The bridge to possible

Wi-Fi 6E Adoption and Sneak Peek into the Future With Wi-Fi 7

Anand Gurumurthy, Sr. Technical Leader,
Technical Marketing

BRKEWN-2024

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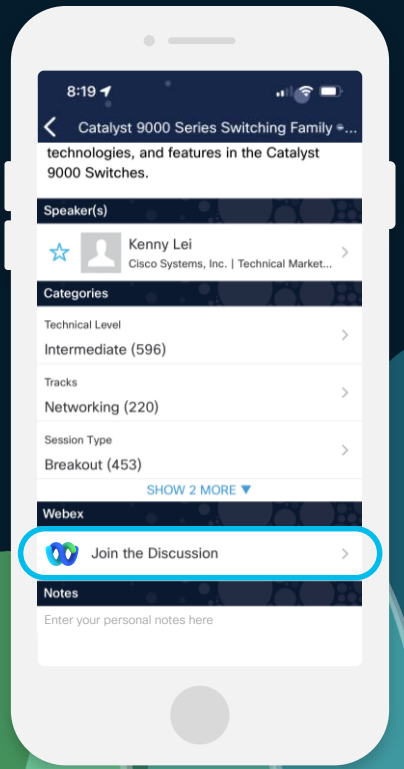

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Agenda

- Explore Wi-Fi 6E
- Deployment & Migration Considerations
- Get to know Wi-Fi 7
- The Wi-Fi 6E vs Wi-Fi 7 Dilemma!

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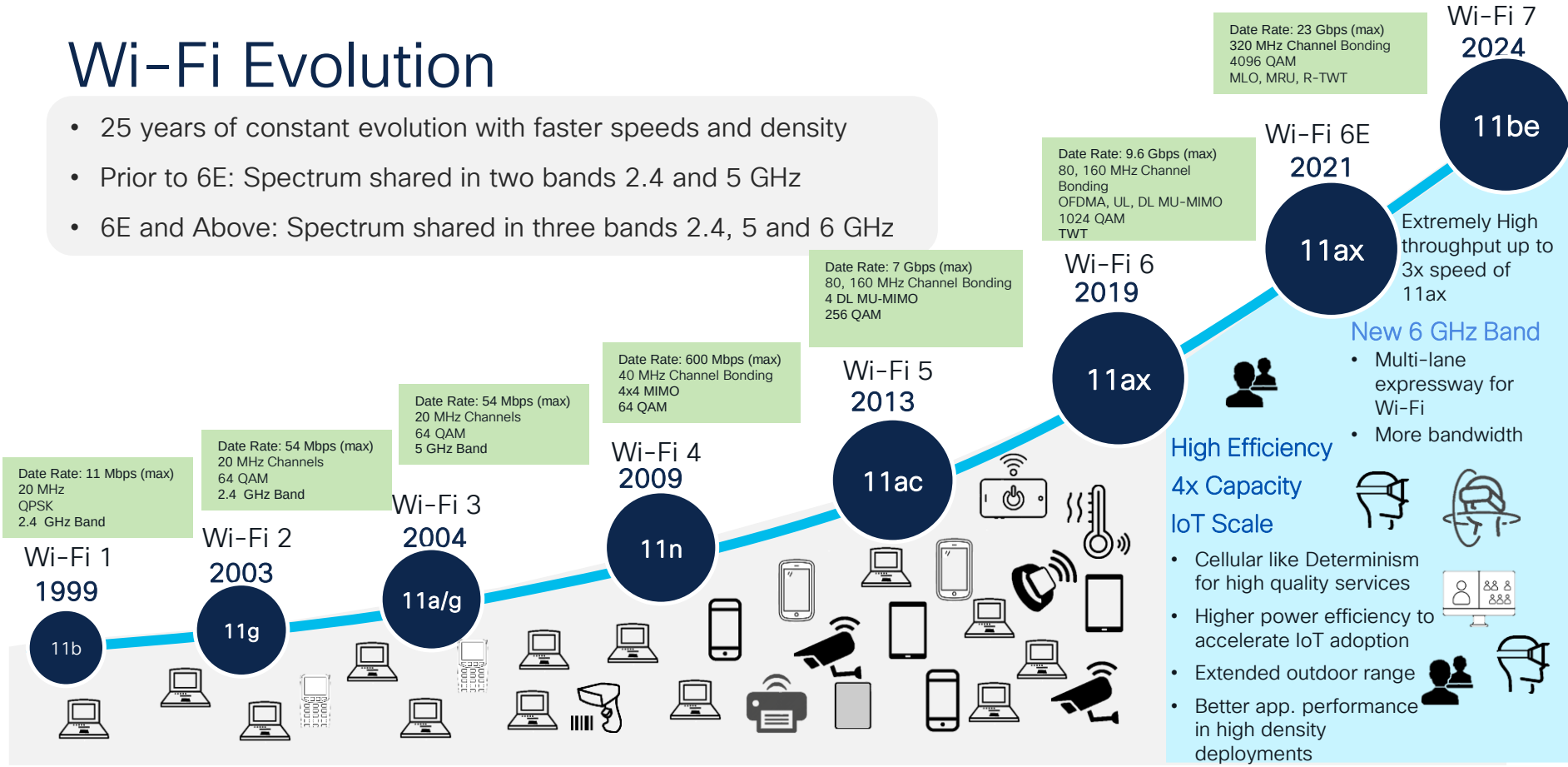
25
YEARS
Wi Fi
ALLIANCE

Wi-Fi Evolution

- 25 years of constant evolution with faster speeds and density
- Prior to 6E: Spectrum shared in two bands 2.4 and 5 GHz
- 6E and Above: Spectrum shared in three bands 2.4, 5 and 6 GHz



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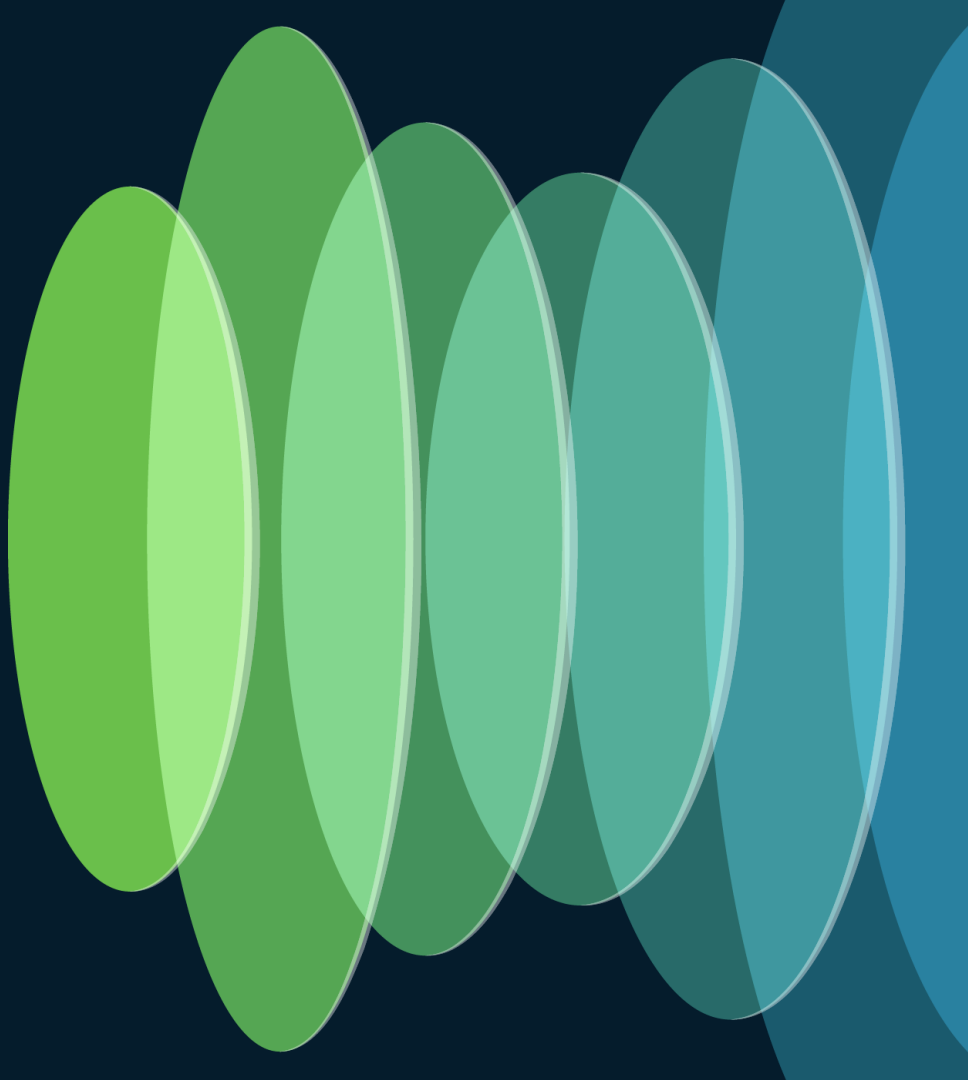
Why Wi-Fi 6E ?



Primitive applications of the past to ....

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Immersive Experiences of Today...

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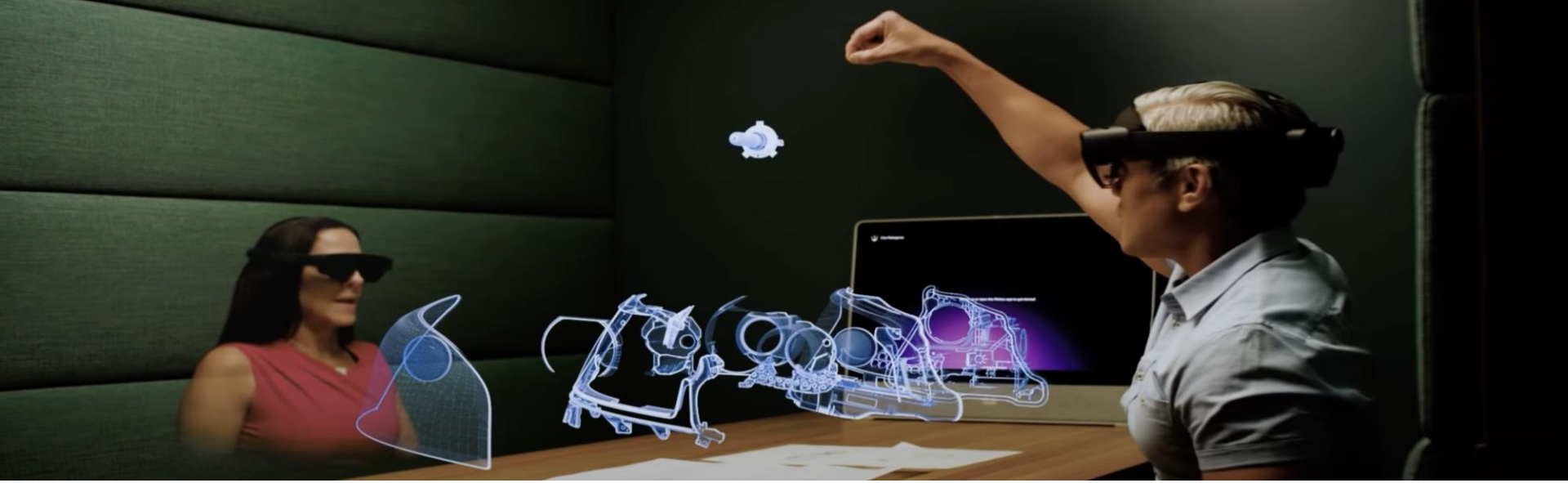

Webex Hologram https://www.youtube.com/watch?v=YEx7h0NKnXE

and Tomorrow...

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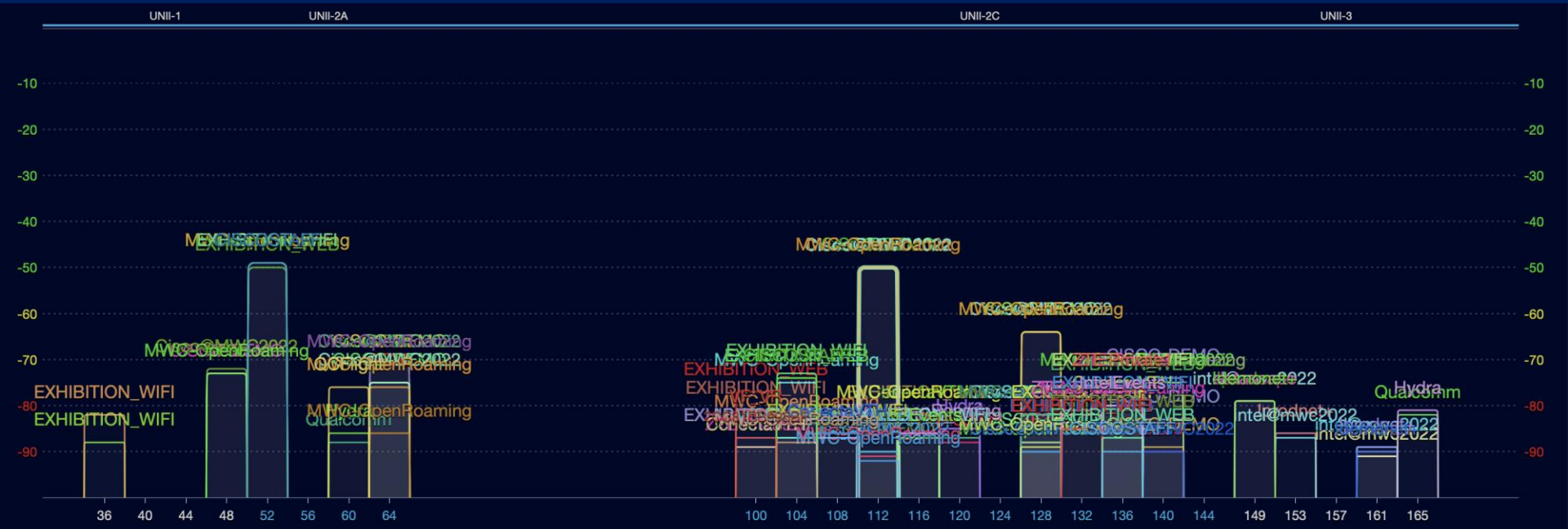
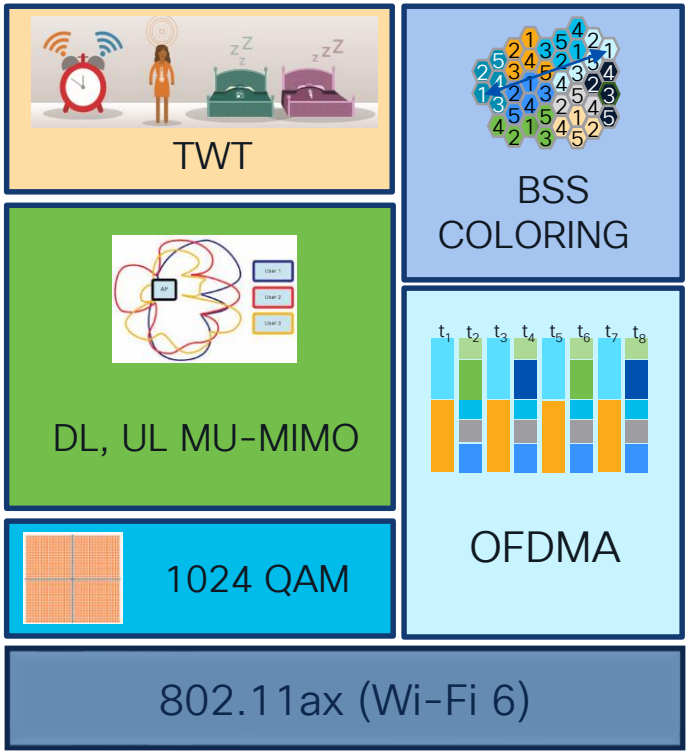
What is the Problem?

- Existing 2.4 GHz and 5 GHz spectrum is congested
- Interference
- Limited re-usable channels
- No way to use 80 or 160 MHz channels



Wi-Fi 6E
Wi-Fi 6 and 6GHz are friends!



1. **Additional Spectrum**
   1200 MHz (5.925 to 7.125 MHz) – US
   500 MHz (5.925 to 6.425) - EU
2. **Security Upgrade**
   WPA3 Mandatory
   Improves Security
3. **Clean RF**
   (Fixed Mobile Service Operators in UNI-5 and UNI-7)
4. **No Legacy (Slow) Devices**
   Improves performance
5. **Protocol Enhancements**
   Airtime Efficiency
6. **Wider RF Channels**
   80 MHz channels – 1200 MHz
   40 MHz channels – 500 MHz

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With Wi-Fi 6E ....

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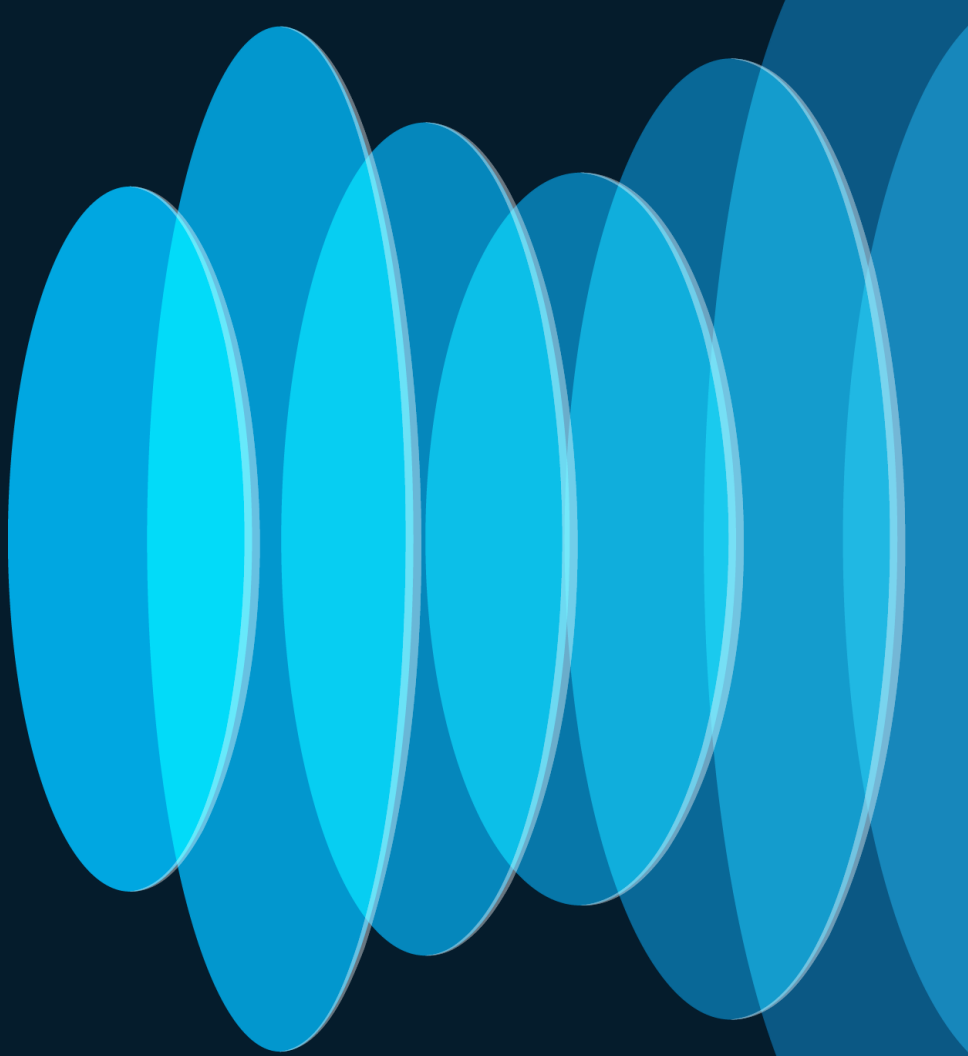
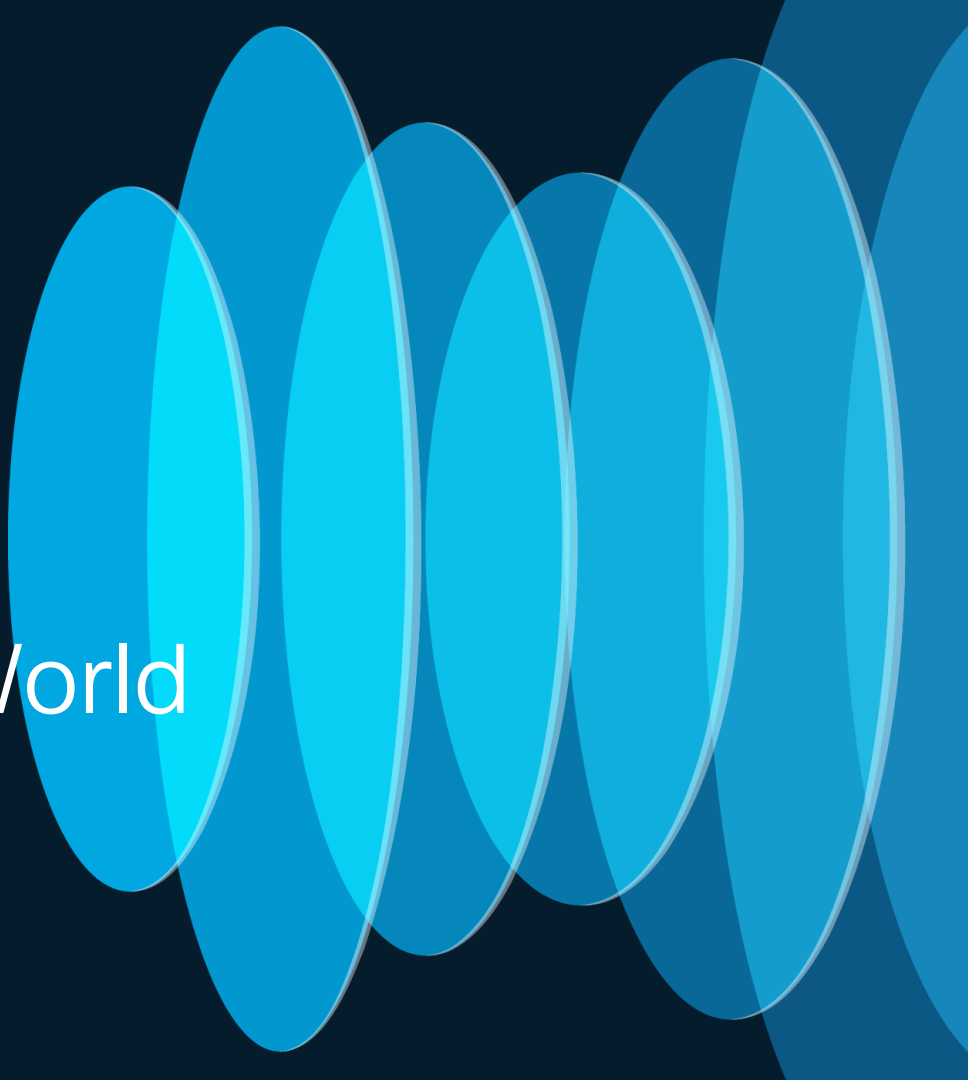
Setting the stage ....



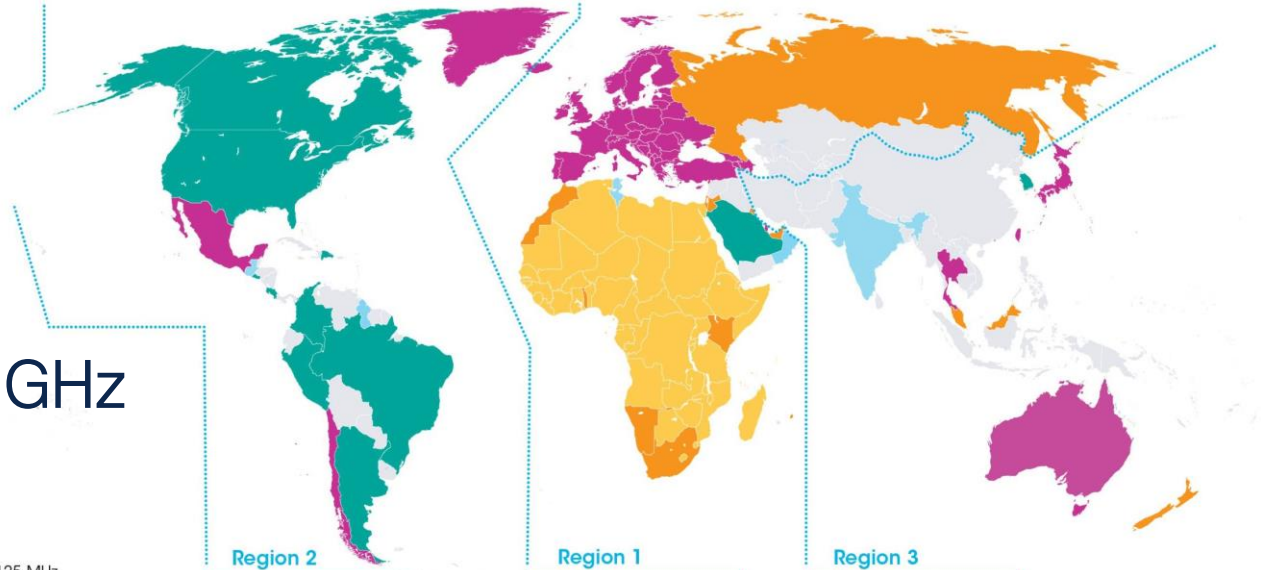
Setting the stage ....
- New 6 GHz Band
- Regulatory Considerations
- Protocol enhancements



Wi-Fi 6E
6GHz Around the World

cisco Live!

Global availability of 6 GHz band for Wi-Fi



- Adopted 5925-7125 MHz
- Adopted 5925/45-6425 MHz, and evaluating 6425-7125 MHz
- Adopted 5925-6425 MHz
- Recommended 5925-6425 MHz
- Under consultation

Region 2

1200 MHz
- Canada
- USA
- Honduras
- Costa Rica
- Brazil
- Peru
- Dominican Republic
- Colombia
- Argentina
- El Salvador

500 MHz (& evaluating 1200 MHz)
- Chile
- Mexico

Region 1

1200 MHz
- Saudi Arabia

500 MHz (& evaluating 1200 MHz)
- CEPT Area
- European Union (480 MHz)
- Qatar
- United Kingdom

500 MHz
- Morocco
- UAE
- Jordan
- Kuwait
- Kenya
- Israel
- Mauritius (480 MHz)
- Bahrain
- Togo
- Russia
- South Africa
- Namibia
- Africa / ATU

Region 3

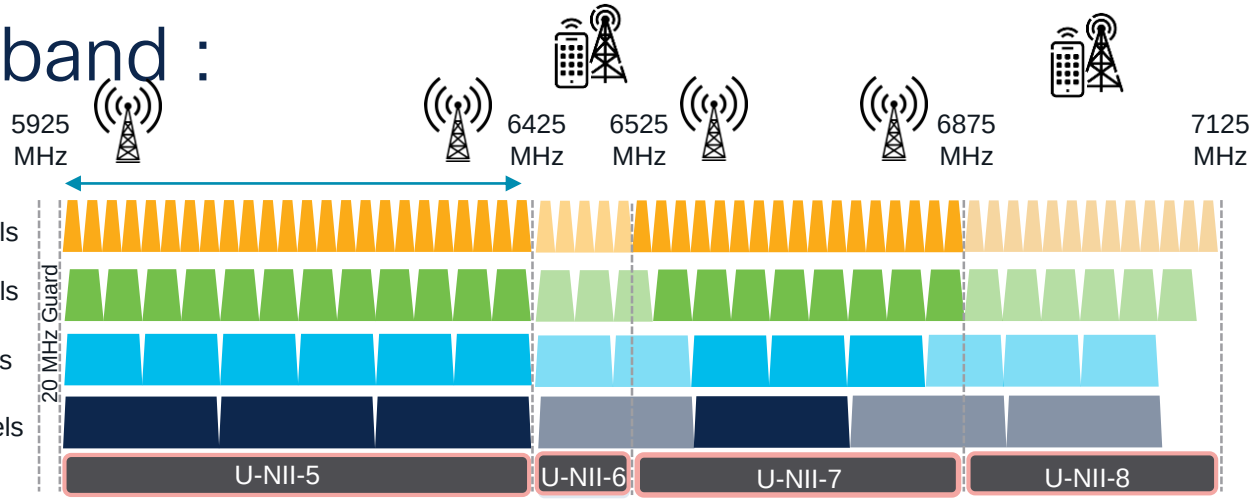
1200 MHz
- South Korea

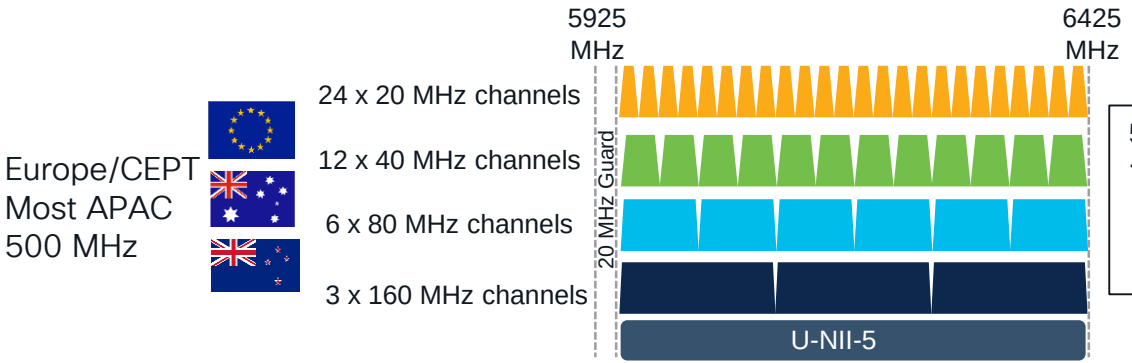
500 MHz (& evaluating 1200 MHz)
- Australia
- Japan
- Taiwan
- Thailand

500 MHz
- Hong Kong
- Malaysia
- New Zealand
- Singapore

Source: https://6ghz.info

The new 6 GHz band :





5955 – Central Frequency of the first 20 MHz channel
→ Starting at 5925 MHz +
20 MHz of guard band +
10 MHz to get to the center of the first 20 MHz channel

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6 GHz – New Device Classes

Wi-Fi 6E introduces new device classes for optimized capability

Low Power Indoor AP

- Indoor Only
- Integrated Antenna Required
- Can use the full 1200 MHz
- Wired Power

Standard Power AP

- Indoor or Outdoor
- Integrated or External Antenna
- UNII-5 and UNII-7 Only (US)
- Requires AFC

Very Lower Power AP

- Mobile Indoor or Outdoor
- Limited Range
- Can use the full 1200 MHz
- Does not require AFC

Client Devices

- Indoor or Outdoor
- Only Indoor under control of LPI AP
- 6 dBm lower power than AP

Regulations vary by country

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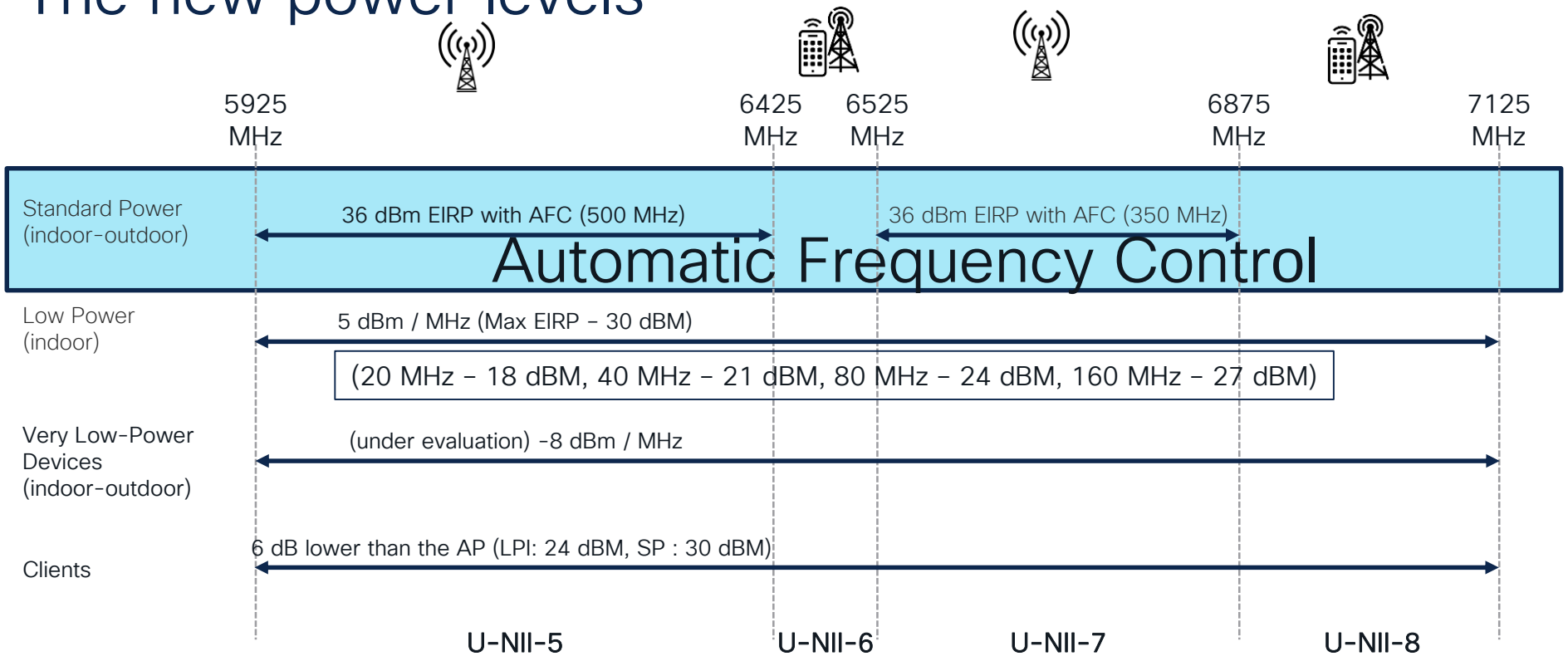
The new power levels



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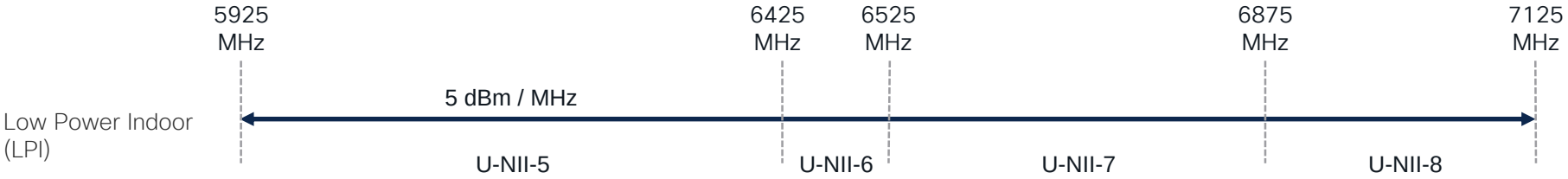
Low-Power Access Points (indoor)



6 GHz power is measured as **Power Spectral Density (PSD)** a Maximum of 5 dBm/MHz is permitted for LPI
(Power Spectral Density – *Amount of power over a given bandwidth)*

5 dBm = 3.162278 mW

3.162278 mW x 20 MHz = 63.24556 mW = 18 dBm
3.162278 mW x 40 MHz = 126.4911 mW = 21 dBm

Client power also has a PSD rule of 6 dB less than the AP's max EIRP

Channel BW	AP EIRP	Client EIRP
20 MHz	18 dBm	12 dBm
40 MHz	21 dBm	15 dBm
80 MHz	24 dBm	18 dBm
160 MHz	27 dBm	21 dBm

Note: Indoor AP's with an external antenna, must operate under the Standard Power rules, LPI only applies to I models

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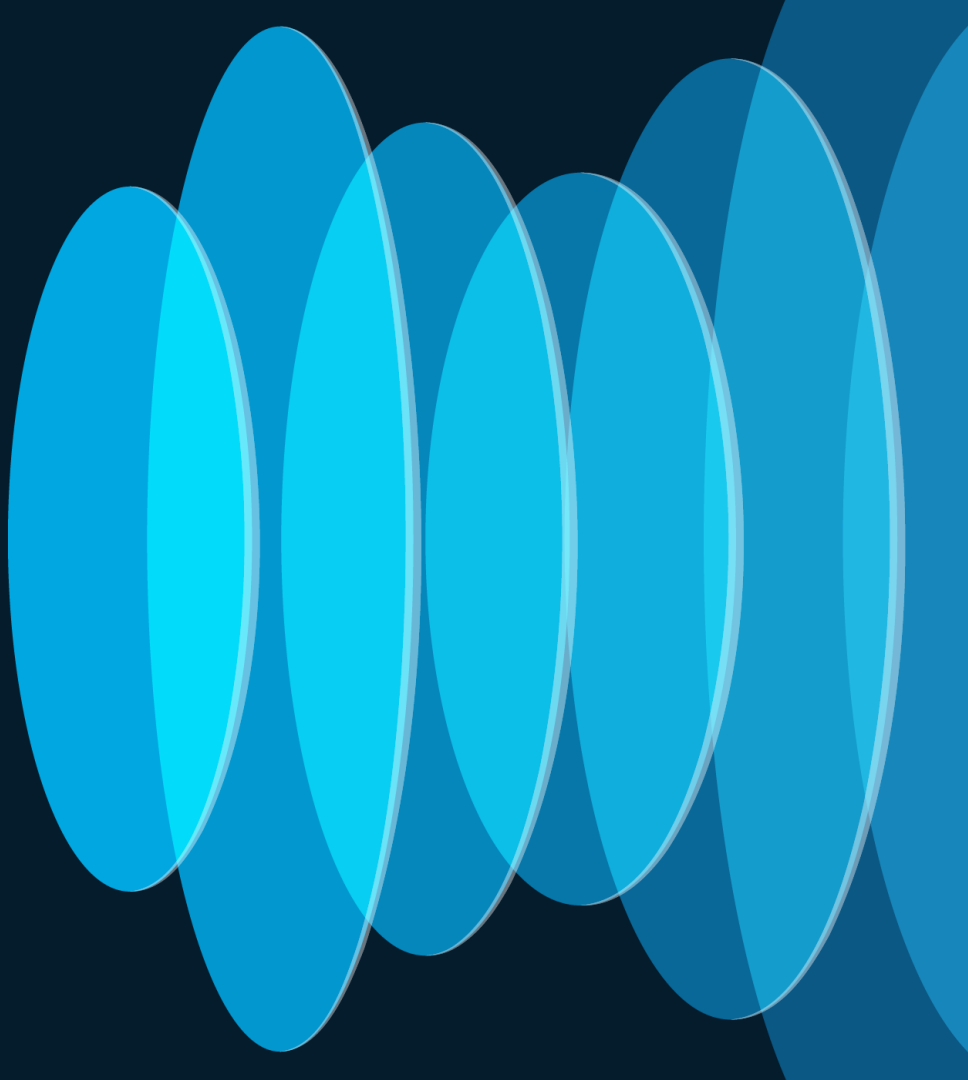
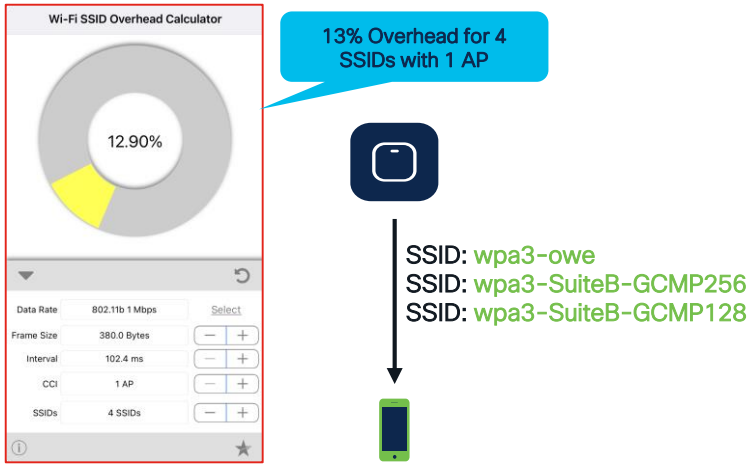
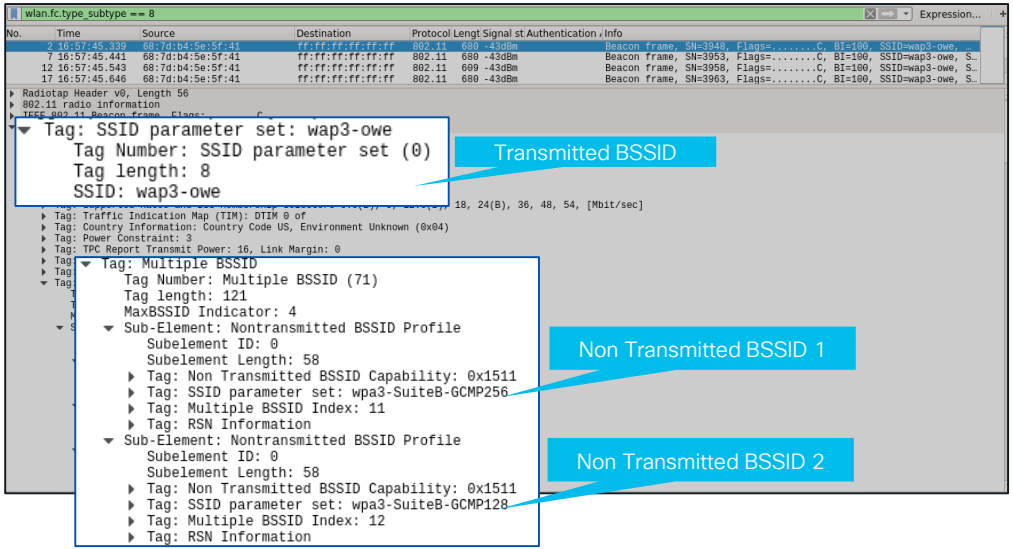
Protocol Enhancements



Multiple BSSID

- Capability originally specified in 802.11v
- Combines multiple SSID information in a single beacon frame





- Conserves Airtime
- Mandated in Wi-Fi 6E

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Wi-Fi 6E – New AP Discovery Mechanisms

Out of Band

Reduced Neighbor Report

Co-located Discovery

In Band

Passive Scan:

Fast Link Setup (FILS) Discovery Frames
Unsolicited Broadcast Probe Response Frames

Active Scan:

Preferred Scanning Channels (PSC)

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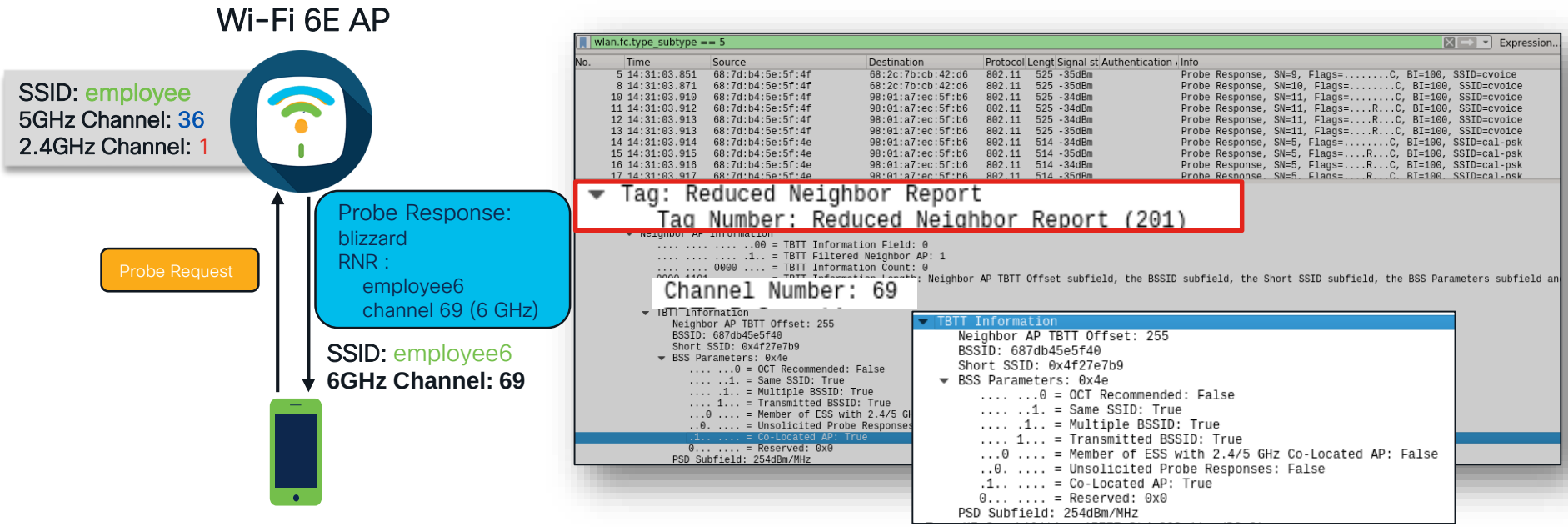
Reduced Neighbor Report

Co-located “Neighbor” 6 GHz radio information in Beacon and Probe Response of 2.4 and 5 GHz radios.



Clients start with 2.4 and 5 GHz bands discovery mechanism to learn 6 GHz SSIDs

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Wireless Clients always Probe!

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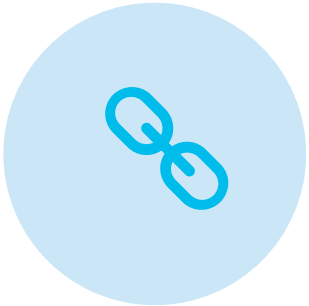
FILS Discovery Frames helps AP Discovery Faster

Reduces AirTime Utilization by Management Frames

SMALLER BEACONS THAT IS TRANSMITTED MORE FREQUENTLY (APPROX. 20 MSEC), CONSUMES LESS AIR TIME.



CONTAINS INFORMATION FOR THE CLIENT TO DECIDE ON THE AP TO CONNECT (SHORT SSID, CHANNEL, TBTT ETC)

REDUCES PROBE REQUEST OVERHEAD

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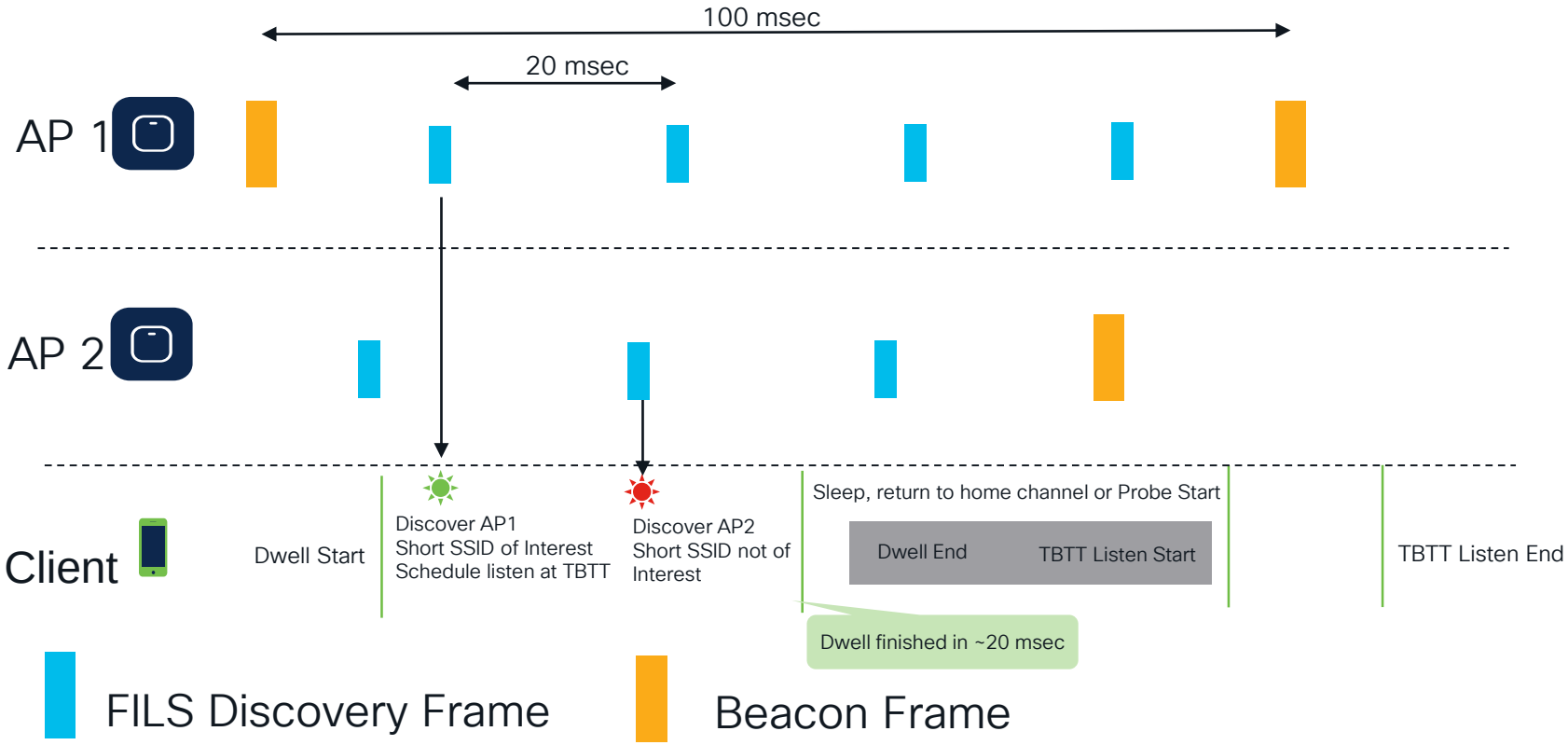
Fast Initial Link Setup (FILS) Discovery Frames



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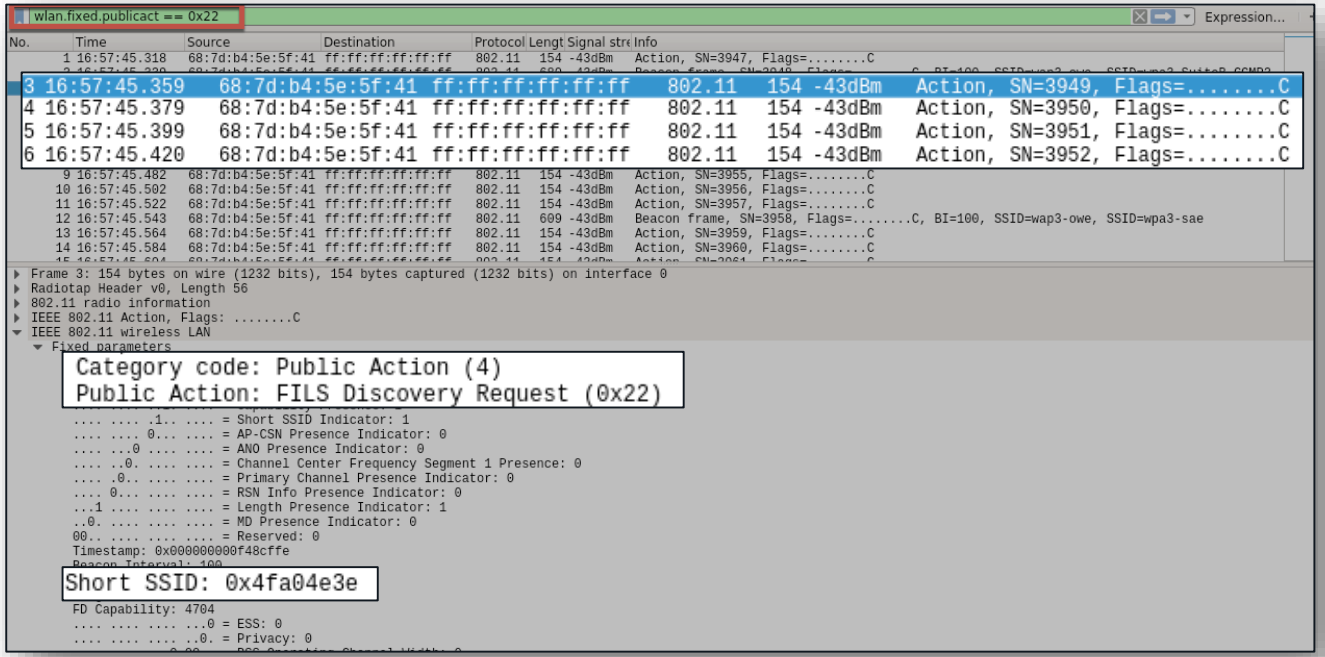
FILS Discovery Frame – Packet Capture

Wireshark Filter Expression: wlan.fixed.publicact == 0x22



Broadcast Action Frames

Contains Short SSID, Channel, TBTT etc

Transmitted every 20 msec

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Unsolicited Broadcast Probe Response

Reduces Probe Request Overhead

Broadcast probe response every 20 msec

Contains detailed information as a Beacon

Helps Avoid Probe Storm

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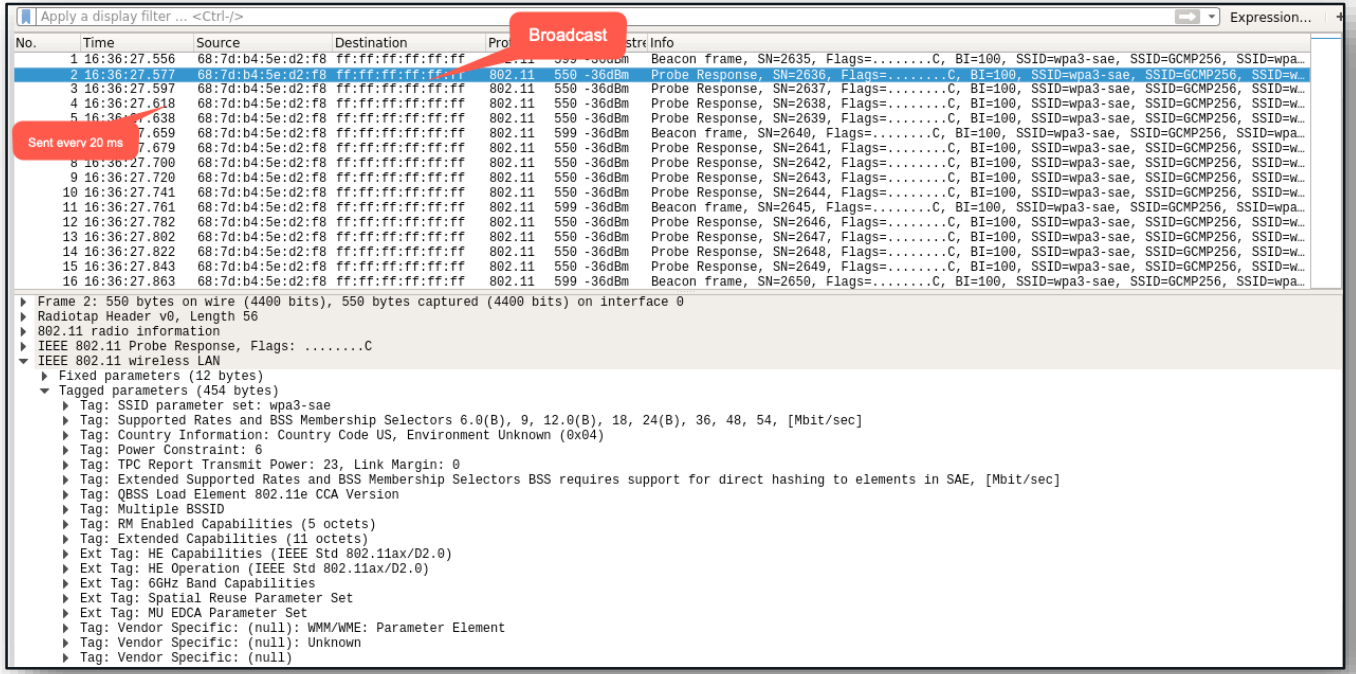
Unsolicited Broadcast Probe Response Packet Capture



- Broadcast frames
- Transmitted every 20ms
- Carry Multiple BSSID
- Contains all information needed for association

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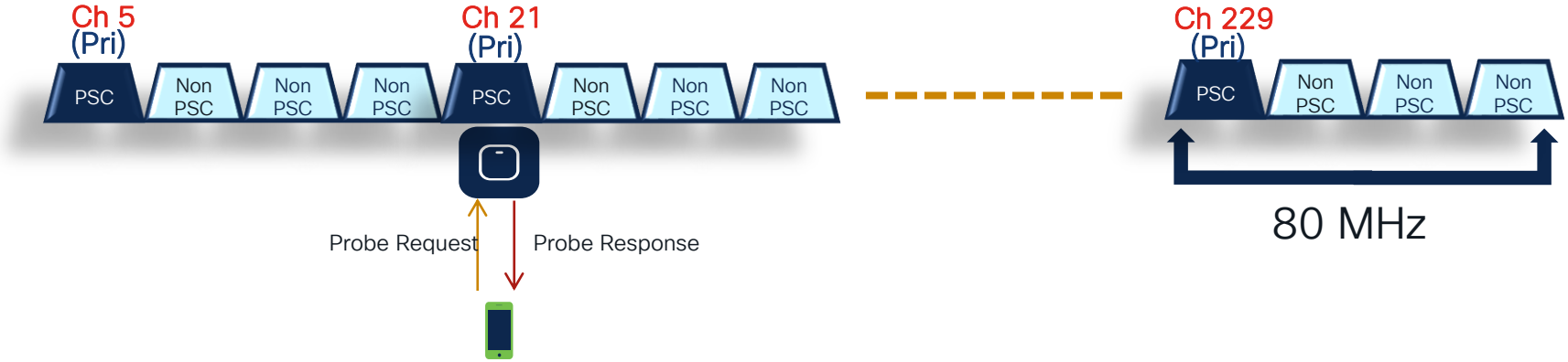
Preferred Scanning Channels (PSC)

- Every fourth 20MHz channel designated for active probing by Wi-Fi 6E Clients; restricts scanning to 15 channels, instead of 59.
- PSC channels serve as the primary channel for channel bonding in 80 MHz



PSC Channel List:
5, 21, 37, 53, 69, 85, 101, 117, 133, 149, 165, 181, 197, 213 and 229

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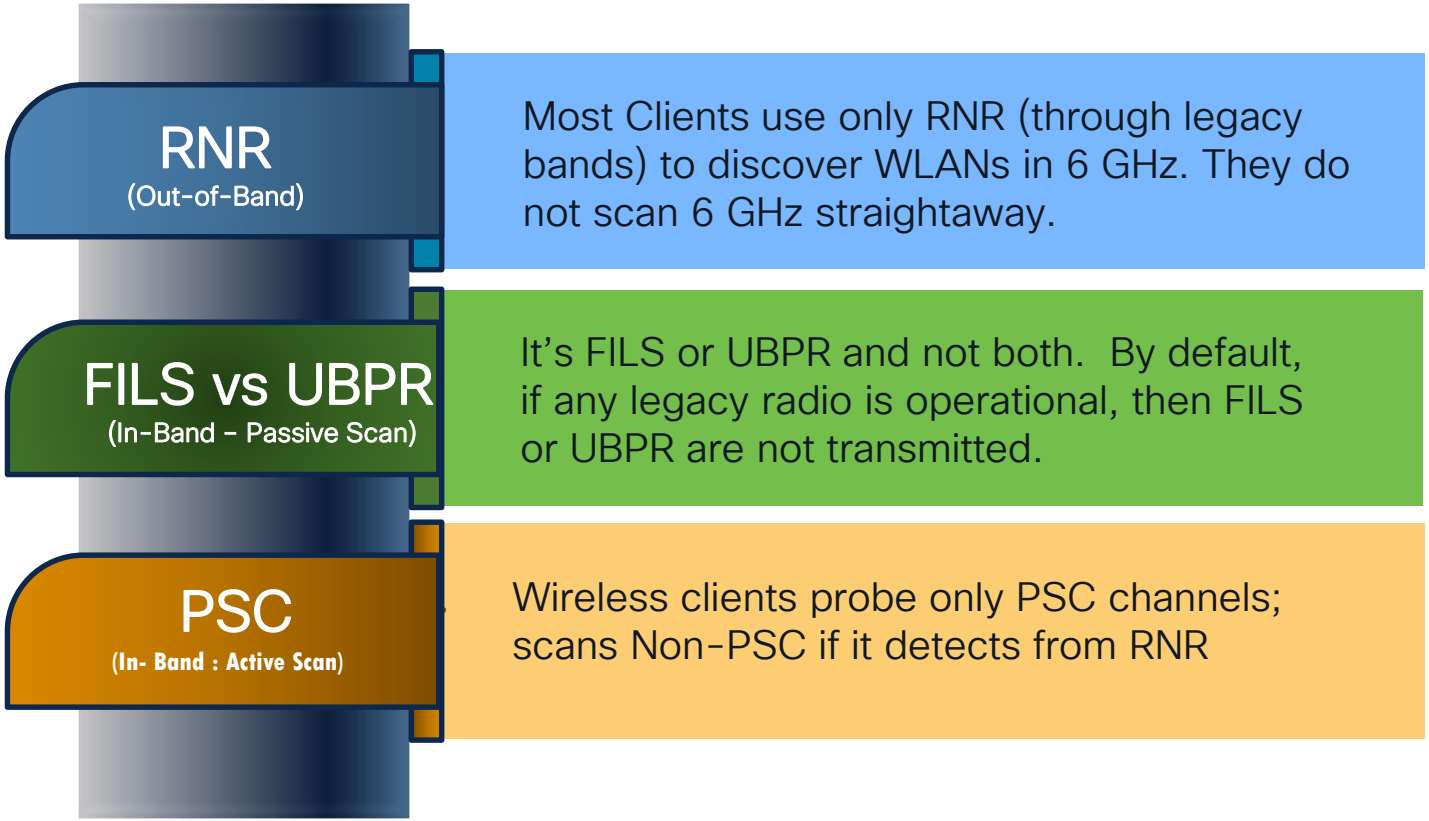
Key Takeaways



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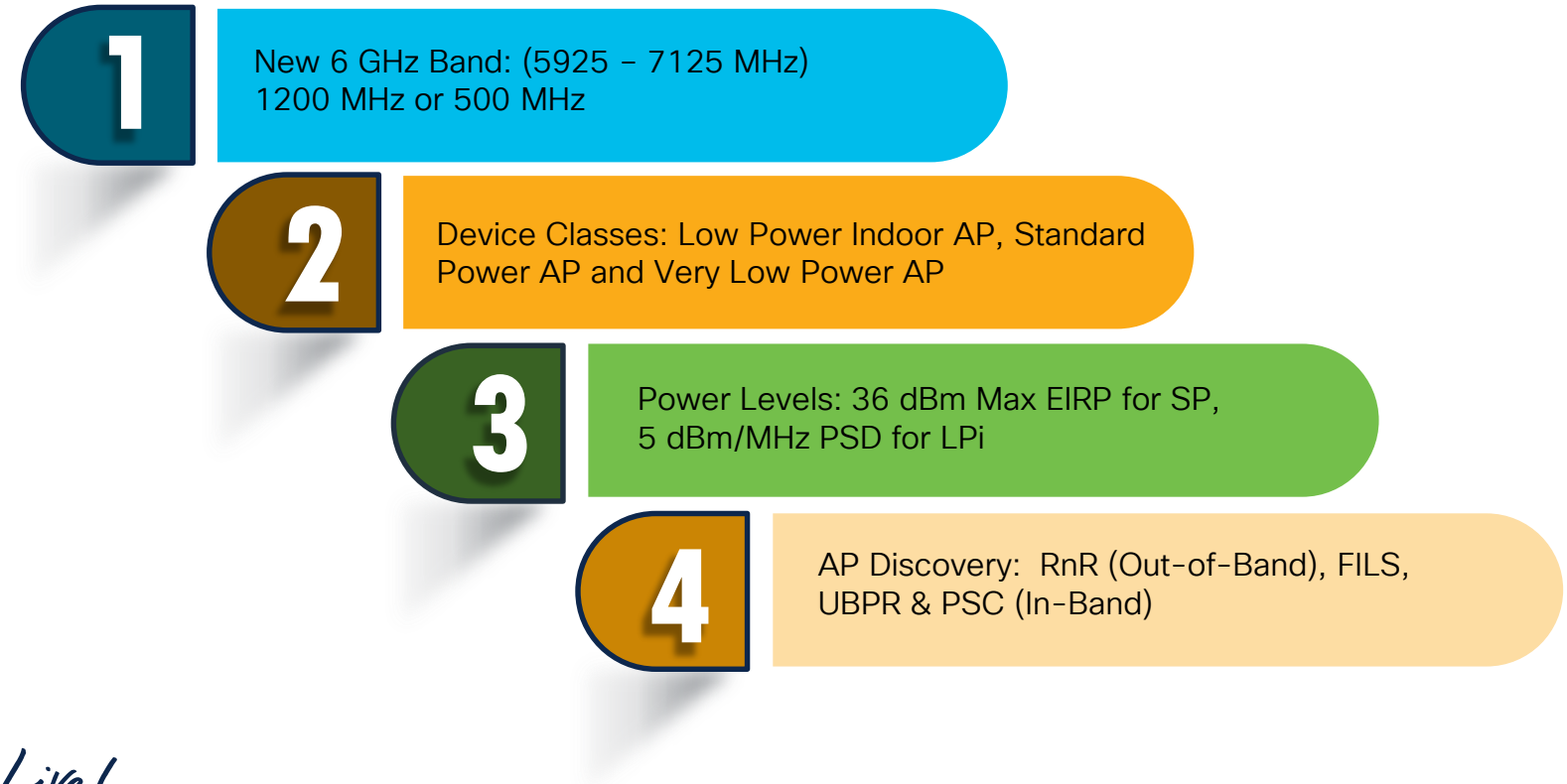
Section Summary



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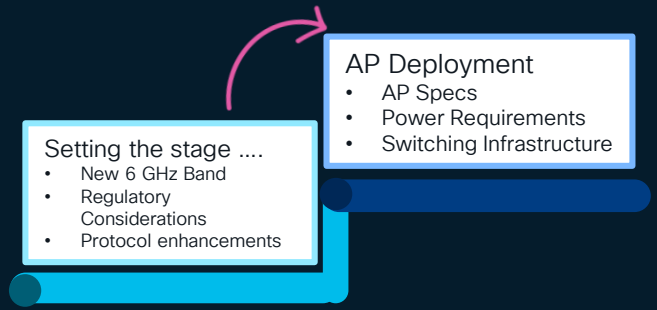
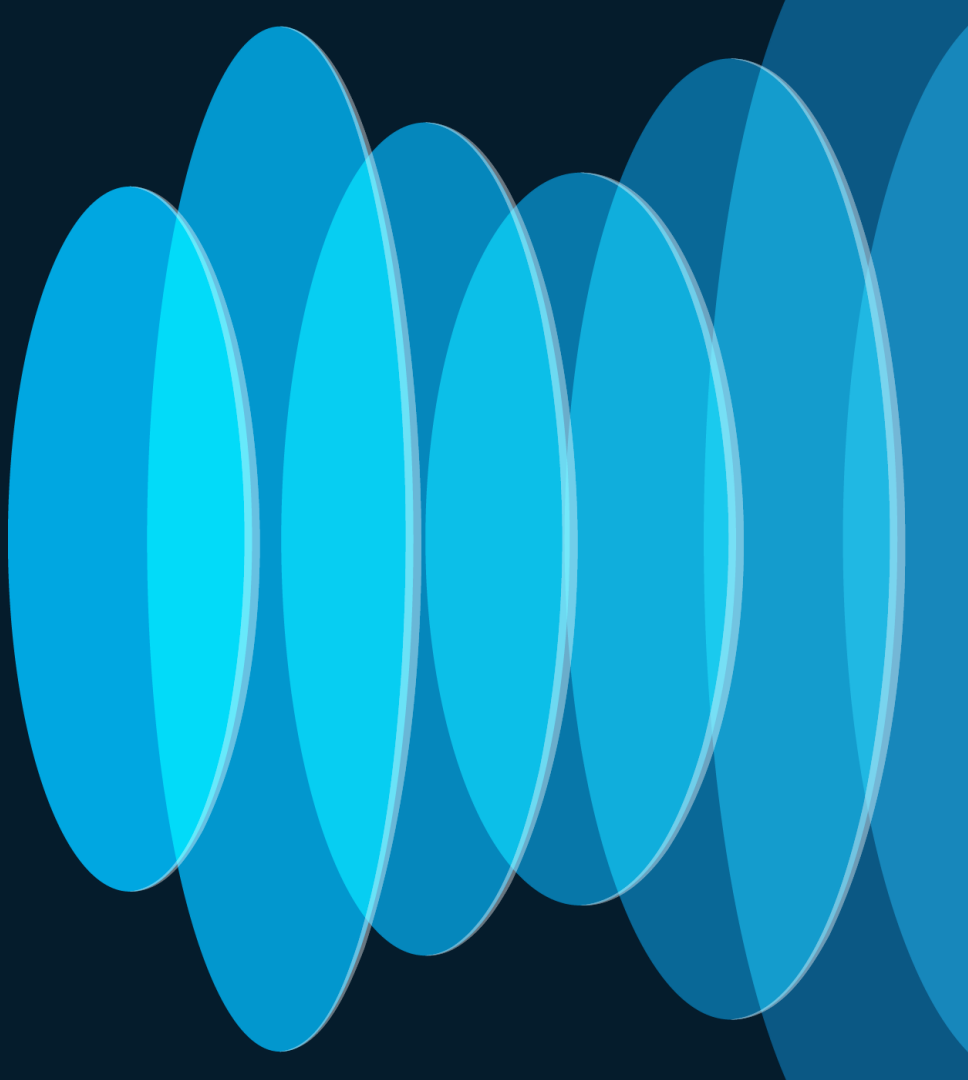
AP Deployment





One Product – Two Management Modes

Cisco On-Prem **Management Mode**
C9800 & Catalyst Center Stack

Meraki **Management Mode**
MR Dashboard Stack

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Industry's best & broadest Wi-Fi 6E portfolio

Indoor Access Points

Outdoor Access Point

Management mode can be changed

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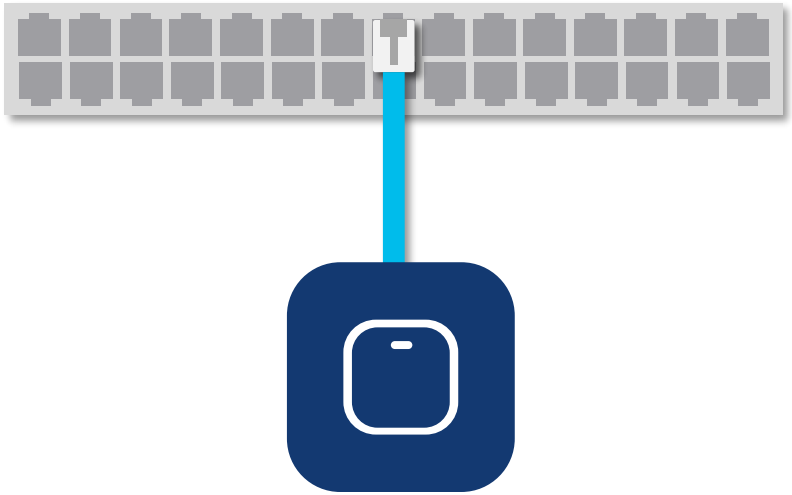
Network Infrastructure

Catalyst AP to Switch connection



AP negotiates power, speed and duplex at boot time via CDP/LLDP

MGig switchport is recommended as Wi-Fi 6/6E speed may exceed 1 Gbps

Cabling: Cat 6/6A recommended. Cat 5e can support up to 5Gbps

CDP = Cisco Discovery Protocol
LLDP = Link Layer Discovery Protocol
Cat = Category (of ethernet cable)

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Wi-Fi 6E Performance Comparison

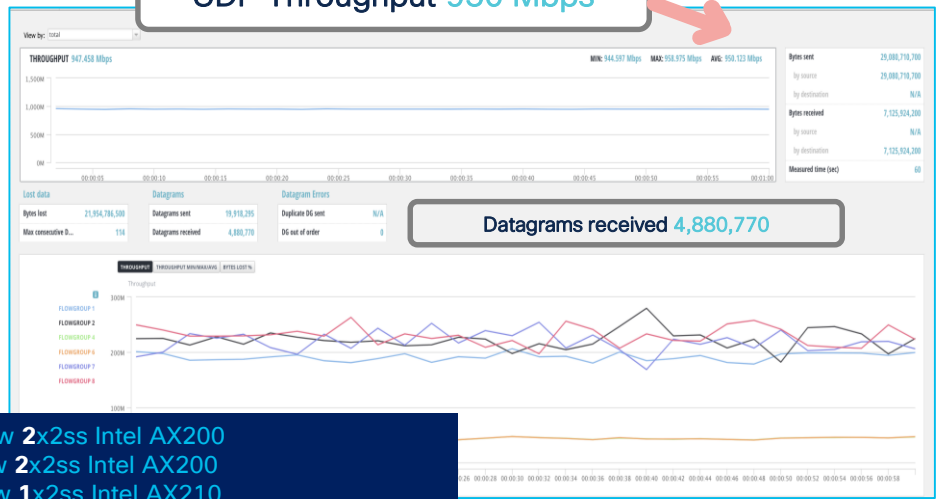
5 Gig (mGig) AP Uplink vs. 1 Gig AP Uplink

Wi-Fi 6E Performance with mGig (5 Gig) Switch

UDP Throughput 2.88 Gbps

Wi-Fi 6E Performance with Gigabit Switch

UDP Throughput 950 Mbps



2.4 GHz @20 MHz w **2**x2ss Intel AX200
5 GHz @80 MHz w **2**x2ss Intel AX200
6 GHz @160 MHz w **1**x2ss Intel AX210

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Catalyst AP C9136 to Switch connection

AP C9136

C9136 has two mGig uplink ports

Dual port is for PoE power and uplink redundancy with hitless failover

Switchport and AP can be configured for LAG or standalone ports (default)

mGig = multi gigabit ethernet
PoE = Power over Ethernet
LAG = Link Aggregation Group

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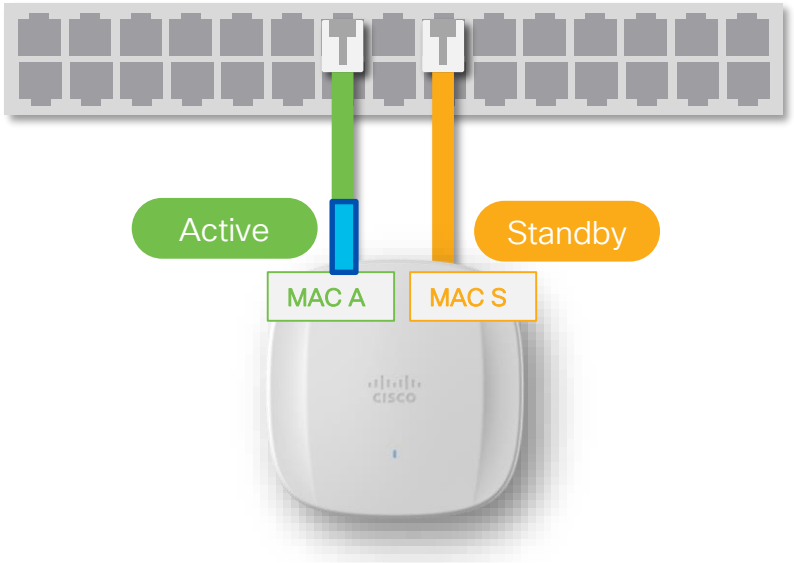
Catalyst AP C9136 to Switch connection



AP C9136

- When configured as standalone ports, one becomes active and the other one standby
  - If power is equal on both ports, Port 0 becomes active. Otherwise, the one with more power
- Traffic is exchanged on active port using active MAC A (CAPWAP, ARP, etc.)
- Standby port only exchanges CDP/LLDP messages with its own MAC S, no other traffic

MAC = Media Access Control
ARP = Address Resolution Protocol
CAPWAP = Control and Provisioning of Wireless Access Points

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Catalyst AP C9136 to Switch connection

AP C9136

- When configured as standalone ports, one becomes active and the other one standby
  - If power is equal on both ports, Port 0 becomes active. Otherwise, the one with more power
- Traffic is exchanged on active port using active MAC A (CAPWAP, ARP, etc.)
- Standby port only exchanges CDP/LLDP messages with its own MAC S, no other traffic
- In case of active port failure, standby becomes active and exchanges traffic using MAC A. Minimal to zero traffic interruption

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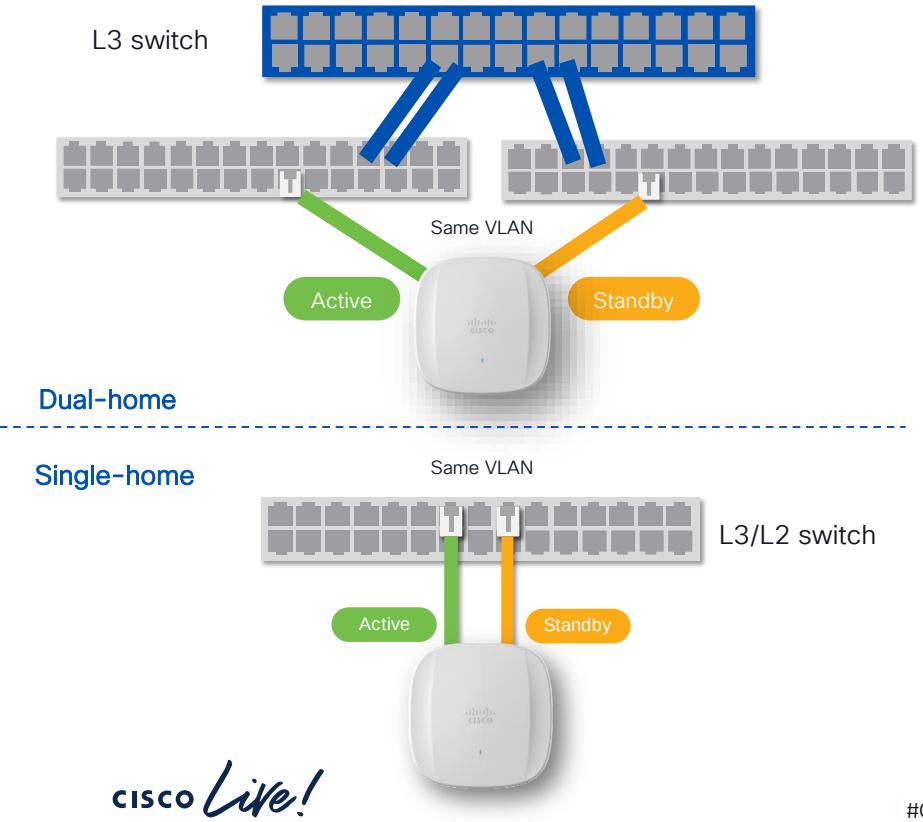
Catalyst AP C9136 to Switch connection



- When configured with standalone ports, you have two options…
- Dual-home to two different switches
  - Recommend to connect to switches in different IDF, whenever possible
- Single-home to one logical switch (Stack Wise, vPC, Multi-layer switch, etc.)
  - Recommend to connect to two different members of the stack or line-cards
- In both scenario, the switchports must be configured in the same VLAN

VLAN = Virtual Local Area Network
IDF = Intermediate Distribution Frame
vPC = virtual Port Channel

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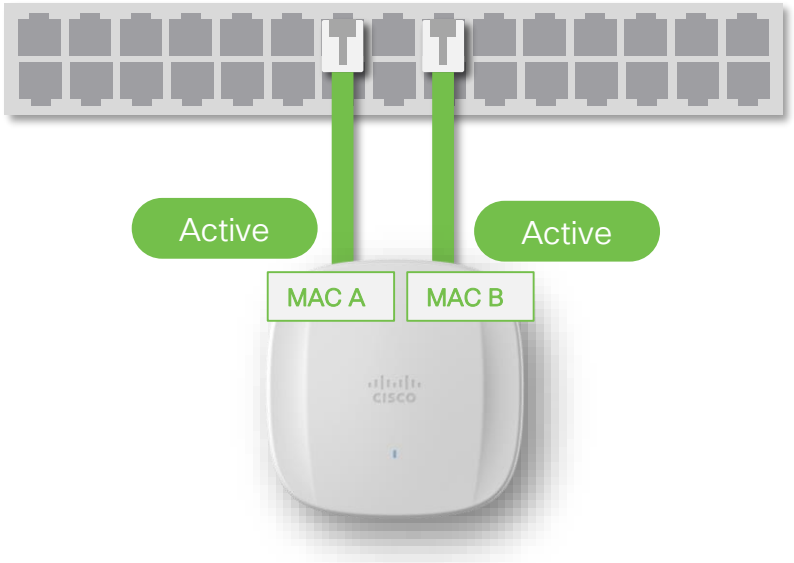
Catalyst AP C9136 to Switch connection



AP C9136

- When configured with LAG, both ports are Active
- LAG must be configured on both AP and switchport side.
- AP supports static LAG config (mode on) or dynamic with LACP
- Traffic is load balanced across the two links using src-dst-port algorithm. CAPWAP uses random source UDP ports
- LAG must be connected to one single (physical or logical) switch

LACP = Link Aggregation Control Protocol
src-dst-port = source-destination-port

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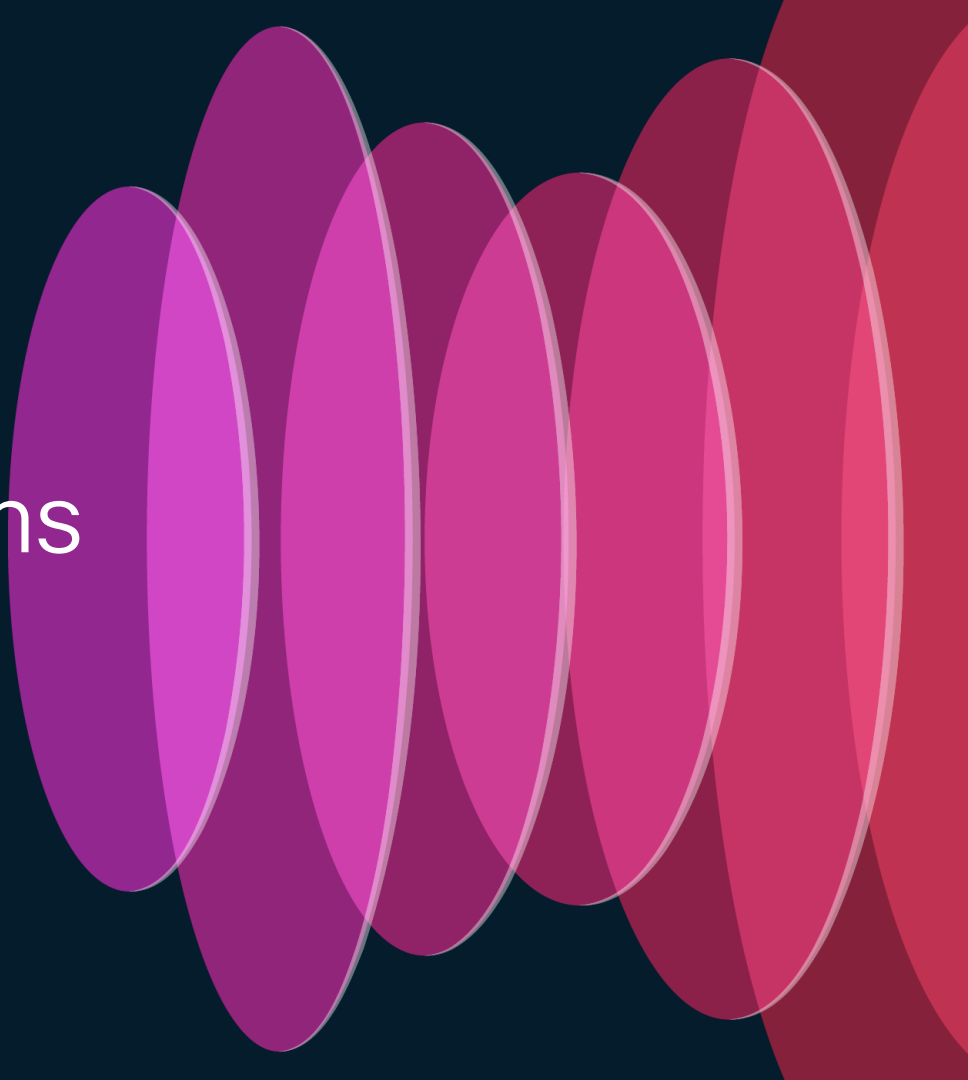
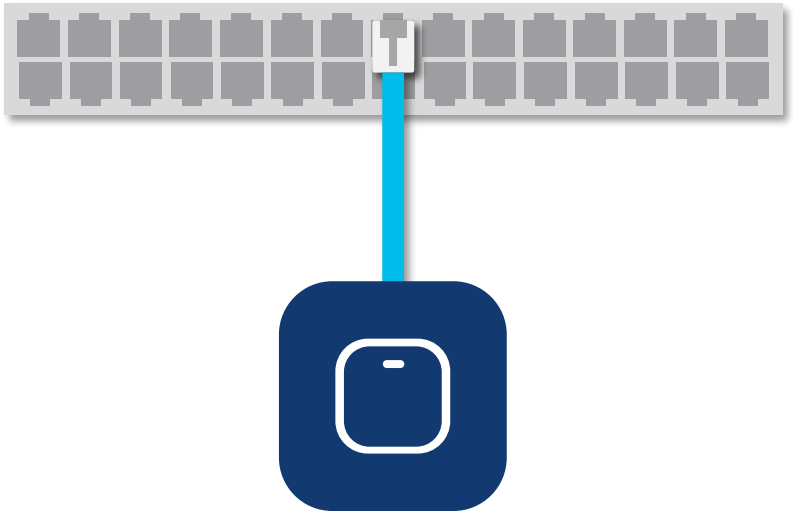
Power considerations



AP Power Consumption



Power Allocated	Power Consumed
48.3 W	16.5 W

PoE Power Negotiation happens at boot time through CDP/LLDP

Power allocation is what you need to consider for power budget

Actual Power consumption is dependent on the AP operation

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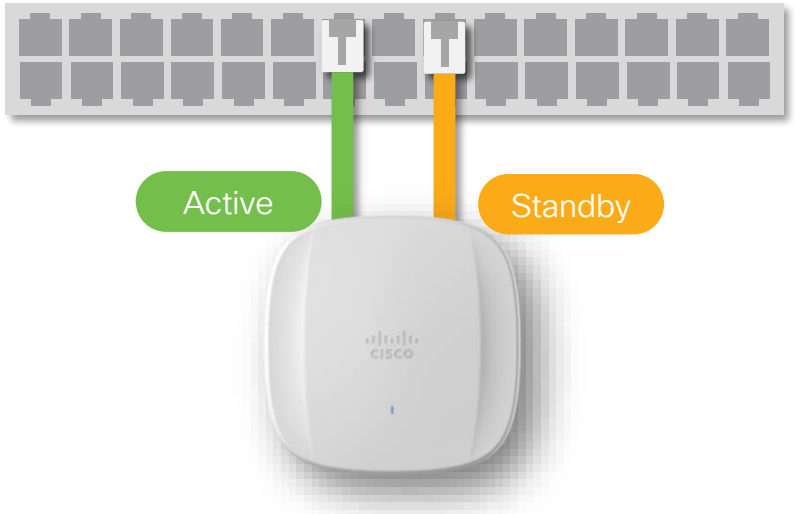
Catalyst 9136 Power Consumption (dual port)



	Power Allocated	Power Consumed
Port 0	48.3 W	16.5 W
Port 1	48.3 W	0.5 W

Both ports negotiate power and need to be considered for budget

If no-LAG, Standby port consumes very little power

If LAG, both ports are active, and they both draw power

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Section Summary

1. Catalyst Wi-Fi 6E Access Point Portfolio
2. Common Hardware and Migration
3. Switch Port Speed (> 1 G)
   Cabling : Cat 5e, Cat 6, Cat 6A and above
4. Power Considerations
5. Catalyst 9136 Dual mGig Link and PoE Redundancy Options

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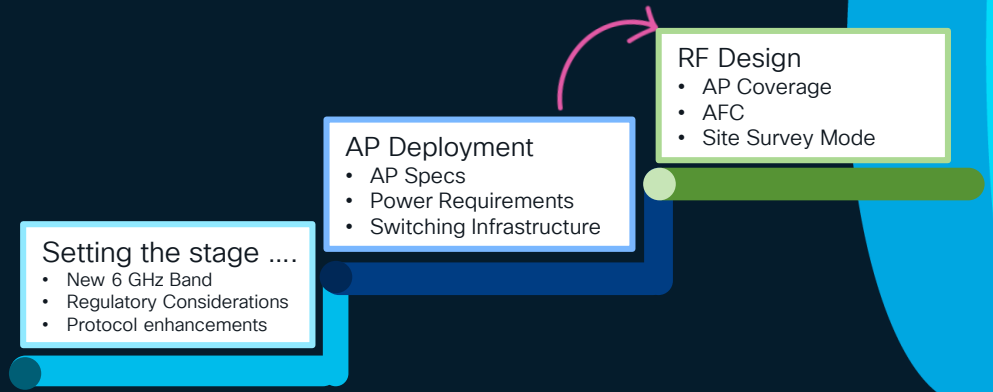
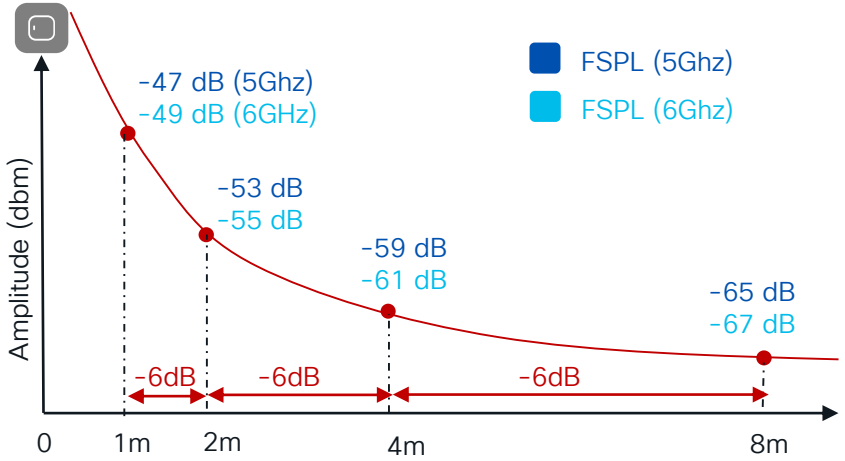
RF Design

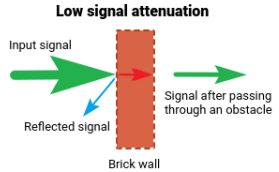

Setting the stage ....
• New 6 GHz Band
• Regulatory Considerations
• Protocol enhancements
AP Deployment
• AP Specs
• Power Requirements
• Switching Infrastructure
RF Design
• AP Coverage
• AFC
• Site Survey Mode

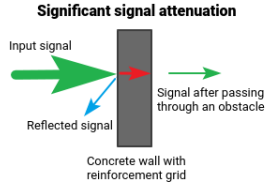
What you need to consider?

- Path Loss (FSPL)* – Path loss in the first meter is on average 2dB higher at 6GHz vs. 5GHz. After that, the 6 dB rule applies: doubling the distance results in a 6 dB loss, regardless of the frequency
- Cell Size – At 6 GHz @ same power level cell is smaller vs. cell size at 5 GHz



- Absorption/Reflectance – 6 GHz will be attenuated more through wall or other surface
- Noise floor at 6 GHz is much lower than 5 GHz, at least for some time ☺
- Coverage type: Today 6GHz is indoor only





(*) FSPL = Free Space Path Loss: https://en.wikipedia.org/wiki/Free-space_path_loss

https://help.keenetic.com/hc/en-us/articles/213968869-Wi-Fi-signal-attenuation-coefficients-when-passing-through-different-materials

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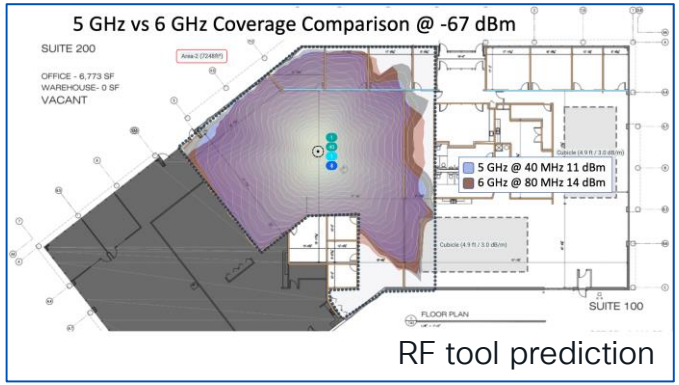
RF Design considerations

- AP antenna patterns at 6GHz are similar to 5GHz
- AP coverage between 5GHz and 6GHz will be similar, especially in open spaces BUT it does require to compensate with power > 3dB higher in 6GHz



RF tool prediction

5GHz @40 MHz 11dbm

6GHz @80 MHz 14 dbm

- With brick walls, elevator and other environments, you would probably need to measure and add few APs

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Where are we then on 5 and 6 GHz assumptions?

Q1: Can a co-resident 6 GHz radio provide the same coverage as the 5 GHz cell while dramatically increasing performance?

A1: Yes!

Q2: Can a one for one replacement of Wi-Fi 6/5 APs with Wi-Fi 6E APs be achieved?

A2: Yes!

*Assuming 1.2 – 2k f^2 (140-190 m^2) of average AP density, carpeted office normal ceiling (3 m /10 ft)

- 5 GHz network with RRM operating at power levels 3-4? >then equal 5 and 6 GHz coverage is possible with a one for one AP replacement in both ETSI and FCC. Assuming 80 MHz channel in FCC and 40 MHz channel in ETSI/UK
- If the power level is in 1-2, then you may need around 10 to 20% additional access points.

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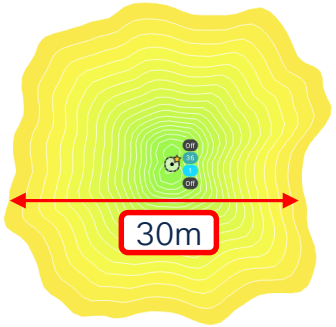
Wi-Fi 6E SP Indoors

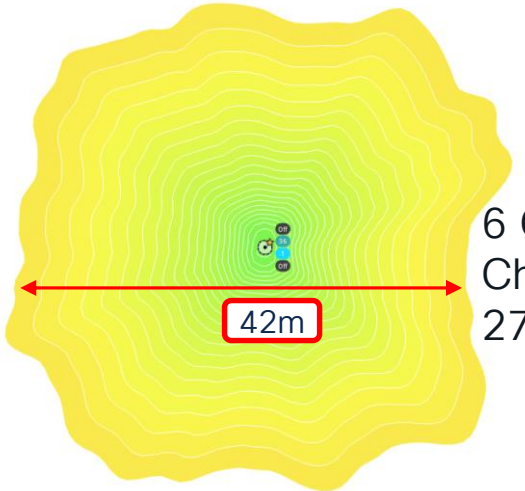
Higher Power In 20 MHz

- Allowing higher power in the first 20 MHz
  - SP: Max – 36 dBm EIRP, LPi: 18 dBm EIRP
  - Creates a larger cell size
  - Allows more power to reach the floor with a higher ceiling!
- High Ceiling Warehouse – larger Cells, less Clients – SP
- Atriums, high ceilings, loading docks, a lecture hall, Stairwells etc.
- Many installations have some or all of the above
- Wi-Fi 6E indoors – allows these use cases to be covered with 6 GHz too!



6 GHz
Ch 1@20-160 MHz
18 dBm EIRP LPI

CW9166i @ 2.4m Height



6 GHz
Ch 1@20-160 MHz
27 dBm EIRP SP

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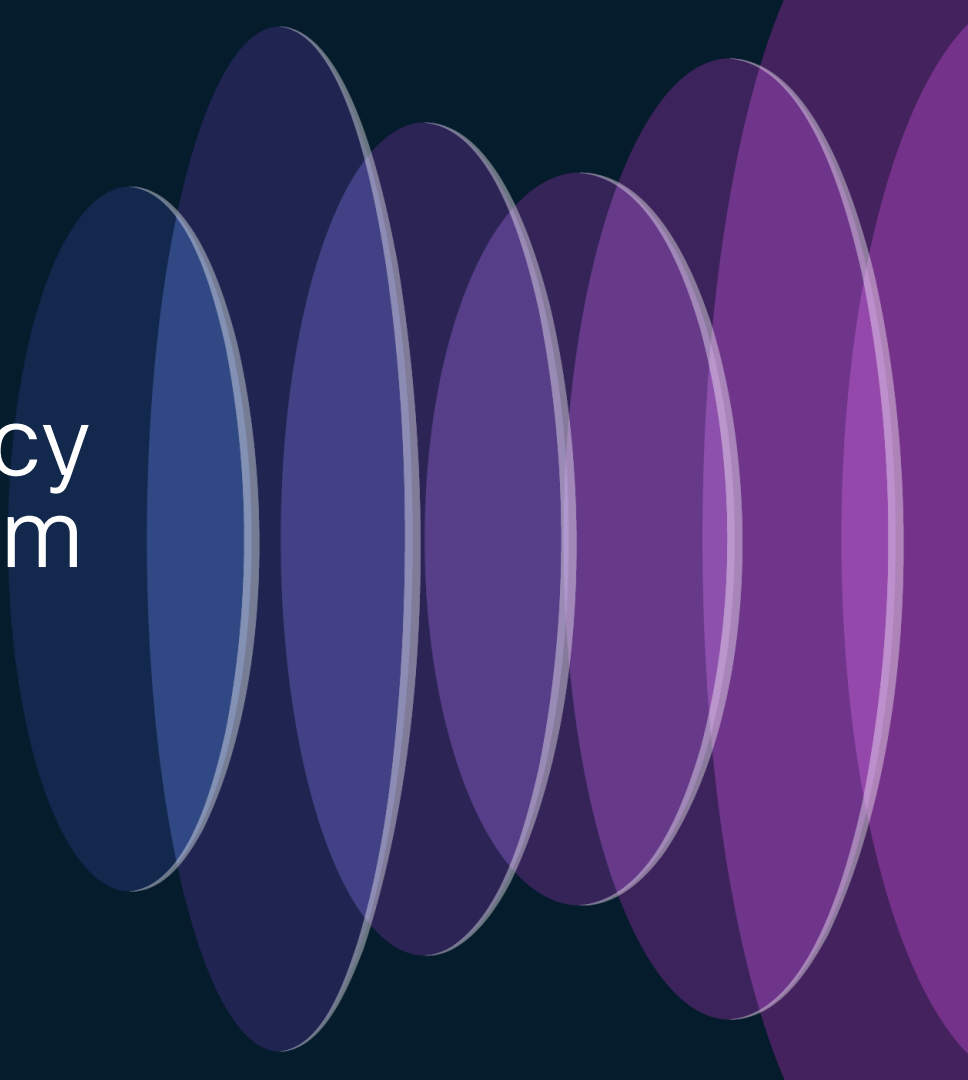
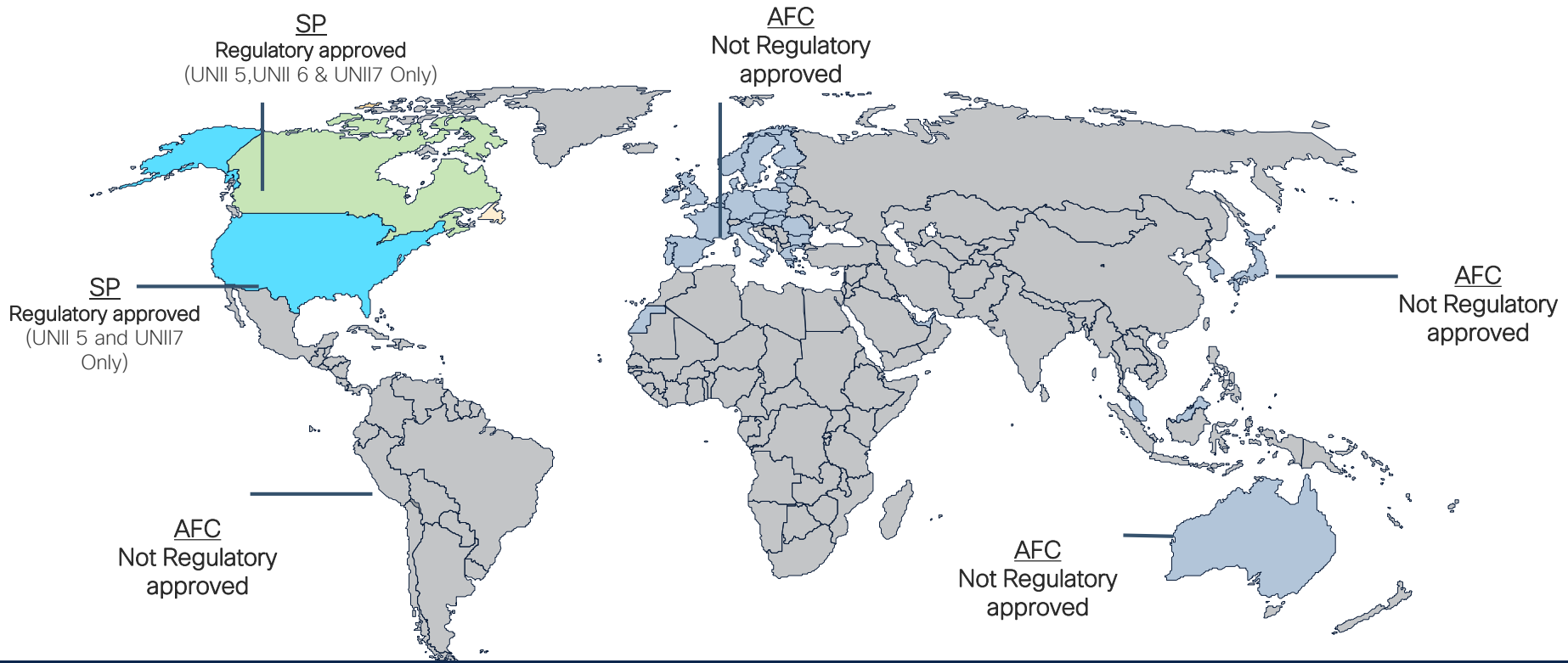
Automated Frequency Co-ordination System (AFC)



cisco Live!

External(SP)/Outdoor Antenna Wi-Fi 6E Status



AFC approved and in production in USA

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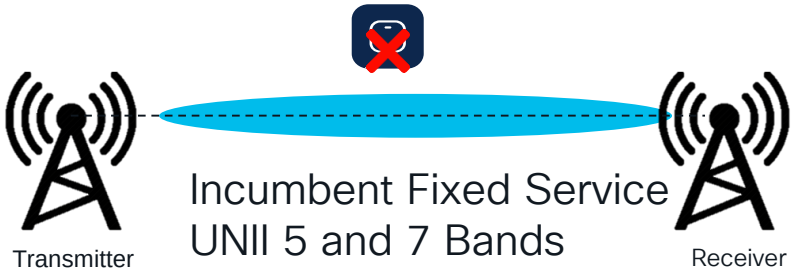
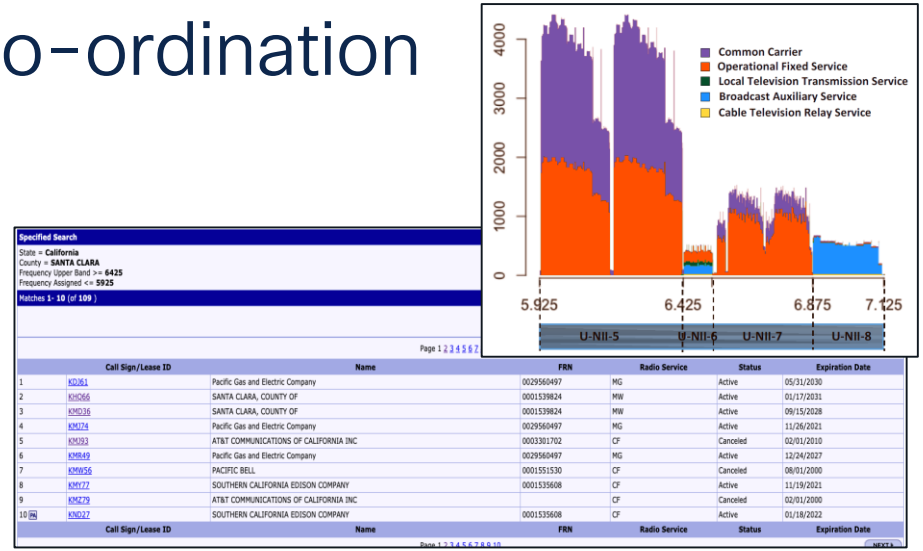
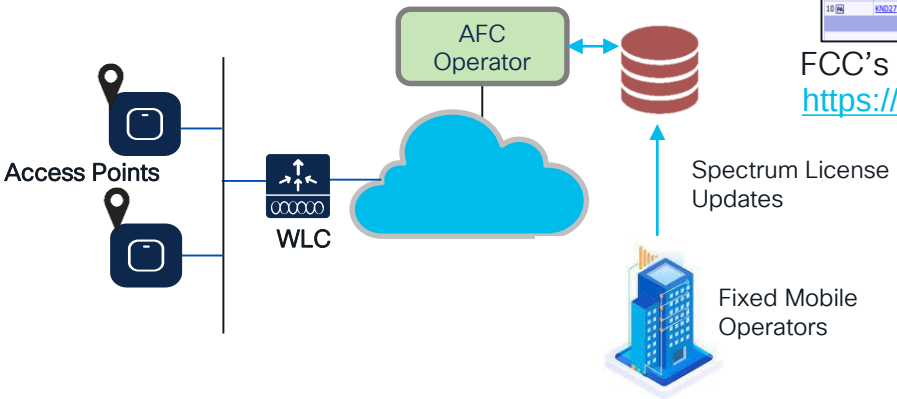
Automated Frequency Co-ordination





FCC's Universal Licensing System:
https://wireless2.fcc.gov/UlsApp/UlsSearch/searchGeographic.jsp



Automated Frequency Coordination (AFC): Central database of frequencies, which are available in the AP's same geographical location, and where the AP does not risk to interfere with other systems (e.g. fixed satellites)

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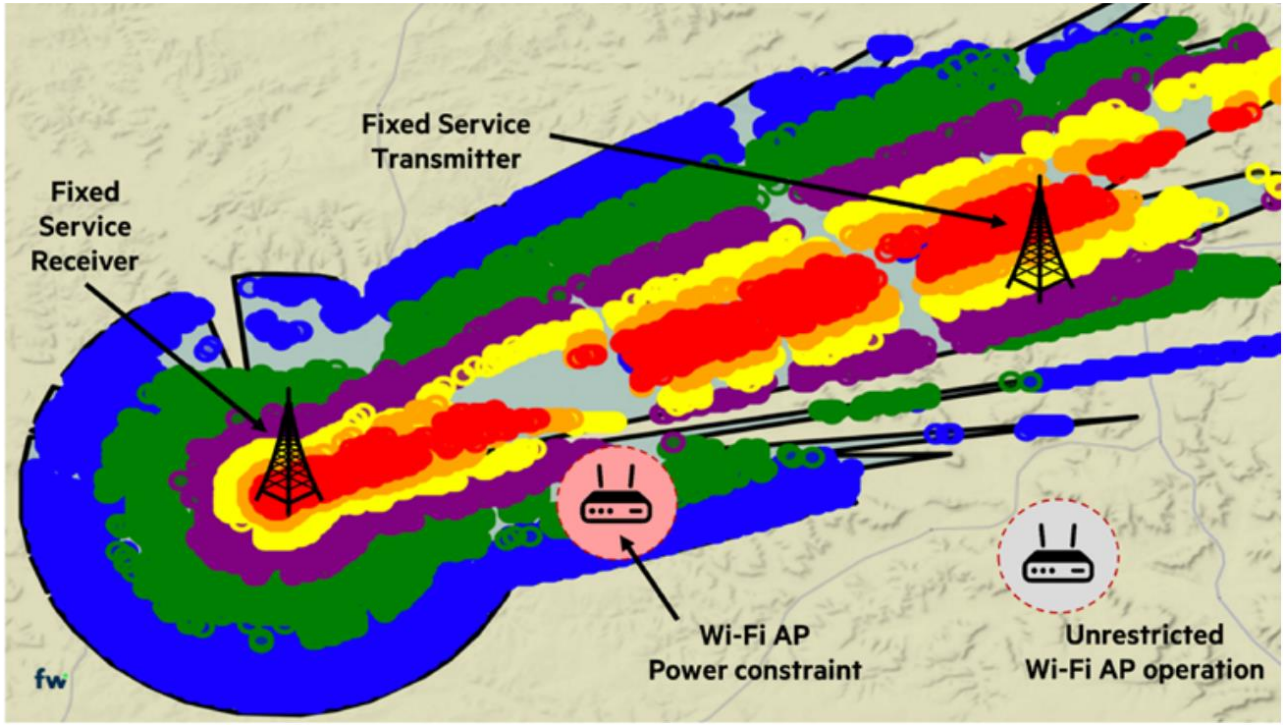
Fixed Service Receiver Protection Contour



PSD in dBM/MHz

- < 0
- 0 -5
- 5 -10
- 10 -15
- 15 -20
- 20 -23

Courtesy: Federated Wireless

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Access Point – GPS Module

Dimension : W x L x D
1.09 x 4 x 0.63 inch

Access Point with GPS module installed

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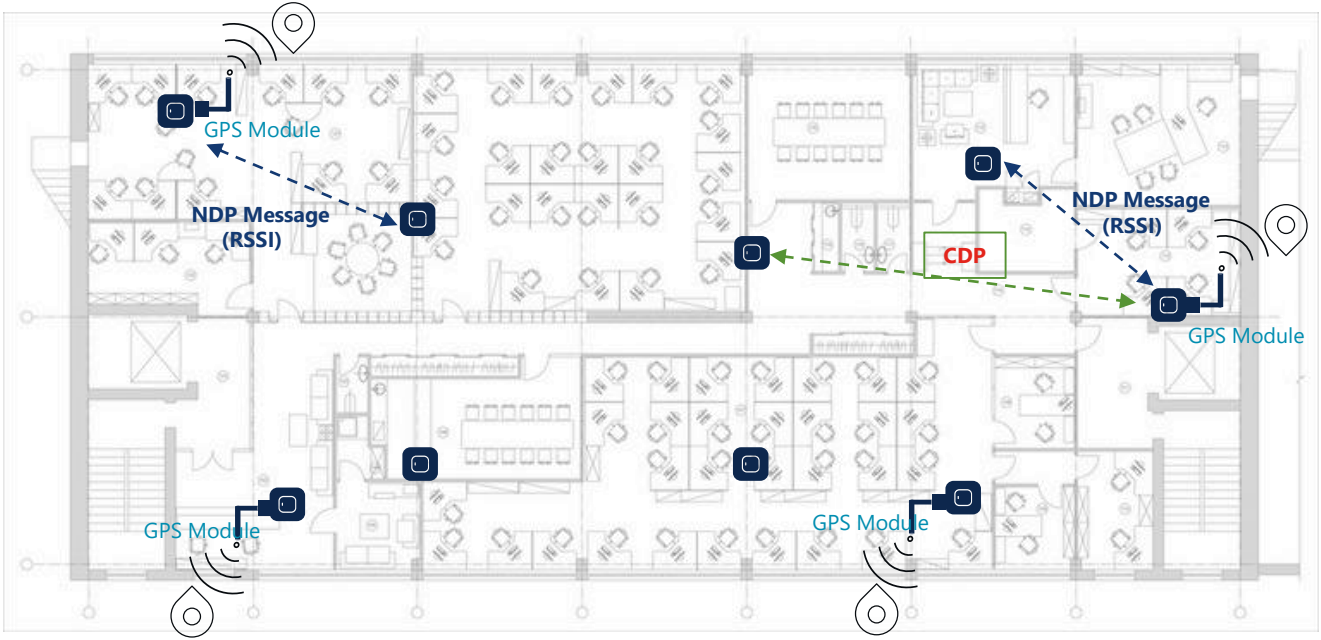
Location (Lat & Long) Calculation



Access Point's Latitude & Longitude needs to be auto derived through GPS.
Manual entry of height allowed in the configuration.

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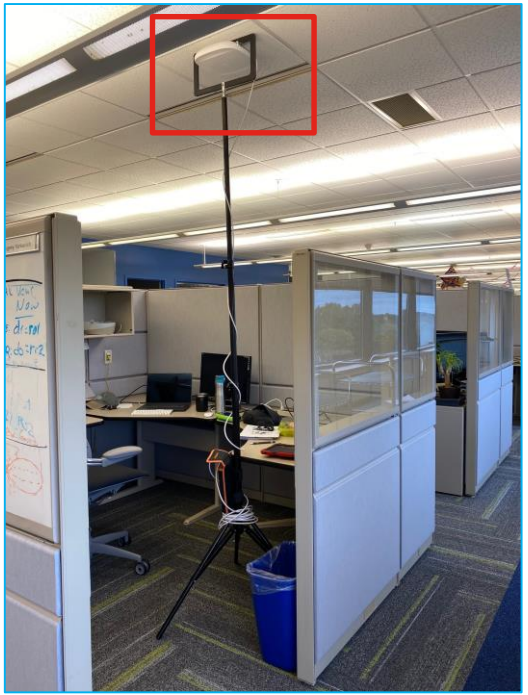
New Gear!!! Wi-Fi 6E Measurement !

Ekahau Sidekick 2
- 2.4, 5, 6 GHz
- Ekahau AI Pro
- Ekahau Analyzer

Hamina Nomad
- 2.4, 5 & 6 GHz
- Hamina Onsite App

NetAlly Aircheck G3 Pro
- 2.4, 5, 6 GHz
- NetAlly Link-Live



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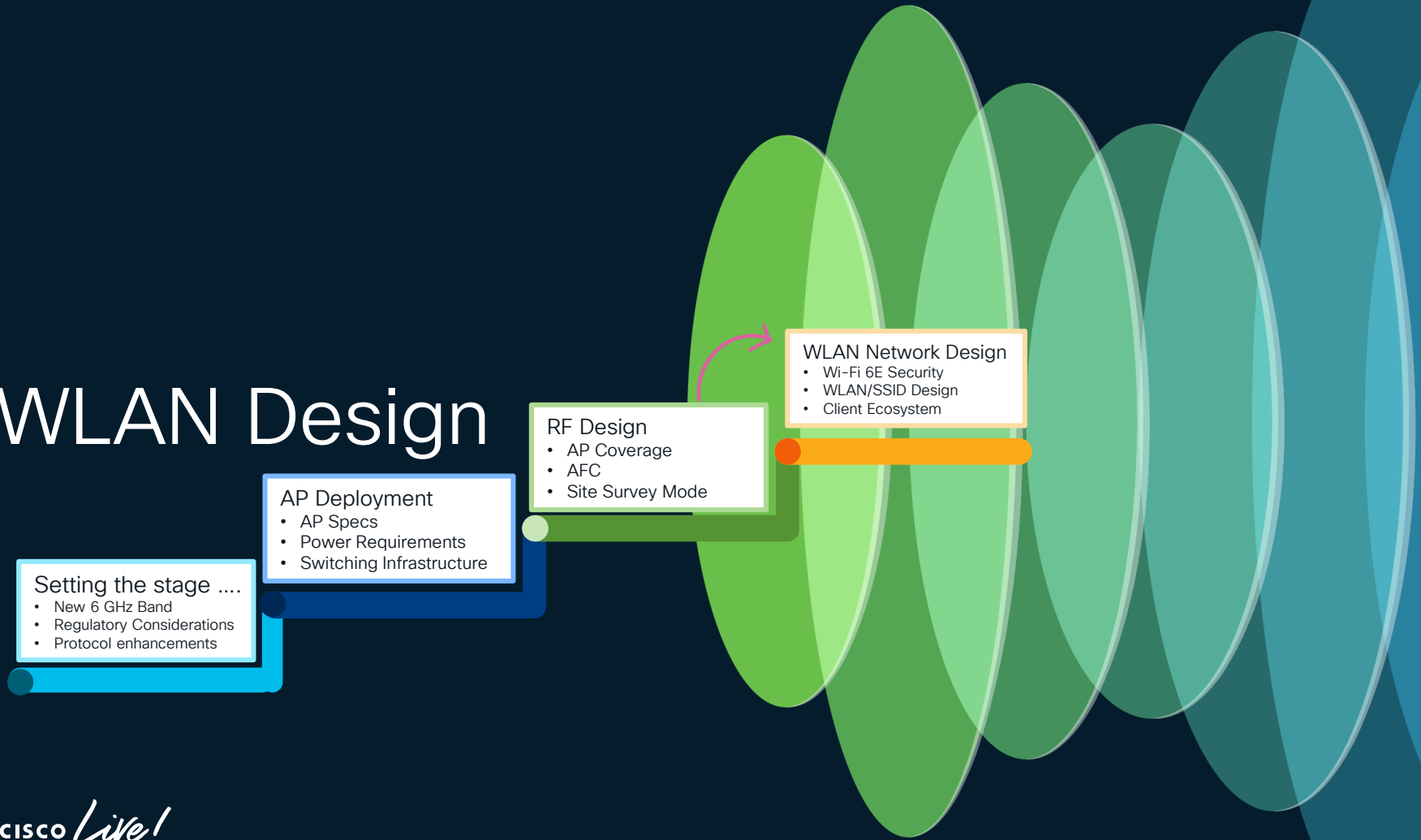
WLAN Design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• AFC
• Site Survey Mode
WLAN Network Design
• Wi-Fi 6E Security
• WLAN/SSID Design
• Client Ecosystem

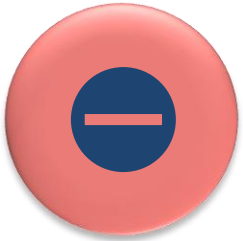
Wi-Fi 6E – Security

Wi-Fi 6E Security

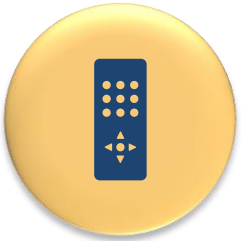
Wi-Fi 6E uplevels security.

WPA3 L2 Security: OWE, SAE*, 802.1x-SHA256

WPA3 and Enhanced Open Security made mandatory for Wi-Fi 6E certification.



No backward compatibility with Open and WPA2 Security.



Requires Protected Management Frame (PMF) in both AP and Clients.

*Only SAE-H2E (Hash to Element) Method Supported.
SAE (Hunting N Pecking) – Not Supported

AKM = Authentication and Key Management
OWE = Opportunistic Wireless Encryption
SAE = Simultaneous Authentication of Equals
SHA-256 = Secure Hash Algorithm (SHA) 256 bit

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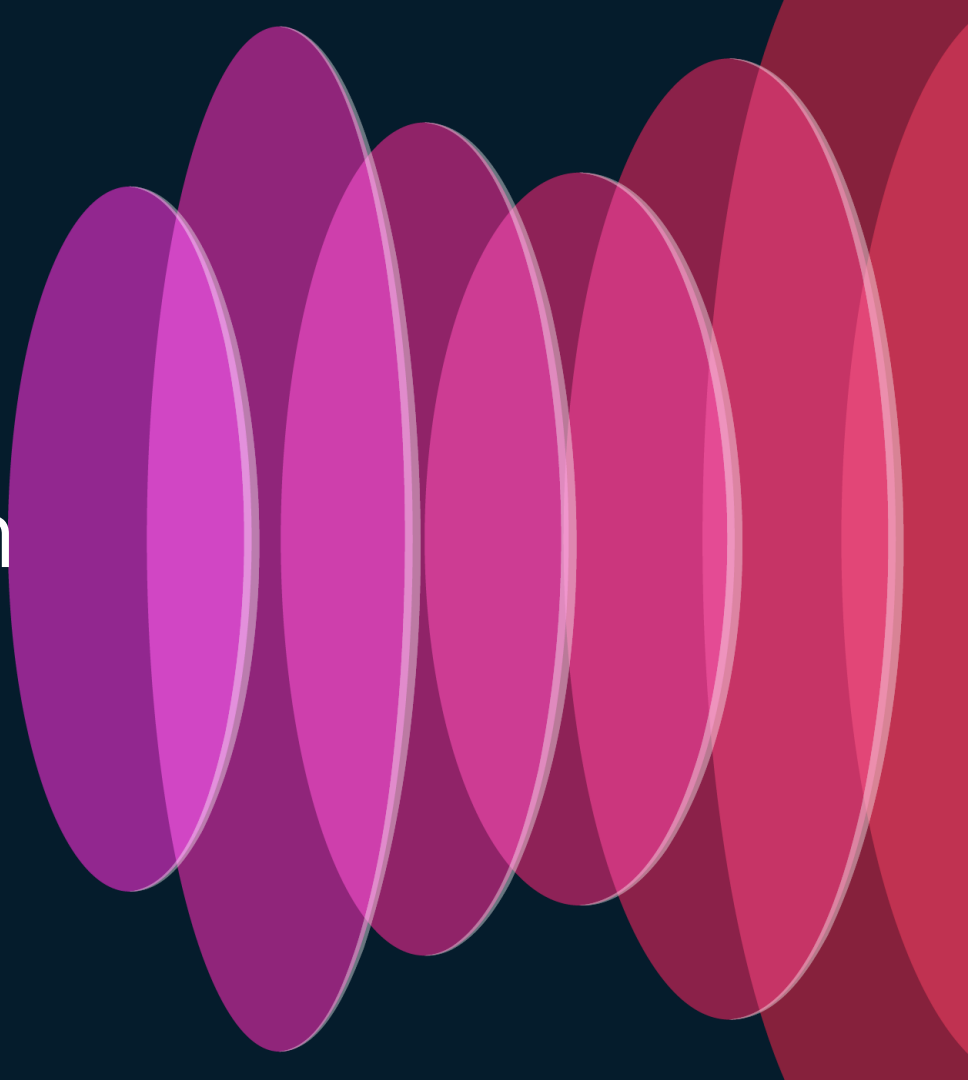
WLAN/SSID Design



6GHz WLAN Design Considerations

What options would you have?

1. "All-In" Option: Reconfigure the existing WLAN to WPA3, one SSID for all radio policies (2.4/5/6 GHz) – Most unlikely
2. "Multiple SSIDs" Option: Redesign your SSIDs, adding specific SSID/WLAN with specific security settings – Most flexible
3. "One SSID" Option: Configure multiple WLANs with same SSID name, different security settings – Most conservative

Most likely your current SSID configuration would prevent it from being broadcasted on 6GHz
Note: as 17.12.3, there is a limit of 8 SSIDs broadcasted on 6GHz radio

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Option 1

Pros

- Cleanest and simplest option
- No new WLAN and SSID to be managed
- Most secure with WPA3 everywhere

Cons

- Breaks support for existing clients that don't support WPA3 and PMF in 2.4 and 5GHz
- Requires full control on client devices and drivers

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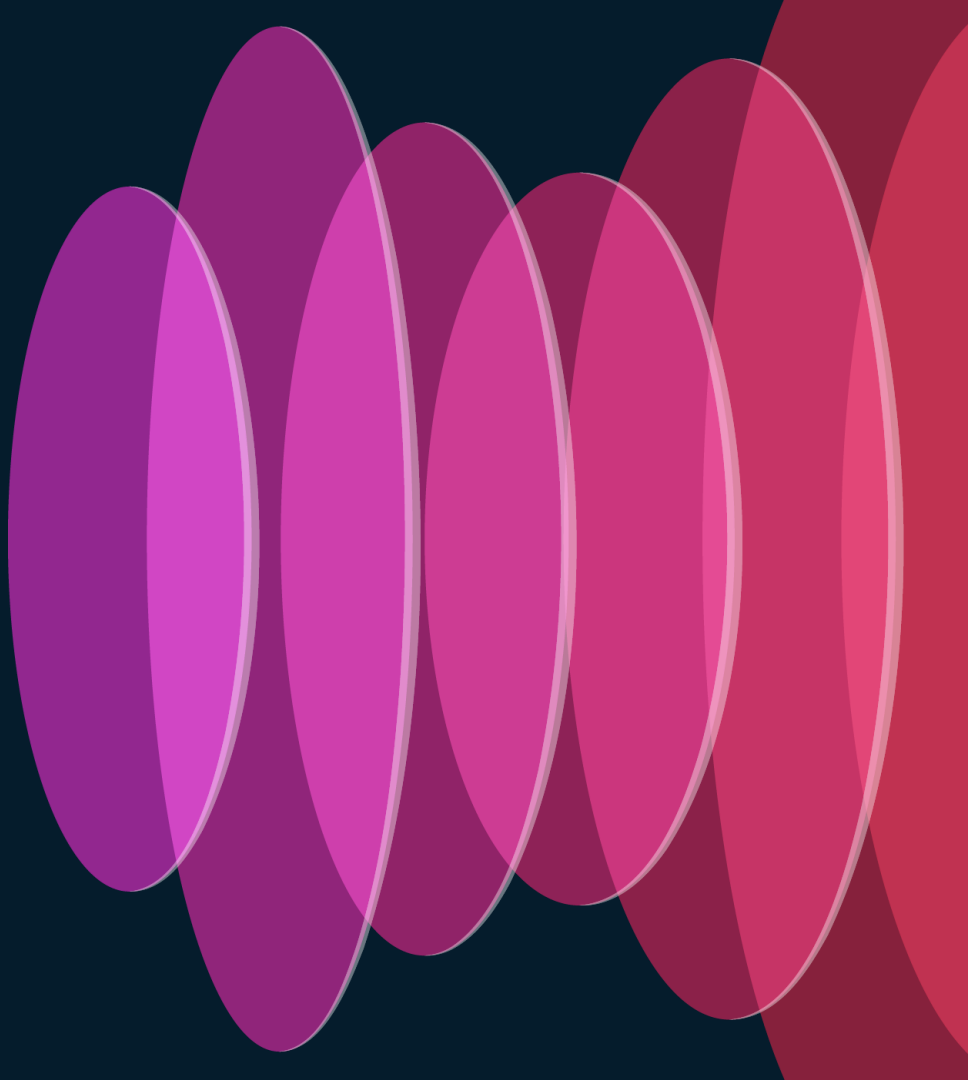
Option 2



Option 2 – WLAN design considerations

- Option 2: Redesign the SSIDs. This entails adding a WPA3 separate SSID for 6GHz and then decide which bands to enable to address different customer use cases.
  - Example 1: customer wants to adopt 6GHz without touching the existing SSIDs > add a separate SSID with WPA3 and broadcast it in all bands.
  - Example 2: Customer wants to redesign the SSIDs dedicating each band for a specific device/use case

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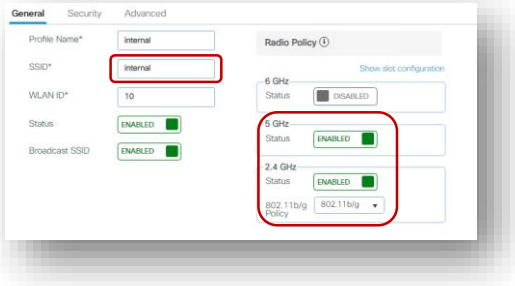
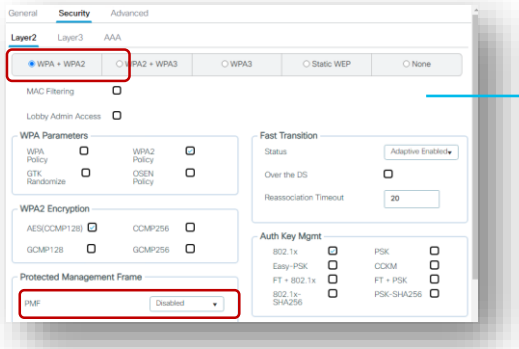
Option 2 > Example 1

Add a separate WLAN with different SSID name for WPA3 and broadcast it in all bands. Leave the existing WLAN/SSID untouched.

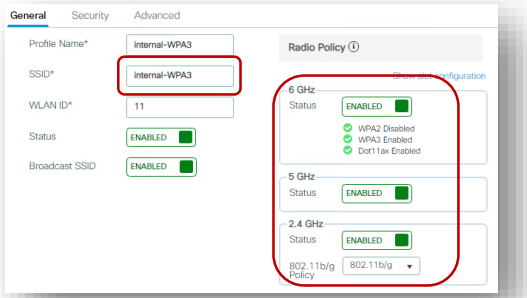
Legacy SSID

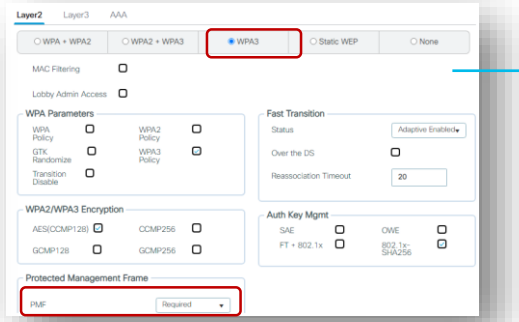




Existing WPA/WPA2 SSID in 2.4 and 5GHz for legacy clients

New SSID





Dedicated SSID for WPA3 (new name) capable clients in all bands. This is the SSID for 6GHz

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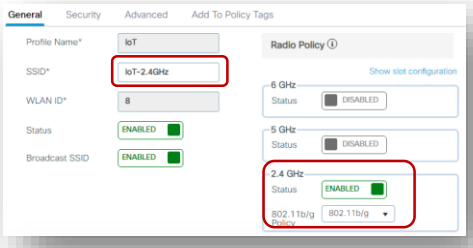
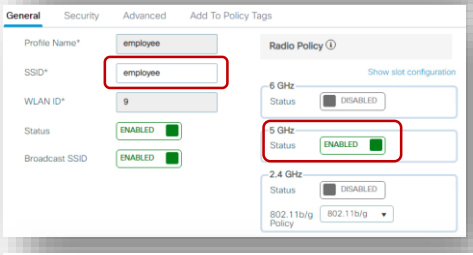
Option 2 > Example 2

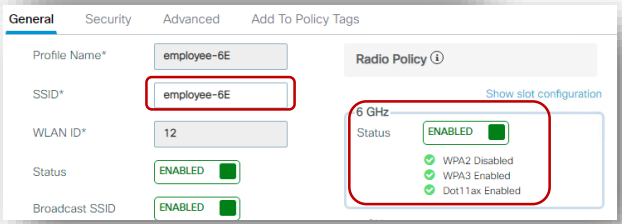
Redesign the WLANs, reserving each band for a specific device/use case



2.4GHz dedicated to specifc devices. These could be legacy devices or IoT devices. If IoT will be mostly PSK



5GHz dedicated to majority of existing clients



WPA3 on 6GHz band only, for the newest clients

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Option 2

Pros

- Cleanest option from a client compatibility point of view
- Most secure options as clients can adopt WPA3 security
- WPA3 clients can roam across different bands
- Automated via Catalyst Center

Cons

- Additional SSIDs to configure & manage on WLC
- Need to manage additional SSID profiles on clients

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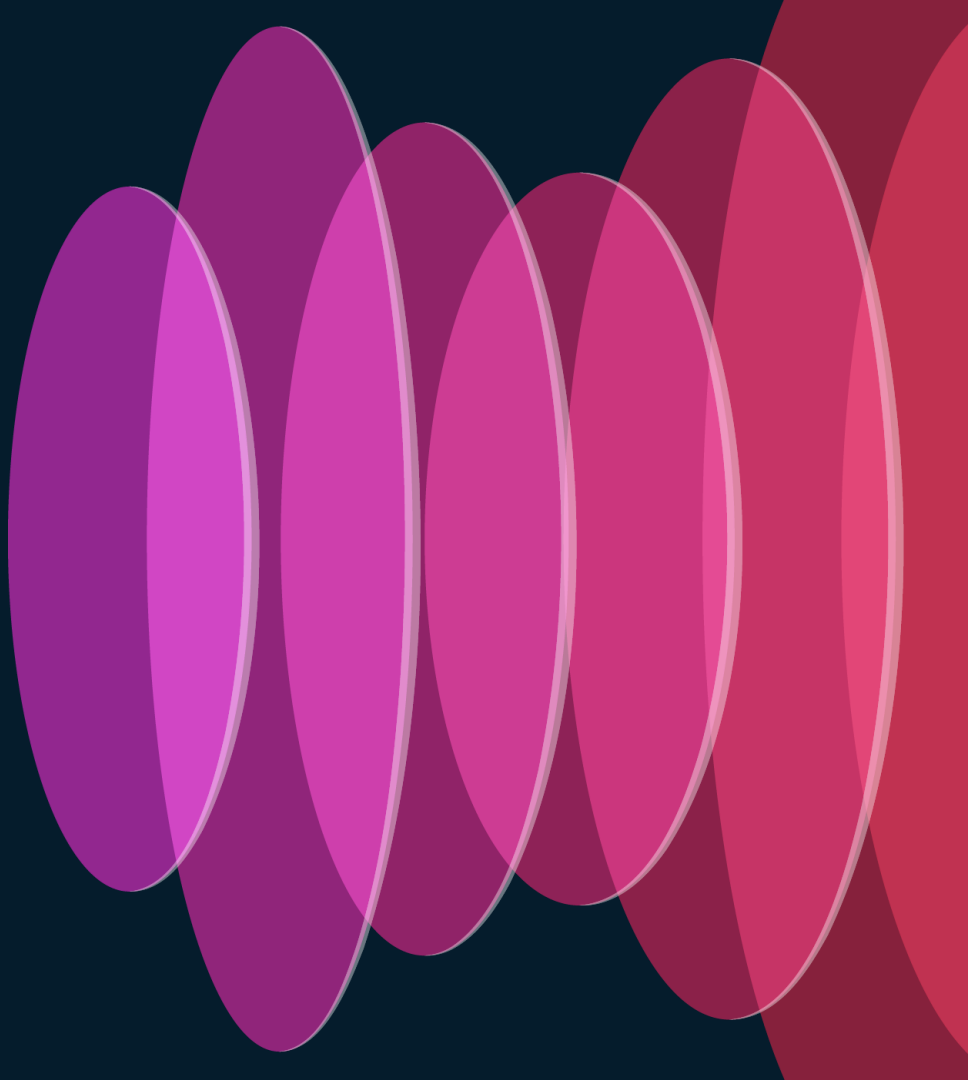
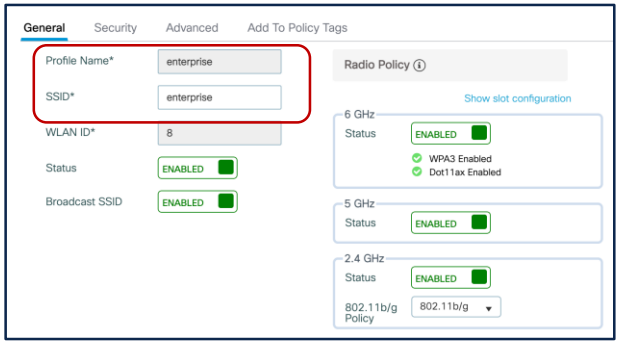
Option 3

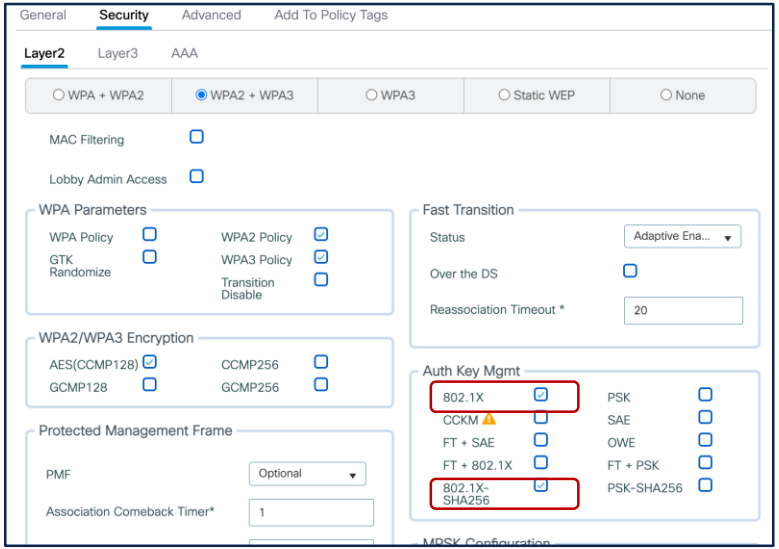


Option 3 – WLAN design considerations

Starting: IOS-XE 17.12.1

Single WLAN Profile for 2.4/5 and 6 GHz





- L2 Security would be WPA2+ WPA3.
- AKM should be set to **802.1x-SHA256** and **802.1x** (SHA1) for Enterprise; SAE and PSK for Personal.
- PMF as **Optional**

- How to configure the client side?
  - For clients that don't support 6 GHz, configure a **WPA2 profile or WPA3 Enterprise with PMF as Optional** depending on the client support.
  - For clients that support 6 GHz, configure **WPA3 Enterprise**. They will use these settings to connect to both 2.4/5 GHz and 6GHz

WFA = Wi-Fi Alliance

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Option 3

Pros

- Provide an adoption path to more secure Wi-Fi via WPA3 Transition mode
- Maintain support for older clients using WPA2.
- No new SSID profile to be managed on the client side

Cons

- Older clients may have issues connecting to an SSID with WPA3 Transition mode

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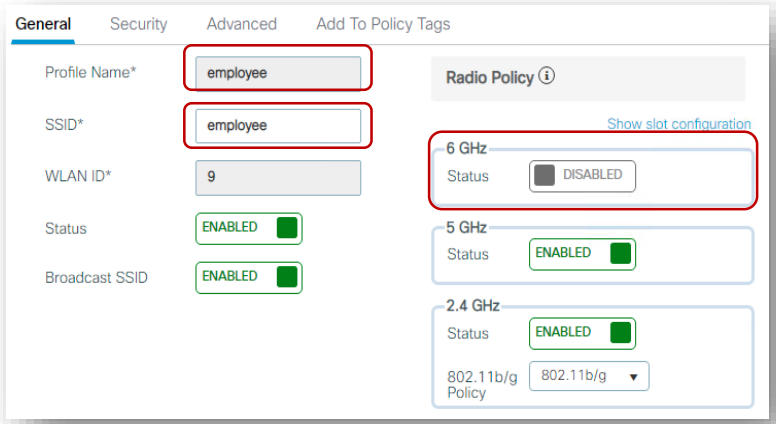
Option 3- WLAN design considerations

Till: IOS-XE 17.11.1

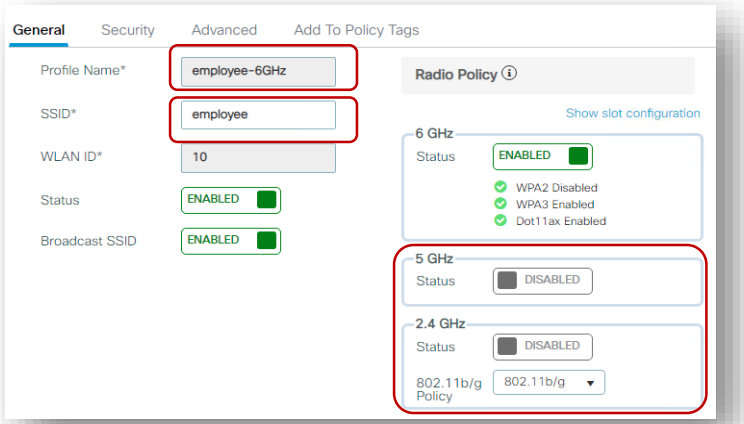
Single SSID, Dual WLAN Profile for 2.4/5 and 6 GHz

- Single SSID but different AKM per band. For Cisco today, this means creating an additional WLAN for 6GHz, with same SSID name but different WLAN profile name and security settings (AKM):

Existing WLAN serving 2.4 and 5GHz



New WLAN, same SSID name serving 6GHz



AKM = Authentication and Key Management

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Option 3

Pros

- Maintain support for older clients using WPA/WPA2.
- No new SSID profile to be managed on the client side

Cons

- Clients may complain going from a WPA3 SSID to a lower security
- Roaming across different WLANs (same SSID) is not supported
- Not supported by Cisco Catalyst Center Automation

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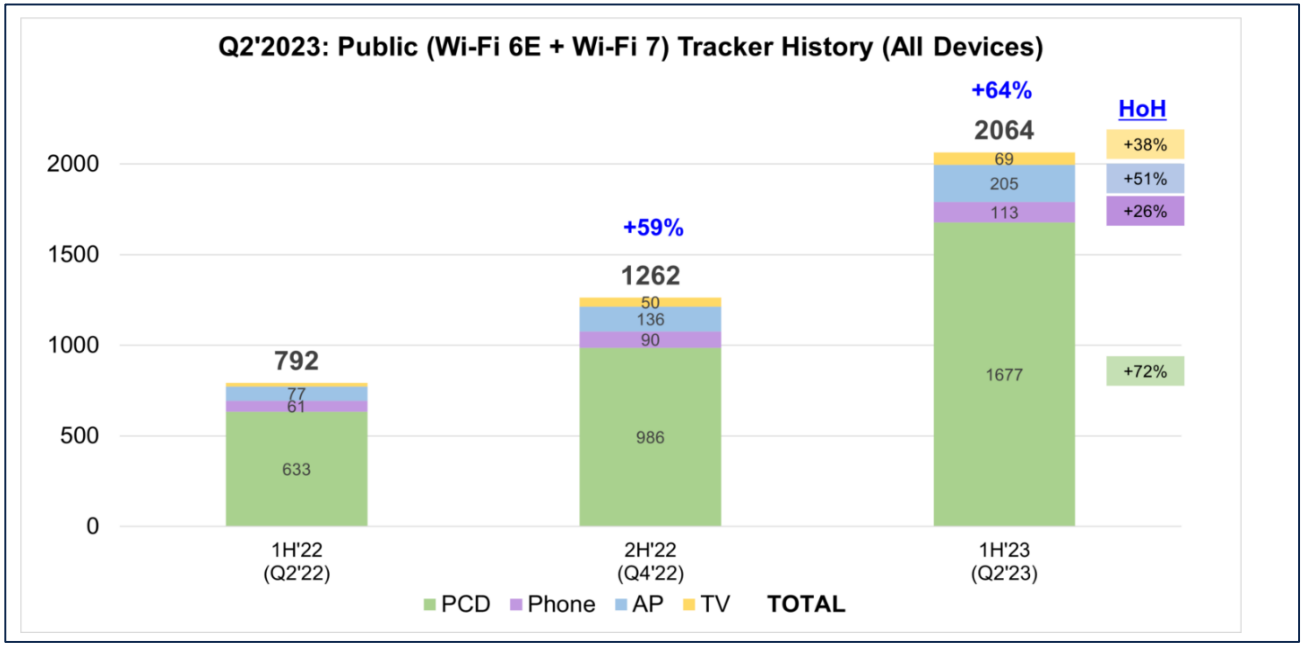
Wi-Fi 6E – Client Eco System

Wi-Fi 6E Device Support



Source: https://wifinowglobal.com/news-blog/intel-ecosystem-tracking-2064-wi-fi-6e-devices-now-available-wi-fi-7-reaches-67-devices/

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Getting clients to join 6E – from bad to better

Bad: Early days of 6E

6E Capable clients *always* preferred 5 GHz

Working closely with client device vendors

Better: Now

More of 6E-capable clients join 6 GHz*

Recommendations:

1. Upgrade to the Latest Driver
2. Configure same network name across all bands

*** Assuming latest driver**

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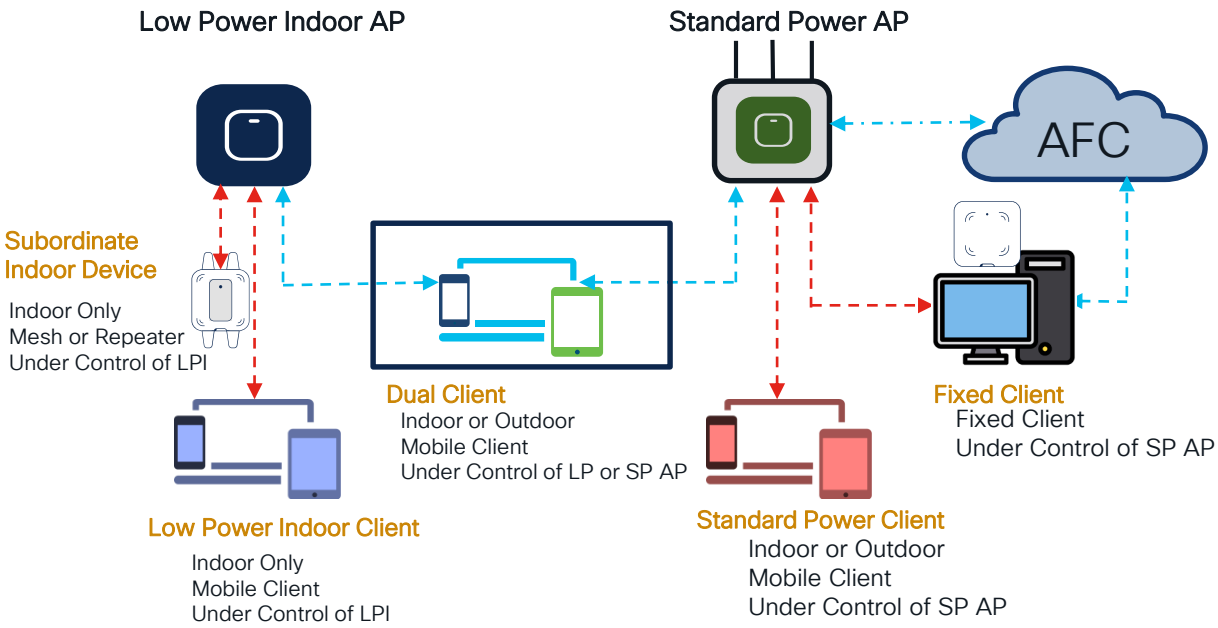
UNII 6 GHz Device Classes by FCC

Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

Part 15 Subpart E U-NII 6 GHz
General Guidance Bands 5, 6, 7, 8

August 9, 2023



LPI Clients

Equipment Class
6XD = 6GHz low power indoor client
2012

SP Only Clients

Equipment Class
6FX = 6GHz standard power client
0

Dual Mode Clients

Equipment Class
6CD = 6GHz standard power client
1218

Source: https://apps.fcc.gov/oetcf/eas/reports/GenericSearch.cfm

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Section Summary

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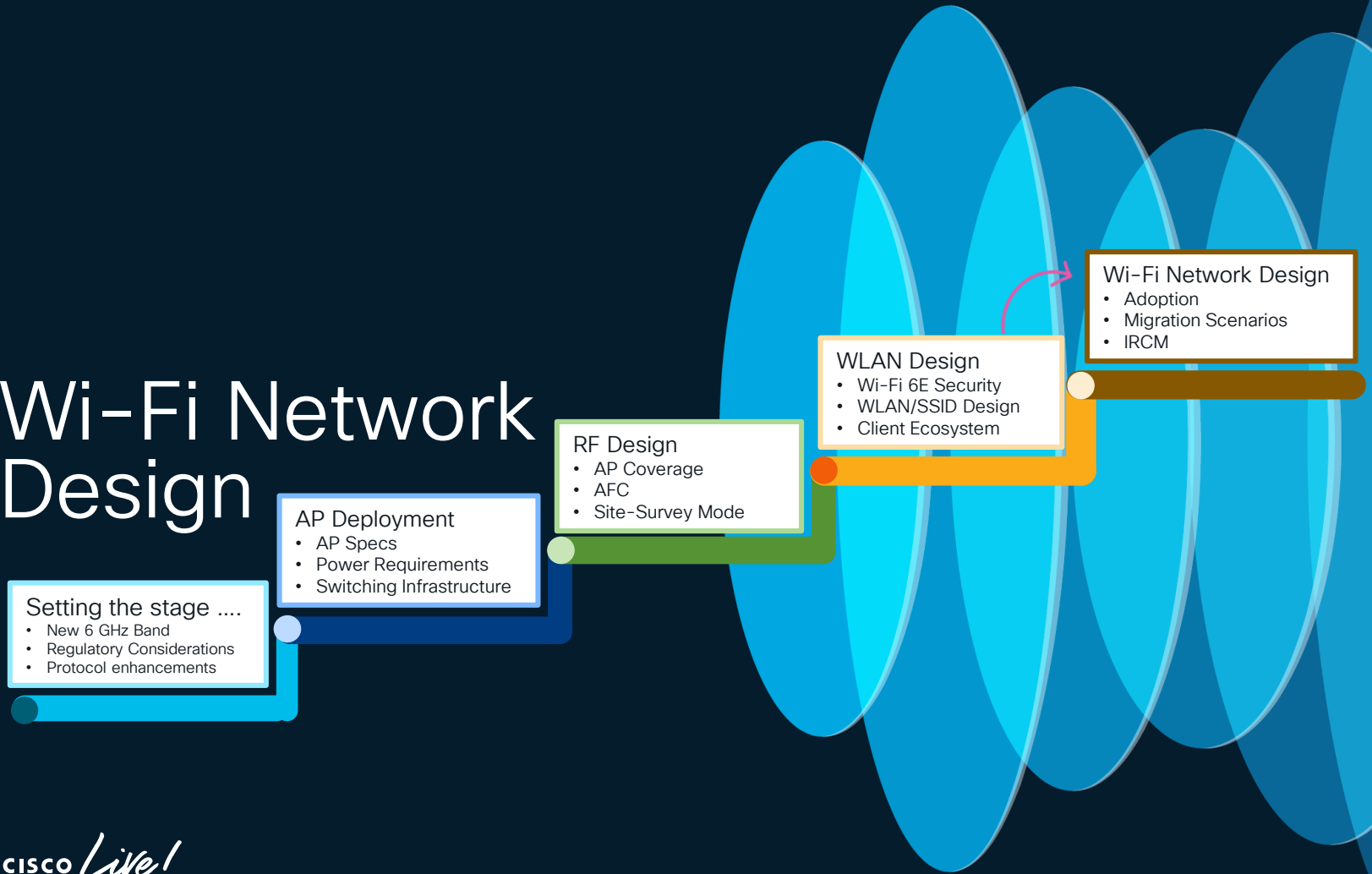
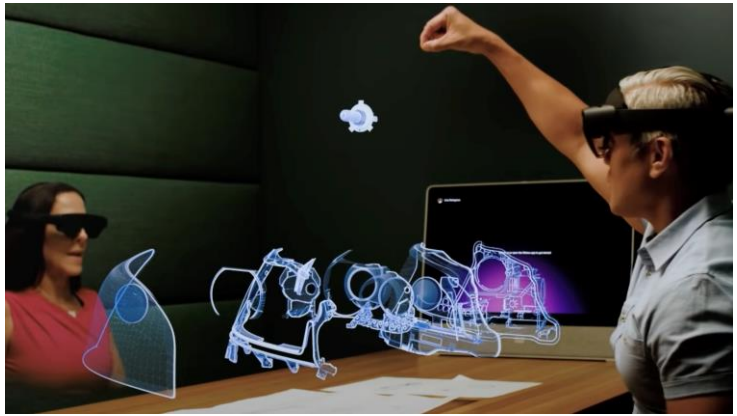
Wi-Fi Network Design



Start with Use Cases



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Observe Channel Utilization in your Network

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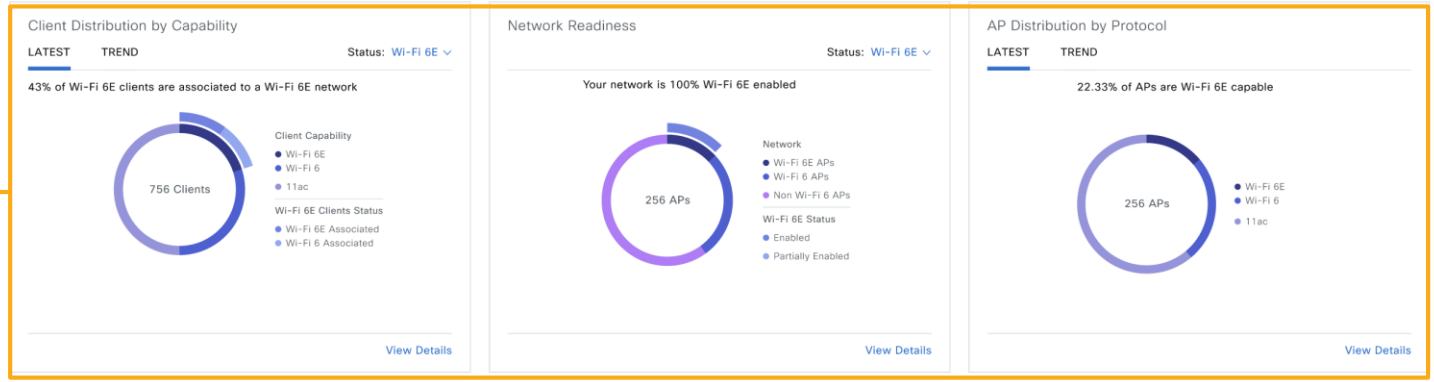
Observe the Client Types in your Network

Readiness and benefits of 6 GHz from Cisco Catalyst Center 2.3.2

Readiness



Benefits

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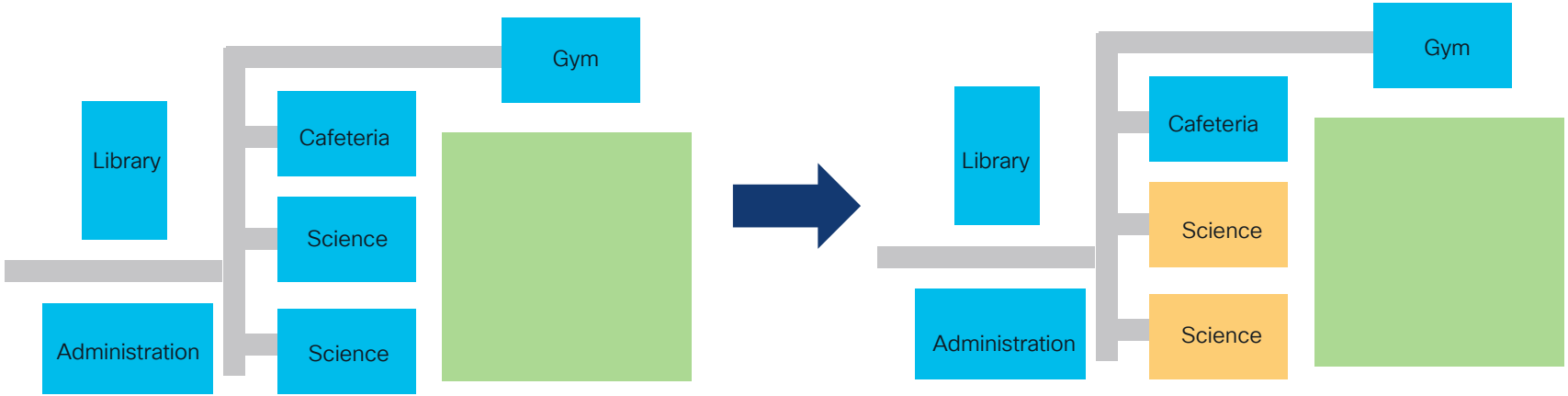
Migration Scenarios

- Move “per RF blocks”
- Move a building or complete floor into the new hardware and software



Avoid “Sale & Pepper” Deployments. Do not mix APs on different controllers at same time.

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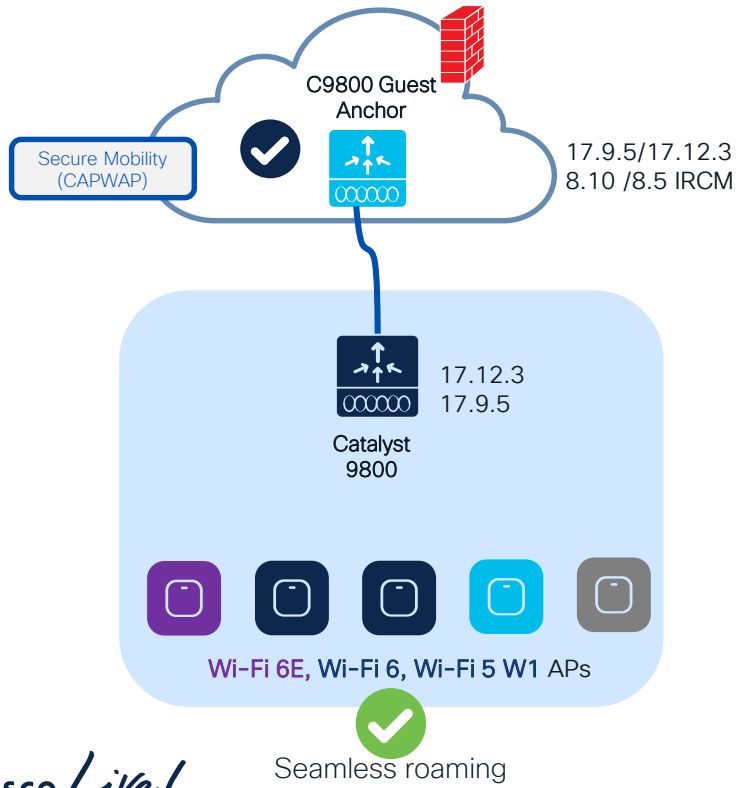
How do I start adopting 6GHz?



Scenario 1: If you have already started your C9800 journey

- Controller code is 17.12.3 or 17.9.5
- Wave 1 Aps support added (1700/2700/3700).
- Note: Anchor can be on AireOS as well (8.10 or 8.5 IRCM) latest
- Note: 17.12.1 for APJ Countries

(*) https://www.cisco.com/c/en/us/td/docs/wireless/controller/technotes/8-8/b_c9800_wireless_controller-aireos_ircm_dg.html

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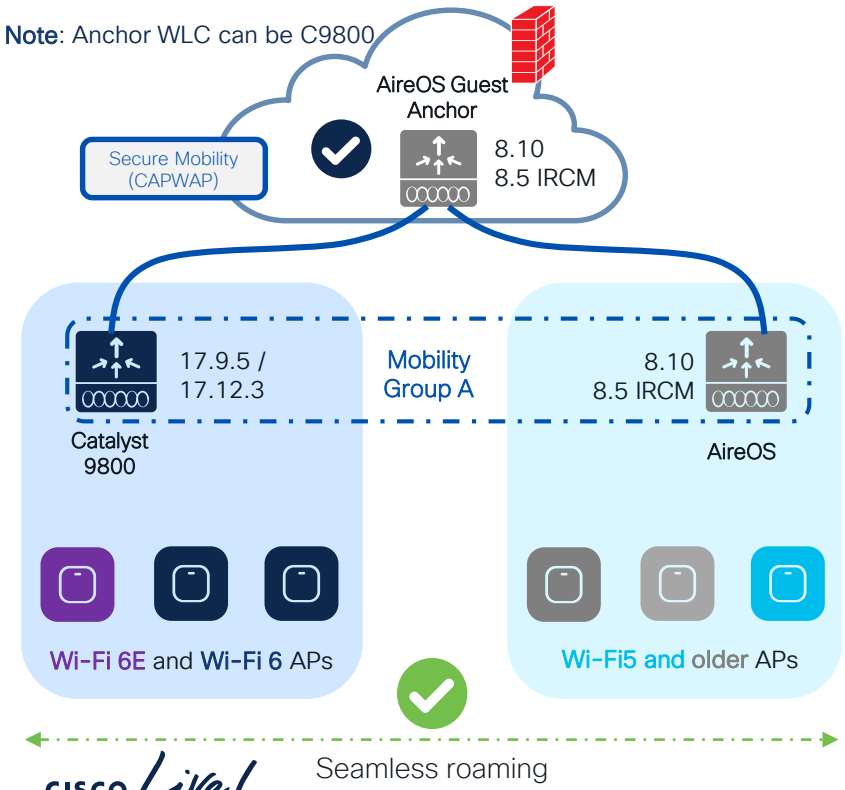
How do I start adopting 6GHz?
Answer: Inter Release Controller Mobility (IRCM)



Scenario 1: Legacy Controller Supports IRCM

- Introduce new 6/6E AP hadware on the new C9800 and support seamless roaming and Guest Anchor with existing networks
- This method allows the smooth coexistence of both controllers, with RF areas migrated as needed, without any overnight switchover.
- Things to consider:
  - If the controller is limited to 8.5 (5508, 8510), we will need a special IRCM version (8.5.182.104), to connect them to IOS-XE
  - Best to split the RF network into different areas, configuring different RF group names between the legacy and IOS-XE controllers.
  - Always configure the primary/secondary controller name in access points. The new controllers will reject unsupported APs, but if any AP could work in both controller types, this will avoid APs joining the wrong one, or flip-flopping between them, until the migration is ready to proceed
- Fast & secure roam will only be supported if the WLAN profile is the same on the two WLCs

(*) https://www.cisco.com/c/en/us/td/docs/wireless/controller/technotes/8-8/b_c9800_wireless_controller-aireos_ircm_dg.html

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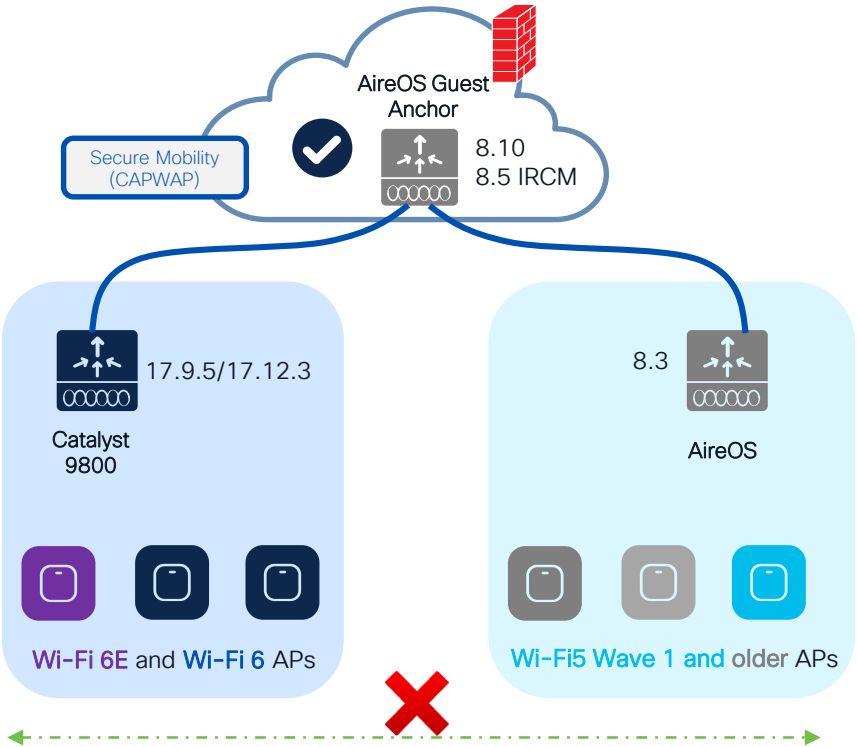
How do I start adopting 6GHz?
Answer: Inter Release Controller Mobility (IRCM)



Scenario 2: Legacy Controller not supporting IRCM

- Not possible to establish IRCM between old controller and new 9800 handling 6E Aps
- Limits options available. Forces more aggressive migration process.
- Migration alternatives:
  - Keep the two networks separated ; migrate physical RF areas as new Aps are added.
  - Roaming is not possible.
  - Avoid migrations “per floor” as in most building types, it is normal to see clients roaming between Aps on different floor.
  - Temporarily, replace the legacy controller with one that supports IRCM.
- The release combinations shown have been tested at scale, check IRCM deployment guide*

(*) https://www.cisco.com/c/en/us/td/docs/wireless/controller/technotes/8-8/b_c9800_wireless_controller-aireos_ircm_dg.html

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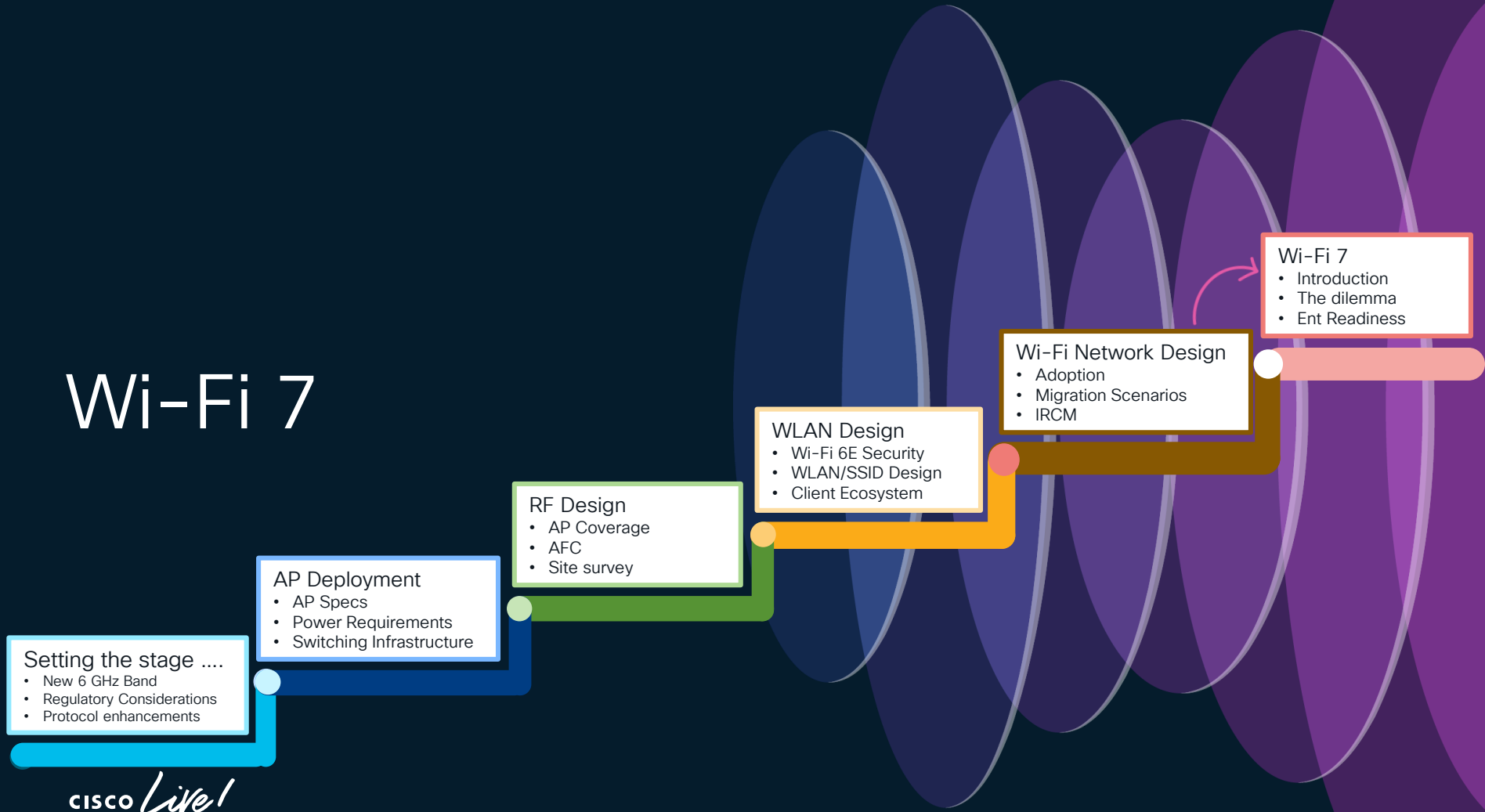
Wi-Fi 7


Setting the stage ....
• New 6 GHz Band
• Regulatory Considerations
• Protocol enhancements
AP Deployment
• AP Specs
• Power Requirements
• Switching Infrastructure
RF Design
• AP Coverage
• AFC
• Site survey
WLAN Design
• Wi-Fi 6E Security
• WLAN/SSID Design
• Client Ecosystem
Wi-Fi Network Design
• Adoption
• Migration Scenarios
• IRCM
Wi-Fi 7
• Introduction
• The dilemma
• Ent Readiness

Wi-Fi 7 & 802.11be in 1 slide

Wi-Fi 7 R1 spec finalized in Jan ’24. WFA certification for R1 in progress. R2 expected Dec 2025. 802.11be is still not ratified (Exp Dec 2024)

In the enterprise, Wi-Fi 7 is a modest upgrade compared to Wi-Fi 6E. Enterprises can fully utilize the 6GHz spectrum with Wi-Fi 6E

Very few Wi-Fi 7 clients exist, and there is no Wi-Fi 7 support in Windows or MacOS

Cisco has been closely involved in development of Wi-Fi 7, and advocates for thorough client interop testing

6 GHz Wi-Fi with Wi-Fi 6E is mature

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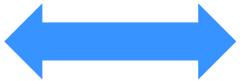
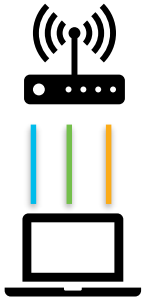
What is Wi-Fi 7 (and a bit of 11be)



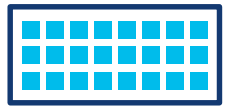
320 MHz in 6 GHz

4K QAM



MLO

Enhanced Security



Compressed Block Ack
(512 MPDUs)

Multi-RU

Preamble puncturing
Mandatory in 6. Optional in 5
Min ch. width of 80

Triggered UL Access Optimization

EPCS

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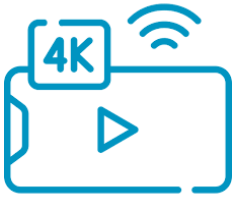
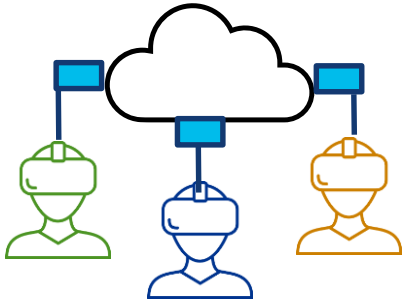
Wi-Fi 7 Use Cases



High Definition Video Streaming



Multi-user AR/VR/XR

Emergency Preparedness Communication Services

Industrial IoT

Hybrid Work

Immersive Gaming & Entertainment

Automotive

Immersive Learning

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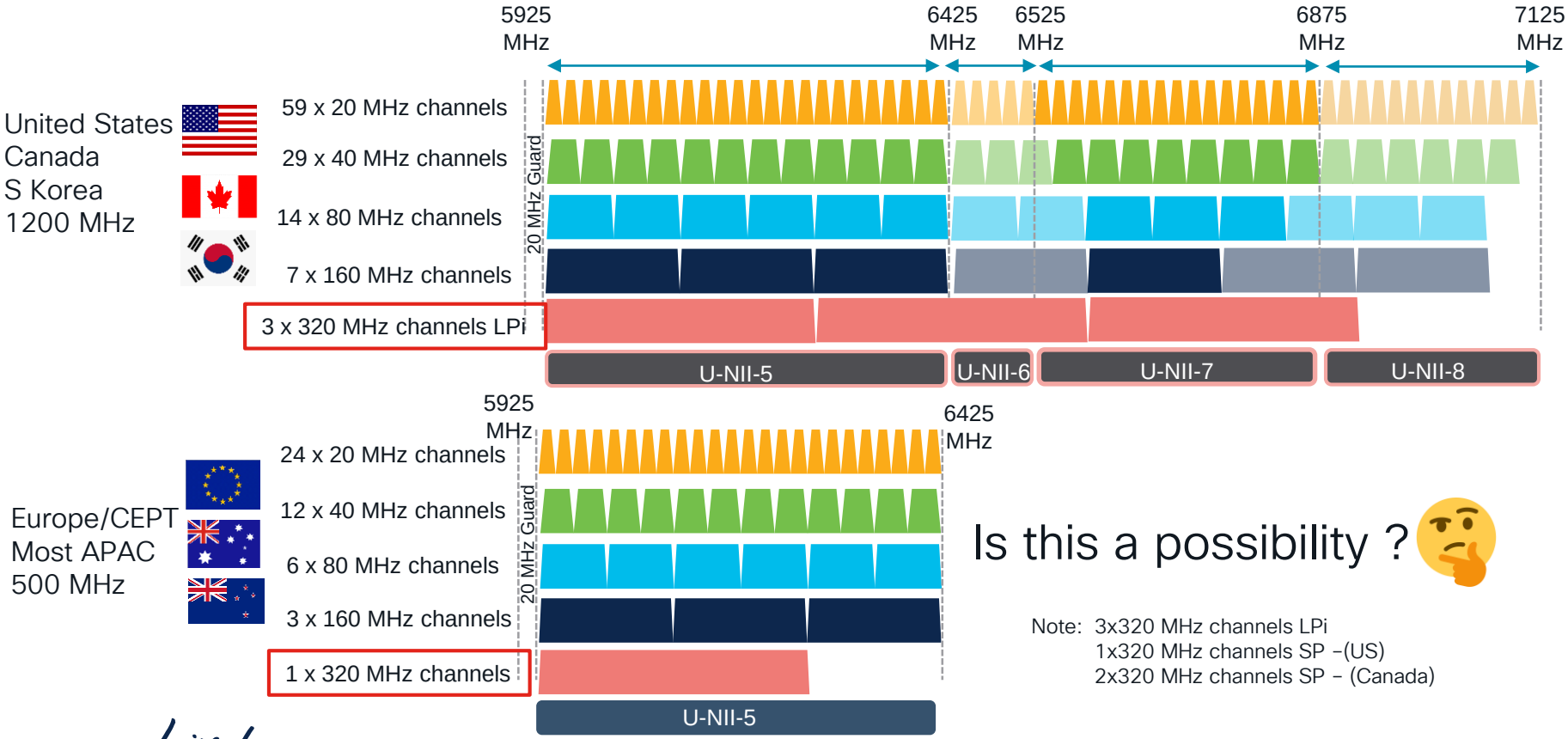
Wi-Fi 7 – 320 MHz Channel Width



Is this a possibility ? 🤔

Note: 3x320 MHz channels LPi
1x320 MHz channels SP –(US)
2x320 MHz channels SP – (Canada)

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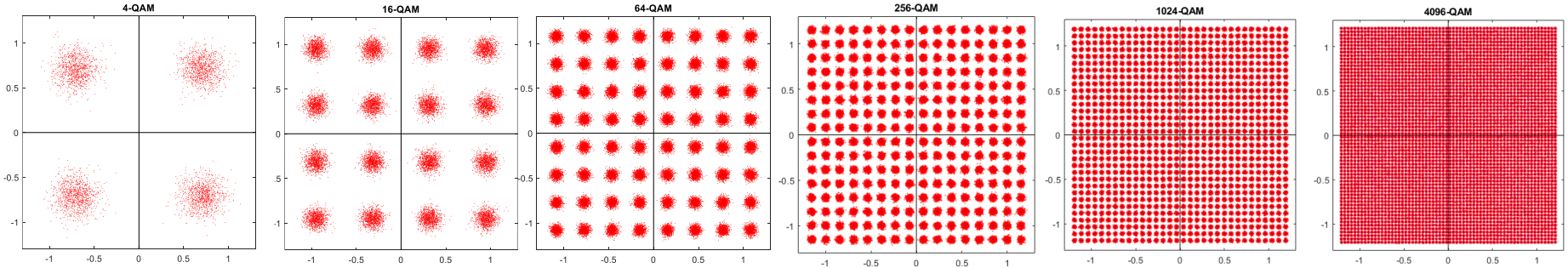
Wi-Fi 7 4K-QAM
(MCS12/13) increases the peak PHY data rate

- MCS 12 and MCS 13 indicate a 4096-QAM constellation with a code rate of ¾ and ⅚ respectively
- Very short range and most suited to a 1 antenna client with a multi-antenna AP (beamforming, MRC)

Need very high SNR for 4K QAM

Each increment in constellation size reduces range by approx. 50%

Incremental data rate	+100%	+50%	+33%	+25%	+20%
Relative Range	80	40	20	10	5



Wi-Fi4 Wi-Fi5 Wi-Fi6 Wi-Fi7

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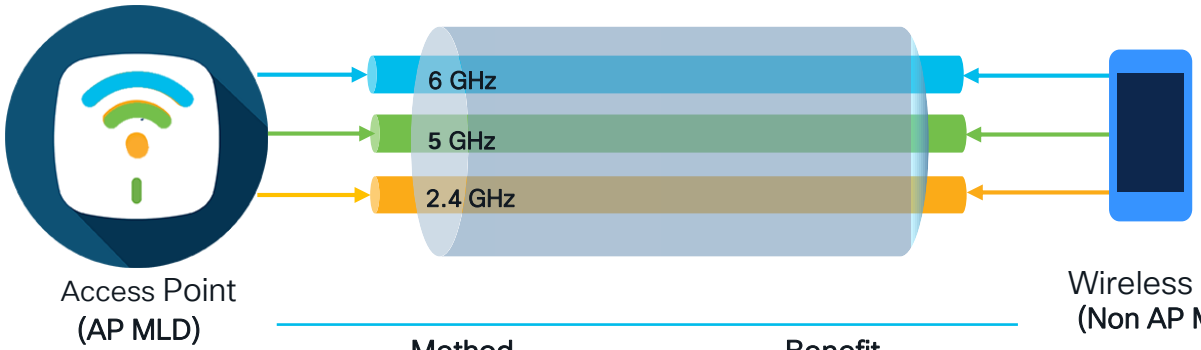
Wi-Fi 7 – Multilink (MLO)



Method	Benefit
Aggregation	Throughput
Steering	Lower Latency
Redundancy	Reliability

MLD: Multi Link Device

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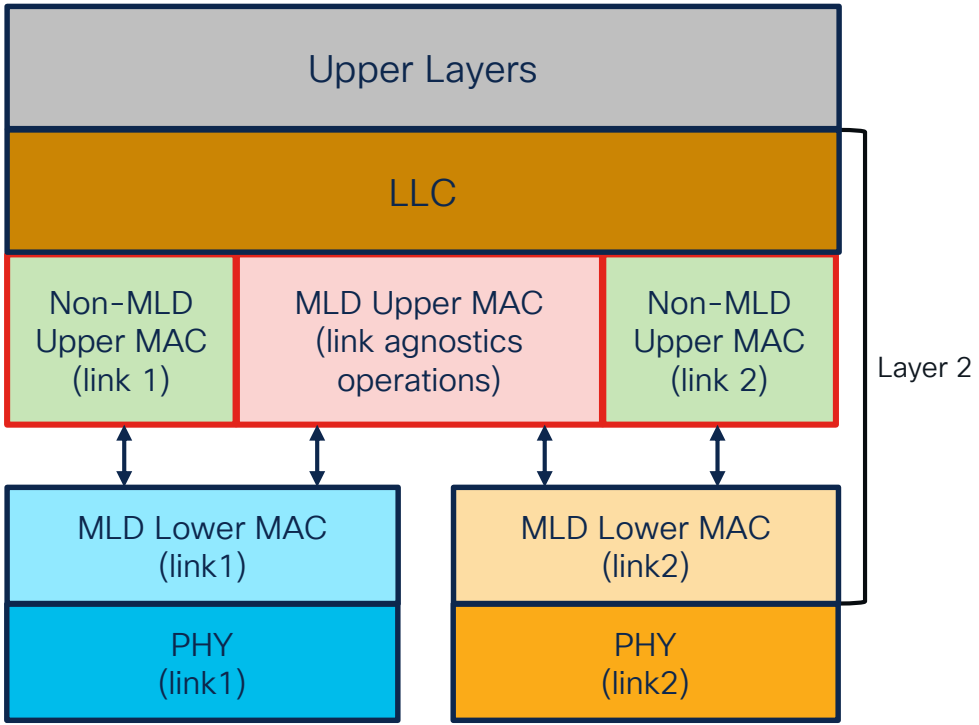
Wi-Fi 7 MLD MAC Layers



MLD Upper MAC Layer functions :

- Auth, (Re)Association
- Security association
- SN assignment for unicast & groupcast frames
- Encryption/Decryption of unicast frames
- Power save buffering of unicast frames
- MLD level management frames
- Unified Block Ack scoreboard
- Packet re-ordering, replay detection
- Selection of MLD lower MAC for Tx

Non-MLD Upper MAC Layer functions:

- Non-MLO peer operation (above MLD lower MAC)
- Link specific group keys
- Link specific encryption/decryption of groupcast
- Power save buffering of groupcast frames

MLD Lower MAC Layer functions:

- Link specific mgmt. frames (beacons)
- Control Frames (RTS, CTS, Ack,...)
- Power save state and mode
- Per-link Block Ack scoreboard

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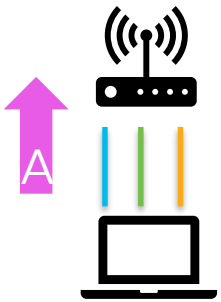
The many “modes” of MLO

…because clients have different hardware capabilities

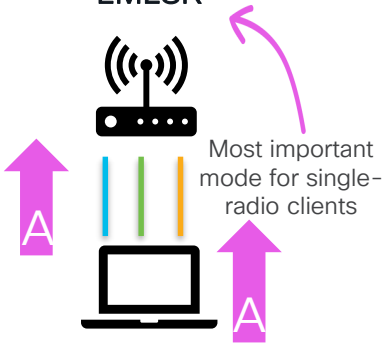
Single Radio

MLSR



Only one link operational at a given time

EMLSR

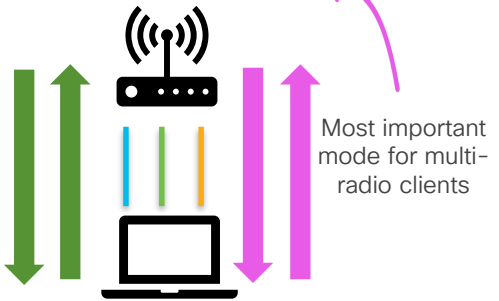


MLSR plus additional capability to listen to two links.

Acronyms:
MLMR *– Multi-link Multi Radio*
MLSR *– Multi-link Single Radio*
EMLSR *– Enhanced Multi-link Single Radio*

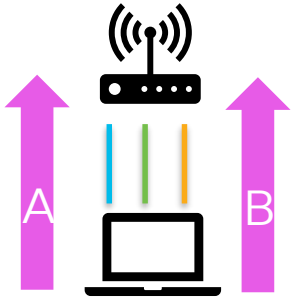
Multi Radio

MLMR
Simultaneous TX + RX
(STR)



Each link operating independently for Tx and Rx

MLMR
Non-Simultaneous Tx+Rx
(nSTR)



Tx or Rx at the same time on different links

(Not included in Wi-Fi 7 Certification)

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Wi-Fi 7 MLO Modes

MLO Modes	Number of Radios	Characteristics
Multi-Link Single Radio (MLSR)	1	Tx/Rx over one link at a time
Enhanced Multi-Link Single Radio (EMLSR)	1	MLSR with additional capability to listen on multiple links simultaneously in low capability mode
Simultaneous Tx and Rx (STR)*	>= 2	Simultaneous Tx/Tx, Rx/Rx or Tx/Rx on a pair of STR links independent of each other
Non-Simultaneous Tx and Rx (NSTR)*	>= 2	Simultaneous Tx/Tx or Rx/Rx over a pair of links with careful alignment of PPDUs end time
Enhanced Multi Link Multi Radio (EMLMR)*	>= 2	MLMR (STR) with additional capability to dynamically reconfigure spatial multiplexing support on each link

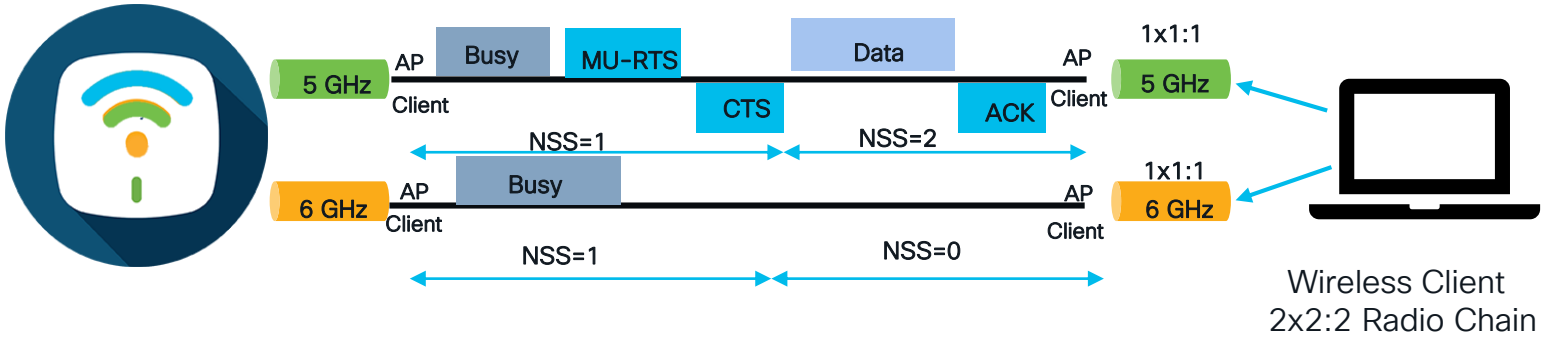
Requirement:

- MLSR is supported by all MLO devices.
- An AP MLD is required to support both EMLSR and STR .
- A non-AP MLD with 2SS and 160 MHz channel width on at least one link is required to support either EMLSR or STR.

* The last three modes are MLMR (Multi-Link Multi-Radio) operation modes. Only STR is part of Wi-Fi 7 R1. NSTR and EMLMR modes have significant implementation complexity and are not adopted in Wi-Fi 7.

Wi-Fi 7 – EMLSR Operation

Downlink Transmission from AP to EMLSR Wireless Client



- Single Radio Wireless Clients with 2x2:2 Radio listens to two channels
  Example: 1x1:1 on 5 GHz and 1x1:1 on 6 GHz
- Switches to 2x2:2 during active data transmission on the channel with TXOP
- After TxOP, goes back to listening mode with 1x1:1 on each channel.

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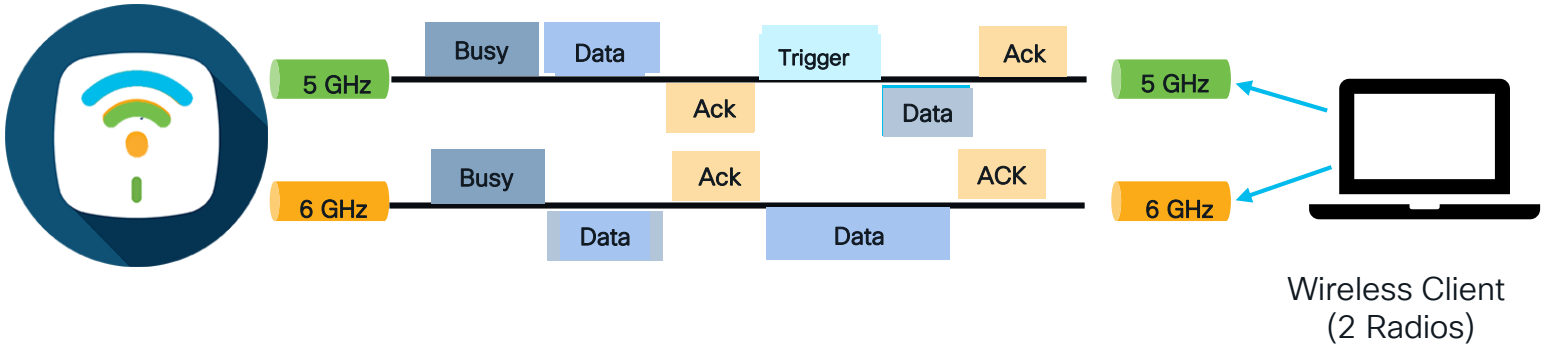
Wi-Fi 7 – MLMR – STR Operation

Downlink Transmission from AP to MLMR-STR Wireless Client



- Each link can transmit or receive independently
- Maximum throughput and performance

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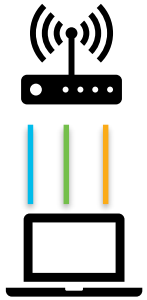
On Multilink Operation (MLO)

- Client (STA) connected on multiple bands to the **same** AP, **not** to multiple APs (that is Wi-Fi 8)
- MLO is most likely going to be 2 band on clients – not 3 band
- Single radio client – EMLSR on two links.
- Band-isolation on clients between 5 and 6 determines MLO capabilities; so some clients might “only” do 2.4 + 5, or 2.4 + 6 in MLMR-STR
- Devil is in the detail: Single radio (SR) vs Multi radio (MR). STR vs EMLSR
- Same AKM across all links in an MLO Group (!).



MLO

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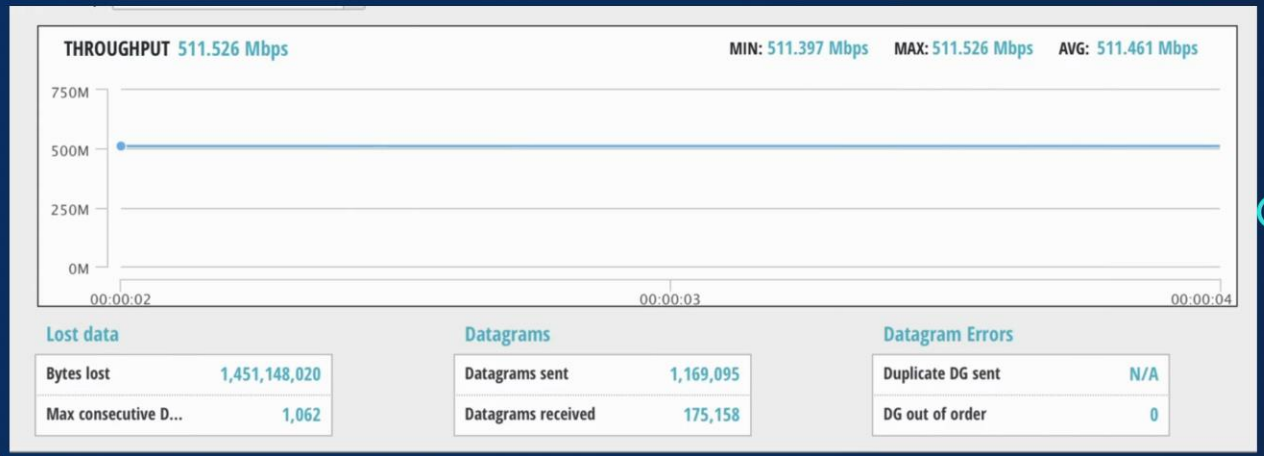
Downlink Throughput Test

MLO: 5+6GHz/40MHz
Average Throughput: 980Mbps



SLO: 5GHz/40MHz
Average Throughput: 510Mbps

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Wi-Fi 7 Preamble Puncturing

Without Preamble Puncturing:

With Preamble Puncturing:

Puncturing allowed for
80 MHz channel width or wider

Channel Width	Allowed Puncturing
80 MHz	20 MHz
160 MHz	20 or 40 MHz
320 MHz	40 or 80 MHz (or) 40 + 80 MHz

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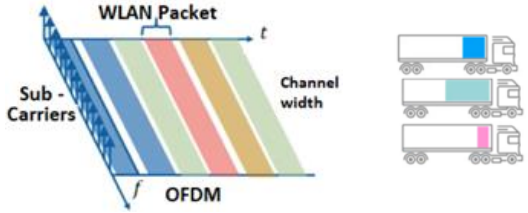
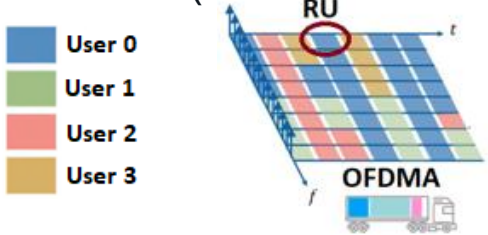
Wi-Fi 7 Multiple Resource Unit (MRU)

OFDM (Before Wi-Fi 6)



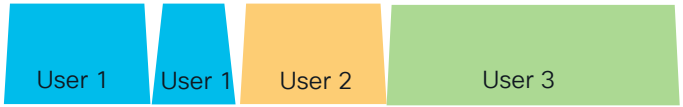
OFDMA (Wi-Fi 6 and later)



Wi-Fi 6

← One user can have only one RU

Wi-Fi 7



← One user can have multiple RUs

Resource Unit (RU) is a unit to denote a group of subcarriers (tones) in OFDMA

Multiple RUs make efficient use of spectrum

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16 Spatial Streams

- Won’t be supported in Wi-Fi 7
- Will stay at max 8 spatial streams
- Public docs refer to 16 spatial streams

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Wi-Fi 7 Security

Wi-Fi 7 brings new AKM support for WPA3-SAE and new increased ciphers for OWE & SAE
WPA3 /OWE mandatory for EHT (11be MCS rates) & MLO

Older	Wi-Fi 6E (6 GHz)	Wi-Fi 7
Open	OWE (AKM: 18) (Cipher: CCMP 128)	OWE (AKM: 18) (Cipher: CCMP 128 or GCMP 256)
WPA2/WPA3 Transition/ WPA3-SAE(Personal), PMF Optional (WPA 2 - AKM - 2, 4 & 6) (WPA 3 - AKM - 8 & 9) (Cipher: CCMP 128 or AES)	WPA3-SAE (Personal), PMF Mandatory (AKM: 8 & 9) (Cipher: CCMP 128 or AES)	WPA3-SAE (Personal), PMF Mandatory (AKM: 24 & 25) (Cipher: CCMP128 or GCMP 256)
WPA/WPA3 Transition/ WPA3-SAE Enterprise, PMF Optional (AKM 1, 3 & 5, 11 & 12) (Cipher: AES, CCMP 128, GCMP128 GCMP256)	WPA3 Enterprise, PMF Mandatory (AKM: 3, 5, 11 & 12) (Cipher: GCMP 128 & GCMP 256)	WPA3 Enterprise, PMF Mandatory (AKM: 3, 5, 11 & 12) (Cipher: GCMP 128 & GCMP 256)

Cipher: GCMP 256 – Better Encryption & Speed; AKM: Better security

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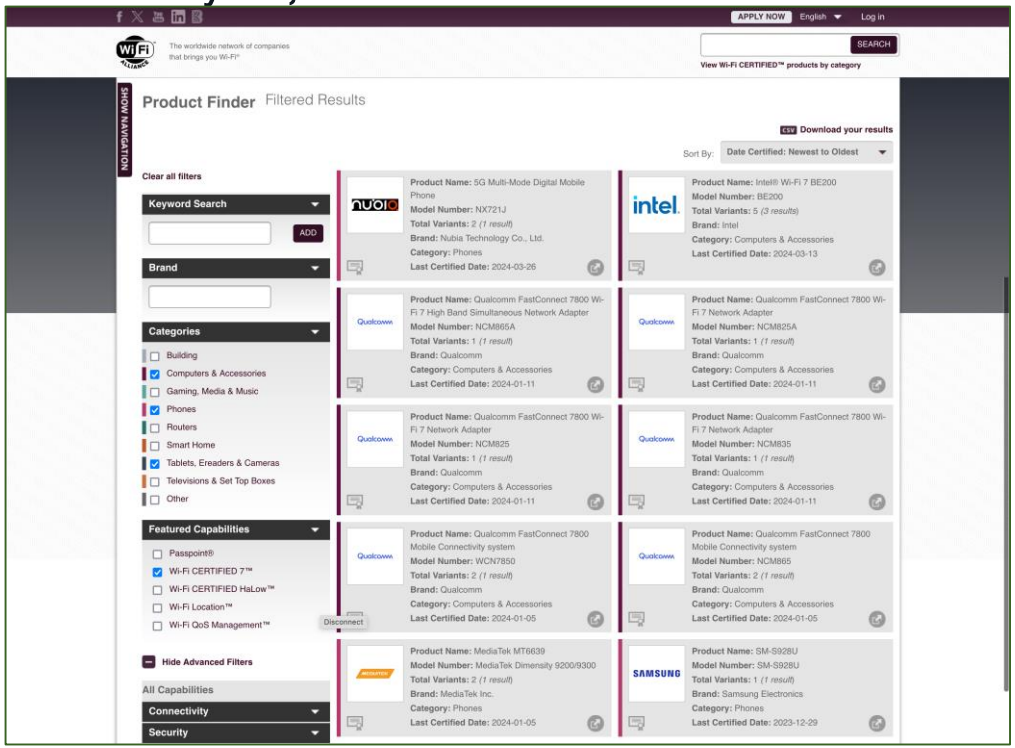
Wi-Fi 7 Certified Client List

As of May 20, 2024



- **Windows**:
  - Wi-Fi 7 support planned in Windows 11 version in , Second Half of 2024
  - Current support Only in Insider Preview Program (Canary and Dev Channels)
- **MAC**:
  - No support yet.
- **Android**:
  - Support available in Android 13 or greater
- **ChromeBook**:
  - Available 2H, 2024

https://www.wi-fi.org/product-finderresults?sort_by=certified&sort_order=desc&categories=1,2,3,5,6,7&capabilities=1652&certifications=1275

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Wi-Fi 7 for enterprise …

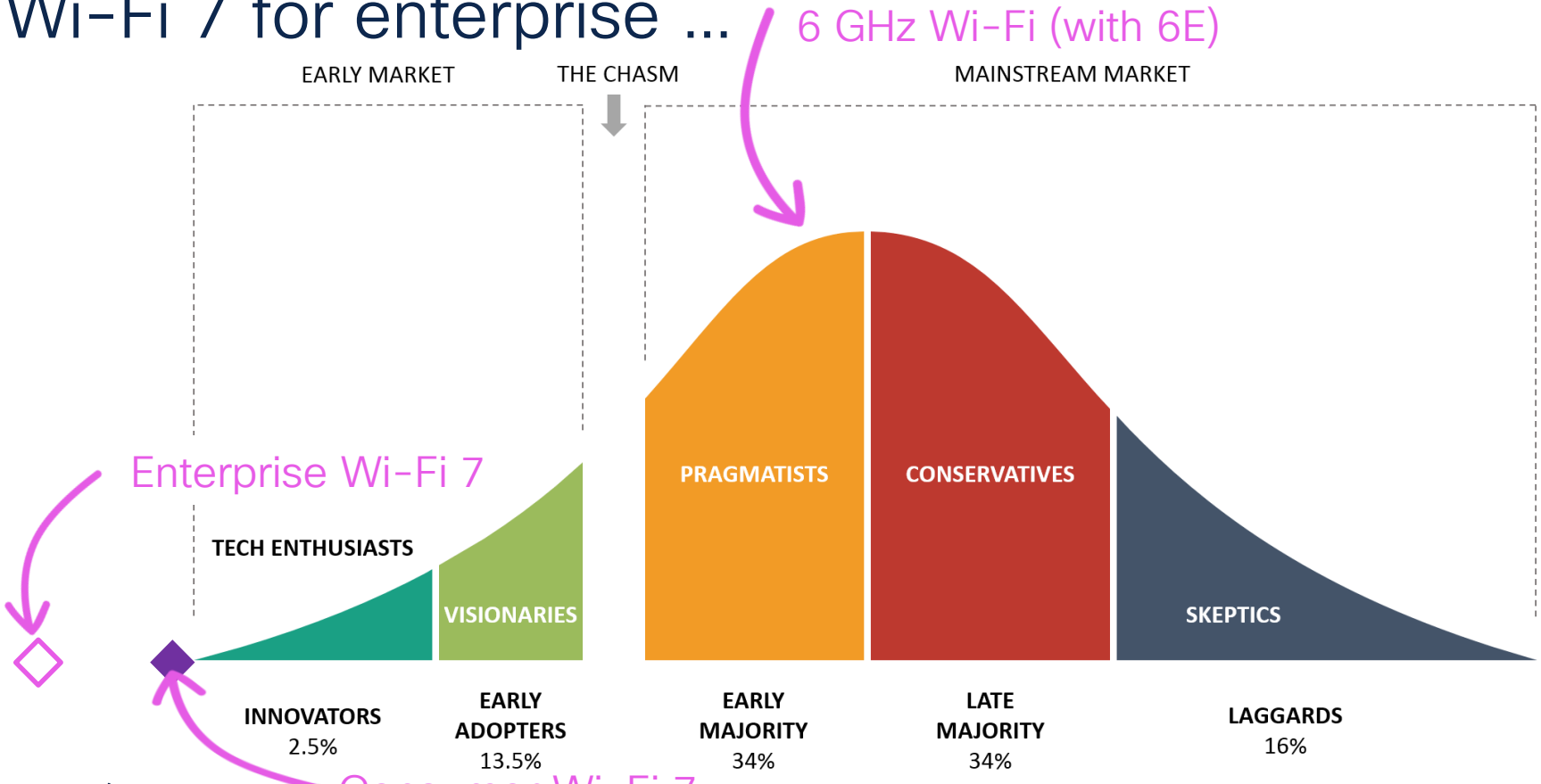

Image credit" https://www.business-to-you.com/crossing-the-chasm-technology-adoption-life-cycle/

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7 Key takeaways:

1. Wi-Fi in 6 GHz is the paradigm shift.
2. Cisco has a full portfolio of products to help customers realize 6 GHz Wi-Fi today.
3. Wi-Fi 7 certification just got available; understand what features are certified.
4. Short to mid-term, Wi-Fi 7 brings only slight benefits in the enterprise vs 6E.
5. Plan for security upgrade. Client interop will be key!
6. Plan for more than 30W per port, and plan for more than 1 Gbps per port.
7. Isn’t quite ready for enterprise yet …

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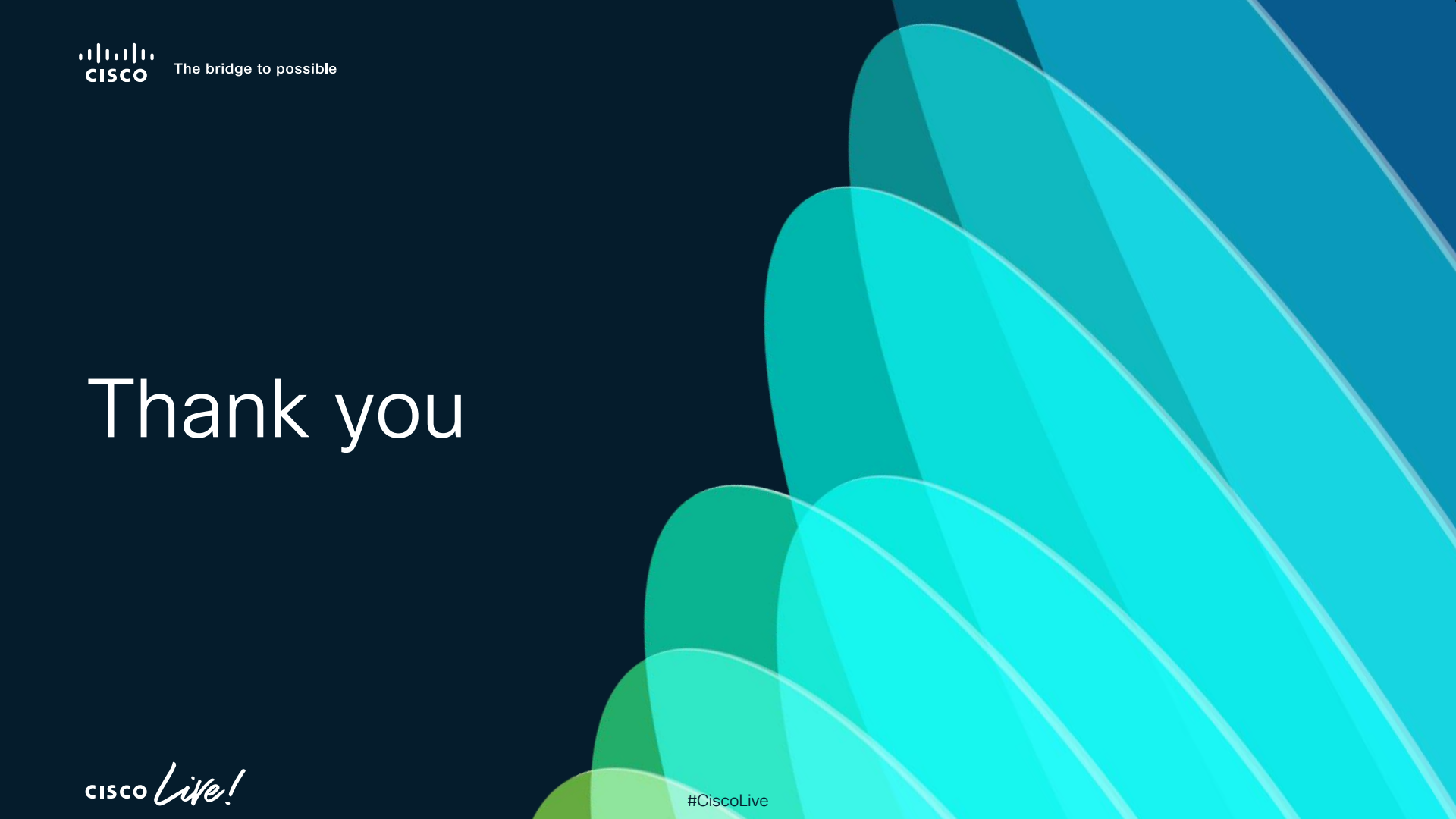
The bridge to possible
Thank you
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