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Cisco Catalyst RF Innovations

WiFi 6 and Beyond

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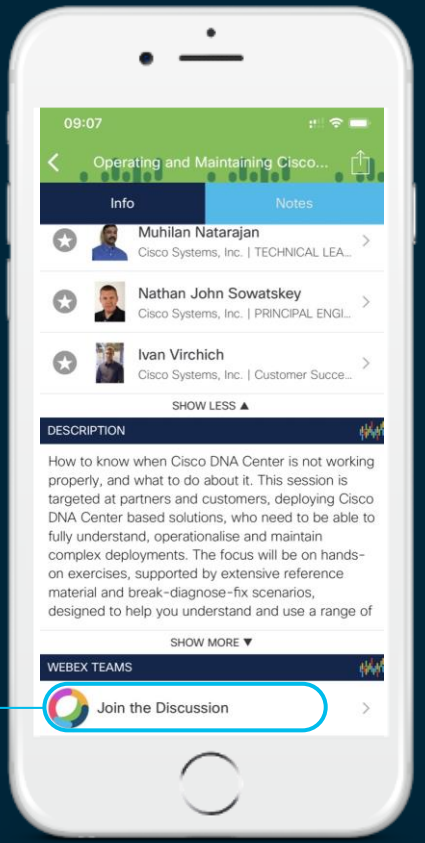


Agenda

- Wi-Fi 6 or 5G ?
- Wi-Fi 6 Technology Overview
  - Deterministic Capacity
  - OFDM and OFDMA – Why this matters
  - BSS Coloring, Spatial Re-Use
  - IOT and Why Wi-Fi 6
- Wi-Fi 6 AP portfolio
  - C9130/C9120 E models
  - SIA (Self Identifying Antenna)
- Cisco RF ASIC
  - Capabilities
  - New Features
  - 6 GHz?

Wi-Fi 6 or 5G?

The three things you should know about Wi-Fi 6 and 5G

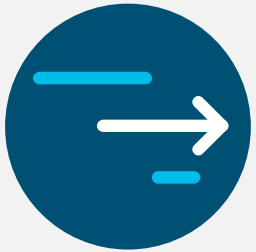
1. Wi-Fi 6 and 5 G are complementary technologies that will extend the reach and use of wireless technology. Cisco is invested in both of these technologies.

2. Cisco has you covered. We partner with the leading device and service providers for both technologies to offer unrivaled value and integration into a single solution stack: Cisco DNA

3. For enterprise campus and branch deployments, Wi-Fi 6 will remain the favored technology. It provides the essential security and control necessary to support mission critical connectivity.

Cisco is excited about 5G & Wi-Fi 6, and the possibilities they hold…

Higher data rates & lower latency



Support new applications and outcomes

Increase in network capacity

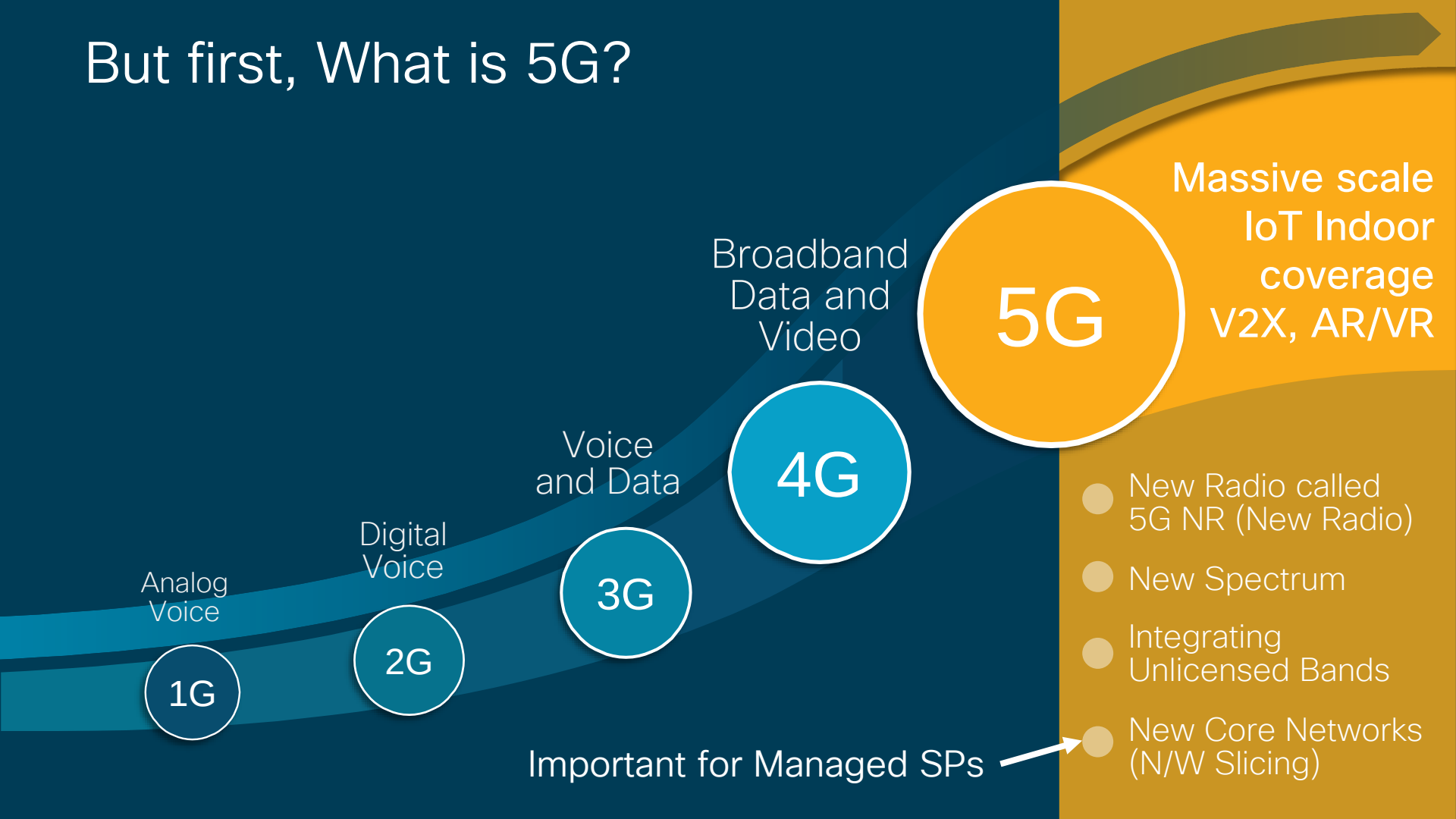
Seamless Connectivity

IoT at scale

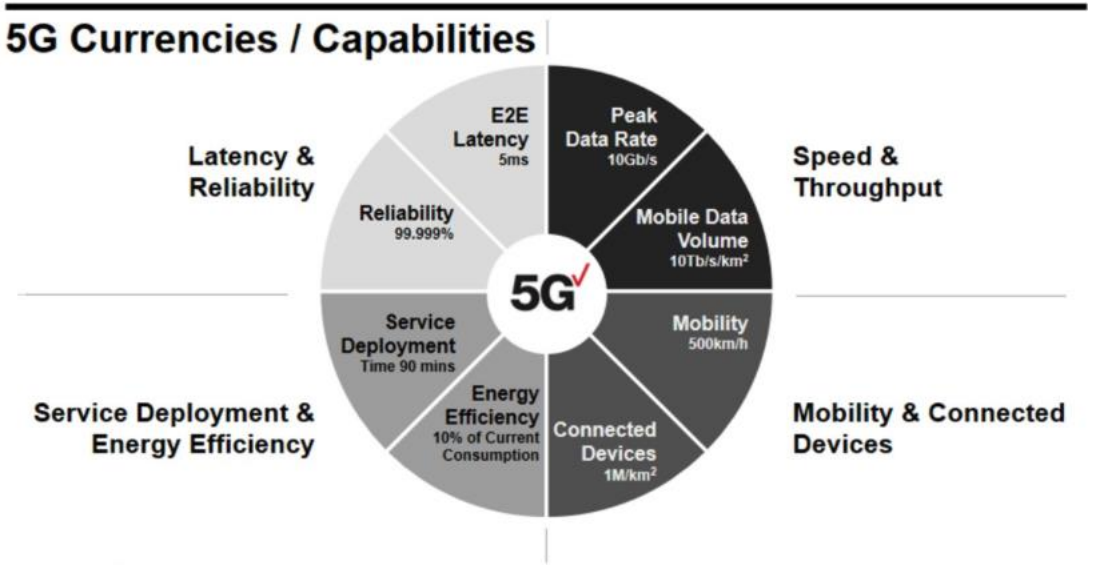
Explosion of devices including IOT

The world has two dominant wireless access ecosystems in transformation today, Wi-Fi 6 and 5G, which are built on the same wireless foundation

But first, What is 5G?



What is 5G?

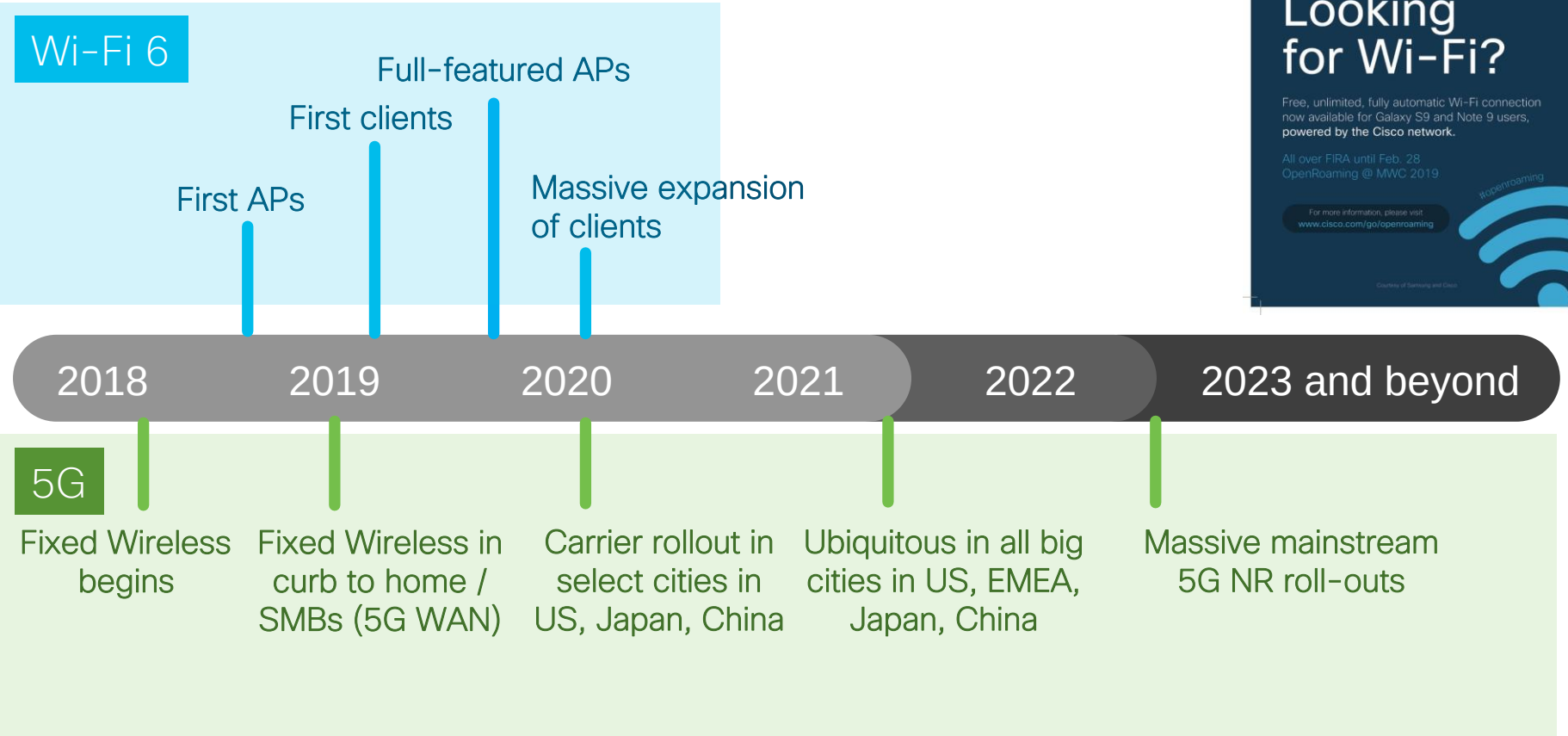


Source: Verizon 2019

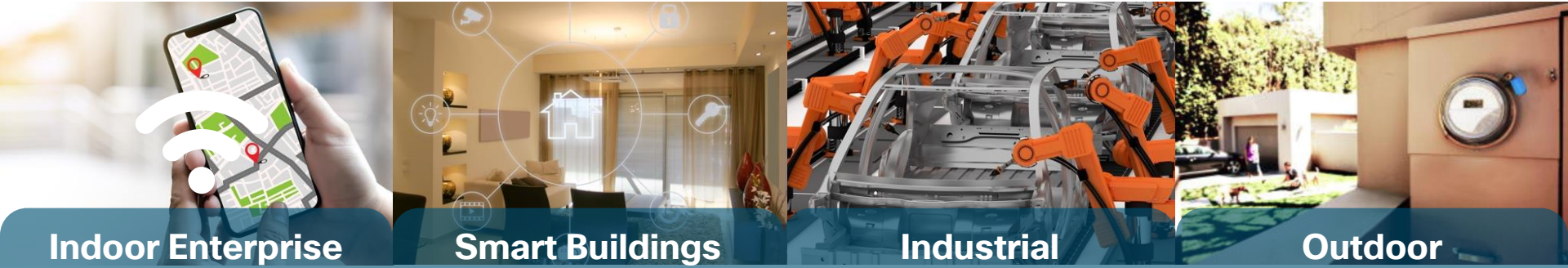
What's fundamentally new?

- New dedicated 5G spectrum
- New Shared spectrum with Wi-Fi – LTE-LAA
- Network slicing
- Edge computing
- Disaggregated architecture

Wi-Fi 6 will mainstream well ahead of 5G



5G and Wi-Fi 6 are complementary, but Wi-Fi 6 will continue to be preferred & primary wireless access in the Enterprise



Indoor Enterprise	Smart Buildings	Industrial	Outdoor
Wi-Fi / BLE	ZigBee / Thread	Wired / 5G	LoRaWAN / 5G

Sensors | Devices | Machines

Challenges

- Users
- Manage
- Secure
- Interpret

5G use cases and potential impact to Enterprise

Enhanced Mobile Broadband

- Provide better connectivity and performance to mobile devices
  - Ultra-fast internet (50 MBPs or higher to every user in dense environments)
  - Enhanced video (4K, 8K, 3D, mobile live streaming), AR/VR

Fixed Wireless Access

- Low cost alternative to broadband access/ fiber to provide high speed data rates to home/SMBs

Mission critical services

- Ultra reliable and low latency IoT (e.g., process automation, healthcare, urban air space)
- Support a massive number and very high density of IoT devices (e.g., asset tracking, smart cities)

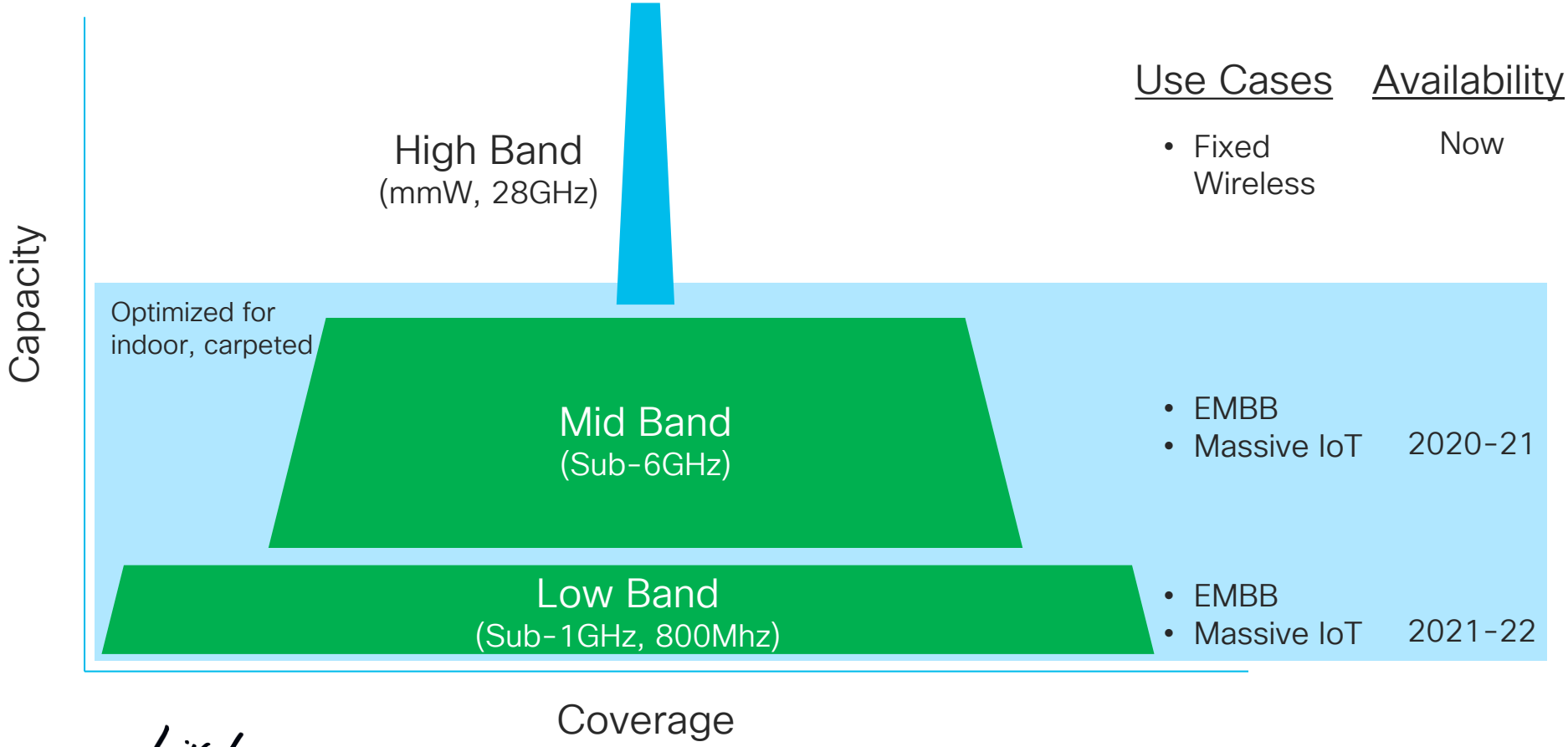
Timeline

- Only flagship devices starting 2019
- Buildout through 2020
- Mainstream starting 2022

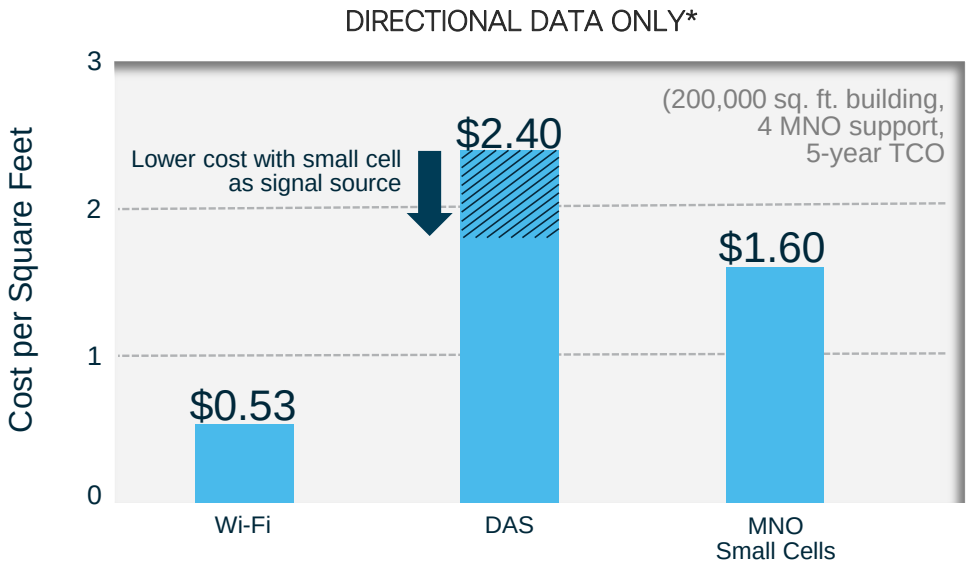
- Starting 2019 primarily in US urban & rural

- Trials starting in 2019 focused on sensor, process control
- Factory automation dependent on 5G TSN, Release 16, by 2021

5G spectrum rollout: Americas



Wi-Fi vs 5G/LTE Cost Comparison



Source: Mobile Experts

- ✓ Wi-Fi deployment costs typically 3x to 5x less than licensed

Wi-Fi 6, IS NOW!

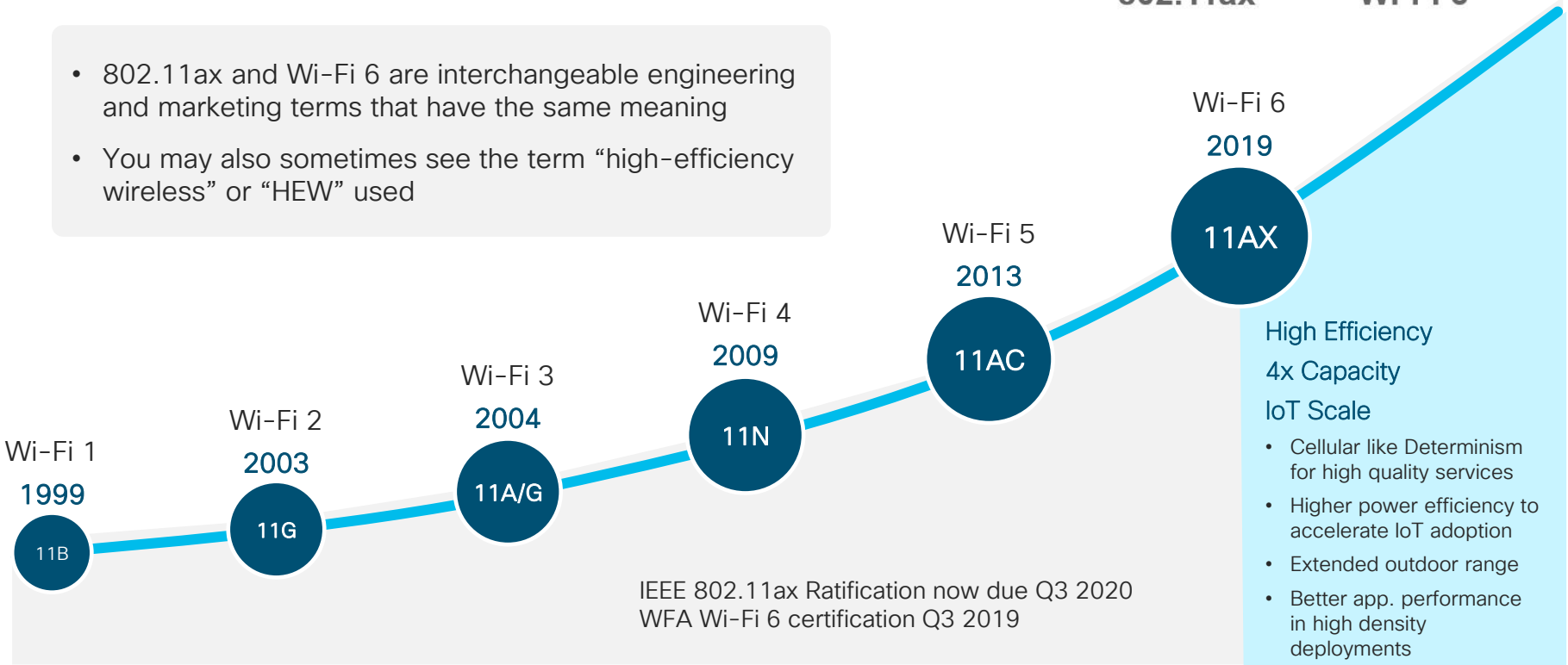
Wi-Fi 6:
802.11ax overview

What is Wi-Fi 6 (or 11ax)?

IEEE Advancing Technology for Humanity — 802.11ax

Wi Fi Alliance — Wi-Fi 6

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



Experience: Wi-Fi 6 (802.11ax)

What is the big deal?

Higher data rates

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

Increase in overall network capacity

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

Reduced latency and greater reliability

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

Improved power efficiency

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

For more information, see: https://www.cisco.com/c/en/us/products/collateral/wireless/white-paper-c11-740788.html

Next-generation Cisco Catalyst access points

Ready for next-generation applications and devices

Cisco® Catalyst® 9100

Increased capacity with Wi-Fi 6 technology

Platform benefits

Resiliency

- Superior battery life for IoT and mobile devices
- Steady performance in demanding environments

Integrated security

- WPA3, Trustworthy systems
- Multi-lingual AP with RF snapshots

Intelligent

- Analytics for iOS and enhanced Cisco DNA Assurance
- Container support to host IOT applications

Delivering RF innovations | Extending Cisco's intent-based network | Expanding the device ecosystem

Wi-Fi 6 - Enhancements

For your reference

Uplink and Downlink Orthogonal Frequency Division Multiple Access (OFDMA): Increases network efficiency and lowers latency for high demand environments

Packet latency improvements

Multi-User Multiple Input Multiple Output (MU-MIMO): allows more data to be transferred at once and enables an access point to transmit to a larger number of concurrent clients at once

Channel Reuse With BSS Color

Parallel processing: enables greater capacity by allowing MU-MIMO and OFDMA to function in UPLINK and DOWNLINK mode

Parallel transmissions

1024 Quadrature Amplitude Modulation Mode (1024-QAM): increases throughput in Wi-Fi devices by encoding more data in the same amount of spectrum

Faster Speed more Radios and 1024 QAM

Target Wake Time (TWT): significantly improves battery life in Wi-Fi devices, such as Internet
of Things (IoT) devices

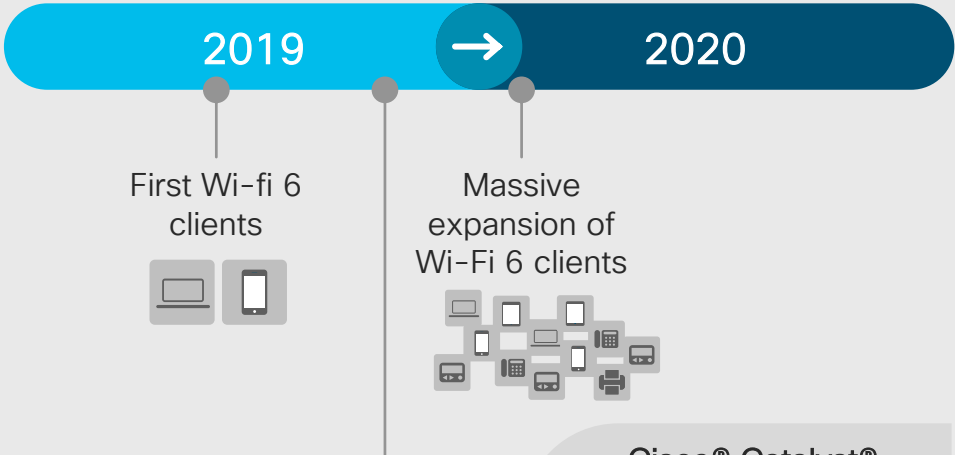
Better Battery Life

Wi-Fi 6: Certification and Standards

Not all IEEE 802.11ax elements are certified for WFA interoperability.

Certification for 8x8 mode, where you have 8 transmitters and 8 receivers, is optional on the AP.

Since it is optional on the AP, WFA certification is still in flux, as some chipsets (clients and APs) may not support all the options for these features.



802.11ax

Wi-Fi 6

Cisco® Catalyst® 9117AX is an 8x8 pre-standard access point.

According to the Wi-Fi Alliance (WFA), the certification process should come in the third quarter of 2019

Increasing Wi-Fi adoption Cisco partners with major manufacturers to provide the best device experience

Best Wi-Fi 6 standards solution

- Client & network interoperability
- Up to 4x performance increase
- Consistent
- Improved power efficiency

Differentiation through standards +

- Client network analytics providing a client-centric view to DNAC Assurance
- Improve Wi-Fi roaming
- Performance: 5x faster Wi-Fi & cellular handoff

Open Partner Framework

- Enable partners to integrate with Cisco autonomously
- Promote standards+ features across multiple client devices

Resilient

Deterministic capacity at scale

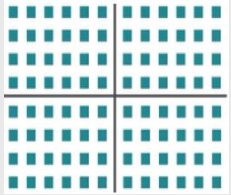
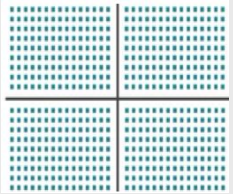
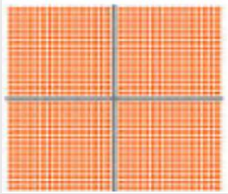
Increasing “on air” efficiency

Wi-Fi 6 is all about high efficiency wireless

Four things determine Air Time Efficiency

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

Modulation density gains

64 QAM	256 QAM	1024 QAM
		
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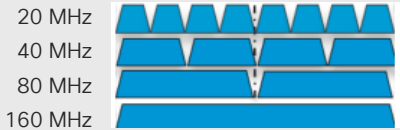
Wi-Fi channel width

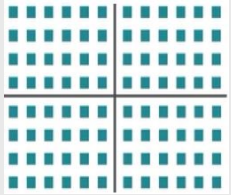
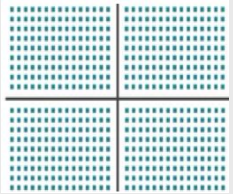
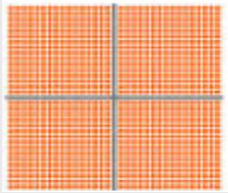


Wi-Fi 6 and Data Rates

OFDMA Orthogonal Frequency Division Multiple Access

- Peak modulation rate up from 256 QAM to 1024 QAM
- 256 QAM = 8 bits/symbol, 1024 QAM = 10 bits/symbol a 25% phy throughput increase
- 256 QAM – is more robust
- 1024 QAM requires no more hardware or spectrum than 256 QAM to operate
- More is More ;-)

Modulation density gains

64 QAM	256 QAM	1024 QAM
		
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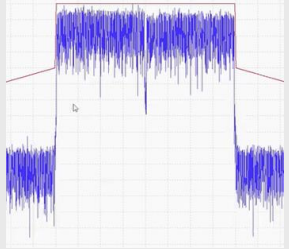

.11ax data-rate chart for 1 spatial stream

For your reference

New 1024 QAM offers a 25% performance in throughput with single Radio and introduces MCS rates 10 & 11

MCS Index	Modulation type	Coding Rate	Data rate (in Mb/s)							
			20 MHz channels		40 MHz channels		80 MHz channels		160 MHz channels	
			1600 ns GI	800 ns GI	1600 ns GI	800 ns GI	1600 ns GI	800 ns GI	1600 ns GI	800 ns GI
0	BPSK	1/2	4[1]	8.6	8[1]	17.2	17[1]	36	34[1]	36[1]
1	QPSK	1/2	16	17.2	33	34.4	68	72.1	136	144
2	QPSK	3/4	24	25.8	49	51.6	102	108.1	204	216
3	16-QAM	1/2	33	34.4	65	68.8	136	144.1	272	282
4	16-QAM	3/4	49	51.6	98	103.2	204	216.2	408	432
5	64-QAM	2/3	65	68.8	130	137.6	272	288.2	544	576
6	64-QAM	3/4	73	77.4	146	154.9	306	324.4	613	649
7	64-QAM	5/6	81	86	163	172.1	340	360.3	681	721
8	256-QAM	3/4	98	103.2	195	206.5	408	432.4	817	865
9	256-QAM	5/6	108	114.7	217	229.4	453	480.4	907	961
10	1024-QAM	3/4	122	129	244	258.1	510	540.4	1021	1081
11	1024-QAM	5/6	135	143.4	271	286.8	567	600.5	1134	1201

Up to **1.2Gb with 1 radio**, up to 10 Gb* with 8 radios @ 160 MHz

*Devices were presented at CES 2018 with a top speed of 11Gbit/s

[1]Source https://en.wikipedia.org/wiki/IEEE_802.11ax

1024-QAM 40 MHz Channel

314 Sq. meters 3.3K F^2

- Single-antenna devices (smart-phone) should see MCS10-11 with 40 dB SNR

Four things determine “Air Time Efficiency”
Wi-Fi’s 1-5 have delivered on 3 of these....

1. Data rate (Modulation density)
2. Number of spatial streams
3. Channel bandwidth
4. Protocol overhead

Modulation density gains

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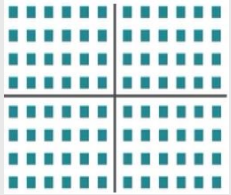	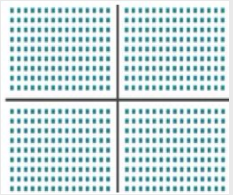	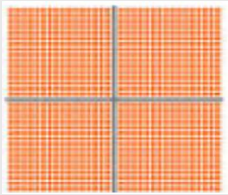
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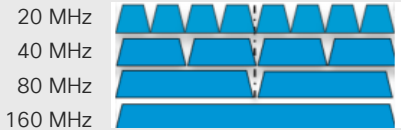
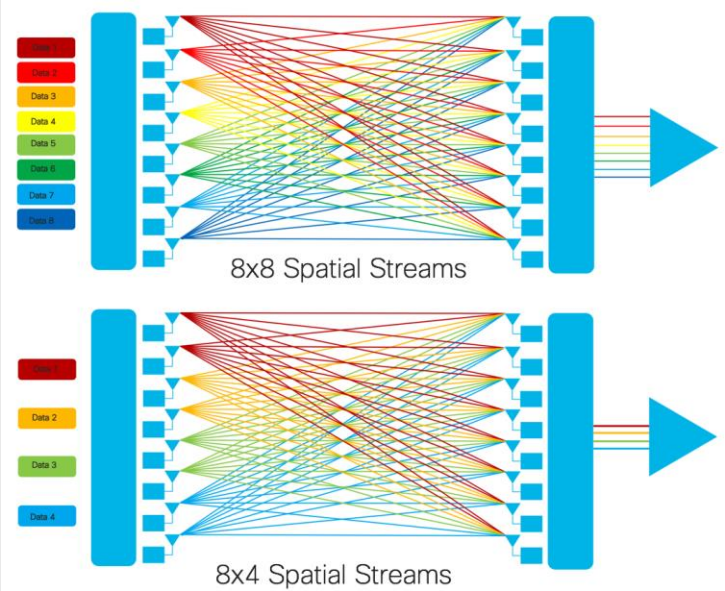
Wi-Fi channel width



Wi-Fi 6 Spatial Streams – Up from 4 to 8 SS

100% more to Work with!

- Spatial reuse is not new, however we have twice as many with 802.11ax
- Spatial multiplexing allows for a 1-1 increase in the spectrum under ideal conditions – MU-MIMO x 8? – More later….
- Higher modulation densities require higher SNR to protect against corruption
- 802.11ax provides 8 SS which can be mixed and matched to reinforce signal and increase SNR for any other SS's data



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

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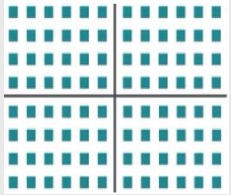	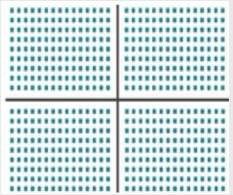	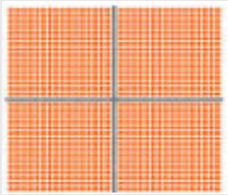
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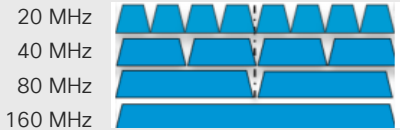
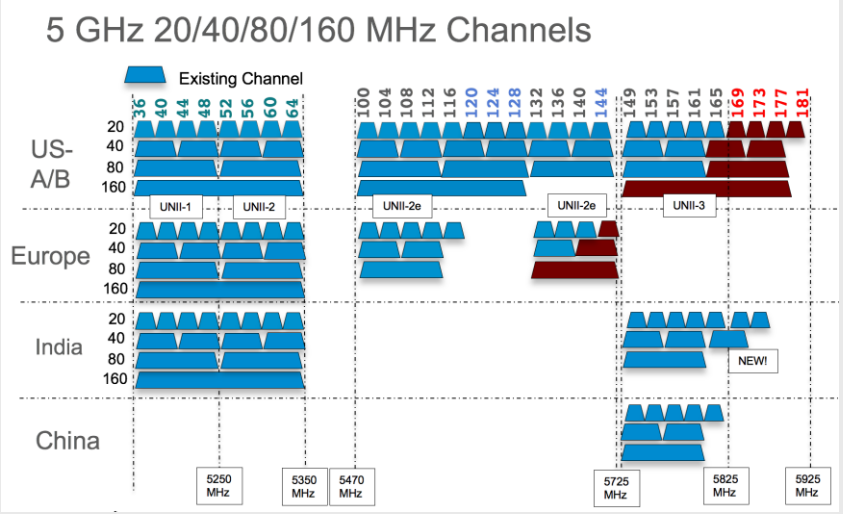


Channel Bonding – 20/40/80/80+80

Wi-Fi 6 Maintains Wi-Fi 5's abilities

- Channel bonding enables OFDM and OFDMA to increase the amount of throughput per frame by bonding existing 20 MHz channel assignments together to create very wide 40/80/160 or 80+80 MHz channel
- Each bonded 20 MHz channel comes with a 3dB SNR penalty because of the wider channel
- 80 MHz channels on Dual 5 Ghz AP's consume 8 channels per AP placement – the net result if, not careful, is the same N=3 channel re-use as 2.4 GHz band and heavy loss due to co-channel interference
- In a drag race, 80 MHz is pretty impressive
- Most installations are about driving a bus – not racing dragsters



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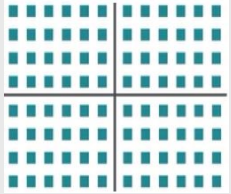	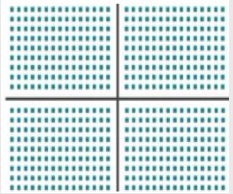	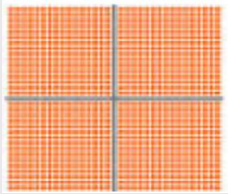
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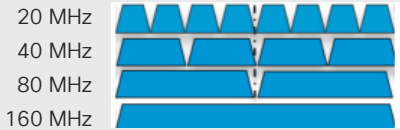


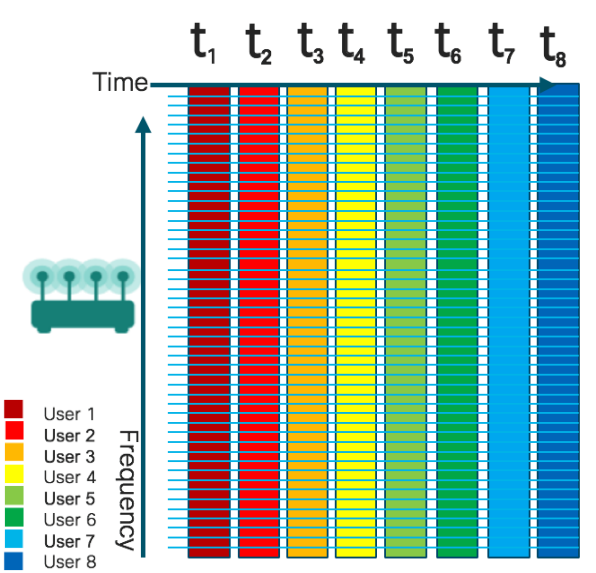
OFDMA – Multiple Access Phy IS the game changer!

Resilient Capacity: Understanding OFDM and Why OFDMA matters

So, What's Wrong with OFDM you say?

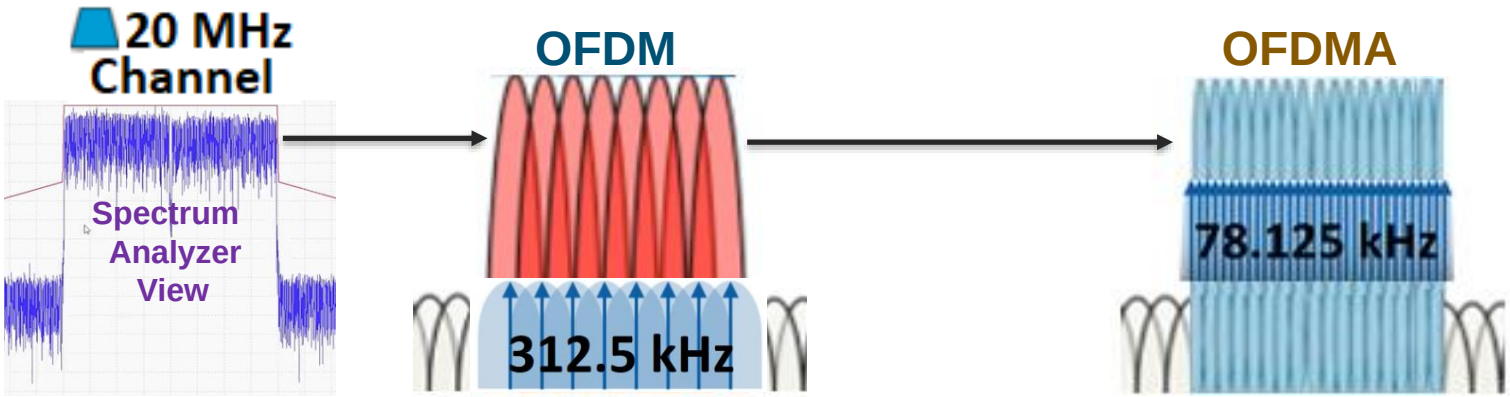
Nothing really- It's a dear old friend, But.....

- OFDM has made fantastic strides in throughput, and capacity
- Design methodologies and the technology have evolved by leaps and bounds
- OFDM (Wi-Fi's 1-5) only supports one Client PPDU per Frame. Each Clients data must have it's own Framing, this is inefficient and leaves Airtime on the table.
- As more Clients join the cell, latency will increase – Inevitably
- Today, we compensate with over design



Deconstructing OFDM and OFDMA

OFDM and OFDMA populate a 20 MHz channel using sub-carriers but OFDMA has More



- **"OFDM" channel is divided by Larger subcarriers which are not individually addressable**
- **"OFDMA" channel Sub-Carriers can be grouped into individually addressable "Resource Units", user data can be "Multiplexed" onto a Frames RU's**

All packets big and small get processed MUCH FASTER

Understanding OFDMA Resource Units

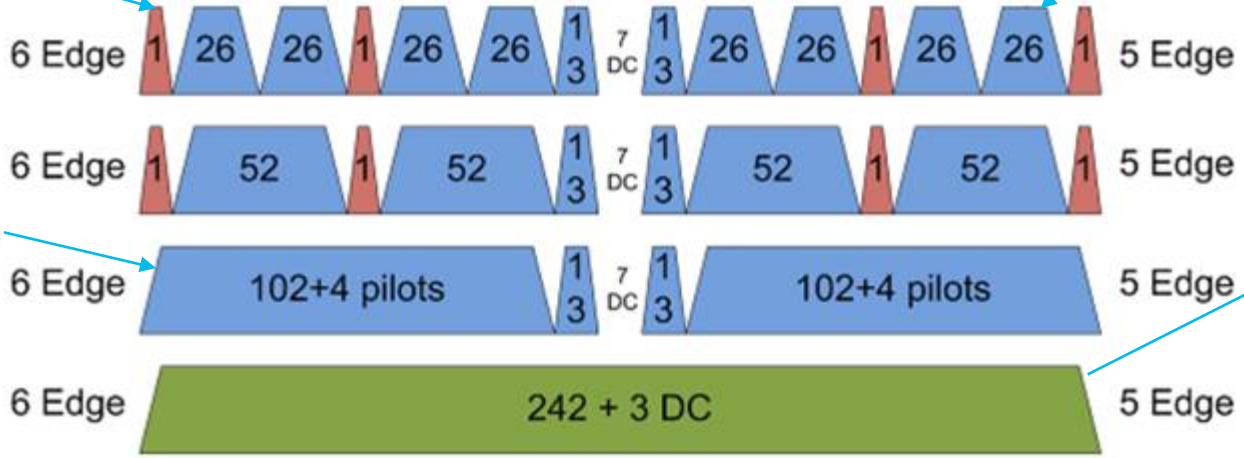
For your reference

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

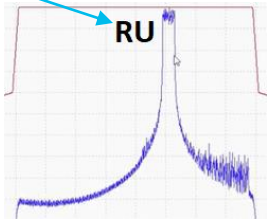
Up to 9 users per 20 MHz
Tiny RUs ideal for IoT

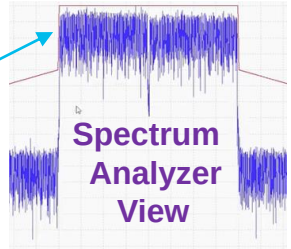
RU's are indexed

20 MHz Channel RUs



Min. RU size For MU-MIMO





20 MHz

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

Higher Efficiency: Requires a Design Philosophy

OFDM Today

- 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, back-off, 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
- More clients – also results in longer intervals between Tx-Ops – increasing jitter (latency)

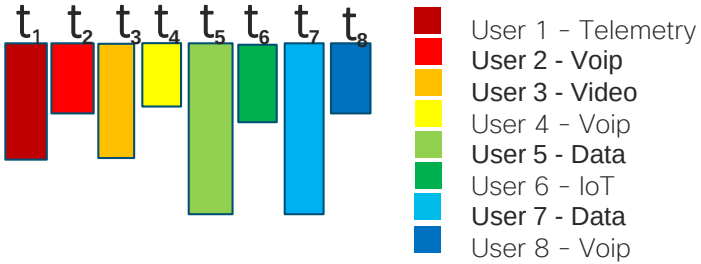
Topic / Item	Count	Average	Min val	Max val	Rate (ms)	Percent
Packet Lengths	105198	225.52	14	1623	1.6173	100%
0-19	14274	14.00	14	14	0.2194	13.57%
20-39	10605	26.89	20	39	0.1630	10.08%
40-79	1122	64.11	40	79	0.0172	1.07%
80-159	6447	115.83	80	159	0.0991	6.13%
160-319	59472	283.61	160	319	0.9143	56.53%
320-639	12440	363.13	320	636	0.1913	11.83%
640-1279	326	892.03	640	1278	0.0050	0.31%

87.37% of Frames =<320 bytes of data!

OFDMA – Using Subcarriers more efficiently

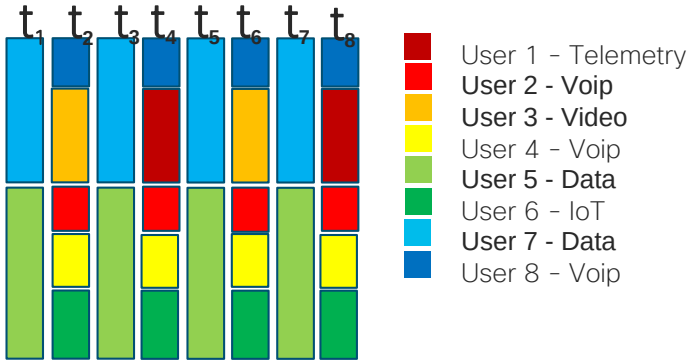
Maximizing Client Count – Lowering Latency

OFDM



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

OFDMA



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

Each subcarrier is a transport – Latency goes up when subcarriers go out "half empty"… OFDMA solves this by allowing <u>multi-user packets to go out on one subcarrier</u>

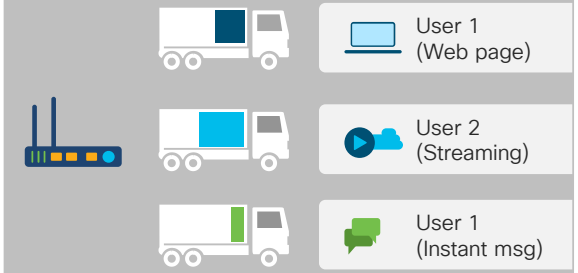
Device only improvements vs whole cell/network:

OFDM vs. OFDMA and sub-carriers

Introduction of OFDMA

Orthogonal Frequency-Division Multiple Access

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

Creates

Playload

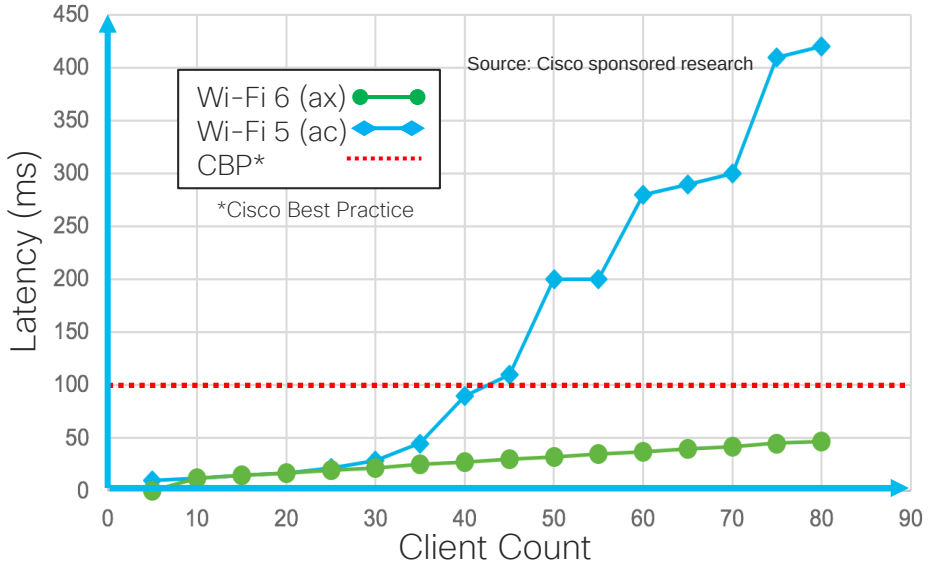
Efficiency

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

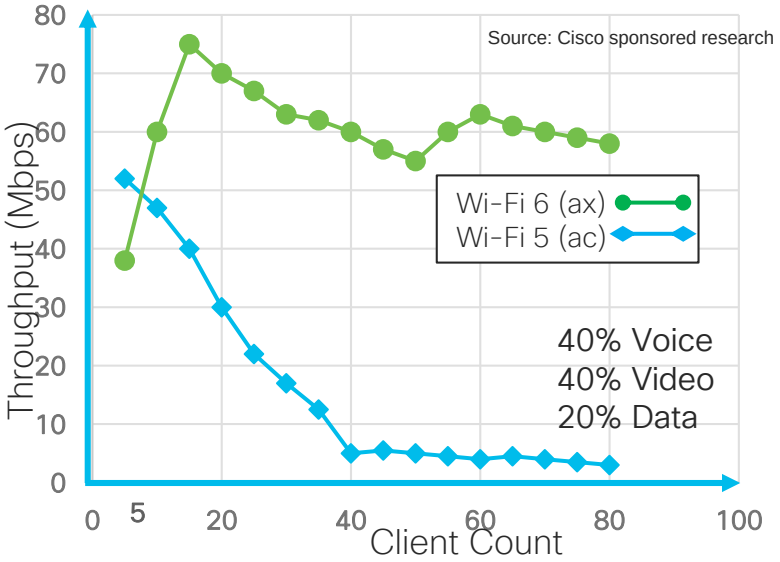
802.11ax (OFDMA) provides determinism at scale:

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

Linear **VOICE** delay



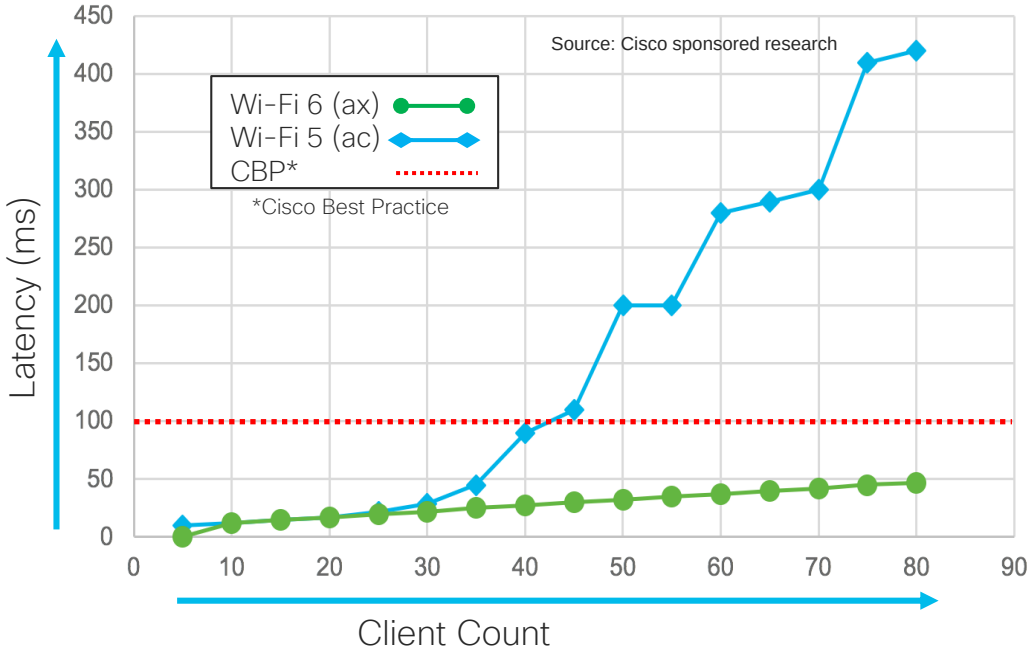
Consistent **DATA** throughput



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

802.11ax provides higher VOICE/VIDEO capacity

Lower latency at increased density



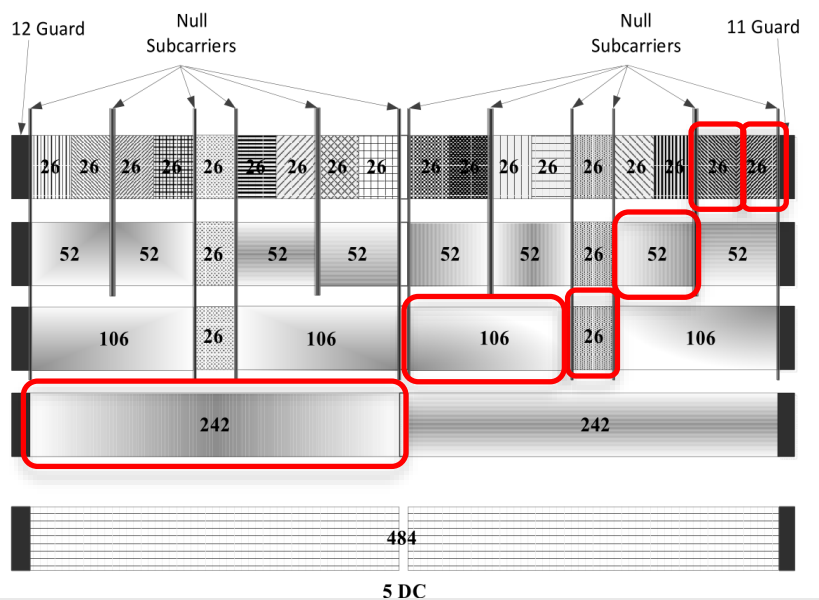
- With 11ac, as density (Clients/AP) increase from 25 (e.g. class room) to 50 (e.g. conference hall), latency increases 4x from an acceptable 50ms (99%-ile) to an unacceptable 200ms – unusable service!
- By leveraging OFDMA, delay is bounded to 50ms up to 75 Clients/AP resulting in 2- 3x the VOICE user capacity with high quality

Wi-Fi 6 can achieve up to 3x the VOICE capacity over 11ac in High-Density (HD)

But Wait – It Gets Better!

DL and UL-OFDMA – Is Multi User but not MU-MIMO, yet

- OFDMA RU's permit multiple users PPDU's to be transported within the same frame – Multi Access
- This reduces transport overhead and increases air time efficiency
- MU-MIMO is about Spatial re-use though
- Within OFDMA – any RU 106 or Larger can multiplex up to 8 SS split between users– MU-MIMO



Resilient

Capacity: Parallel Processing and handling Multiple users with MU-MIMO

Review of MU-MIMO 802.11acW2 (Wi-Fi 5) and enhancements in (Wi-Fi 6)

Multi-User MIMO (MU-MIMO) introduced 11ac Wave-2

How does it work? Why is it an advantage?

SU – MIMO vs. MU - MIMO

This is Single-User MIMO
SU-MIMO

Only one Frame in the Air to any One client at a time

Effective # SS is limited to the # of SS available on the client

All Spatial Steams send the same data

This is Multi-User MIMO
MU-MIMO

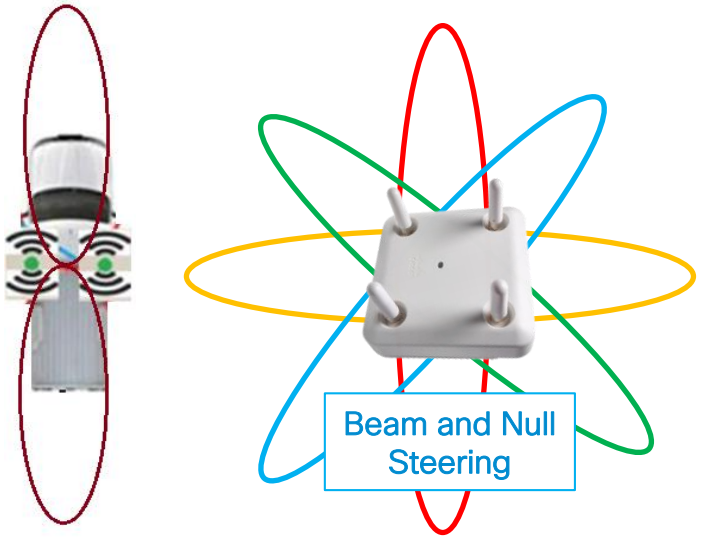
Up to 1+2 SS
Or 1+1+1

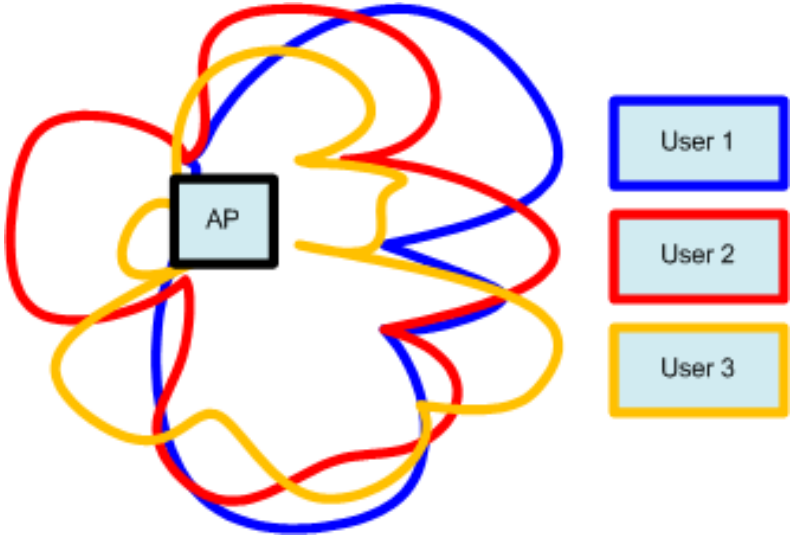
Max 3SS simultaneously

Data can be directed to Different clients in Concurrent streams in a1+1, 1+1+1 or 1+2 stream combination

Multi-User MIMO (MU-MIMO) .11ac Wave2

Occurs when TxBF is able to focus the RF at a client while creating a null to the other clients





With TxBF we have 4 (or more) antennas/Tx Chains, and can place the signal <u>anywhere we want</u>

While TxBF (directing) the signal at say <u>User1</u>, you have to <u>also</u> create a NULL or lower signal for <u>Users 2 & 3 etc.</u>

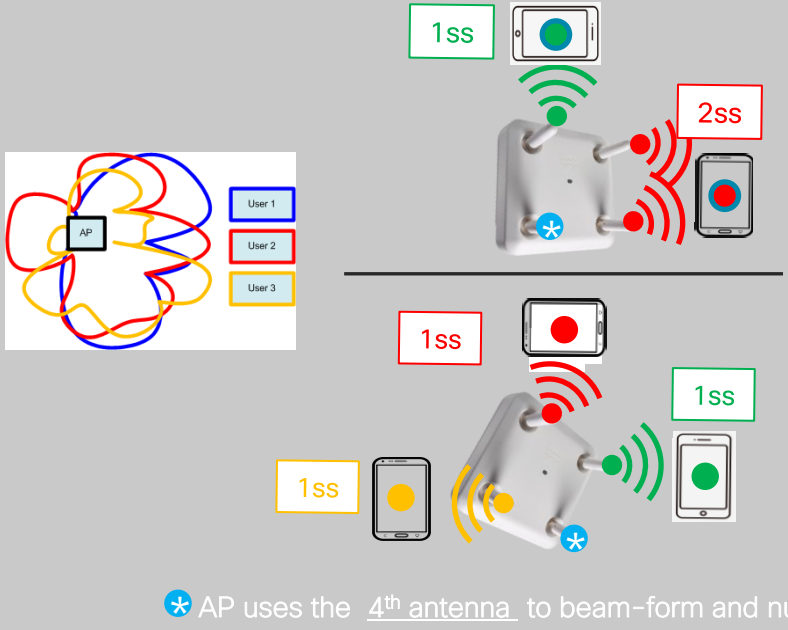
Multi-User MIMO (MU-MIMO) .11ac Wave-2

Performs TxBF, while nulling and also sending similar size data packets using 4th antenna TxBF

Each Wave-2 client sends CSI (Channel Sounding Information) about how to best beam-form to it.

The AP then determines how it will beam-form and null to each of the 2-3 clients and then clusters these "ideal" clients into groups.

On a per-packet-basis each member of a group receives a similar size packet at the same time (downstream).



Data can be directed to different clients as 1+1, 1+1+1, or 1+2 Spatial Stream combinations

Multi-User MIMO-Wi-Fi 5
What Happened?

MU-MIMO is complex and challenging:

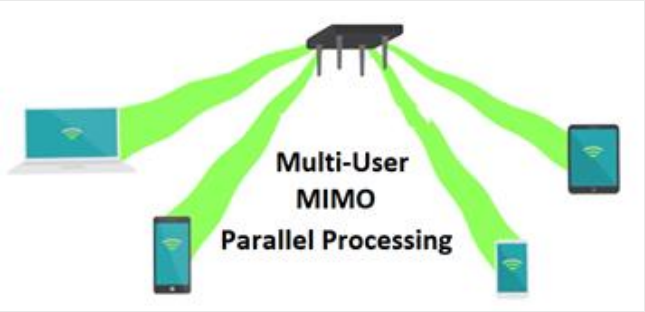
- Requires accurate (CSI) channel sounding information to maintain deep nulls so each MU-MIMO client can properly decode its data without too much interference from the other clients
- MU-MIMO CSI adds overhead as does the client acknowledgements etc.
- Client implementation and Adoption were SLOW –
- Lower quality clients – may be sensitive to MU grouping overhead, client driver version issues, they might report less helpful data in the CSI "sounding"
- Wi-Fi 6 (channel sounding is now table stakes) making smarter clients and MU-MIMO a more practical and easier reality – ☺

Note: Channel sounding (CSI) is needed for MU-MIMO – the lack of channel sounding (TxBF) on legacy clients (Pre-Wave2) made Client-Link attractive but is no longer applicable to Wi-Fi 6 clients.

Wi-Fi 6 enhancements to Multi-User MIMO
OFDMA changes the game

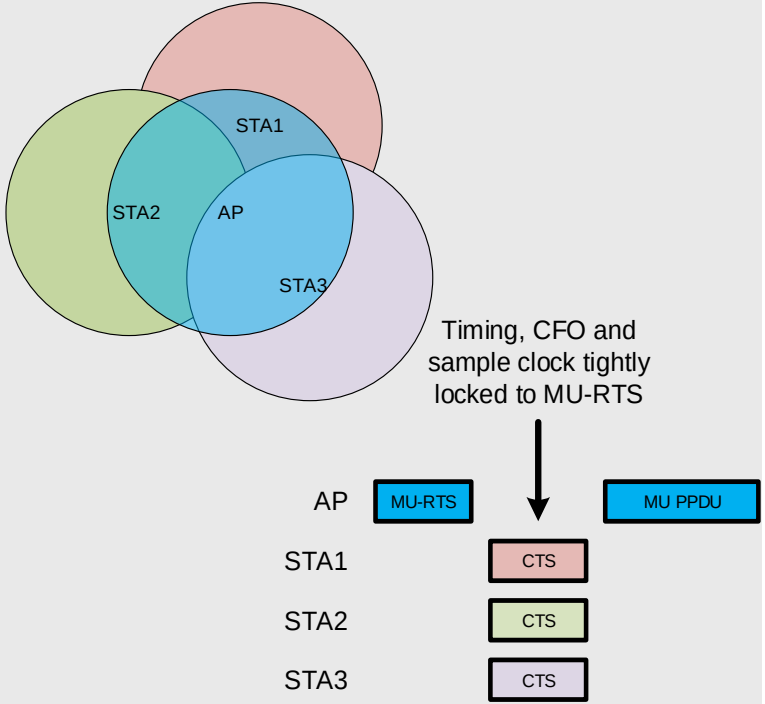
- Up to 8 MU-MIMO transmissions (Concurrent users in a group) for any RU 106 or larger
- MU Station UL and DL CSI/ACKs/CTS processed in parallel – Efficient Leveraging new UL-MUMIMO analogue requirements
- AP maintains a channel matrix for each station and simultaneously beam steers to different clusters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

Wi-Fi 6 drives Performance into the clients



OFDMA MU-RTS/CTS

- CTS2self:
  - Protects the volume around the TX
- RTS/CTS
  - Protects the volume around the TX and RX
  - Verifies that the NAV is unset at the RX and any interference is low-moderate
- DL-MU (MIMO or OFDMA) : many receivers, in very different places / interference environments
- MU-RTS/CTS:
  - Modified RTS on the DL, and a “trigger frame”
  - Lists all target receivers
  - Allocates at least one STA per 20MHz for CTS

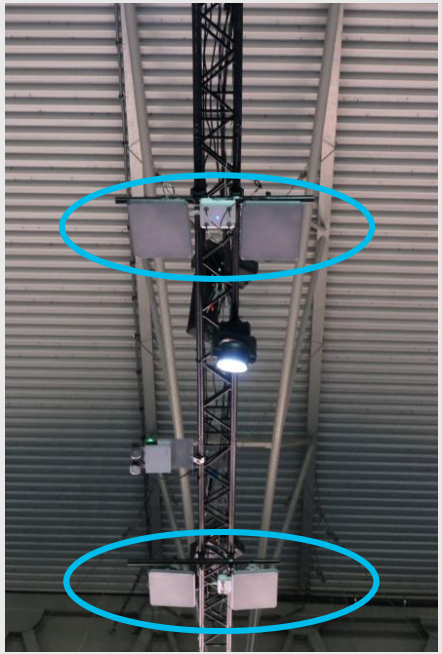


Resilient

Throughput: BSS Coloring & Spatial Frequency Reuse

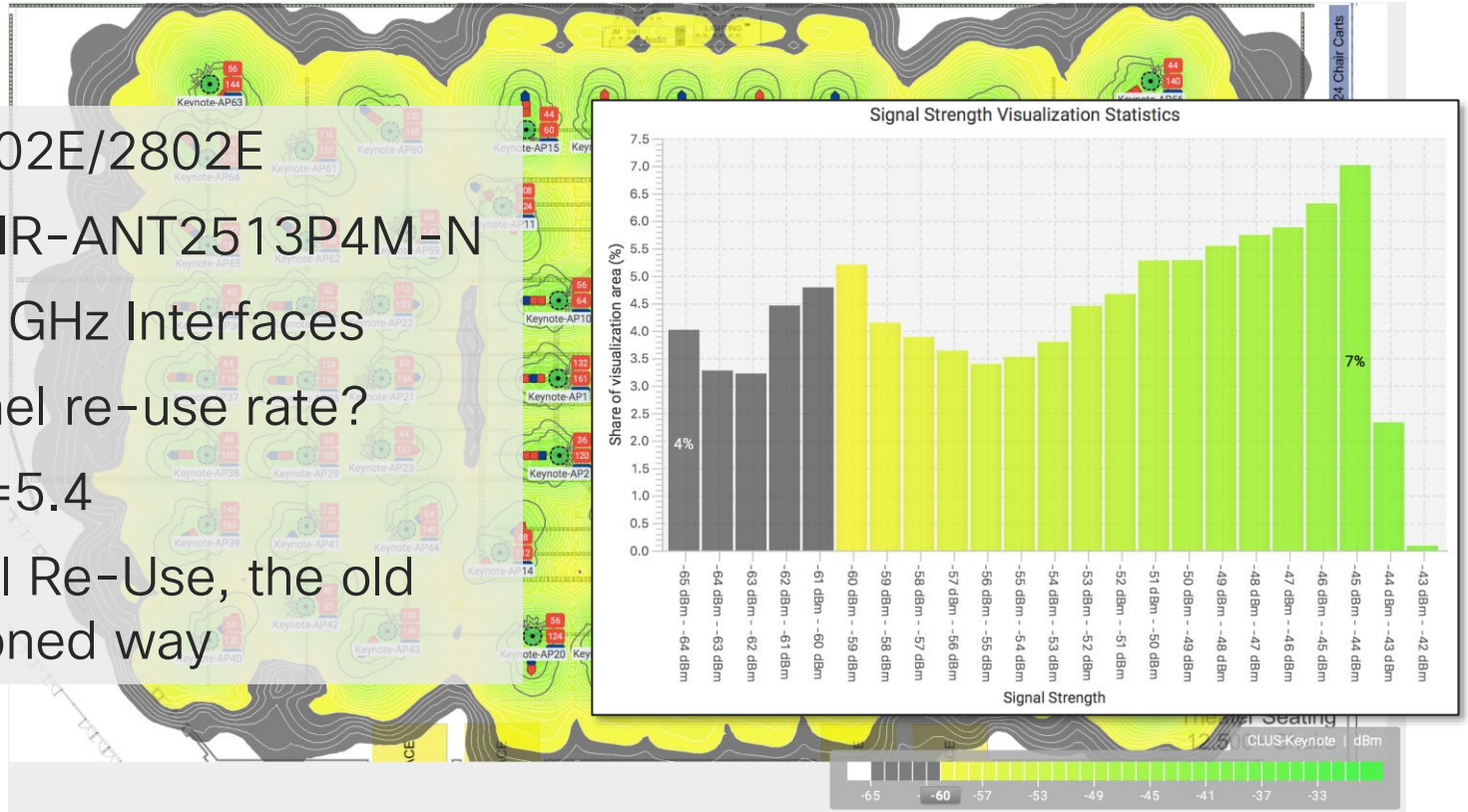
Spatial reuse today – Prior to Wi-Fi 6

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



US Opening Keynote 6/10/2019

- 69 3802E/2802E
- 138 AIR-ANT2513P4M-N
- 135 5 GHz Interfaces
- Channel re-use rate?
  - N=5.4
- Spatial Re-Use, the old Fashioned way



US Opening Keynote 6/10/2019

- 85
- Avg.
- Ch
  50%
- Avg.
  - 2.4 GHz -75.73 dBm
  - 5

Chris O'Donnell – Architect, Customer Delivery

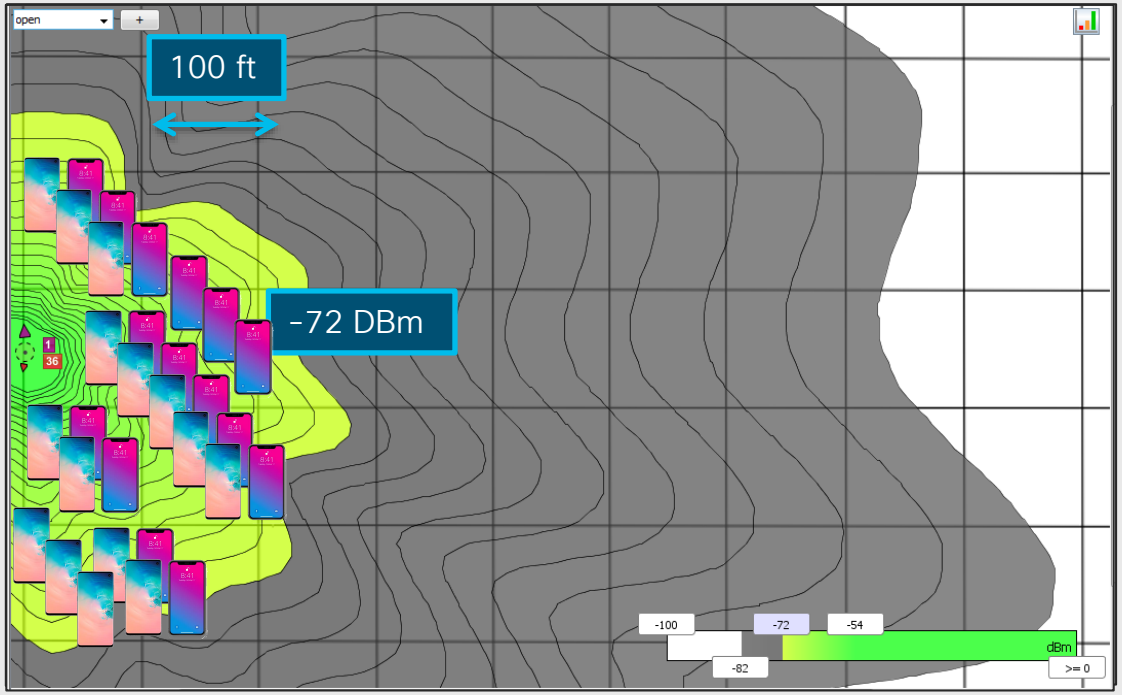
Tim Barnes – Architect, Customer Delivery

Nathan Boyd – Technical Solutions Architect

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

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

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



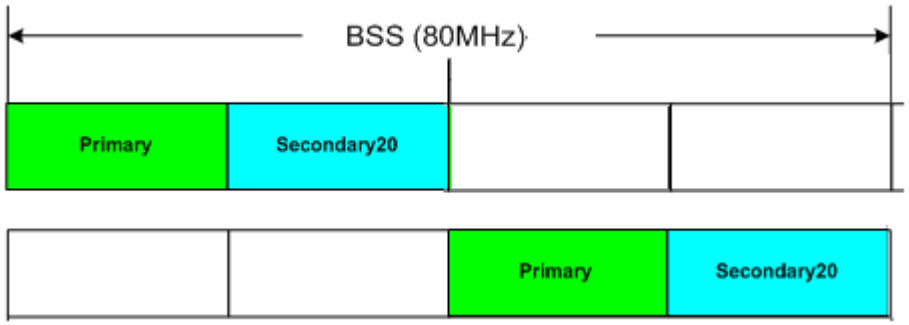
What is an OBSS (Overlapping BSS) and Why?

Protocol	Primary	Secondary 20 MHz	Secondary 40 MHz
802.11a	-82 dBm		
802.11n	-82 dBm	-62 dBm (20 dB liberty)	
802.11ac	-82 dBm	-72 dBm (10 dB liberty)	-76 to -79 (3-6 dB liberty)

- Never Fear – LBT (Listen before Talk) to the rescue – CCA! (Clear Carrier Assessment)
- CCA thresholds where adjusted in the 802.11ac specification to allow Overlapping BSS and IBSS stations coexist by adjusting the contention requirements for Sub Channels
- In the table above – you can see that all 3 protocols have equal contention on the primary.
- Any primary operating within a secondary 20 or 40 will loose contention
- Any secondary 20 operating in a secondary 40 will win contention over other secondary's!

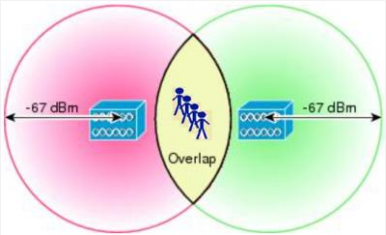
RTS/CTS with Bandwidth Indication (Wi-Fi 6)

- The Wi-Fi 5 specification allowed for an RTS to be sent on all secondary channels as an 802.11a frame, and expect a CTS (Mandatory) if a primary channel exists on any one of the secondaries
- Turns out, that was in-efficient
- For Wi-Fi 6, CTS is unchanged but now sent simulcast and identically by all STAs
  - Leverages UL-MUMIMO analog requirements, not part of Wi-Fi 5
  - Will set the NAV around every RX
  - Low overhead, effective
- If just 1 intended RX sends a CTS then the AP can send its PPDU
- Can be used to protect both DL MU and UL MU (Trigger Frames)

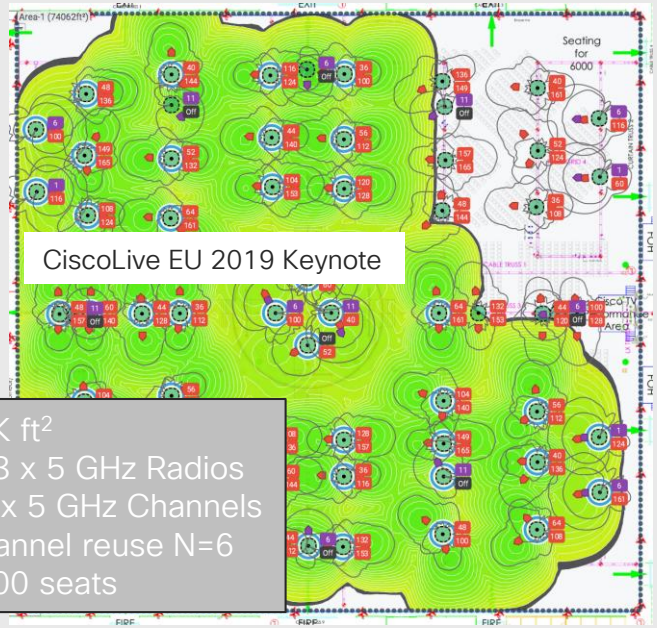


Contention, Spatial Re-use and Wi-Fi Why you care

High Client Density - Capacity requires more Cells. More Cells = More bandwidth to all users within a given cell – assuming it's Isolated in Frequency (Contention)



- The limiting factor in a high density design is typically co-channel interference "CCI".
- Dual 5 GHz AP's at 80 MHz channel width will consume 8 Channels per AP
- The limiting factor in Capacity is the number of isolated cells you can populate over any spot on the floor – cell Size is everything

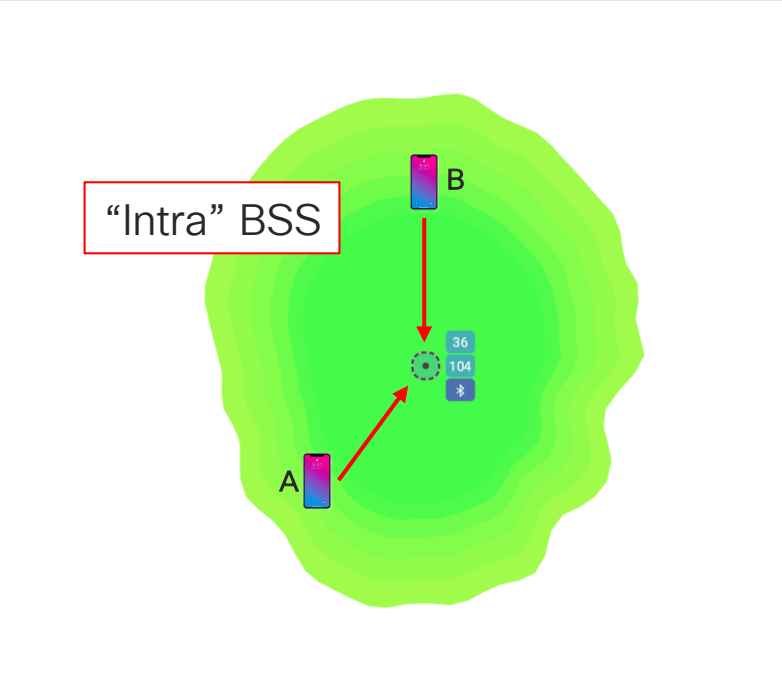


CiscoLive EU 2019 Keynote

74K ft^2
108 x 5 GHz Radios
18 x 5 GHz Channels
Channel reuse N=6
5000 seats

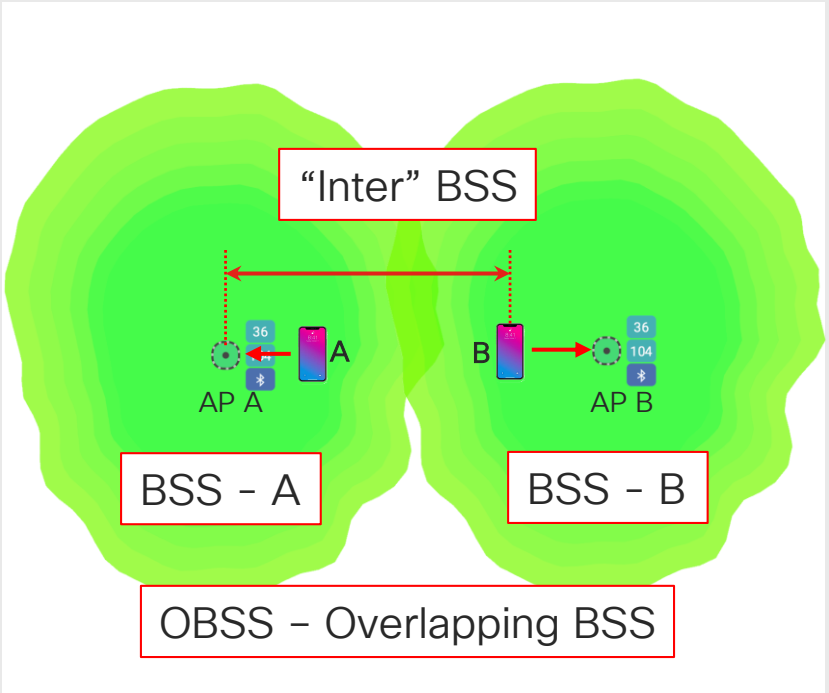
Wi-Fi Contention and Spatial Reuse 101– Why is BSS coloring important?

- Two stations associated to the same AP can not both talk to the same AP at the same time, they will “Interfere” with one another at the AP’s receiver
- To prevent this Wi-Fi uses a “contention mechanism” – CCA (Clear Channel Assessment)
- If Sta A listens to the channel – and can hear anyone at or above -82 dBm – then the channel is in use and Sta A must back off and try again
- In this way – stations will all take turns using the channel and avoid harmful or destructive interference
- An AP and all the Stations associated to it are considered a BSS as all the stations



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

- What if 2 Sta's are talking to two different AP's on the same channel but are close enough to hear one another
- In Wi-Fi 1-5, this still causes all stations that are close enough to hear one another above -82 dBm to back off and take wait for a clear channel
- Realistically though, Sta A and Sta B are close enough to their respective AP's to both Tx at the same time without interfering at their intended receivers
- AP A is far enough from Sta B, and AP B is far enough from Sta A that both transmissions would be successful without one interfering with the other
- In Wi-Fi 1-5 though – there is only the Channel defined as a shared medium, there is no concept of individual BSS's
- BSS A and B form an Overlapping BSS or "OBSS"

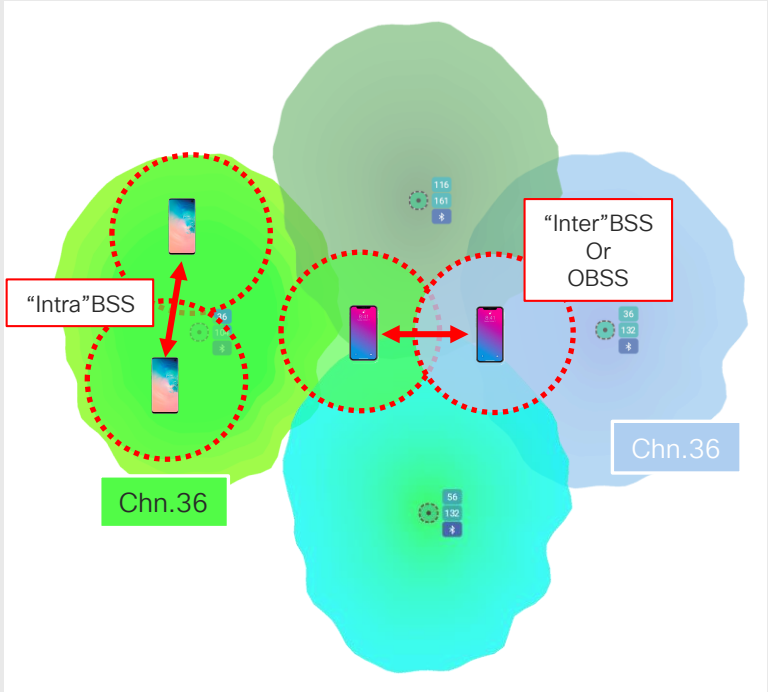


BSS Coloring – Spatial Reuse
Basic service set “BSS” and the overlapping basic service set “OBSS”

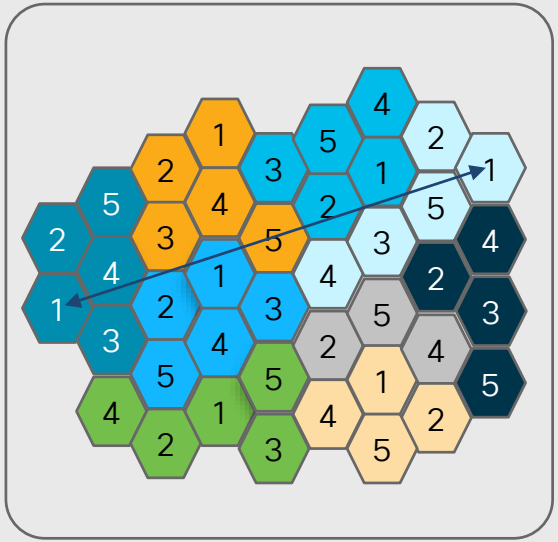
- All clients associated on a given AP are operating within the same BSS and will operate on the same BSS color (regardless of the SSID)
- Stations operating on a different AP, may have the same SSID and channel – but will be assigned a different color than mine.
- Each user (station) learns its BSS’s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

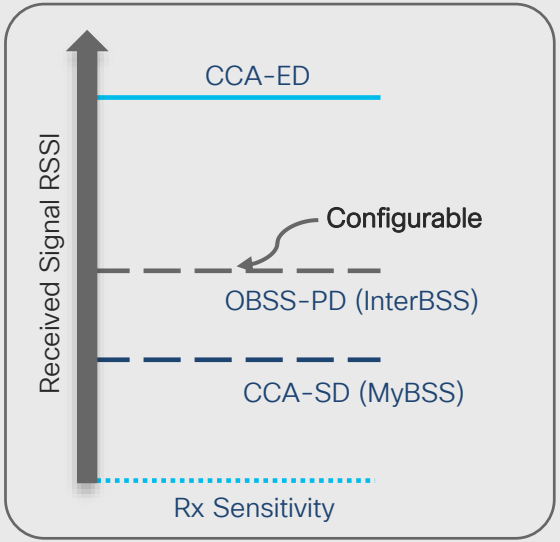
Every Client becomes a sensor reporting what they can hear from the floor – in realtime

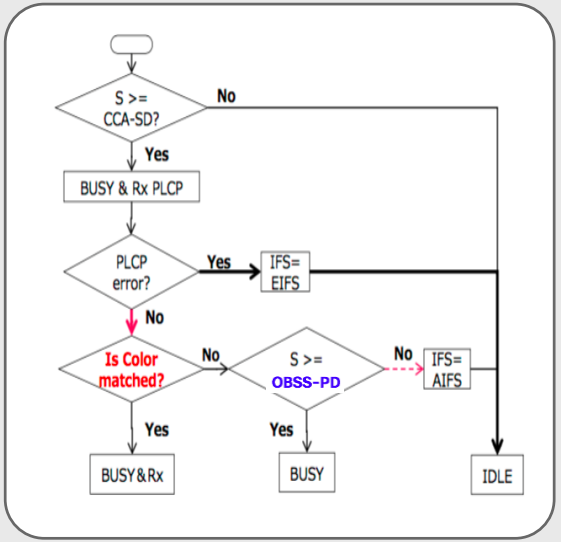
*RRM will make the determination and assignment
**OBSS-PD Overlapping BSS – Packet Detection



BSS-Color,OBSS-PD and RRM







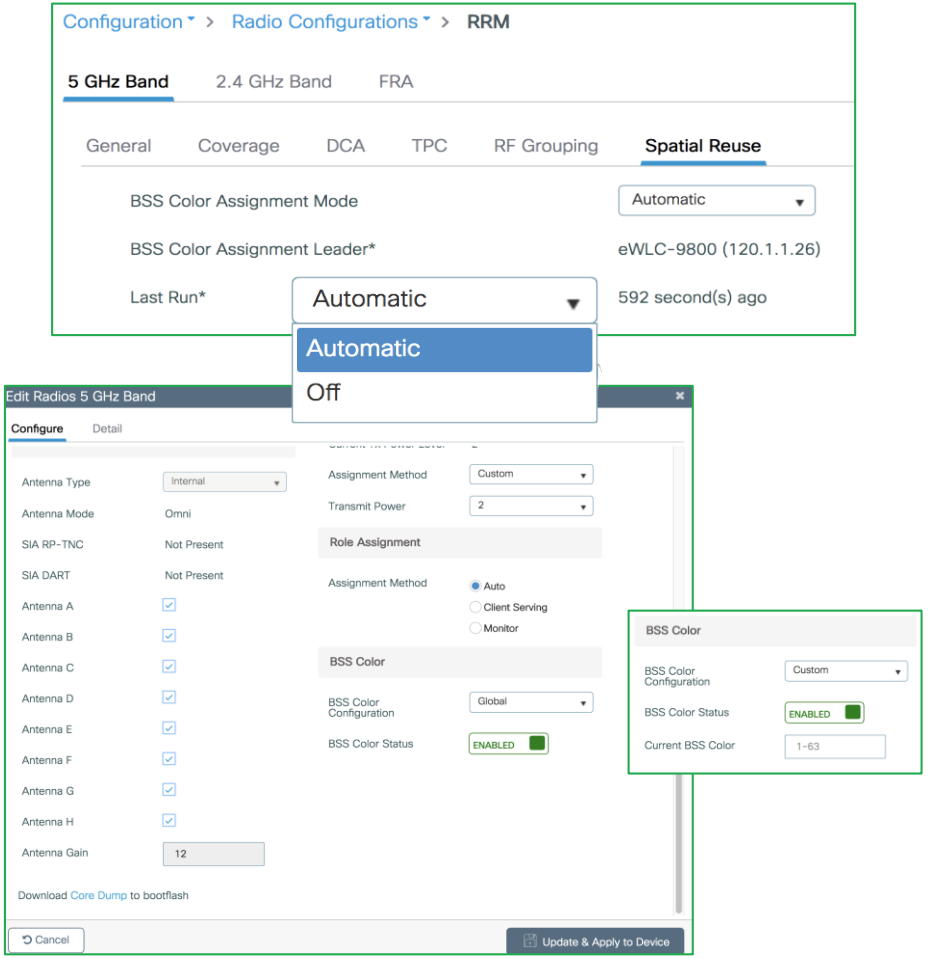
Same channel BSS only blocked on the color match	CCA adjustments For IntraBSS Vs InterBSS	Channel access rules

What's expected, and When is it coming??

- WFA requiring BSS-Color to Pass for Certification of AP's for management and Data Frames
- Phase 1 – now – all about OTA messaging
  - Supported IOS-XE 17.1.1 and AireOS 8.10 MR1 for BSS color Only
  - RRM assigns BSS color's
  - Client colors also captured
- Initial OBSS-PD support in IOS-XE 17.1.2, AireOS 8.10 MR2

C9800 BSS Color GUI

- BSS-Color must be enabled at the global level per band
- Choices are
  - Auto – RRM
  - Off – OFF!
- At the radio –
  - Global – RRM
  - Custom – assign a number



Benefits of OFDMA and BSS coloring

IOT and VoIP – OFDMA allows parallel processing of multiple clients greatly reducing jitter and latency of packets both large and small

OFDMA and BSS Coloring are enhancements that also benefit 2.4 GHz where many IOT clients operate and/or High-density networks are desired

Outdoor distances increase as additional Guard Interval time, longer preamble and narrower subcarriers are easier to decode better in interference prone areas

Algorithms for BSS coloring reward the client by letting it transmit if it can reduce power (making airwaves more efficient) allowing more clients on the air at the same time. **Channel reuse now possible for higher performance**

Resilient

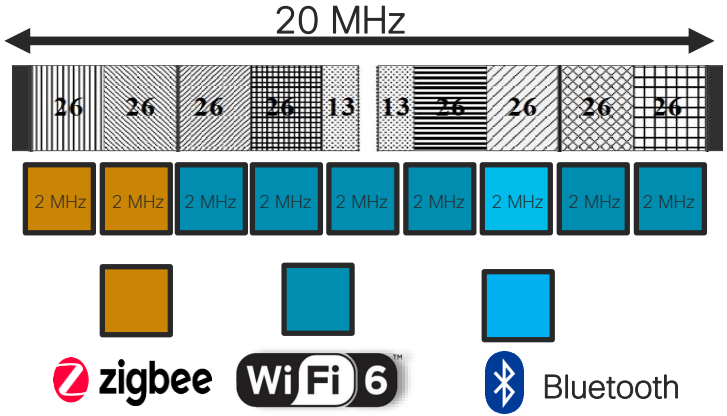
IoT – Wi-Fi 6 Enhancements

Key Wi-Fi 6 Enhancements – Target Wake Time

Target Wake Time (TWT): significantly improves battery life in Wi-Fi devices, such as Internet of Things (IOT) devices

Better Battery Life

- 802.11ax RUs and TWT available in 2.4/5G GHz for IoT
- Thanks to 2 MHz channels, Coexistence with other 2.4 GHz IOT technologies is possible
- Preamble Puncturing would allow Any RU to be left blank (modulation) to allow other technologies to operate – Steering the frame around an obsticle



Target Wake Time

Target Wake Time (TWT) provides an effective mechanism to schedule transmissions in time.

Phones and IoT devices can sleep conserving battery life and then wake to take advantage of multi-user transmissions, and coexist in high-density RF environments with ease.

802.11ax Target Wake Time Benefits for IoT

Better Battery Life and co-existence via RF efficiency improvements

Target Wake Time

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

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

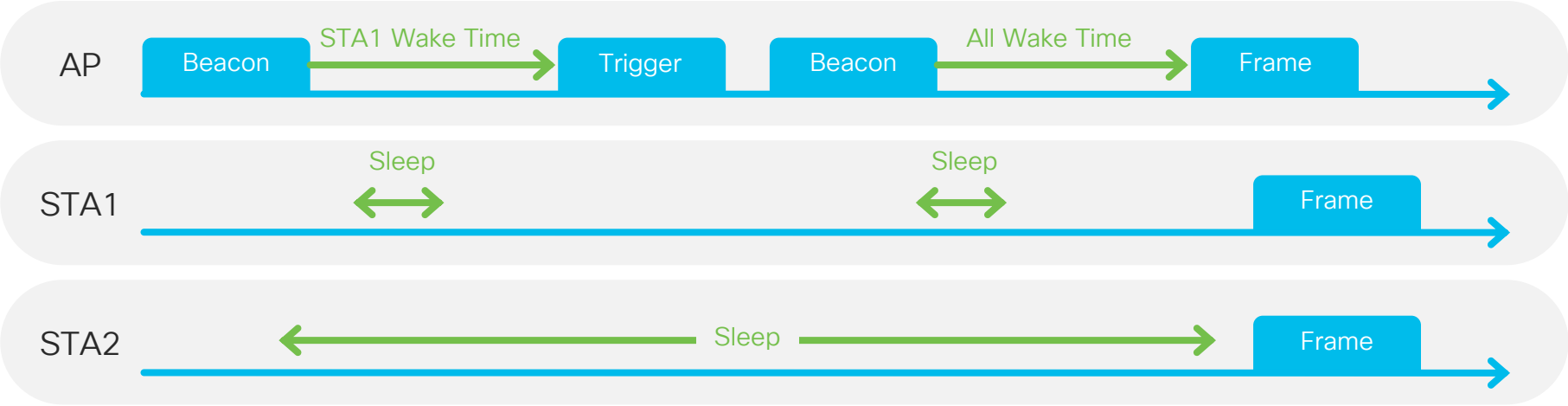


Image source: Broadcom

IoT Benefits using Wi-Fi 6

More IoT devices coming on line everyday – Strong need for 2.4 GHz

- Superior battery life for IoT and mobile devices – Using Target Wake Time
- Parallel Processing for Spectrum Efficiency MU-MIMO
- Small Packet aggregation (using OFDMA) for reduced latency
- Longer Guard interval for greater range outdoor links
- BSS Coloring helps increase channel reuse
- Better spectrum coexistence with other technologies e.g. Bluetooth, Zigbee

2.4 GHz No longer a junk band – It simply needs to work

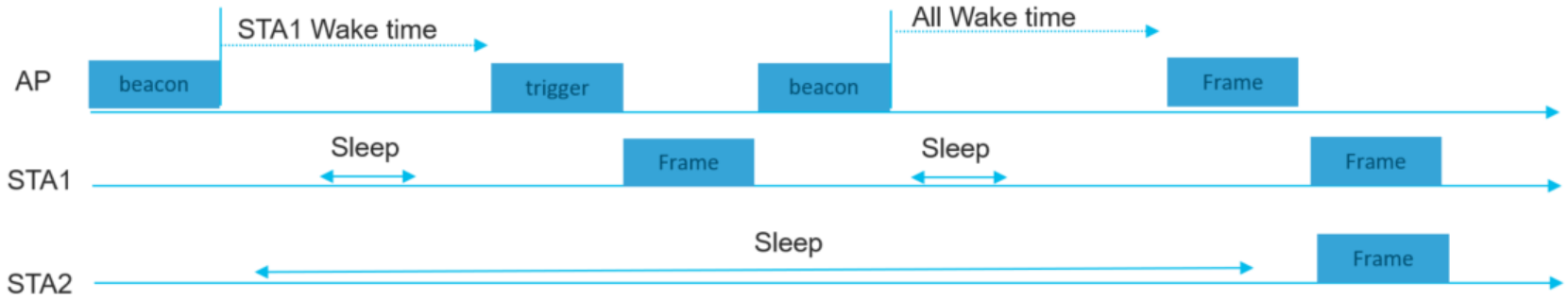
Target Wake Time – Putting Devices to Sleep

For your reference

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

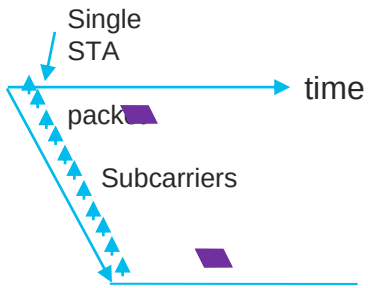
- Devices can be configured to wake up as a group to communicate at the same time sharing the channel for increased network capacity and reduced battery drain.

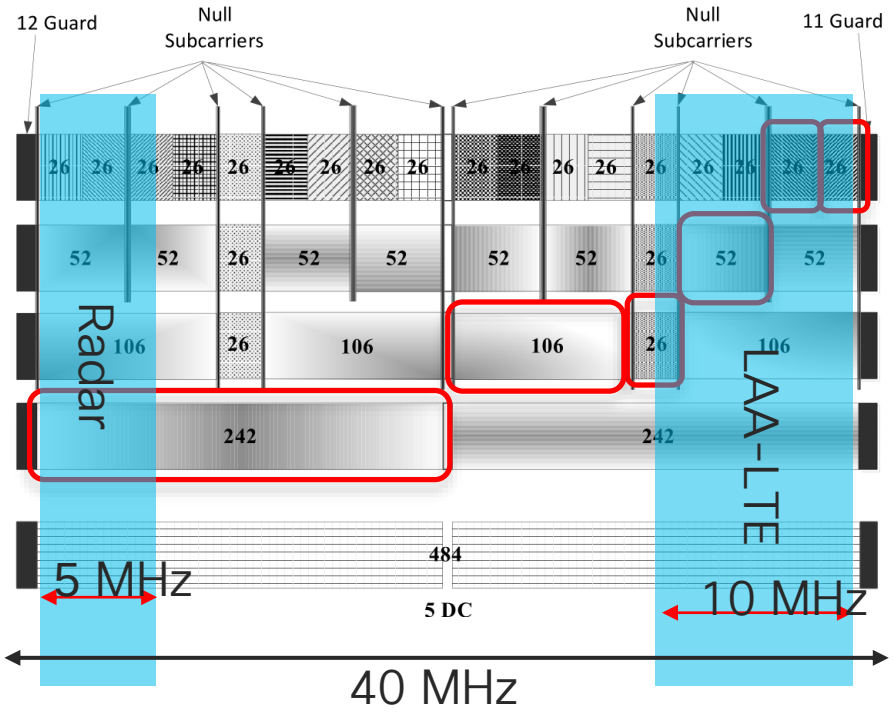
- Use of BSS Color field and UL/DL flag in preamble to enable intra PPDU power Saving



Miscellaneous PHY Features

- Preamble Puncturing:
  - If radar or another interferer like LTE-LAA/LTE-U / another BSS is using 10/20 MHz within the BSS operating bandwidth, we have waveforms now to transmit around it!
- Dual Carrier Modulation (DCM) mode: repeated information for narrowband interference protection





Miscellaneous PHY Features

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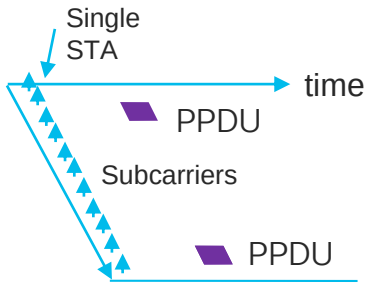
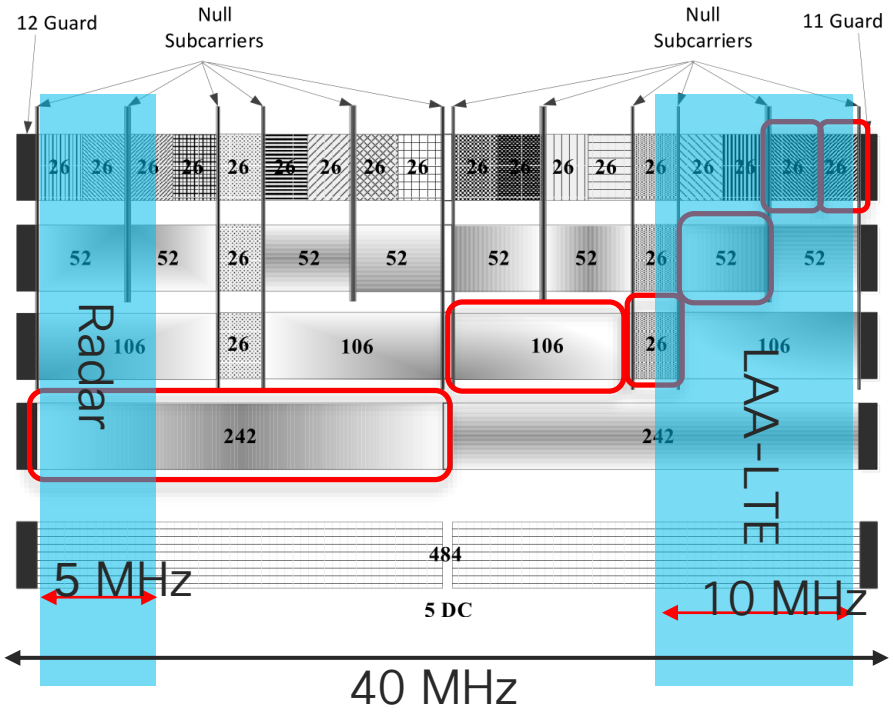
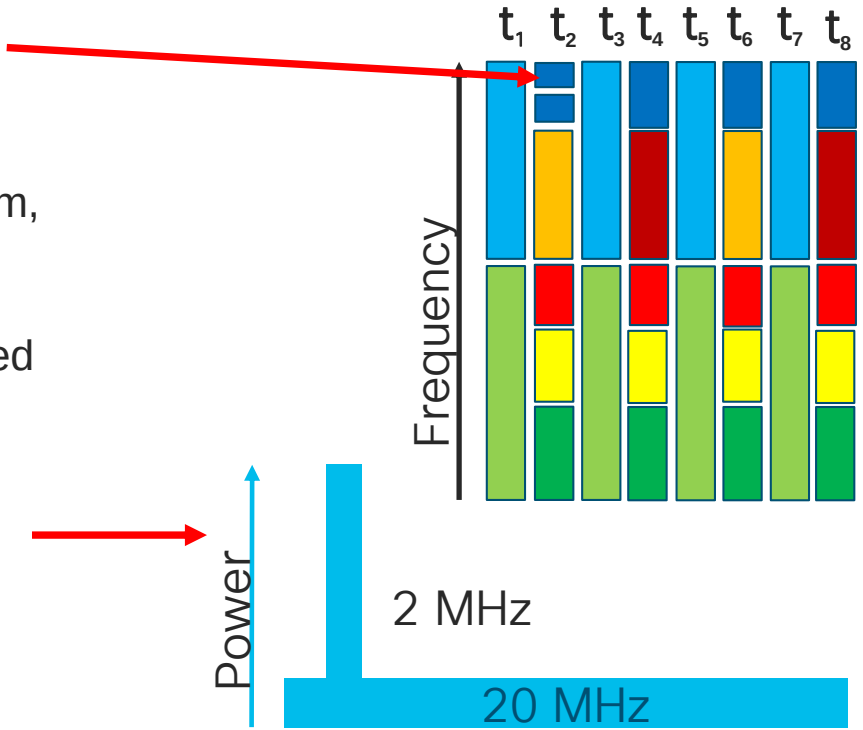




Benefits of 802.11ax for IOT
OFDMA, 375 kbps Low Power, Low Throughput

- 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/distance)
- 802.11a/g allowed only 6 Mbps minimum, 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



Resilient

Access Point Portfolio

Cisco Catalyst 9100 Series – Wi-Fi 6

For all campus types – deploy in infrastructure of choice

Introducing Catalyst 9130AX Access Point

Ideal for small to medium deployments | Mission critical | Best in Class

Powered by Cisco RF ASIC

9115AX

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

9117AX

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

9120AX

- 4x4 + 4x4
- Cisco RF ASIC
- Dual 5GHz, HDX
- RF Layer 1 detail
- IoT ready (Zigbee, Thread)
- Application Hosting
- 1 x 2.5 mGig
- TWT

9130AX

- 8x8 + 4x4 or 4x4 + 4x4 + 4x4
- Tri-radio (Dual 5GHz + 2.4GHz), HDX
- Cisco RF ASIC
- RF Layer 1 detail, Application Hosting
- Decrypted data packet iCAP
- IoT ready (Zigbee, Thread)
- Industry-first 8x8 AP with external antennas
- 8 port Smart Antennas
- 1 x 5 mGig

Cisco DNA Assurance with iCAP | Bluetooth 5 | USB | Integrated or external antenna SKUs

** Prices in USD, Cisco Global List Price. External antenna SKU are priced $100 more for C9115, C9120, and C9130*

Wi-Fi 6 Assurance Use Cases

DNAC Assisted Migration

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

Wi-Fi 6 Benefits

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

Cisco Wi-Fi 6 Innovations

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

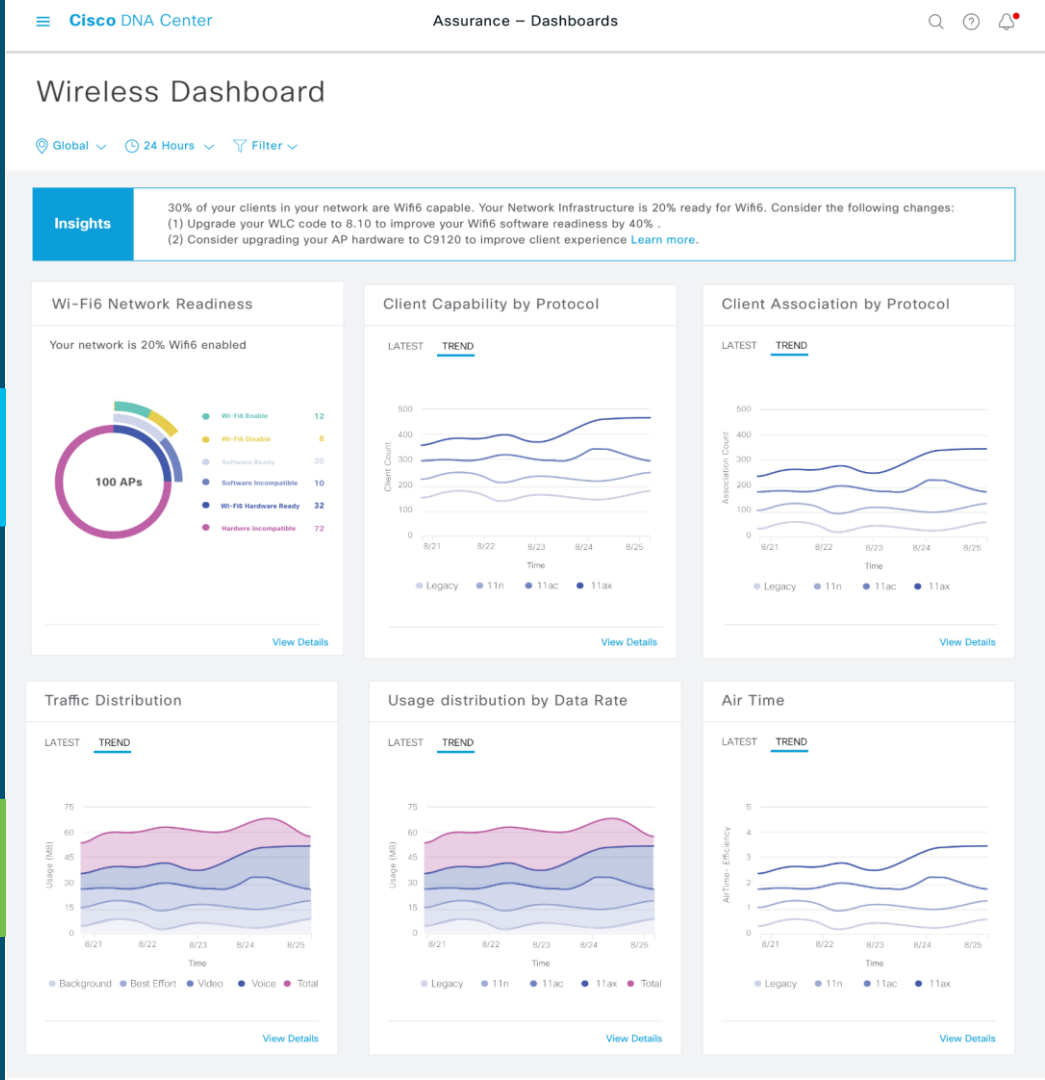
Client Troubleshooting

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

DNAC UX

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

Wi-Fi 6 Benefits
- Traffic Distribution based on AX technology
- AirTime Efficiency



DNAC UX

Client Troubleshooting

Cisco DNA Center DESIGN POLICY PROVISION ASSURANCE PLATFORM

Dashboards Insights

Client Health

Healthy Percent 100 40 0 2a

Location: Global

LATEST TREND

Wireless Clients

45% TOTAL: 38 Active: 38

38 Active Clients

Connectivity SNR

LATEST TREND

Clients

As of Aug 22, 2019 9:40 am

24 Hours TREND: Aug 22, 8:40 am - Aug 22, 9:40 am Global

Wireless Clients

LATEST TREND

45 % Healthy Clients

TOTAL: 38 Active: 38 Inactive: 0 New: 0

38 Active Clients

9 Not Onboarded

29 Onboarded

Association 13.16 %

Authentication 5.26 %

DHCP 5.26 %

Fair Connectivity 32 %

Good Connectivity 45 %

What locations having client Issues

What device types are impacted

What Wi-Fi standard is impacted most

Select a data type below to filter the proceeding table details.

Top Association Failure Reasons (Client Count)

cl_FLEXCONNECT_IE_MISSING_AID (5)

Top Locations (Client Count)

Global/San Francisco/One Bush Street/#1300 (5)

Top Access Points (Client Count)

AP4800.922C (4)

AP4800.606E (1)

Top Host Device Types (Client Count)

Android-Motorola (10)

Sensor-Client-1800S (1)

Sensor-Client-AP (1)

Top SSIDs (Client Count)

CiscoSensorProvisioning (5)

Top Bands (Client Count)

2.4 GHz (5)

Top Host Operating Systems (Client Count)

Sensor-Client-1800S (5)

Client Capability

11ax

11ac

Device ecosystem: Samsung Analytics

Client classification

Device Type | SW-OS | Firmware version | Tx Power

Client onboarding

Client-side forensics: Leverage client onboarding state machine failures to root cause issues

SAMSUNG

Client roaming

Client-side forensics: Leverage client authentication failures while roaming to root cause issues

Wi-Fi coverage*

Client RF View: Use client's RF to draw coverage view

*Roadmap

Samsung Analytics – Cisco DNA Center

Client 360 View

Client Health

Client 360

24 Hours: Oct 02, 1:09 pm – Oct 03, 1:09 pm

10/10 Galaxy-S10e

Device: Samsung Galaxy S10e OS: Android 9 MAC: 10:98:C3:7B:AF:4E IPv4: 12.1.0.7 IPv6: fe80:0:0:0:6200:353d:8832:fa41 VLAN ID: 12 Status: Connected Last seen: Oct 3, 2019 1:07:00 pm

Connected Network Device: AP7872.5DED.D23C SSID: samsung-analytics Last Known Location: -- View All Details

Relevant device information that only Cisco DNA Center Assurance will be able to show

Cisco DNA Center DESIGN POLICY PROVISION ASSURANCE PLATFORM

Detail Information Oct 3, 2019 1:09 pm

Device Info Connectivity RF

Information	
Device Type	Samsung Galaxy S10e
Operating System	Android 9
Firmware Version	SD7
Sales Code	TMB
Country Code	US
User Name	Unknown Wireless User
Host Name	Galaxy-S10e
MAC Address	10:98:C3:7B:AF:4E
IPv4 Address	12.1.0.7
IPv6 Address	fe80:0:0:0:6200:353d:8832:fa41
Status	CONNECTED

Connection Information	
Band	5 GHz
Spatial Streams	2
Channel Width	20 MHz
WMM	Supported
U-APSD	Disabled

Samsung Analytics – Cisco DNA Center
Client Event View

- Critical insights into client behavior – e.g. disassociation reason

Cisco DNA Center | DESIGN | POLICY | PROVISION | ASSURANCE | PLATFORM

Filter | Find

Oct 2, 2019

DHCP	AP:AP7872.5DED.D23C | WLC:veWLC | WLAN:samsung-analytics
Onboarding	AP:AP7872.5DED.D23C | WLC:veWLC | WLAN:samsung-analytics
Delete	Due to Idle Timeout | AP:AP7872.5DED.D23C | WLC:veWLC | WLAN:samsung-analytics
Client Sent DisAssociation	AP:AP7872.5DED.D23C | WLC:veWLC | WLAN:samsung-analytics
Client Sent DisAssociation	Disassociation Triggered by User - Airplane Mode
INTRA-WLC Roaming	AP:AP7872.5DED.D23C | WLC:veWLC | WLAN:samsung-analytics
Client Sent DisAssociation	AP:AP7872.5DED.D23C | WLC:veWLC | WLAN:samsung-analytics
DHCP	AP:AP7872.5DED.D23C | WLC:veWLC | WLAN:samsung-analytics

Client Sent DisAssociation — Oct 2, 2019 3:29:57 pm

Detailed Information

Status: Success

Details:

AP_MAC	78:72:5D:EE:B5:E0
AP_Name	AP7872.5DED.D23C
Frequency(GHz)	5.0
WLC_Name	veWLC
Radio	0
WLAN	samsung-analytics

Samsung Analytics – C9800 Web GUI

Cisco Catalyst 9800-CL Wireless Controller
17.1.20190820

Welcome Cisco

Monitoring > Wireless > Clients

Clients | Sleeping Clients | Excluded Clients

Total Client(s) in the Network: 1
Number of Client(s) selected: 0

Client MAC Address	IPv4 Address	IPv6 Address
1098.c37b.af4e	12.1.0.173	fe80::6200:353d:8832:fa4

Client

360 View | General | QOS Statistics | ATF Statistics | Mobility History | Call Statistics

General

User Name
N/A

MAC Address	1098.c37b.af4e
Uptime(sec)	14 seconds
WLAN Name	nbangalo-sa-open
AP Name	AP4C77.6D9E.61B2
Device Type	Samsung Galaxy S10e(Phone)
Software Version (Carrier Code)	SD7(TMB)
Device OS	Android 9
Client Performance	Signal Strength:-28 dBm Signal Quality:55 dB
Capabilities	HTTP
Fabric Status	Disabled
Last Disconnect Reason	User initiated disconnection - Device was switched to airplane mode

Top Applications

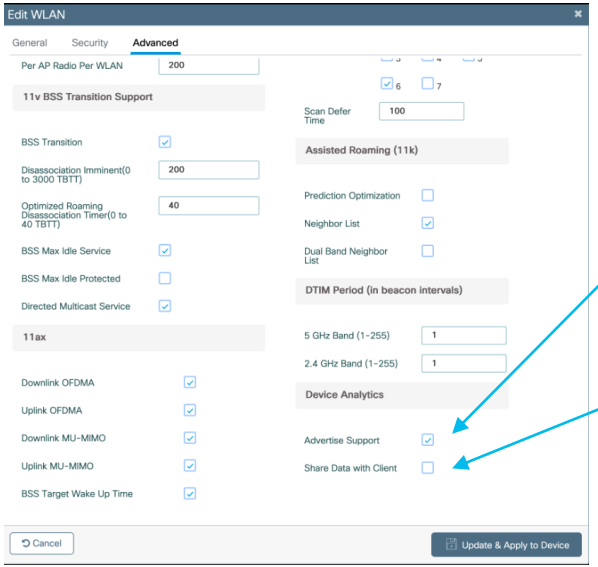
No data available

Information about the model number and the OS

Last user disconnect or failure reason

Samsung Analytics – Capability Exchange

- Samsung device will identify the Cisco infrastructure and vice versa
- This is configurable on a WLAN



- Advertises the capability to Samsung devices
- This will help Samsung Devices to send telemetry to Cisco AP's .
- This is enabled by Default
- Note : Enable Device classifier on the WLC to see this information on the controller

- Shares some information about Cisco Infrastructure with Samsung
- Shares the Generic Platforms Types and Firmware version
- This is disabled by default
- No identifiable information is send

Cisco Catalyst C9130AX I and E

Cisco Catalyst 9130 access points

Coming Soon

Ready for mission critical applications and devices

Note: Only 8x8 AP in the industry with external antennas

Cisco® Catalyst® 9130

Best in Class Wi-Fi 6 technology

Powered by Cisco RF ASIC

Platform benefits

Scale and Performance

- 8x8 + 4x4 or 4x4 + 4x4 + 4x4
- Tri-radio (Dual 5GHz + 2.4GHz)
- **4.8 Gbps** of total throughput, OFDMA with **37 RUs**
- 8-Port Smart Antennas

Integrated security

- WPA3, Trustworthy systems
- Multi-lingual AP with RF snapshots

Intelligent

- Full iCAP with decrypted data packet captures
- Client Analytics to enhance Cisco DNA Assurance

Delivering RF innovations | Extending Cisco's intent-based network | Expanding the device ecosystem

Comparing Catalyst 9117 to the 9130

- WFA certified for Wi-Fi 5
- No support for Dual 5 GHz
- Internal antenna only
- 8x8 pre-standard – Note: Uplink OFDMA not supported

- WFA certified for Wi-Fi 6
- Full Dual 5 GHz + 2.4 concurrently (true Tri-Radio)
- Internal and EXTERNAL

Bluetooth Low Energy (BLE) – Zigbee – Thread (*)

All Catalyst APs have Dedicated IoT Radio – 9120AX and 9130AX are hardware ready for IoT applications by also supporting BLE, Zigbee and Thread

BLE

Beacons, asset tracking, Way Finding

Zigbee

Home Automation, Lighting, telemetry for metering

Thread

IPv6 based for Manufacturing, Industrial, commercial

(*) This functionality is planned for future release CY20

Mounting Bracket Comparison
Aruba requires bracket take-down/replace

Mounting Bracket cost included in the access point price

AIR-AP-BRACKET-1

Customer need to purchase a mounting kit for an additional cost

Aruba AP backside with pre-installed mounting bracket

AP-MNT-MP10-D mounting kit to attach the bracket

Easy to deploy with Aironet series mounting brackets

Aruba Wi-Fi 6 APs cannot be mounted with Wave1 or 2 Aruba brackets

Catalyst 9130AX Power over Ethernet (PoE) Draw

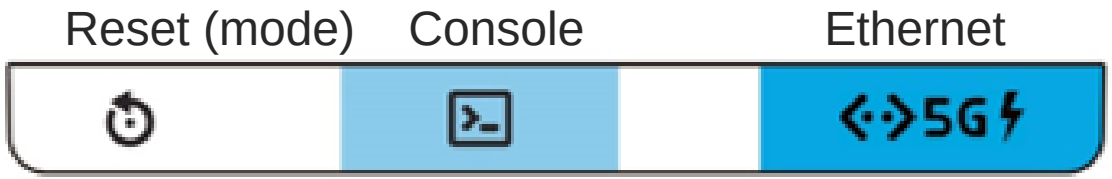
Catalyst 9130AXI					
PoE Power Consumption	2.4 GHz	5 GHz	Link Speed	USB	LLDP
802.3at (PoE+)	4x4	8x8	5Gbps	N	25.5W
802.3at (PoE+)	4x4	1x 4x4	5Gbps	Y (4.5W)	25.5W
802.3bt (UPoE)	4x4	8x8	5Gbps	Y (4.5W)	30.5W
Catalyst 9130AXE					
802.3at (PoE+)	4x4	1x 4x4	5Gbps	Y (4.5W)	25.5W
802.3bt	4x4	8x8	5Gbps	Y (4.5W)	30.5W
802.3bt (UPoE)	4x4	8x8	5Gbps	Y (4.5W)	30.5W
Catalyst 9130AX E and I					
802.3af (PoE)	1x1	1x1	1G	N	13.4W

Cisco's power efficiency over Aruba

	aruba (a Hewlett Packard Enterprise company)	cisco
PoE 802.3af	✗	✓ Limited Functionality
PoE+ 802.3at	✓ Limited Functionality	✓
UPoE 802.3bt	✓	✓

- ✗ Aruba recommends deploying 2x cables per AP → Extra cable/ deployment cost + Extra switch port cost $$$
- ✗ **Hitless PoE feature** would be **disabled** if using 2x 802.3at to power the AP
- ✗ Aruba only offer **2 low end switches** to support **3bt** power → **Downgraded** switching performance

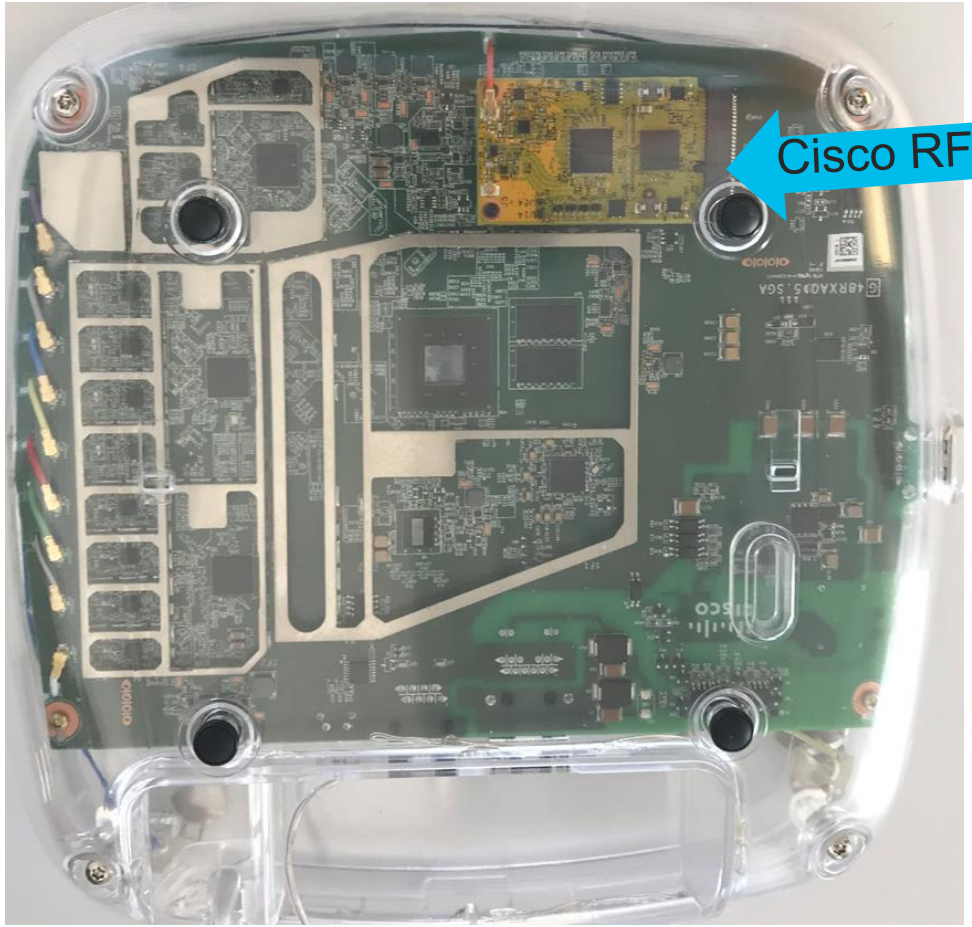
Catalyst 9130AX Ports



USB 2.0 Type “A”

USB Port w/cap

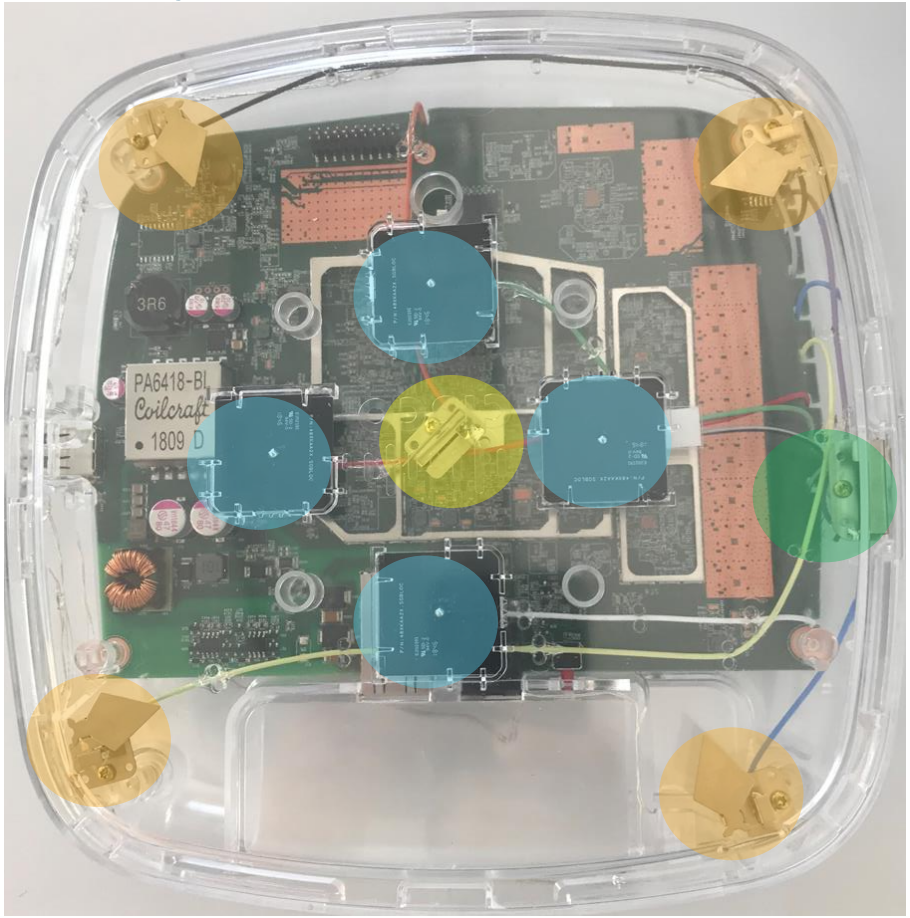
Catalyst 9130AX (backside)



Cisco custom RF ASIC

Software Defined Radio using a Mini-PCIe slot.

Catalyst 9130AXI Antenna System



(4) Dual Band “Macro” antennas
2.4 GHz @ 4 dBi
5.0 GHz @ 5 dBi

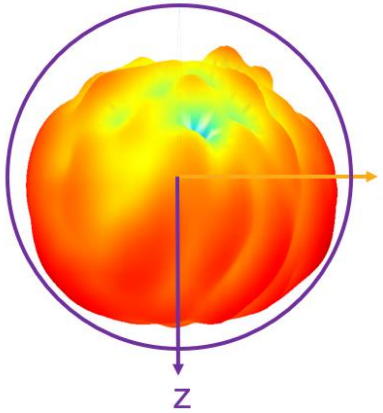
(4) 5 GHz “Micro” antennas
5 GHz @ 5 dBi

(1) IOT Antenna
2.4 GHz @ 2.5 dBi

(1) RF ASIC Antenna
2.4 GHz @ 4.5 dBi
5.0 GHz @ 5 dBi

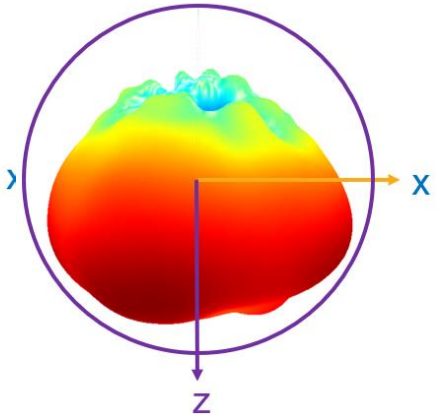
9130AXI Antenna improved over AP-4800

C9130AXI



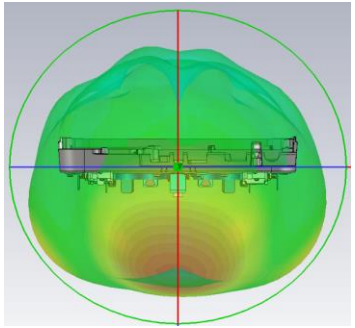
2.4/5G Macro

C9130AXI



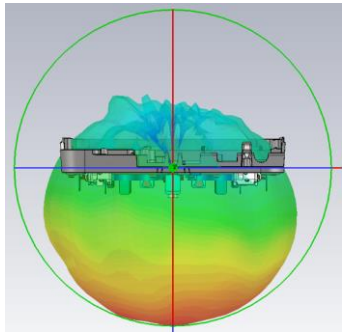
5G Micro/Meso Cell

AP-4800



2.4/5GHz Macro

AP-4800



5GHz Micro Cell

C9130AXI Antenna System expands Micro concept to Meso

Meso is a middle; intermediate cell (larger than Micro)

“FRA” Flexible Radio Assignment – Short version…

Fixing Problems Understanding dual XoR radio design – Dual 5 GHz design

- **Problem:** You designed a network for dense 5 GHz coverage, now you have too many 2.4 GHz radios as (2.4G range is 1.5x farther)
- Prior to the 2800/3800 your only option was to disable these radios. Disabling the radio provides no value other than making the 2.4 GHz spectrum manageable – Take-way without FRA you effectively wasted ½ the functionality of the Access Point crippling it to 5 GHz only. (FRA “Dual 5 GHz” allows the AP to run at 100%)

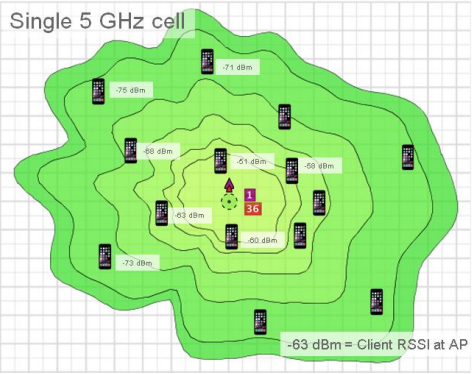
- Pervasive 2.4GHz and 5GHz coverage
- Default operating mode

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

Catalyst 9130 has Flexible Radio Assignment (FRA)

5 GHz is still more efficient than 2.4 GHz and Dual 5 GHz lowers channel utilization

Why does dual 5GHz matter with Wi-Fi 6 – A dual 5 GHz AP offers more cell coverage and flexibility options



Single 5 GHz Channel

Single channel 36 utilization at 60%
(clients far away take longer airtime)

Take-away

Using dual 5 GHz Means Equal Client Airtime - Faster data-rates & Less channel utilization

Dual 5 GHz Channels

Using Micro/Macro (Dual 5 GHz)
Channel 36 @ 20% channel utilization
Channel 108 @ 24% channel utilization.

Note: Internal antenna 9130 does Micro/Macro omni-directional cells

External antenna 9130 supports Macro/Macro or any combination as well as directional cell support.

C9130AXI and E 5 GHz Operational Modes and Criteria

5 GHz Radio Role		Drivers
Radio 1	Radio 2	
8x8 Client serving	NA	Preferred Operation in 160MHz or 80+80MHz Higher MU-MIMO Stations Lower Channel reuse requirement Required Higher Number of Spatial Streams (SS)
4x4 Client serving	4x4 Client serving	High Client Density and Capacity requirements Directional Antenna Units (Coverage Slicing) Operation as 80MHz or below
4x4 Client Serving	Monitor	Lower MU-MIMO Stations Low density, better channel reuse Monitoring Application Requires 4x4 RX

The Cisco Catalyst 9130 Tri-Radio transforms your network for scale and capacity

Cisco RF ASIC

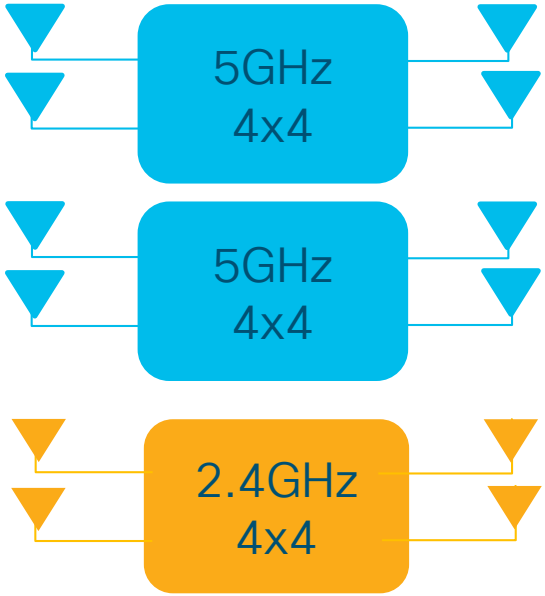
Cisco IOT Radio

Why Tri-Radio?

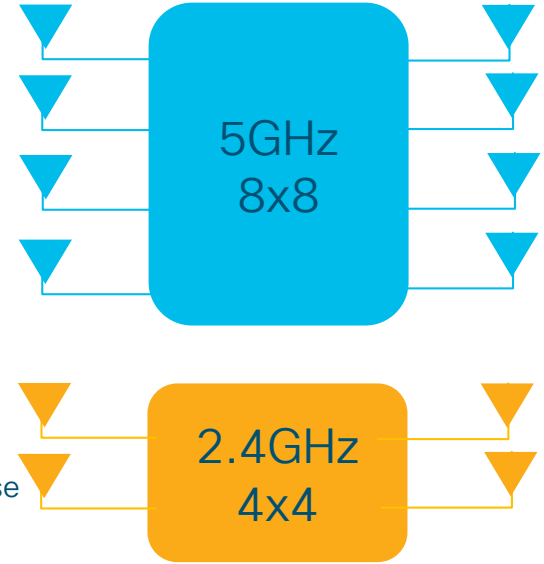
- 2 radios are better than 1, 3 is the best!
- More clients, greater performance across all Wi-Fi clients

Why 8x8?

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



Software enabled



Note: coming in 17.2 release

New Cisco Catalyst 9100 Series Access Points

Ideal for small to medium deployments | Mission critical | Best in Class

Powered by Cisco RF ASIC

9115AX

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

9117AX

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

9120AX

- 4x4 + 4x4
- Cisco RF ASIC for Next gen CleanAir
- Dual 5GHz, HDX
- RF Layer 1 detail
- IoT ready (Zigbee, Thread)
- Application Hosting
- 1 x 2.5 mGig
- TWT

9130AX

- 8x8 + 4x4 or 4x4 + 4x4 + 4x4
- Tri-radio (Dual 5GHz + 2.4GHz), HDX
- Cisco RF ASIC for Next gen CleanAir
- RF Layer 1 details, Application Hosting
- Decrypted data packet iCAP
- IoT ready (Zigbee, Thread)
- 8 port Smart Antennas
- 1 x 5 mGig
- TWT

Cisco DNA Assurance with iCAP | Bluetooth 5 | USB | Integrated or external antenna SKUs

Cisco Recommended Releases

Catalyst 9800 and 3504/5520/8540 AireOS Wireless Controllers

Access Points	IOS-XE	AireOS	DNA-C	Prime	CMX	ISE
C9115AX, C9117AX , C9120AX-I	16.12.1s	8.10.105.0	1.3.1.2	3.7	10.6.2	2.3 2.4 2.6
C9130AX-I	16.12.1s with AP DP	8.10.105.0	1.3.1.2	3.7	10.6.2	2.3 2.4 2.6
C9120AX-E C9130AX-E	16.12.2	8.10 MR1	1.3.2	3.7	10.6.2	2.3 2.4 2.6
Wave 2 APs	16.12.1s	8.5MR5	1.3.1.2	3.7	10.6.2	2.3 2.4 2.6

Catalyst 9130AXE (External Version)

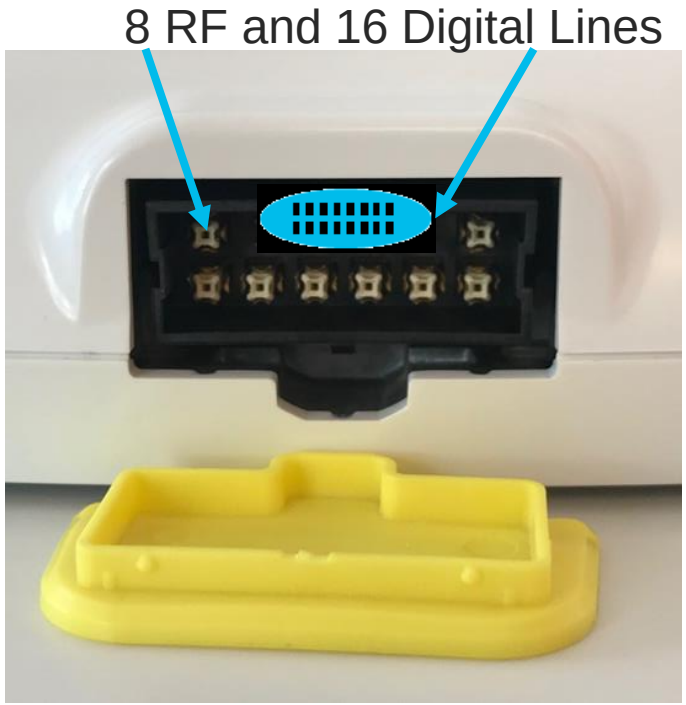
9130AXE – NO RP-TNC Connectors

THIS IS BIG… ☺

Only 8x8 AP with external antennas in the industry

With modes such as Dual 5G using 4x4 + 4x4 + (4x4 in 2.4G) The old RP-TNC was no longer practical for use on this type of device.

Catalyst 9130AXE Smart 8 Connector Port



9130AXE does not have internal antennas or RP-TNC connectors

NOTE: Do not operate unit without first connecting the antennas.

Use **AIR-CAB-002-D8-R=** adapter or new style – with C9130AX-E

New 8x8 External Antennas (Project Marlin)

3 new antennas to support 8 port external antenna APs for Catalyst 9130AXE

1. Catalyst C9101: Ceiling Mount omni, similar to AIR-ANT2524V4C-R=
2. Catalyst C9102: Wall/pole mount omni, similar to AIR-ANT2544V4M-R=
3. Catalyst C9103: Wall/pole mount patch, similar to AIR-ANT2566D4M-R=

1. Develop 8-DART connector to simplify installation
2. Include Self Identifying Antenna (SIA) circuitry to automate provisioning
3. Include LED to mimic AP LED status
4. Include new Industrial Design to match new 11ax APs

C-ANT9101=

C-ANT9102=

C-ANT9103=

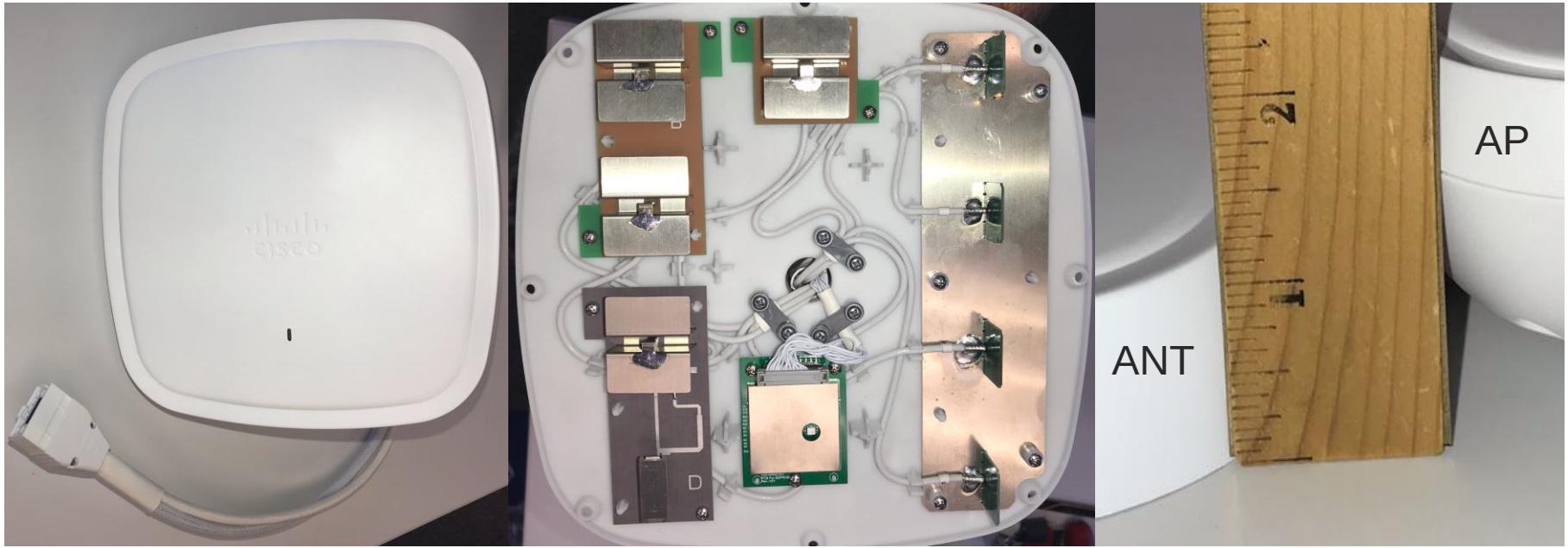
External antenna use cases (Ceiling Mount)

C-ANT9101=

- New antenna design to mimic AP appearance including LED Light
- Aesthetics, smaller profile on the ceiling than the AP
- Mounts in-tile has plenum cable
- Easy to install (DART connector)
- Allows AP to mount above ceiling for a more secure and tamper resistant install

External Antennas for Catalyst 9130

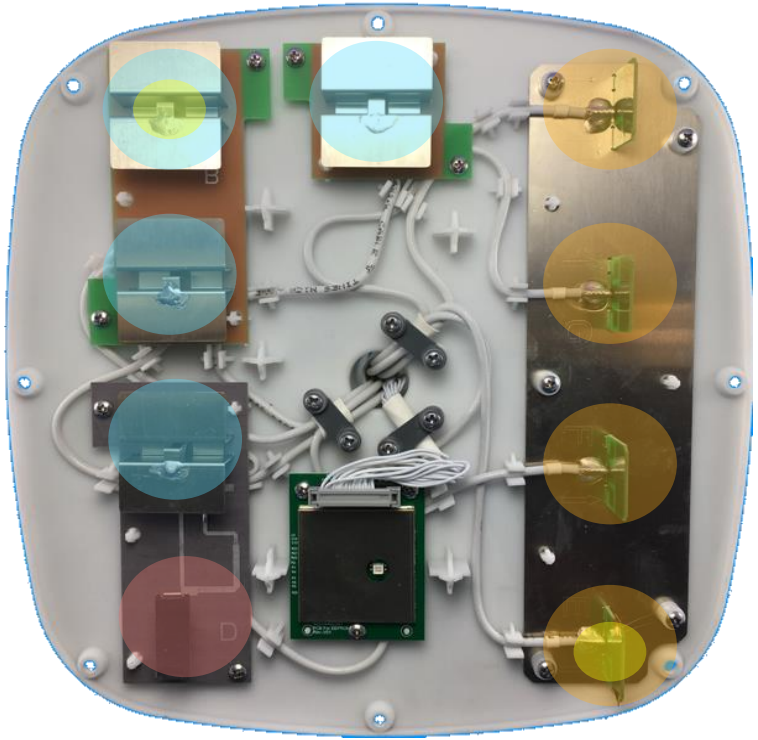
Cisco antenna PID C-ANT9101 – Ceiling Omni



Smart antenna with LED, Plenum cable and ½ thickness of the Access Point

Great for areas where AP needs to be in locked enclosure or for aesthetics

Inside C-ANT9101 Antenna (Marlin-1)



(4) Dual band (Macro) antennas
2.4 GHz @ 2 dBi
5.0 GHz @ 4 dBi

(4) 5 GHz (Meso) antennas
5 GHz @ 4 dBi

(1) IOT Antenna
2.4 GHz @ 2.5 dBi

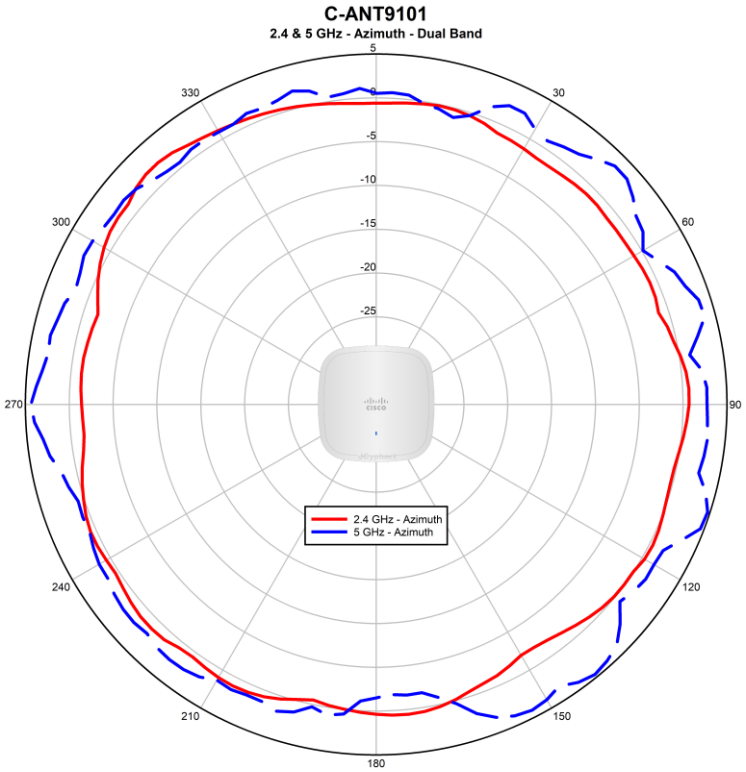
(1) RF ASIC Antenna
(Switched as needed)

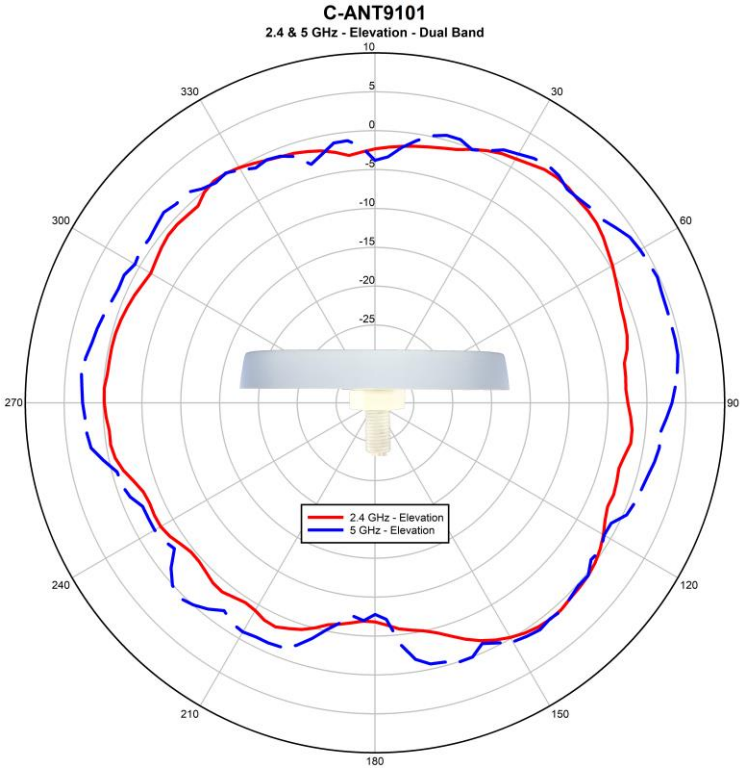
Nut and washer goes behind tile secures antenna

Antenna in the tile – AP and in tile antenna

C-ANT9101 – Dual Band 2.4/5GHz

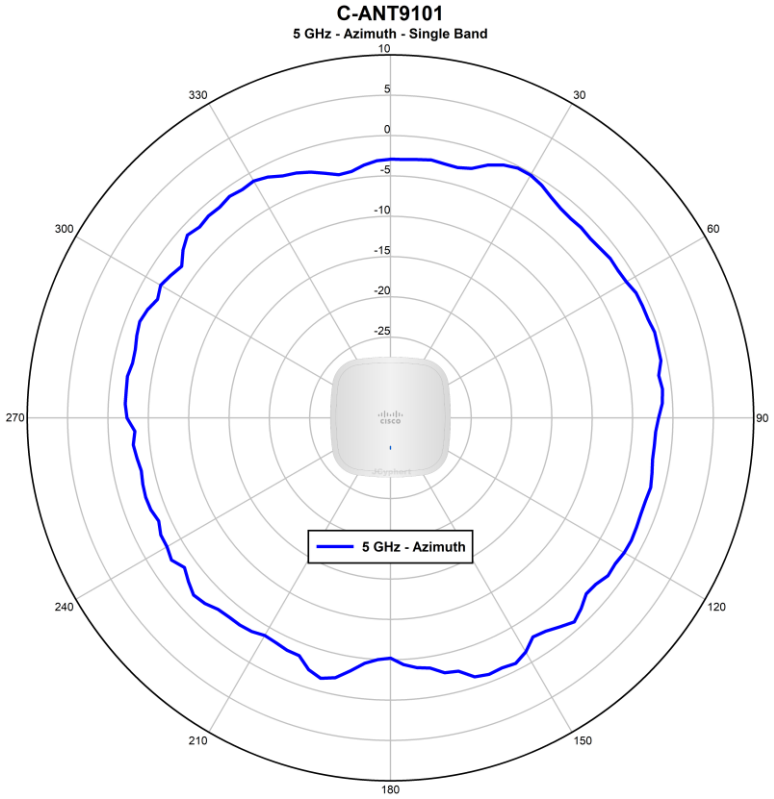
For Your Reference

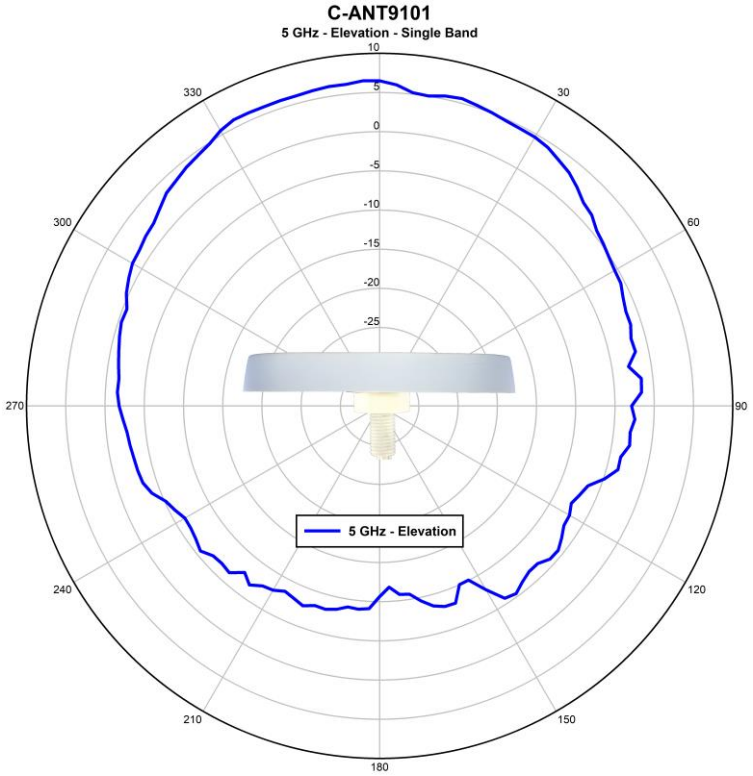




C-ANT9101 – Single Band 5GHz

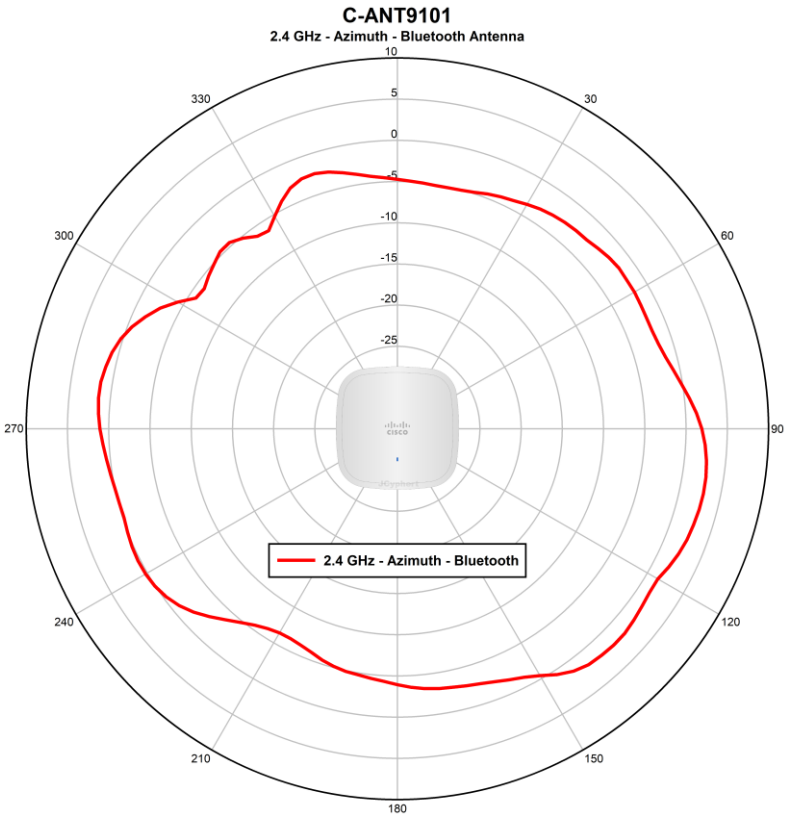
For Your Reference

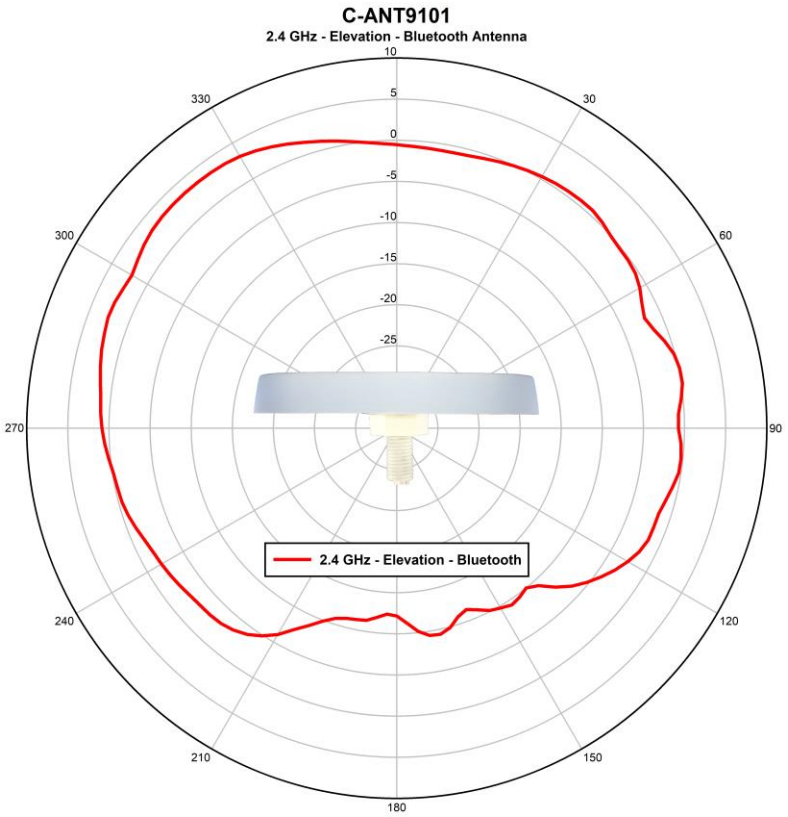




C-ANT9101 – Bluetooth Patterns

For Your Reference





External antenna use cases (Ceiling Pole Mount)

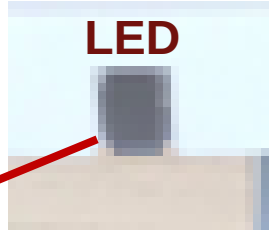
C-ANT9102=

- Non Ceiling mount
- Manufacturing and Retail allows for pole and wall mounting
- Self Identifying / configuring Antenna
- LED light to indicate active
- Supports Dual 5 GHz Macro/Micro operation

External Antennas for Catalyst 9130

Cisco antenna PID C-ANT9102 – Wall/Pole Mount Omni

Lexan
EXL 9330



Smart antenna with LED, will have an 8 Port DART connector,

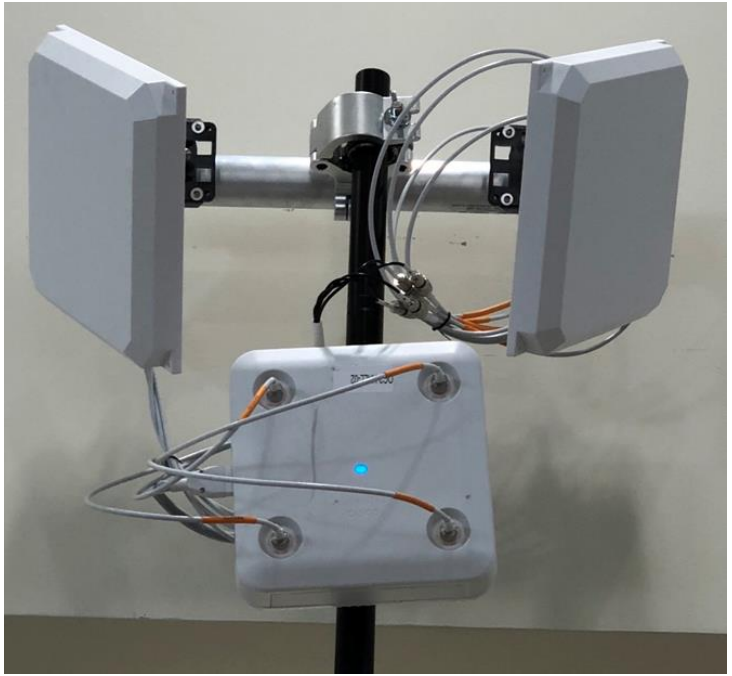
External antenna use cases directional (Patch)

C-ANT9103=

- New design to mimic AP look
- Similar to 6 dBi AIR-ANT2566 focusing signal in a given direction
- Manufacturing and Retail allows for pole and wall mounting
- Option to mount AP behind antenna – right angle DART
- LED light to indicate active
- Supports Dual 5 GHz Macro/Micro operation

Connecting antennas used to be ugly

Cisco 8 antenna ports



Aruba limited 4 antenna port

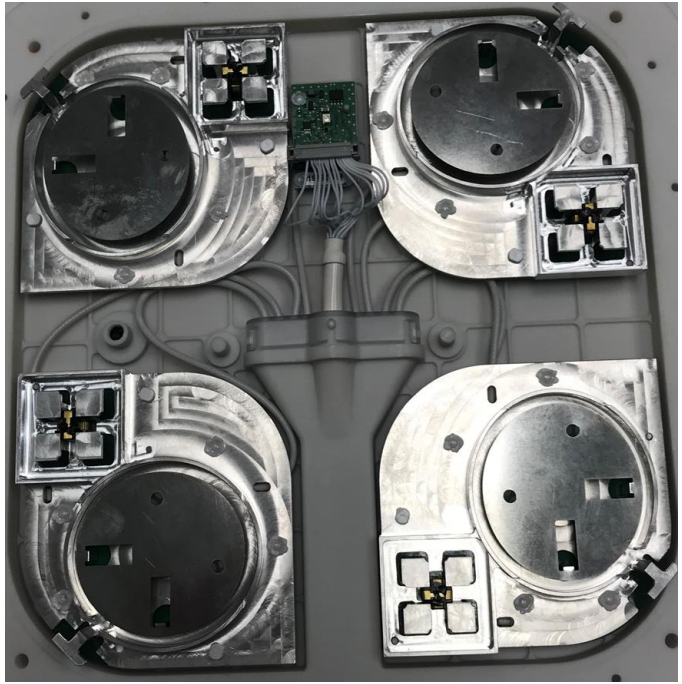
External Antennas for Catalyst 9130

Cisco antenna PID C-ANT9103 – Patch Antenna with 1 connector

Smart antenna with LED, will have a right angle DART connector,
Option to mount the AP behind the antenna for a “no cable look”

External Antennas for Catalyst 9130

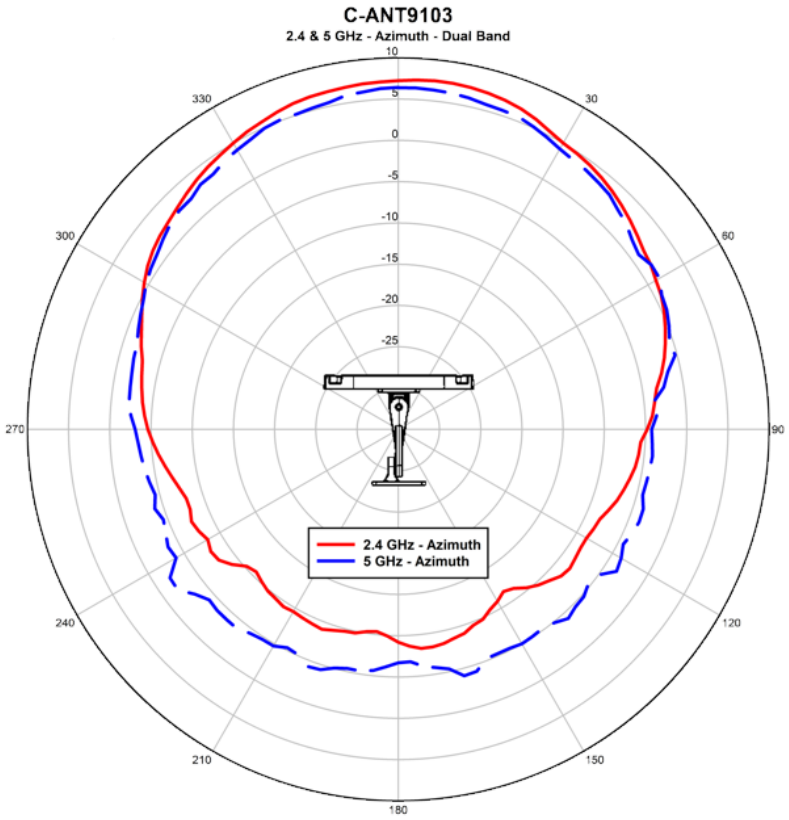
Cisco antenna PID C-ANT9103 – Patch Antenna

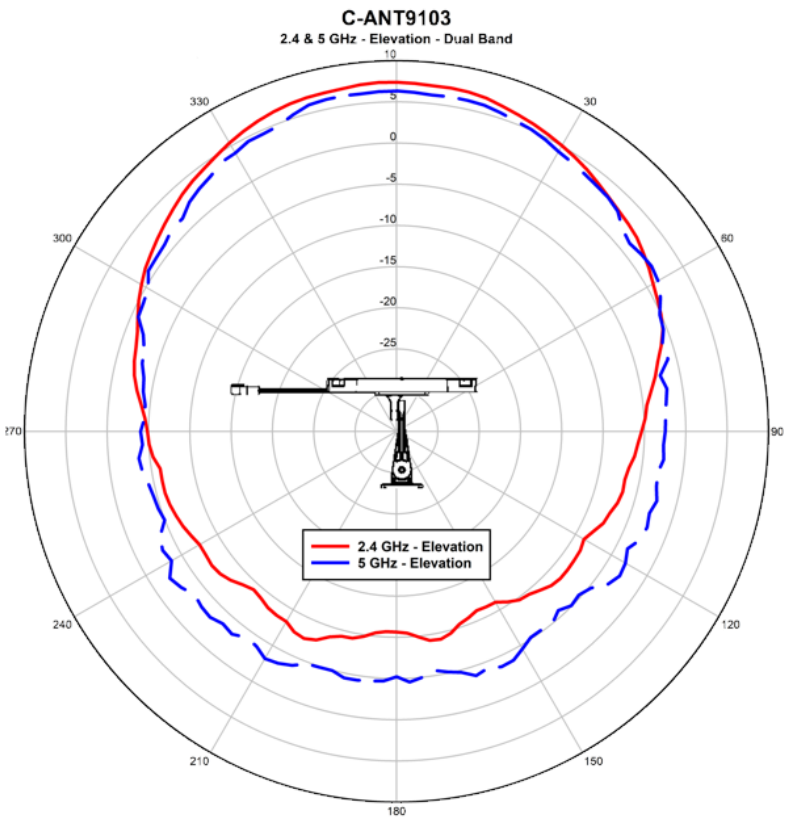


Smart antenna with LED, will have a right angle DART connector,
Option to mount the AP behind the antenna for a “no cable look”

C-ANT9103 – Dual Band Antennas

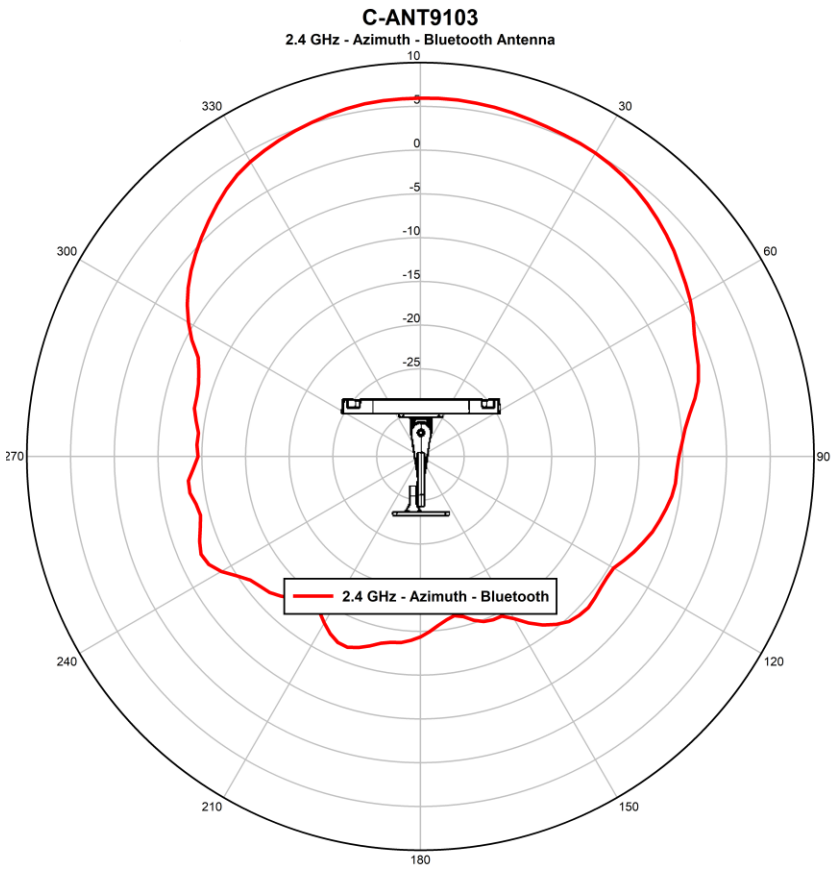
For Your Reference

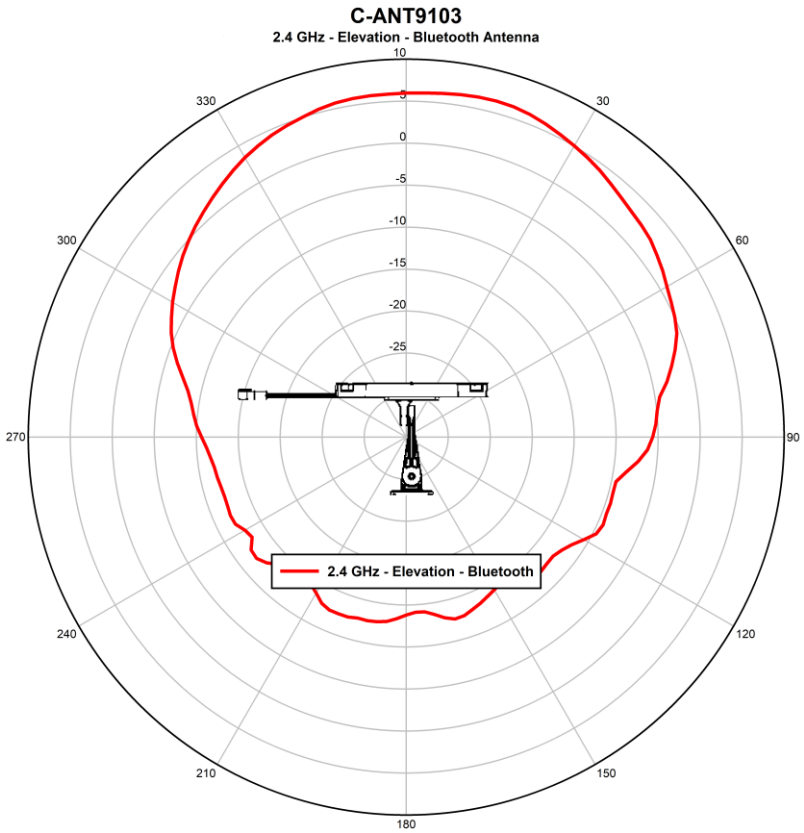




C-ANT9103 – IOT/BLE Antenna

For Your Reference





DART Adapter is for legacy antennas

Catalyst 9130AXE is really designed for use with self identifying antennas

These antennas allow the Access Point to run at Maximum Power

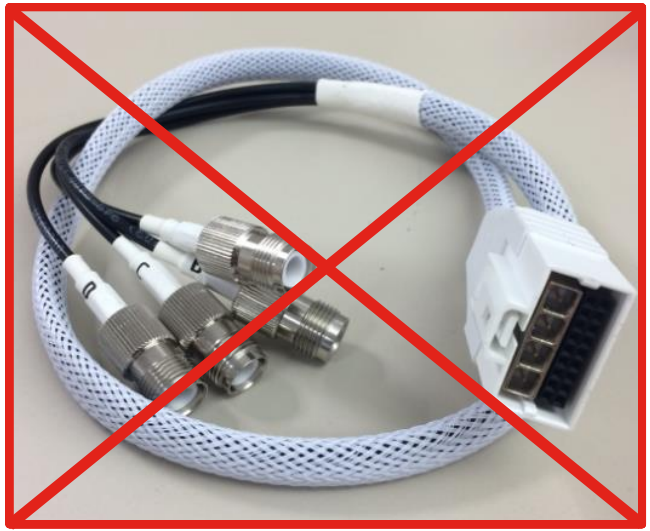
Use of a DART ADAPTER (8 port on 9130AXE) or 4 port on 9120AXE will put the AP in legacy mode and will limit gain to ***6 dBi***

Catalyst 9130AXE with legacy antennas

Note: There are two adapter cables one for RP-TNC and a one for “N” connectors is coming…

Cisco PID AIR-CAB002-D8-R=

This is for Catalyst 9130AXE DART to EIGHT RP-TNC Jacks

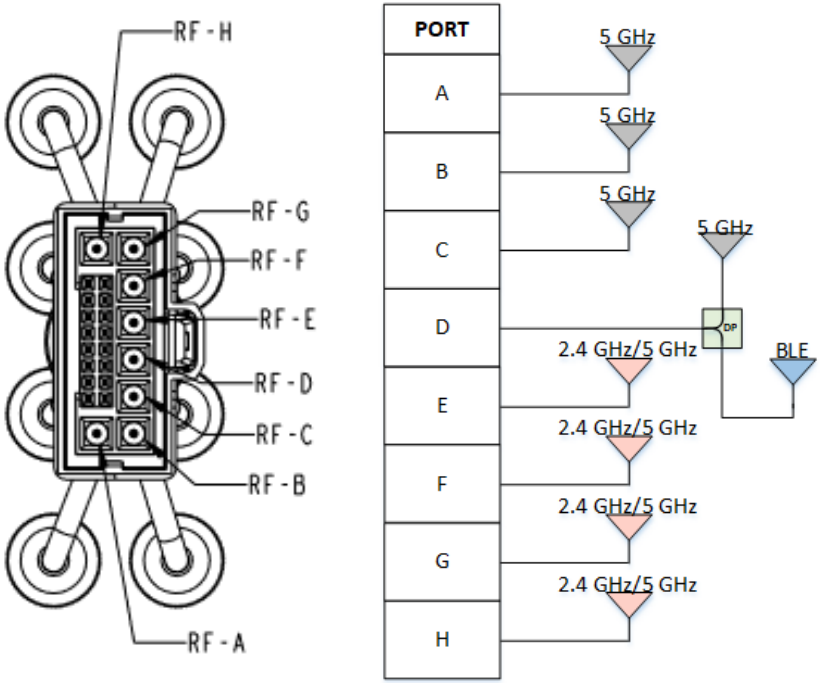


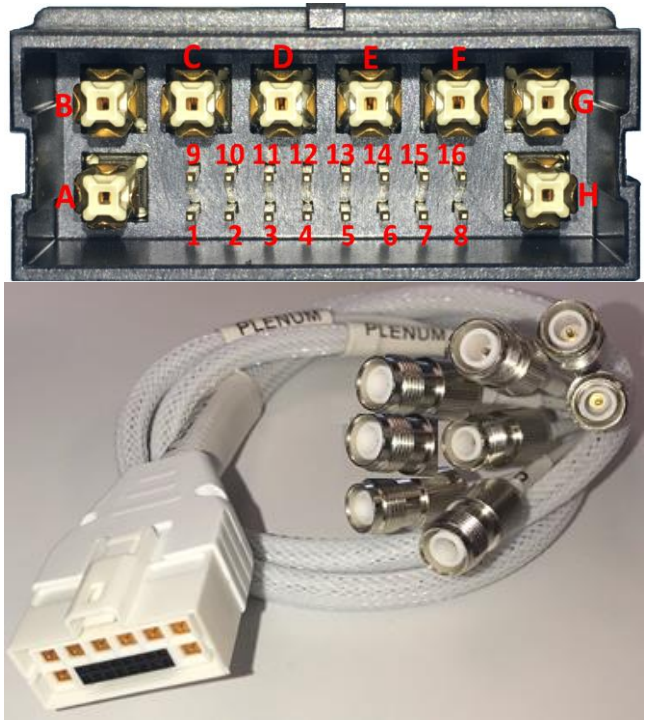
Cisco PID AIR-CAB002-DART-R=

This is only for 2800/3800 and Catalyst 9120AXE this is not compatible with the Catalyst 9130AXE Access Point.

Catalyst 9130AXE uses a NEW SMART connector

Cisco PID AIR-CAB-002-D8-R=





Cable is LMR-100 w/insertion loss @ 2.7 dB and is UL-2043 Plenum Rated

IoT & RF ASIC radios have visibility into ports A-D and E-H

Catalyst 9120AXE (External Version)

New Feature

Self-Identifying Antennas

External models (Far more complex) 9120AXI (internal) and 9120AXE (external)

9120AXI (preferred)

Discrete antennas not combined, no cables very elegant

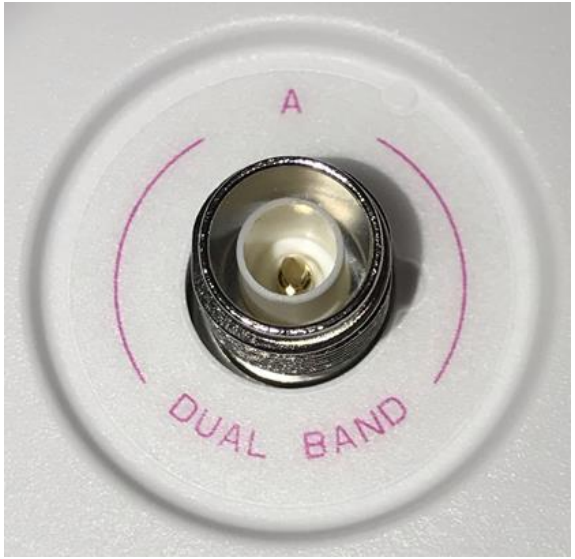
Self-Identifying Antenna Port

4 Dual Band antenna Ports + additional RF ASIC and IoT antennas

Self-Identifying Antenna Port "DART"

4 XOR antenna Ports + additional RF ASIC and IoT antennas

Catalyst 9120AXE has a SIA PORT



RP-TNC PORT “A” on 9120AXI is **PURPLE** and indicates the port can read “SIA” Self Identifying Antennas – There is circuitry to read SIA antennas connected to Port “A” – Orange is our standard non-SIA antenna dual band port color – SIA antennas can be used on any port but are read on “A”

Use case for Self Identifying Antennas

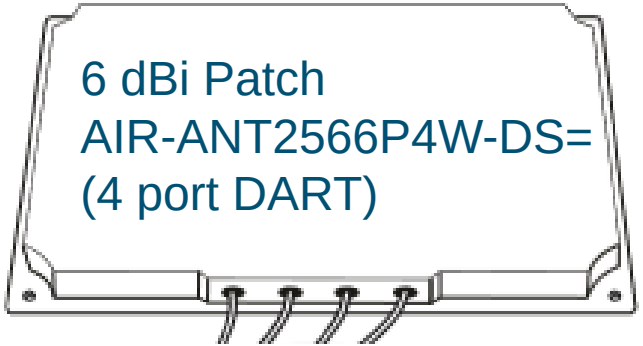
- Without a Self-Identifying Antenna – The Access Point assumes a 6 dBi antenna is connected and sets RF power table accordingly.
- When a SIA 2.2 dBi Dipoles are used the AP can RAISE it's transmit power – An advantage the internal antenna Access Points have.
- If a higher than 6 dBi antenna is recognized via SIA, the AP can dynamically set the power back and allow the antenna to be used.
- Allows for the software to know what antenna is used and potentially eliminates the need (going forward) for "Professional install" models on later versions of APs such as the 9130

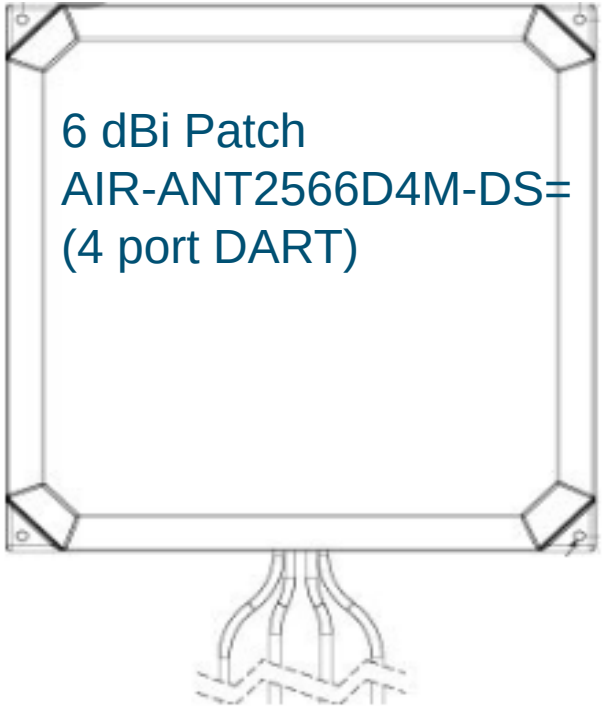
List of Self Identifying Antennas WIP

For Your Reference

Product ID	Description		Gain	Models*
AIR-ANT2524DW-RS/=	2.4 GHz 2 dBi/5 GHz **4 dBi Dipole Ant.,** White, connectors RP-TNC		2 dBi (2.4 GHz) 4 dBi (5 GHz)	9120E 9120P
AIR-ANT2535SDW-RS/=	2.4 GHz 3dBi/5 GHz **5 dBi Low Profile Antenna**, White, connectors RP-TNC		3 dBi (2.4 GHz) 5 dBi (5 GHz)	9120E 9120P
AIR-ANT2566P4W-RS=	2.4 GHz 6 dBi/5 GHz **6 dBi Directionnel Ant.,** 4-port, connectors RP-TNC		6 dBi (2.4 GHz) 6 dBi (5 GHz)	9120E 9120P
AIR-ANT2524V4C-RS=	2.4GHz 2 dBi/5GHz **4 dBi Ceiling Mount Omni Ant**., 4-port, connectors RP-TNC		2 dBi (2.4 GHz) 4 dBi (5 GHz)	9120E 9120P
AIR-ANT2544V4M-RS=	2.4GHz 4 dBi/5GHz **4 dBi Wall Mount Omni Ant.,** 4-port, connectors RP-TNC		4 dBi (2.4 GHz) 4 dBi (5 GHz)	9120E 9120P
AIR-ANT2566D4M-RS=	2.4 GHz 6 dBi/5 GHz **6 dBi 60 Deg. Patch Ant**., 4-port, RP-TNC		6 dBi (2.4 GHz) 6 dBi (5 GHz)	9120E 9120P

NEW ANTENNAS for the Catalyst 9120AXE
6 dBi Directional antennas with DART termination



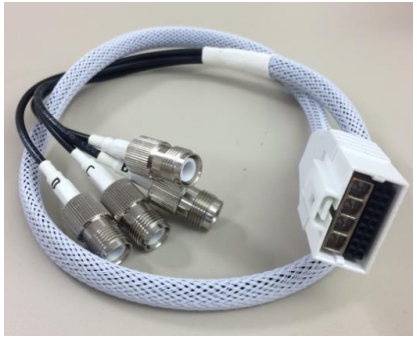


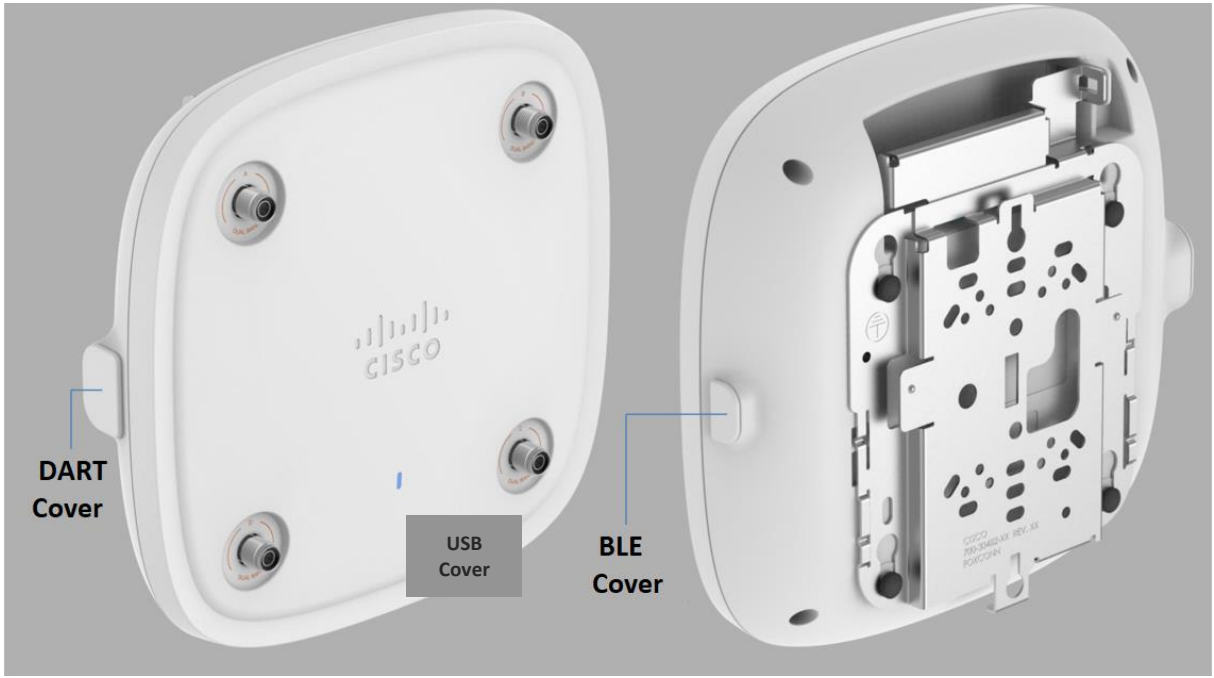
Now available with 4-Port DART connectors

Coming end of year

Catalyst 9120 External Antenna Version – DART

4 Port DART



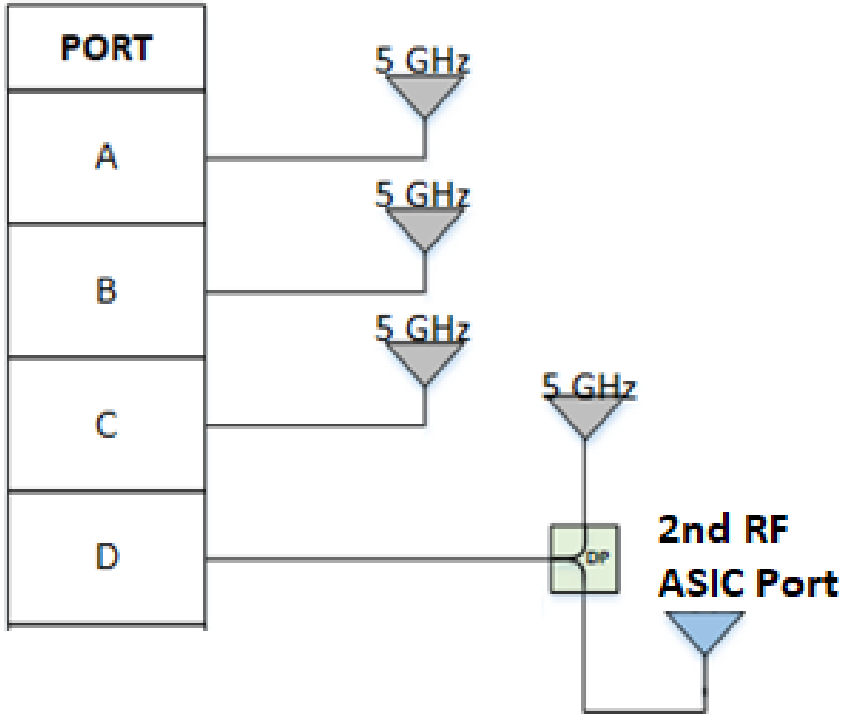


AIR-CAB-002-DART-R= Allows existing antennas to be used and is compatible with 2800, 3800 and Catalyst 9120.

4-Port DART Adapter Port Breakdown

16 Lines of Digital (SIA EEPROM)

Catalyst 9120 when DART adapter is connected RF ASIC 2nd port enabled (for DFS etc.)

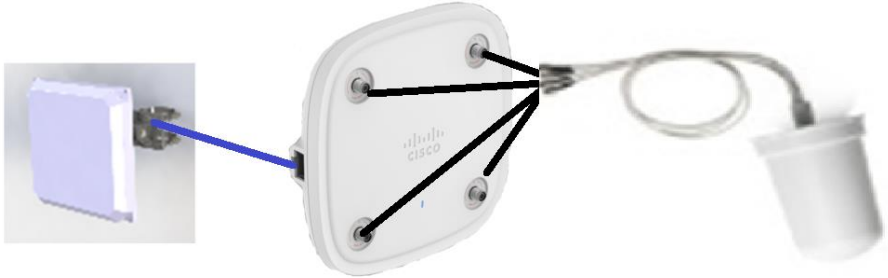


Catalyst 9120 supports Dual 5 GHz on DART

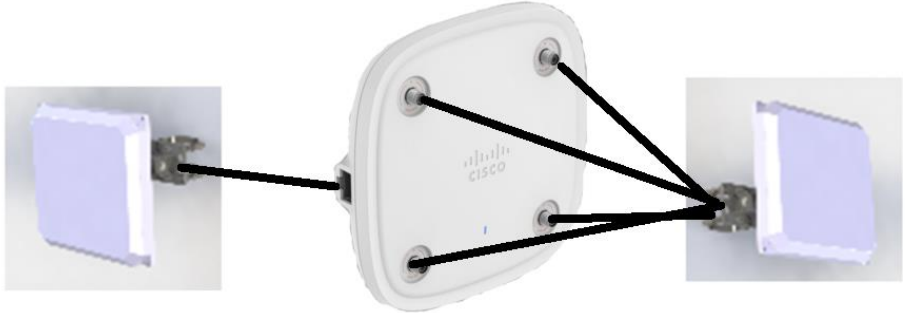
DART connector allows for any combination of Macro & Micro Cells

When DART is not used AP is simply a Dual Band AP

When DART is used 2.4 shuts off on top & another 5 GHz radio enabled on the DART connector.



Supports both Omni and Directional Deployments

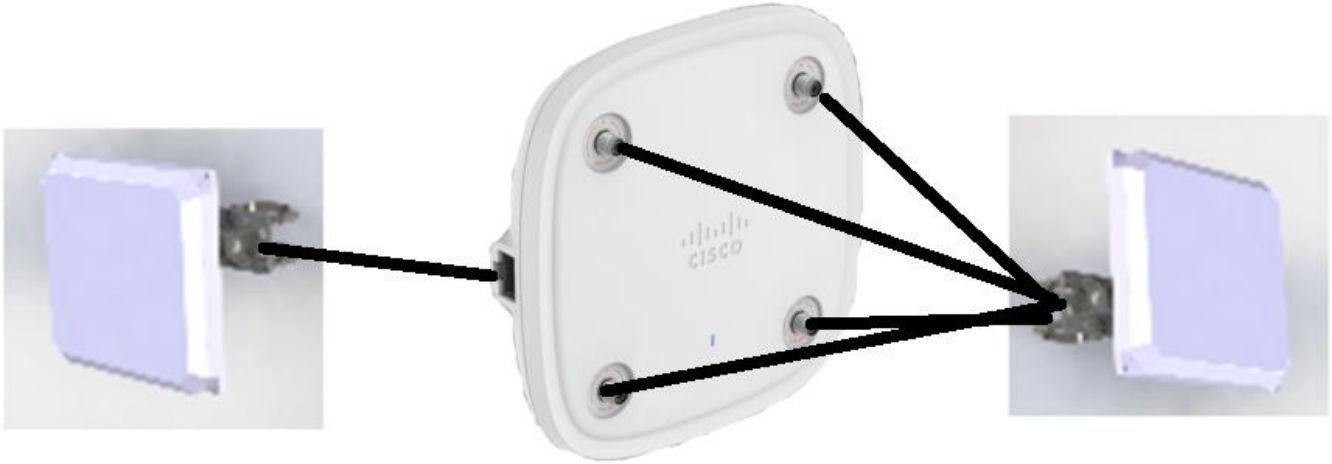


Supports directional antennas when the requirement is for two different coverage areas

Catalyst C9120AXP (Professional Install)

Orderable now

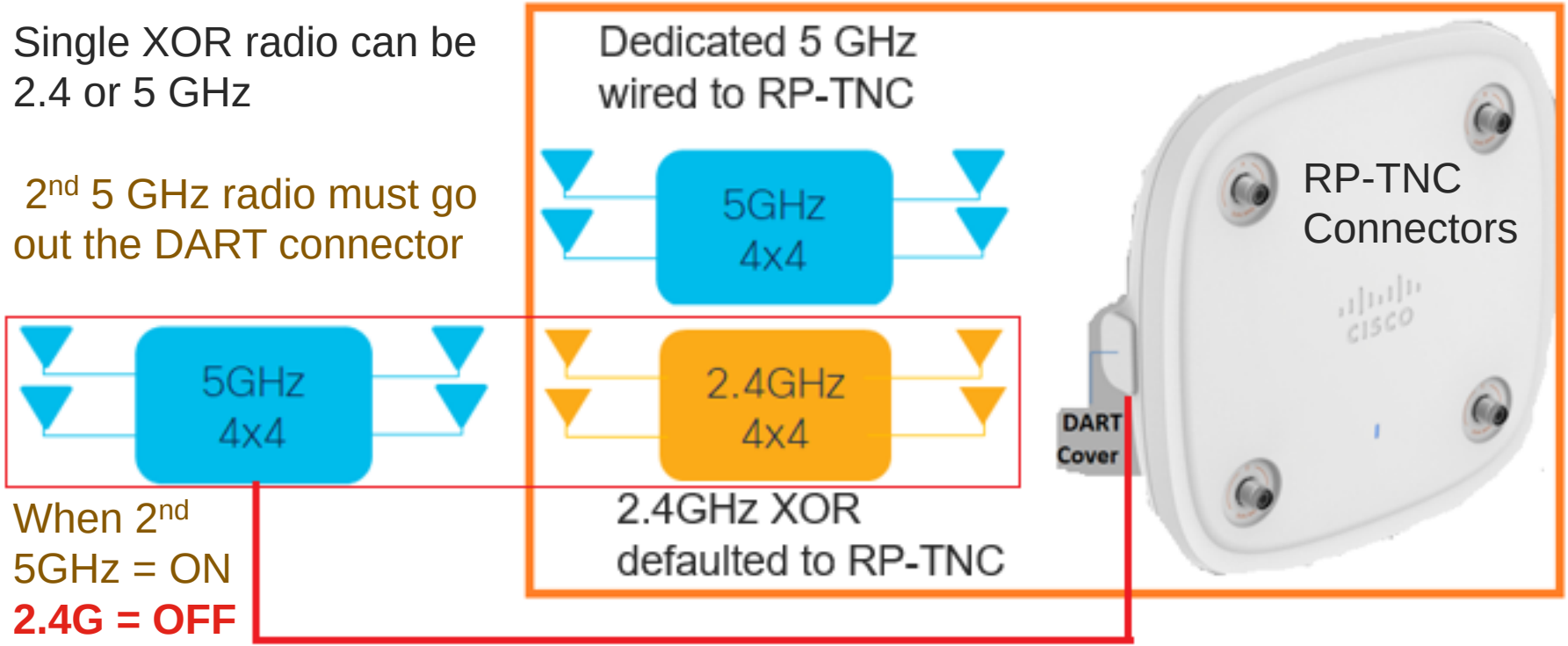
9120P available for Professional install with the High Gain stadium antenna



Dual Radio 5 GHz XOR Example Catalyst 9120AXE

Single XOR radio can be 2.4 or 5 GHz

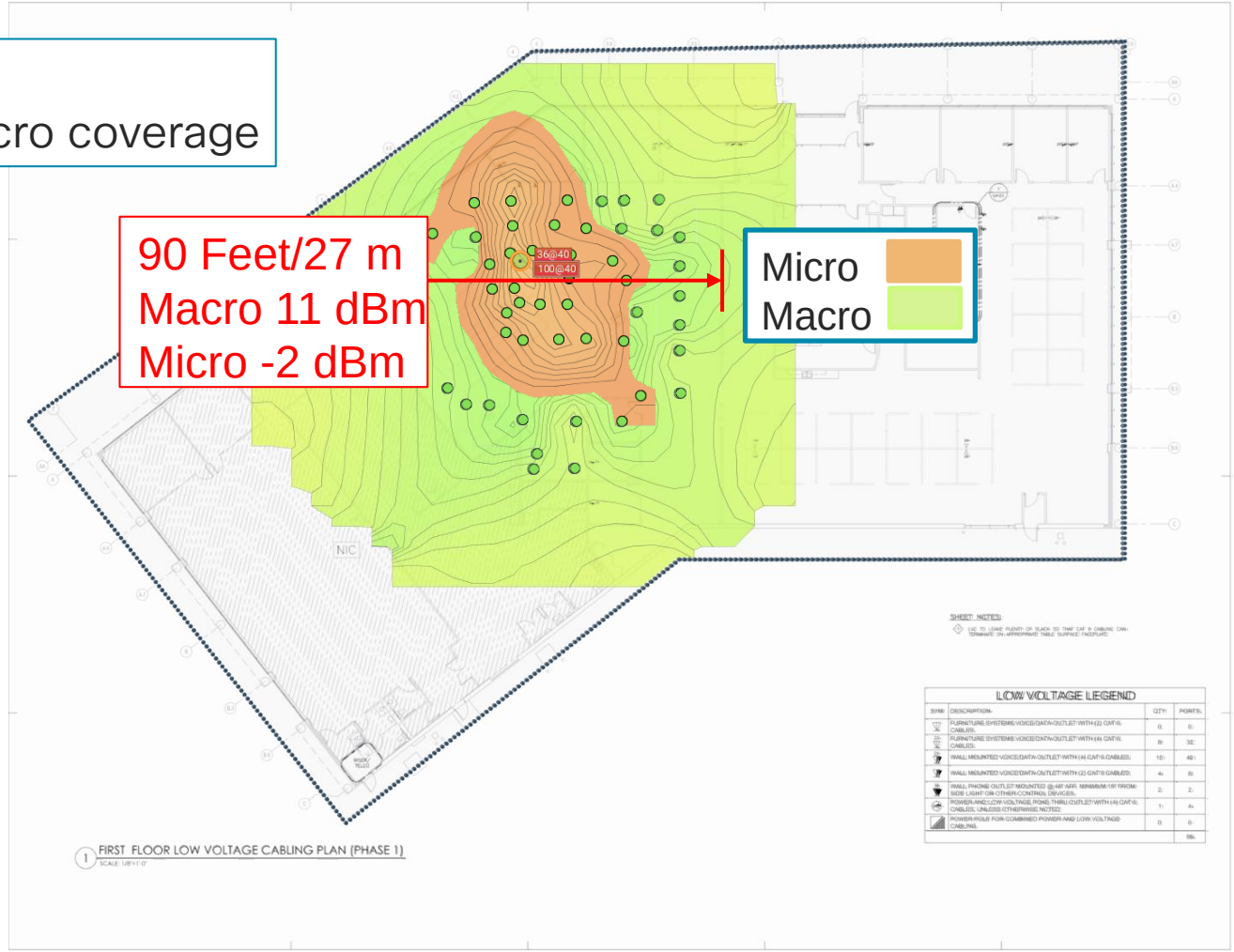
2nd 5 GHz radio must go out the DART connector



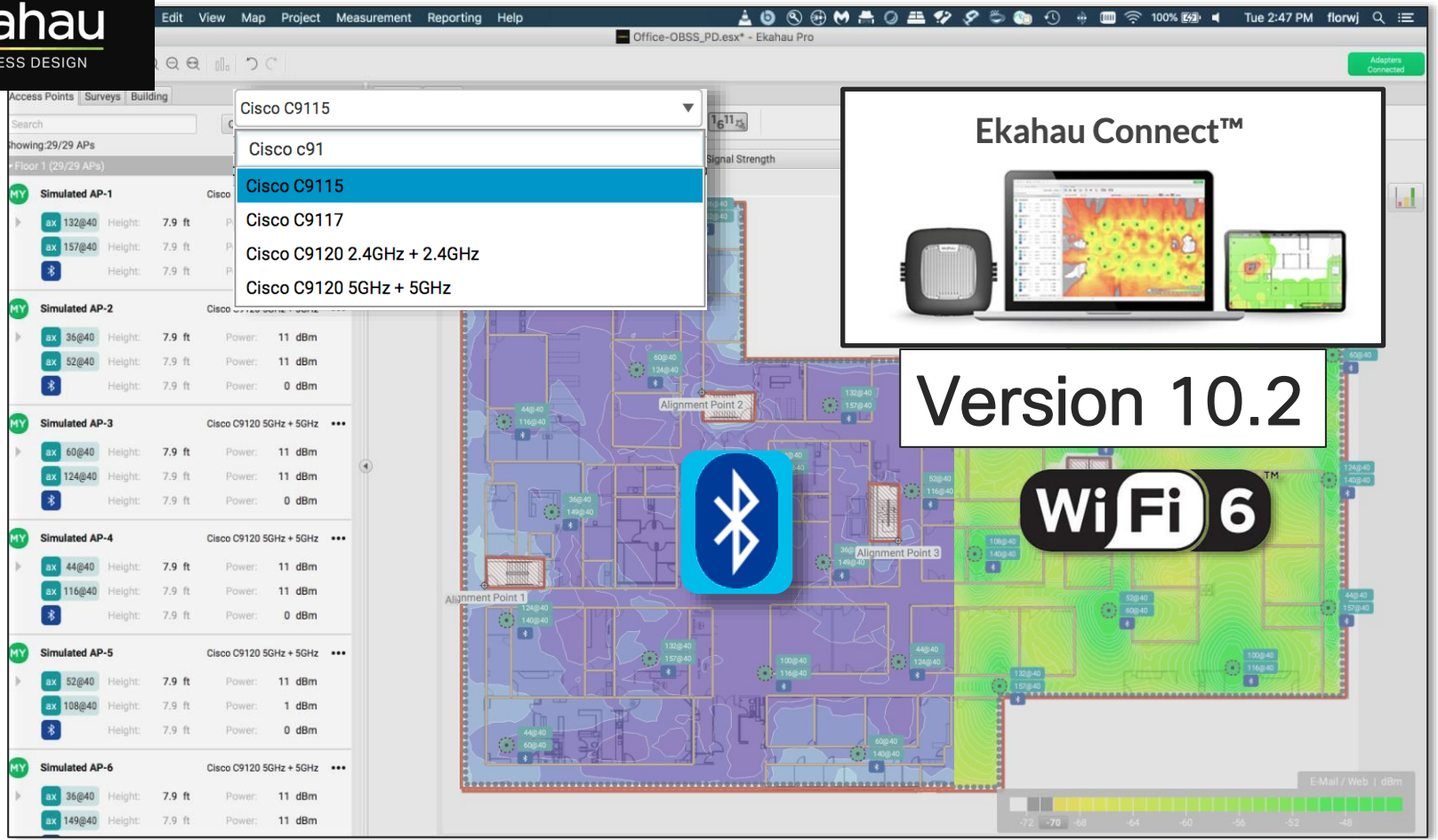
When 2nd 5GHz = ON

2.4G = OFF

C9120AXi
Macro/Micro coverage



ekahau
WIRELESS DESIGN

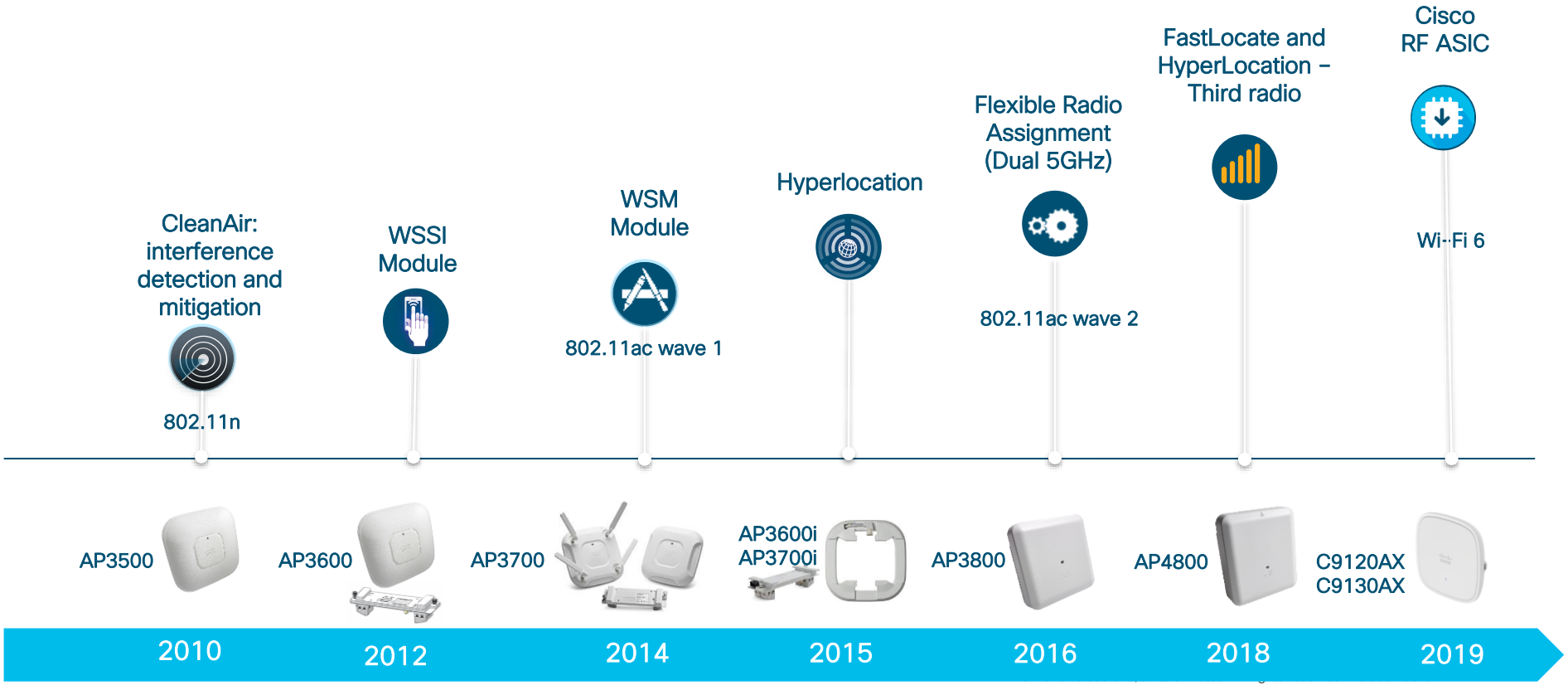


cisco Live!

Cisco RF ASIC – Vector DSP analysis Engine

CleanAir and so Much more– on Steroids

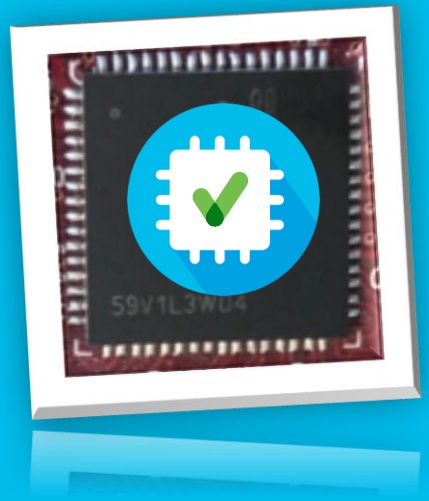
Cisco RF ASIC – A long History of Cisco Innovation



Catalyst 9120 & 9130 Access Point powered by Cisco RF ASIC

Embedded with superior analytics and security for mission critical deployments

Cisco RF ASIC



- Offchannel RRM
- Clean Air
- Zero-Wait DFS*
- Dual Filter DFS
- Fastlocate w/o performance impact
- aWIPS/WIDS Rogue Detection

*Roadmap

Cisco’s IS Best in Class RF Excellence

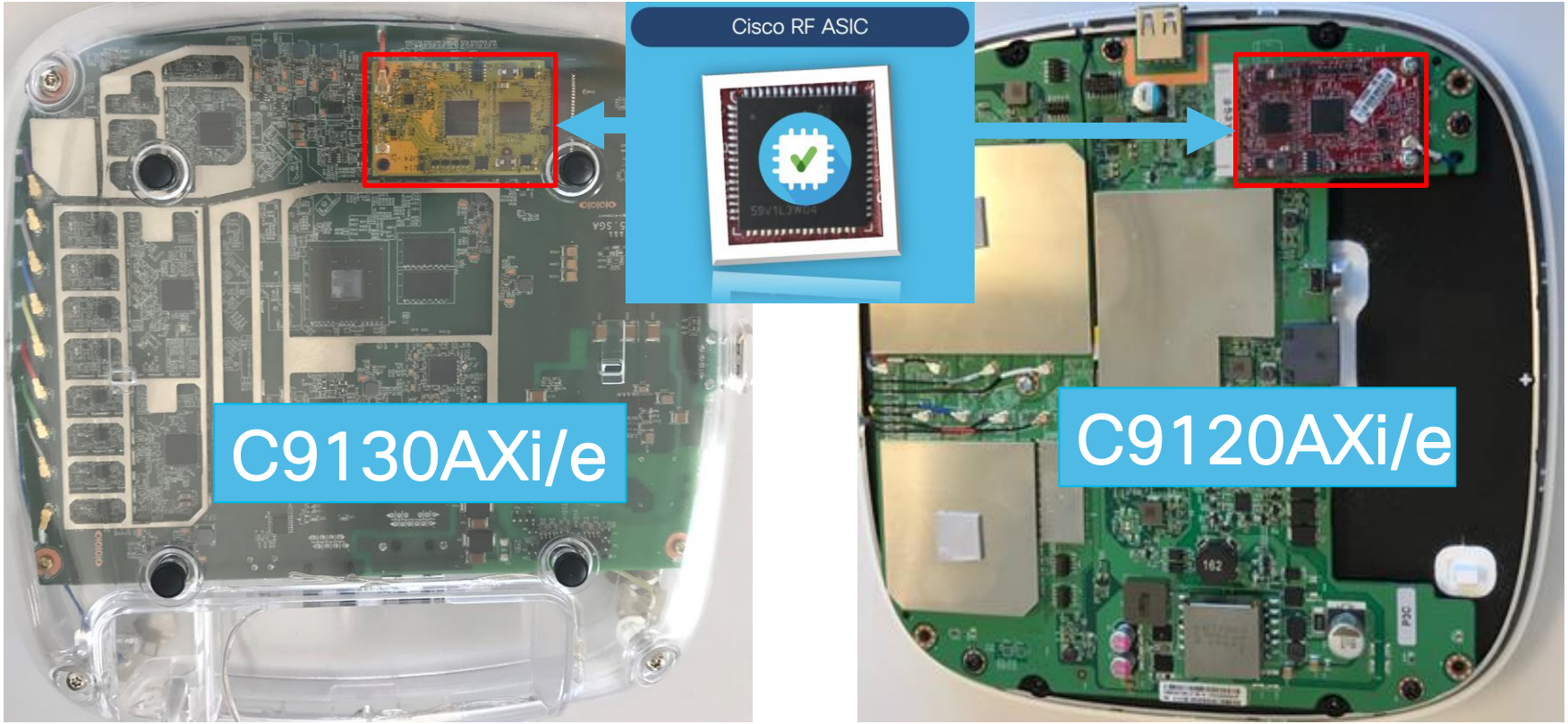
Cisco RF ASIC

Services/Features <u>need</u> Spectrum Information

- Location Services
- RRM
- CleanAir
- aWIPS/WIDS
- Rogue Detection
- DFS Detection
- IOT

- Requires 4 AP’s at greater than -75 dB
- Must constructively coordinate the spectrum
- Identify and manage non Wi-Fi interference sources
- Effective security monitors all threat vectors
- Must monitor all channels for clear resolution
- Highly Regulated, very Important
- Are you the party to whom I have called?

Spectrum Is Precious and getting crowded



OffChannel RRM

Spectrum Management Requires Data
Off Channel Scanning – on Every Cisco AP

OffChannel RRM

- Off Channel Scanning – legacy AP (anything with 2 radio interfaces today)
  - All Channels must be scanned EVERY 180s within 3 Minutes
  - Dwell time is 50 ms, 10 ms for channel change = 60 ms off channel
  - 180s / 25 Channels = off channel dwell every 7.2s
- Off Channel Scanning for WSSI/WSM module and 4800 AP
  - Continuous cycle 1200 ms Dwell across 2.4 and 5 GHz
  - Supports RRM, aWIPS/WIDS, Rogue, fastLocate, Cleanair
  - Serving Radio still required for NDP Tx off channel as the module/third radio has no active transmitter
- C9120AX and C9130AX and RF ASIC
  - All the above
  - Plus! Better radios, Custom ASIC, Tx for NDP, and more.

Roadmap Item

Does it make a Difference?
High Client Density 11ax/11ac Performance Setup

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

High-Density Client Test- Results
Cisco Wi-Fi 6 vs Cisco Wave 2 APs

Cisco 9120AX overperforms Cisco AP2800 by 25%

Cisco 9100 series APs has clear advantage over Cisco Wave 2 APs

CleanAir

The Impact of a Crowded Spectrum Performance

Risk in Unprotected Networks

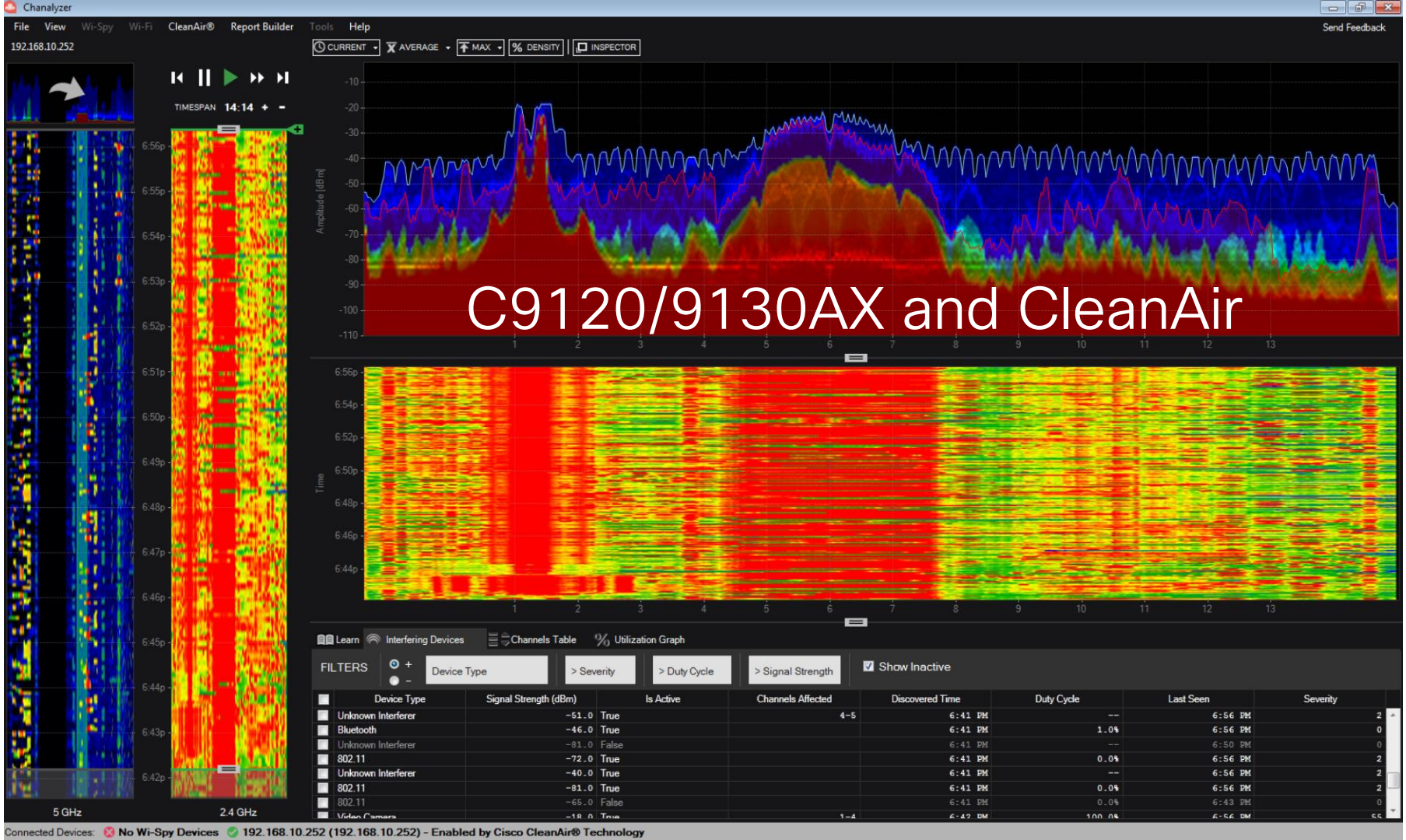
End User Impact

- Reduced network capacity /Coverage
- Poor quality voice and video
- Potential complete link failure

IT Manager Impact

- Potential security breaches
- Support calls
- Increased cost of operation

Interference Type		Throughput Reduction	
		Near (25 ft)	Far (75 ft)
2.4 or 5 GHz Cordless Phones		100%	100%
Video Camera		100%	57%
Wi-Fi (busy neighbor)		90%	75%
Microwave Oven		63%	53%
Bluetooth Headset		20%	17%
DECT Phone		18%	10%

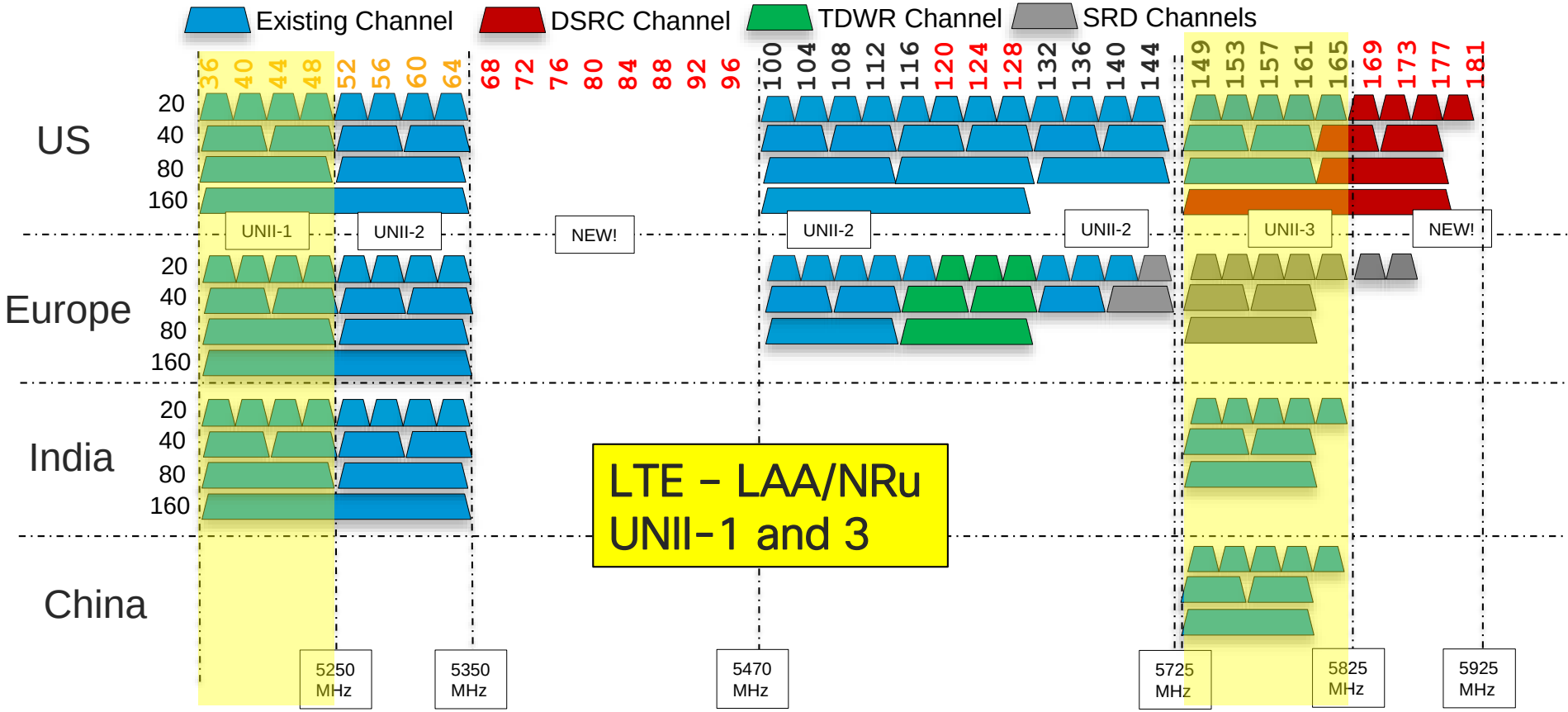


C9120/9130AX and CleanAir

LTE Interference?

5 GHz 20/40/80/160 MHz Channels

OffChannel RRM



NEW

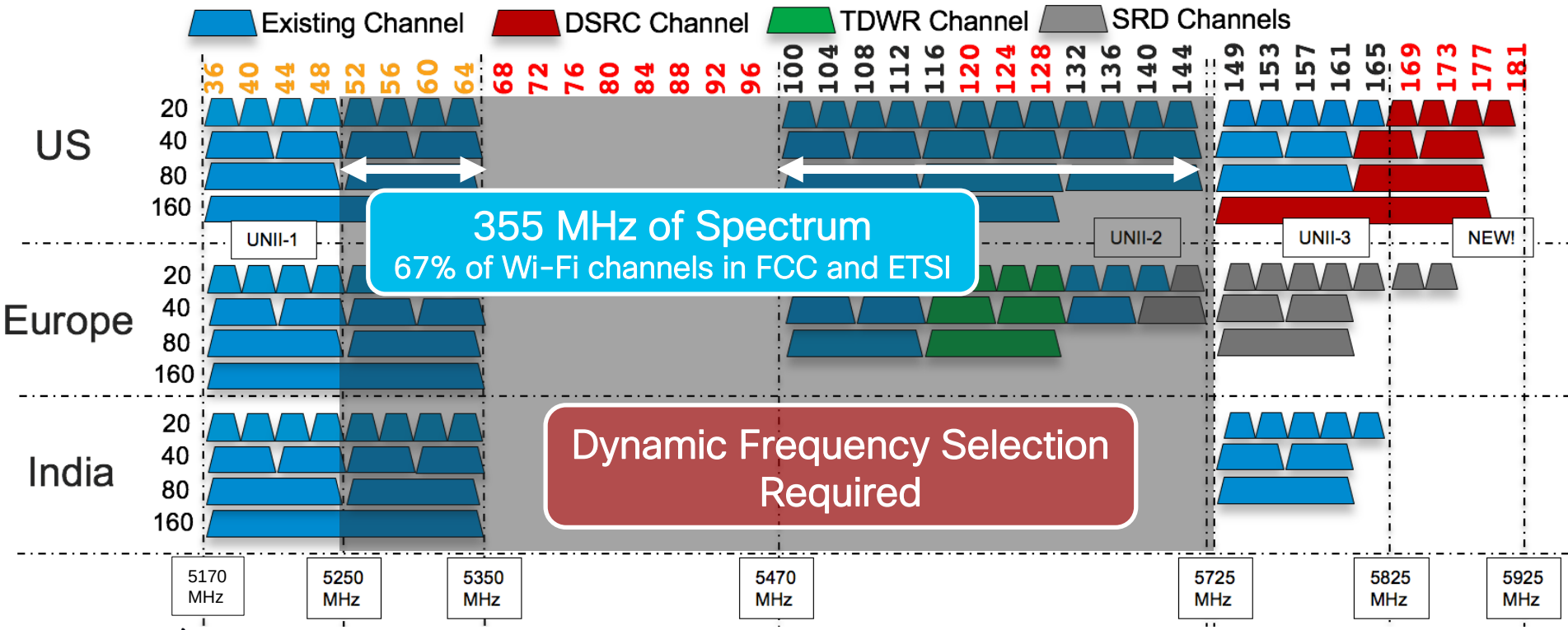
Zero-Wait DFS
Dual Filter DFS

DFS – Dynamic Frequency Control

Detect and Avoid Active Radar

Zero-Wait DFS* (NEW)

Dual Filter DFS



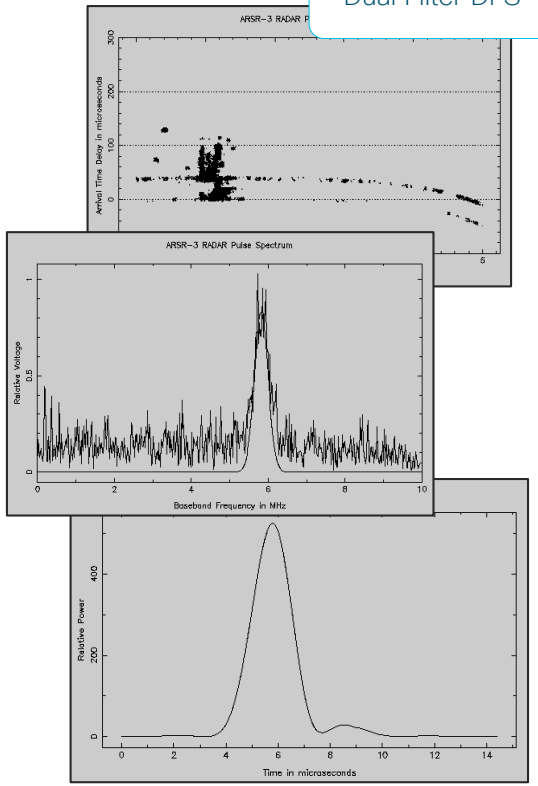
* Roadmap Item

Zero-Wait DFS*

Zero-Wait DFS*

Dual Filter DFS

- DFS rules require a 60 second Dwell in order to ensure no radar is already operating on the channel
- In ETSI, the TDWR channels 120,124,128 require 600 Seconds
- NDP in DFS frequencies requires that a Master's Beacon or Directed Probe response be seen "before" sending – less neighbor resolution results as well
- Once Blacklisted – we start again
  - Revisit to the channel and re-check for 60s or 600s
  - Verify that the Radar has stopped operating and resume
- Once a channel is cleared – it remains operational unless
  - The AP is rebooted/re-started
  - A radar is detected



* Roadmap Item

Zero-Wait DFS*

Zero-Wait DFS*

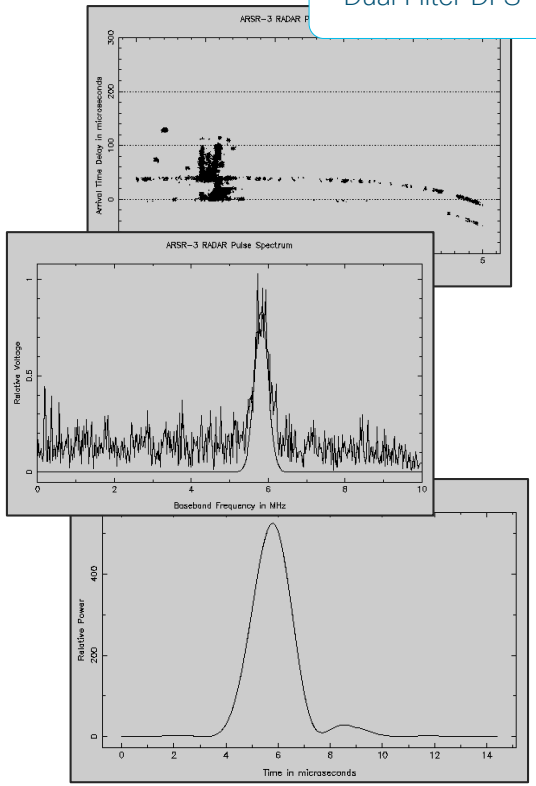
Dual Filter DFS

The Cisco RF ASIC is Purpose Built for this....

- Custom AGC (Automatic Gain Control) and custom components to optimize Radar Detection
- Zero-Wait DFS allows faster more efficient operation
  - More Accurate - Constant dwells provides more/better samples
- In ETSI, this means we can reclaim 60 MHz (16%) of spectrum, painlessly

Better, Faster, More

- And - None of our Competitors DFS detection even comes close



* Roadmap Item

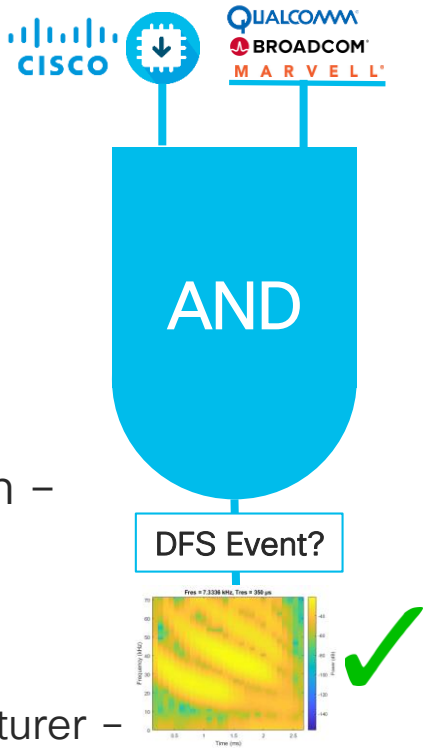
* Roadmap Item

Dual Filter DFS

Zero-Wait DFS*

Dual Filter DFS

- 2015-2017 CiscoLive and Mobile World Congress
  - Before Dual Filter:
    - 2015-2017: DFS had1000 detections per Day
  - After Dual-DFS
    - For 2018-2019:Just one area with an issue at MWC



Using both Wi-Fi Radio <u>AND</u> Cisco RF ASIC for detection –

- False Positives have virtually been eliminated
- We own and maintain the Cisco RF ASIC
- Manufacturers Chipset DFS detection maintained by Manufacturer –

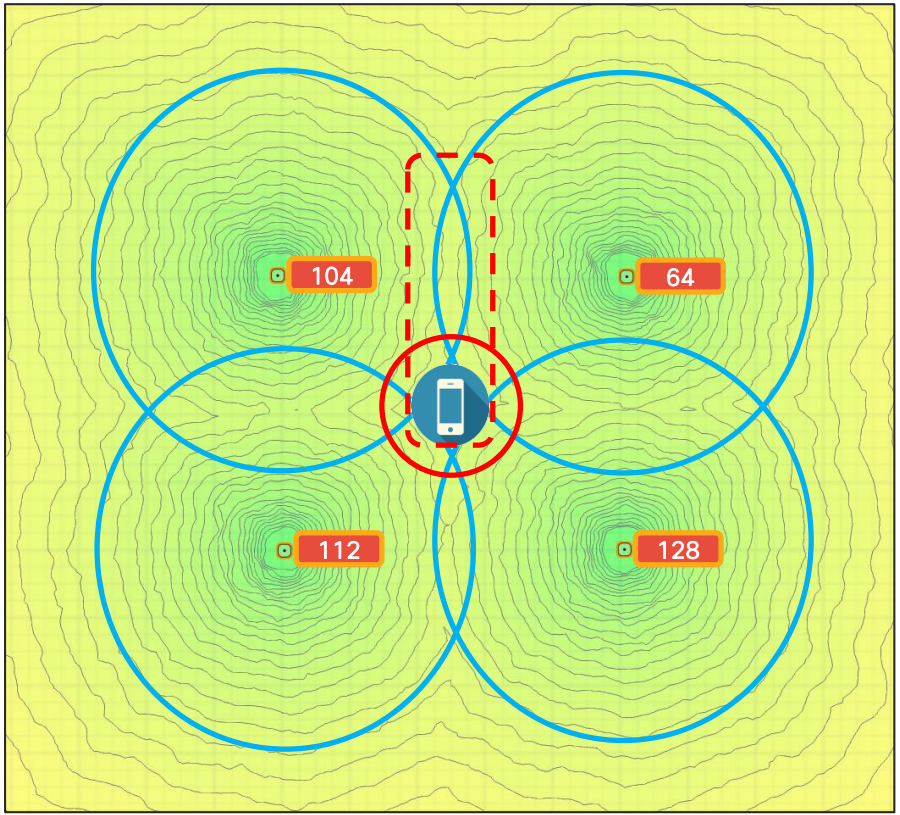
FastLocate

W/O Performance Impact*

FastLocate and Performance

FastLocate w/o performance impact

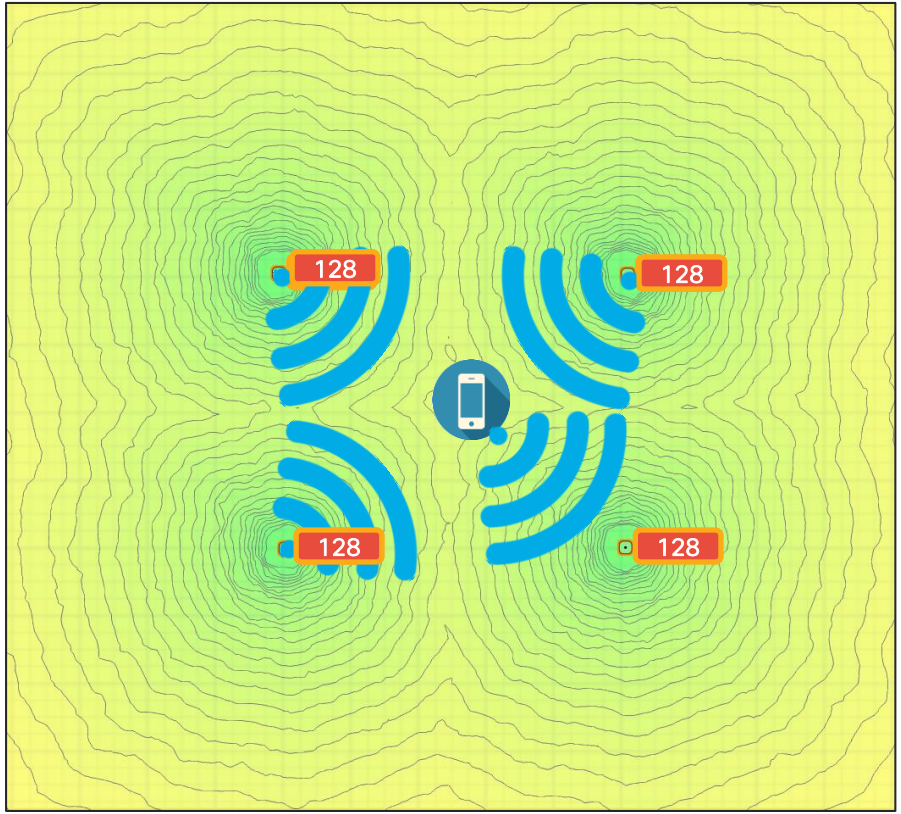
- A client Seen by 1 AP could be anywhere on the circle = Presence
- A client seen by two AP's will be located somewhere between them
- If seen by 4 or more AP's, Accuracy is greatly Improved
- Relying purely on Client Probes
  - Clients update probe frequency?
  - Between 10s and 5Min's
  - Not enough data points



FastLocate and Performance

FastLocate w/o performance impact

- Clients send Data – more Frequently and consistently
- But – Client is only talking to the associated AP on channel 128
- Need more listening radios on channel 128 for accuracy! The RF Asic is that radio for additional location reports and does this without impacting client traffic of the host AP



FastLocate and Performance

FastLocate w/o performance impact

	AP Model	FastLocate	HyperLocate	Radio 0	Radio 1	Radio 2
	AP3600 AP3700 WSM	Yes	No	Client Serving 2.4 GHz	Client Serving 5 GHz	WSM
	AP3600i AP3700i HyperLocate	Yes	Yes	Client Serving 2.4 GHz	Client Serving 5 GHz	WSM
	AP3800 AP2800	Yes	No	Monitor	Client Serving 5 GHz	N/A
	AP4800	Yes	Yes	2.4 GHz 5.0 GHz Monitor	Client Serving 5 GHz	Monitor/ AOA
	C9120AX C9130AX	Yes	No	2.4 GHz 5.0 GHz Monitor	Client Serving 5 GHz	Cisco RF ASIC

Wi-Fi 6 Feature Timings

Wi-Fi 6 core feature Release Parity
AireOS and IOS-XE

AireOS = IOS-XE

- 8.10 = 16.12.2
- 8.10.MR1=17.1
- 8.10.MR2=17.2
- 8.10.MR3=17.3

All Wi-Fi 6 features for the foreseeable future are available in both Operating systems. There are NO Plans to not release on existing AireOS

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