



Cisco DNA Wireless

Maurijn van Tol

April 2024



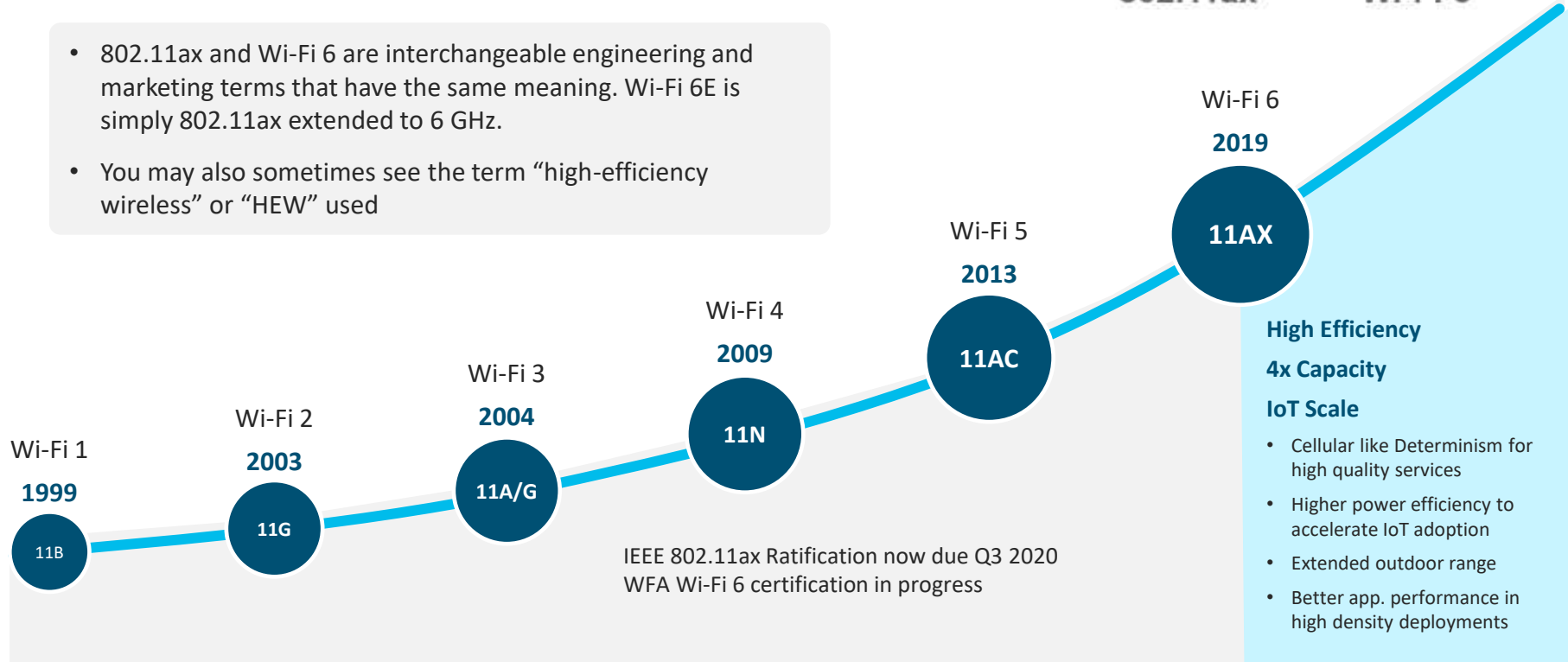
801.11ax aka Wi-Fi6

Yet another next generation

What is Wi-Fi 6 (or 802.11ax)?



- 802.11ax and Wi-Fi 6 are interchangeable engineering and marketing terms that have the same meaning. Wi-Fi 6E is simply 802.11ax extended to 6 GHz.
- You may also sometimes see the term “high-efficiency wireless” or “HEW” used



NEXT GENERATION?

4G

- LTE, Long Term Evolution
- LTE = Technology in use by 4G

4G / 4G Wi-Fi

- Marketing of car-manufacturers
- Wi-Fi 4 (4th gen) Wi-Fi = 802.11n

5G / 5G Wi-Fi

- 5 Generation LTE (still marketing)
- Wi-Fi 5 (5th gen) Wi-Fi = 802.11ac



Wi-Fi 6 is the latest generation of Wi-Fi
(IEEE 802.11ax is marketed as Wi-Fi 6)

Use Cases? Why does Wi-Fi 6 Matter?

Performance and capacity

3-4x Performance and Capacity over 802.11ac wave 2: support high bandwidth applications like next generation video with 4K/8K and AR/VR



Determinism and reliability

Cellular-like [reliability and QoS](#), IoT optimized: APs service hundreds of connected devices with the right QoS and increased amount of data uplink/downlink



Battery savings

Massive battery savings for mobile device with improved reliability & coverage



802.11ax and OFDMA

Why This Matters

Q: What's the Problem to Solve in Wi-Fi?

A: That Depends

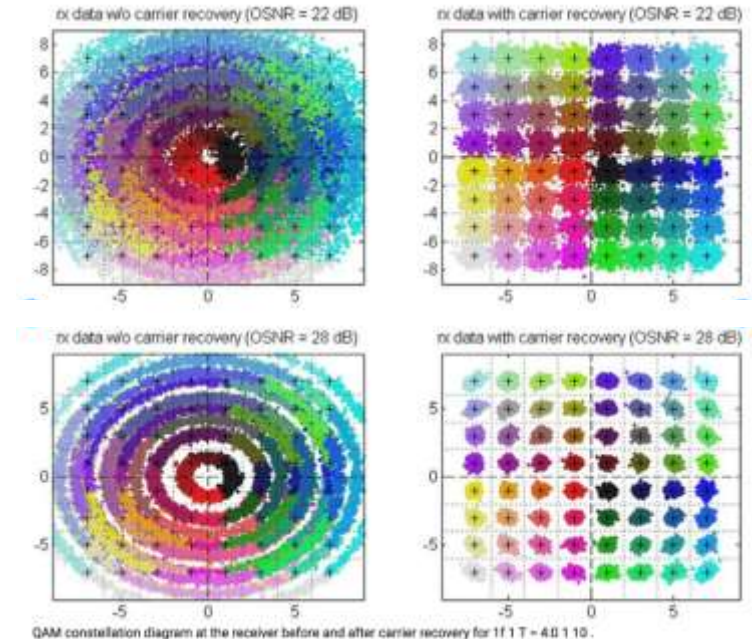
- Peak Wireless Efficiency/Speed is about how much information is in the air during any given Micro second.
- 4 things determine Air Time efficiency
 - ① Data Rate (Constellation Density – how many Bit's per Radio Symbol)
 - ② # Spatial Streams – Spatial reuse
 - ③ Channel Bandwidth – How Many Frequencies can we modulate at one time
 - ④ Protocol Overhead – Preamble/Ack/BA, .etc

OFDM – 802.11g/a/n/ac

Data Rates – and Modulation

- Each successive standard has improved on modulation techniques
- Better Radios/Techniques within each generation allowed Higher Density Constellations

64 QAM Constellation

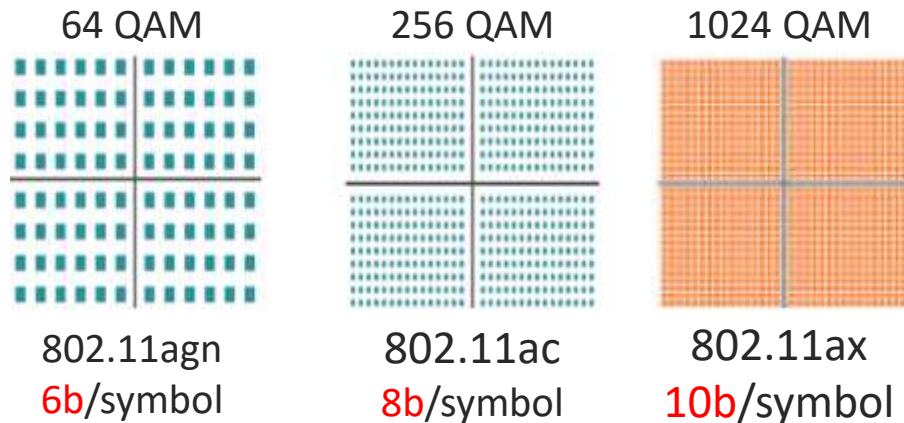
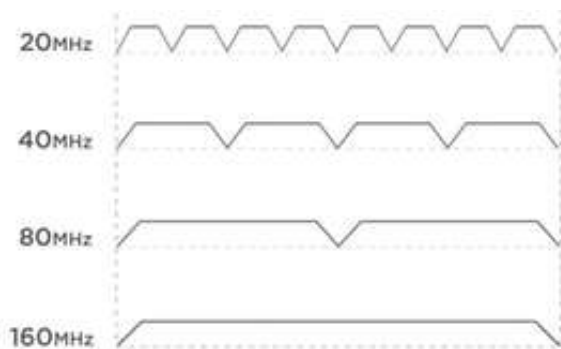


* Hardware-Efficient Coherent Digital Receiver Concept With Feedforward Carrier Recovery for M -QAM Constellations - Scientific Figure on ResearchGate. Available from: <https://www.researchgate.net/64-QAM-constellation-diagram-at-the-receiver-before-and-after-carrier-recovery-for-11-T-40-1-10> [accessed 27 Sep, 2018]

OFDMA – Data Rates

Orthogonal Frequency Division Multiple Access

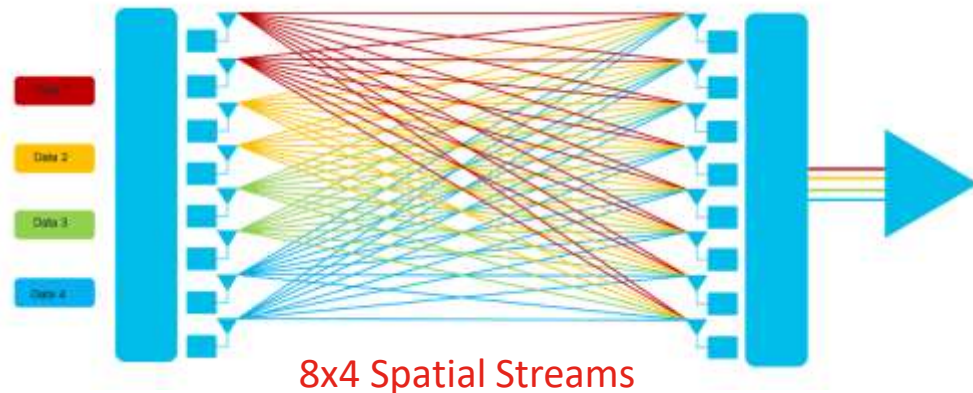
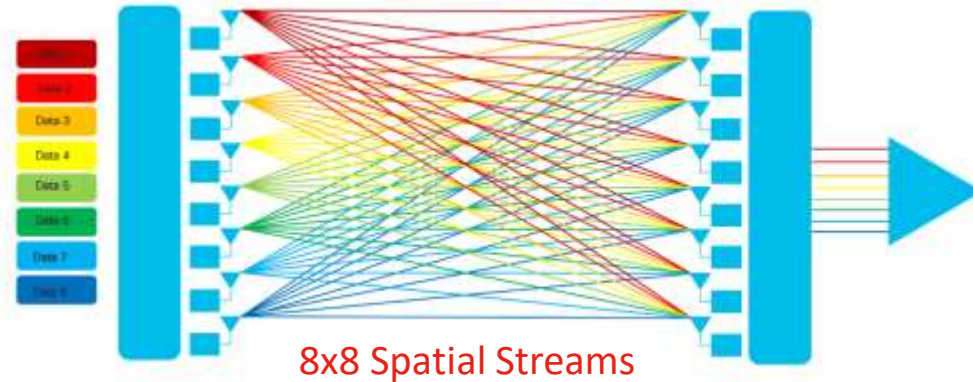
- Peak modulation rate up from 256 QAM to 1024 QAM
- Denser Modulation is more Sensitive to noise
- 256 QAM – is more robust, however 1024 requires no more hardware or spectrum than 256 QAM to operate – implemented easily today



802.11ax Spatial Streams

Up from 4 to 8 SS

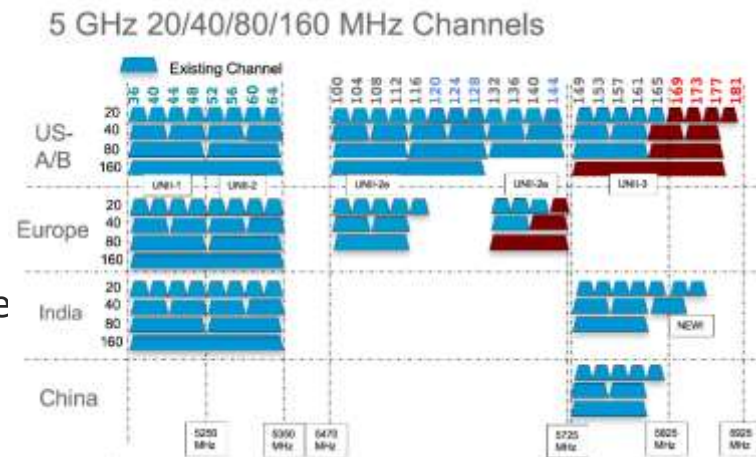
- Spatial Streams are not new, however what we can do with it expands under 802.11ax
- Spatial multiplexing allows for a 1-1 increase in the spectrum under ideal conditions
- Higher modulation densities require higher SNR to protect against corruption, we can use some of the SS's to reinforce other signals
- 802.11ax provides 8 SS which can be mixed and matched to reinforce signal and increase SNR on any of the other SS's data
- MU-MIMO – More on that a bit later



The Fundamentals of Spatial Streams – TechWise TV
<https://www.youtube.com/watch?v=EeK4ISiN0Dw>

Channel Bonding

- Channel bonding enables existing 20 MHz channel assignments to be “bonded” together to create very wide 40/80/160 or 80+80 channel sets
- But this doesn’t come for free, each additional 20 MHz channel comes with a 3dB penalty in SNR because of the wider signal
- 80 MHz channels on Dual 5 Ghz AP’s consume 8 channels per AP placement – and the net result is the same channel re-use essentially as the 2.4 GHz band
- However – in a drag race – it’s pretty impressive



“If you don’t think spectrum is important – just wait until you run out”

802.11g – 802.11ac

A Fantastic Journey

- *OFDM has taken us a long way, but that's over now*
- **4** things determine Air Time efficiency
 - ✓ Data Rate (Constellation Density – how many Bit's per Radio Symbol)
 - ✓ # Spatial Streams – Spatial reuse
 - ✓ Channel Bandwidth – How Many Frequencies can we modulate at one time
 - ⊘ Protocol Overhead – Preamble/Ack/BA, .etc
- OFDMA is the game changer

Higher Efficiency: Requires a Design Philosophy

- When a client has data to transmit, it's given the whole channel, to support bursty data
- As data rates go up, PHY/MAC (preamble, backoff, Ack/BA, any RTS/CTS, etc) overheads don't diminish
- Aggregation can only take us so far
- Example – 87% of frames less than 320 bytes
 - Voice – average 100 bytes
- In an 80 MHz channel – That's a LOT of capacity flying empty and taking precious Air-Time
- More clients – also results in longer intervals between Tx-Ops – increasing jitter (latency)

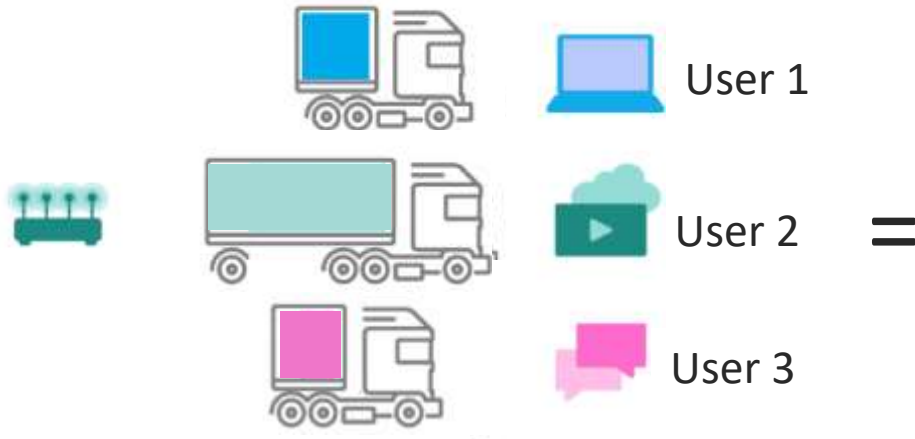
Topic / Item	Count	Average	Min val	Max val	Rate (ms)	Percent
Packet Lengths	105198	225.52	14	1623	1.6173	100%
0-19	14274	14.00	14	14	0.2194	13.57%
20-39	10605	26.89	20	39	0.1630	10.08%
40-79	1122	64.11	40	79	0.0172	1.07%
80-159	6447	115.83	80	159	0.0991	6.13%
160-319	59472	283.61	160	319	0.9143	56.53%
320-639	12440	363.13	320	636	0.1913	11.83%
640-1279	288	888.88	640	1279	0.0050	0.27%
5120 and greater	0	-	-	-	0.0000	0.00%

87.37% of Frames =<320 bytes of data!

Device only improvements vs Whole cell/network

OFDM vs. OFDMA and Sub-Carriers

OFDM



- Fixed Overhead – Independent of Payload Size
- Uses Full Channel bandwidth – per user

Device only improvements vs Whole cell/network

OFDM vs. OFDMA and Sub-Carriers

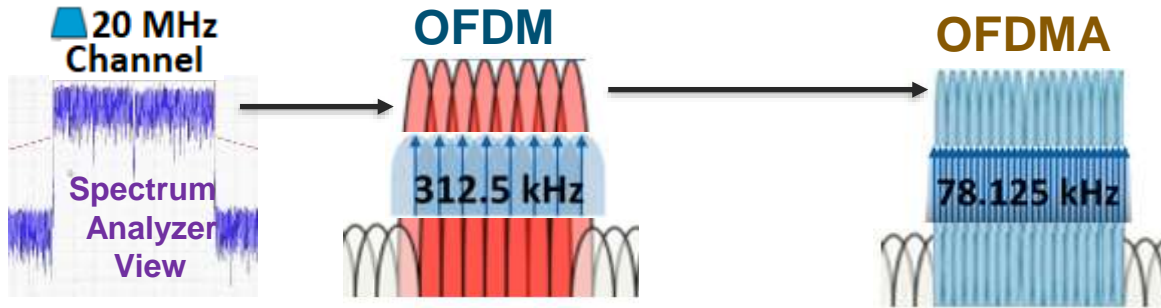
OFDMA



- Overhead – Amortized between users
- Efficient use of Resources
- Scales resources for different traffic mix (IM vs Download)
- Increases overall Efficiency

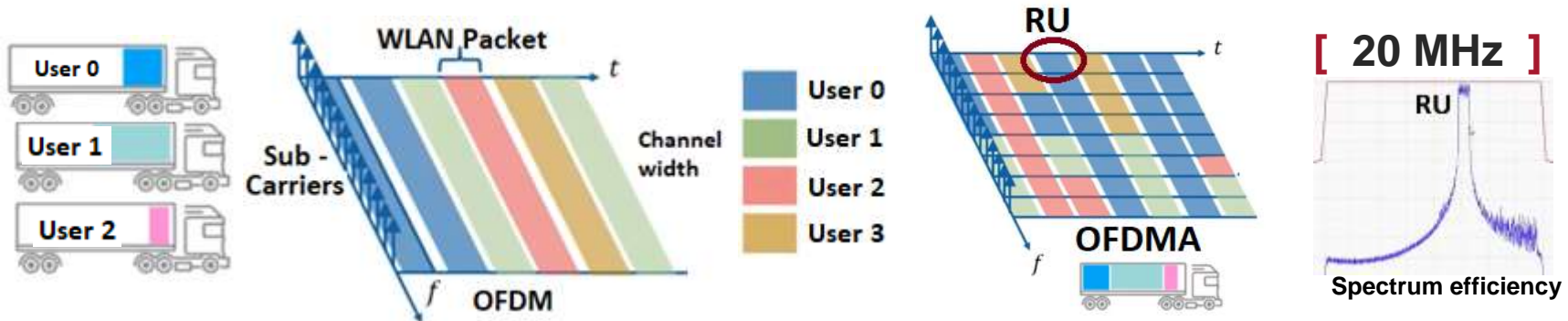
Understanding OFDM and OFDMA

Both divide into sub-channels (carriers) but OFDMA has more and the concept of Resource Units.



OFDMA divides the same 20 MHz spectrum into many more smaller subcarriers that can carry small packets faster.. **Using Resource Units (RU)** it allows each transmission to handle multiple users

OFDM divides the available spectrum into sub-channels that can be independently modulated and demodulated **but each transmission has data for only one user at a time - OFDMA = more users at a time.**

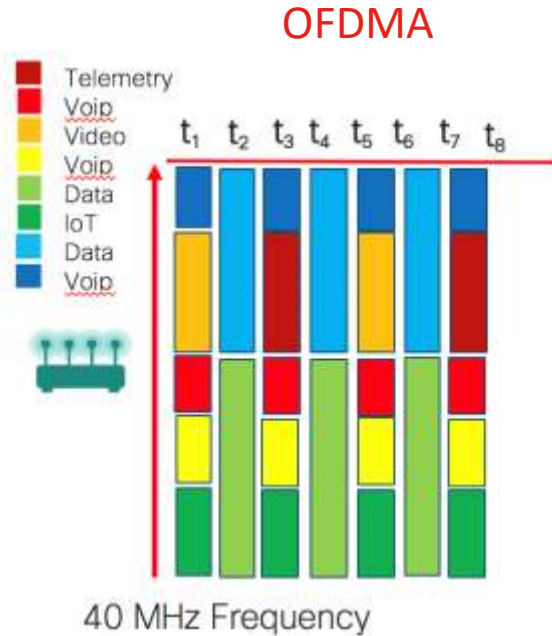


All packets big and small get processed MUCH FASTER

OFDMA –Deterministic

Maximizing Client Count –lowering Latency

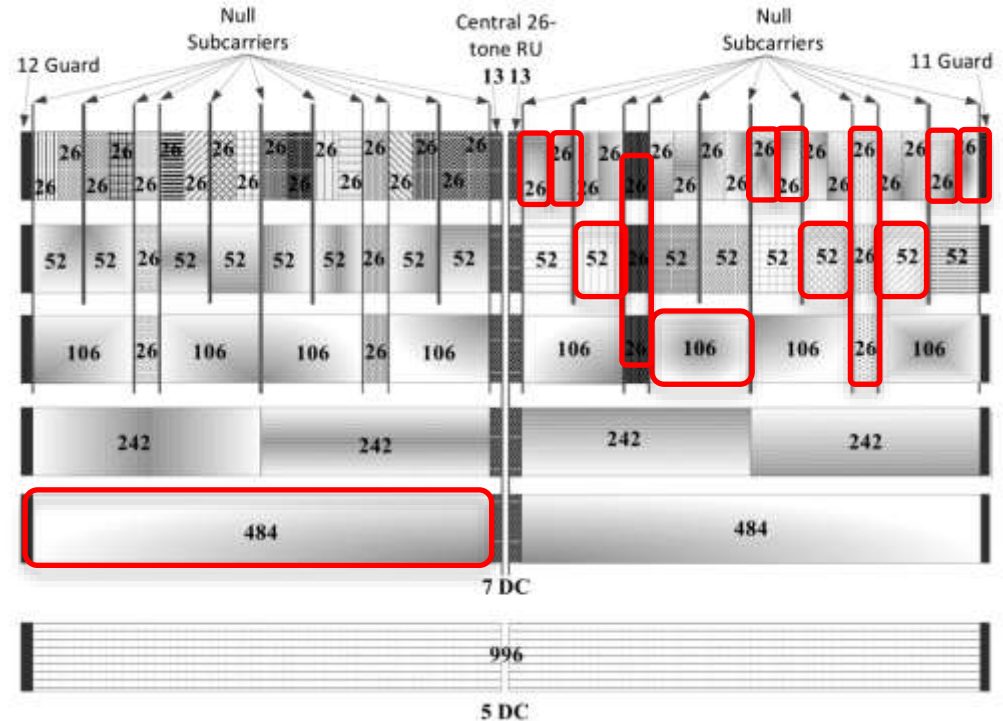
- Multi user Packet makes flight more efficient
- Provides a regular flexible TX_op
- Deterministic nature – miss this buss – no worries here comes another...



UL-OFDMA

- UL OFDMA also splits the frequency axis into 2/4/8/20/40/80/160 MHz **Resource Units**
- AP sends a **Trigger** frame to **order** clients to transmit on a specified RU (width and position)
 - at a specified TX power
 - MCS,
 - and for a specified number of OFDM symbols
- Every user's signal needs to arrive at the AP at:
 - the same time (time offset \ll GI duration)
 - the same center freq (freq offset \ll subcarrier width)
 - similar power levels, different MCSs acceptable

Allowed RU positions for 80MHz

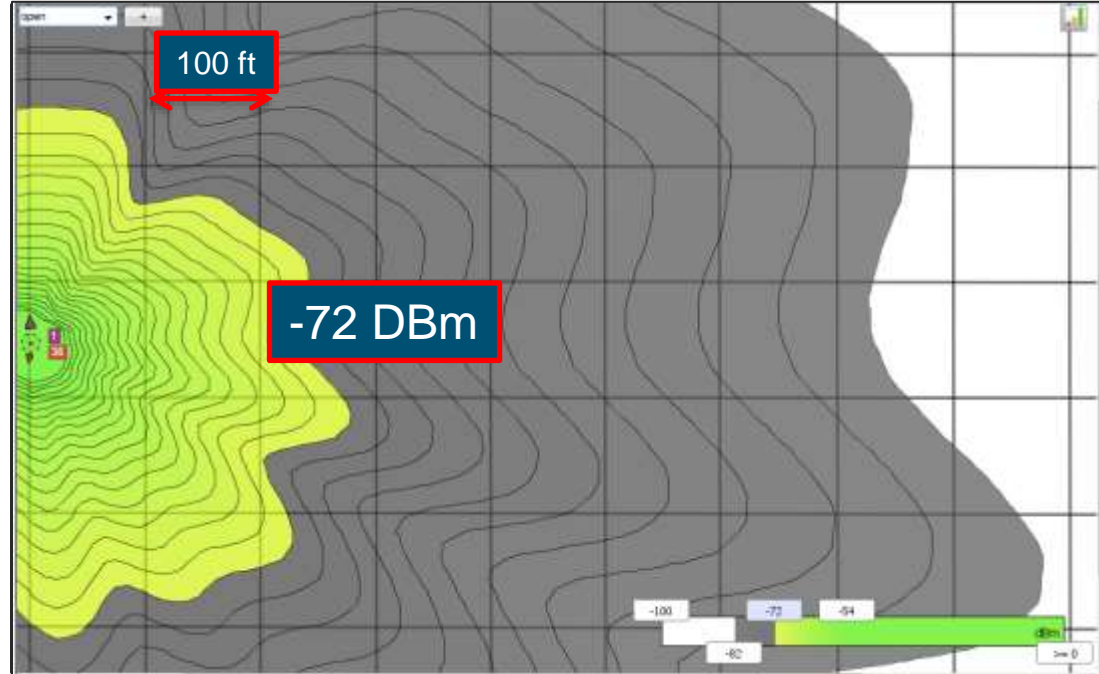


OFDMA and Spatial Re-Use

802.11 Contention Mechanism

Listen Before talk 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



Wireless High Density Client Density Design Guide
<http://cs.co/9001D47PT>

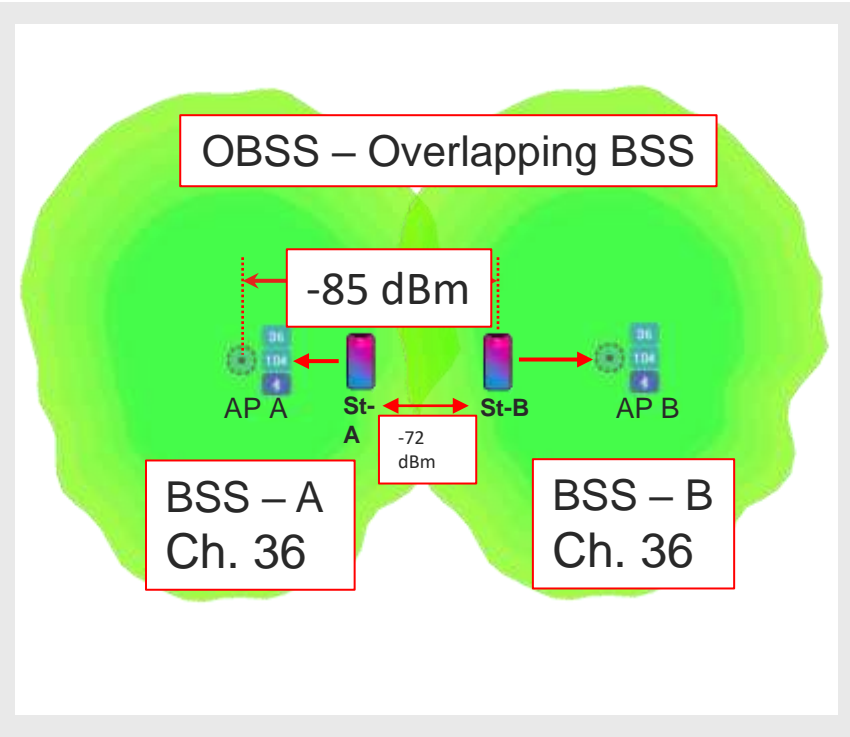
Wi-Fi Contention and Spatial Reuse 101– Why is BSS coloring important?

- Two stations can't talk to the same AP at the same time, they "Interfere"
- Wi-Fi uses a "contention mechanism" to prevent this, Listen Before Talk (LBT)
 - CCA (Clear Channel Assessment)
- If Sta A listens and finds the channel clear at -82 dBm – It transmits
 - Else, it waits until it is clear and re-tries
- Two competing 802.11 stations will share the spectrum and take turns accessing the channel



Wi-Fi Contention and Spatial Reuse 101 – Why is BSS coloring important?

- What if the two stations are talking to two separate AP's though?
 - AP A can't hear St-B
 - AP B can't hear St-A
 - St-A and St-B can hear each other above threshold (-82 dBm)
 - Forcing CCA to block the channel – they will take turns
 - That St-A and B are not talking to the same target – doesn't matter, it can't be determined.



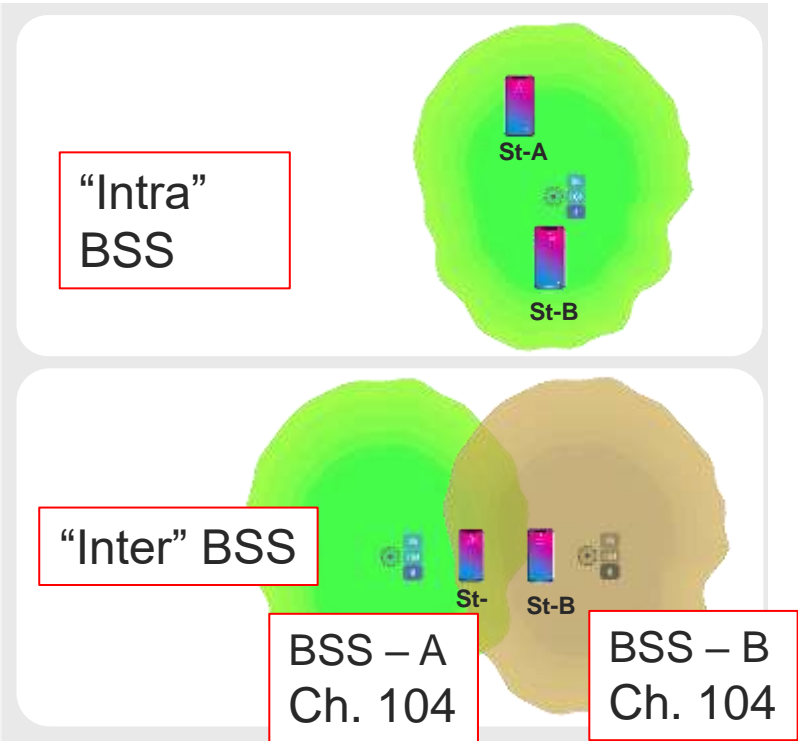
Wi-Fi Contention and Spatial Reuse 101 – What Does BSS coloring do?

BSS Color:

- adds a “Color” (number between 1-63 actually) to the BSSID of the AP
- Is advertised in the Beacon, (re)Association, and probe response frames
- Clients learn their “Color” when associating to the BSS
- Clients and APs can detect a Color Overlap
 - Two BSSID’s on the same channel should each have a different color

An AP can signal a BSS Color change at any time

- Stations can now know if the traffic they hear is
 - “Intra” or My Own BSS
 - “Inter” or Someone else’s BSS



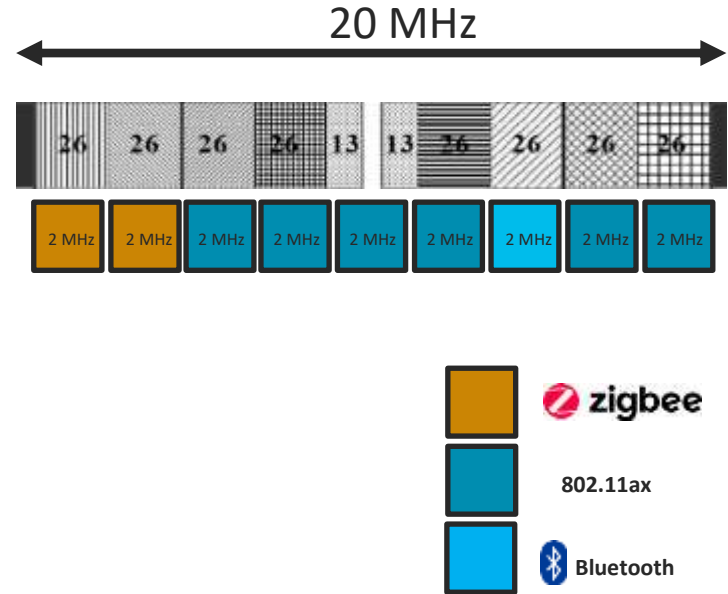
IOT

802.11ax Benefits

802.11ax and IOT

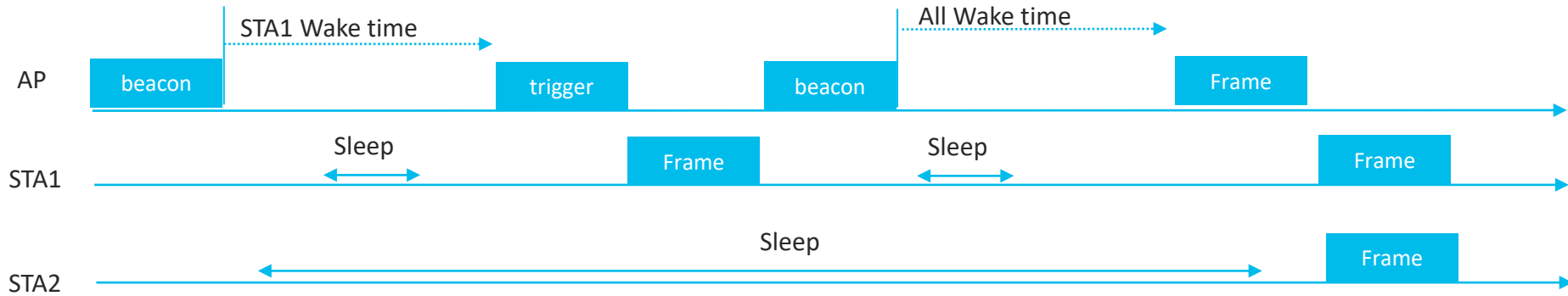
Better Coexistence with Existing IOT

- 802.11ax is in 2.4 GHz
- Thanks to 2 MHz channels, Coexistence with other 2.4 GHz IOT technologies is much more effective
- Any Channel can be left blank (no 802.11ax) to allow other technologies to operate



Benefits of 802.11ax for IOT

TWT and Long Sleep time allowed

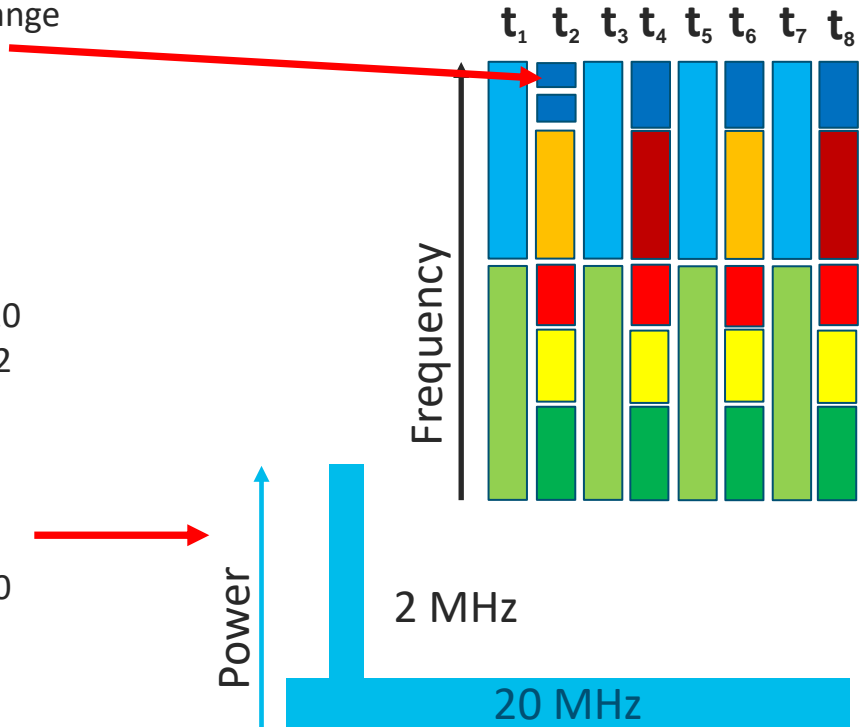


- With Target Wake Time (TWT), AP can let STAs sleep for long durations (battery saved), set per STA or group of STAs
- 802.11ax can allow STAs to sleep up to **5 years**

Benefits of 802.11ax for IOT

OFDMA, 375 kbps Low Power, Low Throughput

- With a single 2 MHz RU, AP and client can exchange at 375 kbps (low power consumption, low throughput, ideal for many IoT use cases)
- 802.11a/g allowed only 6 Mbps maximum, 802.11n/ac 6.5 Mbps (higher power consumed, wasted bandwidth)
- Longer Distance too – all the power used for a 20 MHz channel can be concentrated into a single 2 MHz RU
 - Better Link Budget
 - No more cost to battery
- Or, use the same power – in 2 MHz instead of 20 MHz and significantly reduce battery demand



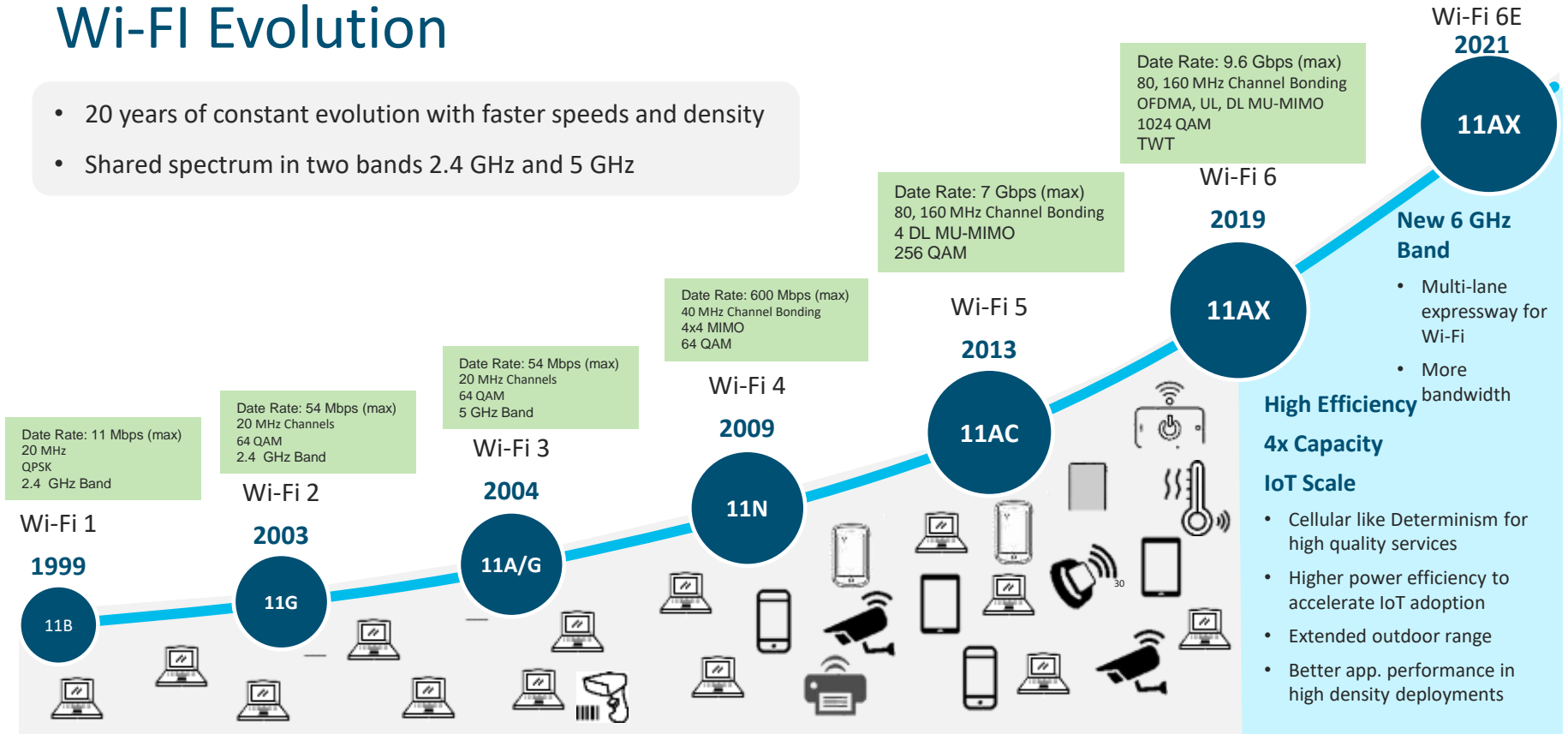


Wi-Fi 6E

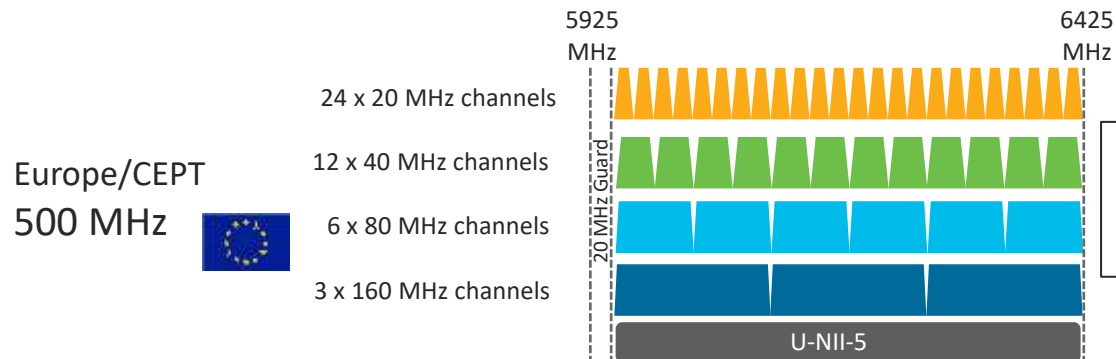
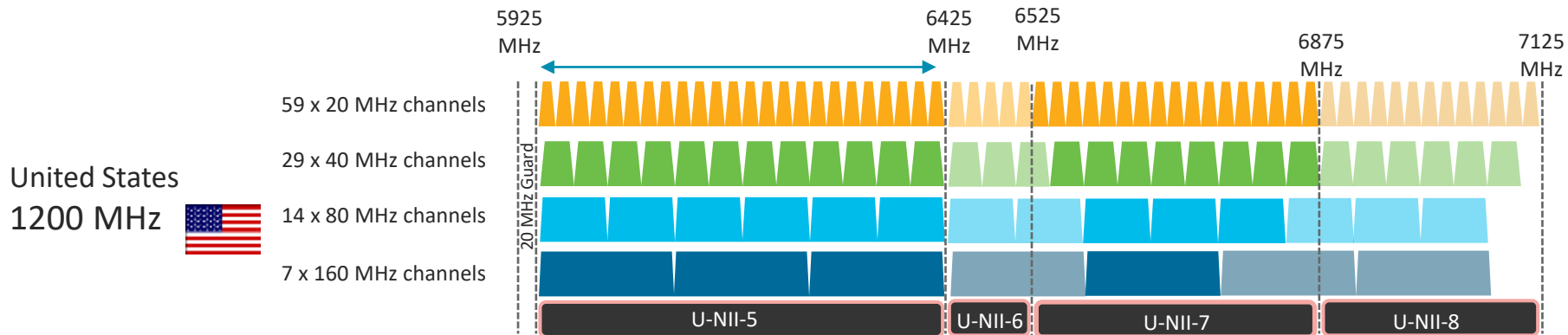
Wi-Fi 6 Extended to 6 GHz

Wi-Fi Evolution

- 20 years of constant evolution with faster speeds and density
- Shared spectrum in two bands 2.4 GHz and 5 GHz



Wi-Fi 6E - The new 6 GHz band :



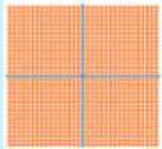
5955 – Central Frequency of the first 20 MHz channel
 → Starting at 5925 MHz +
 20 MHz of guard band +
 10 MHz to get to the center of the first 20 MHz channel

Wi-Fi 6E

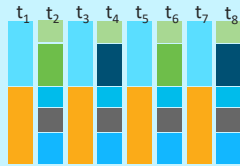
Wi-Fi 6 and 6GHz are friends

802.11ax

1024 QAM



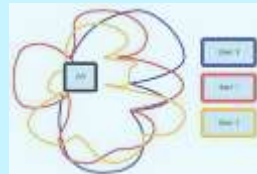
OFDMA



BSS Coloring



DL, UL MU-MIMO



TWT



- Additional Spectrum
 - 1200MHz (5.925 GHz to 7.125 GHz) in US
 - 500 MHz (5.925 GHz to 6.425 GHz) in EU
- Wider Channels
- Clean RF
- No Slow Devices
- Security Upgrade
- 6 GHz WLAN Discovery
- Air Time Efficiency

Wi-Fi 6E

Restrictions

Important restrictions to 6 Ghz

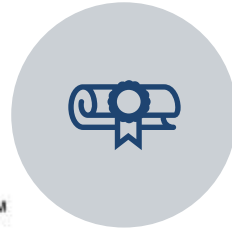
1. Indoor use only in ETSI countries
2. No external antenna's allowed in ETSI countries
3. 802.11ax and later only
4. Mandatory security enhancements (more later)

6GHz WLAN Design

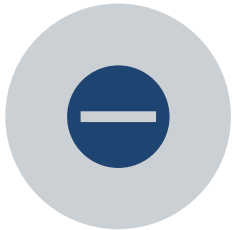
Wi-Fi 6E Security



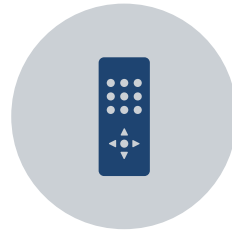
Wi-Fi 6E up levels security with WPA3 and OWE



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.

6GHz WLAN Design Considerations

6GHz SSID Requirements

- WPA3 L2 Security: OWE, SAE or 802.1x-SHA256
- Protected Management Frame (PMF) enabled
- Any non-WPA3 L2 security method is not allowed – **no mixed mode possible**

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. “**One SSID**” option: Configure multiple WLANs with the same SSID name, different security settings – **Most conservative**
3. “**Multiple SSIDs**” option: Redesign your SSIDs, adding specific SSID/WLAN with specific security settings – **Most flexible**

Most likely your current SSID configuration would prevent it from being broadcasted on 6GHz
Note: as 17.9.1, there is a limit of 8 SSIDs broadcasted on 6GHz radio

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

Option 1 – Change all-band single SSID to WPA3



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

Option 2 – Single SSID

- **Option 2:** 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

The screenshot shows the configuration for an existing WLAN. The 'General' tab is active. The 'Profile Name*' is 'employee', the 'SSID*' is 'employee', and the 'WLAN ID*' is '9'. The 'Status' is 'ENABLED' and 'Broadcast SSID' is also 'ENABLED'. Under the 'Radio Policy' section, the '6 GHz' band is 'DISABLED', while the '5 GHz' and '2.4 GHz' bands are 'ENABLED'. The '802.11b/g Policy' is set to '802.11b/g'.

New WLAN, same SSID name serving 6GHz

The screenshot shows the configuration for a new WLAN. The 'General' tab is active. The 'Profile Name*' is 'employee-6GHz', the 'SSID*' is 'employee', and the 'WLAN ID*' is '10'. The 'Status' is 'ENABLED' and 'Broadcast SSID' is also 'ENABLED'. Under the 'Radio Policy' section, the '6 GHz' band is 'DISABLED', while the '5 GHz' and '2.4 GHz' bands are 'ENABLED'. The '802.11b/g Policy' is set to '802.11b/g'. Security settings are shown as 'WPA2 Disabled', 'WPA3 Enabled', and 'DoS (L) Enabled'.

Option 2 Sub-options for 2.4/5 GHz

Two options for WLAN security settings in 2.4/5GHz band:

- a) WPA3 Transition mode
- b) WPA/WPA2

Things to keep in mind:

- From the initial testing done, some older drivers clients may have issues in connecting to a WPA3 transition mode
- Today Cisco doesn't support seamless roaming across WLANs, so for both options it will be a hard roam across bands.

Option 2a



Pros

- Provide an adoption path to more secure Wi-Fi via WPA3 Transition mode
- 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
- Roaming across different WLANs (same SSID) is not supported
- Not supported by Cisco DNA Center Automation

Option 2b



Pros

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



Cons

- WPA2 only for 2.4/5GHz > not as secure as using WPA3
- 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 DNA Center Automation

Option 3 – Redesign SSIDs

- **Option 3:** 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

Option 3



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 DNA Center



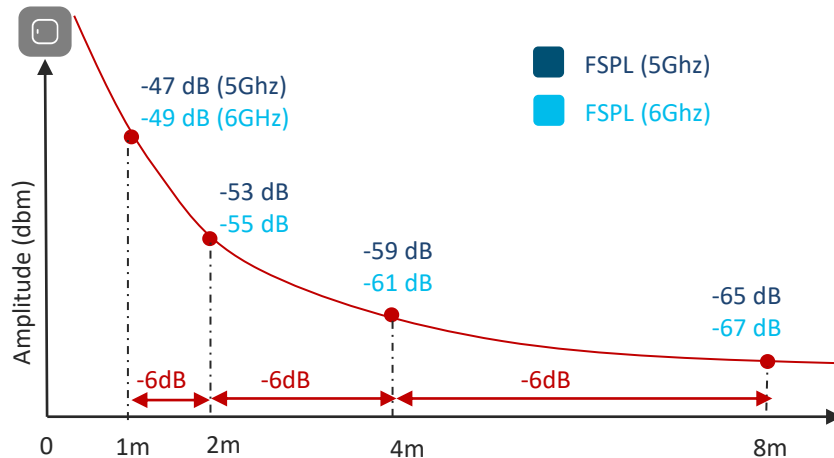
Cons

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

RF considerations

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



RF Design considerations

- 1:1 AP replacement for **brownfield**:
 - Cell size 140 - 190 m² with 3-4 m ceiling height
 - If power level average is 3-4 > 1:1 AP replacement is possible > similar coverage level between 5 and 6 GHz
 - If the power level is 1-2, then you may need to add APs, around 10 to 20% additional access points
- For **greenfield**, a site survey is recommended: leverage the new site survey mode on Cisco Wi-Fi 6E APs
- **Mixing** Wi-Fi6E APs with existing APs in the same area is **not recommended** > avoid “salt & pepper” design if you can



Client Eco System & Partnerships

Wi-Fi 6E Client Device Eco System

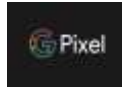
Wide range of client support ..



Samsung Galaxy Ultra S21/S22 & Up



Samsung Galaxy Z Fold



Google Pixel 6 / Pro & Up



XIAOMI



Xiaomi Mi 11 / Ultra



iPad Pro 6th Generation



MacBook Pro M2 Pro/Max



Mac Mini M2



iPhone 15 Pro



ASUS Zenfone 8 and 8 Flip ROG Phones*

Samsung Galaxy Tab S8 series



Laptops with Intel AX210/AX211/AX411 Chipset

© 2019 Cisco and/or its affiliates. All rights reserved. Cisco Public



Chromebook



Redmagic 6s Pro & Up



Zebra TC53/58



Surface Pro 9



Wi-Fi 6E Chipsets



Motorola Edge (2021 & up)

And more getting added.....

Wi-Fi 6E Interop Device Eco System Test Details



- Around 40+ interoperability issues in Wi-Fi 6E & WPA3 found and closed with client vendors.
- Pre-release hardware and software testing.
- Regular cadence with client interop partners
- iPhone 15 Pro is under evaluation by Wireless Client Interop Team.

Wi-Fi 6E Interop Device Eco System Test Details

Client Vendor	6E Clients	Version Tested	6E Preference	Known Issues
Apple	iPad Pro, MacBook Pro M2	iPad OS 16.4, MacOS:13.5.2	Prefers 6G	See next slide.
	iPhone 15 Pro (under testing)	iOS 17		
Samsung	S21 Ultra, Galaxy Z Fold, S22+, S23 S23	Android 13	Prefers 6G	None
Intel	AX210, AX211, AX411	22.250.1	Prefers 6G	See next slide.
Google-Pixel	Pixel 6, 6 Pro, 7 and 8	Android 13	Prefers 6G	None
Google Chrome OS	ChromeOS with Intel AX211	116.0.5845.120	Prefers 6G	None
	ChromeOS with Mediatek MT7922 MT7922	116.0.5845.120		
	ChromeOS with QCA WCN6856 WCN6856	116.0.5845.120		
Zebra	TC22, TC53, TC58, TC73, TC78 TC78	Android 13	Prefers 6G	None
Other Clients	Broadcom, Qualcomm, NXP, Xiaomei, Asus , Redmagic,	QCA: 2.0.0.1016	Prefers 6G	None

IOS-XE Versions Validated: 17.9.4, 17.12.1 & 17.13.1

Note: Above details specific to Wi-Fi 6E Interop

Current Open Issues



Description	Customer Impact	Observed in 6E ?
M1/M2 MacBook Air running macOS 13.4 do not auto join WPA3 SAE network. Needs revalidation after fixing the wpa3-sae issue.	Toggling Wi-Fi multiple times might get the the SSID disconnected with error saying saying wrong password.	Yes
iPhone/iPad - STA doesn't send device analytics report when PMF is enabled	Apple devices are not classified if PMF is is enabled on WLAN	Yes
MacBook Pro frequently goes to Power Save in 6Ghz, which degrades throughput. throughput.	Degradation of throughput in 6Ghz band band	Yes
iPhone/iPad - Client association issue when multiple passpoint profiles are installed on installed on device.	Can not associate to any passpoint SSID SSID	Yes
Intel AX210, 211 Clients not attempting to associate to the previously connected/saved connected/saved networks	Client does not Auto join sometimes when sometimes when it goes out of range and and comes back	Yes
Intel AX210, 211 clients does not associate to the same band after session time- out time- out	Client keeps toggling between the bands bands when session time out happens	Yes

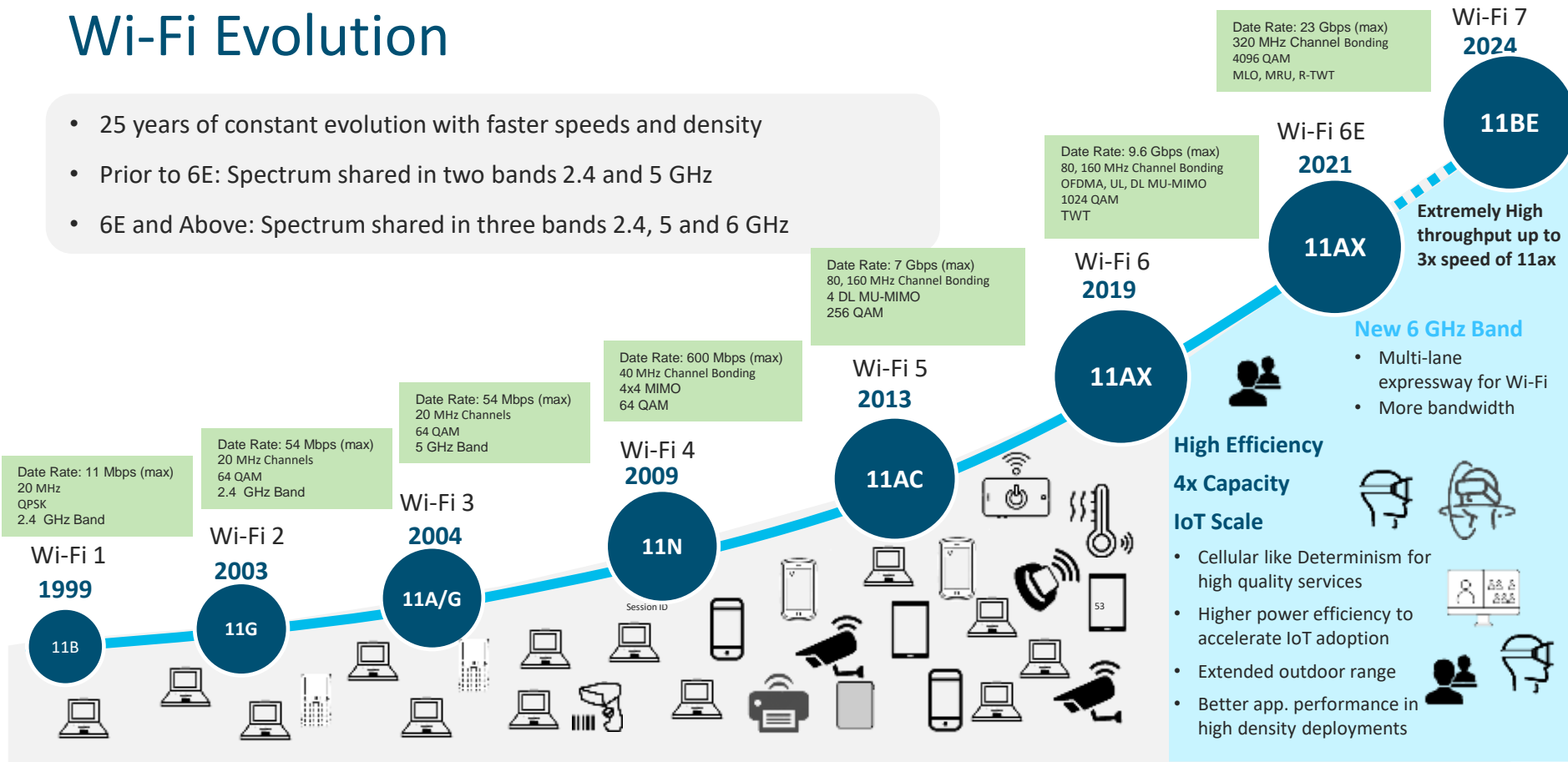


Wi-Fi 7

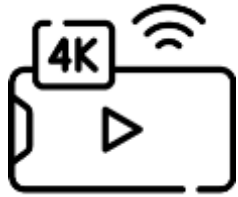
802.11be

Wi-Fi Evolution

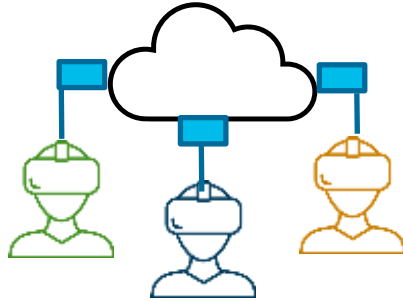
- 25 years of constant evolution with faster speeds and density
- Prior to 6E: Spectrum shared in two bands 2.4 and 5 GHz
- 6E and Above: Spectrum shared in three bands 2.4, 5 and 6 GHz



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

Wi-Fi 7 & 802.11be in 1 slide

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

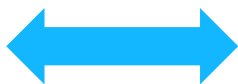
In the enterprise, Wi-Fi 7 is a modest upgrade compared to Wi-Fi 6E.
Enterprises can fully utilize the 6GHz spectrum with Wi-Fi 6E

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

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



320 MHz in 6 GHz
160 MHz in 5 GHz



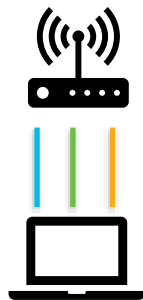
Preamble puncturing
Mandatory in 6. Optional in 5
Min ch. width of 80



4K QAM



Multi-RU



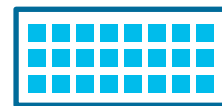
MLO



Triggered UL Access Optimization

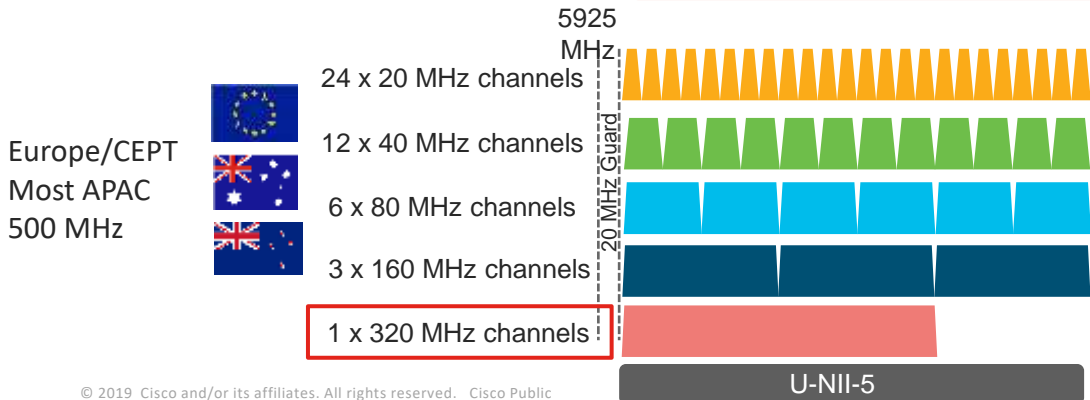
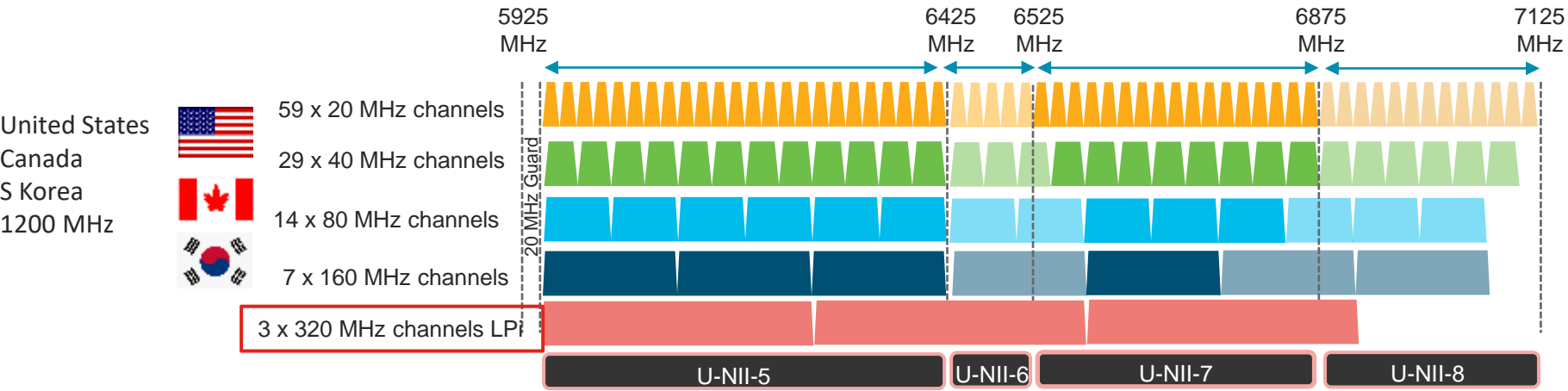


Enhanced Security



Compressed Block Ack

Wi-Fi 7 – 320 MHz Channel Width



Is this a possibility ?



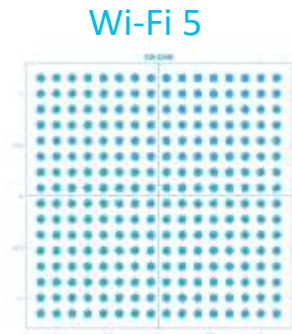
Note: 3x320 MHz channels LPI
 1x320 MHz channels SP –(US)
 2x320 MHz channels SP – (Canada)

Wi-Fi 7 – 4K QAM

QAM – Quadrature Amplitude Modulation

Data rate (Modulation density) or (how many Bit's per Radio Symbol)

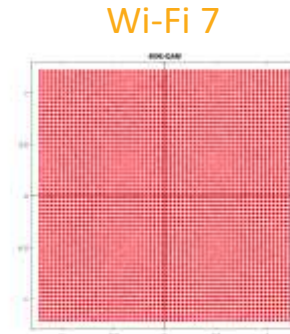
Need very high SNR for 4K QAM



256 QAM



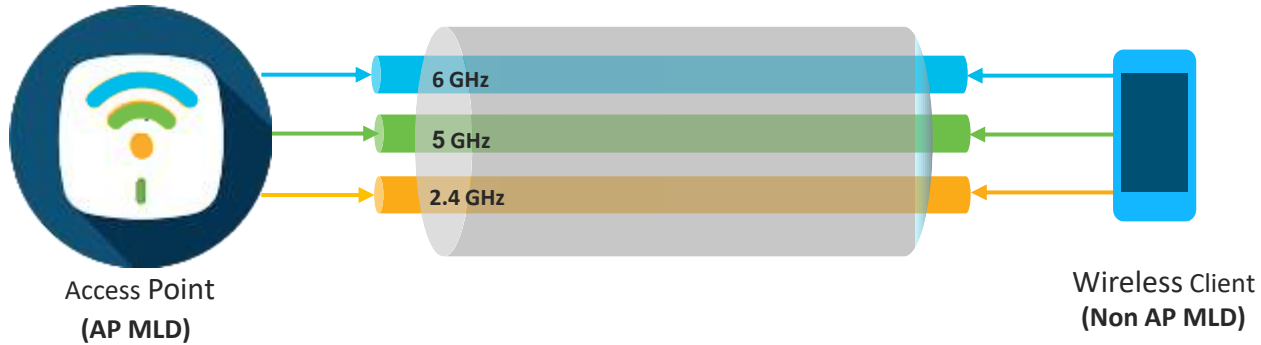
1024 QAM



4096 QAM

20% increase in data rates when compared to Wi-Fi 6

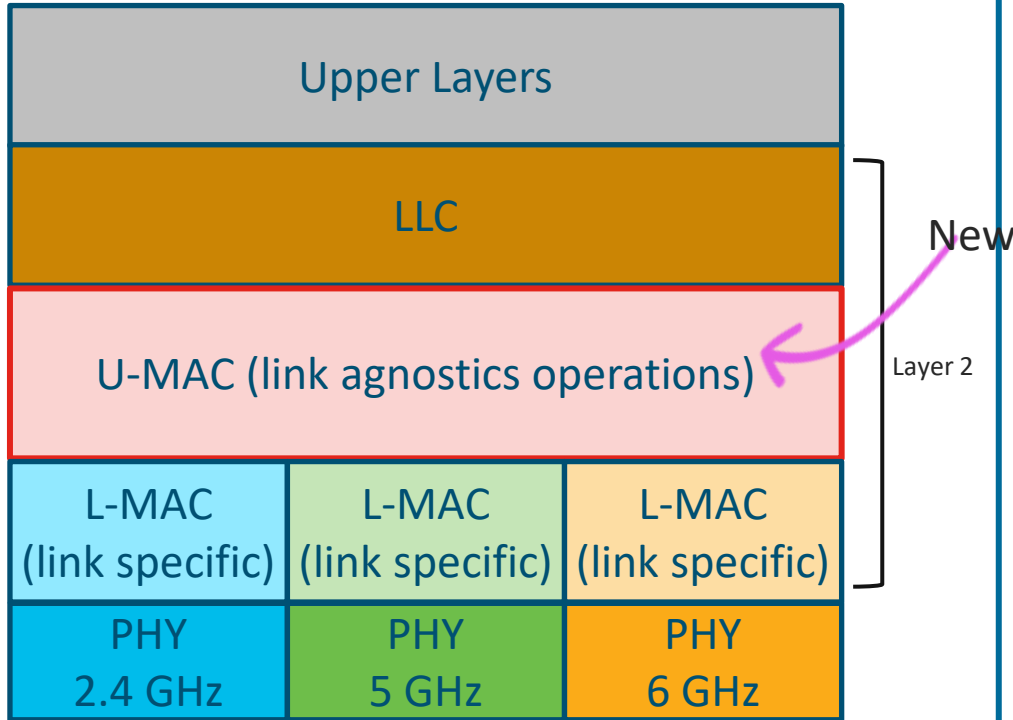
Wi-Fi 7 – Multilink (MLO)



Method	Benefit
Aggregation	Throughput
Steering	Lower Latency
Redundancy	Reliability

MLD: Multi Link Device

Wi-Fi 7 MLO MAC Layers



Multiple MAC Addresses:

- MLD MAC Address
- Link specific MAC Address

MLD MAC Upper Layer functions :

- Auth, Assoc, Reassoc
- Security association
- Encryption/Decryption of Ucast frames
- MLD level management frames
- Packet re-ordering, replay detection

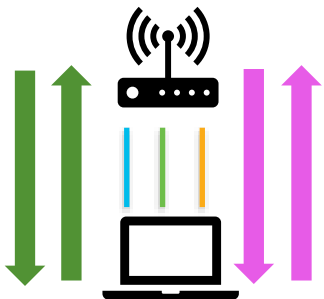
MLD MAC Lower Layer functions:

- Link specific mgmt. frames (beacons)
- Control Frames (RTS, CTS, Ack)
- NDP
- Power Save
- Link specific encryption/decryption using group key

The many “modes” of MLO

Multi Radio

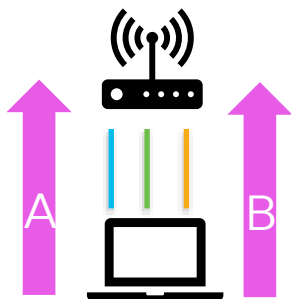
MLMR
Simultaneous TX + RX
(STR)



Each link
operating
independently

This is the one to pay attention to

MLMR
Non-Simultaneous Tx+Rx
(nSTR)

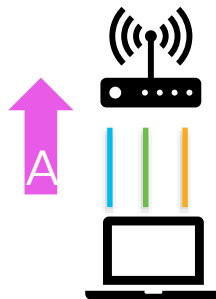


Links Tx or Rx
at the same
time

*(Not included in Wi-Fi 7
Certification)*

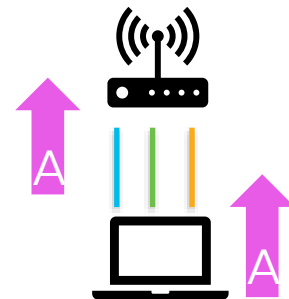
Single Radio

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

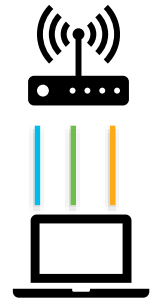
EMLSR – Enhanced Multi-link Single Radio

Wi-Fi 7 MLO Types

MLO Type	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 to two links simultaneously
Multi Link Multi Radio, Simultaneous Tx and Rx (MLMR-STR)	≥ 2	Simultaneous Tx/Tx or Rx/Rx or Tx/Rx over multiple links (asynchronous)
Multi Link Multi Radio, Non-Simultaneous Tx and Rx (MLMR-NSTR)	≥ 2	Simultaneous Tx/Tx or Rx/Rx over multiple links (synchronous)
Enhanced Multi Link Multi Radio (EMLMR)	≥ 2	MLMR with additional capability to dynamically reconfigure spatial multiplexing capability on each link

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

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

Wi-Fi 7 Multiple Resource Unit (MRU)

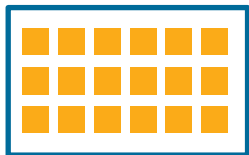


Multiple RUs make efficient use of spectrum

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

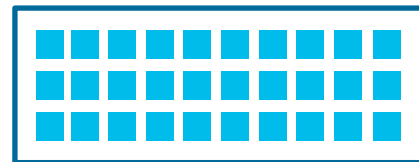
512 Compressed Block Ack

Wi-Fi 6



- Aggregation of upto **256** MPDUs in a single frame.
- Acknowledgement upto **256** MPDUs in a single Block Ack Frame

Wi-Fi 7



- Aggregation of upto **512** MPDUs in a single frame.
- Acknowledgement upto **512** MPDUs in a single Block Ack Frame

Reduces Protocol Overhead. Improve transmitter's performance at higher rates.

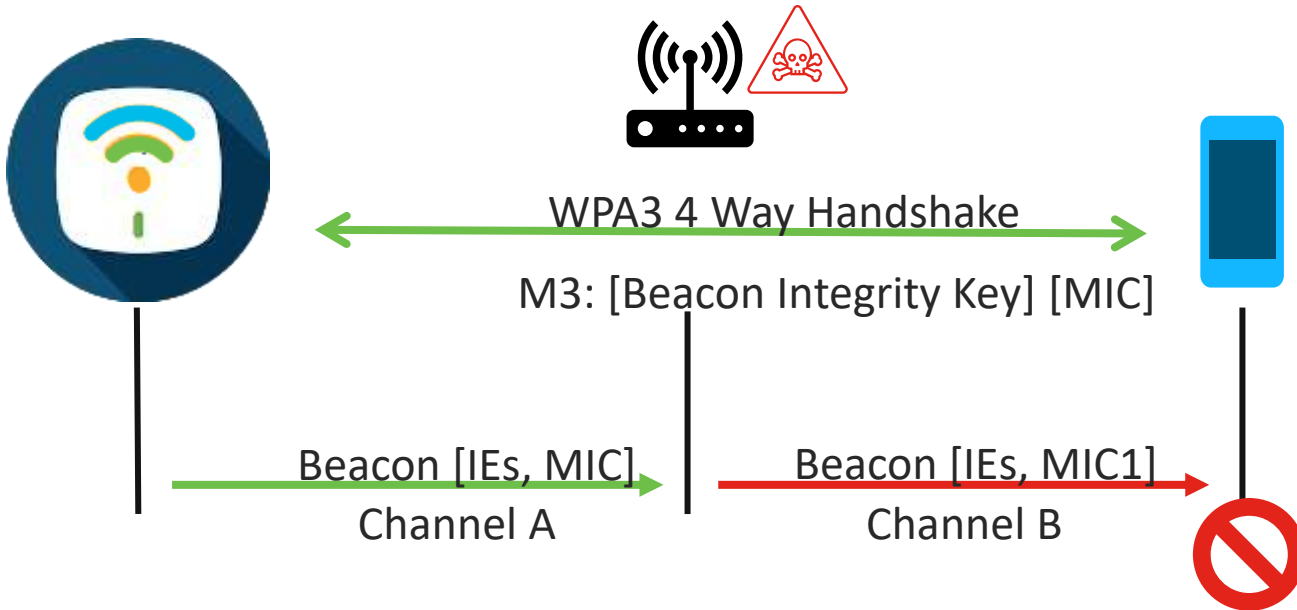
16 Spatial Streams



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

Wi-Fi 7 AP Beacon Protection

Beacons protected with an Integrity Check



Prevents beacon forging by attacker

Wi-Fi 7 Security

Wi-Fi 6	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

Wi-Fi 7 Certified Client List

The screenshot displays a search interface on the left and a grid of 12 product cards on the right. The search filters include Keyword Search, Brand, Categories (Building, Computers & Accessories, Gaming, Media & Music, Phones, Routers, Smart Home, Tablets, E-readers & Cameras, Televisions & Set Top Boxes, Other), Subcategories, and Featured Capabilities (Passthrough, Wi-Fi CERTIFIED 7™, Wi-Fi CERTIFIED HiLink™, Wi-Fi Location™, Wi-Fi GoS Management™). The product cards show details for various Wi-Fi 7 adapters and modules.

Brand	Product Name	Model Number	Total Variants	Category	Last Certified Date
Qualcomm	Qualcomm FastConnect 7800 Wi-Fi 7 High Band Simultaneous Network Adapter	NCM855A	1 / 1 result	Computers & Accessories	2024-01-11
Qualcomm	Qualcomm FastConnect 7800 Wi-Fi 7 Network Adapter	NCM825A	1 / 1 result	Computers & Accessories	2024-01-11
Qualcomm	Qualcomm FastConnect 7800 Wi-Fi 7 Network Adapter	NCM825	1 / 1 result	Computers & Accessories	2024-01-11
Qualcomm	Qualcomm FastConnect 7800 Wi-Fi 7 Network Adapter	NCM830	1 / 1 result	Computers & Accessories	2024-01-11
Intel	Intel Wi-Fi 7 80200	80200	4 / 2 results	Computers & Accessories	2024-01-09
Qualcomm	Qualcomm FastConnect 7800 Wi-Fi 7 High Band Simultaneous (HBS) Network Adapter	NCM860	2 / 1 result	Computers & Accessories	2024-01-09
Mediatek	Mediatek MT8025	Mediatek Dimensity 9300/9300+	2 / 1 result	Phones	2024-01-09
Samsung	SM-S009U	SM-S009U	1 / 1 result	Phones	2023-10-28
Samsung	TV/Monitor/Wi-Fi	MT7505 Module	2 / 1 result	Televisions & Set Top Boxes	2023-10-28

As of Mar 20, 2024

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

However, it is optional

Networking Specifications	BE200	BE202
TX/RX Streams	2x2, 320 MHz, 4K QAM	2x2, 160 MHz, 1K QAM
Bands	2.4, 5, 6 GHz	2.4, 5, 6 GHz (160MHz)

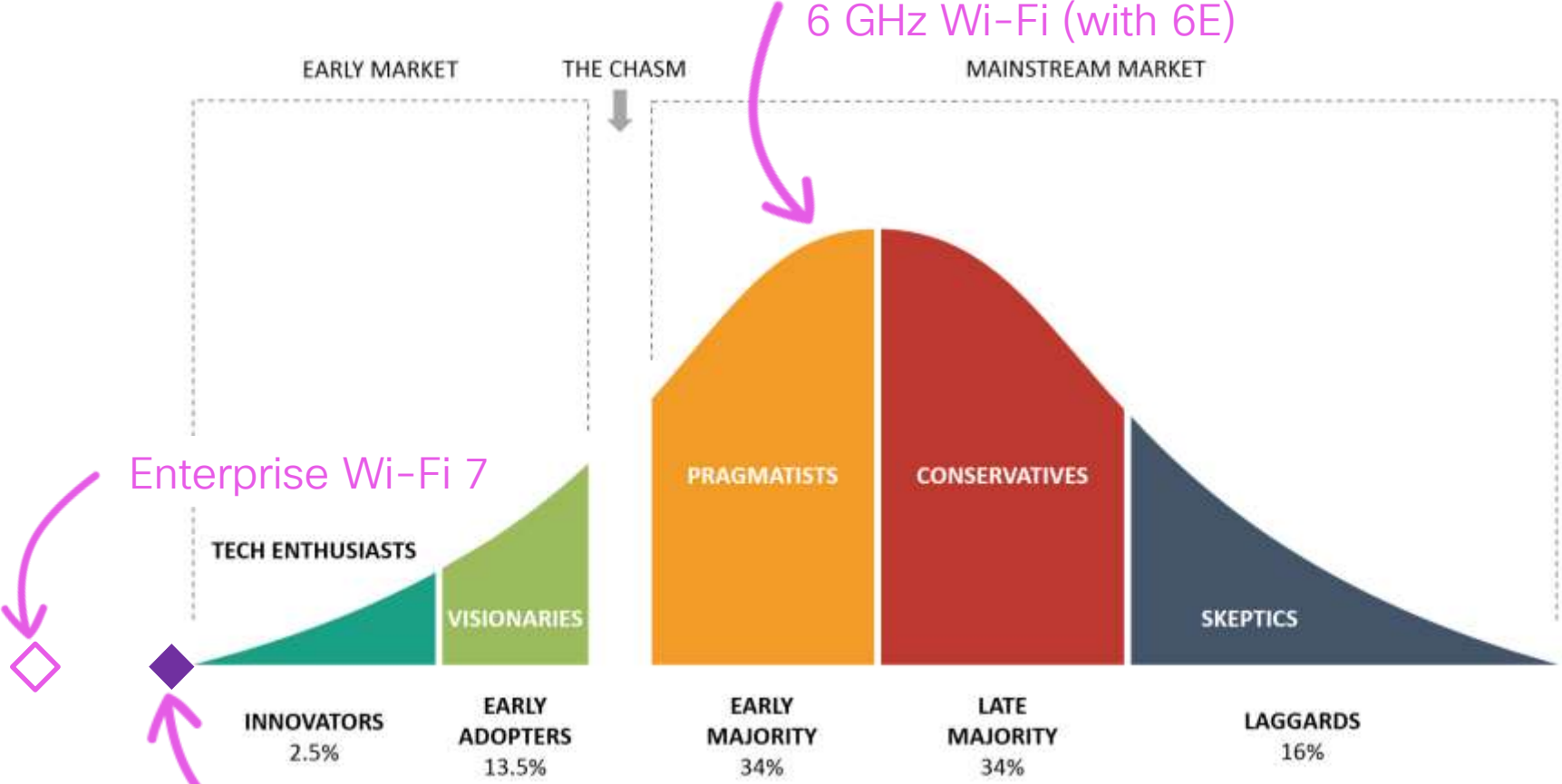
Important Notice

- This software is dedicated **only** for the Intel® Wi-Fi 7 products - Intel® Wi-Fi 7 BE202 and Intel® Wi-Fi 7 BE200. Please do not install this software on the other Intel® wireless products.
- The Wi-Fi 7 features are not currently available because of pending OS support. As a result, after installing the drivers, the Intel® Wi-Fi 7 products function with Wi-Fi 6E capabilities on Windows 11*.
- The Intel's Wi-Fi 7 product "Intel® Wi-Fi 7 BE200" will support Wi-Fi 6E + 320 MHz/4K QAM (known as EHT - Extremely High Throughput) by default when connecting to a Wi-Fi 7 wireless router/AP.

The “Wi-Fi trifecta of readiness”



Wi-Fi 7 for enterprise ...



Consumer Wi-Fi 7

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 ...





Cisco DNA Wireless

Product update

Maurijn van Tol
Solutions Engineer
April 2024

WiFi6 (E) Access points

Enhanced Catalyst Wi-Fi 6/6E Product Line

Purpose-built for Immersive Experiences


Catalyst 9136 Series

Industry-leading Wi-Fi 6E AP, with hexa-radio architecture and concurrent tri-radio with 16SS for client serving

 Powered by Cisco's AI/ML-Driven Scanning Radio


Catalyst 9130 Series

Industry-leading Wi-Fi 6 AP with 8x8, tri-radio architecture

 Powered by Cisco RF ASIC


Catalyst 9124 Series

Delivering best-in-class connectivity in outdoor and challenging environments

 Powered by Cisco RF ASIC

Catalyst 9120 Series

For mission-critical deployments using dual 5 GHz and integrated IoT radio

 Powered by Cisco RF ASIC

Catalyst 9105 Series

Perfect for teleworkers, and smaller branch sites

Catalyst 9115 Series

For small to medium-sized deployments with dual radios

Cisco Catalyst 9136 Access Point

Mission Critical Wi-Fi 6E Technology starting from IOS XE 17.7.1!

Cisco® Catalyst® 9136 Series

Concurrent Tri-radio with 16 Spatial Streams!



Analytics with Cisco DNA Center 2.3.2

Extending Cisco's Intent-Based Network

Location and IoT with DNA Spaces



Hexa-Radio Architecture

1. 2.4 GHz Serving Radio (Slot 0): 4x4:4SS
2. 5 GHz Serving Radio (Slot 1 + Slot 2): 8x8:8SS
3. Dual 5 GHz Serving Radio (Slot 1 or Slot 2*) 4x4:4SS
4. 6 GHz Serving Radio (Slot 3): 4x4:4SS
5. Dedicated AI/ML-Driven Scanning Radio
6. 2.4 GHz IoT Radio



Dual PoE for Power Redundancy

- 2 x 5 Multigigabit (mGig) PoE Ports
- 802.3 Link Aggregation > up to 10 Gbps uplink



Internet of Things Capabilities

- Built-In Environmental Sensors
- Application Hosting Technology
- USB port with 9W power output

Now ...

One Product – Two Choices



DNA
C9800 & DNAC Stack



Meraki
MR Dashboard Stack



Introducing

Cisco Catalyst 916x Wi-Fi 6E Access Points

Common Platforms will have CW PIDs



CW9162



CW9164



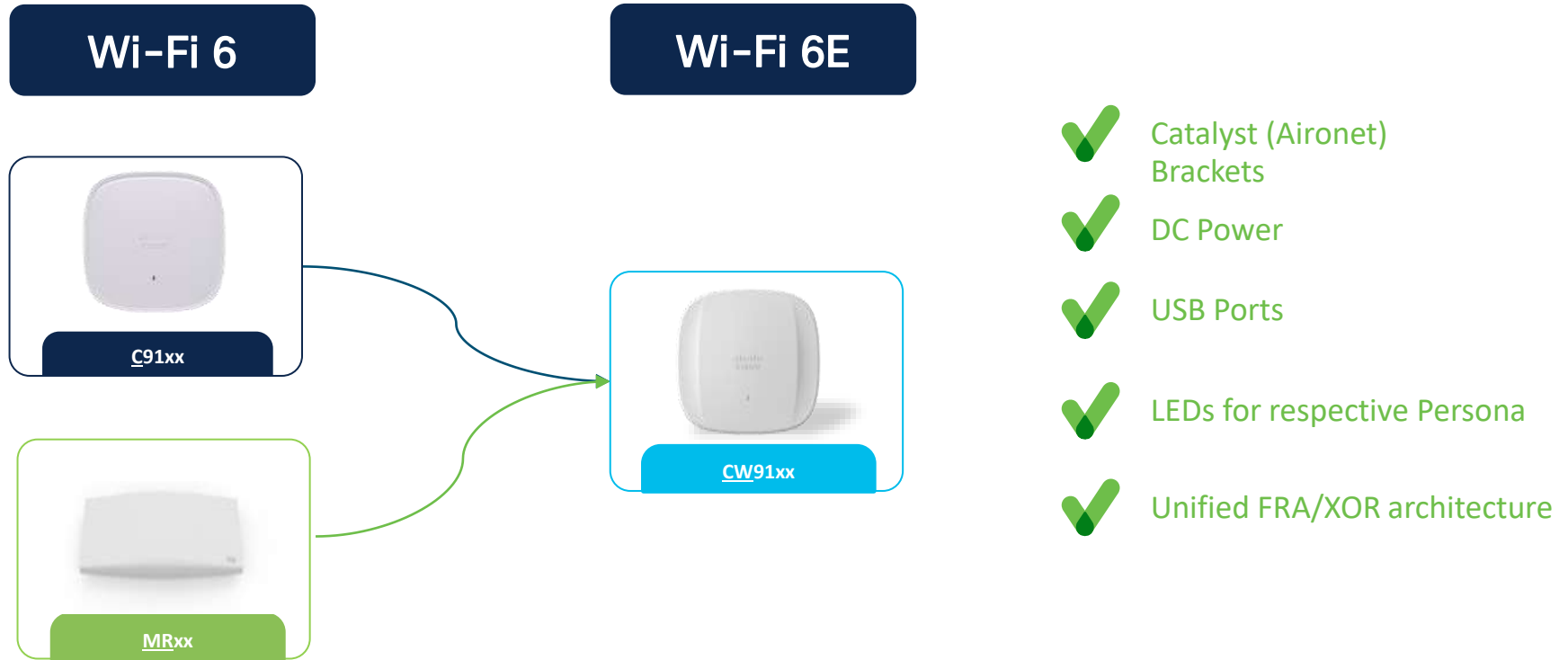
CW9166

★ Available in Fall of 2022

- All APs are indoor and internal antenna only.
- No external antenna and outdoor versions available.
- Environmental sensors will be supported only on DNA persona.

Simplicity | Ease of use | Best in class Hardware

Catalyst Access Point w/best of both world Features



Simplicity | Ease of use | Best in class Hardware

Cisco Wi-Fi 6E Portfolio

Common Platforms will have CW PIDs

MR and C series APs are not convertible

CW9162



- 2x2 + 2x2 + 2x2
- 2.5 Gbps mGig
- Power Options: PoE, DC Power
- Scanning Radio
- IoT ready + Bluetooth 5.x
- Standard Bracket

CW9164



- 2x2, 4x4, 4x4
- 2.5 Gbps mGig
- Power Options: PoE, DC Power
- Scanning Radio
- IoT Ready + Bluetooth 5.x
- Standard Bracket

CW9166



- 4x4 + 4x4, 4x4 (XOR 5/6)
- 5 Gbps mGig
- Power Options: PoE, DC Power
- IoT ready + Bluetooth 5.x
- Scanning Radio
- Environmental Sensor
- Common XOR Architecture
- Standard Bracket

MR57



- 4x4 + 4x4, 4x4 (XOR 5/6)
- Dual 5 Gbps mGig with failover
- Power Options: PoE, DC Power
- IoT ready + Bluetooth 5.x
- Scanning Radio
- XOR Architecture (High/Low band)
- Standard Bracket

C9136



- 4x4 + 8x8 + 4x4 or 4x4+4x4+4x4+4x4
- Dual 5 Gbps mGig with failover
- Power Options: PoE, DC Power
- IoT ready + Bluetooth 5.x
- Scanning Radio
- Environmental Sensor
- XOR Architecture (macro/meso)
- Standard Bracket

Product Specifications

Cisco Catalyst Wireless 6E Access Points

Ideal for Small to Medium-sized deployments

Best In Class, Flexibility

Mission Critical, Performance



CW9162

- 2x2 + 2x2 + 2x2
- 2.5 Gbps mGig
- Power Options: PoE, DC Power
- IoT ready + Bluetooth 5.x
- iCAP for Management Frames
- USB – 4.5 W

★ Available with IOS-XE 17.9.2



CW9164

- 2x2, 4x4, 4x4
- 2.5 Gbps mGig
- Power Options: PoE, DC Power
- IoT Ready + Bluetooth 5.x
- iCAP for Management Frames
- USB- 4.5 W



CW9166

- 4x4 + 4x4 + 4x4 (XOR 5/6)
- 5 Gbps mGig
- Power Options: PoE, DC Power
- IoT ready + Bluetooth 5.x
- Environmental Sensor
- Full Packet Capture (iCAP)
- Zero-Wait DFS*
- USB – 4.5W



C9136

- 4x4, 8x8, 4x4 (or) 4x4, 4x4+4x4, 4x4
- Dual 5 Gbps mGig, active fail over
- PoE Redundancy
- IoT ready
- Bluetooth 5.x
- Environmental Sensor
- Full Packet Capture (iCAP)
- Zero-Wait DFS*
- USB – 9W

*Available in Future

Full radio capability (6 GHz @ LPI) on single 30W PoE+

Dedicated Radio for CleanAir Pro

Same Bracket, Industrial Design

AP Power Optimization

USB



Cisco Catalyst CW9166 Access Point

Best-in-class Wi-Fi 6E Technology starting from IOS XE 17.9.1!

Cisco® Catalyst® CW9166

Common Hardware, Tri-Radio with 12 Spatial Streams!



Penta-Radio Architecture

1. 2.4 GHz Serving Radio (Slot 0): 4x4:4SS
2. 5 GHz Serving Radio (Slot 1): 4x4:4SS
3. 6 GHz Serving Radio (Slot 2): 4x4:4SS (XOR)
5GHz Serving Radio (Slot 2): 4x4:4SS
4. Dedicated AI/ML-Driven Scanning Radio
5. 2.4 GHz IoT Radio



5 Multigigabit (mGig) PoE Ports

- Optional DC Power



Internet of Things Capabilities

- Built-In Environmental Sensors
- Application Hosting Technology
- USB port with 4.5 W power output

Analytics with Cisco DNA Center 2.3.4

Extending Cisco's Intent-Based Network

Location and IoT with DNA Spaces



Cisco Catalyst CW9164 Access Point

Best-in-class Wi-Fi 6E Technology starting from IOS XE 17.9.1!

Cisco® Catalyst® CW9164

Common Hardware, Tri-Radio with 10 Spatial Streams!



Penta-Radio Architecture

1. 2.4 GHz Serving Radio (Slot 0): 2x2:2SS
2. 5 GHz Serving Radio (Slot 1): 4x4:4SS
3. 6 GHz Serving Radio (Slot 2): 4x4:4SS
4. Dedicated AI/ML-Driven Scanning Radio
5. 2.4 GHz IoT Radio



2.5 Multigigabit (mGig) PoE Ports

- Optional DC Power



Internet of Things Capabilities

- Application Hosting Technology
- USB port with 4.5W power output

Analytics with Cisco DNA Center 2.3.4

Extending Cisco's Intent-Based Network

Location and IoT with DNA Spaces



Cisco Catalyst CW9162 Access Point

Best-in-class Wi-Fi 6E Technology starting from IOS XE 17.9.2!

Cisco® Catalyst® CW9162

Converged Hardware, Tri-Radio with 6 Spatial Streams!



Penta-Radio Architecture

1. 2.4 GHz Serving Radio (Slot 0): 2x2:2SS
2. 5 GHz Serving Radio (Slot 1): 2x2:2SS
3. 6 GHz Serving Radio (Slot 2): 2x2:2SS
4. Dedicated AI/ML-Driven Scanning Radio
5. 2.4 GHz IoT Radio



2.5 Multigigabit (mGig) PoE Ports

- Optional DC Power



Internet of Things Capabilities

- Application Hosting Technology
- USB port with 4.5 W power output

Analytics with Cisco DNA Center 2.3.4

Extending Cisco's Intent-Based Network

Location and IoT with DNA Spaces

AIR-AP-BRACKET-1 Photos



Front-side

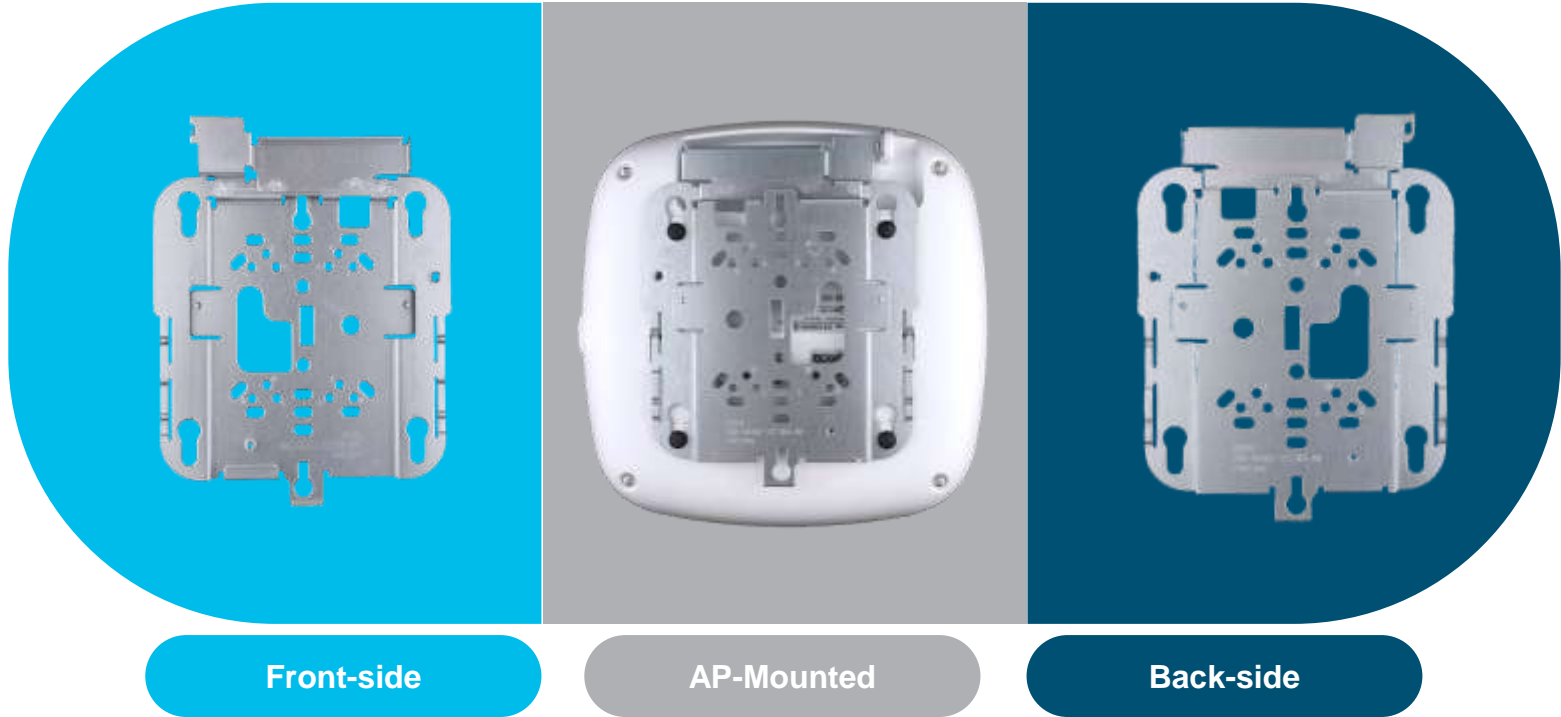


AP-Mounted



Back-side

AIR-AP-BRACKET-2 Photos



Cisco Catalyst 9166D Access Point

Expanding Wi-Fi 6E to advanced RF environments



Expected Q3 2023

Cisco® Catalyst® 9166D

Directional, Tri-Radio with 12 Spatial Streams!



Penta-Radio Architecture

1. 2.4 GHz : 4x4:4SS
2. 5 GHz : 4x4:4SS
3. 6 GHz : 4x4:4SS (XOR to 5GHz)
4. Dedicated tri-band auxiliary radio
5. 2.4 GHz IoT Radio



Directional antenna architecture

- 2.4+5 GHz: 6 dBi gain (70x70 deg), 6 GHz: 8 dBi (60x60)*
- Same X,Y as CW9166I – and only 0.1cm taller!
- Wide support for pan/tilt combinations
- Accelerometer to determine AP tilt†



Internet of Things Capabilities

- Built-In Environmental Sensors
- USB port with 4.5 W power output

*2/5/6 mode
† SW support post-FCS

Transition ext. antenna deployments to 6E

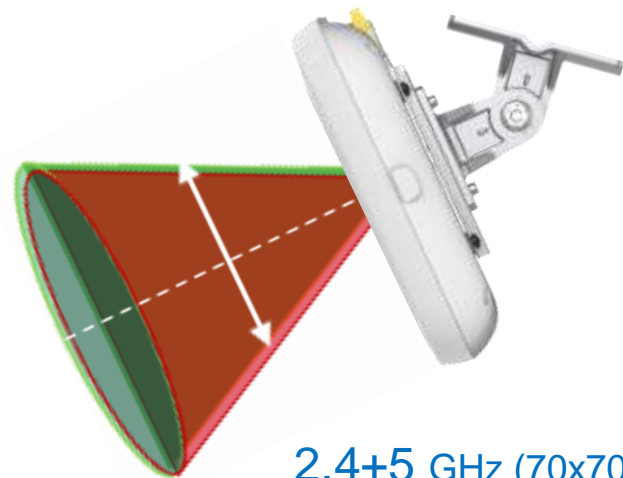
Simple and clean installation – no antenna cables

C9800/DNA or Meraki Cloud

Antenna differences between CW9166i and CW9166D1



CW9166i designed with an integrated omni-directional antenna ceiling mount for a “360 degree” coverage pattern – ideal for offices, conventional buildings



2.4+5 GHz (70x70)
6 GHz (60x60)

CW9166D1 designed with an integrated directional antenna allowing the coverage pattern to favor the area the AP is facing - ideal for warehouse, auditoriums etc.

CW9166D1 Mounting brackets



AIR-AP-Bracket-2

The default bracket shipped with the 9166D designed to adapt to electrical boxes ideal for ceiling or wall mounting. Adapts to Articulating Arm.



Articulating Arm

Optional bracket kit that attaches to AIR-AP-Bracket-2 allowing the AP to be articulated to cover many different mounting positions (left, right, up, down) etc. Recommended for the most flexibility in aiming the radio signal.

Articulating Mount Bracket Dimensions (Wall / Pole Install)



Horz 60deg / Vert 0 Pivot



Horz 60deg / Vert -60 Pivot



Horz 0 / Vert -90 Pivot



Horz 0 / Vert +60 Pivot



PoE Configuration Scenarios

AP Power Optimizations Feature Suite

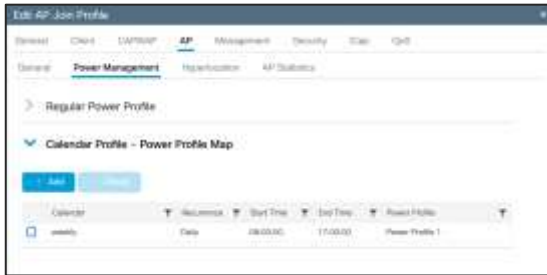
Save Power, Reallocate Power, and Visibility into Savings

AP Power Save Mode

Lower AP Power Usage



- Create a calendar profile for off-peak hours.
- Create a power profile to lower the power consumption budget during off-peak hours.
- Power Profile: Shut AP Radio or lower spatial Stream, lower port speed, disable USB port.



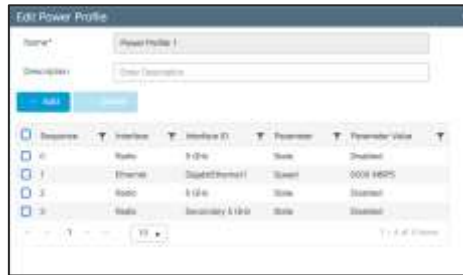
IOS-XE 17.8

AP Power Distribution

Control over how power is used



- Reallocate extra AP Power to different radios while operating on PoE+ (30W).
- Customization of your PoE power budget.
- Example: Disable 2.4 GHz radio -> use extra power for 6 GHz radio.



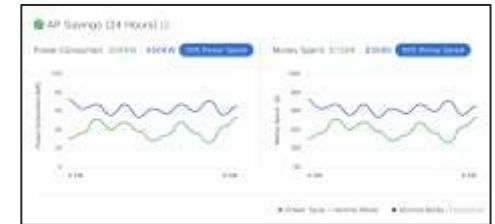
IOS-XE 17.10

AP Power Savings Insight

Power, Money, and Emissions Savings on Cisco DNA Center



- Cisco DNA Center PoE dashboard integration.
- Power Savings, Money Savings, Emissions Reductions.
- Visibility into trends and insights.
- Both site level and AP level view.



Note: Cisco DNA Center integration is on the roadmap

Supported on 9115, 9120, 9130, 9136, 9166, 9164, 9162

Catalyst 9136I Power over Ethernet

Default Configuration (Fixed Power profile)

Power source	Number of spatial streams	2.4-GHz radio (slot 0)	Primary 5-GHz radio (slot 1)	Secondary 5-GHz radio (slot 2)	6-GHz radio (slot 3)	mGig PHY 0 link speed	mGig PHY 1 link speed	USB	AI/ML-driven scanning radio	Env. sensors	Max power draw
802.3af (PoE)	0	Disabled	Disabled		Disabled	1G	Disabled	Disabled	Y	Y	14W
802.3at (PoE+)	8	2x2	4x4	Disabled	2x2	2.5G	2.5G (Standby)	Disabled	Y	Y	24.4W
802.3bt (UPOE)	16	4x4	8x8 or dual 4x4		4x4	5G	5G	Yes/9W	Y	Y	47.3W

Note:

- Slot 2 can operate only together with slot 1 in 8x8 mode. Independent slot 2 operation is not supported until a future software release.
- AIR-PWRINJ7 is the 9136I's official 802.3bt power injector.

CW Series Power over Ethernet Default Configurations

CW9166i (mGig 5G)

All features on 30W .3at
(USB power requires .3bt)

Power Source	Number of SS	2.4 GHz Radio	5 GHz Radio	5 GHz /6 GHz Radio (LPI)	mGig Link Speed	USB	AI/ML Driven Scanning Radio
802.3af	NA	Disabled	Disabled	Disabled	1G	Disabled	Y
802.3at	12	4x4	4x4	4x4	5G	Disabled	Y
802.3bt	12	4x4	4x4	4x4	5G	Y/4.5 W	Y
DC Power	12	4x4	4x4	4x4	5G	Y/4.5 W	Y

CW9164i (mGig 2.5)

All features on 30W .3at
(USB power requires .3bt)

Power Source	Number of SS	2.4 GHz Radio	5 GHz Radio	6 GHz Radio	mGig Link Speed	USB	AI/ML Driven Scanning Radio
802.3af	NA	Disabled	Disabled	Disabled	1G	Disabled	Y
802.3at	10	2x2	4x4	4x4	2.5G	Disabled	Y
802.3bt	10	2x2	4x4	4x4	2.5G	Y/4.5 W	Y
DC Power	10	2x2	4x4	4x4	2.5G	Y/4.5 W	Y

Note:

If Power Injector is required, **AIR-PWRINJ7** is CW9166's official 802.3bt Power Injector

Catalyst 9162I Power over Ethernet

Default Configurations

Power Source	Number of SS	2.4 GHz Radio	5 GHz Radio	6 GHz Radio	mGig Link Speed	USB	AI/ML Driven Scanning Radio
802.3af	2	Disabled	1x1	1x1	1G	Disabled	Y
802.3at	6	2x2	2x2	2x2	2.5G	Y/4.5 W	Y
802.3bt	6	2x2	2x2	2x2	2.5G	Y/4.5 W	Y
DC Power	6	2x2	2x2	2x2	2.5G	Y/4.5 W	Y

Note:

1. AIR-PWRINJ7 is Catalyst 9164I's official 802.3bt Power Injector
2. Actual Power Draw data will be available later (as final testing is in progress)

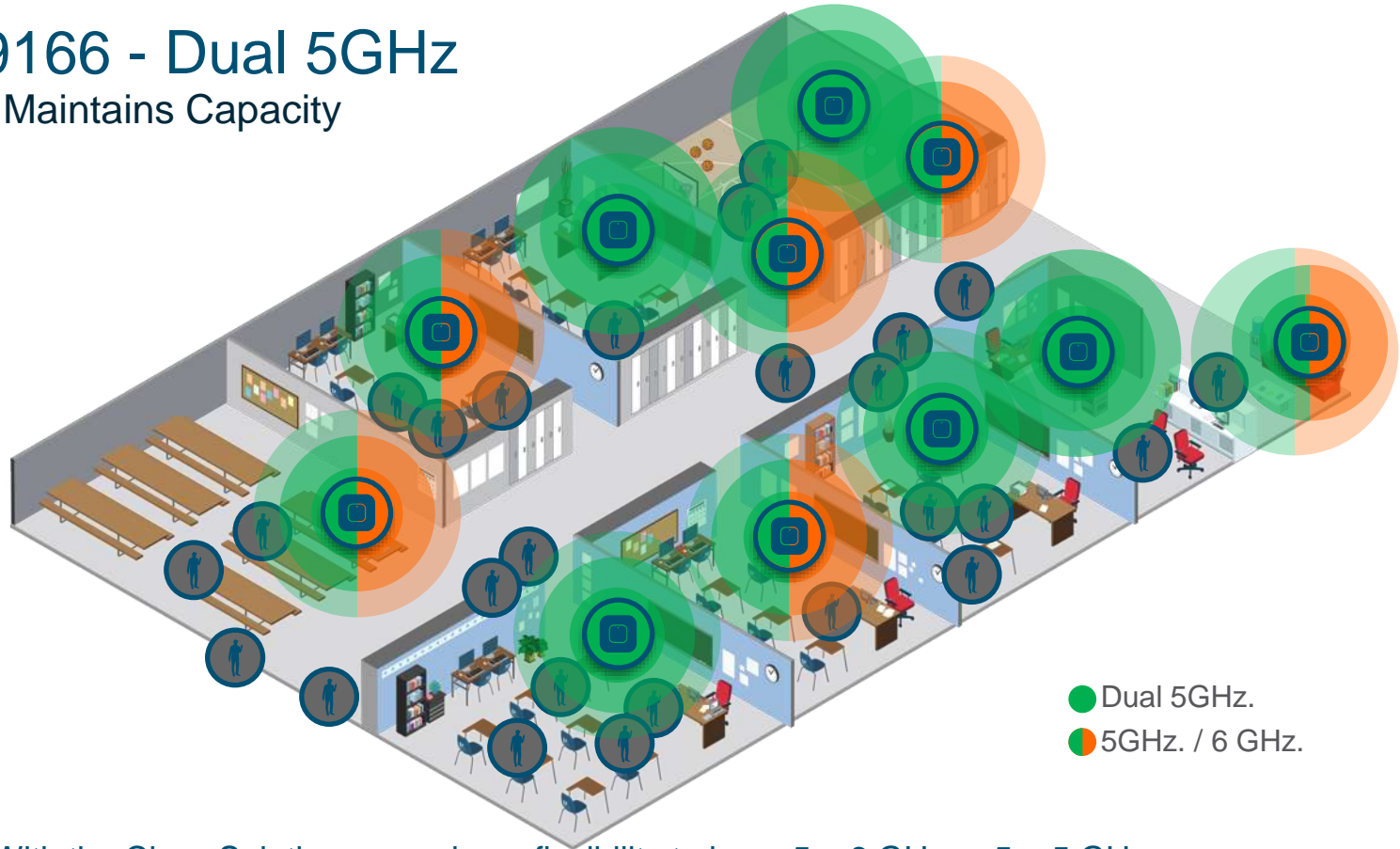
Dual 5 GHz on CW9166

Catalyst 9166 - Dual 5GHz

Flexibility and Maintains Capacity



Flexible Radio
Assignment based on
Availability and
Capability

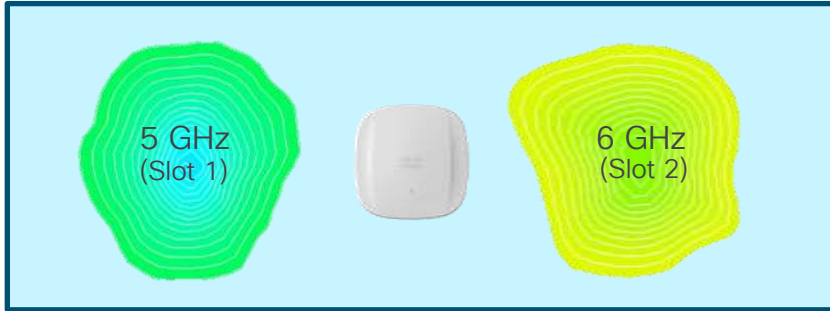


- Dual 5GHz.
- 5GHz. / 6 GHz.

With the Cisco Solution, users have flexibility to have 5 + 6 GHz or 5 + 5 GHz

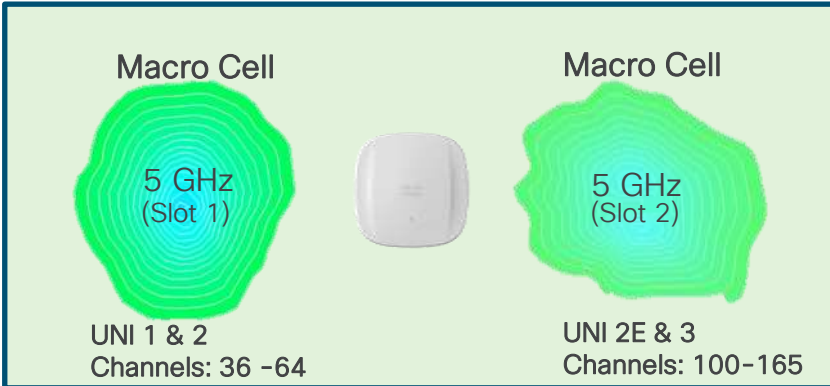
Cisco Catalyst 9166 – Dual 5 GHz

Macro-Macro Omnidirectional cells in Dual 5GHz.



- Enabled by default in countries that supports 6 GHz

XOR



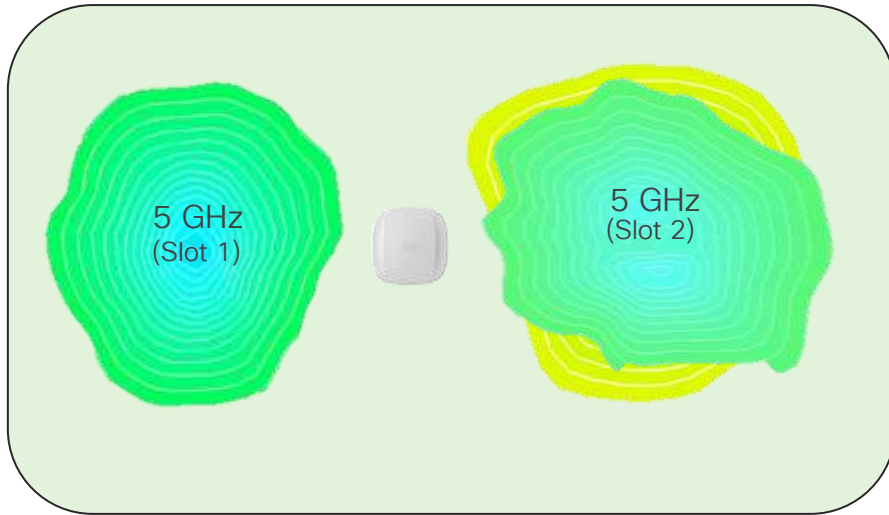
Take-away

- Dual 5 GHz provides flexibility where no/minimal use of 6GHz
- Investment Protection

- Dual 5 GHz enabled by default for countries that does not support 6 GHz.
- Role selection is manual or Automatic – FRA/RRM

Cisco Catalyst 9166 – Dual 5 GHz













FRA Offers the flexibility



- Parameters used:
 - Rx, Tx Utilization
 - Client Density
- FRA Algorithm runs every 1 hour (by default)
- WLC maintains the historical data for 7 days
- Decision to switchover based on a threshold with the historical data over a period of 17 cycles.

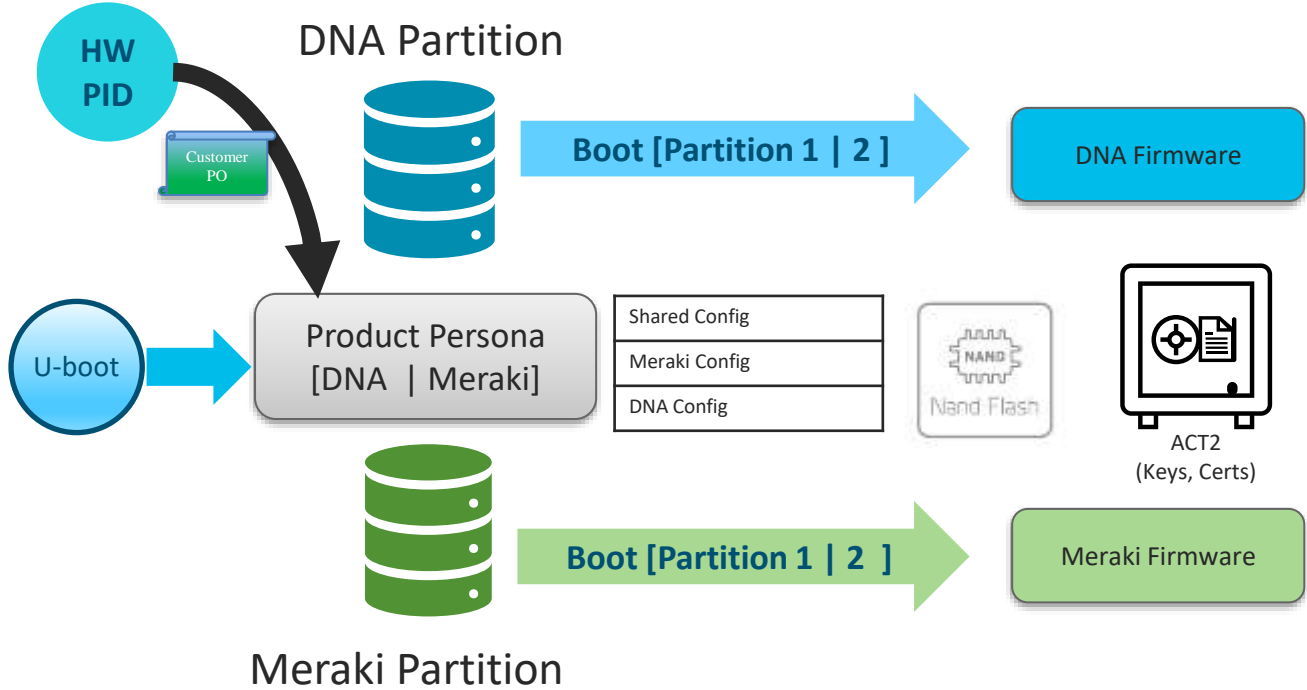
Catalyst 9166/9164/9162 Flexible Radio Roles

Flexible Radio Assignment

Slot 0	Slot 1	Slot 2	C9166	C9164	C9162	
2.4 GHz 	5 GHz 	6 GHz 	✓	✓	✓	<ul style="list-style-type: none"> Pervasive 2.4/5/6 GHz Coverage Default Role in countries with 6 GHz Support
2.4 GHz 	5 GHz 	5 GHz 	✓	✗	✗	<ul style="list-style-type: none"> Increase Network Capacity and Performance with 5 GHz Radio where 6 GHz for WiFi is not available (or) dense 5 GHz clients.
Monitor 	5 GHz 	6 GHz 	✓	✓	✓	<ul style="list-style-type: none"> Reduce Interference in 2.4 GHz. Proactively Monitor and Secure Network.
Monitor 	5 GHz 	5 GHz 	✓	✗	✗	<ul style="list-style-type: none"> Reduce Interference in 2.4 GHz. Proactively Monitor and Secure Network. Increase Network Capacity with 5 GHz Radio

Management Change

Cisco Catalyst CW916x Boot Procedure



Common PIDs but the same way of ordering



Order CW916xl-A,B,E,..ROW,
and it will ship with DNA
Persona

Always check the WLAN compliance tool for which regulatory domain to buy; remember we have –ROW now



Order CW916xl-**MR**, and it
will ship with Meraki
Persona

No "MRxx" PIDs for converged products. Going forward –MR will indicate ordered with Meraki persona

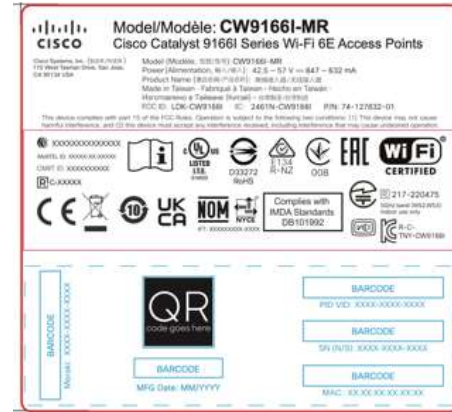
Conversion overview



Done from C9800 WLC



Call Meraki Support
(Needs license)



Regulatory domain flow during conversion

Scenario A

-B AP (us)



FCC AP (us)



“Hey Dashboard, I’m a US AP”

Scenario B

-MR AP (DK)



-MR AP (DK)



“Hey WLC, the AP is allowed to operate in Denmark (DK)”

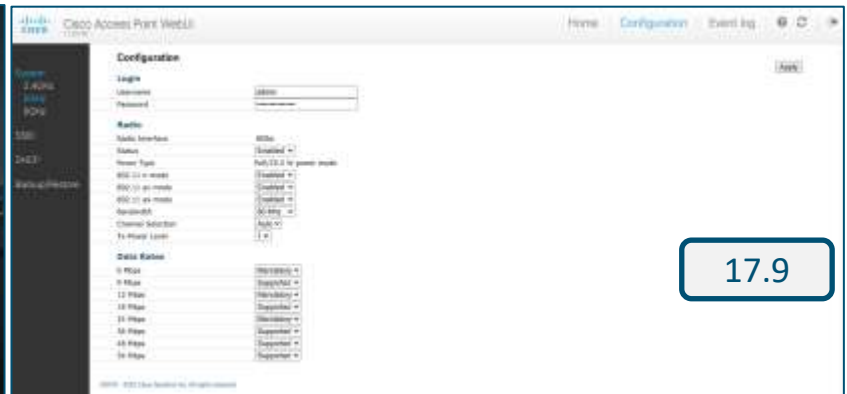
WLC internally treats AP as -E since it was last operating in DK, which is a -E country

Site survey mode

(No more EWC)

Site survey mode configuration steps

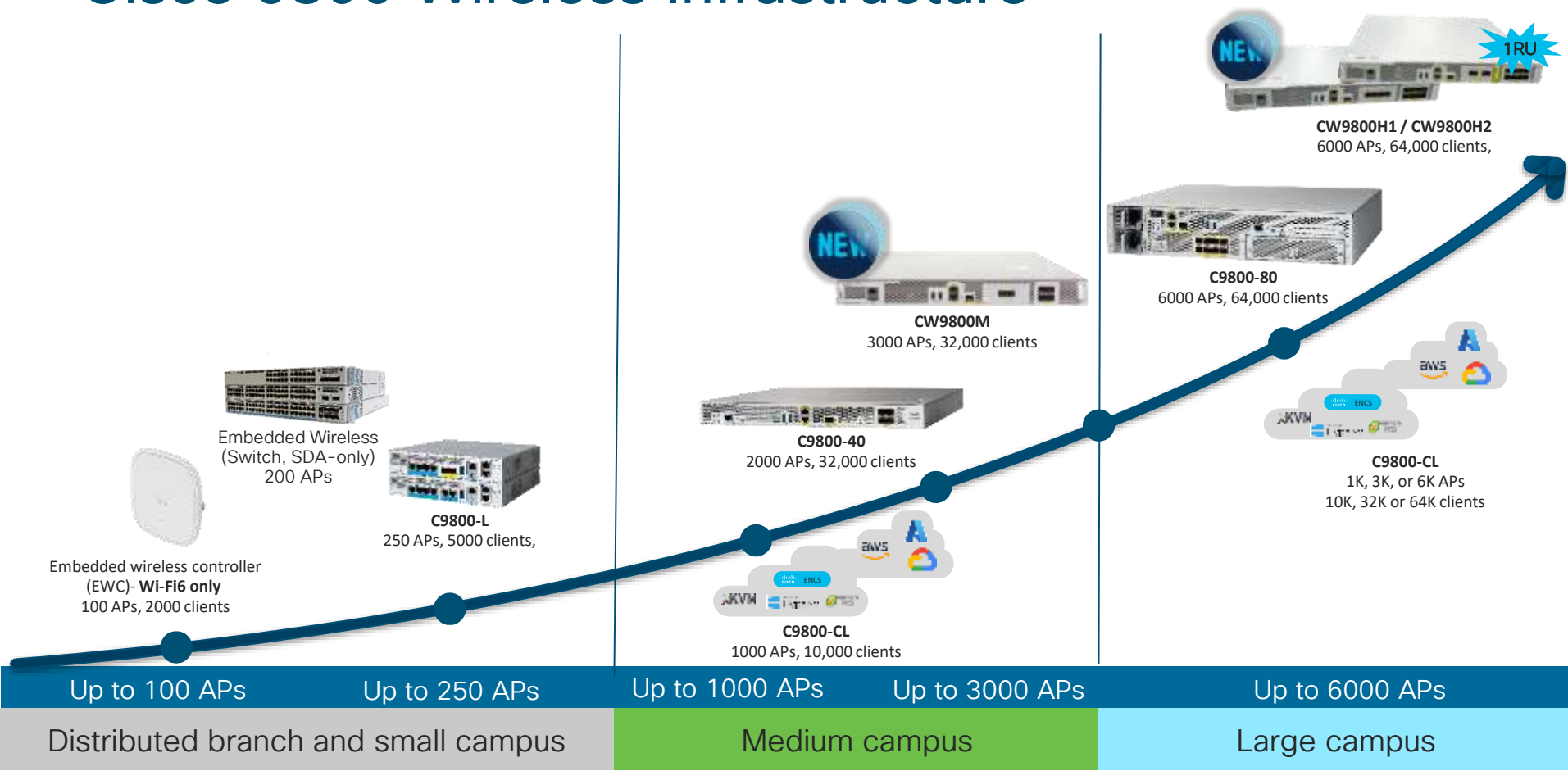
1. Change AP to site survey mode > Enter command “ap site-survey”
C9166#ap ?
capwap Switch to CAPWAP AP type
site-survey Switch to Site Survey AP type
2. After bootup, the AP is automatically assigned a static IP of 10.0.23.1.
3. AP will start broadcasting the C9166_site_survey with open authentication security.
4. Connect your wireless client with the site survey SSID and it'll receive an IP from 10.0.23.0/24.
5. Access the Catalyst® 9166I's Site Survey WebUI via 10.0.23.1.



New Platform

CW9800 Next-Gen WLC

Cisco 9800 Wireless Infrastructure



CW9800 Wireless Controller Family

CW9800M



CW9800H1

CW9800H2

Orderable April 23

Shipping Mid-May

Cisco Catalyst CW9800M Wireless Controller



1/10/25G Uplinks

32,000 Clients

3,000 APs

50Gbps

Up to 53% faster than C9800-40, while using up to 18% less power!

Simple

- Familiar WebUI and config structure reduces upgrade friction
- 10G HA port allows for easier deployments in modern data centers

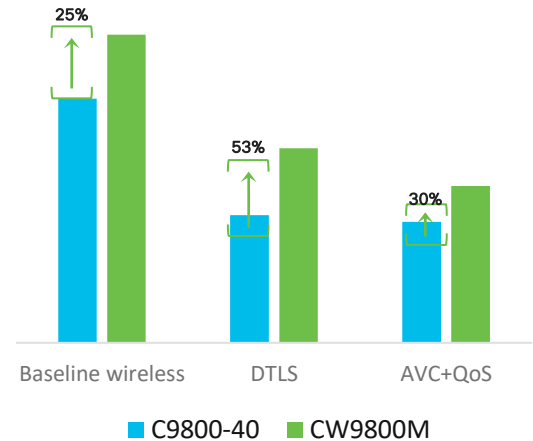
Secure

- Designed for WPA3 and beyond
- Line rate encryption with HW offload eliminates performance degradation from enabling advanced encryption

Sustainable

- Up to 18% more power efficient than C9800-40
- 55% higher average performance per Watt when compared to C9800-40
- Increased AP scale by 1.5x allows for future growth

Throughput



Performance tests consist of bi-directional (simultaneous 50% up/down) "IMIX" real-world traffic

Cisco Catalyst CW9800H1 & CW9800H2 Wireless Controllers



1/10 & [25G or 40G] Uplinks

64,000 Clients

6,000 APs

100Gbps

1RU

The only difference between H1/H2:
CW9800H1 = 4x 25G
CW9800H2 = 2x 40G

Up to 36% faster than C9800-80, while using up to 40% less power!

Simple

- Familiar WebUI and config structure reduces upgrade friction
- 10G HA port allows for easier deployments in modern data centers

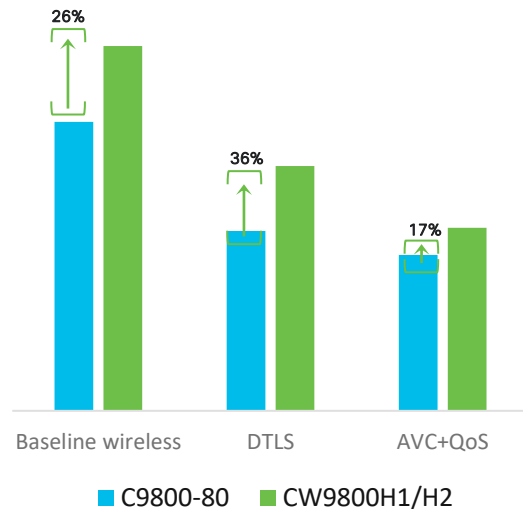
Secure

- Designed for WPA3 and beyond
- Line rate encryption with HW offload eliminates performance degradation from enabling advanced encryption

Sustainable

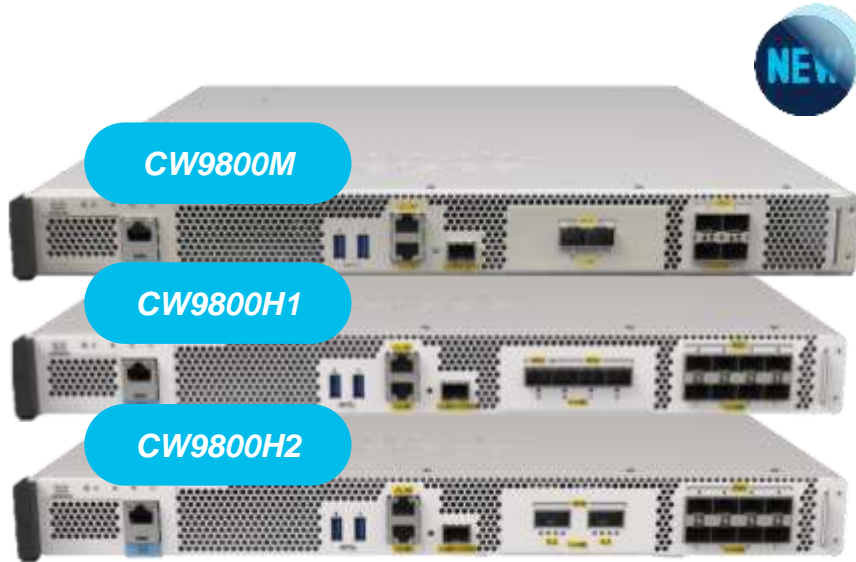
- Up to 40% more power efficient, with an average of 90% more performance per Watt than C9800-80
- \$1310 in power savings over 5 years @ \$0.169/kWh
- New 1RU design saves space, allowing for more efficient data centers

Throughput



Performance tests consist of bi-directional (simultaneous 50% up/down) "IMIX" real-world traffic

Cisco Catalyst CW9800 Product Family Overview



	CW9800M	CW9800H1	CW9800H2
Max APs	3,000	6,000	6,000
Max Clients	32,000	64,000	64,000
Max Throughput	50Gbps	100Gbps	100Gbps
Chassis height	1RU	1RU	1RU
Connectivity	4x 1G/10G 2x 25G	8x 1G/10G 4x 25G	8x 1G/10G 2x 40G
Console port	RJ45 / USB	RJ45 / USB	RJ45 / USB
HA ports	1x 1G RJ45 1x 10G SFP+	1x 1G RJ45 1x 10G SFP+	1x 1G RJ45 1x 10G SFP+
Power Supply	750W x1 (up to 2)	750W x2	750W x2
Noise	73.5dBA	73.0dBA	73.0dBA
Operating temp.	5-40C Short term: 5-55C	5-40C Short term: 5-55C	5-40C Short term: 5-55C

Cheat sheet

Features	C9800-40	CW9800M	C9800-80	CW9800H
Scale	2K/32K	3K/32K	6K/64K	6K/64K
Uplinks	1/10G	1/10/25G	1/10G	1/10/25/40G
CP – Cores*	8-Cores	12-Cores	12-Cores	20-Cores
DP	ASIC	ASIC^	ASIC	ASIC^
HA Ports**	Single(1G)	Dual(1G & 10G)	Single(1G)	Dual(1G & 10G)
QSFP support	No	Yes	Yes (Around 10)	Yes (More than 40)
App Hosting	Yes	Yes	Yes	Yes
Cisco DNAC Support	Yes	Yes	Yes	Yes
PI Support	Yes	No	Yes	No
Fabric Wireless	Yes	Yes	Yes	Yes
Dashboard Monitoring	Yes	Yes(17.15.1)	Yes	Yes(17.15.1)

* Higher CPU & Memory for future proofing

** 10G RP Port & RP Port Bonding

SFP/SFP+ Supported on CW9800

Wide range of SFP+/QSFP addition

50% more SFPs included

~50+ SFP/SFP+/QSFP are supported



SFP / SFP+ / QSFP Module Support

1G	10G		25G	40G	
GLC-LH-SMD (RP)	SFP-10G-SR	SFP-H10GB-CU1M	SFP-10/25G-CSR-S	QSFP-40G-SR4	QSFP-H40G-AOC5M
GLC-SX-MMD (RP)	SFP-10G-SR-S	SFP-H10GB-CU1-5M	SFP-10/25G-LR-S	QSFP-40G-CSR4	QSFP-H40G-CU2M
GLC-TE	SFP-10G-LR	SFP-H10GB-CU2M	SFP-25G-SR-S	QSFP-40G-SR4-S	QSFP-H40G-CU3M
GLC-ZX-SMD	SFP-10G-LR-X	SFP-H10GB-CU2-5M	SFP-25G-AOC2M	QSFP-40G-SR-BD	QSFP-H40G-CU1M
GLC-BX-U	SFP-10G-ER	SFP-H10GB-CU3M	SFP-25G-AOC10M	QSFP-40G-LR4-S	QSFP-H40G-ACU7M
GLC-BX-D	SFP-H10GB-ACU10M	SFP-H10GB-ACU7M	SFP-25G-AOC5M	QSFP-40G-LR4	QSFP-H40G-AOC1M
GLC-EX-SMD	SFP-H10GB-CU5M	SFP-10G-AOC1M	SFP-H25G-CU1M	QSFP-40G-ER4	QSFP-H40G-AOC3M
	SFP-10G-AOC10M	SFP-10G-AOC2M	SFP-H25G-CU5M	QSFP-H40G-CU5M	QSFP-H40G-AOC7M
	SFP-10G-T-X	SFP-10G-AOC3M	SFP-25G-AOC3M	QSFP-H40G-AOC10M	QSFP-H40G-AOC15M
	Finisar-LR	SFP-10G-AOC5M	SFP-25G-AOC7M	QSFP-H40G-AOC30M	QSFP-H40G-AOC20M
	Finisar-SR	SFP-10G-AOC7M	SFP-25G-AOC1M	QSFP-H40G-CU4M	QSFP-H40G-AOC25M
				QSFP-H40G-ACU10M	QSFP-H40G-CU0-5M
				QSFP-H40G-AOC2M	

Cisco Live! Keynote design

Maurijn van Tol
Cisco

CISCO *Live!*



Cisco 9104



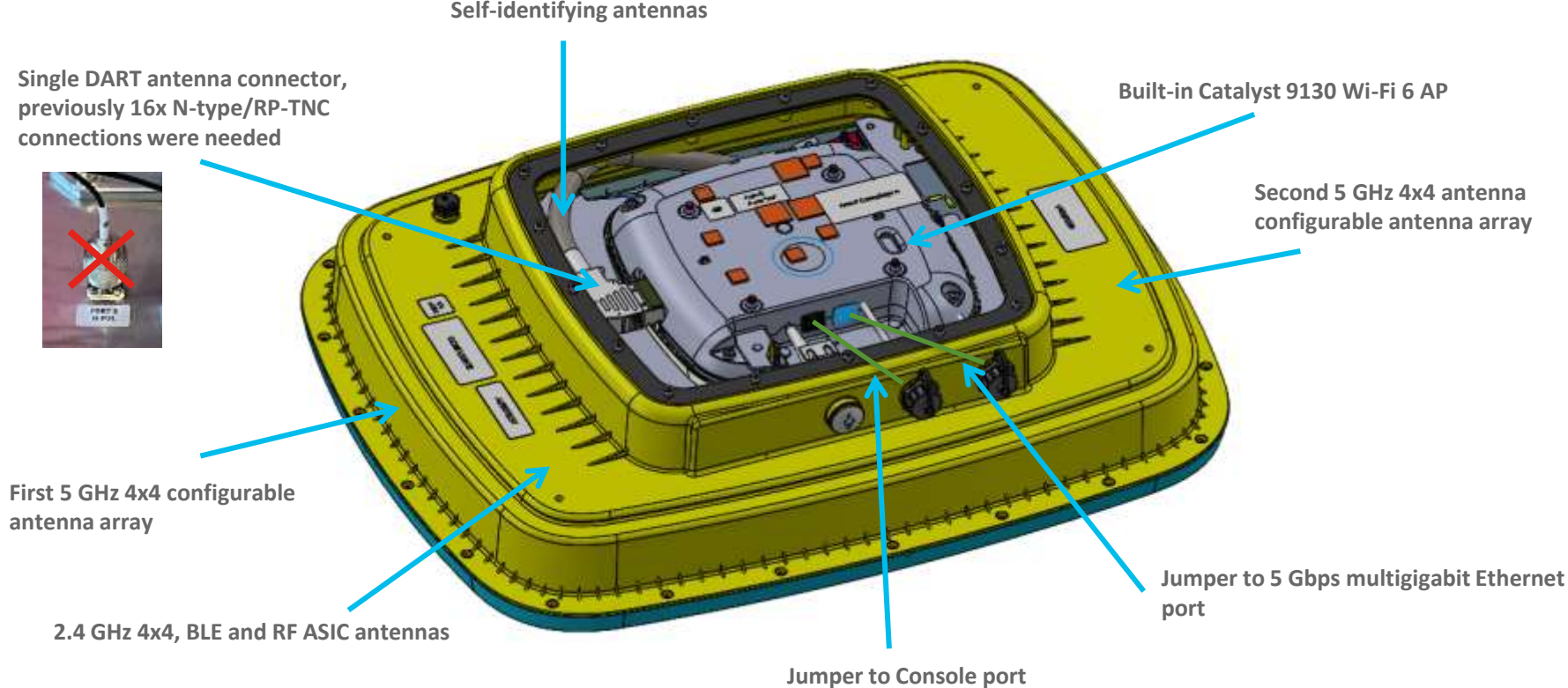
Get the
resiliency.



C-ANT9104
next to
AIR-ANT2513P4M-N



Catalyst 9104 all-in-one unit changes the game



Beam switching and Beam steering

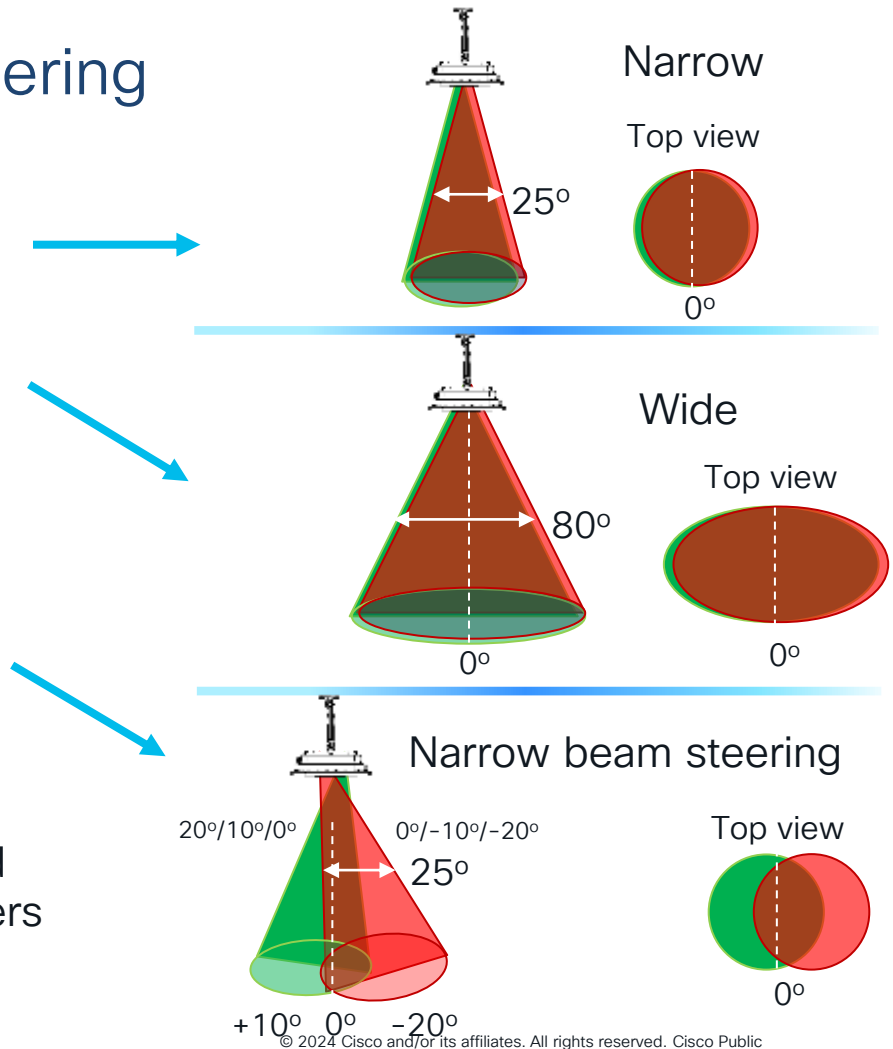
Beam switching

- Narrow 25° beams - dual 4x4 5 GHz, gain 10 dBi
- Wide 80° x 25° beams - dual 4x4 5 GHz, gain 8 dBi
- Fixed 2.4 GHz 75° x 85°

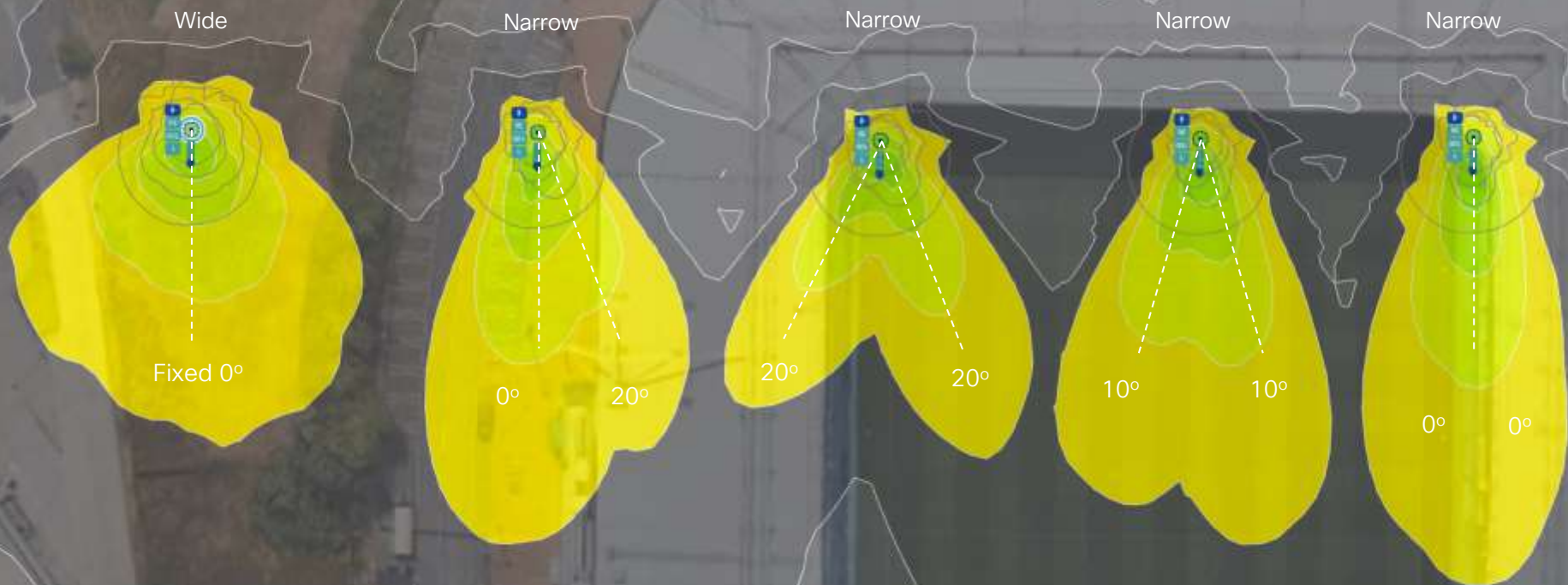
Beam steering

- Electronically steerable beams - each Narrow beam can independently steer by 10° or 20° off center, gain 10 dBi

All beam configurations done in software and centrally managed by Catalyst 9800 controllers



One product, many software beam configurations!



Planning & Design

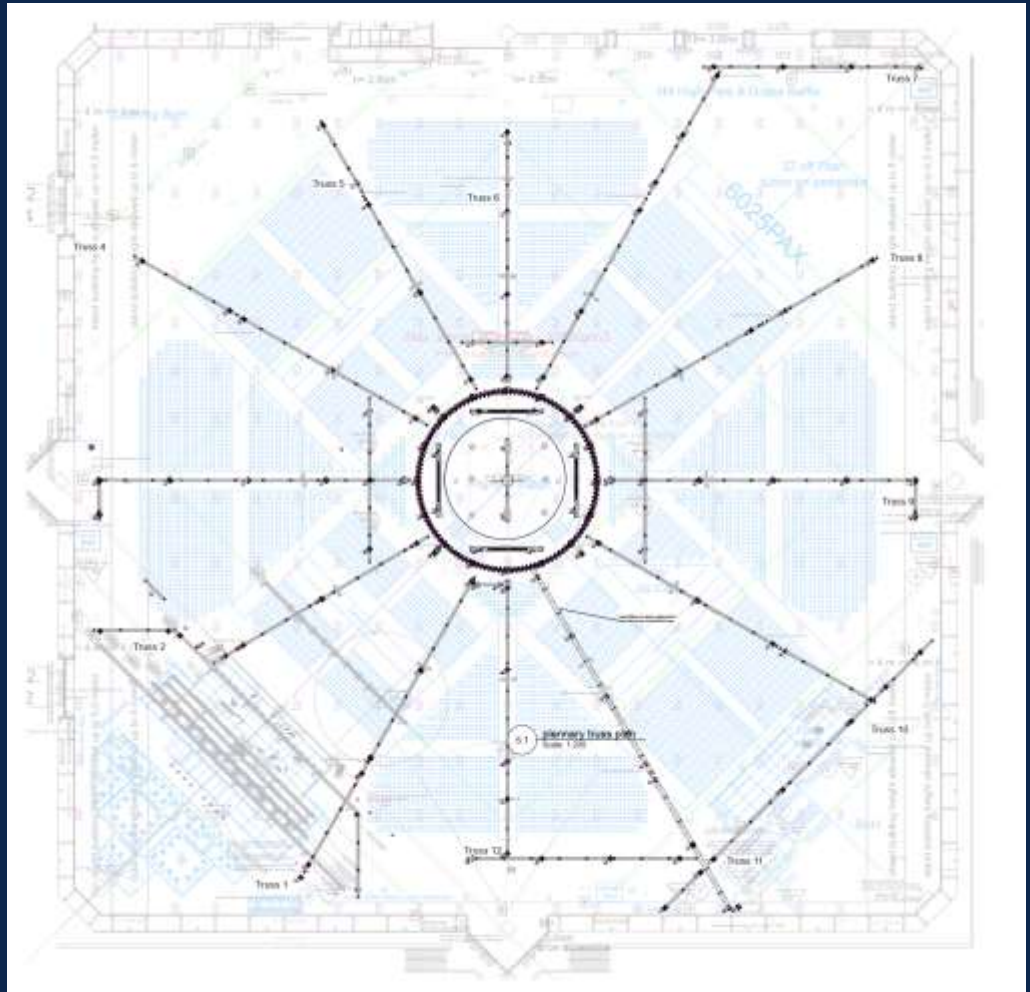


Keynote: Planning

- Preliminary (truss) plan
- 6025 people
- RF planning needed!

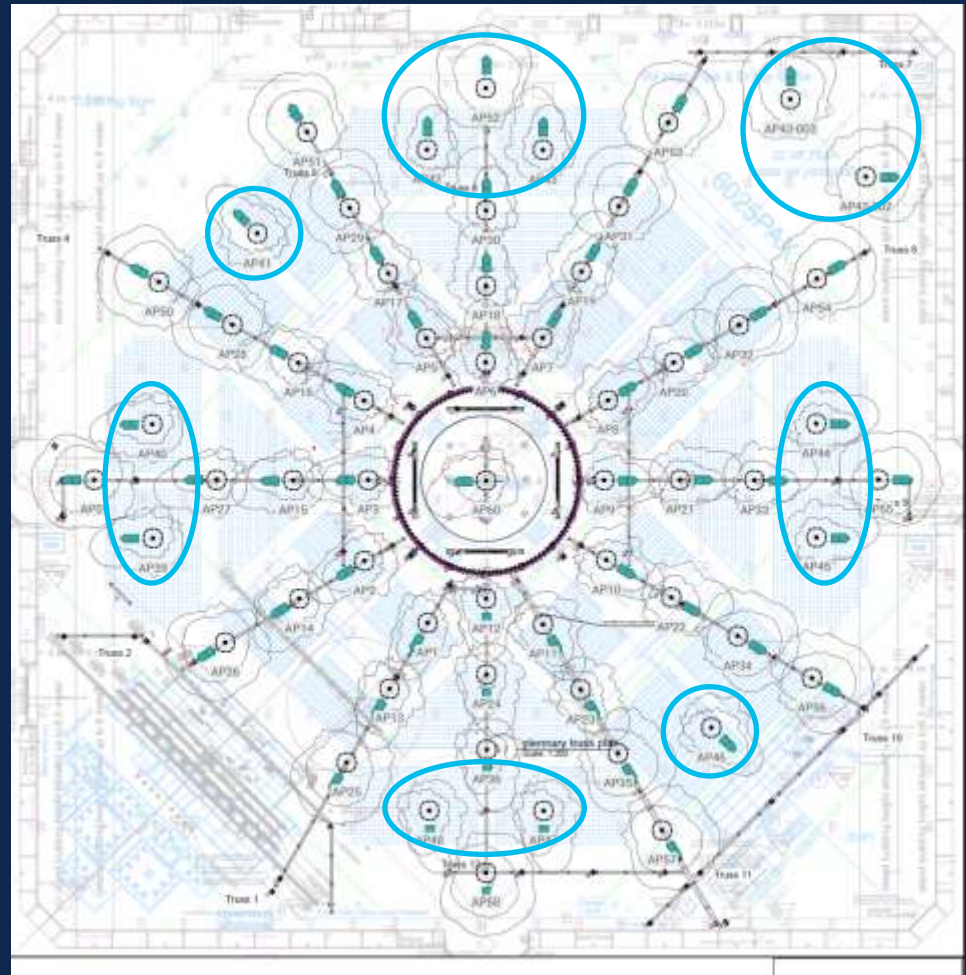


Michal Kowalik
Customer Delivery Architect



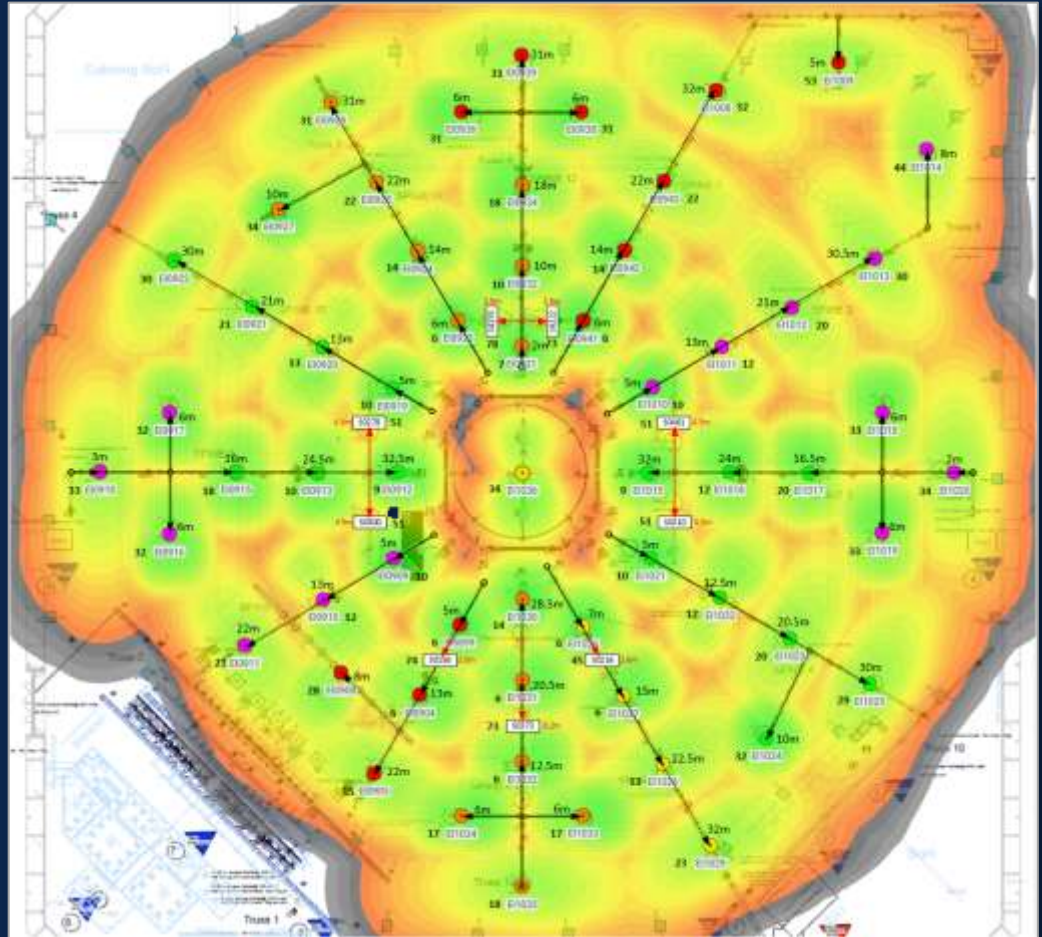
Keynote: Planning

- 6025 people -> 6275
- Preliminary RF plan ->
- More truss needed!



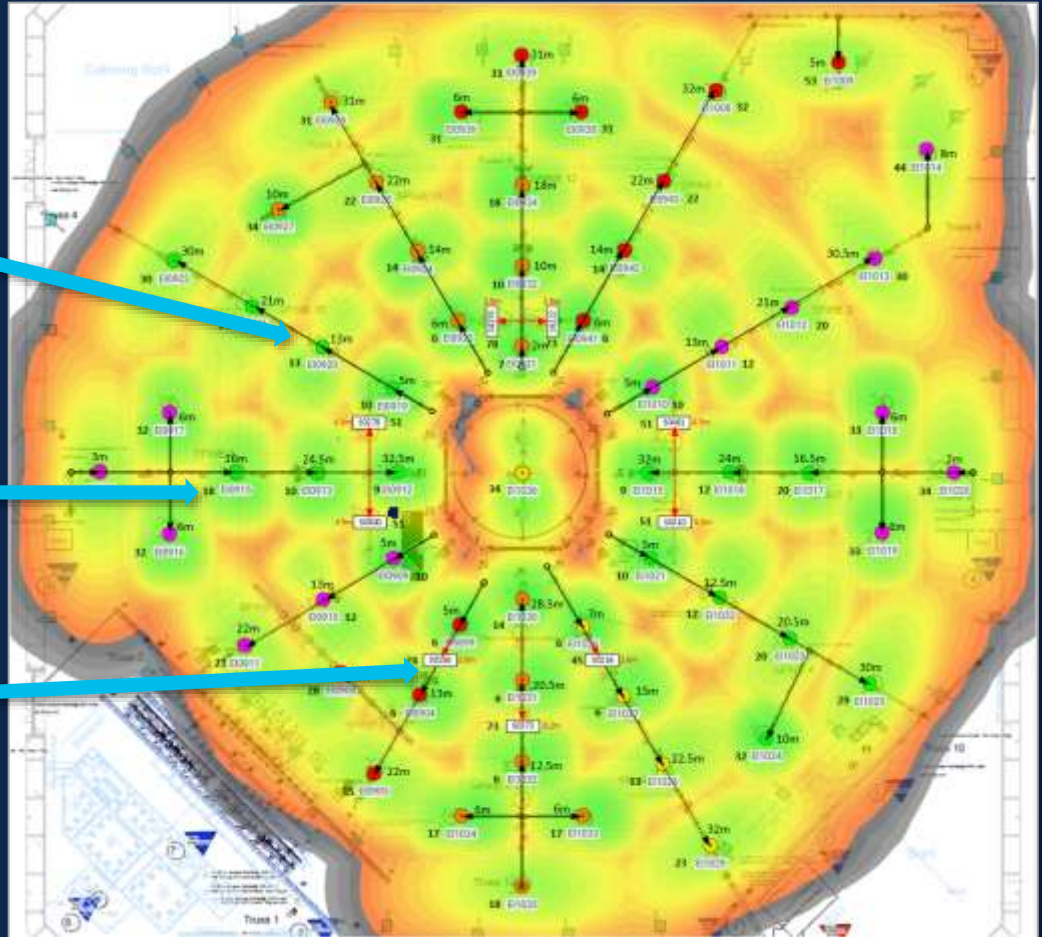
Keynote: Result

- Planned for 6275 pax
- Up 1000 from last year
- 60x ANT-9104
- 52 clients per radio
- Mandatory 36 Mbps
- RxSOP -74 dBm



Keynote: Result

- AP Positions measured from end of trusses, color indicates switch
- Cables prepared and marked for each section
- Cat 3560-CX



Deployment

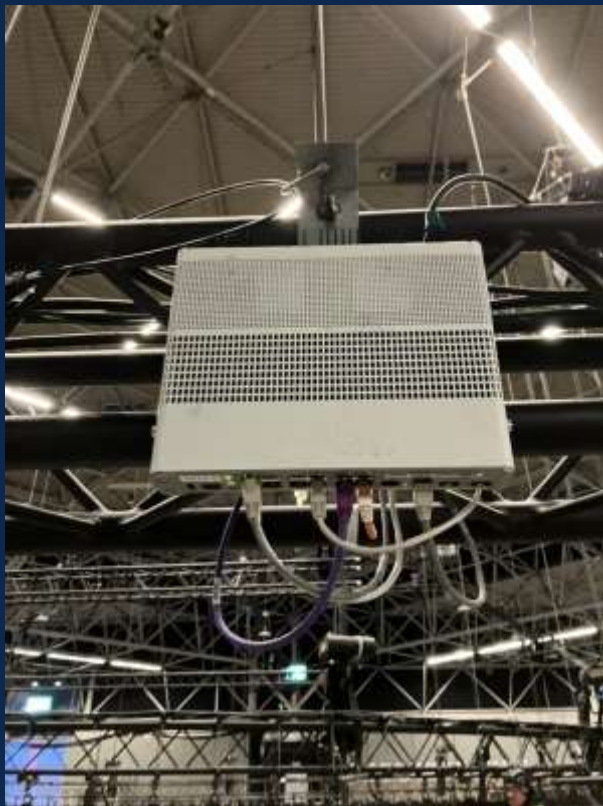


Stadium and high-density large public venue design today



- Number of components required, multiple mounting points
- Plenty of room for cabling and mounting errors during installation
- Highly directional antennas
- Capacity and dual 5 GHz first, overhead deployment highly recommended
- Trained installers to avoid manual errors
- Plan around AP to AP co-channel contention

Keynote: Material used



9104 stadium antenna's and 3560CX switches in the sound & light trusses

Keynote: Material used



Home designed
bracket with
standard truss
calmp

Keynote: Dual 2513 to Single 9104



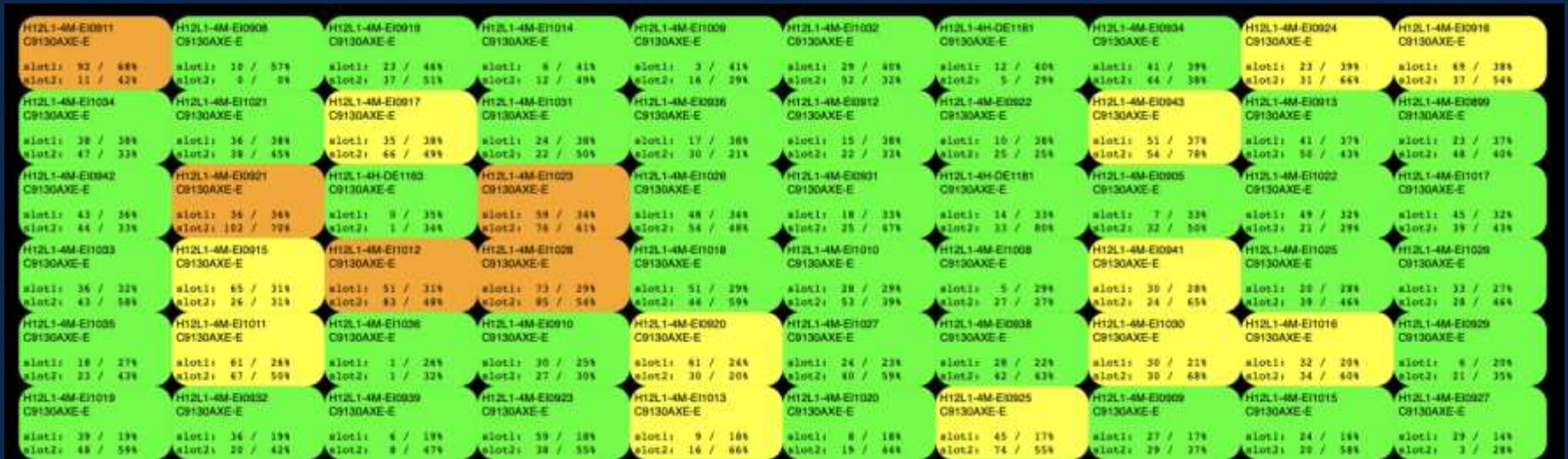
Keynote Deployment

The Dream Team

Deployed
60 APs 12 Switches 72 Patches
in about 5 hours



Parting Thought: Tx power balance is your friend



Custom dashboard shows clients & channel utilization % - per slot

Keynote WLC @ 11am, >4000 clients connected (not at peak)

Overall, very good client distribution per radio



The bridge to possible

Thank you

CISCO *Live!*

