01#show spanning-tree
MST0
  Spanning tree enabled protocol mstp
  Root ID Priority 4096
     Address b0c5.3c60.fba0
     This bridge is the root
     Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 4096 (priority 4096 sys-id-ext 0)
    Address b0c5.3c60.fba0
    Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Interface     Role Sts Cost       Prio.Nbr Type
---------------------------------------------------
Twe1/0/1      Desg FWD 2000       128.193 P2p
```

```
Twe1/0/2       Desg FWD 2000       128.194 P2p
Twe2/0/1       Back BLK 2000       128.385 P2p
Twe2/0/2       Back BLK 2000       128.386 P2p
Po1            Desg FWD 10000      128.2089 P2p
Po2            Desg FWD 1000       128.2090 P2p
9500-01#
```

55. **Configure Multiple Spanning Tree Protocol (802.1s)** in Dashboard for MS390 and C9300 switches: Navigate to **Switching > Configure > Switch settings** and select your stack and choose the appropriate STP priority per stack (61440 for all Access Switch Stacks) then click Save at the bottom of the page.



- Verify that the Access Stacks are seeing the C9500 Core Stack as the root by navigating to **Switching > Monitor > Switches** then click on any switch and under the RSTP root menu check the root bridge information

56. **Configure Dynamic ARP Inspection (DAI) on your C9500 Core Switches:** All Downlinks to Access Switches and Uplinks to MX Edge must be configured as **Trusted** and all other interfaces as **Untrusted.** (Please note that the order of commands is important to avoid loss of connectivity)

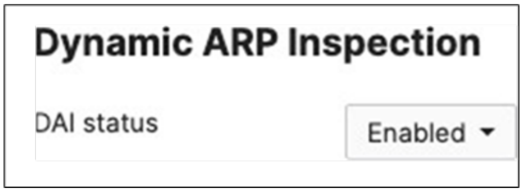
```
9500-01#show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone,
                  D - Remote, C - CVTA, M - Two-port Mac Relay

Device ID      Local Intrfce     Holdtme Capability Platform Port ID
a4b4395f2a80  Twe 1/0/24        124      S C9300-24U Port C9300-NM-8X/1
2c3f0b0fec00  Twe 2/0/23        174      S MS390-24 Port 1
2c3f0b047e80  Twe 1/0/23        159      S MS390-24U Port 1
4ce175b0ba00  Twe 2/0/24        177      S C9300-24U Port C9300-NM-8X/1
```

```
Total cdp entries displayed : 4
9500-01#configure terminal
9500-01(config)#interface TwentyFiveGigE1/0/1
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
9500-01(config)#interface TwentyFiveGigE1/0/2
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
9500-01(config)#interface TwentyFiveGigE2/0/1
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
9500-01(config)#interface TwentyFiveGigE2/0/2
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
9500-01(config)#interface Po1
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
9500-01(config)#interface Po2
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
9500-01(config)#ip arp inspection vlan 1,10,20,30,40
9500-01(config)#ip dhcp snooping vlan 1,10,20,30,40
9500-01(config)#end
9500-01#show ip dhcp snooping
Switch DHCP snooping is enabled
Switch DHCP gleaning is disabled
DHCP snooping is configured on following VLANs:
1,10,20,30,40
DHCP snooping is operational on following VLANs:
1,10,20,30,40
DHCP snooping is configured on the following L3 Interfaces:

Insertion of option 82 is enabled
   circuit-id default format: vlan-mod-port
   remote-id: b0c5.3c60.fba0 (MAC)
Option 82 on untrusted port is not allowed
```

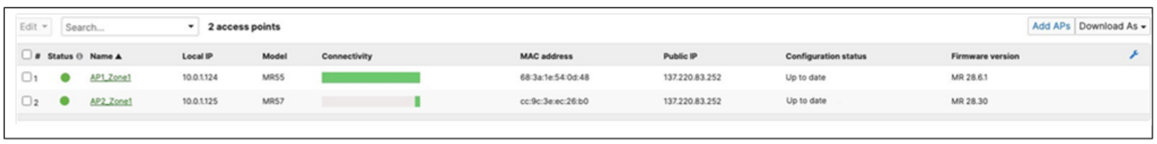
```
Verification of hwaddr field is enabled
Verification of giaddr field is enabled
DHCP snooping trust/rate is configured on the following Interfaces:


Interface                Trusted      Allow option      Rate limit (pps)
-----------------------------------------------------------------------
TwentyFiveGigE1/0/1         yes        yes           unlimited
Custom circuit-ids:
TwentyFiveGigE1/0/2         yes        yes           unlimited
Custom circuit-ids:
TwentyFiveGigE1/0/23        yes        yes           unlimited
Custom circuit-ids:
TwentyFiveGigE1/0/24        yes        yes           unlimited
Custom circuit-ids:
TwentyFiveGigE2/0/1         yes        yes           unlimited
Custom circuit-ids:
TwentyFiveGigE2/0/2         yes        yes           unlimited
Custom circuit-ids:
TwentyFiveGigE2/0/23        yes        yes           unlimited
Custom circuit-ids:
TwentyFiveGigE2/0/24        yes        yes           unlimited
Custom circuit-ids:
Port-channel1               yes        yes           unlimited
Custom circuit-ids:
Port-channel2               yes        yes           unlimited
Custom circuit-ids:
9500-01#
9500-01#show ip arp inspection

Source Mac Validation : Disabled
Destination Mac Validation : Disabled
IP Address Validation : Disabled

Vlan      Configuration        Operation     ACL Match     Static ACL
-----------------------------------------------------
1         Enabled               Active
10         Enabled              Active
20         Enabled              Active
30         Enabled              Active
40         Enabled              Active
9500-01#wr mem
```

```
Building configuration...
[OK]
9500-01#
```

57. **Configure Dynamic Arp Inspection (DAI) on your Access Switch Stacks:** Navigate to **Switching > Monitor > DHCP Servers and ARP** and scroll down to Dynamic ARP Inspection and enable it. Then click **Save** at the bottom of the page.



58. **Setting up your Access Points:** Connect your APs to the respective ports on the Access Switches (e.g. Ports 13-16) and wait for them to come online on dashboard and download their firmware and configuration files. To check the status of your APs navigate to **Wireless > Monitor > Access points** and check the status, configuration and firmware of your APs.



59. **Re-addressing your Network Devices:** In this step, you will adjust your IP addressing configuration to align with your network design. This step could have been done earlier in the process however it will be easier to adjust after all your network devices have come online since the MX (The DHCP server for Management VLAN 1) has kept a record of the actual MAC addresses of all DHCP clients. Follow these steps to re-assign the desired IP addresses: (Please note that this will cause disruption to your network connectivity)

    A. Navigate to **Organization > Monitor > Overview** then click on **Devices** tab to check the current IP addressing for your network devices

    B. Navigate to **Security and SD-WAN > Monitor > Appliance status** then click on the Tools tab and click on **Run** next to ARP Table

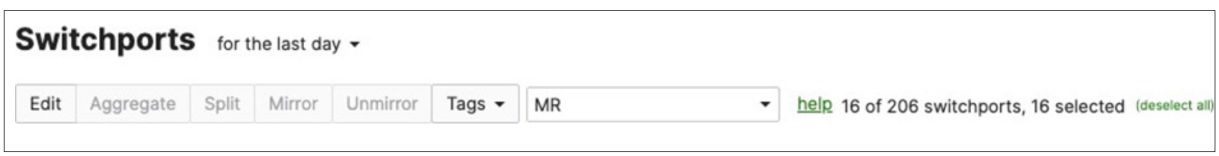
    C. Take a note of the MAC addresses of your network devices

    D. Navigate to **Security and SD-WAN > Configure > DHCP** then under **Fixed IP assignments** click on **Add a fixed IP assignment** and add entries for your network devices using the MAC addresses you have from Step #3 above then click on **Save** at the bottom of the page

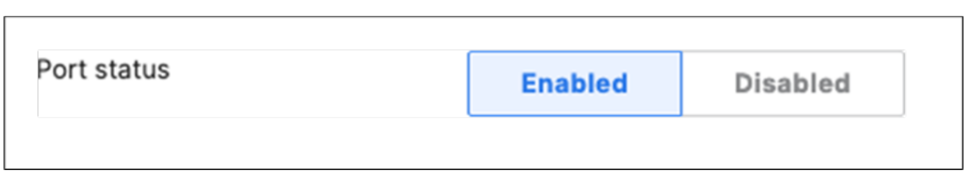
Client name	MAC address	LAN IP	Actions
9500-Core-Stack	b0:c5:3c:60:fc:3f	10.0.1.2	X
C9300-Access-Stack2	4c:e1:75:b0:ba:00	10.0.1.4	X
TFTP	8c:ae:4c:dd:15:19	10.0.1.117	X
MS390-Access-Stack1	2c:3f:0b:04:7e:80	10.0.1.3	X
AP1_Zone1	68:3a:1e:54:0d:48	10.0.1.5	X
AP2_Zone1	cc:9c:3e:ec:26:b0	10.0.1.6	X
AP3_Zone2	68:3a:1e:54:2e:45	10.0.1.7	X
AP4_Zone2	cc:9c:3e:ec:28:d0	10.0.1.8	X

Add a fixed IP assignment
Import CSV

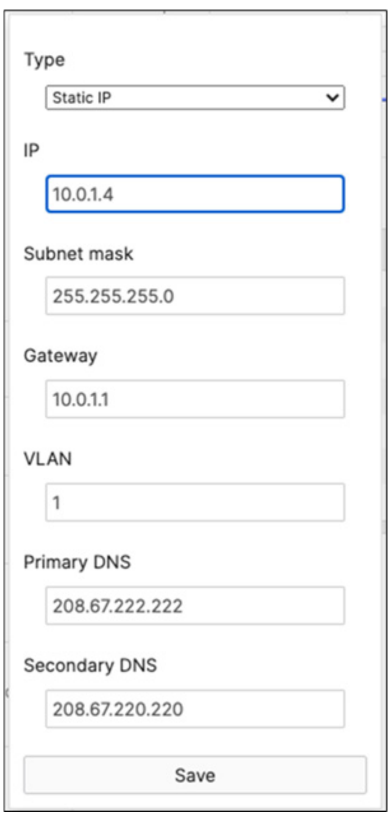
E. Navigate to **Switching > Configure > Switch ports** then filter for MR (in case you have previously tagged your ports or select ports manually if you haven't) then select those ports and click on **Edit**, then set **Port status** to Disabled then click on **Save**.



F. After a few minutes (*For configuration to be up to date*) Navigate to **Switching > Configure > Switch ports** then filter for MR (in case you have previously tagged your ports or select ports manually if you haven't) then select those ports and click on **Edit**, then set **Port status** to **Enabled** then click on **Save**.



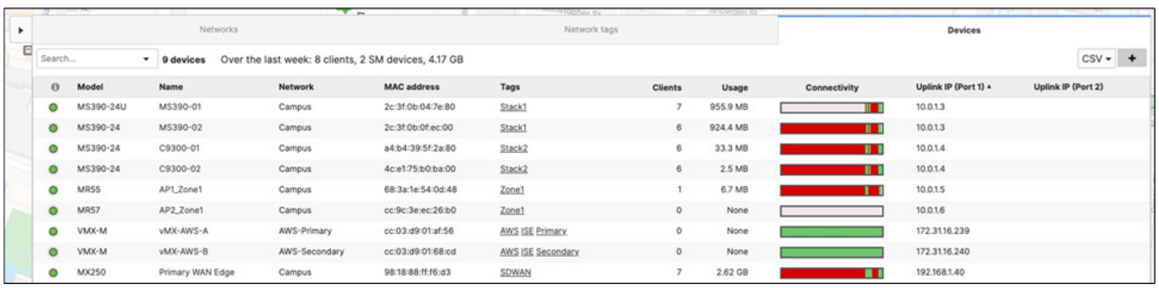
G. Navigate to **Switching > Monitor > Switches** then click on each master switch to change its IP address to the one desired using Static IP configuration (remember that all members of the same stack need to have the **same** static IP address)



H. On your C9500 Core Stack, bounce your VLAN 1 interface. Then verify that the interface VLAN 1 came up with the correct IP address (e.g. 10.0.0.2 per this design)

```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#interface vlan 1
9500-01(config-if)#shutdown
9500-01(config-if)#no shutdown
9500-01(config-if)#end
9500-01#sh ip interface brief vlan 1
Interface      IP-Address OK?   Method Status    Protocol
Vlan1          10.0.1.2         YES DHCP up      up
9500-01#
```

I. Navigate to **Organization > Monitor > Overview** then click on **Devices** tab to check the current IP addressing for your network devices



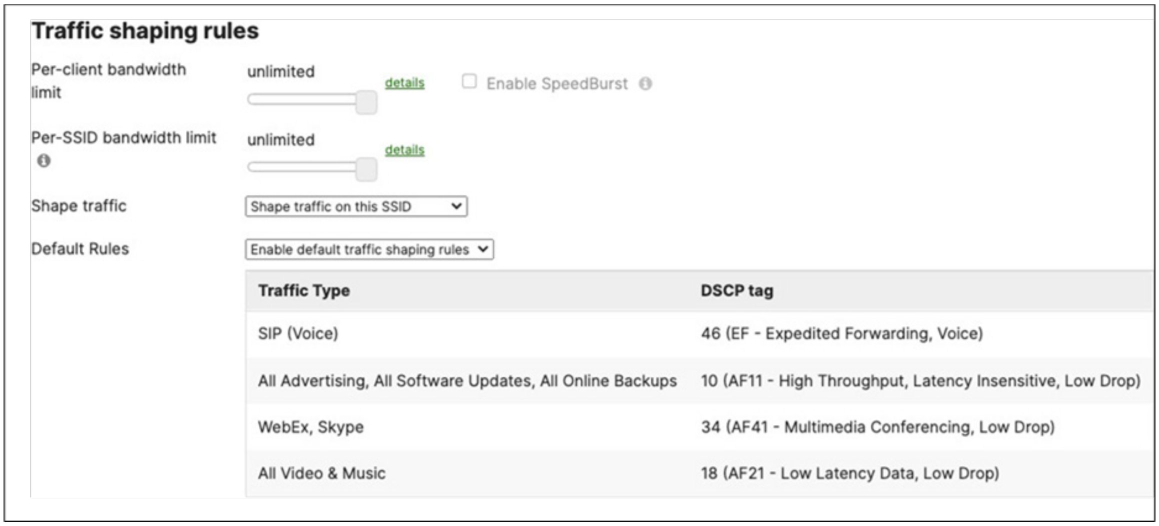
Networks | Network tags | Devices

Search... **9 devices** Over the last week: 8 clients, 2 SM devices, 4.17 GB CSV +

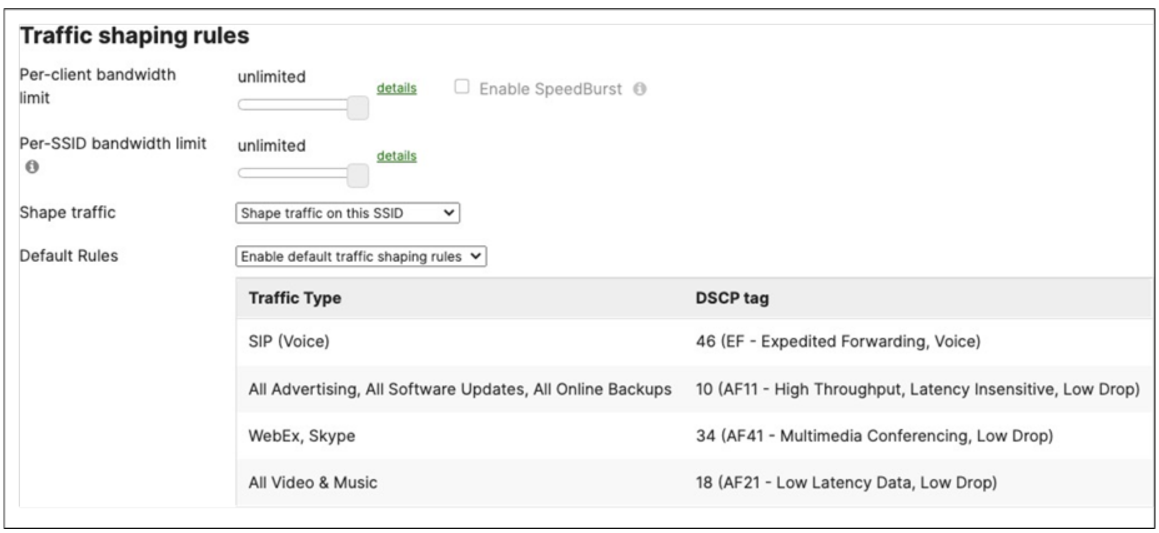
Model	Name	Network	MAC address	Tags	Clients	Usage	Connectivity	Uplink IP (Port 1) ▲	Uplink IP (Port 2)
MS390-24U	MS390-01	Campus	2c:3f:0b:04:7e:80	Stack1	7	955.9 MB		10.0.1.3	
MS390-24	MS390-02	Campus	2c:3f:0b:0f:ec:00	Stack1	6	924.4 MB		10.0.1.3	
MS390-24	C9300-01	Campus	a4:b4:39:5f:2a:80	Stack2	6	33.3 MB		10.0.1.4	
MS390-24	C9300-02	Campus	4c:e1:75:b0:ba:00	Stack2	6	2.5 MB		10.0.1.4	
MR55	AP1_Zone1	Campus	68:3a:1e:54:0d:48	Zone1	1	6.7 MB		10.0.1.5	
MR57	AP2_Zone1	Campus	cc:9c:3e:ec:26:b0	Zone1	0	None		10.0.1.6	
VMX-M	vMX-AWS-A	AWS-Primary	cc:03:d9:01:af:56	AWS ISE Primary	0	None		172.31.16.239	
VMX-M	vMX-AWS-B	AWS-Secondary	cc:03:d9:01:68:cd	AWS ISE Secondary	0	None		172.31.16.240	
MX250	Primary WAN Edge	Campus	98:18:88:ff:f6:d3	SDWAN	7	2.62 GB		192.168.1.40	

60. **Configure QoS in your Campus LAN:** Quality of Service configuration needs to be consistent across the whole Campus LAN. Please refer to the above table as an example. To configure QoS, please follow these steps: (*For the purpose of this CVD, **Default traffic shaping rules** will be used to mark traffic with DSCP values without setting any traffic limits. Please adjust traffic shaping rules based on your own requirements*)

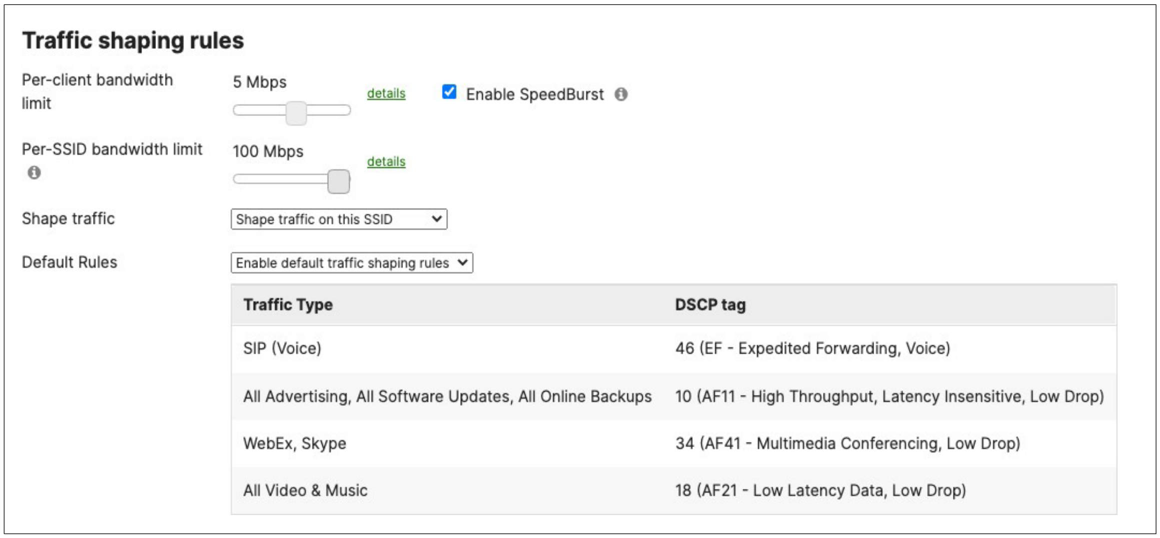
    A. Navigate to **Wireless > Configure > Firewall and Traffic Shaping** and choose the **Acme Corp** SSID from the above drop-down menu. Under **Traffic Shaping rules**, choose the per-client and per-SSID limits desired and select **Shape traffic on this SSID** then select Enable default traffic shaping rules. Click **Save** at the bottom of the page when you are done. Click **Save** at the bottom of the page when you are done.



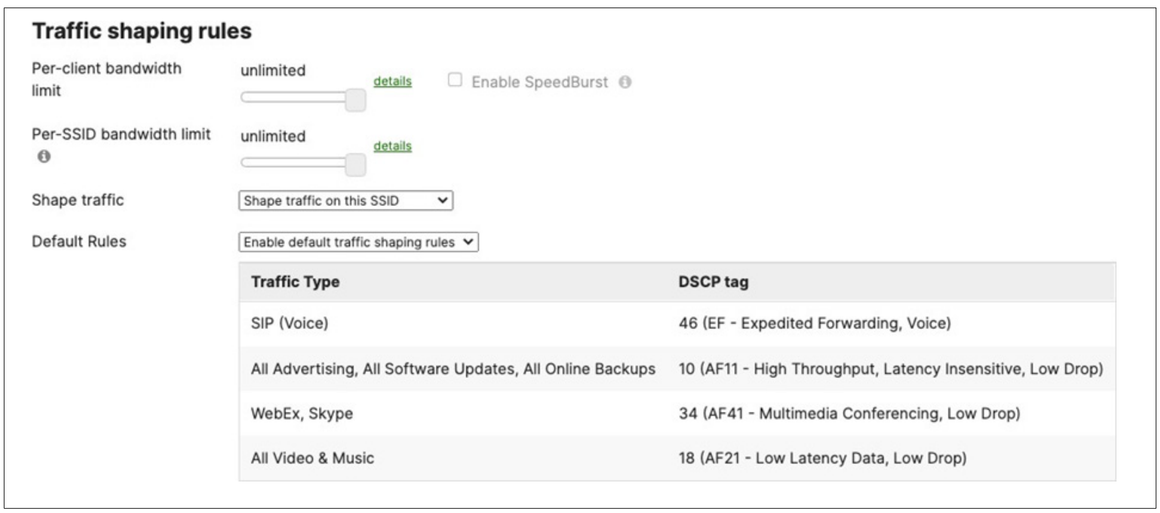
B. Navigate to **Wireless > Configure > Firewall and Traffic Shaping** and choose the **Acme BYOD** SSID from the above drop-down menu. Under **Traffic Shaping rules**, choose the per-client and per-SSID limits desired and select **Shape traffic on this SSID** then select Enable default traffic shaping rules.



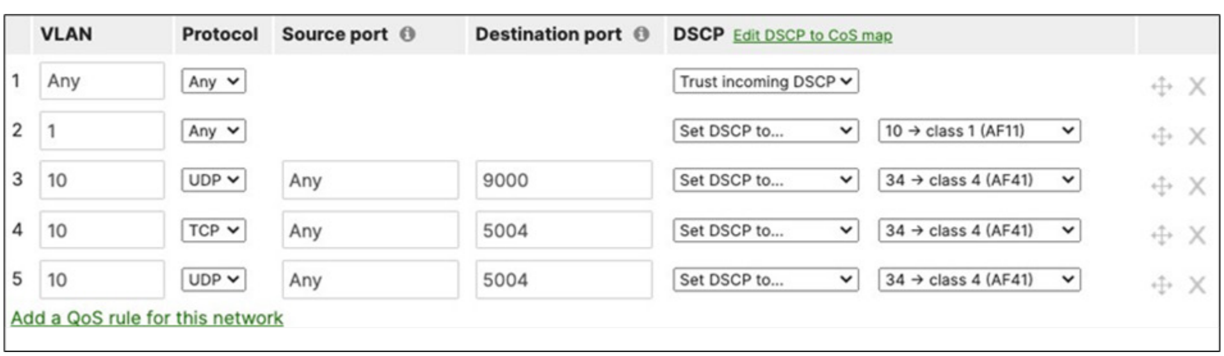
C. Navigate to **Wireless > Configure > Firewall and Traffic Shaping** and choose the **Guest** SSID from the above drop-down menu. Under **Traffic Shaping rules**, choose the per-client and per-SSID limits desired and select **Shape traffic on this SSID** then select Enable default traffic shaping rules.
Click **Save** at the bottom of the page when you are done.

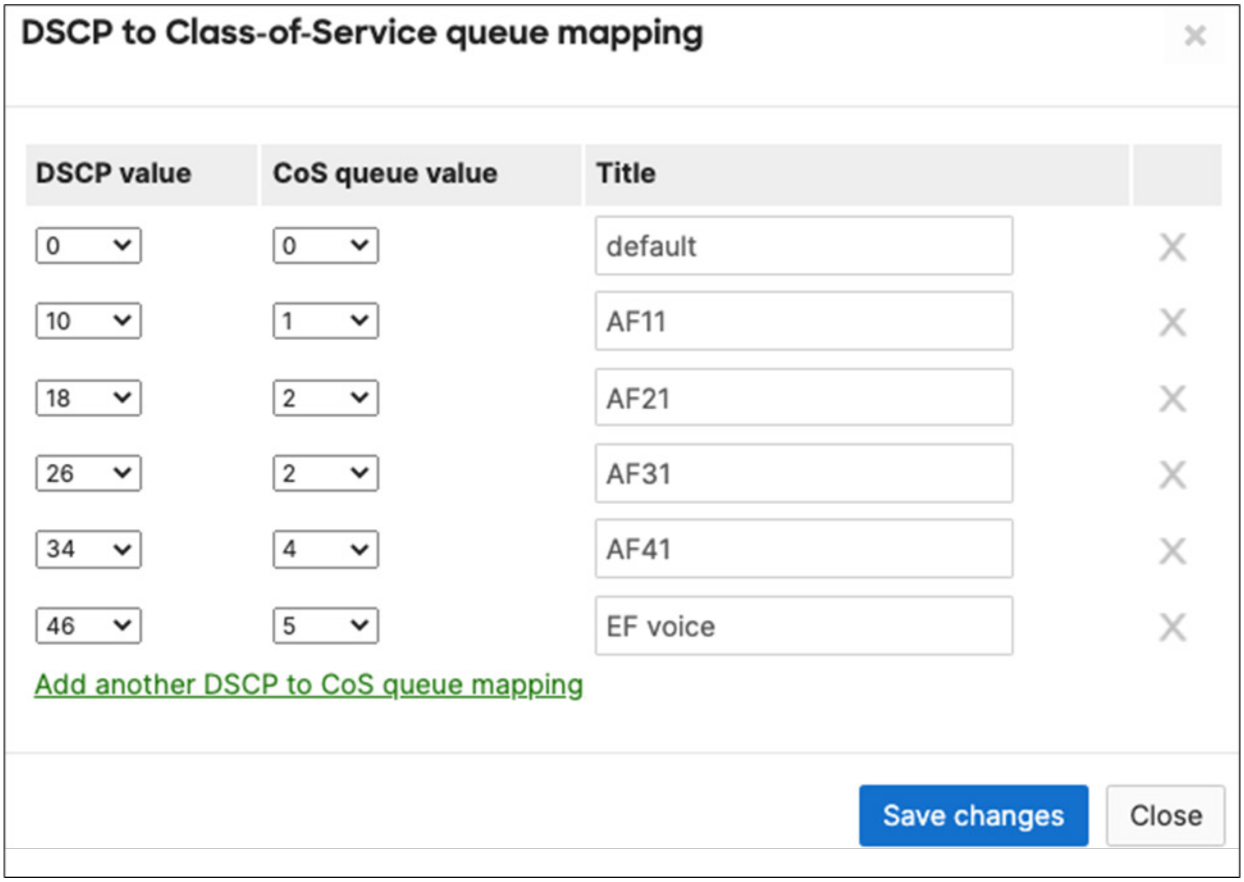


D. Navigate to **Wireless > Configure > Firewall and Traffic Shaping** and choose the **IoT** SSID from the above drop-down menu. Under **Traffic Shaping rules**, choose the per-client and per-SSID limits desired and select **Shape traffic on this SSID** then select Enable default traffic shaping rules. Click **Save** at the bottom of the page when you are done.



E. Navigate to **Switching > Configure > Switch settings** and under the **Quality of Service** menu configure the VLAN to DSCP mappings. Please click on Edit DSCP to CoS map to change settings per your requirements. (*For more information on MS QoS settings and operation, please refer to the following article*) Click **Save** at the bottom of the page when you are done. (Please note that the ports used in the below example are based on Cisco Webex traffic flow)



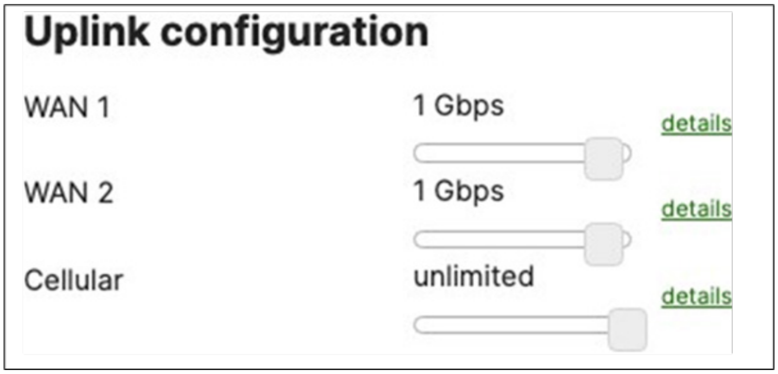


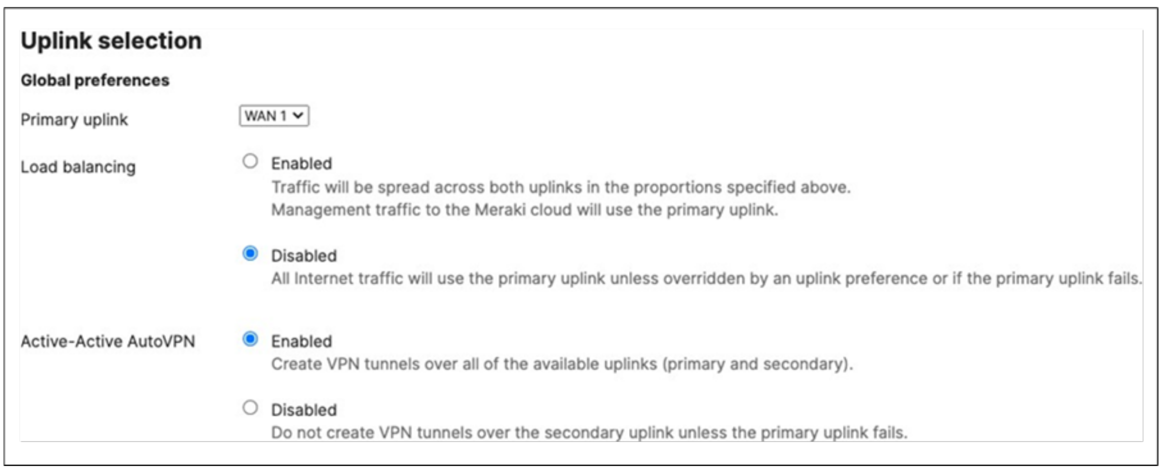
F. Please ensure that your C9500 Core Stack is configured to trust incoming QoS. Here's a reference of the configuration needed to be applied:

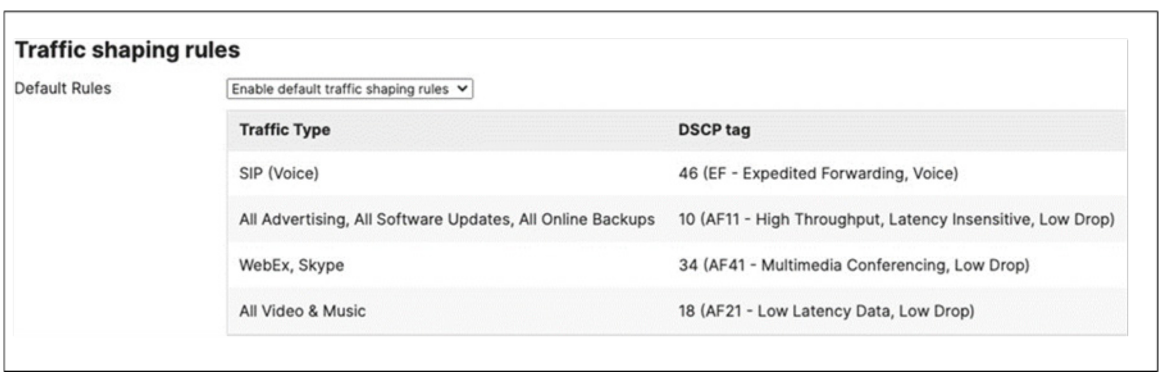
```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#interface TwentyFiveGigE1/0/1
9500-01(config-if)#auto qos trust dscp
9500-01(config-if)#interface TwentyFiveGigE1/0/2
9500-01(config-if)#auto qos trust dscp
9500-01(config-if)#interface TwentyFiveGigE2/0/1
9500-01(config-if)#auto qos trust dscp
9500-01(config-if)#interface TwentyFiveGigE2/0/2
9500-01(config-if)#auto qos trust dscp
9500-01(config-if)#interface TwentyFiveGigE1/0/23
9500-01(config-if)#auto qos trust dscp
Warning: add service policy will cause inconsistency with port TwentyFiveGigE2/0/23
in ether
channel 1.
9500-01(config-if)#interface TwentyFiveGigE1/0/24
9500-01(config-if)#auto qos trust dscp
```

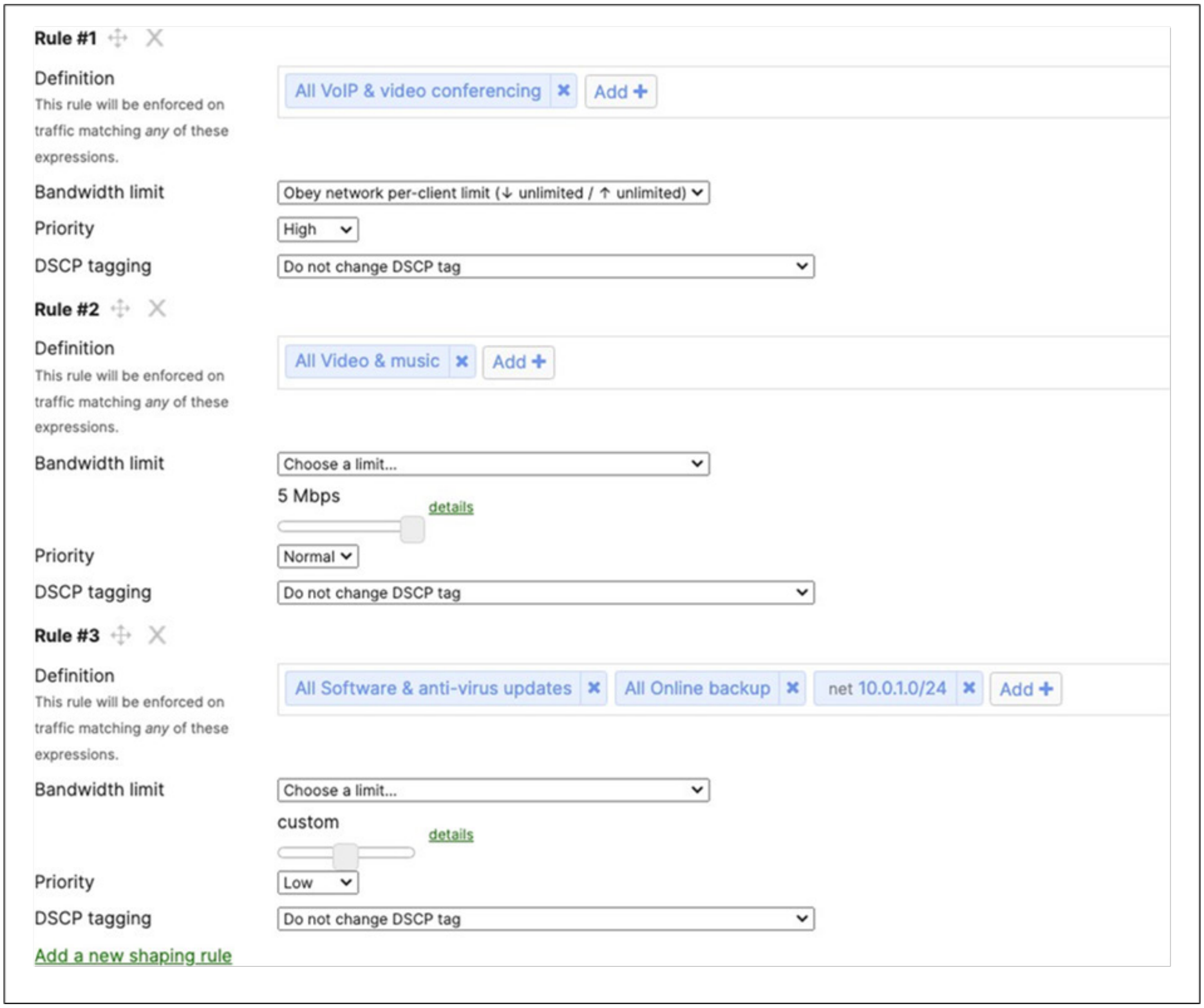
```
Warning: add service policy will cause inconsistency with port TwentyFiveGigE2/0/24
in ether
channel 2.
9500-01(config-if)#interface TwentyFiveGigE1/0/24
9500-01(config-if)#auto qos trust dscp
9500-01(config-if)#end
9500-01#show auto qos

TwentyFiveGigE1/0/1
auto qos trust dscp

TwentyFiveGigE1/0/2
auto qos trust dscp

TwentyFiveGigE1/0/23
auto qos trust dscp

TwentyFiveGigE1/0/24
auto qos trust dscp

TwentyFiveGigE2/0/1
auto qos trust dscp

TwentyFiveGigE2/0/2
auto qos trust dscp

TwentyFiveGigE2/0/23
auto qos trust dscp

TwentyFiveGigE2/0/24
auto qos trust dscp

9500-01#wr mem
```

G. Navigate to **Security and SD-WAN > Configure > SD-WAN and Traffic shaping** and make sure your **Uplink configuration** matches your WAN speed. Then, under **Uplink selection** choose the settings that match your requirements (e.g. Load balancing). Under **Traffic shaping rules**, select **Enable default traffic shaping rules** then click on **Add a new shaping rule** to create the rules needed for your network (*for more information about Traffic shaping rules on MX appliances, please refer to the following* *article*). Please see the following example:









For more information about any of the above configurations, please refer to Meraki Documentation for further guidance on configuring Etherchannels, stacking, switch ports, SSId configuration and more. Here is a useful MR – Wireless section and a MS – Switching section.

Testing and Verification

Firmware

The following table indicates the firmware versions used in this Campus LAN:

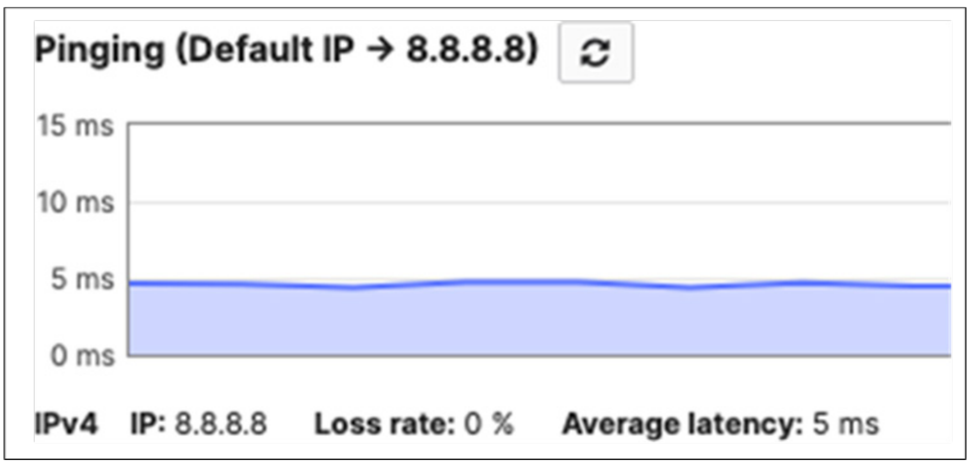
Device	Firmware Version	Notes
MX250 WAN Edge	MX 16.16	GA
C9500 Core Stack	IOS XE 17.3.4	Stable
MS390 Access Stack	MS 15.14	Beta
C9300 Access Stack	MS 15.14	Beta
MR55	28.6.1	GA
C9166 (MR57)	28.30	Beta

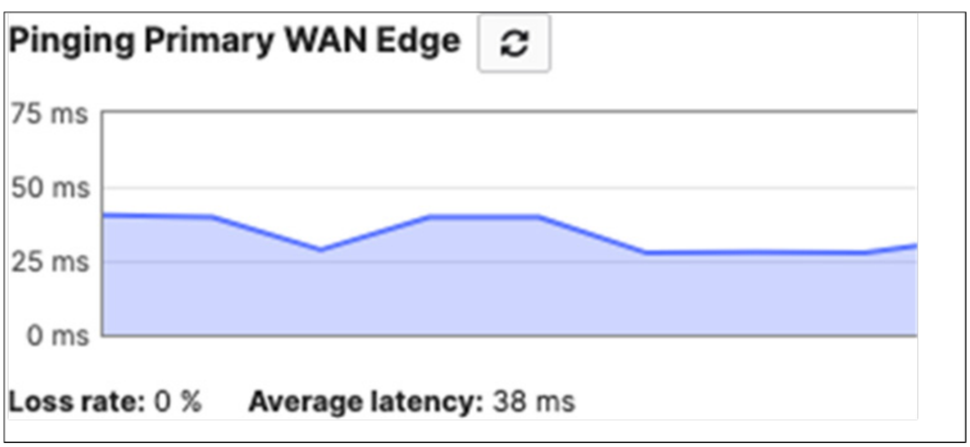
Device Connectivity

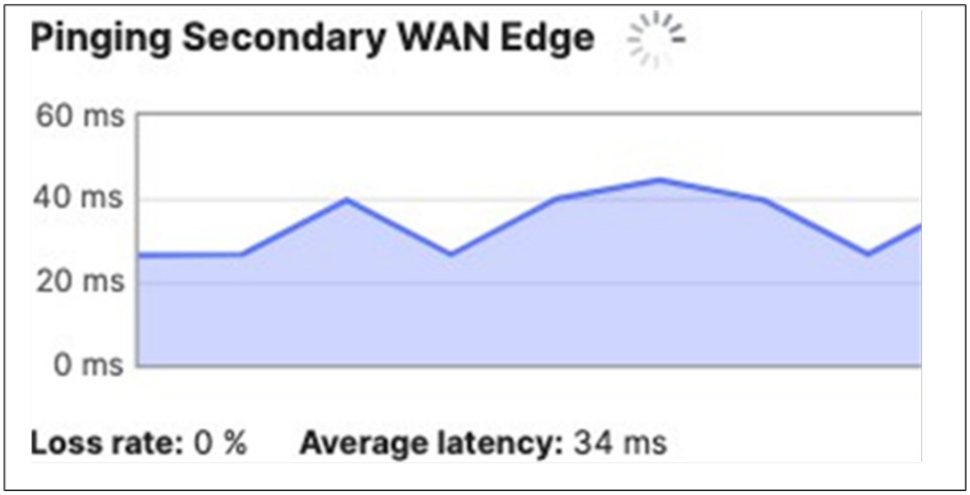
MX WAN Edge

Upstream Connectivity

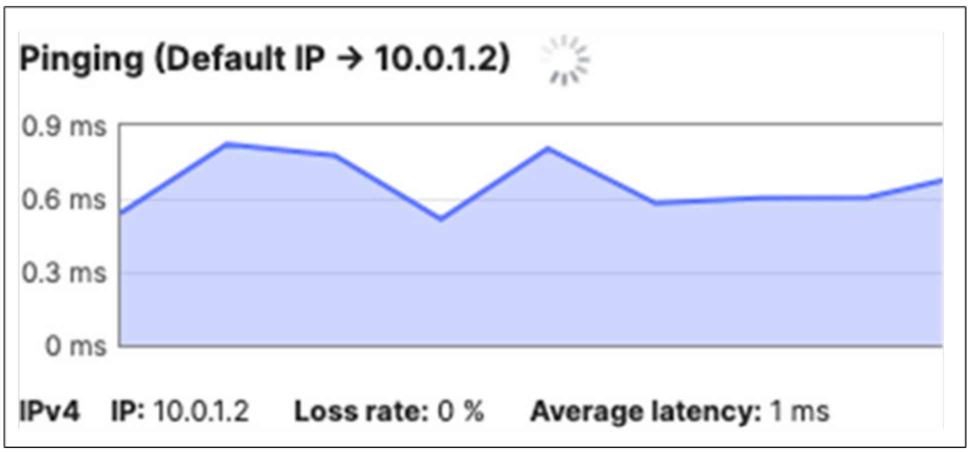
Internet/Cloud Connectivity

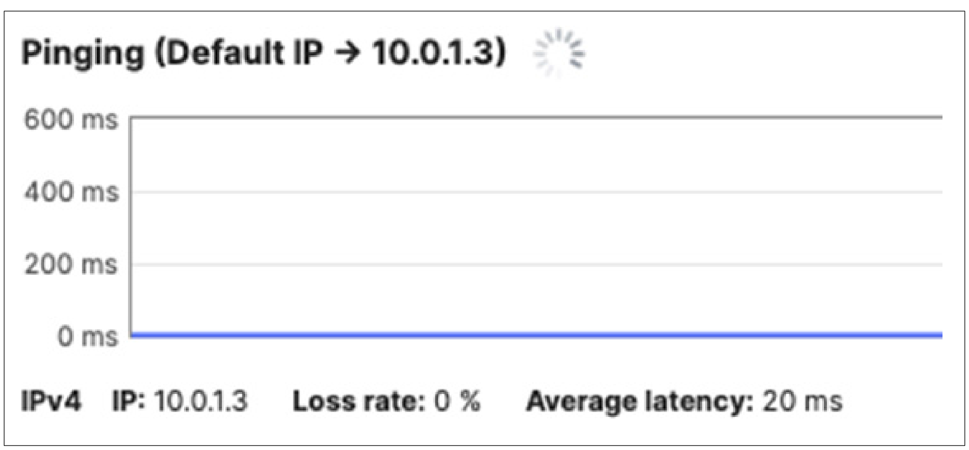


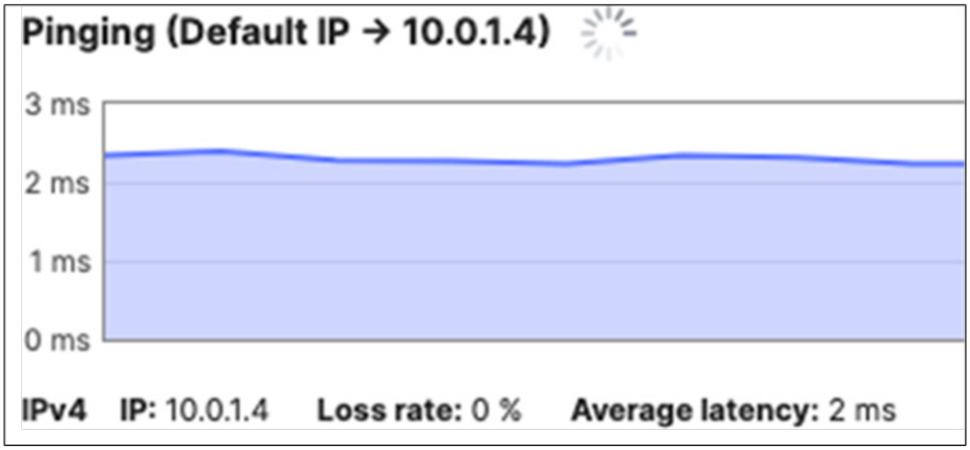


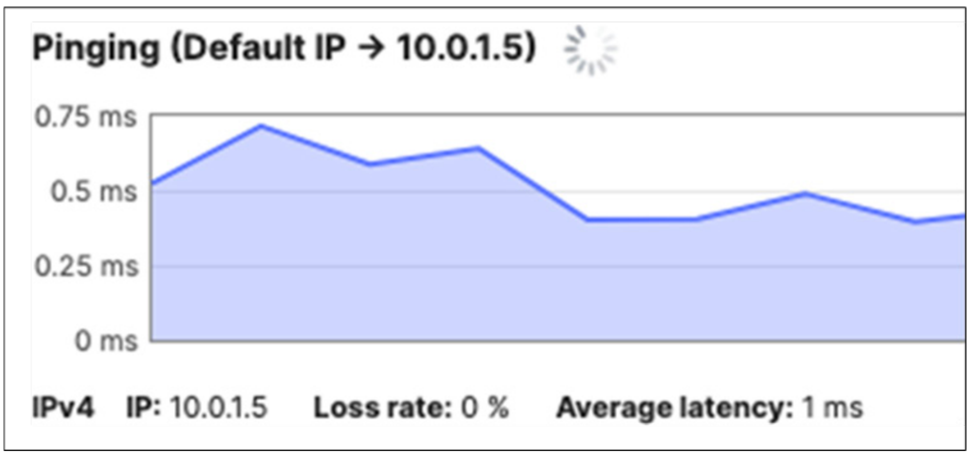


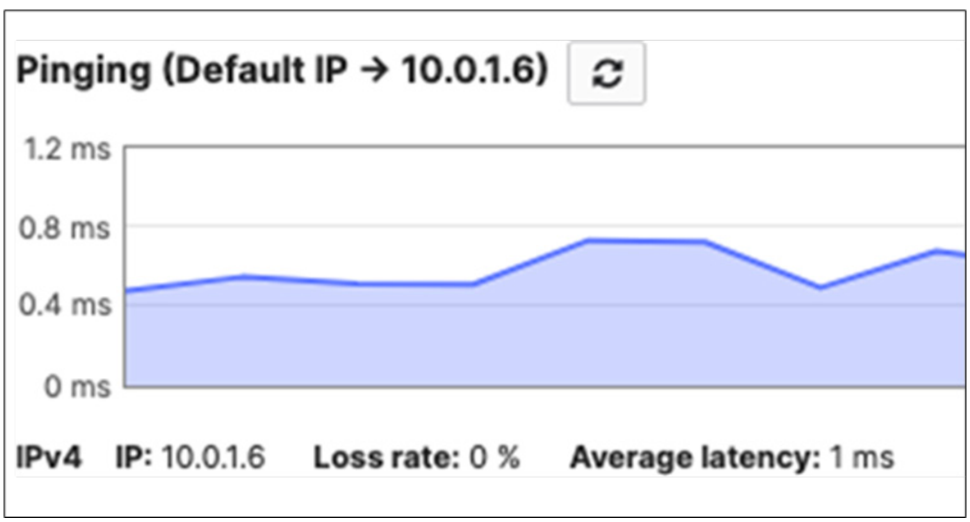
Downstream Connectivity

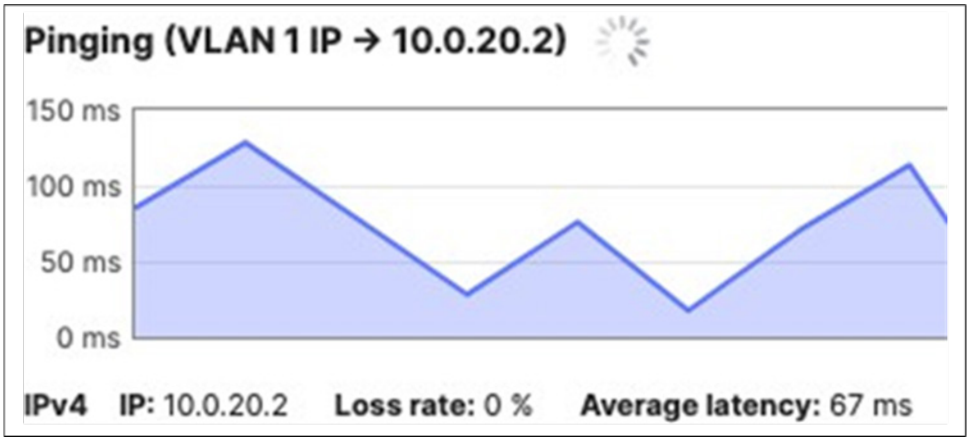





Pinging (Default IP → 10.0.1.4)
3 ms
2 ms
1 ms
0 ms
IPv4 IP: 10.0.1.4 Loss rate: 0 % Average latency: 2 ms


Pinging (Default IP → 10.0.1.5)
0.75 ms
0.5 ms
0.25 ms
0 ms
IPv4 IP: 10.0.1.5 Loss rate: 0 % Average latency: 1 ms


Pinging (Default IP → 10.0.1.6)
1.2 ms
0.8 ms
0.4 ms
0 ms
IPv4 IP: 10.0.1.6 Loss rate: 0 % Average latency: 1 ms



C9500 Core Stack

Upstream Connectivity

```
9500-01#ping 10.0.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
9500-01#
```

Internet Connectivity

```
9500-01#ping 8.8.8.8
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 8.8.8.8, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 5/5/5 ms
9500-01#ping cisco.com
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 72.163.4.185, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 108/110/112 ms
9500-01#
```

Downstream Connectivity (Please note that the MS390 and C9300-M platforms will prioritize packet forwarding over ICMP echo replies so it's expected behavior that you might get some drops)

```
9500-01#ping 10.0.1.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.1.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 2/2/3 ms
9500-01#ping 10.0.1.4
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.1.4, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 2/2/4 ms
9500-01#ping 10.0.1.5
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.1.5, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
9500-01#ping 10.0.1.6
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.1.6, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
9500-01#
```

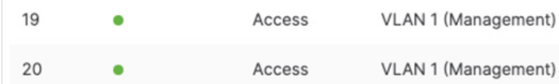
In case of connectivity issues, please check the following:

Item	Expected Configuration/ Status	Verification	Actual Configuration

C9500 Uplinks to
MX Edge:
TwentyFiveGigE1/0/1
TwentyFiveGigE1/0/2
TwentyFiveGigE2/0/1
TwentyFiveGigE2/0/2
	Access , VLAN 1
	DAI Trusted
	up/up
		`sh ip int brief`
		`sh run int <interface>`
		`sh spanning-tree int <interface>`
			`!all uplinks!`
			`switchport mode access`
			`ip arp inspection trust`
			`ip dhcp snooping trust`
			`end`
			`!`

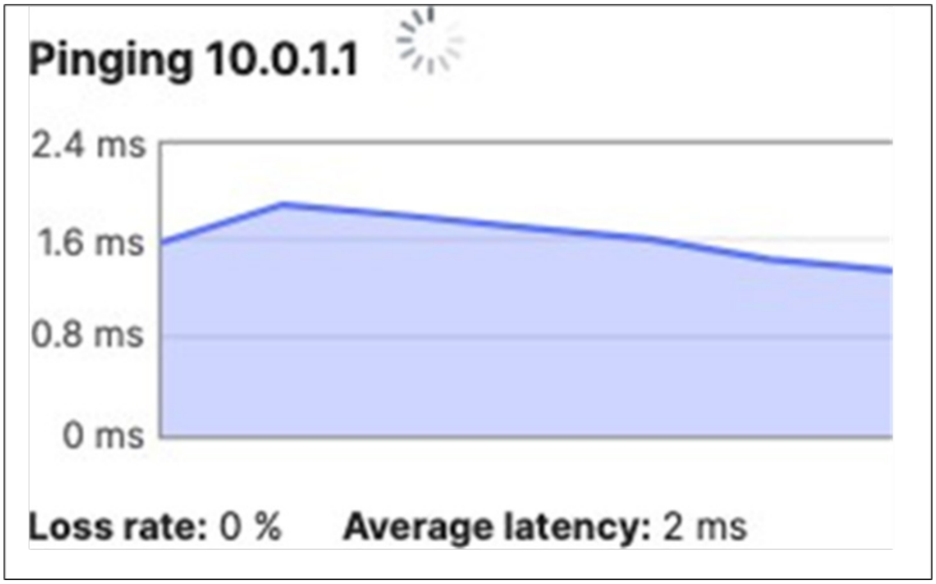
STP interface configuration:	STP Configuration		

<table>
<tr><th>Item</th><th>Expected Configuration/ Status</th><th>Verification</th><th>Actual Configuration</th></tr>
<tr><td>TwentyFiveGigE1/0/1
TwentyFiveGigE1/0/2
TwentyFiveGigE2/0/1
TwentyFiveGigE2/0/2
TwentyFiveGigE1/0/23
TwentyFiveGigE1/0/24
TwentyFiveGigE2/0/23
TwentyFiveGigE2/0/24</td><td>N/A
N/A
N/A
N/A
Root Guard + UDLD aggressive
Root Guard + UDLD aggressive
Root Guard + UDLD aggressive
Root Guard + UDLD aggressive</td><td><code>sh run int <interface></code></td><td><code>!where applicable!</code>
<code>udld port aggressive</code>
<code>spanning-tree guard root</code>
<code>end</code>
<code>!</code></td></tr>
<tr><td colspan="4">STP interface status:</td></tr>
<tr><td>TwentyFiveGigE1/0/1
TwentyFiveGigE1/0/2
TwentyFiveGigE2/0/1
TwentyFiveGigE2/0/2
Po1
Po2</td><td>STP status:
FWD
BLK
FWD
BLK
FWD
FWD</td><td><code>sh spanning-tree</code>
<code>int <interface></code></td><td><code>!only PHY interfaces!</code>
<code>spanning-tree mode mst</code>
<code>spanning-tree extend system-id</code>
<code>!</code>
<code>spanning-tree mst configuration</code>
<code>name region1</code>
<code>revision 1</code>
<code>!</code>
<code>spanning-tree mst 0 priority 4096</code>
<code>!</code></td></tr>
<tr><td>Default Route</td><td>DHCP, VLAN 1</td><td><code>sh int vlan1</code>
<code>sh ip route</code></td><td><code>!</code>
<code>interface Vlan1</code>
<code>ip address dhcp</code>
<code>end</code>
<code>!</code>
<code>sh ip route | in /0</code>
<code>S* 0.0.0.0/0 [254/0] via 10.0.1.1</code></td></tr>
</table>

Item	Expected Configuration/ Status	Verification	Actual Configuration
MX WAN Edge Downlinks: **Port 19** **Port 20**	Access, VLAN 1	Navigate to **Security and SD-WAN > Configure > Addressing and VLANs**	
C9500 Downlinks:			
TwentyFiveGigE1/0/23 **TwentyFiveGigE1/0/24** **TwentyFiveGigE2/0/23** **TwentyFiveGigE2/0/24**	Trunk, Native VLAN 1, Allowed VLANs 1,10,20,30,40 DAI Trusted SGT 2 Trusted No CTS enforcement	sh run int <interface>	! switchport trunk allowed vlan 1,10,20,30,40 switchport mode trunk ip arp inspection trust ! cts manual policy static sgt 2 trusted no cts role-based enforcement ! End
C9500 Ether-Channels:			
TwentyFiveGigE1/0/23 **TwentyFiveGigE1/0/24** **TwentyFiveGigE2/0/23** **TwentyFiveGigE2/0/24** **Po1** **Po2**	Channel-Group 1 Channel-Group 2 Channel-Group 1 Channel-Group 2 up/up up/up	sh run int <interface> sh etherchannel <#> sum sh ip int brief | in Po	!PHY 23! channel-group 1 mode active !PHY 24! channel-group 2 mode active ! End

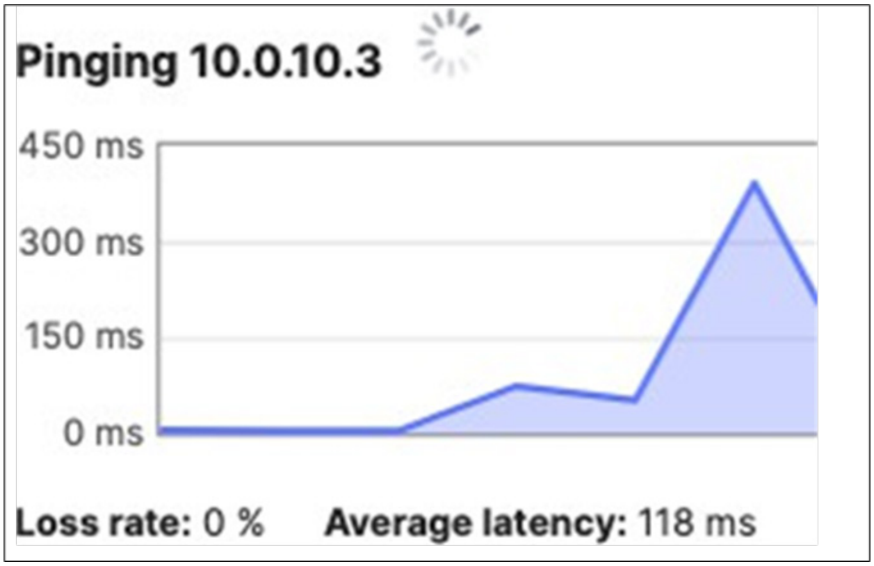
MS390 Access Stack

Upstream Connectivity



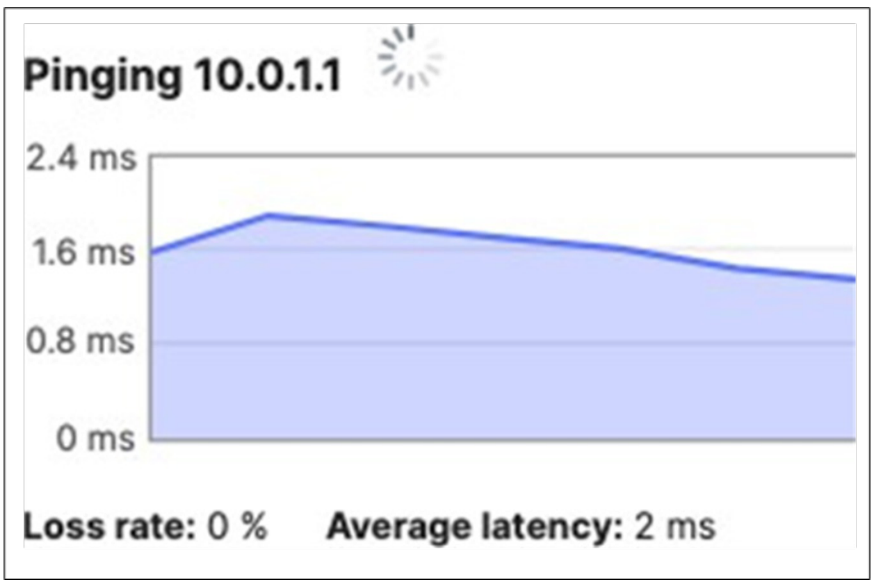
Internet/Cloud Connectivity

Downstream Connectivity

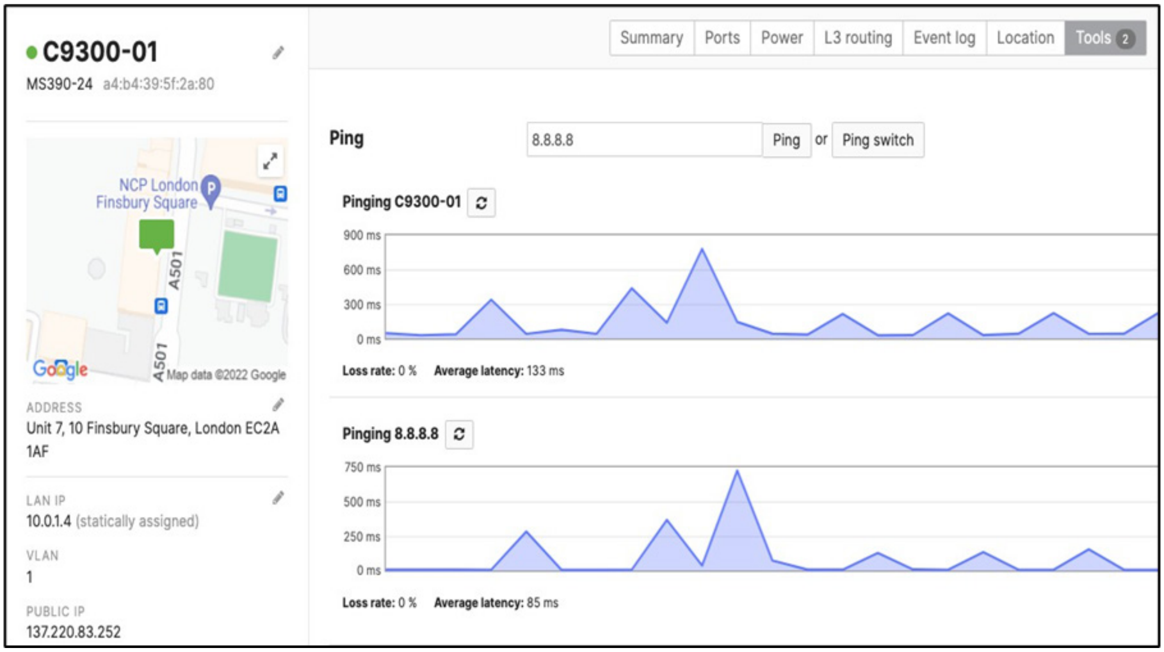


C9300 Access Stack

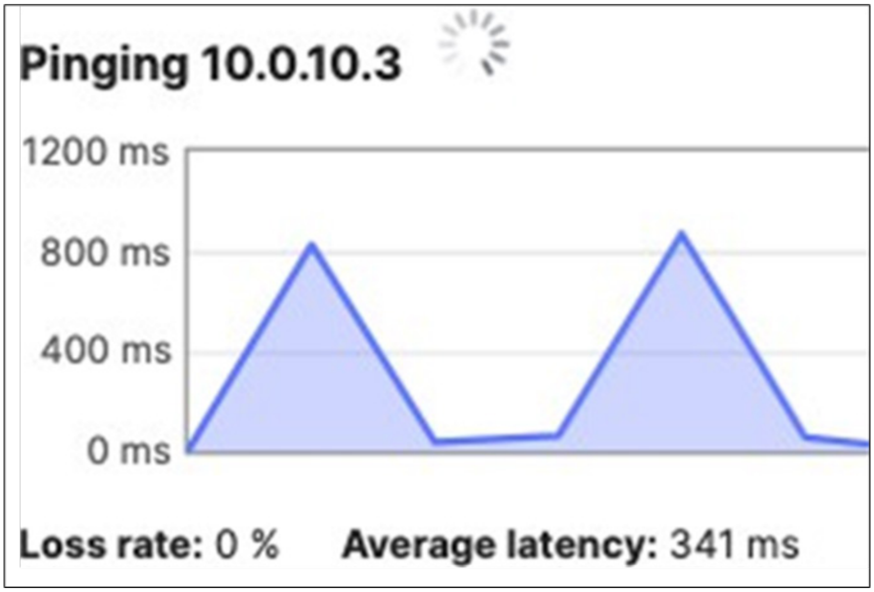
Upstream Connectivity



Internet/Cloud Connectivity



Downstream Connectivity



MR Access Points

Client Connectivity

```
samsackl@SAMSACKL-M-F859 ~ % ifconfig en0
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether 3c:22:fb:30:da:69
        inet6 fe80::1075:6c6c:6758:39e%en0 prefixlen 64 secured scopeid 0x7
        inet 10.0.20.4 netmask 0xffffff00 broadcast 10.0.20.255
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
samsackl@SAMSACKL-M-F859 ~ %
```

```
samsackl@SAMSACKL-M-F859 ~ % ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8): 56 data bytes
64 bytes from 8.8.8.8: icmp_seq=0 ttl=51 time=25.638 ms
64 bytes from 8.8.8.8: icmp_seq=1 ttl=51 time=14.667 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=51 time=7.580 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=51 time=14.387 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=51 time=8.437 ms
64 bytes from 8.8.8.8: icmp_seq=5 ttl=51 time=9.119 ms
64 bytes from 8.8.8.8: icmp_seq=6 ttl=51 time=13.621 ms
^C
--- 8.8.8.8 ping statistics ---
7 packets transmitted, 7 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 7.580/13.350/25.638/5.722 ms
samsackl@SAMSACKL-M-F859 ~ %
```



```
samsackl@SAMSACKL-M-F859 ~ % nslookup
> cnn.com
Server:         208.67.222.222
Address:        208.67.222.222#53

Non-authoritative answer:
Name:   cnn.com
Address: 151.101.1.67
Name:   cnn.com
Address: 151.101.65.67
Name:   cnn.com
Address: 151.101.129.67
Name:   cnn.com
Address: 151.101.193.67
>
```

Current clients 2

Description	IP address	VLAN	MAC address	Usage	Associated for	SSID	Channel	Current channel width	Signal strength	Tools
iPhone-11	10.0.20.3	20	cc:66:0a:3e:44:69	193.0 MB	1 hour	Testing	161	80	38 dB	Ping
Macbook Pro	10.0.20.4	20	3c:22:fb:30:da:69	531.2 MB	1 hour	Testing	161	80	30 dB	Ping

CLIENTS

Macbook Pro

Overview Connections Performance Timeline

Status	associated since May 19 10:07
SSID	Testing
Access point	AP2_Zone1 topology
Splash	N/A
Signal	30dB (channel 161, 5 GHz)
Device type, OS	Apple

Health for the last 2 hours

100%
Connections successful

Most common failure step
Association

Most problematic SSID
Testing

Most common failure AP
AP2_Zone1

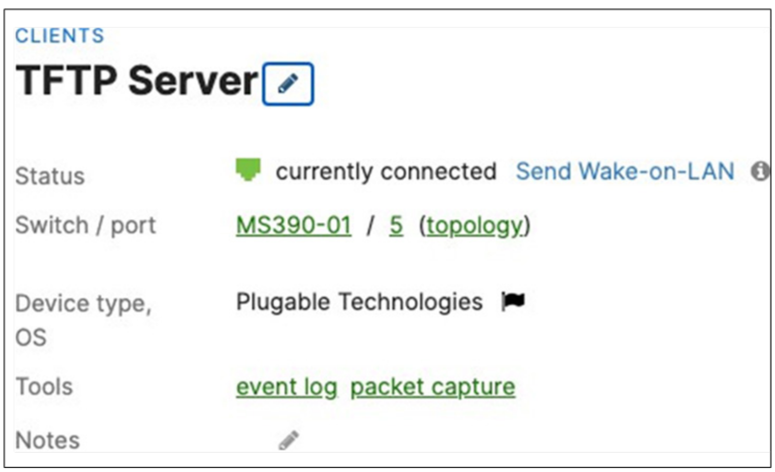
99%
latency less than 64ms

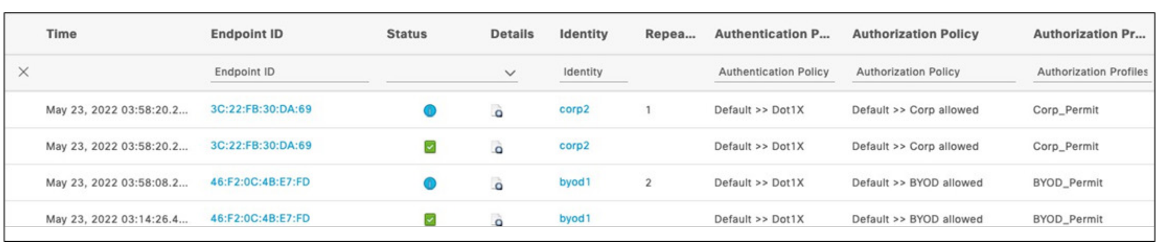
802.1x Authentication

802.1x authentication has been tested on both Corp and BYOD SSIDs. Dashboard will be checked to verify the correct IP address assignment and username. Packet captures will also be checked to verify the correct SGT assignment. In the final section, ISE logs will show the authentication status and authorization policy applied.

Client	SSID / Port	Username	VLAN	SGT
MacBook Pro **3c:22:fb:30:da:69** **10.0.10.3**	Acme Corp	Corp1	10	10
iPhone 11 **46:f2:0c:4b:e7:fd** **10.0.20.5**	Acme BYOD	Byod1	20	20
MacBook Pro **8C:AE:4C:DD:15:19** **10.0.10.6**	MS390-01 Port 6	Corp1	10 (Auth-fail VLAN 30)	10

Status	Description	Last seen	Usage	Device type, OS	IPv4 address ▲	Policy	Adaptive Policy Group	Connected To	Recent SSID	VLAN
	Macbook Pro	May 23 16:32	1.14 GB	Other	10.0.10.3	normal	10: Corp	AP2_Zone1	Acme Corp	10
	iPhone-11	May 23 16:32	68.7 MB	iPhone 11, iOS15.4.1	10.0.20.5	normal	20: BYOD	AP2_Zone1	Acme BYOD	20





Time	Endpoint ID	Status	Details	Identity	Repea...	Authentication P...	Authorization Policy	Authorization Pr...
	Endpoint ID			Identity		Authentication Policy	Authorization Policy	Authorization Profiles
May 23, 2022 03:58:20.2...	3C:22:FB:30:DA:69			corp2	1	Default >> Dot1X	Default >> Corp allowed	Corp_Permit
May 23, 2022 03:58:20.2...	3C:22:FB:30:DA:69			corp2		Default >> Dot1X	Default >> Corp allowed	Corp_Permit
May 23, 2022 03:58:08.2...	46:F2:0C:4B:E7:FD			byod1	2	Default >> Dot1X	Default >> BYOD allowed	BYOD_Permit
May 23, 2022 03:14:26.4...	46:F2:0C:4B:E7:FD			byod1		Default >> Dot1X	Default >> BYOD allowed	BYOD_Permit

Overview

Event	5200 Authentication succeeded
Username	byod1
Endpoint Id	46:F2:0C:4B:E7:FD
Endpoint Profile	Unknown
Authentication Policy	Default >> Dot1X
Authorization Policy	Default >> BYOD allowed
Authorization Result	BYOD_Permit

Overview

Event	5200 Authentication succeeded
Username	corp2
Endpoint Id	3C:22:FB:30:DA:69
Endpoint Profile	Apple-Device
Authentication Policy	Default >> Dot1X
Authorization Policy	Default >> Corp allowed
Authorization Result	Corp_Permit

Authentication Details

Authentication Details	
Source Timestamp	2022-05-23 18:27:05.857
Received Timestamp	2022-05-23 18:27:05.857
Policy Server	ISE-Campus
Event	5200 Authentication succeeded
Username	corp1
User Type	User
Endpoint Id	8C:AE:4C:DD:15:19
Calling Station Id	8C-AE-4C-DD-15-19
Endpoint Profile	Unknown
Authentication Identity Store	Internal Users
Identity Group	User Identity Groups:Employee,Unknown
Audit Session Id	0103010100000025F1F3E55F
Authentication Method	dot1x
Authentication Protocol	PEAP (EAP-MSCHAPv2)
Service Type	Framed
Network Device	Campus
Device Type	All Device Types
Location	All Locations
NAS IPv4 Address	10.0.1.3
NAS Port Id	2C:3F:0B:04:7E:80/5
NAS Port Type	Ethernet

Result

Class	CACS:0103010100000025F1F3E55F:ISE-Campus/442276467/106
Tunnel-Type	(tag=1) VLAN
Tunnel-Medium-Type	(tag=1) 802
Tunnel-Private-Group-ID	(tag=1) 10
EAP-Key-Name	19:62:8b:c3:e3:7c:cb:d8:f1:a0:7d:e1:30:01:a6:27:af:78:ab:3d:9a:fc:07:5e:d3:27:9b:bc:0a:0a:f2:bd:e5:df:b4:5d:9a:eb:99:d4:81:55:3a:3e:3e:44:bb:1e:94:a2:2e:00:c3:0f:7c:97:90:9f:60:6d:6d:74:74:b2:f7
cisco-av-pair	cts:security-group-tag=000A-00
cisco-av-pair	cts:security-group-tag=000a-00
MS-MPPE-Send-Key	****
MS-MPPE-Recv-Key	****
LicenseTypes	Essential license consumed.

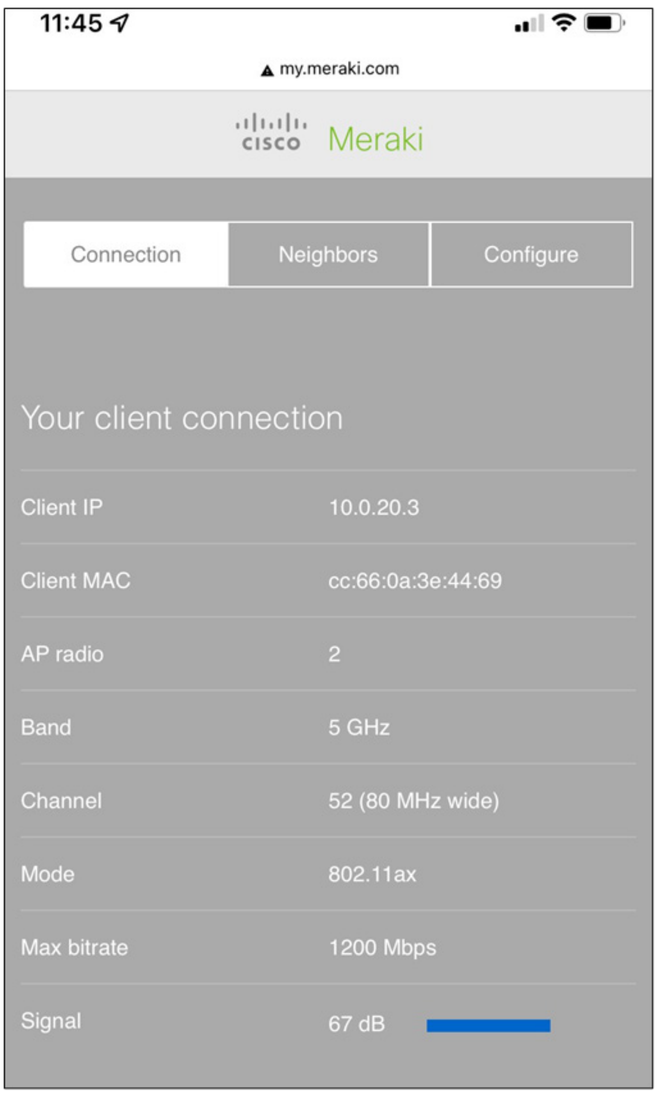
Note: Please note that the configuration of Cisco ISE is out of scope of this CVD. Please refer to Cisco ISE administration guide for details on configuring policy sets on Cisco ISE. Also, please refer to this article for more information on the configuration of Cisco ISE with Cisco Meraki devices.

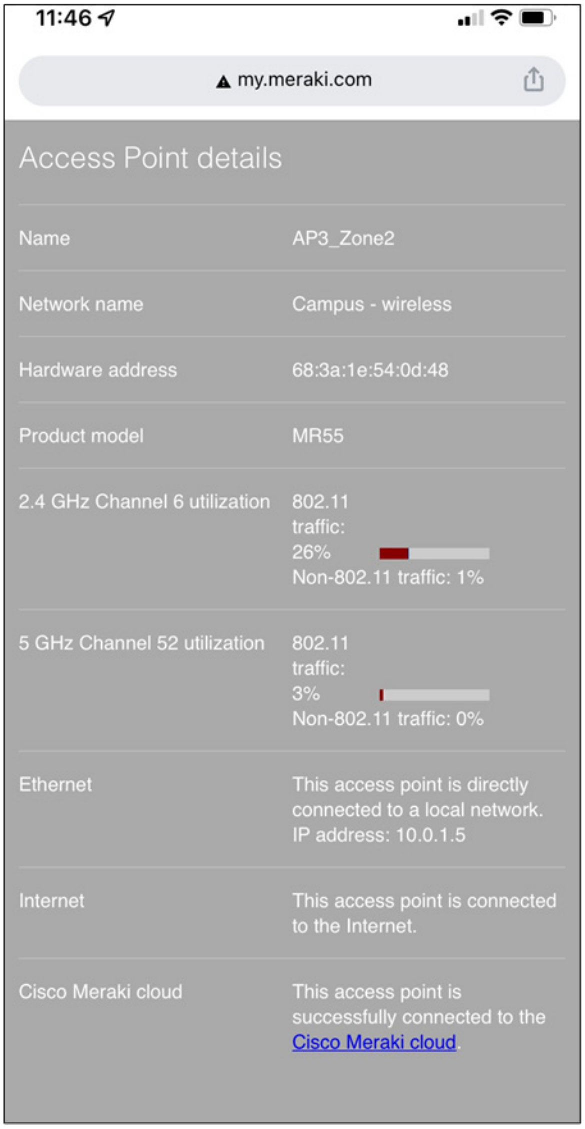
Wireless roaming

Wireless roaming has been tested between two zones and APs homed to different switch stacks whilst being on a Webex meeting with Audio/Video and Content share. Device and Client details in the following table:

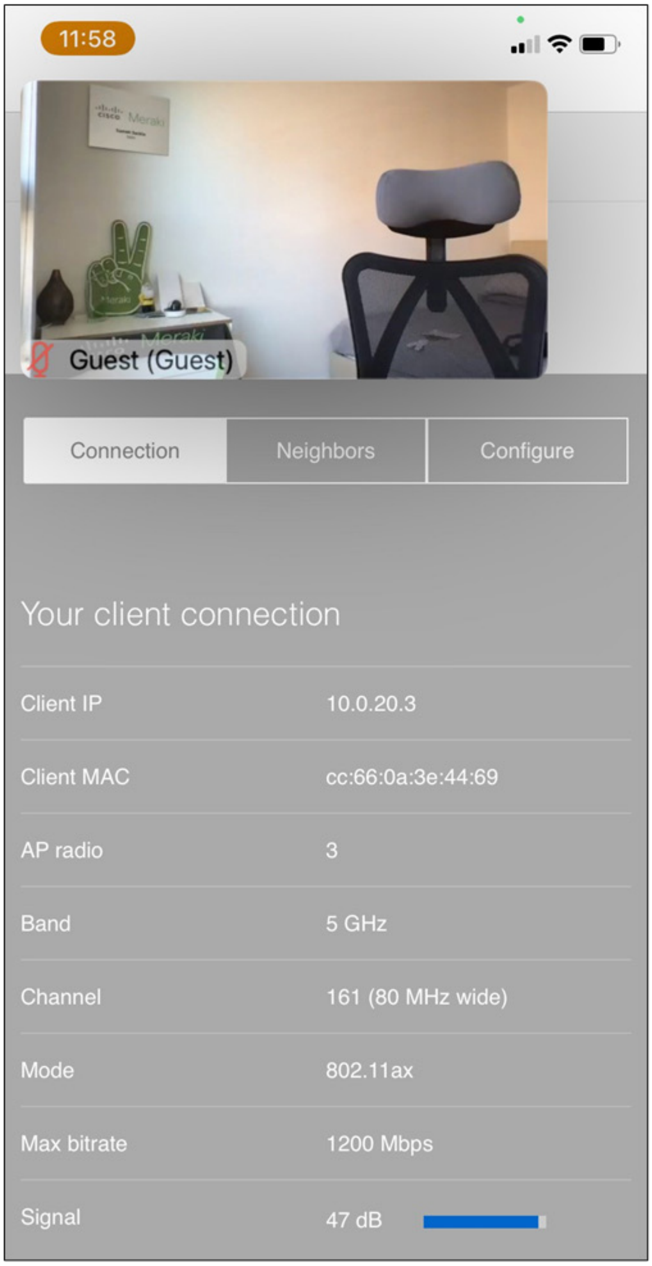
Device Type	Details	Connected to
MR55 (AP3_Zone2)	68:3a:1e:54:0d:48 10.0.1.5	C9300-2 (Stack2)
MR57 (AP2_Zone1)	cc:9c:3e:ec:26:b0 10.0.1.6	MS390-1 (Stack1)
Client (iPhone 11)	cc:66:0a:3e:44:69 10.0.20.3	AP3_Zone2 AP2_Zone1 (Layer 2 Roaming)

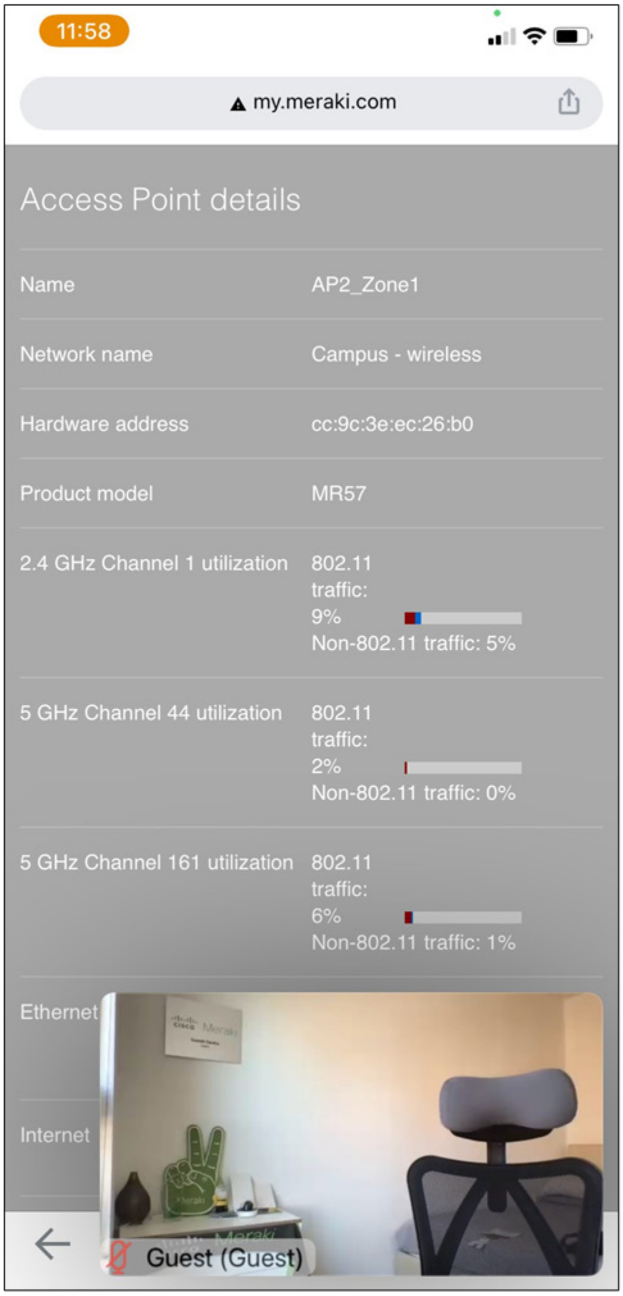
First association




11:46
my.meraki.com
Access Point details
Name
AP3_Zone2
Network name
Campus - wireless
Hardware address
68:3a:1e:54:0d:48
Product model
MR55
2.4 GHz Channel 6 utilization
802.11 traffic: 26%
Non-802.11 traffic: 1%
5 GHz Channel 52 utilization
802.11 traffic: 3%
Non-802.11 traffic: 0%
Ethernet
This access point is directly connected to a local network. IP address: 10.0.1.5
Internet
This access point is connected to the Internet.
Cisco Meraki cloud
This access point is successfully connected to the Cisco Meraki cloud.

Second Association (The video overlay is the stream from a Webex meeting while the client was roaming)




11:58
my.meraki.com
Access Point details
Name
AP2_Zone1
Network name
Campus - wireless
Hardware address
cc:9c:3e:ec:26:b0
Product model
MR57
2.4 GHz Channel 1 utilization
802.11 traffic: 9%
Non-802.11 traffic: 5%
5 GHz Channel 44 utilization
802.11 traffic: 2%
Non-802.11 traffic: 0%
5 GHz Channel 161 utilization
802.11 traffic: 6%
Non-802.11 traffic: 1%
Ethernet
Internet
Guest (Guest)

Traffic Flow (Packet #27)

Webex meeting statistics (Snapshot taken after roaming)

Audio & video statistics

Audio & video connection | Shared content

Video codec: **H.264**

VoIP codec (computer audio): **Opus**

Connection ports:

Audio: **UDP (31043)**

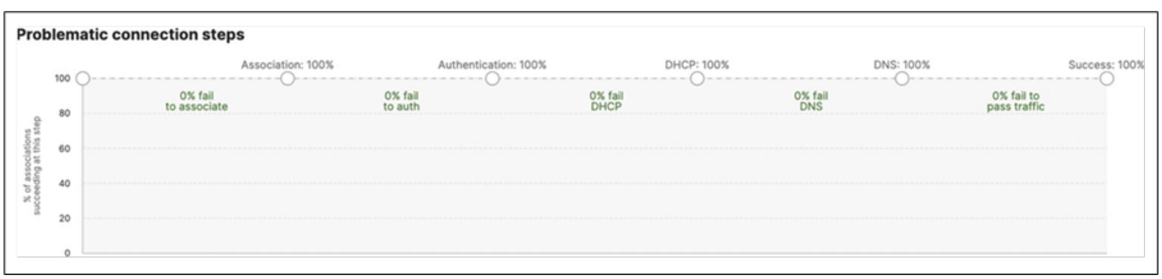
Video: **UDP (32601,30079)**

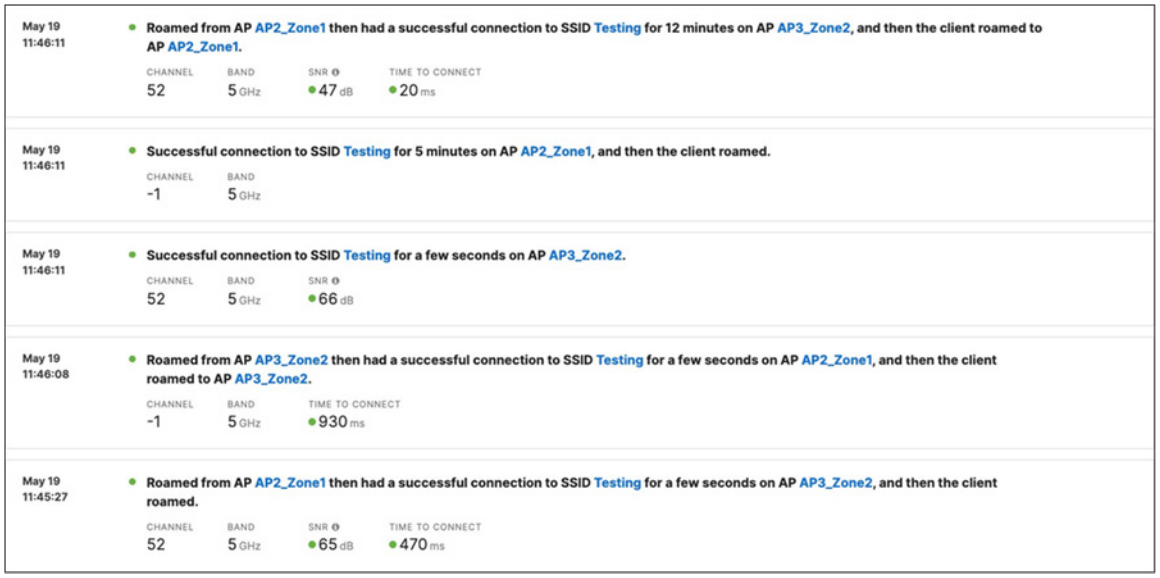
	Send	Receive
General		
Bandwidth	526.71 Kbps	66.26 Kbps

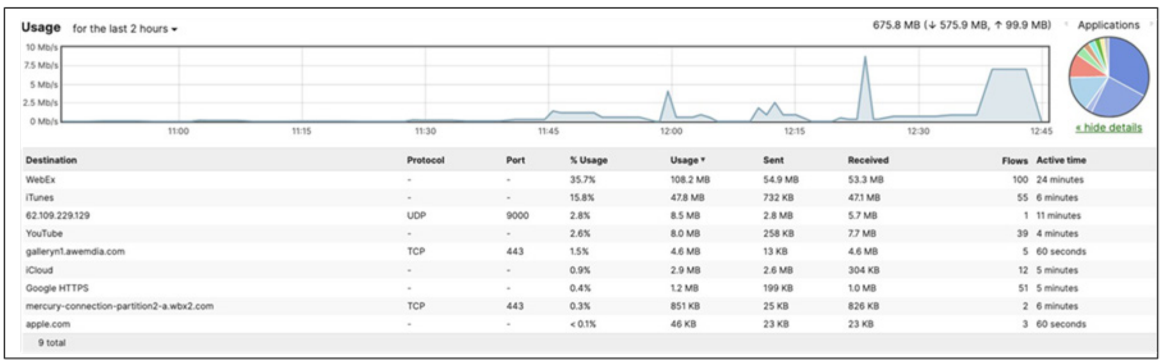
	Send	Receive
Audio		
Latency	6 ms	-
Jitter	5 ms	32 ms
Bandwidth	0.46 Kbps	0.92 Kbps
Packet loss	0%	0%
Audio level	-	0
Rendering delay	-	344 ms
Packets per second	4	2

	Send	Receive
Video		
Latency	5 ms	-
Jitter	1 ms	14 ms
Bandwidth	494.42 Kbps	87.84 Kbps
Packet loss	0%	0%
Video resolution	640 X 360 (30 fps)	**640 X 360 (24.2 fps)**
Rendering delay	-	50 ms
Packets per second	65	48

Dashboard logs





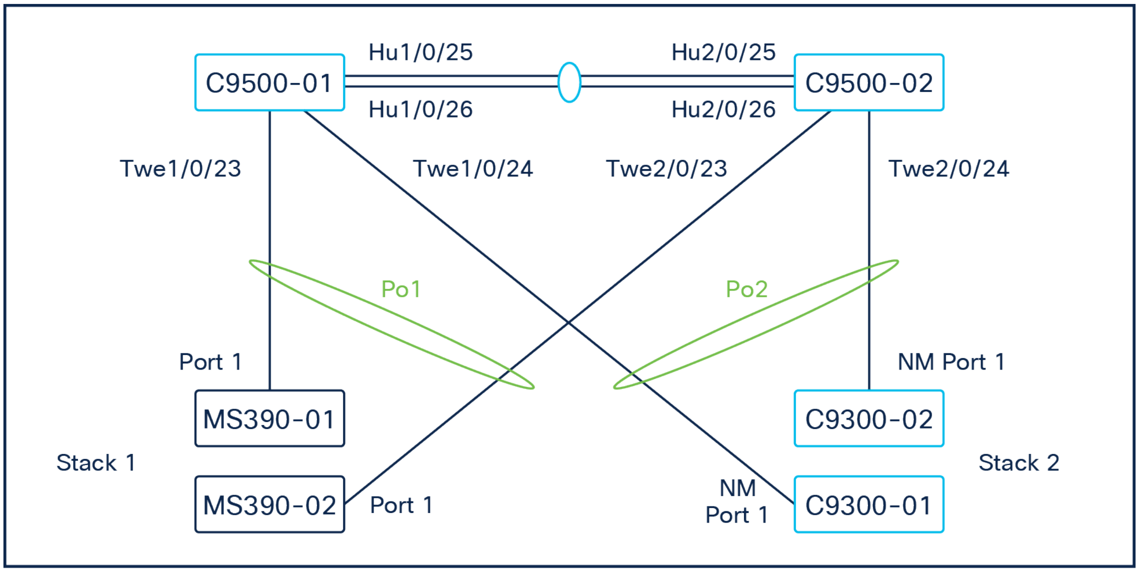


Destination	Protocol	Port	% Usage	Usage ▾	Sent	Received	Flows	Active time
WebEx	-	-	35.7%	108.2 MB	54.9 MB	53.3 MB	100	24 minutes
iTunes	-	-	15.8%	47.8 MB	732 KB	47.1 MB	55	6 minutes
62.109.229.129	UDP	9000	2.8%	8.5 MB	2.8 MB	5.7 MB	1	11 minutes
YouTube	-	-	2.6%	8.0 MB	258 KB	7.7 MB	39	4 minutes
galleryn1.awemdia.com	TCP	443	1.5%	4.6 MB	13 KB	4.6 MB	5	60 seconds
iCloud	-	-	0.9%	2.9 MB	2.6 MB	304 KB	12	5 minutes
Google HTTPS	-	-	0.4%	1.2 MB	199 KB	1.0 MB	51	5 minutes
mercury-connection-partition2-a.wbx2.com	TCP	443	0.3%	851 KB	25 KB	826 KB	2	6 minutes
apple.com	-	-	< 0.1%	46 KB	23 KB	23 KB	3	60 seconds
9 total								

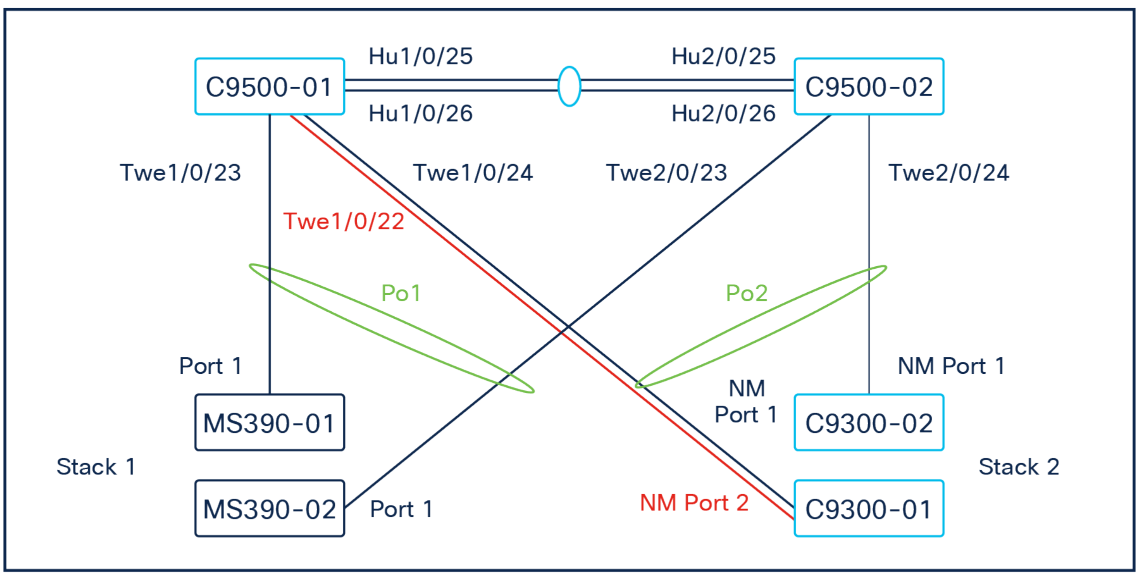
STP Convergence

STP convergence will be tested using several methods as outlined below. Please see the following table for steady-state of the Campus LAN before testing:

<table>
<tr><th></th><th></th><th>Bridge ID</th><th>STP Status</th></tr>
<tr><td>C9500-01</td><td>Master</td><td>4096:b0c5.3c60.fba0</td><td rowspan="2"><pre>Interface   Role Sts Cost   Prio.Nbr Type
------------------- ---- --- --------- -------- ------
Twe1/0/1   Desg FWD 2000   128.193 P2p
Twe2/0/1   Back BLK 2000   128.385 P2p
Po1   Desg FWD 10000   128.2089 P2p
Po2   Desg FWD 1000   128.2090 P2p</pre></td></tr>
<tr><td>C9500-02</td><td>Member</td><td>4096.40b5.c111.01e0</td></tr>
<tr><td>MS390-01</td><td>Master</td><td>61440:2c3f.0b04.7e80</td><td>STP ROOT
b0:c5:3c:60:fb:a0 (priority 4096)</td></tr>
<tr><td>MS390-02</td><td>Member</td><td></td><td>Blocking ports
None</td></tr>
</table>



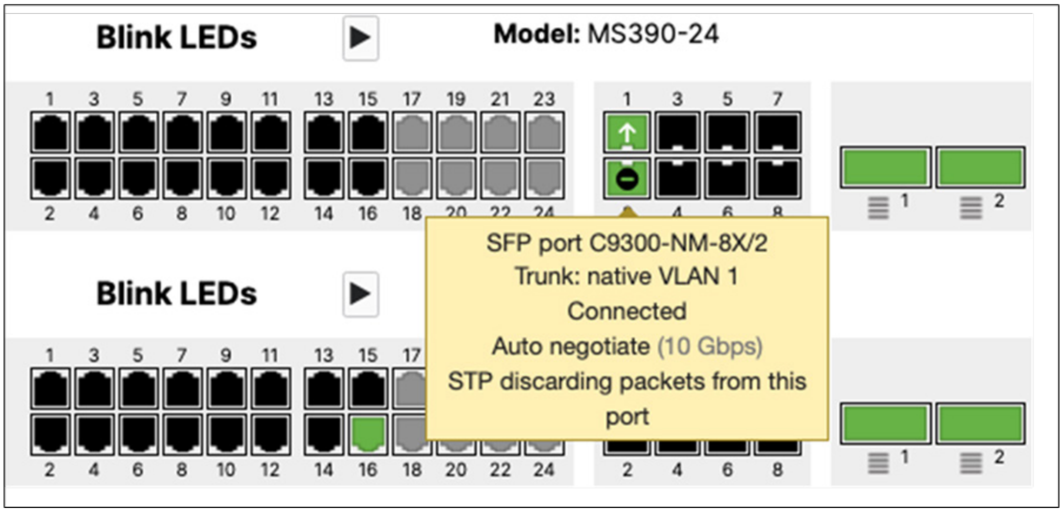
Introducing loops (Access to Core)



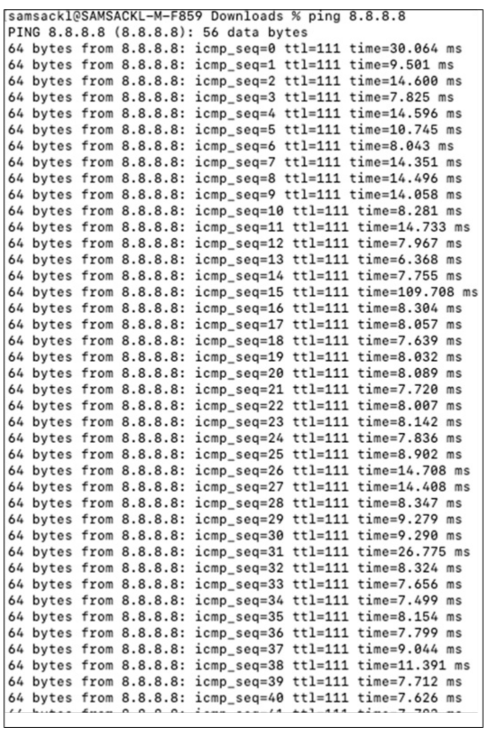
A loop was introduced by adding a link between C9300-01 /NM Port 2 and C9500 Core Stack / Port TwentyFiveGigE1/0/22 (Please note that for the purposes of this test, the interface has been unshut and configured as a Trunk port with Native VLAN 1 with STP guards on that interface).

```
9500-01#show ip interface brief | in TwentyFiveGigE1/0/22
TwentyFiveGigE1/0/22 unassigned YES unset up up
ow9500-01#show run interface TwentyFiveGigE1/0/22
Building configuration...

Current configuration : 132 bytes
!
interface TwentyFiveGigE1/0/22
switchport trunk allowed vlan 1,10,20,30,40
switchport mode trunk
spanning-tree guard root
end

9500-01#
9500-01#show spanning-tree

MST0
Spanning tree enabled protocol mstp
Root ID Priority 4096
    Address b0c5.3c60.fba0
    This bridge is the root
    Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Bridge ID Priority 4096 (priority 4096 sys-id-ext 0)
    Address b0c5.3c60.fba0
    Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost        Prio.Nbr Type
------------------------------------------------
Twe1/0/1       Desg FWD 2000        128.193 P2p
Twe1/0/2       Desg FWD 2000        128.194 P2p
Twe1/0/22      Desg FWD 2000        128.214 P2p
Twe2/0/1       Back BLK 2000        128.385 P2p
Twe2/0/2       Back BLK 2000        128.386 P2p
Po1            Desg FWD 10000       128.2089 P2p
Po2            Desg FWD 1000        128.2090 P2p
```

Note: Interface Twe1/0/22 is in STP FWD state (As expected since this is the Root bridge)



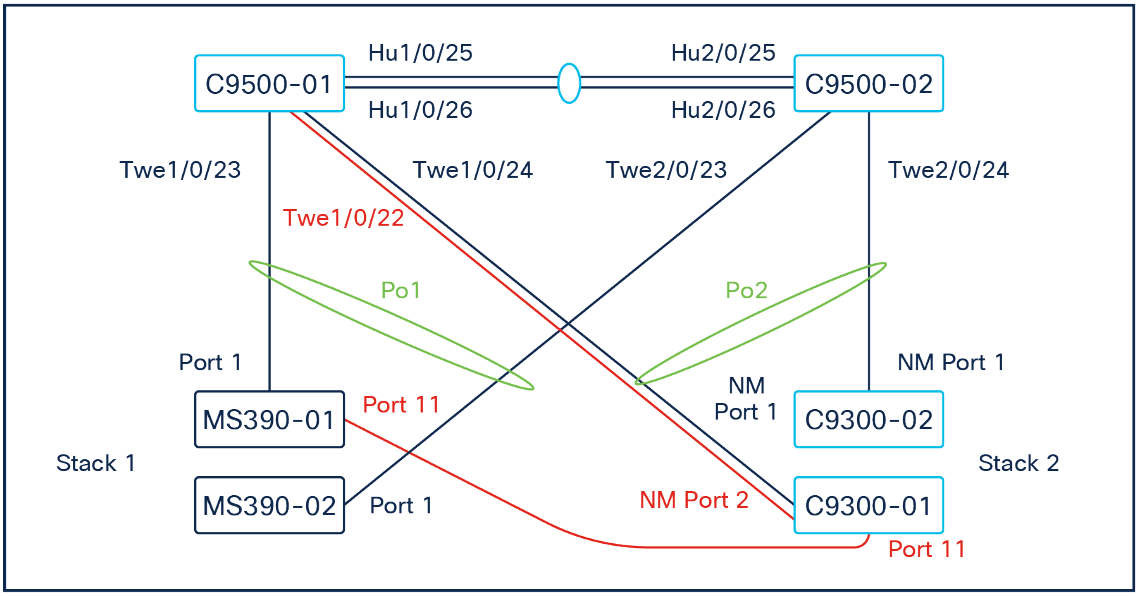
Note: Interface 26 is in STP BLK state (As expected since the Ether-channel is in FWD state)



```
samsackl@SAMSACKL-M-F859 Downloads % ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8): 56 data bytes
64 bytes from 8.8.8.8: icmp_seq=0 ttl=111 time=30.064 ms
64 bytes from 8.8.8.8: icmp_seq=1 ttl=111 time=9.501 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=111 time=14.600 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=111 time=7.825 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=111 time=14.596 ms
64 bytes from 8.8.8.8: icmp_seq=5 ttl=111 time=10.745 ms
64 bytes from 8.8.8.8: icmp_seq=6 ttl=111 time=8.043 ms
64 bytes from 8.8.8.8: icmp_seq=7 ttl=111 time=14.351 ms
64 bytes from 8.8.8.8: icmp_seq=8 ttl=111 time=14.496 ms
64 bytes from 8.8.8.8: icmp_seq=9 ttl=111 time=14.058 ms
64 bytes from 8.8.8.8: icmp_seq=10 ttl=111 time=8.281 ms
64 bytes from 8.8.8.8: icmp_seq=11 ttl=111 time=14.733 ms
64 bytes from 8.8.8.8: icmp_seq=12 ttl=111 time=7.967 ms
64 bytes from 8.8.8.8: icmp_seq=13 ttl=111 time=6.368 ms
64 bytes from 8.8.8.8: icmp_seq=14 ttl=111 time=7.755 ms
64 bytes from 8.8.8.8: icmp_seq=15 ttl=111 time=109.708 ms
64 bytes from 8.8.8.8: icmp_seq=16 ttl=111 time=8.304 ms
64 bytes from 8.8.8.8: icmp_seq=17 ttl=111 time=8.057 ms
64 bytes from 8.8.8.8: icmp_seq=18 ttl=111 time=7.639 ms
64 bytes from 8.8.8.8: icmp_seq=19 ttl=111 time=8.032 ms
64 bytes from 8.8.8.8: icmp_seq=20 ttl=111 time=8.089 ms
64 bytes from 8.8.8.8: icmp_seq=21 ttl=111 time=7.720 ms
64 bytes from 8.8.8.8: icmp_seq=22 ttl=111 time=8.007 ms
64 bytes from 8.8.8.8: icmp_seq=23 ttl=111 time=8.142 ms
64 bytes from 8.8.8.8: icmp_seq=24 ttl=111 time=7.836 ms
64 bytes from 8.8.8.8: icmp_seq=25 ttl=111 time=8.902 ms
64 bytes from 8.8.8.8: icmp_seq=26 ttl=111 time=14.708 ms
64 bytes from 8.8.8.8: icmp_seq=27 ttl=111 time=14.408 ms
64 bytes from 8.8.8.8: icmp_seq=28 ttl=111 time=8.347 ms
64 bytes from 8.8.8.8: icmp_seq=29 ttl=111 time=9.279 ms
64 bytes from 8.8.8.8: icmp_seq=30 ttl=111 time=9.290 ms
64 bytes from 8.8.8.8: icmp_seq=31 ttl=111 time=26.775 ms
64 bytes from 8.8.8.8: icmp_seq=32 ttl=111 time=8.324 ms
64 bytes from 8.8.8.8: icmp_seq=33 ttl=111 time=7.656 ms
64 bytes from 8.8.8.8: icmp_seq=34 ttl=111 time=7.499 ms
64 bytes from 8.8.8.8: icmp_seq=35 ttl=111 time=8.154 ms
64 bytes from 8.8.8.8: icmp_seq=36 ttl=111 time=7.799 ms
64 bytes from 8.8.8.8: icmp_seq=37 ttl=111 time=9.044 ms
64 bytes from 8.8.8.8: icmp_seq=38 ttl=111 time=11.391 ms
64 bytes from 8.8.8.8: icmp_seq=39 ttl=111 time=7.712 ms
64 bytes from 8.8.8.8: icmp_seq=40 ttl=111 time=7.626 ms
```

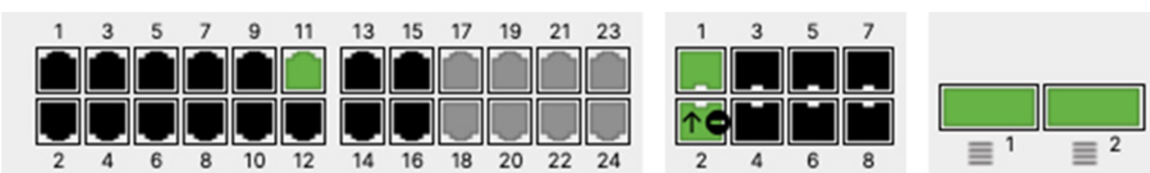
Note: No impact on traffic flow for wireless clients

Introducing Loops (Access Layer, with STP Guard: Loop Guard)



For the purposes of this test and in addition to the previous loop connections, the following ports were connected: MS390-01 / Port 11 < - > C9300-01 / Port 11

Note: Port 11 on MS390-01 in STP BLK state



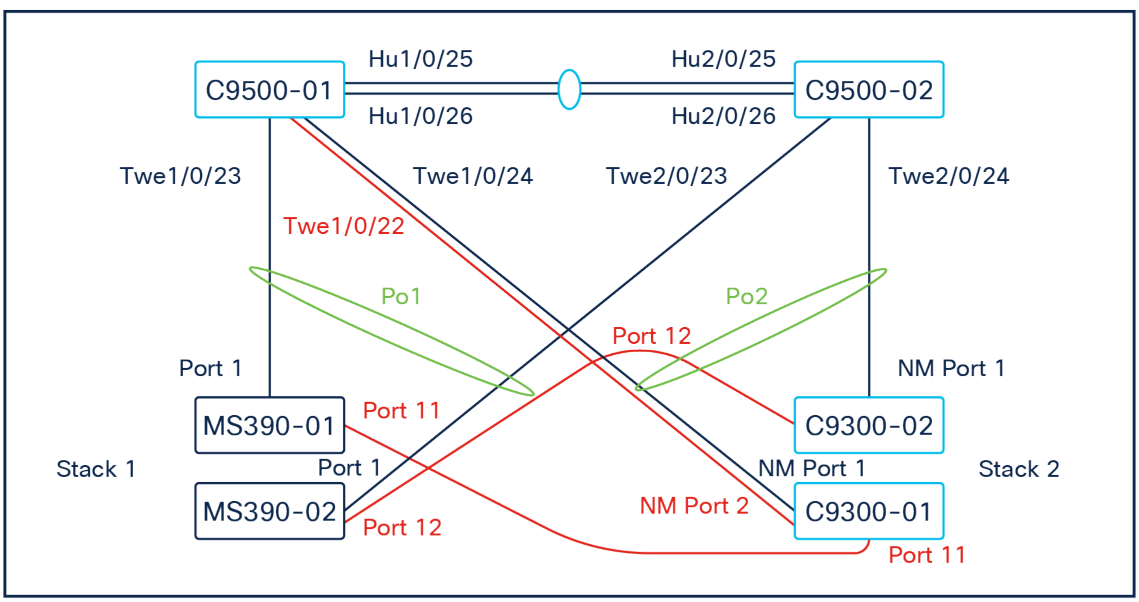
Note: Port 11 on C9300-01 in STP FWD state (Bridge ID: **61440:a4b4.395f.2a8b**)

```
Spanning Tree Protocol
    Protocol Identifier: Spanning Tree Protocol (0x0000)
    Protocol Version Identifier: Multiple Spanning Tree (3)
    BPDU Type: Rapid/Multiple Spanning Tree (0x02)
  > BPDU flags: 0x3c, Forwarding, Learning, Port Role: Designated
  > Root Identifier: 4096 / 0 / b0:c5:3c:60:fb:a0
    Root Path Cost: 0
  > Bridge Identifier: 4096 / 0 / b0:c5:3c:60:fb:a0
    Port identifier: 0x806b
```

```
MST Extension
    MST Config ID format selector: 0
    MST Config name: region1
    MST Config revision: 1
    MST Config digest: ac36177f50283cd4b83821d8ab26de62
    CIST Internal Root Path Cost: 1000
  > CIST Bridge Identifier: 61440 / 0 / 4c:e1:75:b0:ba:00
    CIST Remaining hops: 19
```

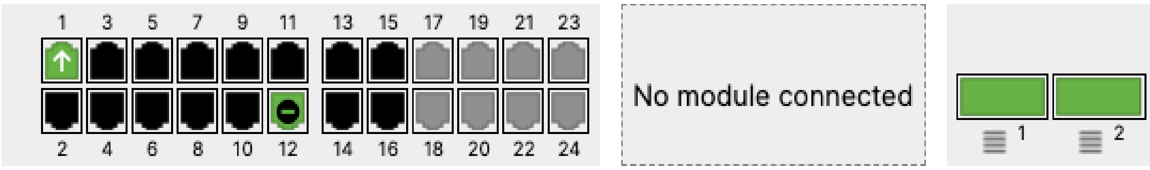
Note: Packet capture on MS390-01 / Port 11 shows that Bridge ID: **61440:4ce1.75b0.ba00** is relaying the Root bridge BPDUs with Root Bridge ID: **4096:b0c5.3c60.fba0**

Introducing Loops (Access Layer, without STP Guard)



For the purposes of this test and in addition to the previous loop connections, the following ports were connected:

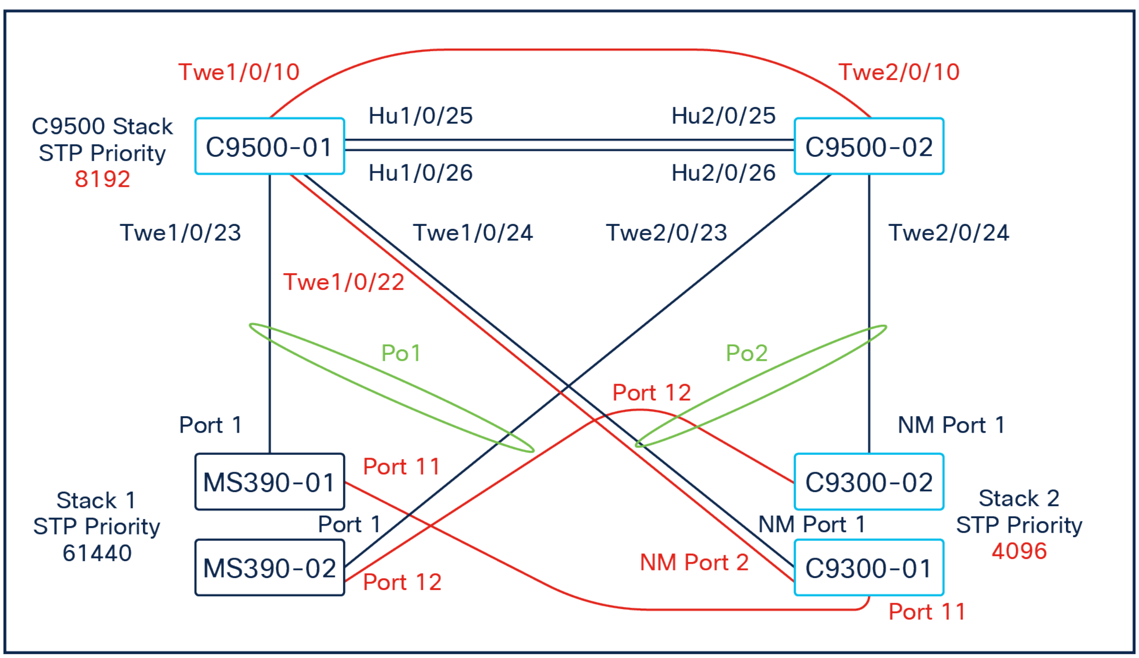
MS390-02 / Port 12 < - > C9300-02 / Port 12



Note: MS390-02 / Port 12 is in STP BLK state (Bridge ID: **61440:2c3f.0b0f.ec00**)

Note: C9300-02 / Port 12 is in STP FWD state (Bridge ID: **61440:4ce1.75b0.ba00**)

Introducing Loops (Core Layer)



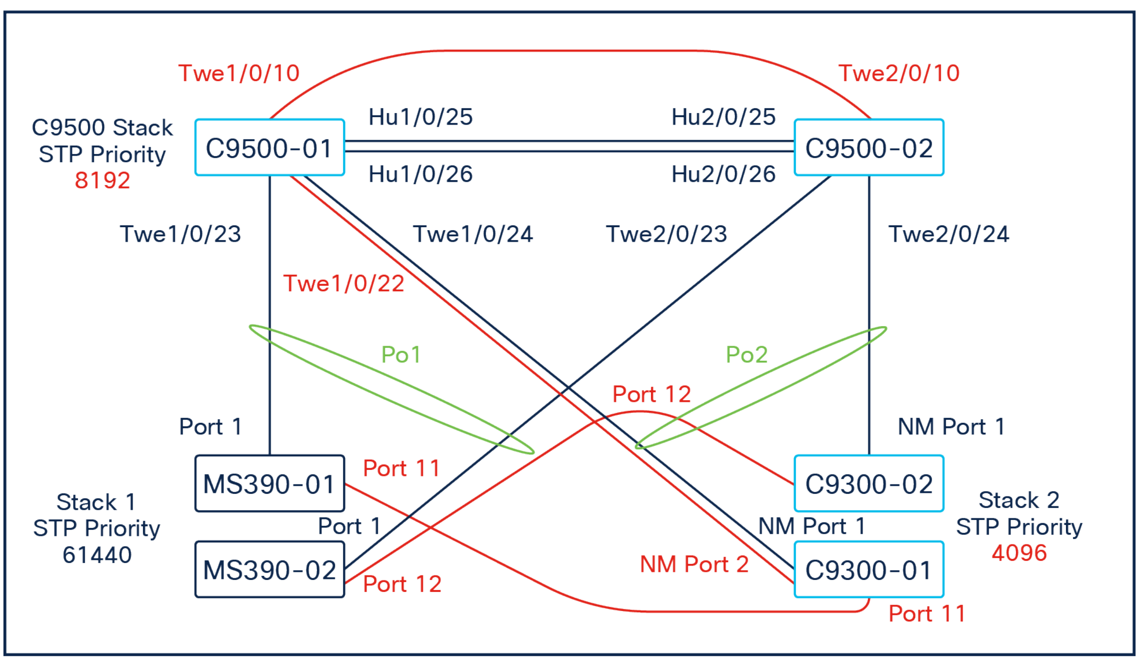
For the purpose of this test and in addition to the previous loop connections, the following ports were connected:

Port Twe1/0/10 to port Twe2/0/10 on the C9500 Core switches.

```
9500-01#show run interface Twe1/0/10
Building configuration...
Current configuration : 132 bytes
!
interface TwentyFiveGigE1/0/10
switchport trunk allowed vlan 1,10,20,30,40
switchport mode trunk
spanning-tree guard root
end
9500-01#show run interface Twe2/0/10
Building configuration...
Current configuration : 132 bytes
!
interface TwentyFiveGigE2/0/10
switchport trunk allowed vlan 1,10,20,30,40
switchport mode trunk
spanning-tree guard root
end
9500-01#
9500-01#show ip interface brief | in TwentyFiveGigE1/0/10
TwentyFiveGigE1/0/10 unassigned YES unset up up
9500-01#
9500-01#show ip interface brief | in TwentyFiveGigE2/0/10
TwentyFiveGigE2/0/10 unassigned YES unset up up
9500-01#show spanning-tree
MST0
Spanning tree enabled protocol mstp
Root ID Priority 4096
      Address b0c5.3c60.fba0
      This bridge is the root
      Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Bridge ID Priority 4096 (priority 4096 sys-id-ext 0)
      Address b0c5.3c60.fba0
      Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Interface      Role Sts Cost        Prio.Nbr Type
------------------------------------------------
Twe1/0/1       Desg FWD 2000        128.193 P2p
```

```
Twe1/0/2         Desg FWD 2000         128.194 P2p
Twe1/0/10        Desg BLK 2000         128.202 P2p
Twe1/0/22        Desg FWD 2000         128.214 P2p
Twe2/0/1         Back BLK 2000         128.385 P2p
Twe2/0/2         Back BLK 2000         128.386 P2p
Twe2/0/10        Desg BKN*2000        128.394 P2p *ROOT_Inc
Po1              Desg FWD 10000        128.2089 P2p
Po2              Desg FWD 1000         128.2090 P2p

9500-01#show spanning-tree interface Twe2/0/10 detail
Port 394 (TwentyFiveGigE2/0/10) of MST0 is broken (Root Inconsistent)
  Port path cost 2000, Port priority 128, Port Identifier 128.394.
  Designated root has priority 4096, address 4ce1.75b0.ba00
  Designated bridge has priority 8192, address b0c5.3c60.fba0
  Designated port id is 128.394, designated path cost 0
  Timers: message age 4, forward delay 0, hold 0
  Number of transitions to forwarding state: 0
  Link type is point-to-point by default, Internal
  PVST Simulation is enabled by default
  Root guard is enabled on the port
  BPDU: sent 2592, received 5175
9500-01#
```

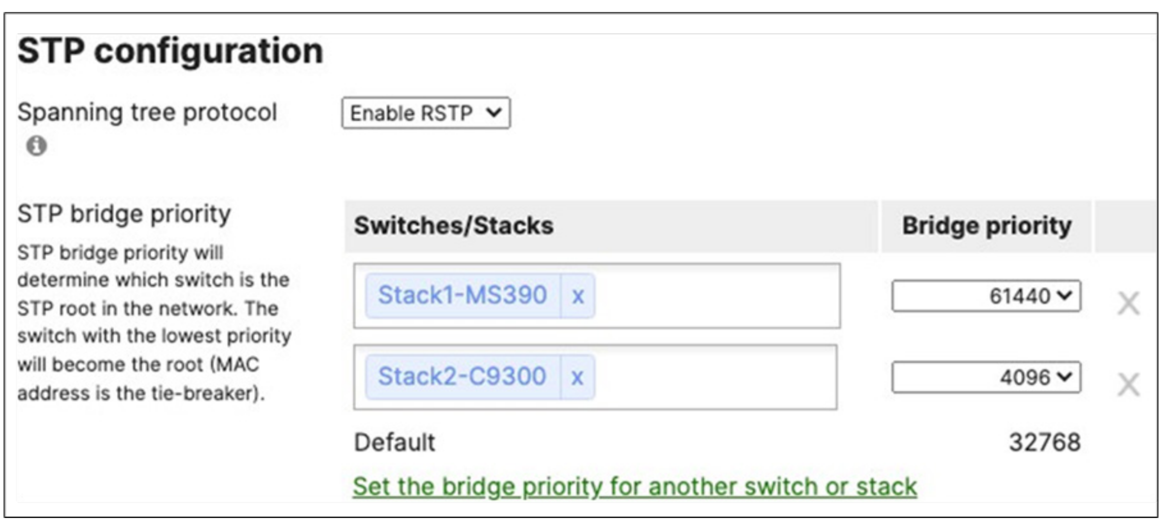
Introducing Rogue Bridge in VLAN 1



For the purpose of this test and in addition to the previous loop connections, the Bridge priority on C9300 Stack will be reduced to 4096 (likely root) and increasing the Bridge priority on C9500 to 8192.

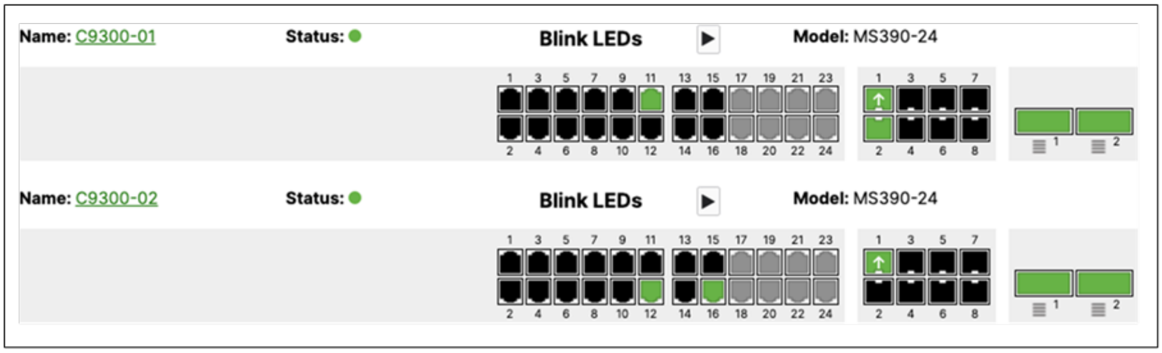
- Downlinks on C9500 are configured with STP Root Guard
- Access Layer Links (Stack to Stack) are configured with STP Loop Guard + UDLD

```
9500-01(config)#spanning-tree mst 0 priority 8192
9500-01(config)#end
9500-01#show spanning-tree
MST0
  Spanning tree enabled protocol mstp
  Root ID Priority 8192
      Address b0c5.3c60.fba0
      This bridge is the root
      Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Bridge ID Priority 8192 (priority 8192 sys-id-ext 0)
    Address b0c5.3c60.fba0
    Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Interface     Role Sts Cost           Prio.Nbr Type
Twe1/0/1      Desg FWD 2000           128.193 P2p
Twe1/0/10     Desg FWD 2000           128.202 P2p
Twe1/0/22     Desg FWD 2000           128.214 P2p
Twe2/0/1      Back BLK 2000           128.385 P2p
Twe2/0/10     Desg BKN*2000           128.394 P2p *ROOT_Inc
Po1           Desg FWD 10000          128.2089 P2p
Po2           Desg FWD 1000           128.2090 P2p
9500-01#
```

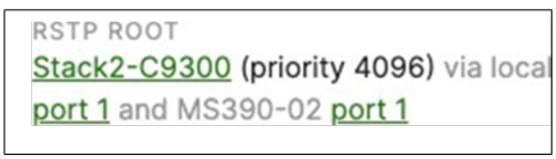


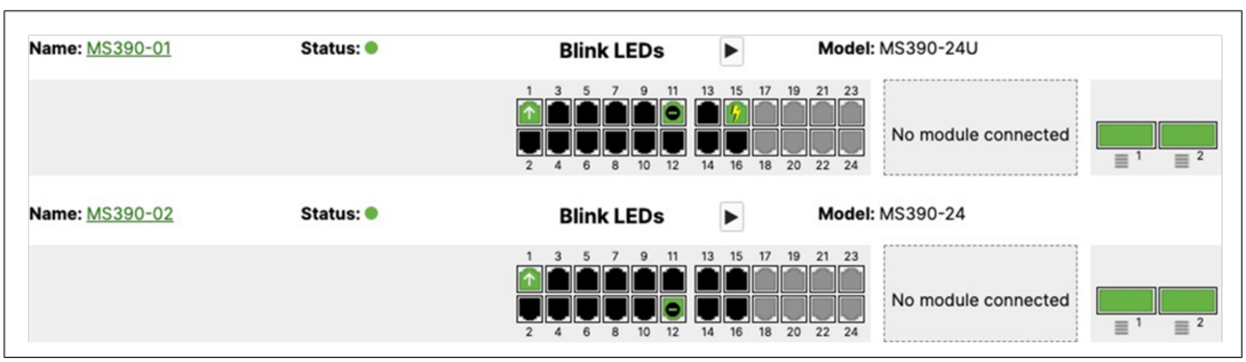
```
9500-01#show spanning-tree
MST0
   Spanning tree enabled protocol mstp
   Root ID Priority 8192
      Address b0c5.3c60.fba0
      This bridge is the root
      Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Bridge ID Priority 8192 (priority 8192 sys-id-ext 0)
      Address b0c5.3c60.fba0
      Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

Interface            RoleSts Cost         Prio.Nbr Type
--------------------------------------------------------
Twe1/0/1            Desg FWD 2000         128.193 P2p
Twe1/0/2            Desg FWD 2000         128.194 P2p
Twe1/0/10           Desg FWD 2000         128.202 P2p
Twe1/0/22           Desg BKN*2000        128.214 P2p *ROOT_Inc
Twe2/0/1            Back BLK 2000         128.385 P2p
Twe2/0/2            Back BLK 2000         128.386 P2p
Twe2/0/10           Desg BKN*2000        128.394 P2p *ROOT_Inc
Po1                 Desg FWD 10000        128.2089 P2p
Po2                 Desg FWD 1000         128.2090 P2p

9500-01#
9500-01#show spanning-tree interface Twe1/0/22 detail
  Port 214 (TwentyFiveGigE1/0/22) of MST0 is broken (Root Inconsistent)
  Port path cost 2000, Port priority 128, Port Identifier 128.214.
  Designated root has priority 4096, address 4ce1.75b0.ba00
  Designated bridge has priority 8192, address b0c5.3c60.fba0
  Designated port id is 128.214, designated path cost 0
  Timers: message age 5, forward delay 0, hold 0
  Number of transitions to forwarding state: 2
  Link type is point-to-point by default, Internal
  PVST Simulation is enabled by default
  Root guard is enabled on the port
  BPDU: sent 4611, received 319
9500-01#
```

Note: C9500 Core Stack is still the Root Bridge (i.e. The root Bridge placement has been enforced).
Downlink to C9300-01 is in **STP Inconsistent State**



Note: C9300 Stack is root
All C9300 ports are in FWD state





Note: C9300 Stack is root for MS390
All MS390 to C9300 are in STP BLK state

```
64 bytes from 8.8.8.8: icmp_seq=5725 ttl=51 time=7.581 ms
64 bytes from 8.8.8.8: icmp_seq=5726 ttl=51 time=8.358 ms
64 bytes from 8.8.8.8: icmp_seq=5727 ttl=51 time=9.050 ms
64 bytes from 8.8.8.8: icmp_seq=5728 ttl=51 time=8.256 ms
64 bytes from 8.8.8.8: icmp_seq=5729 ttl=51 time=6.798 ms
Request timeout for icmp_seq 5730
Request timeout for icmp_seq 5731
Request timeout for icmp_seq 5732
Request timeout for icmp_seq 5733
Request timeout for icmp_seq 5734
Request timeout for icmp_seq 5735
Request timeout for icmp_seq 5736
Request timeout for icmp_seq 5737
Request timeout for icmp_seq 5738
Request timeout for icmp_seq 5739
Request timeout for icmp_seq 5740
Request timeout for icmp_seq 5741
Request timeout for icmp_seq 5742
Request timeout for icmp_seq 5743
Request timeout for icmp_seq 5744
Request timeout for icmp_seq 5745
Request timeout for icmp_seq 5746
Request timeout for icmp_seq 5747
Request timeout for icmp_seq 5748
Request timeout for icmp_seq 5749
Request timeout for icmp_seq 5750
Request timeout for icmp_seq 5751
Request timeout for icmp_seq 5752
Request timeout for icmp_seq 5753
Request timeout for icmp_seq 5754
Request timeout for icmp_seq 5755
Request timeout for icmp_seq 5756
Request timeout for icmp_seq 5757
Request timeout for icmp_seq 5758
Request timeout for icmp_seq 5759
64 bytes from 8.8.8.8: icmp_seq=5760 ttl=51 time=8.006 ms
64 bytes from 8.8.8.8: icmp_seq=5761 ttl=51 time=6.702 ms
64 bytes from 8.8.8.8: icmp_seq=5762 ttl=51 time=8.582 ms
64 bytes from 8.8.8.8: icmp_seq=5763 ttl=51 time=9.595 ms
64 bytes from 8.8.8.8: icmp_seq=5764 ttl=51 time=7.773 ms
64 bytes from 8.8.8.8: icmp_seq=5765 ttl=51 time=8.236 ms
64 bytes from 8.8.8.8: icmp_seq=5766 ttl=51 time=8.071 ms
64 bytes from 8.8.8.8: icmp_seq=5767 ttl=51 time=8.211 ms
64 bytes from 8.8.8.8: icmp_seq=5768 ttl=51 time=8.462 ms
64 bytes from 8.8.8.8: icmp_seq=5769 ttl=51 time=7.462 ms
```

Note: Wireless client traffic flow disrupted for about **30** secs

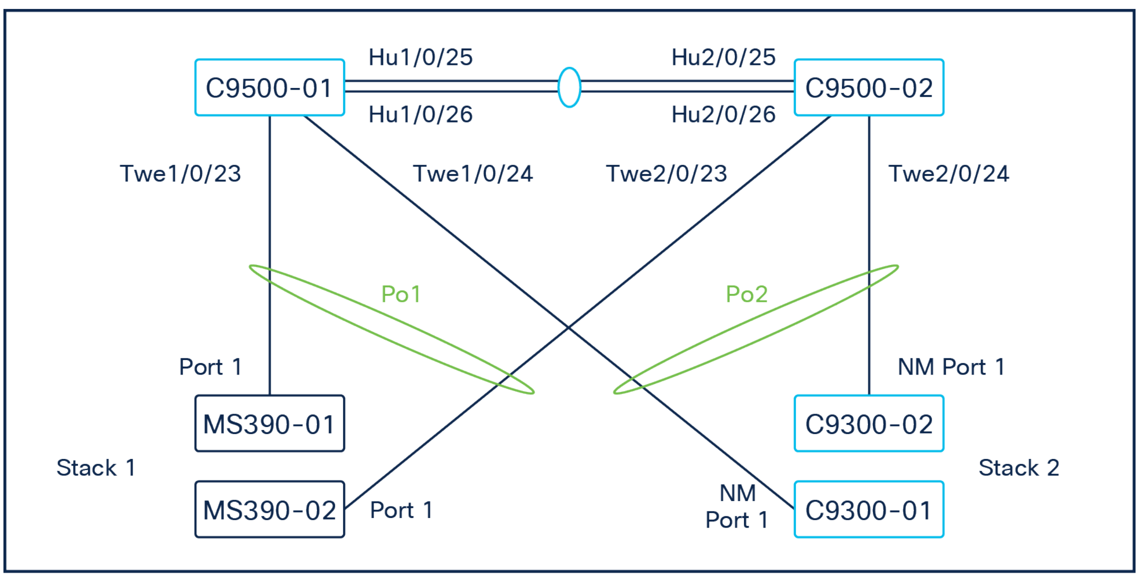
Notes:

Reverting all configuration back to original state:

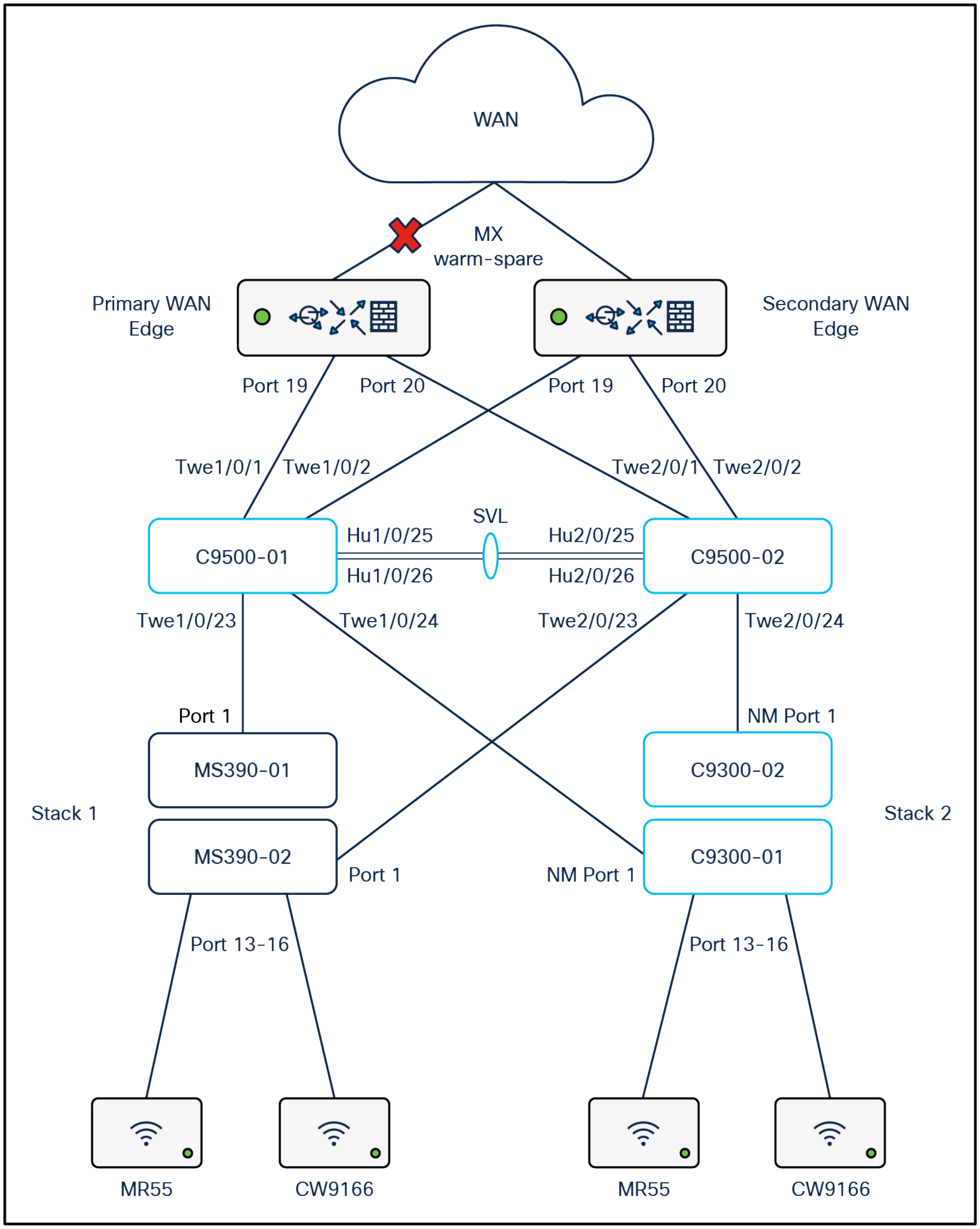
1. Disconnect and shutdown interface TwentyFiveGigE1/0/22
2. Disconnect port 11 on MS390-01 and C9300-01 and remove Loop Guard and UDLD
3. Disconnect port 12 on MS390-02 and C9300-02.
4. Disconnect and revert port TwentyFiveGigE1/0/10 and TwentyFiveGigE20/10 back to access with VLAN 1 and shutdown
5. Change MST priority on C9300 stack to 61440
6. Change MST priority on C9500 Core Stack to 4096

High Availability and Failover

Here's the steady-state physical architecture for reference:

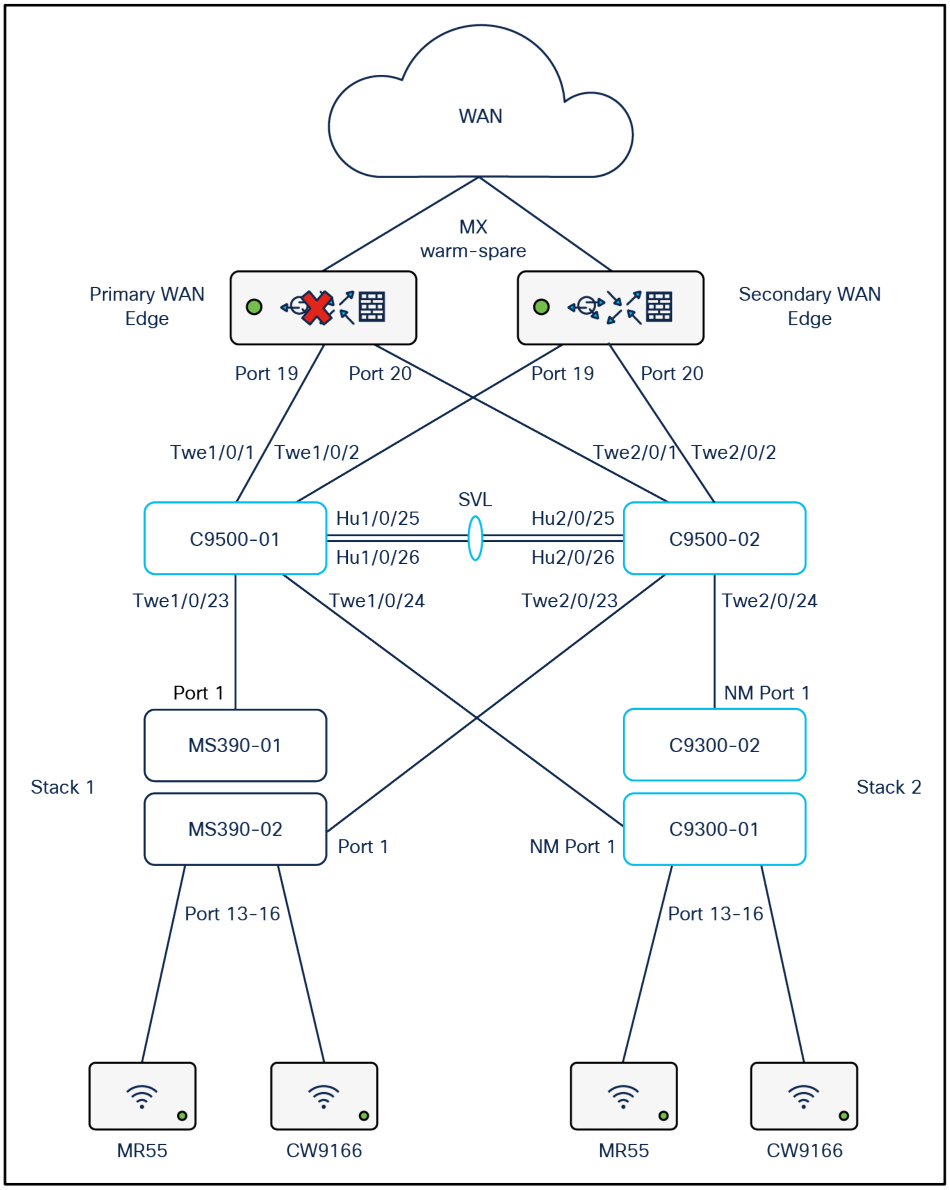


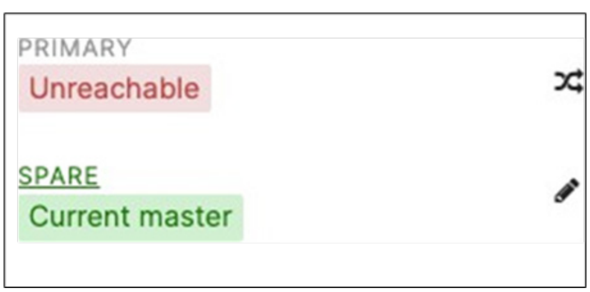
MX WAN Edge Failover




```
samsackl@SAMSACKL-M-F859 ~ % ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8): 56 data bytes
64 bytes from 8.8.8.8: icmp_seq=0 ttl=111 time=40.604 ms
64 bytes from 8.8.8.8: icmp_seq=1 ttl=111 time=3.981 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=111 time=4.124 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=111 time=5.089 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=111 time=5.054 ms
64 bytes from 8.8.8.8: icmp_seq=5 ttl=111 time=4.542 ms
64 bytes from 8.8.8.8: icmp_seq=6 ttl=111 time=4.594 ms
64 bytes from 8.8.8.8: icmp_seq=7 ttl=111 time=4.612 ms
64 bytes from 8.8.8.8: icmp_seq=8 ttl=111 time=10.067 ms
64 bytes from 8.8.8.8: icmp_seq=9 ttl=111 time=4.570 ms
64 bytes from 8.8.8.8: icmp_seq=10 ttl=111 time=4.503 ms
64 bytes from 8.8.8.8: icmp_seq=11 ttl=111 time=4.372 ms
64 bytes from 8.8.8.8: icmp_seq=12 ttl=111 time=4.496 ms
64 bytes from 8.8.8.8: icmp_seq=13 ttl=111 time=4.348 ms
64 bytes from 8.8.8.8: icmp_seq=14 ttl=111 time=4.019 ms
64 bytes from 8.8.8.8: icmp_seq=15 ttl=111 time=4.435 ms
64 bytes from 8.8.8.8: icmp_seq=16 ttl=111 time=5.242 ms
Request timeout for icmp_seq 17
64 bytes from 8.8.8.8: icmp_seq=18 ttl=111 time=949.483 ms
64 bytes from 8.8.8.8: icmp_seq=19 ttl=111 time=4.377 ms
64 bytes from 8.8.8.8: icmp_seq=20 ttl=111 time=4.037 ms
64 bytes from 8.8.8.8: icmp_seq=21 ttl=111 time=4.362 ms
64 bytes from 8.8.8.8: icmp_seq=22 ttl=111 time=4.245 ms
64 bytes from 8.8.8.8: icmp_seq=23 ttl=111 time=4.367 ms
64 bytes from 8.8.8.8: icmp_seq=24 ttl=111 time=4.620 ms
64 bytes from 8.8.8.8: icmp_seq=25 ttl=111 time=5.048 ms
64 bytes from 8.8.8.8: icmp_seq=26 ttl=111 time=3.963 ms
64 bytes from 8.8.8.8: icmp_seq=27 ttl=111 time=4.202 ms
64 bytes from 8.8.8.8: icmp_seq=28 ttl=111 time=3.945 ms
64 bytes from 8.8.8.8: icmp_seq=29 ttl=111 time=4.068 ms
64 bytes from 8.8.8.8: icmp_seq=30 ttl=111 time=4.085 ms
64 bytes from 8.8.8.8: icmp_seq=31 ttl=111 time=4.602 ms
64 bytes from 8.8.8.8: icmp_seq=32 ttl=111 time=4.046 ms
64 bytes from 8.8.8.8: icmp_seq=33 ttl=111 time=4.312 ms
64 bytes from 8.8.8.8: icmp_seq=34 ttl=111 time=4.178 ms
64 bytes from 8.8.8.8: icmp_seq=35 ttl=111 time=4.562 ms
64 bytes from 8.8.8.8: icmp_seq=36 ttl=111 time=4.594 ms
64 bytes from 8.8.8.8: icmp_seq=37 ttl=111 time=4.754 ms
64 bytes from 8.8.8.8: icmp_seq=38 ttl=111 time=10.587 ms
64 bytes from 8.8.8.8: icmp_seq=39 ttl=111 time=4.121 ms
64 bytes from 8.8.8.8: icmp_seq=40 ttl=111 time=4.241 ms
```

Note: Client traffic was very briefly disrupted during failover event (1 packet drop)

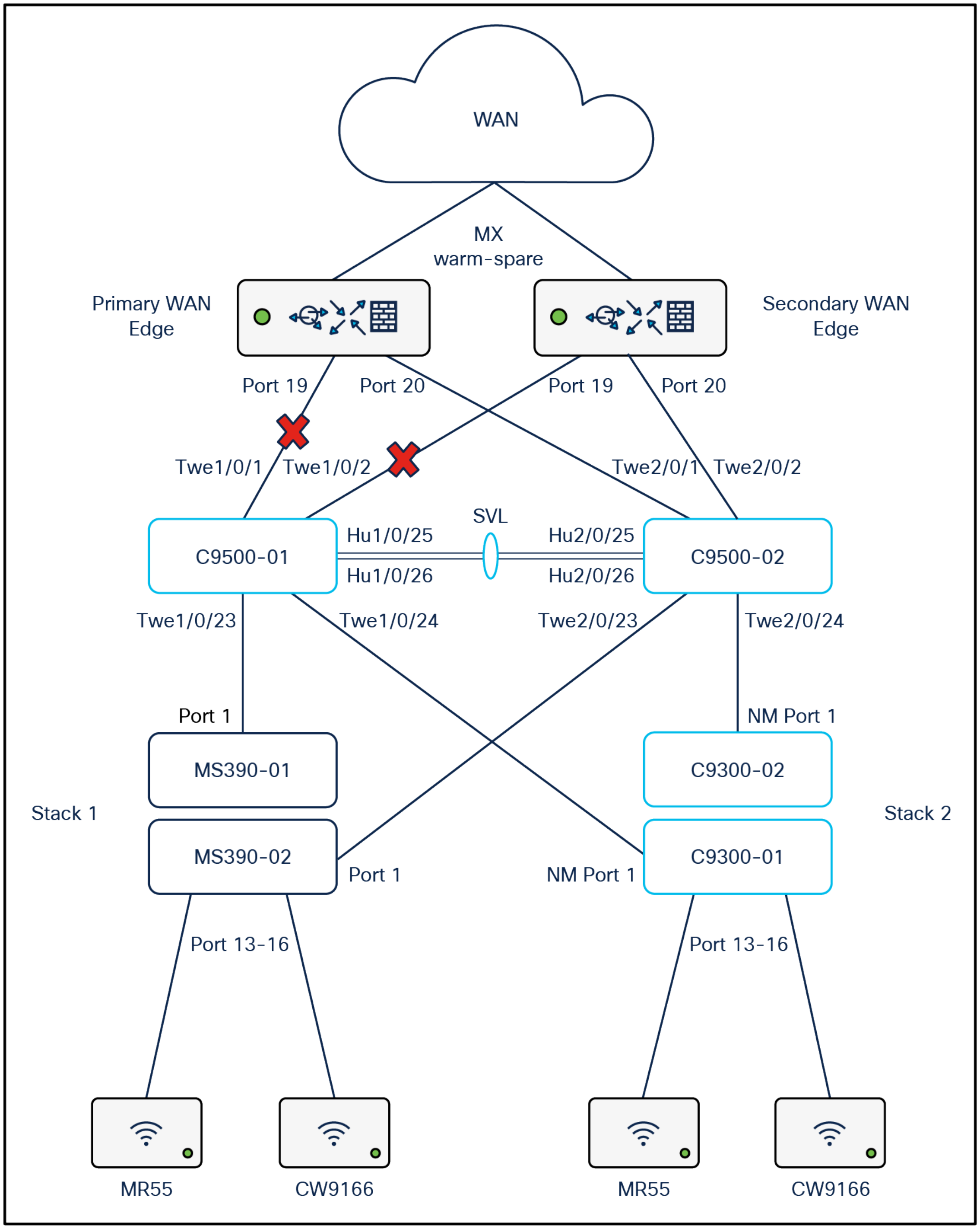

WAN
MX
warm-spare
Primary WAN
Edge
Secondary WAN
Edge
Port 19
Port 20
Port 19
Port 20
Twe1/0/1
Twe1/0/2
Twe2/0/1
Twe2/0/2
SVL
C9500-01
Hu1/0/25
Hu1/0/26
Hu2/0/25
Hu2/0/26
C9500-02
Twe1/0/23
Twe1/0/24
Twe2/0/23
Twe2/0/24
Port 1
NM Port 1
MS390-01
C9300-02
Stack 1
Stack 2
MS390-02
Port 1
NM Port 1
C9300-01
Port 13-16
Port 13-16
MR55
CW9166
MR55
CW9166


PRIMARY
Unreachable
SPARE
Current master

```
64 bytes from 8.8.8.8: icmp_seq=1187 ttl=114 time=4.070 ms
64 bytes from 8.8.8.8: icmp_seq=1188 ttl=114 time=4.027 ms
64 bytes from 8.8.8.8: icmp_seq=1189 ttl=114 time=4.068 ms
64 bytes from 8.8.8.8: icmp_seq=1190 ttl=114 time=3.961 ms
64 bytes from 8.8.8.8: icmp_seq=1191 ttl=114 time=4.215 ms
64 bytes from 8.8.8.8: icmp_seq=1192 ttl=114 time=3.904 ms
64 bytes from 8.8.8.8: icmp_seq=1193 ttl=114 time=4.066 ms
64 bytes from 8.8.8.8: icmp_seq=1194 ttl=114 time=4.140 ms
Request timeout for icmp_seq 1195
Request timeout for icmp_seq 1196
Request timeout for icmp_seq 1197
64 bytes from 8.8.8.8: icmp_seq=1198 ttl=114 time=35.212 ms
64 bytes from 8.8.8.8: icmp_seq=1199 ttl=114 time=4.369 ms
64 bytes from 8.8.8.8: icmp_seq=1200 ttl=114 time=4.658 ms
64 bytes from 8.8.8.8: icmp_seq=1201 ttl=114 time=4.484 ms
64 bytes from 8.8.8.8: icmp_seq=1202 ttl=114 time=4.179 ms
64 bytes from 8.8.8.8: icmp_seq=1203 ttl=114 time=4.160 ms
64 bytes from 8.8.8.8: icmp_seq=1204 ttl=114 time=4.604 ms
64 bytes from 8.8.8.8: icmp_seq=1205 ttl=114 time=4.475 ms
64 bytes from 8.8.8.8: icmp_seq=1206 ttl=114 time=4.277 ms
64 bytes from 8.8.8.8: icmp_seq=1207 ttl=114 time=4.741 ms
64 bytes from 8.8.8.8: icmp_seq=1208 ttl=114 time=4.527 ms
64 bytes from 8.8.8.8: icmp_seq=1209 ttl=114 time=4.501 ms
64 bytes from 8.8.8.8: icmp_seq=1210 ttl=114 time=3.691 ms
64 bytes from 8.8.8.8: icmp_seq=1211 ttl=114 time=4.332 ms
64 bytes from 8.8.8.8: icmp_seq=1212 ttl=114 time=4.093 ms
64 bytes from 8.8.8.8: icmp_seq=1213 ttl=114 time=4.193 ms
64 bytes from 8.8.8.8: icmp_seq=1214 ttl=114 time=4.363 ms
64 bytes from 8.8.8.8: icmp_seq=1215 ttl=114 time=4.303 ms
64 bytes from 8.8.8.8: icmp_seq=1216 ttl=114 time=4.387 ms
64 bytes from 8.8.8.8: icmp_seq=1217 ttl=114 time=4.271 ms
```

Note: Client traffic disrupted for about **1-3** secs

C9500 Core Stack Loss of Uplink



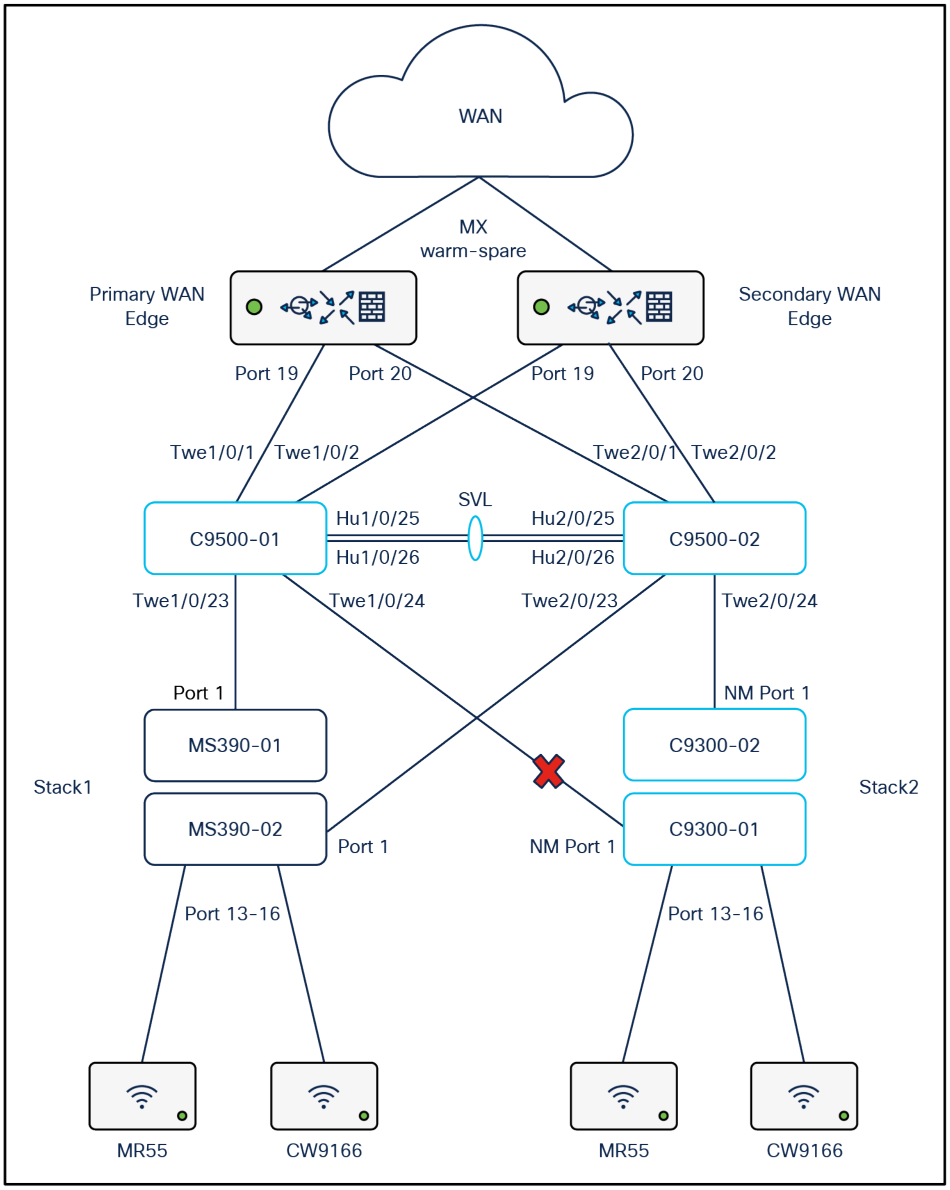
For the purpose of this test, ports TwentyFiveGigE1/0/1 and TwentyFiveGigE1/0/2 will be disconnected.

```
9500-01#show ip interface brief
TwentyFiveGigE1/0/1    unassigned      YES unset down    down
TwentyFiveGigE1/0/2    unassigned      YES unset down    down
TwentyFiveGigE2/0/1    unassigned      YES unset up      up
TwentyFiveGigE2/0/2    unassigned      YES unset up      up
9500-01#show switch
Switch/Stack Mac Address : b0c5.3c60.fba0 - Local Mac Address
Mac persistency wait time: Indefinite
                           H/W Current

Switch#    Role     Mac Address          Priority   Version   State
-------------------------------------------------------------------
*1         Active    b0c5.3c60.fba0       5         V02        Ready
2          Standby  40b5.c111.01e0        1         V02        Ready

9500-01#
```

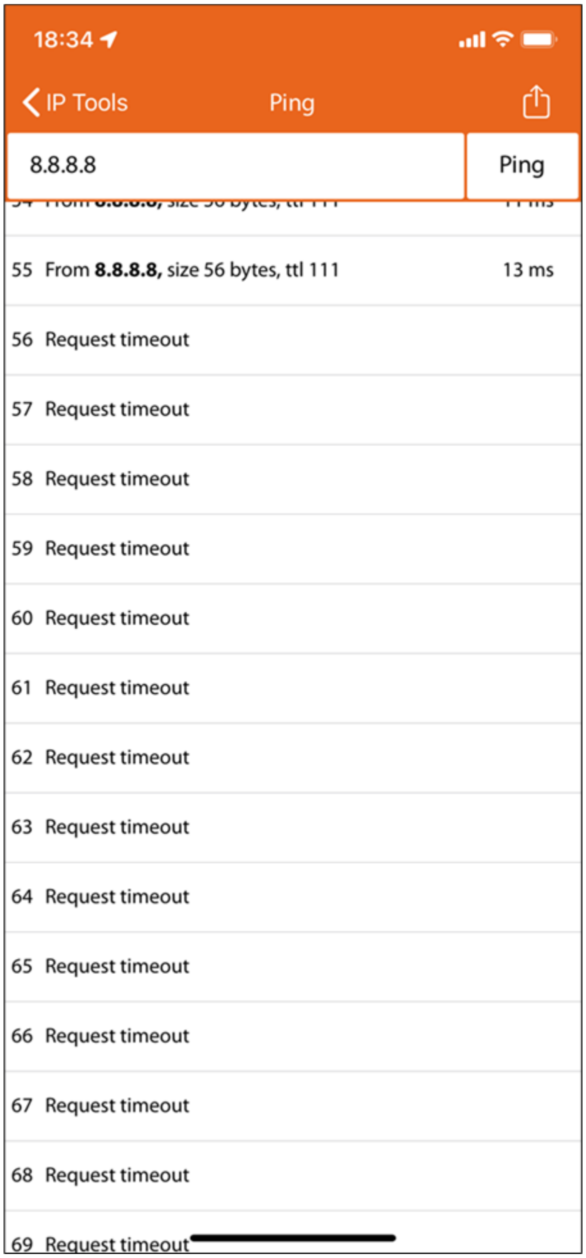
```
Request timeout for icmp_seq 9192
Request timeout for icmp_seq 9193
Request timeout for icmp_seq 9194
Request timeout for icmp_seq 9195
Request timeout for icmp_seq 9196
Request timeout for icmp_seq 9197
Request timeout for icmp_seq 9198
Request timeout for icmp_seq 9199
Request timeout for icmp_seq 9200
Request timeout for icmp_seq 9201
Request timeout for icmp_seq 9202
Request timeout for icmp_seq 9203
Request timeout for icmp_seq 9204
Request timeout for icmp_seq 9205
Request timeout for icmp_seq 9206
Request timeout for icmp_seq 9207
Request timeout for icmp_seq 9208
Request timeout for icmp_seq 9209
Request timeout for icmp_seq 9210
Request timeout for icmp_seq 9211
Request timeout for icmp_seq 9212
Request timeout for icmp_seq 9213
Request timeout for icmp_seq 9214
Request timeout for icmp_seq 9215
Request timeout for icmp_seq 9216
Request timeout for icmp_seq 9217
Request timeout for icmp_seq 9218
Request timeout for icmp_seq 9219
Request timeout for icmp_seq 9220
Request timeout for icmp_seq 9221
Request timeout for icmp_seq 9222
Request timeout for icmp_seq 9223
Request timeout for icmp_seq 9224
Request timeout for icmp_seq 9225
Request timeout for icmp_seq 9226
64 bytes from 8.8.8.8: icmp_seq=9227 ttl=111 time=7.469 ms
64 bytes from 8.8.8.8: icmp_seq=9228 ttl=111 time=6.849 ms
64 bytes from 8.8.8.8: icmp_seq=9229 ttl=111 time=7.060 ms
64 bytes from 8.8.8.8: icmp_seq=9230 ttl=111 time=7.252 ms
```

Note: Wireless client traffic flow disrupted for about **30** secs

C9300 Stack Loss of Uplink

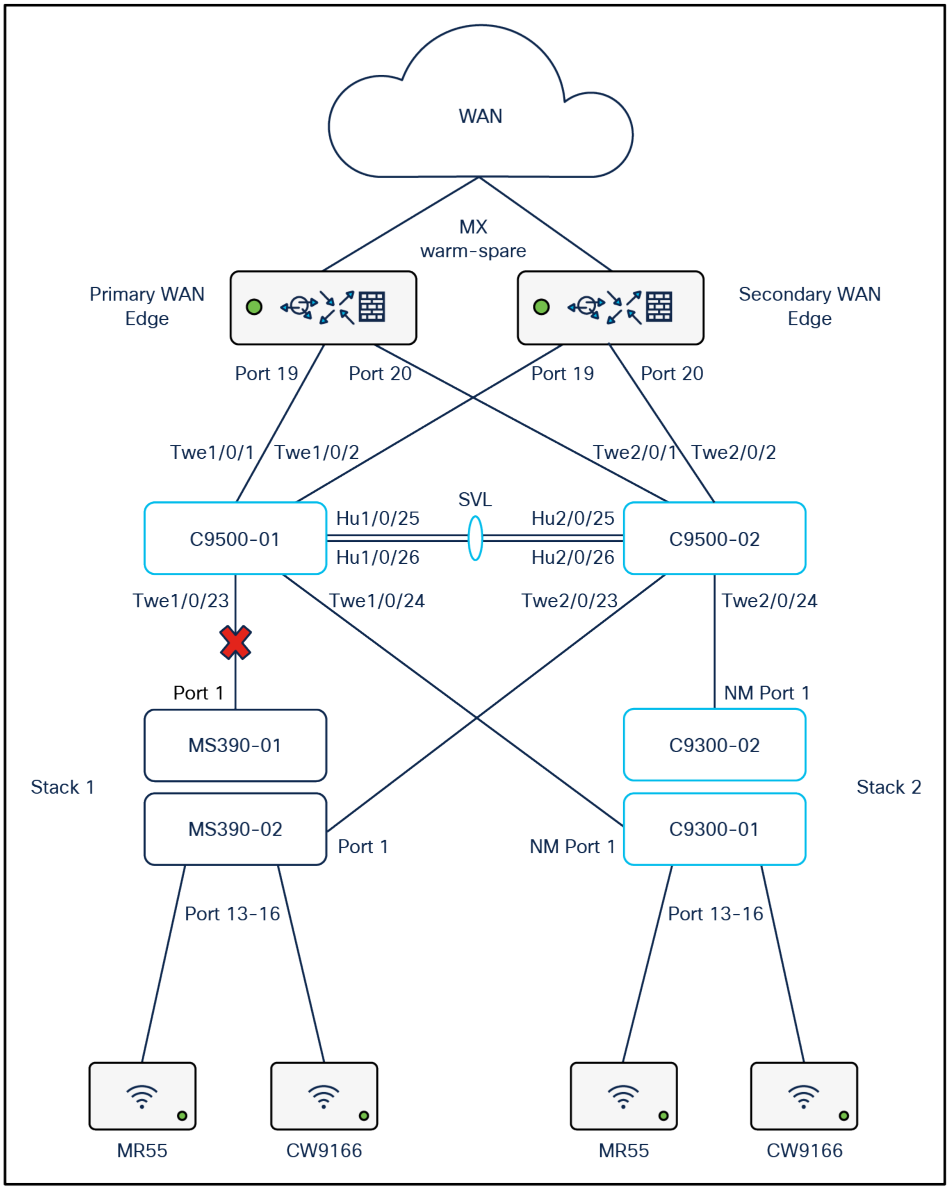


For the purpose of this test, NM Port 1 on C9300-01 (Master switch) will be disconnected.



Note: Wireless client traffic flow disrupted for about **30** secs

MS390 Stack Loss of Uplink



For the purpose of this test, port 1 on MS390-01 (Master switch) will be disconnected.


```
64 bytes from 8.8.8.8: icmp_seq=10439 ttl=111 time=7.219 ms
64 bytes from 8.8.8.8: icmp_seq=10440 ttl=111 time=9.558 ms
64 bytes from 8.8.8.8: icmp_seq=10441 ttl=111 time=13.315 ms
64 bytes from 8.8.8.8: icmp_seq=10442 ttl=111 time=7.202 ms
Request timeout for icmp_seq 10443
64 bytes from 8.8.8.8: icmp_seq=10444 ttl=111 time=7.644 ms
64 bytes from 8.8.8.8: icmp_seq=10445 ttl=111 time=6.427 ms
64 bytes from 8.8.8.8: icmp_seq=10446 ttl=111 time=8.329 ms
64 bytes from 8.8.8.8: icmp_seq=10447 ttl=111 time=20.515 ms
64 bytes from 8.8.8.8: icmp_seq=10448 ttl=111 time=15.399 ms
Request timeout for icmp_seq 10449
64 bytes from 8.8.8.8: icmp_seq=10450 ttl=111 time=26.488 ms
64 bytes from 8.8.8.8: icmp_seq=10451 ttl=111 time=8.758 ms
64 bytes from 8.8.8.8: icmp_seq=10452 ttl=111 time=22.565 ms
64 bytes from 8.8.8.8: icmp_seq=10453 ttl=111 time=20.149 ms
64 bytes from 8.8.8.8: icmp_seq=10454 ttl=111 time=17.307 ms
64 bytes from 8.8.8.8: icmp_seq=10455 ttl=111 time=7.371 ms
Request timeout for icmp_seq 10456
Request timeout for icmp_seq 10457
64 bytes from 8.8.8.8: icmp_seq=10458 ttl=111 time=25.008 ms
64 bytes from 8.8.8.8: icmp_seq=10459 ttl=111 time=7.907 ms
64 bytes from 8.8.8.8: icmp_seq=10460 ttl=111 time=13.606 ms
64 bytes from 8.8.8.8: icmp_seq=10461 ttl=111 time=17.955 ms
64 bytes from 8.8.8.8: icmp_seq=10462 ttl=111 time=20.984 ms
64 bytes from 8.8.8.8: icmp_seq=10463 ttl=111 time=26.031 ms
64 bytes from 8.8.8.8: icmp_seq=10464 ttl=111 time=21.931 ms
64 bytes from 8.8.8.8: icmp_seq=10465 ttl=111 time=17.613 ms
64 bytes from 8.8.8.8: icmp_seq=10466 ttl=111 time=27.587 ms
64 bytes from 8.8.8.8: icmp_seq=10467 ttl=111 time=22.066 ms
64 bytes from 8.8.8.8: icmp_seq=10468 ttl=111 time=25.890 ms
64 bytes from 8.8.8.8: icmp_seq=10469 ttl=111 time=23.064 ms
64 bytes from 8.8.8.8: icmp_seq=10470 ttl=111 time=16.053 ms
64 bytes from 8.8.8.8: icmp_seq=10471 ttl=111 time=20.443 ms
64 bytes from 8.8.8.8: icmp_seq=10472 ttl=111 time=22.713 ms
64 bytes from 8.8.8.8: icmp_seq=10473 ttl=111 time=21.381 ms
64 bytes from 8.8.8.8: icmp_seq=10474 ttl=111 time=8.151 ms
64 bytes from 8.8.8.8: icmp_seq=10475 ttl=111 time=6.894 ms
64 bytes from 8.8.8.8: icmp_seq=10476 ttl=111 time=5.762 ms
64 bytes from 8.8.8.8: icmp_seq=10477 ttl=111 time=7.449 ms
64 bytes from 8.8.8.8: icmp_seq=10478 ttl=111 time=13.023 ms
```

Note: Wireless client traffic to the internet disrupted for about **2** secs


```
64 bytes from 10.0.20.5: icmp_seq=9 ttl=64 time=99.045 ms
64 bytes from 10.0.20.5: icmp_seq=10 ttl=64 time=15.473 ms
64 bytes from 10.0.20.5: icmp_seq=11 ttl=64 time=5.512 ms
64 bytes from 10.0.20.5: icmp_seq=12 ttl=64 time=6.149 ms
64 bytes from 10.0.20.5: icmp_seq=13 ttl=64 time=5.916 ms
64 bytes from 10.0.20.5: icmp_seq=14 ttl=64 time=6.030 ms
64 bytes from 10.0.20.5: icmp_seq=15 ttl=64 time=5.890 ms
64 bytes from 10.0.20.5: icmp_seq=16 ttl=64 time=5.969 ms
64 bytes from 10.0.20.5: icmp_seq=17 ttl=64 time=64.174 ms
Request timeout for icmp_seq 18
64 bytes from 10.0.20.5: icmp_seq=19 ttl=64 time=105.541 ms
64 bytes from 10.0.20.5: icmp_seq=20 ttl=64 time=5.780 ms
64 bytes from 10.0.20.5: icmp_seq=21 ttl=64 time=5.950 ms
64 bytes from 10.0.20.5: icmp_seq=22 ttl=64 time=66.381 ms
64 bytes from 10.0.20.5: icmp_seq=23 ttl=64 time=5.679 ms
64 bytes from 10.0.20.5: icmp_seq=24 ttl=64 time=100.983 ms
64 bytes from 10.0.20.5: icmp_seq=25 ttl=64 time=5.750 ms
64 bytes from 10.0.20.5: icmp_seq=26 ttl=64 time=4.784 ms
64 bytes from 10.0.20.5: icmp_seq=27 ttl=64 time=4.764 ms
64 bytes from 10.0.20.5: icmp_seq=28 ttl=64 time=5.699 ms
64 bytes from 10.0.20.5: icmp_seq=29 ttl=64 time=7.896 ms
64 bytes from 10.0.20.5: icmp_seq=30 ttl=64 time=5.511 ms
64 bytes from 10.0.20.5: icmp_seq=31 ttl=64 time=4.974 ms
64 bytes from 10.0.20.5: icmp_seq=32 ttl=64 time=5.492 ms
```

Note: Wireless client traffic on Campus LAN disrupted for about **1** sec

QoS

For the purpose of this test, packet capture will be taken between two clients running a Webex session. Packet capture will be taken on the Edge (i.e. MR wireless and wired interfaces) then on the Access (i.e. the MS390 or C9300 uplink port) then on the MX WAN Downlink and finally on the MX WAN Uplink. The table below shows the testing components and the expected QoS behavior:

Client	Application	Access Point (Wired) Expected QoS	Access Switch Uplink Port Expected QoS	MX Appliance Uplink Port Expected QoS
Client #1 (10.0.20.2) **iPhone 11 (cc:66:0a:3e:44:69)**	Webex (UDP 9000)	AP3_Zone2 / AF41 / DSCP 34	C9300-02 (Port 25) / AF41 / DSCP 34	AF41 / DSCP 34
	iTunes	AP3_Zone2 / AF21 / DSCP 18	C9300-02 (Port 25) / AF21 / DSCP 18	AF21 / DSCP 18
Client #2 (10.0.20.3) **MacBook Pro (3c:22:fb:30:da:69)**	Webex (UDP 9000)	AP2_Zone1 / AF41 / DSCP 34	MS390-01 (Port 1) / AF41 / DSCP 34	AF41 / DSCP 34
	Dropbox	AP2_Zone1 / AF0 / DSCP 0	MS390-01 (Port 1) / AF0 / DSCP 0	AF0 / DSCP 0

Access Point Wireless Port pcaps

Client #1

```
> Frame Control Field: 0x8881
  .000 0000 0011 0000 = Duration: 48 microseconds
  Receiver address: 7a:3a:0e:54:0d:48 (7a:3a:0e:54:0d:48)
  Transmitter address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  Destination address: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f)
  Source address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  BSS Id: 7a:3a:0e:54:0d:48 (7a:3a:0e:54:0d:48)
  STA address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  .... .... .... 0000 = Fragment number: 0
  0110 0010 0110 .... = Sequence number: 1574
v Qos Control: 0x0a15
    .... .... .... 0101 = TID: 5
    [.... .... .... .101 = Priority: Video (Video) (5)]
    .... .... ...1 .... = QoS bit 4: Bits 8-15 of QoS Control field are Queue Size
    .... .... .00. .... = Ack Policy: Normal Ack (0x0)
```

```
> Frame Control Field: 0x8881
  .000 0000 0011 0000 = Duration: 48 microseconds
  Receiver address: 7a:3a:0e:54:0d:48 (7a:3a:0e:54:0d:48)
  Transmitter address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  Destination address: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f)
  Source address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  BSS Id: 7a:3a:0e:54:0d:48 (7a:3a:0e:54:0d:48)
  STA address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  .... .... .... 0000 = Fragment number: 0
  0100 1001 0110 .... = Sequence number: 1174
v Qos Control: 0x1310
    .... .... .... 0000 = TID: 0
    [.... .... .... .000 = Priority: Best Effort (Best Effort) (0)]
    .... .... ...1 .... = QoS bit 4: Bits 8-15 of QoS Control field are Queue Size
```

Note: Please note that QoS values in this case could be arbitrary as they are upstream (i.e. Client to AP) unless you have configured Wireless Profiles on the client devices. Please check the following article for more details on creating Wireless Profiles and using FastLane with Meraki Systems Manager.

Client #2

```
> Frame Control Field: 0x8801
  .000 0000 0011 0000 = Duration: 48 microseconds
  Receiver address: de:9c:1e:ec:26:b0 (de:9c:1e:ec:26:b0)
  Transmitter address: Apple_30:da:69 (3c:22:fb:30:da:69)
  Destination address: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f)
  Source address: Apple_30:da:69 (3c:22:fb:30:da:69)
  BSS Id: de:9c:1e:ec:26:b0 (de:9c:1e:ec:26:b0)
  STA address: Apple_30:da:69 (3c:22:fb:30:da:69)
  .... .... .... 0000 = Fragment number: 0
  0100 0100 1010 .... = Sequence number: 1098
v Qos Control: 0x0006
    .... .... .... 0110 = TID: 6
    [.... .... .... .110 = Priority: Voice (Voice) (6)]
    .... .... ...0 .... = QoS bit 4: Bits 8-15 of QoS Control field are TXOP Duration Requested
```

```
v IEEE 802.11 QoS Data, Flags: .......T
    Type/Subtype: QoS Data (0x0028)
  > Frame Control Field: 0x8801
    .000 0000 0011 0000 = Duration: 48 microseconds
    Receiver address: de:9c:1e:ec:26:b0 (de:9c:1e:ec:26:b0)
    Transmitter address: Apple_30:da:69 (3c:22:fb:30:da:69)
    Source address: Apple_30:da:69 (3c:22:fb:30:da:69)
    BSS Id: de:9c:1e:ec:26:b0 (de:9c:1e:ec:26:b0)
    STA address: Apple_30:da:69 (3c:22:fb:30:da:69)
    .... .... .... 0000 = Fragment number: 0
    1000 1101 1001 .... = Sequence number: 2265
  v Qos Control: 0x0081
      .... .... .... 0001 = TID: 1
      [.... .... .... .001 = Priority: Background (Background) (1)]
```

Note: Please note that QoS values in this case could be arbitrary as they are upstream (i.e. Client to AP) unless you have configured Wireless Profiles on the client devices. Please check the following article for more details on creating Wireless Profiles and using FastLane with Meraki Systems Manager.

Access Point Wired Port pcaps

Client #1

```
Internet Protocol Version 4, Src: 10.0.20.2, Dst: 62.109.209.152
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
    Total Length: 682
    Identification: 0x991e (39198)
  > Flags: 0x00
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: UDP (17)
    Header Checksum: 0xb095 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 10.0.20.2
    Destination Address: 62.109.209.152
User Datagram Protocol, Src Port: 61534, Dst Port: 9000
    Source Port: 61534
    Destination Port: 9000
```

```
Internet Protocol Version 4, Src: 10.0.20.2, Dst: 23.41.8.48
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x48 (DSCP: AF21, ECN: Not-ECT)
    Total Length: 76
    Identification: 0x0000 (0)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: TCP (6)
    Header Checksum: 0xfd09 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 10.0.20.2
    Destination Address: 23.41.8.48
```

Client #2

```
Internet Protocol Version 4, Src: 10.0.20.3, Dst: 62.109.209.152
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
    Total Length: 50
    Identification: 0x6e9a (28314)
  > Flags: 0x00
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: UDP (17)
    Header Checksum: 0xdd90 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 10.0.20.3
    Destination Address: 62.109.209.152
User Datagram Protocol, Src Port: 52633, Dst Port: 9000
    Source Port: 52633
    Destination Port: 9000
```

```
Internet Protocol Version 4, Src: 10.0.20.3, Dst: 10.0.20.255
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 174
    Identification: 0xa62f (42543)
  > Flags: 0x00
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: UDP (17)
    Header Checksum: 0x970e [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 10.0.20.3
    Destination Address: 10.0.20.255
User Datagram Protocol, Src Port: 17500, Dst Port: 17500
    Source Port: 17500
    Destination Port: 17500
    Length: 154
    Checksum: 0x15e8 [unverified]
    [Checksum Status: Unverified]
    [Stream index: 3]
  > [Timestamps]
    UDP payload (146 bytes)
> Dropbox LAN sync Discovery Protocol
```

Access Switch Uplink pcaps

Client #1

```
v Internet Protocol Version 4, Src: 10.0.20.2, Dst: 62.109.209.152
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
    Total Length: 625
    Identification: 0xde42 (56898)
  > Flags: 0x00
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: UDP (17)
    Header Checksum: 0x6baa [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 10.0.20.2
    Destination Address: 62.109.209.152
> User Datagram Protocol, Src Port: 61534, Dst Port: 9000
```

```
v Internet Protocol Version 4, Src: 10.0.20.2, Dst: 23.41.8.48
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x48 (DSCP: AF21, ECN: Not-ECT)
    Total Length: 52
    Identification: 0x0000 (0)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: TCP (6)
    Header Checksum: 0xfd21 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 10.0.20.2
    Destination Address: 23.41.8.48
> Transmission Control Protocol, Src Port: 65273, Dst Port: 443, Seq: 1, Ack: 26, Len: 0
```

Client #2

```
Internet Protocol Version 4, Src: 10.0.20.3, Dst: 62.109.209.152
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
    Total Length: 50
    Identification: 0xaebf (44735)
  > Flags: 0x00
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: UDP (17)
    Header Checksum: 0x9d6b [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 10.0.20.3
    Destination Address: 62.109.209.152
> User Datagram Protocol, Src Port: 52633, Dst Port: 9000
```

```
Internet Protocol Version 4, Src: 62.109.209.152, Dst: 10.0.20.3
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
    Total Length: 1370
    Identification: 0x7e24 (32292)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 236
    Protocol: TCP (6)
    Header Checksum: 0xdce8 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 62.109.209.152
    Destination Address: 10.0.20.3
> Transmission Control Protocol, Src Port: 443, Dst Port: 58008, Seq: 3890, Ack: 41, Len: 1330
```

MX appliance Downlink pcaps

Client #1

```
    Type: IPv4 (0x0800)
Internet Protocol Version 4, Src: 10.0.20.2, Dst: 62.109.209.152
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
```

```
Internet Protocol Version 4, Src: 10.0.20.2, Dst: 23.41.8.48
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x48 (DSCP: AF21, ECN: Not-ECT)
```

Client #2

```
Internet Protocol Version 4, Src: 10.0.20.3, Dst: 62.109.209.152
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
```

```
Internet Protocol Version 4, Src: 10.0.20.3, Dst: 142.250.179.227
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
```

MX Appliance Uplink pcaps

```
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
    Total Length: 74
    Identification: 0x3dfc (15868)
  > Flags: 0x00
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 62
    Protocol: UDP (17)
    Header Checksum: 0x6c49 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 192.168.1.40
    Destination Address: 62.109.209.152
> User Datagram Protocol, Src Port: 52633, Dst Port: 9000
```

```
Internet Protocol Version 4, Src: 192.168.1.40, Dst: 17.188.3.12
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x48 (DSCP: AF21, ECN: Not-ECT)
    Total Length: 52
    Identification: 0x0000 (0)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 62
    Protocol: TCP (6)
    Header Checksum: 0x65e4 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 192.168.1.40
    Destination Address: 17.188.3.12
> Transmission Control Protocol, Src Port: 49494, Dst Port: 443, Seq: 518, Ack: 5193, Len: 0
```

Option 2: STP-Based Convergence without Native VLAN 1

Overview

This option is similar to the above except that the *default* VLAN 1 does not exist and the Native VLAN is replaced with another non-trivial VLAN assignment which can be considered a more preferable option for customers as it's separate from the Management VLAN. Also, a Transit VLAN has been introduced between the C9500 Core Stack and the MX WAN Edge to facilitate the separation between Management traffic (VLAN 100) and Client Traffic (Transit VLAN 192)

This design is based on consistent STP protocols running in this campus deployment, as such **Multiple Spanning Tree Protocol (MST, aka 802.1s)** will be configured since it is supported on both the Meraki and Catalyst platforms.

Tech Tip: It is recommended to run the same STP protocol across all switches (MST in this case). Running any other protocol on Catalyst (e.g. PVST) can introduce undesired behavior and can be more difficult to troubleshoot.

Tech Tip: Running PVST/PVST+ on Catalyst in this design will result in very slow STP convergence and create an inconsistent STP domain due to the fact that PVST/PVST+ backward compatible BPDUs only run in VLAN 1 **tagged** whereas Meraki switches will send 802.1D BPDUs in the Native VLAN **untagged**

You should consider this option if you need to steer away from having VLAN 1 in your Campus LAN. Here's some things to consider about this design option:

Pros:

- Flexibility in your VLAN design
- Facilitates Wireless Roaming across the whole campus
- Easier to deploy and consistent configuration across the entire Campus LAN
- Minimize the risk of VLAN hopping
- Considered more secure due to separation between Management traffic and Client traffic

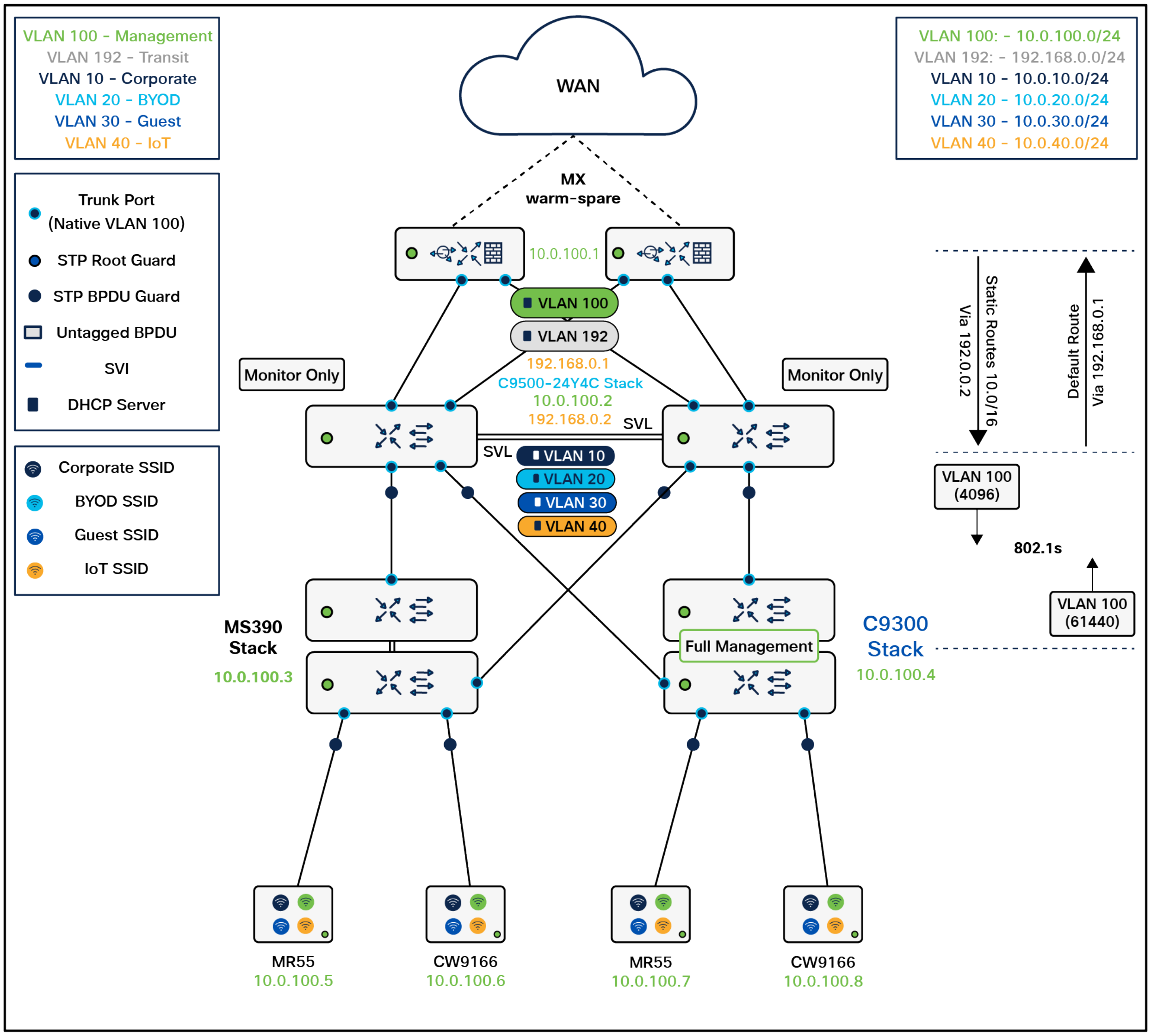
Cons:

- Non-deterministic route failover
- Slow convergence
- Different STP protocols on Cloud Managed and Cloud Monitored Catalyst Switches

Tech Tip: Since STP will be used as a loop prevention mechanism, all SVIs will be created on the collapsed core layer with the exception of the Management (aka Infrastructure VLAN) and Transit VLAN.

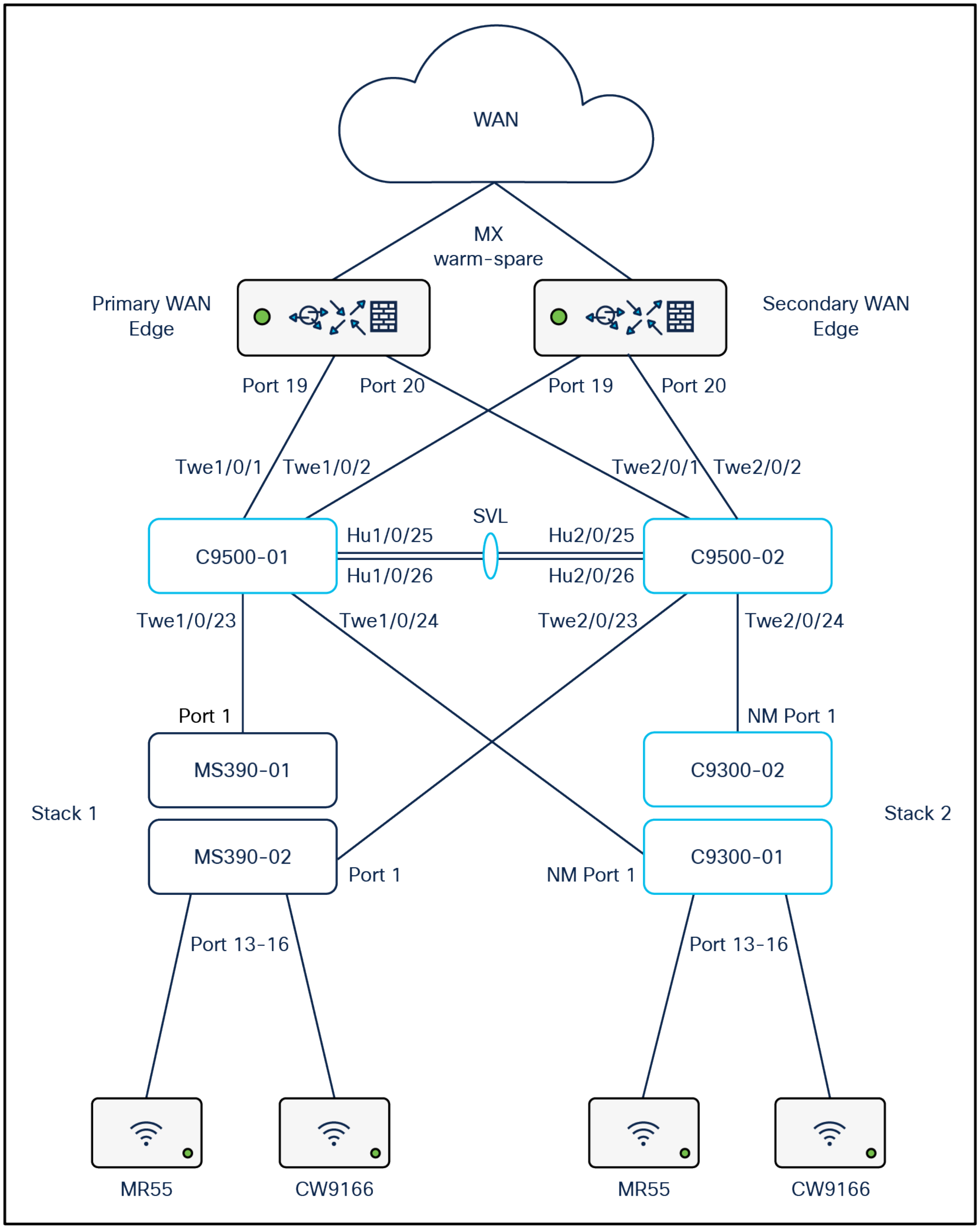
Logical Architecture

The following diagram shows the logical architecture highlighting STP convergence within a campus LAN design leveraging Cloud Managed and Cloud Monitored Catalyst platforms:

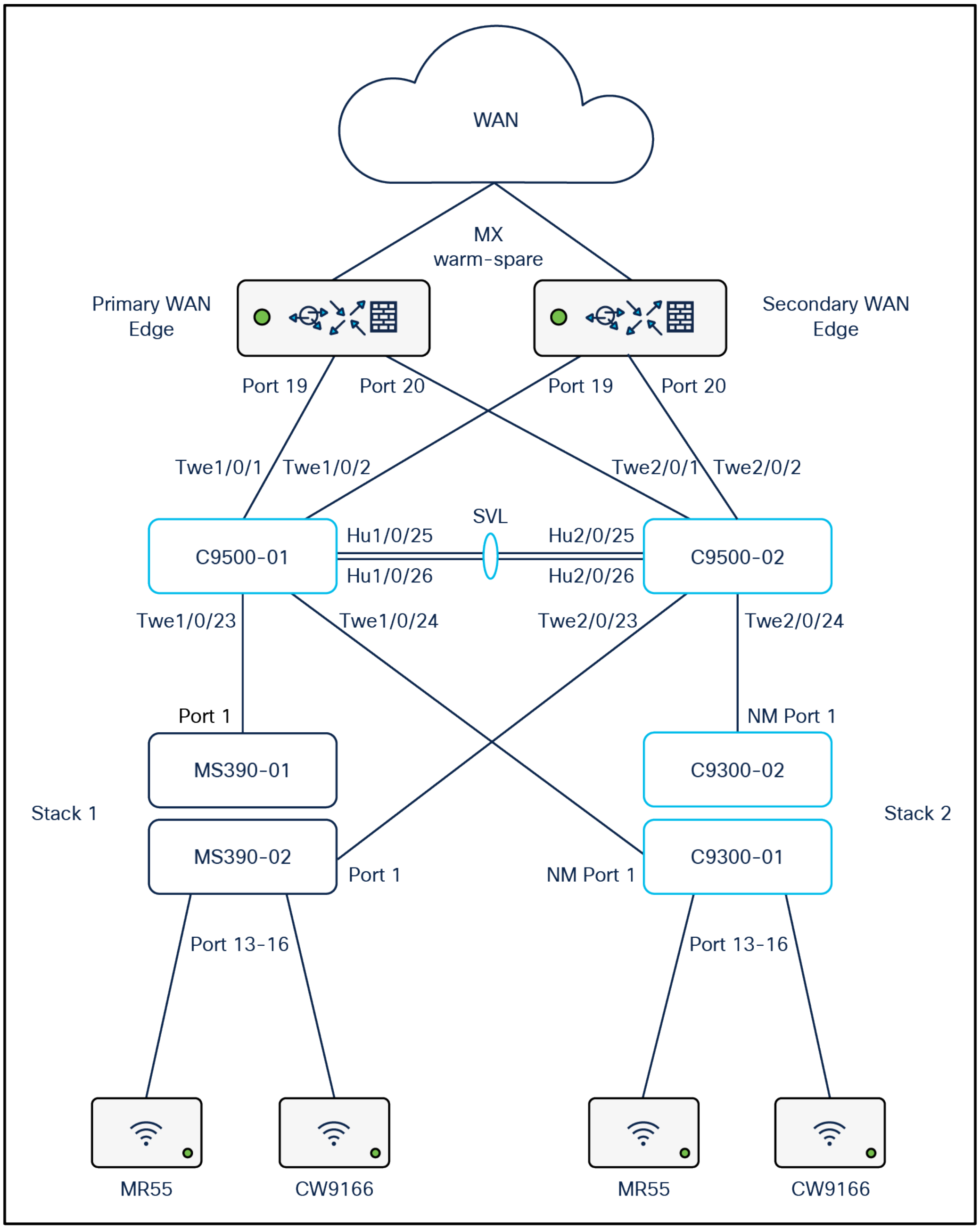


Physical Architecture

The following diagram shows the physical architecture and port list for this design:



WAN
MX
warm-spare
Primary WAN
Edge
Secondary WAN
Edge
Port 19
Port 20
Port 19
Port 20
Twe1/0/1
Twe1/0/2
Twe2/0/1
Twe2/0/2
SVL
C9500-01
Hu1/0/25
Hu1/0/26
Hu2/0/25
Hu2/0/26
C9500-02
Twe1/0/23
Twe1/0/24
Twe2/0/23
Twe2/0/24
Port 1
NM Port 1
MS390-01
C9300-02
Stack 1
Stack 2
MS390-02
Port 1
NM Port 1
C9300-01
Port 13-16
Port 13-16
MR55
CW9166
MR55
CW9166



Assumptions

The following assumptions have been considered:

- VLAN 1 should not be configured on any switchport in this Campus LAN
- It is assumed that Wireless roaming is required **everywhere** in the Campus
- It is assumed that VLANs are **spanning** across multiple zones
- **Corporate** SSID *(Broadcast in all zones*) users are assigned VLAN **10** on all APs. CoA VLAN is VLAN **30** (Via Cisco ISE)
- **BYOD** SSID (*Broadcast in all zones*) users are assigned VLAN **20** on all APs. CoA VLAN is VLAN **30** (Via Cisco ISE)

- **Guest** SSID (*Broadcast in all zones*) users are assigned VLAN **30** on all APs
- **IoT** SSID (*Broadcast in all zones*) users are assigned VLAN **40** on all APs
- Access Switches will be running in Layer 2 mode (*No SVIs or DHCP*)
- **MS390-M** Access Switches physically stacked together
- **C9300-M** Access Switches physically stacked together
- **C9500** Core Switches with Stackwise-virtual stacking using SVLs
- Access Switch uplinks are in **trunk mode** with native VLAN = VLAN 1 (Management VLAN*)
- STP root is at Distribution/Collapsed-core
- Distribution/Collapsed-core uplinks are in **Trunk mode** with Native VLAN = VLAN 1 (Management VLAN)
- All VLAN **SVIs** are hosted on the **core layer**
- Network devices will be assigned **fixed IPs** from the management VLAN DHCP pool. Default Gateway is **10.0.100.1**

Network Segments

Please check the following table for more information about the network segments (e.g. VLANs, SVIs, etc.) for this design:

Network Segment	VLAN ID	Subnet	Default Gateway	Notes
Infrastructure	100	10.0.100.0/24	10.0.100.1	SVI hosted on edge MX
Transit	192	192.168.0.0/24	192.168.0.1	SVI hosted on edge MX
Corporate Devices (Wireless and Wired)	10	10.0.10.0/24	10.0.10.1	SVI hosted on core switches
BYOD Wireless Devices	20	10.0.20.0/24	10.0.20.1	SVI hosted on core switches
Guest Wireless Devices	30	10.0.30.0/24	10.0.30.1	SVI hosted on core switches
IoT Wireless Devices	40	10.0.40.0/24	10.0.40.1	SVI hosted on core switches

Tech Tip: Please size your subnets based on your own requirements. The above table is for illustration purposes only

Tech Tip: In this example, the Infrastructure VLAN has been created on the Edge MX. Alternatively, you can create the SVI on the C9500 Core Stack

Quality of Service

Application	MR	Access Switches	Core Switches
SIP (Voice)	EF DSCP 46 AC_Vo	Trust incoming values DSCP 46 CoS 5	Trust incoming values
Webex and Skype	AF41 DSCP 34 AC_VI	Trust incoming values DSCP 34 CoS 4	Trust incoming values
All Video and Music	AF21 DSCP 18 AC_BE	Trust incoming values DSCP 18 CoS 2	Trust incoming values
Software Updates	AF11 DSCP 10 AC_BK	Trust incoming values DSCP 10 CoS 1	Trust incoming values

Tech Tip:

Please note that the above table is for illustration purposes only. Please configure QoS based on your network requirements. Refer to the following articles for more information on traffic shaping and QoS settings on Meraki devices:

SD-WAN and traffic shaping

MS QoS and traffic shaping

MR traffic shaping rules

Device list

Device	Name	Management IP address	Notes
MX250 **MX250**	Primary WAN Edge Spare WAN Edge	10.0.100.1	warm-spare
C9500-24YCY **C9500-24YCY**	C9500-01 C9500-02	10.0.100.2	Stackwise Virtual (C9500-Core-Stack)
MS390-24P **MS390-24P**	MS390-01 MS390-02	10.0.100.3	Physical Stacking (Stack1-MS390)
C9300-24P **C9300-24P**	C9300-01 C9300-02	100.100.4	Physical Stacking (Stack2-C9300)

Device	Name	Management IP address	Notes
MR55	AP1_Zone1	10.0.100.5	Tag = Zone1
C9166 (eq MR57)	AP2_Zone1	10.0.100.6	Tag = Zone1
MR55	AP3_Zone2	10.0.100.7	Tag = Zone2
C9166 (eq MR57)	AP4_Zone2	10.0.100.8	Tag = Zone2

Access policies

Access Policy Name	Purpose	Configuration	Notes
Wired-1x	802.1x Authentication via Cisco ISE for wired clients that support 802.1x	Authentication method = my Radius server Radius CoA = enabled Host mode = Single-Host Access Policy type = 802.1x Guest VLAN = 30 Failed Auth VLAN = 30 Critical Auth VLAN = 30 Suspend Port Bounce = Enabled Voice Clients = Bypass authentication Walled Garden = enabled	Cisco ISE authentication and posture checks
Wired-MAB	MAB Authentication via Cisco ISE for wired clients that do not support 802.1x	Authentication method = my Radius server Radius CoA = disabled Host mode = Single-Host Access Policy type = MAC authentication bypass Guest VLAN = 30 Failed Auth VLAN = 30 Critical Auth VLAN = 30 Suspect Port Bounce = Enabled Voice Clients = Bypass authentication Walled Garden = disabled	Cisco ISE authentication

Port list

Device name	Port	Far-end	Port details	Notes
Primary WAN Edge / Spare WAN Edge	1	WAN1		VIP1

Device name	Port	Far-end	Port details	Notes
Primary WAN Edge / Spare WAN Edge	2	WAN2		VIP2
Primary WAN Edge	19	9500-01 (PortTwe1/0/1)	Trunk (Native VLAN 100) Allowed VLANs 100, 192	Downlink
	20	9500-02 (PortTwe2/0/1)	Trunk (Native VLAN 100) Allowed VLANs 100, 192	Downlink
Spare WAN Edge	19	9500-01 (Port Twe1/0/2)	Trunk (Native VLAN 100) Allowed VLANs 100, 192	Downlink
	20	9500-02 (Port Twe2/0/2)	Trunk (Native VLAN 100) Allowed VLANs 100, 192	Downlink
9500-01	Twe1/0/1	Primary WAN Edge (Port 19)	switchport mode trunk switchport trunk native vlan 100 switchport trunk allowed vlan 100,192	Uplink
	Twe1/0/2	Spare WAN Edge (Port 19)	switchport mode trunk switchport trunk native vlan 100 switchport trunk allowed vlan 100,192	Uplink
9500-02	Twe2/0/1	Primary WAN Edge (Port 20)	switchport mode trunk switchport trunk native vlan 100 switchport trunk allowed vlan 100,192	Uplink
	Twe2/0/2	Spare WAN Edge (Port 20)	switchport mode trunk switchport trunk native vlan 100 switchport trunk allowed vlan 100,192	Uplink

Device name	Port	Far-end	Port details	Notes
9500-01	Twe1/0/23	MS390-01 (Port 1)	switchport mode trunk switchport trunk native vlan 100 switchport trunk allowed vlans 10,20,30,40, 100 channel-group 1 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	Downlink
	Twe1/0/24	C9300-01 (Port 1)	switchport mode trunk switchport trunk native vlan 100 switchport trunk allowed vlans 10,20,30,40,100 channel-group 2 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	Downlink
9500-02	Twe2/0/23	MS390-02 (Port 1)	switchport mode trunk switchport trunk native vlan 100 switchport trunk allowed vlans 10,20,30,40,100 channel-group 1 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	Downlink
	Twe2/0/24	C9300-02 (Port 1)	switchport mode trunk switchport trunk native vlan 100 switchport trunk allowed vlans 10,20,30,40,100 channel-group 2 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	Downlink

Device name	Port	Far-end	Port details	Notes
9500-01	Hu1/0/25	C9500-02 (Port Hu2/0/26)	stackwise-virtual link 1	Stackwise Virtual
	Hu1/0/26	C9500-02 (Port Hu2/0/25)	stackwise-virtual link 1	Stackwise Virtual
9500-02	Hu2/0/25	C9500-01 (PortHu1/0/26)	stackwise-virtual link 1	Stackwise Virtual
	Hu2/0/26	C9500-01 (PortHu1/0/25)	stackwise-virtual link 1	Stackwise Virtual
MS390-01 **MS390-02** **C9300-01** **C9300-02**	5-8	Wired Clients	Access (Data VLAN 10) Access Policy = Wired-1x PoE Enabled STP BPDU Guard Tag = Wired Clients 802.1x AdP: Corp	For wired clients supporting 802.1x
MS390-01 **MS390-02** **C9300-01** **C9300-02**	9-12	Wired Clients	Access (Data VLAN 10) Access Policy = MAB PoE Enabled STP BPDU Guard Tag = Wired Clients MAB AdP: Corp	For wired clients that do not support 802.1x
MS390-01 **MS390-02** **C9300-01** **C9300-02**	13-16	MR	Trunk (Native VLAN 100) PoE Enabled STP BPDU Guard Tag = MR WLAN Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 10,20,30,40,100
MS390-01	1	9500-01 (Port Twe1/0/23)	Trunk (Native VLAN 100) PoE Disabled Name: Core 1 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 10,20,30,40,100
MS390-02	1	9500-02 (Port Twe2/0/23)	Trunk (Native VLAN 100) PoE Disabled Name: Core 2 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 10,20,30,40,100

Device name	Port	Far-end	Port details	Notes
C9300-01	C9300-01 / C9300-NM-8X / 1	9500-01 (Port Twe1/0/24)	Trunk (Native VLAN 100) PoE Disabled Name: Core 1 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 10,20,30,40,100
C9300-02	C9300-02 / C9300-NM-8X / 1	C9500-02 (Port Twe2/0/24)	Trunk (Native VLAN 100) PoE Disabled Name: Core 2 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 10,20,30,40,100

Wireless SSID list

SSID Name	Broadcast	Configuration	Notes	Firewall and Traffic Shaping
Acme Corp	All APs	Association = Enterprise with my Radius server Encryption = WPA2 only Splash Page = Cisco ISE Radius CoA = Enabled SSID mode = Bridge mode VLAN Tagging = 10 (ISE Override) AdP Group = 10:Corp Radius override = Enabled Mandatory DHCP = Enabled Layer 2 isolation = Disabled Allow Clients access LAN = Allow Traffic Shaping = Enabled with default settings	Cisco ISE Authentication and posture checks (172.31.16.32/1812)	Layer 2 Isolation = Disabled Allow Access to LAN = Enabled Per-Client Bandwidth Limit = 50Mbps Per-SSID Bandwidth Limit = Unlimited Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34) All Video and Music - AF21 (DSCP 18)

SSID Name	Broadcast	Configuration	Notes	Firewall and Traffic Shaping
Acme BYOD	All APs	Association = Enterprise with my Radius server Encryption = WPA2 only 802.11w = Enabled Splash Page = Cisco ISE SSID mode = Bridge mode VLAN Tagging = 20 AdP Group = 20:BYOD Radius override = Disabled Mandatory DHCP = Enabled Layer 2 isolation = Disabled Allow Clients access LAN = Allow Traffic Shaping = Enabled with default settings	Cisco ISE Authentication (via Azure AD) and posture checks. Dynamic GP assignment (Radius attribute = Airospace-ACLNAME)	Layer 2 Isolation = Disabled Allow Access to LAN = Enabled Per-Client Bandwidth Limit = 50Mbps Per-SSID Bandwidth Limit = Unlimited Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34) All Video and Music - AF21 (DSCP 18)
Guest	All APs	Association = Enterprise with my Radius server Encryption = WPA1 and WPA2 802.11w = Enabled Splash Page = Click-Through SSID mode = Bridge mode VLAN Tagging = 30 AdP Group = 30:Guest Radius override = Disabled Mandatory DHCP = Enabled Layer 2 isolation = Enabled Allow Clients access LAN = Deny Per SSID limit = 100Mbps Traffic Shaping = Enabled with default settings	Meraki Authentication	Layer 2 Isolation = Enabled Allow Access to LAN = Disabled Per-Client Bandwidth Limit = 5Mbps Per-SSID Bandwidth Limit = 100Mbps Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34) All Video and Music - AF21 (DSCP 18)

SSID Name	Broadcast	Configuration	Notes	Firewall and Traffic Shaping
Acme IoT	All APs	Association = identity PSK with Radius Encryption = WPA1 and WPA2 802.11r = Disabled 802.11w = Disabled Splash Page = None Radius CoA = Disabled SSID mode = Bridge mode VLAN Tagging = 40 AdP Group = 40:IoT Radius override = Disabled Mandatory DHCP = Enabled Allow Clients access LAN = Deny Per SSID limit = 10Mbps Traffic Shaping = Enabled with default settings	Cisco ISE is queried at association time to obtain a passphrase for a device based on its MAC address. Dynamic GP assignment (Radius attribute Filter-Id)	Layer 2 Isolation = Disabled Allow Access to LAN = Enabled Per-Client Bandwidth Limit = 5Mbps Per-SSID Bandwidth Limit = Unlimited Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34) All Video and Music - AF21 (DSCP 18)

Tech Tips:

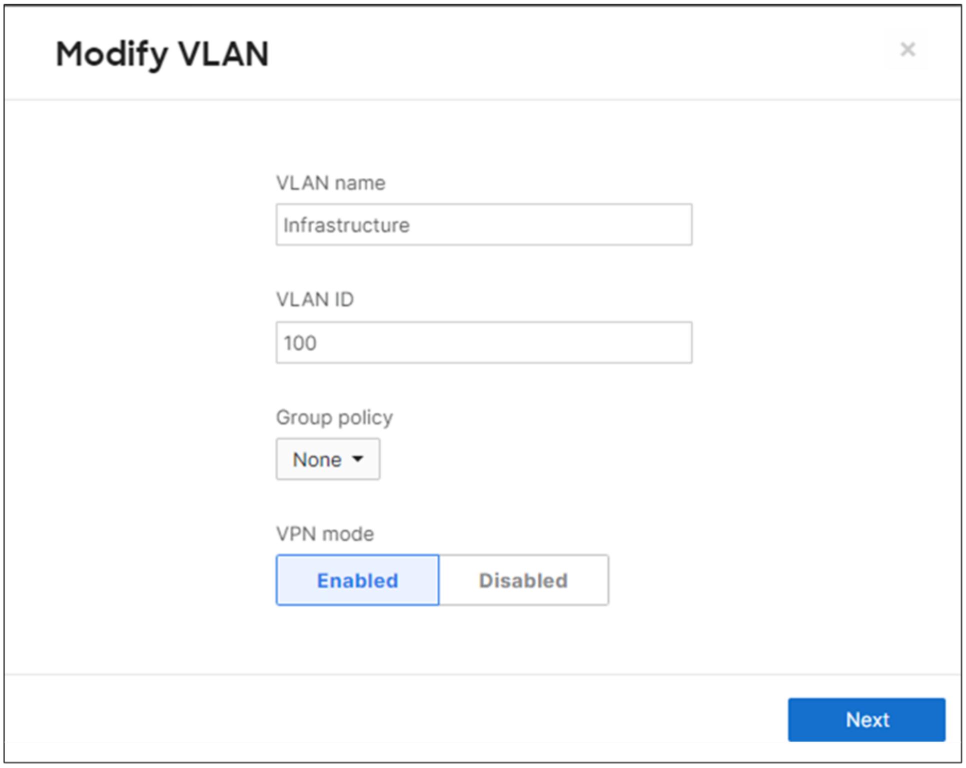
- The above configuration is for illustration purposes only. Please configure your SSIDs based on your own requirements (mode, IP assignment, etc.)
- Please note that Adaptive Policy on MR requires MR-ADV license. For more information about the requirements, please refer to this document.

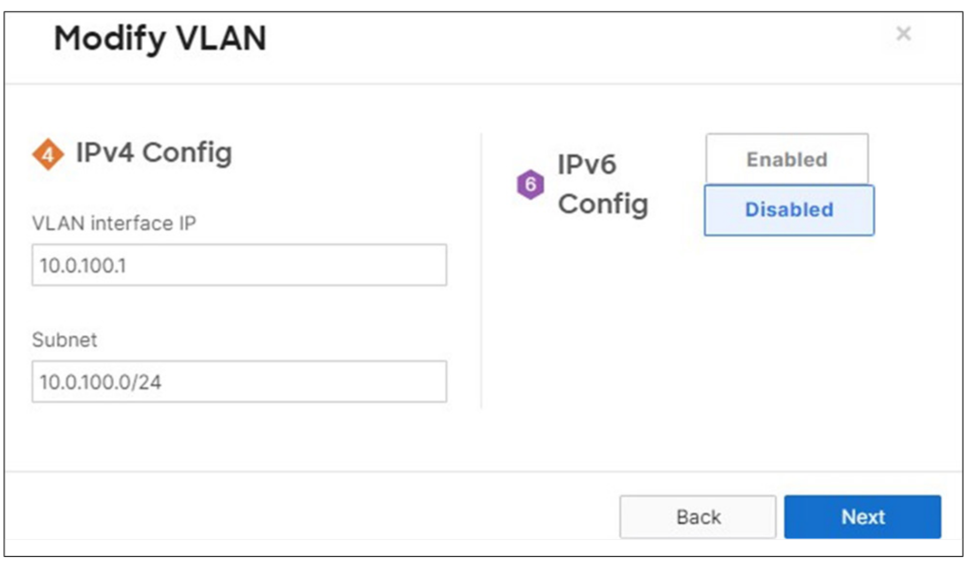
Configuration and implementation guidelines

The following section will take you through the steps to amend your design by removing VLAN 1 and creating the desired new Native VLAN (e.g. VLAN 100) across your Campus LAN. The steps below should **not** be followed in isolation as first you have to complete the configuration of your Campus LAN based on the above previous section. The below steps are meant to replace VLAN 1 in your Campus LAN with a new one.

Tech Tip: It is vital to follow the below steps in chronological order. This is to avoid loss of connectivity to downstream devices and consequently the requirement to do a factory reset. This will result in traffic interruption. It is therefore recommended to do this in a maintenance window where applicable.

1. Login to your dashboard account
2. **MX Addressing and VLANs**; Navigate to **Security and SD-WAN > Configure > Addressing and VLANs**, then click on **VLANs** then click on **Add VLAN** to add your new infrastructure and Transit VLANs then click on **Create.** Please do **not** delete the existing VLAN 1 yet. Then, click on **Save** at the bottom of the page.





Subnets

Search by VLAN name, MX IP | Delete | Add VLAN

ID ▲	VLAN name	Version	Config	VLAN interface IP	Uplink	Group policy	VPN mode
1	Management	4	Manual	10.0.1.1/24	Any	None	Enabled
		6	Disabled	--	Any		
100	Infrastructure	4	Manual	10.0.100.1/24	Any	None	Enabled
		6	Disabled	--	Any		
192	Transit	4	Manual	192.168.0.1/24	Any	None	Disabled
		6	Disabled	--	Any		

3 results

- *As seen above, VLAN 1 needs to be kept at this stage to avoid losing connectivity to all downstream devices*.

3. **MX Addressing and VLANs:** Navigate to **Security and SD-WAN > Configure > DHCP**, then under VLAN 100 **AND** 192 click on **Fixed IP assignments** and add entries for your network devices. (Tip: You can copy the MAC addresses from VLAN 1 and make sure to add the correct IP assignment to them). Then, click on **Save** at the bottom of the page.

Fixed IP assignments

Client name	MAC address	LAN IP	Actions
9500-Core-Stack	b0:c5:3c:60:fc:3f	10.0.100.2	X
MS390-Access-Stack1	2c:3f:0b:04:7e:80	10.0.100.3	X
C9300-Access-Stack2	4c:e1:75:b0:ba:00	10.0.100.4	X
AP1_Zone1	68:3a:1e:54:0d:48	10.0.100.5	X
AP3_Zone2	cc:9c:3e:ec:26:b0	10.0.100.6	X
TFTP Server	8c:ae:4c:dd:15:19	10.0.100.7	X

Add a fixed IP assignment
Import CSV

Fixed IP assignments

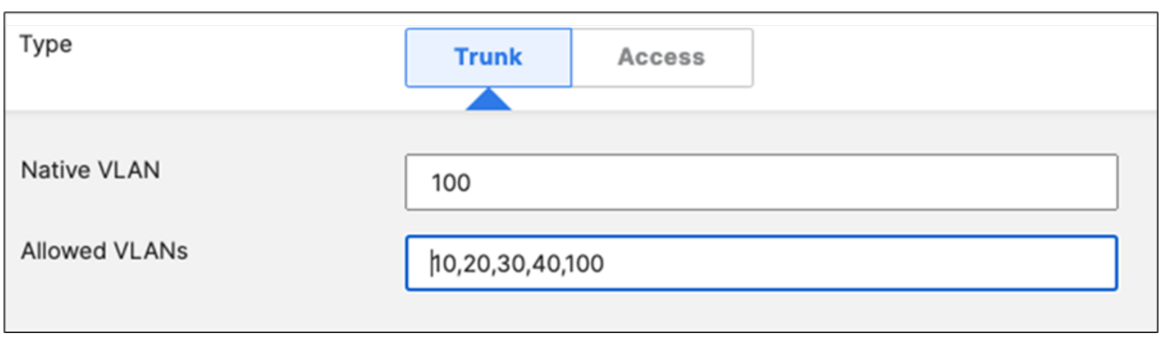
Client name	MAC address	LAN IP	Actions
9500-Core-Stack	b0:c5:3c:60:fc:3f	192.168.0.2	X

Add a fixed IP assignment
Import CSV

4. Create VLAN **100** and **192** on your C9500 Core Stack

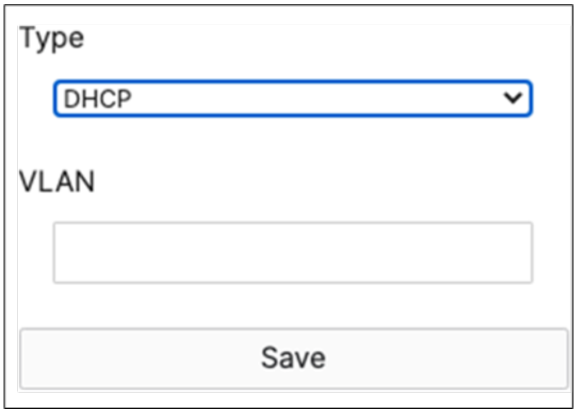
```
Switch>en
Switch#conf t
Enter configuration commands, one per line. End with CNTL/Z.
9500-02(config)#interface vlan 100
9500-02(config-if)#ip address dhcp
9500-02(config-if)#no shut
9500-02(config)#interface vlan 192
9500-02(config-if)#ip address dhcp
9500-02(config-if)#no shut
9500-02(config)#vlan 100
9500-02(config-if)#no shut
9500-02(config)#vlan 192
9500-02(config-if)#no shut
9500-02(config-if)#end
9500-02#wr mem
Building configuration...
[OK]
```

5. Navigate to **Switching > Configure > Switch ports** and filter for **MR** (if you have tagged the ports accordingly, otherwise select your downlink ports manually), then change the Native VLAN on these switchports from Native VLAN **1** to Native VLAN **100.** Also, please add VLAN **100** to the list of Allowed VLANs and remove VLAN 1 from the allowed list of VLANs. Then, click on **Save** at the bottom of the page.



- Please note that this will cause disruption to client traffic

6. Navigate to **Switching > Monitor > Switches** and click on the first master switch then change the IP address settings from Static to DHCP and please leave the VLAN field **blank**. (**DO NOT** add VLAN 100 at this stage). Then, click on **Save** at the bottom of the window. Please repeat this for **all** master switches in your network.

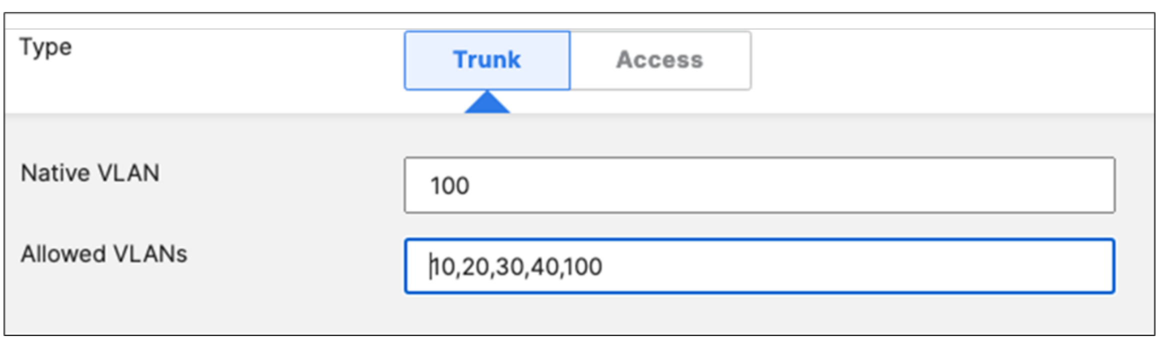


- As seen from the above screen shot, the VLAN value has been kept **empty** at this stage

7. On your C9500 Core Stack, add an MST instance in VLAN **100** and VLAN **192**

```
9500-01(config)#spanning-tree mst configuration
9500-01(config-mst)#instance 0 vlan 100
9500-01(config-mst)#instance 0 vlan 192
9500-01(config-mst)#name region1
9500-01(config-mst)#revision 1
9500-01(config-mst)#exit
9500-01(config)#spanning-tree mode mst
9500-01(config)#spanning-tree mst 0 priority 4096
9500-01(config)#exit
9500-01#wr mem
Building configuration... [OK]
9500-01#
```

8. Navigate to **Switching > Monitor > Switch ports** and filter for **uplink** (if you have tagged the ports accordingly, otherwise select your uplink ports manually), then change the Native VLAN on these switchports from Native VLAN **1** to Native VLAN **100.** Also, please add VLAN **100** to the list of Allowed VLANs and remove VLAN **1** from the allowed list of VLANs. Then, click on **Save** at the bottom of the page.



- Please note that this will cause the Access Stacks to go **offline** on the Meraki dashboard

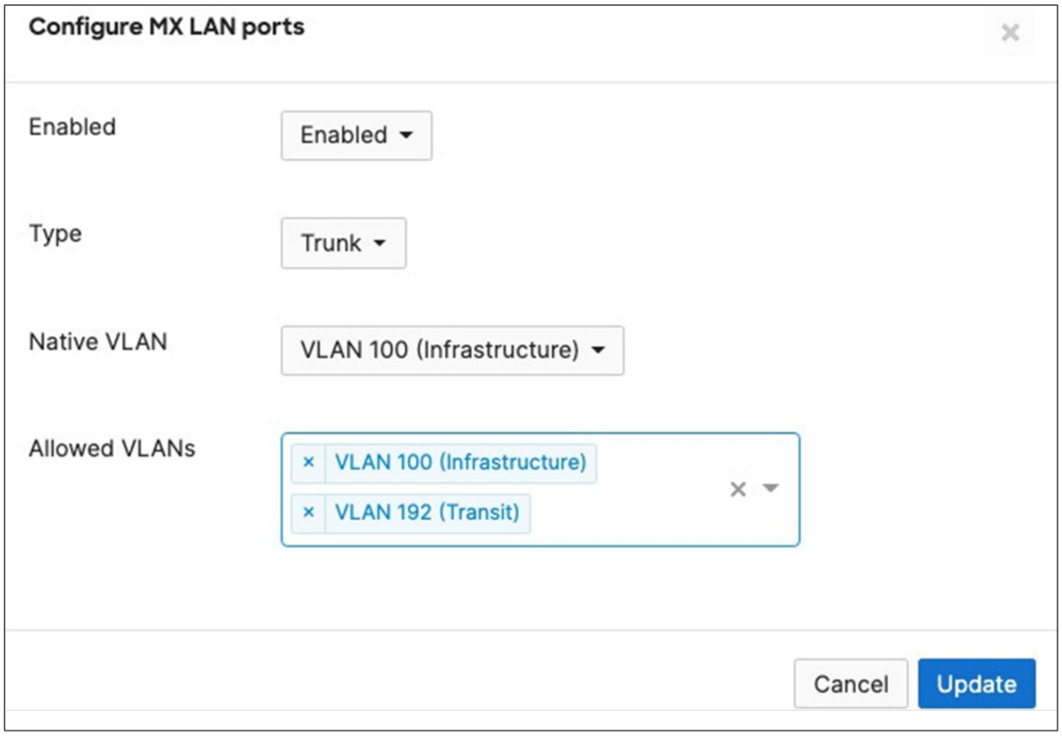
9. On your C9500 Core Stack, change the Native VLAN on your downlink Port-channels to VLAN **100**

```
9500-01(config)#interface po1
9500-01(config-if)#switchport trunk allowed vlan 10,20,30,40,100
9500-01(config-if)#switchport trunk native vlan 100
9500-01(config-if)#interface po2
9500-01(config-if)#switchport trunk allowed vlan 10,20,30,40,100
9500-01(config-if)#switchport trunk native vlan 100
9500-01(config)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

10. Shutdown all uplinks from C9500 Core Stack to Port 19 and 20 on your **Secondary WAN** Edge appliance to avoid having a dual-active situation.

```
9500-01(config)#interface twe1/0/24
9500-01(config-if)#shutdown
9500-01(config-if)#interface twe2/0/24
9500-01(config-if)#shutdown
9500-01(config)#end
9500-01#
```

11. **MX Addressing and VLANs**: Navigate to **Security and SD-WAN > Configure > Addressing and VLANs**, then under Per-port settings, change the Native VLAN on your downlinks to VLAN **100** and allow both VLAN **100** and **192.**



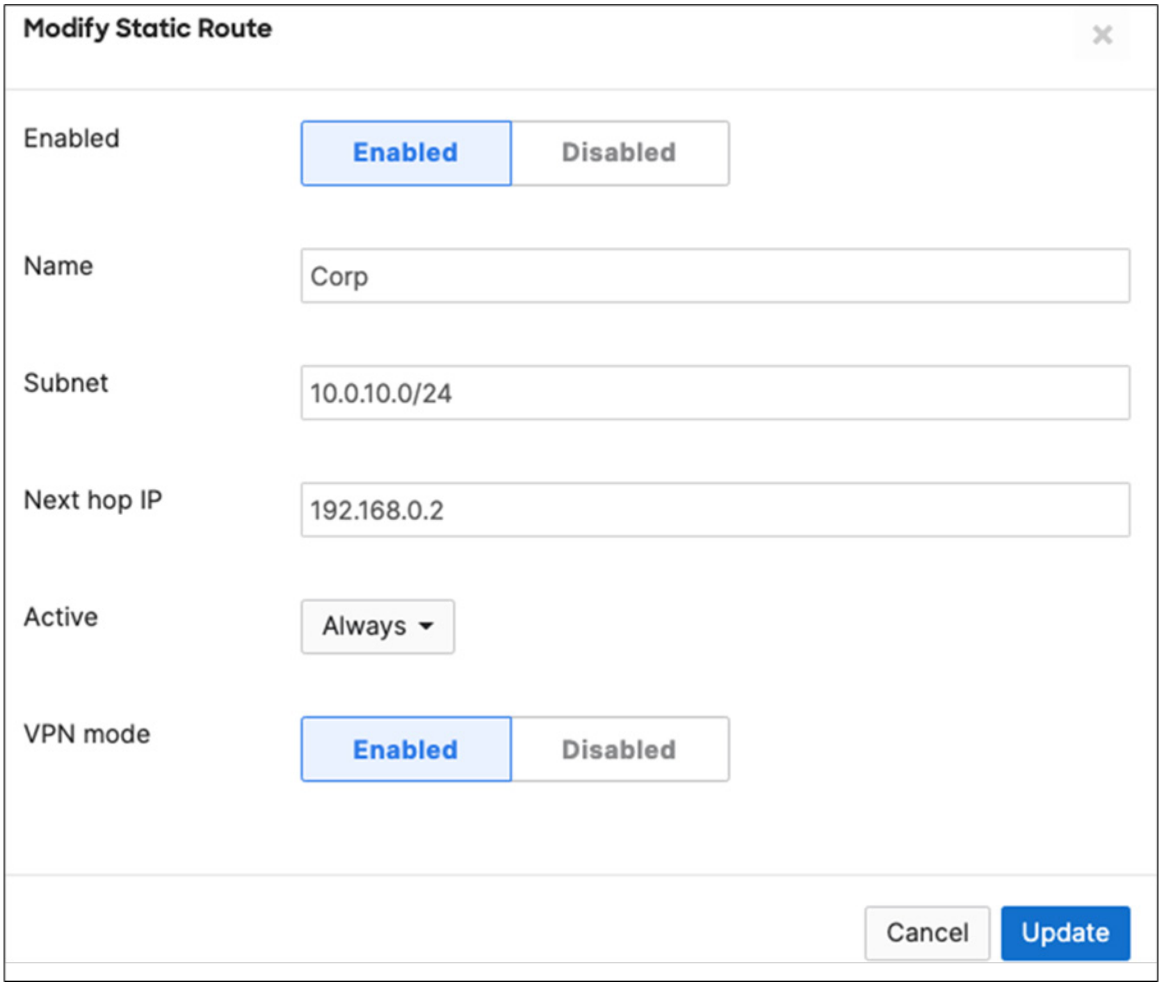
12. On your C9500 Core Stack, change the Native VLAN on your uplink to VLAN **100** and allow VLANs **100** and **192** (Please note that you will need to connect to your C9500 Core Stack via console access since VLAN 1 does not exist anymore on the upstream device which is the MX WAN Edge in this case):

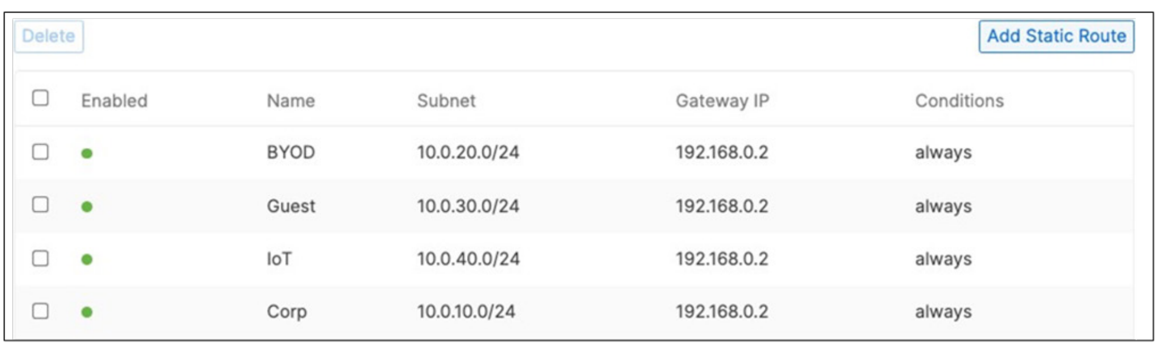
```
9500-01(config)#define interface-range uplinks TwentyFiveGigE1/0/1-2 ,
TwentyFiveGigE2/0/1-2
9500-01(config)#interface range macro uplinks
9500-01(config-if)#switchport mode trunk
9500-01(config-if)#switchport trunk allowed vlan 100,192
9500-01(config-if)#switchport trunk native vlan 100
9500-01(config)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

13. On your C9500 Core Stack, create a default route for your SVI interfaces:

```
9500-01(config)#ip route 0.0.0.0 0.0.0.0 192.168.0.1
9500-01(config)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

14. Adjust your Static Routes on the MX to point to the transit VLAN instead of VLAN 1. Navigate to **Security and SD-WAN > Configure > Addressing and VLANs** and under Static routes click on a static route to change the next-hop. Please repeat that for all your static routes. Then, click on **Save** at the bottom of the page:

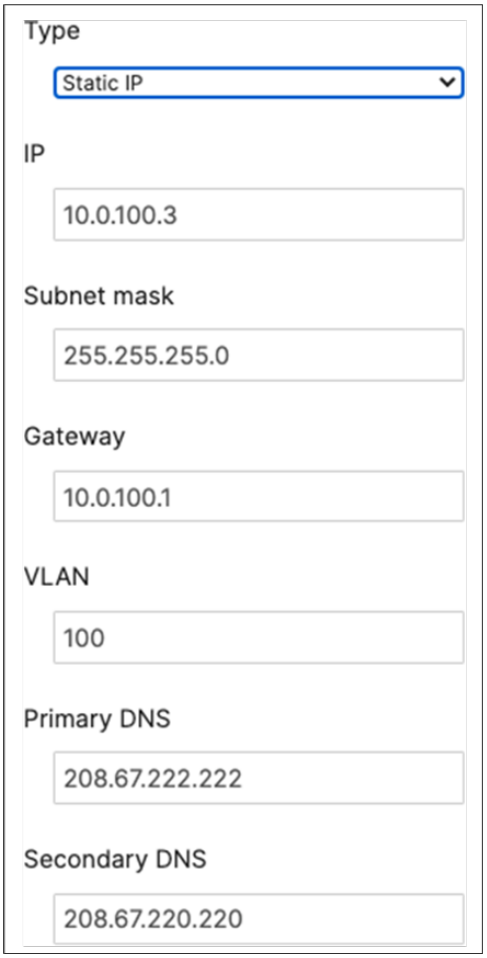




15. Wait for your Access Switches to come back online and acquire an IP address in the new Native VLAN 100. Then, proceed to the next step.

16. Now your switches should have acquired an IP address per the fixed IP assignment configuration. Navigate to **Switching > Monitor > Switches** then click on the first master switch and then change the

IP address settings to static. Then, click on **Save** at the bottom of the window. Repeat this for all master switches in your network.



- Please repeat the above step for **all** stacks in your network

17. Navigate to your Primary WAN Edge device and ping 10.0.100.2 to make sure that it is reachable via VLAN 100. Then proceed to the next step.

18. Unshut the uplinks on your C9500 Core Stack to the **Secondary WAN Edge** appliance:

```
9500-01(config)#interface twe1/0/24
9500-01(config-if)#no shutdown
9500-01(config-if)#interface twe2/0/24
9500-01(config-if)#no shutdown
9500-01(config)#end
9500-01#
```

19. Verify that all your devices have come back online and acquired an IP address in the new Management VLAN. Navigate to **Organization > Monitor > Overview** then click on the devices tab:

	Model	Name	Network	Uplink IP (Port 1) ▲	MAC address
	MT10	Lobby	Campus		a8:46:9d:76:01:ec
	MT10	Server Room	Campus		a8:46:9d:76:02:e4
	MS390-24	MS390-02	Campus	10.0.100.3	2c:3f:0b:0f:ec:00
	MS390-24U	MS390-01	Campus	10.0.100.3	2c:3f:0b:04:7e:80
	MS390-24	C9300-02	Campus	10.0.100.4	4c:e1:75:b0:ba:00
	MS390-24	C9300-01	Campus	10.0.100.4	a4:b4:39:5f:2a:80
	MR55	AP3_Zone2	Campus	10.0.100.5	68:3a:1e:54:0d:48
	MR57	AP2_Zone1	Campus	10.0.100.6	cc:9c:3e:ec:26:b0
	VMX-M	vMX-AWS-A	AWS-Primary	172.31.16.239	cc:03:d9:01:af:56
	VMX-M	vMX-AWS-B	AWS-Secondary	172.31.16.240	cc:03:d9:01:68:cd
	MX250	Primary WAN Edge	Campus	192.168.1.40	98:18:88:ff:f6:d3
	MX250	Secondary WAN Edge	Campus	192.168.1.45	f8:9e:28:40:10:fd

12 total

20. Navigate to **Switching > Configure > Switch settings** then change the Management VLAN configuration to VLAN 100. Then, click on **Save** at the bottom of the page.

VLAN configuration

Management VLAN: 100

21. Delete VLAN 1 from your MX appliance. Navigate to **Security and SD-WAN > Configure > Addressing and VLANs** and select the old Management VLAN 1 and then click on **Delete.** Then, click on **Save** at the bottom of the page.

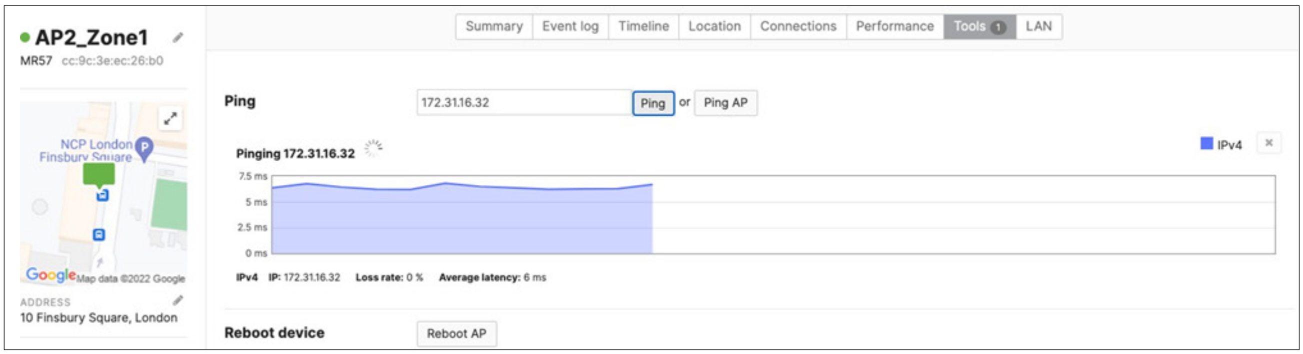
LAN setting: VLANs | Single LAN

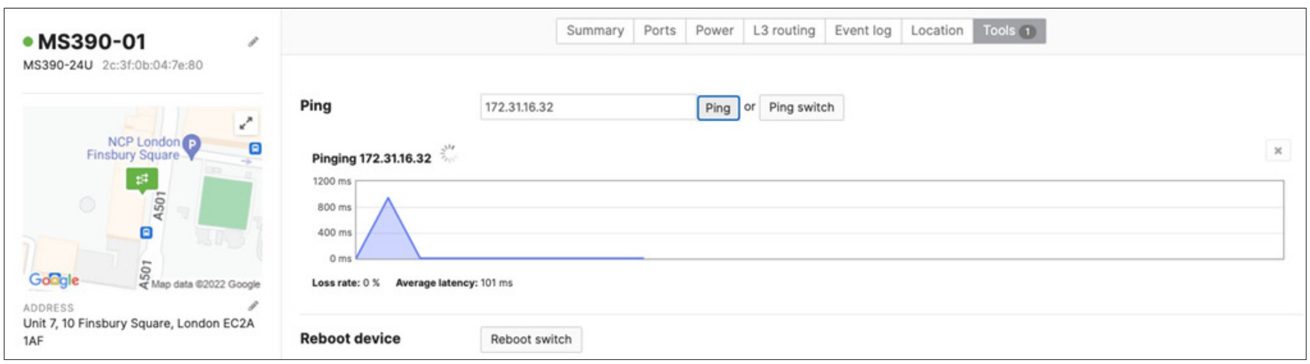
Subnets: Search by VLAN name, MX IP — Delete — Add VLAN

	ID ▲	VLAN name	Version	Config	VLAN interface IP	Uplink	Group policy	VPN mode
☐	100	Infrastructure	4	Manual	10.0.100.1/24	Any	None	Enabled
			6	Disabled	--	Any		
☐	192	Transit	4	Manual	192.168.0.1/24	Any	None	Disabled
			6	Disabled	--	Any		

2 results

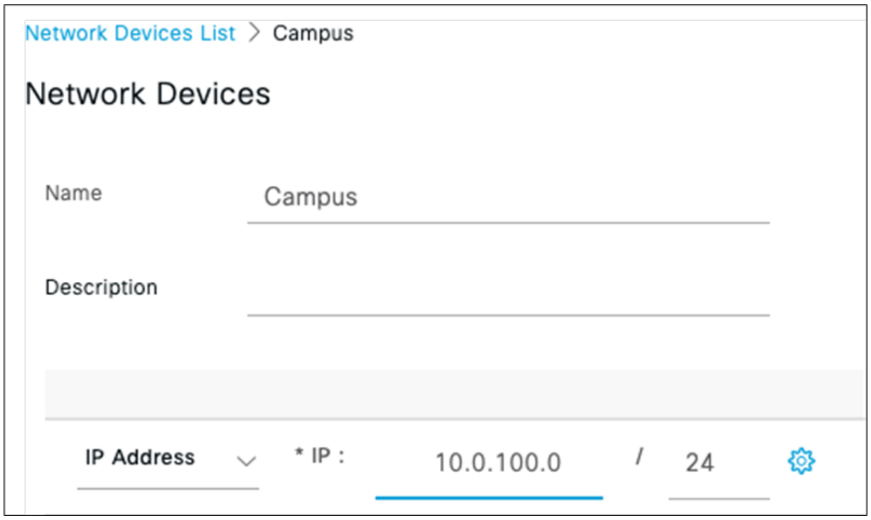
22. *Where applicable* - Please remember to adjust any routing between your Campus LAN and remote servers (e.g. Cisco ISE for 802.1x auth) as in this case devices will use the new Management VLAN 100 as the source of Radius requests. To verify that you have connectivity to your remote servers, Navigate to **Wireless > Monitor > Access points** then click on any AP and from the Tools section ping your remote server. Repeat this process from one of your switches.





- With the current scope of the design, Cisco ISE resides in AWS and is reachable via AutoVPN which terminates on the vMX in AWS as well. As such, it was required to add a route on the VPC to 10.0.100.0/24 pointing to the vMX
- Also, please ensure that the new Management VLAN has been enabled with AutoVPN by navigating to **Security and SD-WAN > Configure > Site-to-site VPN** and ensure that VLAN 100 is enabled.

23. *Where applicable* - Please remember to adjust your Radius server configuration (e.g. Cisco ISE) as the Network devices now are grouped in a new Management VLAN 100. Please see the below example for Cisco ISE:



Option 3: Layer 3 Access

Overview

This option assumes that your OSPF domain is extended all the way to your core layer and thus there is no need to rely on STP between your Access and Core for convergence (as long as there are separate broadcast domains between Access and Core). It offers fast convergence since it relies on ECMP rather than STP layer 2 paths. However, it doesn't offer great flexibility in your VLAN design as each VLAN cannot span between multiple stacks/closets.

Pros:

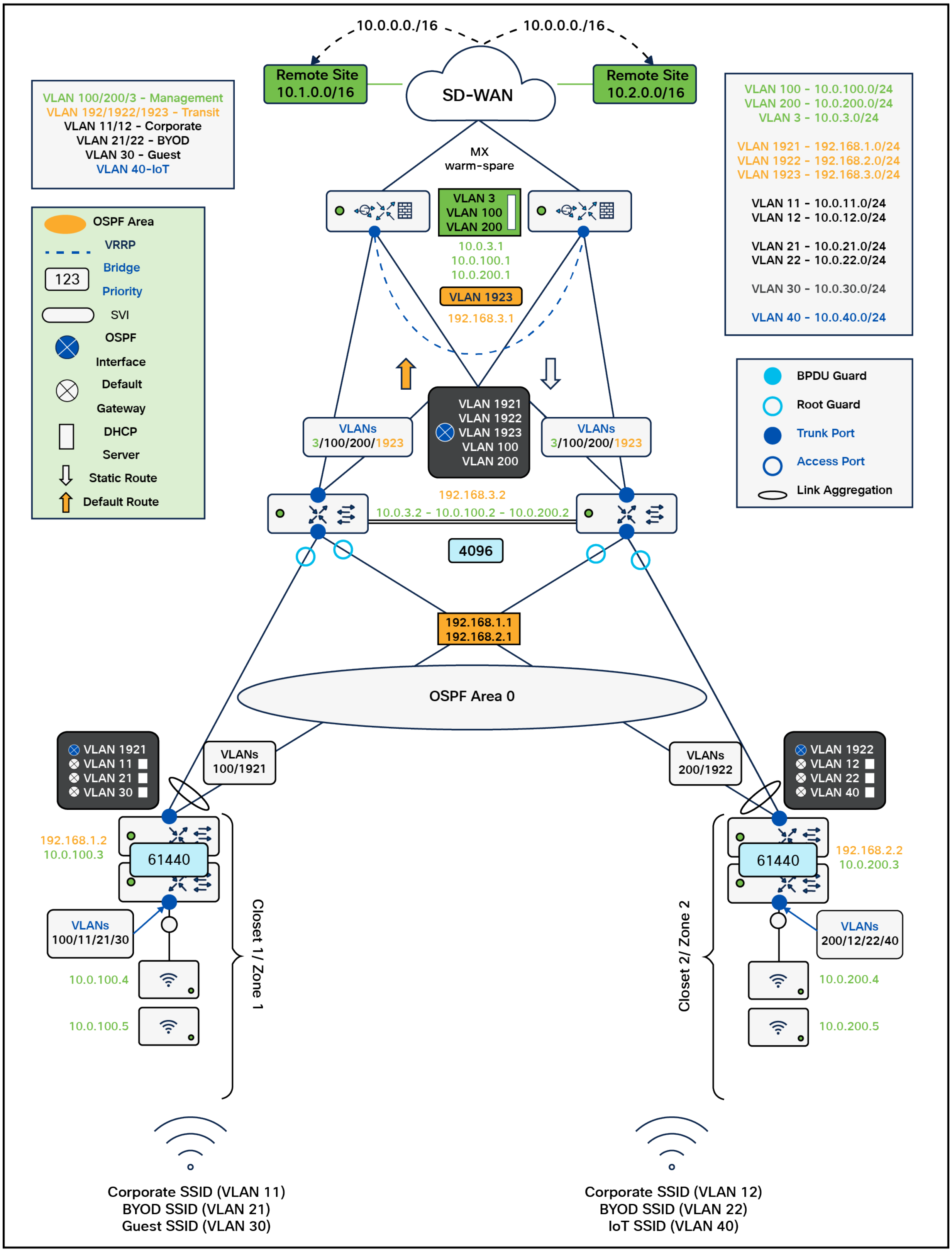
- Deterministic route failover
- Fast convergence
- Relies on either stacking or gateway redundancy at upper layers
- Complete end to end separation between Management traffic and Client traffic

Cons:

- VLANs cannot span multiple stacks/closets
- Your backbone area size can be unmanageable
- Forces Layer 3 roaming across the Campus LAN
- Additional VLANs needed to route traffic between Campus LAN layers (aka Transit VLAN)

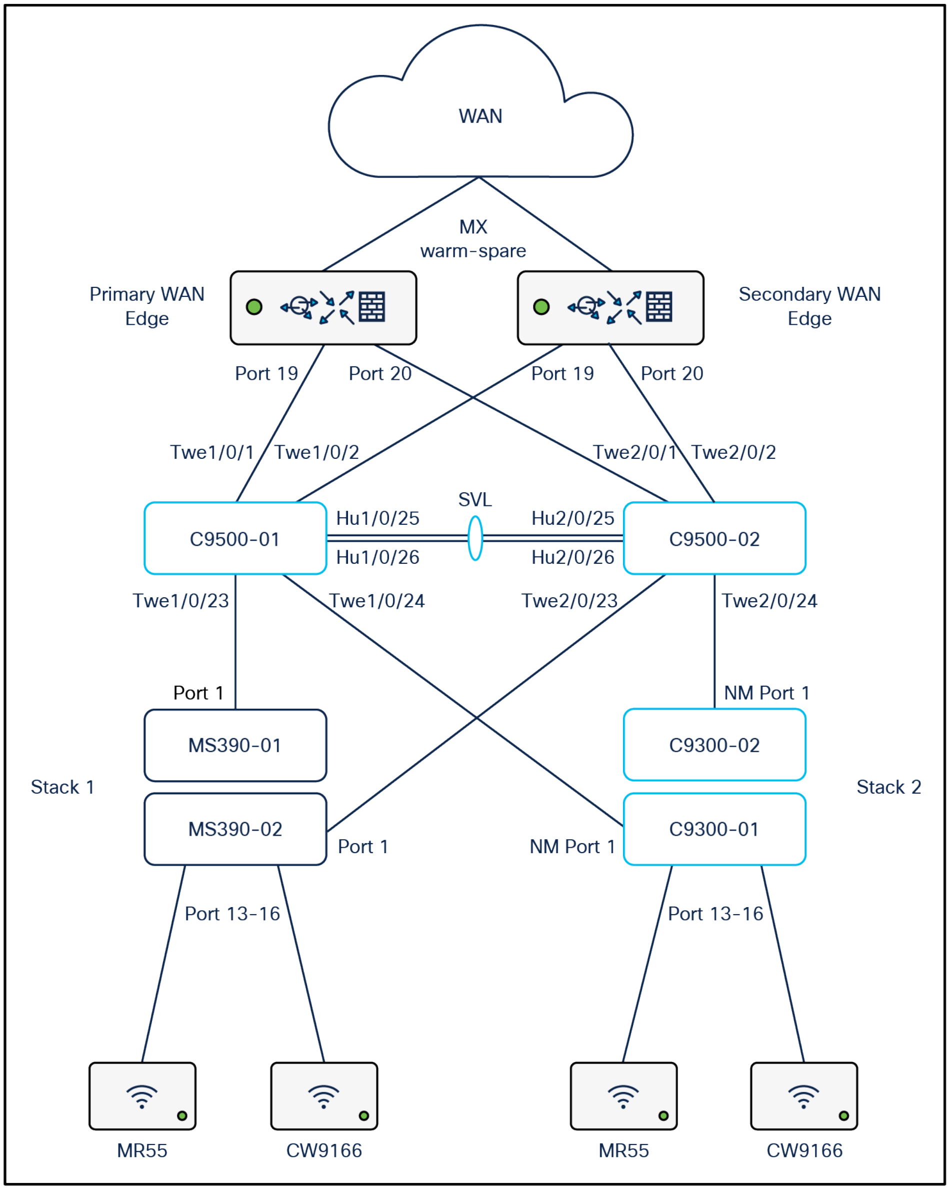
Logical Architecture

The following diagram shows the logical architecture for Layer 3 convergence within a campus LAN design leveraging Cloud Managed and Cloud Monitored Catalyst platform components:



Physical Architecture

The following diagram shows the physical architecture and port list for this design:



Assumptions

The following assumptions have been considered:

- It is assumed that Wireless roaming is required **only** within a specific Campus **Zone**
- It is assumed that VLANs are **NOT** spanning across multiple zones
- There will be **NO** use of **VLAN 1** across the Campus LAN
- **Corporate** SSID (*Broadcast in all zones*) users are assigned VLAN **11/12** based on the AP zone.
- **BYOD** SSID (*Broadcast in all zones*) users are assigned VLAN **21/22** based on the AP zone.
- **Guest** SSID (*Broadcast in Zone1*) users are assigned VLAN **30** on all APs in that zone
- **IoT** SSID (*Broadcast in zone2*) users are assigned VLAN **40** on all APs in that Zone
- Access Switches will be running **Layer 3** (*SVIs and DHCP*)
- **MS390** Access Switches physically stacked together

- **C9300-M** Access Switches physically stacked together
- **C9500** Core Switches with Stackwise-virtual stacking using SVLs
- Access Switch uplinks are in **trunk mode** with native VLAN = VLAN 1 (Management VLAN)
- STP root is at Distribution/Collapsed-core
- Network devices will be assigned **fixed IPs** from the management VLAN DHCP pool. Default Gateway will vary based on the Zone and stack.

Network Segments

Please check the following table for more information about the network segments (e.g. VLANs, SVIs, etc.) for this design:

Network Segment	VLAN ID	Subnet	Default Gateway	Notes
Management (Core)	3	10.0.3.0/24	10.0.3.1	SVI hosted on edge MX
Management (Stack1)	100	10.0.100.0/24	10.0.100.1	SVI hosted on edge MX
Management (Stack2)	200	10.0.200.0/24	10.0.200.1	SVI hosted on edge MX
Corporate Devices (Wireless and Wired)	11	10.0.11.0/24	10.0.11.1	SVI hosted on Access switches (Zone 1)
	12	10.0.12.0/24	10.0.12.1	
BYOD Wireless Devices	21	10.0.21.0/24	10.0.21.1	SVI hosted on Access switches (Zone 2)
	22	10.0.22.0/24	10.0.22.1	
Guest Wireless Devices	30	10.0.30.0/24	10.0.30.1	SVI hosted on Access switches (Zone 1)
IoT Wireless Devices	40	10.0.40.0/24	10.0.40.1	SVI hosted on Access switches (Zone 2)

Tech Tip: Please size your subnets based on your own requirements. The above table is for illustration purposes only.

Quality of Service

Application	MR	Access switches	Core switches	MX Appliance
SIP (Voice)	EF DSCP 46 AC_Vo	Trust incoming values DSCP 46 CoS 5	Trust incoming values	EF DSCP 45 LLQ Unlimited

Application	MR	Access switches	Core switches	MX Appliance
Webex and Skype	AF41 DSCP 34 AC_VI	Trust incoming values DSCP 34 CoS 4	Trust incoming values	Af41 DSCP 34 High Priority
All Video and Music	AF21 DSCP 18 AC_BE	Trust incoming values DSCP 18 CoS 2	Trust incoming values	AF21 DSCP 18 Medium Priority 5Mbps / Client
Software Updates	AF11 DSCP 10 AC_BK	Trust incoming values DSCP 10 CoS 1	Trust incoming values	AF11 DSCP 10 Low Priority 10Mbps / Client

Device List

Device	Name	Management IP address	Notes
MX250 **MX250**	Primary WAN Edge Spare WAN Edge	10.0.3.1	warm-spare
C9500-24YCY **C9500-24YCY**	C9500-01 C9500-02	10.0.3.2	Stackwise Virtual (C9500-Core-Stack)
MS390-24P **MS390-24P**	MS390-01 MS390-02	10.0.100.2	Physical Stacking (Stack1-MS390)
C9300-24P **C9300-24P**	C9300-01 C9300-02	10.0.200.2	Physical Stacking (Stack2-C9300)
MR55	AP1_Zone1	10.0.100.3	Tag = Zone1
MR55	AP2_Zone1	10.0.100.4	Tag = Zone1
C9166 (eq MR57)	AP3_Zone2	10.0.200.3	Tag = Zone2
C9166 (eq MR57)	AP4_Zone2	10.0.200.4	Tag = Zone2

Access Policies

Access Policy Name	Purpose	Configuration	Notes
Wired-1x	802.1x Authentication via Cisco ISE for wired clients that support 802.1x	Authentication method = my Radius server	Cisco ISE authentication and posture checks

		Radius CoA = enabled Host mode = Single-Host Access Policy type = 802.1x Suspend Port Bounce = Enabled Voice Clients = Bypass authentication Walled Garden = enabled	
Wired-MAB	MAB Authentication via Cisco ISE for wired clients that do not support 802.1x	Authentication method = my Radius server Radius CoA = disabled Host mode = Single-Host Access Policy type = MAC authentication bypass Suspect Port Bounce = Enabled Voice Clients = Bypass authentication Walled Garden = disabled	Cisco ISE authentication

Port List

Device Name	Port	Far-end	Port details	Notes
WAN Edge				
Primary WAN Edge	19	9500-01 (port Twe1/0/1)	Trunk (Native VLAN 3)	Downlink, allowed VLANs 3, 100, 200, 1923
	20	9500-02 (port Twe2/0/1)	Trunk (Native VLAN 3)	Downlink, allowed VLANs 3, 100, 200, 1923
Spare WAN Edge	19	9500-01 (port Twe1/0/2)	Trunk (Native VLAN 3)	Downlink, allowed VLANs 3, 100, 200, 1923
	20	9500-02 (port Twe2/0/2)	Trunk (Native VLAN 3)	Downlink, allowed VLANs 3, 100, 200, 1923
9500-01	Twe1/0/1	Primary WAN Edge (Port 19)	switchport mode trunk switchport trunk native vlan 3 switchport trunk allowed vlan 3,100,200,1923 auto qos trust dscp policy static sgt 2 trusted	Uplink
	Twe1/0/2	Spare WAN Edge (Port 19)	switchport mode trunk switchport trunk native vlan 3	Uplink

Device Name	Port	Far-end	Port details	Notes
			switchport trunk allowed vlan 3,100,200,1923 auto qos trust dscp policy static sgt 2 trusted	
9500-02	Twe2/0/1	Primary WAN Edge (Port 20)	switchport mode trunk switchport trunk native vlan 3 switchport trunk allowed vlan 3,100,200,1923 auto qos trust dscp policy static sgt 2 trusted	Uplink
	Twe2/0/2	Spare WAN Edge (Port 20)	switchport mode trunk switchport trunk native vlan 3 switchport trunk allowed vlan 3,100,200,1923 auto qos trust dscp policy static sgt 2 trusted	Uplink
9500-01	Twe1/0/23	MS390-01 (Port 1)	switchport mode trunk switchport trunk native vlan 100 switchport trunk allowed vlan 100,1921 channel-group 1 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	Downlink
	Twe1/0/24	C9300-01 (Port 1)	switchport mode trunk switchport trunk native vlan 200 switchport trunk allowed vlan 200,1922 channel-group 2 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	Downlink
9500-02	Twe2/0/23	MS390-02 (Port 1)	switchport mode trunk switchport trunk native vlan 100	Downlink

Device Name	Port	Far-end	Port details	Notes
			switchport trunk allowed vlan 100,1921 channel-group 1 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	
	Twe2/0/24	C9300-02 (Port 1)	switchport mode trunk switchport trunk native vlan 200 switchport trunk allowed vlan 200,1922 channel-group 2 mode active spanning-tree guard root auto qos trust dscp policy static sgt 2 trusted	Downlink
9500-01	Hu1/0/25	C9500-02 (Port Hu2/0/26)	stackwise-virtual link 1	Stackwise Virtual
	Hu1/0/26	C9500-02 (Port Hu2/0/25)	stackwise-virtual link 1	Stackwise Virtual
9500-02	Hu2/0/25	C9500-01 (Port Hu1/0/26)	stackwise-virtual link 1	Stackwise Virtual
	Hu2/0/26	C9500-01 (Port Hu1/0/25)	stackwise-virtual link 1	Stackwise Virtual
MS390-01 **MS390-02** **C9300-01** **C9300-02**	5-8	Wired Clients	"Access (Data VLAN 11/12) Access Policy = Wired-1x PoE Enabled STP BPDU Guard Tag = Wired Clients 802.1x AdP: Corp"	For wired clients supporting 802.1x
MS390-01 **MS390-02** **C9300-01** **C9300-02**	9-12	Wired Clients	Access (Data VLAN 11/12) Access Policy = MAB PoE Enabled STP BPDU Guard Tag = Wired Clients MAB	For wired clients that do not support 802.1x

Device Name	Port	Far-end	Port details	Notes
			AdP: Corp	
MS390-01	13-16	MR	Trunk (Native VLAN 100/200) PoE Enabled STP BPDU Guard Tag = MR WLAN Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 11/12, 21/22, 30 or 40, 100/200
MS390-01	1	9500-01 (port Twe1/0/23)	Trunk (Native VLAN 100) PoE Disabled Name: Core 1 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 100,1921
MS390-02	1	9500-02 (Port Twe2/0/23)	Trunk (Native VLAN 100) PoE Disabled Name: Core 2 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 100,1921
C9300-01	C9300-01 / C9300-NM-8X / 1	9500-01 (Port Twe1/0/24)	Trunk (Native VLAN 200) PoE Disabled Name: Core 1 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 200,1922

Device Name	Port	Far-end	Port details	Notes
C9300-02	C9300-02 / C9300-NM-8X / 1	9500-02 (Port Twe2/0/24)	Trunk (Native VLAN 200) PoE Disabled Name: Core 2 Tag = Uplink Peer SGT Capable AdP: Infrastructure	Allowed VLANs: 200,1922

Wireless SSID List

SSID Name	Broadcast	Configuration	Notes	Firewall and Traffic Shaping
Acme Corp	All APs	Association = Enterprise with my Radius server Encryption = WPA2 only Splash Page = Cisco ISE Radius CoA = Enabled SSID mode = Bridge mode VLAN Tagging = 11/12 (based on AP tag) AdP Group = 10:Corp Radius override = Enabled Mandatory DHCP = Enabled Layer 2 isolation = Disabled Allow Clients access LAN = Allow Traffic Shaping = Enabled with default settings	Cisco ISE Authentication and posture checks (172.31.16.32/1812)	Layer 2 Isolation = Disabled Allow Access to LAN = Enabled Per-Client Bandwidth Limit = 50Mbps Per-SSID Bandwidth Limit = Unlimited Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34) All Video and Music - AF21 (DSCP 18)
Acme BYOD	All APs	Association = Enterprise with my Radius server Encryption = WPA2 only 802.11w = Enabled Splash Page = Cisco ISE SSID mode = Bridge mode VLAN Tagging = 21/22 (based on AP tag) AdP Group = 20:BYOD Radius override = Disabled Mandatory DHCP = Enabled Layer 2 isolation = Disabled	Cisco ISE Authentication (via Azure AD) and posture checks. Dynamic GP assignment (Radius attribute = Airospace-ACLNAME)	Layer 2 Isolation = Disabled Allow Access to LAN = Enabled Per-Client Bandwidth Limit = 50Mbps Per-SSID Bandwidth Limit = Unlimited Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34)

SSID Name	Broadcast	Configuration	Notes	Firewall and Traffic Shaping
		Allow Clients access LAN = Allow Traffic Shaping = Enabled with default settings		All Video and Music - AF21 (DSCP 18)
Guest	Zone1	Association = Enterprise with my Radius server Encryption = WPA1 and WPA2 802.11w = Enabled Splash Page = Click Through SSID mode = Bridge mode VLAN Tagging = 30 AdP Group = 30:Guest Radius override = Disabled Mandatory DHCP = Enabled Layer 2 isolation = Enabled Allow Clients access LAN = Deny Per SSID limit = 100Mbps Traffic Shaping = Enabled with default settings	Meraki Authentication	Allow Access to LAN = Disabled Per-Client Bandwidth Limit = 5Mbps Per-SSID Bandwidth Limit = 100Mbps Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34) All Video and Music - AF21 (DSCP 18)
Acme IoT	Zone2	Association = identity PSK with Radius Encryption = WPA1 and WPA2 802.11r = Disabled 802.11w = Disabled Splash Page = None Radius CoA = Disabled SSID mode = Bridge mode VLAN Tagging = 40 AdP Group = 40:IoT Radius override = Disabled Mandatory DHCP = Enabled Allow Clients access LAN = Deny Per SSID limit = 10Mbps Traffic Shaping = Enabled with default settings	Cisco ISE is queried at association time to obtain a passphrase for a device based on its MAC address. Dynamic GP assignment (Radius attribute Filter-Id)	Layer 2 Isolation = Disabled Allow Access to LAN = Enabled Per-Client Bandwidth Limit = 5Mbps Per-SSID Bandwidth Limit = Unlimited Enable Default Traffic Shaping rules SIP - EF (DSCP 46) Software Updates - AF11 (DSCP 10) Webex and Skype - AF41 (DSCP 34) All Video and Music - AF21 (DSCP 18)

Tech Tip:

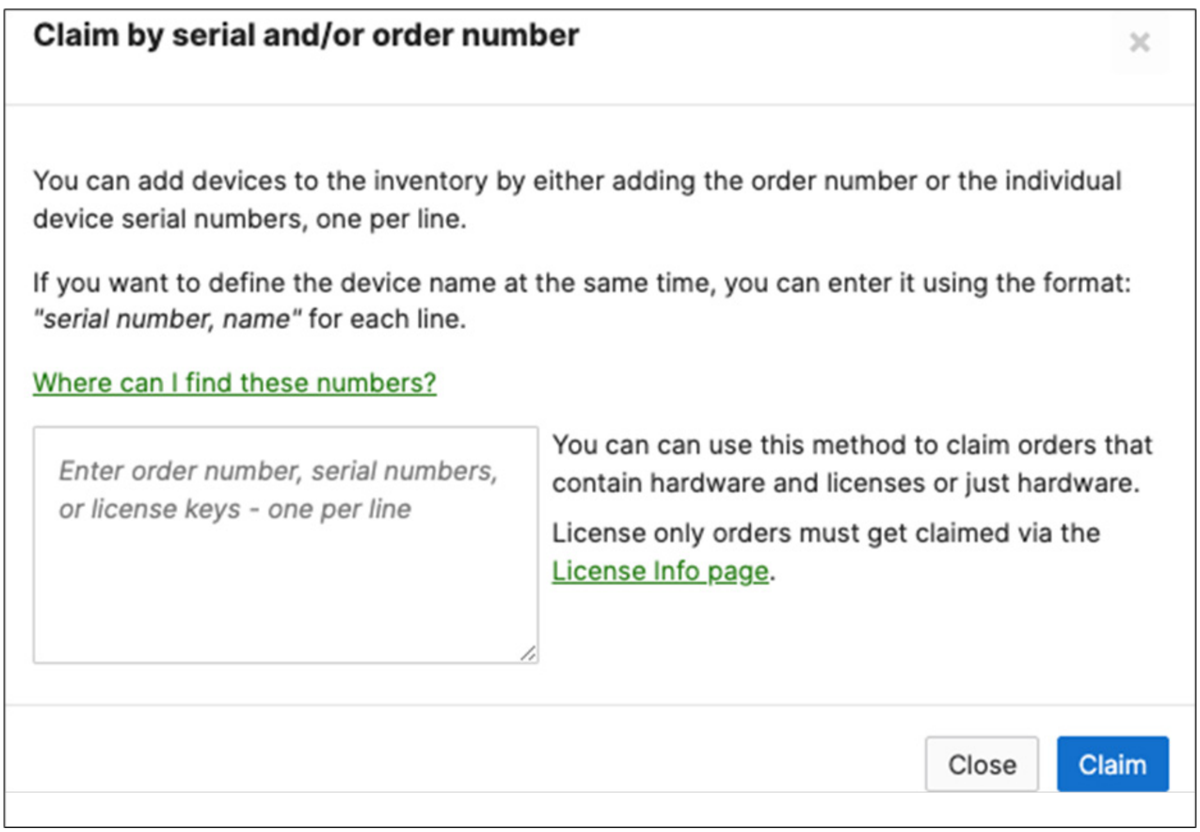
- The above configuration is for illustration purposes only. Please configure your SSIDs based on your own requirements (mode, IP assignment, etc.).
- Please note that Adaptive Policy on MR requires MR-ADV license. For more information about the requirements, please refer to this document.

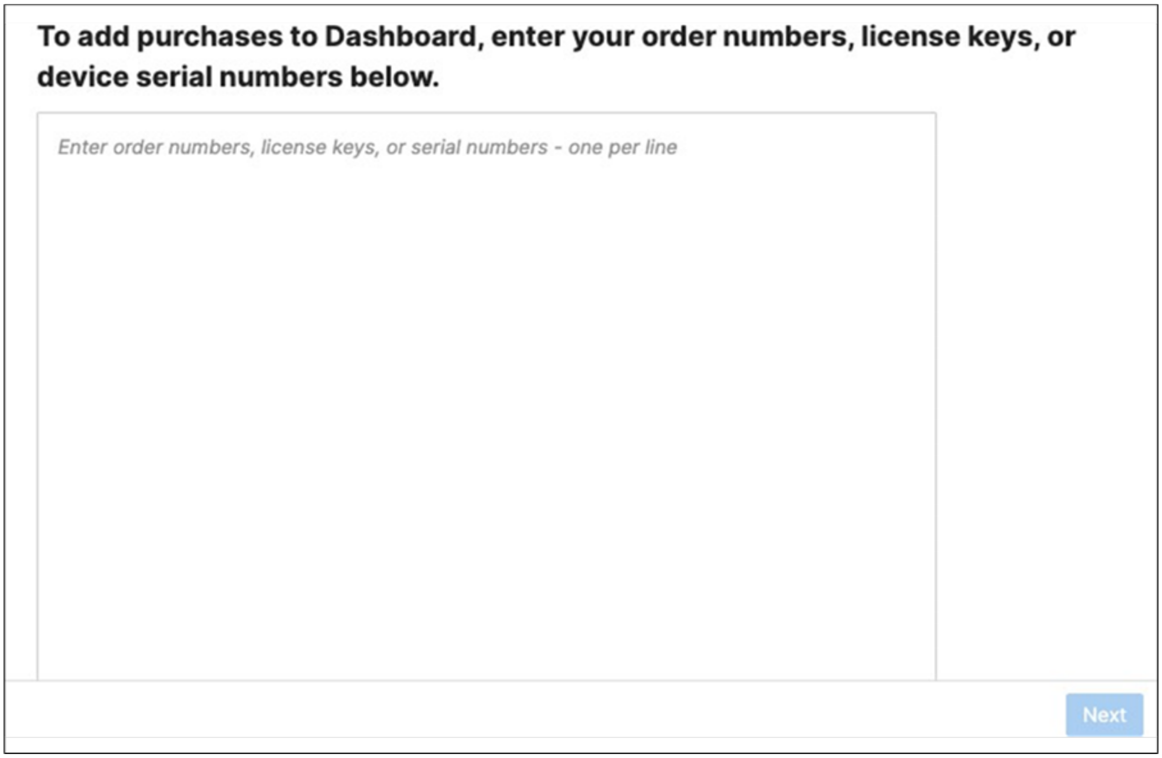
Configuration and Implementation Guidelines

It is assumed that by this stage, Catalyst devices have been added to dashboard for either Monitoring (e.g. C9500) and/or Management (e.g. C9300). For more information, please refer to the above section.

Before proceeding, please make sure that you have the appropriate licenses claimed into your dashboard account.

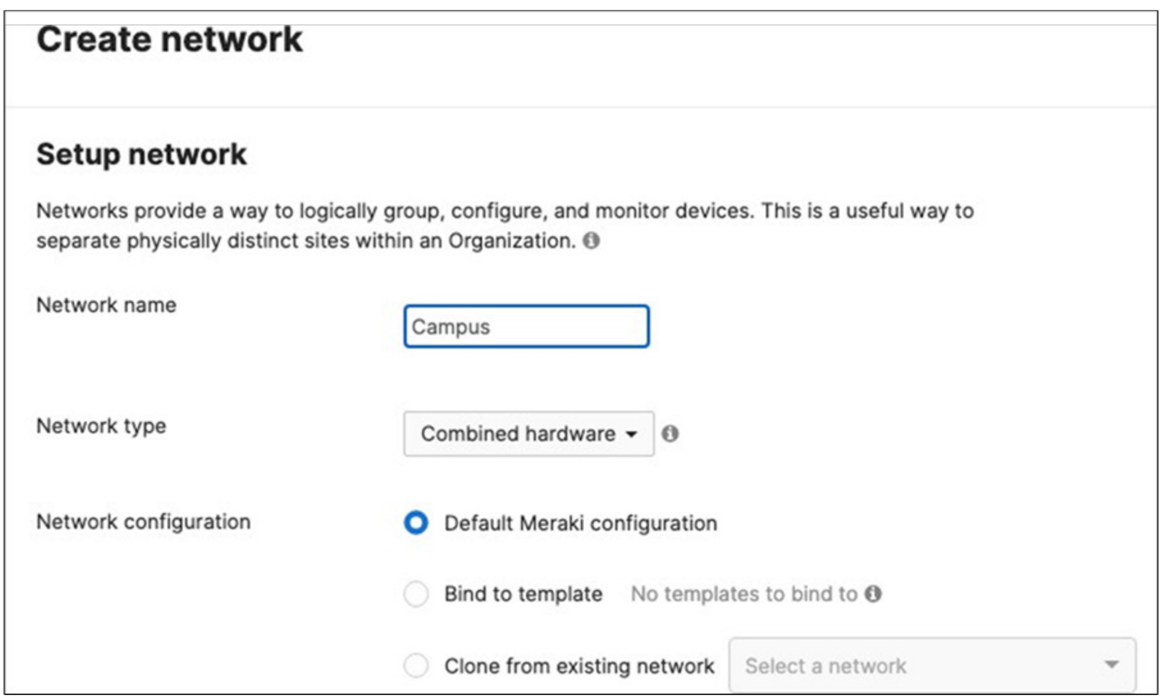
1. Login to your dashboard account (or create an account if you don't have one)
2. Navigate to **Organization > Configure > Inventory**
3. For Co-term license model, click on **Claim**. And for PDL, please click on **Add**

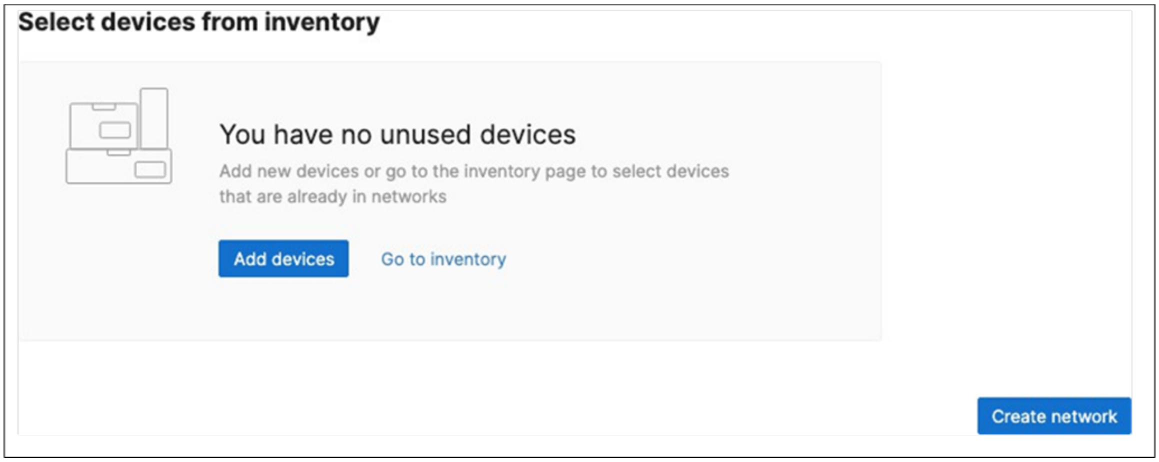




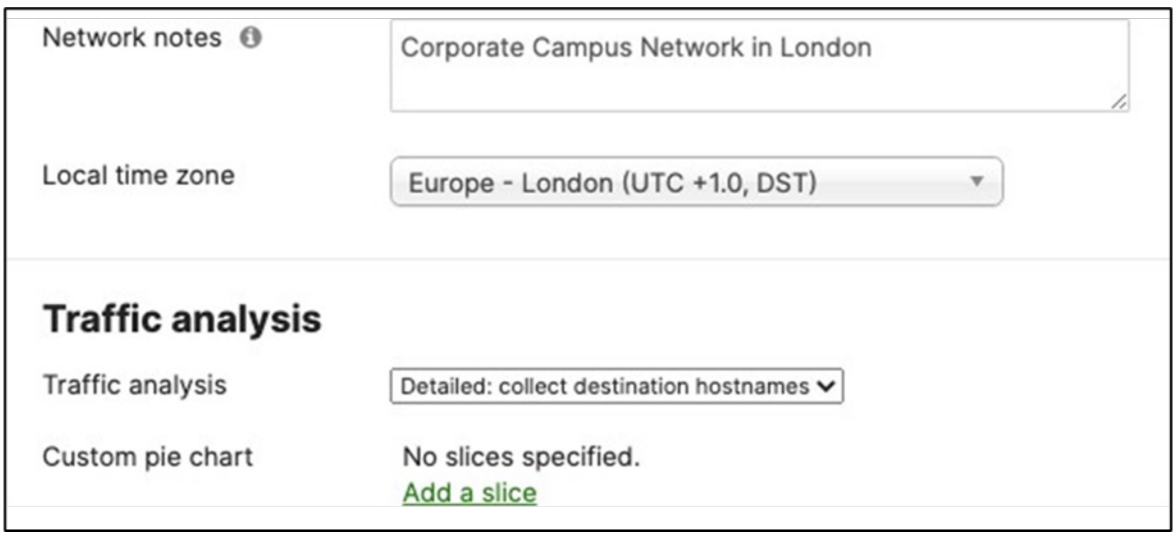
4. Enter the order and/or serial number(s) to claim the devices into your account. For PDL, click **Next** then please choose to add them to **Inventory** (Do not add them to a network)

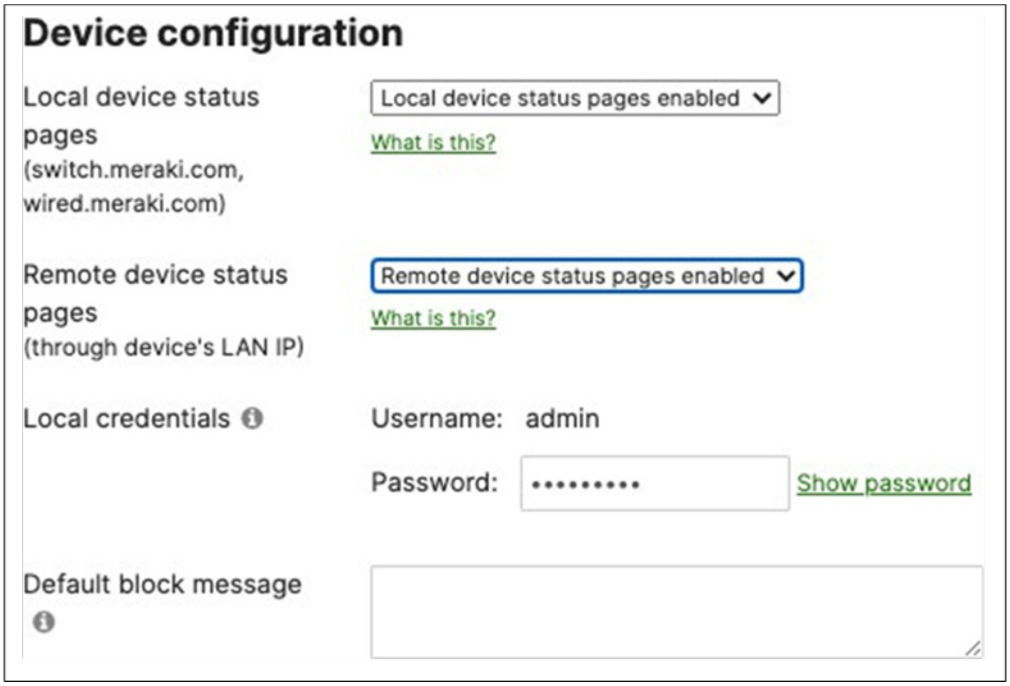
5. **Create a Dashboard Network:** Navigate to **Organization > Configure > Create network** to [create a network](#) for your Campus LAN (Or use an existing network if you already have one). If you are creating a new network, please choose "Combined" as this will facilitate a single topology diagram for your Campus LAN. Choose a name (e.g. Campus) and then click **Create network**

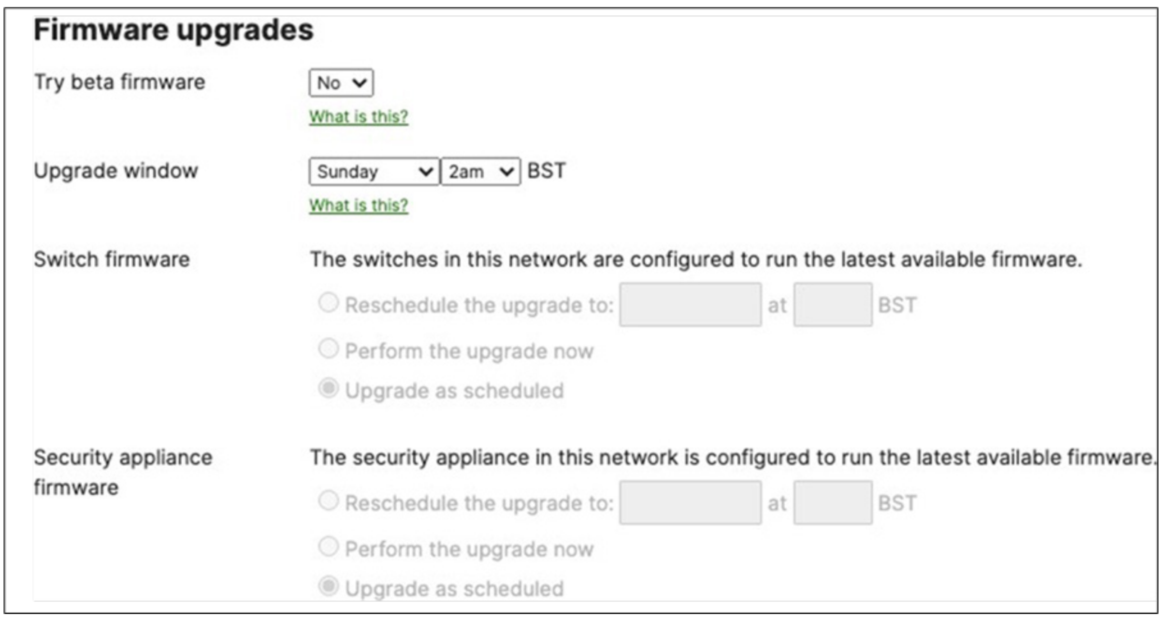




6. **Dashboard Network Settings:** Navigate to **Network-wide > Configure > General** and choose the settings for your network (e.g. Time zone, Traffic Analytics, firmware upgrade day/time, etc.)

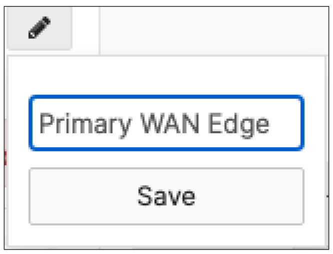




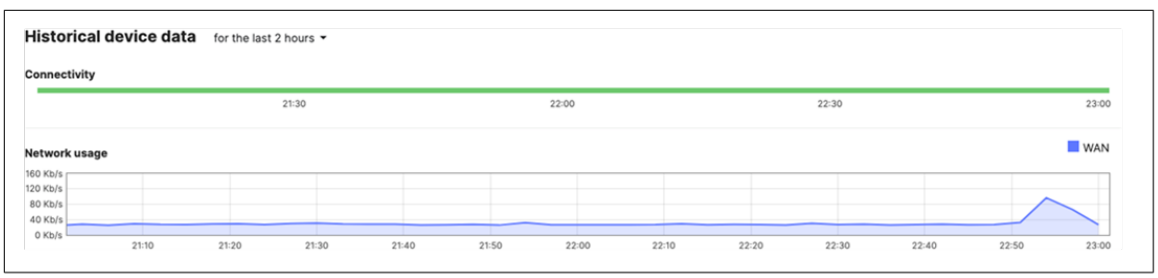


7. **Schedule Firmware Upgrade**: Navigate to **Organization > Configure > Firmware upgrades** to select the firmware for your devices such that devices upgrade once they connect to dashboard. Select the device type then click on **Schedule upgrade**.

8. **Add Devices to a Dashboard Network**: Navigate to **Organization > Configure > Inventory.**
   - For Co-term licensing model, select the MS390 and C9300 switches and the Primary WAN Edge then click on **Add** then choose the Network Campus
   - For PDL licensing model, select the MS390 and C9300 switches and the Primary WAN Edge then click on **Change network assignment** and then choose the Network Campus
   - Please **DO NOT** add the Secondary WAN Edge device at this stage
9. **Rename MX Security Appliance**: Navigate to **Security and SD-WAN > Monitor > Appliance status** then click on the edit button to rename the MX to Primary WAN Edge then click on **Save.**



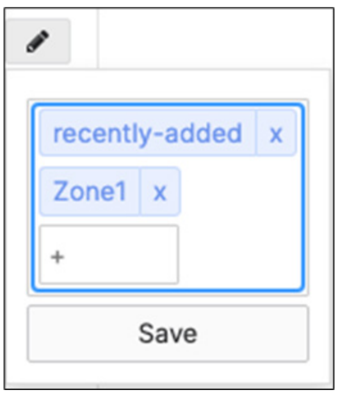
10. **MX Connectivity:** Plug in your WAN uplink(s) on the Primary WAN Edge MX then power it on and wait for it to come online on dashboard. This might take a few minutes as the MX will download its firmware and configuration. Navigate to **Security and SD-WAN > Configure > Appliance status** and verify that the MX has come online and that its firmware and configuration is **up to date.**



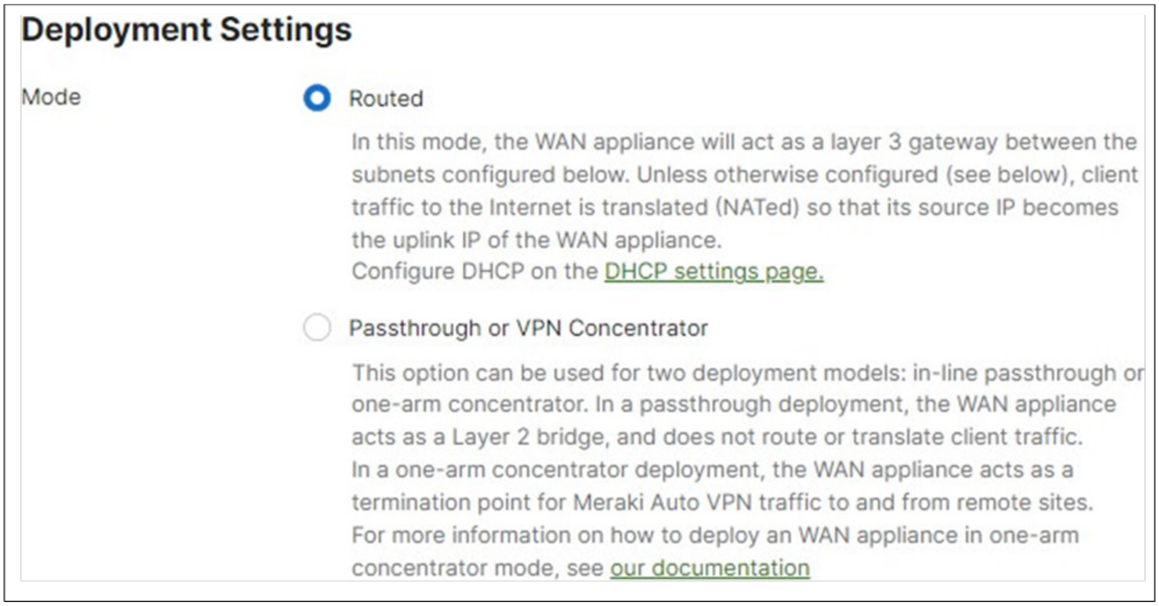
11. **Rename Access Switches:** Navigate to **Switching > Monitor > Switches** then click on each MS390 and C9300 switch and then click on the edit button on top of the page to rename it per the above table then click on **Save** such that all your switches have their designated names.

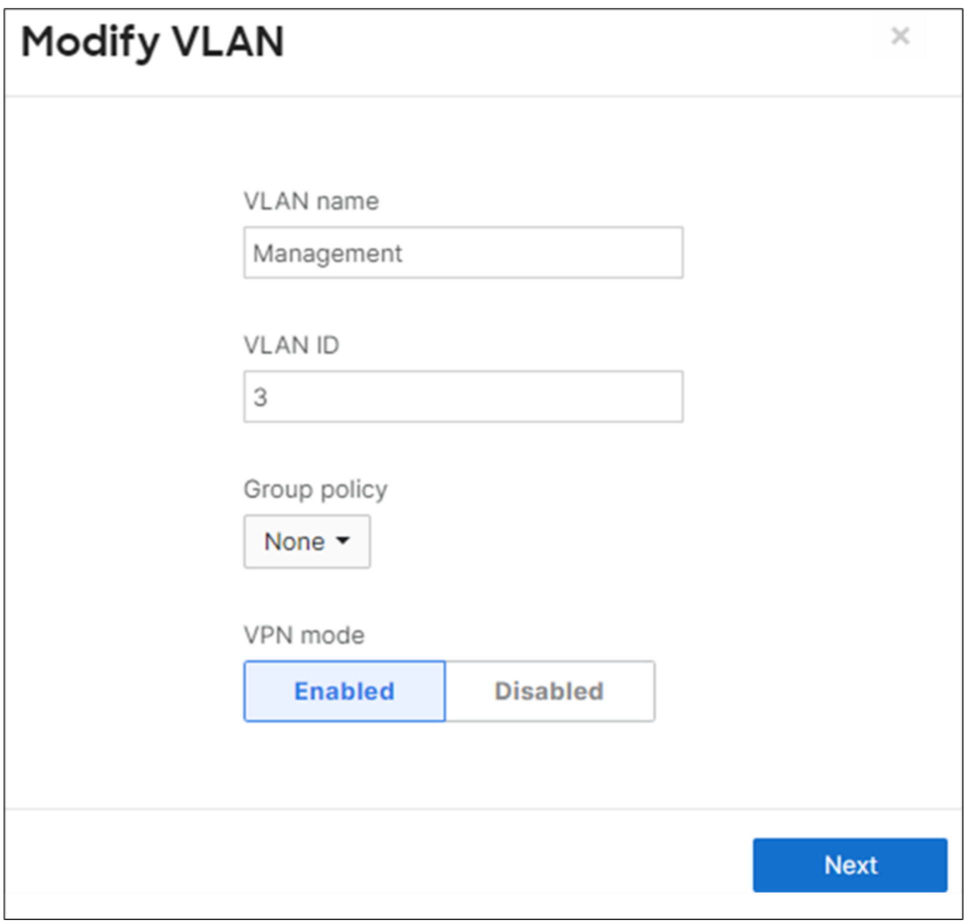
12. **Rename MR APs**: Navigate to **Wireless > Monitor > Access points** then click on each AP and then click on the edit button on top of the page to rename it per the above table then click on **Save** such that all your APs have their designated names.

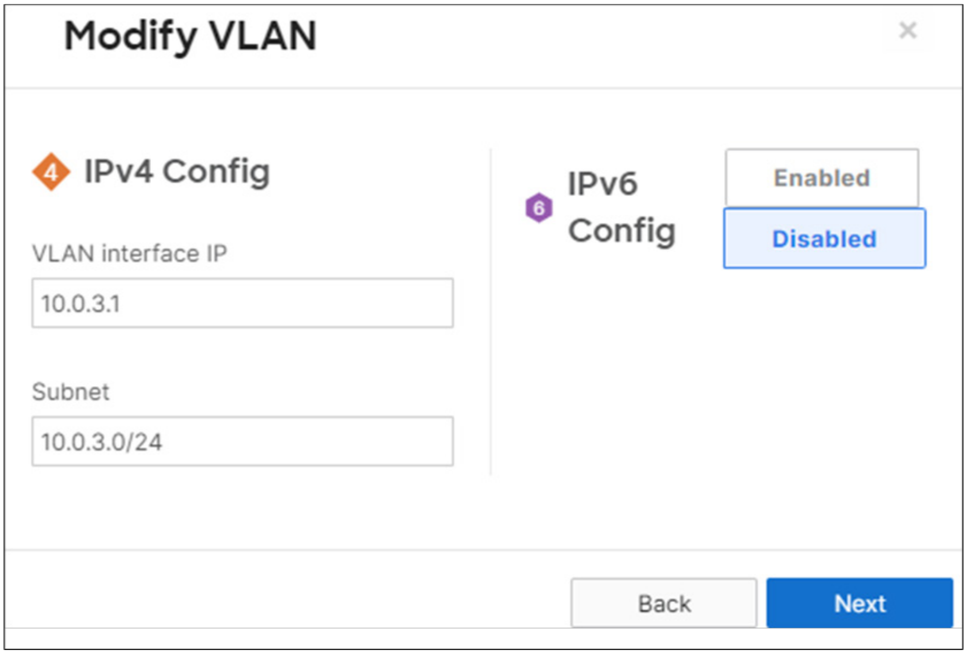
13. **MR AP Tags:** Navigate to **Wireless > Monitor > Access points** then click on each AP and then click on the edit button next to **TAGS** to add Tags to your AP per the above table then click on Save such that all your APs have their designated tags.

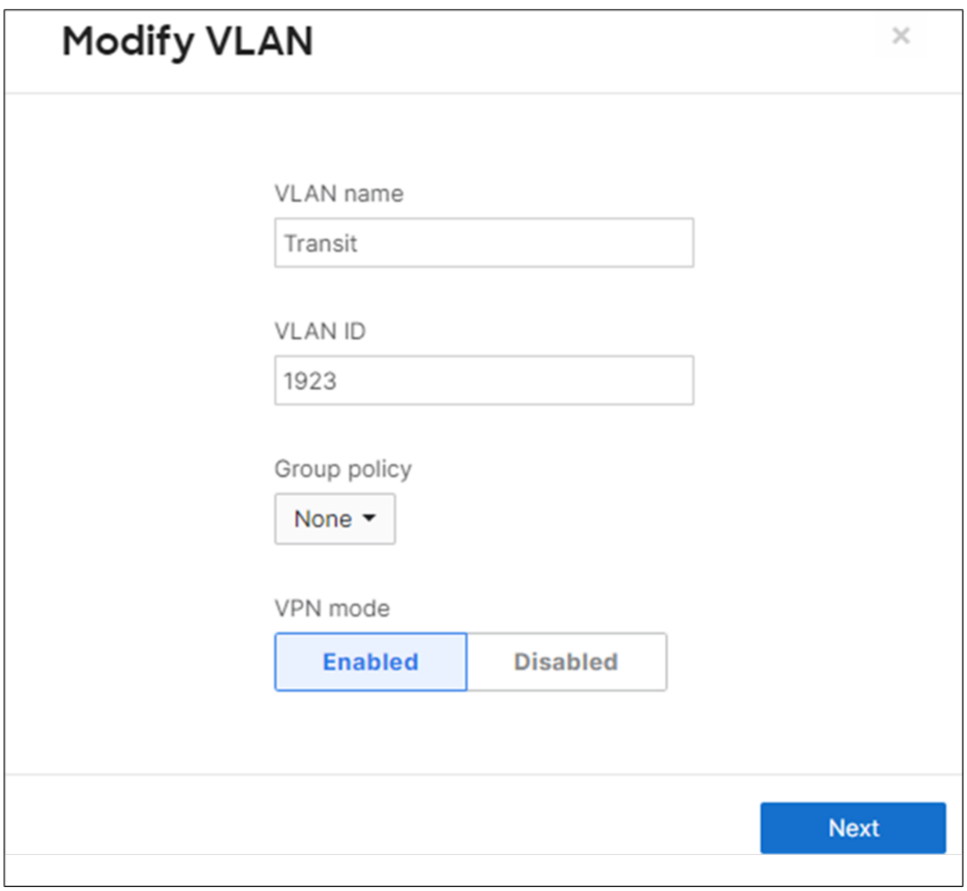


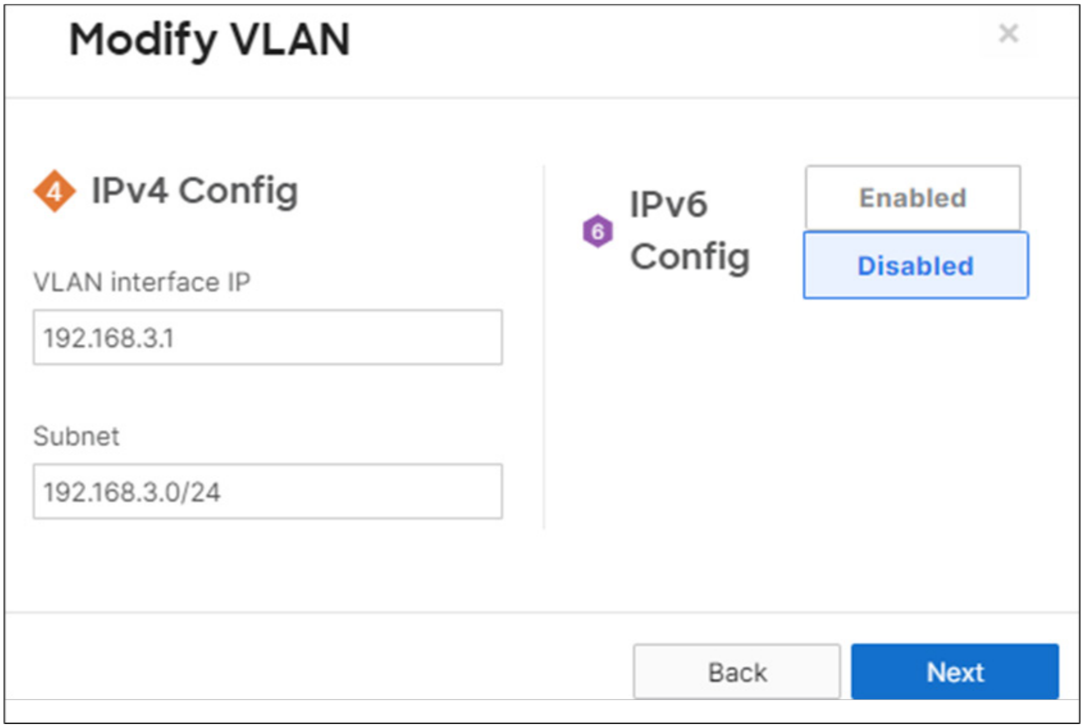
14. **MX Addressing and VLANs:** Navigate to **Security and SD-WAN > Configure > Addressing and VLANs**, and in the Deployment Settings menu select **Routed** mode. Further down the page on the Routing menu, click on **VLANs** then click on **Add VLAN** to add your Management and Transit VLANs then click on **Create.** Then for the per-port VLAN settings, select your downlink ports (19 and 20) and click on **Edit** and configure them as Trunk with VLAN 3 (Allowed VLANs 3, 100, 200, 1923) and click on **Update.** Finally, click on **Save** at the bottom of the page.


Deployment Settings
Mode
Routed
In this mode, the WAN appliance will act as a layer 3 gateway between the subnets configured below. Unless otherwise configured (see below), client traffic to the Internet is translated (NATed) so that its source IP becomes the uplink IP of the WAN appliance.
Configure DHCP on the DHCP settings page.
Passthrough or VPN Concentrator
This option can be used for two deployment models: in-line passthrough or one-arm concentrator. In a passthrough deployment, the WAN appliance acts as a Layer 2 bridge, and does not route or translate client traffic.
In a one-arm concentrator deployment, the WAN appliance acts as a termination point for Meraki Auto VPN traffic to and from remote sites.
For more information on how to deploy an WAN appliance in one-arm concentrator mode, see our documentation

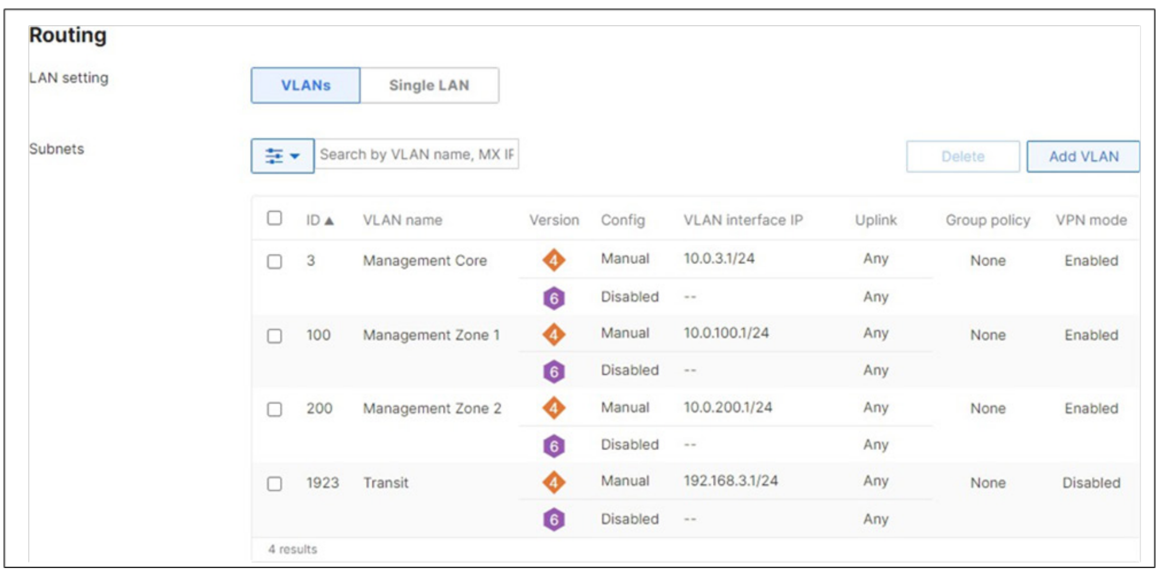

Modify VLAN
VLAN name
Management
VLAN ID
3
Group policy
None
VPN mode
Enabled
Disabled
Next

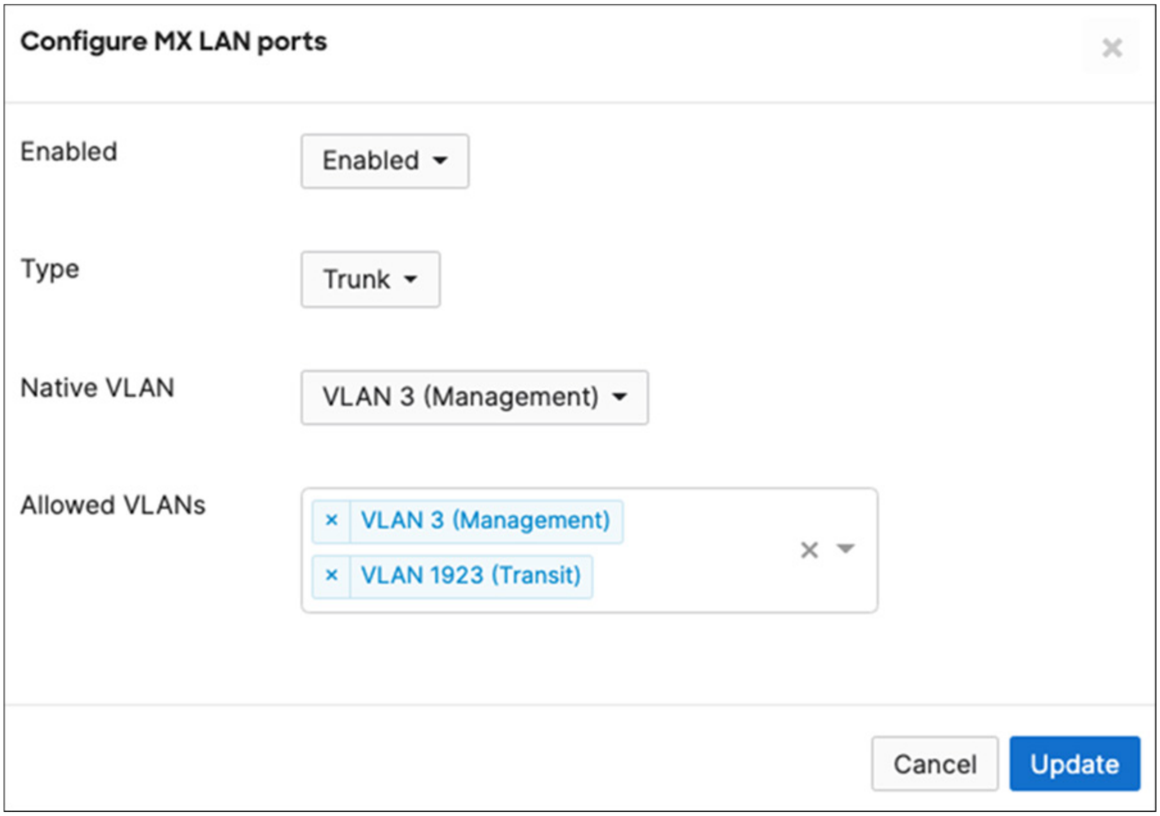

Modify VLAN
IPv4 Config
VLAN interface IP
10.0.3.1
Subnet
10.0.3.0/24
IPv6 Config
Enabled
Disabled
Back
Next


Modify VLAN
VLAN name
Transit
VLAN ID
1923
Group policy
None
VPN mode
Enabled
Disabled
Next

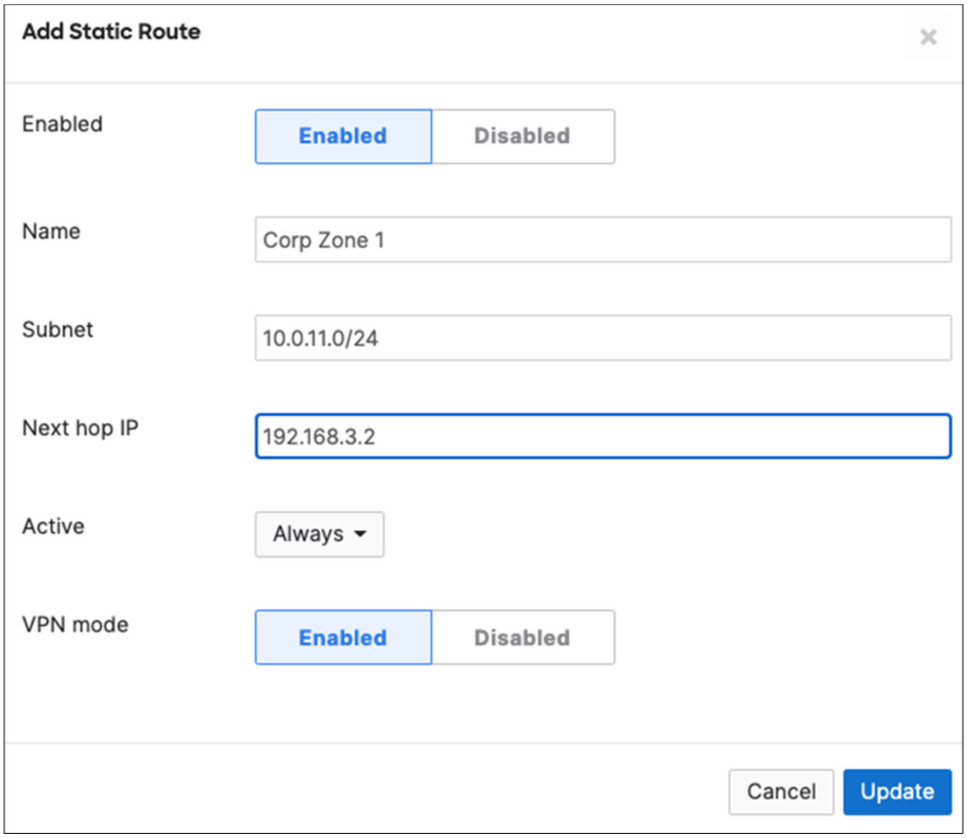


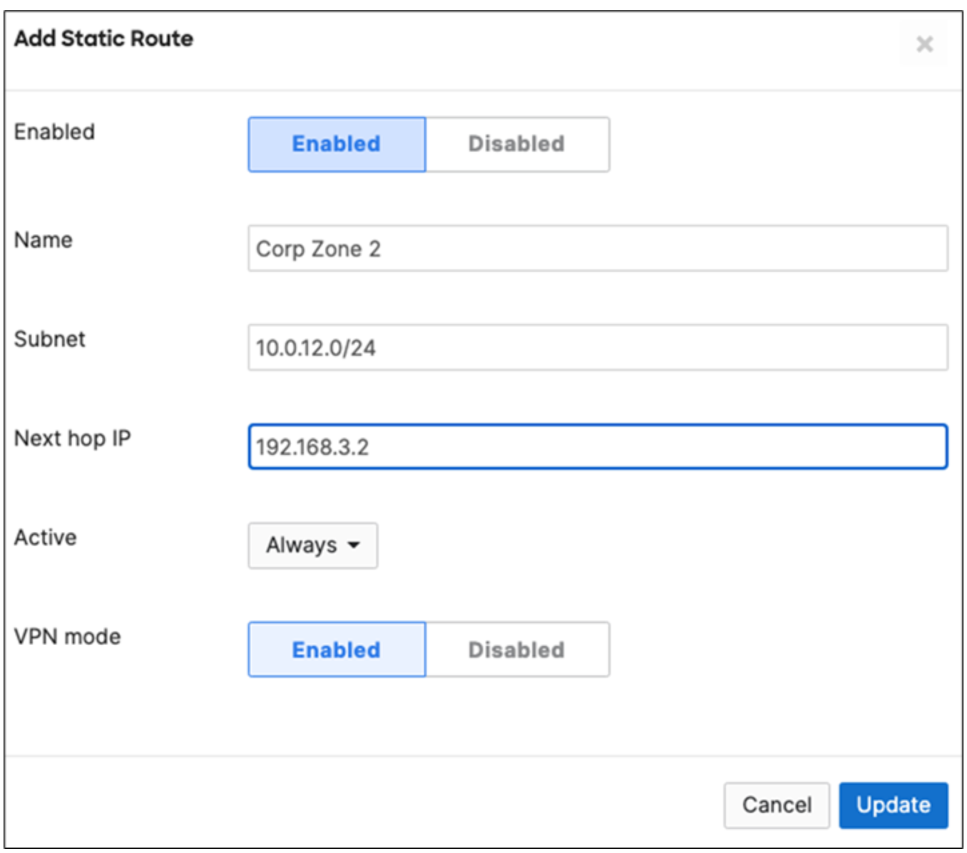
- Please repeat the above steps to create VLANs 100 and 200

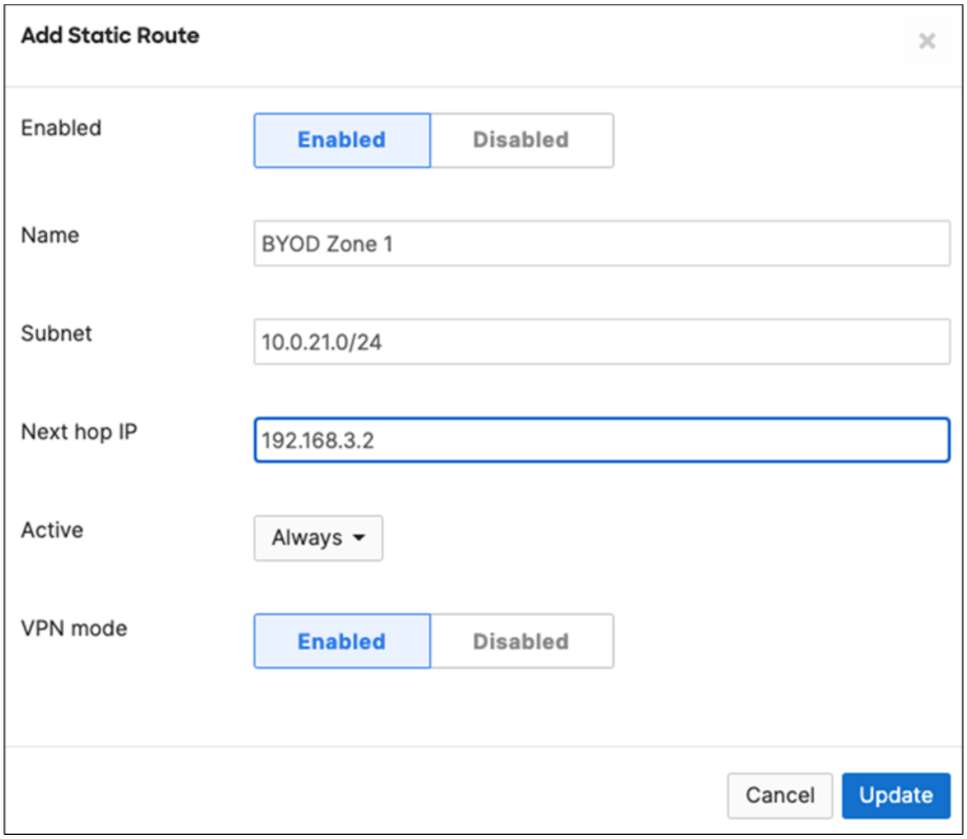


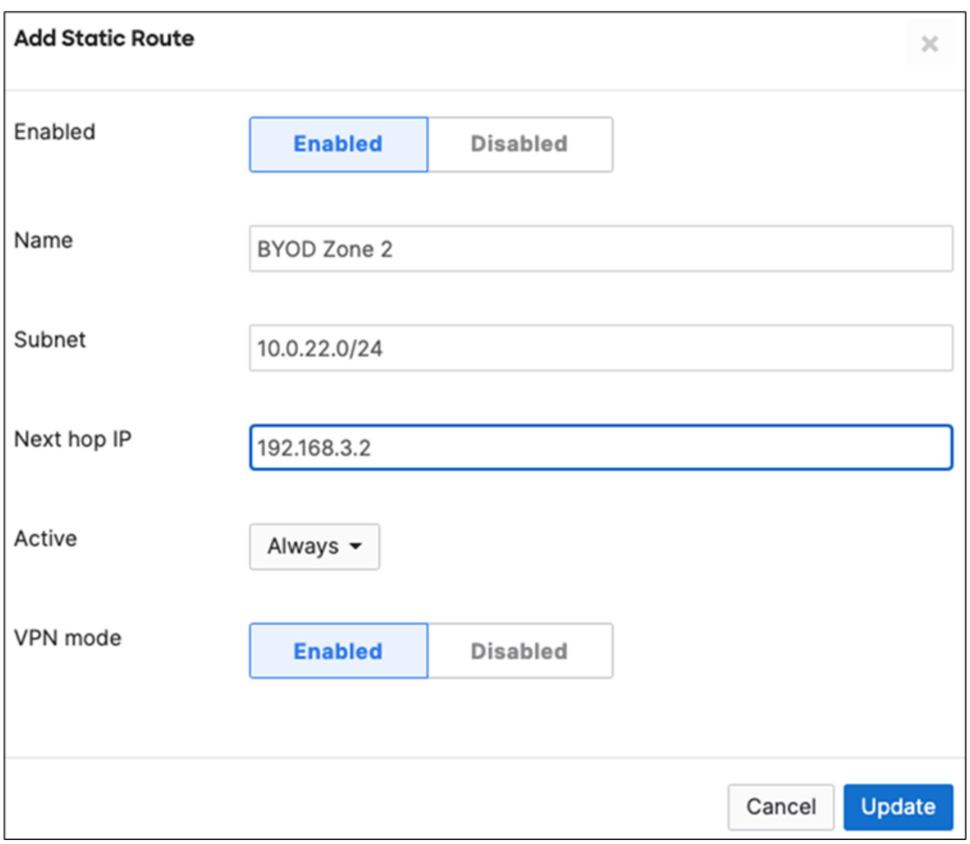


15. **Campus LAN Static Routes:** Create Static Routes for your Campus network by navigating further down the page to Static routes then click on **Add Static Route.** Start by adding your Corporate LAN subnet then click on **Update** and then add static routes to all other subnets (e.g. BYOD, Guest and IoT). Finally, click on **Save** at the bottom of the page. (*The Next hop IP that you have used here will be used to create a fixed assignment for the Core Stack later in DHCP settings*).


Add Static Route
Enabled
Enabled
Disabled
Name
Corp Zone 1
Subnet
10.0.11.0/24
Next hop IP
192.168.3.2
Active
Always
VPN mode
Enabled
Disabled
Cancel
Update


Add Static Route
Enabled
Enabled
Disabled
Name
Corp Zone 2
Subnet
10.0.12.0/24
Next hop IP
192.168.3.2
Active
Always
VPN mode
Enabled
Disabled
Cancel
Update


Add Static Route
Enabled
Enabled
Disabled
Name
BYOD Zone 1
Subnet
10.0.21.0/24
Next hop IP
192.168.3.2
Active
Always
VPN mode
Enabled
Disabled
Cancel
Update

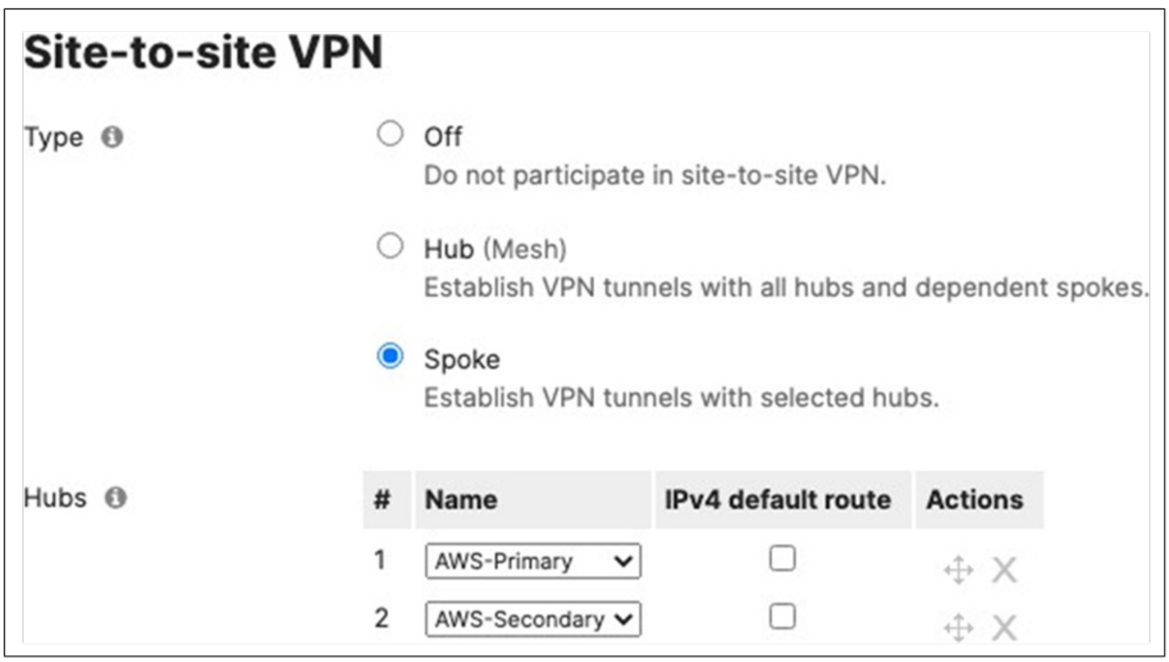

Add Static Route
Enabled
Enabled
Disabled
Name
BYOD Zone 2
Subnet
10.0.22.0/24
Next hop IP
192.168.3.2
Active
Always
VPN mode
Enabled
Disabled
Cancel
Update

Delete | Add Static Route

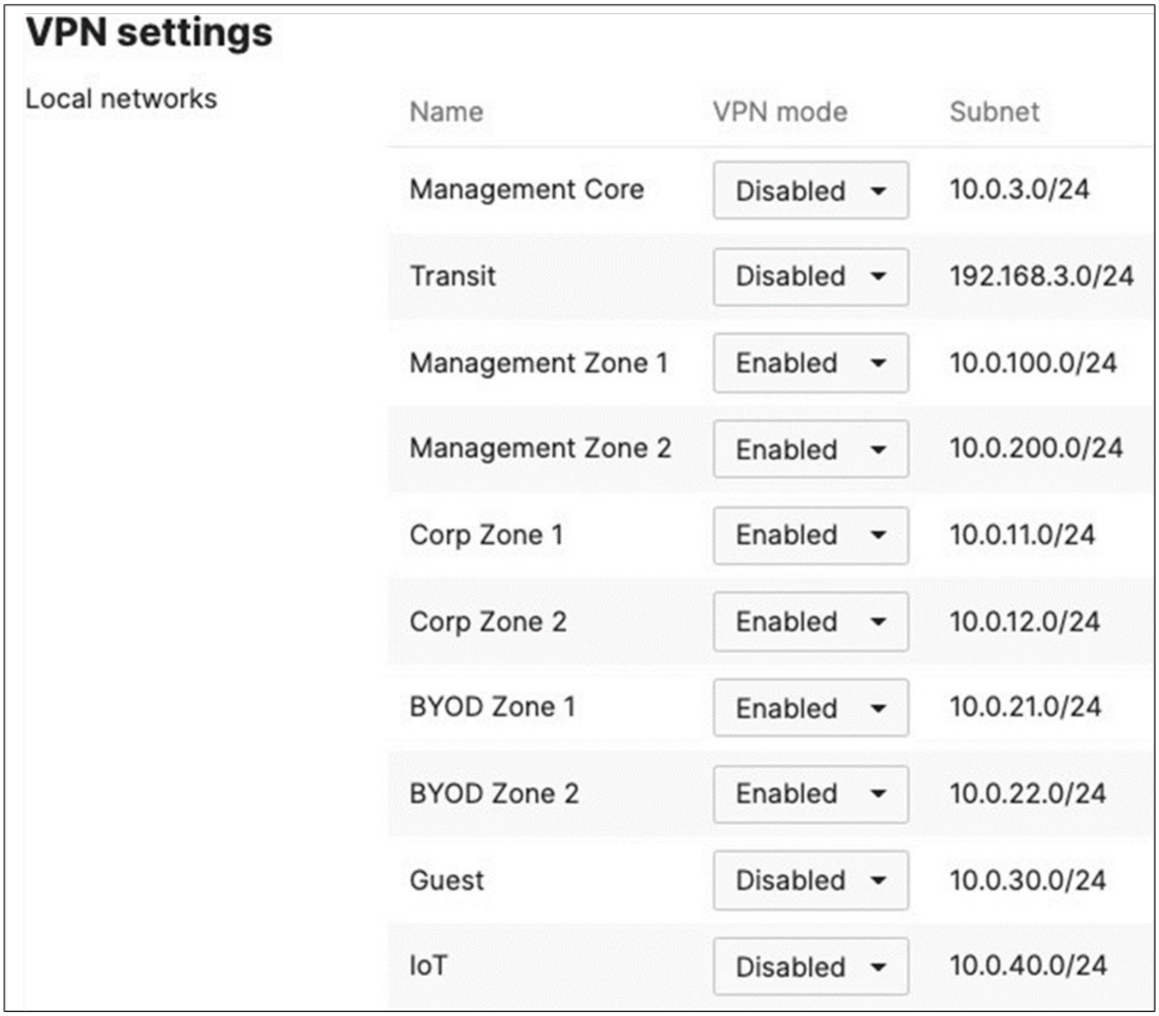
	Enabled	Name	Subnet	Gateway IP	Conditions
☐	●	Corp Zone 1	10.0.11.0/24	192.168.3.2	always
☐	●	Corp Zone 2	10.0.12.0/24	192.168.3.2	always
☐	●	BYOD Zone 1	10.0.21.0/24	192.168.3.2	always
☐	●	BYOD Zone 2	10.0.22.0/24	192.168.3.2	always
☐	●	Guest	10.0.30.0/24	192.168.3.2	always
☐	●	IoT	10.0.40.0/24	192.168.3.2	always

16. *Optional* - If you are accessing any resources over Meraki SD-WAN, please navigate to **Security and SD-WAN > Configure > Site-to-site VPN** and enable VPN based on your topology and traffic flow requirements. (In this case, we will configure this Campus as **Spoke** with **Split Tunneling**)

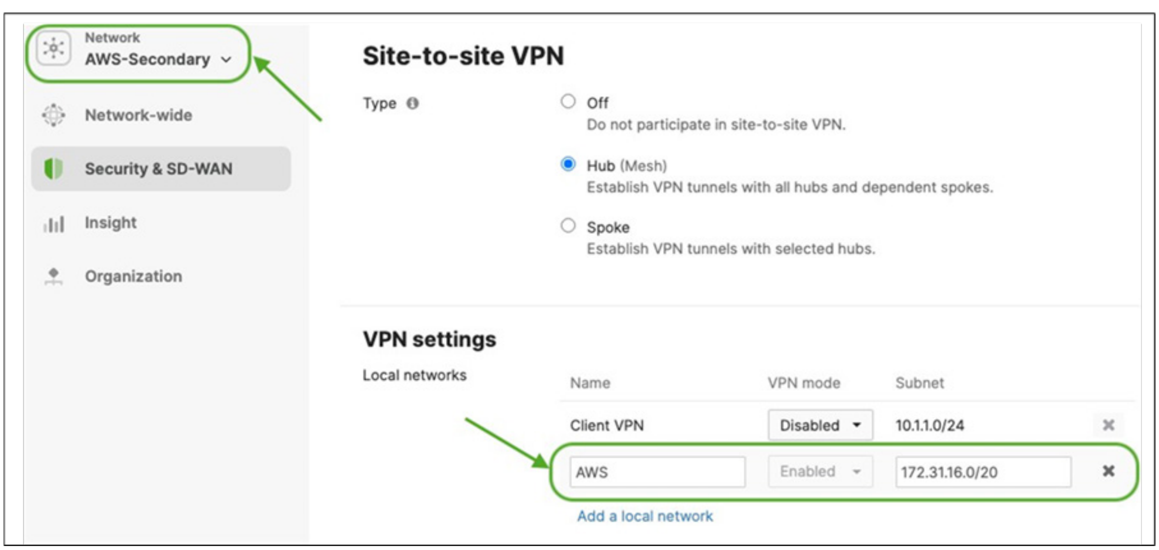
    - Choose Type: **Spoke** then click on **Add a hub** and select your hub site where you need access to resources via VPN. You can also add multiple hubs for resiliency. To choose Split Tunneling, please leave the box next to the Hub *unticked* as shown below.



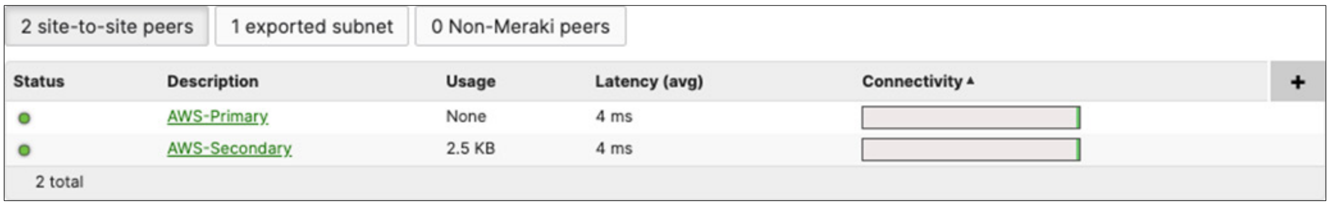
    - Under **VPN Settings**, choose which subnet to be **Enabled** in VPN (*e.g. Management VLAN will be required for Radius authentication purposes as the MR/MS390/C9300 devices will reach out to Cisco ISE using their management IP*). Any Subnet that needs to access resources via VPN must be Enabled otherwise keep it as Disabled.

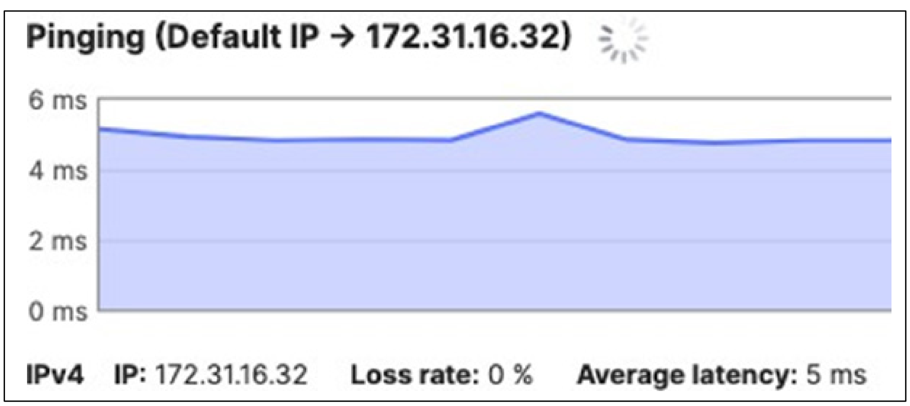


- Finally, click on **Save** at the bottom of the page on the Hub site, please make sure to advertise the subnets that are required to be reachable via VPN. Navigate to **Security and SD-WAN > Configure > Site-to-site VPN** then add a local network then click **Save** at the bottom of the page (*Please make sure that you are configuring this on the Hub's dashboard network*).



17. *Optional* – Verify that your VPN has come up by selecting your Campus LAN dashboard network from the Top-Left Network drop-down list and then navigate to **Security and SD-WAN > Monitor > VPN status** then check the status of your VPN peers. Next, navigate to **Security and SD-WAN > Monitor > Route table** and check the status of your remote subnets that are reachable via VPN. You can also verify connectivity by pinging a remote subnet (e.g. 172.31.16.32 which is Cisco ISE) by navigating to **Security and SD-WAN > Monitor > Appliance status** then click on **Tools** and ping the specified IP address (*Please note that the MX will choose the highest VLANs interface IP participating in VPN by default as the source*).





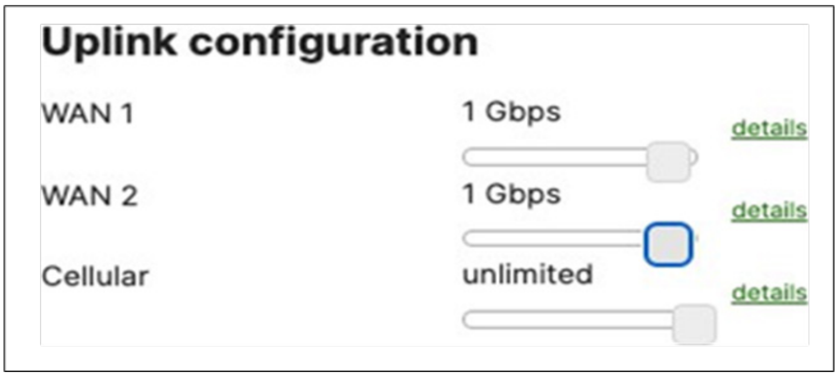
Please note that in order to ping a remote subnet, you must either have BGP enabled or have static routes at the far-end pointing back to the Campus LAN local subnets. (In other words, the source of your traffic which for ping by default is the highest VLAN participating in AutoVPN if not otherwise specified).

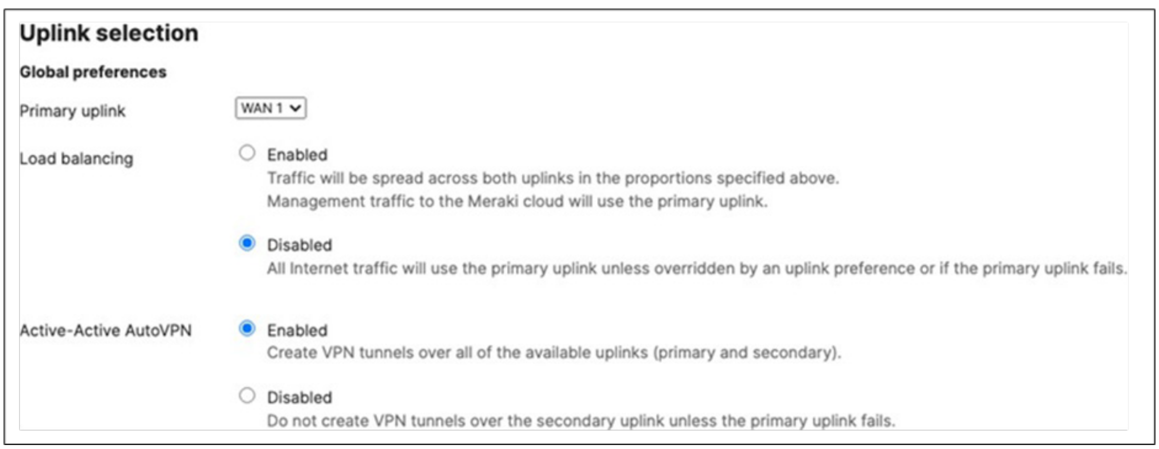
In this example, the VPC in AWS has been configured with a Route Entry to route 10.0.100.0/24 and 10.0.200.0/24 via the vMX deployed in AWS that has a VPN tunnel back to the Campus LAN site.

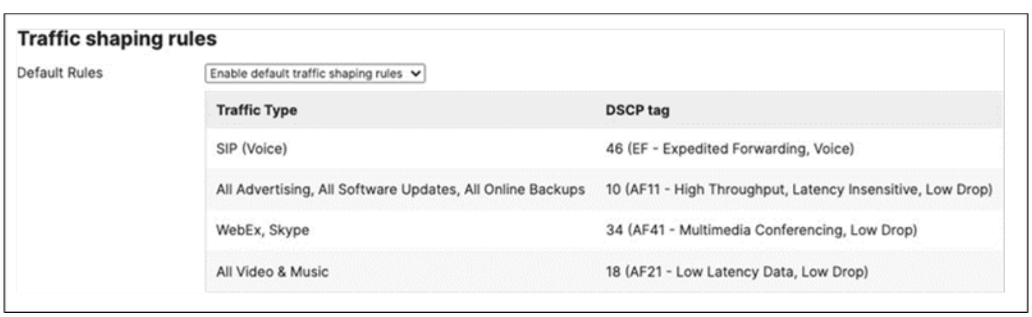
10.0.100.0/24	eni-084dc5077f2b8175c	Active	No
10.0.200.0/24	eni-084dc5077f2b8175c	Active	No
172.31.0.0/16	local	Active	No
0.0.0.0/0	igw-0ada19cb363a89af6	Active	No

If the remote VPN peer (e.g. AWS) is configured in Routed mode, the static route is not required since traffic will always be NAT'd to a local reachable IP address. Please also don't forget to create Network Device groups on Cisco ISE for your network devices to be able to send authentication messages to Cisco ISE. See the below example:

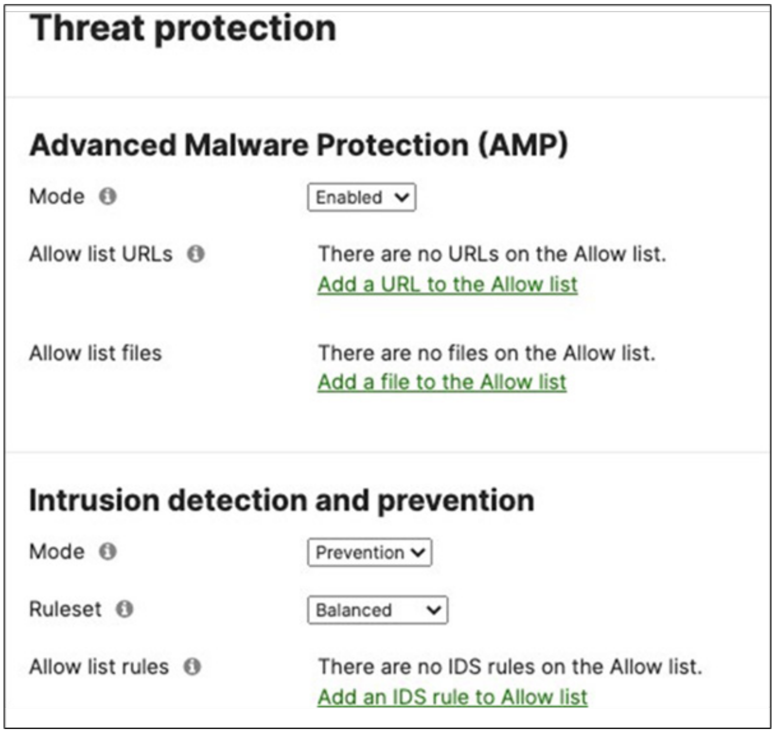
18. **SD-WAN and Traffic Shaping Configuration:** To configure Traffic Shaping settings for your Campus LAN site. Navigate to **Security and SD-WAN > Configure > SD-WAN and Traffic Shaping** to configure your preferred settings. For the purpose of this CVD, the **default traffic shaping rules** will be used to mark traffic with a DSCP tag without policing egress traffic (except for traffic marked with DSCP 46) or applying any traffic limits. (*Please adjust these settings based on your requirements such as traffic limits or priority queue values. For more information about traffic shaping settings on the MX devices, please refer to the following article*).





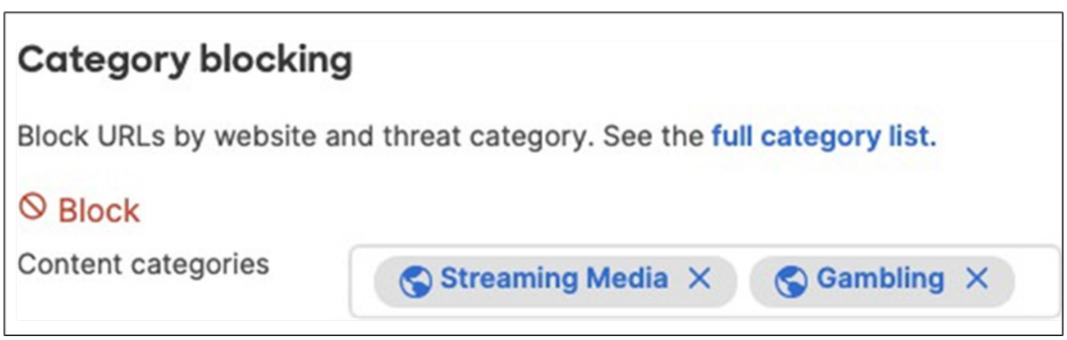


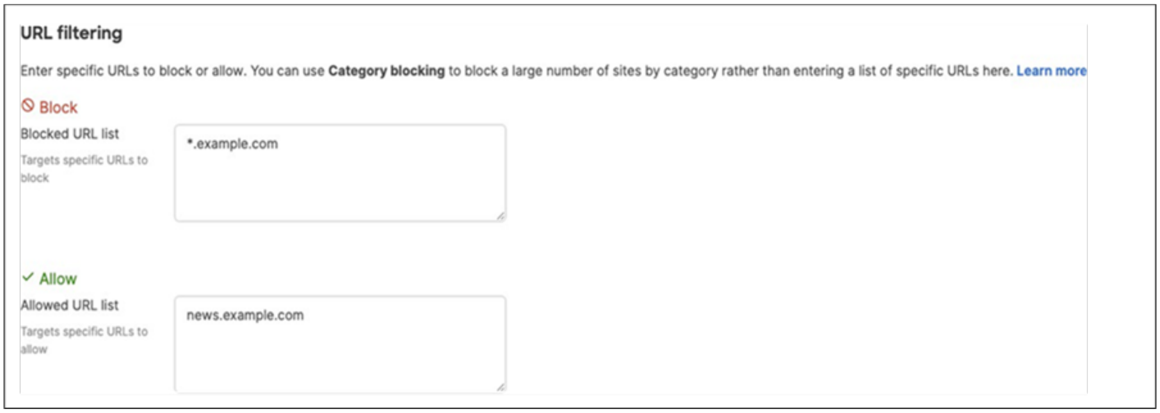
19. *Optional* – Configure [Threat Protection]() (Requires Advanced License or above) for your Campus LAN site. Navigate to **Security and SD-WAN > Configure > Threat Protection** and choose the settings that meet your site requirements. Please see the following configuration example:



20. Click on **Save** at the bottom of the page.

21. *Optional* – Configure [Content Filtering]() Settings (Requires Advanced License or above) for your Campus LAN site. Navigate to **Security and SD-WAN > Configure > Content filtering** and choose the settings that meet your site requirements. Please see the following configuration example:





22. Click on **Save** at the bottom of the page.

23. **Core Switch Uplinks:** On the Catalyst 9500 core switches, Connect their uplinks to the Primary WAN Edge MX and power them both on.

24. **Core Switch Network Access:** Connect to the first C9500 switch via console and configure it with the following commands:

```
Switch>en
Switch#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#hostname 9500-01
9500-01(config)#ip domain name meraki-cvd.local
9500-01(config)#cdp run
9500-01(config)#lldp run
9500-01(config)#stackwise
Please reload the switch for Stackwise Virtual configuration to take effect
Upon reboot, the config will be part of running config but not part of start-up
config. 9500-01(config-stackwise-virtual)#domain 1
9500-01(config)#exit
9500-01(config)#interface Twe1/0/1
9500-01(config-if)#switchport mode trunk
9500-01(config-if)#switchport trunk native vlan 3
9500-01(config-if)#switchport trunk allowed vlan 3,100,200,1923
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface Twe1/0/2
9500-01(config-if)#switchport mode trunkk
9500-01(config-if)#switchport trunk native vlan 3
9500-01(config-if)#switchport trunk allowed vlan 3,100,200,1923
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface vlan 3
```

```
9500-01(config-if)#ip address dhcp
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface vlan 100
9500-01(config-if)#ip address dhcp
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface vlan 200
9500-01(config-if)#ip address dhcp
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface vlan 1923
9500-01(config-if)#ip address 192.168.3.2 255.255.255.0
9500-01(config-if)#no shut
9500-01(config-if)#end
9500-01#
9500-01#sh ip int brief
Interface             IP-Address       OK? Method Status      Protocol
Vlan3                 10.0.3.2         YES DHCP up             up
Vlan100               10.0.100.2       YES DHCP up             up
Vlan200               10.0.200.2       YES DHCP up             up
Vlan1923              192.168.3.2      YES manual up           up
GigabitEthernet0/0    unassigned       YES NVRAM down          down
TwentyFiveGigE1/0/1   unassigned       YES unset up            up
TwentyFiveGigE1/0/2   unassigned       YES unset up            up
9500-01#ping 8.8.8.8
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 8.8.8.8, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/5 ms
9500-01#ping cisco.com
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 72.163.4.185, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 109/109/109 ms
9500-01#switch 1 renumber 1
9500-01#switch priority 5
9500-01#wr mem
Building configuration...
[OK]
```

25. **Core Switch Network Access:** Connect to the second C9500 switch via console and configure it with the following commands:

```
Switch>en
Switch#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#hostname 9500-02
9500-02(config)#ip domain name meraki-cvd.local
9500-01(config)#cdp run
9500-01(config)#lldp run
9500-02(config)#stackwise
Please reload the switch for Stackwise Virtual configuration to take effect
Upon reboot, the config will be part of running config but not part of start-up
config. 9500-02(config-stackwise-virtual)#domain 1
9500-02(config)#exit
9500-02(config)#interface Twe1/0/1
9500-01(config-if)#switchport mode trunk
9500-02(config-if)#switchport trnk native vlan 3
9500-01(config-if)#switchport trunk allowed vlan 3,100,200,1923
9500-02(config-if)#no shut
9500-02(config-if)#exit
9500-02(config)#interface Twe1/0/2
9500-01(config-if)#switchport mode access
9500-02(config-if)#switchport access vlan 3
9500-01(config-if)#switchport trunk allowed vlan 3,100,200,1923
9500-02(config-if)#no shut
9500-02(config-if)#exit
9500-02(config)#interface vlan 3
9500-02(config-if)#ip address dhcp
9500-02(config-if)#no shut
9500-01(config)#interface vlan 100
9500-01(config-if)#ip address dhcp
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface vlan 200
9500-01(config-if)#ip address dhcp
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface vlan 1923
9500-01(config-if)#no shut
9500-01(config-if)#end
9500-01#
```

```
9500-01#sh ip int brief
Interface              IP-Address          OK? Method Status        Protocol
Vlan3                  10.0.3.3            YES DHCP   up            up
Vlan100                10.0.100.3          YES DHCP   up            up
Vlan200                10.0.200.3          YES DHCP   up            up
Vlan1923               unassigned          YES manual up            down
GigabitEthernet0/0     unassigned          YES NVRAM  down          down
TwentyFiveGigE1/0/1    unassigned          YES unset  up            up
TwentyFiveGigE1/0/2    unassigned          YES unset  up            up
9500-02#ping 8.8.8.8
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 8.8.8.8, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/5 ms
9500-02#ping cisco.com
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 72.163.4.185, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 109/109/109 ms
9500-02#switch 1 renumber 2
9500-02#switch priority 1
9500-02#wr mem
Building configuration...
[OK]
```

26. **SVL Configuration:** Now that both C9500 switches have access to the network, proceed to configure the Stackwise Virtual Links per the port list provided above (In this case using two ports for the SVL providing a total stacking bandwidth of 80 Gbps).

```
9500-01(config)#interface HundredGigE1/0/25
9500-01(config-if)#stackwise-virtual link 1
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface HundredGigE1/0/26
9500-01(config-if)#stackwise-virtual link 1
9500-01(config-if)#no shut
9500-01(config-if)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#reload
Proceed with reload? [confirm]
```

```
9500-02(config)#interface HundredGigE1/0/25
9500-02(config-if)#stackwise-virtual link 1
9500-02(config-if)#no shut
9500-02(config-if)#exit
9500-02(config)#interface HundredGigE1/0/26
9500-02(config-if)#stackwise-virtual link 1
9500-02(config-if)#no shut
9500-02(config-if)#end
9500-02#wr mem
Building configuration...
[OK]
9500-02#reload
Proceed with reload? [confirm]
```

27. **Connect Stacking Cables:** Whilst the C9500 switches are reloading, connect the stacking cables on both switches.

28. **Verify Stackwise Configuration:** Please wait for about **10 minutes** for the switches to come back up and initialize the stack. Then, connect to the 9500-01 (*Stack Master*) via console to verify that the stack is operational. The stackwise-virtual link should be **U** (Up) and **R** (Ready).

```
9500-01#show stackwise-virtual
Stackwise Virtual Configuration:
----------------------------
Stackwise Virtual : Enabled
Domain Number : 1

Switch Stackwise Virtual Link Ports
-----------------------------
    1      HundredGigE1/0/25
           HundredGigE1/0/26
    2      HundredGigE2/0/25
           HundredGigE2/0/26
9500-01#
9500-01#show stackwise-virtual link
Stackwise Virtual Link(SVL) Information:
-----------------------------
Flags:
-----
Link Status
-----------
U-Up D-Down
```

```
Protocol Status
-----------
S-Suspended P-Pending E-Error T-Timeout R-Ready
-----------------------------
Switch SVL Ports Link-Status Protocol-Status
---------------------------------------
1     1   HundredGigE1/0/25      U    R
         HundredGigE1/0/26       U    R
2     1   HundredGigE2/0/25      U    R
         HundredGigE2/0/26       U    R

9500-01#
9500-01#show stackwise-virtual bandwidth
Switch Bandwidth
----------------
1    80G
2    80G

9500-01#
9500-01#sh switch
Switch/Stack Mac Address : b0c5.3c60.fba0 - Local Mac Address
Mac persistency wait time: Indefinite
                       H/W Current
Switch#      Role      Mac Address     Priority     Version     State
*1          Active     b0c5.3c60.fba0     5           V02       Ready
2          Standby     40b5.c111.01e0      1          V02       Ready

9500-01#
```

29. *Optional* - Attach and configure stackwise-virtual dual-active-detection: DAD is a feature used to avoid a dual- active situation within a stack of switches. It will rely on a direct attachment link between the two switches to send hello packets and determine if the active switch is responding or not. Please note that DAD **cannot** be applied to any SVL links and has to be a dedicated interface. For the purpose of this CVD, interface HundredGigE1/0/27 and HundredGigE2/0/27 will be used for enabling DAD between the two C9500 switches.

```
9500-01#configure terminal
9500-01(config)#interface HundredGigE1/0/27
9500-01(config-if)#stackwise-virtual dual-active-detection
WARNING: All the extraneous configurations will be removed for HundredGigE1/0/27 on
reboot.
INFO: Upon reboot, the config will be part of running config but not part of start-up
config.
9500-01(config-if)#interface HundredGigE2/0/27
9500-01(config-if)#stackwise-virtual dual-active-detection
WARNING: All the extraneous configurations will be removed for HundredGigE1/0/27 on
reboot.
INFO: Upon reboot, the config will be part of running config but not part of start-up
config. 9500-01(config-if)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#reload
Reload command is being issued on Active unit, this will reload the whole stack
Proceed with reload? [confirm]Connection to 10.0.3.2 closed by remote host.
Connection to 10.0.3.2 closed.
>>
9500-01#sh stackwise-virtual dual-active-detection
In dual-active recovery mode: No
Recovery Reload: Enabled
Dual-Active-Detection Configuration:
-----------------------------------
Switch Dad port Status
----------------------------
1      HundredGigE1/0/27   up
2      HundredGigE2/0/27   up

9500-01#
```

30. Configure [Multiple Spanning Tree Protocol]() (802.1s). Connect to the 9500-01 (*Stack Master*) via console and use the following commands:

```
9500-01(config)#spanning-tree mst configuration
9500-01(config-mst)#instance 0 vlan 3,100,200,1921,1922,1923
9500-01(config-mst)#name region1
9500-01(config-mst)#revision 1
9500-01(config-mst)#exit
9500-01(config)#spanning-tree mode mst
9500-01(config)#spanning-tree mst 0 priority 4096
9500-01(config)#exit
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

31. Verify Spanning Tree Configuration (*Please note that interface Twe2/0/1 will be in STP blocking state due to the fact that both uplinks are connected to the same MX edge device at this stage*).

```
9500-01#show spanning-tree
MST0
  Spanning tree enabled protocol mstp
   Root ID Priority 4096
       Address b0c5.3c60.fba0
       This bridge is the root
       Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
   Bridge ID Priority 4096 (priority 4096 sys-id-ext 0)
       Address b0c5.3c60.fba0
       Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Interface     Role Sts Cost        Prio.Nbr Type
Twe1/0/1     Desg FWD 2000        128.193 P2p
Twe2/0/1     Back BLK 2000        128.385 P2p

9500-01#
```

32. Configure STP Root Guard and UDLD on the Core Stack Downlinks:

```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#int Twe1/0/23
9500-01(config-if)#spanning-tree guard root
9500-01(config-if)#udld port aggressive
9500-01(config-if)#int Twe1/0/24
9500-01(config-if)#spanning-tree guard root
9500-01(config-if)#udld port aggressive
9500-01(config-if)#int Twe2/0/23
9500-01(config-if)#spanning-tree guard root
9500-01(config-if)#udld port aggressive
9500-01(config-if)#int Twe2/0/24
9500-01(config-if)#spanning-tree guard root
9500-01(config-if)#udld port aggressive
9500-01(config-if)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

33. *Optional* **- STP Hygiene**: It is recommended to configure **STP Root Guard** on all C9500 Core Stack downlinks to avoid any new introduced downstream switches from claiming root bridge status.

```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#define interface-range stp-protect TwentyFiveGigE1/0/3 - 22
9500-01(config)#interface range macro stp-protect
9500-01(config-if-range)#spanning-tree guard root
9500-01(config-if-range)#exit
9500-01(config)#define interface-range stp-protect2 TwentyFiveGigE2/0/3 - 22
9500-01(config)#interface range macro stp-protect2
9500-01(config-if-range)#spanning-tree guard root
9500-01(config-if)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

34. *Optional* **- STP Hygiene**: It is recommended to configure **STP Loop Guard** on all C9500 Core Stack **un-used stacking links.**

```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#interface HundredGigE1/0/27
9500-01(config-if)#spanning-tree guard loop
9500-01(config-if-range)#exit
9500-01(config)#interface HundredGigE1/0/28
9500-01(config-if)#spanning-tree guard loop
9500-01(config-if)#exit
9500-01(config)#interface HundredGigE2/0/27
9500-01(config-if)#spanning-tree guard loop
9500-01(config-if-range)#exit
9500-01(config)#interface HundredGigE2/0/28
9500-01(config-if)#spanning-tree guard loop
9500-01(config-if)#end
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

35. Configure **SVIs** for your Campus LAN on the Core Stack:

```
9500-01(config)#interface vlan 1921
9500-01(config-if)#ip address 192.168.1.1 255.255.255.0
9500-01(config-if)#no shut
9500-01(config-if)#interface vlan 1922
9500-01(config-if)#ip address 192.168.2.1 255.255.255.0
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#ip dhcp pool vlan100
9500-01(dhcp-config)#network 10.0.100.0 /24
9500-01(dhcp-config)#default-router 10.0.100.1
9500-01(dhcp-config)#dns-server 208.67.222.222 208.67.220.220
9500-01(dhcp-config)#ip dhcp pool vlan200
9500-01(dhcp-config)#network 10.0.200.0 /24
9500-01(dhcp-config)#default-router 10.0.200.1
9500-01(dhcp-config)#dns-server 208.67.222.222 208.67.220.220
9500-01(dhcp-config)#end
9500-01#wr mem
Building configuration...
```

```
[OK]
9500-01#
```

36. Verify your DHCP pool configuration:

```
9500-01#sh ip dhcp pool
Pool vlan100 :
Utilization mark (high/low) : 100 / 0
Subnet size (first/next) : 0 / 0
Total addresses 254
Leased addresses 0
Excluded addresses 0
Pending event : none
1 subnet is currently in the pool :
Current index    IP address range                Leased/Excluded/Total
10.0.100.1        10.0.100.1 - 10.0.100.254         0 / 0 / 254

Pool vlan200 :
Utilization mark (high/low) : 100 / 0
Subnet size (first/next) : 0 / 0
Total addresses 254
Leased addresses 0
Excluded addresses 0
Pending event : none
1 subnet is currently in the pool :
Current index     IP address range                Leased/Excluded/Total
10.0.100.1        10.0.100.1 - 10.0.100.254         0 / 0 / 254
9500-01#
```

37. Verify your SVI configuration:

```
9500-01#sh ip int brief | in Vlan
Vlan3              10.0.3.113      YES DHCP up        up
Vlan100            10.0.100.2      YES DHCP up        up
Vlan200            10.0.200.2      YES DHCP up        up
Vlan1921           192.168.1.1     YES manual up      down
Vlan1922           192.168.2.1     YES manual up      down
Vlan1923           192.168.3.2      YES manual up     up
9500-01#
```

38. Configure **Layer 2 Switchports**, **SGTs,** and **CST** (Cisco TrustSec) on your Core Stack interfaces. (*Please note that enforcement has been disabled on downlink ports allowing it to happen downstream*)

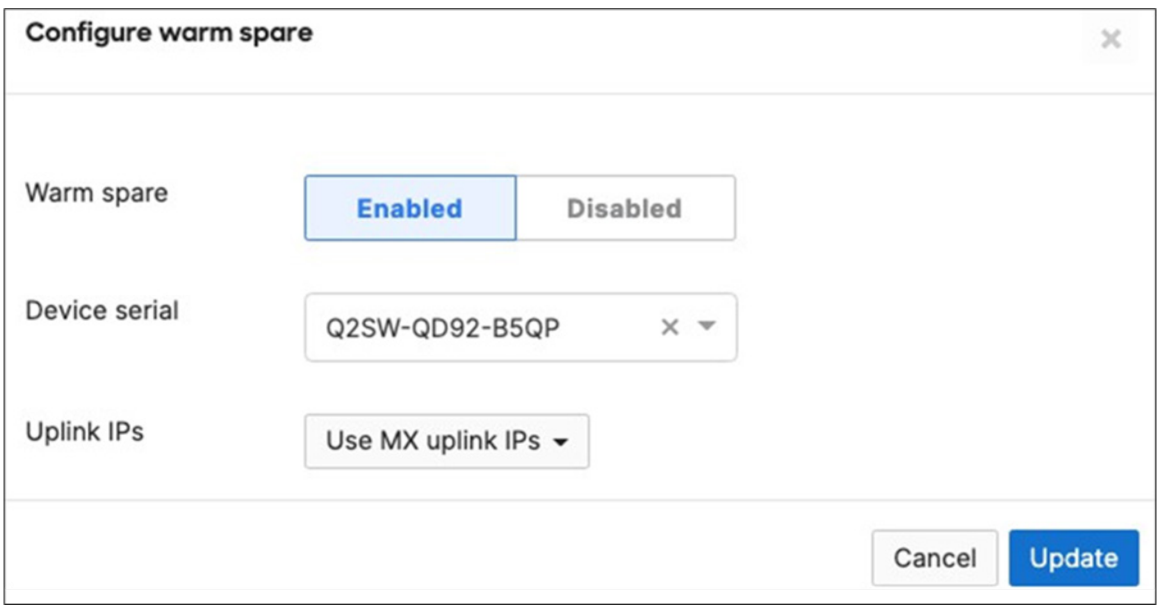
```
9500-01#conf t
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#cts sgt 2
9500-01(config)#cts role-based enforcement vlan-list 3,11,12,21,22,30,40,100,200
9500-01(config)#ip access-list role-based Allow_All
9500-01(config-rb-acl)#permit ip
9500-01(config-rb-acl)#exit
9500-01(config)#cts role-based permissions default Allow_All
9500-01(config)#interface TwentyFiveGigE1/0/23
9500-01(config-if)#switchport mode trunk
9500-01(config-if)#switchport trunk native vlan 100
9500-01(config-if)#switchport trunk allowed vlan 100,1921
9500-01(config-if)#no cts role-based enforcement
9500-01(config-if)#cts manual
9500-01(config-if-cts-manual)#propagate sgt
9500-01(config-if-cts-manual)#policy static sgt 2 trusted
9500-01(config)#interface TwentyFiveGigE1/0/24
9500-01(config-if)#switchport mode trunk
9500-01(config-if)#switchport trunk native vlan 200
9500-01(config-if)#switchport trunk allowed vlan 200,1922
9500-01(config-if)#no cts role-based enforcement
9500-01(config-if)#cts manual
9500-01(config-if-cts-manual)#propagate sgt
9500-01(config-if-cts-manual)#policy static sgt 2 trusted
9500-01(config)#interface TwentyFiveGigE2/0/23
9500-01(config-if)#switchport mode trunk
9500-01(config-if)#switchport trunk native vlan 100
9500-01(config-if)#switchport trunk allowed vlan 100,1921
9500-01(config-if)#no cts role-based enforcement
9500-01(config-if)#cts manual
9500-01(config-if-cts-manual)#propagate sgt
9500-01(config-if-cts-manual)#policy static sgt 2 trusted
9500-01(config)#interface TwentyFiveGigE2/0/24
9500-01(config-if)#switchport mode trunk
9500-01(config-if)#switchport trunk native vlan 200
9500-01(config-if)#switchport trunk allowed vlan 200,1922
9500-01(config-if)#no cts role-based enforcement
9500-01(config-if)#cts manual
9500-01(config-if-cts-manual)#propagate sgt
```

```
9500-01(config-if-cts-manual)#policy static sgt 2 trusted
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

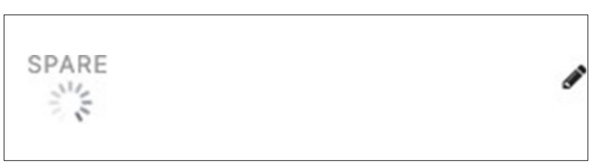
39. **Spare WAN Edge Connectivity:** Follow these steps to create warm-spare with two MX appliances: (*Please note that this might result in a brief interruption of packet forwarding on the MX Appliance*)

- Navigate to **Security and SD-WAN > Monitor > Appliance status** and click on **Configure warm spare**

- Now click on Enabled then choose the Spare MX from the drop-down menu and then choose the Uplink IP option that suits your requirements (Please note that choosing Virtual IPs requires an additional IP address on the upstream network and a single broadcast domain between the two MXs) then click on **Update**



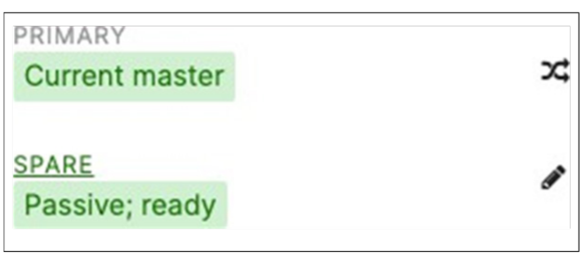
- Now click on **Spare** to access the Appliance status page of your Spare MX and click on the Edit button to rename the spare unit (e.g. Secondary WAN Edge)

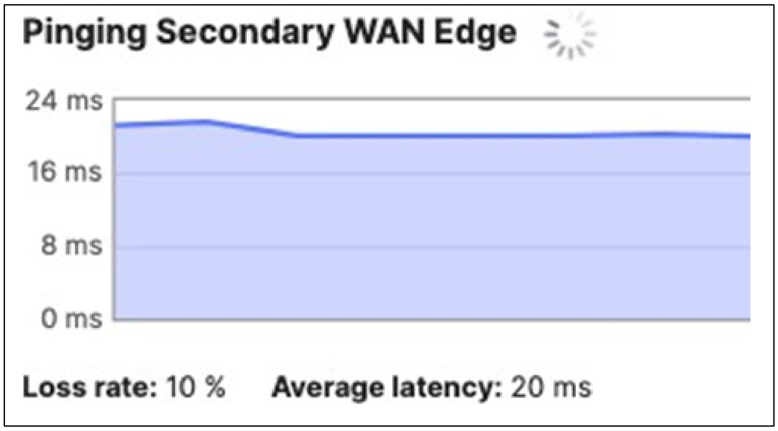


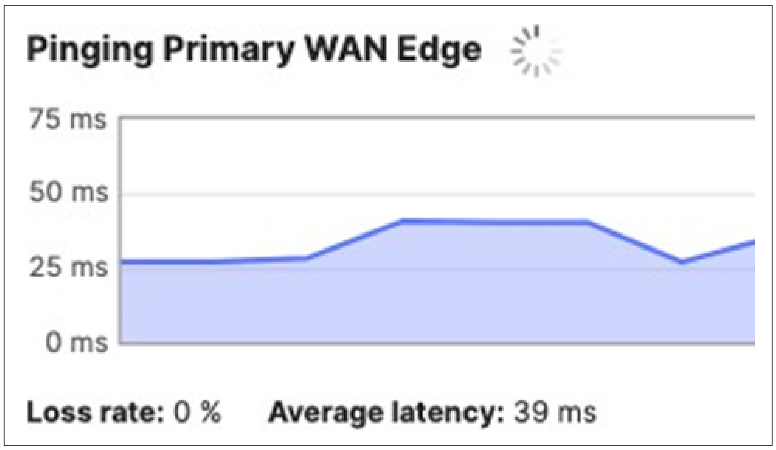
- Then configure the following on your C9500 Core Stack:

```
9500-01#configure terminal
9500-01(config)#interface Twe1/0/2
9500-01(config-if)#switchport mode trunk
9500-01(config-if)#switchport trunk native vlan 3
9500-01(config-if)#switchport trunk allowed vlan 3,100,200,1923
9500-01(config-if)#no shut
9500-01(config-if)#exit
9500-01(config)#interface Twe2/0/2
9500-01(config-if)#switchport mode access
9500-01(config-if)#switchport trunk native vlan 3
9500-01(config-if)#switchport trunk allowed vlan 3,100,200,1923
9500-01(config-if)#no shut
9500-01(config-if)#end
9500-01#wr mem
Building configuration...
[OK]
```

- Then connect the Spare MX downlinks to your C9500 Core Stack (e.g. Spare MX port 19 to Twe1/0/2 and port 20 to Twe2/0/2)
- Then connect the Spare MX with its uplinks (*This must match the uplink configuration on your Primary WAN Edge*)
- Power on the Spare MX and wait for it to come online on dashboard





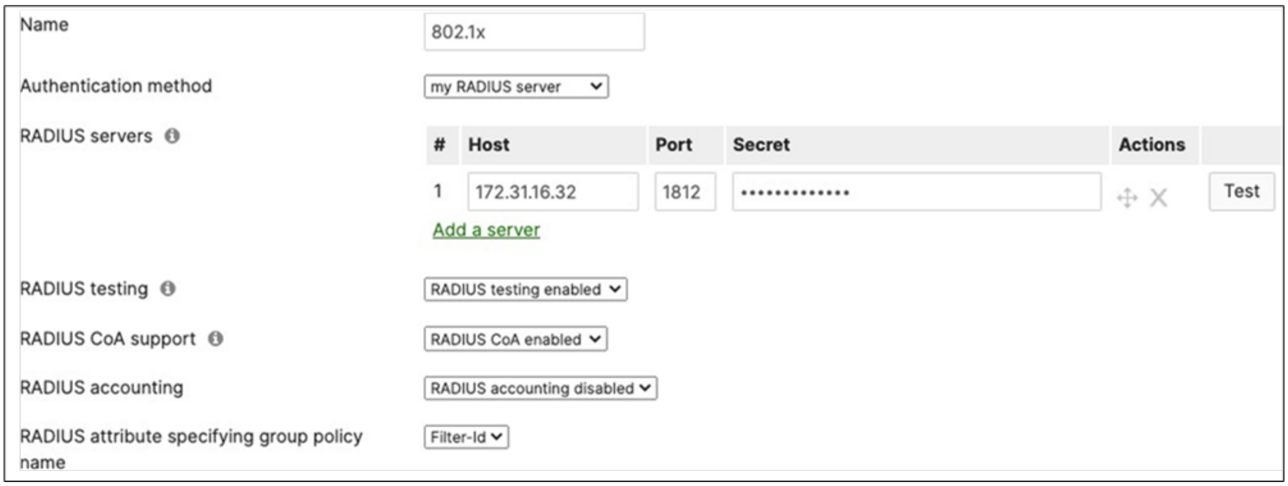


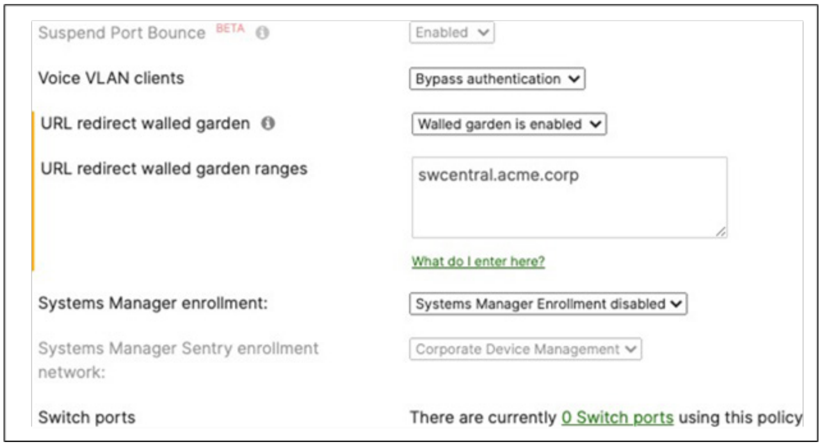
- You can also verify that your C9500 Core Stack interfaces to the Spare MX are up, and that the redundant uplinks are in STP BLK mode

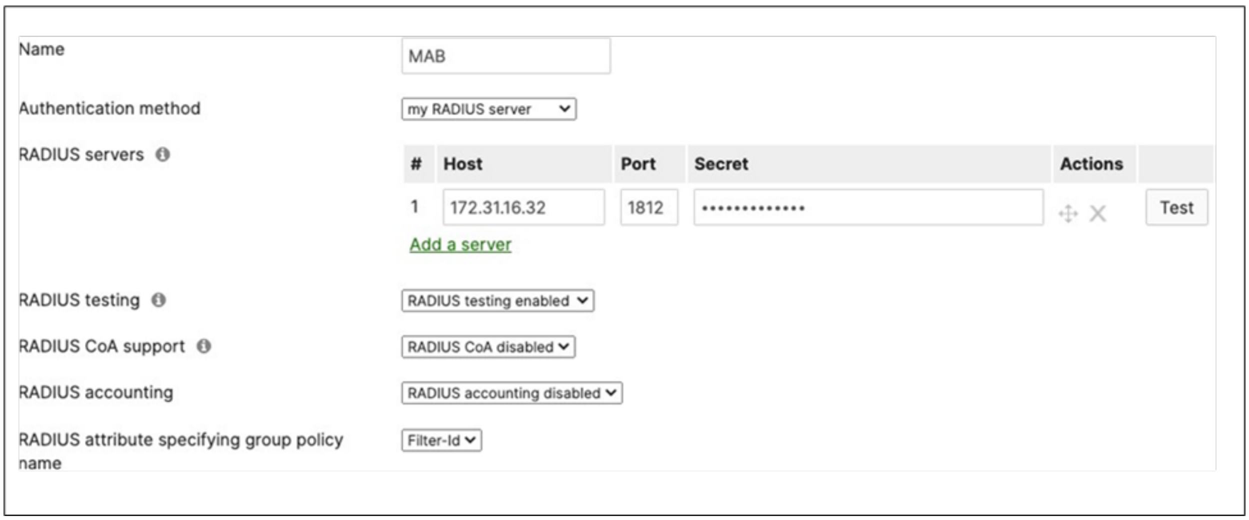
```
9500-01#sh ip interface brief
Interface             IP-Address         OK? Method      Status
TwentyFiveGigE1/0/2   unassigned         YES unset up    up
TwentyFiveGigE2/0/2   unassigned         YES unset up    up
9500-01#
9500-01#show spanning-tree
MST0
Spanning tree enabled protocol mstp
Root ID    Priority    4096
        Address b0c5.3c60.fba0
        This bridge is the root
        Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Bridge ID Priority  4096 (priority 4096 sys-id-ext 0)
        Address b0c5.3c60.fba0
        Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Interface     Role Sts Cost     Prio.Nbr Type
Twe1/0/1      Desg FWD 2000     128.193 P2p
```

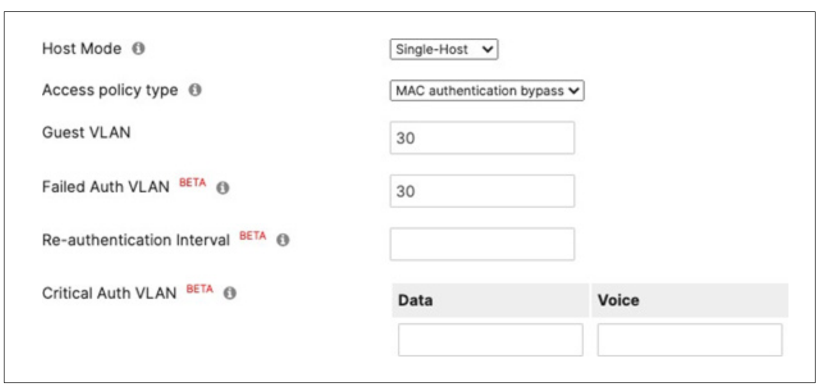
```
Twe1/0/2      Desg FWD 2000    128.194 P2p
Twe2/0/1      Back BLK 2000    128.385 P2p
Twe2/0/2      Back BLK 2000    128.386 P2p

9500-01#
```

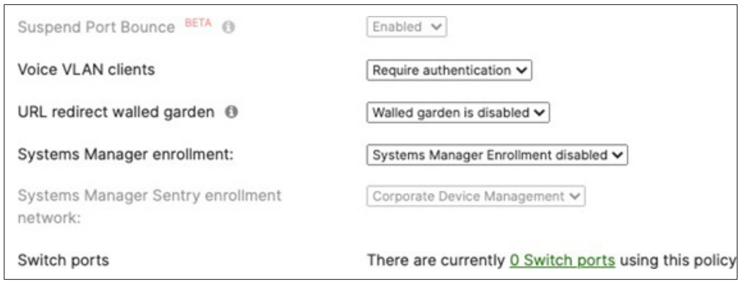
40. **Access Policy configuration:** When you're logged in dashboard, Navigate to **Switching > Configure > Access policies** to configure Access Policies as required for your Campus LAN. Please see the following example for two Access Policies; **802.1x and MAB.**



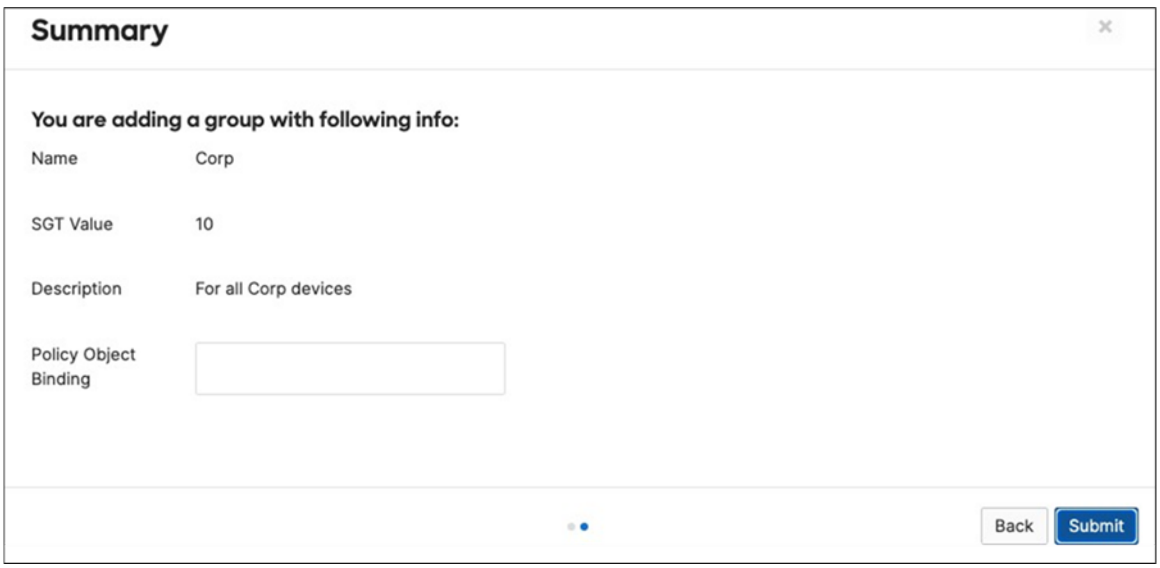

Suspend Port Bounce BETA
Enabled
Voice VLAN clients
Bypass authentication
URL redirect walled garden
Walled garden is enabled
URL redirect walled garden ranges
swcentral.acme.corp
What do I enter here?
Systems Manager enrollment:
Systems Manager Enrollment disabled
Systems Manager Sentry enrollment network:
Corporate Device Management
Switch ports
There are currently 0 Switch ports using this policy

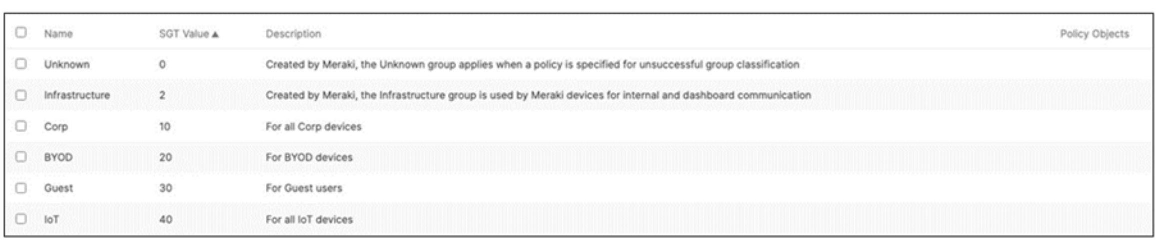

Name
MAB
Authentication method
my RADIUS server
RADIUS servers
Host Port Secret Actions
1 172.31.16.32 1812 ••••••••••••• Test
Add a server
RADIUS testing
RADIUS testing enabled
RADIUS CoA support
RADIUS CoA disabled
RADIUS accounting
RADIUS accounting disabled
RADIUS attribute specifying group policy name
Filter-Id


Host Mode
Single-Host
Access policy type
MAC authentication bypass
Guest VLAN
30
Failed Auth VLAN BETA
30
Re-authentication Interval BETA
Critical Auth VLAN BETA
Data Voice



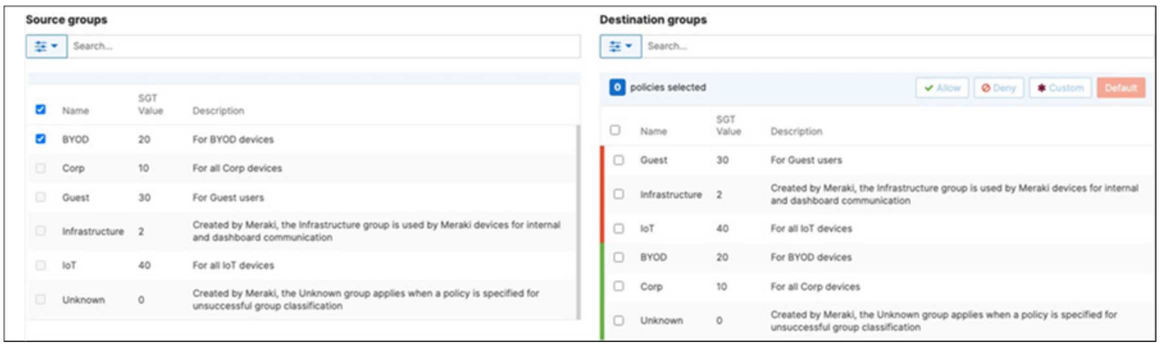
41. **Adaptive Policy Configuration:** Configure Adaptive Policy for your Campus LAN. When you're logged in dashboard, Navigate to **Organization > Configure > Adaptive Policy** then click on the **Groups** tab on the top. There should be two groups (Unknown, Infrastructure) that are already available. Click on **Add group** to add *each* group required for your Campus LAN. You need to fill in the Name, the SGT value, and a description then click on **Review changes** then click on **Submit**. Please see the following examples.

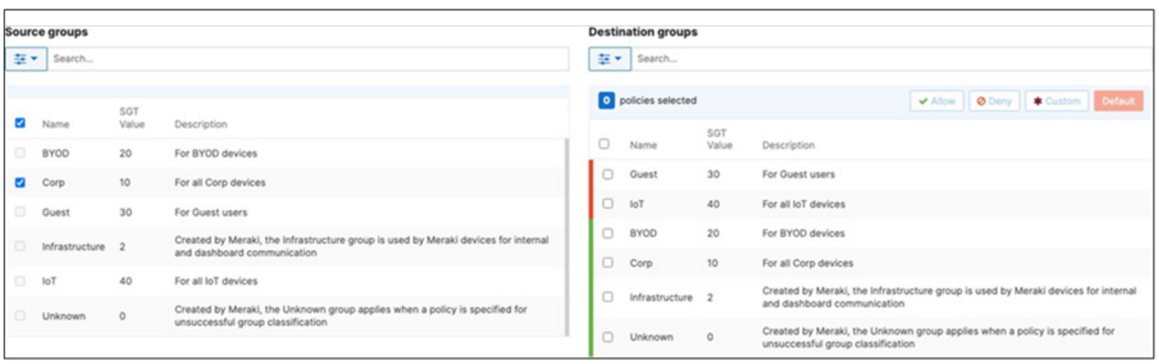


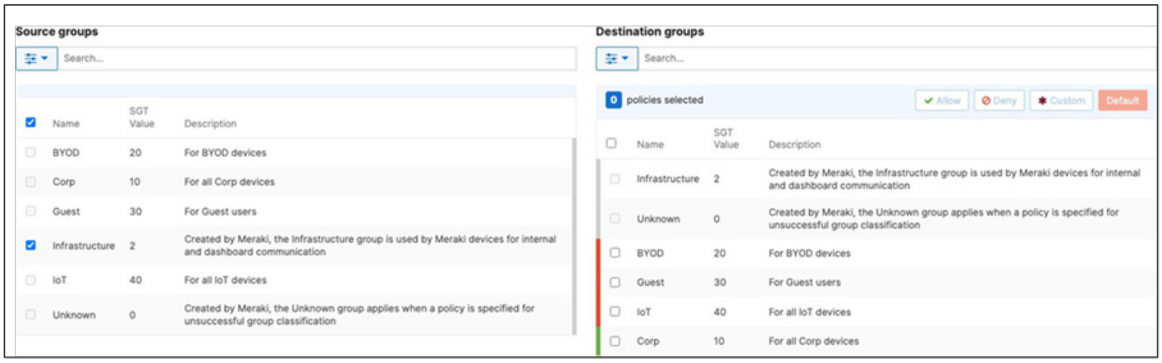


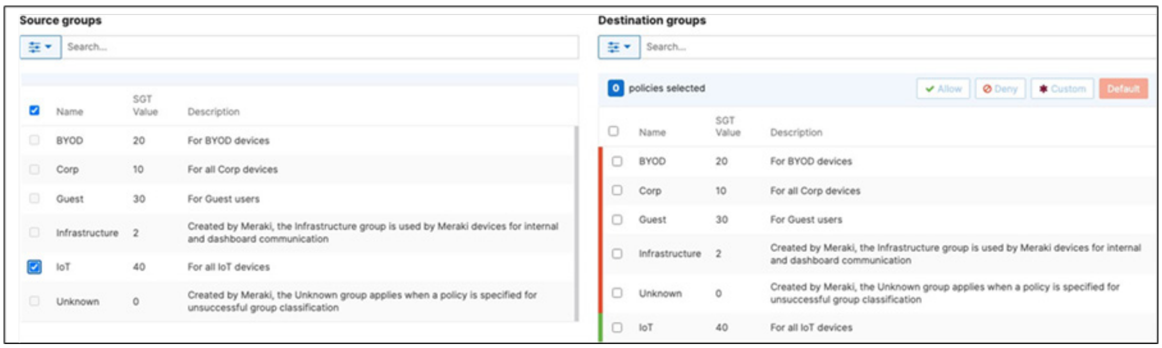
Name	SGT Value ▲	Description	Policy Objects
Unknown	0	Created by Meraki, the Unknown group applies when a policy is specified for unsuccessful group classification	
Infrastructure	2	Created by Meraki, the Infrastructure group is used by Meraki devices for internal and dashboard communication	
Corp	10	For all Corp devices	
BYOD	20	For BYOD devices	
Guest	30	For Guest users	
IoT	40	For all IoT devices	

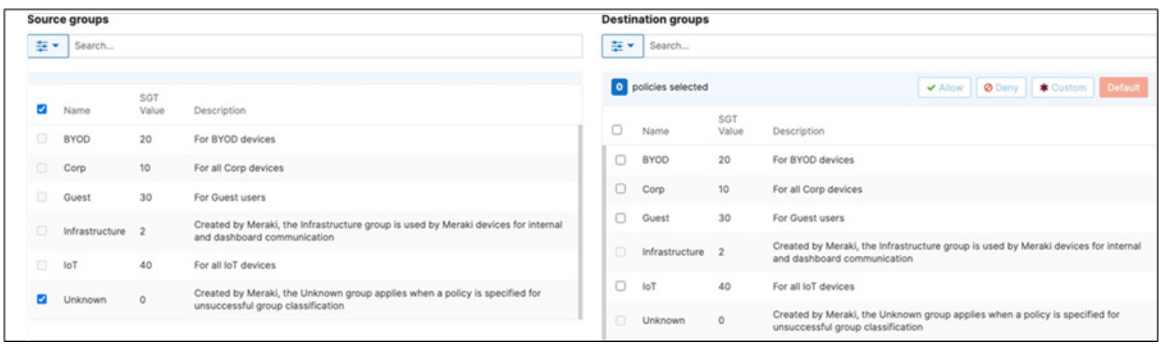
42. **Adaptive Policy Configuration:** Configure Adaptive Policy for your Campus LAN. When you're logged in dashboard, Navigate to **Organization > Configure > Adaptive Policy** then click on the **Policies** tab on the top. The source groups are on the left side, and the destination groups are on the right side. Select a source group from the left side then select all destination groups on the right side that should be allowed then click on **Allow** and click on **Save** at the bottom of the page. Next, select a source group from the left side then select all destination groups on the right side that should be denied (i.e. Blocked) then click on **Deny** and click on **Save** at the bottom of the page. After creating the policy for that specific source group, the allowed destination groups will be displayed with a green tab and the denied destination groups will be displayed with a red tab. Repeat this step for all policies required for all Groups (Allow and Deny).



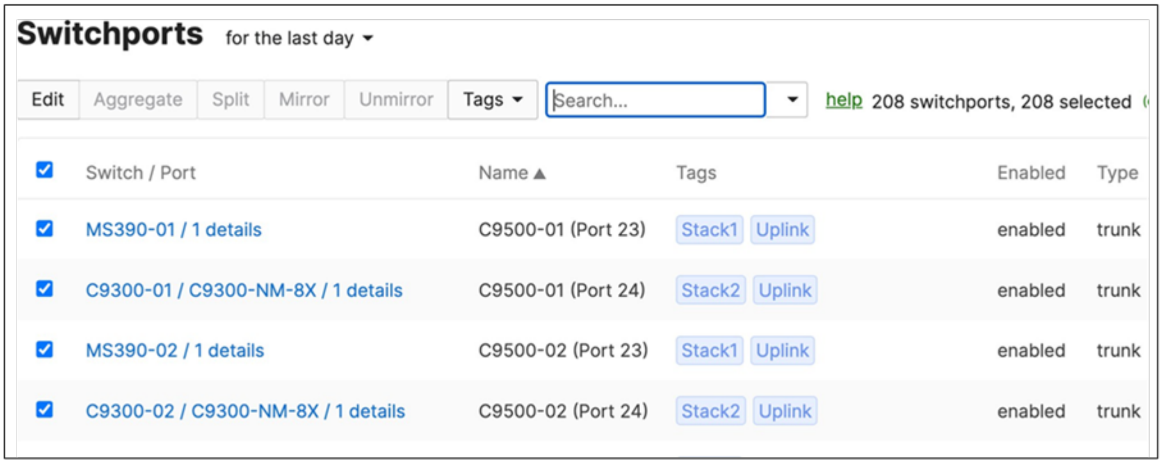








43. **Access Switch Ports Preparation:** MS390 switches support a maximum of 1000 configured VLANs and given that the default configuration has all switchports in Trunk mode with Native VLAN 1 and allowed VLANs 1-1000 (consuming the 1000 limit already), Dashboard will not allow for the configuration of this design to be saved (i.e. configuring VLAN 1921/1922 as this will breach the 1000 VLANs limit). As such, ports will need to be configured with a different range or VLAN set other than the default settings before applying the configuration needed for this design. It is therefore recommended to configure ALL ports in your network as access in a parking VLAN such as 999. To do that, Navigate to **Switching > Monitor > Switch ports** then select all ports (Please be mindful of the page overflow and make sure to browse the different pages and apply configuration to ALL ports) and then make sure to **deselect** stacking ports (*as you cannot change configuration on dedicated stacking ports*) then click on the **Edit** button and configure all ports as shown below:

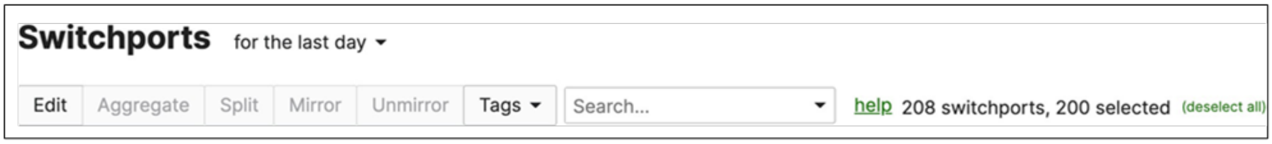

Switchports for the last day
Edit Aggregate Split Mirror Unmirror Tags
Search...
help 208 switchports, 208 selected
Switch / Port Name Tags Enabled Type
MS390-01 / 1 details C9500-01 (Port 23) Stack1 Uplink enabled trunk
C9300-01 / C9300-NM-8X / 1 details C9500-01 (Port 24) Stack2 Uplink enabled trunk
MS390-02 / 1 details C9500-02 (Port 23) Stack1 Uplink enabled trunk
C9300-02 / C9300-NM-8X / 1 details C9500-02 (Port 24) Stack2 Uplink enabled trunk

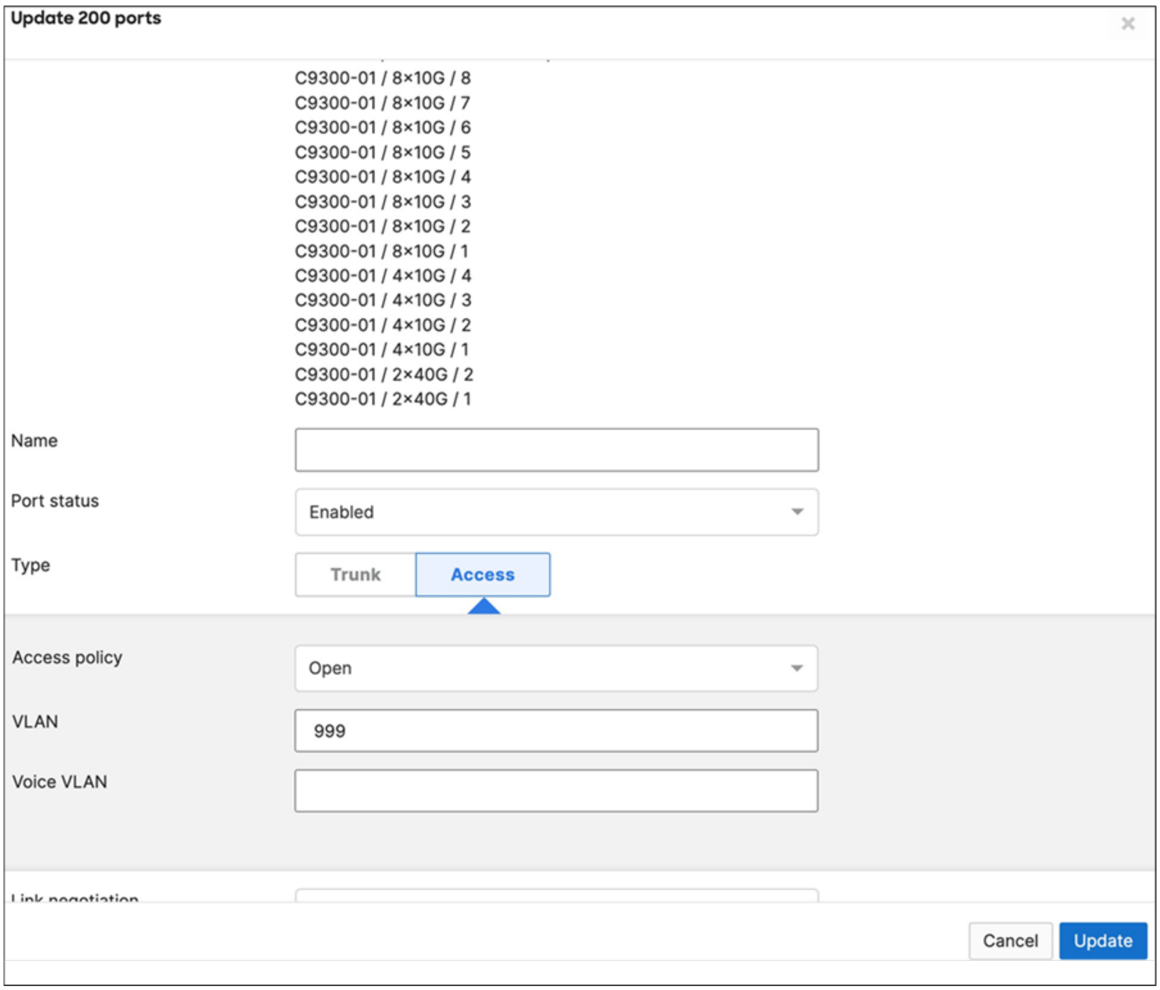

MS390-02 / Dedicated stack port 2 details
MS390-02 / Dedicated stack port 1 details


MS390-01 / Dedicated stack port 2 details
MS390-01 / Dedicated stack port 1 details


C9300-01 / Dedicated stack port 2 details
C9300-01 / Dedicated stack port 1 details

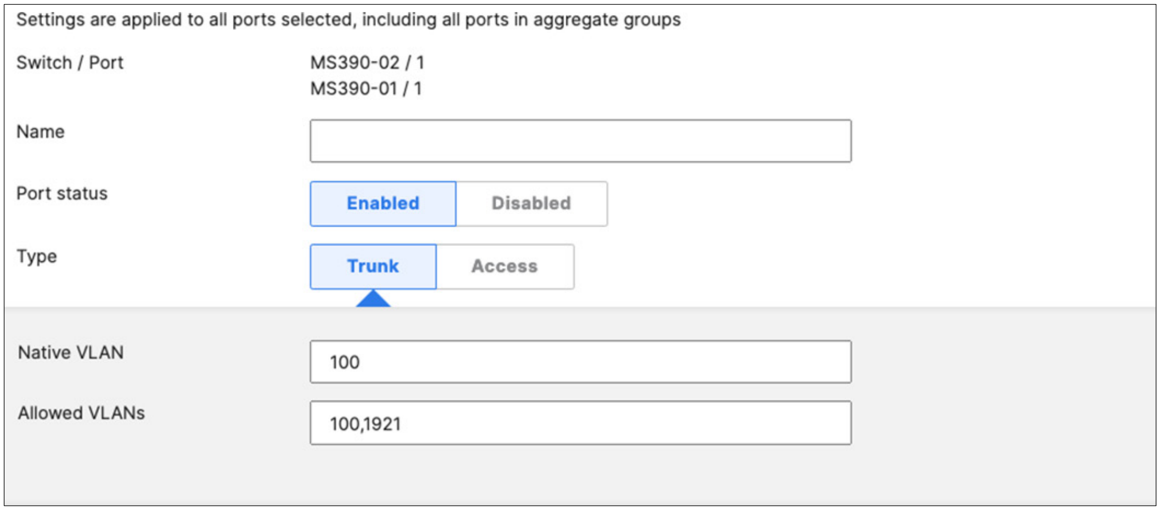

1 2

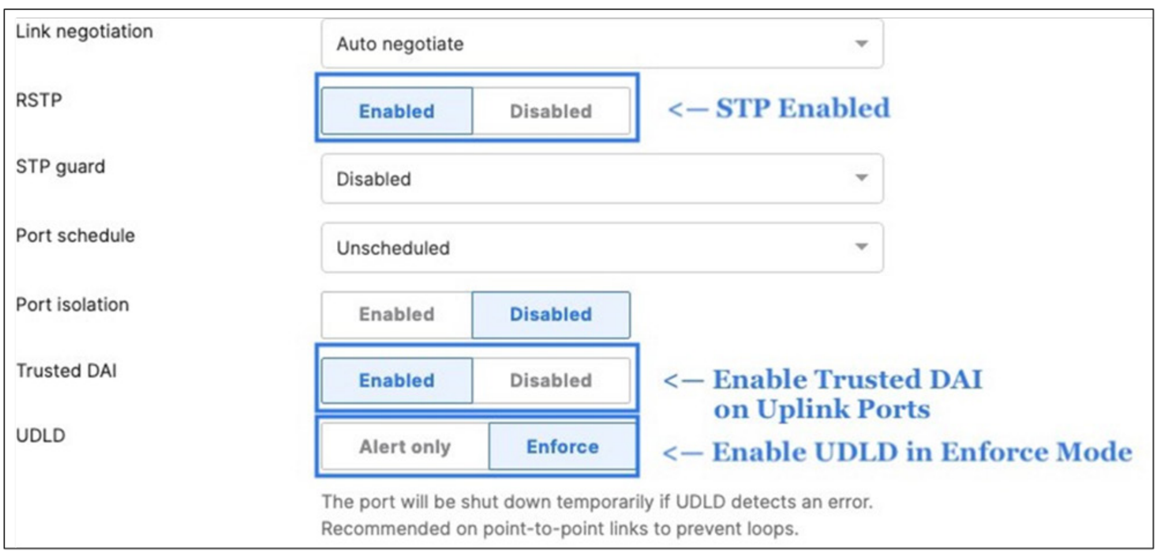


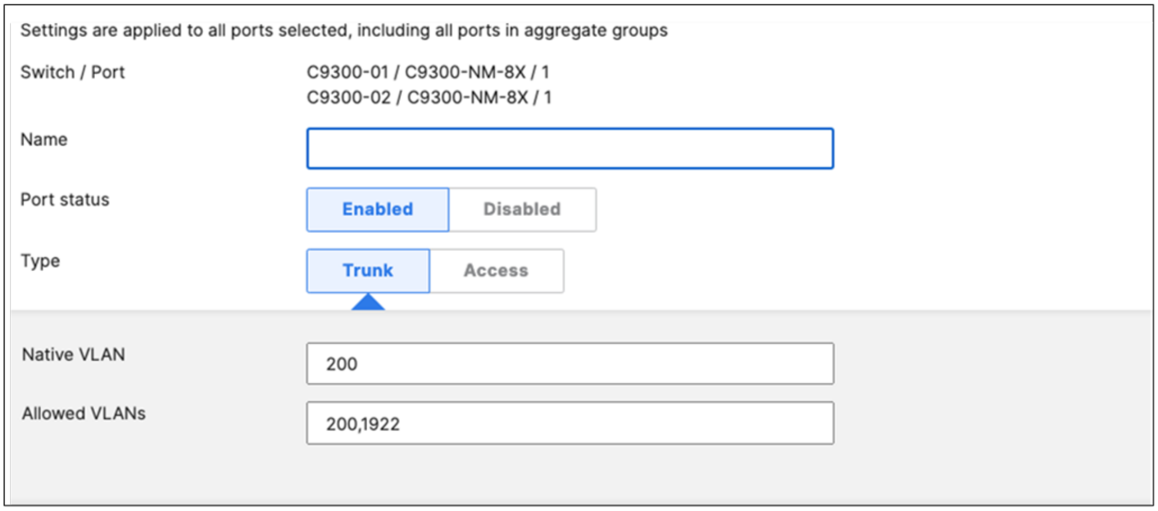


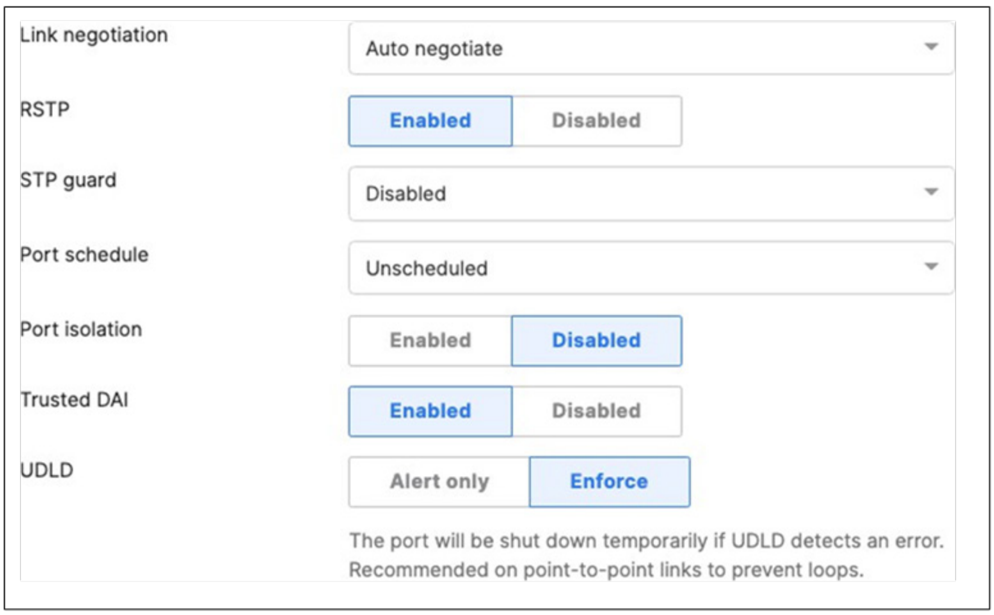
- **IMPORTANT** - The above step is **essential** before proceeding to the next steps. If you proceed to the next step and receive an error on Dashboard then it means that some switchports are still configured with the default configuration. Please revisit the **Switching > Monitor > Switch ports** page and ensure that no ports have a Trunk with allowed VLANs 1-1000

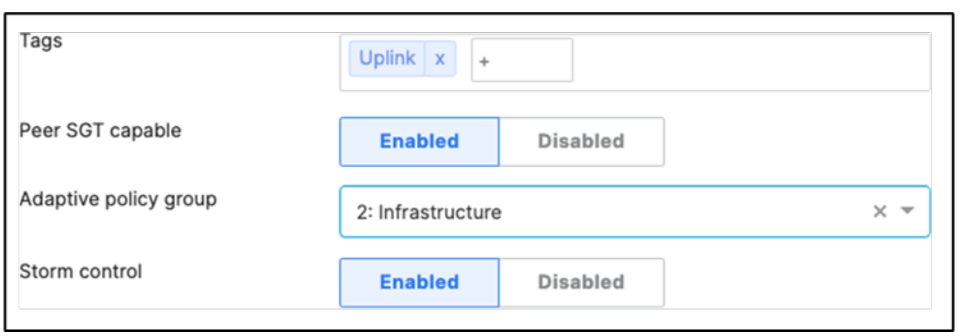
44. **Access Switch Ports Configuration:** Configure **Uplink Ports** on your Access Switches. When you're logged in dashboard, Navigate to **Switching > Monitor > Switch ports**, then select your uplink ports and configure them as shown below. (Tip: You can filter for ports by using search terms in dashboard):






Settings are applied to all ports selected, including all ports in aggregate groups
Switch / Port
C9300-01 / C9300-NM-8X / 1
C9300-02 / C9300-NM-8X / 1
Name
Port status
Enabled
Disabled
Type
Trunk
Access
Native VLAN
200
Allowed VLANs
200,1922

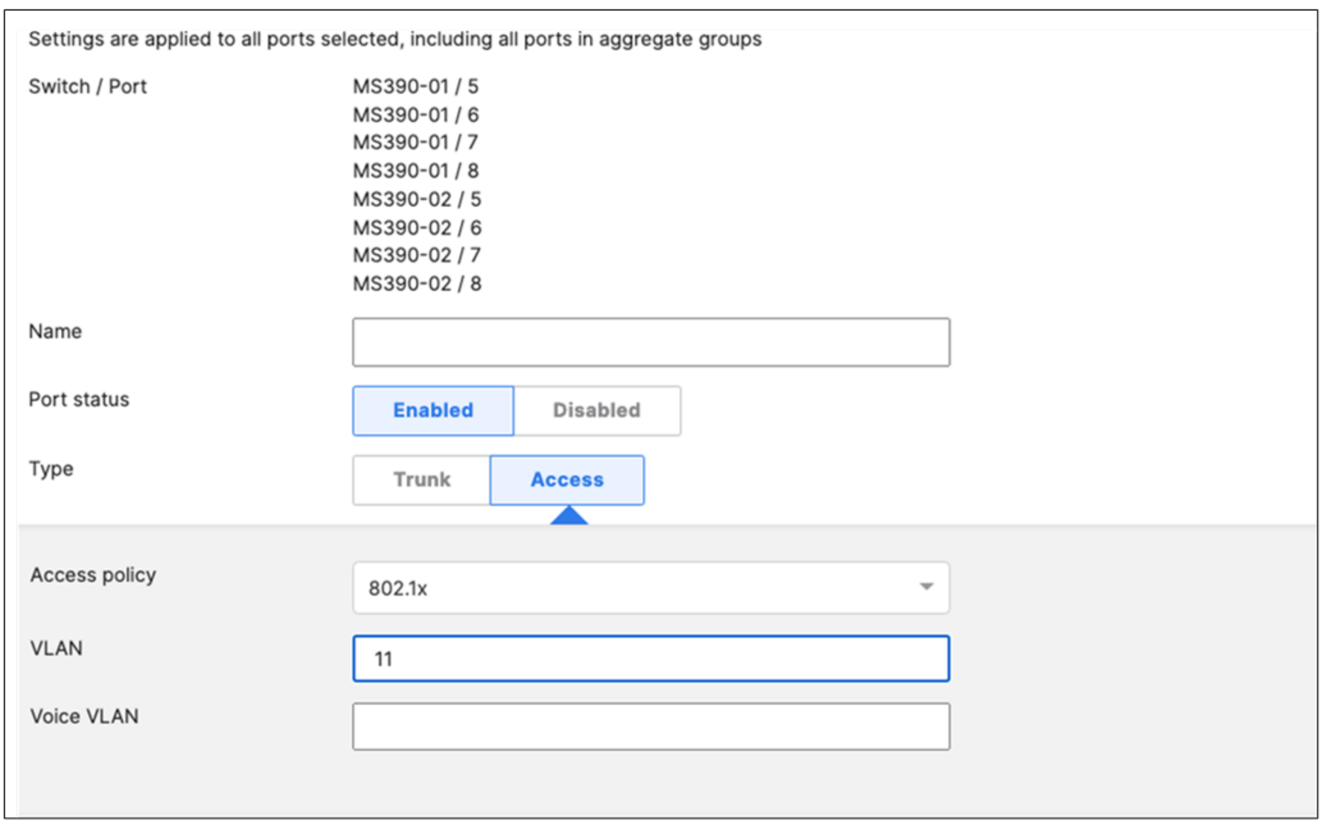

Link negotiation
Auto negotiate
RSTP
Enabled
Disabled
STP guard
Disabled
Port schedule
Unscheduled
Port isolation
Enabled
Disabled
Trusted DAI
Enabled
Disabled
UDLD
Alert only
Enforce
The port will be shut down temporarily if UDLD detects an error.
Recommended on point-to-point links to prevent loops.

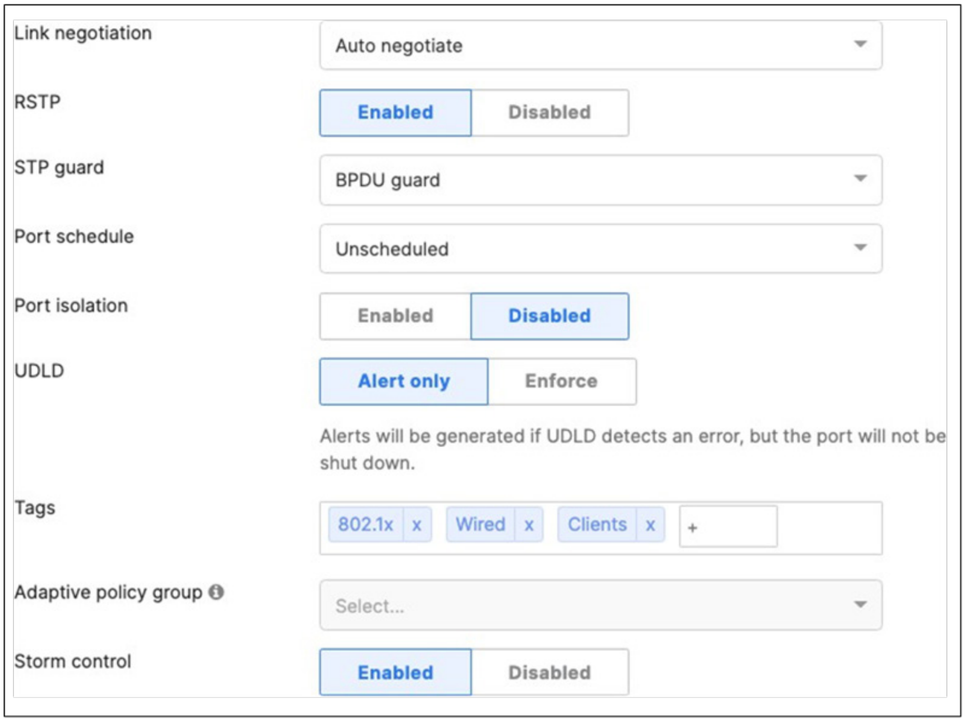

Tags
Uplink x
+
Peer SGT capable
Enabled
Disabled
Adaptive policy group
2: Infrastructure
Storm control
Enabled
Disabled

45. *Optional* – For ease of management, it is recommended that you rename the ports connecting to your Core switches with the actual switch name / Connecting port as shown below.

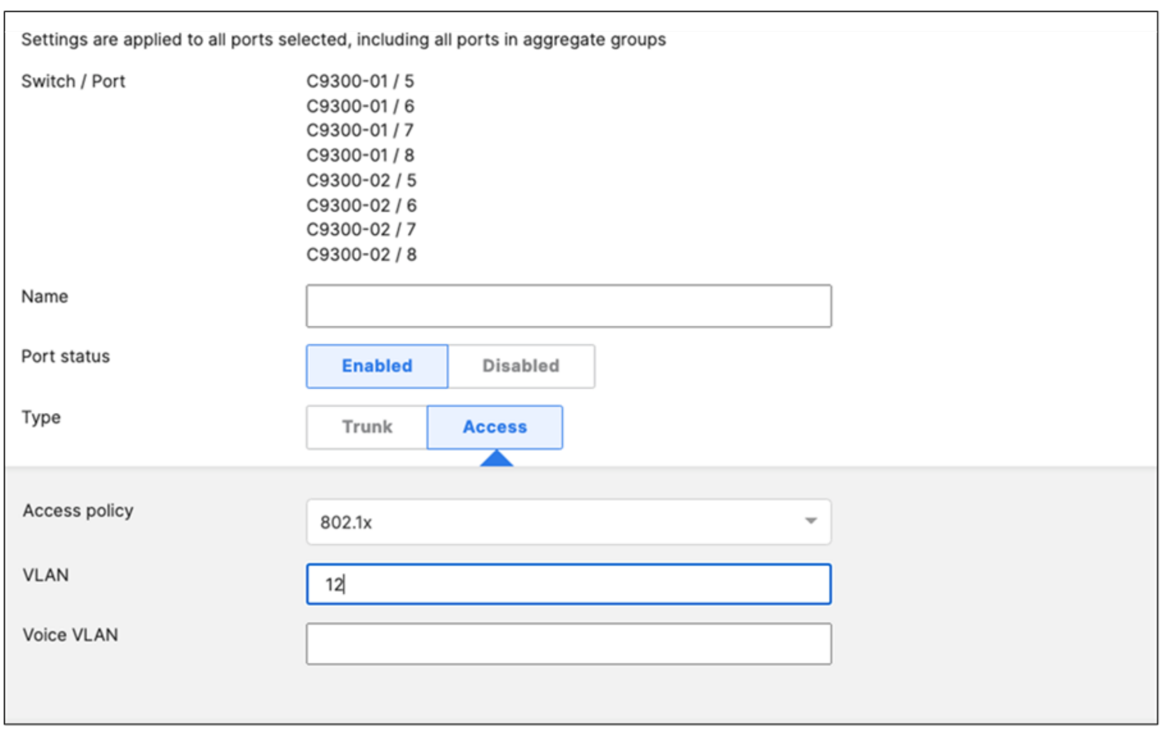
	Switch / Port	Name ▲	Tags	Enabled	Type	VLAN	Allowed VLANs
☐	MS390-01 / 1 details	C9500-01 (Port 23)	Stack1 Uplink	enabled	trunk	native 100	100,1921
☐	C9300-01 / C9300-NM-8X / 1 details	C9500-01 (Port 24)	Stack2 Uplink	enabled	trunk	native 200	200,1922
☐	MS390-02 / 1 details	C9500-02 (Port 23)	Stack1 Uplink	enabled	trunk	native 100	100,1921
☐	C9300-02 / C9300-NM-8X / 1 details	C9500-02 (Port 24)	Stack2 Uplink	enabled	trunk	native 200	200,1922

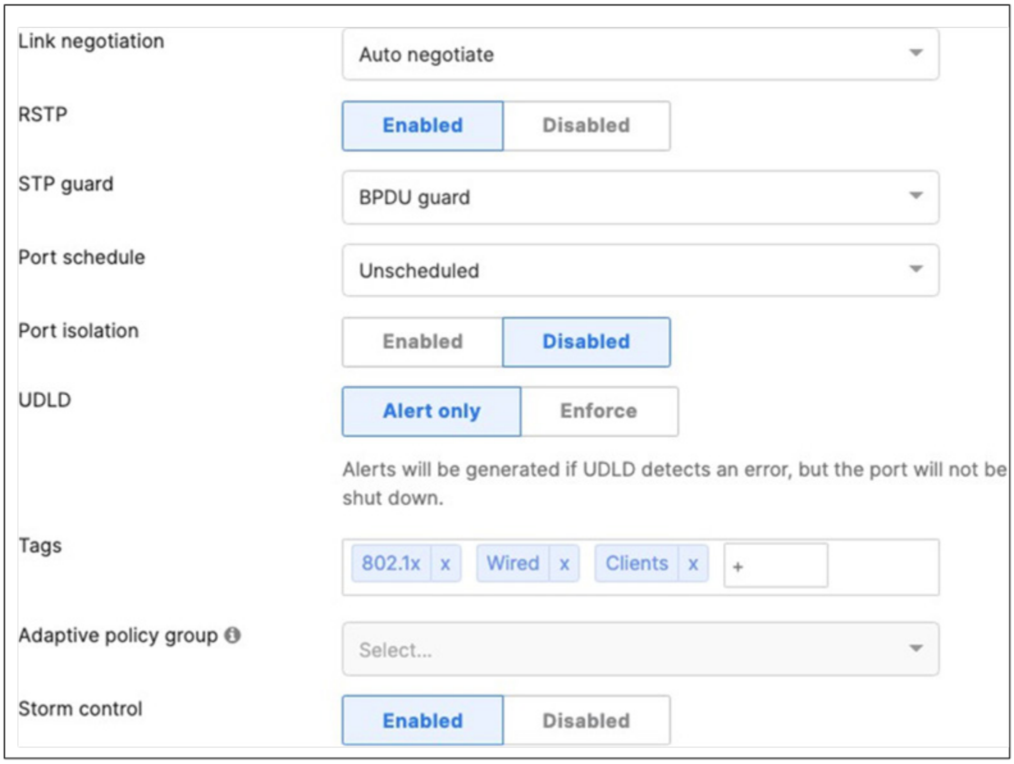
46. **Access Switch Ports Configuration:** Configure **Wired Client Ports (802.1x)** on your Access Switches. Navigate to or Refresh **Switching > Monitor > Switch Ports**, then select your Wired Client ports (5-8) and configure them aso shown below. (Tip: You can filter for ports by using search terms in dashboard)



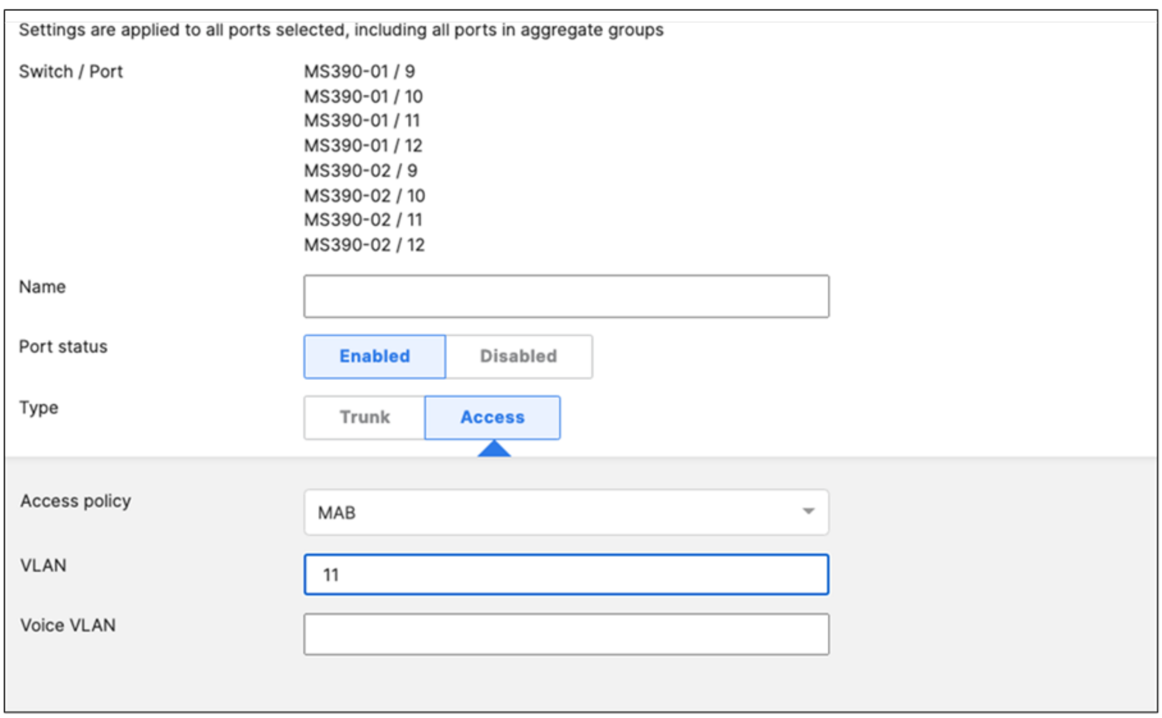

Link negotiation
Auto negotiate
RSTP
Enabled
Disabled
STP guard
BPDU guard
Port schedule
Unscheduled
Port isolation
Enabled
Disabled
UDLD
Alert only
Enforce
Alerts will be generated if UDLD detects an error, but the port will not be shut down.
Tags
802.1x x
Wired x
Clients x
Adaptive policy group
Select...
Storm control
Enabled
Disabled

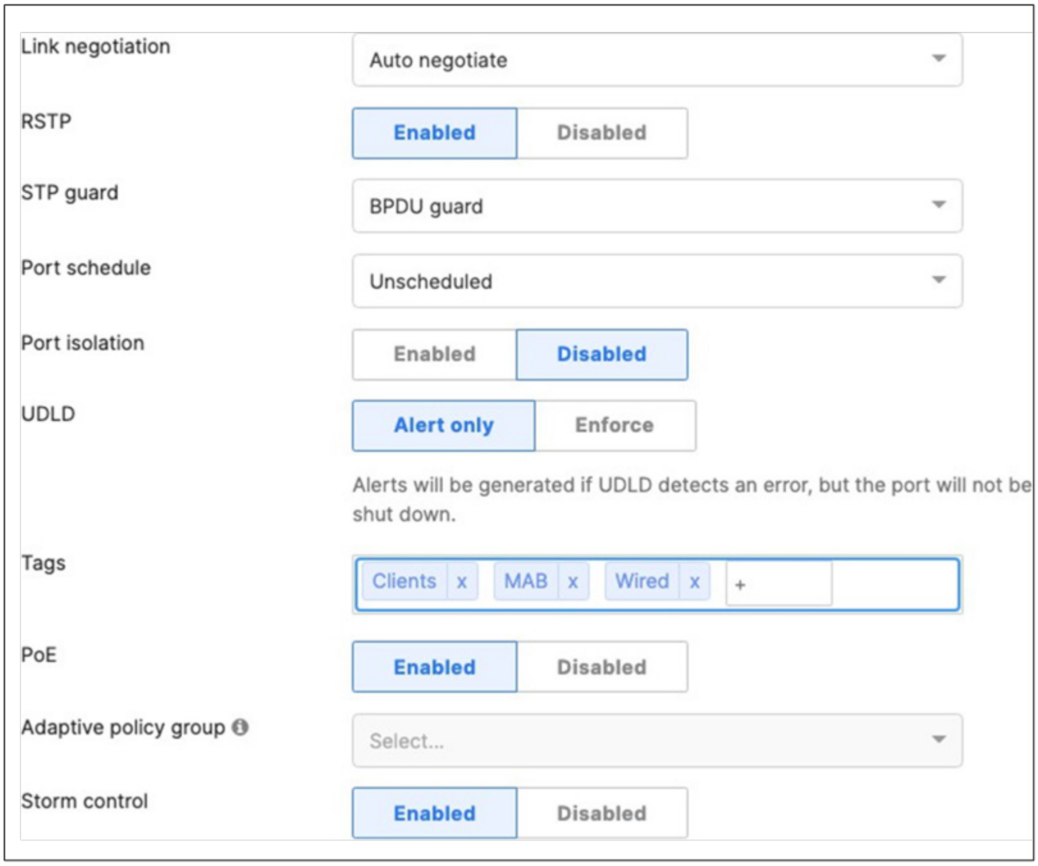

Switchports
for the last day
Edit
Aggregate
Split
Mirror
Unmirror
Tags
5-8 C9300

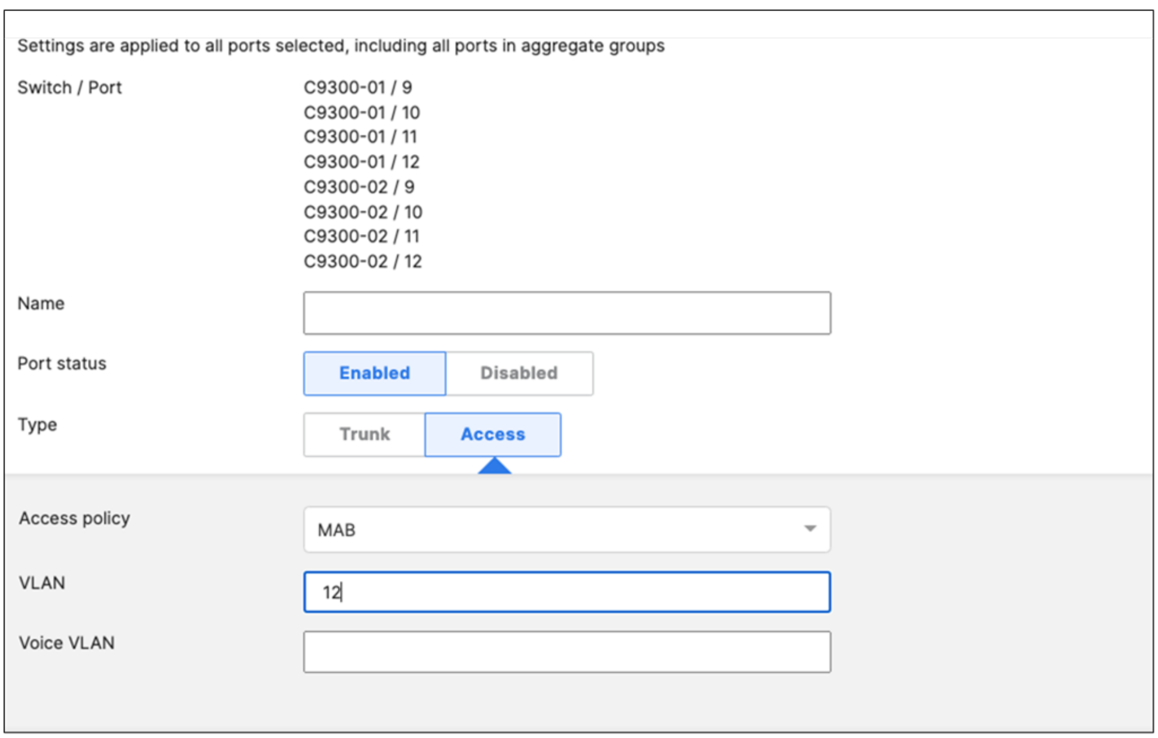

Settings are applied to all ports selected, including all ports in aggregate groups
Switch / Port
C9300-01 / 5
C9300-01 / 6
C9300-01 / 7
C9300-01 / 8
C9300-02 / 5
C9300-02 / 6
C9300-02 / 7
C9300-02 / 8
Name
Port status
Enabled
Disabled
Type
Trunk
Access
Access policy
802.1x
VLAN
12
Voice VLAN



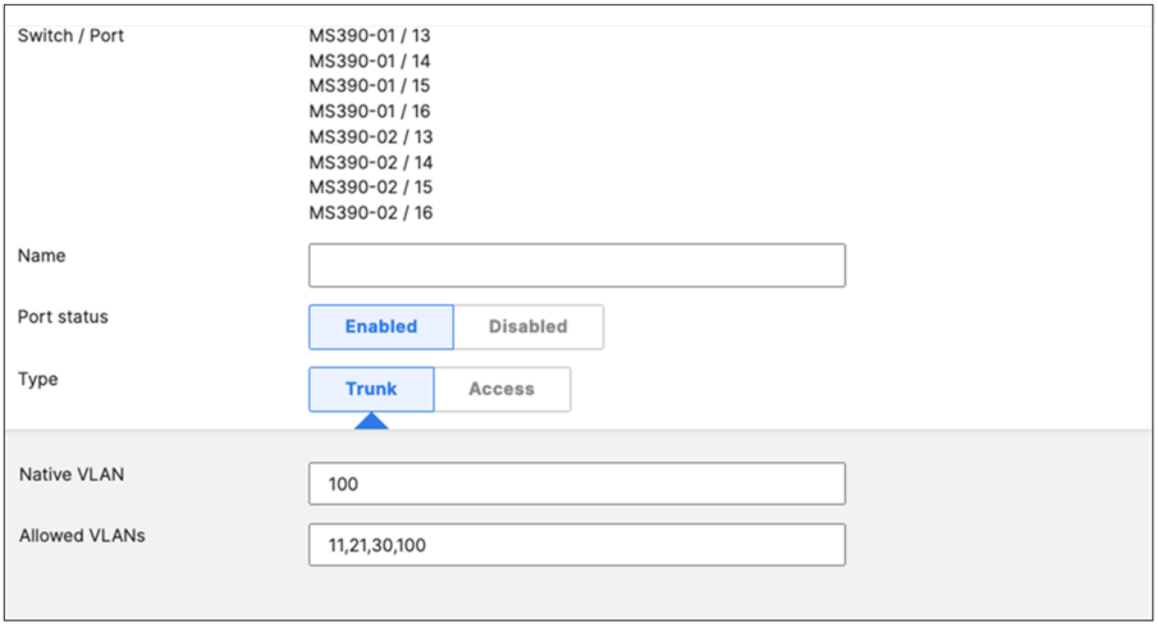
47. **Access Switch Ports Configuration:** Configure **Wired Client Ports (MAB)** on your Access Switches. Navigate to or Refresh **Switching > Monitor > Switch Ports**, then select your Wired Client ports (9-12) and configure them as shown below. (Tip: You can filter for ports by using search terms in dashboard)

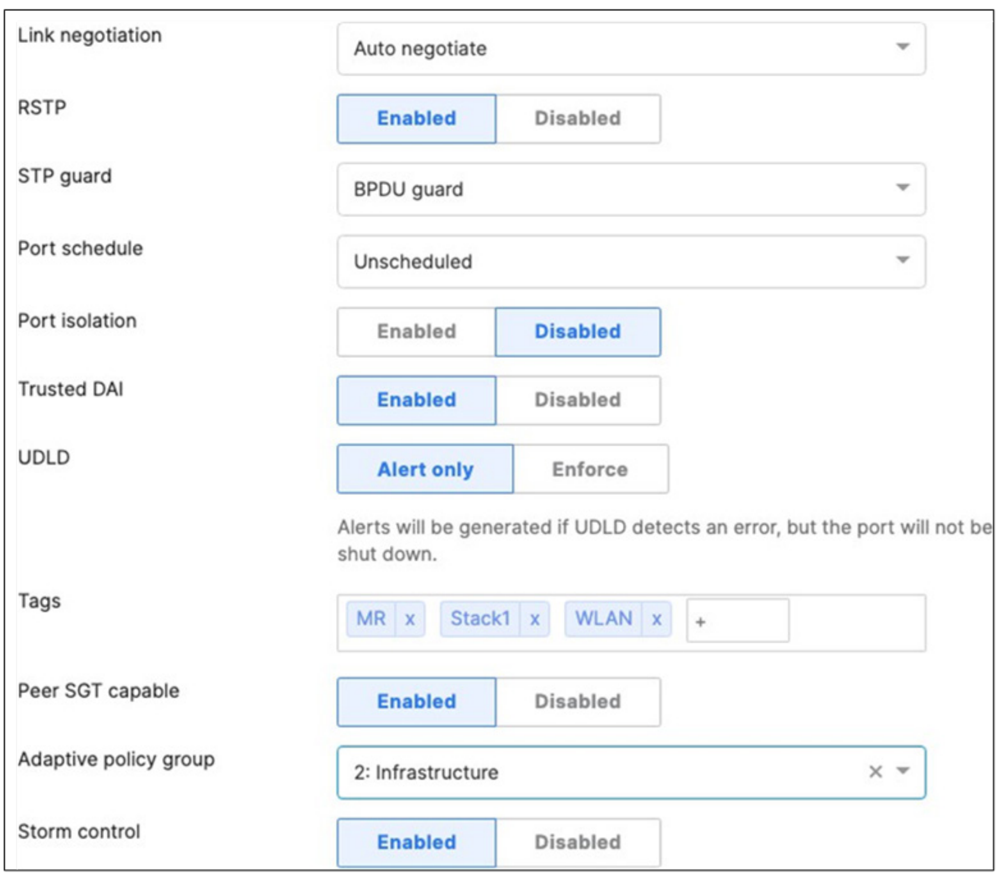


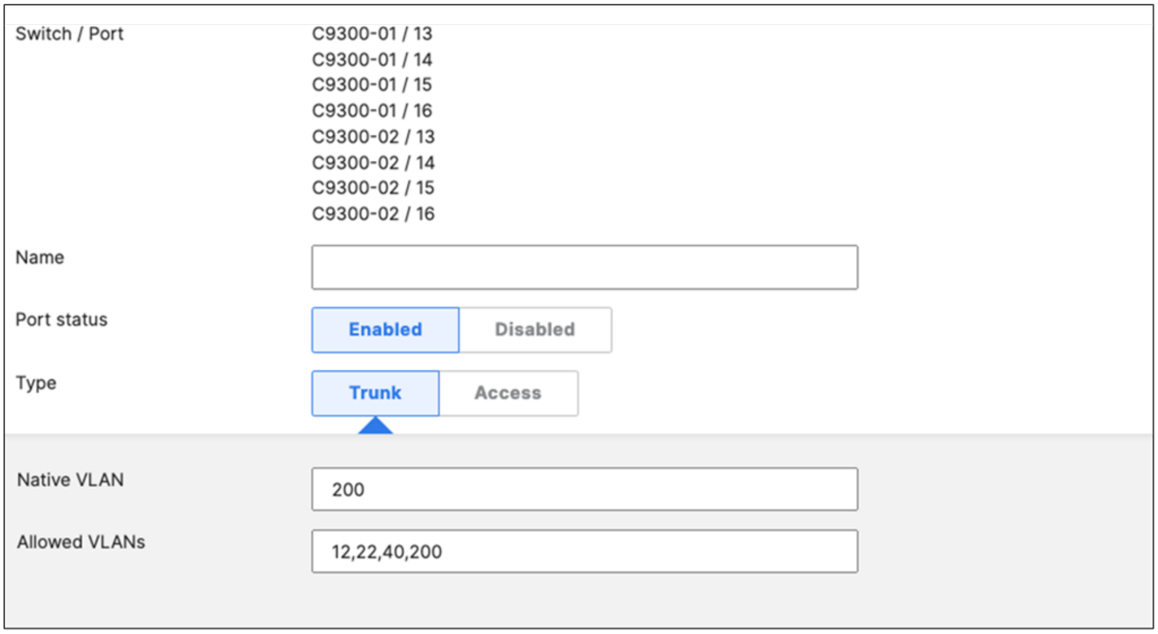

Link negotiation
Auto negotiate
RSTP
Enabled
Disabled
STP guard
BPDU guard
Port schedule
Unscheduled
Port isolation
Enabled
Disabled
UDLD
Alert only
Enforce
Alerts will be generated if UDLD detects an error, but the port will not be shut down.
Tags
Clients x
MAB x
Wired x
+
PoE
Enabled
Disabled
Adaptive policy group
Select...
Storm control
Enabled
Disabled

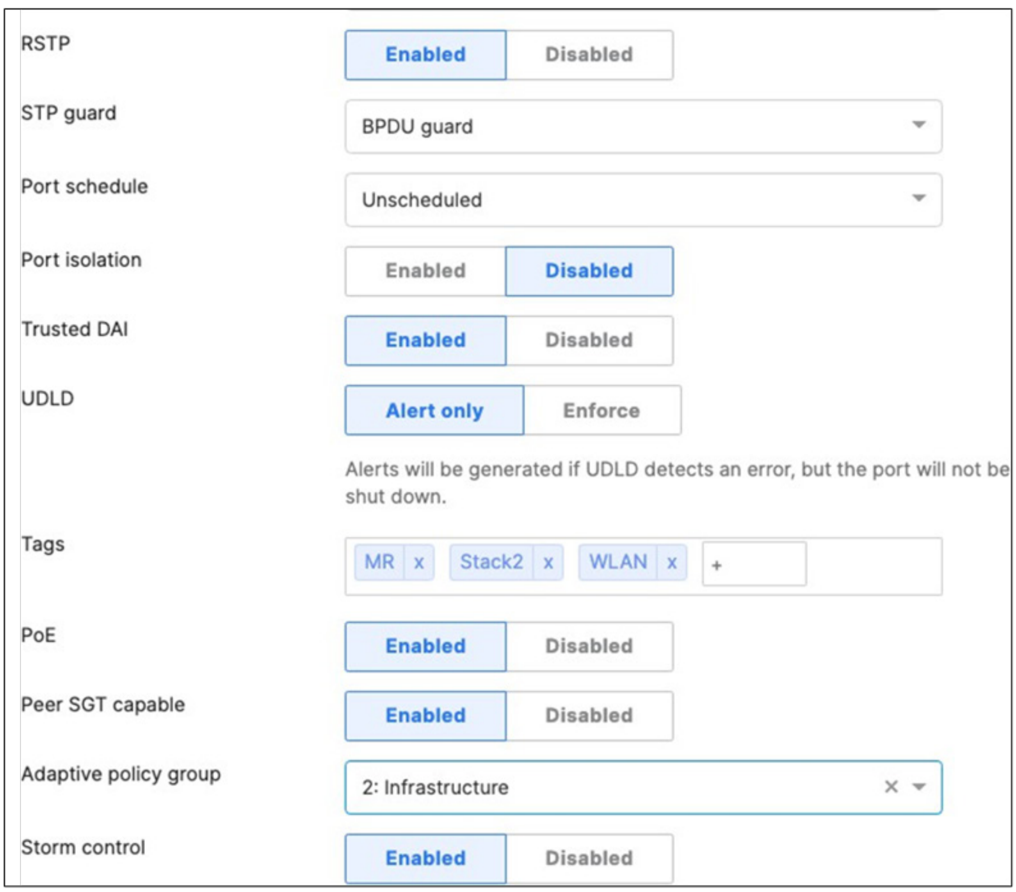

Settings are applied to all ports selected, including all ports in aggregate groups
Switch / Port
C9300-01 / 9
C9300-01 / 10
C9300-01 / 11
C9300-01 / 12
C9300-02 / 9
C9300-02 / 10
C9300-02 / 11
C9300-02 / 12
Name
Port status
Enabled
Disabled
Type
Trunk
Access
Access policy
MAB
VLAN
12
Voice VLAN

48. **Access Switch Ports Configuration:** Configure **MR Ports** on your Access Switches. Navigate to or Refresh **Switching > Configure > Switch Ports**, then select your ports connecting to MR Access Points (13-16) and configure them as shown below. (Tip: You can filter for ports by using search terms in dashboard)

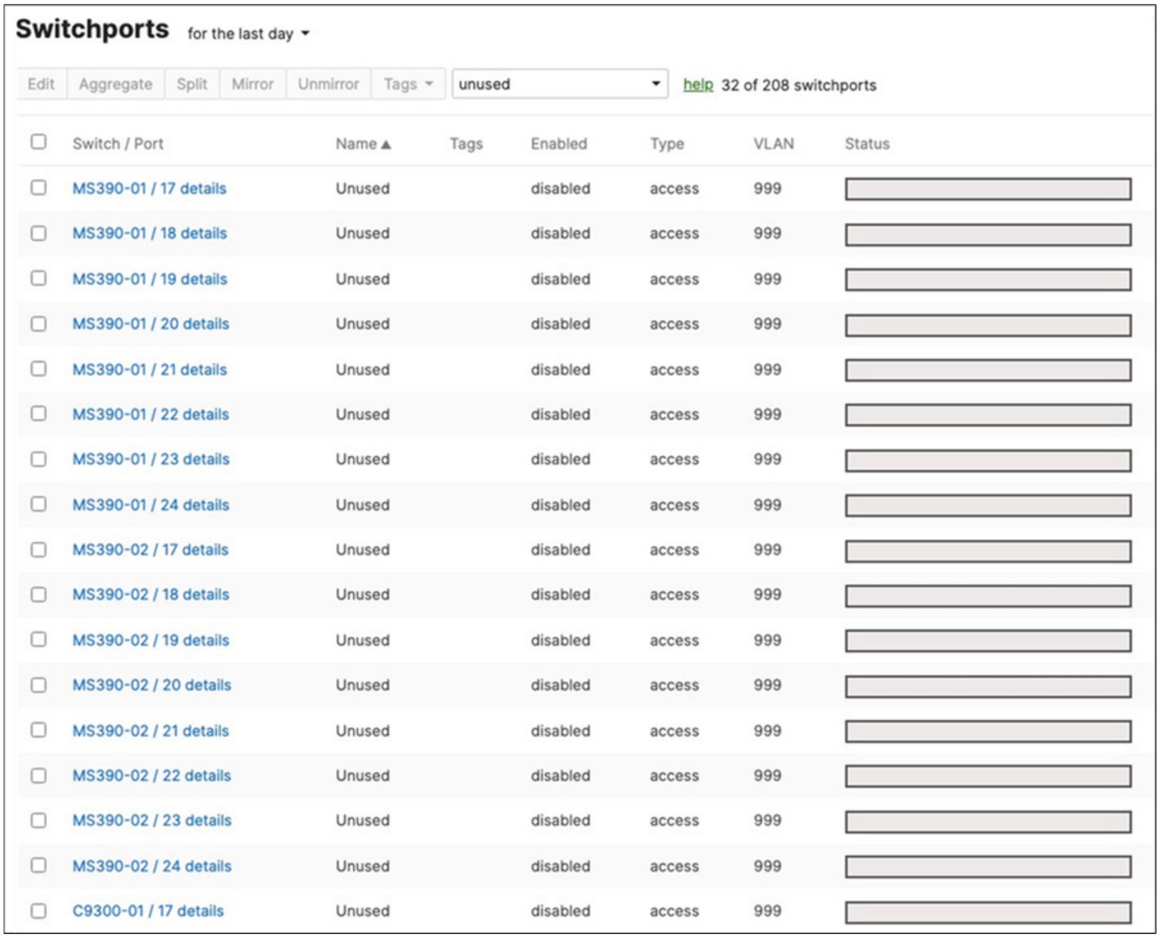





Switch / Port
C9300-01 / 13
C9300-01 / 14
C9300-01 / 15
C9300-01 / 16
C9300-02 / 13
C9300-02 / 14
C9300-02 / 15
C9300-02 / 16
Name
Port status
Enabled
Disabled
Type
Trunk
Access
Native VLAN
200
Allowed VLANs
12,22,40,200


RSTP
Enabled
Disabled
STP guard
BPDU guard
Port schedule
Unscheduled
Port isolation
Enabled
Disabled
Trusted DAI
Enabled
Disabled
UDLD
Alert only
Enforce
Alerts will be generated if UDLD detects an error, but the port will not be shut down.
Tags
MR x
Stack2 x
WLAN x
+
PoE
Enabled
Disabled
Peer SGT capable
Enabled
Disabled
Adaptive policy group
2: Infrastructure
Storm control
Enabled
Disabled

49. *Optional* **– Access Switch Ports Configuration:** Configure unused ports on your Access Switches such that they are disabled and mapped to a parking VLAN such as 999. Navigate to **Switching > Monitor > Switch Ports** and filter for any unused ports (e.g. 17-24) and configure them as shown below.



Switchports for the last day

Edit | Aggregate | Split | Mirror | Unmirror | Tags | unused | help 32 of 208 switchports

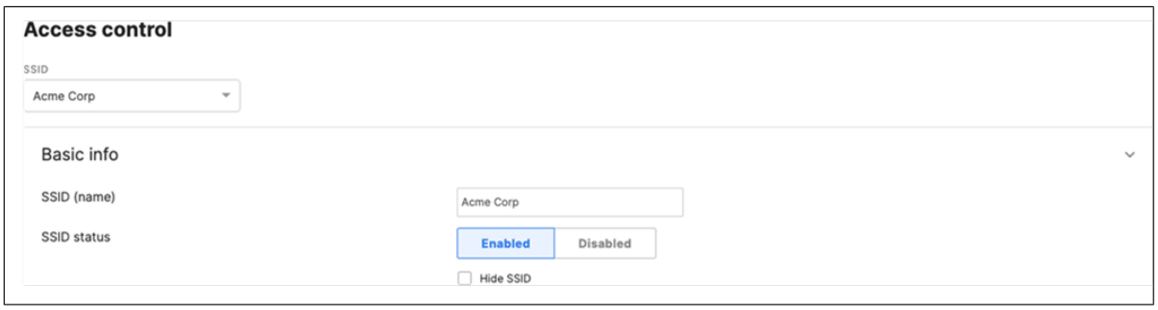
Switch / Port	Name ▲	Tags	Enabled	Type	VLAN	Status
MS390-01 / 17 details	Unused		disabled	access	999	
MS390-01 / 18 details	Unused		disabled	access	999	
MS390-01 / 19 details	Unused		disabled	access	999	
MS390-01 / 20 details	Unused		disabled	access	999	
MS390-01 / 21 details	Unused		disabled	access	999	
MS390-01 / 22 details	Unused		disabled	access	999	
MS390-01 / 23 details	Unused		disabled	access	999	
MS390-01 / 24 details	Unused		disabled	access	999	
MS390-02 / 17 details	Unused		disabled	access	999	
MS390-02 / 18 details	Unused		disabled	access	999	
MS390-02 / 19 details	Unused		disabled	access	999	
MS390-02 / 20 details	Unused		disabled	access	999	
MS390-02 / 21 details	Unused		disabled	access	999	
MS390-02 / 22 details	Unused		disabled	access	999	
MS390-02 / 23 details	Unused		disabled	access	999	
MS390-02 / 24 details	Unused		disabled	access	999	
C9300-01 / 17 details	Unused		disabled	access	999	

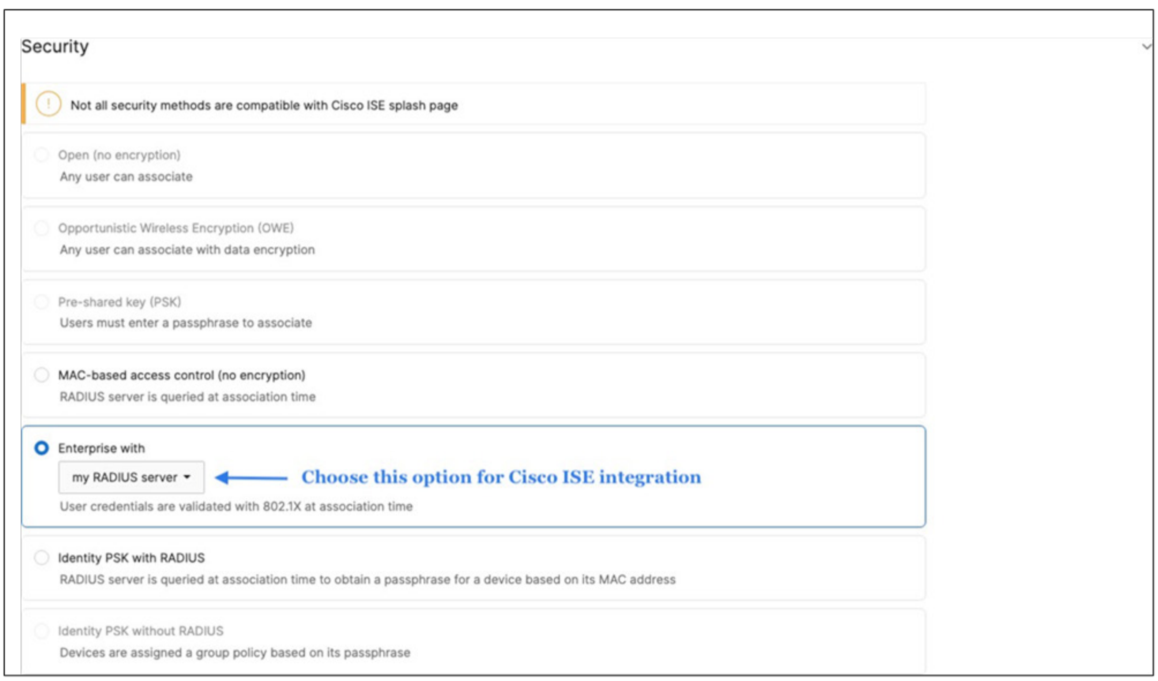
50. **Rename Wireless SSIDs:** To configure your SSIDs per the above table, first navigate to **Wireless > Configure SSIDs** then rename the SSIDs per your requirements (Refer to the above table for guidance).

- **SSID#1** (First column, aka **vap:0, enabled** by default): Click on **rename** and change it to **Acme Corp**
- **SSID#2** (Second column, aka **vap:1**): Click on **rename** and change it to **Acme BYOD**, then click on the top drop-down menu to **enable** it
- **SSID#3** (Third column, aka **vap:2**): Click on **rename** and change it to **Guest**, then click on the top drop-down menu to **enable** it
- **SSID#4** (Fourth column, aka **vap:3**): Click on **rename** and change it to **Acme IoT**, then click on the top drop- down menu to **enable** it
- Click **Save** at the bottom of the page

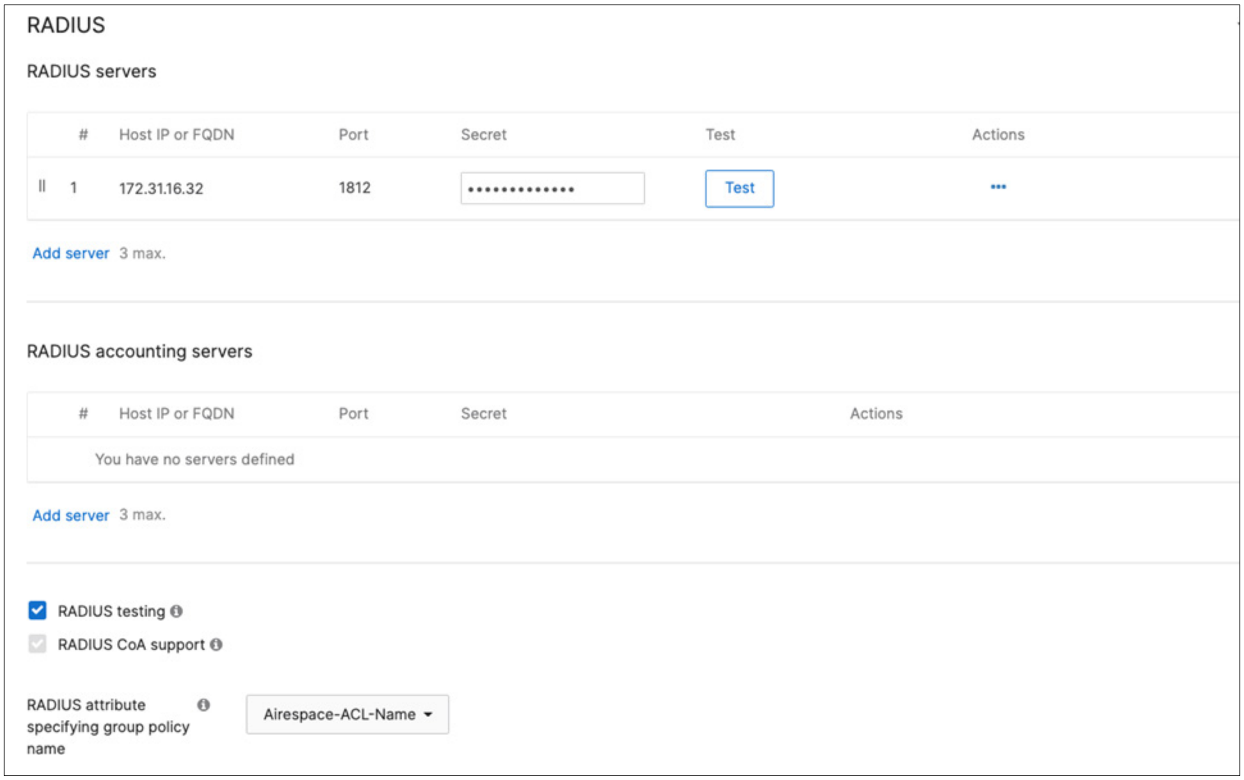
Acme Corp	Acme BYOD	Guest	Acme IoT
enabled	enabled	enabled	enabled
rename	rename	rename	rename
edit settings	edit settings	edit settings	edit settings
Open	Open	Open	Open
None	None	None	None
unlimited	unlimited	unlimited	unlimited
Meraki DHCP	Meraki DHCP	Meraki DHCP	Meraki DHCP
yes	no	no	no
no	no	no	no
n/a	n/a	n/a	n/a
Disabled	Disabled	Disabled	Disabled
no	no	no	no
n/a	n/a	n/a	n/a

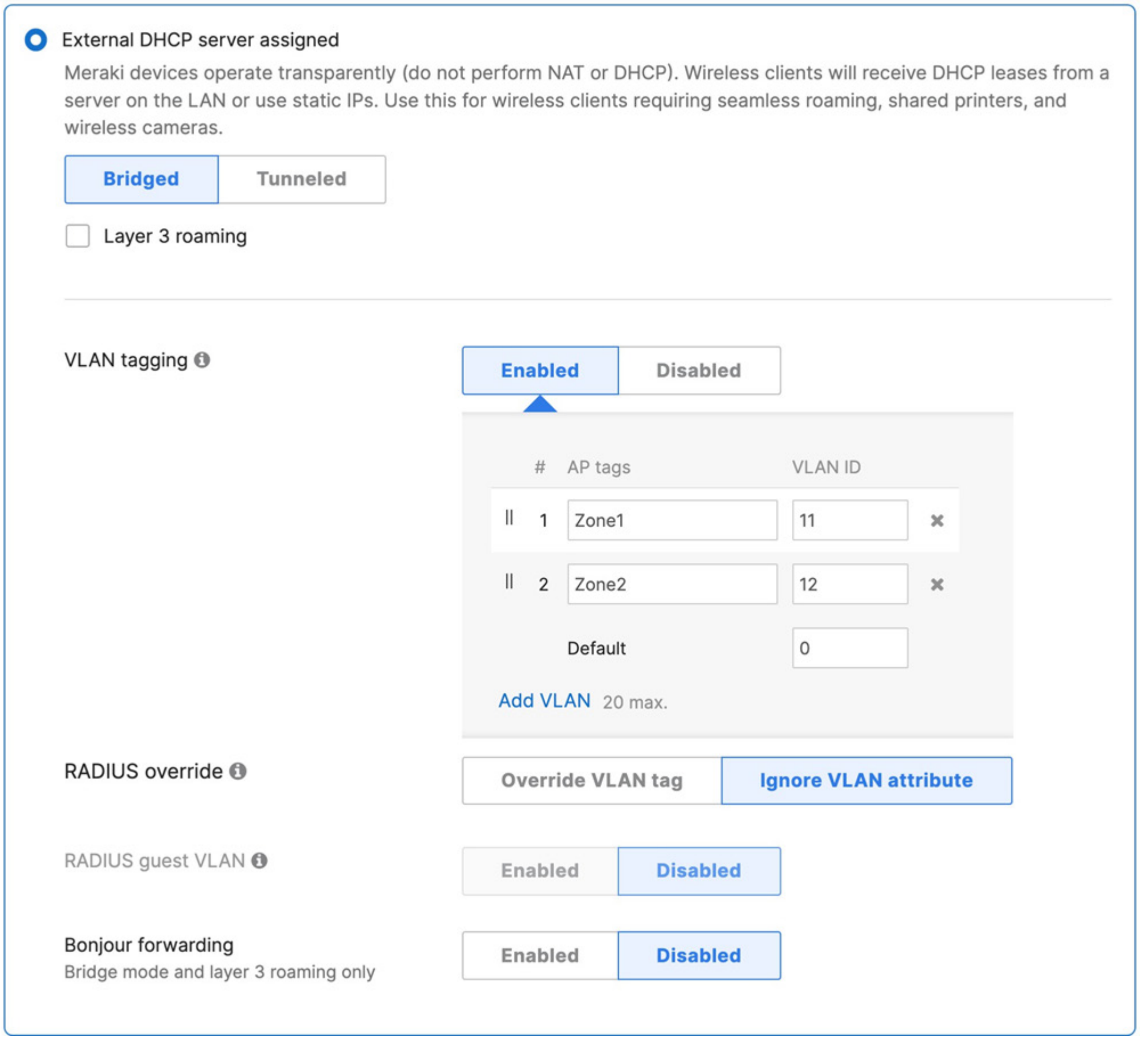
51. **Configure Access Control for Acme Corp**: Navigate to **Wireless > Configure > Access control** then from the top drop-down menu choose **Acme Corp.**



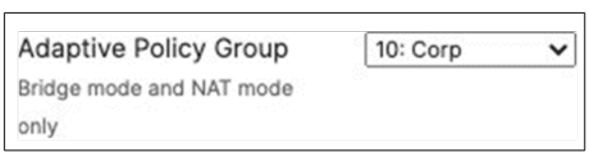



WPA encryption
WPA2 only
Choose the WPA encryption method suitable for your Campus LAN
802.11w
Enabled (allow unsupported clients)
Required (reject unsupported clients)
Disabled (never use)
Disable 802.11w if it's not required
Mandatory DHCP
Enabled
Disabled
Enable Mandatory DHCP to block self-assigned IPs


RADIUS
RADIUS servers
Host IP or FQDN Port Secret Test Actions
1 172.31.16.32 1812
Test
Add server 3 max.
RADIUS accounting servers
Host IP or FQDN Port Secret Actions
You have no servers defined
Add server 3 max.
RADIUS testing
RADIUS CoA support
RADIUS attribute specifying group policy name
Airespace-ACL-Name



- Click **Save** at the bottom of the page

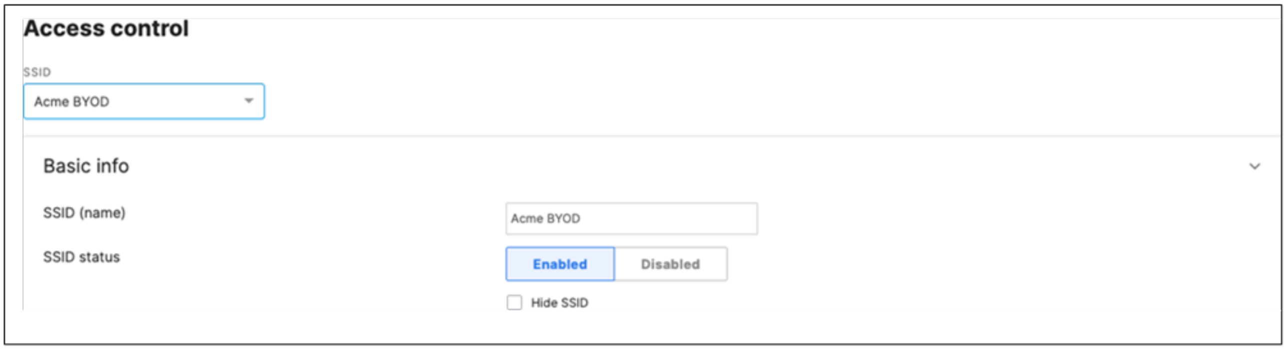


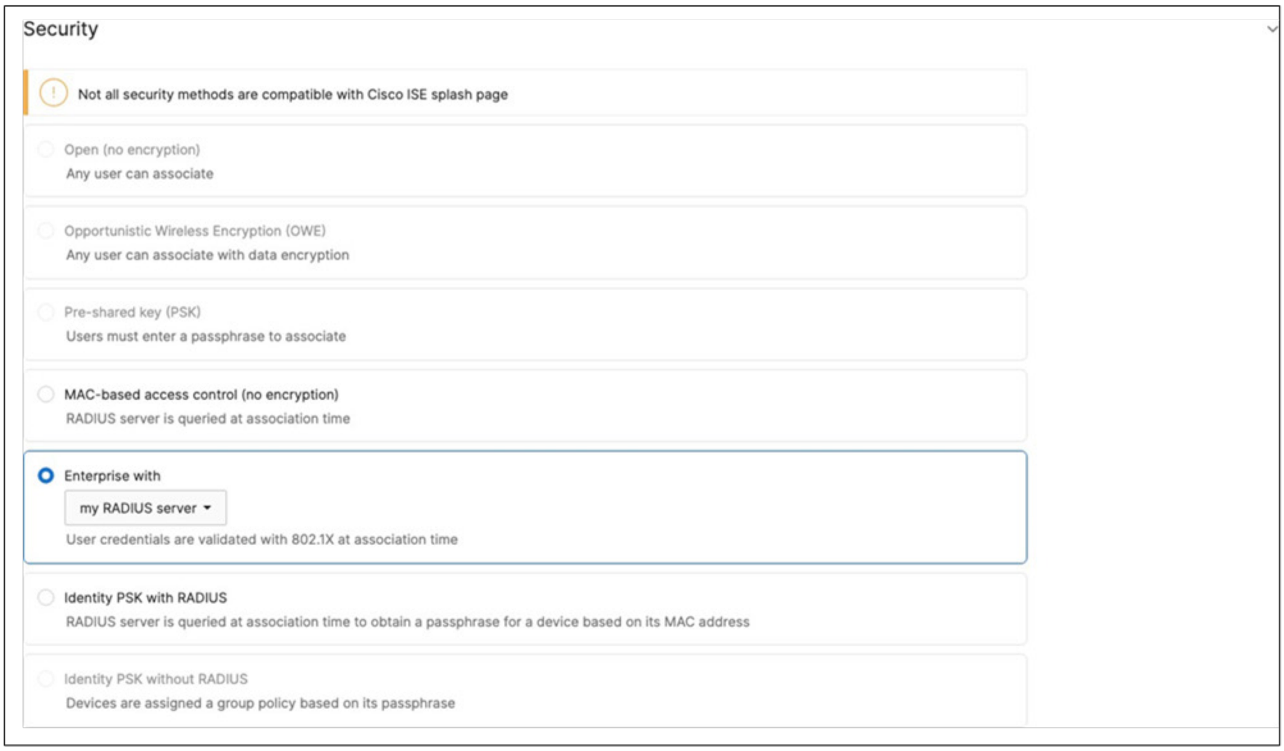
- Please Note: **Adaptive Policy Group** feature is **not** currently available in the New Version of the Access. You will need to click on **View old version**

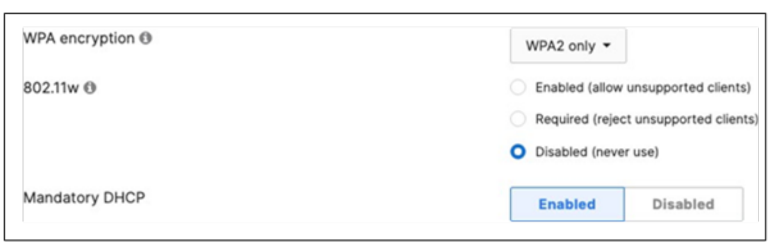
  View old Version

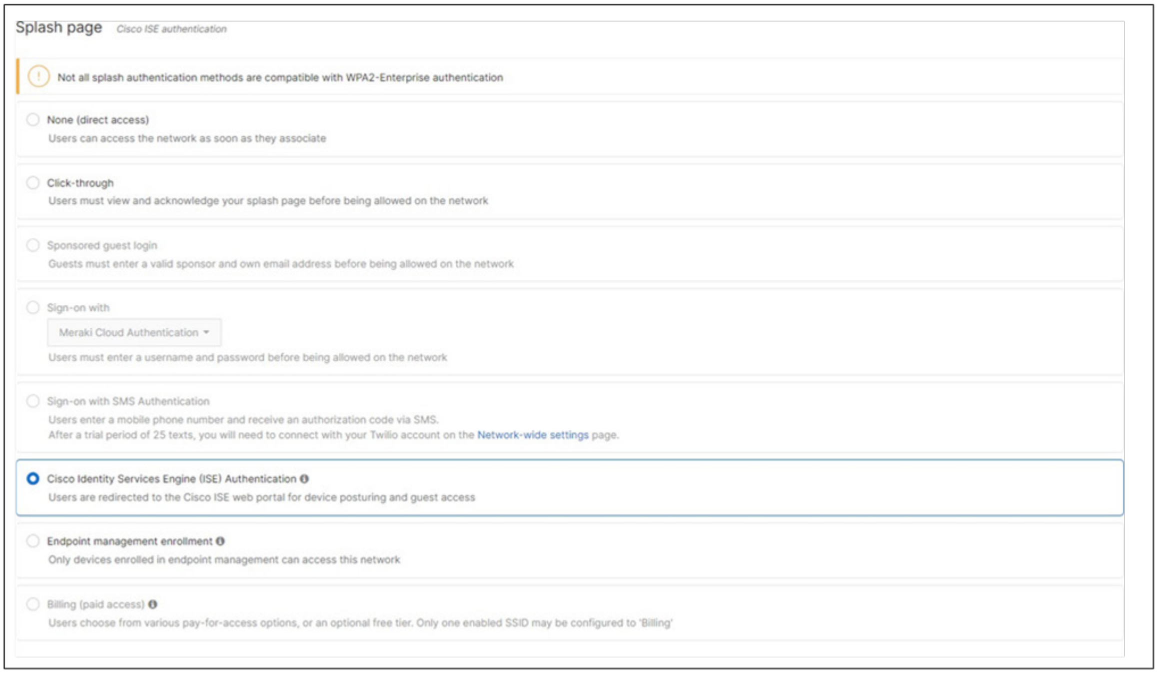
  which is available at the top right corner of the page to be able to access this and configure the Adaptive Policy Group (10: Corp). Then, please click **Save** at the bottom of the page.

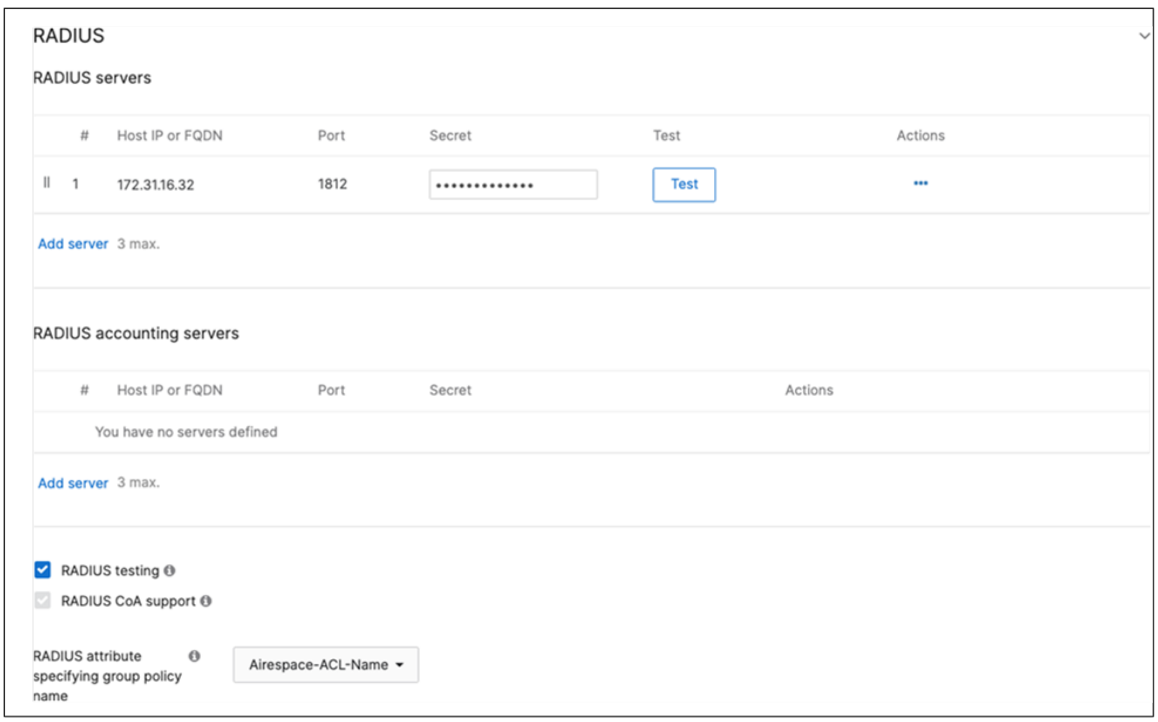
52. **Configure Access Control for Acme BYOD**: Navigate to **Wireless > Configure > Access control** then from the top drop-down menu choose **Acme BYOD.**

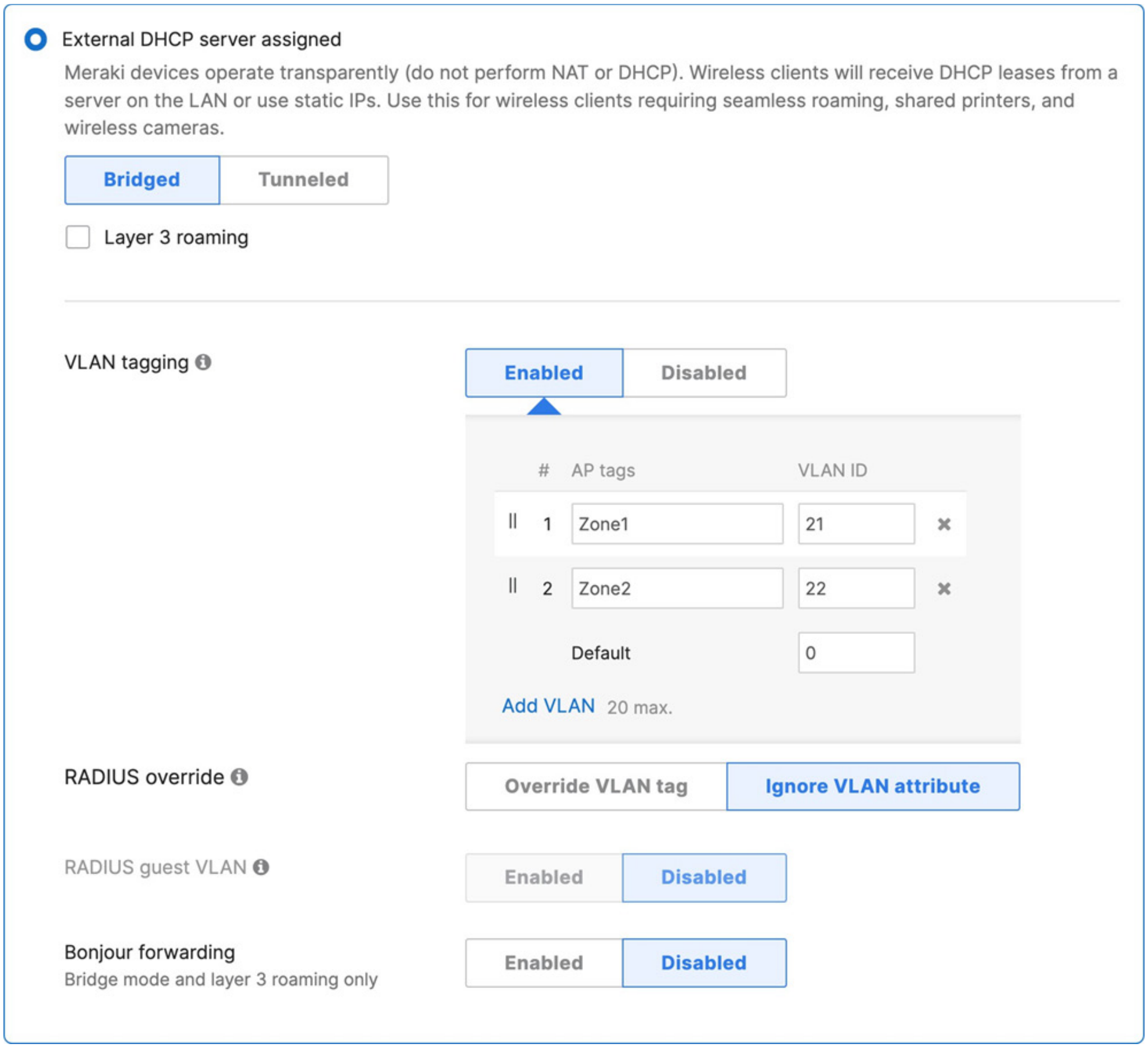







Splash page
Cisco ISE authentication
Not all splash authentication methods are compatible with WPA2-Enterprise authentication
None (direct access)
Users can access the network as soon as they associate
Click-through
Users must view and acknowledge your splash page before being allowed on the network
Sponsored guest login
Guests must enter a valid sponsor and own email address before being allowed on the network
Sign-on with
Meraki Cloud Authentication
Users must enter a username and password before being allowed on the network
Sign-on with SMS Authentication
Users enter a mobile phone number and receive an authorization code via SMS.
After a trial period of 25 texts, you will need to connect with your Twilio account on the Network-wide settings page.
Cisco Identity Services Engine (ISE) Authentication
Users are redirected to the Cisco ISE web portal for device posturing and guest access
Endpoint management enrollment
Only devices enrolled in endpoint management can access this network
Billing (paid access)
Users choose from various pay-for-access options, or an optional free tier. Only one enabled SSID may be configured to 'Billing'

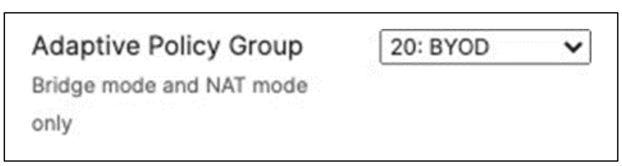

RADIUS
RADIUS servers
Host IP or FQDN Port Secret Test Actions
1 172.31.16.32 1812 Test
Add server 3 max.
RADIUS accounting servers
Host IP or FQDN Port Secret Actions
You have no servers defined
Add server 3 max.
RADIUS testing
RADIUS CoA support
RADIUS attribute specifying group policy name
Airespace-ACL-Name



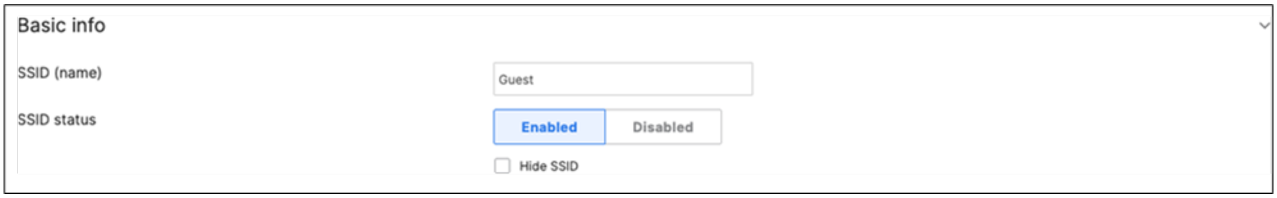
- Click on

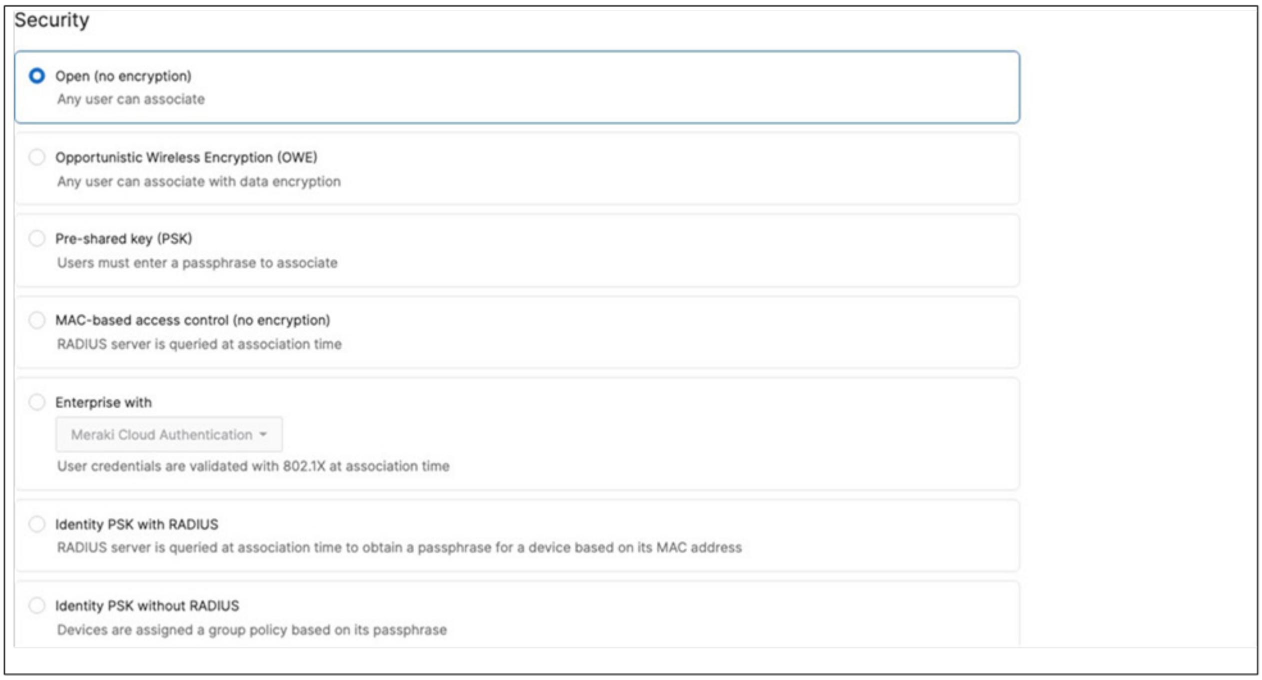
  View old Version

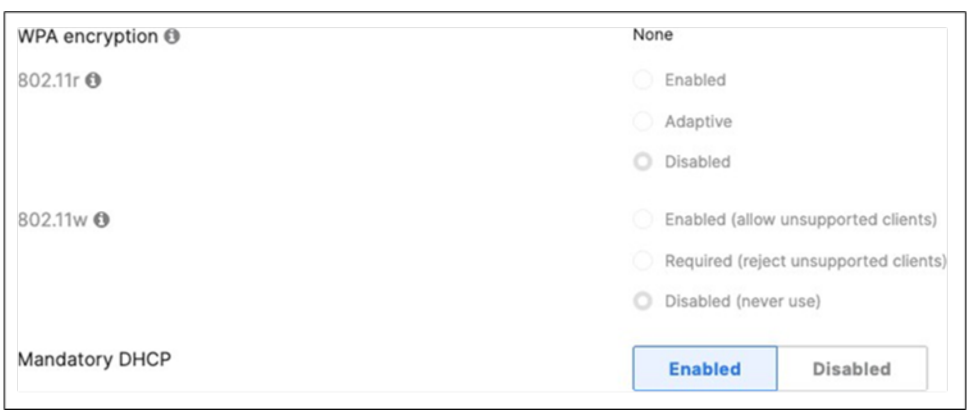
  which is available on the top right corner of the page, then choose the Adaptive Policy Group **20: BYOD** and then click on **Save** at the bottom of the page.

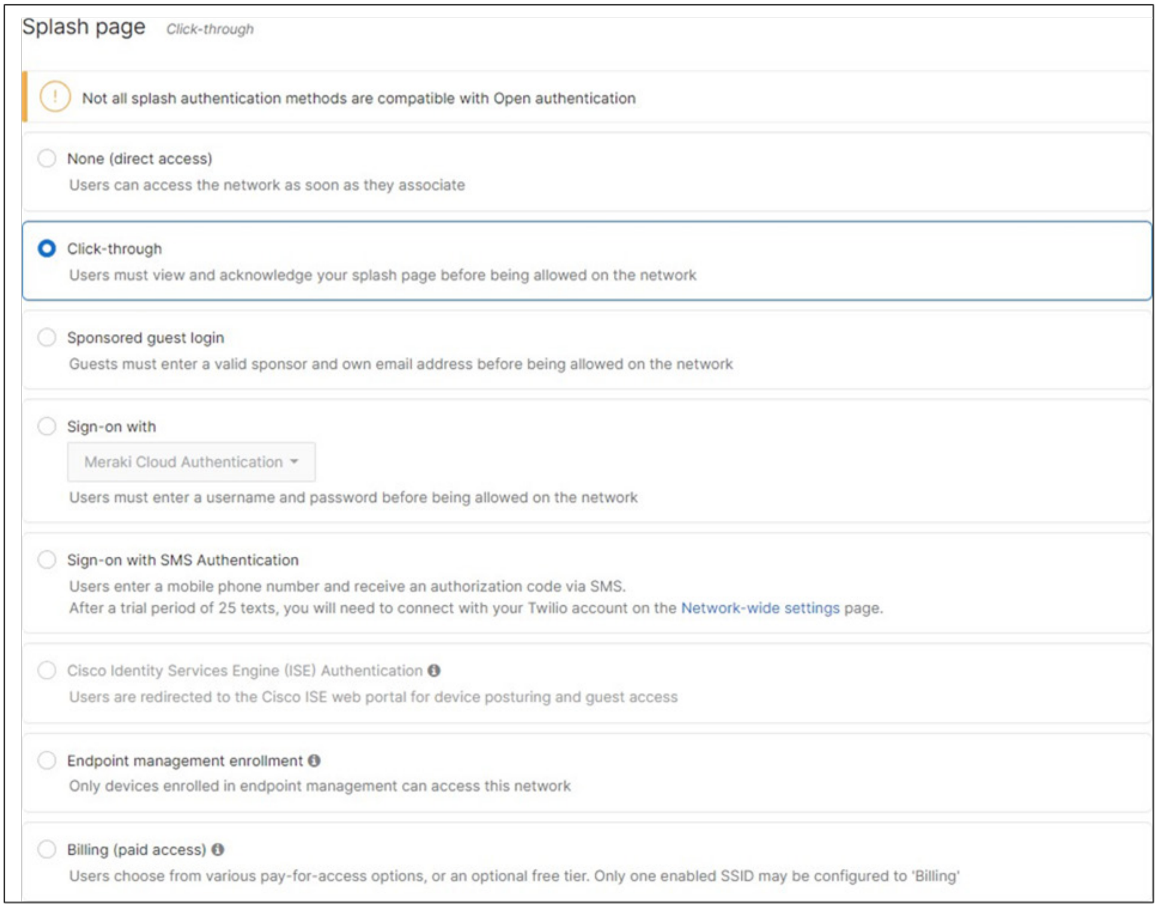


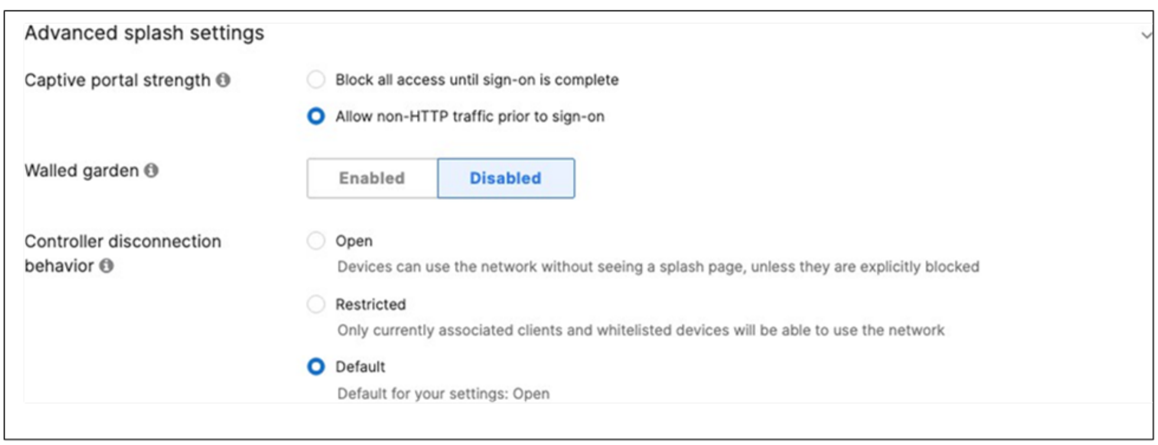
53. **Configure Access Control for Guest**: Navigate to **Wireless > Configure > Access control** then from the top drop-down menu choose **Guest.**

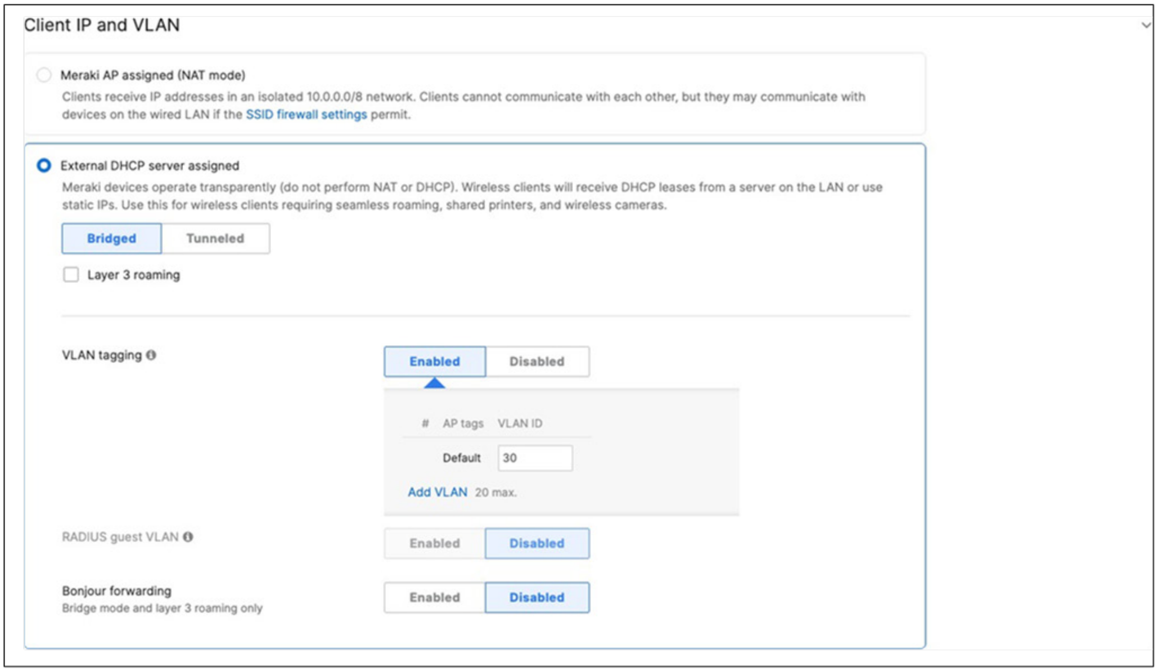




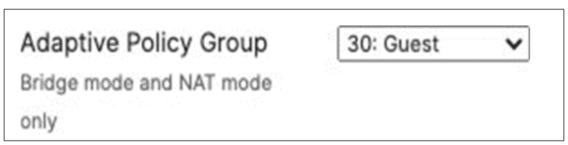



Splash page Click-through
Not all splash authentication methods are compatible with Open authentication
None (direct access)
Users can access the network as soon as they associate
Click-through
Users must view and acknowledge your splash page before being allowed on the network
Sponsored guest login
Guests must enter a valid sponsor and own email address before being allowed on the network
Sign-on with
Meraki Cloud Authentication
Users must enter a username and password before being allowed on the network
Sign-on with SMS Authentication
Users enter a mobile phone number and receive an authorization code via SMS.
After a trial period of 25 texts, you will need to connect with your Twilio account on the Network-wide settings page.
Cisco Identity Services Engine (ISE) Authentication
Users are redirected to the Cisco ISE web portal for device posturing and guest access
Endpoint management enrollment
Only devices enrolled in endpoint management can access this network
Billing (paid access)
Users choose from various pay-for-access options, or an optional free tier. Only one enabled SSID may be configured to 'Billing'

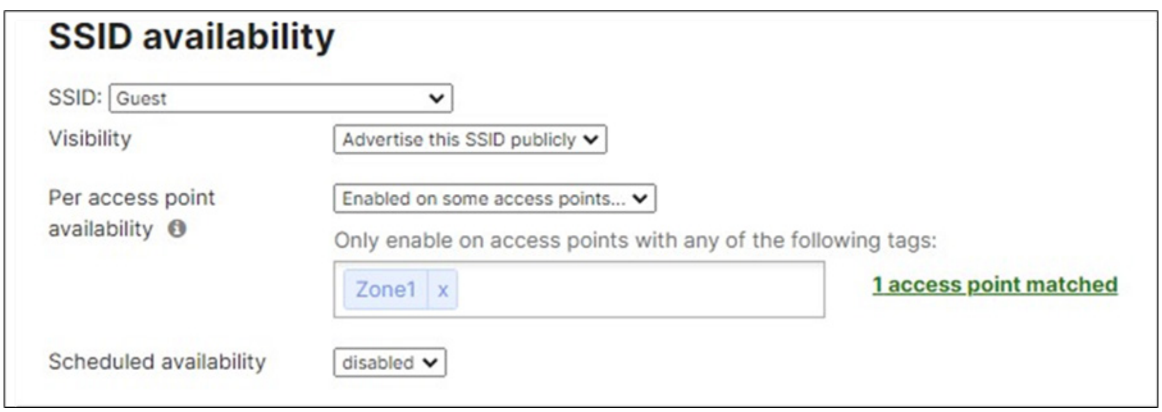

Advanced splash settings
Captive portal strength
Block all access until sign-on is complete
Allow non-HTTP traffic prior to sign-on
Walled garden
Enabled
Disabled
Controller disconnection behavior
Open
Devices can use the network without seeing a splash page, unless they are explicitly blocked
Restricted
Only currently associated clients and whitelisted devices will be able to use the network
Default
Default for your settings: Open



- Click **Save** at the bottom of the page
- Click on the top right corner of the page on "**View Old Version**" then choose the Adaptive Policy Group **30:Guest** then click on **Save** at the bottom of the page

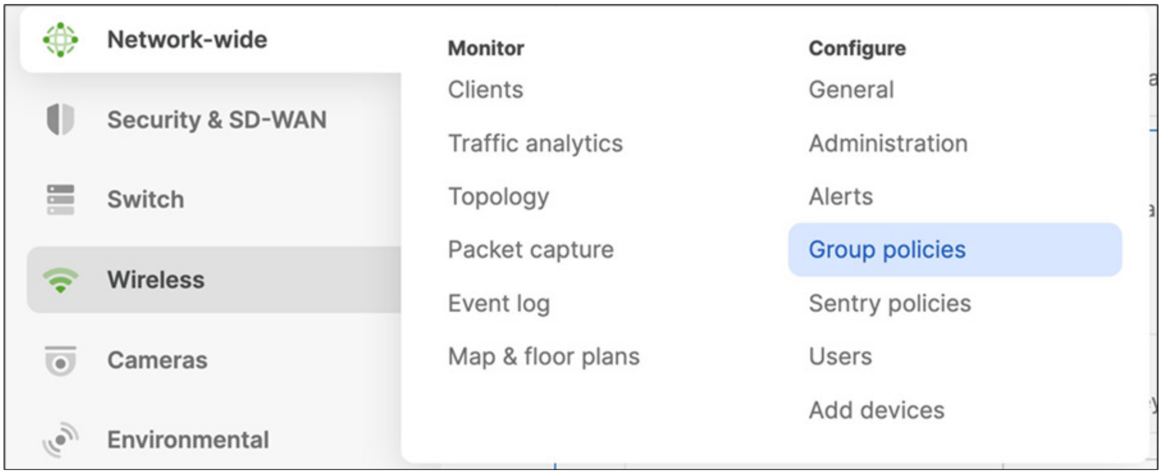


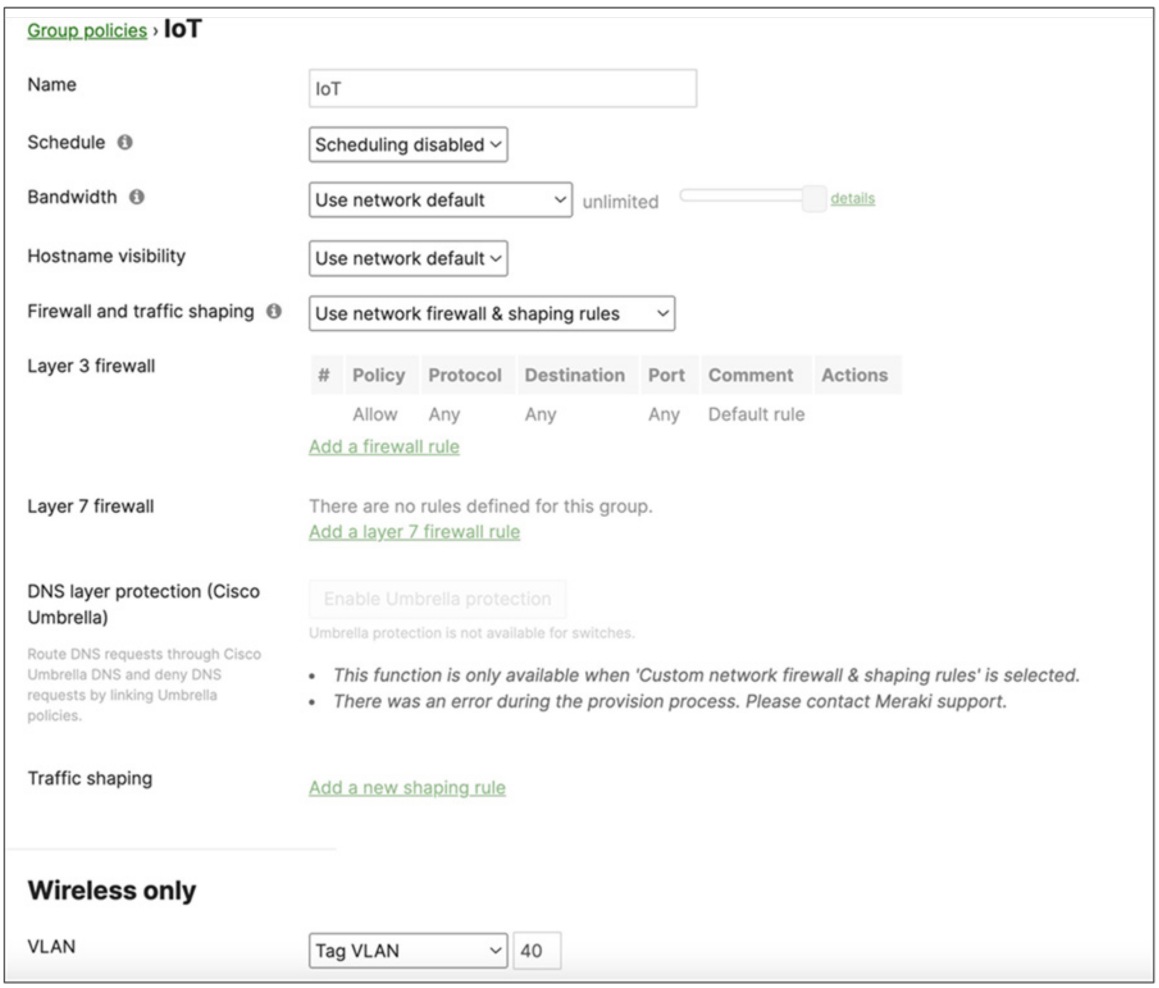
- Navigate to **Wireless > Configure > SSID availability** and configure broadcast via Tag = **Zone 1**



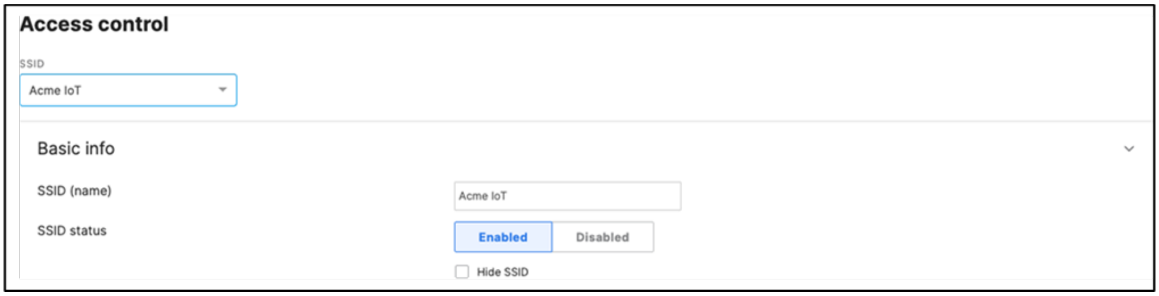
54. **Configure Access Control for Acme IoT:** Navigate to **Wireless > Configure > Access control** then from the top drop-down menu choose **Acme IoT**. (Please note that in this example Acme IoT SSID has been configured with iPSK **without** Radius).

    - Navigate to **Network-wide > Configure > Group policies,** then create a group policy for IoT devices and click **Save** at the bottom of the page

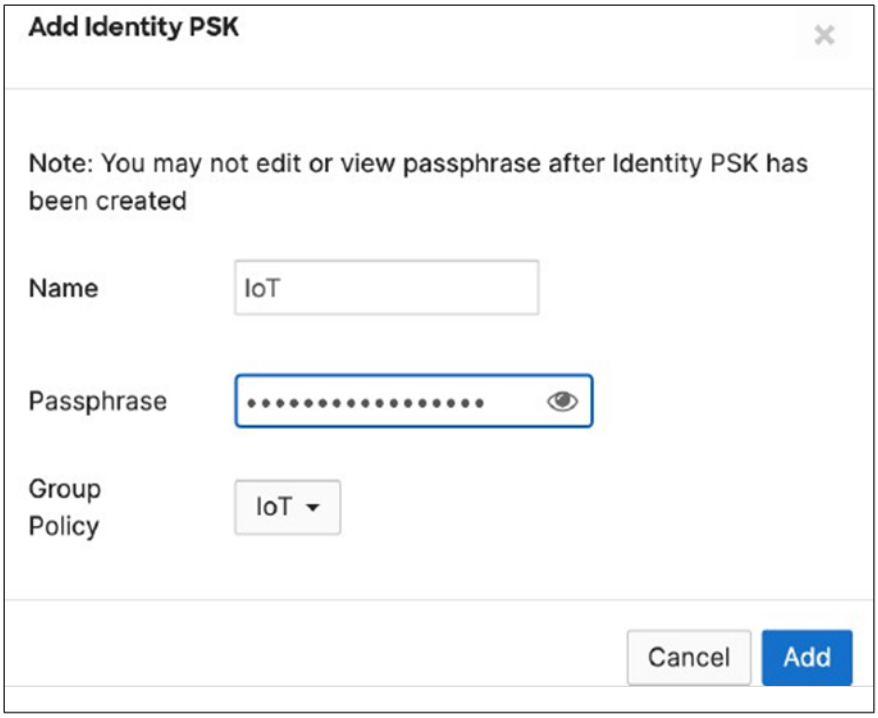


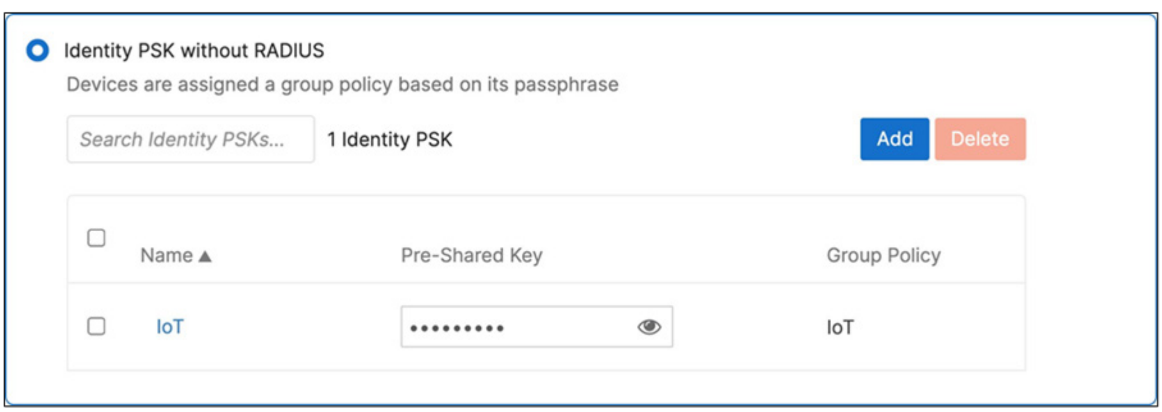


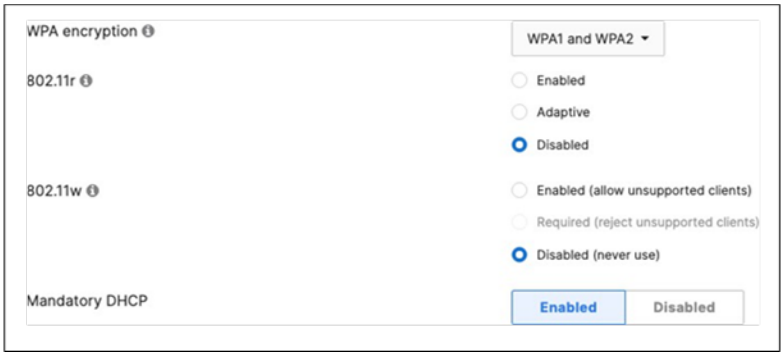
- Then, Navigate to **Wireless > Configure > Access control** and choose Acme IoT from the top drop-menu and configure settings as shown below, First choose iPSK without Radius from the Security menu:

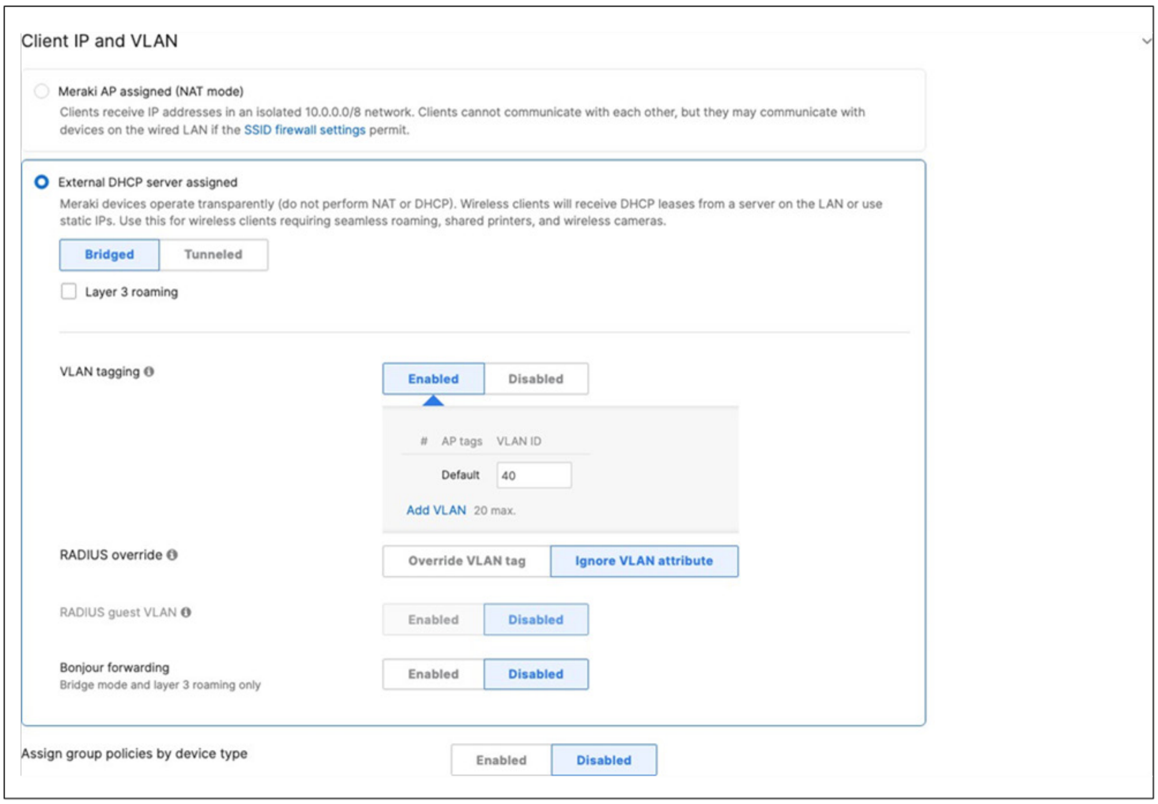


- Then, click on **Add an identity PSK**:





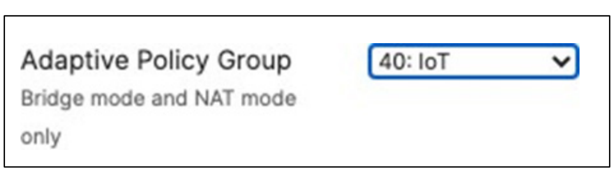




- Click on **Save** at the bottom of the page
- Click on

  View old Version

  at the top right corner of the page then choose the Adaptive Policy Group **40: IoT** then click on **Save** at the bottom of the page**.**



- Navigate to **Wireless > Configure > SSID availability** and configure broadcast via Tag = **Zone 2**

55. **Enabling Stacking on your MS390 and C9300 Switches in Meraki Dashboard**: Please follow these steps.

    A. Connect a single uplink to each switch (e.g. Port 1 on MS390-01 to Port TwentyFiveGigE1/0/23 on C9500)

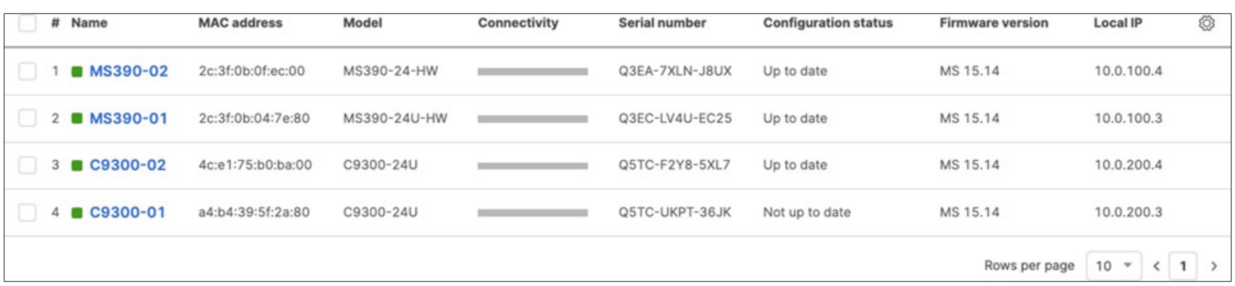
    B. Make sure all stacking cables are unplugged from all switches

    C. Power up all switches

    D. Verify that your C9500 Stack downlinks are up and not shutdown

```
9500-01#sh ip interface brief
Interface              IP-Address OK?    Method Status     Protocol
TwentyFiveGigE1/0/23   unassigned YES    unset up           up
TwentyFiveGigE1/0/24   unassigned YES    unset up           up
TwentyFiveGigE2/0/23   unassigned YES    unset up           up
TwentyFiveGigE2/0/24   unassigned YES    unset up           up
9500-01#
```

    E. Wait for them to come online on dashboard. Navigate to **Switching > Configure > Switches** and check the status of your Access Switches



#	Name	MAC address	Model	Connectivity	Serial number	Configuration status	Firmware version	Local IP
1	MS390-02	2c:3f:0b:0f:ec:00	MS390-24-HW		Q3EA-7XLN-J8UX	Up to date	MS 15.14	10.0.100.4
2	MS390-01	2c:3f:0b:04:7e:80	MS390-24U-HW		Q3EC-LV4U-EC25	Up to date	MS 15.14	10.0.100.3
3	C9300-02	4c:e1:75:b0:ba:00	C9300-24U		Q5TC-F2Y8-5XL7	Up to date	MS 15.14	10.0.200.4
4	C9300-01	a4:b4:39:5f:2a:80	C9300-24U		Q5TC-UKPT-36JK	Not up to date	MS 15.14	10.0.200.3

Rows per page 10 < 1 >

F. After they come online and download their configuration and firmware (Up to date) you can proceed to the next step. You can see their Configuration status and Firmware version from **Switching > Configure > Switches**

#	Name	MAC address	Model	Connectivity	Serial number	Configuration status	Firmware version	Local IP
1	MS390-02	2c:3f:0b:0f:ec:00	MS390-24-HW		Q3EA-7XLN-J8UX	Up to date	MS 15.14	10.0.100.4
2	MS390-01	2c:3f:0b:04:7e:80	MS390-24U-HW		Q3EC-LV4U-EC25	Up to date	MS 15.14	10.0.100.3
3	C9300-02	4c:e1:75:b0:ba:00	C9300-24U		Q5TC-F2Y8-5XL7	Up to date	MS 15.14	10.0.200.4
4	C9300-01	a4:b4:39:5f:2a:80	C9300-24U		Q5TC-UKPT-36JK	Up to date	MS 15.14	10.0.200.3

Rows per page 10 < 1 >

G. Enable stacking in dashboard by Navigating to **Switching > Monitor > Switch stacks** then click on add one

Switch stacks overview

Configured stacks

There are no configured stacks in this network. If you add one, we can help you configure it.

Detected potential stacks

No potential stacks detected

H. Then give your stack a **name** and select it's **members** and click on **Create**

SWITCH STACKS

Create new stack

Name: Stack1-MS390

Stack members

Search switches... **4 switches: 2 checked**

	Name	Serial number	Model
☐	C9300-01	Q5TC-UKPT-36JK	MS390-24
☐	C9300-02	Q5TC-F2Y8-5XL7	MS390-24
☑	MS390-01	Q3EC-LV4U-EC25	MS390-24U
☑	MS390-02	Q3EA-7XLN-J8UX	MS390-24

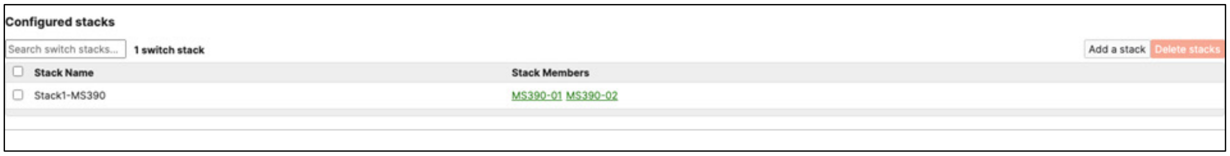
Create

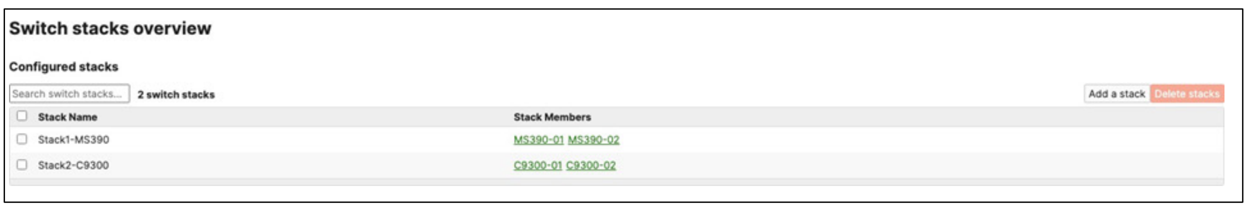
Configured stacks

Search switch stacks... **1 switch stack** Add a stack Delete stacks

	Stack Name	Stack Members
☐	Stack1-MS390	MS390-01 MS390-02

I. Now click on **Add a stack** to create all other stacks in your Campus LAN access layer by repeating the above steps





J. Power off **all** access switches

K. Disconnect all uplink cables from all switches

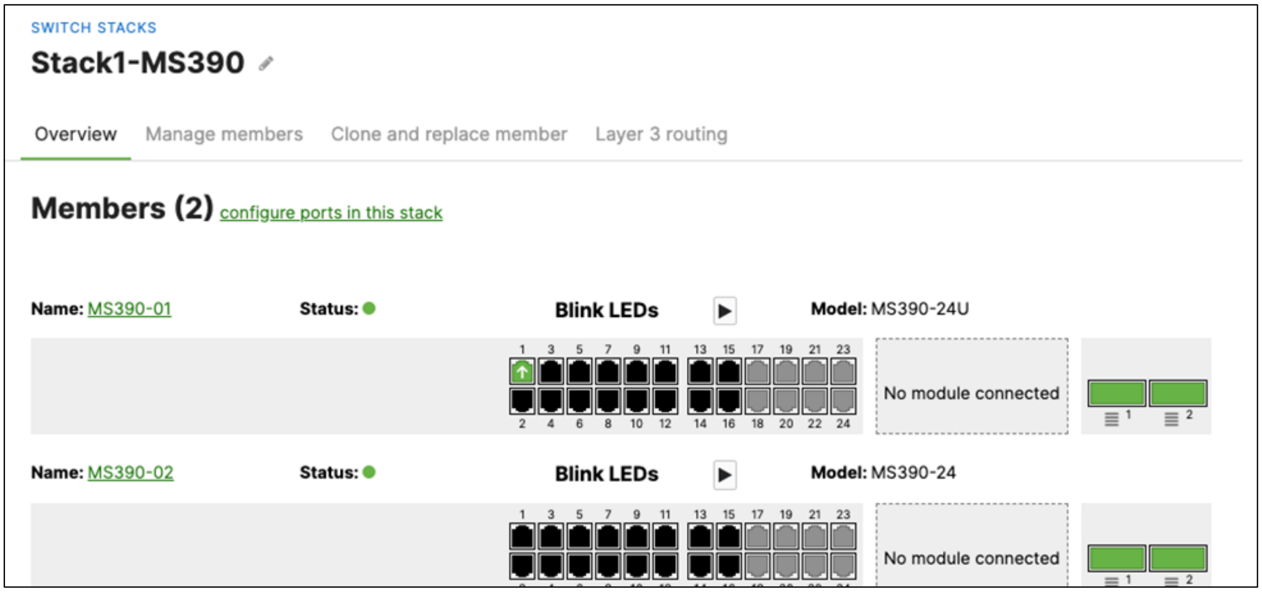
L. Nominate your master switch for each stack (e.g. MS390-01 for stack1 and C9300-01 for stack2)

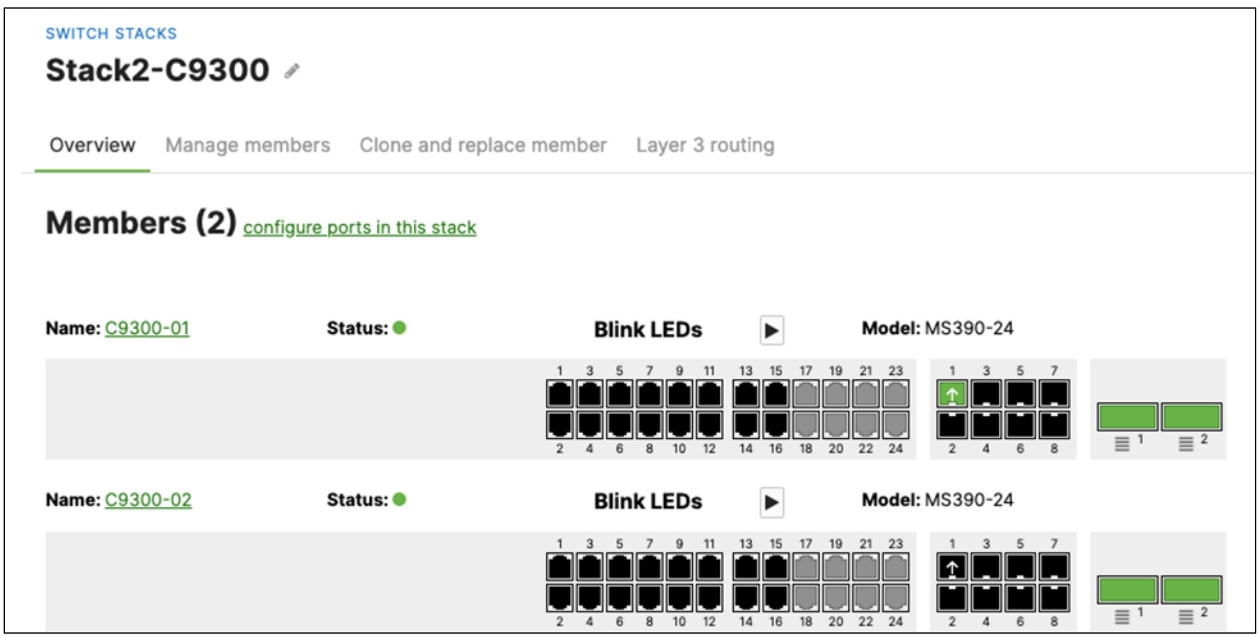
M. On the master switches, plug the uplink again

N. Plug stacking cables on all switches in each stack to form a ring topology and make sure that the Cisco logo is upright

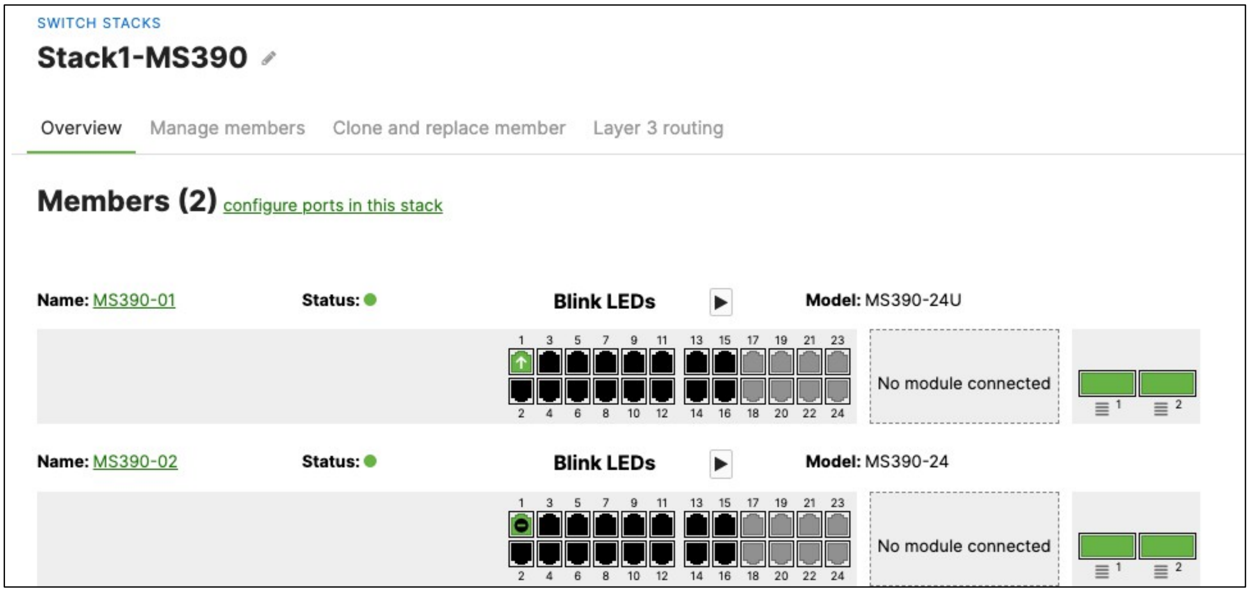
O. Power on your **master** switches **first**, then power other stack members

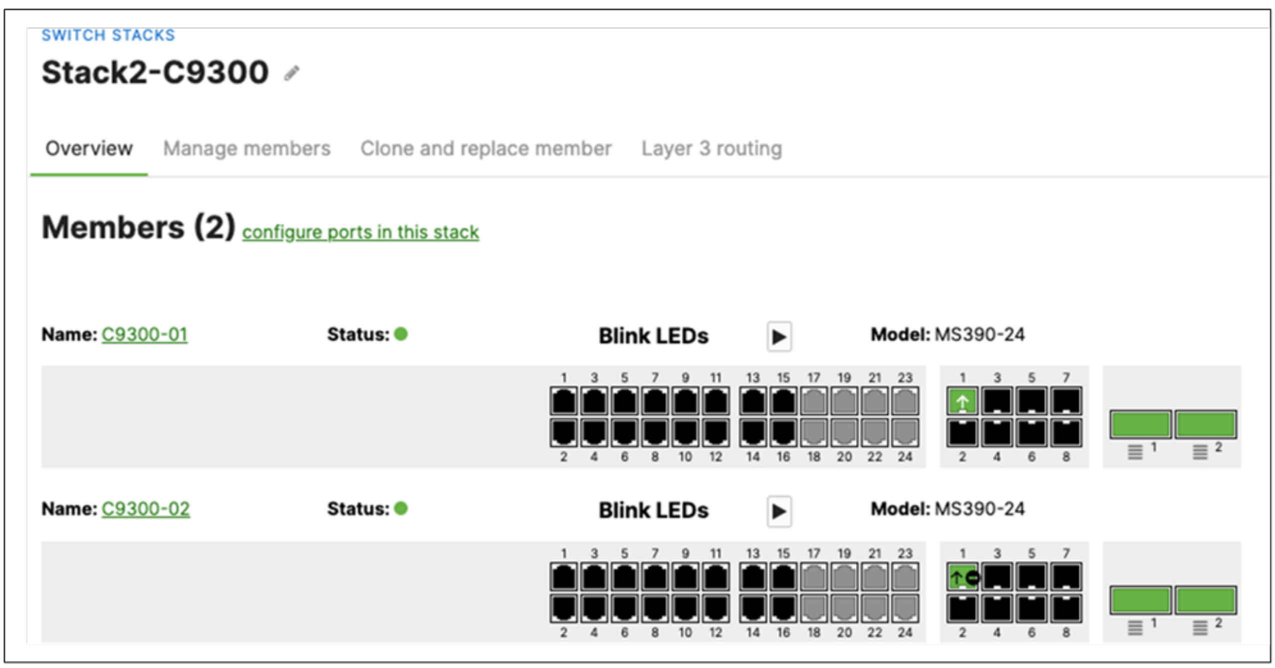
P. Wait for the stack to come online on dashboard. To check the status of your stack, Navigate to **Switching > Monitor > Switch stacks** and then click on each stack to verify that all members are online and that stacking cables show as connected


SWITCH STACKS
Stack1-MS390
Overview
Manage members
Clone and replace member
Layer 3 routing
Members (2) configure ports in this stack
Name: MS390-01
Status:
Blink LEDs
Model: MS390-24U
No module connected
Name: MS390-02
Status:
Blink LEDs
Model: MS390-24
No module connected

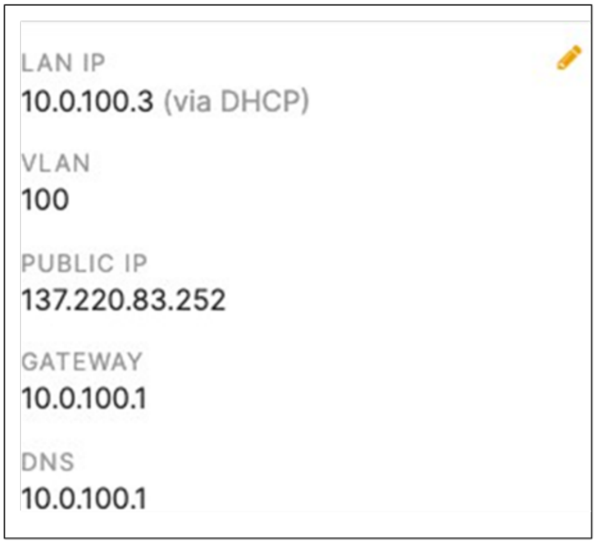

SWITCH STACKS
Stack2-C9300
Overview
Manage members
Clone and replace member
Layer 3 routing
Members (2) configure ports in this stack
Name: C9300-01
Status:
Blink LEDs
Model: MS390-24
Name: C9300-02
Status:
Blink LEDs
Model: MS390-24

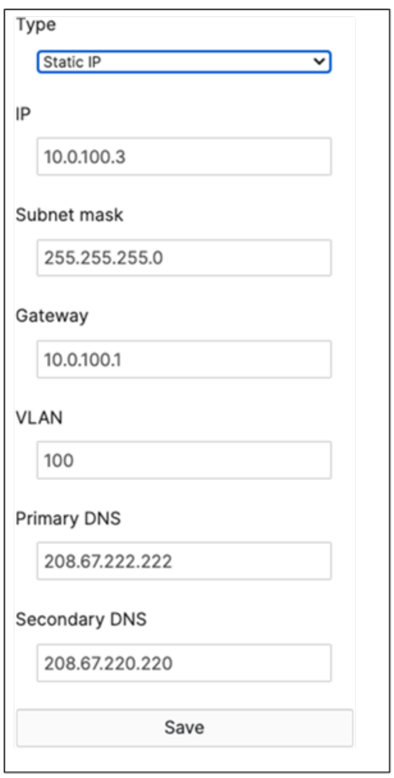
Q. Plug uplinks on all other *non-master* members and verify that the uplink is online in dashboard by navigating to **Switching > Monitor > Switch stacks** and then click on each stack to verify that all uplinks are showing as connected however they should be in ***STP discarding mode***.





R. Configure the same Static IP for all members in each stack by navigating to **Switching > Monitor > Switches** then click on the master switch (e.g. MS390-01 for Stack1) and under LAN IP menu copy the IP address then click on the **edit** button to specify the Static IP address information (You can use the same IP address that was assigned using DHCP) then click **Save.** The same Static IP address information should now be copied for all members of the same stack. You can verify this by navigating to **Switching > Monitor > Switches** (Tip: Click on the configure button on the right-hand side of the table to add Local IP information display).





- And on your Stack2-9300 Master Switch:

Type

Static IP

IP

10.0.200.3

Subnet mask

255.255.255.0

Gateway

10.0.200.1

VLAN

200

Primary DNS

208.67.222.222

Secondary DNS

208.67.220.220

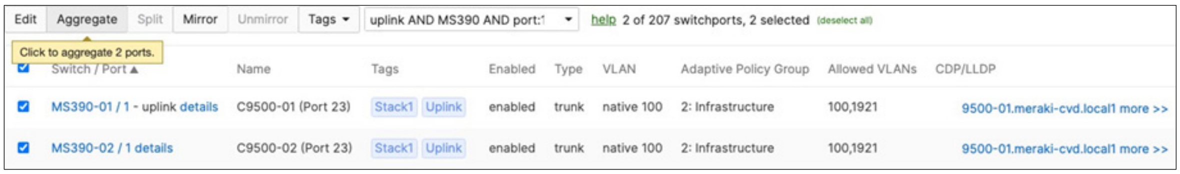
Save

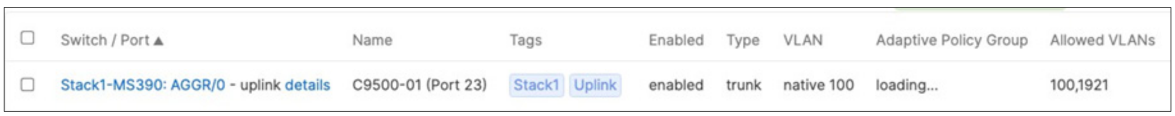
#	Name	MAC address	Model	Connectivity	Serial number	Configuration status	Firmware version	Local IP
1	MS390-02	2c:3f:0b:0f:ec:00	MS390-24-HW		Q3EA-7XLN-J8UX	Up to date	MS 15.14	10.0.100.3
2	MS390-01	2c:3f:0b:04:7e:80	MS390-24U-HW		Q3EC-LV4U-EC25	Up to date	MS 15.14	10.0.100.3
3	C9300-02	4c:e1:75:b0:ba:00	C9300-24U		Q5TC-F2Y8-5XL7	Up to date	MS 15.14	10.0.200.3
4	C9300-01	a4:b4:39:5f:2a:80	C9300-24U		Q5TC-UKPT-36JK	Up to date	MS 15.14	10.0.200.3

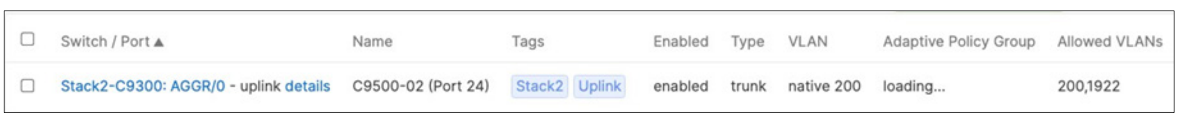
Rows per page 10 1

S. Finally, configure etherchannels on both your Access Switch Stacks and your Core Switch Stacks so that all uplinks can be operational (STP forwarding mode) at the same time. Follow these steps:

- First, disconnect the downlinks to non-master switches from your C9500 Core Stack (e.g. Port TwentyFiveGigE2/0/23 and TwentyFiveGigE2/0/24)
- Navigate to **Switching > Monitor > Switch ports** and search for **uplink** then select all uplinks in the same stack (in case you have tagged your ports otherwise search for them manually and select them all) then click on **Aggregate.** Please note that all port members of the same Ether Channel must have the **same** configuration otherwise Dashboard will not allow you to click the aggregate button.







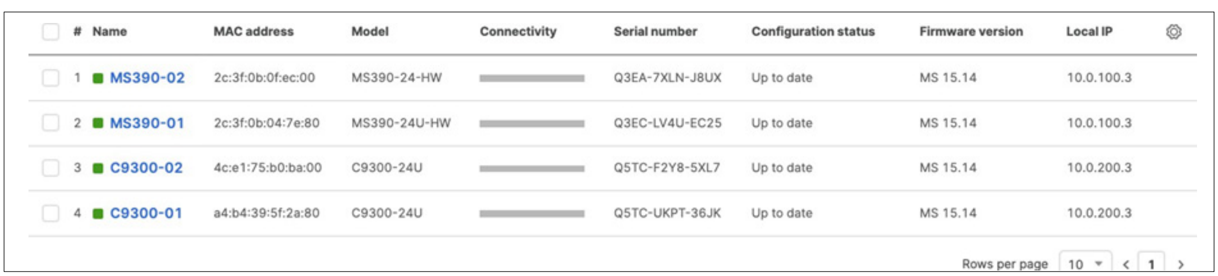
- Please repeat above steps for **all** stacks in your network
- Please note that the above step will cause all members within the stack to go offline in Dashboard

- On your C9500 Core Stack, please configure etherchannel Settings for your downlinks such that *each* Stack downlinks should be in a *separate* Port-channel and that the mode is **active**:

```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#interface TwentyFiveGigE1/0/23
9500-01(config-if)#channel-group 1 mode active
Creating a port-channel interface Port-channel 1

9500-01(config-if)#
9500-01(config-if)#interface TwentyFiveGigE2/0/23
9500-01(config-if)#channel-group 1 mode active
9500-01(config-if)#interface TwentyFiveGigE1/0/24
9500-01(config-if)#channel-group 2 mode active
Creating a port-channel interface Port-channel 2

9500-01(config-if)#interface TwentyFiveGigE2/0/24
9500-01(config-if)#channel-group 2 mode active
9500-01(config-if)#end
9500-01#
9500-01#show etherchannel 1 port-channel
Port-channels in the group:
-------------------------
Port-channel: Po1 (Primary Aggregator)
Age of the Port-channel = 0d:01h:42m:43s
Logical slot/port = 9/1 Number of ports = 2
HotStandBy port = null
Port state = Port-channel Ag-Inuse
Protocol = LACP
Port security = Disabled
Fast-switchover = disabled
Fast-switchover Dampening = disabled

Ports in the Port-channel:
Index    Load    Port    EC state    No of bits
------+------+------+----------------- -+-----------
0   00    Twe1/0/23       Active        0
0   00    Twe2/0/23       Active        0

Time since last port bundled: 0d:01h:40m:21s Twe2/0/23

9500-01#
```

```
9500-01#show etherchannel 2 port-channel
Port-channels in the group:
--------------------------
Port-channel: Po2 (Primary Aggregator)
----------
Age of the Port-channel = 0d:01h:43m:56s
Logical slot/port = 9/2 Number of ports = 2
HotStandBy port = null
Port state = Port-channel Ag-Inuse
Protocol = LACP
Port security = Disabled
Fast-switchover = disabled
Fast-switchover Dampening = disabled

Ports in the Port-channel:

Index   Load Port     EC state      No of bits
------+------+------+--------------+-----------
0 00     Twe1/0/24     Active             0
0 00 Twe2/0/24         Active             0

Time since last port bundled: 0d:01h:42m:04s Twe2/0/24

9500-01#9500-01#wr mem
Building configuration...

[OK]
9500-01#
```

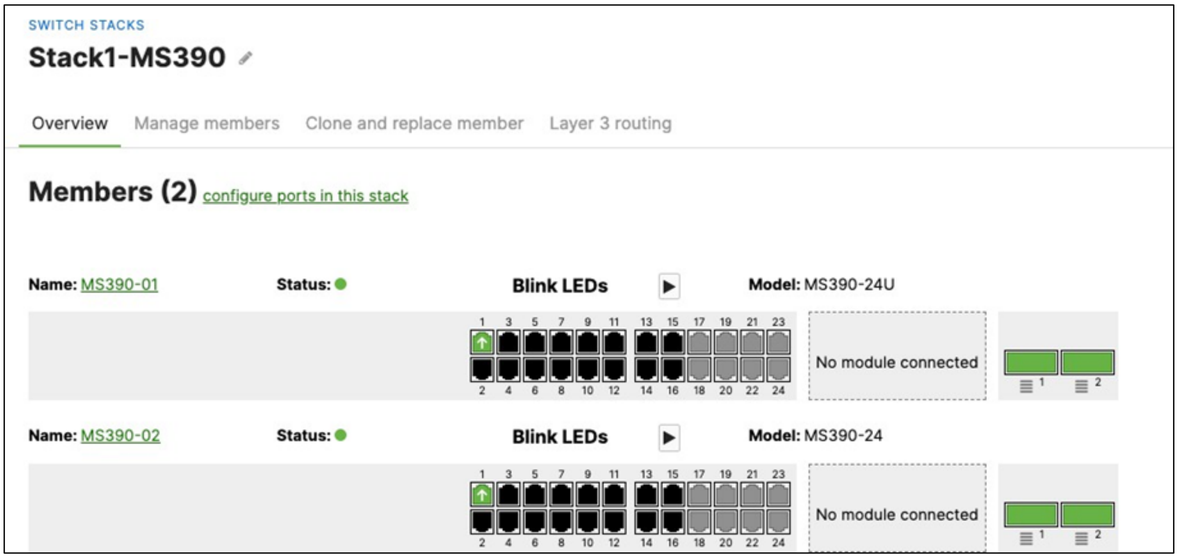
- Plug all uplinks to non-master switches
- Now all your switches should come back online on Dashboard

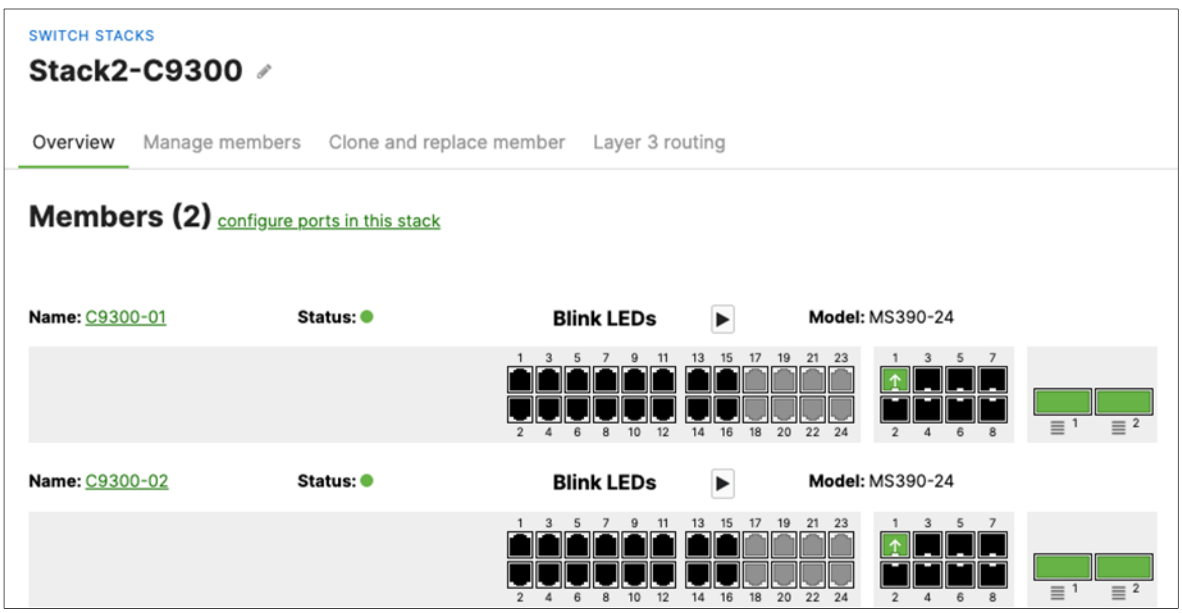


#	Name	MAC address	Model	Connectivity	Serial number	Configuration status	Firmware version	Local IP
1	MS390-02	2c:3f:0b:0f:ec:00	MS390-24-HW		Q3EA-7XLN-J8UX	Up to date	MS 15.14	10.0.100.3
2	MS390-01	2c:3f:0b:04:7e:80	MS390-24U-HW		Q3EC-LV4U-EC25	Up to date	MS 15.14	10.0.100.3
3	C9300-02	4c:e1:75:b0:ba:00	C9300-24U		Q5TC-F2Y8-5XL7	Up to date	MS 15.14	10.0.200.3
4	C9300-01	a4:b4:39:5f:2a:80	C9300-24U		Q5TC-UKPT-36JK	Up to date	MS 15.14	10.0.200.3

Rows per page 10 1

- And now all your uplinks from each stack should be in STP Forwarding mode, which you can verify on Dashboard by navigating to **Switching > Monitor > Switch stacks** and checking the uplink port status. Also, you can check that on your C9500 Core Stack.





```
9500-01#show spanning-tree interface port-channel 1
Mst Instance      Role Sts Cost      Prio.Nbr Type
----------------------------------------------------
MST0             Desg FWD 10000      128.2089 P2p
9500-01#show spanning-tree interface port-channel 2

Mst Instance      Role Sts Cost      Prio.Nbr Type
----------------------------------------------------
MST0              Desg FWD 1000       128.2090 P2p
9500-01#show spanning-tree

MST0
   Spanning tree enabled protocol mstp
   Root ID Priority 4096
        Address b0c5.3c60.fba0
        This bridge is the root
        Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

   Bridge ID Priority 4096 (priority 4096 sys-id-ext 0)
        Address b0c5.3c60.fba0
        Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Interface    Role Sts Cost       Prio.Nbr Type
------------------------------------------------------
Twe1/0/1     Desg FWD 2000        128.193 P2p
Twe2/0/1     Back BLK 2000        128.385 P2p
Po1          Desg FWD 10000       128.2089 P2p
Po2          Desg FWD 1000       128.2090 P2p

9500-01#
```

56. **Configure Multiple Spanning Tree Protocol (802.1s)** in Dashboard for MS390 and C9300 switches: Navigate **to Switch > Configure > Switch settings** and select your stack and choose the appropriate STP priority per stack (61440 for all Access Switch Stacks) then click **Save** at the bottom of the page.

- Please note that changing the STP priority will cause a brief outage as the STP topology will be recalculated.
- Verify that the Access Stacks are seeing the C9500 Core Stack as the root by navigating to **Switching > Monitor > Switches** then click on any switch and under the RSTP root menu check the root bridge information

57. **Configure Dynamic ARP Inspection (DAI) on your C9500 Core Switches:** All Downlinks to Access Switches and Uplinks to MX Edge must be configured as **Trusted** and all other interfaces as **Untrusted**. (*Please note that the order of commands is important to avoid loss of connectivity*)

```
9500-01#show cdp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater, P - Phone,
                  D - Remote, C - CVTA, M - Two-port Mac Relay

Device ID      Local Intrfce     Holdtme Capability Platform Port ID
a4b4395f2a80   Twe 1/0/24        124      S C9300-24U Port C9300-NM-8X/1
2c3f0b0fec00   Twe 2/0/23        174      S MS390-24 Port 1
2c3f0b047e80   Twe 1/0/23        159      S MS390-24U Port 1
4ce175b0ba00   Twe 2/0/24        177      S C9300-24U Port C9300-NM-8X/1

Total cdp entries displayed : 4
9500-01#configure terminal
9500-01(config)#interface TwentyFiveGigE1/0/1
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
```

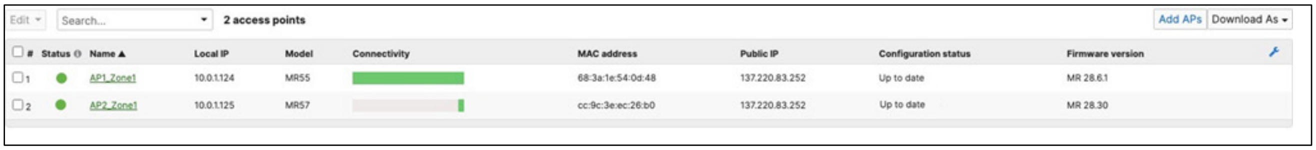
```
9500-01(config)#interface TwentyFiveGigE1/0/2
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
9500-01(config)#interface TwentyFiveGigE2/0/1
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
9500-01(config)#interface TwentyFiveGigE2/0/2
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
9500-01(config)#interface Po1
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
9500-01(config)#interface Po2
9500-01(config-if)#ip arp inspection trust
9500-01(config-if)#ip dhcp snooping trust
9500-01(config-if)#exit
9500-01(config)#ip arp inspection vlan 3,100,200,1921,1922,1923
9500-01(config)#ip arp inspection validate src-mac
9500-01(config)#ip arp inspection validate ip src-mac
9500-01(config)#ip dhcp snooping vlan 3,100,200, 1921,1922,1923
9500-01(config)#end
9500-01#show ip dhcp snooping
Switch DHCP snooping is enabled
Switch DHCP gleaning is disabled
DHCP snooping is configured on following VLANs:
3,100,200,1921-1923
DHCP snooping is operational on following VLANs:
3,100,200,1921-1923
DHCP snooping is configured on the following L3 Interfaces:

Insertion of option 82 is enabled
   circuit-id default format: vlan-mod-port
   remote-id: b0c5.3c60.fba0 (MAC)
Option 82 on untrusted port is not allowed
Verification of hwaddr field is enabled
Verification of giaddr field is enabled
DHCP snooping trust/rate is configured on the following Interfaces:
```

```
Interface             Trusted     Allow option     Rate limit (pps)
-------------------------------------------------------------------
TwentyFiveGigE1/0/1         yes        yes          unlimited
Custom circuit-ids:
TwentyFiveGigE1/0/2         yes        yes          unlimited
Custom circuit-ids:
TwentyFiveGigE1/0/23         yes        yes         unlimited
Custom circuit-ids:
TwentyFiveGigE1/0/24         yes        yes         unlimited
Custom circuit-ids:
TwentyFiveGigE2/0/1         yes        yes          unlimited
Custom circuit-ids:
TwentyFiveGigE2/0/2         yes        yes          unlimited
Custom circuit-ids:
TwentyFiveGigE2/0/23         yes        yes         unlimited
Custom circuit-ids:
TwentyFiveGigE2/0/24         yes        yes         unlimited
Custom circuit-ids:
Port-channel1                yes        yes        unlimited
Custom circuit-ids:
Port-channel2                yes        yes         unlimited
   Custom circuit-ids:
9500-01#
9500-01#show ip arp inspection

Source Mac Validation : Enabled
Destination Mac Validation : Disabled
IP Address Validation : Enable

Vlan      Configuration        Operation     ACL Match     Static ACL
-----------------------------------------------------
3            Enabled              Active
100          Enabled              Active
200          Enabled              Active
1921         Enabled              Active
1922         Enabled              Active
1923         Enabled              Active

Vlan   ACL Logging    DHCP Logging   Probe Logging
--------------------------------------------------
3      Deny     Deny    Off
100    Deny     Deny    Off
```

```
200    Deny     Deny    Off
1921   Deny     Deny    Off
1922   Deny     Deny    Off
1923   Deny     Deny    Off

Vlan     Forwarded     Dropped       DHCP Drops     ACL Drops
-------------------------------------------------------------
3        0             0             0               0
100      0             0             0               0
200      0             0             0               0
1921     0             0             0               0
1922     0             0             0               0
1923     0             0             0               0

Vlan    DHCP Permits   ACL Permits   Probe Permits    Source MAC Failures
-------------------------------------------------------------------------
3        0             0             0               0
100      0             0             0               0
200      0             0             0               0
1921     0             0             0               0
1922     0             0             0               0
1923     0             0             0               0

Vlan     Dest MAC Failures   IP Validation Failures    Invalid Protocol Data
---------------------------------------------------------------------------
3           0                                0             0
100         0                                0             0
200         0                                0             0
1921        0                                0             0
1922        0                                0             0
1923        0                                0             0
9500-01#wr mem
Building configuration...
[OK]
9500-01#
```

58. **Configure Dynamic Arp Inspection (DAI) on your Access Switch Stacks:** Navigate to **Switch > Monitor > DHCP** Servers and ARP and scroll down to **Dynamic ARP Inspection and enable it,** then click Save **at the bottom of the page.**

59. **Setting up your Access Points:** Connect your APs to the respective ports on the Access Switches (e.g. Ports 13-16) and wait for them to come online on dashboard and download their firmware and configuration files. To check the status of your APs navigate to **Wireless > Monitor > Access points** and check the status, configuration and firmware of your APs.



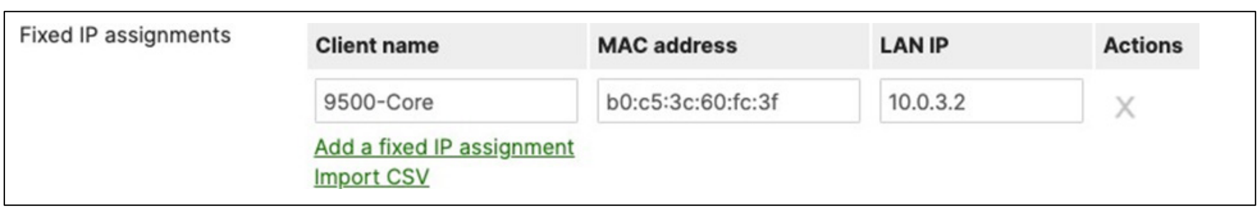
60. **Re-addressing your Network Devices:** In this step, you will adjust your IP addressing configuration - *if required* - to align with your network design. This step could have been done earlier in the process however it will be easier to adjust after all your network devices have come online since the MX (The DHCP server for Management VLAN 1) has kept a record of the actual MAC addresses of all DHCP clients. Follow these steps to re-assign the desired IP addresses. (Please note that this will cause disruption to your network connectivity)

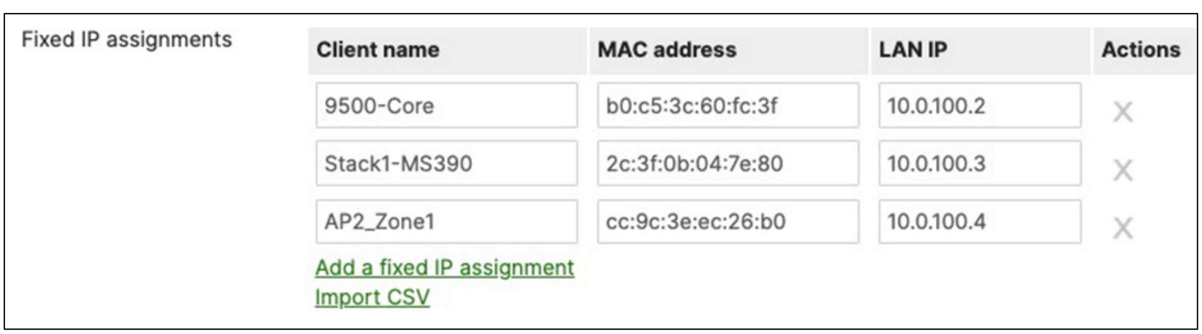
    A. Navigate to **Organization > Monitor > Overview** then click on **Devices** tab to check the current IP addressing for your network devices

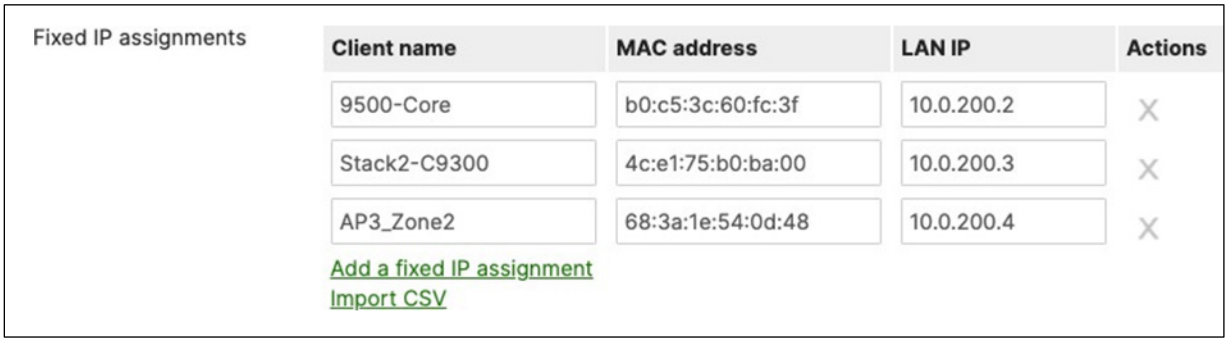
    B. Navigate to **Security and SD-WAN > Monitor > Appliance status** then click on the Tools tab and click on **Run** next to ARP Table

    C. Take a note of the MAC addresses of your network devices

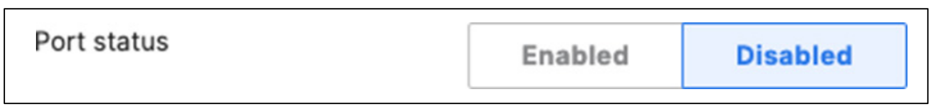
    D. Navigate to **Security and SD-WAN > Configure > DHCP** then under **Fixed IP assignments** click on **Add a fixed IP assignment** and add entries under **each** DHCP Pool *as shown below* for your network devices using the MAC addresses you have from Step #3 above then click on **Save** at the bottom of the page.



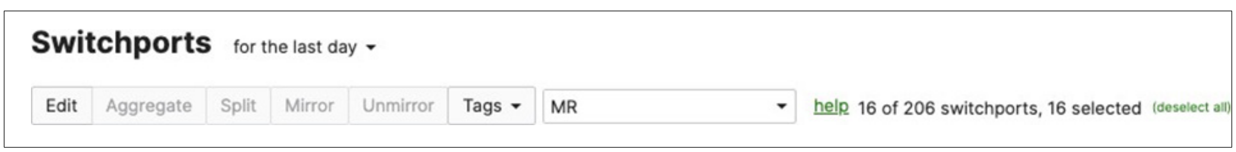


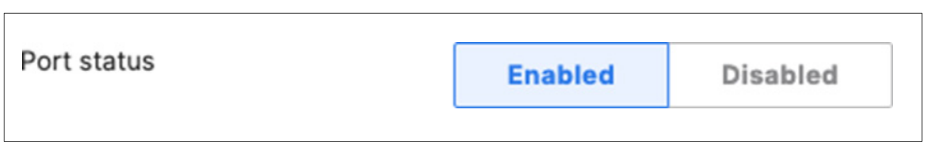


E. Navigate to **Switching > Monitor > Switch ports** then filter for MR (in case you have previously tagged your ports or select ports manually if you haven't) then select those ports and click on **Edit**, then set **Port status** to Disabled then click on **Save**.

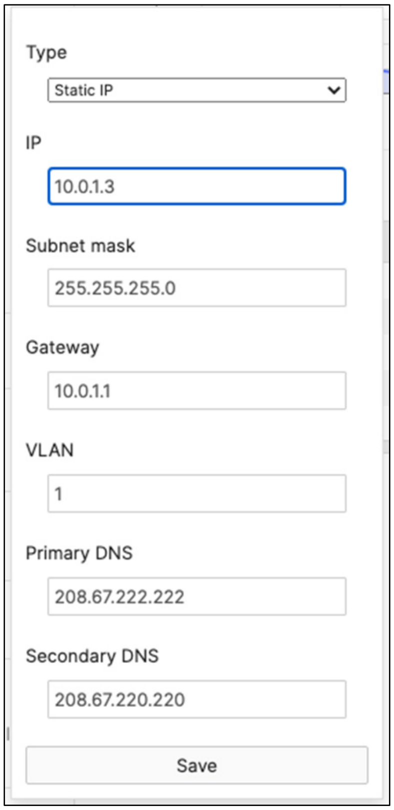


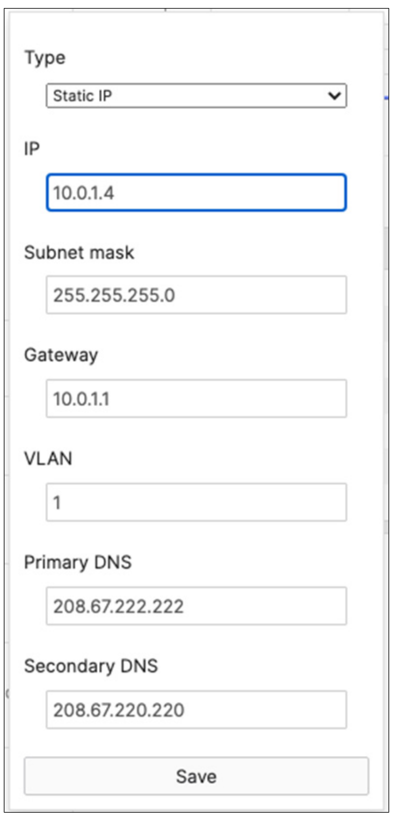
F. After a few minutes (*For configuration to be up to date*) navigate to **Switching > Monitor > Switch ports,** then filter for MR (in case you have previously tagged your ports or select ports manually if you haven't) then select those ports and click on **Edit**, then set **Port status** to **Enabled** then click on **Save**.





G. Navigate to **Switching > Monitor > Switches,** then click on each master switch to change its IP address to the one desired using Static IP configuration (remember that all members of the **same** stack need to have the same static IP address)

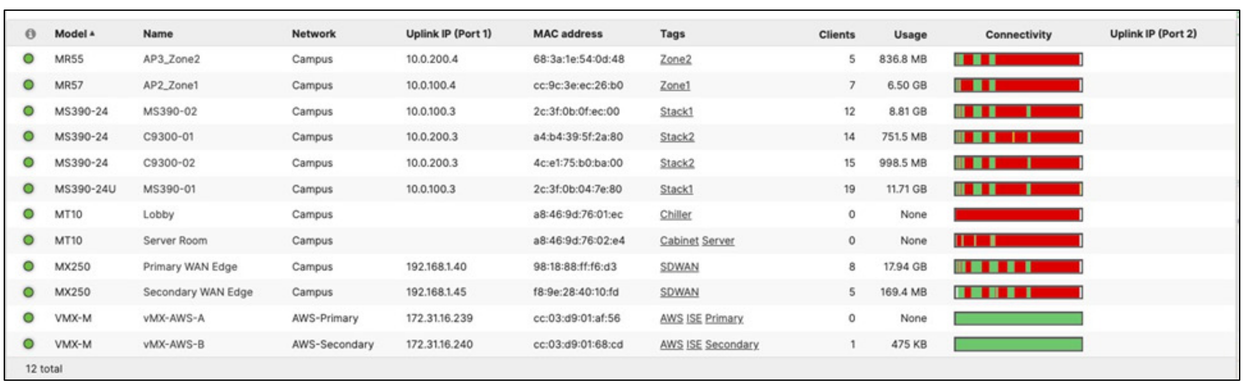

Type
Static IP
IP
10.0.1.3
Subnet mask
255.255.255.0
Gateway
10.0.1.1
VLAN
1
Primary DNS
208.67.222.222
Secondary DNS
208.67.220.220
Save


Type
Static IP
IP
10.0.1.4
Subnet mask
255.255.255.0
Gateway
10.0.1.1
VLAN
1
Primary DNS
208.67.222.222
Secondary DNS
208.67.220.220
Save

H. On your C9500 Core Stack, bounce your VLAN 3,100,200 interfaces. Then verify that the interfaces VLAN 3/ 100/200 came up with the correct IP address (e.g. 10.0.3.2 per this design)

```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#interface vlan 3
9500-01(config-if)#shutdown
9500-01(config-if)#no shutdown
9500-01(config-if)#interface vlan 100
9500-01(config-if)#shutdown
9500-01(config-if)#no shutdown
9500-01(config-if)#interface vlan 200
9500-01(config-if)#shutdown
9500-01(config-if)#no shutdown
9500-01(config-if)#end
9500-01#sh ip interface brief | in Vlan
Vlan1      unassigned      YES NVRAM administratively down   down
Vlan3       10.0.3.2       YES DHCP up                       up
Vlan100     10.0.100.2     YES DHCP up                       up
Vlan200     10.0.200.2     YES DHCP up                       up
9500-01#
```

I. Navigate to **Organization > Monitor > Overview** then click on **Devices** tab to check the current IP addressing for your network devices:

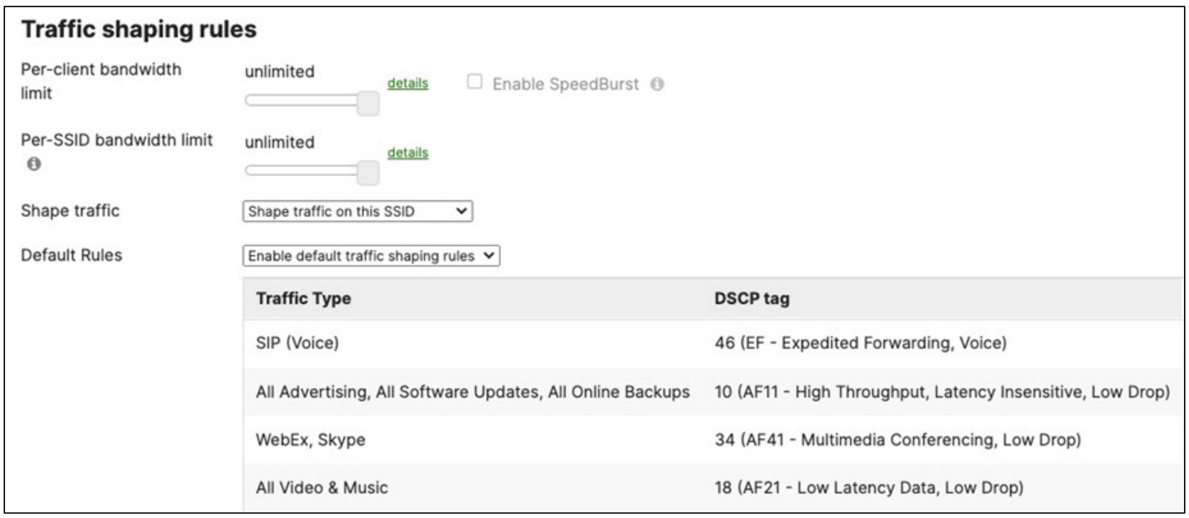


Model	Name	Network	Uplink IP (Port 1)	MAC address	Tags	Clients	Usage	Connectivity	Uplink IP (Port 2)
MR55	AP3_Zone2	Campus	10.0.200.4	68:3a:1e:54:0d:48	Zone2	5	836.8 MB		
MR57	AP2_Zone1	Campus	10.0.100.4	cc:9c:3e:ec:26:b0	Zone1	7	6.50 GB		
MS390-24	MS390-02	Campus	10.0.100.3	2c:3f:0b:0f:ec:00	Stack1	12	8.81 GB		
MS390-24	C9300-01	Campus	10.0.200.3	a4:b4:39:5f:2a:80	Stack2	14	751.5 MB		
MS390-24	C9300-02	Campus	10.0.200.3	4c:e1:75:b0:ba:00	Stack2	15	998.5 MB		
MS390-24U	MS390-01	Campus	10.0.100.3	2c:3f:0b:04:7e:80	Stack1	19	11.71 GB		
MT10	Lobby	Campus		a8:46:9d:76:01:ec	Chiller	0	None		
MT10	Server Room	Campus		a8:46:9d:76:02:e4	Cabinet Server	0	None		
MX250	Primary WAN Edge	Campus	192.168.1.40	98:18:88:ff:f6:d3	SDWAN	8	17.94 GB		
MX250	Secondary WAN Edge	Campus	192.168.1.45	f8:9e:28:40:10:fd	SDWAN	5	169.4 MB		
VMX-M	vMX-AWS-A	AWS-Primary	172.31.16.239	cc:03:d9:01:af:56	AWS ISE Primary	0	None		
VMX-M	vMX-AWS-B	AWS-Secondary	172.31.16.240	cc:03:d9:01:68:cd	AWS ISE Secondary	1	475 KB		

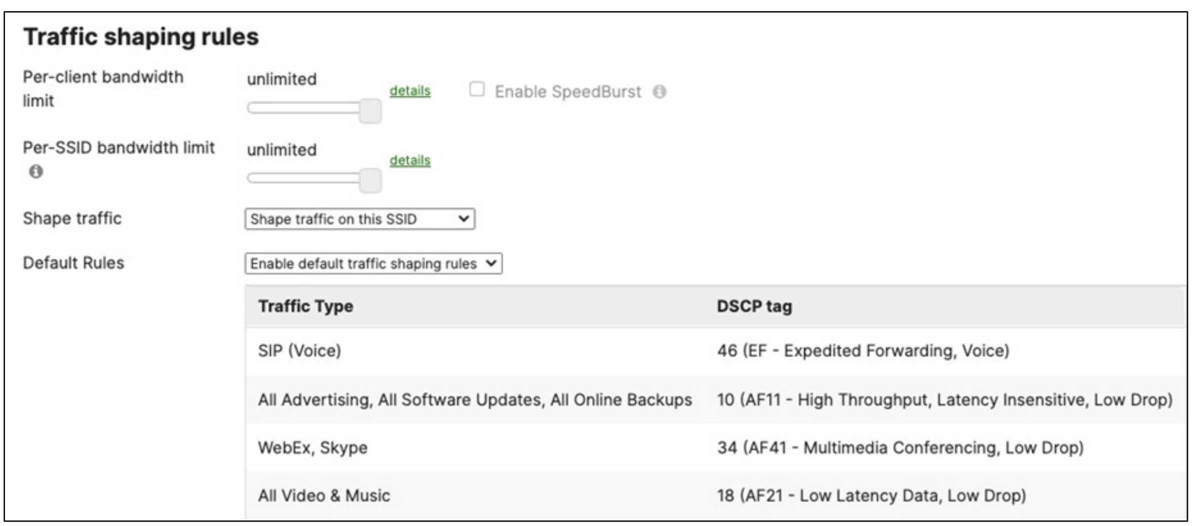
12 total

61. **Configure QoS** in your Campus LAN: Quality of Service configuration needs to be consistent across the whole Campus LAN. Please refer to the above table as an example. (*For the purpose of this CVD, **Default traffic shaping rules** will be used to mark traffic with DSCP values without setting any traffic limits. Please adjust traffic shaping rules based on your own requirements*). To configure QoS, please follow these steps.

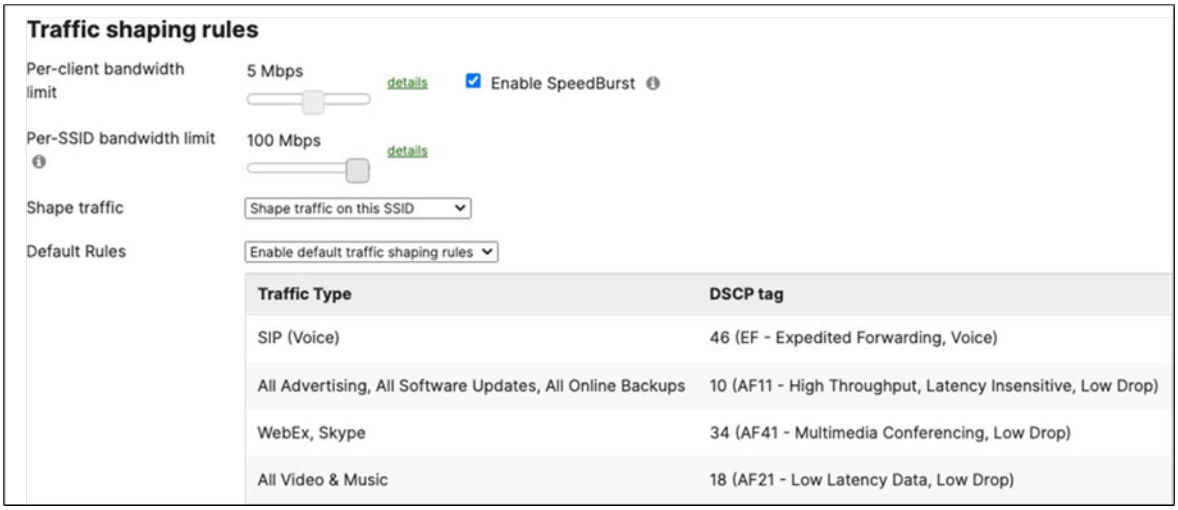
   A. Navigate to **Wireless > Configure > Firewall and Traffic Shaping** and choose the **Acme Corp** SSID from the above drop-down menu. Under **Traffic Shaping rules**, choose the per-client and per-SSID limits desired and select **Shape traffic on this SSID** then select Enable default traffic shaping rules. Click **Save** at the bottom of the page when you are done. Click **Save** at the bottom of the page when you are done.



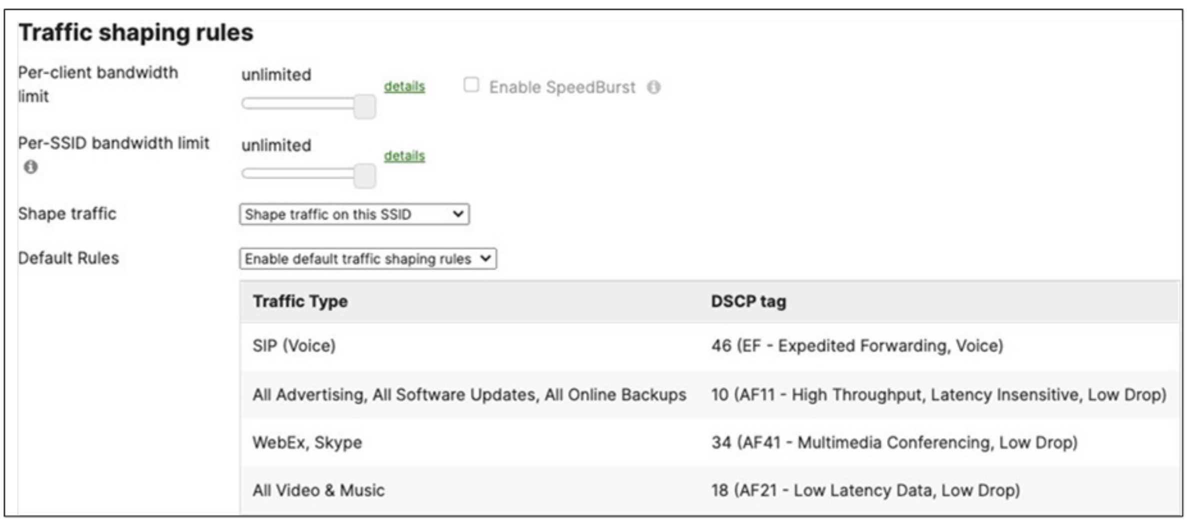
   B. Navigate to **Wireless > Configure > Firewall and Traffic Shaping** and choose the **Acme BYOD** SSID from the above drop-down menu. Under **Traffic Shaping rules**, choose the per-client and per-SSID limits desired and select **Shape traffic on this SSID** then select Enable default traffic shaping rules.



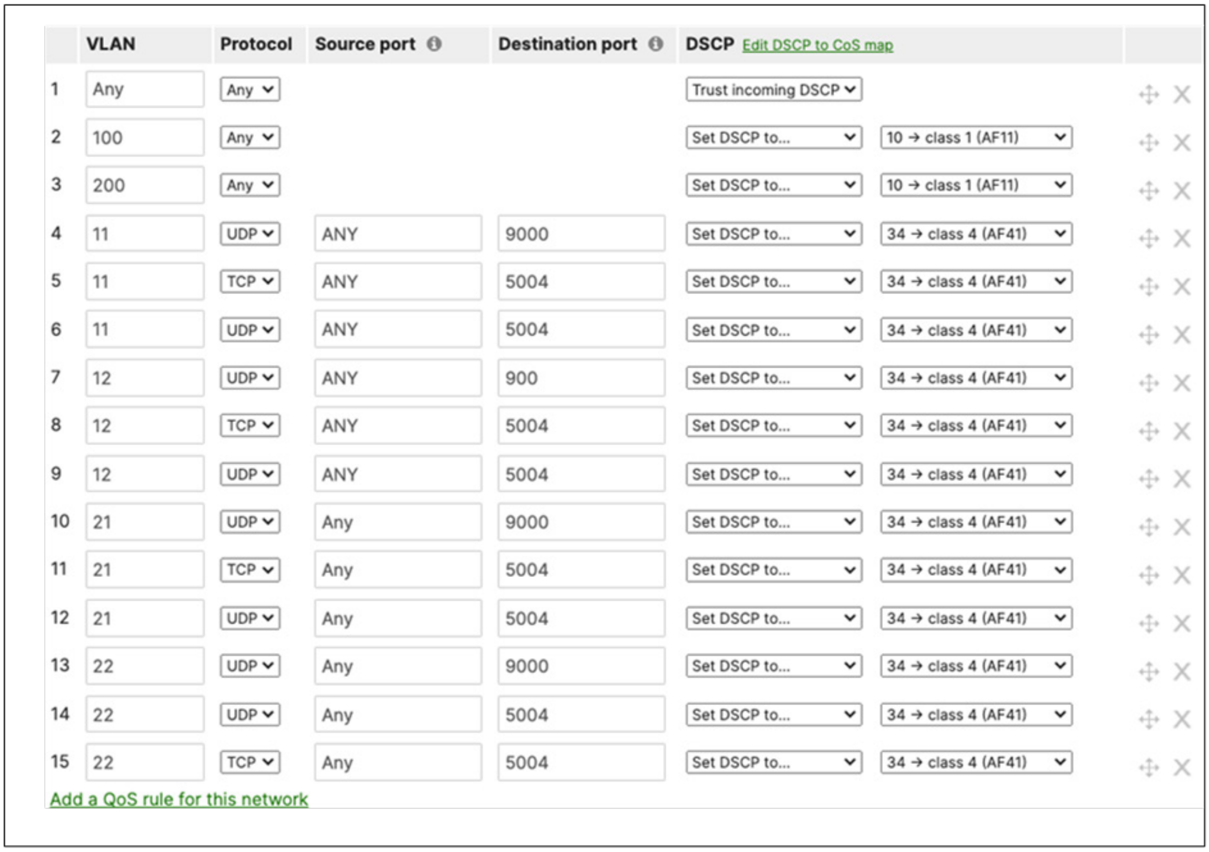
C. Navigate to **Wireless > Configure > Firewall and Traffic Shaping** and choose the **Guest** SSID from the above drop-down menu. Under **Traffic Shaping rules**, choose the per-client and per-SSID limits desired and select **Shape traffic on this SSID** then select Enable default traffic shaping rules. Click **Save** at the bottom of the page when you are done.



D. Navigate to **Wireless > Configure > Firewall and Traffic Shaping** and choose the **IoT** SSID from the above drop-down menu. Under **Traffic Shaping rules**, choose the per-client and per-SSID limits desired and select **Shape traffic on this SSID** then select Enable default traffic shaping rules. Click **Save** at the bottom of the page when you are done.

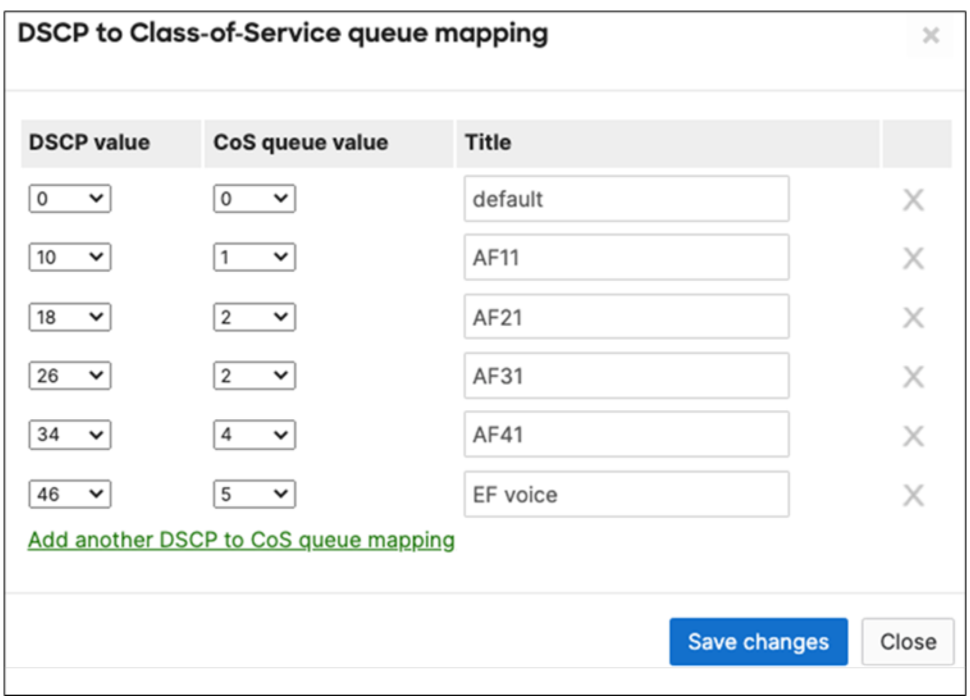


E. Navigate to **Switching > Configure > Switch settings** and under the **Quality of Service** menu configure the VLAN to DSCP mappings. Please click on Edit DSCP to CoS map to change settings per your requirements. Click **Save** at the bottom of the page when you are done. (Please note that the ports used in the below example are based on Cisco Webex traffic flow)



	VLAN	Protocol	Source port	Destination port	DSCP Edit DSCP to CoS map	
1	Any	Any			Trust incoming DSCP	
2	100	Any			Set DSCP to...	10 → class 1 (AF11)
3	200	Any			Set DSCP to...	10 → class 1 (AF11)
4	11	UDP	ANY	9000	Set DSCP to...	34 → class 4 (AF41)
5	11	TCP	ANY	5004	Set DSCP to...	34 → class 4 (AF41)
6	11	UDP	ANY	5004	Set DSCP to...	34 → class 4 (AF41)
7	12	UDP	ANY	900	Set DSCP to...	34 → class 4 (AF41)
8	12	TCP	ANY	5004	Set DSCP to...	34 → class 4 (AF41)
9	12	UDP	ANY	5004	Set DSCP to...	34 → class 4 (AF41)
10	21	UDP	Any	9000	Set DSCP to...	34 → class 4 (AF41)
11	21	TCP	Any	5004	Set DSCP to...	34 → class 4 (AF41)
12	21	UDP	Any	5004	Set DSCP to...	34 → class 4 (AF41)
13	22	UDP	Any	9000	Set DSCP to...	34 → class 4 (AF41)
14	22	UDP	Any	5004	Set DSCP to...	34 → class 4 (AF41)
15	22	TCP	Any	5004	Set DSCP to...	34 → class 4 (AF41)

Add a QoS rule for this network



DSCP to Class-of-Service queue mapping

DSCP value	CoS queue value	Title
0	0	default
10	1	AF11
18	2	AF21
26	2	AF31
34	4	AF41
46	5	EF voice

Add another DSCP to CoS queue mapping

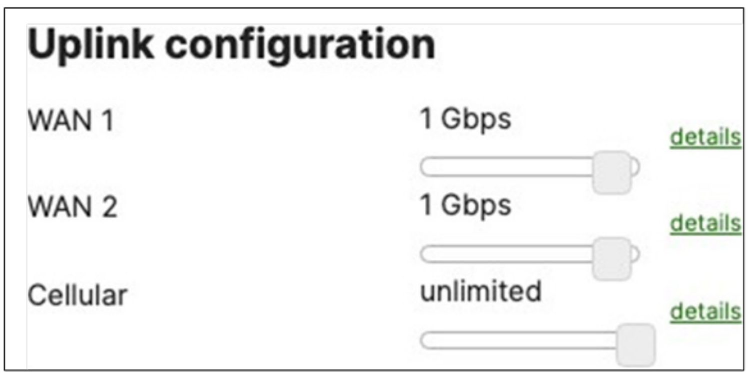
Save changes Close

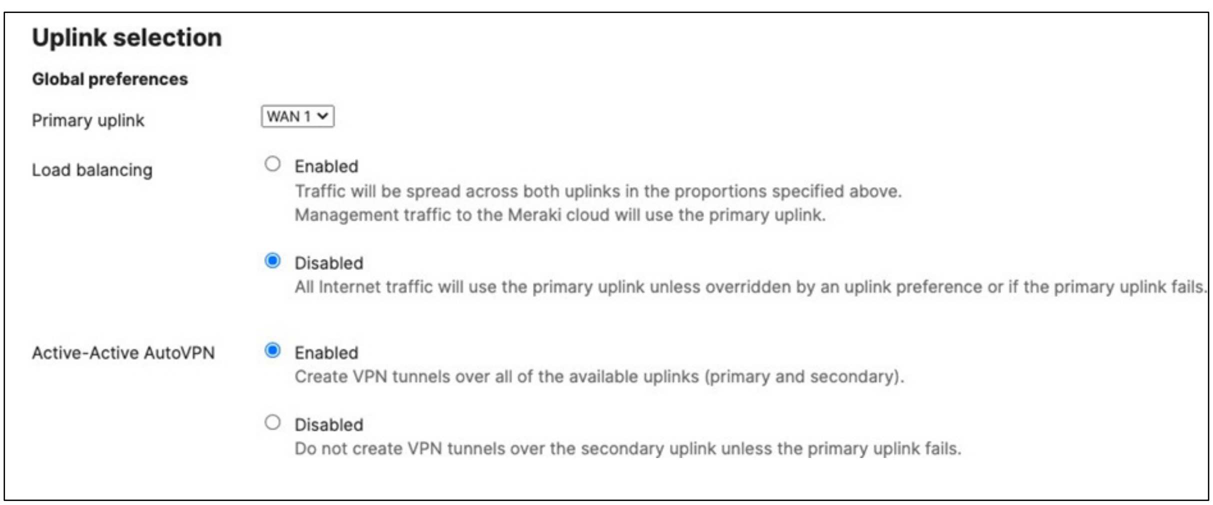
F. Please ensure that your C9500 Core Stack is configured to trust incoming QoS. Here's a reference of the configuration needed to be applied:

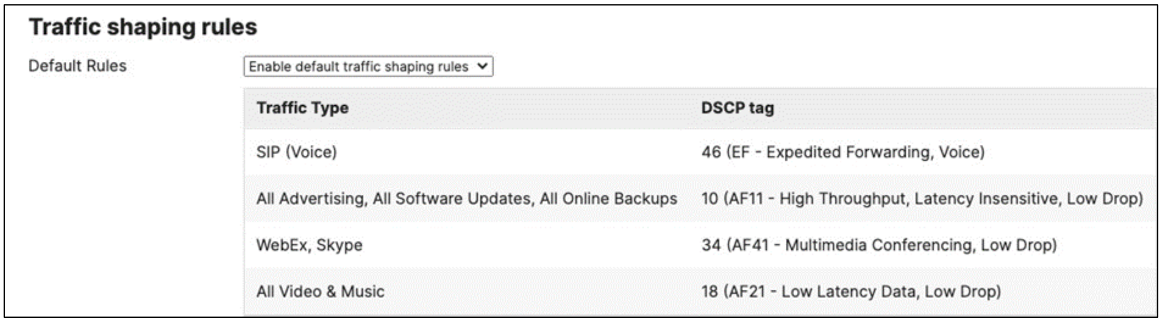
```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#interface TwentyFiveGigE1/0/1
9500-01(config-if)#auto qos trust dscp
9500-01(config-if)#interface TwentyFiveGigE1/0/2
9500-01(config-if)#auto qos trust dscp
9500-01(config-if)#interface TwentyFiveGigE2/0/1
9500-01(config-if)#auto qos trust dscp
9500-01(config-if)#interface TwentyFiveGigE2/0/2
9500-01(config-if)#auto qos trust dscp
9500-01(config-if)#interface TwentyFiveGigE1/0/23
9500-01(config-if)#auto qos trust dscp
Warning: add service policy will cause inconsistency with port TwentyFiveGigE2/0/23
in ether
channel 1.
9500-01(config-if)#interface TwentyFiveGigE1/0/24
9500-01(config-if)#auto qos trust dscp
Warning: add service policy will cause inconsistency with port TwentyFiveGigE2/0/24
in ether
channel 2.
9500-01(config-if)#interface TwentyFiveGigE1/0/24
9500-01(config-if)#auto qos trust dscp
9500-01(config-if)#end
9500-01#show auto qos
TwentyFiveGigE1/0/1
auto qos trust dscp

TwentyFiveGigE1/0/2
auto qos trust dscp

TwentyFiveGigE1/0/23
auto qos trust dscp

TwentyFiveGigE1/0/24
auto qos trust dscp

TwentyFiveGigE2/0/1
auto qos trust dscp

TwentyFiveGigE2/0/2
```

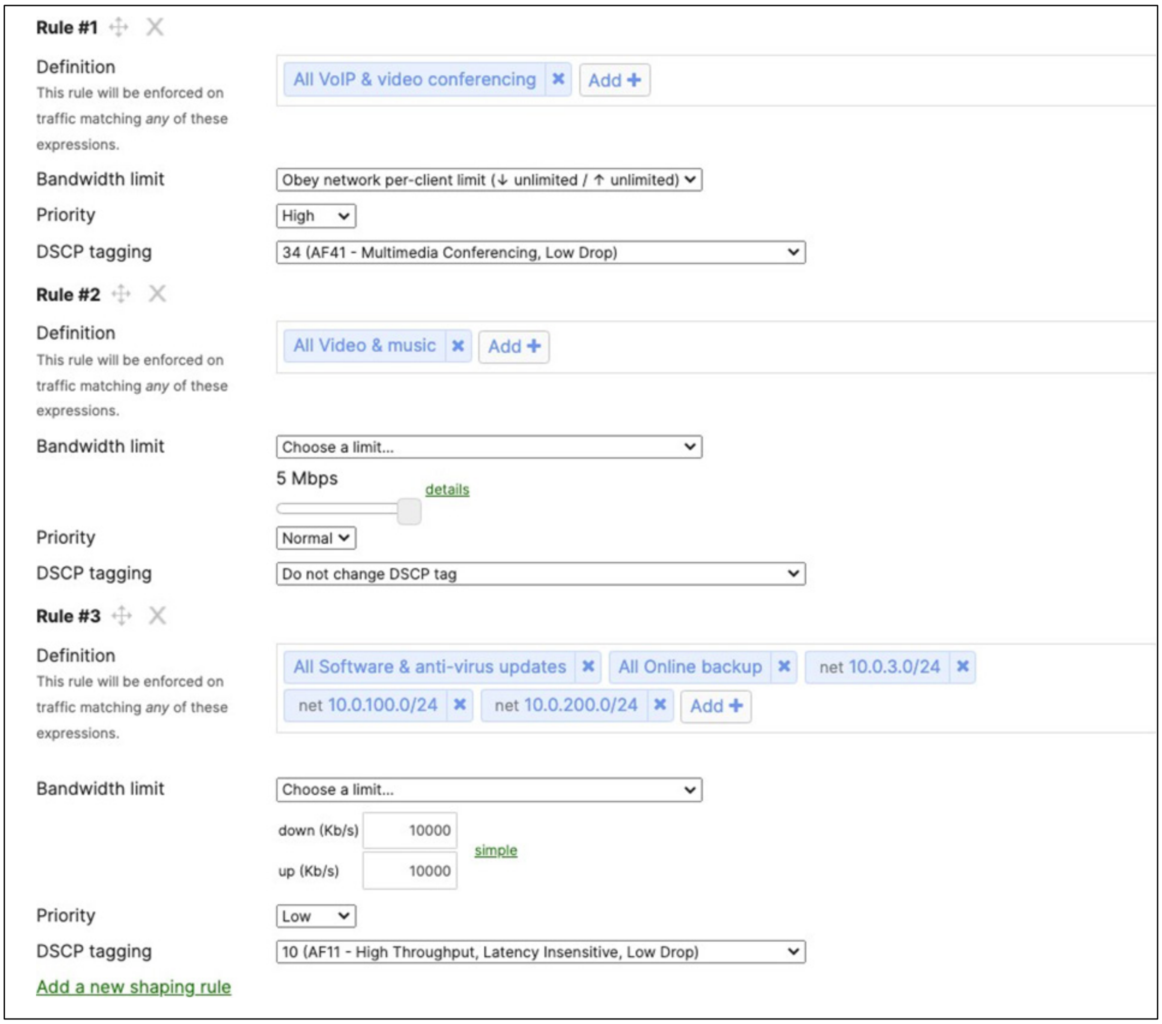
```
auto qos trust dscp

TwentyFiveGigE2/0/23
auto qos trust dscp

TwentyFiveGigE2/0/24
auto qos trust dscp

9500-01#wr mem
```

G. Navigate to **Security and SD-WAN > Configure > SD-WAN and Traffic shaping** and make sure your **Uplink configuration** matches your WAN speed. Then, under Uplink selection choose the settings that match your requirements (e.g. Load balancing). Under **Traffic shaping rules**, select **Enable default traffic shaping rules** then click on **Add a new shaping rule** to create the rules needed for your network. (*for more information about Traffic shaping rules on MX appliances, please refer to the following article*). Please see the following example:






Traffic shaping rules
Default Rules
Enable default traffic shaping rules
Traffic Type
DSCP tag
SIP (Voice)
46 (EF - Expedited Forwarding, Voice)
All Advertising, All Software Updates, All Online Backups
10 (AF11 - High Throughput, Latency Insensitive, Low Drop)
WebEx, Skype
34 (AF41 - Multimedia Conferencing, Low Drop)
All Video & Music
18 (AF21 - Low Latency Data, Low Drop)

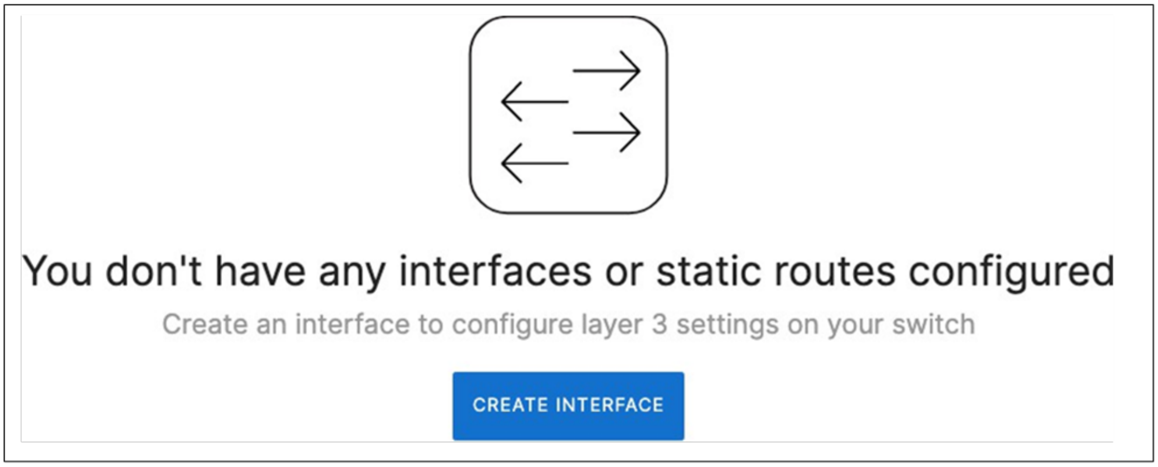

Rule #1
Definition
This rule will be enforced on traffic matching any of these expressions.
All VoIP & video conferencing
Add
Bandwidth limit
Obey network per-client limit (↓ unlimited / ↑ unlimited)
Priority
High
DSCP tagging
34 (AF41 - Multimedia Conferencing, Low Drop)
Rule #2
Definition
This rule will be enforced on traffic matching any of these expressions.
All Video & music
Add
Bandwidth limit
Choose a limit...
5 Mbps
details
Priority
Normal
DSCP tagging
Do not change DSCP tag
Rule #3
Definition
This rule will be enforced on traffic matching any of these expressions.
All Software & anti-virus updates
All Online backup
net 10.0.3.0/24
net 10.0.100.0/24
net 10.0.200.0/24
Add
Bandwidth limit
Choose a limit...
down (Kb/s) 10000
up (Kb/s) 10000
simple
Priority
Low
DSCP tagging
10 (AF11 - High Throughput, Latency Insensitive, Low Drop)
Add a new shaping rule

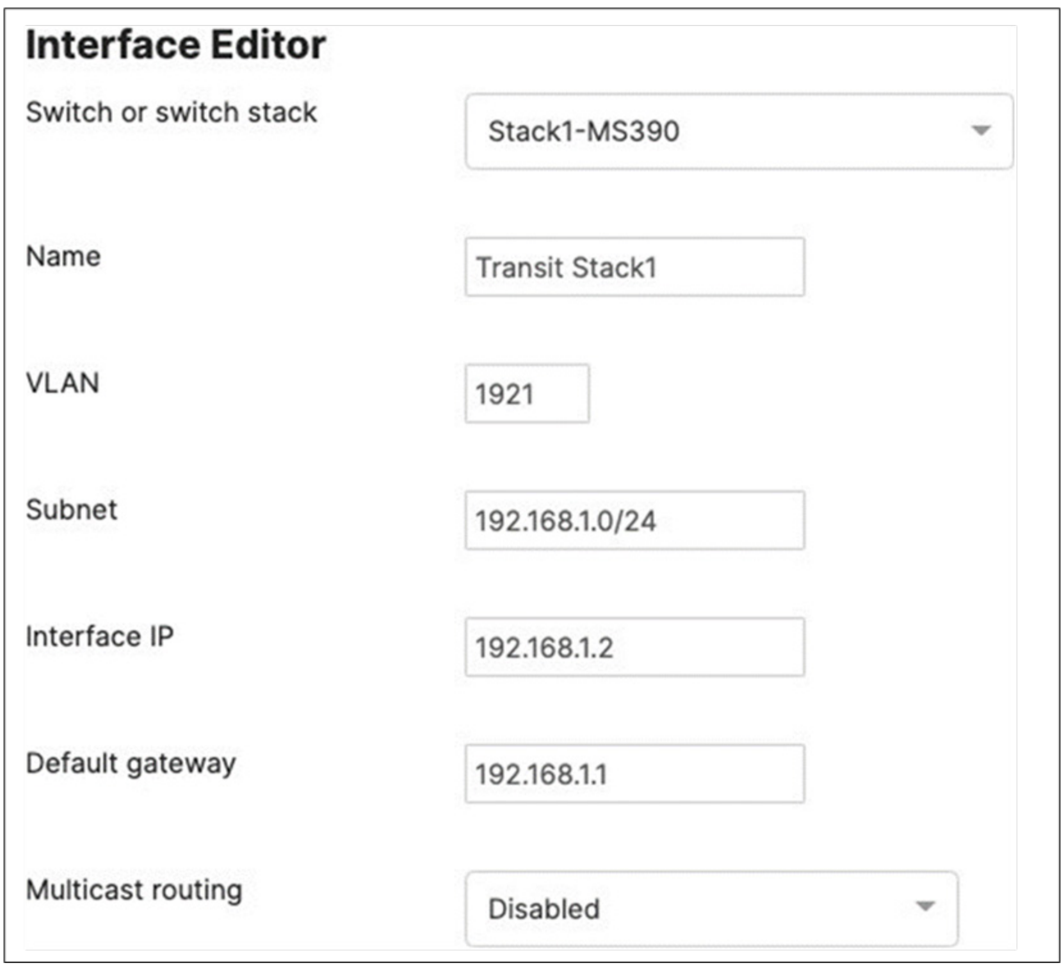
62. **Enable OSPF Routing:** Navigate to **Switching > Configure > OSPF routing** and then click on **Enabled** to enable OSPF. Add the details required and create an OSPF area for your Campus Network. Then, click **Save** at the bottom of the page.

63. **Enable OSPF Routing on your Core Stack:** Please use the following commands to add an OSPF instance and create OSPF neighbors.

```
9500-01#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
9500-01(config)#router ospf 1
9500-01(config-router)#network 192.168.1.0 0.0.0.255 area 0
9500-01(config-router)#network 192.168.2.0 0.0.0.255 area 0
9500-01(config-router)#neighbor 192.168.1.1
9500-01(config-router)#neighbor 192.168.2.1
9500-01(config-router)#end
9500-01#
9500-01#show ip ospf neighbor
Neighbor ID         Pri       State      Dead Time  Address    Interface
192.168.2.2         1         FULL/DR    00:00:33   192.168.2.2Vlan1922
192.168.1.2         1         FULL/DR    00:00:38   192.168.1.2Vlan1921
9500-01#wr mem
```

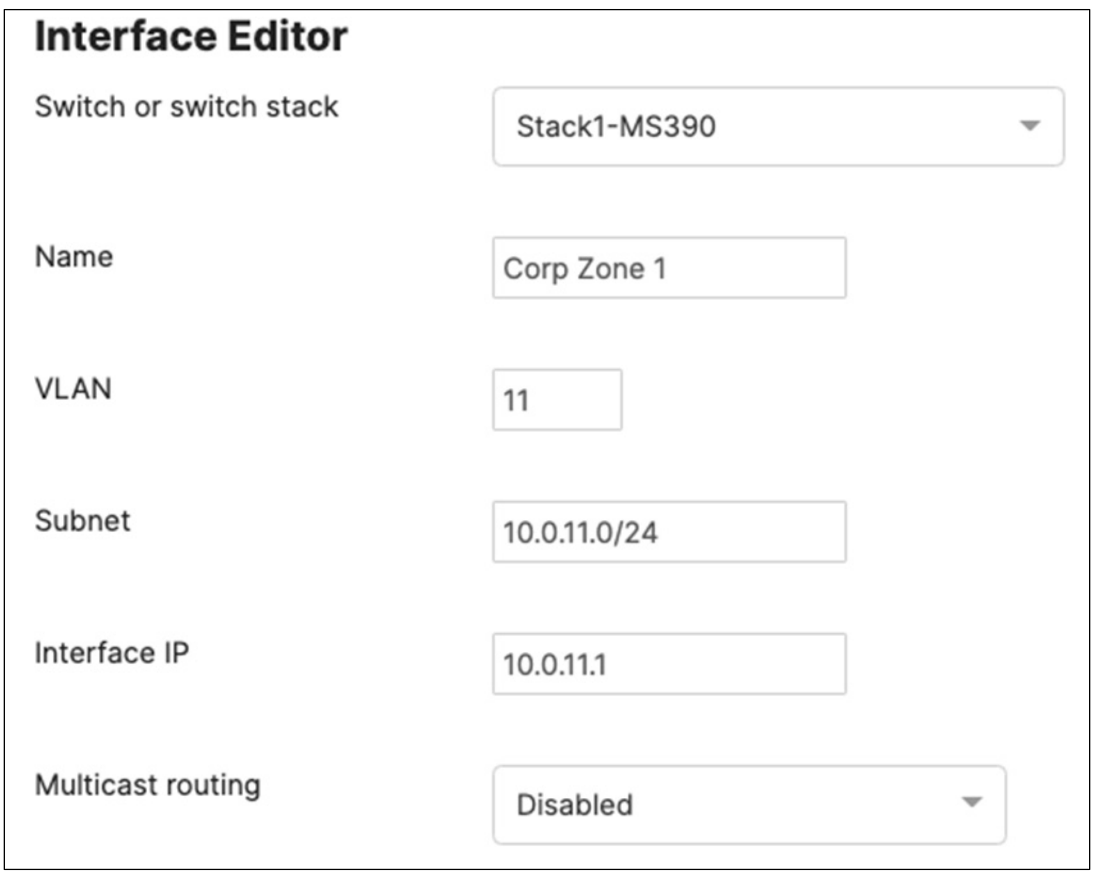
64. **Create SVI Interfaces** on your Access Switch Stacks: Navigate to **Switching > Configure > Routing and DHCP** and click on **CREATE INTERFACE** and start adding your interfaces but first start with the Transit VLANs. Once you have created an interface click on **Save and add another** at the bottom of the page to add more interfaces.

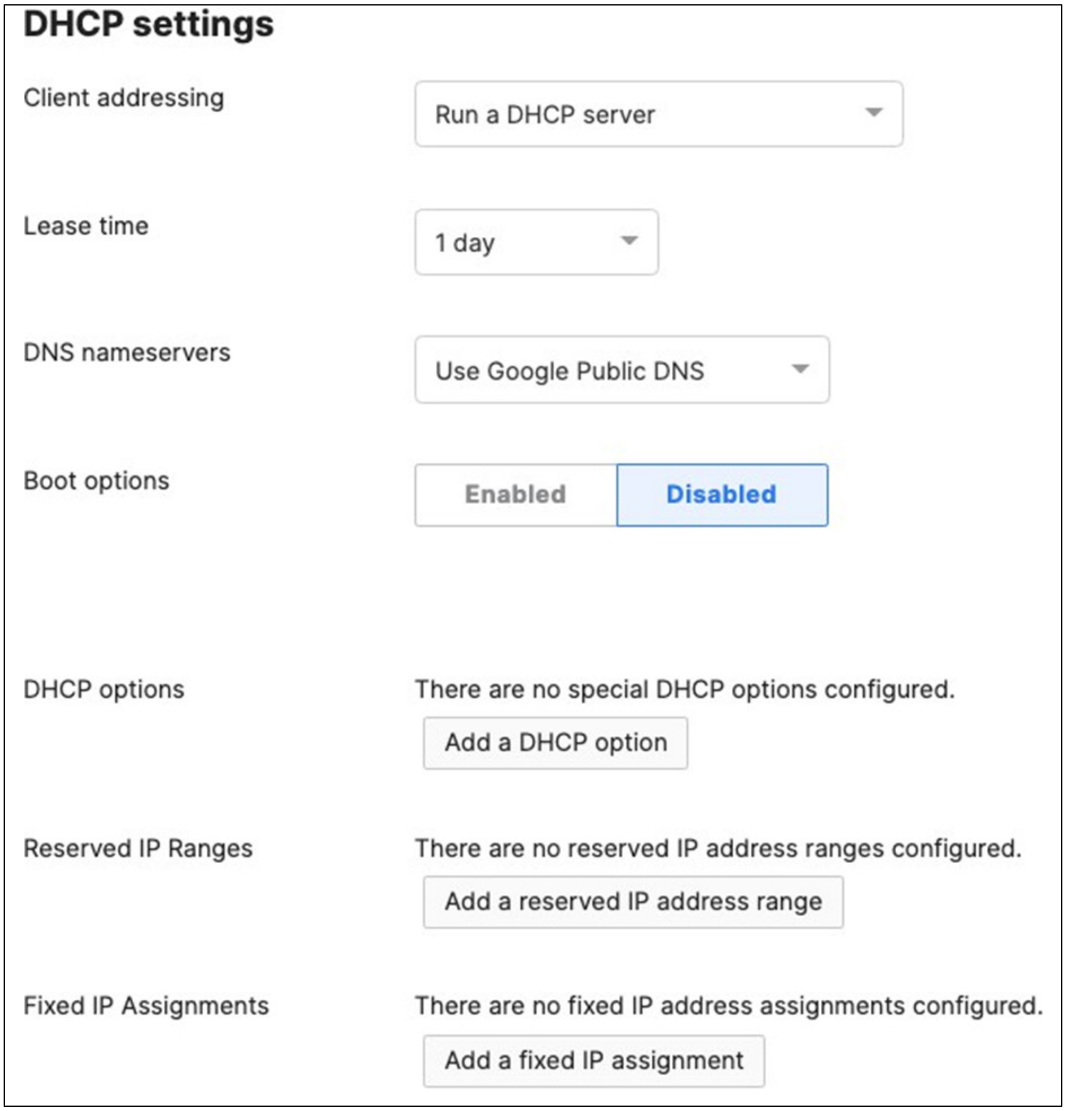





DHCP settings
Client addressing
Do not respond to DHCP requests

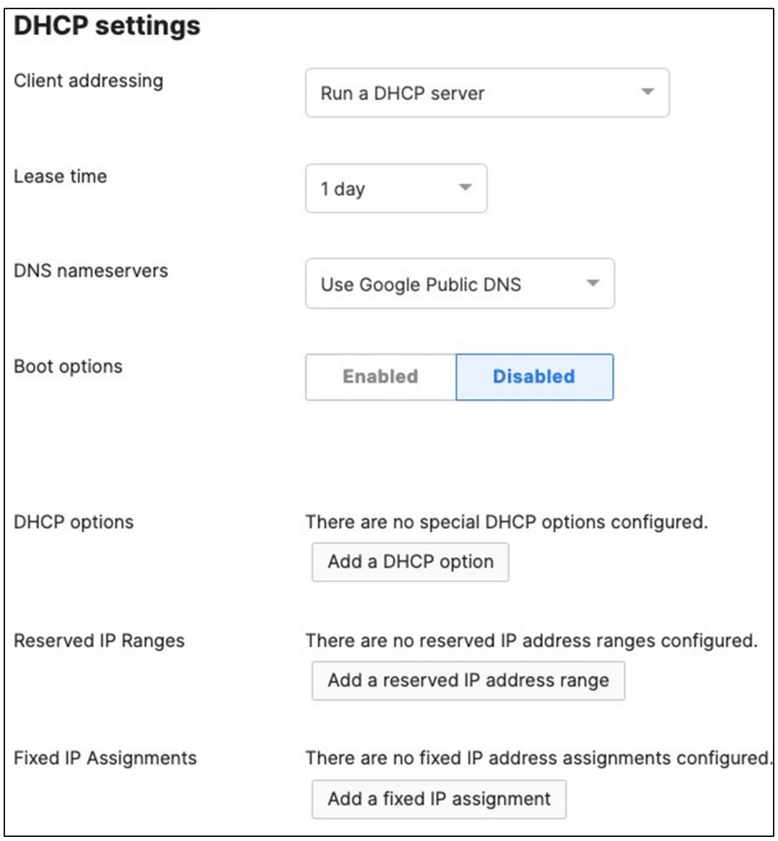

OSPF settings
Area
0: backbone
Cost
1
Passive?
No

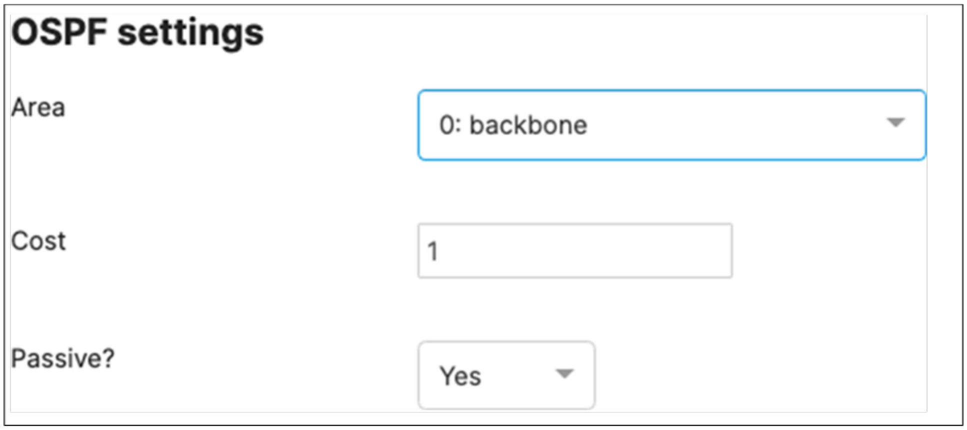

Interface Editor
Switch or switch stack
Stack1-MS390
Name
Corp Zone 1
VLAN
11
Subnet
10.0.11.0/24
Interface IP
10.0.11.1
Multicast routing
Disabled

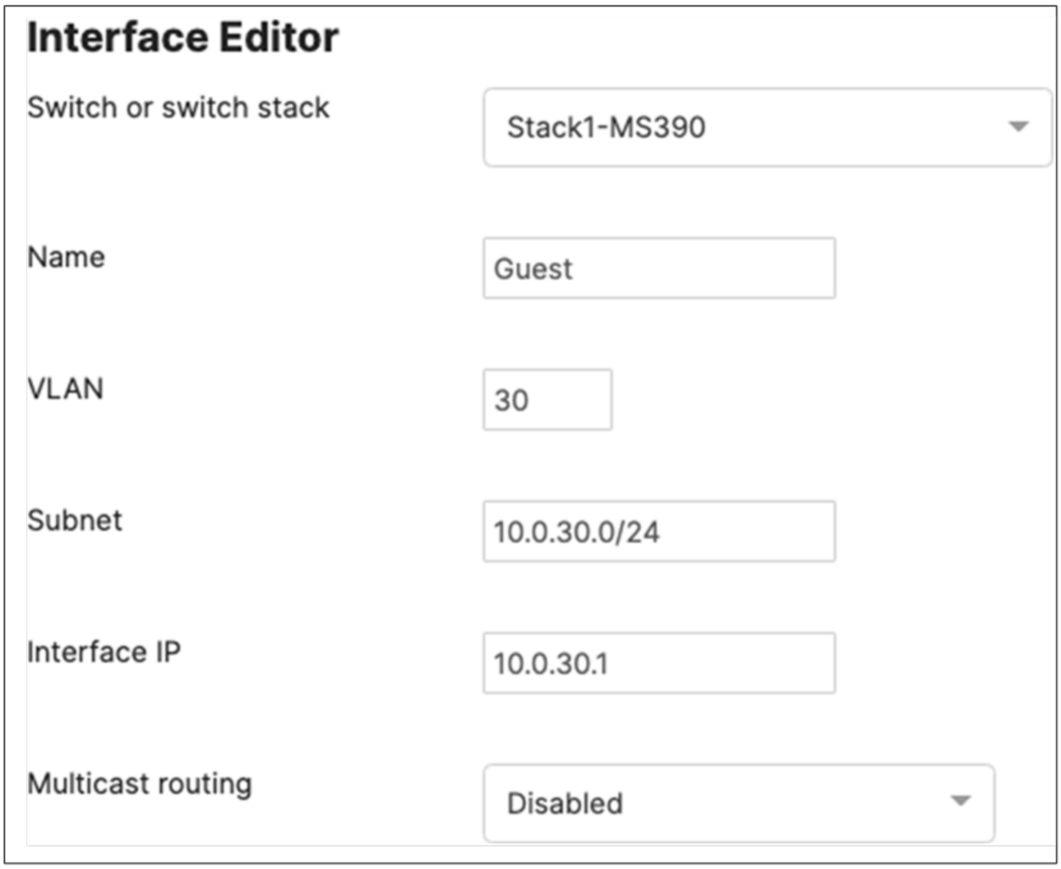

DHCP settings
Client addressing
Run a DHCP server
Lease time
1 day
DNS nameservers
Use Google Public DNS
Boot options
Enabled
Disabled
DHCP options
There are no special DHCP options configured.
Add a DHCP option
Reserved IP Ranges
There are no reserved IP address ranges configured.
Add a reserved IP address range
Fixed IP Assignments
There are no fixed IP address assignments configured.
Add a fixed IP assignment

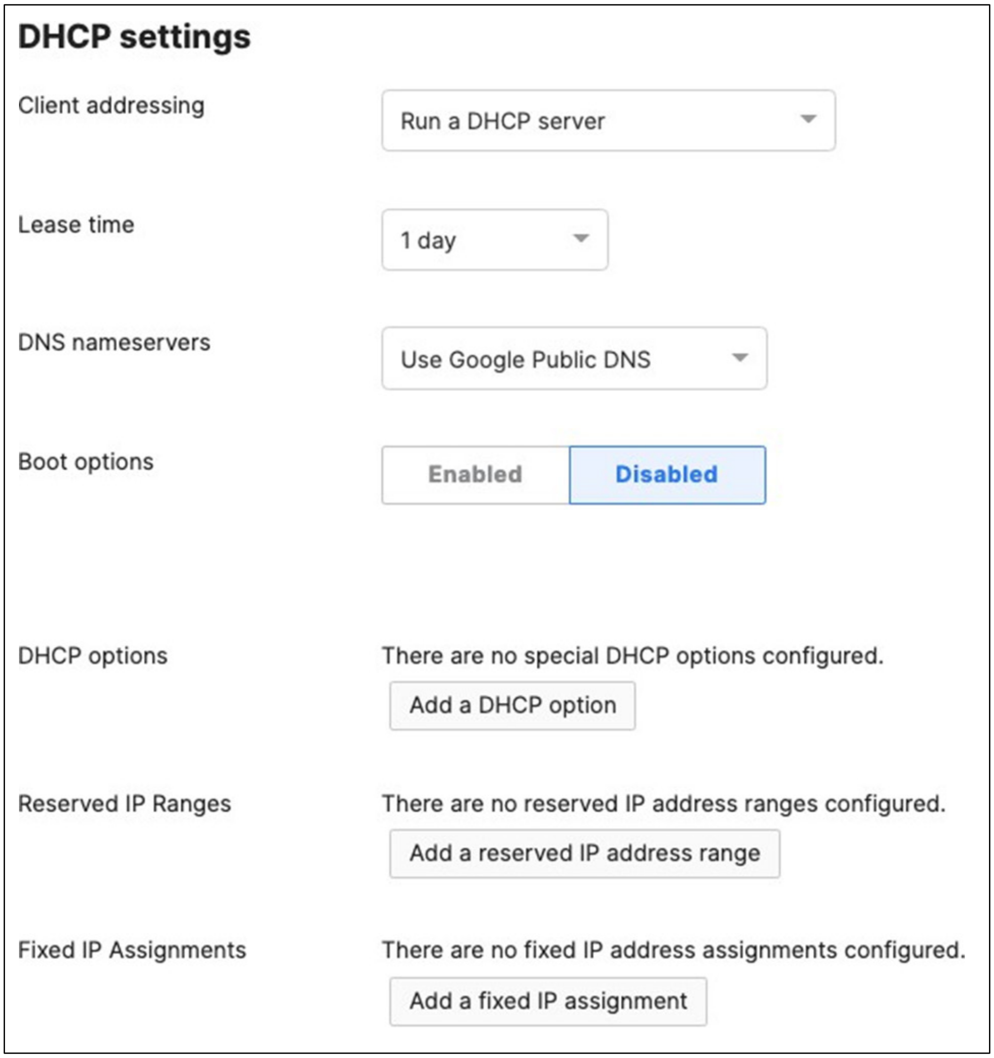

OSPF settings
Area
0: backbone
Cost
1
Passive?
Yes

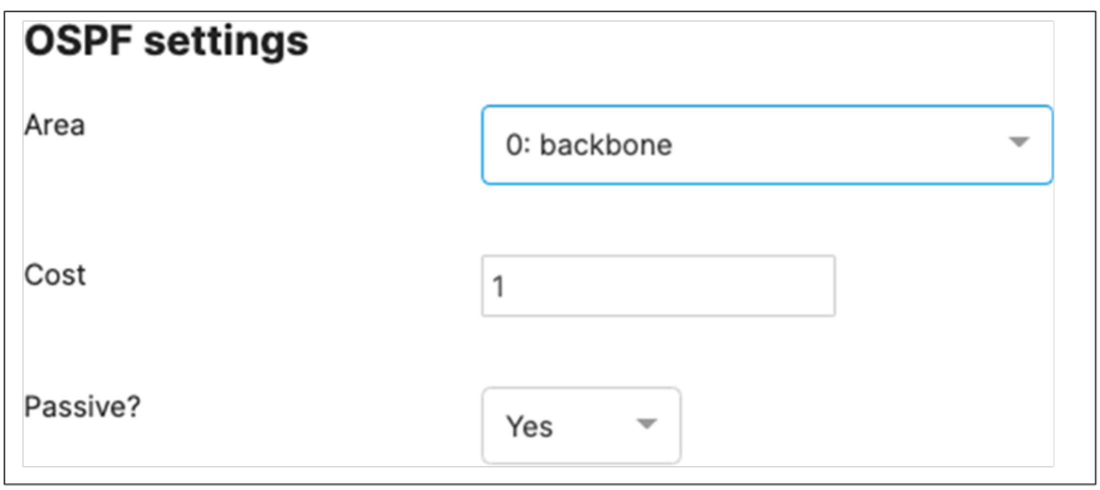

Interface Editor
Switch or switch stack
Stack1-MS390
Name
BYOD one 1
VLAN
21
Subnet
10.0.21.0/24
Interface IP
10.0.21.1
Multicast routing
Disabled

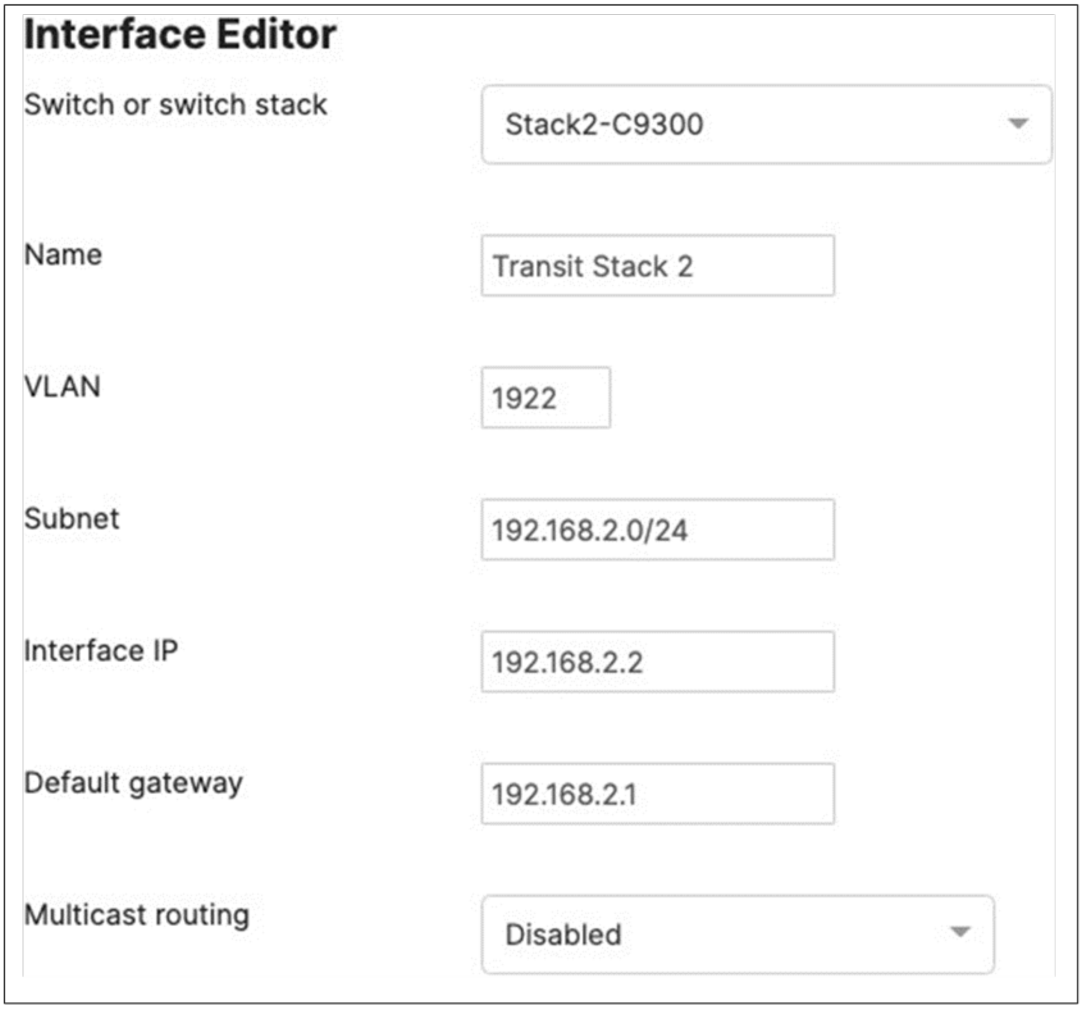

DHCP settings
Client addressing
Run a DHCP server
Lease time
1 day
DNS nameservers
Use Google Public DNS
Boot options
Enabled
Disabled
DHCP options
There are no special DHCP options configured.
Add a DHCP option
Reserved IP Ranges
There are no reserved IP address ranges configured.
Add a reserved IP address range
Fixed IP Assignments
There are no fixed IP address assignments configured.
Add a fixed IP assignment


OSPF settings
Area
0: backbone
Cost
1
Passive?
Yes


Interface Editor
Switch or switch stack
Stack1-MS390
Name
Guest
VLAN
30
Subnet
10.0.30.0/24
Interface IP
10.0.30.1
Multicast routing
Disabled

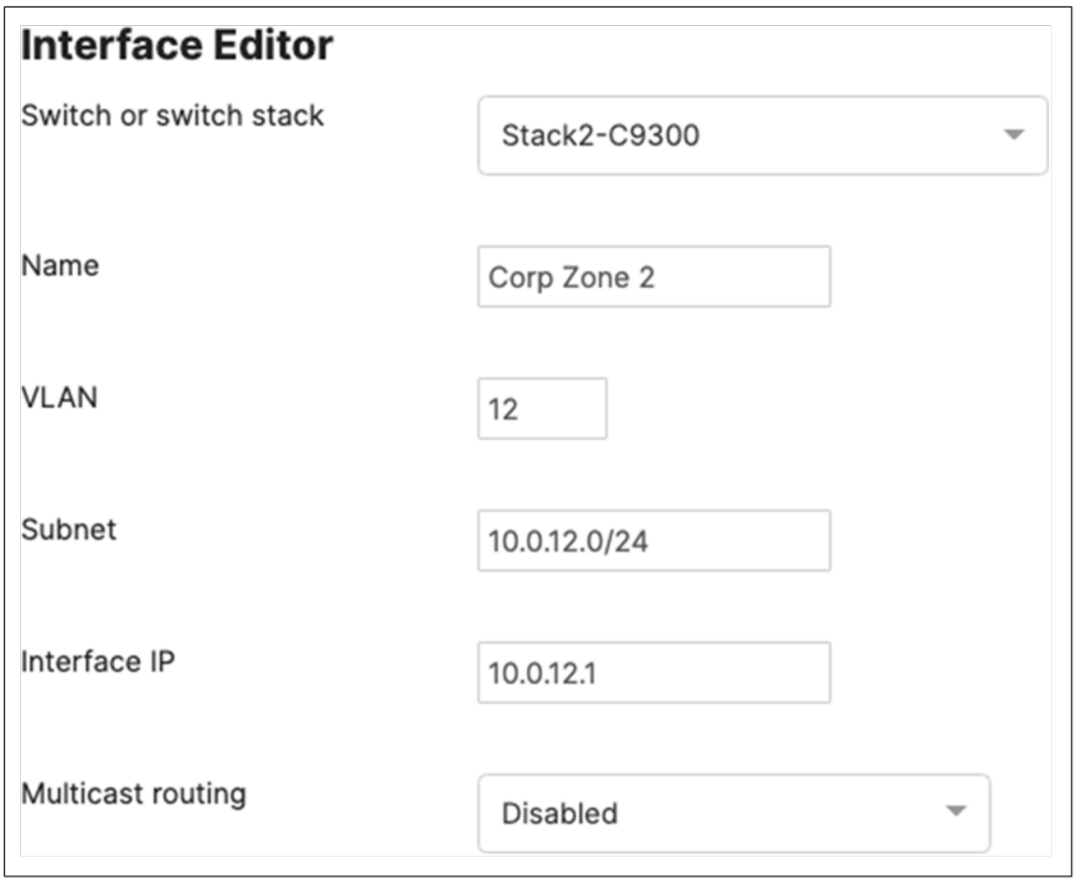

DHCP settings
Client addressing
Run a DHCP server
Lease time
1 day
DNS nameservers
Use Google Public DNS
Boot options
Enabled
Disabled
DHCP options
There are no special DHCP options configured.
Add a DHCP option
Reserved IP Ranges
There are no reserved IP address ranges configured.
Add a reserved IP address range
Fixed IP Assignments
There are no fixed IP address assignments configured.
Add a fixed IP assignment

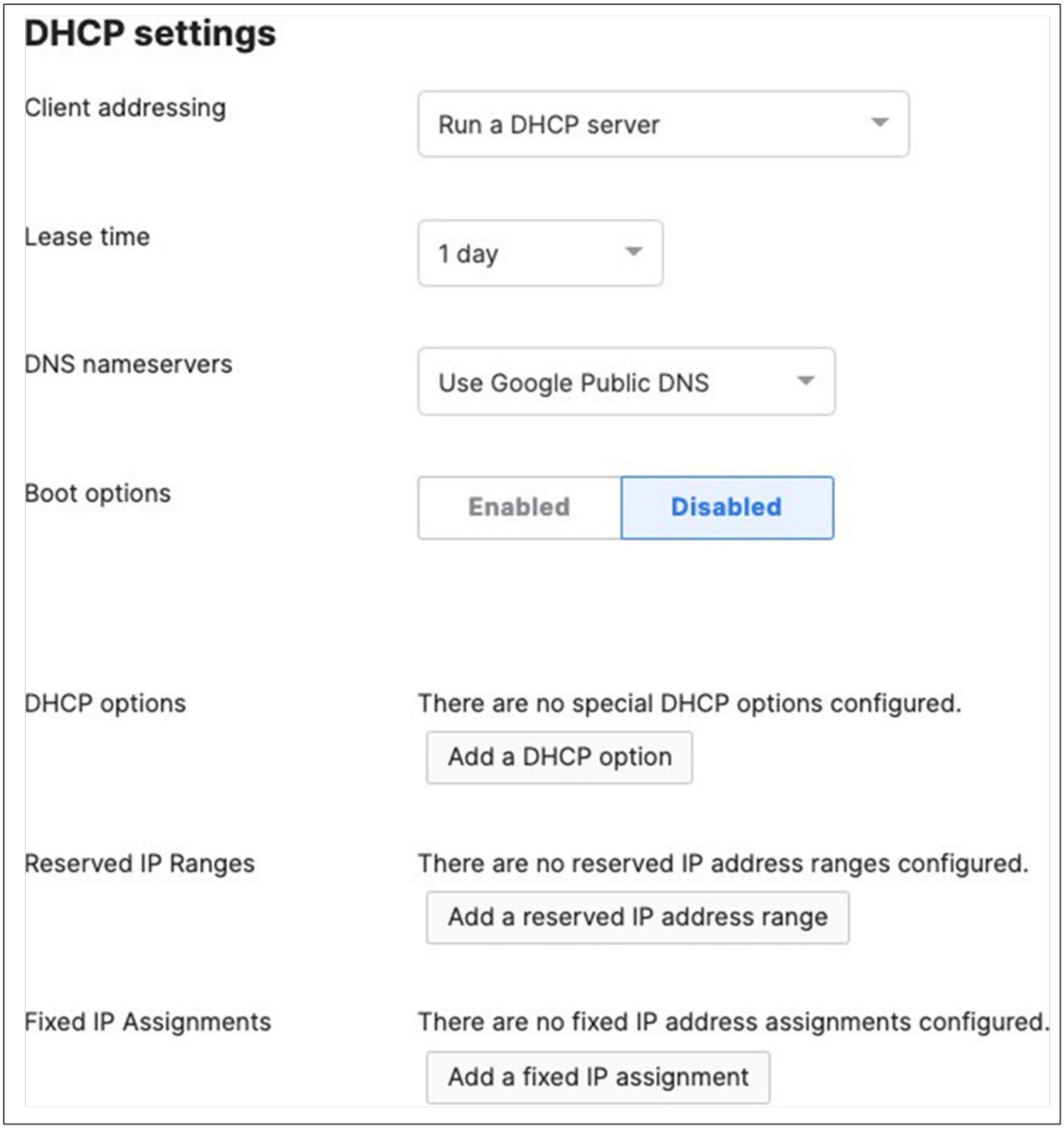

OSPF settings
Area
0: backbone
Cost
1
Passive?
Yes

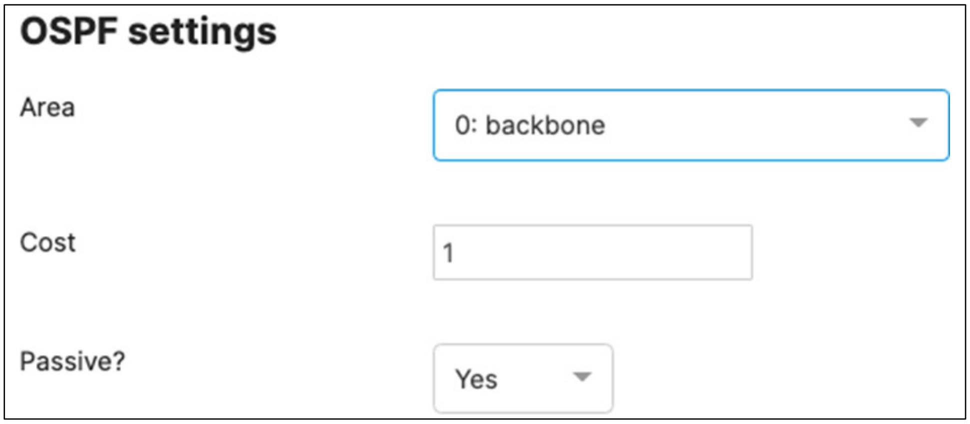

Interface Editor
Switch or switch stack
Stack2-C9300
Name
Transit Stack 2
VLAN
1922
Subnet
192.168.2.0/24
Interface IP
192.168.2.2
Default gateway
192.168.2.1
Multicast routing
Disabled


DHCP settings
Client addressing
Do not respond to DHCP requests

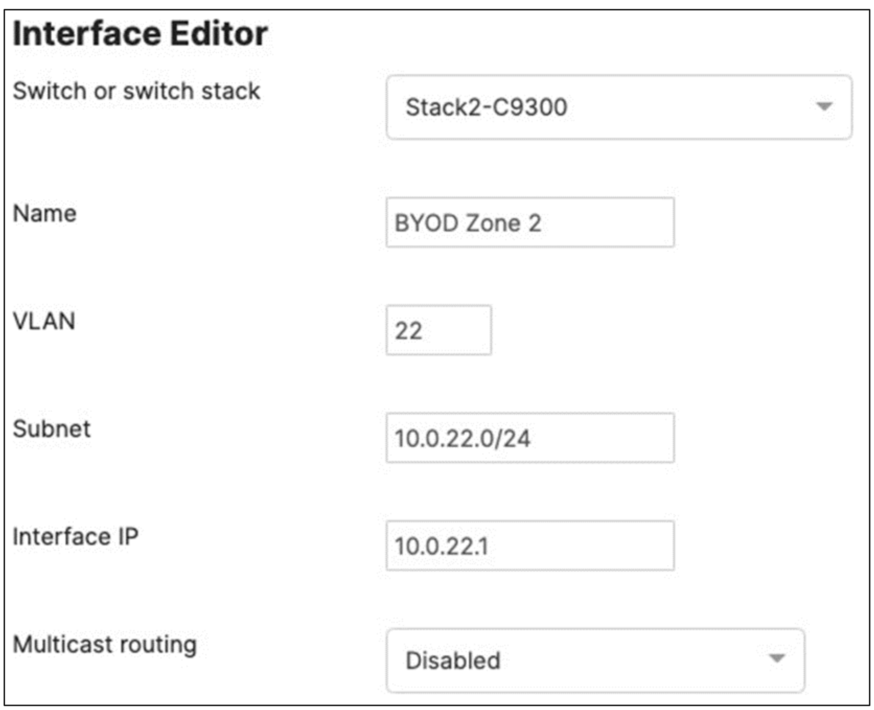

OSPF settings
Area
0: backbone
Cost
1
Passive?
No

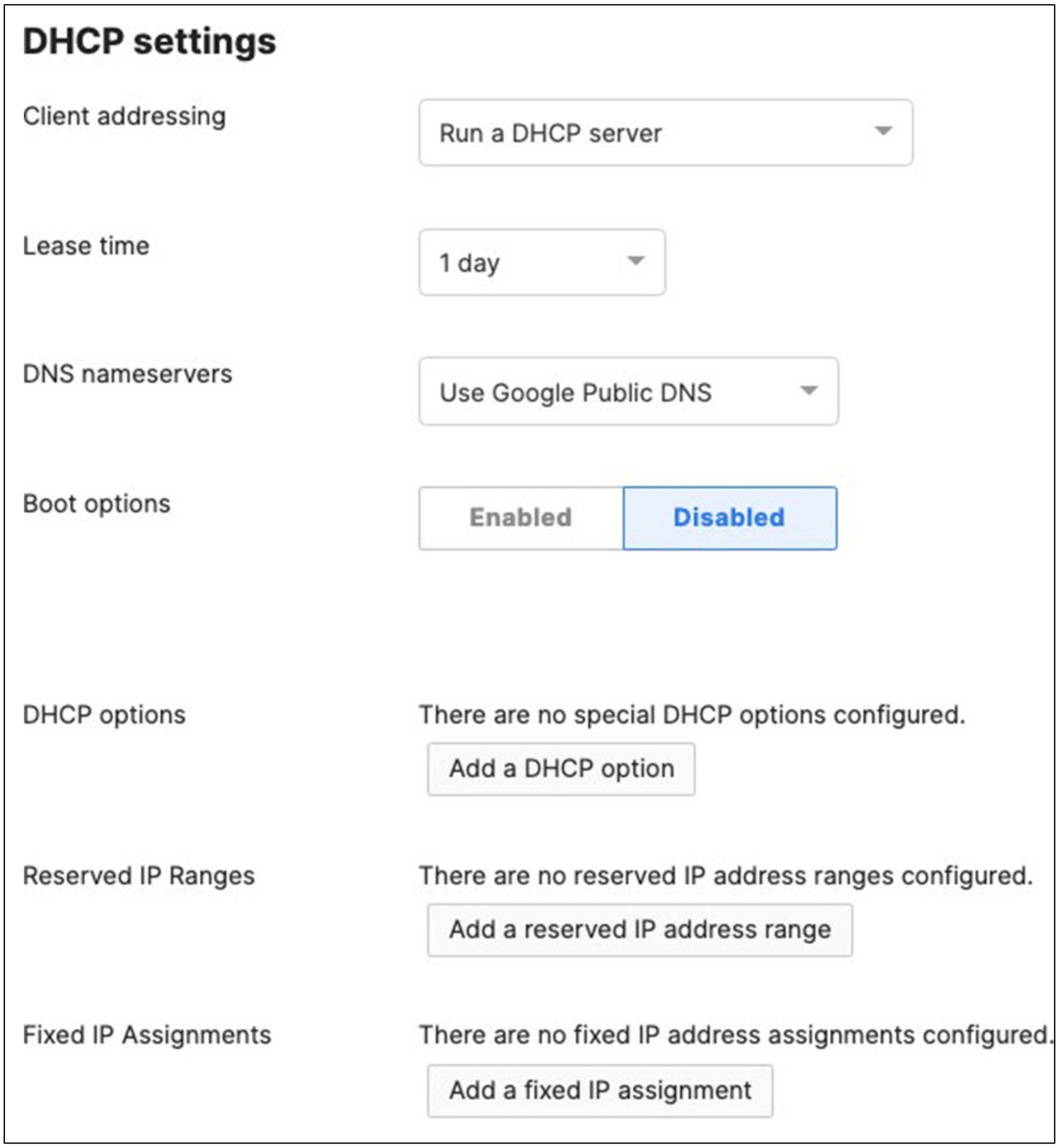

Interface Editor
Switch or switch stack
Stack2-C9300
Name
Corp Zone 2
VLAN
12
Subnet
10.0.12.0/24
Interface IP
10.0.12.1
Multicast routing
Disabled

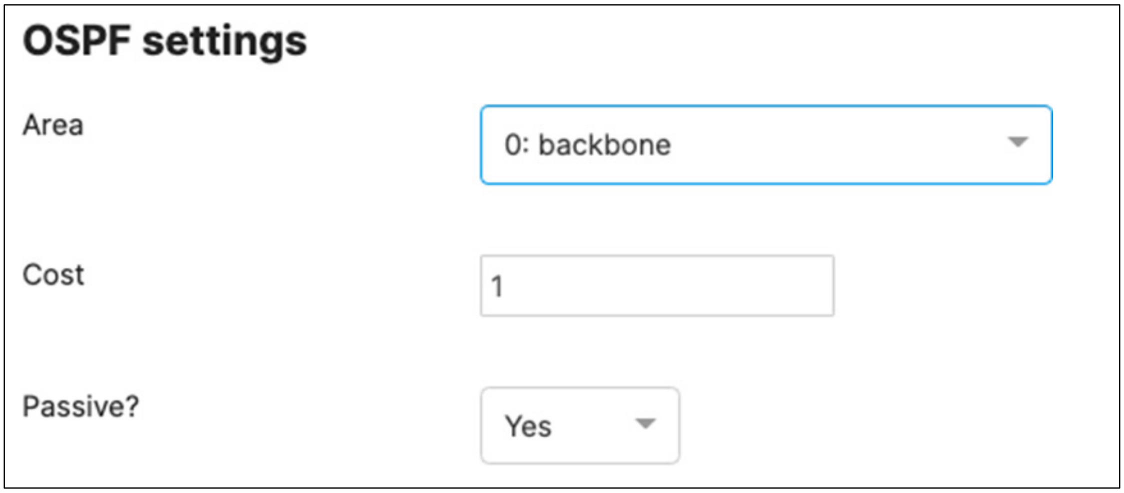

DHCP settings
Client addressing
Run a DHCP server
Lease time
1 day
DNS nameservers
Use Google Public DNS
Boot options
Enabled
Disabled
DHCP options
There are no special DHCP options configured.
Add a DHCP option
Reserved IP Ranges
There are no reserved IP address ranges configured.
Add a reserved IP address range
Fixed IP Assignments
There are no fixed IP address assignments configured.
Add a fixed IP assignment

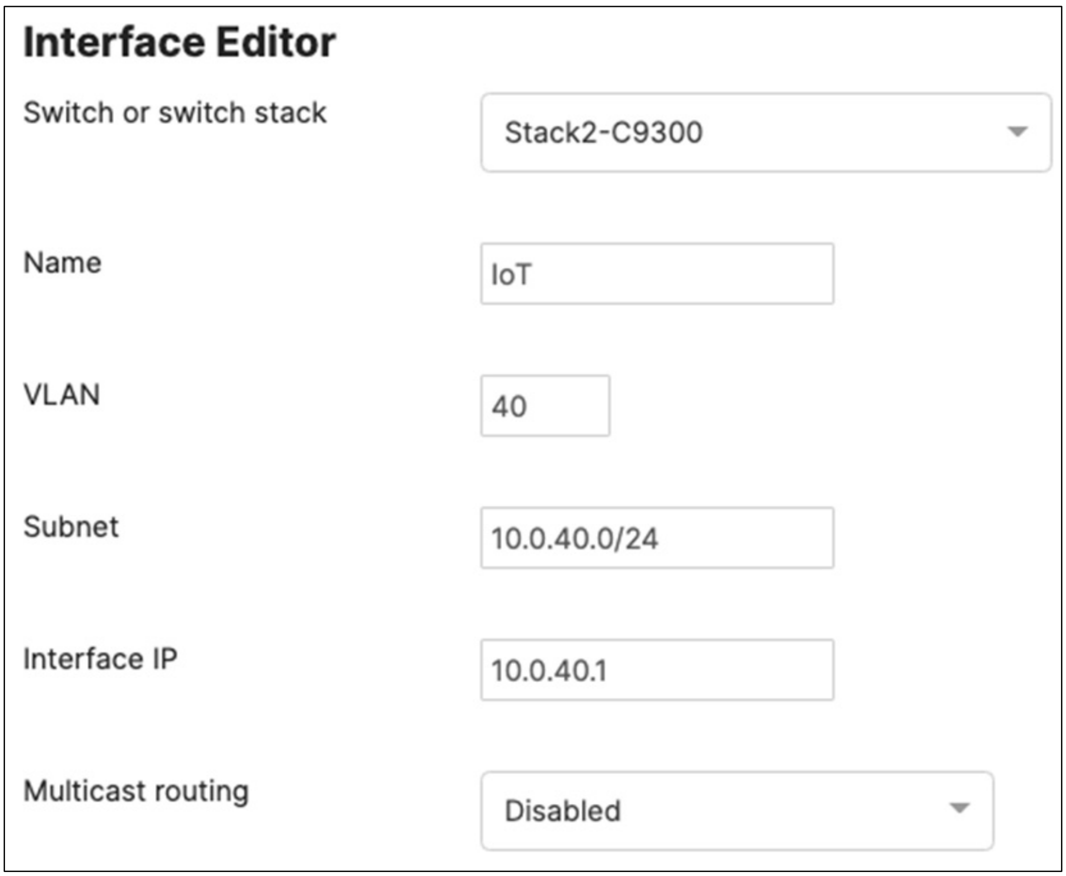

OSPF settings
Area
0: backbone
Cost
1
Passive?
Yes

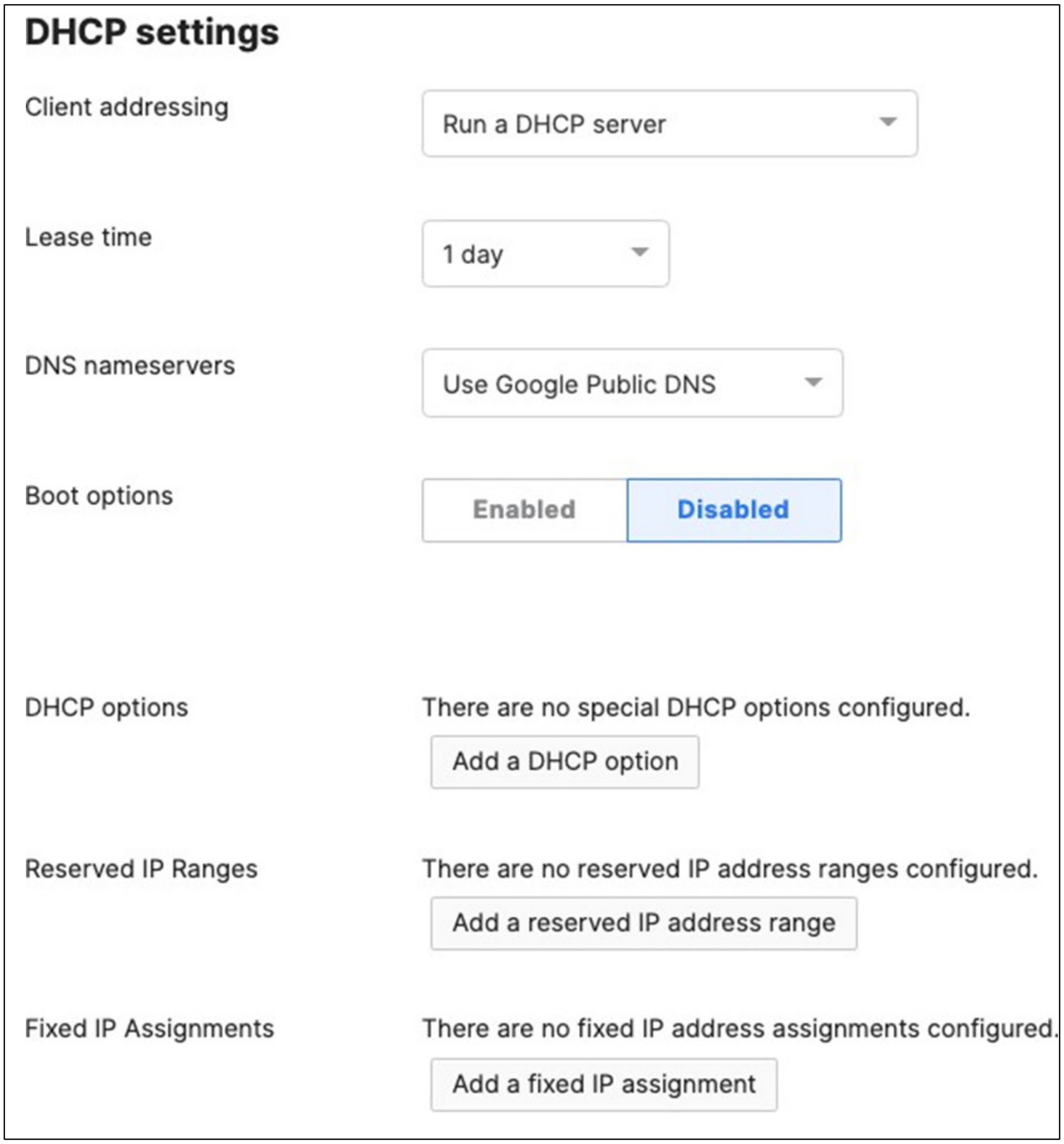

OSPF settings
Area
0: backbone
Cost
1
Passive?
Yes

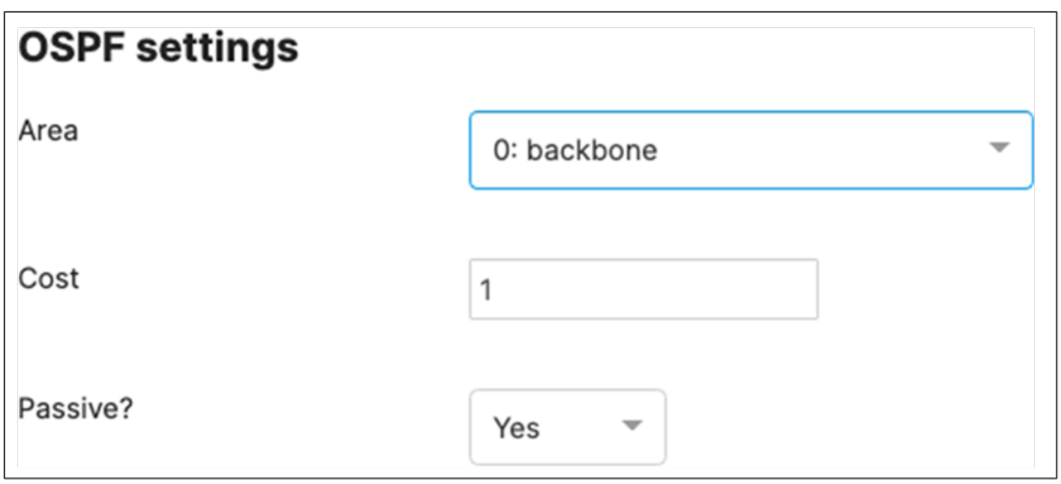

Interface Editor
Switch or switch stack
Stack2-C9300
Name
BYOD Zone 2
VLAN
22
Subnet
10.0.22.0/24
Interface IP
10.0.22.1
Multicast routing
Disabled


DHCP settings
Client addressing
Run a DHCP server
Lease time
1 day
DNS nameservers
Use Google Public DNS
Boot options
Enabled
Disabled
DHCP options
There are no special DHCP options configured.
Add a DHCP option
Reserved IP Ranges
There are no reserved IP address ranges configured.
Add a reserved IP address range
Fixed IP Assignments
There are no fixed IP address assignments configured.
Add a fixed IP assignment


OSPF settings
Area
0: backbone
Cost
1
Passive?
Yes


Interface Editor
Switch or switch stack
Stack2-C9300
Name
IoT
VLAN
40
Subnet
10.0.40.0/24
Interface IP
10.0.40.1
Multicast routing
Disabled


DHCP settings
Client addressing
Run a DHCP server
Lease time
1 day
DNS nameservers
Use Google Public DNS
Boot options
Enabled
Disabled
DHCP options
There are no special DHCP options configured.
Add a DHCP option
Reserved IP Ranges
There are no reserved IP address ranges configured.
Add a reserved IP address range
Fixed IP Assignments
There are no fixed IP address assignments configured.
Add a fixed IP assignment


OSPF settings
Area
0: backbone
Cost
1
Passive?
Yes

Interfaces

Search... **8 Interfaces** Add Edit

Switch	VLAN	Name	Subnet	IP	DHCP Settings	OSPF Routing	Multicast Routing
Stack1-MS390	11	Corp Zone 1	10.0.11.0/24	10.0.11.1	Server	Enabled	Disabled
Stack1-MS390	21	BYOD one 1	10.0.21.0/24	10.0.21.1	Server	Enabled	Disabled
Stack1-MS390	30	Guest	10.0.30.0/24	10.0.30.1	Server	Enabled	Disabled
Stack1-MS390	1921	Transit Stack1	192.168.1.0/24	192.168.1.2	Off	Enabled	Disabled
Stack2-C9300	12	Corp Zone 2	10.0.12.0/24	10.0.12.1	Server	Enabled	Disabled
Stack2-C9300	22	BYOD Zone 2	10.0.22.0/24	10.0.22.1	Server	Enabled	Disabled
Stack2-C9300	40	IoT	10.0.40.0/24	10.0.40.1	Server	Enabled	Disabled
Stack2-C9300	1922	Transit Stack 2	192.168.2.0/24	192.168.2.2	Off	Enabled	Disabled

Static routes

Search... **2 Static routes** Add Edit

Switch	Name	Subnet	Next Hop IP	Advertise via OSPF?	Preferred over OSPF routes?
Stack1-MS390	Default route	0.0.0.0/0	192.168.1.1	No	Not preferred
Stack2-C9300	Default route	0.0.0.0/0	192.168.2.1	No	Not preferred

- Please note that the Static Routes shown above are automatically created per stack and they reflect the default gateway settings that you have configured with the first SVI interface created which is in this case the Transit VLAN interface for each Stack

65. Verify that your Core Stack is receiving OSPF routes from its neighbors:

```
9500-01#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
  D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
  N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
  E1 - OSPF external type 1, E2 - OSPF external type 2, m - OMP
  n - NAT, Ni - NAT inside, No - NAT outside, Nd - NAT DIA
  i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
  ia - IS-IS inter area, * - candidate default, U - per-user static route
  H - NHRP, G - NHRP registered, g - NHRP registration summary
  o - ODR, P - periodic downloaded static route, l - LISP
  a - application route
  + - replicated route, % - next hop override, p - overrides from PfR
  & - replicated local route overrides by connected

  Gateway of last resort is 10.0.200.1 to network 0.0.0.0

  S* 0.0.0.0/0 [254/0] via 10.0.200.1
     [254/0] via 10.0.100.1
     [254/0] via 10.0.3.1
```

```
  10.0.0.0/8 is variably subnetted, 12 subnets, 2 masks
C 10.0.3.0/24 is directly connected, Vlan3
L 10.0.3.2/32 is directly connected, Vlan3
O 10.0.11.0/24 [110/2] via 192.168.1.2, 00:04:13, Vlan1921
O 10.0.12.0/24 [110/2] via 192.168.2.2, 00:03:56, Vlan1922
O 10.0.21.0/24 [110/2] via 192.168.1.2, 00:04:13, Vlan1921
O 10.0.22.0/24 [110/2] via 192.168.2.2, 00:03:56, Vlan1922
O 10.0.30.0/24 [110/2] via 192.168.1.2, 00:04:13, Vlan1921
O 10.0.40.0/24 [110/2] via 192.168.2.2, 00:03:56, Vlan1922
C 10.0.100.0/24 is directly connected, Vlan100 L
10.0.100.2/32 is directly connected, Vlan100 C
10.0.200.0/24 is directly connected, Vlan200 L
10.0.200.2/32 is directly connected, Vlan200
   192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.1.0/24 is directly connected, Vlan1921
L 192.168.1.1/32 is directly connected, Vlan1921
   192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.2.0/24 is directly connected, Vlan1922 L
192.168.2.1/32 is directly connected, Vlan1922
    192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks
C 192.168.3.0/24 is directly connected, Vlan1923
L 192.168.3.2/32 is directly connected, Vlan1923
9500-01#
```

66. And that concludes the configuration requirements for this design option. Please remember to always click **Save** at the bottom of the page once you have finished configuring each item on the Meraki Dashboard.

Testing and Verification

Firmware

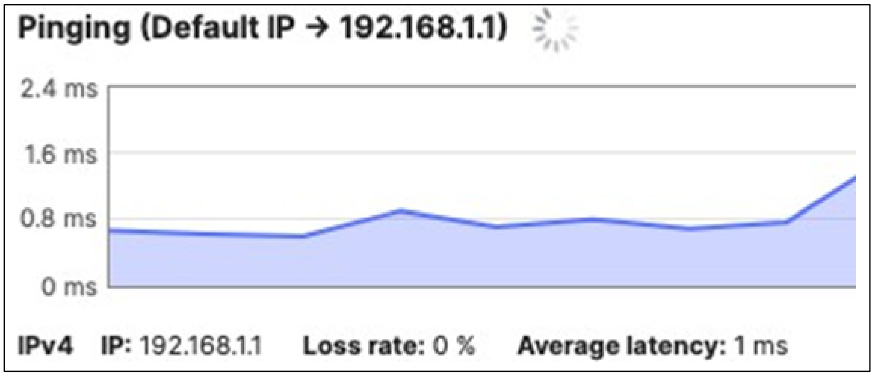
The following table indicates the firmware versions used in this Campus LAN:

Device	Firmware Version	Notes
MX250 WAN Edge	MX 16.16	GA
C9500 Core Stack		
MS390 Access Stack	MS 15.14	Beta
C9300 Access Stack	MS 15.14	Beta
MR55	28.6.1	GA
C9166 (MR57)	28.30	Beta

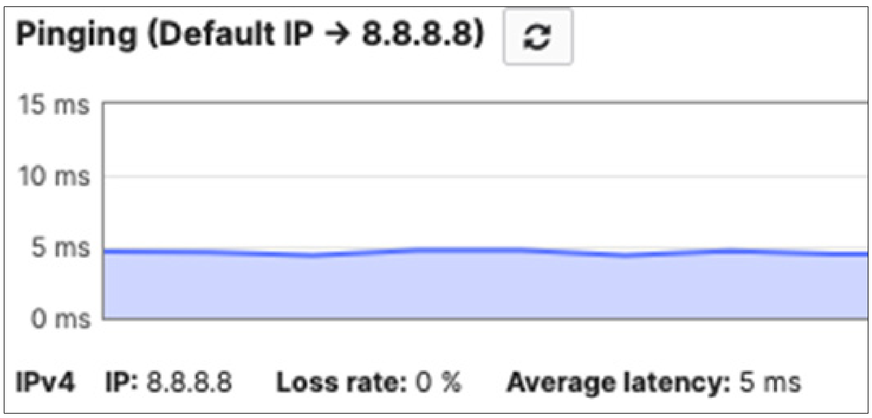
Device Connectivity

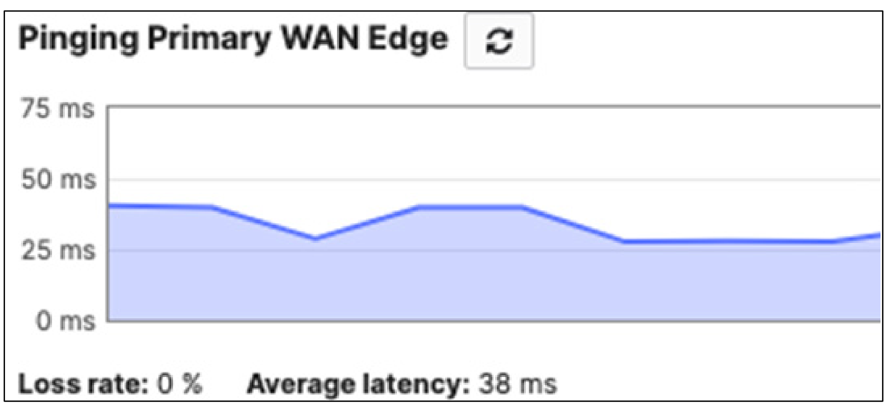
MX WAN Edge

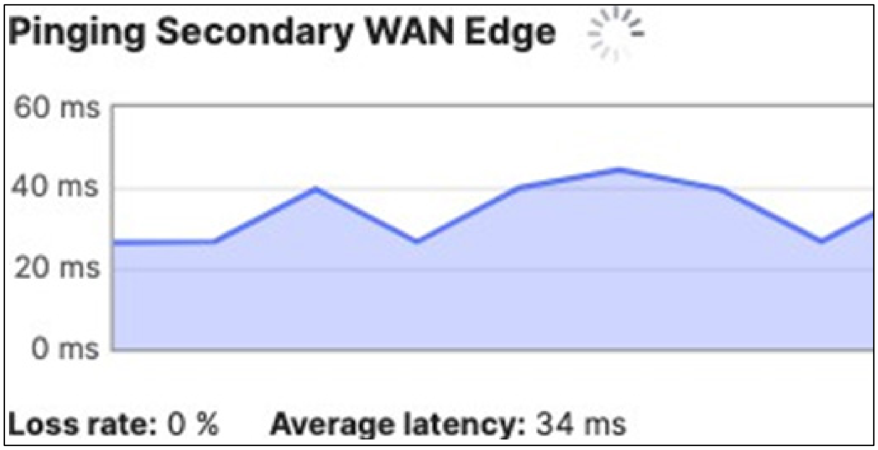
Upstream Connectivity



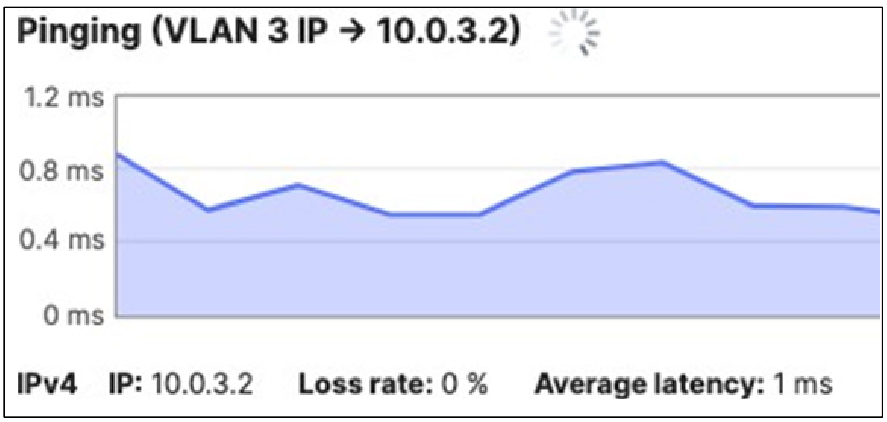
Internet/Cloud Connectivity

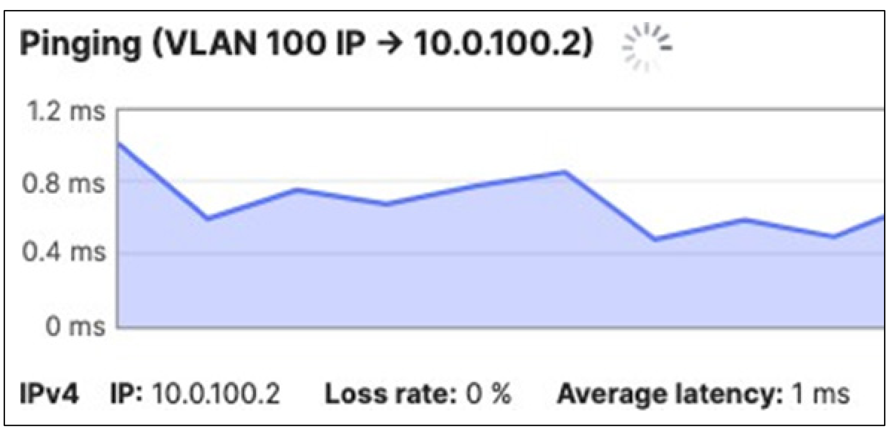


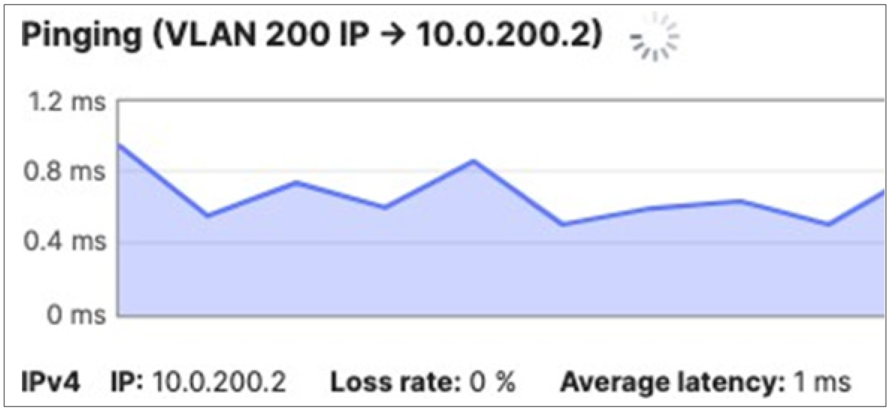


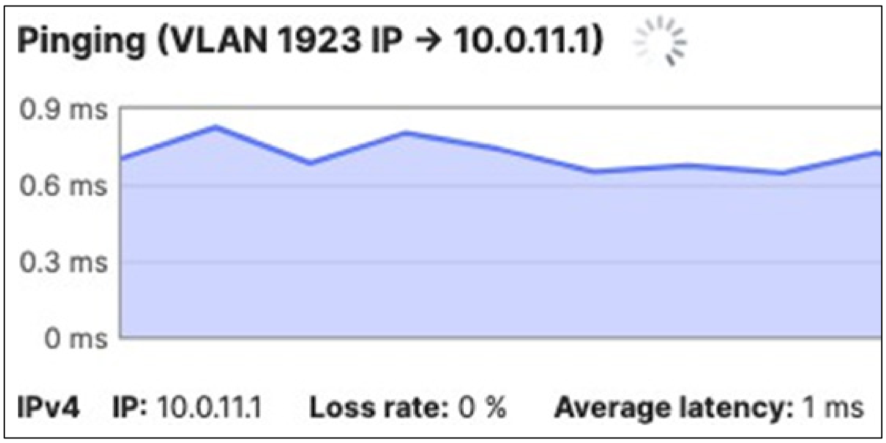


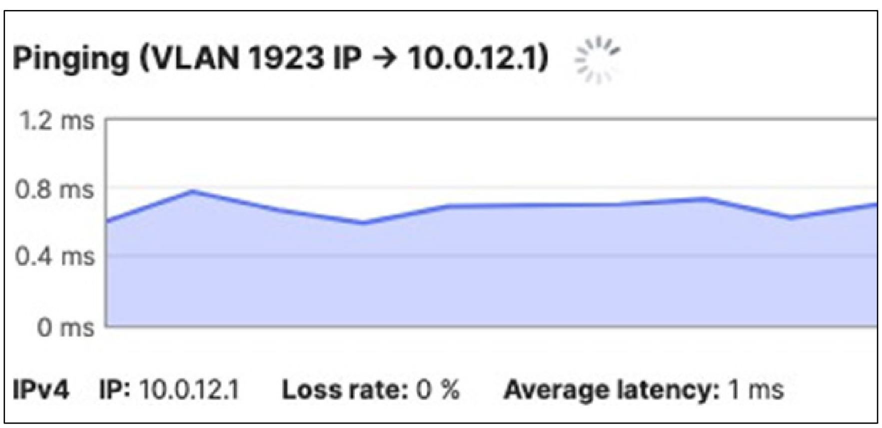
Downstream Connectivity

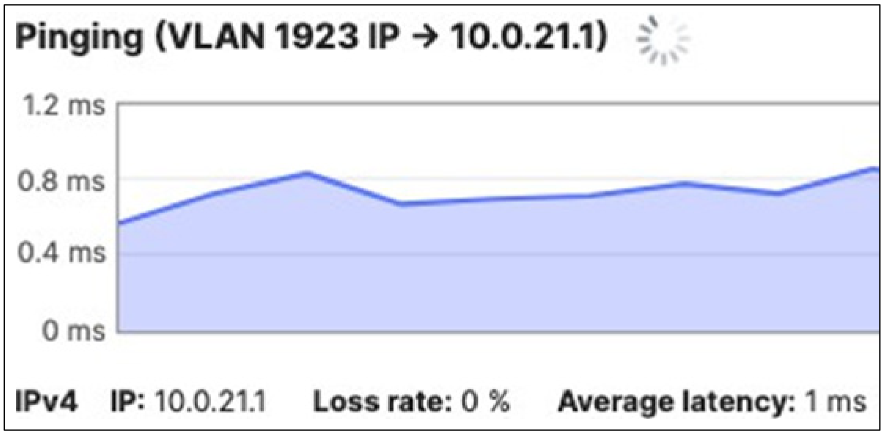




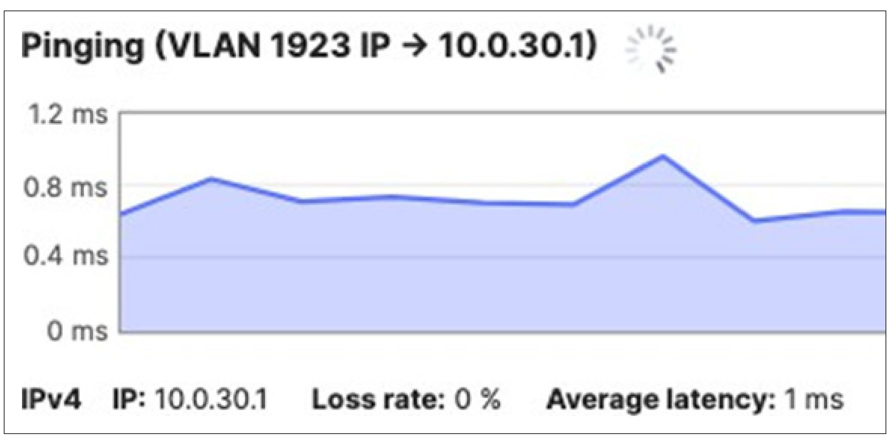

Pinging (VLAN 200 IP → 10.0.200.2)
1.2 ms
0.8 ms
0.4 ms
0 ms
IPv4 IP: 10.0.200.2 Loss rate: 0 % Average latency: 1 ms


Pinging (VLAN 1923 IP → 10.0.11.1)
0.9 ms
0.6 ms
0.3 ms
0 ms
IPv4 IP: 10.0.11.1 Loss rate: 0 % Average latency: 1 ms


Pinging (VLAN 1923 IP → 10.0.12.1)
1.2 ms
0.8 ms
0.4 ms
0 ms
IPv4 IP: 10.0.12.1 Loss rate: 0 % Average latency: 1 ms


Pinging (VLAN 1923 IP → 10.0.21.1)
1.2 ms
0.8 ms
0.4 ms
0 ms
IPv4 IP: 10.0.21.1 Loss rate: 0 % Average latency: 1 ms


Pinging (VLAN 1923 IP → 10.0.22.1)
0.9 ms
0.6 ms
0.3 ms
0 ms
IPv4 IP: 10.0.22.1 Loss rate: 0 % Average latency: 1 ms


Pinging (VLAN 1923 IP → 10.0.30.1)
1.2 ms
0.8 ms
0.4 ms
0 ms
IPv4 IP: 10.0.30.1 Loss rate: 0 % Average latency: 1 ms

C9500 Core Stack

Upstream Connectivity

```
9500-01#ping 10.0.3.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
9500-01#ping 192.168.3.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.3.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
9500-01#
```

Internet Connectivity

```
9500-01#ping 8.8.8.8 source 192.168.3.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 8.8.8.8, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/4 ms
9500-01#
9500-01#ping cisco.com source 192.168.3.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 72.163.4.185, timeout is 2 seconds:
Packet sent with a source address of 192.168.3.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 108/108/109 ms
9500-01#
```

Downstream Connectivity (Please note that the MS390 and C9300-M platforms will prioritize packet forwarding over ICMP echo replies so it's expected behavior that you might get some drops when you ping the management interface)

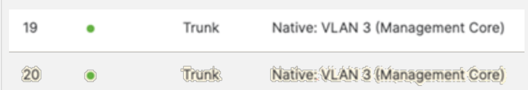
```
9500-01#ping 10.0.100.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.100.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 2/2/3 ms
9500-01#ping 10.0.100.4
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.100.4, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 2/2/4 ms
9500-01#ping 10.0.200.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.200.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
9500-01#ping 10.0.200.4
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.200.4, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
9500-01#
```

In case of connectivity issues, please check the following:

Item	Expected Configuration/ Status	Verification	Actual Configuration
C9500 Uplinks to MX Edge:	Trunk , VLAN 3	`sh ip int brief`	`!all uplinks!`
TwentyFiveGigE1/0/1	DAI Trusted	`sh run int <interface>`	`switchport mode access`
TwentyFiveGigE1/0/2	up/up	`sh spanning-tree int <interface>`	`ip arp inspection trust`
TwentyFiveGigE2/0/1			`ip dhcp snooping trust`
TwentyFiveGigE2/0/2			`End` `!`
STP interface Configuration:	STP Configuration	`sh run int <interface>`	`!where applicable!`
TwentyFiveGigE1/0/1	N/A		`udld port aggressive`
TwentyFiveGigE1/0/2	N/A		`spanning-tree guard root`
TwentyFiveGigE2/0/1	N/A		`end`
TwentyFiveGigE2/0/2	N/A		`!`
TwentyFiveGigE1/0/23	Root Guard + UDLD aggressive		
TwentyFiveGigE1/0/24	Root Guard + UDLD aggressive		
TwentyFiveGigE2/0/23	Root Guard + UDLD aggressive		
TwentyFiveGigE2/0/24	Root Guard + UDLD aggressive		
STP interface Status:	STP status:	`sh spanning-tree int <interface>`	`!only PHY interfaces!`
TwentyFiveGigE1/0/1	FWD		`spanning-tree mode mst`
TwentyFiveGigE1/0/2	BLK		`spanning-tree extend system-id`
TwentyFiveGigE2/0/1	FWD		`!`
TwentyFiveGigE2/0/2	BLK		`spanning-tree mst configuration`
Po1	FWD		`name region1`
Po2	FWD		`revision 1`

Item	Expected Configuration/ Status	Verification	Actual Configuration
			!
			spanning-tree mst 0 priority 4096

Default Route	DHCP, VLAN 1923	`sh int vlan1923`
		`297 hip route`
			`!`
			`interface Vlan1923`
			`ip address 192.168.3.2 255.255.255.0`
			`end`
			`!`
			`sh ip route | in /0`
			`S* 0.0.0.0/0 [254/0] via 192.168.3.1`

MX WAN Edge Downlinks:	Trunk , VLAN 3	Navigate to Security and SD-WAN > Configure > Addressing and VLANs	
Port 19			
Port 20			
C9500 Downlinks:	**Trunk**	**sh run int <interface>**	**!PHY 23!**
	DAI Trusted		`switchport trunk allowed vlan 100,1921`
	SGT 2 Trusted		`switchport mode trunk`
	No CTS enforcement		`ip arp inspection trust`
TwentyFiveGigE1/0/23	VLAN 100 / 100, 1921		`!PHY 24!`
TwentyFiveGigE1/0/24	VLAN 200 / 200, 1922		`switchport trunk allowed vlan 200,1922`
TwentyFiveGigE2/0/23	VLN 100 / 100, 1921		`switchport mode trunk`

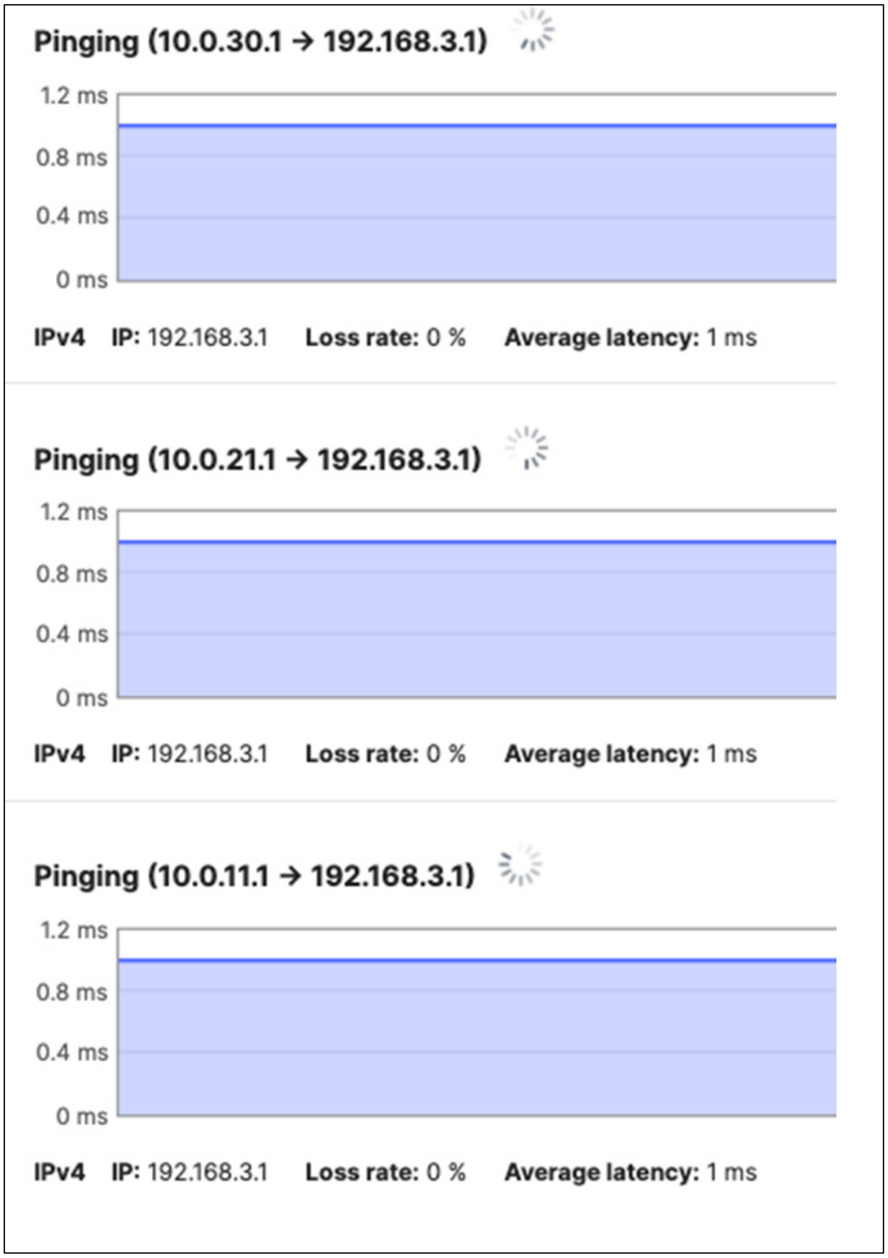
TwentyFiveGigE2/0/24	VLAN 200 / 200, 1922		`ip arp inspection trust`
			`!BOTH!`
			`cts manual`
			`  policy static sgt 2 trusted`
			`no cts role-based enforcement`
			`!`
			`end`

Item	Expected Configuration/ Status	Verification	Actual Configuration
C9500 Ether-Channels:			`!PHY 23!`
TwentyFiveGigE1/0/23	Channel-Group 1	`sh run int <interface>`	`channel-group 1 mode active`
TwentyFiveGigE1/0/24	Channel-Group 2	`sh etherchannel <#> sum`	`!PHY 24!`
TwentyFiveGigE2/0/23	Channel-Group 1	`sh ip int brief | in Po`	`channel-group 2 mode active`
TwentyFiveGigE2/0/24	Channel-Group 2		`!`
Po1	up/up		`end`
Po2	up/up		

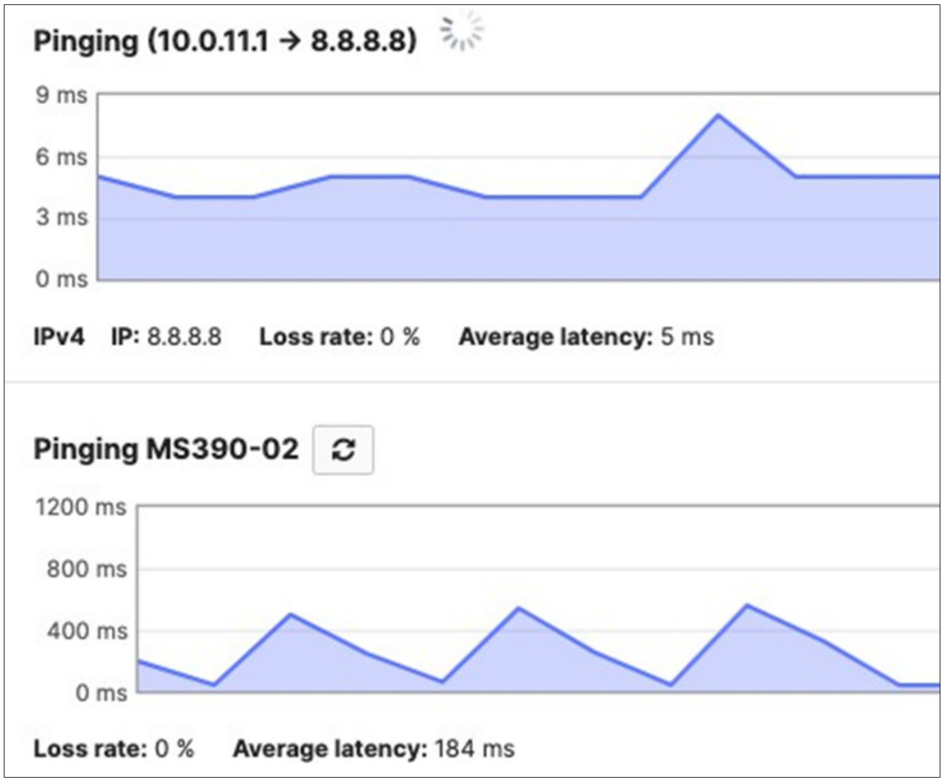
MS390 Access Stack

Upstream Connectivity

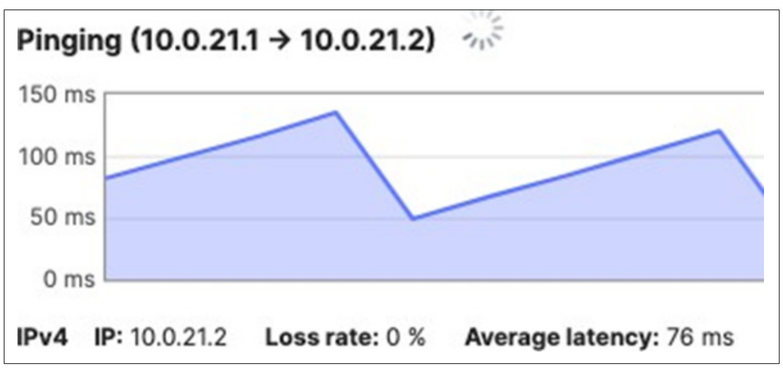
Tech Tip: Please note that the MS390 and C9300 switches use a separate routing table for management traffic than the configured SVIs. As such, you won't be able to verify connectivity using ping tool from the switch page to its default gateway (e.g. 10.0.100.1) since we have not created a L3 interface for the Management VLAN (e.g. VLAN 100). Upstream connectivity verification should be done using one of the SVI interfaces configured on the stack/ switch to the upstream Transit VLAN configured on the Edge MX appliance. (e.g. VLAN 1923)


Pinging (10.0.30.1 → 192.168.3.1)
1.2 ms
0.8 ms
0.4 ms
0 ms
IPv4 IP: 192.168.3.1 Loss rate: 0 % Average latency: 1 ms
Pinging (10.0.21.1 → 192.168.3.1)
1.2 ms
0.8 ms
0.4 ms
0 ms
IPv4 IP: 192.168.3.1 Loss rate: 0 % Average latency: 1 ms
Pinging (10.0.11.1 → 192.168.3.1)
1.2 ms
0.8 ms
0.4 ms
0 ms
IPv4 IP: 192.168.3.1 Loss rate: 0 % Average latency: 1 ms

Internet/Cloud Connectivity

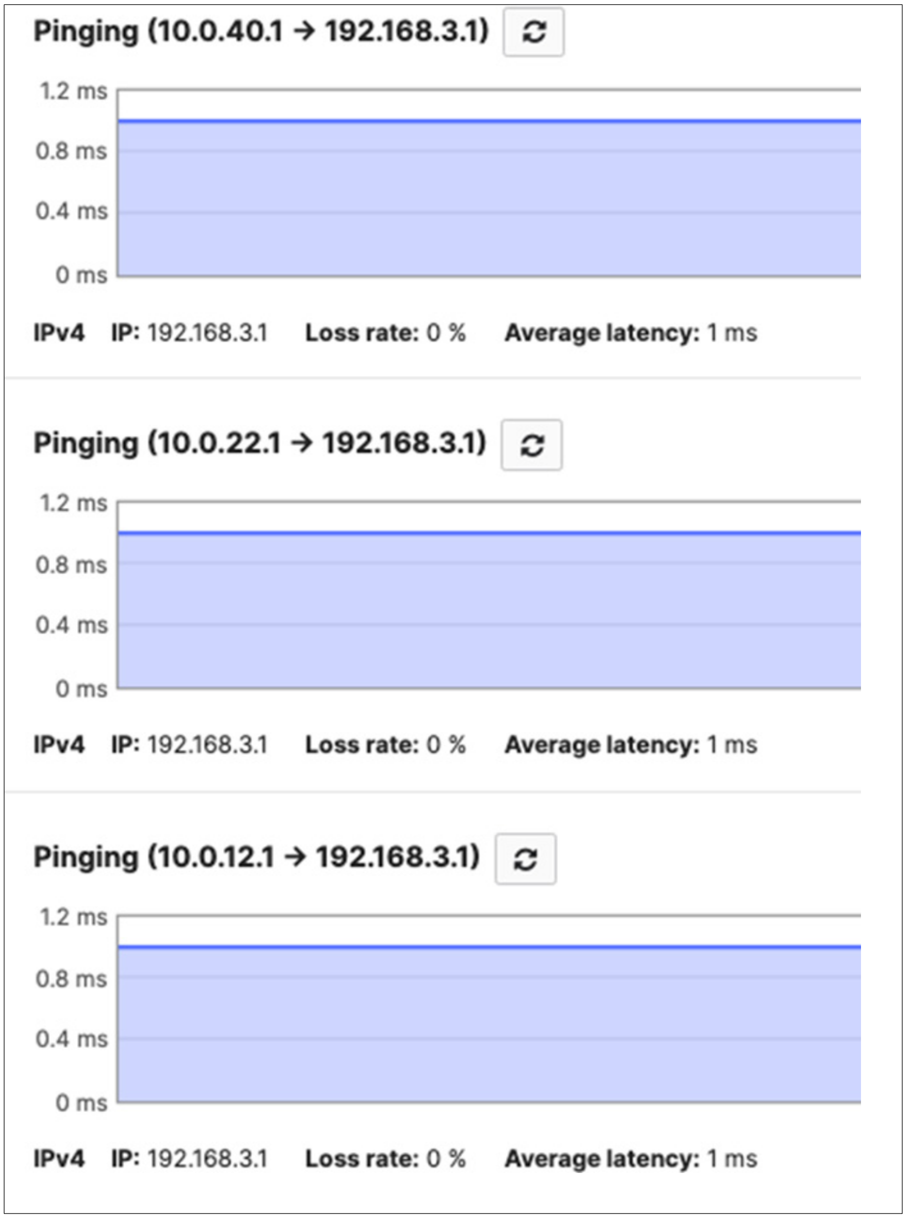


Downstream Connectivity

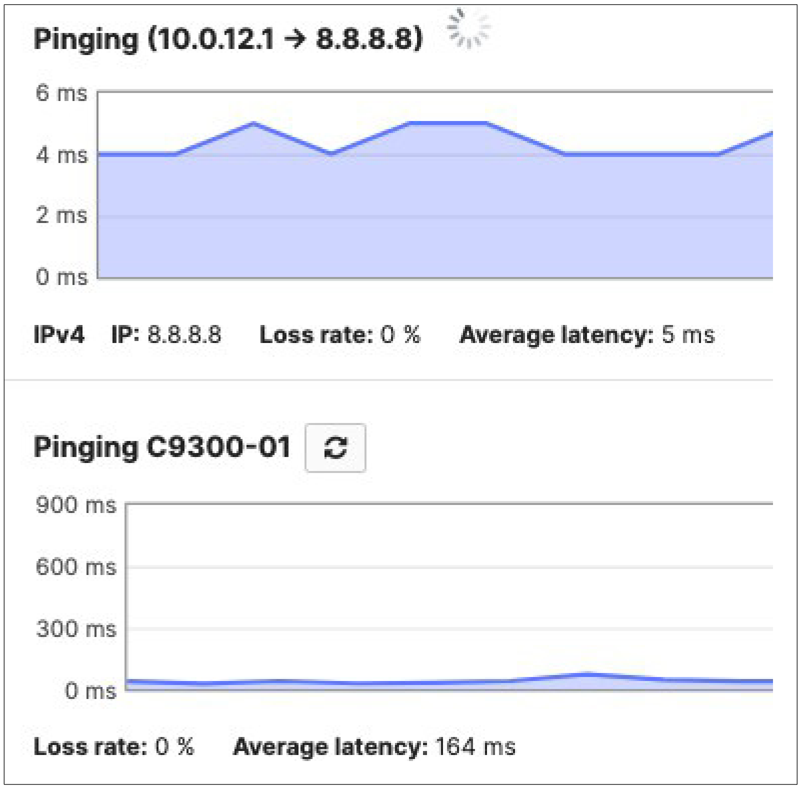


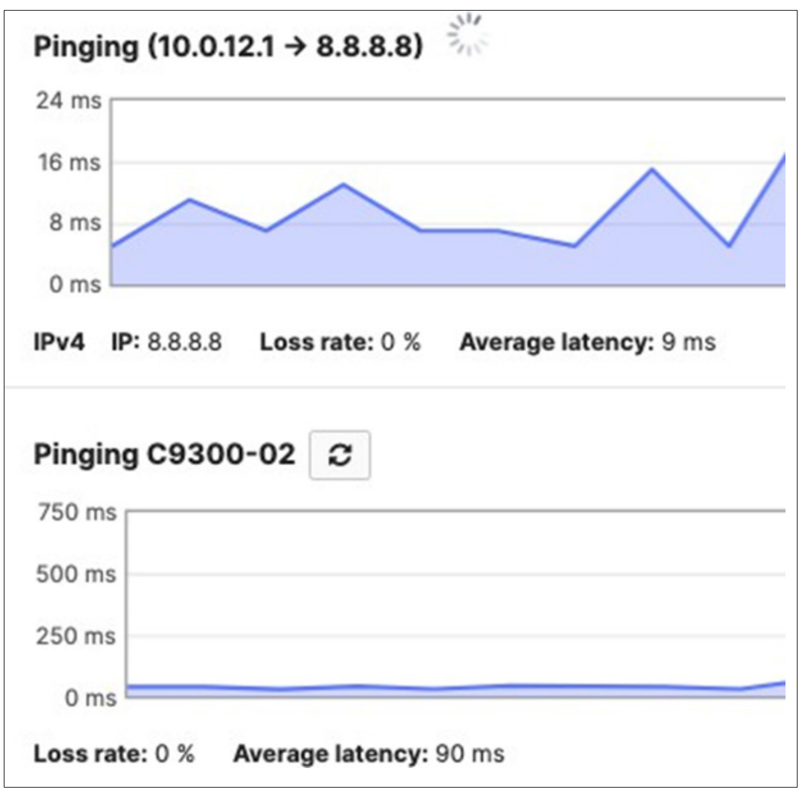
C9300 Access Stack

Upstream Connectivity

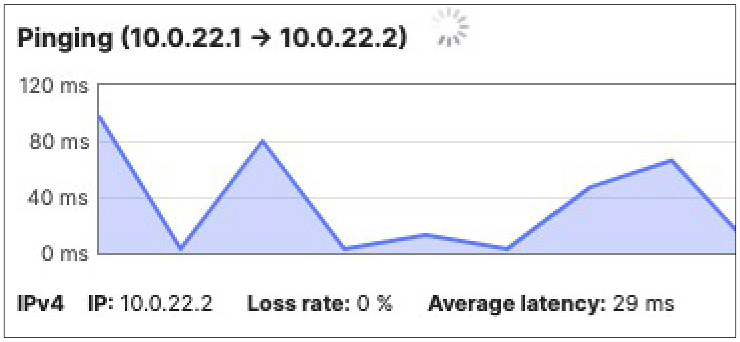


Internet/Cloud Connectivity





Downstream Connectivity



MR Access Points

Downstream Connectivity

Client Connectivity

```
samsackl@SAMSACKL-M-F859 Downloads % ifconfig en0
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=6463<RXCSUM,TXCSUM,TSO4,TSO6,CHANNEL_IO,PARTIAL_CSUM,ZEROINVERT_CSUM>
        ether 3c:22:fb:30:da:69
        inet6 fe80::1075:6c6c:6758:39e%en0 prefixlen 64 secured scopeid 0x7
        inet 10.0.30.2 netmask 0xffffff00 broadcast 10.0.30.255
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
samsackl@SAMSACKL-M-F859 Downloads %
```

```
samsackl@SAMSACKL-M-F859 Downloads % ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8): 56 data bytes
64 bytes from 8.8.8.8: icmp_seq=0 ttl=114 time=60.636 ms
64 bytes from 8.8.8.8: icmp_seq=1 ttl=114 time=5.139 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=114 time=4.078 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=114 time=5.912 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=114 time=3.914 ms
64 bytes from 8.8.8.8: icmp_seq=5 ttl=114 time=3.983 ms
^C
--- 8.8.8.8 ping statistics ---
6 packets transmitted, 6 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 3.914/13.944/60.636/20.894 ms
samsackl@SAMSACKL-M-F859 Downloads % ping cisco.com
PING cisco.com (72.163.4.185): 56 data bytes
64 bytes from 72.163.4.185: icmp_seq=0 ttl=230 time=172.629 ms
64 bytes from 72.163.4.185: icmp_seq=1 ttl=230 time=109.022 ms
64 bytes from 72.163.4.185: icmp_seq=2 ttl=230 time=108.654 ms
64 bytes from 72.163.4.185: icmp_seq=3 ttl=230 time=108.465 ms
64 bytes from 72.163.4.185: icmp_seq=4 ttl=230 time=108.425 ms
^C
--- cisco.com ping statistics ---
5 packets transmitted, 5 packets received, 0.0% packet loss
round-trip min/avg/max/stddev = 108.425/121.439/172.629/25.596 ms
samsackl@SAMSACKL-M-F859 Downloads %
```

	Status	Description	Last seen	Usage	Device type, OS	IPv4 address	Policy	Adaptive Policy Group ▲	Connected To	Recent SSID	VLAN
		TFTP Server	Jun 1 12:52	17.0 MB	Other	10.0.11.3	normal	10: Corp	MS390-02		11
		Macbook Pro	Jun 1 12:52	69.7 MB	Other	10.0.11.4	normal	10: Corp	AP2_Zone1	Acme Corp	11
		ikarem	Jun 1 12:53	1.9 MB	Mac OS X 10.13	10.0.22.2	normal	20: BYOD	AP3_Zone2	Acme BYOD	22

802.1x Authentication

802.1x authentication has been tested on both Corp and BYOD SSIDs. Dashboard will be checked to verify the correct IP address assignment and username. Packet captures will also be checked to verify the correct SGT assignment. In the final section, ISE logs will show the authentication status and authorization policy applied.

Client	SSID/Port	Username	VLAN	SGT
iKarem **f4:5c:89:b9:35:09** **10.0.22.2**	Acme BYOD	byod1	22	20
iPhone 11 **12:99:2a:2d:d5:d6** **10.0.30.2**	Guest	N/A	30	30
MacBook Pro **8c:ae:4c:dd:15:19** **10.0.11.3**	MS390-02 Port 4	Corp1	10	10

Jun 01, 2022 12:52:59.1...	F4:5C:89:B9:35:09			Campus_zone2	Default >> Dot1X	Default >> BYOD allowed	BYOD_Permit	Apple-Device
Jun 01, 2022 12:13:44.6...	12:34:5C:8C:16:04			Campus_zone1	Default >> Dot1X	Default >> Corp allowed	Corp_Permit	Unknown
Jun 01, 2022 12:13:39.0...	F4:5C:89:B9:35:09			Campus_zone2	Default >> Dot1X	Default >> Corp allowed	Corp_Permit	Apple-Device
Jun 01, 2022 12:11:33.8...	3C:22:FB:30:DA:69			Campus_zone1	Default >> Dot1X	Default >> Corp allowed	Corp_Permit	Apple-Device

Overview

Event	5200 Authentication succeeded
Username	corp1
Endpoint Id	F4:5C:89:B9:35:09
Endpoint Profile	Apple-Device
Authentication Policy	Default >> Dot1X
Authorization Policy	Default >> Corp allowed
Authorization Result	Corp_Permit

Result

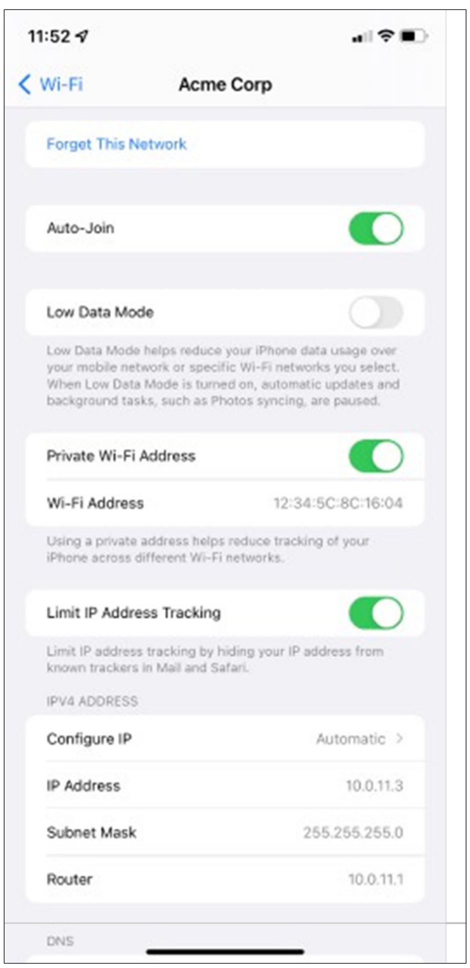
Class	CACS:480d54060000000629749d0:ISE-Campus/442276467/441
Tunnel-Type	(tag=1) VLAN
Tunnel-Medium-Type	(tag=1) 802
Tunnel-Private-Group-ID	(tag=1) 10
cisco-av-pair	cts:security-group-tag=000A-00
cisco-av-pair	cts:security-group-tag=000a-00
MS-MPPE-Send-Key	****
MS-MPPE-Recv-Key	****
LicenseTypes	Essential license consumed.

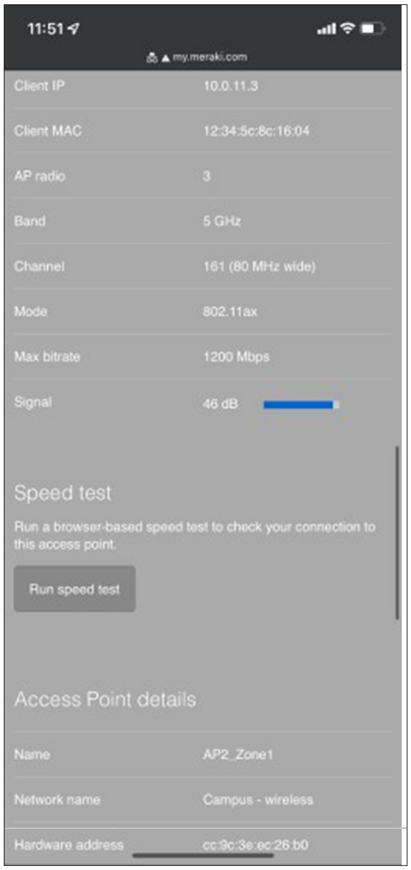
Tech Tip: Please note that the configuration of the Cisco ISE is out of scope of this CVD. Please refer to Cisco ISE administration guide for details on configuring policy sets on Cisco ISE. Also, please refer to this [article] for more information on configuring Cisco ISE with Cisco Meraki Devices

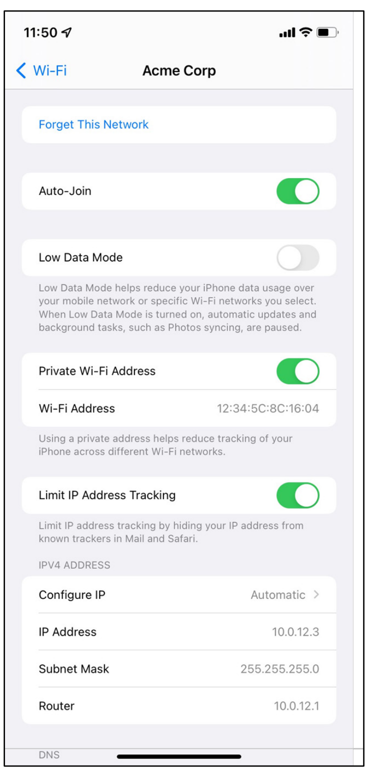
VLAN Assignment

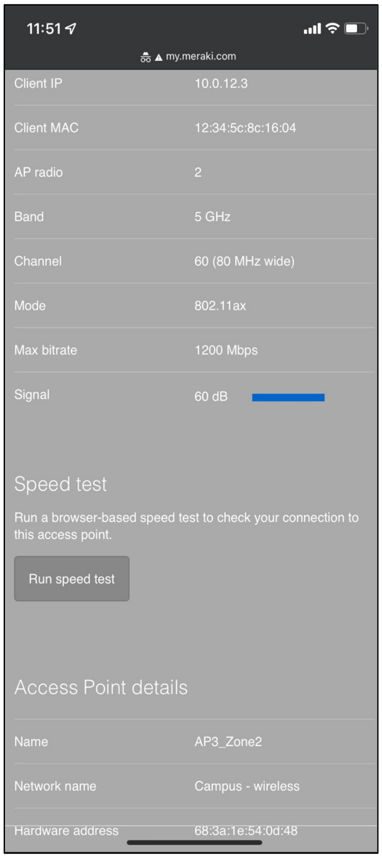
This section will validate that VLANs are assigned correctly based on the VLAN tag. The following client was used to test the connectivity in the designated VLAN:

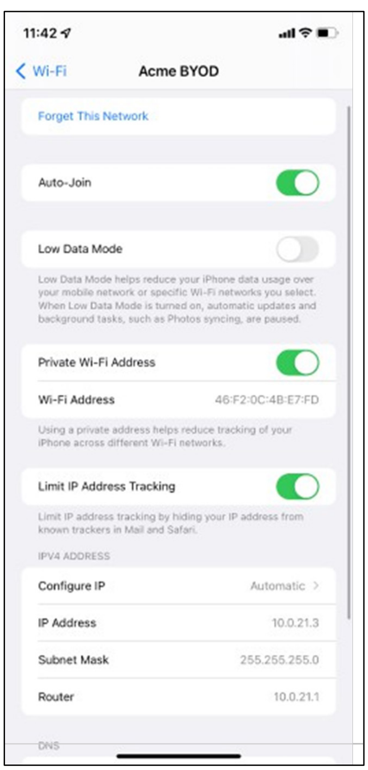
	Acme Corp		Acme BYOD	
AP	AP2_Zone1	AP3_Zone2	AP2_Zone1	AP3_Zone2
Expected VLAN	11	12	21	22
Testing Client	12:34:5C:8C:16:0	12:34:5C:8C:16:0	46:F2:0C:4B:E7:FD	46:F2:0C:4B:E7:FD
Assigned IP Address / VLAN	10.0.11.3 / VLAN 11	10.0.12.3 / VLAN 12	10.0.21.3 / VLAN 21	10.0.22.2 / VLAN 22

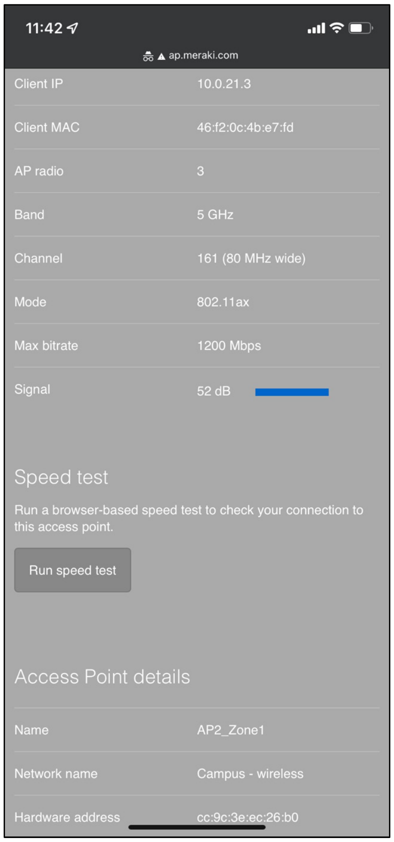



11:51
my.meraki.com
Client IP
10.0.11.3
Client MAC
12:34:5c:8c:16:04
AP radio
3
Band
5 GHz
Channel
161 (80 MHz wide)
Mode
802.11ax
Max bitrate
1200 Mbps
Signal
46 dB
Speed test
Run a browser-based speed test to check your connection to this access point.
Run speed test
Access Point details
Name
AP2_Zone1
Network name
Campus - wireless
Hardware address
cc:9c:3e:ec:26:b0

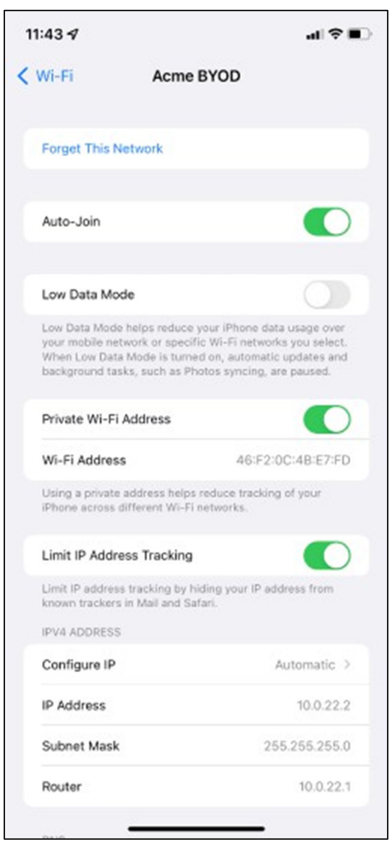

11:50
Wi-Fi
Acme Corp
Forget This Network
Auto-Join
Low Data Mode
Low Data Mode helps reduce your iPhone data usage over your mobile network or specific Wi-Fi networks you select. When Low Data Mode is turned on, automatic updates and background tasks, such as Photos syncing, are paused.
Private Wi-Fi Address
Wi-Fi Address
12:34:5C:8C:16:04
Using a private address helps reduce tracking of your iPhone across different Wi-Fi networks.
Limit IP Address Tracking
Limit IP address tracking by hiding your IP address from known trackers in Mail and Safari.
IPV4 ADDRESS
Configure IP
Automatic
IP Address
10.0.12.3
Subnet Mask
255.255.255.0
Router
10.0.12.1
DNS


11:51
my.meraki.com
Client IP
10.0.12.3
Client MAC
12:34:5c:8c:16:04
AP radio
2
Band
5 GHz
Channel
60 (80 MHz wide)
Mode
802.11ax
Max bitrate
1200 Mbps
Signal
60 dB
Speed test
Run a browser-based speed test to check your connection to this access point.
Run speed test
Access Point details
Name
AP3_Zone2
Network name
Campus - wireless
Hardware address
68:3a:1e:54:0d:48

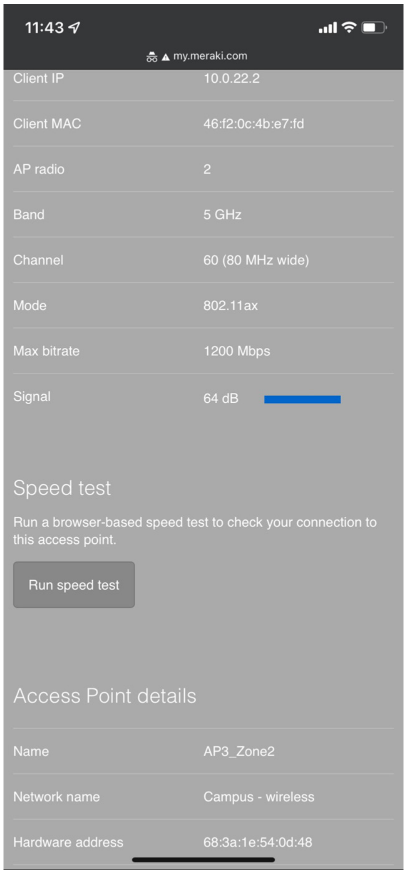

11:42
Wi-Fi
Acme BYOD
Forget This Network
Auto-Join
Low Data Mode
Low Data Mode helps reduce your iPhone data usage over your mobile network or specific Wi-Fi networks you select. When Low Data Mode is turned on, automatic updates and background tasks, such as Photos syncing, are paused.
Private Wi-Fi Address
Wi-Fi Address
46:F2:0C:4B:E7:FD
Using a private address helps reduce tracking of your iPhone across different Wi-Fi networks.
Limit IP Address Tracking
Limit IP address tracking by hiding your IP address from known trackers in Mail and Safari.
IPV4 ADDRESS
Configure IP
Automatic
IP Address
10.0.21.3
Subnet Mask
255.255.255.0
Router
10.0.21.1
DNS



11:42
ap.meraki.com
Client IP
10.0.21.3
Client MAC
46:f2:0c:4b:e7:fd
AP radio
3
Band
5 GHz
Channel
161 (80 MHz wide)
Mode
802.11ax
Max bitrate
1200 Mbps
Signal
52 dB
Speed test
Run a browser-based speed test to check your connection to this access point.
Run speed test
Access Point details
Name
AP2_Zone1
Network name
Campus - wireless
Hardware address
cc:9c:3e:ec:26:b0



11:43
Wi-Fi
Acme BYOD
Forget This Network
Auto-Join
Low Data Mode
Low Data Mode helps reduce your iPhone data usage over your mobile network or specific Wi-Fi networks you select. When Low Data Mode is turned on, automatic updates and background tasks, such as Photos syncing, are paused.
Private Wi-Fi Address
Wi-Fi Address
46:F2:0C:4B:E7:FD
Using a private address helps reduce tracking of your iPhone across different Wi-Fi networks.
Limit IP Address Tracking
Limit IP address tracking by hiding your IP address from known trackers in Mail and Safari.
IPV4 ADDRESS
Configure IP
Automatic
IP Address
10.0.22.2
Subnet Mask
255.255.255.0
Router
10.0.22.1



STP Convergence

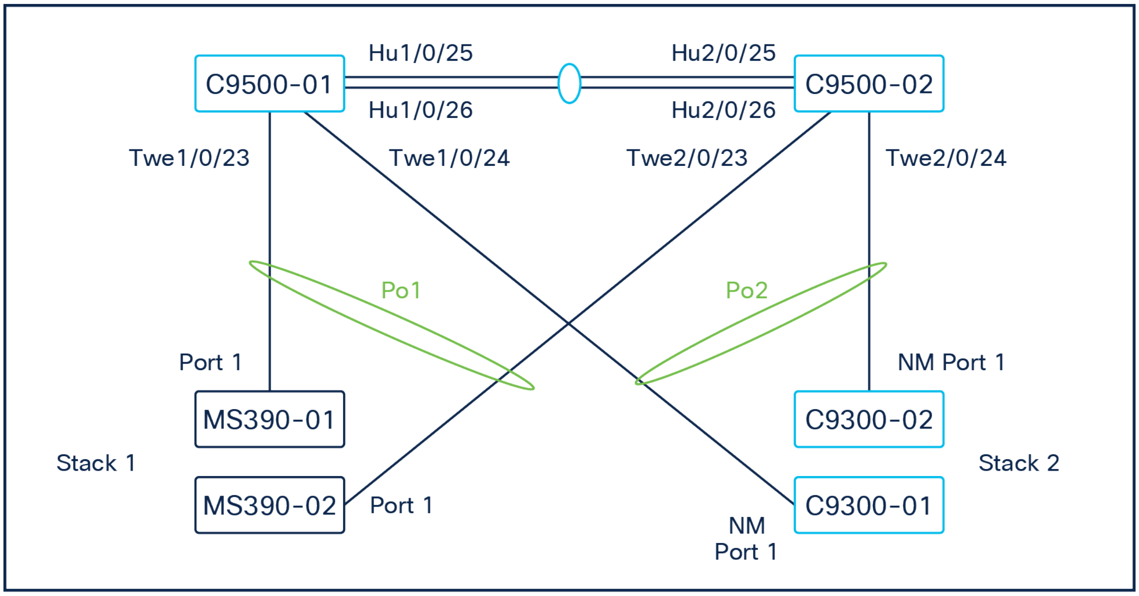
STP convergence will be tested using several methods as outlined below. Please see the following table for steady-state of the Campus LAN before testing:

		Bridge ID	STP Status

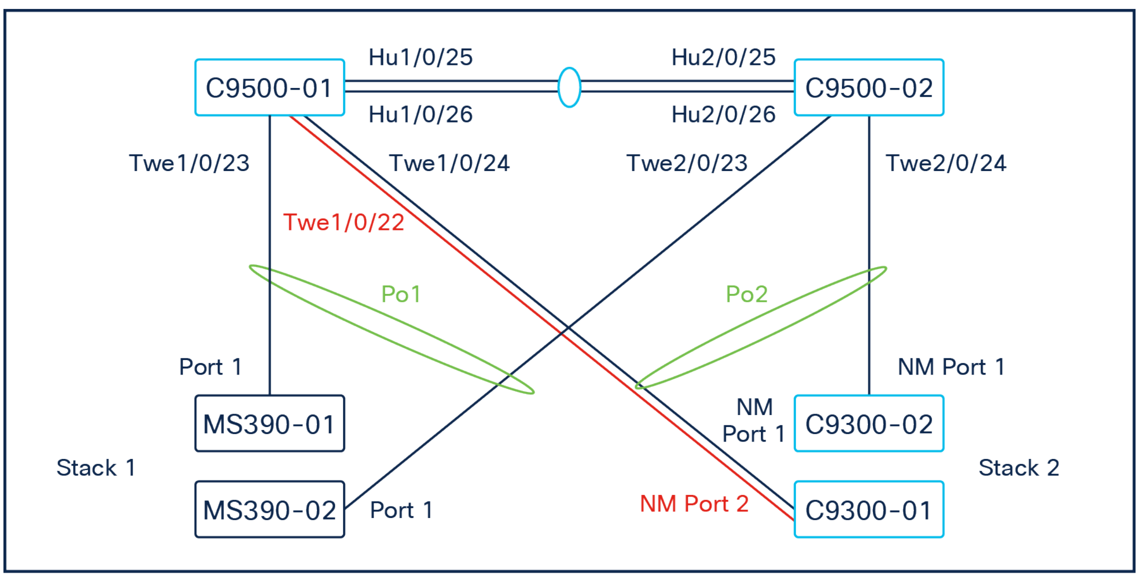
C9500-01	Master	4096:b0c5.3c60.fba0	`Interface Role Sts Cost Prio.Nbr Type`
			`------------------- ---- --- --------- -------- ------`
			`Twe1/0/1 Desg FWD 2000 128.193 P2p`
			`Twe2/0/1 Back BLK 2000 128.385 P2p`
			`Po1 Desg FWD 10000 128.2089 P2p`
			`Po2 Desg FWD 1000 128.2090 P2p`

C9500-02	Member	4096.40b5.c111.01e0	
MS390-01	Master	61440:2c3f.0b04.7e80	STP ROOT b0:c5:3c:60:fb:a0 (priority 4096)
MS390-02	Member	61440:2c3f.0b0f.ec00	**Blocking ports** None
C9300-01	Master	61440:a4b4.395f.2a8b	STP ROOT b0:c5:3c:60:fb:a0 (priority 4096)
C9300-02	Member	61440:4ce1.75b0.ba00	**Blocking ports**

		Bridge ID	STP Status
			None
Client Device		IP Address: 10.0.20.4	



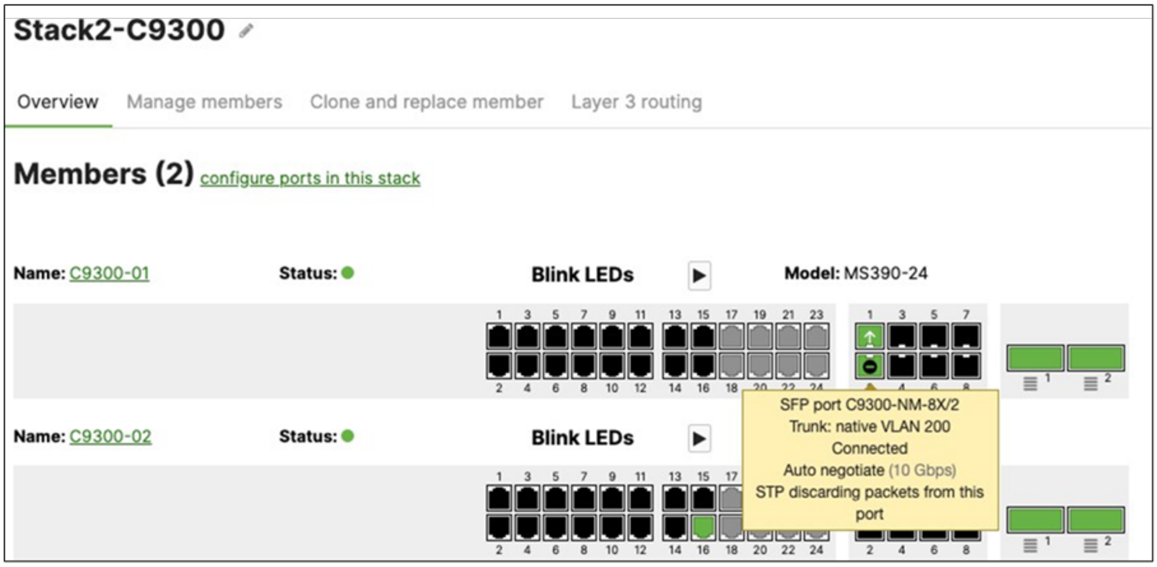
Introducing loops (Access to Core)



A loop was introduced by adding a link between C9300-01 /NM Port 2 and C9500 Core Stack / Port TwentyFiveGigE1/0/22 (Please note that for the purposes of this test, the interface has been unshut and configured as a Trunk port with Native VLAN 1 with STP guards on that interface)

```
9500-01#show ip interface brief | in TwentyFiveGigE1/0/22
TwentyFiveGigE1/0/22 unassigned YES unset up up
ow9500-01#show run interface TwentyFiveGigE1/0/22
Building configuration...

Current configuration : 132 bytes
!
interface TwentyFiveGigE1/0/22
switchport trunk native vlan 200
switchport trunk allowed vlan 200,1922
switchport mode trunk
spanning-tree guard root
end

9500-01#
9500-01#show spanning-tree

MST0
  Spanning tree enabled protocol mstp
  Root ID Priority 4096
       Address b0c5.3c60.fba0
       This bridge is the root
       Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

  Bridge ID Priority 4096 (priority 4096 sys-id-ext 0)
       Address b0c5.3c60.fba0
       Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Interface      Role Sts Cost       Prio.Nbr Type
-------------------------------------------------------
Twe1/0/1       Desg FWD 2000       128.193 P2p
Twe1/0/2       Desg FWD 2000       128.194 P2p
Twe1/0/22      Desg FWD 2000       128.214 P2p
Twe2/0/1       Back BLK 2000       128.385 P2p
Twe2/0/2       Back BLK 2000       128.386 P2p
Po1            Desg FWD 10000       128.2089 P2p
Po2            Desg FWD 1000       128.2090 P2p
```

Interface Twe1/0/22 is in STP FWD state (As expected since this is the Root bridge)

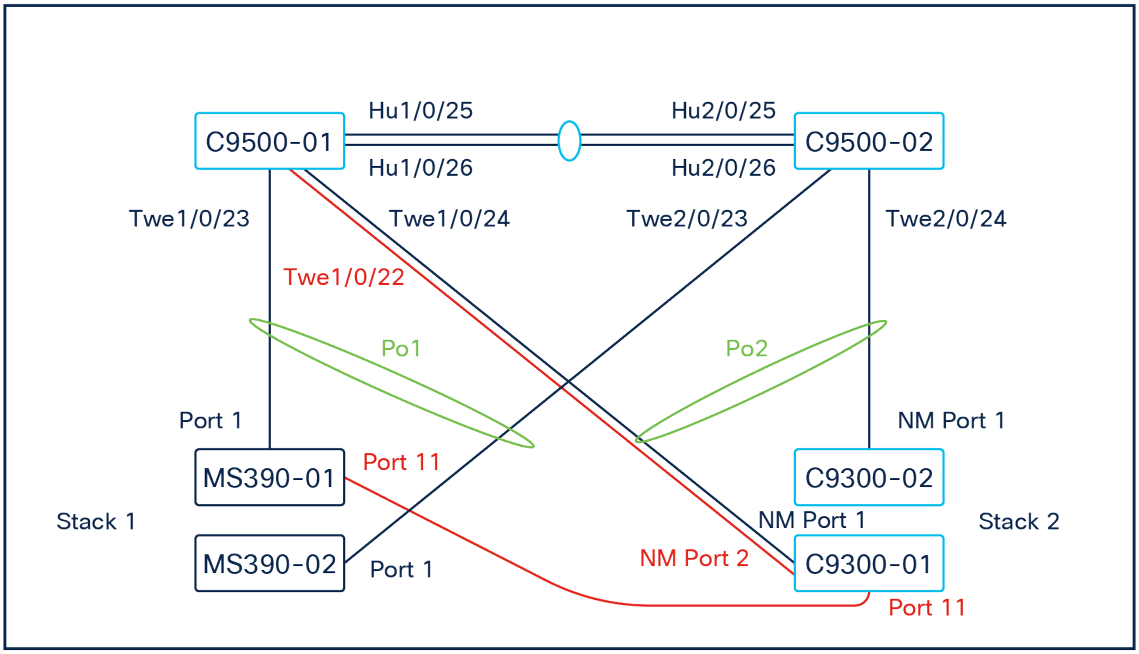


Interface 26 is in STP BLK state (As expected since the Ether-channel is in FWD state)

```
samsackl@SAMSACKL-M-F859 Downloads % ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8): 56 data bytes
64 bytes from 8.8.8.8: icmp_seq=0 ttl=111 time=30.064 ms
64 bytes from 8.8.8.8: icmp_seq=1 ttl=111 time=9.501 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=111 time=14.600 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=111 time=7.825 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=111 time=14.596 ms
64 bytes from 8.8.8.8: icmp_seq=5 ttl=111 time=10.745 ms
64 bytes from 8.8.8.8: icmp_seq=6 ttl=111 time=8.043 ms
64 bytes from 8.8.8.8: icmp_seq=7 ttl=111 time=14.351 ms
64 bytes from 8.8.8.8: icmp_seq=8 ttl=111 time=14.496 ms
64 bytes from 8.8.8.8: icmp_seq=9 ttl=111 time=14.058 ms
64 bytes from 8.8.8.8: icmp_seq=10 ttl=111 time=8.281 ms
64 bytes from 8.8.8.8: icmp_seq=11 ttl=111 time=14.733 ms
64 bytes from 8.8.8.8: icmp_seq=12 ttl=111 time=7.967 ms
64 bytes from 8.8.8.8: icmp_seq=13 ttl=111 time=6.368 ms
64 bytes from 8.8.8.8: icmp_seq=14 ttl=111 time=7.755 ms
64 bytes from 8.8.8.8: icmp_seq=15 ttl=111 time=109.708 ms
64 bytes from 8.8.8.8: icmp_seq=16 ttl=111 time=8.304 ms
64 bytes from 8.8.8.8: icmp_seq=17 ttl=111 time=8.057 ms
64 bytes from 8.8.8.8: icmp_seq=18 ttl=111 time=7.639 ms
64 bytes from 8.8.8.8: icmp_seq=19 ttl=111 time=8.032 ms
64 bytes from 8.8.8.8: icmp_seq=20 ttl=111 time=8.089 ms
64 bytes from 8.8.8.8: icmp_seq=21 ttl=111 time=7.720 ms
64 bytes from 8.8.8.8: icmp_seq=22 ttl=111 time=8.007 ms
64 bytes from 8.8.8.8: icmp_seq=23 ttl=111 time=8.142 ms
64 bytes from 8.8.8.8: icmp_seq=24 ttl=111 time=7.836 ms
64 bytes from 8.8.8.8: icmp_seq=25 ttl=111 time=8.902 ms
64 bytes from 8.8.8.8: icmp_seq=26 ttl=111 time=14.708 ms
64 bytes from 8.8.8.8: icmp_seq=27 ttl=111 time=14.408 ms
64 bytes from 8.8.8.8: icmp_seq=28 ttl=111 time=8.347 ms
64 bytes from 8.8.8.8: icmp_seq=29 ttl=111 time=9.279 ms
64 bytes from 8.8.8.8: icmp_seq=30 ttl=111 time=9.290 ms
64 bytes from 8.8.8.8: icmp_seq=31 ttl=111 time=26.775 ms
64 bytes from 8.8.8.8: icmp_seq=32 ttl=111 time=8.324 ms
64 bytes from 8.8.8.8: icmp_seq=33 ttl=111 time=7.656 ms
64 bytes from 8.8.8.8: icmp_seq=34 ttl=111 time=7.499 ms
64 bytes from 8.8.8.8: icmp_seq=35 ttl=111 time=8.154 ms
64 bytes from 8.8.8.8: icmp_seq=36 ttl=111 time=7.799 ms
64 bytes from 8.8.8.8: icmp_seq=37 ttl=111 time=9.044 ms
64 bytes from 8.8.8.8: icmp_seq=38 ttl=111 time=11.391 ms
64 bytes from 8.8.8.8: icmp_seq=39 ttl=111 time=7.712 ms
64 bytes from 8.8.8.8: icmp_seq=40 ttl=111 time=7.626 ms
```

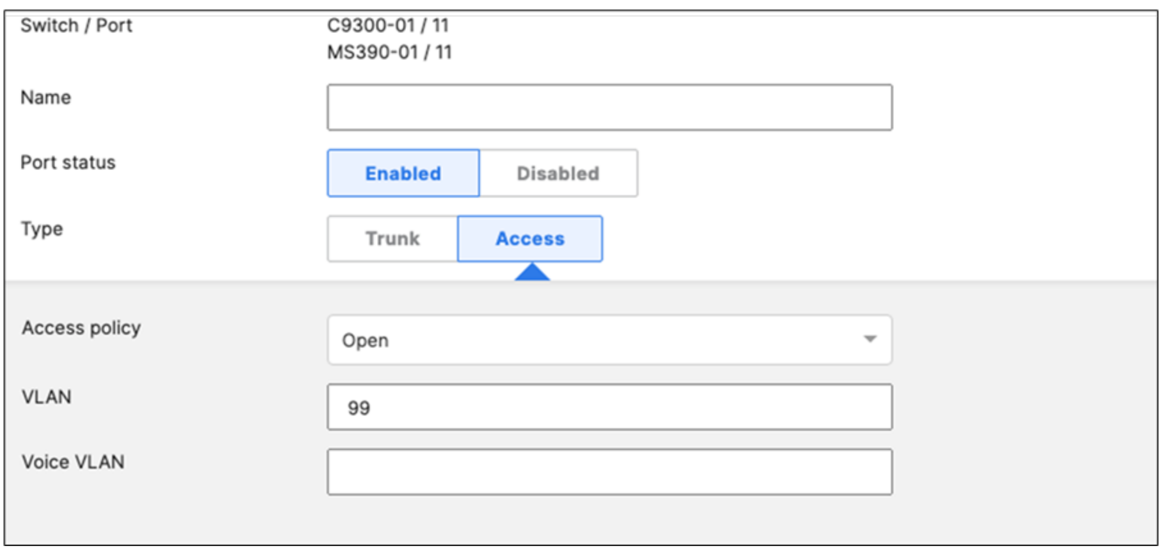
Note: No impact on traffic flow for wireless **and** wired clients

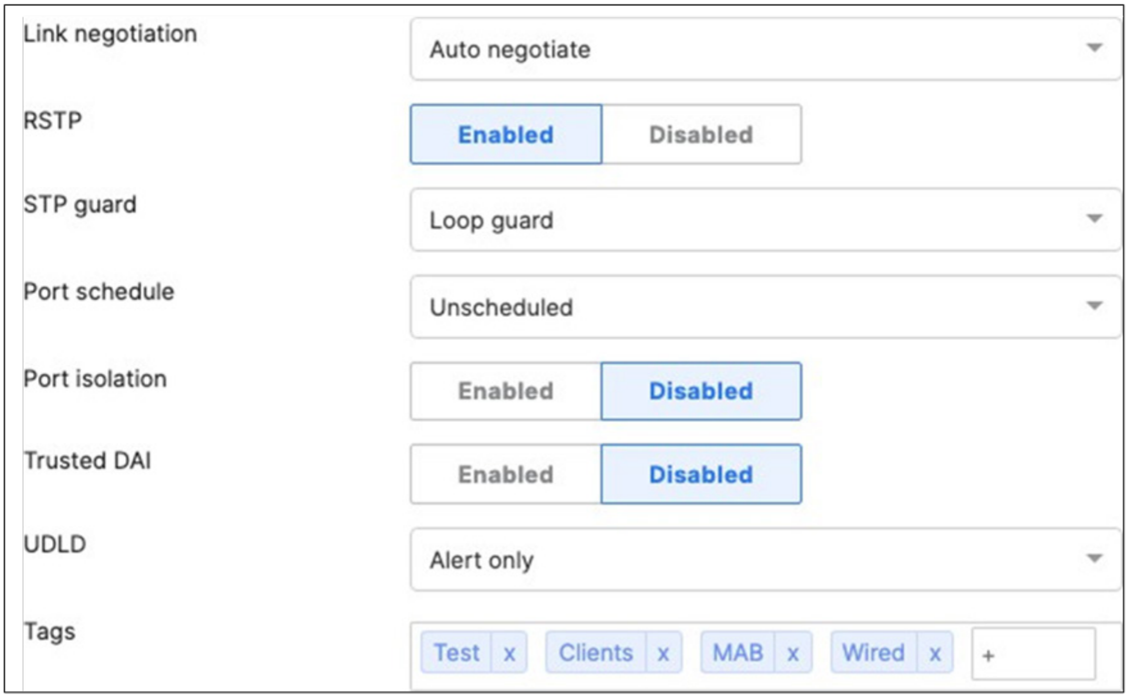
Introducing Loops (Access Layer, with STP Guard: Loop Guard)

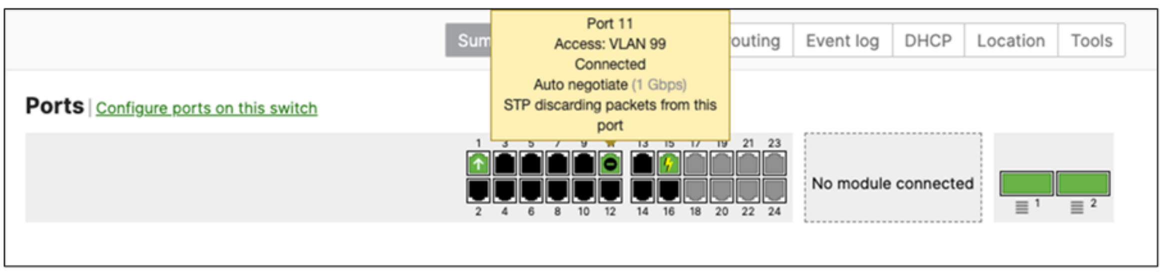


For the purposes of this test and in addition to the previous loop connections, the following ports were connected: MS390-01 / Port 11 < - > C9300-01 / Port 11

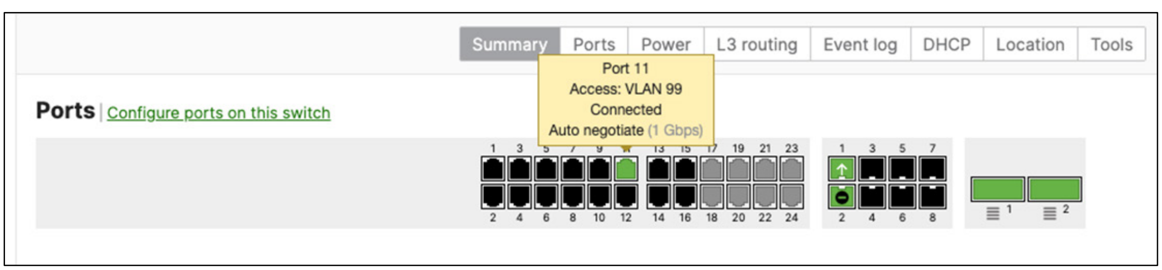
Please note that the port configuration for both ports was changed to assign a common VLAN (in this case VLAN 99). Please see the following configuration that has been applied to both ports:







Note: Port 11 on MS390-01 in STP BLK state (Bridge ID: **61440:2c3f.0b04.7e80**)



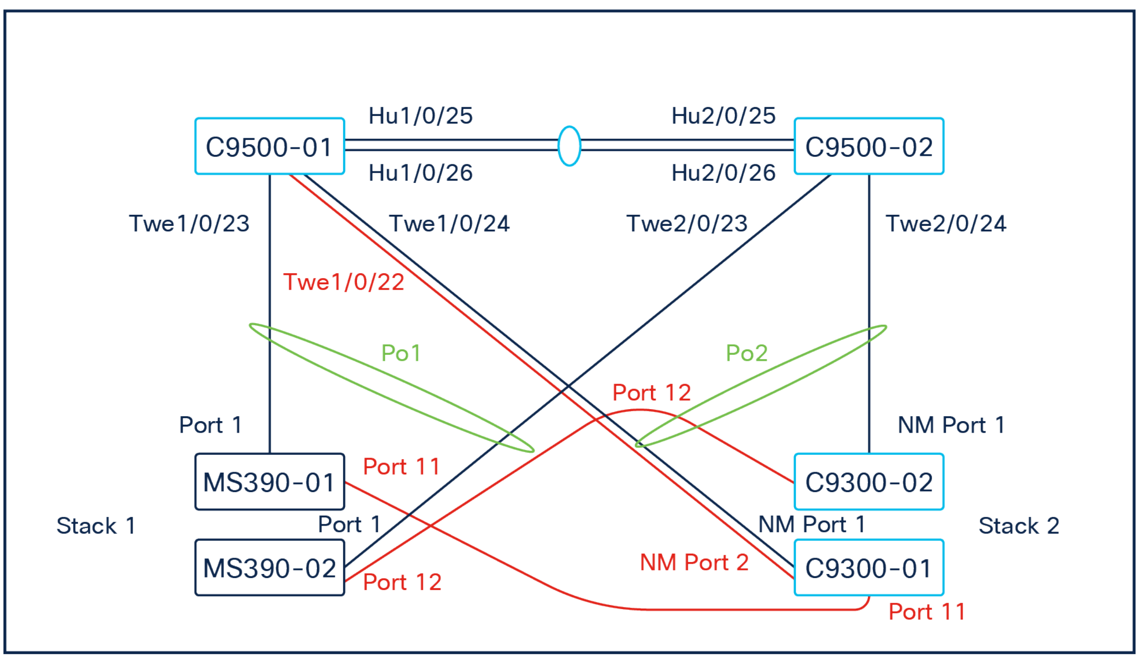
Note: Port 11 on C9300-01 in STP FWD state (Bridge ID: **61440:a4b4.395f.2a8b**)

```
  Protocol Identifier: Spanning Tree Protocol (0x0000)
  Protocol Version Identifier: Multiple Spanning Tree (3)
  BPDU Type: Rapid/Multiple Spanning Tree (0x02)
> BPDU flags: 0x3c, Forwarding, Learning, Port Role: Designated
> Root Identifier: 4096 / 0 / b0:c5:3c:60:fb:a0
  Root Path Cost: 0
> Bridge Identifier: 4096 / 0 / b0:c5:3c:60:fb:a0
```

```
MST Extension
    MST Config ID format selector: 0
    MST Config name: region1
    MST Config revision: 1
    MST Config digest: ac36177f50283cd4b83821d8ab26de62
    CIST Internal Root Path Cost: 1000
  > CIST Bridge Identifier: 61440 / 0 / 4c:e1:75:b0:ba:00
    CIST Remaining hops: 19
```

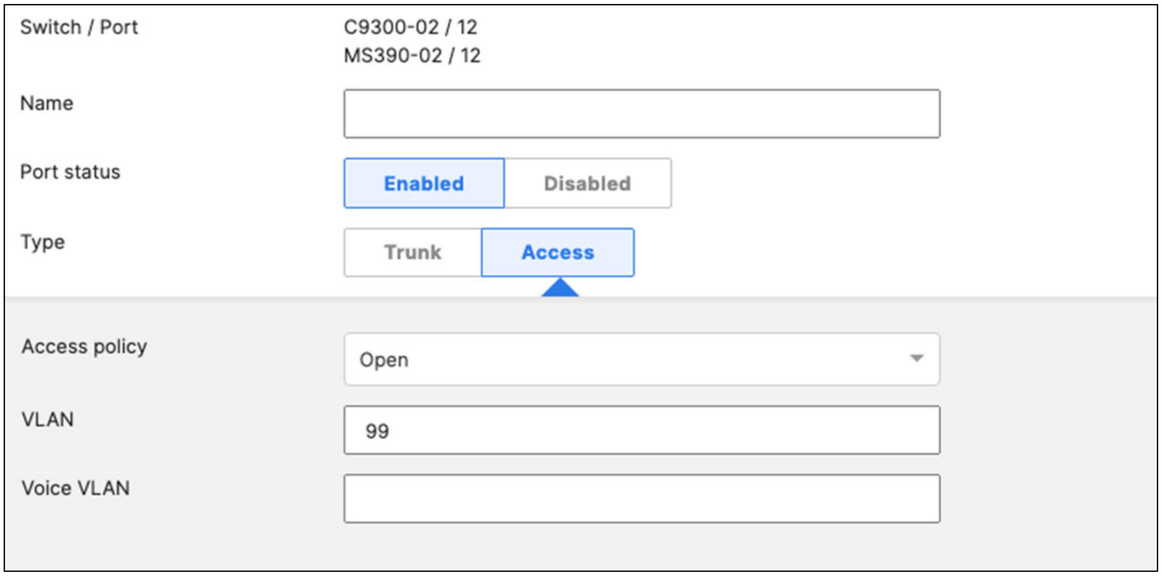
Note: Packet capture on MS390-01 / Port 11 shows that Bridge ID: **61440:4ce1.75b0.ba00** is relaying the Root bridge BPDUs with Root Bridge ID: **4096:b0c5.3c60.fba0**

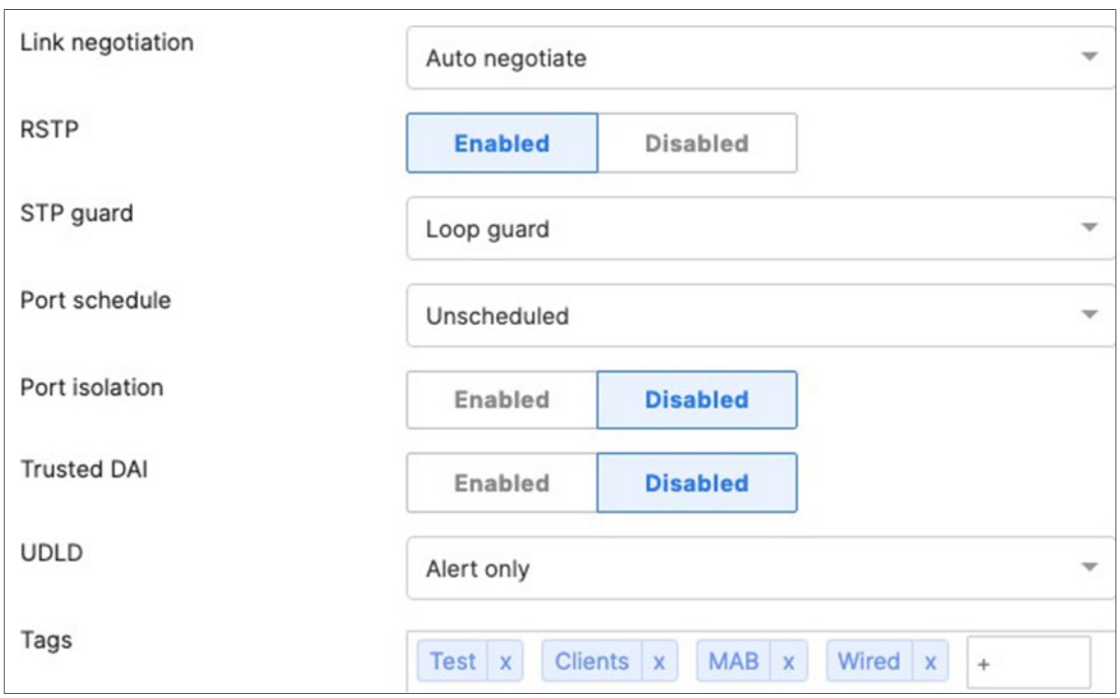
Introducing Loops (Access Layer, without STP Guard)



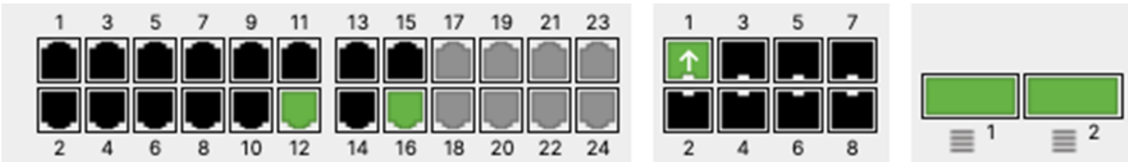
For the purposes of this test and in addition to the previous loop connections, the following ports were connected: MS390-02 / Port 12 < - > C9300-02 / Port 12.

Please note that the port configuration for both ports was changed to assign a common VLAN (in this case VLAN 99). Please see the following configuration that has been applied to both ports:



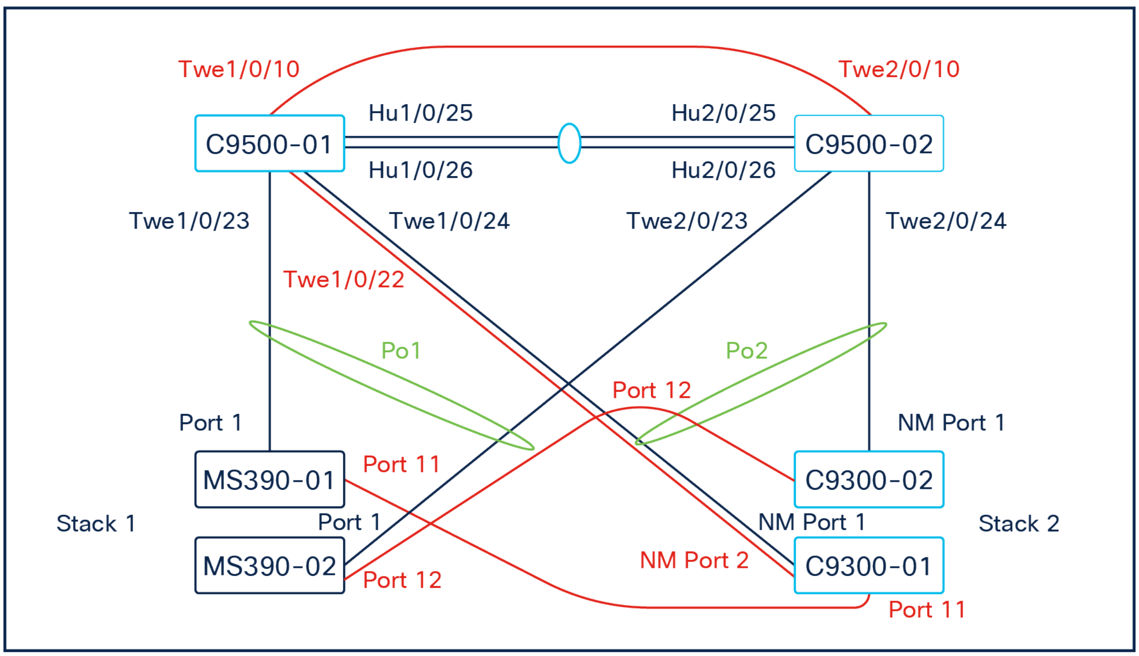


Note: MS390-02 / Port 12 is in STP BLK state (Bridge ID: **61440:2c3f.0b0f.ec00**)



Note: C9300-02 / Port 12 is in STP FWD state (Bridge ID: **61440:4ce1.75b0.ba00**)

Introducing Loops (Core Layer)



For the purpose of this test and in addition to the previous loop connections, the following ports were connected:

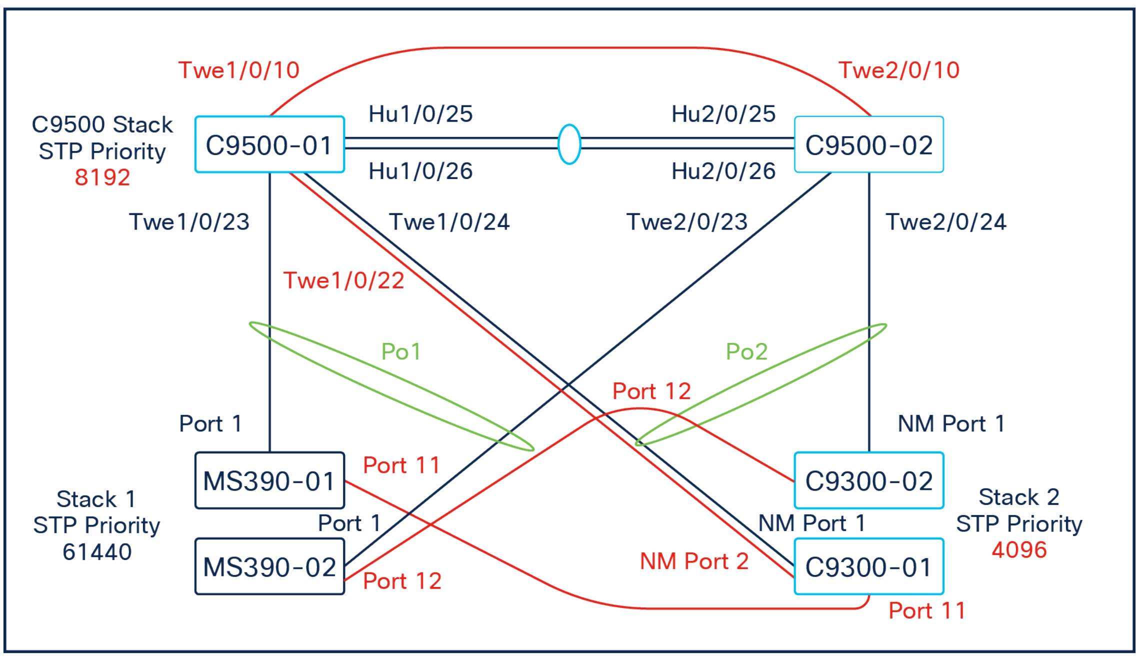
Port Twe1/0/10 to port Twe2/0/10 on the C9500 Core switches.

```
9500-01#show run interface Twe1/0/10
Building configuration...

Current configuration : 132 bytes
!
interface TwentyFiveGigE1/0/10
switchport trunk native vlan 3
switchport trunk allowed vlan 3,100,200,1921,1922,1923
switchport mode trunk
spanning-tree guard loop
end
```

```
9500-01#show run interface Twe2/0/10
Building configuration...

Current configuration : 132 bytes
!
interface TwentyFiveGigE2/0/10
switchport trunk native vlan 3
switchport trunk allowed vlan 3,100,200,1921,1922,1923
switchport mode trunk
spanning-tree guard loop
end

9500-01#
9500-01#show ip interface brief | in TwentyFiveGigE1/0/10
TwentyFiveGigE1/0/10 unassigned YES unset up up
9500-01#
9500-01#show ip interface brief | in TwentyFiveGigE2/0/10
TwentyFiveGigE2/0/10 unassigned YES unset up up
9500-01#show spanning-tree

MST0
  Spanning tree enabled protocol mstp
  Root ID Priority 4096
          Address b0c5.3c60.fba0
          This bridge is the root
          Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
  Bridge ID Priority 4096 (priority 4096 sys-id-ext 0)
          Address b0c5.3c60.fba0
          Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Interface   Role Sts Cost     Prio.Nbr Type
--------------------------------------------
Twe1/0/1    Desg FWD 2000     128.193 P2p
Twe1/0/2    Desg FWD 2000     128.194 P2p
Twe1/0/10   Desg FWD 2000     128.202 P2p
Twe1/0/22   Desg FWD 2000     128.214 P2p
Twe2/0/1    Back BLK 2000     128.385 P2p
Twe2/0/2    Back BLK 2000     128.386 P2p
Twe2/0/10   Back BLK 2000     128.394 P2p
Po1         Desg FWD 10000    128.2089 P2p
Po2         Desg FWD 1000     128.2090 P2p
```

```
9500-01#show spanning-tree interface Twe2/0/10 detail
Port 394 (TwentyFiveGigE2/0/10) of MST0 is backup blocking
  Port path cost 2000, Port priority 128, Port Identifier 128.394.
  Designated root has priority 4096, address b0c5.3c60.fba0
  Designated bridge has priority 4096, address b0c5.3c60.fba0
  Designated port id is 128.202, designated path cost 0
  Timers: message age 4, forward delay 0, hold 0
  Number of transitions to forwarding state: 0
  Link type is point-to-point by default, Internal
  PVST Simulation is enabled by default
  Loop guard is enabled on the port
  BPDU: sent 2, received 66
9500-01#
```

Introducing Rogue Bridge in VLAN 200



For the purpose of this test and in addition to the previous loop connections, the Bridge priority on C9300 Stack will be reduced to 4096 (likely root) and increasing the Bridge priority on C9500 to 8192.

- Downlinks on C9500 are configured with STP Root Guard
- Access Layer Links (Stack to Stack) are configured with STP Loop Guard + UDLD

```
9500-01(config)#spanning-tree mst 0 priority 8192
9500-01(config)#end
9500-01#show spanning-tree
MST0
  Spanning tree enabled protocol mstp
  Root ID Priority 8192
        Address b0c5.3c60.fba0
        This bridge is the root
        Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
  Bridge ID Priority 8192 (priority 8192 sys-id-ext 0)
        Address b0c5.3c60.fba0
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Interface       Role StsCost       Prio.Nbr Type
-----------------------------------------------------
Twe1/0/1      Desg FWD 2000        128.193 P2p
Twe1/0/2      Desg FWD 2000        128.194 P2p
Twe1/0/10     Desg FWD 2000        128.202 P2p
Twe1/0/22     Desg BKN*2000        128.214 P2p *ROOT_Inc
Twe2/0/1      Back BLK 2000        128.385 P2p
Twe2/0/2      Back BLK 2000        128.386 P2p
Twe2/0/10     Back BLK 2000        128.394 P2p
Po1           Desg BKN*10000       128.2089 P2p *ROOT_Inc
Po2           Desg BKN*1000        128.2090 P2p *ROOT_Inc

9500-01#
```


```
9500-01#show spanning-tree
MST0
  Spanning tree enabled protocol mstp
  Root ID Priority 8192
        Address b0c5.3c60.fba0
        This bridge is the root
        Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
  Bridge ID Priority 8192 (priority 8192 sys-id-ext 0)
  Address b0c5.3c60.fba0
        Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Interface     Role Sts Cost     Prio.Nbr Type
---------------------------------------------
9500-01#sh spanning-tree
MST0
  Spanning tree enabled protocol mstp
  Root ID Priority 8192
           Address b0c5.3c60.fba0
           This bridge is the root
           Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec

  Bridge ID Priority 8192 (priority 8192 sys-id-ext 0)
           Address b0c5.3c60.fba0
           Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Interface       Role StsCost       Prio.Nbr Type
-----------------------------------------------------
Twe1/0/1      Desg FWD 2000        128.193 P2p
Twe1/0/2      Desg FWD 2000        128.194 P2p
Twe1/0/10     Desg FWD 2000        128.202 P2p
Twe1/0/22     Desg BKN*2000        128.214 P2p *ROOT_Inc
Twe2/0/1      Back BLK 2000        128.385 P2p
Twe2/0/2      Back BLK 2000        128.386 P2p
Twe2/0/10     Back BLK 2000        128.394 P2p
Po1           Desg BKN*10000       128.2089 P2p *ROOT_Inc
Po2           Desg BKN*1000        128.2090 P2p *ROOT_Inc

9500-01#
9500-01#show spanning-tree interface Po1 detail
Port 2089 (Port-channel1) of MST0 is broken (Root Inconsistent)
  Port path cost 10000, Port priority 128, Port Identifier 128.2089.
  Designated root has priority 8192, address b0c5.3c60.fba0
  Designated bridge has priority 8192, address b0c5.3c60.fba0
```

```
  Designated port id is 128.2089, designated path cost 0
  Timers: message age 5, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
  Link type is point-to-point by default, Internal
  PVST Simulation is enabled by default
  Root guard is enabled on the port
  BPDU: sent 15929, received 1230

9500-01#show spanning-tree interface Po2 detail
Port 2090 (Port-channel2) of MST0 is broken (Root Inconsistent)
  Port path cost 1000, Port priority 128, Port Identifier 128.2090.
  Designated root has priority 8192, address b0c5.3c60.fba0
  Designated bridge has priority 8192, address b0c5.3c60.fba0
  Designated port id is 128.2090, designated path cost 0
  Timers: message age 5, forward delay 0, hold 0
  Number of transitions to forwarding state: 1
  Link type is point-to-point by default, Internal
  PVST Simulation is enabled by default
  Root guard is enabled on the port
  BPDU: sent 15849, received 1330
9500-01#
```

C9500 Core Stack is **still** the Root Bridge (i.e. The root Bridge placement has been enforced).

Downlinks to C9300 and MS390 stacks are in **STP Root Inconsistent State** which caused all access switches to go offline on Dashboard.

Note: Please note that this caused client disruption, and no traffic was passing since the C9500 Core Stack put all downlink ports into Root inconsistent state.

To recover access switches, you will need to change the STP priority on the C9500 Core stack to 0 which ensures that your core stack becomes the root of the CIST. Alternatively, you can configure STP root Guard on the MS390 ports facing the C9300 and thus the MS390s will come back online.

The reason why all access switches went online on dashboard is that the C9300 was the root for the access layer (priority 4096) and thus the MS390s were passing traffic to Dashboard via the C9300s. Configuring STP Root Guard on the ports facing C9300 recovered the MS390s and client connectivity.

On the other hand, changing the STP priority on the C9500 core stack pulled back the Root to the core layer and recovered all switches on the access layer.

Tech Tip: It is considered best practices to avoid assigning STP priority on your network to 0 on any device which gives you room for adding devices in the future and for maintenance purposes. In this instance, configuring STP priority 0 allowed us to recover the network which wouldn't have been possible if priority 0 was configured already on the network. Having said that, please remember to revert the STP priority on your C9500 Core Stack after recovering the network. (Default value 4096)

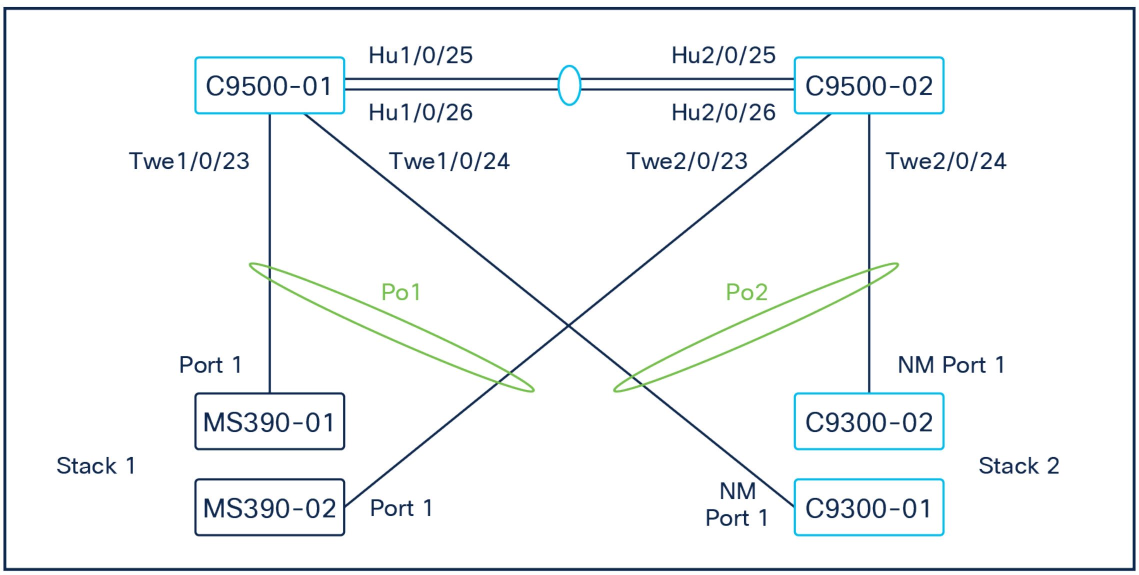
```
9500-01(config)#spanning-tree mst 0 priority 0
9500-01(config)#
9500-01(config)#end
9500-01#show spanning-tree
MST0
  Spanning tree enabled protocol mstp
  Root ID Priority 0
        Address b0c5.3c60.fba0
        This bridge is the root
        Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
  Bridge ID Priority 0 (priority 0 sys-id-ext 0)
        Address b0c5.3c60.fba0
        Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Interface    Role Sts Cost      Prio.Nbr Type
---------------------------------------------
Twe1/0/1    Desg FWD 2000       128.193 P2p
Twe1/0/2    Desg FWD 2000       128.194 P2p
Twe1/0/10   Desg FWD 2000       128.202 P2p
Twe1/0/22   Desg FWD 2000       128.214 P2p
Twe2/0/1    Back BLK 2000       128.385 P2p
Twe2/0/2    Back BLK 2000       128.386 P2p
Twe2/0/10   Back BLK 2000       128.394 P2p
Po1         Desg FWD 10000       128.2089 P2p
Po2         Desg FWD 1000       128.2090 P2p
9500-01#ping 10.0.200.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.200.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/3 ms
9500-01#ping 10.0.100.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.100.3, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 2/2/3 ms
9500-01#
```

Reverting all configurations back to its original state:

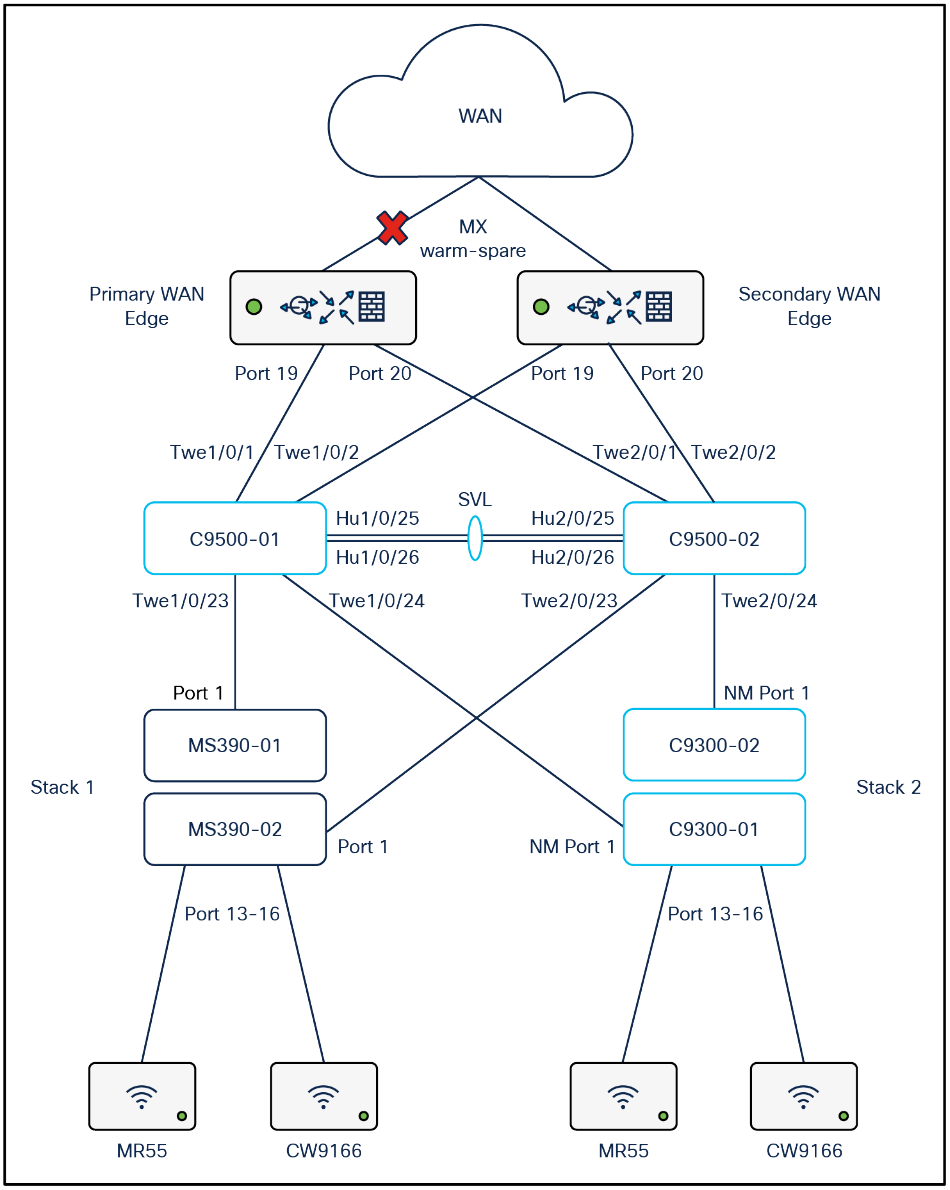
1. Disconnect and shutdown interface TwentyFiveGigE1/0/22
2. Disconnect port 11 on MS390-01 and C9300-01 and remove Loop Guard and UDLD
3. Disconnect port 12 on MS390-02 and C9300-02
4. Disconnect and revert port TwentyFiveGigE1/0/10 and TwentyFiveGigE20/10 back to access with VLAN 1 and shutdown
5. Change MST priority on C9300 stack to 61440
6. Change MST priority on C9500 Core Stack to 4096

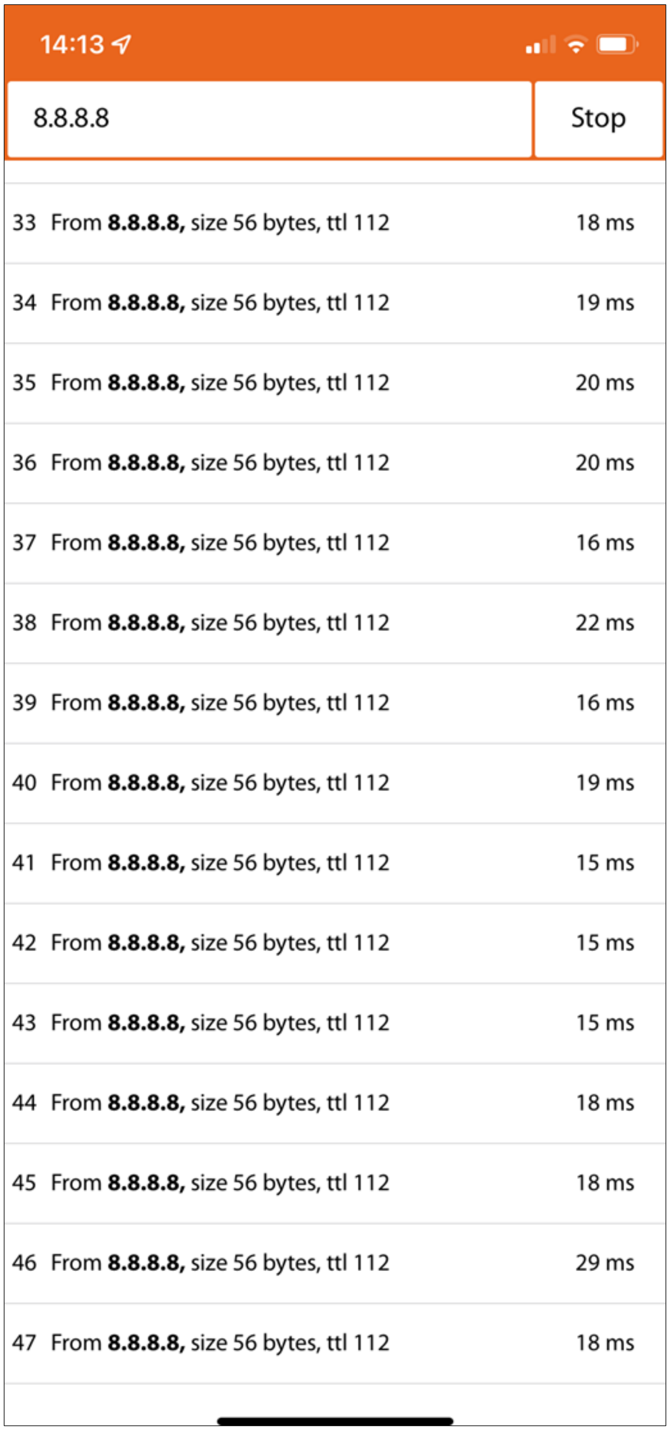
High Availability and Failover

Here's the steady-state physical architecture for reference:



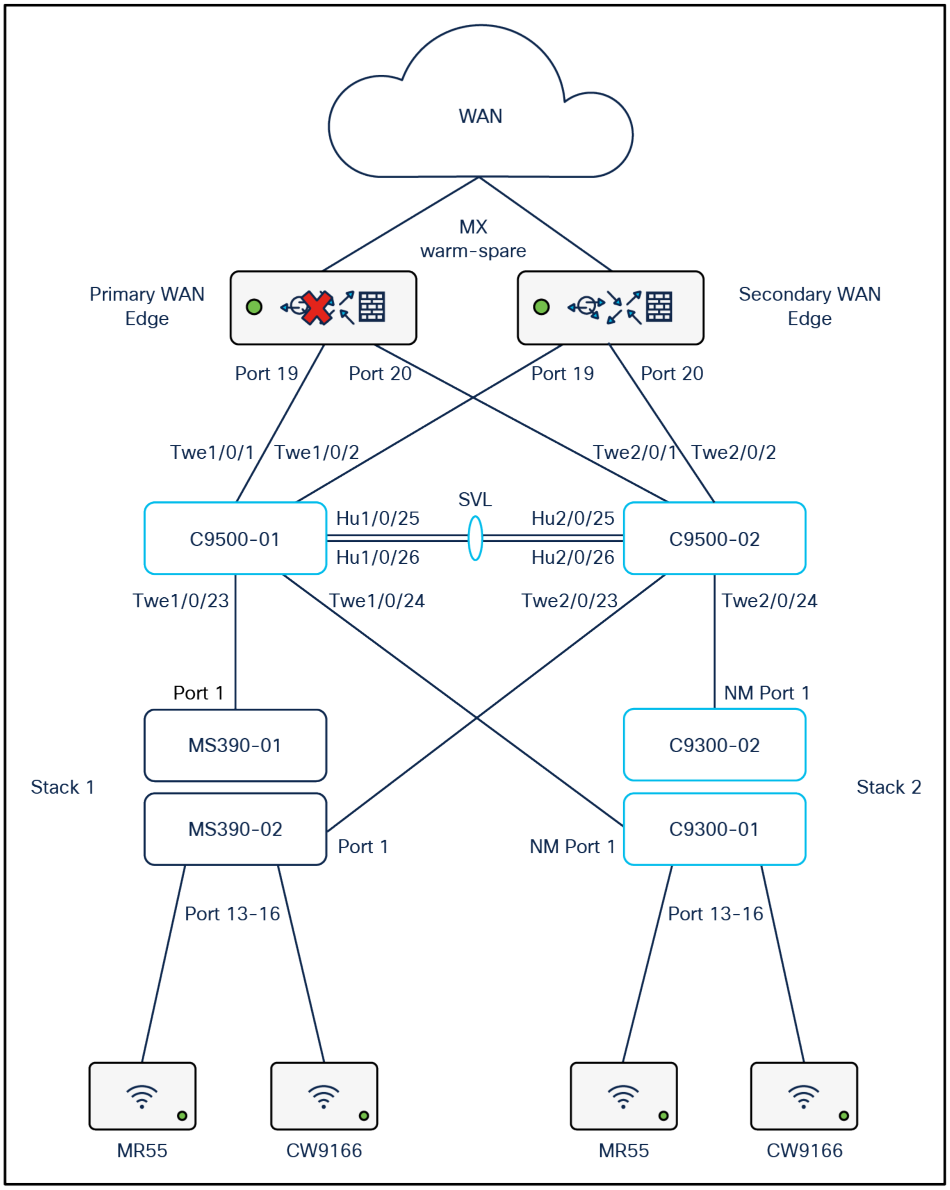
MX WAN Edge Failover




14:13
8.8.8.8
Stop
33 From 8.8.8.8, size 56 bytes, ttl 112 18 ms
34 From 8.8.8.8, size 56 bytes, ttl 112 19 ms
35 From 8.8.8.8, size 56 bytes, ttl 112 20 ms
36 From 8.8.8.8, size 56 bytes, ttl 112 20 ms
37 From 8.8.8.8, size 56 bytes, ttl 112 16 ms
38 From 8.8.8.8, size 56 bytes, ttl 112 22 ms
39 From 8.8.8.8, size 56 bytes, ttl 112 16 ms
40 From 8.8.8.8, size 56 bytes, ttl 112 19 ms
41 From 8.8.8.8, size 56 bytes, ttl 112 15 ms
42 From 8.8.8.8, size 56 bytes, ttl 112 15 ms
43 From 8.8.8.8, size 56 bytes, ttl 112 15 ms
44 From 8.8.8.8, size 56 bytes, ttl 112 18 ms
45 From 8.8.8.8, size 56 bytes, ttl 112 18 ms
46 From 8.8.8.8, size 56 bytes, ttl 112 29 ms
47 From 8.8.8.8, size 56 bytes, ttl 112 18 ms

```
64 bytes from 8.8.8.8: icmp_seq=74 ttl=112 time=7.527 ms
64 bytes from 8.8.8.8: icmp_seq=75 ttl=112 time=8.212 ms
64 bytes from 8.8.8.8: icmp_seq=76 ttl=112 time=91.591 ms
64 bytes from 8.8.8.8: icmp_seq=77 ttl=112 time=47.030 ms
64 bytes from 8.8.8.8: icmp_seq=78 ttl=112 time=40.951 ms
64 bytes from 8.8.8.8: icmp_seq=79 ttl=112 time=162.646 ms
64 bytes from 8.8.8.8: icmp_seq=80 ttl=112 time=8.258 ms
64 bytes from 8.8.8.8: icmp_seq=81 ttl=112 time=104.672 ms
64 bytes from 8.8.8.8: icmp_seq=82 ttl=112 time=9.280 ms
64 bytes from 8.8.8.8: icmp_seq=83 ttl=112 time=7.689 ms
64 bytes from 8.8.8.8: icmp_seq=84 ttl=112 time=7.088 ms
64 bytes from 8.8.8.8: icmp_seq=85 ttl=112 time=8.194 ms
64 bytes from 8.8.8.8: icmp_seq=86 ttl=112 time=7.642 ms
64 bytes from 8.8.8.8: icmp_seq=87 ttl=112 time=166.694 ms
64 bytes from 8.8.8.8: icmp_seq=88 ttl=112 time=211.235 ms
64 bytes from 8.8.8.8: icmp_seq=89 ttl=112 time=64.639 ms
64 bytes from 8.8.8.8: icmp_seq=90 ttl=112 time=108.789 ms
64 bytes from 8.8.8.8: icmp_seq=91 ttl=112 time=154.092 ms
64 bytes from 8.8.8.8: icmp_seq=92 ttl=112 time=195.791 ms
64 bytes from 8.8.8.8: icmp_seq=93 ttl=112 time=7.521 ms
64 bytes from 8.8.8.8: icmp_seq=94 ttl=112 time=8.194 ms
64 bytes from 8.8.8.8: icmp_seq=95 ttl=112 time=7.427 ms
64 bytes from 8.8.8.8: icmp_seq=96 ttl=112 time=45.216 ms
64 bytes from 8.8.8.8: icmp_seq=97 ttl=112 time=91.350 ms
64 bytes from 8.8.8.8: icmp_seq=98 ttl=112 time=120.614 ms
64 bytes from 8.8.8.8: icmp_seq=99 ttl=112 time=150.742 ms
64 bytes from 8.8.8.8: icmp_seq=100 ttl=112 time=162.672 ms
64 bytes from 8.8.8.8: icmp_seq=101 ttl=112 time=123.627 ms
64 bytes from 8.8.8.8: icmp_seq=102 ttl=112 time=251.045 ms
64 bytes from 8.8.8.8: icmp_seq=103 ttl=112 time=305.056 ms
64 bytes from 8.8.8.8: icmp_seq=104 ttl=112 time=351.764 ms
64 bytes from 8.8.8.8: icmp_seq=105 ttl=112 time=8.535 ms
64 bytes from 8.8.8.8: icmp_seq=106 ttl=112 time=16.349 ms
64 bytes from 8.8.8.8: icmp_seq=107 ttl=112 time=17.625 ms
64 bytes from 8.8.8.8: icmp_seq=108 ttl=112 time=7.122 ms
64 bytes from 8.8.8.8: icmp_seq=109 ttl=112 time=22.681 ms
64 bytes from 8.8.8.8: icmp_seq=110 ttl=112 time=6.893 ms
64 bytes from 8.8.8.8: icmp_seq=111 ttl=112 time=8.228 ms
64 bytes from 8.8.8.8: icmp_seq=112 ttl=112 time=6.981 ms
64 bytes from 8.8.8.8: icmp_seq=113 ttl=112 time=5.515 ms
64 bytes from 8.8.8.8: icmp_seq=114 ttl=112 time=27.871 ms
64 bytes from 8.8.8.8: icmp_seq=115 ttl=112 time=80.179 ms
64 bytes from 8.8.8.8: icmp_seq=116 ttl=112 time=6.963 ms
64 bytes from 8.8.8.8: icmp_seq=117 ttl=112 time=7.068 ms
64 bytes from 8.8.8.8: icmp_seq=118 ttl=112 time=6.465 ms
64 bytes from 8.8.8.8: icmp_seq=119 ttl=112 time=7.289 ms
64 bytes from 8.8.8.8: icmp_seq=120 ttl=112 time=14.539 ms
```

Note: Client traffic was **not** disrupted during failover event for both Wireless and Wired clients.



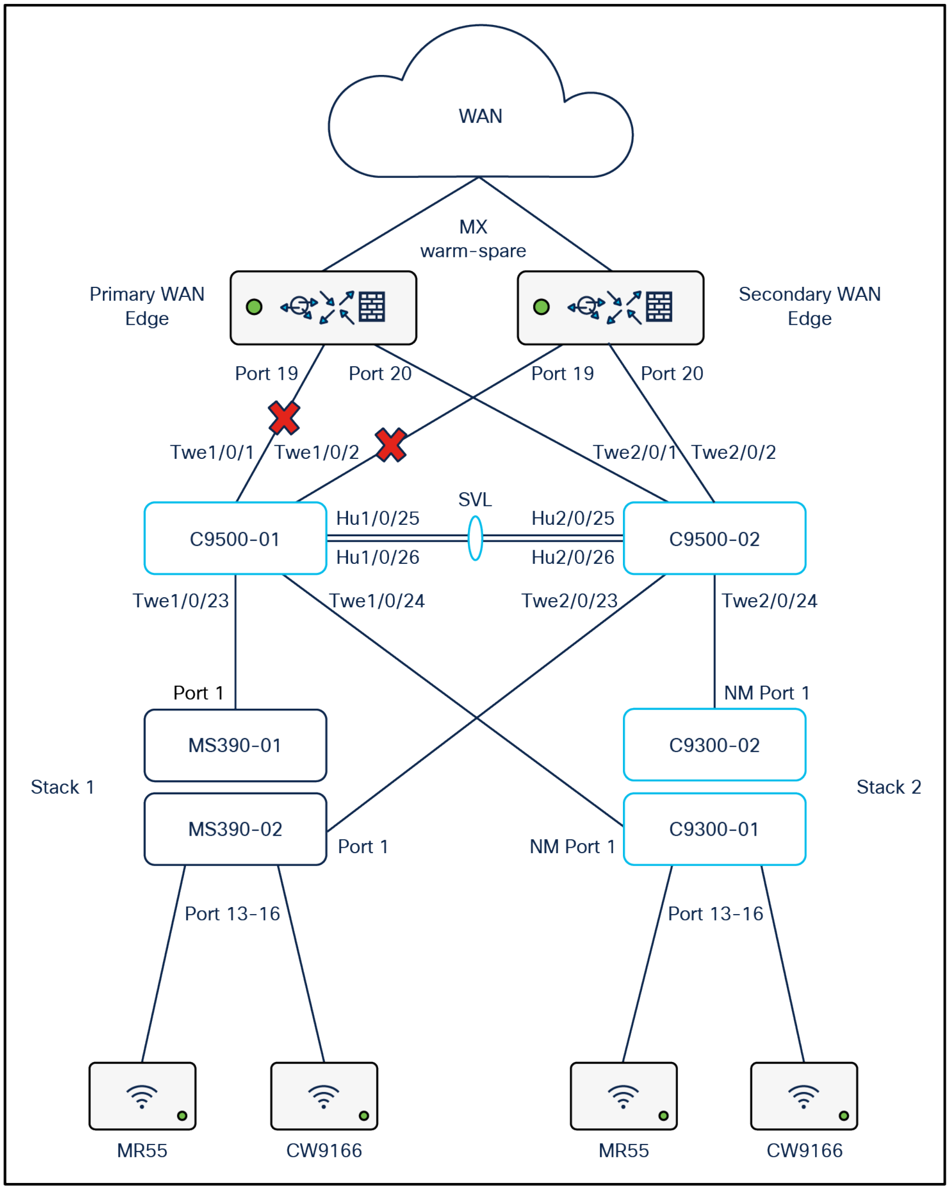
WAN
MX
warm-spare
Primary WAN
Edge
Secondary WAN
Edge
Port 19
Port 20
Port 19
Port 20
Twe1/0/1
Twe1/0/2
Twe2/0/1
Twe2/0/2
SVL
C9500-01
Hu1/0/25
Hu1/0/26
Hu2/0/25
Hu2/0/26
C9500-02
Twe1/0/23
Twe1/0/24
Twe2/0/23
Twe2/0/24
Port 1
NM Port 1
MS390-01
C9300-02
Stack 1
Stack 2
MS390-02
Port 1
NM Port 1
C9300-01
Port 13-16
Port 13-16
MR55
CW9166
MR55
CW9166

PRIMARY
Unreachable
SPARE
Current master

```
64 bytes from 8.8.8.8: icmp_seq=1629 ttl=112 time=47.803 ms
64 bytes from 8.8.8.8: icmp_seq=1630 ttl=112 time=7.525 ms
64 bytes from 8.8.8.8: icmp_seq=1631 ttl=112 time=7.891 ms
64 bytes from 8.8.8.8: icmp_seq=1632 ttl=112 time=7.080 ms
64 bytes from 8.8.8.8: icmp_seq=1633 ttl=112 time=7.034 ms
64 bytes from 8.8.8.8: icmp_seq=1634 ttl=112 time=7.069 ms
64 bytes from 8.8.8.8: icmp_seq=1635 ttl=112 time=7.314 ms
Request timeout for icmp_seq 1636
Request timeout for icmp_seq 1637
Request timeout for icmp_seq 1638
64 bytes from 8.8.8.8: icmp_seq=1639 ttl=112 time=240.011 ms
64 bytes from 8.8.8.8: icmp_seq=1640 ttl=112 time=8.005 ms
64 bytes from 8.8.8.8: icmp_seq=1641 ttl=112 time=13.687 ms
64 bytes from 8.8.8.8: icmp_seq=1642 ttl=112 time=13.163 ms
64 bytes from 8.8.8.8: icmp_seq=1643 ttl=112 time=9.468 ms
64 bytes from 8.8.8.8: icmp_seq=1644 ttl=112 time=6.821 ms
64 bytes from 8.8.8.8: icmp_seq=1645 ttl=112 time=14.942 ms
64 bytes from 8.8.8.8: icmp_seq=1646 ttl=112 time=6.533 ms
64 bytes from 8.8.8.8: icmp_seq=1647 ttl=112 time=7.280 ms
64 bytes from 8.8.8.8: icmp_seq=1648 ttl=112 time=10.863 ms
64 bytes from 8.8.8.8: icmp_seq=1649 ttl=112 time=6.432 ms
64 bytes from 8.8.8.8: icmp_seq=1650 ttl=112 time=6.386 ms
64 bytes from 8.8.8.8: icmp_seq=1651 ttl=112 time=6.270 ms
64 bytes from 8.8.8.8: icmp_seq=1652 ttl=112 time=12.704 ms
64 bytes from 8.8.8.8: icmp_seq=1653 ttl=112 time=13.550 ms
64 bytes from 8.8.8.8: icmp_seq=1654 ttl=112 time=7.204 ms
64 bytes from 8.8.8.8: icmp_seq=1655 ttl=112 time=7.145 ms
64 bytes from 8.8.8.8: icmp_seq=1656 ttl=112 time=8.219 ms
64 bytes from 8.8.8.8: icmp_seq=1657 ttl=112 time=13.242 ms
64 bytes from 8.8.8.8: icmp_seq=1658 ttl=112 time=13.057 ms
64 bytes from 8.8.8.8: icmp_seq=1659 ttl=112 time=7.644 ms
64 bytes from 8.8.8.8: icmp_seq=1660 ttl=112 time=5.898 ms
64 bytes from 8.8.8.8: icmp_seq=1661 ttl=112 time=7.452 ms
64 bytes from 8.8.8.8: icmp_seq=1662 ttl=112 time=13.106 ms
```

Note: Client traffic disrupted for about **1-3** secs

C9500 Core Stack Loss of Uplink



For the purpose of this test, ports TwentyFiveGigE1/0/1 and TwentyFiveGigE1/0/2 will be disconnected.

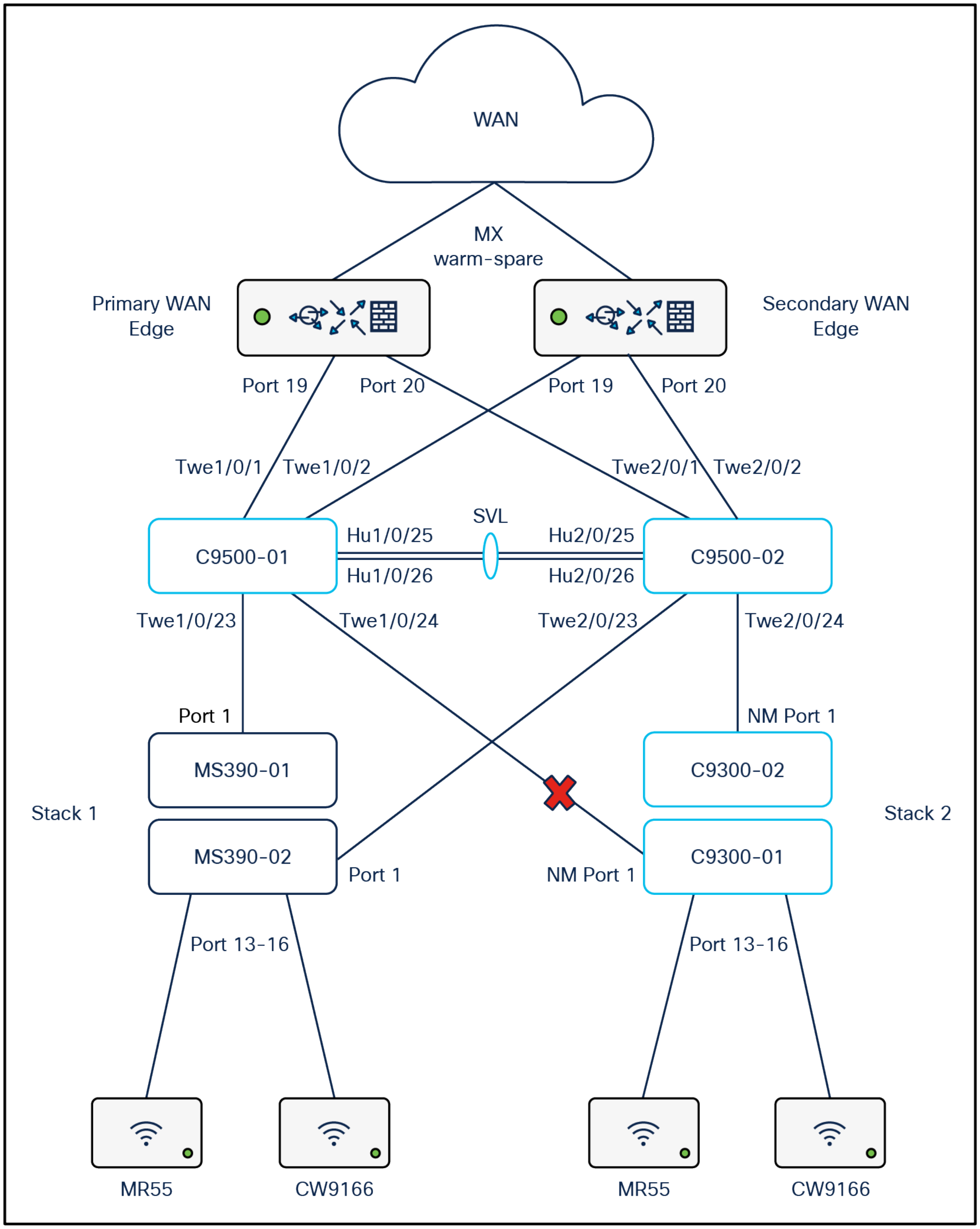
```
9500-01#show ip interface brief
TwentyFiveGigE1/0/1    unassigned    YES unset down     down
TwentyFiveGigE1/0/2    unassigned    YES unset down     down
TwentyFiveGigE2/0/1    unassigned    YES unset up       up
TwentyFiveGigE2/0/2    unassigned    YES unset up       up
9500-01#show switch
Switch/Stack Mac Address : b0c5.3c60.fba0 - Local Mac Address
Mac persistency wait time: Indefinite
                   H/W Current
----------------------------------------------------------
```

```
Switch#    Role      Mac Address      Priority Version State
*1        Active    b0c5.3c60.fba0     5        V02     Ready
2        Standby    40b5.c111.01e0     1        V02     Ready
9500-01#
```

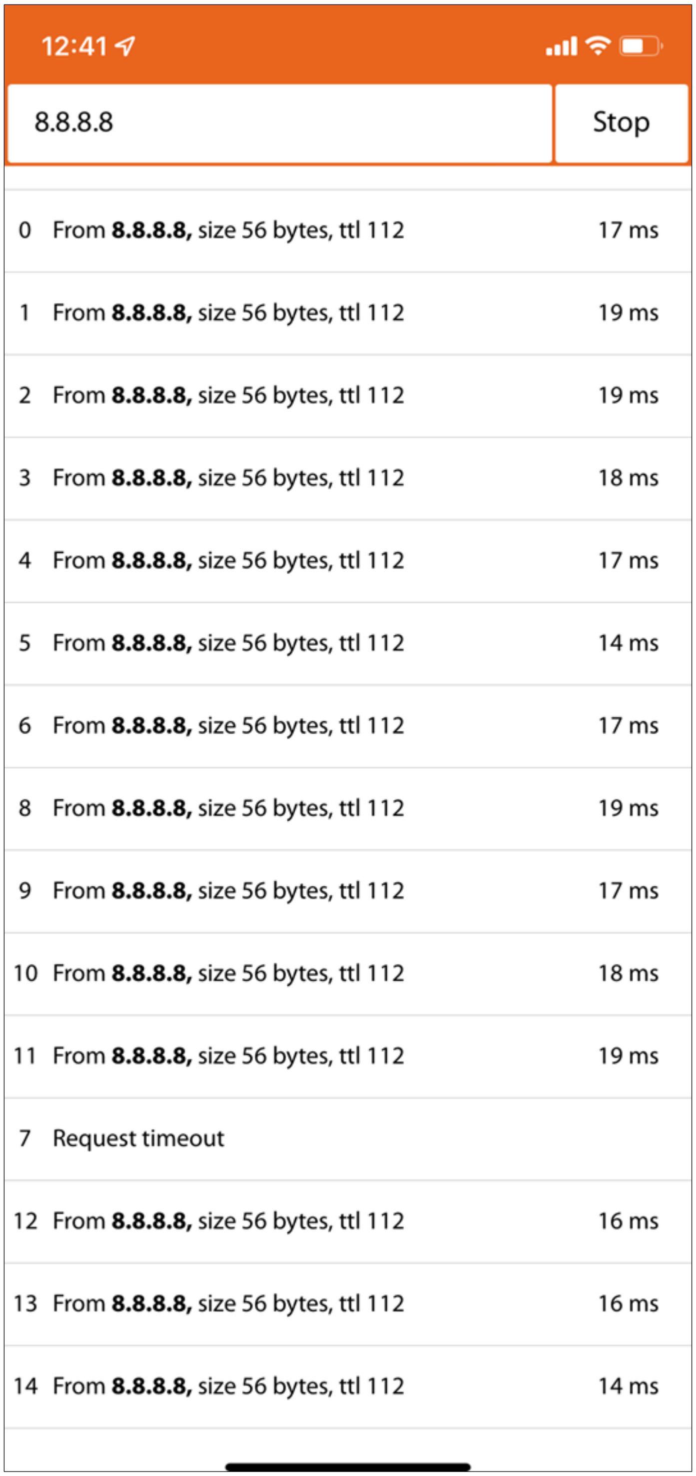
Note: Wireless client traffic flow disrupted for about **30** secs

```
64 bytes from 8.8.8.8: icmp_seq=4774 ttl=112 time=9.681 ms
Request timeout for icmp_seq 4775
Request timeout for icmp_seq 4776
Request timeout for icmp_seq 4777
Request timeout for icmp_seq 4778
Request timeout for icmp_seq 4779
Request timeout for icmp_seq 4780
Request timeout for icmp_seq 4781
Request timeout for icmp_seq 4782
Request timeout for icmp_seq 4783
Request timeout for icmp_seq 4784
Request timeout for icmp_seq 4785
Request timeout for icmp_seq 4786
Request timeout for icmp_seq 4787
Request timeout for icmp_seq 4788
Request timeout for icmp_seq 4789
Request timeout for icmp_seq 4790
Request timeout for icmp_seq 4791
Request timeout for icmp_seq 4792
Request timeout for icmp_seq 4793
Request timeout for icmp_seq 4794
Request timeout for icmp_seq 4795
Request timeout for icmp_seq 4796
Request timeout for icmp_seq 4797
Request timeout for icmp_seq 4798
Request timeout for icmp_seq 4799
Request timeout for icmp_seq 4800
Request timeout for icmp_seq 4801
Request timeout for icmp_seq 4802
Request timeout for icmp_seq 4803
Request timeout for icmp_seq 4804
Request timeout for icmp_seq 4805
Request timeout for icmp_seq 4806
Request timeout for icmp_seq 4807
Request timeout for icmp_seq 4808
Request timeout for icmp_seq 4809
Request timeout for icmp_seq 4810
Request timeout for icmp_seq 4811
Request timeout for icmp_seq 4812
Request timeout for icmp_seq 4813
64 bytes from 8.8.8.8: icmp_seq=4814 ttl=112 time=7.705 ms
64 bytes from 8.8.8.8: icmp_seq=4815 ttl=112 time=7.098 ms
64 bytes from 8.8.8.8: icmp_seq=4816 ttl=112 time=6.809 ms
64 bytes from 8.8.8.8: icmp_seq=4817 ttl=112 time=7.850 ms
64 bytes from 8.8.8.8: icmp_seq=4818 ttl=112 time=7.446 ms
64 bytes from 8.8.8.8: icmp_seq=4819 ttl=112 time=6.877 ms
64 bytes from 8.8.8.8: icmp_seq=4820 ttl=112 time=7.061 ms
64 bytes from 8.8.8.8: icmp_seq=4821 ttl=112 time=6.619 ms
64 bytes from 8.8.8.8: icmp_seq=4822 ttl=112 time=8.331 ms
64 bytes from 8.8.8.8: icmp_seq=4823 ttl=112 time=6.823 ms
64 bytes from 8.8.8.8: icmp_seq=4824 ttl=112 time=6.174 ms
64 bytes from 8.8.8.8: icmp_seq=4825 ttl=112 time=7.599 ms
```


C9300 Stack Loss of Uplink

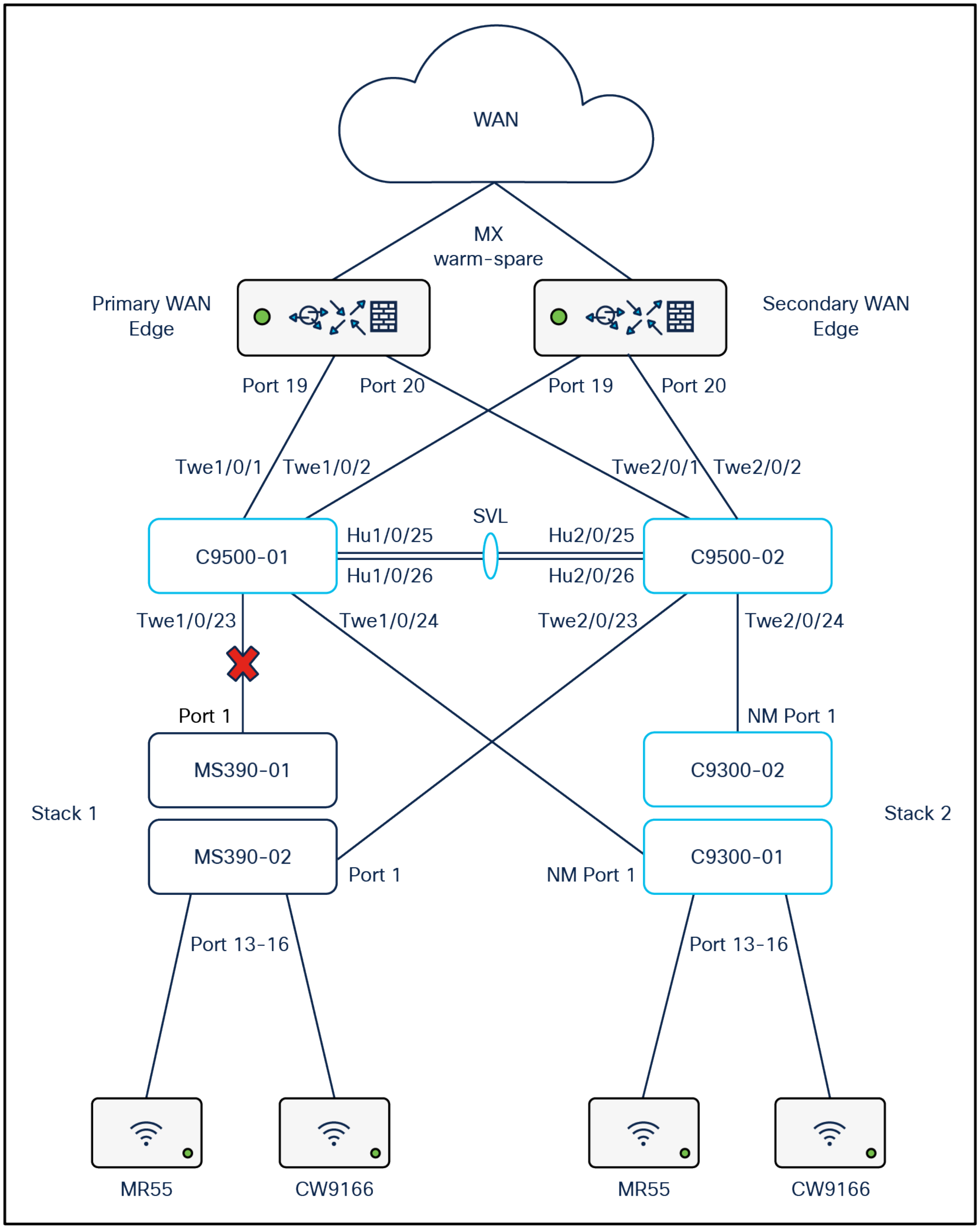


For the purpose of this test, NM Port 1 on C9300-01 (Master switch) will be disconnected.



Note: Wireless client traffic flow disrupted for about **1** sec

MS390 Stack Loss of Uplink



For the purpose of this test, port 1 on MS390-01 (Master switch) will be disconnected.

```
64 bytes from 8.8.8.8: icmp_seq=10439 ttl=111 time=7.219 ms
64 bytes from 8.8.8.8: icmp_seq=10440 ttl=111 time=9.558 ms
64 bytes from 8.8.8.8: icmp_seq=10441 ttl=111 time=13.315 ms
64 bytes from 8.8.8.8: icmp_seq=10442 ttl=111 time=7.202 ms
Request timeout for icmp_seq 10443
64 bytes from 8.8.8.8: icmp_seq=10444 ttl=111 time=7.644 ms
64 bytes from 8.8.8.8: icmp_seq=10445 ttl=111 time=6.427 ms
64 bytes from 8.8.8.8: icmp_seq=10446 ttl=111 time=8.329 ms
64 bytes from 8.8.8.8: icmp_seq=10447 ttl=111 time=20.515 ms
64 bytes from 8.8.8.8: icmp_seq=10448 ttl=111 time=15.399 ms
Request timeout for icmp_seq 10449
64 bytes from 8.8.8.8: icmp_seq=10450 ttl=111 time=26.488 ms
64 bytes from 8.8.8.8: icmp_seq=10451 ttl=111 time=8.758 ms
64 bytes from 8.8.8.8: icmp_seq=10452 ttl=111 time=22.565 ms
64 bytes from 8.8.8.8: icmp_seq=10453 ttl=111 time=20.149 ms
64 bytes from 8.8.8.8: icmp_seq=10454 ttl=111 time=17.307 ms
64 bytes from 8.8.8.8: icmp_seq=10455 ttl=111 time=7.371 ms
Request timeout for icmp_seq 10456
Request timeout for icmp_seq 10457
64 bytes from 8.8.8.8: icmp_seq=10458 ttl=111 time=25.008 ms
64 bytes from 8.8.8.8: icmp_seq=10459 ttl=111 time=7.907 ms
64 bytes from 8.8.8.8: icmp_seq=10460 ttl=111 time=13.606 ms
64 bytes from 8.8.8.8: icmp_seq=10461 ttl=111 time=17.955 ms
64 bytes from 8.8.8.8: icmp_seq=10462 ttl=111 time=20.984 ms
64 bytes from 8.8.8.8: icmp_seq=10463 ttl=111 time=26.031 ms
64 bytes from 8.8.8.8: icmp_seq=10464 ttl=111 time=21.931 ms
64 bytes from 8.8.8.8: icmp_seq=10465 ttl=111 time=17.613 ms
64 bytes from 8.8.8.8: icmp_seq=10466 ttl=111 time=27.587 ms
64 bytes from 8.8.8.8: icmp_seq=10467 ttl=111 time=22.066 ms
64 bytes from 8.8.8.8: icmp_seq=10468 ttl=111 time=25.890 ms
64 bytes from 8.8.8.8: icmp_seq=10469 ttl=111 time=23.064 ms
64 bytes from 8.8.8.8: icmp_seq=10470 ttl=111 time=16.053 ms
64 bytes from 8.8.8.8: icmp_seq=10471 ttl=111 time=20.443 ms
64 bytes from 8.8.8.8: icmp_seq=10472 ttl=111 time=22.713 ms
64 bytes from 8.8.8.8: icmp_seq=10473 ttl=111 time=21.381 ms
64 bytes from 8.8.8.8: icmp_seq=10474 ttl=111 time=8.151 ms
64 bytes from 8.8.8.8: icmp_seq=10475 ttl=111 time=6.894 ms
64 bytes from 8.8.8.8: icmp_seq=10476 ttl=111 time=5.762 ms
64 bytes from 8.8.8.8: icmp_seq=10477 ttl=111 time=7.449 ms
64 bytes from 8.8.8.8: icmp_seq=10478 ttl=111 time=13.023 ms
```

Note: Wireless client traffic flow disrupted for about **2** secs

```
64 bytes from 10.0.20.5: icmp_seq=9 ttl=64 time=99.045 ms
64 bytes from 10.0.20.5: icmp_seq=10 ttl=64 time=15.473 ms
64 bytes from 10.0.20.5: icmp_seq=11 ttl=64 time=5.512 ms
64 bytes from 10.0.20.5: icmp_seq=12 ttl=64 time=6.149 ms
64 bytes from 10.0.20.5: icmp_seq=13 ttl=64 time=5.916 ms
64 bytes from 10.0.20.5: icmp_seq=14 ttl=64 time=6.030 ms
64 bytes from 10.0.20.5: icmp_seq=15 ttl=64 time=5.890 ms
64 bytes from 10.0.20.5: icmp_seq=16 ttl=64 time=5.969 ms
64 bytes from 10.0.20.5: icmp_seq=17 ttl=64 time=64.174 ms
Request timeout for icmp_seq 18
64 bytes from 10.0.20.5: icmp_seq=19 ttl=64 time=105.541 ms
64 bytes from 10.0.20.5: icmp_seq=20 ttl=64 time=5.780 ms
64 bytes from 10.0.20.5: icmp_seq=21 ttl=64 time=5.950 ms
64 bytes from 10.0.20.5: icmp_seq=22 ttl=64 time=66.381 ms
64 bytes from 10.0.20.5: icmp_seq=23 ttl=64 time=5.679 ms
64 bytes from 10.0.20.5: icmp_seq=24 ttl=64 time=100.983 ms
64 bytes from 10.0.20.5: icmp_seq=25 ttl=64 time=5.750 ms
64 bytes from 10.0.20.5: icmp_seq=26 ttl=64 time=4.784 ms
64 bytes from 10.0.20.5: icmp_seq=27 ttl=64 time=4.764 ms
64 bytes from 10.0.20.5: icmp_seq=28 ttl=64 time=5.699 ms
64 bytes from 10.0.20.5: icmp_seq=29 ttl=64 time=7.896 ms
64 bytes from 10.0.20.5: icmp_seq=30 ttl=64 time=5.511 ms
64 bytes from 10.0.20.5: icmp_seq=31 ttl=64 time=4.974 ms
64 bytes from 10.0.20.5: icmp_seq=32 ttl=64 time=5.492 ms
```

Note: Wireless client traffic on Campus LAN disrupted for about **1** sec

QoS

For the purpose of this test, packet capture will be taken between two clients running a Webex session. Packet capture will be taken on the Edge (i.e. MR wireless and wired interfaces) then on the Access (i.e. the MS390 or C9300 uplink port) then on the MX WAN Downlink and finally on the MX WAN Uplink. The table below shows the testing components and the expected QoS behavior:

Client	Application	Access Point (Wired) Expected QoS	Access Switch Uplink Port Expected QoS	MX Appliance Uplink Port Expected QoS
Client #1 (10.0.20.2) **iPhone 11 (cc:66:0a:3e:44:69)**	Webex (UDP 9000)	AP3_Zone2 / AF41 / DSCP 34	C9300-02 (Port 25) / AF41 / DSCP 34	AF41 / DSCP 34
	iTunes	AP3_Zone2 / AF21 / DSCP 18	C9300-02 (Port 25) / AF21 / DSCP 18	AF21 / DSCP 18
Client #2 (10.0.20.3) **MacBook Pro (3c:22:fb:30:da:69)**	Webex (UDP 9000)	AP2_Zone1 / AF41 / DSCP 34	MS390-01 (Port 1) / AF41 / DSCP 34	AF41 / DSCP 34
	Dropbox	AP2_Zone1 / AF0 / DSCP 0	MS390-01 (Port 1) / AF0 / DSCP 0	AF0 / DSCP 0

Access Point Wired Port pcaps

Client #1

```
> Frame Control Field: 0x8881
  .000 0000 0011 0000 = Duration: 48 microseconds
  Receiver address: 7a:3a:0e:54:0d:48 (7a:3a:0e:54:0d:48)
  Transmitter address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  Destination address: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f)
  Source address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  BSS Id: 7a:3a:0e:54:0d:48 (7a:3a:0e:54:0d:48)
  STA address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  .... .... .... 0000 = Fragment number: 0
  0110 0010 0110 .... = Sequence number: 1574
v Qos Control: 0x0a15
    .... .... .... 0101 = TID: 5
    [.... .... .... .101 = Priority: Video (Video) (5)]
    .... .... ...1 .... = QoS bit 4: Bits 8-15 of QoS Control field are Queue Size
    .... .... .00. .... = Ack Policy: Normal Ack (0x0)
```

```
> Frame Control Field: 0x8881
  .000 0000 0011 0000 = Duration: 48 microseconds
  Receiver address: 7a:3a:0e:54:0d:48 (7a:3a:0e:54:0d:48)
  Transmitter address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  Destination address: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f)
  Source address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  BSS Id: 7a:3a:0e:54:0d:48 (7a:3a:0e:54:0d:48)
  STA address: Apple_3e:44:69 (cc:66:0a:3e:44:69)
  .... .... .... 0000 = Fragment number: 0
  0100 1001 0110 .... = Sequence number: 1174
v Qos Control: 0x1310
    .... .... .... 0000 = TID: 0
    [.... .... .... .000 = Priority: Best Effort (Best Effort) (0)]
    .... .... ...1 .... = QoS bit 4: Bits 8-15 of QoS Control field are Queue Size
```

Client #2

```
> Frame Control Field: 0x8801
  .000 0000 0011 0000 = Duration: 48 microseconds
  Receiver address: de:9c:1e:ec:26:b0 (de:9c:1e:ec:26:b0)
  Transmitter address: Apple_30:da:69 (3c:22:fb:30:da:69)
  Destination address: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f)
  Source address: Apple_30:da:69 (3c:22:fb:30:da:69)
  BSS Id: de:9c:1e:ec:26:b0 (de:9c:1e:ec:26:b0)
  STA address: Apple_30:da:69 (3c:22:fb:30:da:69)
  .... .... .... 0000 = Fragment number: 0
  0100 0100 1010 .... = Sequence number: 1098
v Qos Control: 0x0006
    .... .... .... 0110 = TID: 6
    [.... .... .... .110 = Priority: Voice (Voice) (6)]
    .... .... ...0 .... = QoS bit 4: Bits 8-15 of QoS Control field are TXOP Duration Requested
```

```
IEEE 802.11 QoS Data, Flags: .......T
    Type/Subtype: QoS Data (0x0028)
  > Frame Control Field: 0x8801
    .000 0000 0011 0000 = Duration: 48 microseconds
    Receiver address: de:9c:1e:ec:26:b0 (de:9c:1e:ec:26:b0)
    Transmitter address: Apple_30:da:69 (3c:22:fb:30:da:69)
    Source address: Apple_30:da:69 (3c:22:fb:30:da:69)
    BSS Id: de:9c:1e:ec:26:b0 (de:9c:1e:ec:26:b0)
    STA address: Apple_30:da:69 (3c:22:fb:30:da:69)
    .... .... .... 0000 = Fragment number: 0
    1000 1101 1001 .... = Sequence number: 2265
  v Qos Control: 0x0081
      .... .... .... 0001 = TID: 1
      [.... .... .... .001 = Priority: Background (Background) (1)]
```

Access Point Wired Port pcaps

Client #1

```
> Frame 3520: 184 bytes on wire (1472 bits), 184 bytes captured (1472 bits)
> Ethernet II, Src: 12:34:5c:8c:16:04 (12:34:5c:8c:16:04), Dst: CiscoMer_4f:00:02 (00:18:0a:4f:00:02)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 12
v Internet Protocol Version 4, Src: 10.0.12.4, Dst: 173.243.0.86
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
    Total Length: 166
    Identification: 0x0000 (0)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: TCP (6)
    Header Checksum: 0x757d [validation disabled]
    [Header checksum status: Unverified]
```

```
> Frame 947: 94 bytes on wire (752 bits), 94 bytes captured (752 bits)
> Ethernet II, Src: 12:34:5c:8c:16:04 (12:34:5c:8c:16:04), Dst: CiscoMer_4f:00:02 (00:18:0a:4f:00:02)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 12
v Internet Protocol Version 4, Src: 10.0.12.4, Dst: 172.217.16.238
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x48 (DSCP: AF21, ECN: Not-ECT)
    Total Length: 76
    Identification: 0x0000 (0)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: TCP (6)
    Header Checksum: 0x6699 [validation disabled]
    [Header checksum status: Unverified]
```

Client #2

```
> Frame 6: 1356 bytes on wire (10848 bits), 1356 bytes captured (10848 bits)
> Ethernet II, Src: CiscoMer_4f:00:01 (00:18:0a:4f:00:01), Dst: Apple_30:da:69 (3c:22:fb:30:da:69)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 21
v Internet Protocol Version 4, Src: 62.109.229.100, Dst: 10.0.21.2
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
    Total Length: 1338
    Identification: 0x30ee (12526)
  > Flags: 0x00
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 109
    Protocol: UDP (17)
    Header Checksum: 0xd469 [validation disabled]
    [Header checksum status: Unverified]
```

```
> Frame 280: 70 bytes on wire (560 bits), 70 bytes captured (560 bits)
> Ethernet II, Src: Apple_30:da:69 (3c:22:fb:30:da:69), Dst: CiscoMer_4f:00:01 (00:18:0a:4f:00:01)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 21
v Internet Protocol Version 4, Src: 10.0.21.2, Dst: 209.206.57.130
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 52
    Identification: 0x0000 (0)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 64
    Protocol: TCP (6)
    Header Checksum: 0x1072 [validation disabled]
    [Header checksum status: Unverified]
```

Access Switch Uplink pcaps

Client #1

```
> Frame 4341: 105 bytes on wire (840 bits), 105 bytes captured (840 bits)
> Ethernet II, Src: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f), Dst: CiscoMer_4f:00:02 (00:18:0a:4f:00:02)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 1922
> Cisco MetaData
v Internet Protocol Version 4, Src: 170.72.231.161, Dst: 10.0.12.4
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x8a (DSCP: AF41, ECN: ECT(0))
    Total Length: 79
    Identification: 0x20ce (8398)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 31
    Protocol: TCP (6)
    Header Checksum: 0x9263 [validation disabled]
```

```
> Frame 1951: 355 bytes on wire (2840 bits), 355 bytes captured (2840 bits)
> Ethernet II, Src: CiscoMer_4f:00:02 (00:18:0a:4f:00:02), Dst: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 1922
v Internet Protocol Version 4, Src: 10.0.12.4, Dst: 142.250.178.14
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x48 (DSCP: AF21, ECN: Not-ECT)
    Total Length: 337
    Identification: 0x0000 (0)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 63
    Protocol: TCP (6)
    Header Checksum: 0xe352 [validation disabled]
    [Header checksum status: Unverified]
```

Client #2

```
> Frame 12: 1324 bytes on wire (10592 bits), 1324 bytes captured (10592 bits)
> Ethernet II, Src: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f), Dst: CiscoMer_4f:00:01 (00:18:0a:4f:00:01)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 1921
> Cisco MetaData
v Internet Protocol Version 4, Src: 62.109.229.100, Dst: 10.0.21.2
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
    Total Length: 1298
    Identification: 0x4534 (17716)
  > Flags: 0x00
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 110
    Protocol: UDP (17)
    Header Checksum: 0xbf4b [validation disabled]
```

```
> Frame 6272: 70 bytes on wire (560 bits), 70 bytes captured (560 bits)
> Ethernet II, Src: CiscoMer_4f:00:01 (00:18:0a:4f:00:01), Dst: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 1921
v Internet Protocol Version 4, Src: 10.0.21.2, Dst: 162.125.19.131
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 52
    Identification: 0x0000 (0)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 63
    Protocol: TCP (6)
    Header Checksum: 0x66c2 [validation disabled]
    [Header checksum status: Unverified]
```

MX appliance Downlink pcaps

Client #1

```
> Frame 68: 89 bytes on wire (712 bits), 89 bytes captured (712 bits)
> Ethernet II, Src: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f), Dst: CiscoMer_ff:f6:d3 (cc:03:d9:ff:f6:d3)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 1923
v Internet Protocol Version 4, Src: 10.0.12.4, Dst: 64.68.120.47
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
    Total Length: 71
    Identification: 0x0000 (0)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 62
    Protocol: TCP (6)
    Header Checksum: 0x6db2 [validation disabled]
    [Header checksum status: Unverified]
```

```
> Frame 30: 587 bytes on wire (4696 bits), 587 bytes captured (4696 bits)
> Ethernet II, Src: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f), Dst: CiscoMer_ff:f6:d3 (cc:03:d9:ff:f6:d3)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 1923
v Internet Protocol Version 4, Src: 10.0.12.4, Dst: 216.58.212.206
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x48 (DSCP: AF21, ECN: Not-ECT)
    Total Length: 569
    Identification: 0x0000 (0)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 62
    Protocol: TCP (6)
    Header Checksum: 0x776a [validation disabled]
    [Header checksum status: Unverified]
```

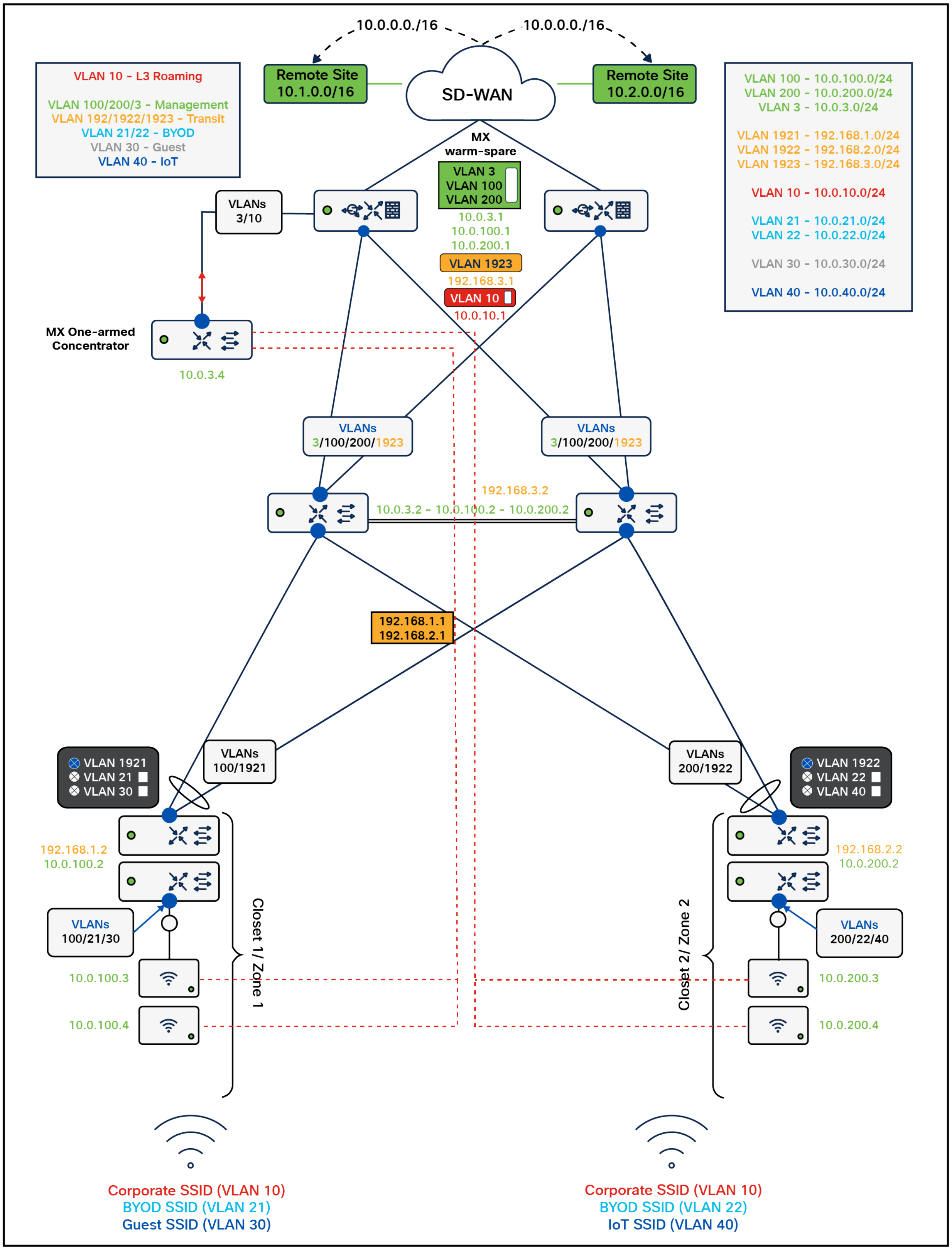
Client #2

```
> Frame 6: 99 bytes on wire (792 bits), 99 bytes captured (792 bits)
> Ethernet II, Src: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f), Dst: CiscoMer_ff:f6:d3 (cc:03:d9:ff:f6:d3)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 1923
v Internet Protocol Version 4, Src: 10.0.21.2, Dst: 62.109.229.44
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x88 (DSCP: AF41, ECN: Not-ECT)
    Total Length: 81
    Identification: 0x4b26 (19238)
  > Flags: 0x00
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 62
    Protocol: UDP (17)
    Header Checksum: 0xee52 [validation disabled]
    [Header checksum status: Unverified]
```

```
> Frame 42: 214 bytes on wire (1712 bits), 214 bytes captured (1712 bits)
> Ethernet II, Src: Cisco_60:fc:3f (b0:c5:3c:60:fc:3f), Dst: CiscoMer_ff:f6:d3 (cc:03:d9:ff:f6:d3)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 1923
v Internet Protocol Version 4, Src: 10.0.21.2, Dst: 209.206.57.130
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 196
    Identification: 0x0000 (0)
  > Flags: 0x40, Don't fragment
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 62
    Protocol: TCP (6)
    Header Checksum: 0x11e2 [validation disabled]
    [Header checksum status: Unverified]
```

Layer 3 Roaming with concentrator

The previous design which extends the Layer 3 domain to the Access Layer offered several benefits but one of the drawbacks was that VLANs cannot span between different stacks and therefore roaming is restricted within a single zone/closet. As such, to enable Layer 3 roaming in this Campus network the SSID needs to be tunneled to a Meraki MX operating as a concentrator. Please see the below diagram for the logical architecture of this design option:


10.0.0.0./16
10.0.0.0./16
Remote Site 10.1.0.0/16
SD-WAN
Remote Site 10.2.0.0/16
VLAN 10 - L3 Roaming
VLAN 100/200/3 - Management
VLAN 192/1922/1923 - Transit
VLAN 21/22 - BYOD
VLAN 30 - Guest
VLAN 40 - IoT
VLAN 100 - 10.0.100.0/24
VLAN 200 - 10.0.200.0/24
VLAN 3 - 10.0.3.0/24
VLAN 1921 - 192.168.1.0/24
VLAN 1922 - 192.168.2.0/24
VLAN 1923 - 192.168.3.0/24
VLAN 10 - 10.0.10.0/24
VLAN 21 - 10.0.21.0/24
VLAN 22 - 10.0.22.0/24
VLAN 30 - 10.0.30.0/24
VLAN 40 - 10.0.40.0/24
MX warm-spare
VLAN 3
VLAN 100
VLAN 200
10.0.3.1
10.0.100.1
10.0.200.1
VLAN 1923
192.168.3.1
VLAN 10
10.0.10.1
VLANs 3/10
MX One-armed Concentrator
10.0.3.4
VLANs 3/100/200/1923
VLANs 3/100/200/1923
192.168.3.2
10.0.3.2 - 10.0.100.2 - 10.0.200.2
192.168.1.1
192.168.2.1
VLAN 1921
VLAN 21
VLAN 30
VLANs 100/1921
VLANs 200/1922
VLAN 1922
VLAN 22
VLAN 40
192.168.1.2
10.0.100.2
192.168.2.2
10.0.200.2
VLANs 100/21/30
VLANs 200/22/40
Closet 1/ Zone 1
Closet 2/ Zone 2
10.0.100.3
10.0.100.4
10.0.200.3
10.0.200.4
Corporate SSID (VLAN 10)
BYOD SSID (VLAN 21)
Guest SSID (VLAN 30)
Corporate SSID (VLAN 10)
BYOD SSID (VLAN 22)
IoT SSID (VLAN 40)

The design will not change any of the elements previously configured except that the Acme Corp SSID will be configured in Layer 3 Roaming with Concentrator mode which requires having a Meraki MX Appliance configured as a concentrator. Subsequently, VLANs 11 and 12 will not be required anymore and the SVI for the new Corp VLAN will move to the WAN Edge MX. The WAN Edge MX in this case needs to provide DHCP services to roaming clients.

Tech Tip: Please note that the MX concentrator in the above diagram was plugged directly into the MX WAN Edge appliance on port 3. Alternatively, this could have been plugged on the C9500 Core Stack which could be also beneficial should you wish to use warm-spare concentrators. In this case, please make sure that the switchports where these concentrator(s) are plugged on the C9500 Core Stack are configured as trunk ports and that the Roaming VLAN is allowed. For more information on MX concentrator sizing, please refer to this article.

Tech Tip: Please note that though it is possible to use an MX appliance in routed mode to concentrate the SSID, it will not be possible in the case of this design. The reason is that the AutoVPN tunnel will fail to establish as it terminates on the MX uplink interface (on the WAN side, not the LAN side).

Special considerations for this design option:

- APs will create a Layer 2 AutoVPN tunnel to the MX Concentrator using their management IP address
- Radius requests from the Acme Corp SSID will have the NAS ID referring to the AP's management IP address where the client is attached however the device IP in the request will refer to the uplink IP address of the MX concentrator (e.g. 10.0.3.4 in this case)
- The Radius server (in our case Cisco ISE) will require an IP route to the MX concentrator's uplink IP address (e.g. 10.0.3.4)
- The Radius server will also need to be configured with the concentrator as a network device since the Radius requests will have its IP address as the device IP address (Otherwise testing 802.1x auth failed)
- If the Radius server is reachable from the Campus via VPN tunnel (e.g. AutoVPN) then the Concentrator's uplink IP address/network will need to be advertised via the VPN as well

The following steps will outline the configuration changes to enable Layer 3 Roaming in this Campus LAN:

1. Please ensure that you have an additional MX appliance in your dashboard and the appropriate license(s) claimed
2. Add the appliance(s) to a new network (e.g. Roaming)
3. Navigate to your **Roaming** network
4. Navigate to **Security and SD-WAN > Configure > Addressing and VLANs**
5. Select **Passthrough or VPN Concentrator** and click **Save** at the bottom of the page

Mode	○	**Routed** In this mode, the MX will act as a layer 3 gateway between the subnets configured below. Client traffic to the Internet is translated (NATed) so that its source IP becomes the uplink IP of the security appliance. Configure DHCP on the DHCP settings page.
	●	**Passthrough or VPN Concentrator** This option can be used for two deployment models: in-line passthrough or one-arm concentrator. In a passthrough deployment, the security appliance acts as a Layer 2 bridge, and does not route or translate client traffic. In a one-arm concentrator deployment, the security appliance acts as a termination point for Meraki Auto VPN traffic to and from remote sites. For more information on how to deploy an MX in one-arm concentrator mode, see our documentation

6. Navigate to your **Campus** Network

7. Navigate to **Security and SD-WAN > Addressing and VLANs** and create a new VLAN for the Roaming SSID (e.g. VLAN 10)

ID ▲	VLAN name	Version	Config	VLAN interface IP	Uplink	Group policy	VPN mode
1	Default	4	Manual	172.21.12.1/24	Any	None	Enabled
		6	Disabled	--	Any		
10	Roaming SSID	4	Manual	10.0.10.1/24	Any	None	Enabled
		6	Disabled	--	Any		
100	Management Zone 1	4	Manual	10.0.100.1/24	Any	None	Enabled
		6	Disabled	--	Any		
200	Management Zone 2	4	Manual	10.0.200.1/24	Any	None	Enabled
		6	Disabled	--	Any		
1923	Transit	4	Manual	192.168.3.1/24	Any	None	Disabled
		6	Disabled	--	Any		

5 results

8. Navigate further down the page to the **Per-port VLAN settings** and configure the port connecting the MX Concentrator (e.g. Port 3 in this design) with a Native VLAN (e.g. VLAN 3) and allow both the native VLAN and the Roaming SSI VLAN that you have just created in the above step

Built-in	3	●	Trunk	Native: VLAN 3 (Management Core)	VLAN 10 (Roaming SSID) VLAN 3 (Management Core)

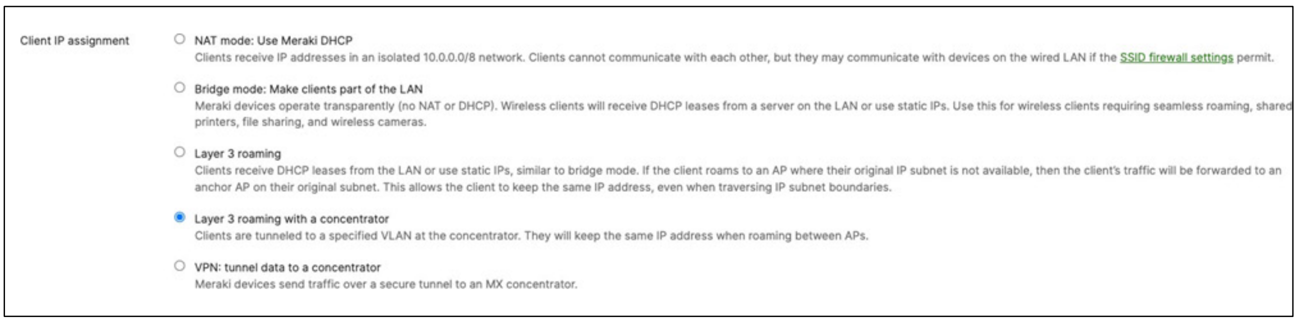
9. Click **Save** at the bottom of the page

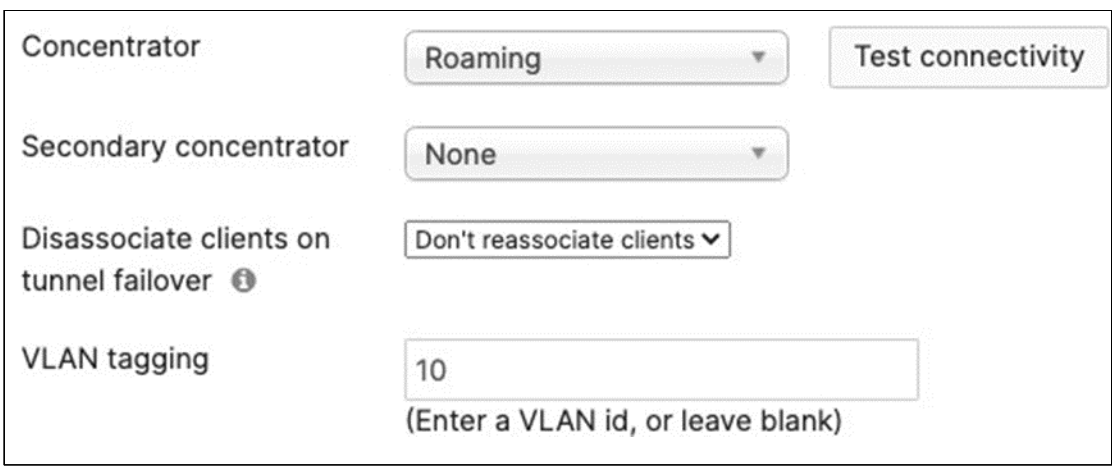
10. Plug your MX Concentrator and connect it to the designated port (Port #3) on the WAN Edge MX. Please note that the MX concentrator needs to be connected **ONLY** via a single uplink (*No other uplinks or LAN ports*)

11. Once the MX Concentrator comes **online** on dashboard you can proceed to the next step (Waiting for the concentrator to come online will allow you to test the tunnel connectivity from the APs to the Concentrator)

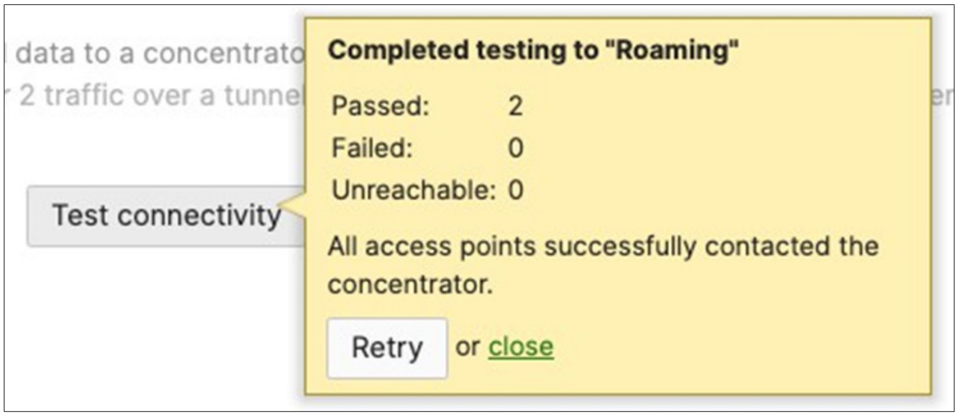
12. Navigate to **Wireless > Configure > Access control** and from the top drop-down menu select the Acme Corp SSID

13. Navigate further down the page and under the **Client IP assignment** menu, select the Layer 3 with Concentrator option then choose VLAN 10 as the terminating VLAN for this SSID. Click **Save** at the bottom of the page.



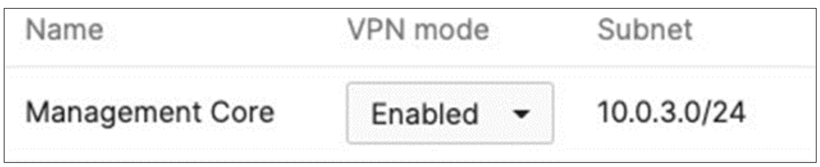


14. To test the Tunnel connectivity, click on **Test Connectivity**



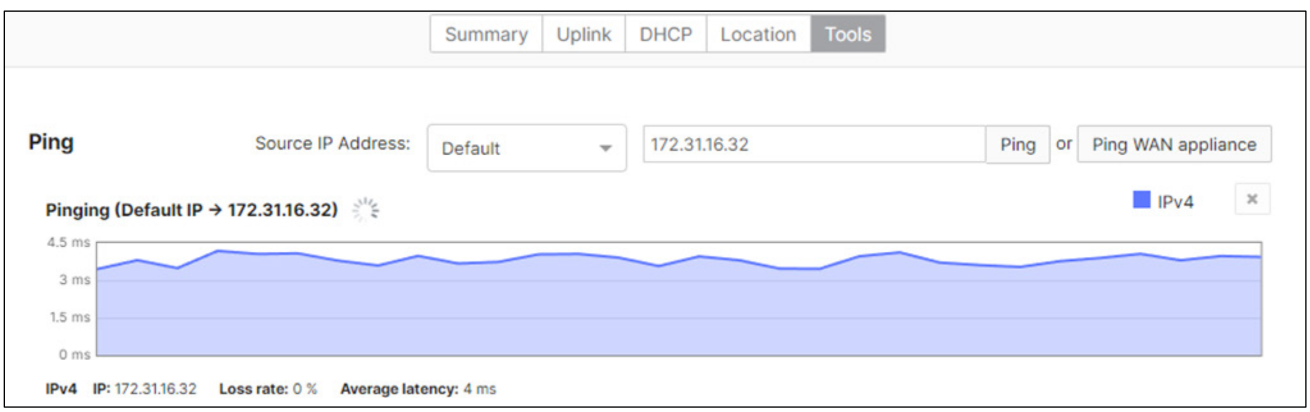
- The test above will check the IP connectivity between the APs with the Acme Corp SSID (AP's uplink IP address) and the MX concentrator (MX's uplink IP address) and return back how many APs passed the test (valid IP route) and how many failed (due to IP routing issues)

15. Navigate to **Security and SD-WAN > Configure > Site-to-site VPN** and enable the upstream network of the MX Concentrator in AutoVPN (e.g. VLAN 3 in our case)

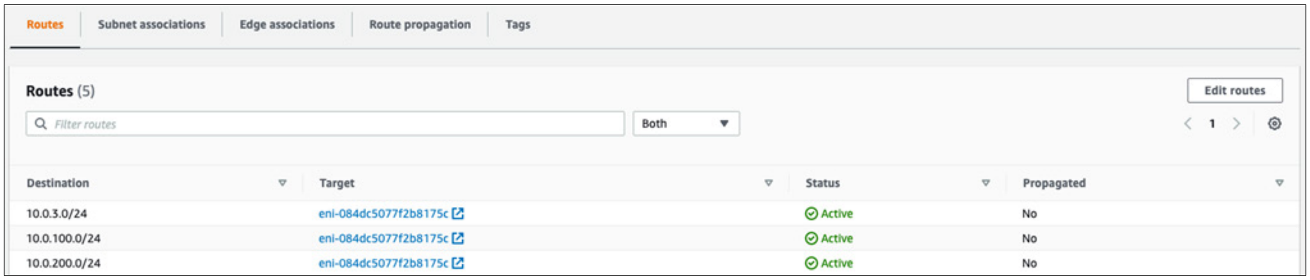


- As explained earlier, this step is essential for the Cisco ISE server to accept Access-Requests from the MX concentrator

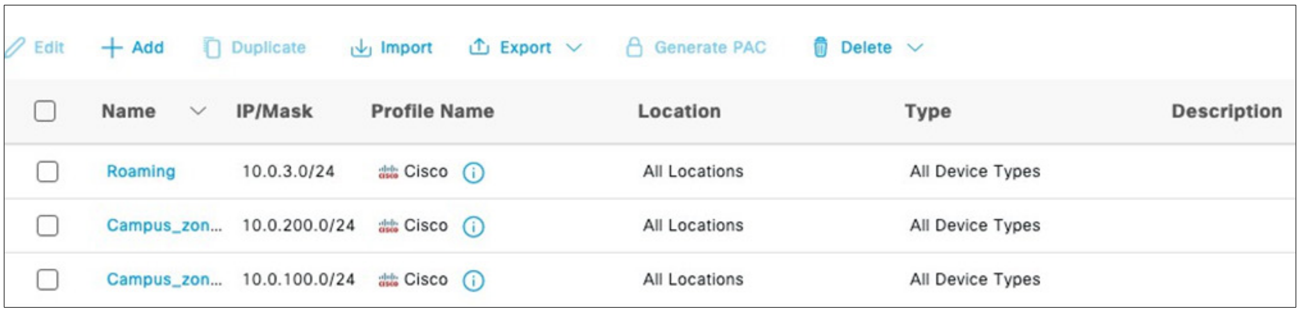
16. After you have configured the appropriate routing on the Radius server side to allow it to communicate with VLAN 3, you can proceed with testing IP connectivity between the MX concentrator and the Radius Server



- Please note that you won't be able to ping unless the Upstream network of the MX Concentrator has been enabled in AutoVPN and that the Radius Server has an IP route back to the Campus LAN. Please check the following example for this implementation of Cisco ISE in AWS where a route has been added on the VPC where the ISE server resides



17. After you have added the MX concentrator on your Radius server as a **network device**, you can test using a client attached to the Acme Corp SSID

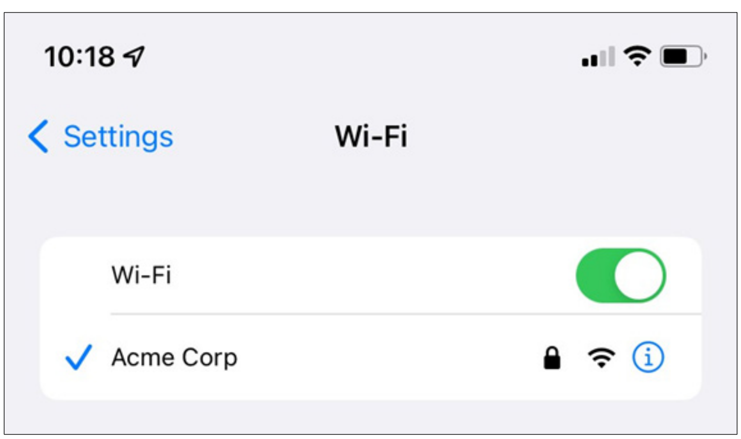


Testing and Verification:

The following client was used for testing and verification:

Device	Mac address	IP address
iPhone	12:34:5c:8c:16:04	10.0.10.2

Device Connectivity



Note: As seen above, the Client successfully associated with the **Acme Corp** SSID and acquired an IP address in **VLAN 10** (10.0.10.2)

Radius Authentication

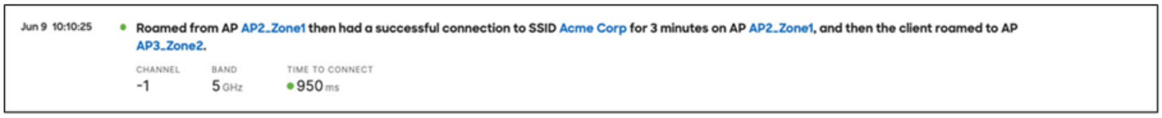
Overview

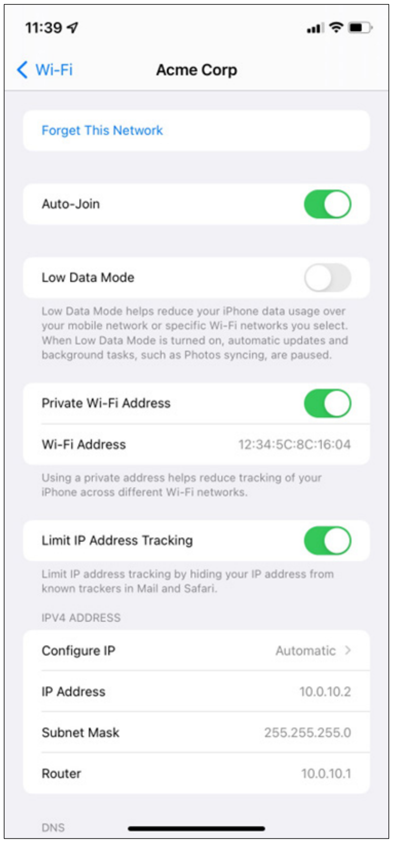
Event	5200 Authentication succeeded
Username	corp1
Endpoint Id	12:34:5C:8C:16:04
Endpoint Profile	Unknown
Authentication Policy	Default >> Dot1X
Authorization Policy	Default >> Corp allowed WiFi
Authorization Result	Corp_Permit

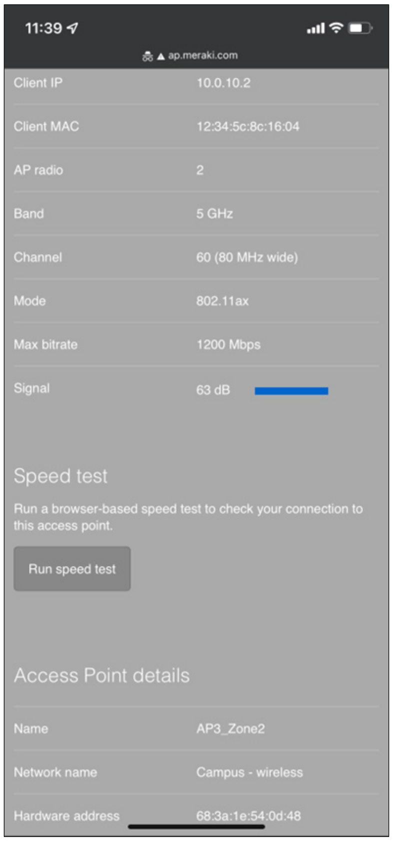
RADIUS Username	corp1
NAS-Identifier	CC-9C-3E-EC-26-B0
Device IP Address	10.0.3.4
CPMSessionID	b026ec060000000362a1af89
Called-Station-ID	Acme Corp
CiscoAVPair	audit-session-id=b026ec060000000362a1af89, AuthenticationIdentityStore=Internal Users, FQSubjectName=9273fe30-8c01-11e6-996c-525400b48521#corp1, UniqueSubjectID=5eacdd87b290fe8f8ea83a1dd2dee52954e0dc19

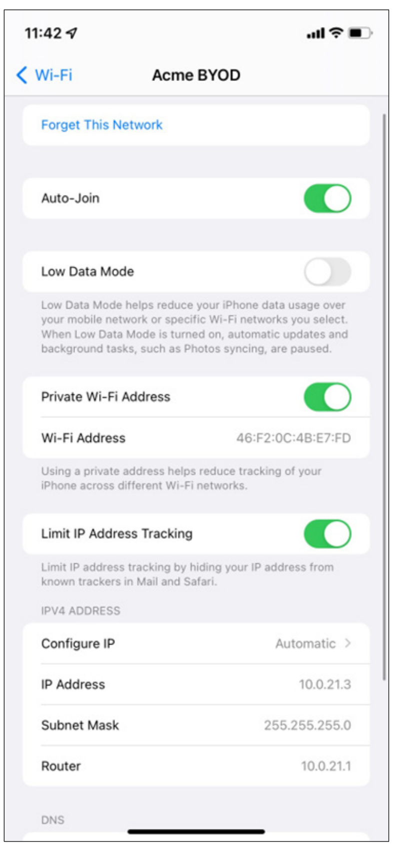
Tech Tip: As seen above from the Cisco ISE live logs, 802.1x authentication was successful and the client was permitted on the network. Please note the Device IP Address field which shows 10.0.3.4 (MX Concentrator uplink IP address in this case)

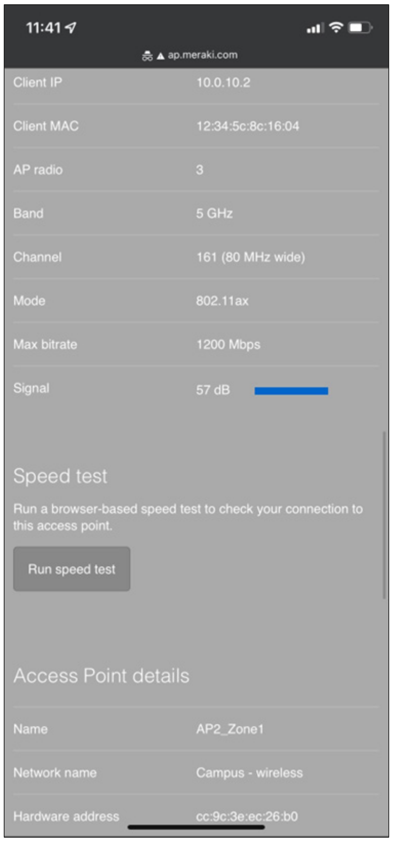
Layer 3 Wireless Roaming

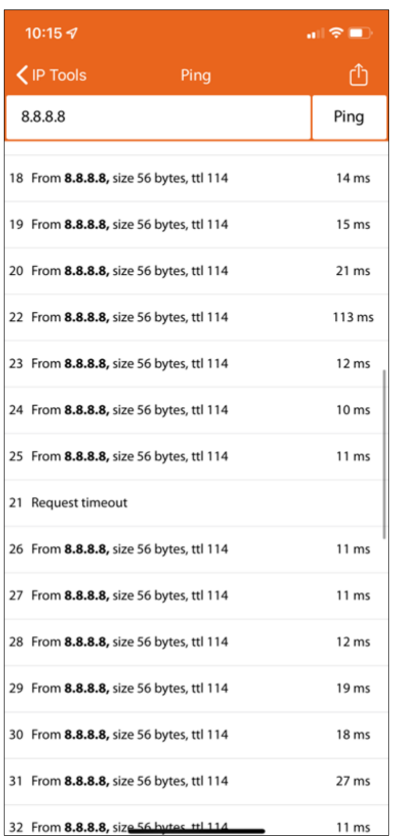





11:39
ap.meraki.com
Client IP 10.0.10.2
Client MAC 12:34:5c:8c:16:04
AP radio 2
Band 5 GHz
Channel 60 (80 MHz wide)
Mode 802.11ax
Max bitrate 1200 Mbps
Signal 63 dB
Speed test
Run a browser-based speed test to check your connection to this access point.
Run speed test
Access Point details
Name AP3_Zone2
Network name Campus - wireless
Hardware address 68:3a:1e:54:0d:48


11:42
Wi-Fi
Acme BYOD
Forget This Network
Auto-Join
Low Data Mode
Low Data Mode helps reduce your iPhone data usage over your mobile network or specific Wi-Fi networks you select. When Low Data Mode is turned on, automatic updates and background tasks, such as Photos syncing, are paused.
Private Wi-Fi Address
Wi-Fi Address 46:F2:0C:4B:E7:FD
Using a private address helps reduce tracking of your iPhone across different Wi-Fi networks.
Limit IP Address Tracking
Limit IP address tracking by hiding your IP address from known trackers in Mail and Safari.
IPV4 ADDRESS
Configure IP Automatic
IP Address 10.0.21.3
Subnet Mask 255.255.255.0
Router 10.0.21.1
DNS


11:41
ap.meraki.com
Client IP 10.0.10.2
Client MAC 12:34:5c:8c:16:04
AP radio 3
Band 5 GHz
Channel 161 (80 MHz wide)
Mode 802.11ax
Max bitrate 1200 Mbps
Signal 57 dB
Speed test
Run a browser-based speed test to check your connection to this access point.
Run speed test
Access Point details
Name AP2_Zone1
Network name Campus - wireless
Hardware address cc:9c:3e:ec:26:b0


10:15
IP Tools
Ping
8.8.8.8
Ping
18 From 8.8.8.8, size 56 bytes, ttl 114 14 ms
19 From 8.8.8.8, size 56 bytes, ttl 114 15 ms
20 From 8.8.8.8, size 56 bytes, ttl 114 21 ms
22 From 8.8.8.8, size 56 bytes, ttl 114 113 ms
23 From 8.8.8.8, size 56 bytes, ttl 114 12 ms
24 From 8.8.8.8, size 56 bytes, ttl 114 10 ms
25 From 8.8.8.8, size 56 bytes, ttl 114 11 ms
21 Request timeout
26 From 8.8.8.8, size 56 bytes, ttl 114 11 ms
27 From 8.8.8.8, size 56 bytes, ttl 114 11 ms
28 From 8.8.8.8, size 56 bytes, ttl 114 12 ms
29 From 8.8.8.8, size 56 bytes, ttl 114 19 ms
30 From 8.8.8.8, size 56 bytes, ttl 114 18 ms
31 From 8.8.8.8, size 56 bytes, ttl 114 27 ms
32 From 8.8.8.8, size 56 bytes, ttl 114 11 ms

Note: Roaming back and forth between APs caused a brief packet loss of one packet

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