Cisco Next Generation WLAN Controller

CT5760 Controller
Deployment Guide

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Cisco Next Generation WLAN Controller, CT5760.

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Introduction

This document introduces two new controllers within the Cisco Unified Access architecture and provides general guidelines for their deployment. The purpose of this document is to:

- Provide an overview of the new Cisco 5760 Next Generation Wireless LAN Controller and the Next Generation Catalyst 3850 Wired/Wireless Switch.
- Provide design recommendations and deployment considerations specific to the Centralized Access deployment.

Product Overview

This section provides an overview of the two new controllers:

Unified Access CT5760 Wireless Controller

The CT5760 Wireless LAN Controller (WLC) is the first Cisco IOS® software-based controller built with smart ASIC intended to be deployed as a centralized controller in the next generation unified wireless architecture. CT5760 controllers are specifically designed to function like the older unified model central wireless controllers. They also support the newer Mobility functionality with Next Generation Wireless Controllers 3850 switches in the wireless architecture.

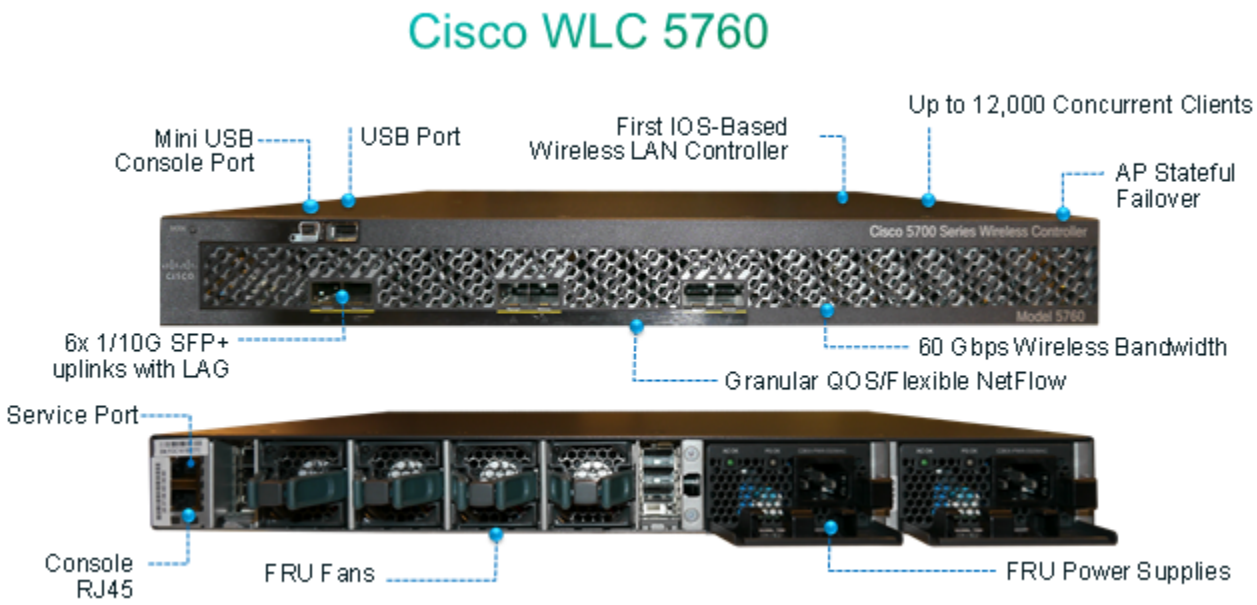
CT5760 controllers are deployed behind a core switch/router. The core switch/router is the only gateway into the network for the controller. The uplink ports connected to the core switch are configured as EtherChannel trunk to ensure port redundancy.

This new controller is an extensible and high performance wireless controller, which can scale up to 1000 access points (AP) and 12,000 clients. The controller has eight 6-10 Gbps data ports.

As a component of the Cisco Unified Wireless Network, the 5760 series works in conjunction with Cisco Aironet Access Points, the Cisco Prime Infrastructure, and the Cisco Mobility Services Engine to support business-critical wireless data, voice, and video applications. See Figure 1 for the WLC5760 overview.

CT5760 Platform Overview

Figure 1: WLC5760 Overview



Unified Access Catalyst 3850 Switches

The Unified Access Catalyst 3850 switch is a flexible ASIC-based hardware that can support multiple protocols and has many advantages over the current hardware platform. The Catalyst 3850 switch has an integrated hardware-based wireless support with Control and Provisioning of Wireless Access Points (CAPWAP) and fragmentation. It also has 40 GB of uplink bandwidth when all ports function at line rate.

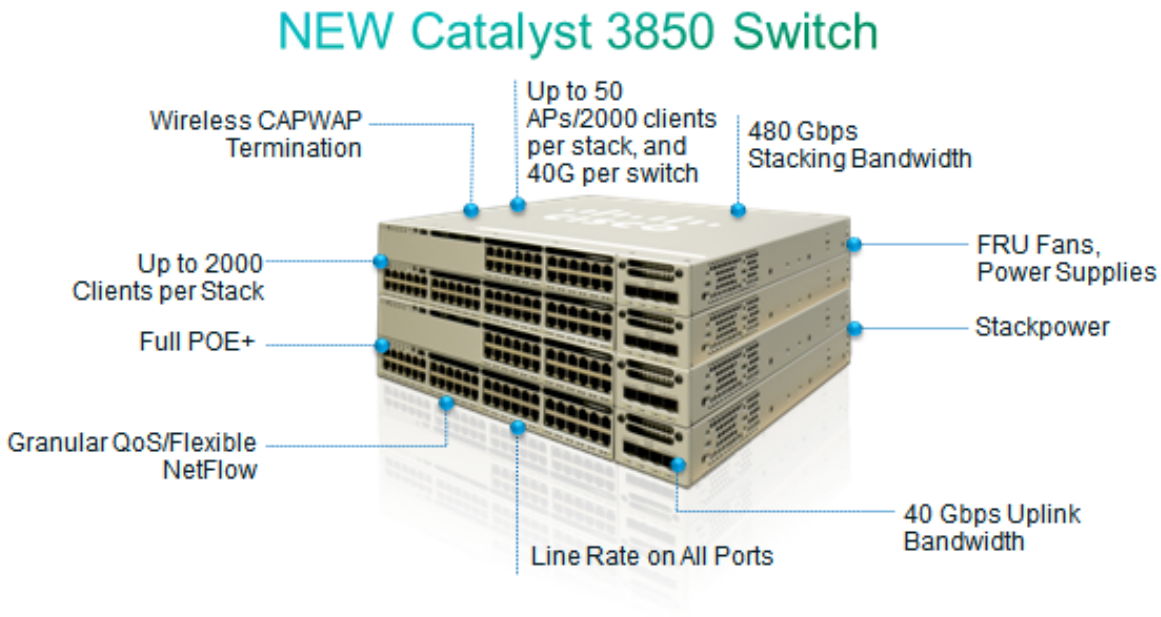
The Catalyst 3850 switch provides an open service platform. It has a 4-core CPU to leverage the operating system (OS) and to host various services. The Catalyst 3850 hardware is the next-generation switching hardware.

The UA Catalyst 3850 switch has unified wired and wireless architecture. The wireless operating system is Cisco IOS® software-based. UA Catalyst 3850 switch provides uniform wired and wireless policies. It can house 50 access points (802.11n) and support 2000 clients per stack. Figure 2 shows the platform overview for the Catalyst 3850.

Refer to the Catalyst 3850 Configuration Guides page for detailed information on configuration recommendation.

Catalyst 3850 Platform Overview

Figure 2: New Catalyst 3850



Supported Features

The CT5760 WLC is an industry-leading platform designed for 802.11ac performance with maximum services, scalability, and high resiliency for mission-critical wireless networks. Through enhanced software programmable ASIC, it delivers a wide range of features highlighted in Table 1.

Table 1: Cisco 5760 WLC Features

Feature	Benefits
Scalability	• Supports up to 1000 APs and 12,000 wireless clients for business-critical wireless services. • Unparalleled scalable wireless solution, which comprises multiple controllers, can support up to 72,000 APs and 864,000 wireless clients.
High Performance	• Optimized for 802.11ac standard. • Six 10G Cisco SFP+ (Small Form-Factor Pluggable) uplinks. • Hardware assisted processing to provide up to 60 Gbps throughput with services such as a downloadable access control list (ACL), granular quality of service (QoS) queues, fairness algorithm, NetFlow v9 processing, and so on.

High Resiliency	• Converged Access deployment mode provides hierarchical network design that constraints failure to smaller domains. Thereby it provides higher resiliency. Wireless clients recover quickly from switch failures within the Catalyst 3850 series switch stack automatically through stateful switchover (AP SSO). • CT5760 in centralized deployment mode (also known as local mode) supports 1+1 and N+1 resiliency. • Multiple link aggregation (LAG) support to protect against link failures, while optimal network connectivity is maintained.
Cisco IOS® Software-based Controller	• Proven and security-hardened Cisco IOS® operating system. • Well-known Cisco IOS® software CLI allows customers to leverage current management tools for operations. • Cisco's rich NetFlow eco-system enables customers to report on, monitor, analyze traffic on, and troubleshoot the wireless network.
ClientLink 2.0	• Cisco ClientLink 2.0 technology improves downlink performance to all mobile devices including one, two, and three-spatial-stream devices on 802.11n and improves battery life on mobile devices such as smartphones and tablets.
CleanAir	• Cisco CleanAir™ technology provides proactive, high-speed spectrum intelligence to combat performance problems due to wireless interference.
Radio Frequency (RF) Management	• Provides both real-time and historical information about RF interference that impacts network performance across controllers via system-wide Cisco CleanAir™ technology integration.
Comprehensive End-to-End Security	• Offers CAPWAP compliant Diagram Transport layer Security (DTLS) encryption to ensure encryption between access points and controllers or between controllers.
High Performance Video	• Optimized video delivery via single stream for both wired and wireless clients. • Supports Cisco VideoStream technology to optimize the delivery of business-critical multicast video applications across the WLAN.
End-to-end Voice	• Supports Unified Communications for improved collaboration through messages, presence, and conferences. • Supports all Cisco Unified Communications Wireless IP Phones for cost-effective, real-time voice services.
Advanced QoS	• Consistent configuration CLI for both wired and wireless QoS through Modular QoS CLI. • Granular QoS policies per access point (AP), service set identifier (SSID), radio, and client. • Fair bandwidth allocation across wireless clients on an AP. • Leverages Cisco's proven Cisco IOS® software and ASIC technology to provide line-rate performance.
Advanced ACL	• Simplifies and centralizes security policies through downloadable ACLs. • ACLs are processed in hardware to provide line-rate performance.

Flexible Netflow v9	• Network-wide visibility with Flexible Netflow for wireless clients.
Environmentally Responsible	• Organizations may choose to turn off AP radios to reduce power consumption during off peak hours. • Integrated WLC avoids the deployment of an additional device in the network.
Mobility and Security	• Secure, reliable wireless connectivity and consistent end-user experience. • Increased network availability through proactive blocking of known threats.
IPv6	• Supports IPv6 addressing on interfaces with appropriate show commands for monitoring and troubleshooting. • IPv6 ACLs are processed in hardware to provide line-rate performance.

For a complete list of features and specifications, refer to the Cisco 5760 Series Wireless Controller page and Data Sheet.

Cisco Controllers Comparisons

This table shows the Cisco high-scale controllers comparison at a glance:

Table 2: Cisco Controllers Comparison

	8500	7500	5500	WiSM2	5760
Deployment Type	Enterprise Large campus + SP Wi-Fi	Central site controller for large number of distributed, controller-less branches	Enterprise Campus and full-service branch	Enterprise campus	Large campus
Operational Modes	Local mode, FlexConnect, Mesh	FlexConnect only	Local mode, FlexConnect, Mesh	Local mode, FlexConnect, Mesh	Centralized (local mode) or Converged Access mode
Maximum Scale	6000 APs 64,000 clients	6000 APs 64,000 clients	500 APs 7000 clients	1000 APs 15,000 clients	1000 APs 12,000 clients
AP Count Range	300–6k APs	300–6k APs	12–500 APs	100–1000 APs	25-1000 APs
Licenses	Right to Use (with EULA))	Right to Use (with EULA	CISL based (unchanged)	CISL based (unchanged)	Right to Use (with EULA)
Connectivity	2x10G ports	2x10G ports	8x1G ports	Internal connections to the Catalyst Backplanes	6x10G ports
Power	AC/DC dual redundant	AC dual redundant	AC (redundant PSU option)	AC/DC Catalyst chassis (redundant PSU option)	AC (redundant PSU option)

Maximum Number of FlexConnect Groups	2000	2000	100	100	N/A
Maximum Number of APs per FlexConnect Group	100	100	25	25	N/A
Maximum Number of Rogue APs Management	24,000	24,000	2000	4000	4000
Maximum Number of Rogue Clients Management	32,000	32,000	2500	5000	5000
Maximum Number of RFID	50,000	50,000	5000	10,000	10,000
Maximum APs per RRM Group	6000	6000	1000	2000	2000
Maximum AP Groups	6000	6000	500	500	1000
Maximum Interface Groups	512	512	64	64	64
Maximum Interfaces per Interface Group	64	64	64	64	64
Maximum VLANs Supported	4095	4095	512	512	512
Maximum WLANs Supported	512	512	512	512	512
Supported Fast Secure Roaming (FSR)	64,000	64,000	14,000	30,000	24,000

New Operating System using Cisco IOS® Software CLI Commands

The CT5760 controllers use the same Cisco IOS® software CLI command used on the Cisco switches and routers. New wireless CLI commands have been added to the existing Cisco IOS® CLI. For a complete list of the wireless Cisco IOS® software CLI commands, refer to the Cisco 5700 Series Wireless LAN Controllers Command References document.

Licenses

Licenses are based on the Right-To-Use license model (per AP license price for the Catalyst 3850 and CT5760). AP licenses are enabled on the mobility controller. The mobility controller can be a Catalyst 3850 switch (or switches), CT5760, 5500, or WiSM2. There is not a separate license for mobility agent functionality (for example, CAPWAP termination on the switch). The same AP licenses can be used as before when the 5500/WiSM2 is used as mobility controller. AP licenses are transferable between Catalyst 3850 and CT5760, Catalyst 3850 and Catalyst 3850, and CT5760 and CT5760.

Please refer to the Cisco Right to Use Licensing FAQ for additional information.

Software Release Numbers

The first 5760 release is Cisco IOS XE 3.2.0SE.

Supported Platforms

Controllers:

- Converged access mode: CT5760, CT5508, WS-SVC-WISM2, 3850
- Centralized mode: CT5760

APs:

- 1040, 1140, 1260, 1600, 2600, 3500, 3600

Cisco Prime 2.0

- Appliance and Virtual Instance

Mobility Services Engine (MSE):

- MSE 7.4 on 3300 and Virtual Instance

Identity Service Engine (ISE):

- ISE 1.1.1 on 3315, 3355, 3395 and Virtual Instance

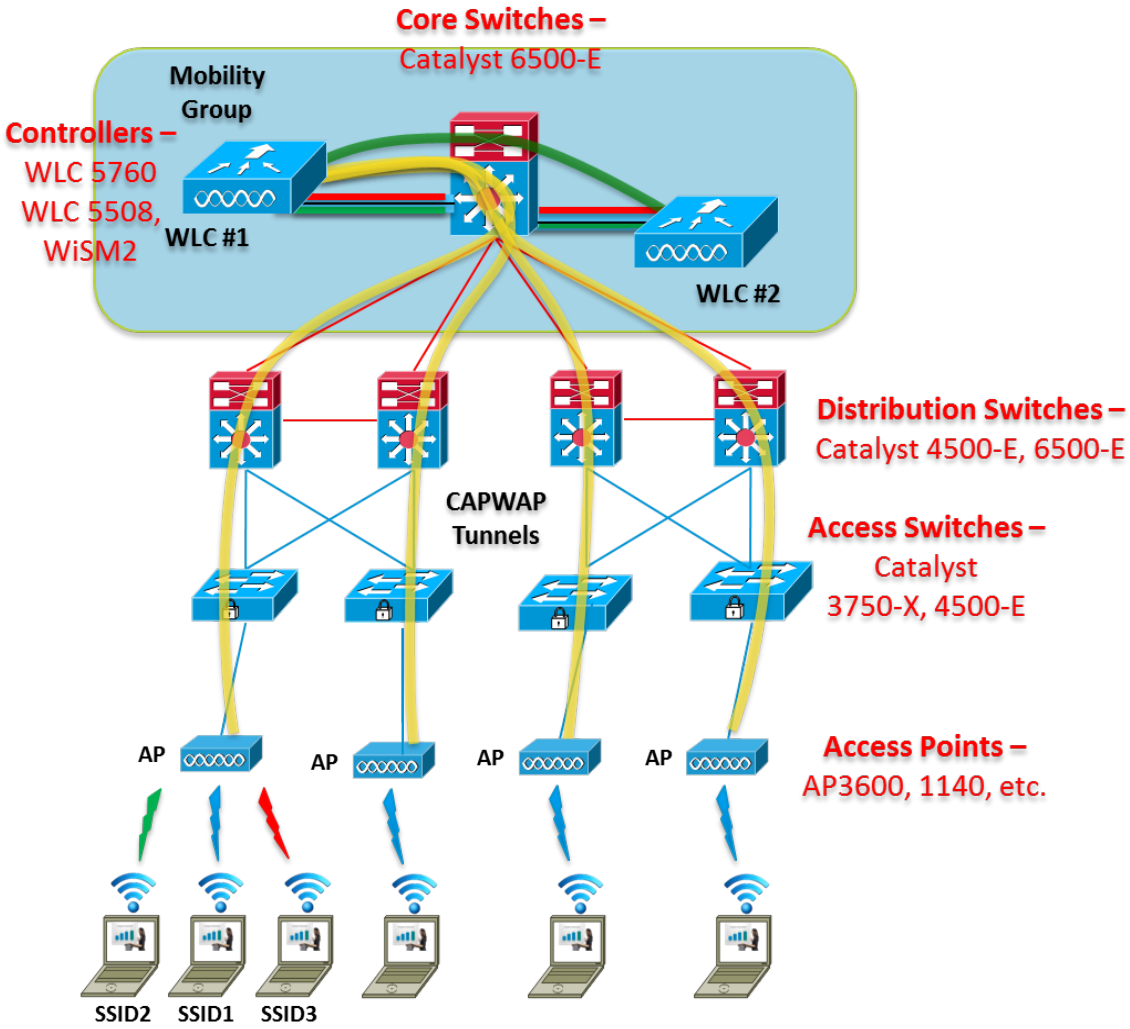
Unified Access Deployment Modes

With the introduction of the CT5760 and Catalyst 3850, there are two deployment modes within the Cisco Unified Access Architecture - Centralized and Converged Access.

Centralized Mode

The centralized mode (also known as local mode on legacy controllers) is the same deployment model currently used today at various points in the Cisco Unified Wireless Network (CUWN) solution set for wireless as well as wired connectivity. The current CUWN provides centralized tunneling of user traffic to the controller (data plane and control plane) and system-wide coordination for channel and power assignment, rogue detection, security attacks, interference, roaming, and so on.

Figure 3: Centralized Mode

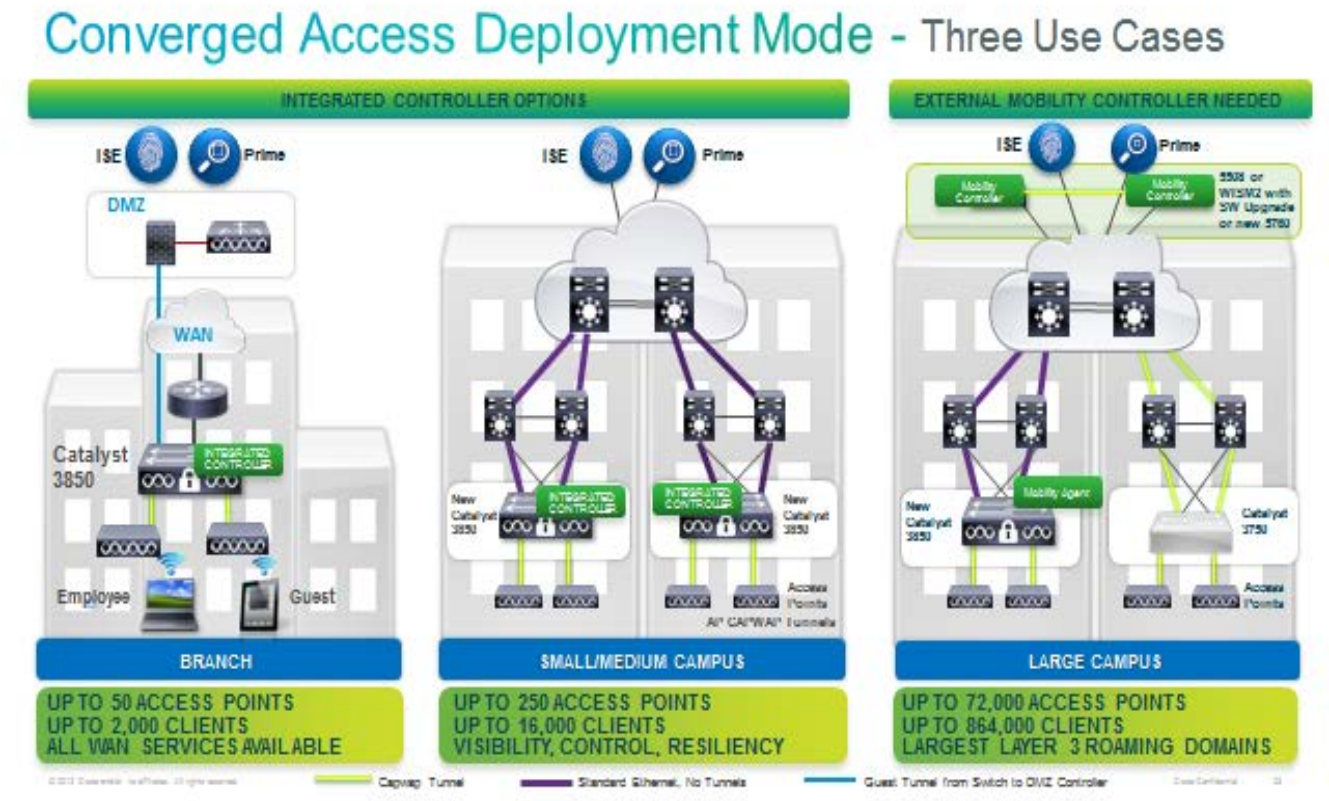


Converged Access Mode

Converged mode is an evolution of the current wireless deployments and offers an additional deployment mode for mobility. With the converged access model, there are a few design differences to note:

- The Catalyst 3850 can act as a mobility agent for terminating CAPWAP tunnels for locally connected APs.
- The Catalyst 3850 can act as a mobility controller for other mobility agent switches in small deployments.
- Handles roaming across a switch peer group (SPG) (L2 / L3).
- Mobility agents within an SPG are fully meshed (auto-created at SPG formation).

Figure 4: Converged Access Deployment Mode

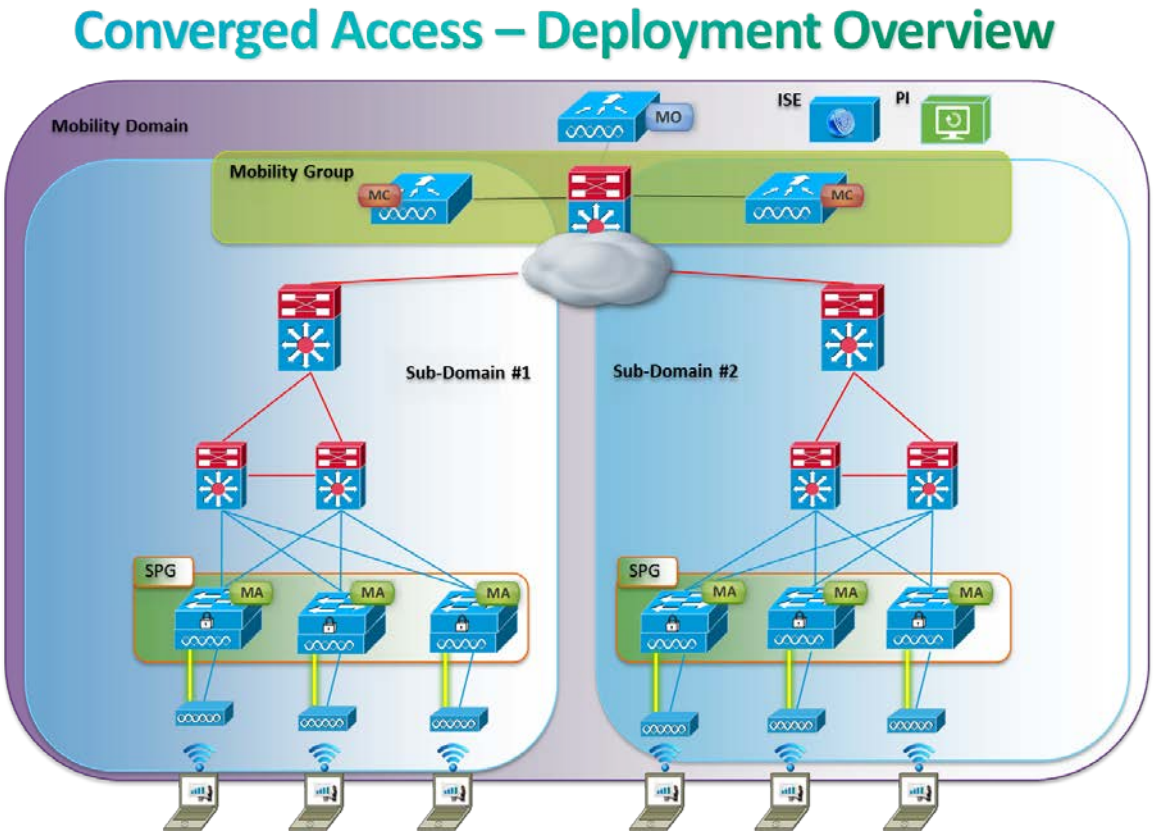


Converged Access Components

A few components are highlighted in order to understand the Converged Access model. These components are shown in Figure 5.

1. **Physical Entities:**
   - Mobility Agent – Terminates CAPWAP tunnel from AP.
   - Mobility Controller – Manages mobility within and across sub-domains.
   - Mobility Oracle – Superset of mobility controller, allows for scalable mobility management within a domain.
2. **Logical Entities:**
   - Mobility Groups – The grouping of mobility controllers to enable fast roaming, radio frequency management, and so on.
   - Switch Peer Group – Localizes traffic for roams within its distribution block.

Figure 5: Converged Access - Deployment Overview



This deployment guide focuses on the configuration of the new CT5760 feature set with the Cisco IOS® software. For detailed information on the new Catalyst 3850 wired/wireless switch and its deployment scenarios, refer to the Catalyst 3850 Deployment/Configuration Guides page.

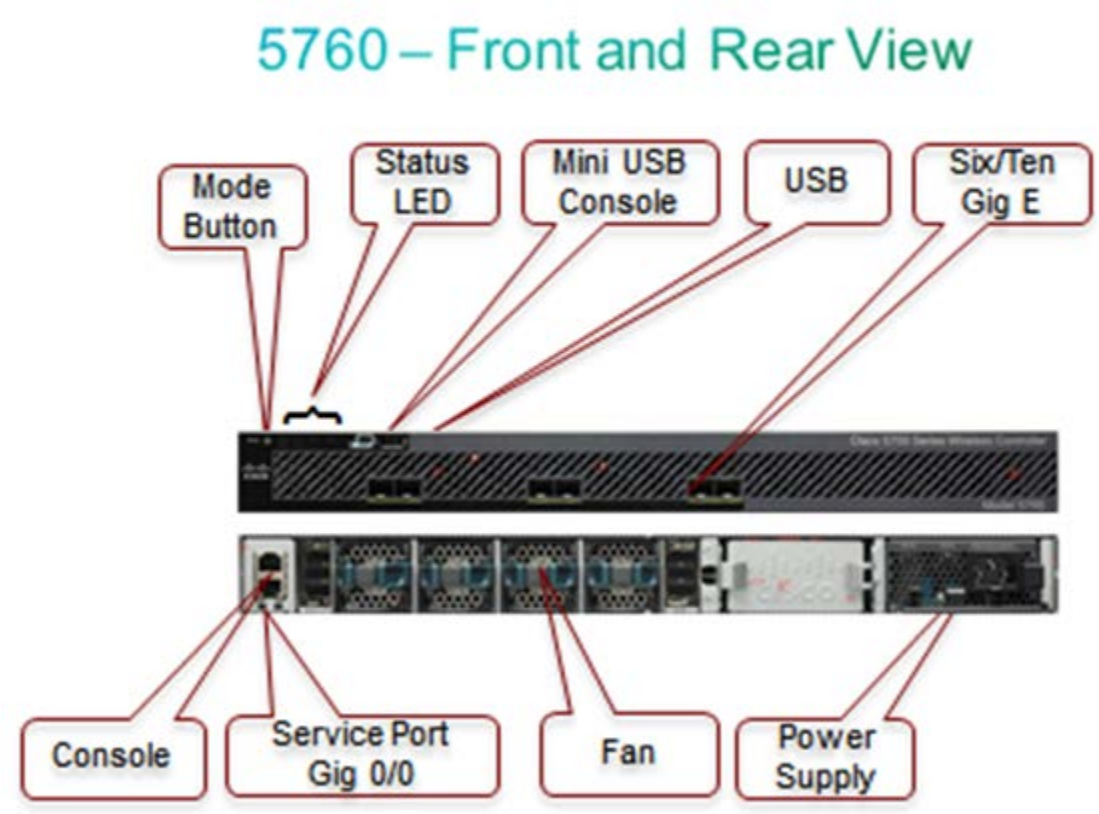
Deployment Basics: Ports, Interfaces, WLAN

This section covers information about the CT5760 ports, interfaces, and WLANs.

Information about Ports

A port is a physical entity that is used for connections on the controller platform. Controllers have two types of ports: distribution system ports and a service port. The ports available on the CT5760 controller are shown in Figure 6.

Figure 6: CT5760 Controller - Front and Rear View



Management Port (Service Port) (RJ-45):
The Cisco 5760 Series Controllers have a 10/100/1000 copper Ethernet Management port (GE 0/0). The management port is reserved for out-of-band management of the controller, system recovery, and maintenance in the event of a network failure.

Console Ports (RJ-45) and Mini USB Type B port:
The CT5760 WLC has two console ports: the RJ45 and Mini USB Type B port.

Note: You can use only one console port (either RJ-45 or mini USB). When you connect to one console port, the other is disabled.

USB Ports 0 (Type A):
The USB console port on the Cisco 5760 Series Controllers connects directly to the USB connector of a PC using a USB Type A-to-5-pin mini Type B cable.

SFP Distribution System Ports 1-6:
The Cisco 5760 Controllers have six 10 Gigabit Ethernet (GE) distribution system ports, through which the controller can manage multiple APs. Cisco 5760 controllers support a maximum of 1000 APs and have no restrictions on the number of APs per port. However, Cisco recommends using link aggregation (LAG) or EtherChannel to balance the load automatically. LAG is covered in another section in this document. The part numbers for the supported SFPs on the 10GE ports are listed in Table 3.

Table 3: Part Numbers for Supported SFPs on the 10GE

SFP+/SFP (only Cisco SFPs supported)	• SFP-10G-ER, • SFP-10G-LR, • SFP-10G-SR, • SFP-10G-LRM, • SFP-H10GB-CU1M • SFP-H10GB-CU3M • SFP-H10GB-CU5M • GLC-BX-D, • GLC-BX-U, • GLC-SX-MM, • GLC-SX-MMD, • GLC-T, • GLC-LH-SM, • GLC-ZX-SM, • CWDM-SFP, • DWDM-SFP, • SFP-GE-L, • SFP-GE-S, • GLC-LH-SMD, • GLC-EX-SMD, • GLC-GE-100FX

Information about Interfaces

An interface is a logical entity on the controller. The next-generation controllers contain multiple interfaces, but these interfaces should be configured:

1. Wireless management interface (can be configured at setup time; mandatory)

   The wireless management interface is used for AP to controller discovery, mobility and Radio Resource Management (RRM). This interface is also used for in-band management: Telnet/SSH CLI, SNMP, and WebGUI.

2. VLANs, which are considered dynamic interfaces, where WLAN traffic is mapped to them.

Information about WLANs

A WLAN associates a service set identifier (SSID) to a VLAN interface. It is configured with security, quality of service (QoS), radio policies, and other wireless network parameters. Up to 512 AP WLANs can be configured per controller.

WLANs are directly mapped to VLANs, which are mapped to physical interfaces.

Note: Cisco recommends that you assign one set of VLANs for WLANs and a different set of VLANs for management interfaces to ensure that controllers properly route VLAN traffic.

AP Join Controller Discovery Process

In a CAPWAP environment, a lightweight AP discovers a controller by using CAPWAP discovery mechanisms and then sends the controller a CAPWAP join request. The controller sends the AP a CAPWAP join response, allowing the AP to join the controller. When the AP joins the controller, the controller manages its configuration, firmware, control transactions, and data transactions.

APs must be discovered by a controller before they can become an active part of the network. The lightweight APs support the following controller discovery process:

- **Layer 3 CAPWAP discovery:** This feature can be enabled on different subnets from the AP and uses IP addresses and UDP packets rather the MAC addresses used by Layer 2 discovery.
- **Locally stored controller IP address discovery:** If the AP was previously associated to a controller, the IP addresses of the primary, secondary, and tertiary controllers are stored in the AP's nonvolatile memory. This process of storing controller IP addresses on an AP for later deployment is known as priming the AP.
- **DHCP server discovery:** This feature uses DHCP option 43 to provide controller IP addresses to the APs. Cisco switches support a DHCP server option that is typically used for this capability. For more information about DHCP option 43, refer to the Configuring DHCP Option 43 for Lightweight Access Points document.
- **DNS discovery:** The AP can discover controllers through your DNS. In order for the AP to do so, you must configure your DNS to return controller IP addresses in response to CISCO-LWAPP-CONTROLLER.*localdomain* or CISCO-CAPWAP-CONTROLLER.*localdomain*, where *localdomain* is the AP domain name. When an AP receives an IP address and DNS information from a DHCP server, it contacts the DNS to resolve CISCO-CAPWAP-CONTROLLER.*localdomain* or CISCO-CAPWAP-CONTROLLER.*localdomain*. When the DNS sends a list of controller IP addresses, the AP sends discovery requests to the controllers.

Link Aggregation/Load Balancing/Port Redundancy

The Cisco 5760 WLC has no restrictions on the number of APs per port, but Cisco recommends using LAG or EtherChannel on each 10GE port to automatically balance the load.

LAG functionality is achieved for a CT5760 controller through configuration of EtherChannels in the Cisco IOS® software. Through EtherChannels, the controller dynamically manages port redundancy and load balances APs transparently to the user.

Information about Link Aggregation

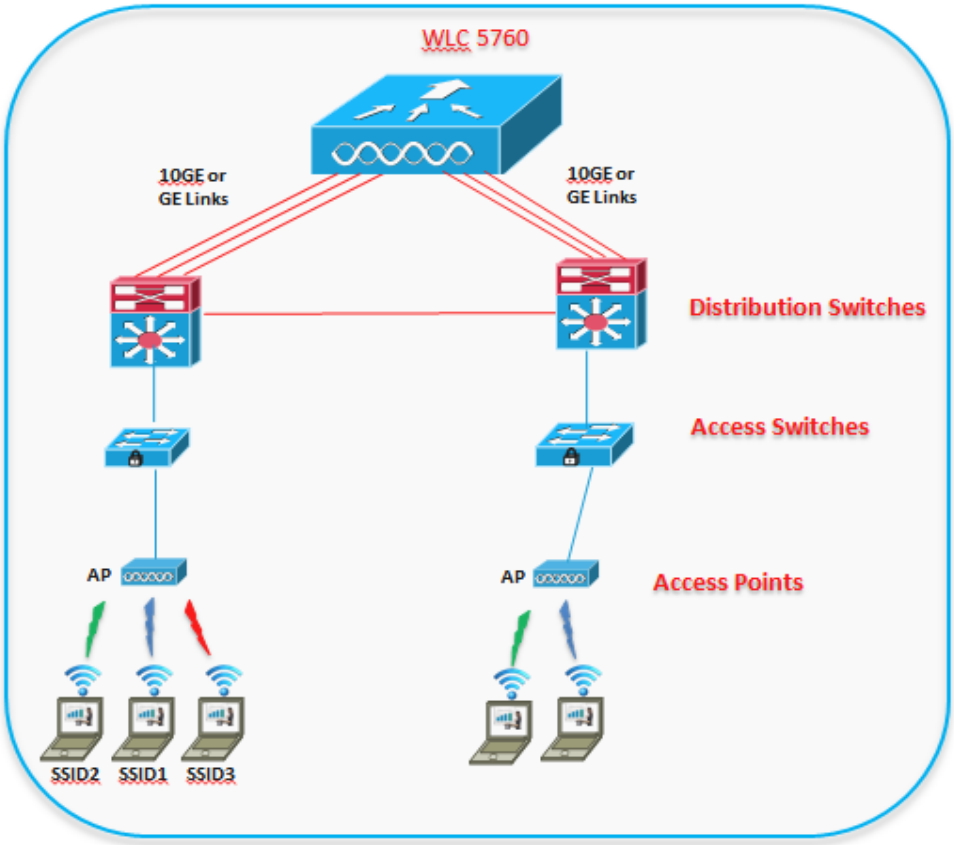
LAG is a partial implementation of the 802.3ad port aggregation standard. It bundles all of the controller's distribution system ports into a single 802.3ad port channel, thereby reducing the number of IP addresses needed to configure the ports on your controller. When LAG is enabled, the system dynamically manages port redundancy and load balances APs transparently to the user.

LAG simplifies controller configuration because you no longer need to configure primary and secondary ports for each interface. If any of the controller ports fail, traffic is automatically migrated to one of the other ports. As long as at least one controller port is functioning, the system continues to operate, APs remain connected to the network, and wireless clients continue to send and receive data.

Multiple LAGs

Multiple LAG groups can be configured to support configurations requiring connectivity to multiple switches for redundancy. APs are load balanced across multiple LAG groups by configuring an AP manager for each LAG group.

Figure 7: Multiple LAGs



Configure the Controller and Neighbor Devices to Support LAG

The controller's neighbor devices must be configured properly to support LAG.

- Each neighbor port to which the controller is connected should be configured with these commands:

```
interface GigabitEthernet <interface id>
      switchport
      channel-group <id> mode on
      no shutdown
```

- The port channel on the neighbor switch should be configured with these commands:

```
interface port-channel <id>
      switchport
      switchport trunk encapsulation dot1q
      switchport trunk native vlan <native vlan id>
      switchport trunk allowed vlan <allowed vlans>
      switchport mode trunk
      no shutdown
```

With the introduction of Cisco IOS® software on the WLC5760, LAG configuration is similar to the neighboring switch configuration.

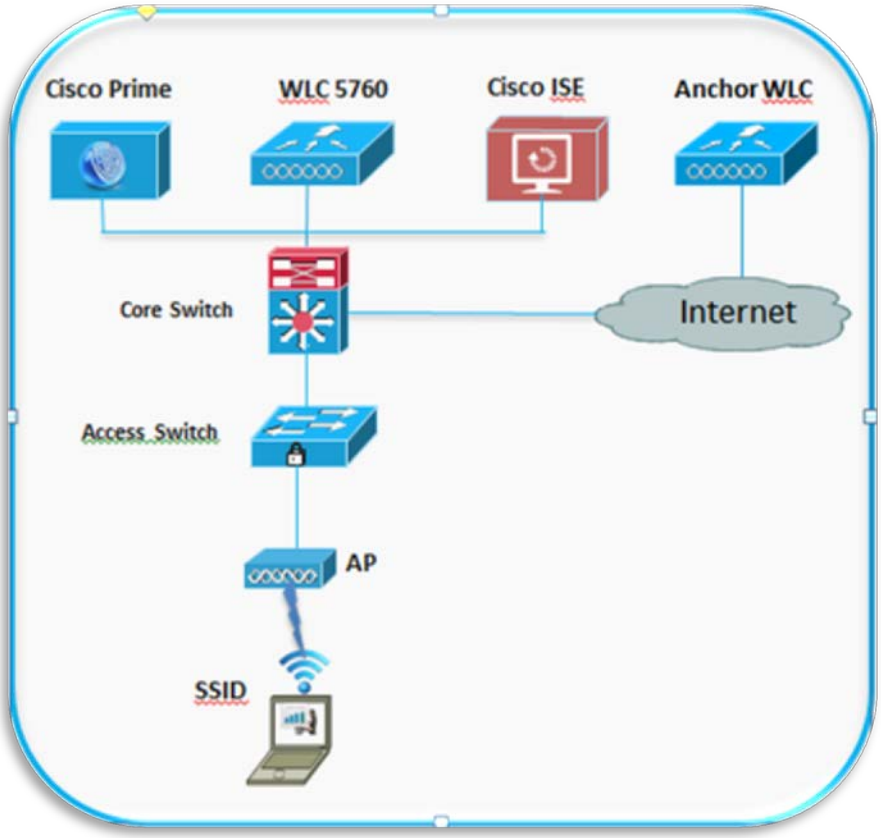
Note: Load balancing that uses multiple AP manager interfaces is supported on the CT5760 WLAN controller similar to the legacy controller. However, Cisco recommends using LAG for redundancy and load balancing.

CT5760 Centralized Configuration Example

Network Topology

The diagram in Figure 8 shows the network topology with *only* the Unified Access CT5760 controller in a centralized deployment.

Figure 8: Network Topology Centralized Configuration



VLANs and IP Addresses

Table 4: VLANs and IP Address by Device

Device	VLAN	IP Address
DHCP Server	Gateway	10.10.100.1 / 10.10.200.1
Cisco Prime Infrastructure	200	10.10.200.30
Cisco ISE	200	10.10.200.60
Anchor WLC	300	192.168.1.5
Core Switch	200, 100	10.10.100.1 / 10.10.200.1
AP	200	DHCP
5760 WLC	200	10.10.200.5
Client VLAN	100	DHCP
Management VLAN	200	10.10.200.5
NTP Server	Gateway	10.10.200.1

CT5760 Controller Configuration Example using CLI

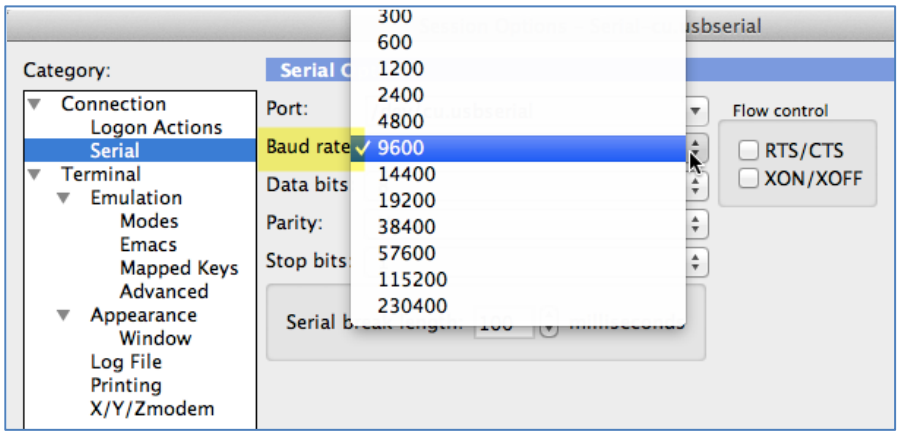
Before you start the controller configuration, ensure that there is complete connectivity between all of the switches in the configuration above.

Console Connection

Before you can configure the switch or controller for basic operations, you must connect it to a PC that uses a VT-100 terminal emulator (such as HyperTerminal, ProComm, or Putty).

The controller has both EIA/TIA-232 asynchronous (RJ-45) and USB 5-pin mini Type B, 2.0 compliant serial console ports. The default parameters for the console ports are 9600 baud, eight data bits, one stop bit, and no parity. The console ports do not support hardware flow control. Choose the serial baud rate of 9600; if you have issues, try a baud rate of 115200. Figure 9 shows an example of a Mac Secure CRT; use similar for PC/Windows Putty, and so on.

Figure 9: Mac Secure CRT Example



Startup Wizard

Before you launch the startup wizard, have your IP addresses and VLANs information available. Start without the wizard/initial configuration dialog (check the initial configuration).

```
% Please answer 'yes' or 'no'.
Would you like to enter the initial configuration dialog? [yes/no]: no
Would you like to terminate autoinstall? [yes]:
Controller>
Press RETURN to get started!
```

Start with the wizard/initial configuration dialog (check the initial config).

```
Enable secret warning
----------------------------------
In order to access the device manager, an enable secret is required
If you enter the initial configuration dialog, you will be prompted for the enable
secret
If you choose not to enter the intial configuration dialog, or if you exit setup
without setting the enable secret,
please set an enable secret using the following CLI in configuration mode-
enable secret 0 <cleartext password>
----------------------------------
Would you like to enter the initial configuration dialog? [yes/no]: yes

At any point you may enter a question mark '?' for help.
Use ctrl-c to abort configuration dialog at any prompt.
Default settings are in square brackets '[]'.


Basic management setup configures only enough connectivity
for management of the system, extended setup will ask you
to configure each interface on the system

Would you like to enter basic management setup? [yes/no]: yes
Configuring global parameters:

  Enter host name [Controller]: CT5760-Controller

  The enable secret is a password used to protect access to
  privileged EXEC and configuration modes. This password, after
  entered, becomes encrypted in the configuration.
  Enter enable secret: Cisco123

  The enable password is used when you do not specify an
  enable secret password, with some older software versions, and
  some boot images.
  Enter enable password: Cisco123

  The virtual terminal password is used to protect
  access to the router over a network interface.
  Enter virtual terminal password: Cisco123

Configure a NTP server now? [yes]: yes
Enter ntp server address : 10.10.200.1

Enter a polling interval between 16 and 131072 secs which is power of 2:16

Do you want to configure wireless network? [no]: yes

  Enter mobility group name: New-Mobility

  Enter the country code[US]:US
```

```
Configure SNMP Network Management? [no]: no

Current interface summary

Any interface listed with OK? value "NO" does not have a valid configuration

Interface              IP-Address      OK? Method Status                Protocol
Vlan1                  unassigned      NO  unset  up                    down
GigabitEthernet0/0     unassigned      YES unset  up                    up
Te1/0/1                unassigned      YES unset  down                  down
Te1/0/2                unassigned      YES unset  down                  down
Te1/0/3                unassigned      YES unset  down                  down
Te1/0/4                unassigned      YES unset  down                  down
Te1/0/5                unassigned      YES unset  down                  down
Te1/0/6                unassigned      YES unset  down                  down

Enter interface name used to connect to the
management network from the above interface summary: GigabitEthernet0/0[service
port)

Configuring interface GigabitEthernet0/0:
Configure IP on this interface? [no]: yes
    IP address for this interface: 192.168.2.50
    Subnet mask for this interface [255.255.0.0] : 255.255.255.0

Wireless management interface needs to be configured at startup
It needs to be mapped to an SVI that's not Vlan 1 (default)

Enter VLAN No for wireless management interface: 200
Enter IP address: 10.10.200.5
   Enter IP address mask:: 255.255.255.0

[0] Go to the IOS command prompt without saving this config.
[1] Return back to the setup without saving this config.
[2] Save this configuration to nvram and exit.
   Enter your selection [2]:2
   Press RETURN to get started!
```

Version

```
#show version
IOS XE 3.X (3.2.0SE at FCS ) is the official version for 3850/5760 & should be the
only version number used when referring to 3850/5760.

#show version running
Will show the WCM and IOSd versions

#show ap name apname config general
Will show AP version, which will be 15.X at FCS.
```

Date and Time Configuration

clock set *hh:mm:ss day month year*

Enable the CT5760 Controller Web GUI

Configuring Admin User

```
username admin privilege 15 password 0 Cisco123
```

Configure HTTP on controller

```
ip http server
ip http authentication local
```

```
username root privilege 15 password 0 cisco
```

Configure Web Services Management Agent (WSMA)

```
wsma agent exec
profile webui_service
profile httplistener
wsma agent config
profile webui_service
profile httplistener
wsma agent filesys
profile webui_service
profile httplistener
wsma agent notify
profile webui_service
profile httplistener

wsma profile listener webui_service
transport http path /webui

wsma profile listener httplistener
transport http path /index
```

Basic Configuration

This section shows the configuration options from the console of the CT5760 for the following:

- Network uplink to core switch
- Management and client interfaces
- DHCP configuration

```
Disable VLAN 1
   int vlan 1
   no ip address
   shutdown
   exit
```

DHCP Snooping and Trust Configuration on CT5760

```
ip dhcp snooping vlan 100, 200
ip dhcp snooping wireless bootp-broadcast enable
ip dhcp snooping

interface TenGigabitEthernet1/0/1
 description Connection to Core Switch
 switchport trunk allowed vlan 100, 200
 switchport mode trunk
 ip dhcp relay information trusted
 ip dhcp snooping trust

interface Vlan100
description Client Vlan
ip dhcp relay information trusted
```

Add Management and Client Interface

```
   interface Vlan200
   description “Management VLAN”
   ip address 10.10.200.5 255.255.255.0
   no shut

   interface Vlan100
```

```
description “Client VLAN”
no shut

ip route 0.0.0.0 0.0.0.0 10.10.200.1
default-gateway 10.10.200.1
```

WLAN Configuration

Configure a WLAN and assign a client VLAN. Use WPA/PSK for security, and the passkey is ‘cisco123’.

```
 wlan corporate 1 corporate
 band-select
 client vlan 100
 no security wpa akm dot1x
 security wpa akm psk set-key ascii 0 cisco123
 no shutdown
```

Enter this command to allow management over wireless.

```
wireless mgmt-via-wireless <cr>
```

AP Joins

Connect an AP to any port on the L2 switch. Wait until it joins and enter command:

```
show ap summary
```

```
show ap summary
Number of APs: 1
Global AP User Name: Not configured
Global AP Dot1x User Name: Not configured
AP Name              AP Model  Ethernet MAC    Radio MAC       State
-------------------------------------------------------------------------------
AP44d3.ca42.321a     3602I     44d3.ca42.321a  64d9.8942.4090  Registered
```

Connect a wireless client to the corporate SSID with the WPA key ‘cisco123’. On the controller, you might see the following successful authorization for new client association.

Show wireless client summary from controller to confirm wireless clients.

Security Configuration

This section shows the configuration options from the console of the CT5760:

- Enable Authentication, Authorization, and Accounting (AAA)
- Configure ISE as RADIUS server (10.10.200.60)
- Shared secret – ‘secret’

```
Form CT5760 console (telnet/serial) - Configure AAA
```

```
aaa new-model
!
aaa group server radius Cisco
 server 10.10.200.60
!
aaa authentication login no_auth none
aaa authentication dot1x default group radius
aaa authentication dot1x Cisco_dot1x group Cisco
```

```
aaa authorization network default group Cisco
aaa accounting network default start-stop group Cisco
dot1x system-auth-control
!
aaa server radius dynamic-author
 auth-type any
!
radius-server attribute 6 on-for-login-auth
radius-server dead-criteria time 10 tries 3
radius-server deadtime 3
radius-server vsa send accounting
radius-server vsa send authentication
!

radius server Cisco
 address ipv4 10.10.200.60 auth-port 1812 acct-port 1813
 key secret
```

This command creates the WLAN with 802.1x security.

```
wlan corporate1x 2 corporate1x
accounting-list Cisco
client vlan 100
security dot1x authentication-list Cisco
session-timeout 600
no shutdown
```

Connect wireless client to corporate-1x with the following credentials:

a. Username = cisco ; Password = Cisco123

```
Controller#show wireless client summary
```

Wireless WebAuth and Guest Anchor Solutions

The following sections show a WebAuthentication (WebAuth) configuration and Guest Anchor examples on the CT5760.

Configure Parameter-Map Section in Global Configuration

The **parameter map** connection configuration mode commands allow you to define a connection-type parameter map. After you create the connection parameter map, you can configure TCP, IP, and other settings for the map.

```
! First section is to define our global values and the internal Virtual Address.
! This should be common across all WCM nodes.

PARAMETER-MAP TYPE WEBAUTH GLOBAL
VIRTUAL-IP IPV4 1.1.1.1

PARAMETER-MAP TYPE WEBAUTH WEBPARALOCAL
TYPE WEBAUTH
BANNER TEXT ^C WEBAUTHX^C
REDIRECT ON-SUCCESS HTTP://9.12.128.50/WEBAUTH/LOGINSUCCESS.HTML
REDIRECT PORTAL IPV4 9.12.128.50
```

Configure Customized WebAuth Tar Packages

Transfer each file to flash:

```
copy tftp://10.1.10.100/WebAuth/webauth/ webauth_consent.html  flash:
webauth_consent.html

copy tftp://10.1.10.100/WebAuth/ webauth_success.html flash: webauth_success.html

copy tftp://10.1.10.100/WebAuth/ webauth_failure.html flash: webauth_failure.html

copy tftp://10.1.10.100/WebAuth/ webauth_expired.html flash: webauth_expired.html
```

Configure Parameter Pap with Custom Pages

```
parameter-map type webauth webparalocal
 type webauth
 custom-page login device flash:webauth_consent.html
 custom-page success device flash:webauth_success.html
 custom-page failure device flash: webauth_failure.html
 custom-page login expired device flash:webauth_expired.html
```

Configure Parameter Map with Type Consent and Email Options

```
parameter-map type webauth webparalocal
 type consent
 consent email
 custom-page login device flash:webauth_consent.html
 custom-page success device flash:webauth_success.html
 custom-page failure device flash:webauth_failure.html
 custom-page login expired device flash:webauth_expired.html
```

Configure Local WebAuth Authentication

```
username guest password guest123
aaa new model
dot1x system-auth-control

aaa authentication login EXT_AUTH local
aaa authorization network EXT_AUTH local
aaa authorization network default local
or
aaa authentication login default local
aaa authorization network default local
```

Configure External Radius for WebAuth

```
aaa new model
dot1x system-auth-control

aaa server radius dynamic-author
client 10.10.200.60 server-key cisco  server-key cisco
auth-type any

radius server cisco
address ipv4 10.10.200.60 auth-port 1812 acct-port 1813
key cisco

aaa group server radius cisco
server name cisco

aaa authentication login EXT_AUTH  group cisco
or
aaa authentication login default group cisco
```

Configure WLAN with WebAuth

```
wlan Guest-WbAuth 3 Guest-WbAuth
client vlan 100
mobility anchor 192.168.5.1
 no security wpa
 no security wpa akm dot1x
 no security wpa wpa2
 no security wpa wpa2 ciphers aes
 security web-auth
security web-auth authentication-list EXT_AUTH
security web-auth parameter-map webparalocal
 no shutdown
```

Configure HTTP Server in Global Configuration

```
!--- These are needed to enable Web Services in the Cisco IOS® software.

ip http server
ip http secure-server
```

Other Configurations to be Checked or Enabled

```
!--- These are some global housekeeping Cisco IOS® software commands:

ip device tracking
ip dhcp snooping
```

SNMP Configuration

From the CT5760 console, configure the SNMP strings.

```
snmp---server community public ro
snmp---server community private rw
```

IPv6 Configuration

IPv6 is supported on the data path. Wireless clients will be able to get an IPv6 address.

Enable IPv6 Snooping - CT5760

There are slight differences in configurations on a CT5760 when configuring IPv6. To enable IPv6 on a CT5760, the following step must be completed.

```
ipv6 nd raguard attach-policy testgaurd
Trusted-port
Device-role router

   interface TenGigabitEthernet1/0/1
    description Uplink to Core Switch
    switchport trunk native vlan 200
    switchport mode trunk
    ipv6 nd raguard attach-policy testgaurd
    ip dhcp snooping trust
```

Enable IPv6 on Interface – CT5760

Based on interfaces that need IPv6 configurations and the type of address needed, respective configurations are enabled as follows. IPv6 configurations are enabled on VLAN200.

```
vlan configuration 100 200
ipv6 nd suppress
ipv6 snooping


interface Vlan100
description “Client VLAN”
ip address 10.10.100.5 255.255.255.0
ip helper-address 10.10.100.1 2001:DB8:0:10::1/64
ipv6 address FE80:20:22::16 link-local
ipv6 enable
```

Mobility Architecture

Here are the mobility components in the new mobility architecture:

Mobility Agent: A mobility agent manages AP connectivity, CAPWAP tunnel terminations from APs and builds a database of client stations (endpoints) that are served locally as well as roamed from an Anchor WLC. Mobility agent can be either a Catalyst 3850 or a CT5760 mobility controller with an internal mobility agent running on it.

Mobility Controller: A mobility controller provides mobility management tasks including inter-SPG roaming, RRM, and guest access. Mobility roaming, where a wireless client moves from one physical location to another without losing connectivity and services at any time, can be managed by a single mobility controller if roaming is limited to a mobility sub-domain. Roaming beyond a mobility sub-domain can be managed by multiple mobility controllers in a mobility group. The mobility controller is responsible for caching the Pairwise Master Key (PMK) of all clients on all the mobility controllers, enabling fast roaming of the clients within its sub-domain and mobility group. All the mobility agents in the sub-domain form CAPWAP mobility tunnels to the mobility controller and report local and roamed client states to the mobility controller. The mobility controller builds a database of client stations across all the mobility agents.

Mobility Oracle: Mobility oracle further enhances mobility scalability and performance by coordinating roaming activities among multiple mobility groups, which removes the need for N^2 communications between mobility controllers in different mobility groups to improve efficiency and performance.

Mobility Group: The mobility group is a logical group of mobility controllers to enable fast roaming of clients within the mobility controllers of a mobility group. In addition, the mobility group also provides centralized RRM that is performed by a mobility controller leader that is either elected or statically chosen.

Mobility Sub-domain: Multiple SPGs can be grouped together and collectively managed as a mobility sub-domain. One mobility controller is required for each mobility sub-domain.

Switch Peer Group: The Converged Access deployment defines an SPG as a logical group of mobility agents within one mobility controller (or mobility sub-domain). The main advantage of configuring SPGs is to constrain the roaming traffic to switches that form the SPG. When the

mobility agents are configured in one SPG on the mobility controller, the software automatically forms full mesh CAPWAP tunnels between the mobility agent switches. These CAPWAP tunnels can be formed in a multi-layer network design (where the mobility agent switches are L2 adjacent on a VLAN spanned across) or a routed access design (where the mobility agent switches are L3 adjacent).

The SPGs should be designed as a group of mobility agent switches to where the users frequently roam.

Note: roams *within* an SPG are local to the SPG, and need not involve the mobility controller. Roams *across* a SPG require traffic to traverse the mobility controller.

Figure 10: Mobility Domain

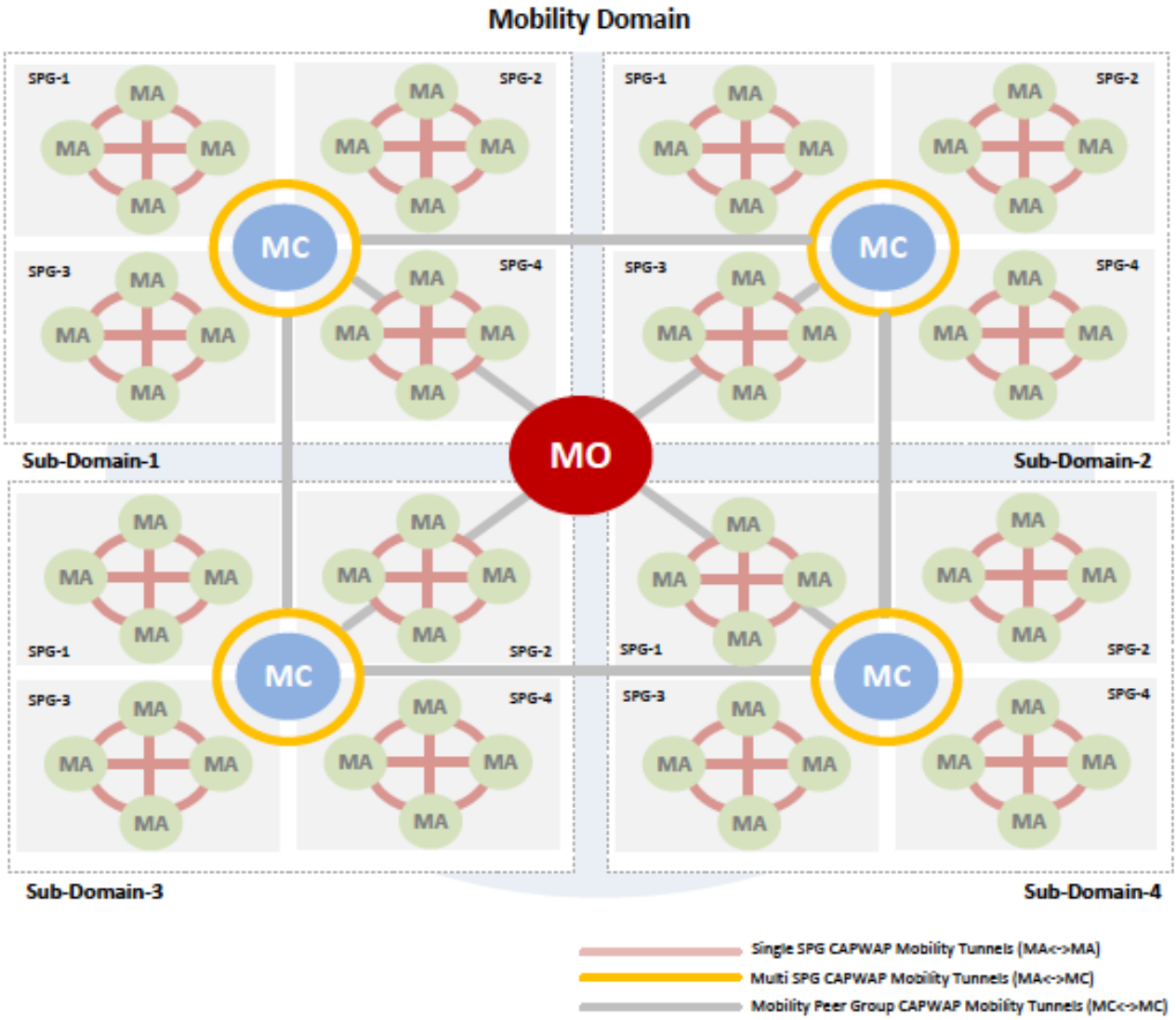
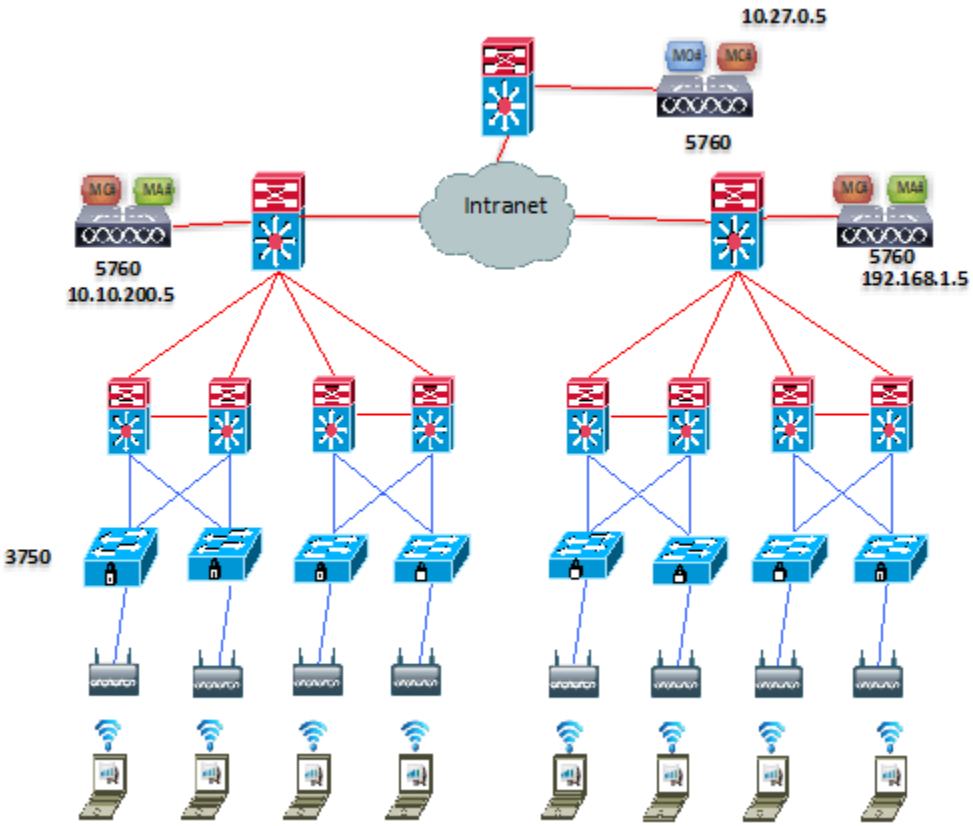


Figure 11: Mobility Design and Configuration: WLC5760 in Centralized Mode



Mobility Configuration on WLC5760-Mobility Controller-Mobility Agent

```
wireless mobility controller

wireless mobility group member ip 10.27.0.5 public-ip 10.27.0.5

wireless mobility group member ip 192.168.1.5 public-ip 192.168.1.5

wireless mobility dscp 46

wireless mobility oracle ip 10.27.0.5

wireless management interface Vlan21
```

Mobility Configuration on WLC5760-Mobility Controller-Mobility Oracle

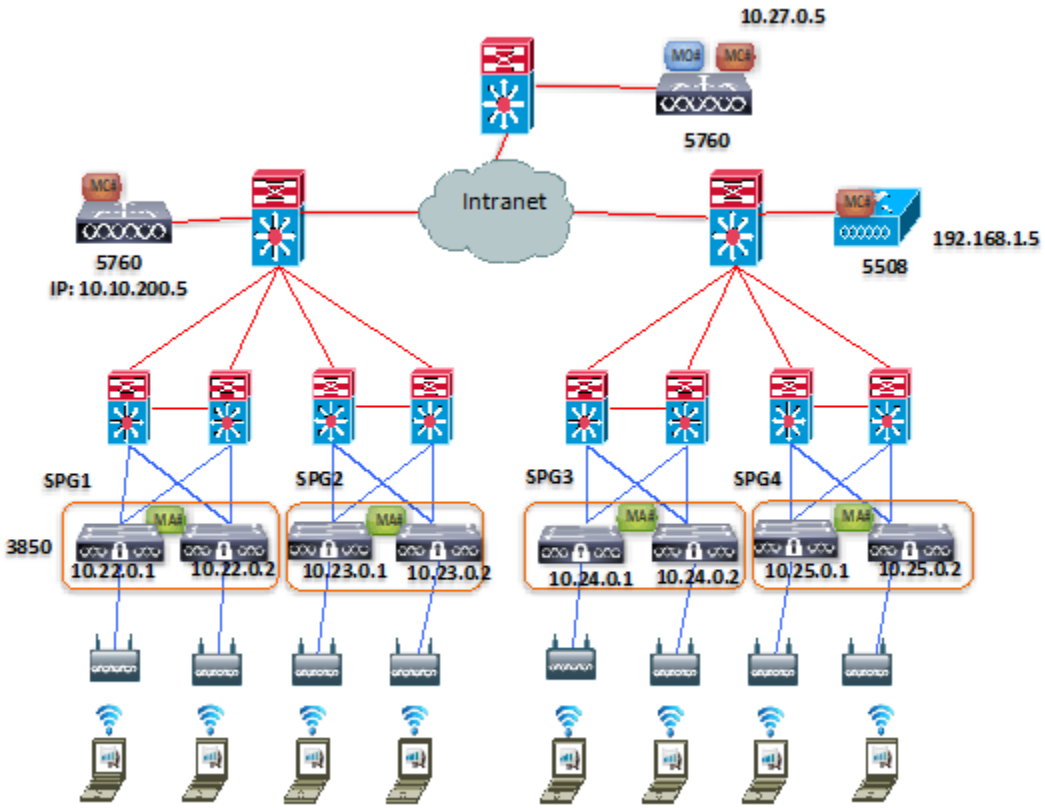
```
wireless mobility group member ip 10.10.200.5 public-ip 10.10.200.5

wireless mobility group member ip 192.168.1.5 public-ip 192.168.1.5

wireless mobility oracle

wireless management interface Vlan27
```

Mobility Configuration on WLC5508-Mobility Controller-Mobility Agent:

```
config mobility new-architecture enable

config mobility mobility-oracle  10.27.0.5

config mobility group member add 10.10.200.5

config mobility group member add 10.27.0.5

config mobility dtls-mode enable

config mobility dscp 46
```

Mobility Design and Configuration: WLC5760 (mobility controller) and Catalyst 3850 (mobility agent) in Converged Access Mode

Figure 12: Mobility Design and Configuration in Converged Access Mode



Mobility Configuration on WLC5760-Mobility Controller-Mobility Agent

```
wireless mobility controller

wireless mobility controller peer-group SPG1

wireless mobility controller peer-group SPG1 member ip 10.22.0.1 public-ip 10.22.0.1

wireless mobility controller peer-group SPG1 member ip 10.22.0.2 public-ip 10.22.0.2

wireless mobility controller peer-group SPG2

wireless mobility controller peer-group SPG2 member ip 10.23.0.1 public-ip 10.23.0.1

wireless mobility controller peer-group SPG2 member ip 10.23.0.2 public-ip 10.23.0.2

wireless mobility group member ip 10.27.0.5 public-ip 10.27.0.5

wireless mobility group member ip 192.168.1.5 public-ip 192.168.1.5

wireless mobility dscp 46

wireless mobility oracle ip 10.27.0.5

wireless management interface Vlan21
```

Mobility Configuration on WLC5760-Mobility Controller-Mobility Oracle

```
wireless mobility group member ip 10.10.200.5 public-ip 10.10.200.5

wireless mobility group member ip 192.168.1.5 public-ip 192.168.1.5

wireless mobility oracle

wireless management interface Vlan27
```

Mobility Configuration on WLC5508-Mobility Controller-Mobility Agent

```
config mobility new-architecture enable

config mobility mobility-oracle  10.27.0.5

config mobility group member add 10.10.200.5

config mobility group member add 10.27.0.5

config mobility switchPeerGroup create SPG3

config mobility switchPeerGroup member add 10.24.0.1 SPG3

config mobility switchPeerGroup member add 10.24.0.2 SPG3

config mobility switchPeerGroup create SPG4
```

```
config mobility switchPeerGroup member add 10.25.0.1 SPG4
config mobility switchPeerGroup member add 10.25.0.2 SPG4
config mobility dtls-mode enable
config mobility dscp 46
```

Mobility Configuration on Catalyst 3850-Mobility Agent 1

```
wireless mobility controller ip 10.10.200.5 public-ip 10.10.200.5
wireless management interface Vlan22
```

Mobility Configuration on Catalyst 3850-Mobility Agent 2

```
wireless mobility controller ip 10.10.200.5 public-ip 10.10.200.5
wireless management interface Vlan22
```

Mobility Configuration on Catalyst 3850-Mobility Agent 3

```
wireless mobility controller ip 10.10.200.5 public-ip 10.10.200.5
wireless management interface Vlan23
```

Mobility Configuration on Catalyst 3850-Mobility Agent 4

```
wireless mobility controller ip 10.10.200.5 public-ip 10.10.200.5
wireless management interface Vlan23
```

Mobility Configuration on Catalyst 3850-Mobility Agent 5

```
wireless mobility controller ip 192.168.1.5 public-ip 192.168.1.5
wireless management interface Vlan24
```

Mobility Configuration on Catalyst 3850-Mobility Agent 6

```
wireless mobility controller ip 192.168.1.5 public-ip 192.168.1.5
wireless management interface Vlan24
```

Mobility Configuration on Catalyst 3850-Mobility Agent 7

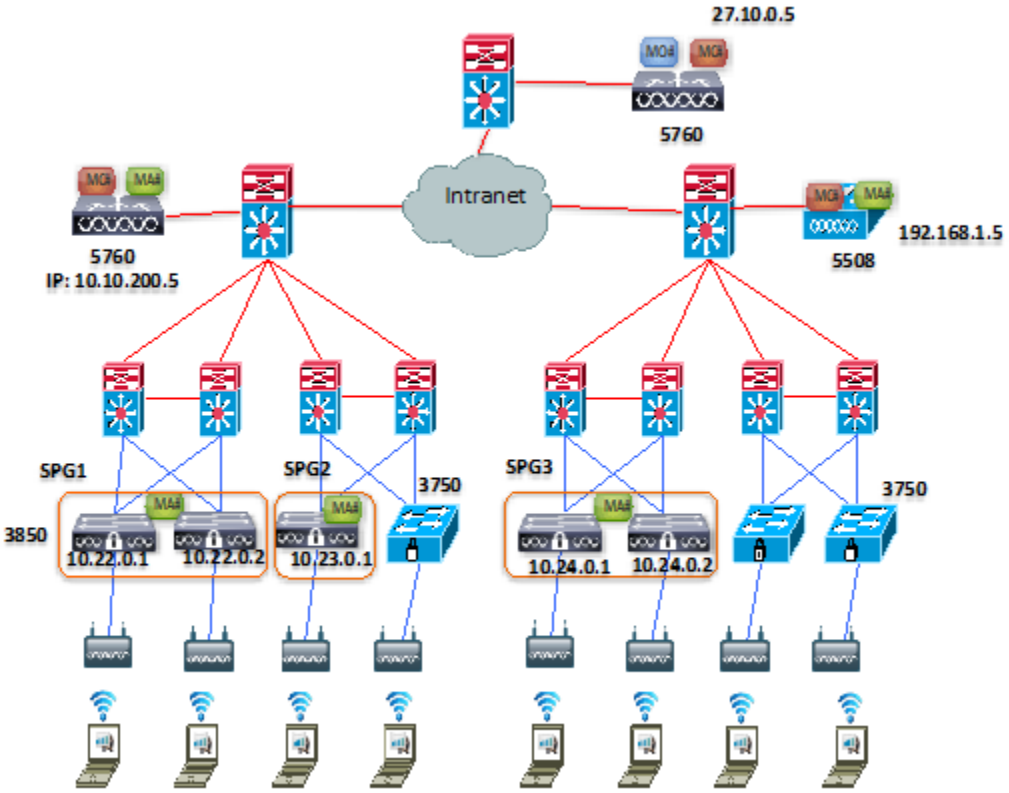
```
wireless mobility controller ip 192.168.1.5 public-ip 192.168.1.5

wireless management interface Vlan25
```

Mobility Configuration on Catalyst 3850-Mobility Agent 8

```
wireless mobility controller ip 192.168.1.5 public-ip 192.168.1.5

wireless management interface Vlan25
```

Mobility Design and Configuration: WLC5760, WLC5508, and Catalyst 3850 in Hybrid Mode

Figure 13: Mobility Design and Configuration: WLC5760, WLC5508, and Catalyst 3850 in Hybrid Mode



Mobility Configuration on WLC5760-Mobility Controller-Mobility Agent

```
wireless mobility controller

wireless mobility controller peer-group SPG1

wireless mobility controller peer-group SPG1 member ip 10.22.0.1 public-ip 10.22.0.1

wireless mobility controller peer-group SPG1 member ip 10.22.0.2 public-ip 10.22.0.2
```

```
wireless mobility controller peer-group SPG2
wireless mobility controller peer-group SPG2 member ip 10.23.0.1 public-ip 10.23.0.1
wireless mobility group member ip 10.27.0.5 public-ip 10.27.0.5
wireless mobility group member ip 192.168.1.5 public-ip 192.168.1.5
wireless mobility dscp 46
wireless mobility oracle ip 10.27.0.5
wireless management interface Vlan21
```

Mobility Configuration on WLC5760-Mobility Controller-Mobility Oracle

```
wireless mobility group member ip 10.10.200.5 public-ip 10.10.200.5
wireless mobility group member ip 192.168.1.5 public-ip 192.168.1.5
wireless mobility oracle
wireless management interface Vlan27
```

Mobility Configuration on WLC5508-Mobility Controller-Mobility Agent

```
config mobility new-architecture enable
config mobility mobility-oracle  10.27.0.5
config mobility group member add 10.10.200.5
config mobility group member add 10.27.0.5
config mobility switchPeerGroup create SPG3
config mobility switchPeerGroup member add 10.24.0.1 SPG3
config mobility switchPeerGroup member add 10.24.0.2 SPG3
config mobility dtls-mode enable
config mobility dscp 46
```

Mobility Configuration on Catalyst 3850-Mobility Agent 1

```
wireless mobility controller ip 10.10.200.5 public-ip 10.10.200.5
wireless management interface Vlan22
```

Mobility Configuration on Catalyst 3850-Mobility Agent 2

```
wireless mobility controller ip 10.10.200.5 public-ip 10.10.200.5

wireless management interface Vlan22
```

Mobility Configuration on Catalyst 3850-Mobility Agent 3

```
wireless mobility controller ip 10.10.200.5 public-ip 10.10.200.5

wireless management interface Vlan23
```

Mobility Configuration on Catalyst 3850-Mobility Agent 4

```
wireless mobility controller ip 192.168.1.5 public-ip 192.168.1.5

wireless management interface Vlan24
```

Mobility Configuration on Catalyst 3850-Mobility Agent 5

```
wireless mobility controller ip 192.168.1.5 public-ip 192.168.1.5

wireless management interface Vlan24
```

Configuring ClientLink (Beamforming)

Cisco ClientLink uses advanced signal processing techniques and multiple transmit paths to optimize the signal received by 802.11 a/g/n clients in the downlink direction without feedback. By default, ClientLink is disabled. You can see ClientLink general status through the show network command: **ap dot11** {24ghz | 5ghz}.

You can enable ClientLink for all APs, with the global configuration command **ap dot11** {24ghz | 5ghz} beamforming. Use the "no" form of the command to disable ClientLink:

```
ap dot11 5ghz shutdown
ap dot11 5ghz beamforming
no ap dot11 5ghz shutdown
```

These commands enable ClientLink globally; then, it disables ClientLink on a specific AP radio:

```
ap dot11 5ghz shutdown
ap dot11 5ghz beamforming
no ap dot11 5ghz shutdown
ap name 3602a dot11 5ghz shutdown
ap name 3602a no dot11 5ghz beamforming
ap name 3602a no dot11 5ghz shutdown
```

Show commands:

```
show ap dot11 5ghz network | include Beamforming
Legacy Tx Beamforming setting : Disabled
show ap name 3602a config dot11 5ghz | include Beamforming
    Legacy Tx Beamforming Setting              : Enabled
```

Bring Your Own Device (BYOD) Security Configuration

This section discusses the self-service additions of personal devices securely. An employee registers a new device, and a certificate is automatically provisioned for that user and device. The certificate is installed along with a supplicant profile that is pre-configured to use that certificate and on-board the device into the corporate network. Two BYOD use cases supported for wireless supplicant included are:

- Single authentication of SSID BYOD for Applie device and
- Dual authentication of SSID BYOD for Apple device..

Single Authentication of SSID BYOD for Apple Device Use Case

In this use case, there is a single SSID (BYOD-Dot1x) for corporate access that is authenticated and authorized with both Protected Extensible Authentication Protocol (PEAP) and Extensible Authentication Protocol Transport Layer Security (EAP-TLS).

1. User associates to BYOD-Dot1x.
2. User enters employee username and password for PEAP authentication.
3. Authenticator authenticates user and performs URL-Redirect based on authorization policy.
4. User opens a browser and is redirected to self-registration portal for device registration.
5. Mac address gets pre-populated in the device registration page for DeviceID, and user enters a description and registers their device.
6. User's supplicant is provisioned, and certificates are installed.
7. After certificate installation, Change of Authorization (CoA) occurs; supplicant is authenticated and authorized using EAP-TLS.
8. Dynamic VLAN assignment occurs, and supplicant is placed in corporate VLAN.

Dual Authentication of SSID BYOD for Apple Device Use Case

In a dual SSID use case, there are two SSIDs — one that is BYOD-Open for guest and one that authenticates for corporate access.

1. User associates to guest BYOD-Open SSID.
2. User opens a browser and is redirected to the Identity Services Engine (ISE) Central Web Authentication (CWA) guest portal.
3. Authenticator authenticates the associate user as an employee and directs the user to the employee device registration guest portal.
4. Mac address is pre-populated in the device registration page, and user enters a description and registers their device.
5. User's supplicant is provisioned and certificate is installed.
6. User disconnects from guest SSID.
7. User connects to corporate SSID and is authenticated/authorized to use the new profile.

Topology

Figure 14: BYOD Topology with Catalyst 3850 as the Authenticator

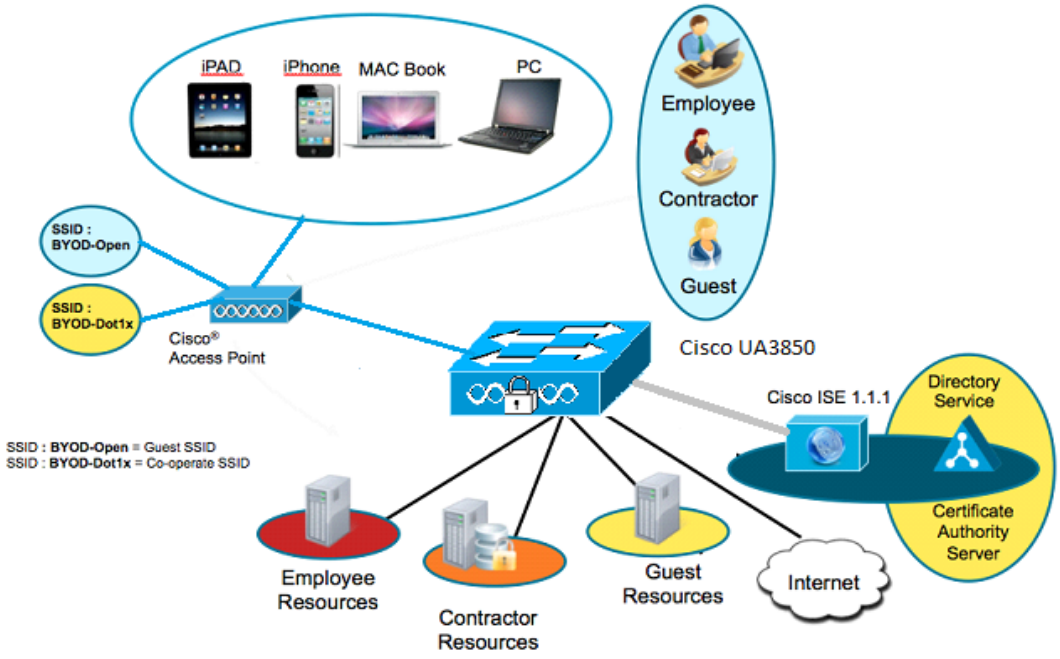
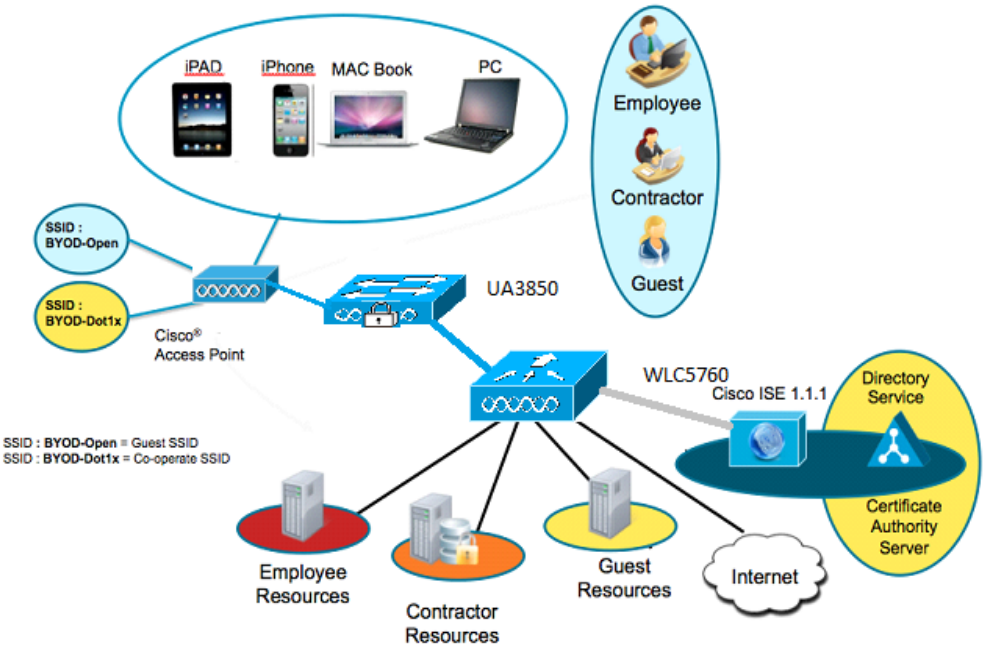


Figure 15: BYOD Topology with WLC5760 as the Authenticator



Components

Component	Hardware	Features Tested	Cisco IOS® Software Release
ISE	UCS Server	AAA override, profiler, posture	ISE 1.1.1
Certificate Authority and AD Server	Windows 2008 R2 Enterprise SP2	SCEP, Certificate Authority, Active Directory Server	—
Wireless Controller	UA3850 CT5760	Authentication/Authorization, URL-Redirection, and CoA	03.07.98.EMP
Apple iOS Device	Apple iPad, iPhone	—	Apple iOS 5.0

Secure WLAN Configuration on Catalyst 3850/WLC5508

Wireless Dot1x Configuration

```
aaa new-model
aaa group server radius Cisco
 server 10.10.200.60 auth-port 1812 acct-port 1813

aaa authentication login no_auth none
aaa authentication dot1x default group radius
aaa authentication dot1x Cisco_dot1x group Cisco
aaa authorization network default group Cisco
aaa accounting network default start-stop group Cisco
dot1x system-auth-control
```

Dynamic Authorization Configuration

```
aaa server radius dynamic-author
 client 10.10.200.60 server-key Cisco123
 auth-type any
```

Radius Server Configuration

```
radius-server attribute 6 on-for-login-auth
radius-server dead-criteria time 10 tries 3
radius-server host 10.10.200.60 auth-port 1812 acct-port 1813 key Cisco123
radius-server deadtime 3
radius-server vsa send accounting
radius-server vsa send authentication
radius server Cisco
```

URL-Redirect Access-list Configuration

```
ip access-list extended NSP-ACL  ← Supplicant Provisioning ACL
 deny   ip any host 10.10.200.60
 permit ip any any
```

HTTP Configuration

```
!
ip http server
ip http authentication local
ip http secure-server
ip http secure-client-auth
```

WLAN Configuration

```
wireless mobility controller
wireless management interface 200
wireless client user-timeout  600
wlan BYOD-Dot1x 1 BYOD-Dot1x     ← Secure Corporate SSID
 aaa-override
 accounting-list Cisco
 client vlan 100
 ip access-group NSP-ACL
 nac
 security dot1x authentication-list Cisco
 session-timeout 600
 no shutdown
wlan BYOD-Open 2 BYOD-Open  ←  Guest SSID
 aaa-override
 client vlan 100
ip access-group NSP-ACL
 nac
 no security wpa
 no security wpa akm dot1x
 no security wpa wpa2
 no security wpa wpa2 ciphers aes
 security dot1x authentication-list Cisco
 no shutdown
```

Verify Wireless Dot1x Session

```
Controller-MC#show access-session method dot1x details

Controller-MC#show access-session interface capwap 1 details

Controller-MC#show access-session mac 6420.0c37.5108 interface capwap 1

Controller-MC#show wireless client summary
```

Deauthenticate Client

```
Controller-MC#wireless client mac-address 6420.0c37.5108 deauthenticate
Controller-MC#show wireless client summary
```

Radio Resource Management Configuration

Information about Radio Resource Management

The Radio Resource Management (RRM) software embedded in the controller acts as a built-in radio frequency (RF) engineer to provide consistant, real-time RF management of your wireless network. RRM enables controllers to continually monitor their associated lightweight APs:

- **Traffic Load** — the total bandwidth used for transmitting and receiving traffic. It enables wireless LAN managers to track and plan network growth before client demand.
- **Interference** — the amount of traffic coming from other 802.11 sources.
- **Noise** — the amount of non-802.11 traffic that is interfering with the currently assigned channel.
- **Coverage** — the receiver signal strength indicator (RSSI) and signal-to-noise ratio (SNR) for all connected clients.
- **Other** — the number of nearby APs.

RRM can periodically reconfigure the 802.11 RF network for best efficiency. In order to do this, RRM performs these functions:

- Radio resource monitoring
- Transmit power control
- Dynamic channel assignment
- Coverage hole detection and correction.

For initial configuration purposes, the following covers items in the order that they occur in the current WLC GUI and focuses on predictable things that need adjustment from the default values.

RF Group Name

Assign the RF group name that RRM will use to identify members of your group and base the grouping algorithm to choose RF group leaders. Cisco recommends that you assign a distinctly different name to this test system to avoid interactions with established, production networks. In order to configure the RF Group Name, enter configuration mode at the command line of the mobility controller.

```
(config)#wireless rf-network <name> <cr>
802.11a/b network command
```

Several commands require that the network be disabled in order to execute. You can enable and disable the network very easily from the configuration terminal prompt.

```
Switch(config)#ap dot11 24/5ghz shut
Or use the no form to enable
config)# no ap dot11 24/5ghz shut)
```

This is the display of the default data-rates values. You might need to change several of these:

```
ap dot11 24/5ghz rate <rate> mandatory/supported/disabled:
```

As an example – disable 1,2,5.5,11 Mbps, enabling 24,54 Mbps as mandatory, all else supported. 5 GHz has 12, 24 Mbps as mandatory, all else supported:

```
ap dot11 2 shut
ap dot11 2 rate RATE_11M disable
ap dot11 2 rate RATE_1M disable
ap dot11 2 rate RATE_2M disable
ap dot11 2 rate RATE_5_5M disable
% Unable to modify rate, Since this is the last available BSS rate.
```

The above warning is issued since there are no other mandatory rates available — you must have at least one mandatory rate.

```
ap dot11 2 rate RATE_24M mandatory
ap dot11 2 rate RATE_5_5M disable
ap dot11 2 rate RATE_54M mandatory
no ap dot11 2 shut
ap dot11 5 shut
ap dot11 5 rate RATE_6M supported
no ap dot11 5 shut
```

The Legacy ClientLink default setting is disabled:

```
ap dot11 24/5ghz beamforming <cr>
```
Use the no form to disable.

The other Network settings are displayed for reference.

Enable 802.11g support (on by default):

```
ap dot11 24ghz dot11g <cr>
```

Beacon interval – default is 100 ms – do not change:

```
ap dot11 24/5ghz beacon  (20-1000 ms)
```

Short Preamble — on a Cisco AP, short preamble is enabled to allow the AP to adjust the preamble automatically. There is no way to set the preamble to always use short or long preamble. Short preamble is enabled by default. To disable short preamble, use the "no" form of the command:

```
ap dot11 24/5ghz preamble short  <cr>
```

Fragmentation threshold – default 2346 – Do not change unless you have a significant reason:

```
ap dot11 24/5ghz fragmentation  <256-2346> (bytes)
```

Dynamic Transmit Power Control (DTPC) support – Default is on. This tells a Cisco Compatible Extension (CCX) client the power level the AP used.

```
ap dot11 24/5ghz dtpc <cr>
```
Use the no form of the command to disable.

CCX Location Measurement — Default is off; enable if you use the CCX location features:

```
ap dot11 24/5ghz rrm ccx location-measurement <cr>
```
Use the no form to disable.

RRM RF Grouping and Next Generation Controller

RF Grouping can be configured for automatic or static modes. For automatic, mobility controllers negotiate with the grouping algorithm in order to choose a group leader. Static mode allows the user to choose a device that will be the group leader as well as add additional members manually. Members must be configured for automatic in order to join the static leader.

Set the RF Grouping Mode

For automatic RF grouping, use this command:
```
ap dot11 24/5Ghz rrm group-mode auto
```

For static and adding static members, member mobility controllers must be in automatic grouping mode:

```
ap dot11 24 rrm group-mode leader
ap dot11 24 rrm group-member Cisco_dd:f8:e4 IP address
```

Enter this command in order to disable/enable RRM RF Grouping:

```
ap dot11 24rrm group mode
```

RRM TPC Transmit Power Control Configuration

To configure RRM Transmit Power Control (TPC), choose the mode for the algorithm to operate or disable it. With the exception of the minimum/maximum commands, all TPC configurations are global commands and must be entered on the RF group leader to have an effect on the RF Group.

The default setting for TPC is configured to automatic (auto). In order to change this value, enter this command:

```
ap dot11 24 rrm txpower ?
  <1-8>  Enter transmit power level
  auto   Enables auto-RF
  max    Configures maximum auto-RF tx power
  min    Configures minimum auto-RF tx power
  once   Enables one-time auto-RF
```

If TPC is configured to automatic, then you may need to adjust the TPC-threshold value – (-70 dBm by default) valid range is -80 dBm to -50dBm:

```
ap dot11 24 rrm tpc threshold -70
```

Here is the command that shows the current RRM TPC configuration:

```
show ap dot11 24 txpower
```

RRM DCA Configuration

Dynamic channel assignment (DCA) is a global algorithm. Like TPC, it requires changes to be made to the RF group leader. Making changes to a member will have no effect on the algorithm, unless that member is changed to a leader.

The default DCA is configured to automatic. Other options include on-demand, as well as values for the anchor time and interval:

Use this command in order to enable DCA to run once and freeze:

```
ap dot11 24 rrm channel global once
```

Use this command in order to restore DCA to automatic:

```
ap dot11 24 rrm channel global auto
```

Use this command in order to set DCA to operate on a fixed interval other than the default of 10 minutes:

```
ap dot11 24 rrm channel dca anchor-time 1
ap dot11 24 rrm channel dca interval 8
```

These commands set the anchor time for 1 AM in the RF group leader's time zone and runs DCA every eight hours. Valid interval values are 1,2,3,4,6,8,12 and 24 hours; 0 = 10 minutes (default).

Use this command in order to set the DCA algorithm sensitivity (medium by default) use:

```
ap dot11 24 rrm channel dca sensitivity low
```
Options are medium/low/high.

Use this command to assign the channels that DCA will manage. Use one entry per channel, and run for both 2.4 and 5 Ghz bands:
```
ap dot11 24 rrm channel dca 1
ap dot11 24 rrm channel dca 6
ap dot11 24 rrm channel dca 11
```

Use the no form of the command to delete a channel from DCA control to manage options for the DCA algorithm, such as noise avoidance, foreign AP avoidance, load, CleanAir persistent device avoidance, and CleanAir Event Driven Radio Resource Management (EDRRM).

```
ap dot11 24 rrm channel ?
cleanair-event  Configure cleanair event-driven RRM parameters
dca             Config 802.11b dynamic channel assignment algorithm
device          no description – CleanAir PDA
foreign         Configure foreign AP 802.11b interference avoidance
global          Configures all 802.11b Cisco APs
load            Configure Cisco AP 802.11b load avoidance
noise           Configure 802.11b noise avoidance
```

Default values are foreign and noise.

Commands are entered one line at a time. Device, foreign, load, noise are on/off values. Use the no form of the command to turn off. The CleanAir event also has a sensitivity level associated with it. The default value is low; other options are medium and high.

The channel update contribution line indicates that our AP's Signal Noise, Interference (foreign), and Load (SNIUs) are at that moment added to DCA.

RRM Coverage Hole Detection and Mitigation

The default values for Coverage Hole Detection and Mitigation (CHDM) are sufficient for most environments. Items to change include the data/voice RSSI thresholds that determine when to consider a client in a coverage hole condition, the global coverage exception, and the percentage of failed clients per AP. There are other controls that are exposed at the command line. Unless directed, accept the defaults.

CHDM is a per controller configuration basis, and is not global. In order o enable or disable coverage hole detection, enter this command:

```
ap dot11 24 rrm coverage
```
Use the no form of the command to disable.

This command adjusts the RSSI threshold for data/voice clients:

```
ap dot11 24 rrm coverage data rssi-threshold -80
ap dot11 24 rrm coverage voice rssi-threshold -80
```

In order to set the level that a client is considered in a coverage hole, the default value is 80 dBm; valid range is -90/-60 dBm. The voice and data clients are two separate commands.

This command sets the minimum failed client count and the coverage exception level per AP:

```
ap dot11 24 rrm coverage level global 3
ap dot11 24 rrm coverage exception global 25
```

Three clients and 25% coverage exception are the default values; the available ranges are 1-75 clients and 0-100%.

The minimum failed client count and the exception level work together as a gating function for the feature. The defaults of three clients and 25% translate as a minimum of three clients must be in a coverage hole, and these three clients must represent at least 25% of the clients currently associated to the AP. This is the criterion for mitigation.

Neighbor Discovery Protocol

Neighbor Discovery Protocol (NDP) establishes RF proximity of all APs in your network. This is the basis for all calculations that RRM uses to balance the network for performance. NDP is an over-the-air open protocol by default. It is possible to secure this using encryption, but every member of the RF group must be in the same mode in order for NDP to function. In order to enable NDP protection, enter this command to every mobility agent and mobility controller on the network.

```
ap dot11 24 rrm ndp-type protected
```

CleanAir

Cisco CleanAir is a spectrum intelligence solution designed to proactively manage the challenges of a shared wireless spectrum. It allows you to see all of the users of the shared spectrum (both native devices and foreign interferers). It also enables you or your network to act upon this information. For example, you could manually remove the interfering device, or the system could automatically change the channel away from the interference.

Information about CleanAir

A Cisco CleanAir system consists of CleanAir-enabled APs, controllers, and Wireless Control Systems (WCS). These APs collect information about all devices that operate in the industrial, scientific, and medical (ISM) bands. They identify and evaluate the information as a potential interference source and forward it to the controller. The controller controls the APs, collects spectrum data, and forwards the information to WCS or to a Cisco Mobility Services Engine (MSE) upon request. The controller provides a local user interface to configure basic CleanAir features and displays basic spectrum information. WCS provides an advanced user interface to configure Cisco CleanAir features, display information, and keep records. The MSE is optional for the basic feature set, but is required for advanced features such as tracking the location of non-Wi-Fi interference devices.

For every device operating in the unlicensed band, Cisco CleanAir tells you what it is, where it is, how it is impacting your wireless network, and what actions you or your network should take. It simplifies RF so that you do not have to be an RF expert.

Wireless LAN systems operate in unlicensed 2.4- and 5-GHz ISM bands. Many devices, such as microwave ovens, cordless phones, and Bluetooth devices also operate in these bands and can negatively affect Wi-Fi operations.

Some of the most advanced WLAN services, such as Voice over Wireless (VoWLAN) and IEEE 802.11n radio communications could be significantly impaired by the interference caused by other legal users of the ISM bands. The integration of Cisco CleanAir functionality into the Cisco Unified Wireless Network resolves RF interference problems.

CleanAir Configuration

CleanAir is disabled by default at the WLC/mobility controller level and must be enabled at all mobility controllers just like a WLC installation. In order to enable CleanAir on the switch, enter this command:

```
ap dot11 24 cleanair
ap dot11 5 cleanair
Controller#show ap dot11 24 sum
```

Enter this command in order to enable or disable CleanAir on a single AP radio:

```
ap name AP0022.bd18.87c0  dot11 24 cleanair
```

The no form of the command disables CleanAir.

Use this command in order to query CleanAir for devices and AirQuality (AQ) at the AP radio and the global levels:

```
show ap dot11 24 cleanair device type all
```

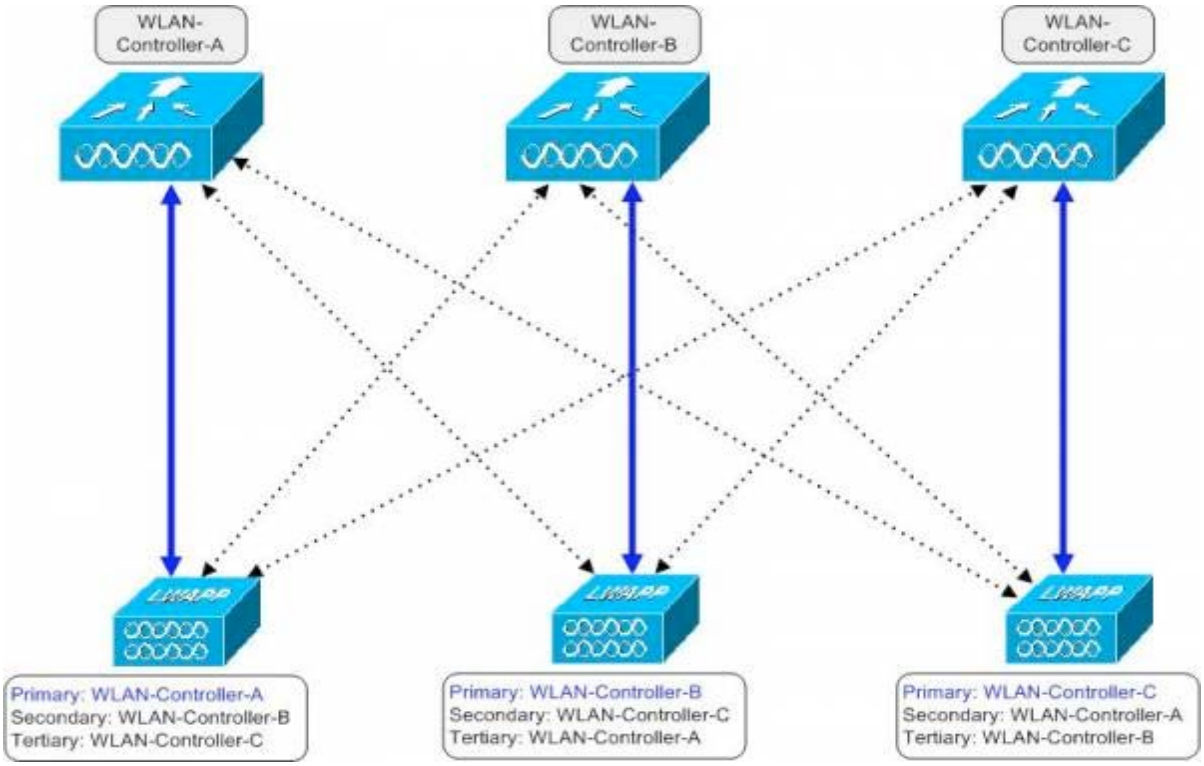
Use this command in order to show the CleanAir configuration for the mobility controller:

```
show ap dot11 24 cleanair config
```

High Availability

With the WLC5760 first release, an AP can be configured with primary, secondary, and tertiary controllers. When the primary controller fails, depending upon the number of APs managed by a controller, the access point fails over to the secondary controller. Once it detects that the primary controller is unavailable, the AP rediscovers the controller and reestablishes the CAPWAP tunnel to the secondary controller. Additionally, the client must reauthenticate with the AP. Figure 16 illustrates the primary, secondary, tertiary controller redundancy.

Figure 16: WLC5760 High Availability

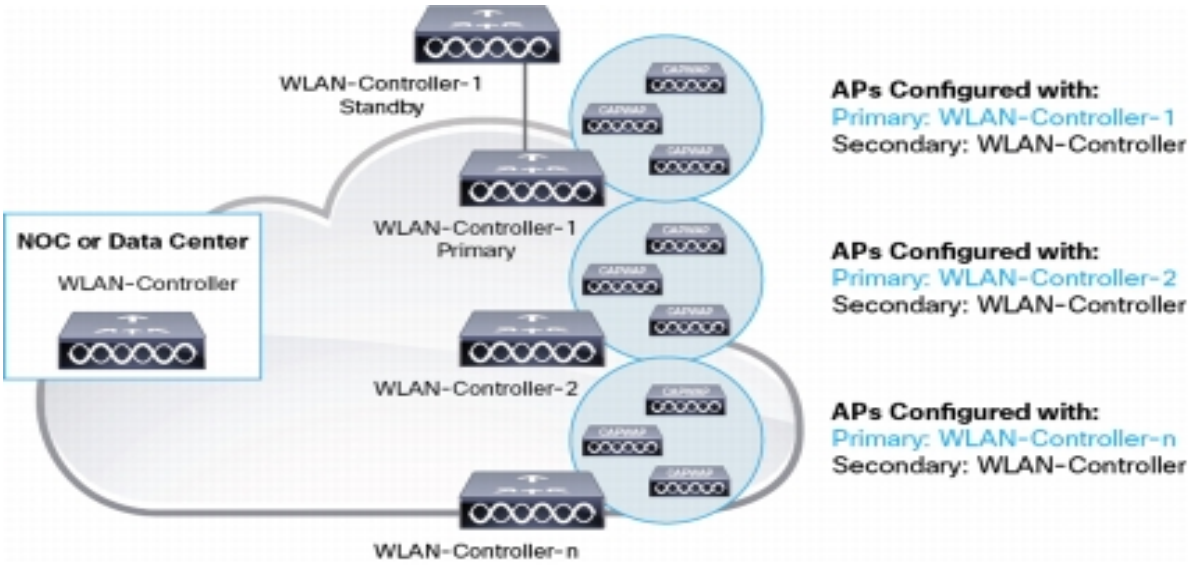


Note: In release 7.3 and later, the legacy WLC controllers support stateful switchover of access points (AP SSO). For additional information about the AP SSO high-availability functionality, refer to the High Availability (AP SSO) Deployment Guide.

N+1 Redundancy

The CT5760 supports N+1 redundancy where the controller is placed in the data center and acts as a backup for multiple WLCs. Each AP is configured with a WLC as the primary and all APs turn to the one redundant controller as secondary.

Figure 17: N+1 Redundancy



High Availability Configuration

```
#ap name apname controller ?
primary    Configures primary controller
secondary  Configures secondary controller
tertiary   Configures tertiary controller
```

Use this command in order to check the configuration:

```
#show ap name <ap-name> config general
```

In order to reduce the controller failure detection time, you can configure the heartbeat interval between the controller and the AP with a smaller timeout value.

```
#ap capwap timers heartbeat-timeout <1-30>
```

In addition to the option to configure primary, secondary, and tertiary controllers for a specific AP, you can also configure primary and secondary backup controllers for a specific controller. If there are no primary, secondary, or tertiary WLCs configured on the AP side, and a primary and/or secondary backup controller are configured on the controller side (downloaded to the AP), the primary and/or secondary backup controller are added to the primary discovery request message recipient list of the AP. In order to configure a primary backup controller for a specific controller, use this command:

```
(config)#ap capwap backup ?
primary    Configures primary Controller
secondary  Configures secondary Controller
```

Interface Group

Interface groups are logical groups of interfaces. Interface groups facilitate user configuration where the same interface group can be configured on multiple WLANs or while overriding a WLAN interface per AP group. An interface group can exclusively contain quarantine or nonquarantine interfaces. An interface can be part of multiple interface groups.

A WLAN can be associated with an interface or interface group. The interface group name and the interface name cannot be the same.

This feature also enables you to associate a client to specific subnets based on the foreign controller to which they are connected. The anchor controller WLAN can be configured to maintain a mapping between foreign controller MAC and a specific interface or interface group (foreign maps), as needed. If this mapping is not configured, clients on that foreign controller acquire VLANs associated from the interface group configured on the WLAN.

You can also configure AAA override for interface groups. This feature extends the current AP group and AAA override architecture where AP groups and AAA override can be configured to override the interface group WLAN to which the interface is mapped. This is accomplished with multiple interfaces using interface groups.

This feature enables network administrators to configure guest anchor restrictions where a wireless guest user at a foreign location can obtain an IP address from multiple subnets on the foreign location and controllers from within the same anchor controller.

Configuration of Interface Group

Use this command in order to create VLAN group on WLC:

```
vlan group word vlan-list 100-200
show vlan group
```

Use this command in order to map VLAN group to WLAN:

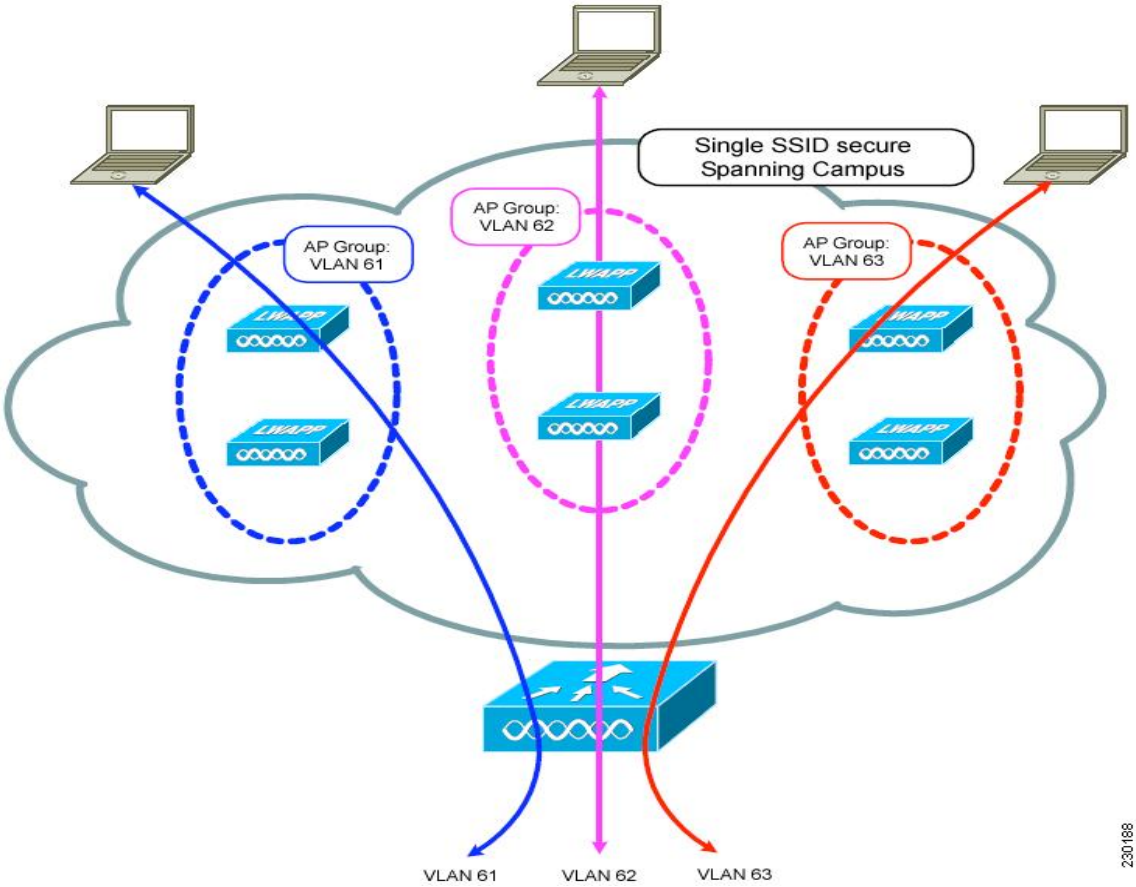
```
wlan corporate 1 corporate
client vlan word

show wlan summary
```

Configure AP Groups

Information about AP Groups

After you create up to 512 WLANs on the controller, you can selectively publish them (using AP groups) to different APs to improve the management of your wireless network. In a typical deployment, all users on a WLAN are mapped to a single interface on the controller. Therefore, all users associated with that WLAN are on the same subnet or VLAN. However, you can choose to distribute the load among several interfaces or to a group of users based on specific criteria such as individual departments (for example, Marketing) through the creation of *AP groups*. Additionally, these AP groups can be configured in separate VLANs to simplify network administration.

Figure 18: Access Point Groups



In Figure 18, three configured dynamic interfaces are mapped to three different VLANs (VLAN 61, VLAN 62, and VLAN 63). Three AP groups are defined, and each is a member of a different VLAN, but all are members of the same SSID. A client within the wireless SSID is assigned an IP address from the VLAN subnet of which its AP is a member. For example, any user that associates with an AP that is a member of AP group VLAN 61 is assigned an IP address from that subnet.

In the example shown in Figure 18, the controller internally treats roaming between APs as a Layer 3 roaming event. In this way, WLAN clients maintain their original IP addresses.

After all APs join the controller, you can create AP groups and assign up to 16 WLANs to each group. Each AP advertises only the enabled WLANs that belong to its AP group. The AP does not advertise disabled WLANs in its AP group or WLANs that belong to another group.

Use this command in order to create an AP Group Name:

```
ap group <WORD>
wlan <apgroup>
vlan < VLAN#>
```

This command maps an AP to an AP Group:

```
ap name <name> ap-groupname <apgroup>
AP will reload after the above command is executed
```

Multicast Configuration

Multicast Forwarding

The default for Multicast forwarding is disabled on the WLC5760 controller. You can enable support for (IPv4 or IPv6) multicast forwarding with this command:

```
(config)#wireless multicast
```

Internet Group Management Protocol (IGMP) Snooping must be enabled on the controller with this command:

```
(config)#ip igmp snooping
```

For IPv6, use this command:

```
(config)#ipv6 mld snooping
```

WLC to AP Forwarding Mode

As soon as multicast is enabled, multicast traffic can be forwarded to the APs. The controller encapsulates the received multicast packet into CAPWAP and then sends this packet to each individual AP. This mode is called Multicast Unicast (MCUC). Alternatively, the controller can encapsulate the multicast packet into another multicast packet, sent once. This mode is more efficient, because only one packet is created on the controller. This mode is called Multicast Multicast (MCMC). To use this mode, you must configure a multicast group on your controller. Each AP connected to the controller subscribes to this multicast group, and can receive the multicast flow. You can enable MCMC and configure the multicast group with this command:

```
(config)#wireless multicast
(config)#ap capwap multicast 239.3.3.3
```

You can revert to the default MCUC mode with the no form in this command:

```
(config)#no ap capwap multicast
```

Just like the legacy solution, multicast groups are created on a VLAN basis. For example, if your WLAN is mapped to VLAN 100, and if a client requests multicast traffic from that WLAN, the controller creates a multicast group identifier (MGID) which maps the multicast source, the multicast address, and the VLAN — in this example, VLAN 100. This is true regardless of the client VLAN in the WLAN.

Multicast VLAN Feature

This example creates two interfaces, and then an interface group maps the two VLANs together:

```
(config)#interface vlan 19
(config-if)#ip address 10.10.19.1 255.255.255.0
(config)#interface vlan 21
(config-if)#ip address 10.10.21.1 255.255.255.0
(config)#vlan group Group19to21 vlan-list 19,21
```

These commands create a WLAN, and map this WLAN to the VLAN group:

```
(config)#wlan open19 4 open19
(config-wlan)# client vlan Group19to21
(config-wlan)#
```

Use the IP Multicast VLAN command that maps multicast traffic to a specific VLAN:

```
(config-wlan)# ip multicast vlan 21
```

The controller uses the VLAN 21 interface to handle multicast traffic for that WLAN.

Note: Once multicast forwarding is configured on the controller, you must also configure your infrastructure for multicast support.

Note: WLC5760 uses IGMP v2. There is no option for the end user to change it.

Broadcast Forwarding

Similar to multicast forwarding, broadcast forwarding is disabled by default (broadcast packets received by the controller are not forwarded to wireless clients). Broadcast forwarding is enabled on a per VLAN basis. You can enable broadcast forwarding for a specific VLAN with this general command:

```
(config)#wireless broadcast vlan 21
```

You can also enable broadcast forwarding for all VLANs, if you do not identify a specific VLAN:

```
(config)#wireless broadcast
```

Then, you can restrict the command by disabling broadcast forwarding for some VLANs:

```
(config)#no wireless broadcast vlan 20
```

Configuration Verification

You can verify multicast in a number of ways. From the controller component, you can display the multicast status, **ap multicast** mode, and each VLAN's broadcast/non-ip multicast status:

```
#show wireless multicast
```

You can display all (S, G, and V) and the corresponding MGID value:

```
#show wireless multicast group summary
```

```
#show ip igmp snooping
```

```
# show ip igmp snooping wireless mgid
```

All of these commands are also available for IPv6 MLD monitoring. You must use the **ipv6** keyword instead of **ip**, and **mld** instead of **igmp**:

```
show ipv6 mld snooping, show ipv6 mld snooping wireless mgid
```

You can also see all the multicast groups and their active interfaces:

```
#show ip igmp groups
```

In order to see which IGMP version is used and the port associated to the group, use this command:

```
#show ip igmp snooping groups
```

Installing and Upgrading Software Image on a CT5760

1. **Copy the new image from a USB memory to flash**

```
Controller#copy usbflash0:/ ct5760-ipservicesk9.SSA.03.07.97.EMD.150-7.97.EMD.bin
flash:
Destination filename [ct5760-ipservicesk9.SSA.03.07.97.EMD.150-7.97.EMD.bin]?
Copy in progress...CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
266151060 bytes copied in 36.030 secs (7386929 bytes/sec)
Controller#
```

2. **Expand your bundled image from flash by using CLI below for the *first install only*. If this is not the first install, see Step 5.**

```
Controller#software expand file flash:ct5760-ipservicesk9.SSA.03.07.97.EMD.150-
7.97.EMD.bin verbose

Preparing expand operation
[1]: Expanding bundle flash:ct5760-ipservicesk9.SSA.03.07.97.EMD.150-7.97.EMD.bin
[1]: Copying package files
[1]: Package files copied
[1]: Finished expanding bundle flash:ct5760-ipservicesk9.SSA.03.07.97.EMD.150-
7.97.EMD.bin
```

3. **Verify the expanded files from flash:**

```
Controller#dir flash:
Directory of flash:/
```

```
311309  -rw-   266151060  Mar 31 2010 05:58:22 +00:00  ct5760-
ipservicesk9.SSA.03.07.97.EMD.150-7.97.EMD.bin
360451  -rw-    96724320  Mar 31 2010 06:00:19 +00:00  ct5760-
base.SSA.03.07.97.EMD.pkg
360452  -rw-     1292972  Mar 31 2010 06:00:25 +00:00  ct5760-
drivers.SSA.03.07.97.EMD.pkg
360453  -rw-    53521356  Mar 31 2010 06:00:21 +00:00  ct5760-
infra.SSA.03.07.97.EMD.pkg
360454  -rw-    43506528  Mar 31 2010 06:00:23 +00:00  ct5760-iosd-
ipservicesk9.SSA.150-7.97.EMD.pkg
360455  -rw-    20646616  Mar 31 2010 06:00:22 +00:00  ct5760-
platform.SSA.03.07.97.EMD.pkg
360456  -rw-    50455240  Mar 31 2010 06:00:25 +00:00  ct5760-
wcm.SSA.03.07.97.EMD.pkg
360450  -rw-        1208 Mar 31 2010 06:00:36 +00:00  packages.conf
```

4. **Configure boot from flash:**

```
Controller#conf t
Controller(config)#boot system flash:packages.conf
Controller(config)#end
Controller#
```

5. **For future upgrades, enter these commands:**

```
software install file flash:ct5760-ipservicesk9.SSA.03.08.58.EMP.150-
8.58.EMP3.bin verbose

Preparing install operation ...
[1]: Starting install operation
[1]: Expanding bundle flash:ct5760-ipservicesk9.SSA.03.08.58.EMP.150-
8.58.EMP3.bin
[1]: Copying package files
[1]: Package files copied
[1]: Finished expanding bundle flash:ct5760-ipservicesk9.SSA.03.08.58.EMP.150-
8.58.EMP3.bin
[1]: Verifying and copying expanded package files to flash:
[1]: Verified and copied expanded package files to flash:
[1]: Starting compatibility checks
[1]: Finished compatibility checks
[1]: Starting application pre-installation processing
[1]: Finished application pre-installation processing
[1]: Old files list:
    Removed ct5760-base.SSA.03.08.58.EMP1.pkg
    Removed ct5760-drivers.SSA.03.08.58.EMP1.pkg
    Removed ct5760-infra.SSA.03.08.58.EMP1.pkg
    Removed ct5760-iosd-ipservicesk9.SSA.150-8.58.EMP1.pkg
    Removed ct5760-platform.SSA.03.08.58.EMP1.pkg
    Removed ct5760-wcm.SSA.03.08.58.EMP1.pkg
[1]: New files list:
    Added ct5760-base.SSA.03.08.58.EMP3.pkg
    Added ct5760-drivers.SSA.03.08.58.EMP3.pkg
    Added ct5760-infra.SSA.03.08.58.EMP3.pkg
    Added ct5760-iosd-ipservicesk9.SSA.150-8.58.EMP3.pkg
    Added ct5760-platform.SSA.03.08.58.EMP3.pkg
    Added ct5760-wcm.SSA.03.08.58.EMP3.pkg
[1]: Creating pending provisioning file
[1]: Finished installing software.  New software will load on reboot.
[1]: Committing provisioning file
[1]: Do you want to proceed with reload? [yes/no]:   yes
```

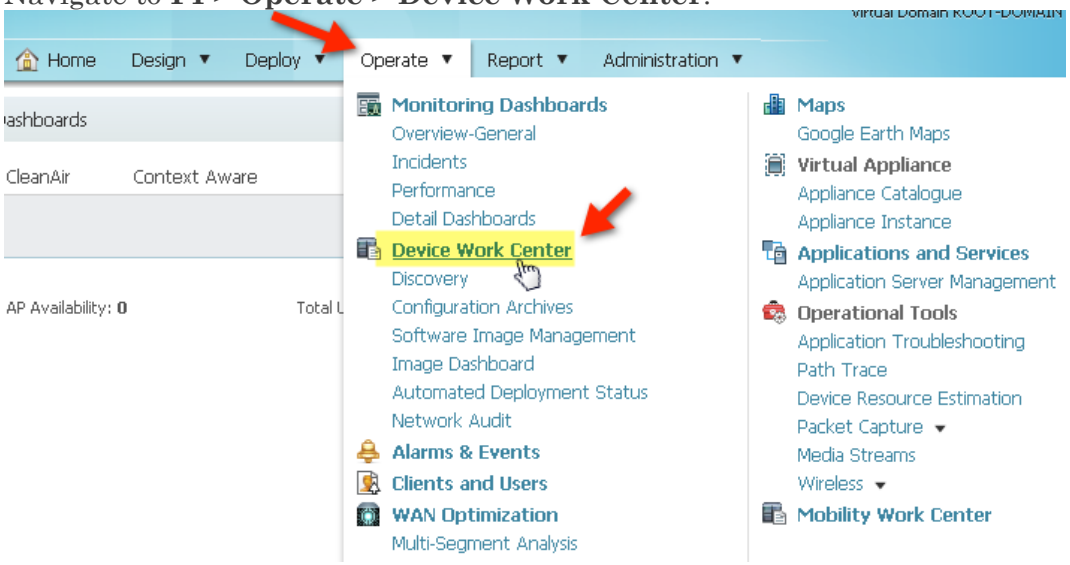
6. **Reset the system.**

Adding WLC to Prime

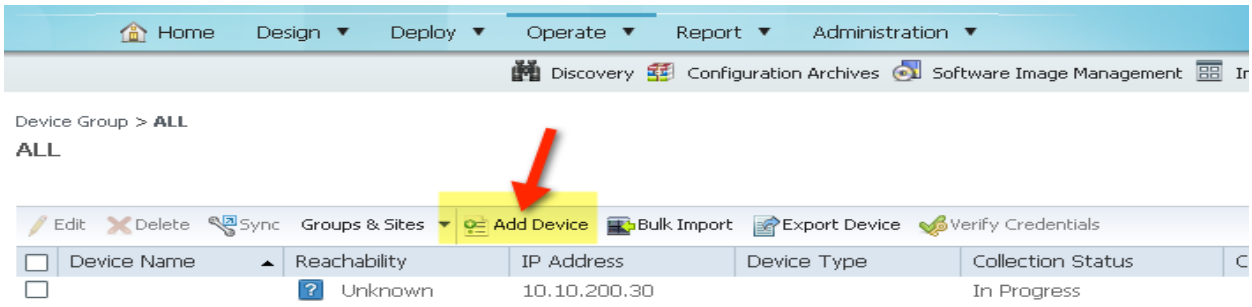
Complete these steps to add controllers:

1. Login to Cisco Prime.

2. Navigate to **PI > Operate > Device Work Center**.



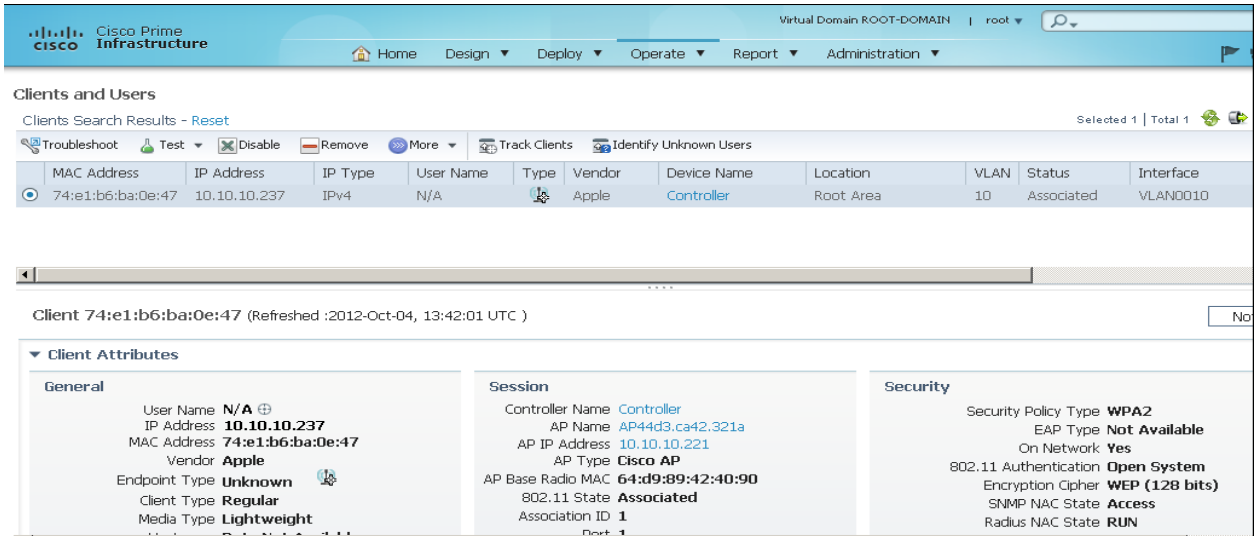
3. Click **Add Device**.



4. Enter CT5760 parameters:
   a. IP address – CT5760 mgt IP
   b. Read–Write SNMP string (private)
   c. Telnet credentials

5. Confirm Cisco Prime Infrastructure discovery of the CT5760 – if reachable and successful, status shows complete with the correct device type.

6. Explore Cisco Prime Infrastructure GUI in management of CT5760, for example, client statistics, details, reports, and so on.



Flexible Netflow

Cisco IOS® Flexible NetFlow is the next-generation in flow technology. It optimizes the network infrastructure, which reduces operation costs and improves capacity planning and security incident detection with increased flexibility and scalability. The ability to characterize IP traffic and identify its source, traffic destination, timing, and application information is critical for network availability, performance, and troubleshooting. When IP traffic flows are monitored, this increases the accuracy of capacity planning and ensures that resource allocation supports organizational goals. Flexible NetFlow helps you determine how to optimize resource usage, plan network capacity, and identify the optimal application layer for QoS. It plays a vital role in network security by the detection of Denial of Service (DoS) attacks and network-propagated worms.

Here are the commands in order to configure Flexible Netflow:

```
!
flow record IPv4flow
 match ipv4 protocol
 match ipv4 source address
 match ipv4 destination address
 match flow direction
 collect counter bytes long
 collect counter packets long
 collect timestamp absolute first
 collect timestamp absolute last
!
!
flow exporter IPv4export-1
destination 10.1.1.6  (IP address of your Netflow Collector. It should be v9
netflow.
transport udp 2055
!
!
flow monitor IPv4flow (you can view the flows on the switch using CLI if netflow
Collector not available)
 description Monitor all IPv4 traffic
 exporter IPv4export-1
 cache timeout active 30
 record IPv4flow
!
```

Here are the Show Commands:

```
show flow monitor name monitor-name cache
show flow record
show flow-sampler
show flow monitor
```

QoS Configuration

The introduction of Cisco IOS® software on the WLC5760 controller brings a wide-range of wired/wireless QoS supports and capabilities:

- Consistent configuration CLI for both wired and wireless QoS through Modular QoS CLI
- Granular QoS policies per AP, SSID, radio, and client
- Fair bandwidth allocation across wireless clients on an AP
- Leverages proven Cisco IOS® and ASIC technology to provide line rate performance

Enabling QoS

Based on the Modular QoS CLI model, QoS is enabled by default on the WLC5760. Explicit marking of traffic is required in order to modify Class of Service (CoS) or Differentiated Services Code Point (DSCP) values for traffic from and to wired ports. Traffic from wireless to wireless ports or wireless to wired ports is considered untrusted. Though QoS is globally enabled if traffic passes through an SSID, it must be marked or trusted specifically, or all QoS values (DSCP, CoS) will be set to default (0).

Managing QoS

QoS policies on the WLC5760 are provisioned in a couple of ways.

- Via CLI
- Via AAA

The configuration examples herein demonstrate attachment of policies via CLI. AAA configuration of policies is shown later in this specific section. The QoS **policy name**, not the actual QoS policy, is passed from the AAA server to the WLC5760 platform. Due to this fact, the QoS policy configuration must be local to the platform regardless of which method is used to manage QoS on the platform.

Marking Models

The WLC5760 supports several marking models:

- Per-Port Marking (wired)
- Per-Client Marking (wireless)
- Per-SSID Marking (wireless)
- Per-VLAN Marking (wired)

From a unified policy standpoint, the Per-Port and Per-Client marking policy can be synonymous but applied to a different target (wireless client, physical client port). Each model is discussed herein.

Per-Port or Per-Client Marking

Similar to the Catalyst 4500, the Per-Port or Per-Client marking model matches VoIP on UDP/RTP ports 16384-32767. The signaling traffic is matched on SCCP ports (TCP 2000-2002), as well as on SIP ports (TCP/UDP 5060-5061). Transactional data traffic are matched on various ports. Unlike the Catalyst 3750-E examples, no explicit default class is required, because the implicit class default performs policy actions (such as marking or policing) on the WLC3850/5760.

```
!ACL configuration

ip access-list extended VOIP
 remark Voice
 permit udp any any range 16384 32767
ip access-list extended SIGNALING
 remark SCCP
 permit tcp any any range 2000 2002
 remark SIP
 permit tcp any any range 5060 5061
 permit udp any any range 5060 5061
ip access-list extended TRANSACTIONAL-DATA
 remark HTTPS
 permit tcp any any eq 443
remark ORACLE-SQL*NET
 permit tcp any any eq 1521
 permit udp any any eq 1521
 remark ORACLE
 permit tcp any any eq 1526
 permit udp any any eq 1526
 permit tcp any any eq 1575
 permit udp any any eq 1575
 permit tcp any any eq 1630
 permit udp any any eq 14002
 permit udp any any eq 14006
```

```
!Class-map configuration

class-map match-all VOIP
  match access-group name VOIP
class-map match-all SIGNALING
  match access-group name SIGNALING
class-map match-all TRANSACTIONAL-DATA
  match access-group name TRANSACTIONAL-DATA

!Per-Port or Per-Client Ingress Marking Policy-map Configuration

policy-map PER-PORT-MARKING
 class VOIP
   set dscp ef
 class SIGNALING
   set dscp cs3
 class TRANSACTIONAL-DATA
   set dscp af21
 class class-default
   set dscp default

!Policy attachment to interfaces

 !Wireless Clients associating to WLAN OPEN

wlan OPEN 2 OPEN
 band-select
 client vlan 3
 ip dhcp server 10.17.1.9
 load-balance
 no security wpa
 no security wpa akm dot1x
 no security wpa wpa2
 no security wpa wpa2 ciphers aes
 service-policy client input PER-PORT-MARKING
 session-timeout 1800
 no shutdown
```

Policing Models

Several policing models are available on the WLC5760.

- Per-Port Policing
- Per-Client Policing
- Per-SSID Policing

Policing is offered in a number of ways and can be used in a hierarchical fashion as will be shown in the instance of client-based policies. In this instance, a policer can be used bi-directionally to police a client's traffic as an aggregate, as well as specific traffic classes associated with the client, such as voice.

Here is an example of **FLAT** Per-Port or Per-Client Policing configuration:

```
!ACL configuration

ip access-list extended VOIP
 remark Voice
 permit udp any any range 16384 32767
ip access-list extended SIGNALING
 remark SCCP
 permit tcp any any range 2000 2002
 remark SIP
 permit tcp any any range 5060 5061
```

```
 permit udp any any range 5060 5061
ip access-list extended TRANSACTIONAL-DATA
 remark HTTPS
 permit tcp any any eq 443
 remark ORACLE-SQL*NET
 permit tcp any any eq 1521
 permit udp any any eq 1521
 remark ORACLE
 permit tcp any any eq 1526
 permit udp any any eq 1526
 permit tcp any any eq 1575
 permit udp any any eq 1575
 permit tcp any any eq 1630
 permit udp any any eq 14002
 permit udp any any eq 14006

!Class-map configuration

class-map match-all VOIP
  match access-group name VOIP
class-map match-all SIGNALING
  match access-group name SIGNALING
class-map match-all TRANSACTIONAL-DATA
  match access-group name TRANSACTIONAL-DATA

!Per-Port or Per-Client Ingress Policing Policy-map Configuration

policy-map PER-PORT-POLICING
 class VOIP
   set dscp ef
    police 128000    conform-action transmit     exceed-action drop
 class SIGNALING
   set dscp cs3
    police 32000    conform-action transmit     exceed-action drop
 class TRANSACTIONAL-DATA
   set dscp af21
 class class-default
   set dscp default

!Policy attachment to interfaces

!Wireless Clients associating to WLAN OPEN Policed bi-directionally

wlan OPEN 2 OPEN
 band-select
 client vlan 3
 ip dhcp server 10.17.1.9
 load-balance
 no security wpa
 no security wpa akm dot1x
 no security wpa wpa2
 no security wpa wpa2 ciphers aes
 service-policy client input PER-PORT-POLICING
 service-policy client output PER-PORT-POLICING
 session-timeout 1800
```

Here is an example of **Hierarchical** Per-Client Policing configuration:

```
!Wireless Client Policy-map Client Aggregate policed to 2Mbps, Voice as a subset to
128k, signaling 32k

policy-map AGG-POLICE
 class class-default
    police 2000000    conform-action transmit     exceed-action drop
   service-policy PER-PORT-POLICING

policy-map PER-PORT-POLICING
 class VOIP
```

```
   set dscp ef
    police 128000    conform-action transmit     exceed-action drop
 class SIGNALING
   set dscp cs3
    police 32000    conform-action transmit     exceed-action drop
 class TRANSACTIONAL-DATA
   set dscp af21
 class class-default
   set dscp default
```

Wireless Queuing

Wireless queuing by default provides a queuing policy. This policy is shown in the **show run** command and contains a static traffic class, which cannot be modified. This class is attached to multicast non-real-time traffic associated with the wireless port only. In order to enable the additional queues on egress of the wireless port, the static policy-map **port_child_policy** must be modified to include the three additional classes. Priority queuing is supported for two of the queues, while class-default makes up the rest of the queue.

Here is an example of egress wireless queuing policy:

```
policy-map port_child_policy
 class non-client-nrt-class
    bandwidth remaining ratio 7
 class RT1
    priority level 1
    police 6400000    conform-action transmit     exceed-action drop
 class RT2
    priority level 2
    police 19200000    conform-action transmit     exceed-action drop
 class class-default
    bandwidth remaining ratio 63
```

In this example, the policy limits as an aggregate the priority queues RT1 and RT2 to an aggregate policed rate as shown. The policy also provides the additional non-real-time classes with a bandwidth associated with the bandwidth remaining ratio command. This ratio of available bandwidth is provided to the non-client-nrt (or multicast and non-client non-real-time traffic queue) and class-default queues.

Wireless MultiMedia Configuration

Wireless MultiMedia (WMM) separates traffic types into four QoS access categories: background, best effort, video, and voice.

```
(config) wlan <your WLAN name>
(config-wlan) shutdown
(config-wlan) broadcast
(config-wlan) radio all (to enable this WLAN configuration on both AP radios  and
all Wi-Fi protocols)
(config-wlan) wmm require
(config-wlan) no security <your Current security setting>
(config-wlan) no shutdown
```

WMM configuration options include:

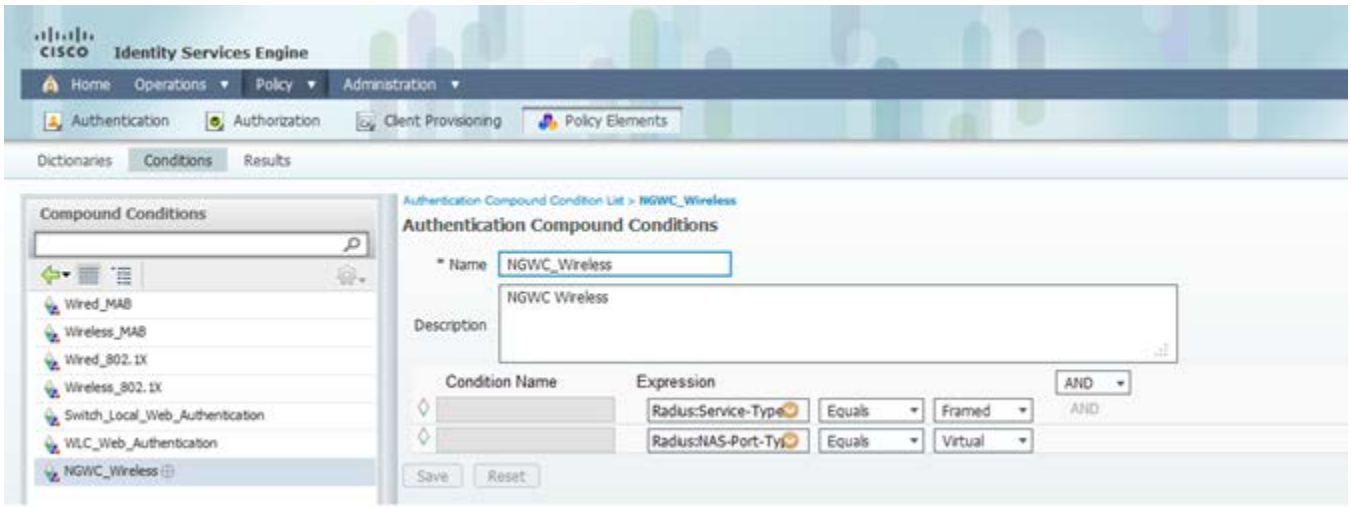
- WMM Required — only WMM enabled clients can join the WLAN
- WMM Optional — both non-WMM clients and WMM enabled client can join the WLAN
  - WMM enabled clients transmit all packets with WMM QoS header.

- Non-WMM clients transmit no packets with WMM QoS header.
  Note that non-WMM cannot receive packets from the AP that have a WMM QoS header.
- All packets from and to non-WMM clients are sent with best effort Wi-Fi channel access.

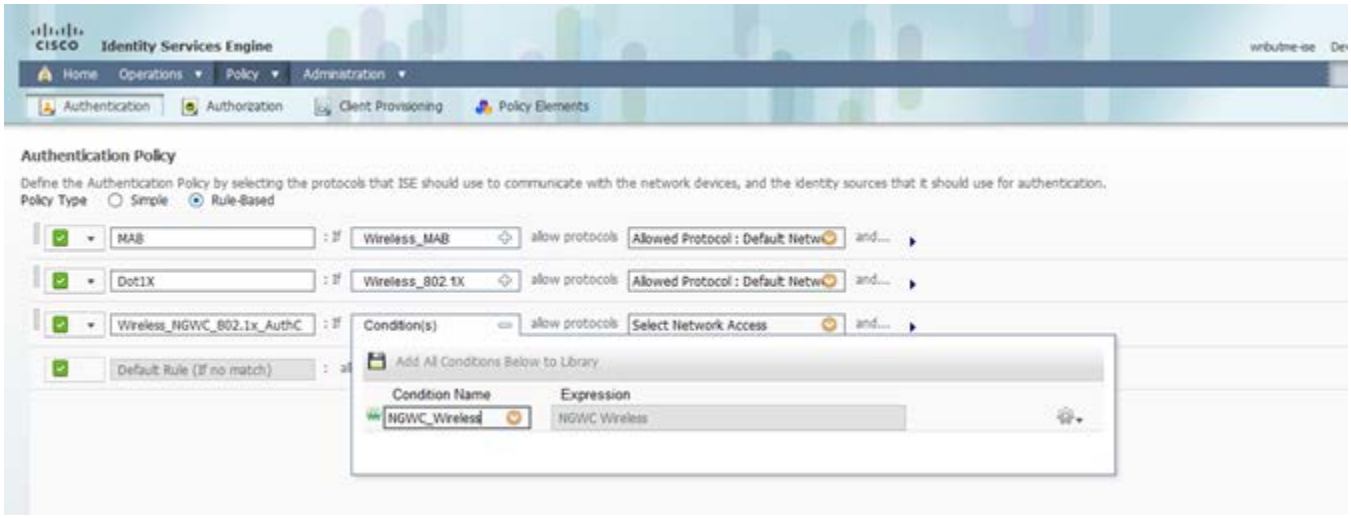
Configure ISE in order to Authenticate and Push QoS Policies

Complete these steps to authenticate and push QoS policies.

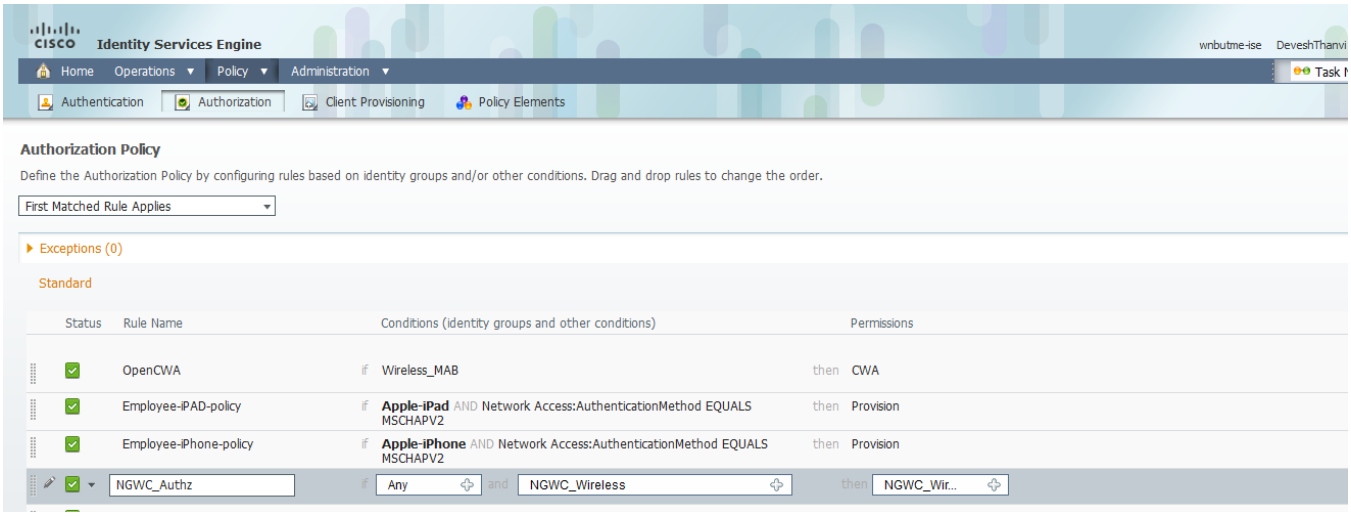
Step 1: Specify a condition where the expression is of NAS-Port-Type "Virtual."



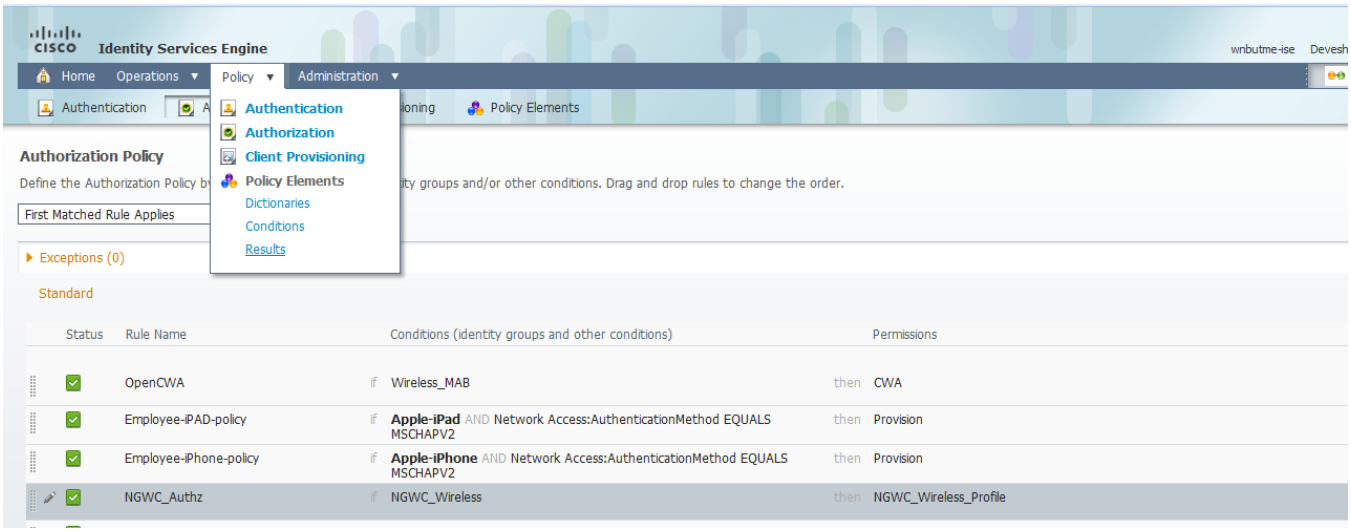
Step 2: Create authentication parameters.



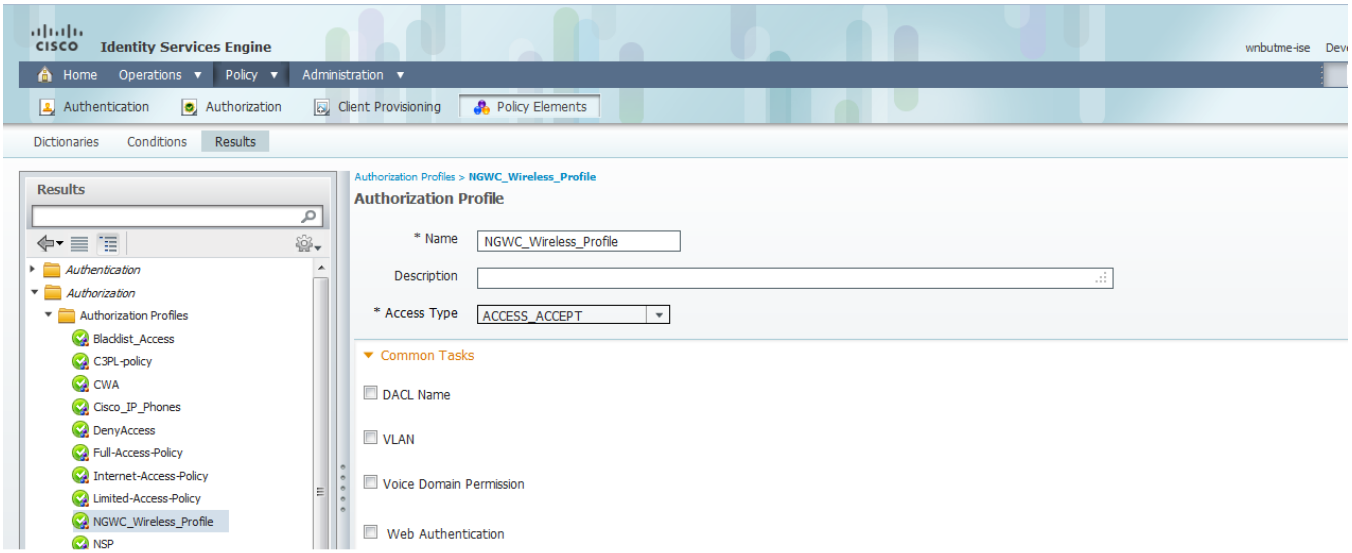
Step 3: Authorization - Define result and use same condition.



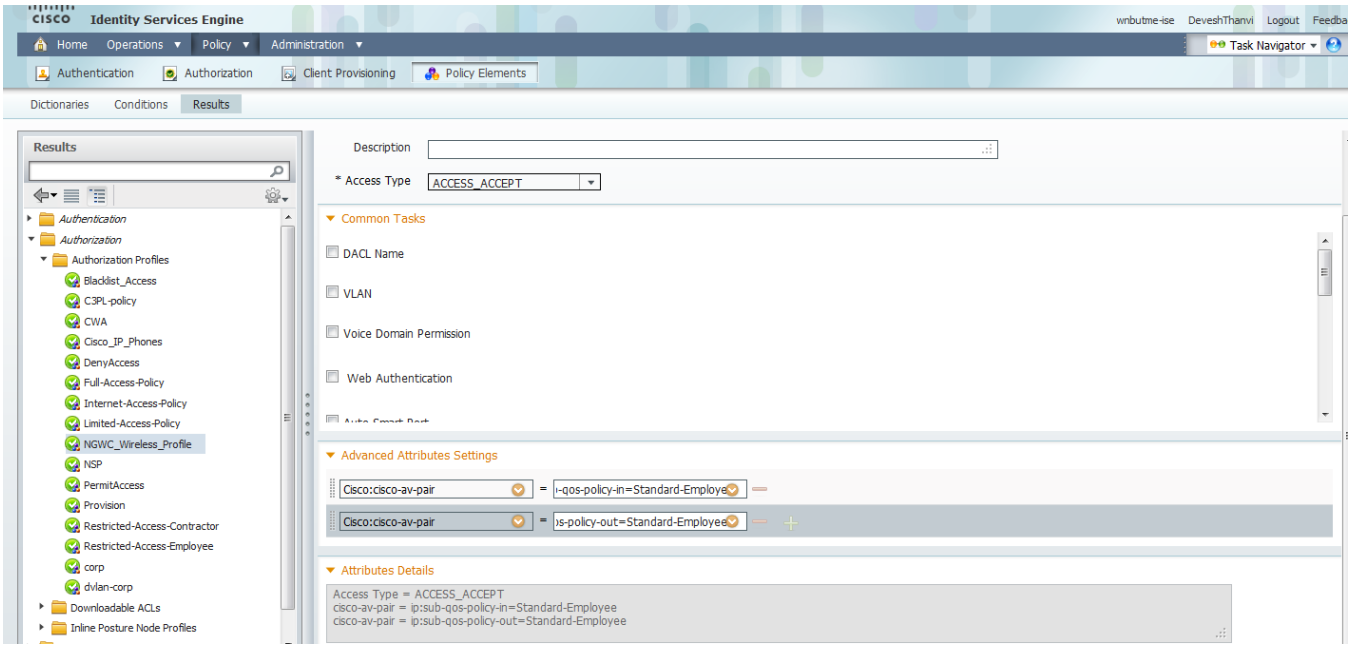
Step 4: Go to **Policy > Results**.



Step 5: Choose Cisco-AV-Pair at bottom shown in Step 6.



Step 6: Modify 'Advanced Attribute Settings' with the 'Cisco av-pair name', 'ip:sub-qos-policy-in', or 'ip:sub-qos-polify-out', plus name of QoS policy local to the WLC3850/5760. When clients are associated and authenticated, the policy name is pushed to the WLC3850/5760.



Cisco IOS® Tool Command Language Scripting

With the introduction of the Cisco IOS® software on the WLC5760 controller, users can now implement the Tool Command Language (TCL) scripting feature on the controller.

For additional details about TCL scripting features, see the Cisco IOS® Scripting with Tcl page on cisco.com.