



Cisco TechClub  
Webináře

# Design a vlastnosti moderních Wi-Fi6 sítí

802.11ax, RF ASIC, propustnost, způsob nasazení, migrace

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*Květen 2020*

# Agenda

- Úvod
  - Wi-Fi 6 – přehled, Cisco Next-Gen WLAN portfolio
- Design a vlastnosti Wi-Fi6 sítě – rádiová část
  - Nové 802.11ax vlastnosti – 1024 QAM, OFDMA, MU-MIMO, BSS Coloring, TWT
  - AP C9120/9130 – Dual-5GHz, Tri-radio (C9130), Cisco RF ASIC
  - Reálné testy propusnosti Wi-Fi 6 AP C91xx, HD design (20/40/80 MHz kanály)
- Design a vlastnosti Wi-Fi6 sítě – celkový pohled
  - Nasazení bezdrátových kontrolerů, vysoká dostupnost, zabezpečení (vč. WPA3), QoS
  - Dohled a analýza provozních parametrů Wi-Fi6 bezdrátové sítě v DNAC
- Migrace na Wi-Fi6
- Shrnutí

# Wi-Fi 6 / IEEE 802.11ax Experience: What is the big deal?



## Higher data rates

- 1024-QAM for up to 9.6 Gbps per radio and single-antenna speeds of 1.2 Gbps
- 8x8:8SS
- Enables next-generation 4K/8K and AR/VR video



## Increase in overall network capacity

- 3x to 4x more throughput than 802.11ac via OFDMA
- Up to 4x capacity gain in dense scenarios with BSS coloring
- Multiuser MIMO gains on all client types



## Reduced latency and greater reliability

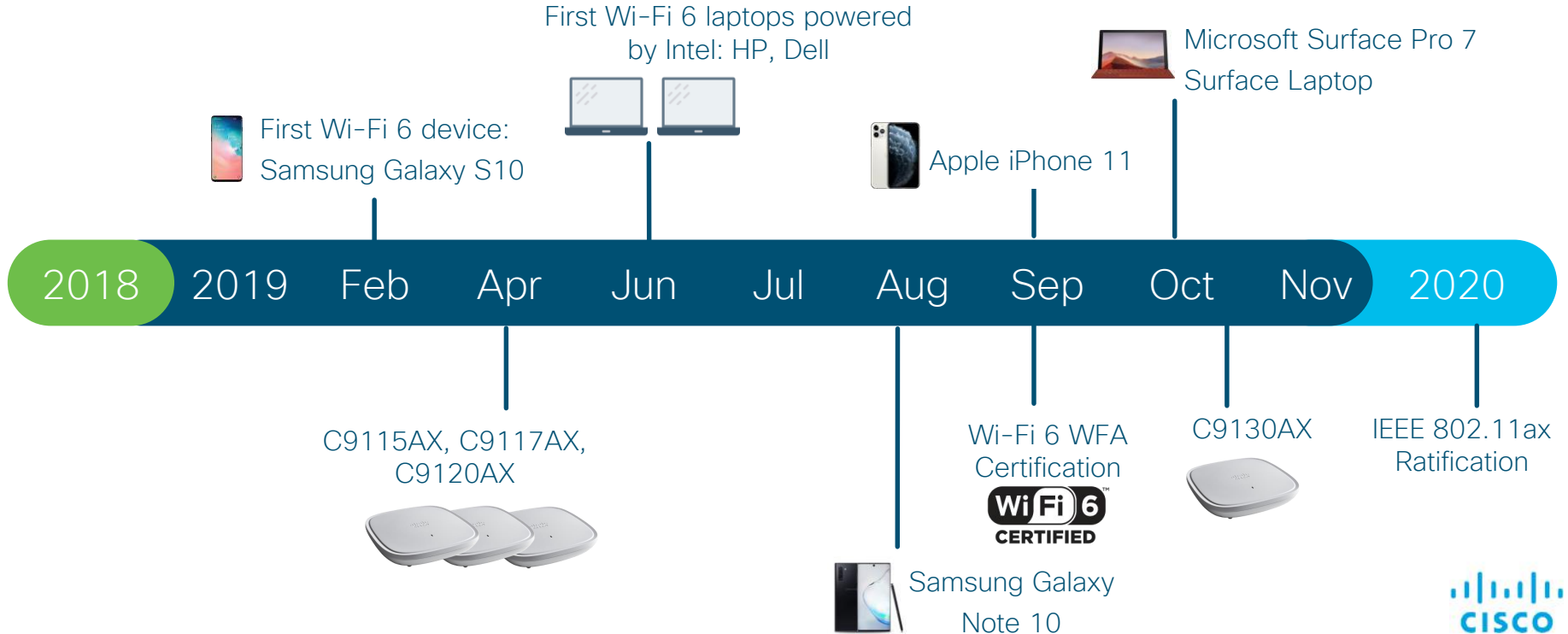
- Scheduled uplink and downlink OFDMA for deterministic “cellular-like” latency, reliability, and QoS
- Optimized for IoT scale with hundreds of devices per AP



## Improved power efficiency

- Up to 3x better battery life with Target Wake Time (TWT)
- New coding structure and signaling procedures for better transmit and receive efficiency

# Wi-Fi 6 is here and now



# Introducing Cisco's Next Gen Wireless Stack



## Cisco DNA Center

Translate business intent into network policy and capture actionable insights



## Cisco DNA Spaces

Digitize people, spaces and things



## Cisco Catalyst 9800 Wireless Controllers



## Cisco Catalyst 9100 Access Points



Resilient



Secure



Intelligent



300,000  
Wi-Fi 6 APs  
shipped



8,000  
units  
shipped



361M  
visitors



80,000  
devices managed  
by DNA Center

# Cisco TechClub Webinář

## *Nové Cisco portfolio pro bezdrátové sítě*

- Zákaznický TechClub WLAN webinář proběhl 18.2.2020
- Záznam a prezentace viz [https://www.cisco.com/c/m/cs\\_cz/training-events/webinars/tech-club-webinars/index.html](https://www.cisco.com/c/m/cs_cz/training-events/webinars/tech-club-webinars/index.html)

CISCO Engage

Cisco Tech Club Webináře

On-line každých 14 dní



### Agenda

- Úvod, trendy v bezdrátových sítích
  - Intent-based Networking, Cisco Next-Gen Wireless Stack, Wi-Fi 6 / 802.11ax, WPA3
- Cisco Next-Generation Wireless Stack
  - WLAN klienti - partnerství s výrobci koncových zařízení, Samsung Analytics
  - Cisco AP C9100, Cisco WLC C9800
  - Cisco Prime Infrastructure, Cisco DNA Center, Cisco DNA Spaces
- Vybrané technické detaily
  - Postupná migrace z AireOS (WLC5520/3504/5508) na IOS-XE (C9800)
  - Doporučené verze AireOS / IOS-XE, PI / DNAC, DNA Spaces
- Shrnutí

# Design a vlastnosti Wi-Fi6 sítě – rádiová část

# Wi-Fi 6 Higher data rates – up to 1024 QAM

Getting the most benefit per transmission –

- Four things determine Air time efficiency

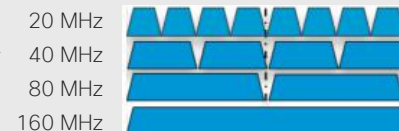
1. **Data rate (Modulation density) or QAM** – (how many Bit's per Radio Symbol) 64 QAM is more robust but 1024 QAM is a lot faster
2. **Number of spatial streams and spatial reuse** (introduction of OFDMA and Resource Units) and UL/DL MU-MIMO
3. **Channel bandwidth** – How Many frequencies can we modulate at one time
4. **Protocol overhead** – Preamble/Ack/BA, Guard Interval “GI” etc.



## Modulation density gains



## Wi-Fi channel width

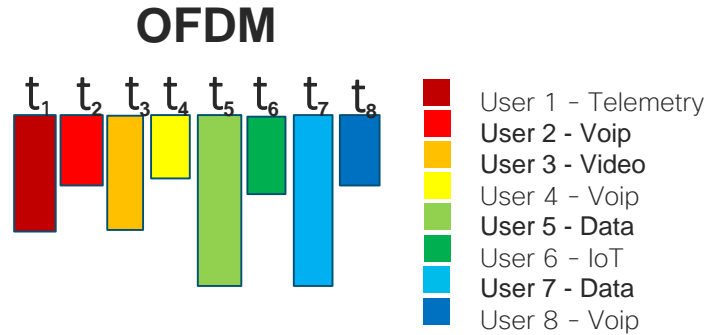


Note: Channel Bonding reduces range as the power is spread out with each additional 20 MHz adding a 3 dB penalty in SNR and the greater the QAM the harder it is for the receiver to decode therefore it is more sensitive to noise.

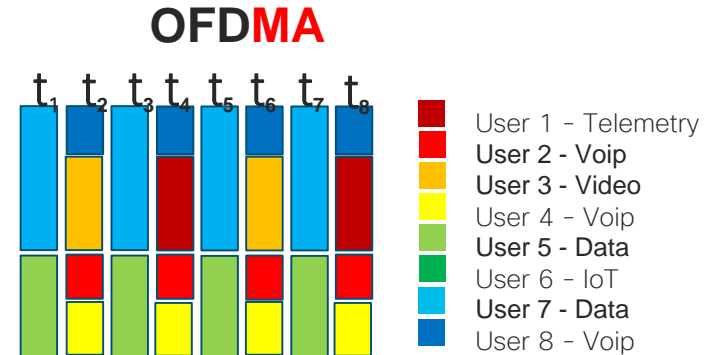


# Wi-Fi 6 OFDMA – Using subcarriers more efficiently

Maximizing Client Count – Lowering Latency



- Each User gets 1 time slot – and uses the whole channel bandwidth
- In this example with 8 users, each User will wait  $t_8$  before Next Tx\_op (Assuming no QoS)
- As more clients Join the cell, Latency –and Jitter Increases



- Multi user Packet makes flight more efficient
- Much more regular and consistent TX\_op
- Deterministic nature –
- Multiplexing Users onto Single frames, reduces overhead, and Latency

Each subcarrier is a transport – Latency goes up when subcarriers go out “half empty” ... OFDMA solves this by allowing multi-user packets to go out on one subcarrier

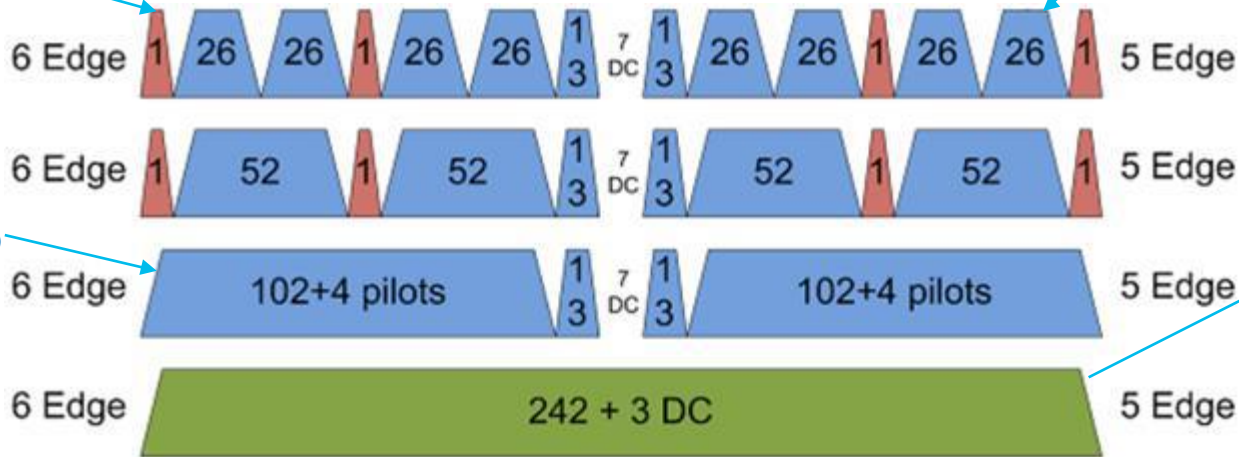
# Understanding OFDMA Resource Units

Each RU can be a different modulation scheme or coding rate determined by control information, scheduling etc.

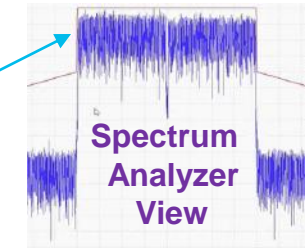
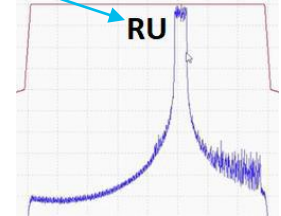
Up to 9 users per 20 MHz  
Tiny RUs ideal for IoT

RU's are indexed

## 20 MHz Channel RUs



Min. RU size For MU-MIMO



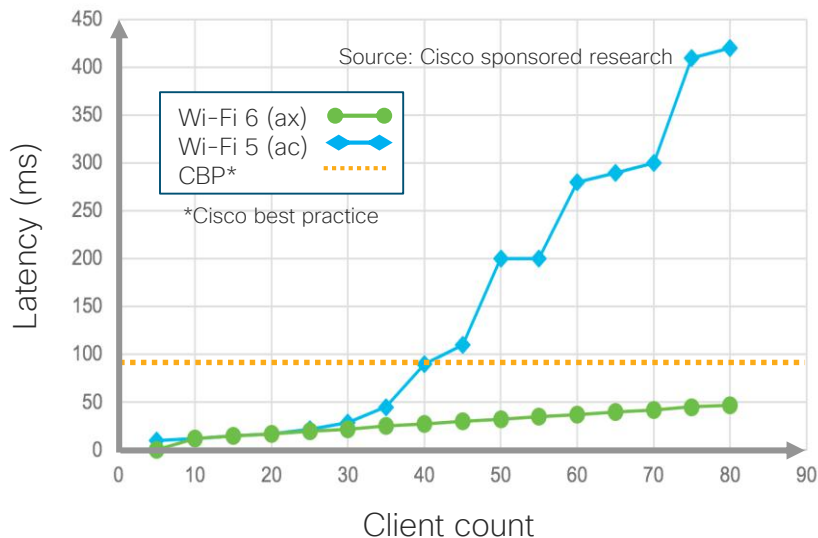
20 MHz

<http://www.ni.com/white-paper/53150/en/>

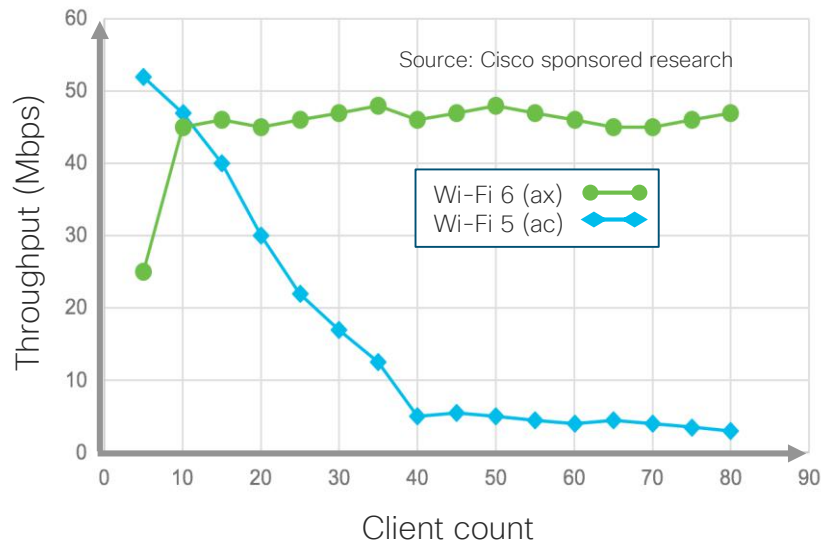
# Wi-Fi 6 OFDMA provides determinism at scale

Enabling high-quality voice/video/data services cost effectively

## Linear VOICE delay



## Consistent DATA throughput



Wi-Fi 6 is not only cost-effective and ubiquitous but is now capable of delivering SLAs



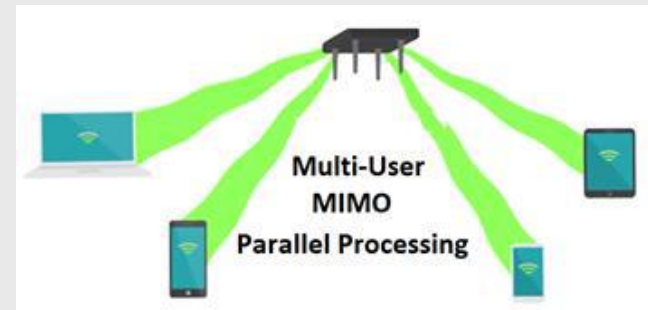
# Wi-Fi 6 enhancements to Multi-User MIMO

## OFDMA changes the game

- Up to 8 MU-MIMO transmissions (Concurrent users in a group) for any RU 106 or larger
- MU Station UL and DL CSI/ACKs/CTS processed in parallel – **Efficient Leveraging new UL-MU MIMO analogue requirements**
- AP maintains a channel matrix for each station and simultaneously beam steers to different clusters of users (managing users as groups)
- Each MU-MIMO client transmission can have different MCS rate
- Larger RU frames 106 and above are used for MU-MIMO
- MU and SU-MIMO is decided by AP w/MU- being favored for larger packets

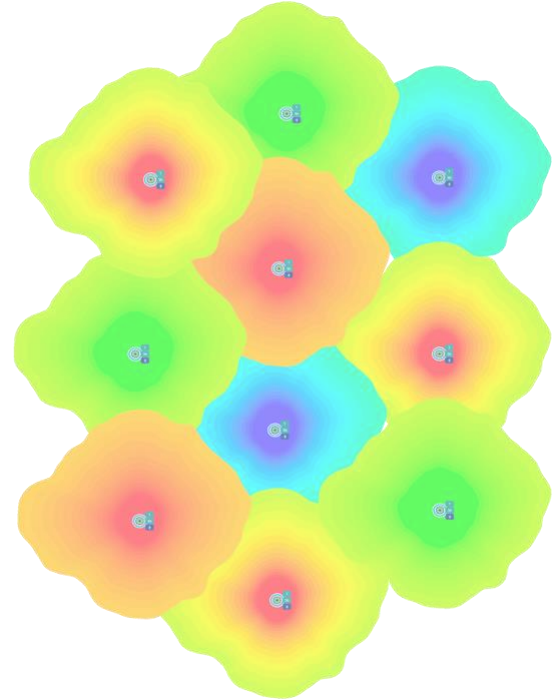


Wi-Fi 6 drives Performance into the clients



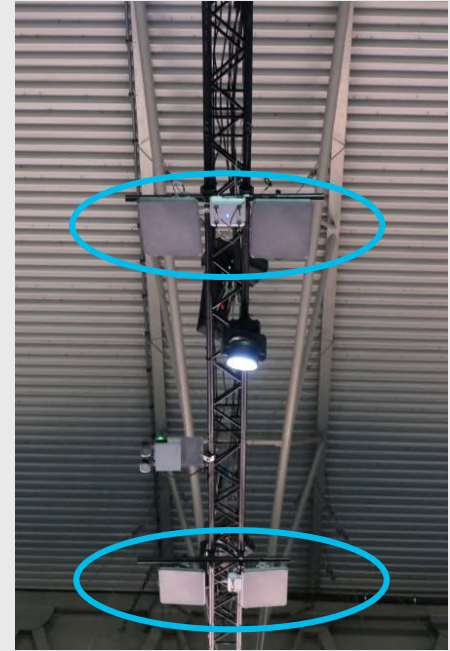
# Wi-Fi 6 BSS Coloring

- Wi-Fi 6 BSS Coloring provides a framework for discovering and measuring Spatial Reuse (SR) opportunities
- Spatial Reuse benefits Wi-Fi by providing
  - Increased throughput and airtime efficiency/less interference
  - Supports better High Client Density designs
- Better ground level neighbor information, less CCI through RRM



# Spatial reuse today – Prior to Wi-Fi 6

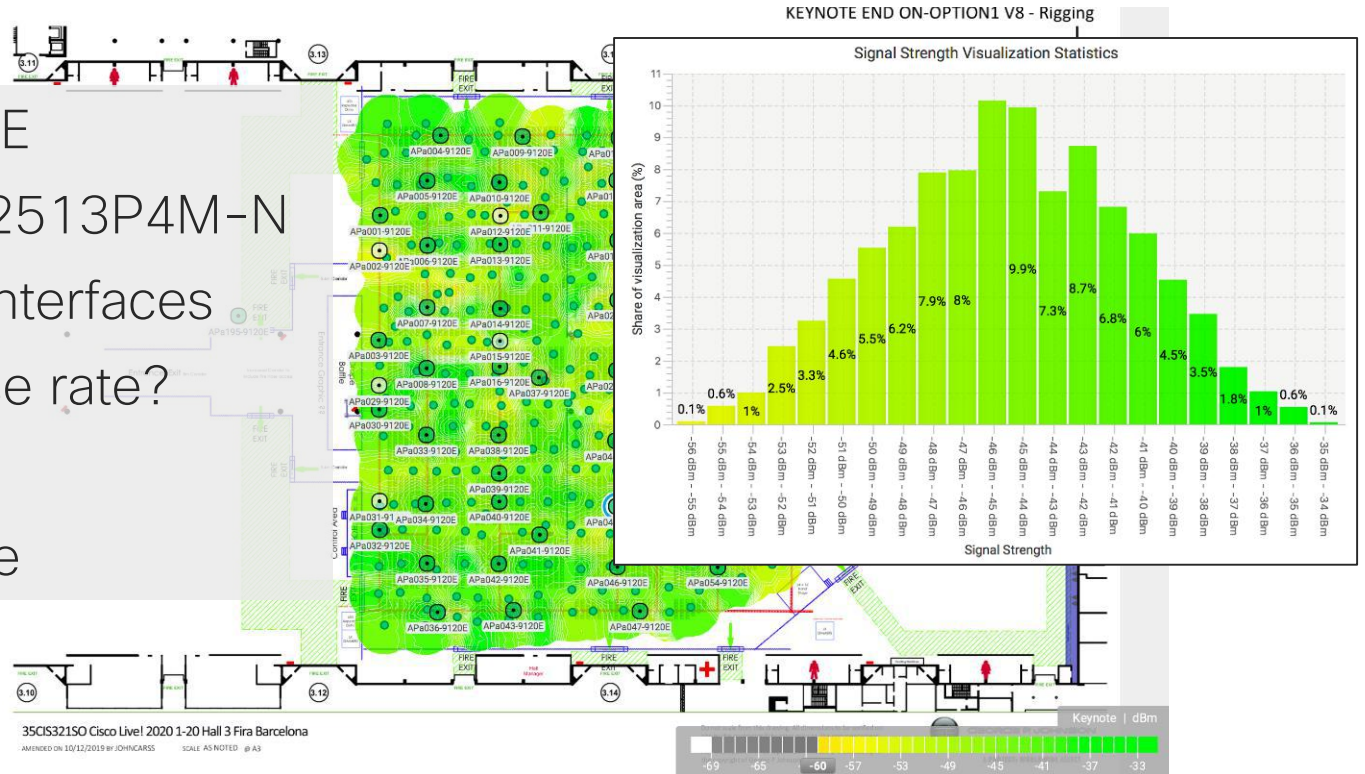
- Today, any other Wi-Fi station above -82 dBm is busy and must defer (back off)
  - LBT – Listen Before Talk
- CCA (Clear Channel Assessment) is generally a 4 dB range (-78 to -82) and adjusted with the noise floor
- This range has been overly cautious due to fears of co-channel interference which can and does impact overall capacity if not designed correctly
- In high client density implementations, we often design for -60 dBm cell edges to maintain SNR in very *noisy* environments
- A lot of expensive hardware (antennas, design) is used to isolate one cell from another on the same channel and maintain capacity and throughput



# CiscoLive EU Opening Keynote 1/27/2020

## Catalyst Powered with C9120AX-E

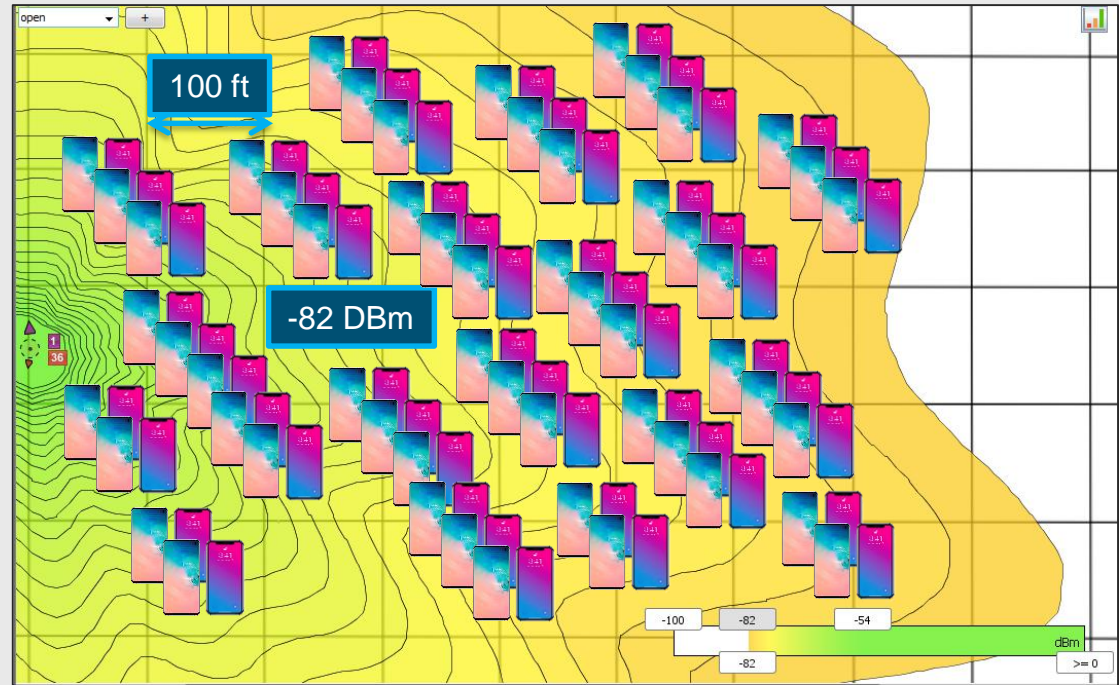
- 61 C9120AX-E
- 122 AIR-ANT2513P4M-N
- 122 x 5 GHz Interfaces
- Channel re-use rate?
  - N=6.4
- Spatial Re-Use



# 802.11 contention mechanism – Listen Before Talk (LBT) and the contention zone

- Using 10 dBm Tx power
  - Cutoff -82 dBm

See the 2019 Wireless  
High density client density  
design guide  
<https://cs.co/9001D47PT>

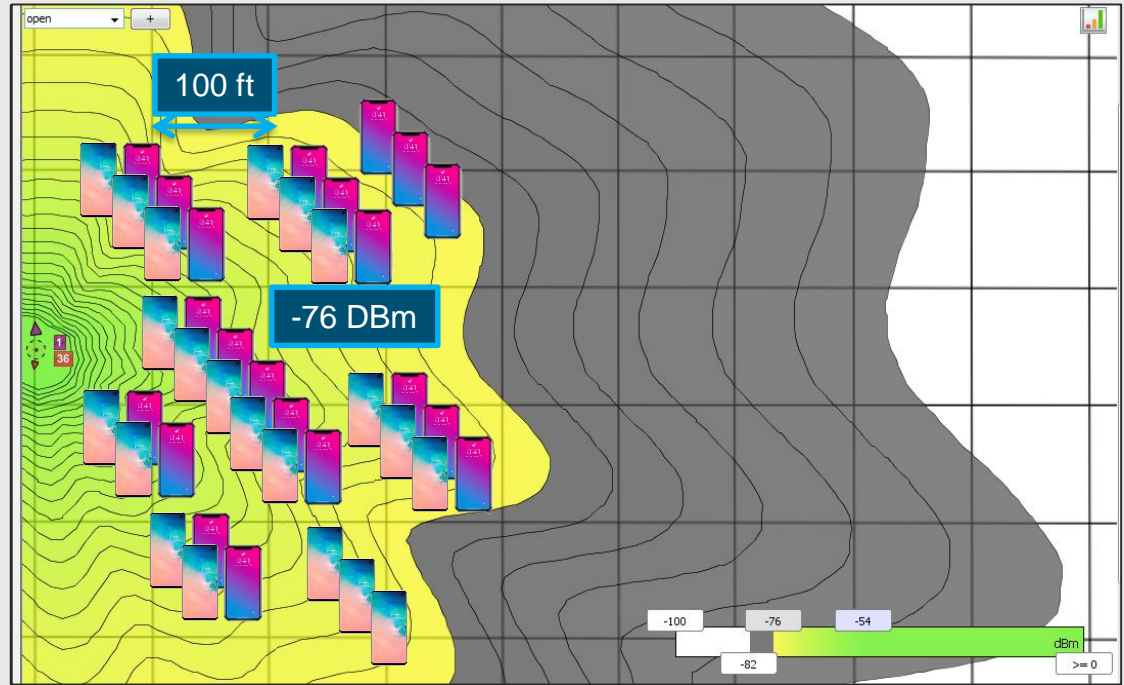




# 802.11 contention mechanism – Listen Before Talk (LBT) and the contention zone

- Using 10 dBm Tx power
  - Cutoff -82 dBm
  - Cutoff -76 dBm

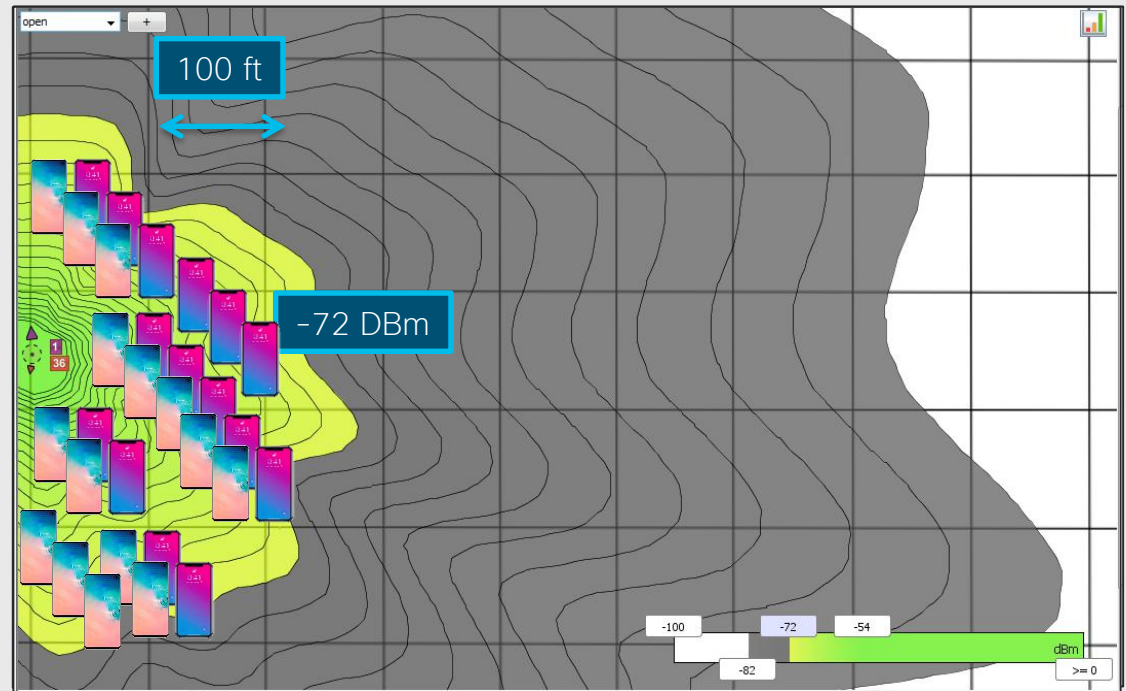
See the 2019 Wireless  
High density client density  
design guide  
<https://cs.co/9001D47PT>



# 802.11 contention mechanism – Listen Before Talk (LBT) and the contention zone

- Using 10 dBm Tx power
  - Cutoff -82 dBm
  - Cutoff -76 dBm
  - Cutoff -72 dBm
- Managed today using:
- High gain directional antenna's
- RX-SOP (changing the start of packet threshold)
- Data rates in use

See the 2019 Wireless  
High density client density  
design guide  
<https://cs.co/9001D47PT>

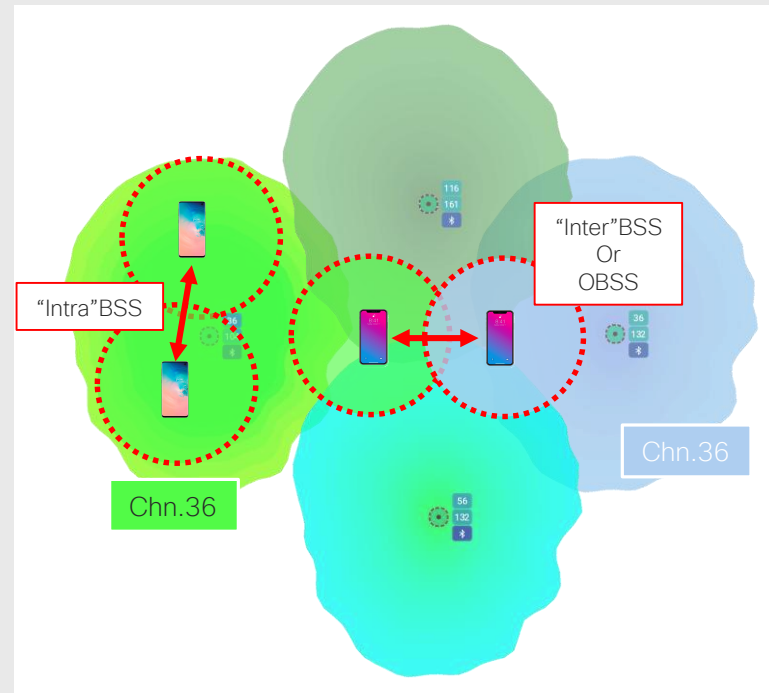


# Wi-Fi 6 BSS Coloring – Spatial Reuse – Basic service set “BSS” and the overlapping basic service set “OBSS”

- All clients associated on a given AP are operating within the same BSS and will operate on the same BSS color (regardless of the SSID)
- Stations operating on a different AP, may have the same SSID and channel – but will be assigned a different color than mine.
- Each user (station) learns its BSS’s color upon association
- Stations detecting the same BSS color (intra-BSS) operate at the default (PD) CCA -82 dBm
- Stations detecting a different BSS color (Inter-BSS) \*may be able to use a higher CCA threshold (lower contention i.e -81 to -62 dBm) through \*\*OBSS-PD and re-use lost space

Every Client becomes a sensor reporting what they can hear from the floor – in realtime

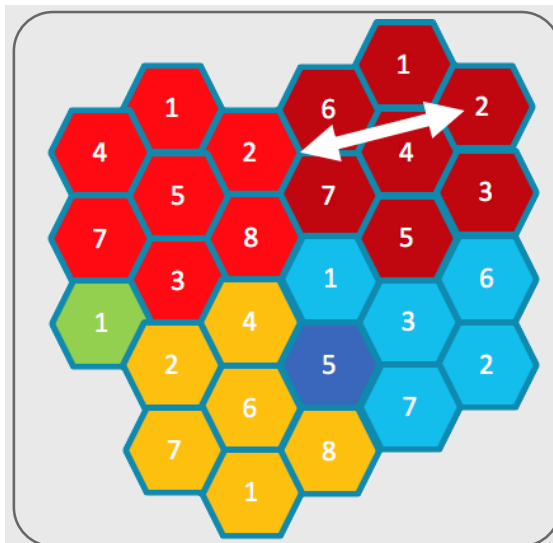
- \*RRM will make the determination and assignment
- \*\*OBSS-PD Overlapping BSS – Packet Detection



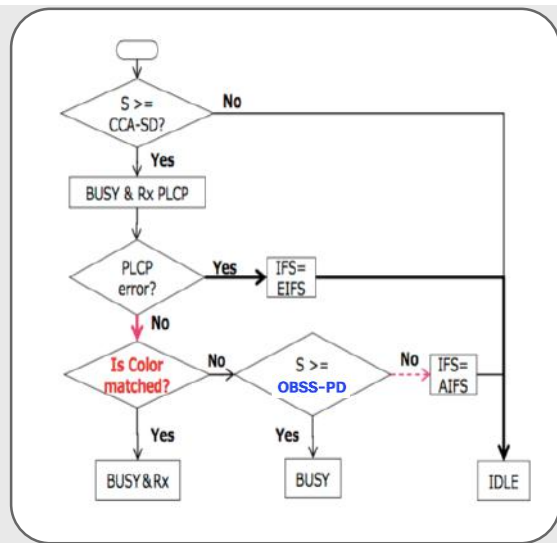
# BSS-Color and RRM

## RRM Manages Color's

- Automated RRM Color assignment
- Identifying SR (Spatial Reuse) opportunities
- Analyze and exploit future SRs



Same channel BSS only blocked on the color match



Channel access rules

# Wi-Fi 6 - Target Wake Time

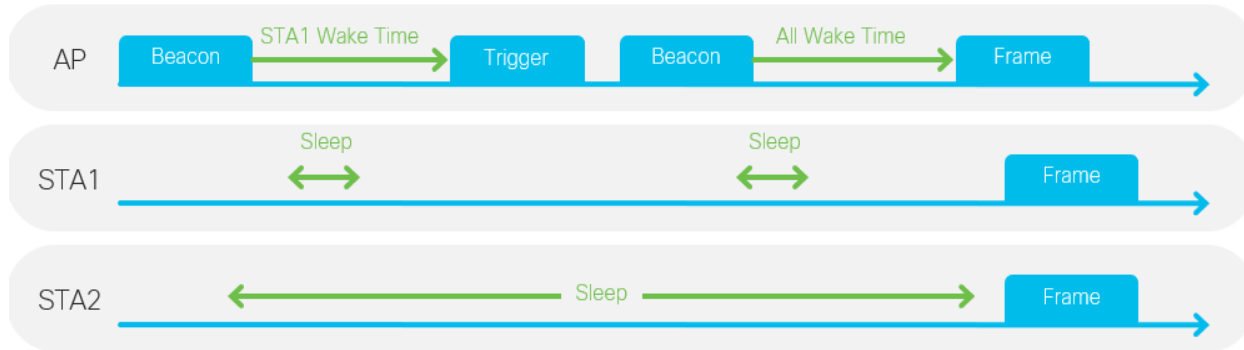
Better Battery Life and co-existence via RF efficiency improvements



## Target Wake Time

With Target Wake Time (TWT), the AP can schedule phones and IoT devices sleep for long durations (up to 5 years) and then wake the individual device up.

Devices can be configured to wake up as a group to communicate at the same time sharing the channel for increased network capacity and reduced battery drain.



**Same Scaling as 802.11ah, 11ax allows STAs to sleep longer minutes, hours or maybe even days (in theory up to 5 years).**

Image source: Broadcom

# New Cisco Catalyst 9100 Series Access Points

Best in Class Wi-Fi 6 technology

Ideal for small to medium deployments

Mission critical

Best in Class



Powered by Cisco RF ASIC



## 9115AX

- 4x4 + 4x4
- MU-MIMO, OFDMA
- 1 x 2.5 mGig
- Spectrum Intelligence



## 9117AX

- 8x8 + 4x4
- MU-MIMO, OFDMA (only DL)
- 1 x 5 mGig
- Spectrum intelligence
- Integrated Antenna only



## 9120AX

- 4x4 + 4x4
- MU-MIMO, OFDMA
- 1 x 2.5 mGig
- Cisco RF ASIC for Next gen CleanAir
- Dual 5GHz, Next Gen HDX
- RF L1 details
- IoT ready (Zigbee)
- Application Hosting



NEW

## 9130AX

- 8x8 + 4x4 or 4x4 + 4x4 + 4x4
- MU-MIMO, OFDMA
- 1 x 5 mGig
- Cisco RF ASIC for Next gen CleanAir
- Tri-radio: Dual 5GHz + 2.4GHz
- RF L1 details
- IoT ready (Zigbee)
- Application Hosting
- Full iCap with data packets
- First 8x8 AP with external antennas

Cisco DNA Assurance with  
iCAP

Bluetooth 5

USB

Integrated or external  
antenna SKUs

# Why Dual 5 GHz and FRA\*?

## AP C9120 and C9130

- **PROBLEM:** You designed a network for dense 5 GHz coverage, now you have too many 2.4 GHz radios (2.4 GHz range is approx. 1.5x farther)
- Prior to dual 5 GHz/FRA your only option was to disable these radios.
- Disabling the radio provides no value other than making the 2.4 GHz spectrum manageable. → you effectively wasted 1/2 the functionality of the Access Point crippling it to 5 GHz only.

**BENEFIT of Dual 5 GHz/FRA: allows the AP to run at 100%, increasing network capacity & performance**

### Dual Band

5GHz  
Serving



2.4GHz  
Serving

- Pervasive 2.4 GHz and 5 GHz coverage (default mode)

### Dual 5GHz

5GHz  
Serving



5GHz  
Serving

- High Density Client Performance improvements
- Maximum over the air data rate up to 5.2 Gbps

# Tri-Radio for scale and capacity

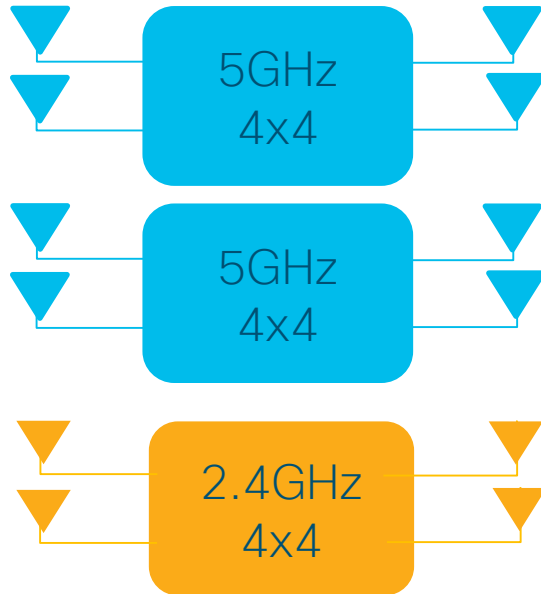
## AP C9130



Cisco RF ASIC  
Cisco IOT Radio

### Why Tri-Radio?

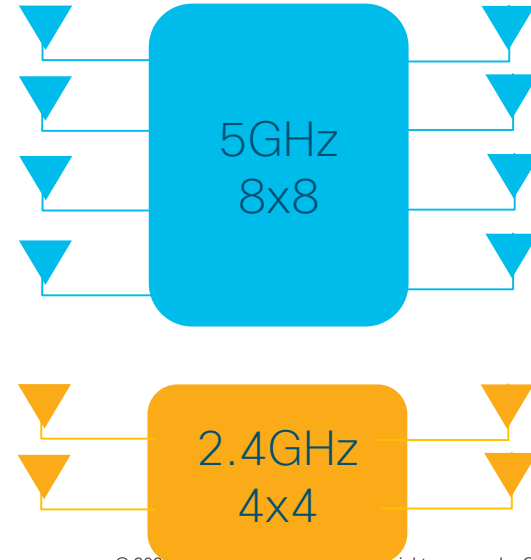
- ✓ 2 radios are better than 1, 3 is the best!
- ✓ More clients, greater performance across all Wi-Fi clients



→  
Software  
enabled  
←

### Why 8x8?

- ✓ Higher throughput from a single radio
- ✓ Performance gains in a majority MU-MIMO client environment
- ✓ Better data-rate vs Range - better MRC





# C9120 and 9130 APs powered by Cisco RF ASIC

Embedded with superior analytics and security for mission critical deployments

Custom ASIC-based Software Defined Radio module  
For Full time Wireless Monitoring and Analytics.



Cisco RF ASIC



Dual Filter DFS	Clean Air	Off-channel RRM	FastLocate w/o Performance Impact	aWIPS/ Rogue Detection
<ul style="list-style-type: none"> <li>• Concurrent Dual DFS detection using Wi-Fi Radio AND Cisco RF ASIC Radio.</li> <li>• Near-Zero False Positives</li> <li>• Any High-Density Area</li> </ul>	<ul style="list-style-type: none"> <li>• Interferer Detection and Impact Analysis</li> <li>• Spectrum Analyzer support in Cisco DNAC</li> <li>• <b>Interference mitigation for Retail, healthcare, manufacturing</b></li> </ul>	<ul style="list-style-type: none"> <li>• Dedicated Dual-Band Off-channel scanning</li> <li>• Tx Radio for NDP.</li> <li>• <b>Improved Low Latency Application performance</b></li> </ul>	<ul style="list-style-type: none"> <li>• Fast Locate (Data Frame RSSI monitoring) from Dedicate Radio</li> <li>• Offload Faster location update using RF ASIC</li> <li>• <b>Beneficial on any location-based service</b></li> </ul>	<ul style="list-style-type: none"> <li>• Dedicate Security Radio Module</li> <li>• Offload Rogue/wIPS monitoring from client serving radio to RF ASIC</li> <li>• <b>Mandatory feature for Enterprise Wireless Operation</b></li> </ul>

Cisco RF-  
ASIC



C9130AX I/E

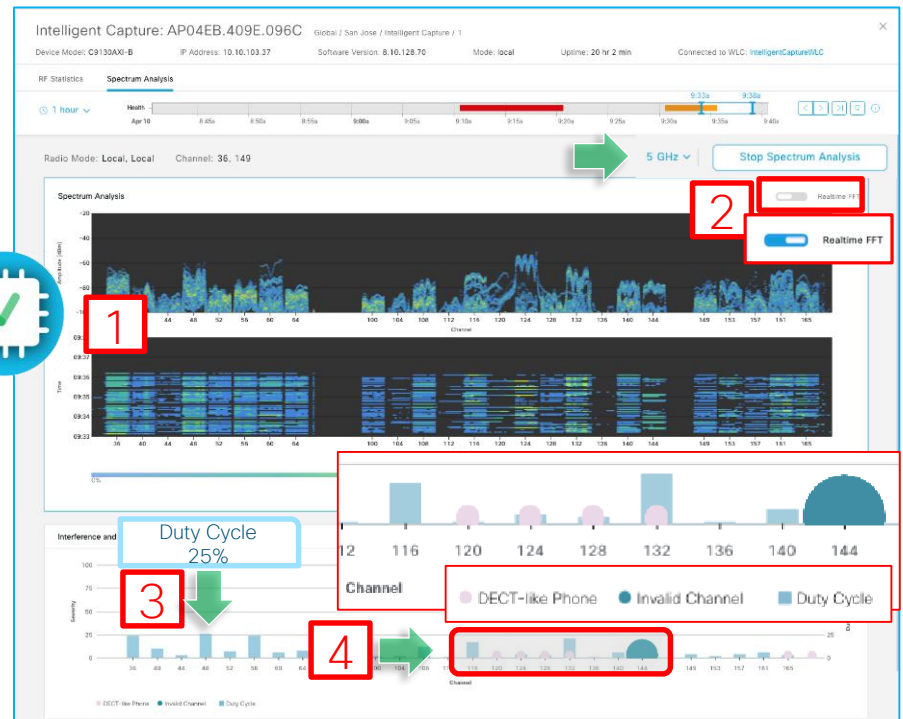


C9120AX I/E

# RF ASIC- Intelligent Capture, Spectrum View Cisco DNA Center Assurance



1. The Cisco RF ASIC allows viewing of the Full Band Selected, with no performance Impact
2. View the Live FFT by selecting Realtime FFT Mode
  - 60 Seconds of Live sweeps
3. Duty Cycle for every channel
4. CleanAir detected Interference also displayed, along with Percentage of Impact



# Spectrum Management Requires Data

## Off Channel Scanning – on Every Cisco AP

OffChannel RRM



- Off Channel Scanning – legacy AP (anything with 2 radio interfaces today)
  - All Channels must be scanned EVERY 180s within 3 Minutes
  - Dwell time is 50 ms, 10 ms for channel change = 60 ms off channel
  - 180s / 25 Channels = off channel dwell every 7.2s
- Off Channel Scanning for WSSI/WSM module and 4800 AP
  - Continuous cycle 1200 ms Dwell across 2.4 and 5 GHz
  - Supports RRM, aWIPS/WIDS, Rogue, FastLocate, CleanAir
  - Serving Radio still required for NDP\* Tx off channel as the module/third radio has no active transmitter



Catalyst AP with RF ASIC:  
All the above!

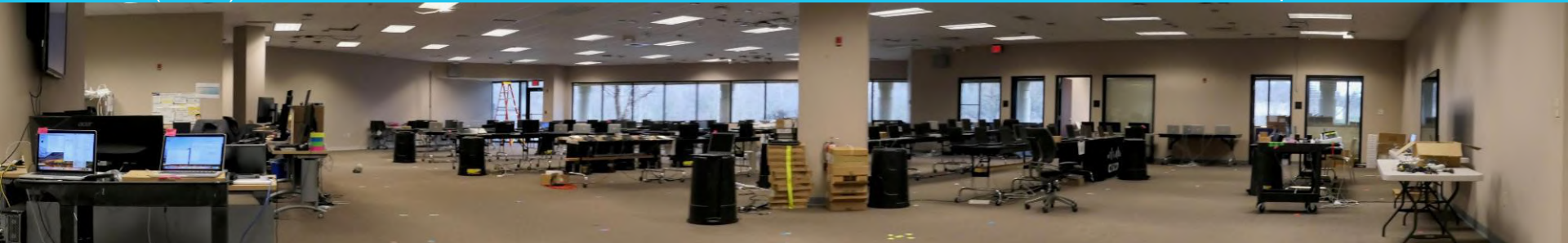
Plus: Better radios, Custom ASIC, Tx for NDP, and more...

\*Neighbor Discovery Protocol

# Performance Tests - Does Wi-Fi 6 make a Difference?

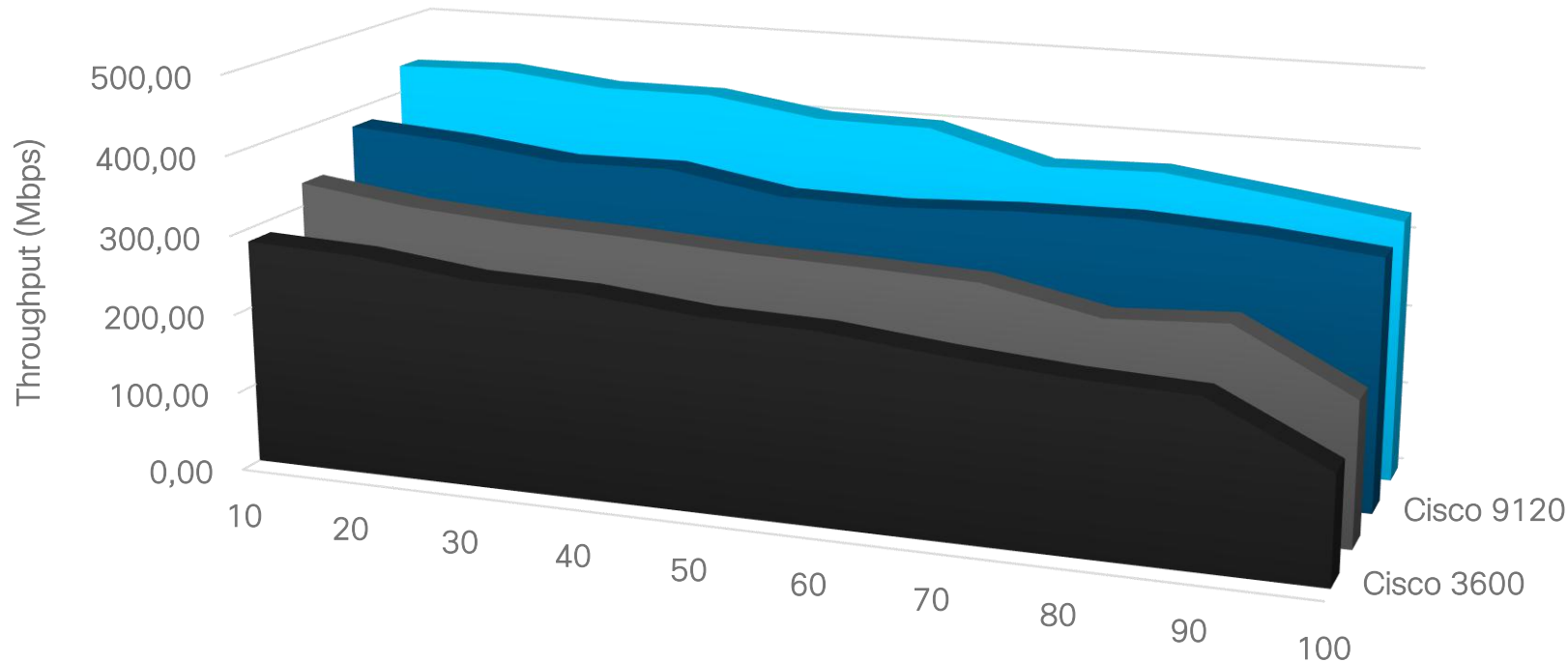
## High Client Density 11ax/11ac Setup

- A real-world mix of 100 clients
  - 5x MacBook Pro 11n (3SS)
  - 40x Intel AX200 Chipset 11ax (2SS)
  - 15x MacBook Pro 11ac (3SS)
  - 20x MacBook Air 11ac (2SS)
  - 20x Dell 6430 w/ Intel 7260 11ac (2SS)
- 80/20 Mix between 5 GHz and 2.4 GHz
- Clients were spread around the AP from 10' (3m) to 45' (13.7m)
- IxChariot tool used to generate traffic from a wired endpoint.

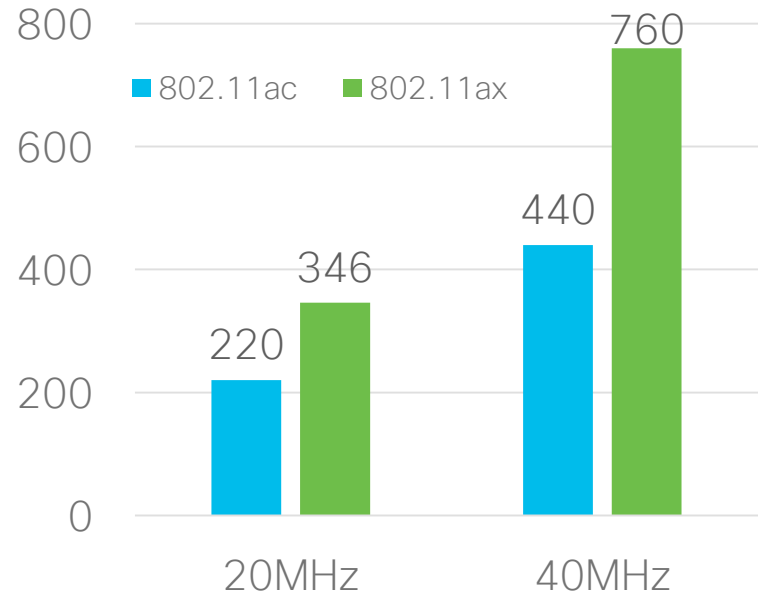


# TCP Throughput – 100 Mix 11ac/11ax clients Cisco Wi-Fi 6 vs Cisco 11ac & 11n, 40MHz channel

Client Mix:  
40% 11ax  
**55% 11ac**  
5% 11n



# 802.11ax Speed Advantages vs. 11ac – 8 AX clients



- 8 (2x2) Clients per radio.
- Turning OFDMA and MU-MIMO Off vs. On.

# Demanding Applications

- High bandwidth
  - 4K/8K Video
  - Bulk data transfer
  - Mission critical transfers.
- Low-Latency
  - HD/2K Video Conference
  - Voice
  - VDI (Trading app, finance)
  - Cloud Apps (O365)
  - VR/AR



# 40 MHz – Single AP 8 Client Test



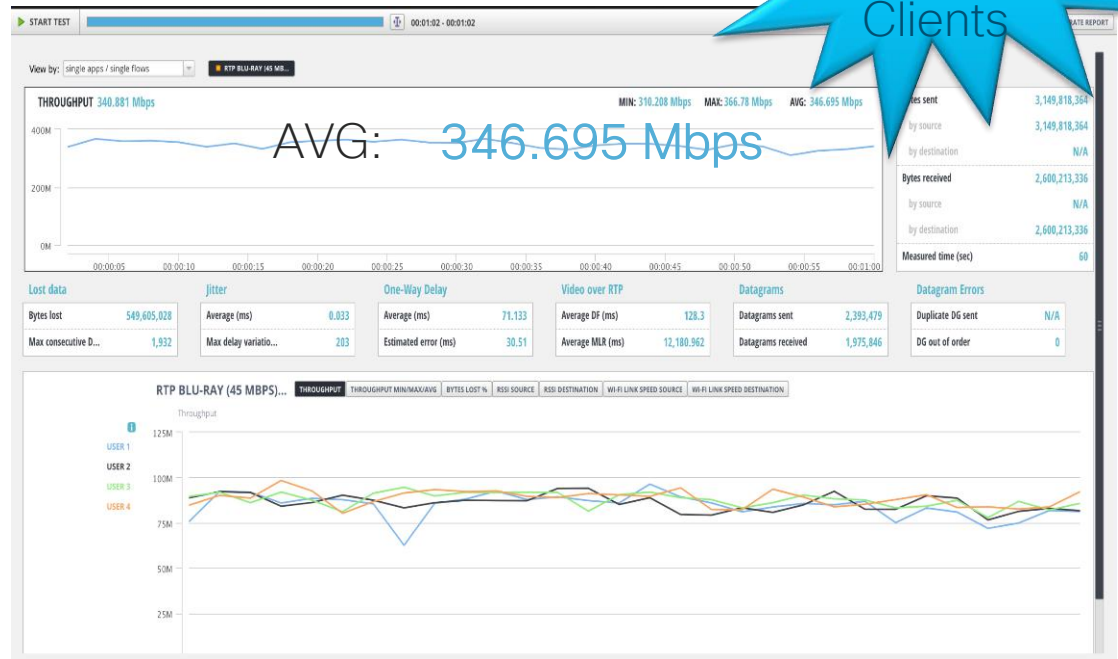
- 40 MHz single cell throughput for 8x 8K video clients performed very well
- 760 Mbps or > 90 Mbps supported for all 8 clients
- One-Way latency <50 ms



# 20 MHz – Single AP 4 Client Test



- 346 Mbps, or 86.6 Mbps/per client
- Excellent jitter and delay
- MU-MIMO and OFDMA advantages present
- Results show that more client could likely be supported



# High Density AP Deployment - Enterprise Design Recommendations

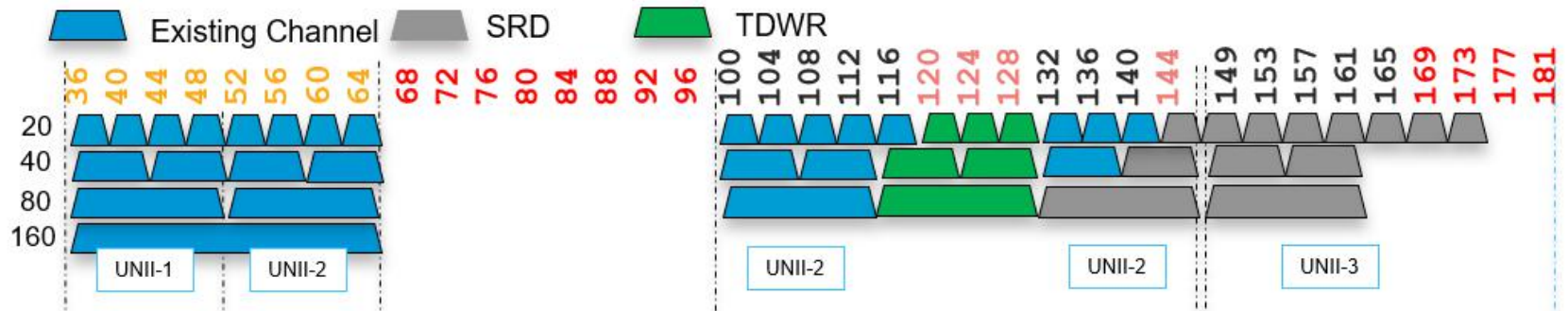
- Does a generalized guideline of 1AP per 2500 ft<sup>2</sup>/(230 m<sup>2</sup>) provide enough capacity for expected increases in application throughput requirements?
- With new digital applications such as 8K video, AR/VR on the horizon do current AP density recommendations meet the demand for the next wave of the digital economy?
- Is a higher density of APs required to satisfy these requirements?

# AP Isolation, Operating Density, and Performance

- Wi-Fi operates on Contention, 2 AP's that hear one another, will share (each get half) the bandwidth, 3 APs will each get 1/3, ...
- If you have more channels than APs, all will be isolated
- Channel bonding requires more channels
- Dual 5 GHz requires 2x the channels per per AP
- AP's must should not hear one another on the same channel above -82 dBm (-78 possible with RX-SOP) interference starts to play a role



19 @ 20 MHz  
9 @ 40 MHz  
4 @ 80 MHz



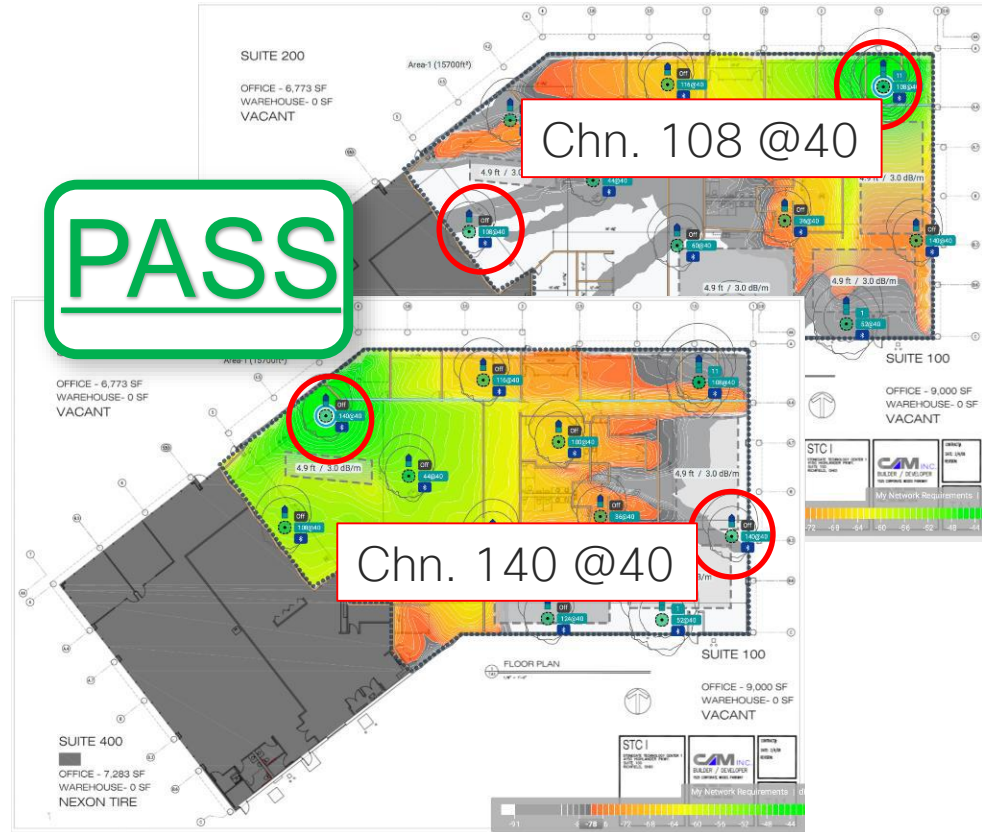
# How Dense is too dense?

- Richfield, OH. Competitive Labs  
Area is 15K ft<sup>2</sup> / 1.4K m<sup>2</sup>
- Tested 20,40,80 MHz channels @  
3 densities
  - 1k ft<sup>2</sup> = 1 AP every 36 feet (11 m)
  - 1.2k ft<sup>2</sup> = 1 AP every 40 feet (12 m)
  - 1.5k ft<sup>2</sup> = 1 AP every 44 feet (13.5 m)
- Evaluate Channel Plan and usability
- Why? Higher Performance needs  
more Cells/Capacity






# 1.2 k ft<sup>2</sup> Co-Channel Interference ETSI 40 MHz Channel Plan

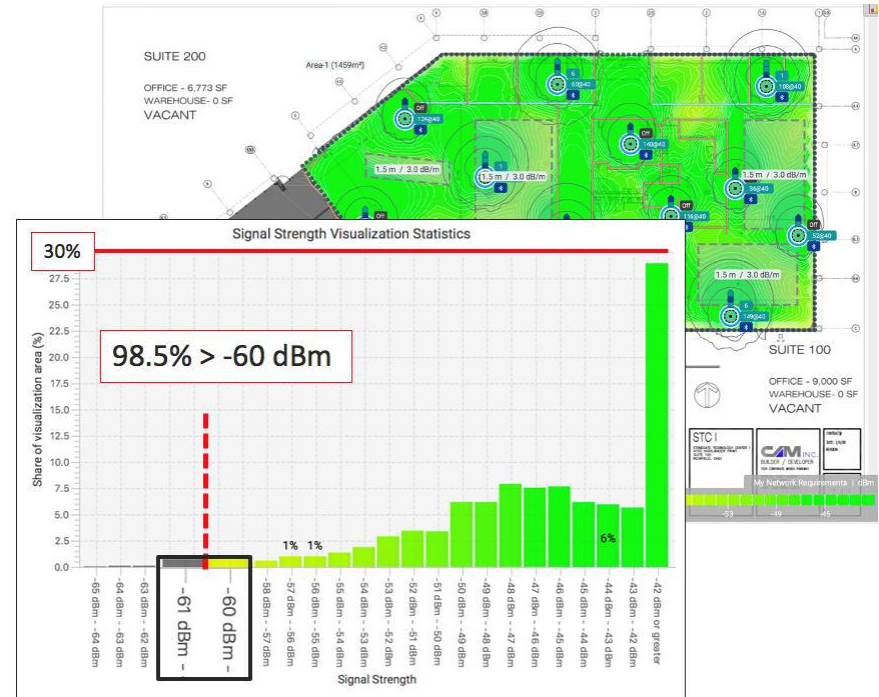
- Using an ETSI channel plan removes 3 channels (@40 MHz).
- 12 (APs) / 9 (Chan)= channel reuse rate of 1.3
- The resulting plan forced the assignment of 2 co-channel pairs on Channels 140 and 108 in the graphics to the right, we compare their impact on one another
- Tuning of RX-SOP at -78 would eliminate the co-channel interference
- The two pairs of AP's are not RF close enough to matter



# HD Design -Conclusions

- Density requires channels to separate
- A network is too dense when channel reuse impacts required performance
- Channel Reuse varies by:
  - The number of Available Channels
  - The Channel Bandwidth
    - 20 MHz is 1 channel per interface
    - 40 MHz is 2 channels per interface
- Excellent results between 1.2k and 1.5K ft<sup>2</sup> densities can be supported @40 MHz in FCC and ETSI

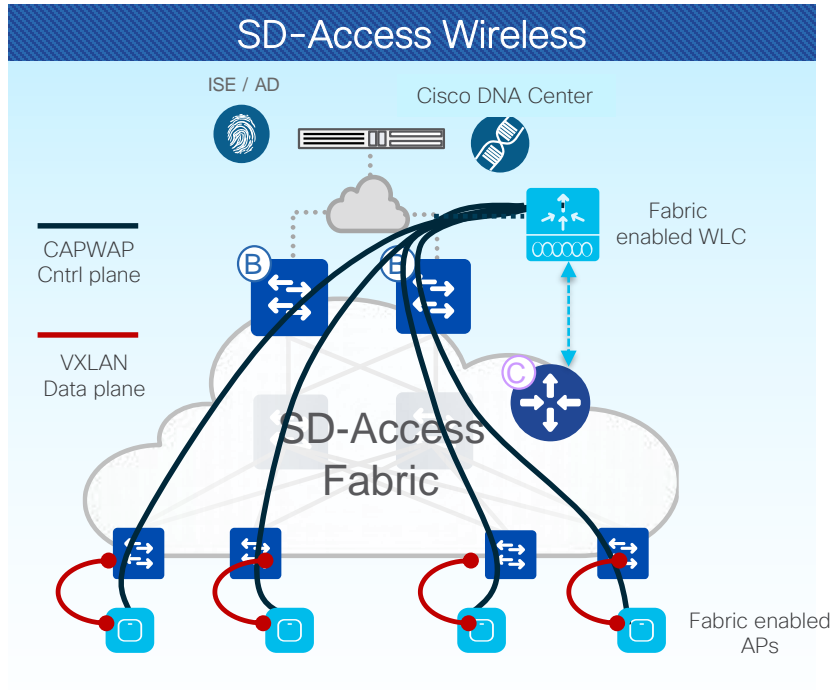
Area	1K ft <sup>2</sup> / 93 m <sup>2</sup>	1.2K ft <sup>2</sup> / 111 m <sup>2</sup>	1.5K ft <sup>2</sup> / 130 m <sup>2</sup>
BW	80 MHz	40 MHz	40 MHz
Pass/Fail			



# Design a vlastnosti Wi-Fi6 sítě – celkový pohled



# (OPTIONAL) SDA for Highest Performance and Security






- CAPWAP Control Plane, VXLAN Data plane
- All integrated in Fabric, SD-Access advantages
- Requires software upgrade (8.5+)
- Optimized for 802.11ac Wave 2 and 11ax APs

- True wireless integration with Fabric
- Provides all the advantages of SDA for wireless clients:
  - Full automation with Cisco DNA Center
  - Hierarchical segmentation (VRF and SGT)
  - Same policy as wired
  - Distributed Data Plane with no drawbacks
  - Optimized traffic path for Guest
- Recommended option

# Cisco's Next Gen Wireless Stack

More resilient, more secure and intelligent than ever before

 <p>Cisco Catalyst 9800 Wireless Controllers</p> <p>Powered by Cisco IOS® XE Open and programmable</p>	 <p>Cisco Catalyst 9100 Access Points</p> <p>Powered by Wi-Fi 6 technology Superior RF experience</p>
---	--

<h2>Resilient</h2> 	<h2>Secure</h2> 	<h2>Intelligent</h2> 
<ul style="list-style-type: none"><li>• Software updates with minimal disruption: ISSU, Rolling AP Upgrades, Hot patching</li><li>• Deterministic capacity at scale</li><li>• Superior battery life for IoT and mobile devices</li></ul>	<ul style="list-style-type: none"><li>• Detect encrypted threats with Encrypted Traffic Analytics (ETA)</li><li>• WPA3 support</li><li>• Software Define Access</li><li>• Multi Lingual Radio</li></ul>	<ul style="list-style-type: none"><li>• Enhanced analytics with Cisco DNA</li><li>• Spectral Intelligence</li><li>• Deploy in infrastructure of choice and cloud of choice</li></ul>
<p>Leadership in RF innovation</p>	<p>Extending Cisco's Intent-based network</p>	<p>Delivering the best experience</p>

# Catalyst 9800 High Availability

## Unplanned Events

Device and network interruptions

- ✓ Stateful Switch Over with an active standby
- ✓ N+1 redundancy for always-on network, services and clients

## Infrastructure Updates

Software maintenance & AP updates

- ✓ Seamless software updates for wireless controllers and APs
- ✓ AP device pack and flexible per-site updates contain impact area

## Software Image Upgrades

Wireless controller image upgrades

- ✓ N+1 rolling AP upgrades ensure seamless client connectivity
- ✓ Radio resource management automates group creation



### Contain impact within release

Fixes for defects and security issues without need to requalify a new release



### Faster resolution to critical issues

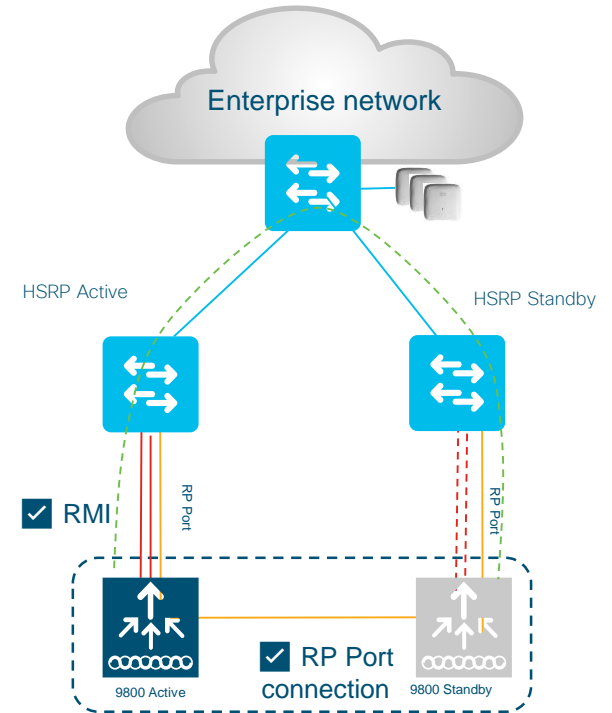
Provide fixes to critical issues found in network devices that are time-sensitive

# SSO Behavior until 16.12

- Gateway check feature not supported
- If RP link fails a switchover is triggered
- RP connection via upstream switches in order to detect gateway failure and trigger a switchover (in case of VSS without split links and HSRP topologies)

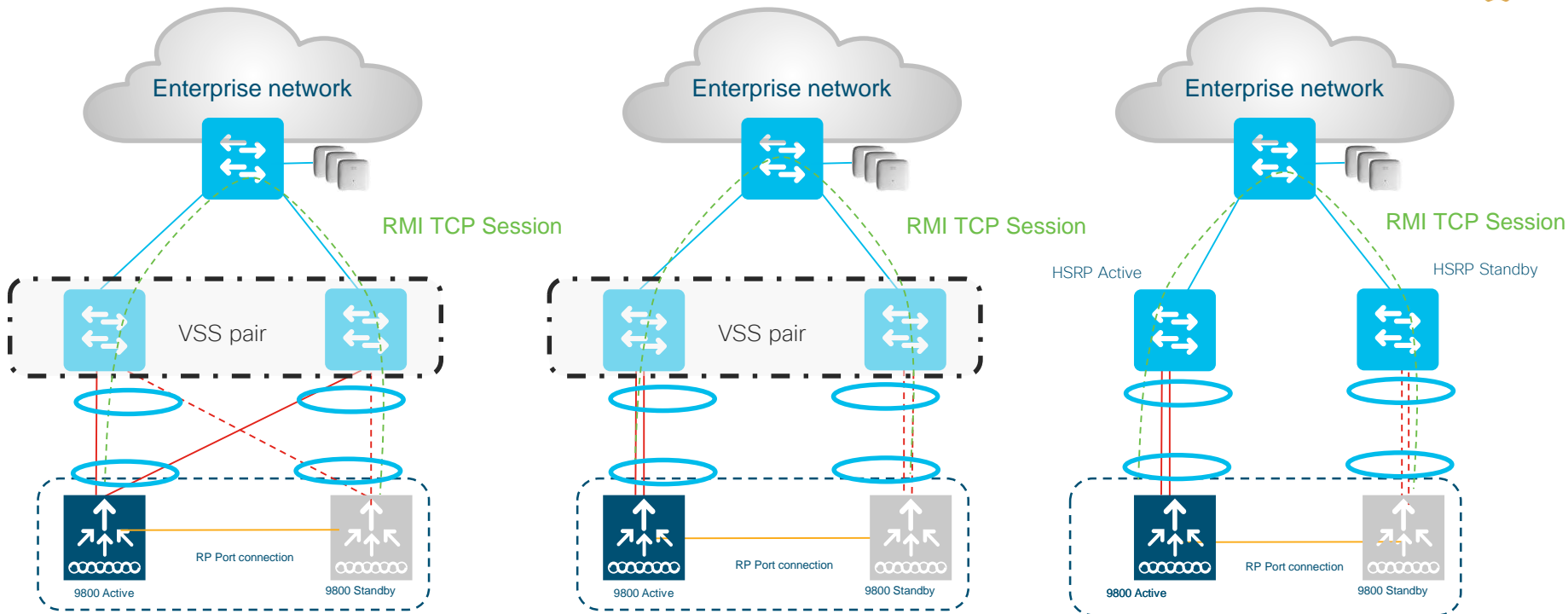
## Solution in 17.1

- ✓ Redundancy Management Interface (RMI) introduced
- ✓ Gateway Check using RMI introduced
- ✓ Direct RP connection (back-to-back or via dedicated switches) supported in case of VSS with split links and HSRP



# Supported SSO Topologies (17.1.x and above)

Gateway Check, RMI and LACP/PAGP are supported



VSS Pair with Split links

VSS Pair - no Split links

HSRP

# How long can my network be down?

★ Catalyst 9800 controller differentiation

Controller Fault



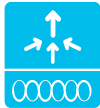
Controller and AP s/w update



Image Upgrade



Standalone



10s of minutes for AP and client recovery



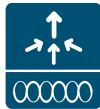
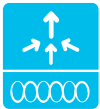
Zero-downtime with SMU and APSP



Tens of minutes for AP and client recovery



N+1 HA



Noticeable Outage to clients and APs



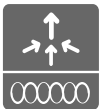
Zero-downtime with SMU and APSP



- No Outage to APs and Client
- Automated Orchestration
- from Cisco DNA Center



SSO Pair



Sub-second AP and client recovery



Zero-downtime with SMU and APSP



16.x - Outage to APs & Clients  
 Need for extra WLC  
 Manual orchestration  
 NEW in 17.1 - ISSU (Beta)  
 In Service Software Upgrade  
 Automated from device and  
 Cisco DNA Center (future)



# ISSU – C9800 Upgrade with ZERO Downtime

## Why? What is it?

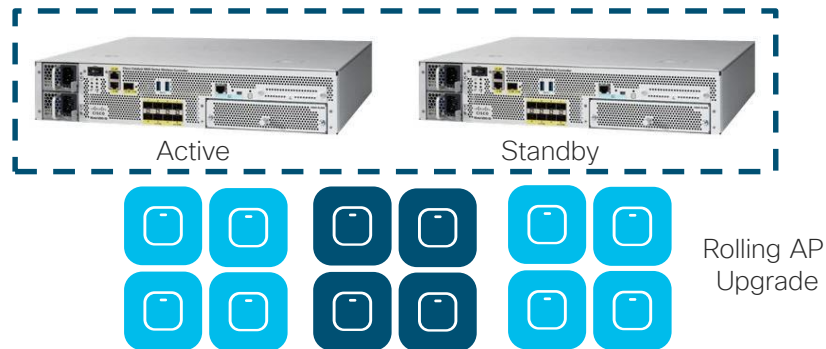
Eliminate network downtime during controller upgrade process



Eliminate the need for a dedicated N+1 controller in the upgrade process



Automate the process of upgrade without manual intervention



Complete image upgrade from one image to another while traffic forwarding continues



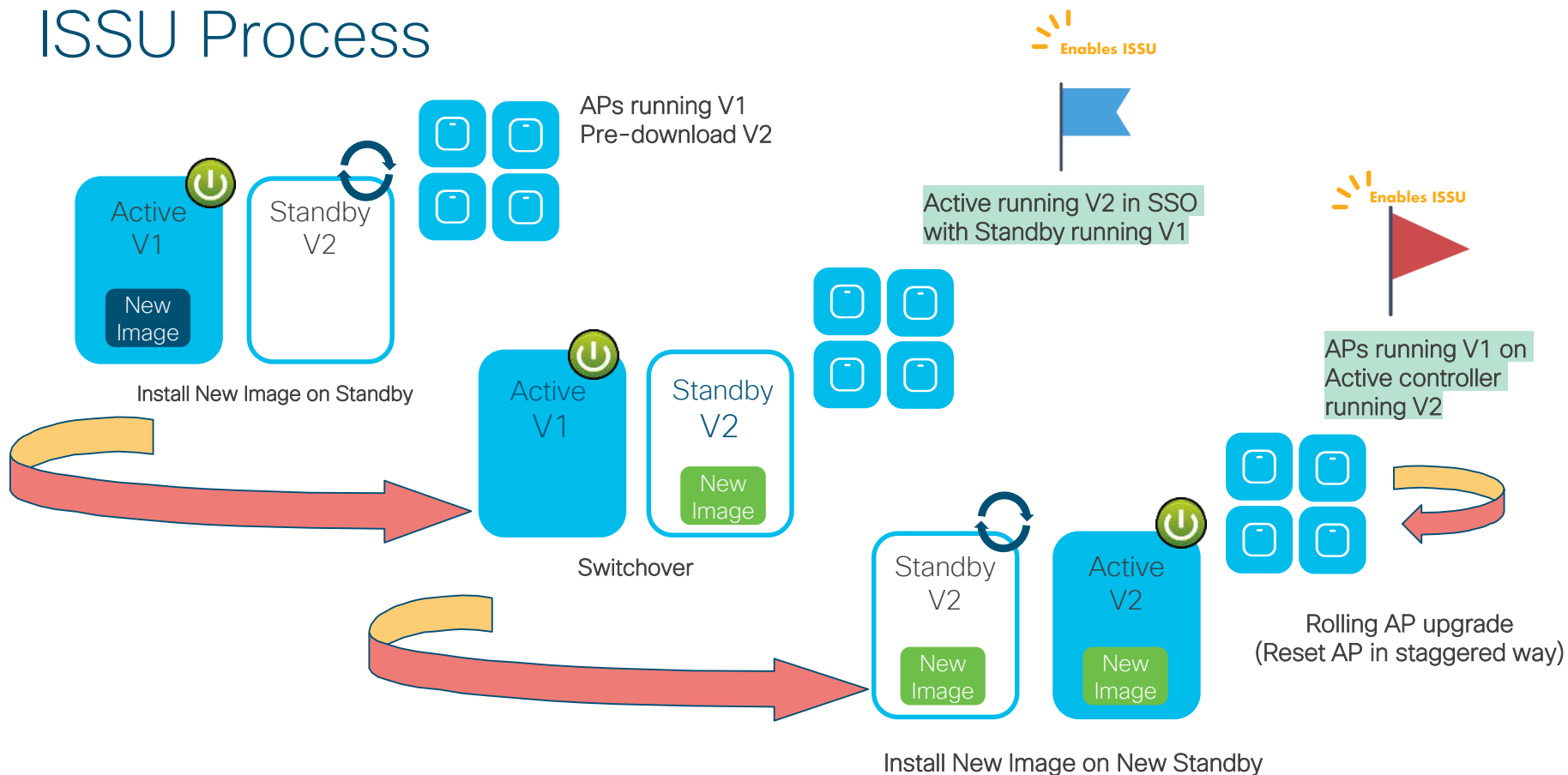
All AP/Client sessions are retained during upgrade process



Pre-requisites:

- ✓ Base image is ISSU capable
- ✓ SSO pair in Active-Hot Standby
- ✓ Controllers in INSTALL mode

# ISSU Process





# End-to-End Wireless Network Security



Air



Devices



Users



Rogue intrusion detection and prevention - WIPS



Enhanced threat detection with ETA



Seamless BYOD onboarding with ISE



Standards compliance with WPA3

- Enhanced security on open Wi-Fi
- Robust password protection
- Superior data protection
- Seamless customer migration



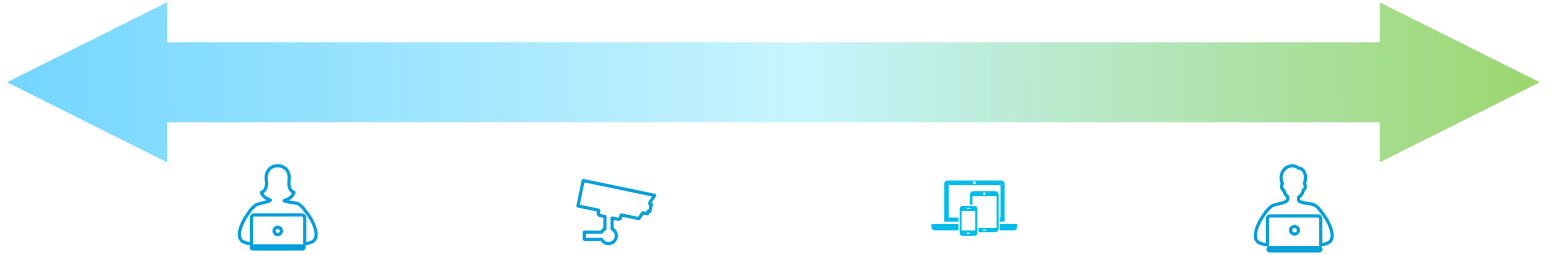
Secure device management with MPSK and iPSK



Identity-Based segmentation with SD-Access

# WLAN Secure device management

## Endpoint Population

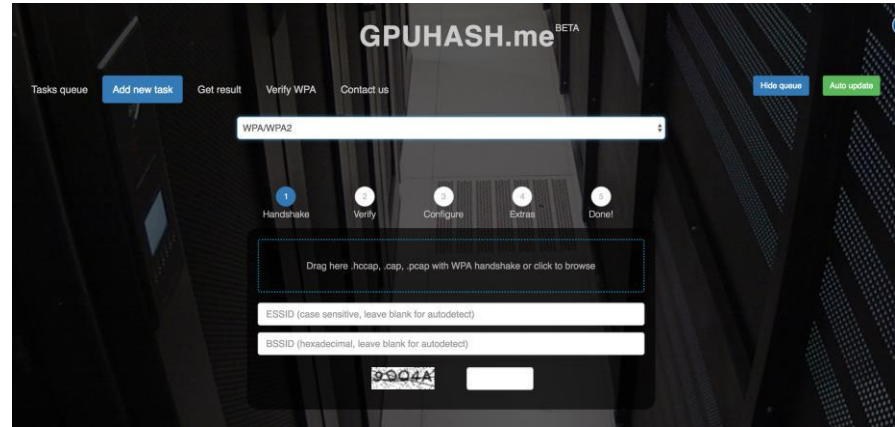


	Guest	IoT (Internet of Things)	BYOD (Bring Your Own Device)	Employee Device (Organization Provided)
Level of Trust	None	Low	Medium	High
Control	Low	Low	Medium	High
Access Requirement	Internet	Internet and/or IoT Controller	Internet and/or Limited Internal	Full Access
Authentication method	Open, WebAuth	<b>PSK</b>	<b>PSK</b> , 802.1X	802.1X

# Why is it easy to crack WPA2-Personal?

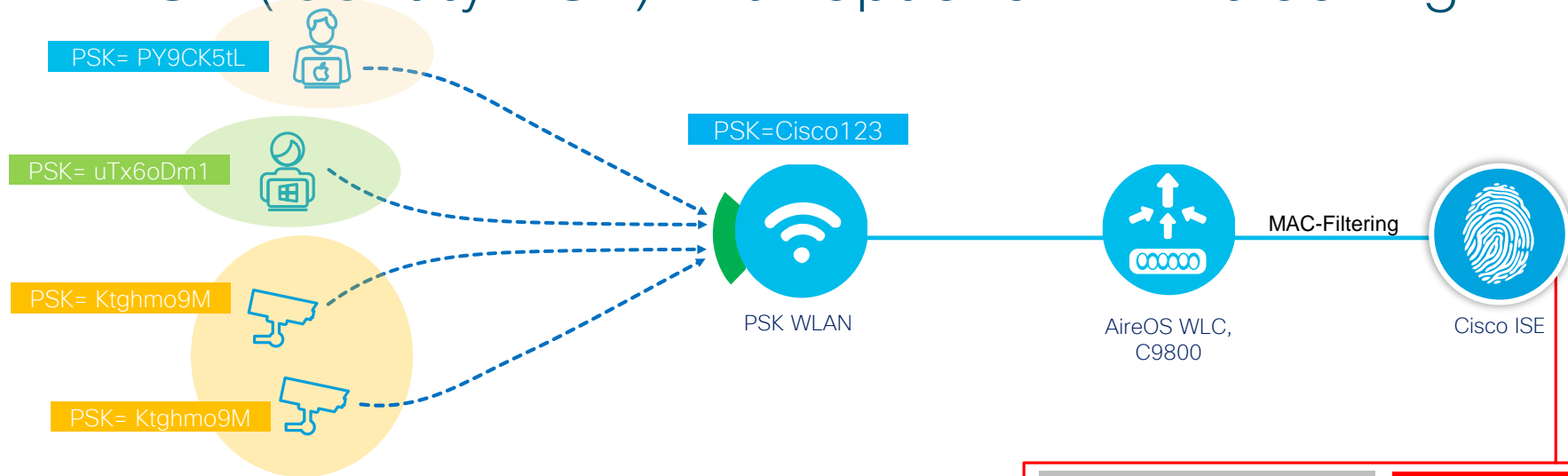
- All I need is a capture of the 4-Way handshake
  - How?– deauth the client
- Upload the entire pcap
- Customers/end users deploy weak passwords
- Results in a easy access to the Wired network (I don't care about capturing over the air data)
- If my intent is to get wired side access MAC based auth + PSK is trivial to bypass

Think IoT, Medical devices, TV's etc etc



# Secure device management with MPSK and iPSK

## - iPSK (identity PSK) with optional P2P blocking



- Each endpoints associate to the single WLAN with it's own PSK value, Endpoints with same PSK value defines segmented network
- ISE provides mapping of MAC address to PSK
- Supported with AireOS 8.5, C9800 16.10.1 / 17.1.1 (P2P blocking), Mobility Express AP 8.8MR2, Embedded WLC on Cat AP 16.12.2, Meraki MR 26.5
- P2P blocking requires AireOS Controller running 8.8 or C9800 Running 17.1

Group == Medical Cart	PSK= zD235o1M
Profile == Smart TV	PSK= 8GB10vaq
MAC= 20:C9:D0:2B:80:F7	PSK= PY9CK5tL
MAC= 9C:3D:CF:4A:72:4D	PSK= uTx6oDm1
MAC= 50:C7:BF:BA:D3:23	PSK= Ktghmo9M
MAC= 50:C7:BF:BA:D9:75	PSK= Ktghmo9M

# Wi-Fi Protected Access (WPA) 3

Coming up with AireOS, IOS-XE and 802.11ac W2 and Wi-Fi6



## New Wi-Fi Alliance (WFA) certification

It certifies new security options defined in the IEEE 802.11-2016 standard

### 3 main innovations:

- **Simultaneous Authentication of Equals (SAE)** for **WPA3-Personal** (a variant of the Dragonfly handshake, resistant to offline dictionary attacks)
- **Protected Management Frame (PMF)** now **mandatory** with WPA3 (already available but not always enforced)
- **192-bit security** equivalent for **WPA3-Enterprise** (256-bit AES-GCM + 384-bit elliptic curves + SHA384 + 3072 bits RSA keys)

**WPA3-Personal = WPA3 PSK based SSID**  
**WPA3-Enterprise = WPA3 802.1X based SSID**

## WPA3 Mandatory Features

- **Simultaneous Authentication of Equals (SAE)**
- PSK replacement / Offline attack resistance
- **Protected Management Frames (PMF)**
- **KRACK Testing**

## WPA3 Optional Features

- **Suite B Cryptography**

## *Wi-Fi Certified Enhanced Open*

- *Opportunistic Wireless Encryption (OWE)*
- *Encryption for Open SSIDs*

## *Wi-Fi Certified Easy Connect\**

- *Device Provisioning Protocol (DPP)*
- *Setup for devices with no UI / IoT*

# WLAN QoS – Consistency is Key

PROPOSED STANDARD  
 Internet Engineering Task Force (IETF)  
 Request for Comments: 8325  
 Category: Standards Track  
 ISSN: 2070-1721

T. Szigeti  
 J. Henry  
 Cisco Systems  
 F. Baker  
 February 2018

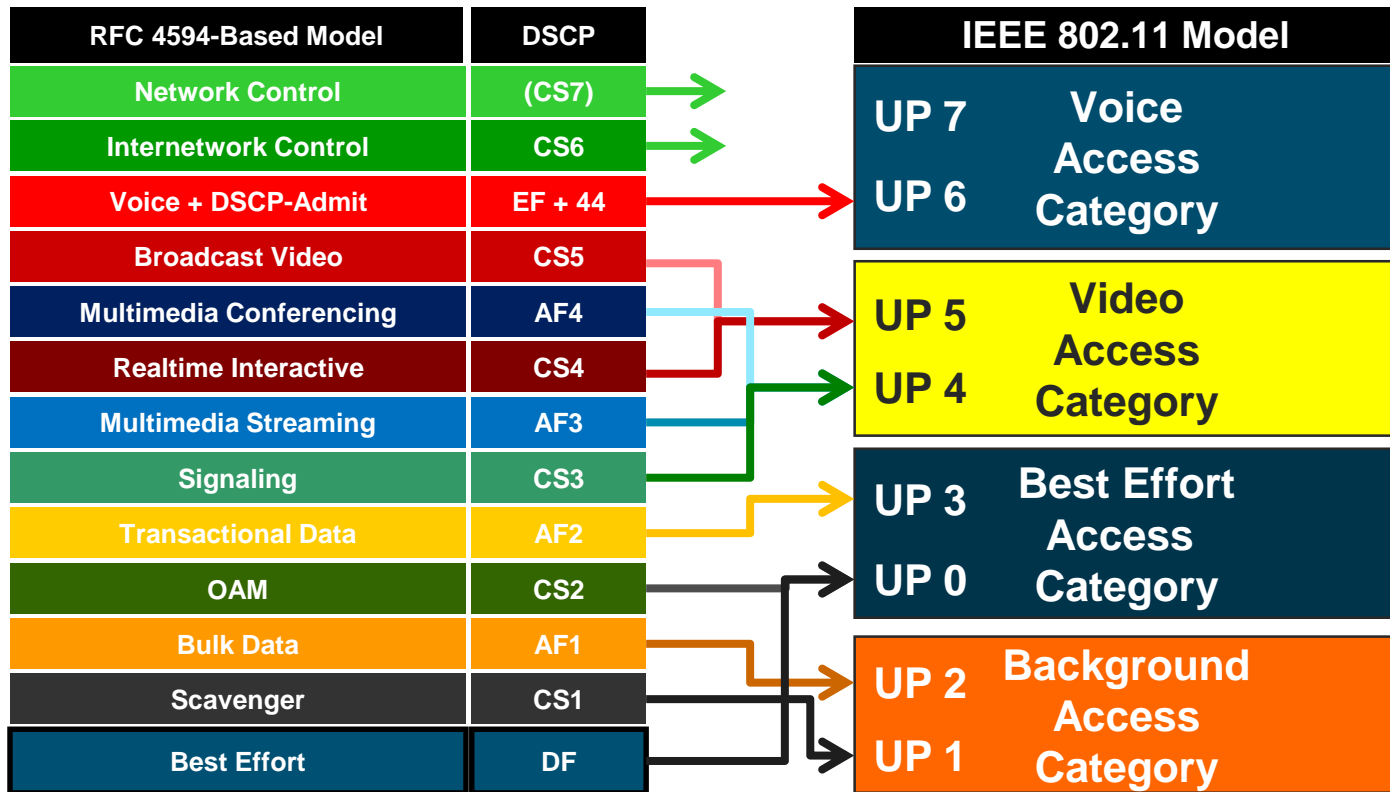
Mapping Diffserv to IEEE 802.11

Abstract

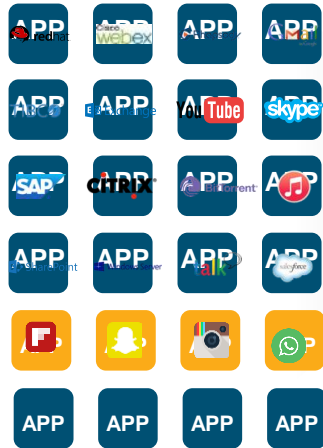
As Internet traffic is increasingly sourced from and destined to wireless endpoints, it is crucial that Quality of Service (QoS) be aligned between wired and wireless networks; however, this is not always the case by default. This document specifies a set of mappings from Differentiated Services Code Point (DSCP) to IEEE 802.11 User Priority (UP) to reconcile the marking recommendations offered by the IETF and the IEEE so as to maintain consistent QoS treatment between wired and IEEE 802.11 wireless networks.

## RFC 8325

- ✓ Apple
- ✓ Samsung/Google
- ✓ Microsoft



# Zero Impact Application Visibility and Control



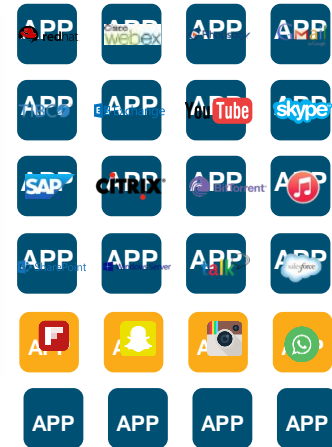
```

krpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="6">
<edit-config xmlns:c="urn:ietf:params:xml:ns:netconf:base:1.0">
  <target>
    <running/>
    </target>
    <test-option>test-then-set</test-option>
    <error-option>rollback-on-error</error-option>
  </config>
  <lan-cfg-data xmlns="http://cisco.com/ns/yang/Cisco-IOS-XE-wireless-wlan-cfg">
    <lan-cfg>
      <vap-id-1/vap-id>
        <rsn-cipher-suite-aes>false</rsn-cipher-suite-aes>
        <id-dot>
          <dumny-attr-to-nvgen>render_shutdwn</dumny-attr-to-nvgen>
          <ssid>
            <profile-name>ciscoLive</profile-name>
            <status>true</status>
          </id-data>
          <profile-name>ciscoLive</profile-name>
          <rsn-is-enabled>false</rsn-is-enabled>
          <security-wifi-sec>false</security-wifi-sec>
          <auth-key-mgmt-suite8021x>false</auth-key-mgmt-suite8021x>
          <li-is-enabled>false</li-remote-lan>
        </vap-id-1>
      </lan-cfg>
    </lan-cfg-data>
  </edit-config>
</krpc>

```

## Programmable Interfaces

Configure AVC via NETCONF/YANG



### Dynamically loaded Apps

Upgrade supported set of protocols without system upgrade or restart



### User-defined Custom Apps

New custom apps can be defined by the user



### Hot Patching Support

Upgrade functionality without system restart/ system upgrade

## Maintain Performance with Zero Impact AVC

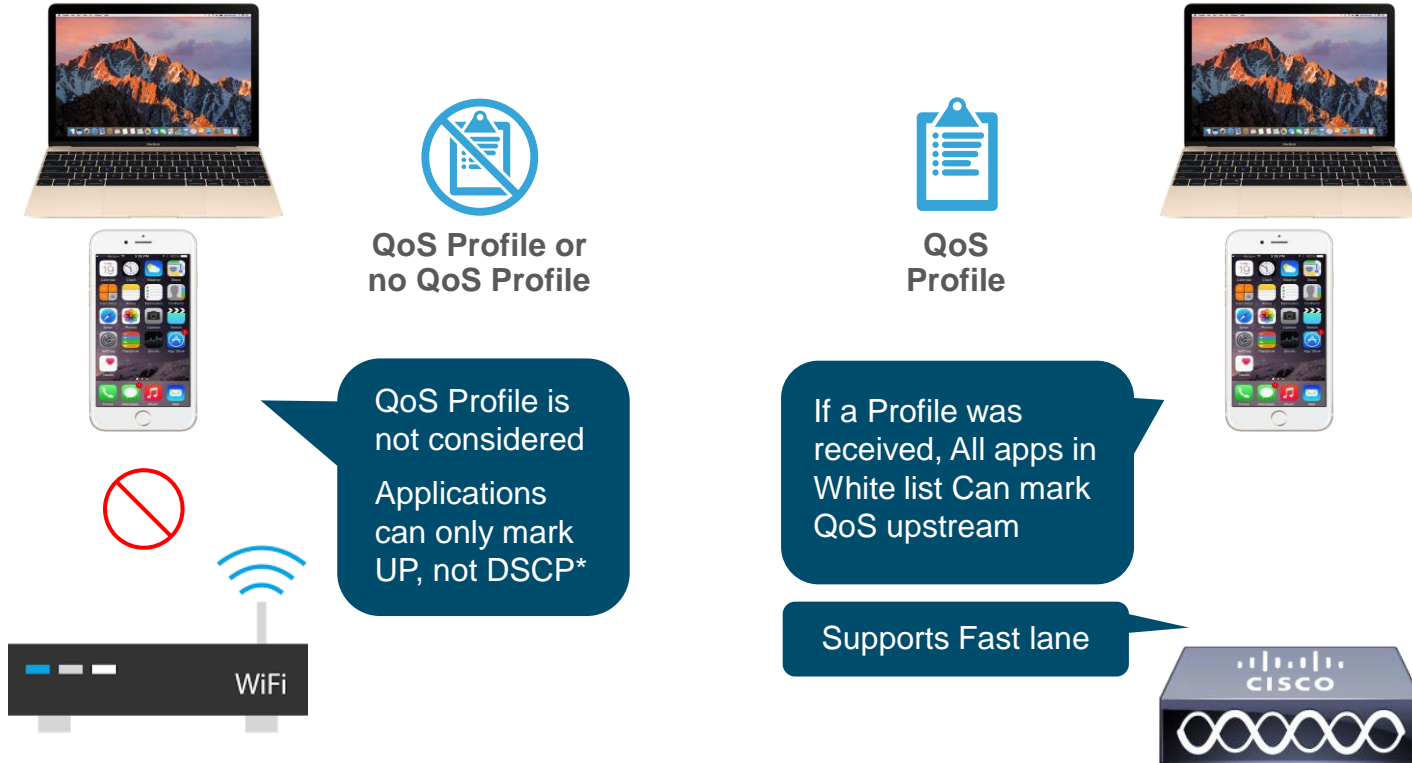
Gain Visibility  
into the Network

Dynamic upgrades  
Custom Apps

Hot Patching  
Support

Programmability  
Support

# Fast Lane only applies to Cisco-Apple Deployments





# Cisco DNA Center - Unified network management for enterprise wireless



Policy



Automation



Assurance



Unified experience



Abstracting network OS and unifying workflows (UX/API) across AireOS and Cisco® Catalyst® WLC

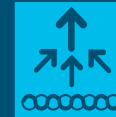
## Intent-based network infrastructure



Cisco Catalyst 9800 Series  
Wireless Controller



Cisco Catalyst and  
Aironet® access points



AireOS wireless  
controller

# Cisco DNA Wireless Assurance



Active Sensor  
Testing



Wi-Fi iOS  
Analytics



Streaming  
Telemetry



Network Time  
Travel



Intelligent Capture  
Auto PCAPs



Intelligent Capture  
Forensics



Actionable  
Insights



Guided  
Remediation

Aironet Active Sensor  
with proactive wireless  
network test



Aironet 2800/3800/4800,  
C9xxx AP with Intelligent  
Capture



\*Roadmap

# Wi-Fi 6 Assurance Use Cases

## DNAC Assisted Migration

- DNAC to provide trends and insights on Wi-Fi 6 clients, h/w and s/w readiness
- Provide recommendations for AP refresh and also which site customer should refresh first

## Wi-Fi 6 Benefits

- Demonstrate Spectrum Efficiency:
  - Higher AirTime Efficiency
  - Lower Channel Utilization
  - Lower Application Latency
- TWT Savings

## Cisco Wi-Fi 6 Innovations

- Dual DFS
- Zero Wait DFS
- Quantify benefits of serving radio not going off-channel

## Client Troubleshooting

- Client Interoperability
  - 11ax client connectivity issue trends
  - Insights on 11ax specific failures
- VIP Full Packet Capture for OFDMA and MU-MIMO packets

# DNAC UX\*

## DNAC Assisted Migration

- Wi-Fi 6 Network Readiness and Insights
- Client capability and association by protocol

## Wi-Fi 6 Benefits

- Traffic Distribution based on AX technology
- AirTime Efficiency

\*Roadmap

## Wireless Dashboard

📍 Global 🕒 24 Hours 🗑️ Filter

### Insights

30% of your clients in your network are Wi6 capable. Your Network Infrastructure is 20% ready for Wi6. Consider the following changes:  
(1) Upgrade your WLC code to 8.10 to improve your Wi6 software readiness by 40%.  
(2) Consider upgrading your AP hardware to C9120 to improve client experience [Learn more](#).

### Wi-Fi6 Network Readiness

Your network is 20% Wi6 enabled



[View Details](#)

### Client Capability by Protocol

LATEST TREND



[View Details](#)

### Client Association by Protocol

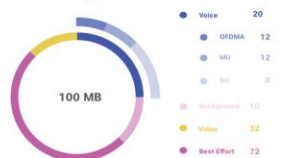
LATEST TREND



[View Details](#)

### Traffic Distribution

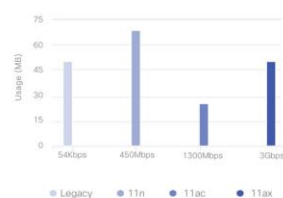
LATEST TREND



[View Details](#)

### Usage distribution by Data Rate

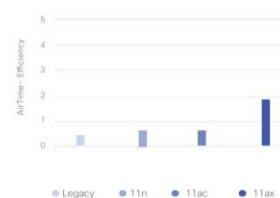
LATEST TREND



[View Details](#)

### Air Time

LATEST TREND



[View Details](#)

# DNAC UX\*

## DNAC Assisted Migration

- Wi-Fi 6 Network Readiness and Insights
- Client capability and association by protocol

## Wi-Fi 6 Benefits

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Your network is 20% Wifi6 enabled



[View Details](#)

### Client Capability by Protocol

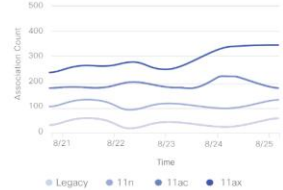
LATEST TREND



[View Details](#)

### Client Association by Protocol

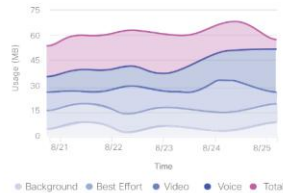
LATEST TREND



[View Details](#)

### Traffic Distribution

LATEST TREND



[View Details](#)

### Usage distribution by Data Rate

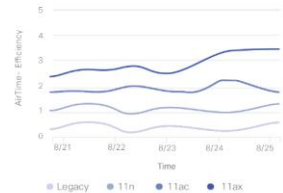
LATEST TREND



[View Details](#)

### Air Time

LATEST TREND

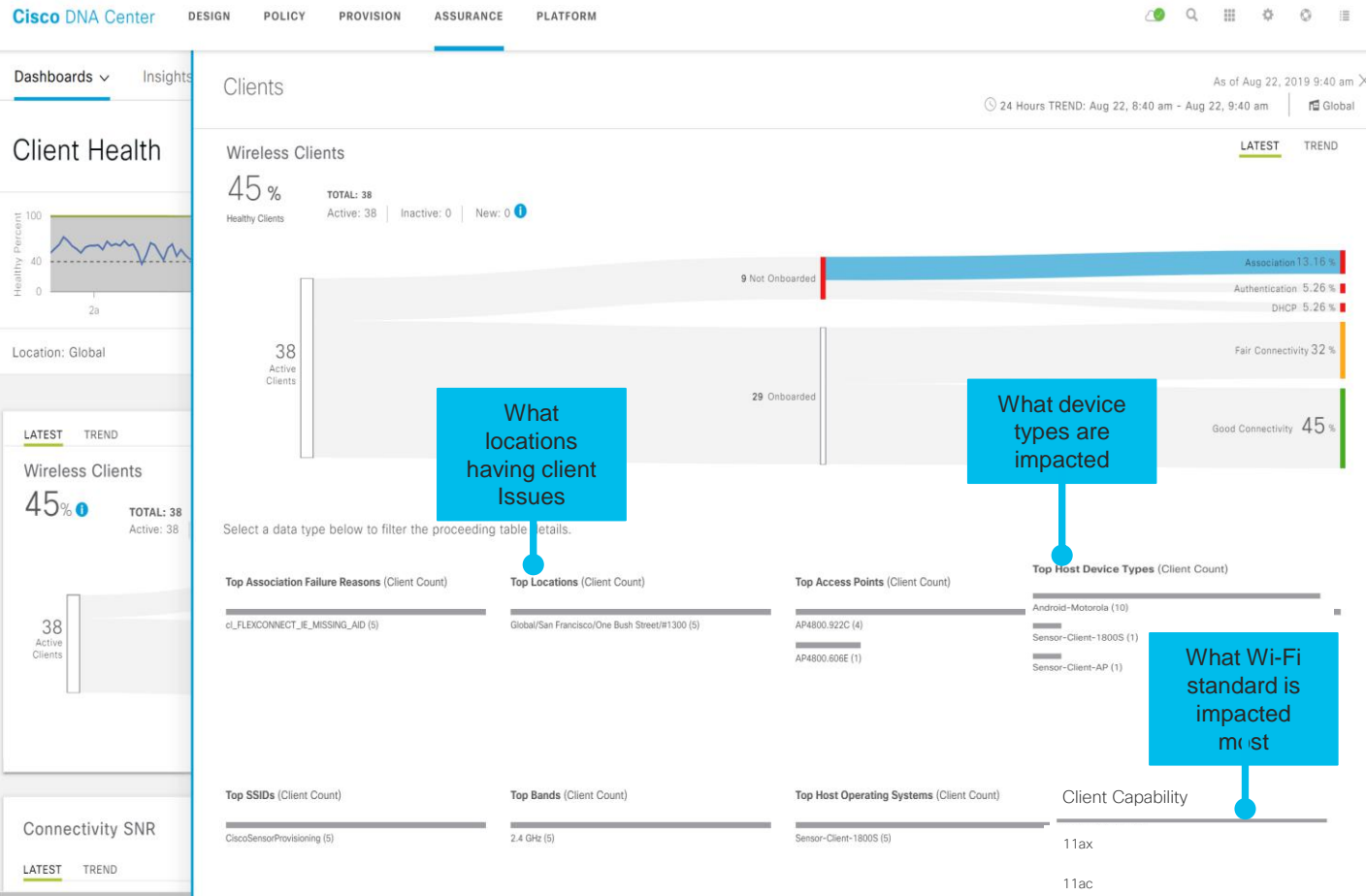


[View Details](#)

# DNAC UX\*

Client Troubleshooting

\*Roadmap



Migrace na Wi-Fi6

# Migration Strategy to the Next-Gen WLAN Stack

## Evaluation



- Understand the advantages of NG stack
- Build the knowledge of NG stack
- Verify platform support
- Evaluate feature gaps
- Evaluate new licensing model

## Design

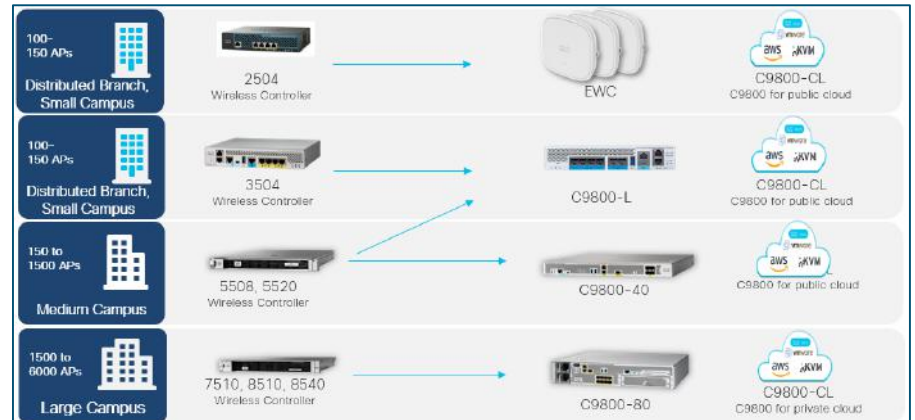


- Select the C9800 and AP platform and chose the deployment mode
- Design for C9800 vs. AireOS WLC coexistence and AP migration areas
- Understand the gotchas
- Choose a Management Platform

## Implementation



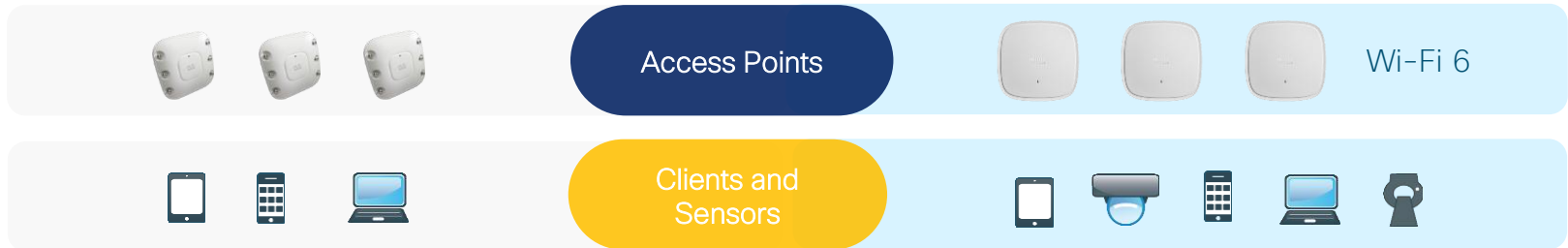
- Check the Site Survey & Heat Map
- Replace the legacy APs
- Check switch PoE
- Lab validation
- Go-Live and Day 2 Support





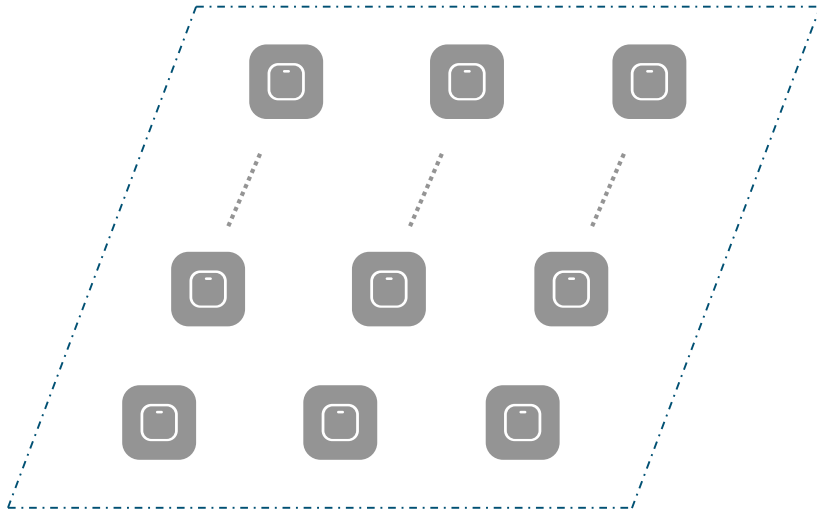
# Catalyst AP Migration - Recommendations

- Do I need a new Site Survey?
- Can I replace APs 1:1?
- How do I deal with “border” areas between nonhomogeneous AP type?
- New Wi-Fi 6 APs, do I need new switches?



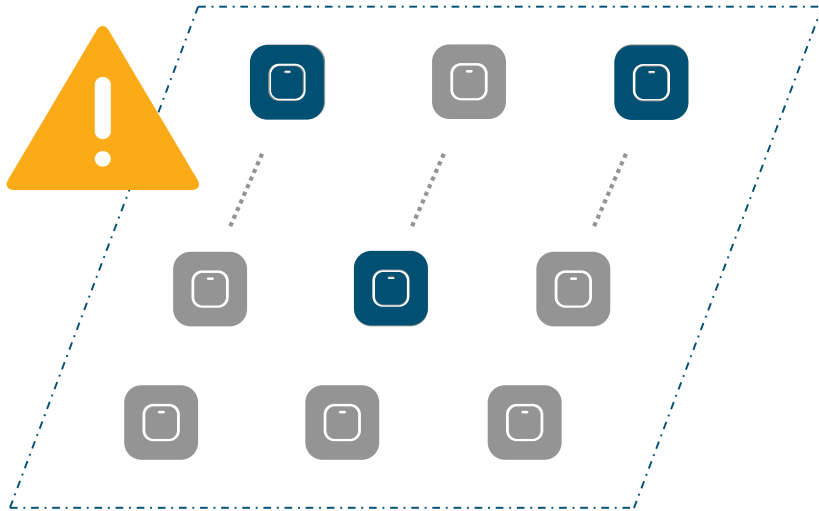
# New Site Survey?

- New **Site Survey** is **not mandatory** (assuming current coverage meets requirements)
- **1:1 Replacement** assumes the APs were originally installed in optimal place



# New Site Survey?

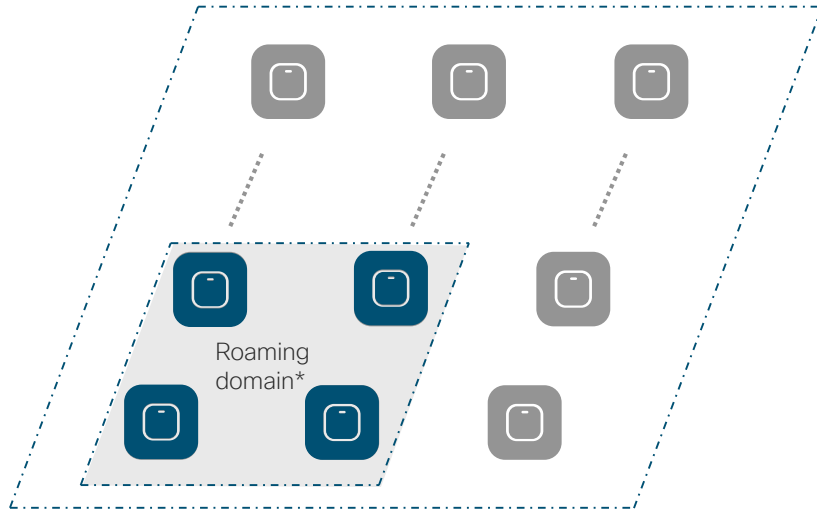
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- New APs are designed to have close to the **same coverage area** as the previous gen product. Coverage will be similar but wireless **capacity will increase**
- “**salt and pepper**” replacement is **not recommended**
- Mixing AP type will prevent customers from taking advantage of the new features being introduced in Catalyst APs (RF ASIC related and Wi-Fi 6 features)

# New Site Survey?

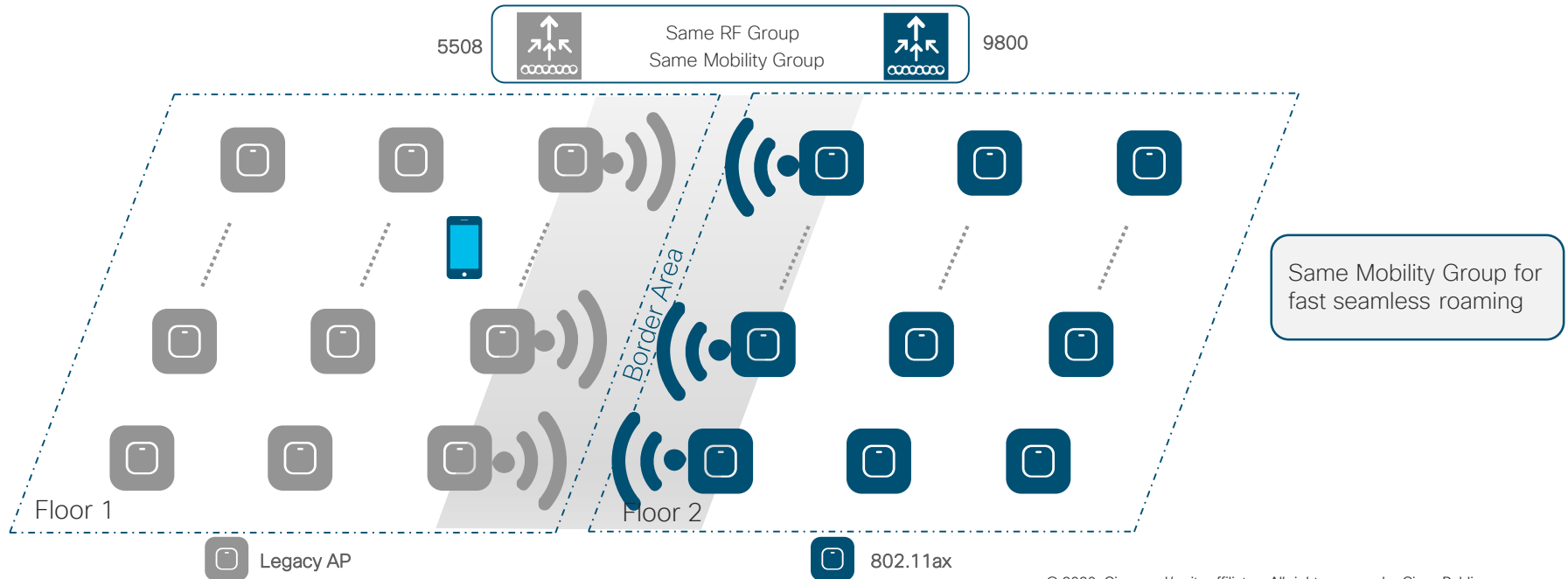
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- “**salt and pepper**”  replacement is **not recommended**
- Mixing AP type will prevent customers from taking advantage of the new features being introduced in Catalyst APs (RF ASIC related and Wi-Fi 6 features)
- **Recommendation:** keep APs of the same type together, replace the APs in a roaming domain
- Roaming domain = e.g. floor/multiple floors /building or area where people tend to roam

# How do I deal with “border” areas?

- As you replace APs per roaming domain, you will have “border areas” between two deployments
- If you have the same RF Group, Cisco **RRM** takes care of setting power and channel plan for the border areas.

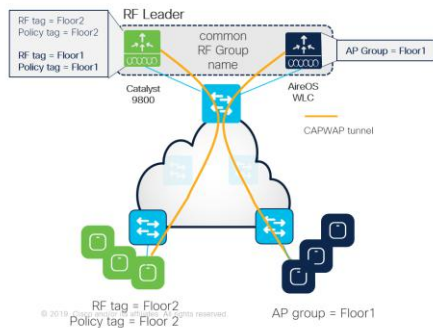


# AireOS and C9800 - coexistence and migration

## RF Group, Roaming, Guest

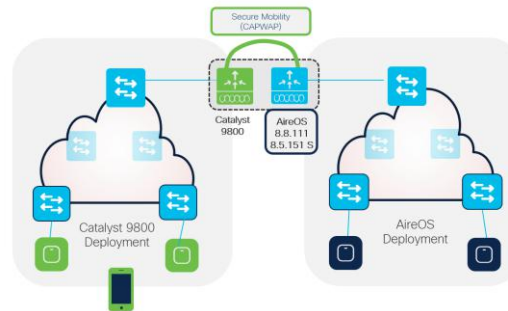
### AireOS to IOS-XE (C9800) migration - common RF Group

RRM works in a mixed controller environment and we can have one RF master:



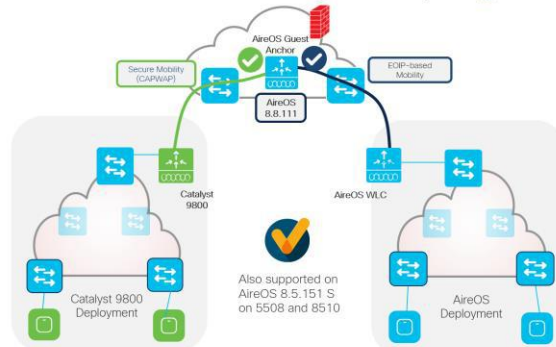
- C9800 and AireOS controllers can create one RF domain and share a common RF plan
- The RF group name on both AireOS and C9800 controllers needs to match
- 8.8 is required on AireOS (8.8.111 recommended)
- A RF leader is elected (based on controller capacity) and common channel and power plan will be used for all APs
- APs will be not show up as rogue on the other controller
- NOTE: in a scenario where you want to have custom RF profiles or enable FRA, then the leader (e.g. C9800 controller) needs to have Policy and RF tags matching the names of the AP Group names on AireOS WLC. Of course the settings of RF profiles on both controllers need to match as well.

### AireOS to IOS-XE (C9800) migration - Roaming



- During migration, if customer plans to cover the same areas with AireOS and C9800 controllers, then Mobility Group needs to be considered
- Mobility Group provides seamless roaming between wireless controllers
- Mobility Group between AireOS and IOS-XE WLCs is only supported on:
  - 3504, 5520, 8540 with 8.8.111 and higher
  - 5508 and 8510 with 8.5.151 special
- This is because C9800 only support CAPWAP based mobility tunnels (Secure Mobility)
- Note: Secure Mobility is NOT supported on WISM2

### AireOS to IOS-XE (C9800) migration - Guest



- For Guest, AireOS WLC running 8.8.111 and higher can talk both tunneling protocols and
- It can provide Guest Anchor functionalities for both the new C9800 based deployments and the legacy AireOS based network

chored to the first WLC that the client joined



Reference

# C9800 Configuration Migration Tool

- Import AireOS configuration to verify if there are any feature gaps
- Migration tool managed by TAC: <https://cway.cisco.com/wlc-config-converter/>

Cisco TAC Tool - WLC Config Converter

✓ Welcome to our new interface

## WLC Config Converter

Migrating wireless controllers to or from across any of these platforms: 2500/5500/7500/8500/WISM2/3650/3850/4500 S8E/5760/Catalyst 9800 controllers?

Please upload the following:  
AireOS: "show run-config commands" output or TFTP config backup  
Converged Access: "show running-config" output

Details

TFTP config backup or 'show run-config commands' output from AireOS WLC.

AIR-CT3504-K9.cfg  
22.5 KB

Platform Conversion Type  
AirOS-->Catalyst 9800

Run

Choose the AireOS to C9800 converter and hit run

Drop the AireOS config file:

- Upload it from directly from GUI:

Cisco GUI - Upload file from Controller

File Type: Configuration

Configuration File Extension: config.txt

Transfer Mode: TFTP

Server Details

IP Address (32+4bits): 10.10.10.10

File Path: config.txt

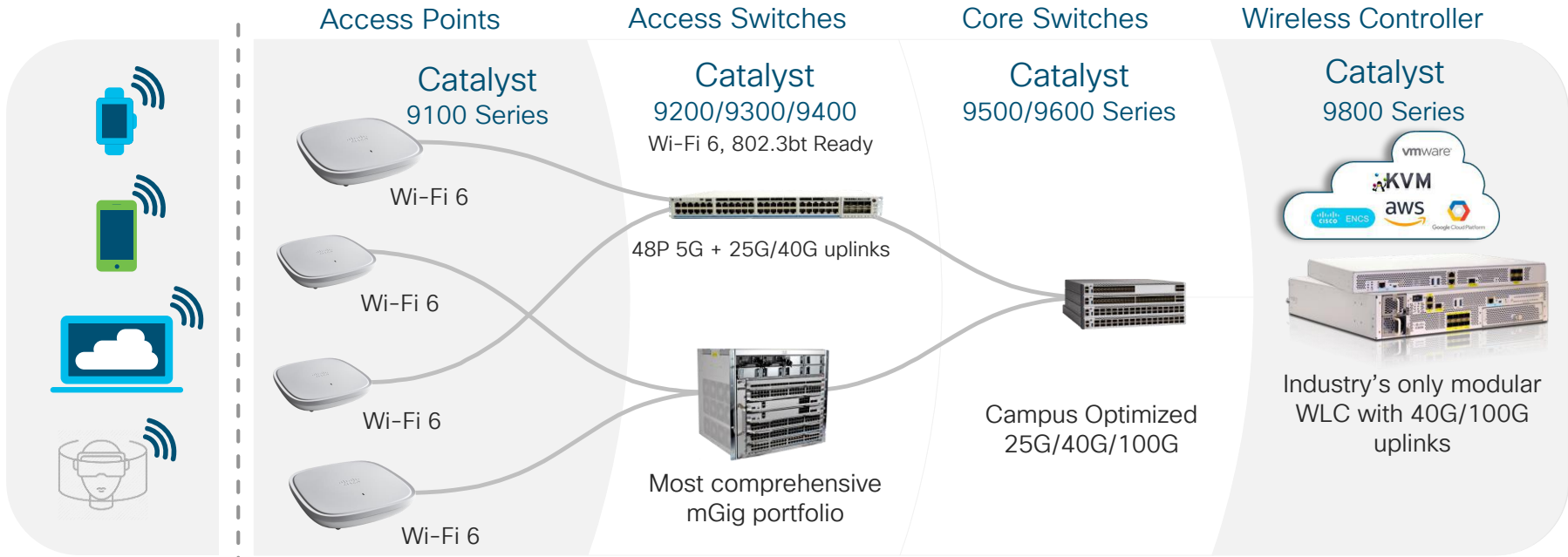
File Name: config.txt

or

- use the "show run-config command" output and put it in a .txt file

# Cisco Catalyst - End-to-end Network

Enabling next-generation Wi-Fi 6 mobility



← The Full Experience End to End →

Built for Intent-based networking

- Automation
- Security
- Analytics



# Migrate with Infrastructure Investment Protection

Switching  
infrastructure

Best

mGig ports and UPOE

E.g. C9300-48UN, C9300L-48UXG-4X



Draws  
30.5W



Catalyst 9130

Full performance & features  
on all Catalyst APs

Better

1G ports and POE+

E.g. C9300L-48P-4X



Catalyst 9130

C9130: 8x8 support with just no USB  
Full performance & features on other APs

Good

1G ports and POE

E.g. C9200-48P or one power supply  
failure on higher end switches



Catalyst 9130

Reduced Performance (1x1 radio)  
but all SSIDs are up!

# Catalyst 9100 Series Flexible power options: 802.3af support for ALL Wi-Fi 6 APs



Reference

	AP Model	Power source	Power Type	2.4 GHz Radio	5 GHz Radio	Link Speed	USB	Power Draw
9130	C9130AXI / C9130AXE	802.3at	PoE+	4x4	8x8	5G	OFF	25.5W
	C9130AXI	802.3at	PoE+	4x4	4x4	5G	ON	25.4W
	C9130AXI / C9130AXE	802.3bt	UPoE	4x4	8x8	5G	ON	30.5W
	C9130AXI / C9130AXE	802.3af	PoE	1x1	1x1	1G	OFF	13.4W
9120	C9120AXI	802.3at	PoE+	4x4	4x4	2.5G	ON	25.5W
	C9120AXE	802.3at	PoE+	4x4	4x4	2.5G	ON	25.5W
	C9120AXI / C9120AXE	802.3af	PoE	1x1	1x1	1G	OFF	13.4 W
	C9120AXI / C9120AXE	802.3af	PoE	2x2	N	1G	OFF	13.4 W
	C9120AXI / C9120AXE	802.3af	PoE	N	2x2	1G	OFF	13.4 W
9115	C9115AXI / C9115AXE	802.3at	PoE+	4x4	4x4	2.5G	ON	20.4W
	C9115AXI / C9115AXE	802.3af	PoE	2x2	2x2	1G	OFF	15.4W
9117	C9117AXI	802.3bt	UPoE	4x4	8x8	5G	ON	28.9W
	C9117AXI	802.3at	PoE+	4x4	8x8	5G	OFF*	25.4W
	C9117AXI	802.3af	PoE	2x2	2x2	2.5G	OFF	13.5W

\* If USB is enabled 5GHz will be reduced to 4x4

Shrnutí

# WLAN Campus of the Future

## Next-Gen Cisco Wireless Stack Designed for Wi-Fi 6



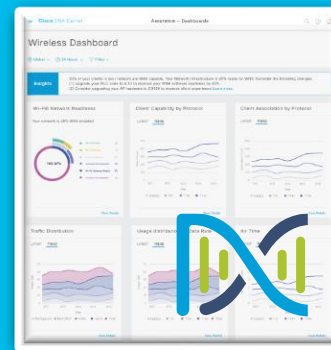
Wi-Fi 6  
Clients



Catalyst 9100  
Access Points



Catalyst 9800  
Wireless Controllers



DNA Automation &  
Assurance



DNA Spaces

Next Generation Cisco Wireless Stack – Resilient, Secure & Intelligent

Wi-Fi 6 Clients are here Today! ~300 Clients in Cisco Interop Testbed

DNA Assurance helps with Wi-Fi 6 Migration, Troubleshooting & Analysis

# Cisco is making Wi-Fi 6 even better



Combining the best of Wi-Fi 6 with Cisco's Intent-based networking



Designed to support automation, analytics and security capabilities



Achieve a better user experience with Flexible Radio Assignment, Fast lane

## Easy to deploy and manage with Cisco DNA Center

Cisco DNA Center



Policy



Automation



Analytics

Cisco goes beyond the standard with innovations that deliver a better future for our customers

# NEW Cisco Catalyst 9800 Series Configuration Best Practices Guide



Reference

Best practice guide  
Cisco public



## Cisco Catalyst 9800 Series Configuration Best Practices

### Introduction

The Cisco® Catalyst® 9800 Series (C9800) is the next-generation wireless LAN controller from Cisco. It combines RF excellence gained in 25 years of leading the wireless industry with Cisco IOS® XE software, a modern, modular, scalable, and secure operating system. The Catalyst Wireless solution is built on three main pillars of network excellence: Resiliency, Security, Intelligence:

Compared to the AireOS WLC, the C9800 software has been rewritten from scratch to leverage the benefits of Cisco IOS XE, and the configuration model has been made more modular and flexible. This means that, although most AireOS features are retained, there might be changes in the way you configure certain functionalities.

This document covers the best practices recommended for configuring a typical Cisco Catalyst 9800 Series wireless infrastructure. The objective is to provide common settings that you can apply to most wireless network implementations. But not all networks are the same. Therefore, some of the tips might not be applicable to your installation. Always verify them before you perform any changes on a live network.

Resilient	Secure	Intelligent
ISSU LACP/PAGP Multi-LAG	User Define Network aWIPS iPSK P2P Blocking	11ax Analytics Samsung Analytics BLE Management with DNA Spaces

<https://www.cisco.com/c/en/us/products/collateral/wireless/catalyst-9800-series-wireless-controllers/guide-c07-743627.html>

# Recommended Reading

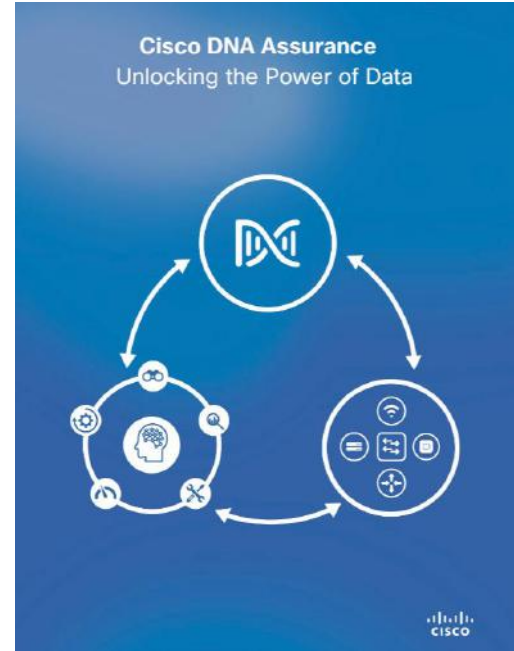
## Cisco Enterprise Wireless & Cisco DNA Assurance



Reference



<http://cs.co/wirelessbook>



<http://cs.co/assurancebook>

