cisco Live!
Let's go

The bridge to possible

Advanced RF Tuning w/Catalyst Wireless:

Become and expert, while getting a little help from Cisco AI

Jim Florwick, Technical Leader, TME Meraki Catalyst Wireless

Agenda

- Cisco AI-Ops and Cisco RF Excellence
  - Cisco NDP – Neighbor Discovery Protocol
  - AI-Enhanced RRM
- Sustainable Design Guidance
  - Planning today, for Tomorrow
- ZeroWait DFS
- CleanAIr Pro

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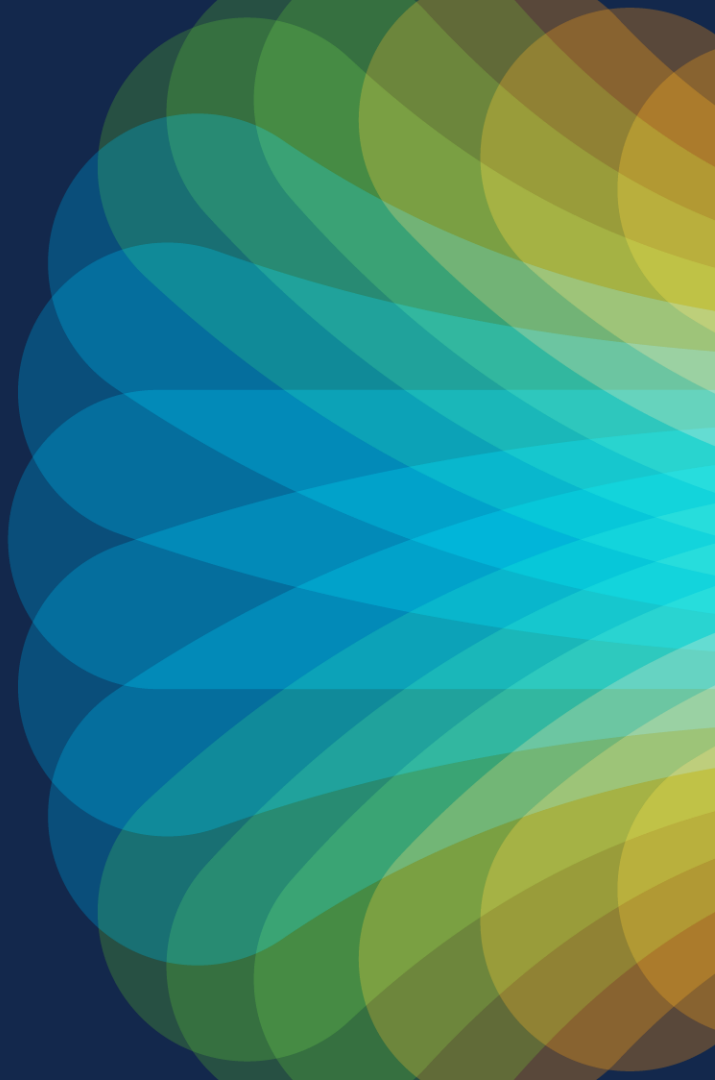
Join the Discussion Webex Space

BRKEWN-3413: Advanced RF Tuning for Wi-Fi6E with Catalyst Wireless:

Cisco AI-Op's – Cisco RF Excellence



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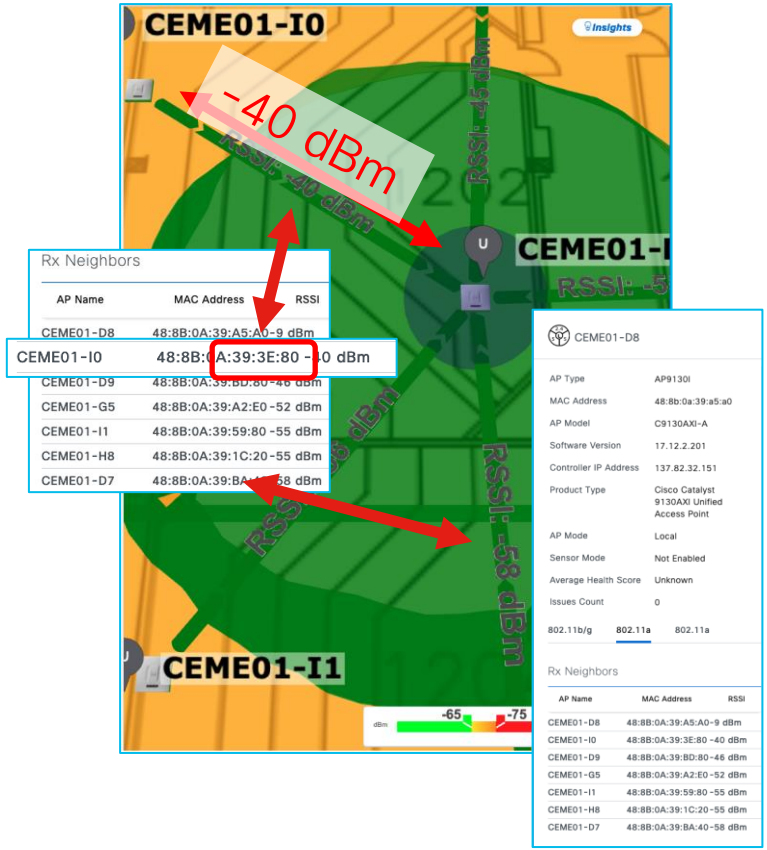
Wi-Fi and the Neighbor Discovery Packet - NDP

- Cisco AI-Ops has been around since before it was cool to call it AI-Ops
- All Cisco WLCs since 2004 have relied on Cisco's RRM
- Cisco's NDP protocol provides RF Distance information to the RRM algorithms in order to make good decisions
  - DCA – Dynamic Channel Assignment
  - TPC – Transmit Power Control
  - FRA – Flexible Radio Assignment
  - CHD – Coverage Hole Detection
- RF Distance is everything to an RF subsystem
- Quality outcomes require Quality Metrics!



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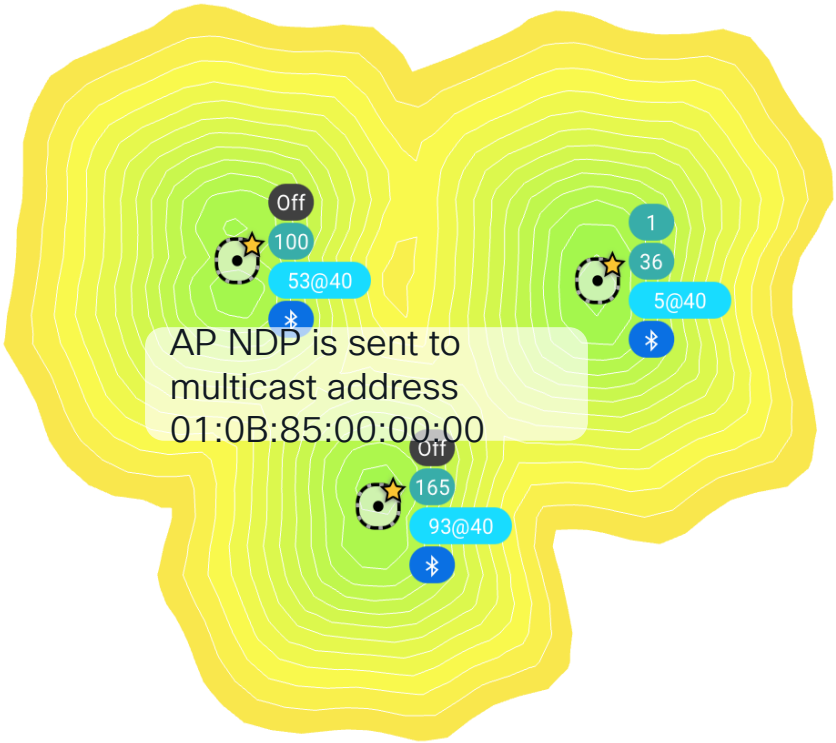
Cisco’s Over The Air NDP- Protocol

- NDP is a proprietary broadcast message that the AP’s all transmit and listen for.
- These messages are always sent at the highest power level for the channel and lowest data rate supported
- The intent is for the packet to reach as far as possible to be heard by as many AP’s as can be reached
- RRM knows the RF Distance between every AP
- We know how it is heard and by whom



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The Cisco NDP packet

Field Name	Description
Radio Identifier	Slot ID for the sending radio
Group ID	IP Address and Priority code of senders WLC
Hash	RF Group name converted to a hash for authentication
IP Address	The IP address of the sending AP's RRM Group Leader
Encrypted?	Are we using Encrypted NDP?
Version	Version of NDP
APs Channel	The operating channel of the sending radio
Encryption Key Length	Key Length
Encryption Key Name	Key Name
Message Channel	The channel the NDP was sent on
Message Power	The power (in dBm) the message was sent at
Antenna	Antenna pattern of the sending radio

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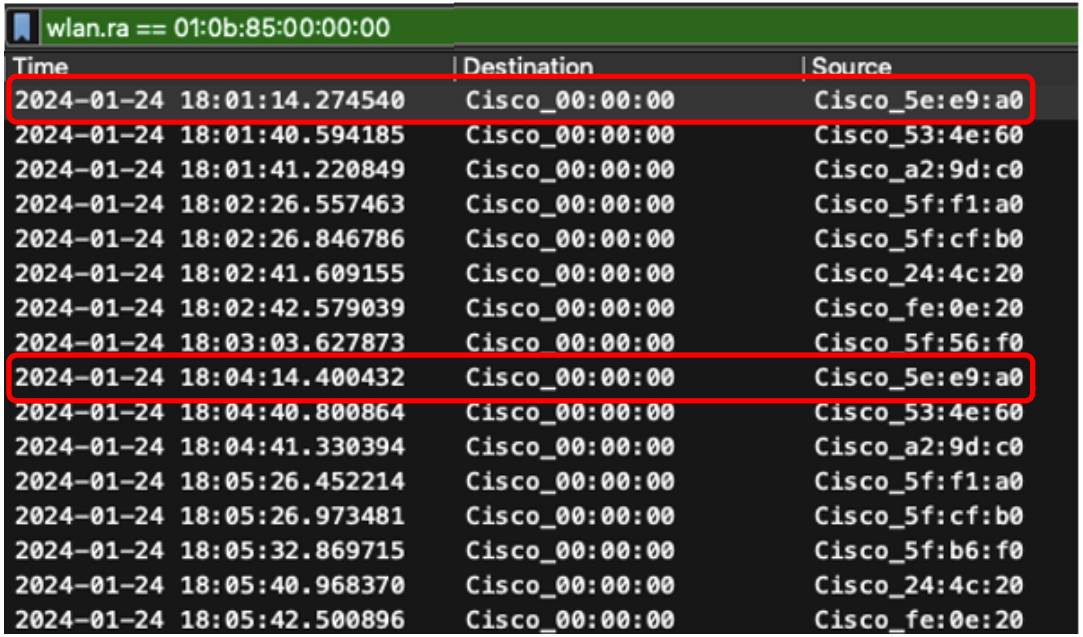
Off Channel NDP

- NDP is sent both on and off channel and must cover all channels being used within 180 seconds
- If 25 channels, then every 7.2 seconds an NDP is sent
- If 59 channels, then every 3 seconds there will be an NDP
- Observing one channel = every 180 seconds



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How to see NDP

- From the command line - you can see an AP's neighbors using the sh ap auto-rf dot11 5 and the NDP is displayed for every AP in the nearby APs. This information will continue for every AP associated
- You can also use the WCAE and parse the sh tech wireless to gain detailed insight

```
Nearby APs
  AP 2c57.4154.eb07 slot 2                :  -33 dBm on ( 52, 20 MHz) (10.130.240.17)
  AP 6cd6.e3b4.464f slot 1                :  -57 dBm on ( 56, 20 MHz) (10.130.240.17)
  AP a4b2.3905.f54f slot 1                :  -60 dBm on ( 40, 20 MHz) (10.130.240.17)
  AP a4b2.3906.6d07 slot 2                :  -67 dBm on ( 44, 20 MHz) (10.130.240.17)
  AP a4b2.3906.6eaf slot 1                :  -69 dBm on ( 64, 20 MHz) (10.130.240.17)
  AP a4b2.3906.72af slot 1                :  -72 dBm on ( 60, 20 MHz) (10.130.240.17)
  AP a4b2.3906.72a7 slot 2                :  -72 dBm on (100, 20 MHz) (10.130.240.17)
  AP 6871.6136.71cf slot 1                :  -74 dBm on (132, 20 MHz) (10.130.240.17)
  AP ac2a.a12f.4aaf slot 1                :  -75 dBm on ( 36, 20 MHz) (10.130.240.17)
  AP a4b2.3906.7547 slot 2                :  -76 dBm on ( 64, 20 MHz) (10.130.240.17)
  AP 6871.6136.702f slot 1                :  -77 dBm on (112, 20 MHz) (10.130.240.17)
  AP 6871.6135.d36f slot 1                :  -78 dBm on (140, 20 MHz) (10.130.240.17)
  AP 6871.6135.e0ef slot 1                :  -78 dBm on (116, 20 MHz) (10.130.240.17)
  AP 6871.6135.e42f slot 1                :  -78 dBm on (108, 20 MHz) (10.130.240.17)
  AP 6871.6135.d54f slot 1                :  -79 dBm on (136, 20 MHz) (10.130.240.17)
  AP 6871.6135.d06f slot 1                :  -79 dBm on (120, 20 MHz) (10.130.240.17)
```

Name	Radio Mac	Model	RX Neighbors	Highest RX Neighbor	On Channel Neighbor Count	Highest RX Neighbor on Channel	Lowest RX Neighbor	TX Neighbors
H08L1-TL-HD1265	68-71-61-36-69-C0	CW9166D1-MR	22	-35	2	-35	-62	41
H08L1-TL-HD1224	68-71-61-36-78-E0	CW9166D1-MR	22	-46	1	-46	-63	40
H08L1-TL-HD1260	68-71-61-36-03-A0	CW9166D1-MR	24	-39	3	-51	-69	11
H08L1-TL-HD1245	68-71-61-35-DD-20	CW9166D1-MR	21	-44	4	-53	-62	46
H08L1-TL-HD1252	68-71-61-35-E4-20	CW9166D1-MR	24	-47	2	-53	-66	30
H08L1-TL-HD1264	68-71-61-36-64-80	CW9166D1-MR	24	-40	3	-53	-65	13
H08L1-TL-HD1266	68-71-61-36-6B-A0	CW9166D1-MR	24	-38	3	-54	-66	11
H03L0-IL-HI0869	AC-2A-A1-2F-4F-80	CW9166I-E	24	-45	1	-56	-66	25
H08L1-TL-HD1262	68-71-61-36-0C-C0	CW9166D1-MR	24	-43	2	-56	-71	4
H08L1-TL-HD1241	68-71-61-36-6A-60	CW9166D1-MR	24	-42	2	-57	-71	5
H08L1-TL-HD1236	68-71-61-35-D5-40	CW9166D1-MR	23	-47	3	-58	-63	56
H08L1-TL-HD1246	68-71-61-35-FD-40	CW9166D1-MR	23	-44	1	-58	-63	54
H03L0-IL-HI0872	6C-8D-77-2F-92-E0	CW9166I-E	24	-45	2	-59	-66	26
H03L0-IL-HI0890	AC-2A-A1-2F-43-40	CW9166I-E	24	-44	1	-59	-64	25
H08L1-IL-HI1312	EC-F4-0C-5C-BE-20	CW9166I-MR	23	-49	3	-59	-64	52
H08L1-TL-HD1223	68-71-61-36-60-80	CW9166D1-MR	24	-44	1	-59	-66	23
H08L1-TL-HD1225	68-71-61-36-79-00	CW9166D1-MR	23	-54	3	-59	-67	30
H03L0-IL-HI0860	6C-8D-77-2F-90-20	CW9166I-E	24	-41	2	-60	-68	21
H03L0-IL-HI0875	AC-2A-A1-2F-38-60	CW9166I-E	24	-41	1	-60	-65	26
H03L0-IL-HI0881	6C-8D-77-2F-99-40	CW9166I-E	24	-46	1	-60	-63	26
H08L1-IL-HI0893	AC-2A-A1-2F-47-80	CW9166I-E	24	-50	4	-60	-65	30
H08L1-TL-HD1235	68-71-61-35-D3-60	CW9166D1-MR	24	-49	2	-60	-64	41
H08L1-TL-HD1250	68-71-61-36-0A-80	CW9166D1-MR	24	-35	3	-60	-67	10
H03L0-IL-HI0879	6C-8D-77-2F-91-00	CW9166I-E	24	-47	1	-61	-65	26
H03L0-IL-HI0882	6C-8D-77-2F-9B-00	CW9166I-E	24	-41	1	-61	-65	26

Cisco WCAE tools -https://developer.cisco.com/docs/wireless-troubleshooting-tools/

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H08L1-TL-HD1260	68-71-61-36-03-A0	CW9166D1-MR	24	-39	3	-51	-69	11
H08L1-TL-HD1245	68-71-61-35-DD-20	CW9166D1-MR	21	-44	4	-53	-62	46
H08L1-TL-HD1252	68-71-61-35-E4-20	CW9166D1-MR	24	-47	2	-53	-66	30
H08L1-TL-HD1264	68-71-61-36-64-80	CW9166D1-MR	24	-40	3	-53	-65	13
H08L1-TL-HD1266	68-71-61-36-6B-A0	CW9166D1-MR	24	-38	3	-54	-66	11
H03L0-IL-HI0869	AC-2A-A1-2F-4F-80	CW9166I-E	24	-45	1	-56	-66	25
H08L1-TL-HD1262	68-71-61-36-0C-C0	CW9166D1-MR	24	-43	2	-56	-71	4
H08L1-TL-HD1241	68-71-61-36-6A-60	CW9166D1-MR	24	-42	2	-57	-71	5
H08L1-TL-HD1236	68-71-61-35-D5-40	CW9166D1-MR	23	-47	3	-58	-63	56
H08L1-TL-HD1246	68-71-61-35-FD-40	CW9166D1-MR	23	-44	1	-58	-63	54
H03L0-IL-HI0872	6C-8D-77-2F-92-E0	CW9166I-E	24	-45	2	-59	-66	26
H03L0-IL-HI0890	AC-2A-A1-2F-43-40	CW9166I-E	24	-44	1	-59	-64	25
H08L1-IL-HI1312	EC-F4-0C-5C-BE-20	CW9166I-MR	23	-49	3	-59	-64	52
H08L1-TL-HD1223	68-71-61-36-60-80	CW9166D1-MR	24	-44	1	-59	-66	23
H08L1-TL-HD1225	68-71-61-36-79-00	CW9166D1-MR	23	-54	3	-59	-67	30
H03L0-IL-HI0860	6C-8D-77-2F-90-20	CW9166I-E	24	-41	2	-60	-68	21
H03L0-IL-HI0875	AC-2A-A1-2F-38-60	CW9166I-E	24	-41	1	-60	-65	26
H03L0-IL-HI0881	6C-8D-77-2F-99-40	CW9166I-E	24	-46	1	-60	-63	26
H08L1-IL-HI0893	AC-2A-A1-2F-47-80	CW9166I-E	24	-50	4	-60	-65	30
H08L1-TL-HD1235	68-71-61-35-D3-60	CW9166D1-MR	24	-49	2	-60	-64	41
H08L1-TL-HD1250	68-71-61-36-0A-80	CW9166D1-MR	24	-35	3	-60	-67	10
H03L0-IL-HI0879	6C-8D-77-2F-91-00	CW9166I-E	24	-47	1	-61	-65	26
H03L0-IL-HI0882	6C-8D-77-2F-9B-00	CW9166I-E	24	-41	1	-61	-65	26

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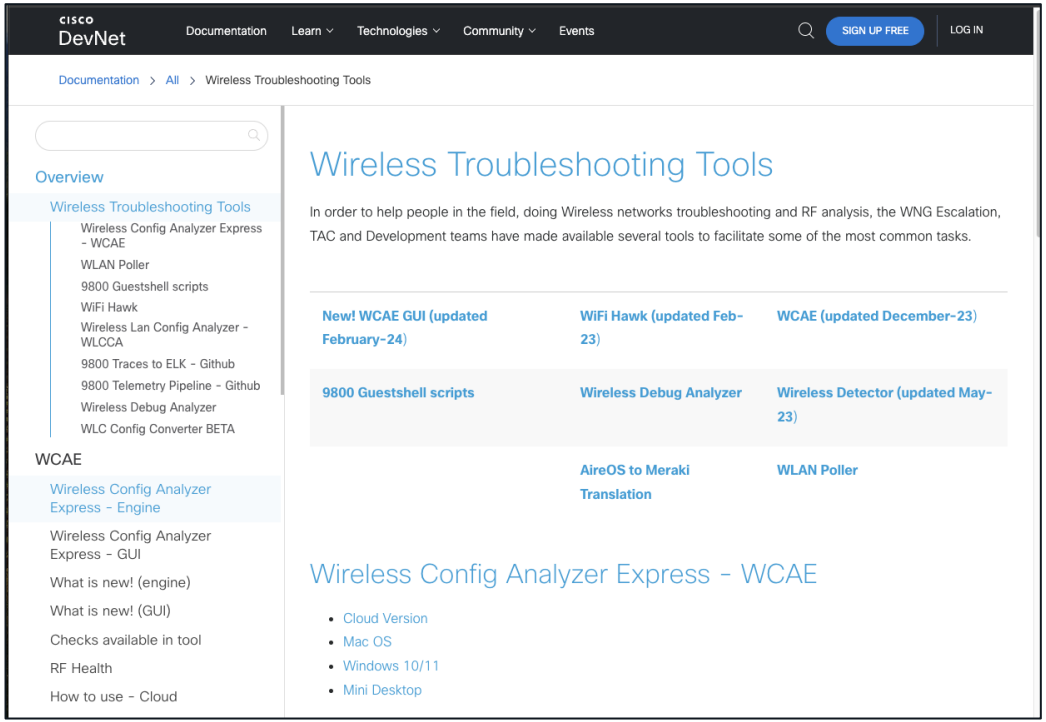

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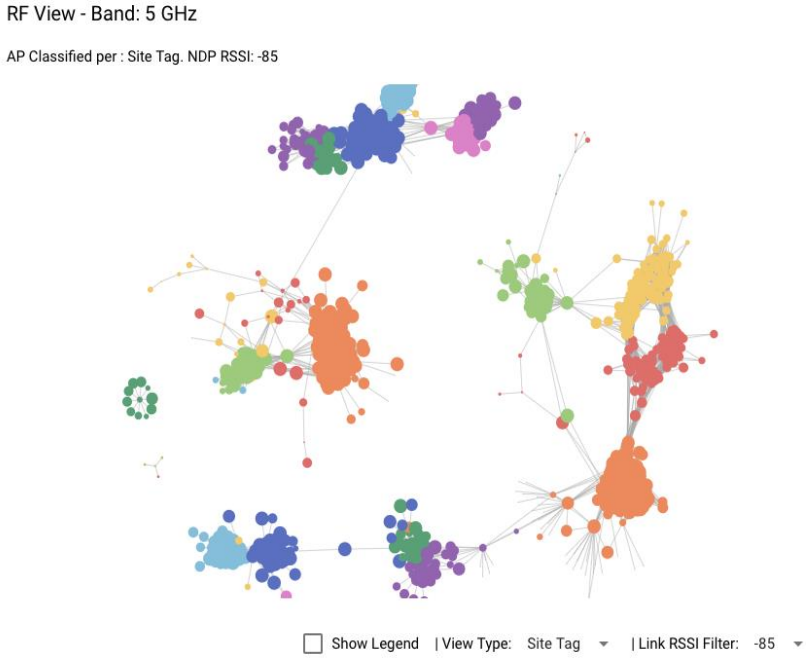
How RRM Uses NDP

- RRM has an RF Group leader – the admin anchor
- And RF Neighborhoods – Clusters of APs that are close enough they need their channel and power calculated together
- APs require isolation
- Its all fun until you get more AP's than you have channels available



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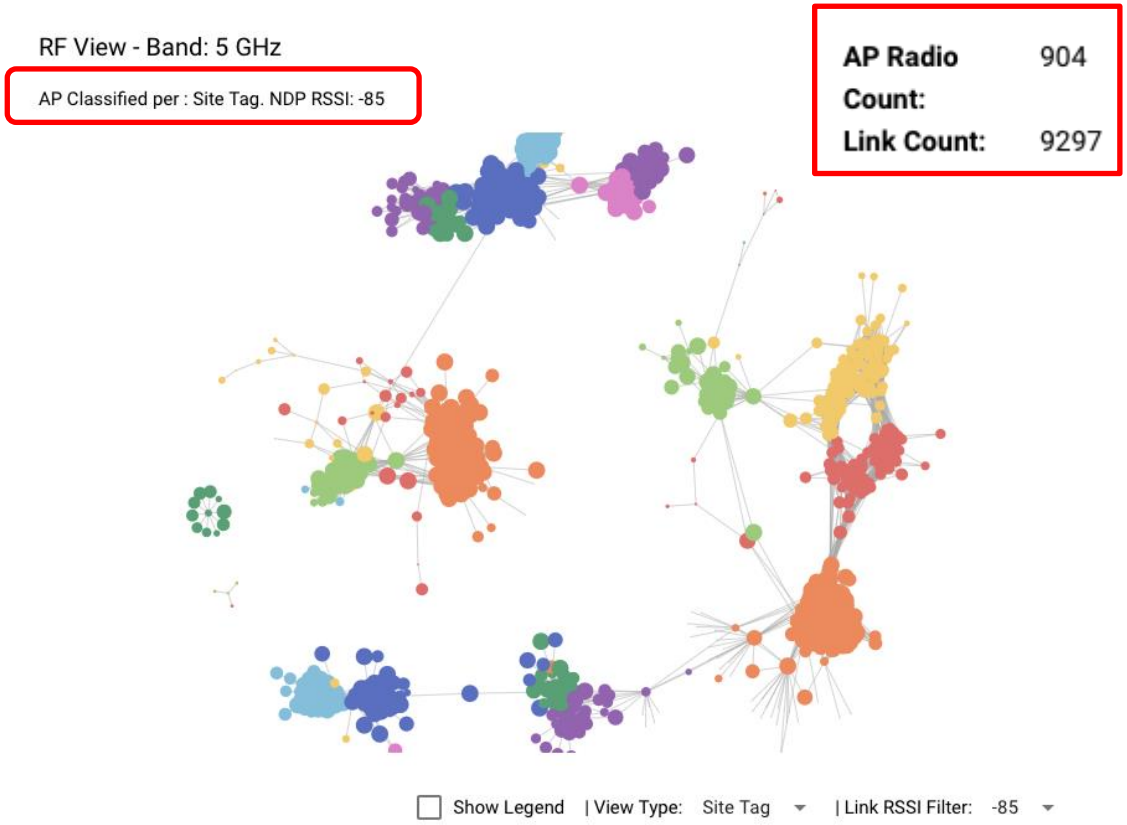
Using the GUI version – AP's RF View



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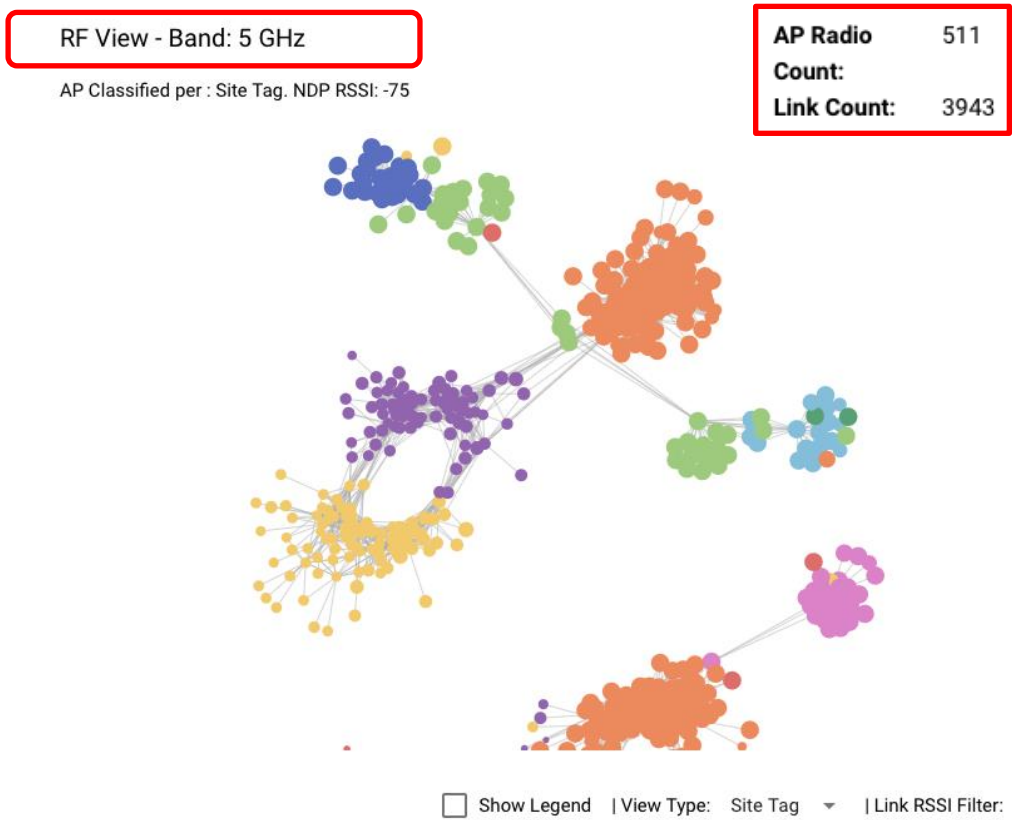
Using the GUI version – AP's RF View



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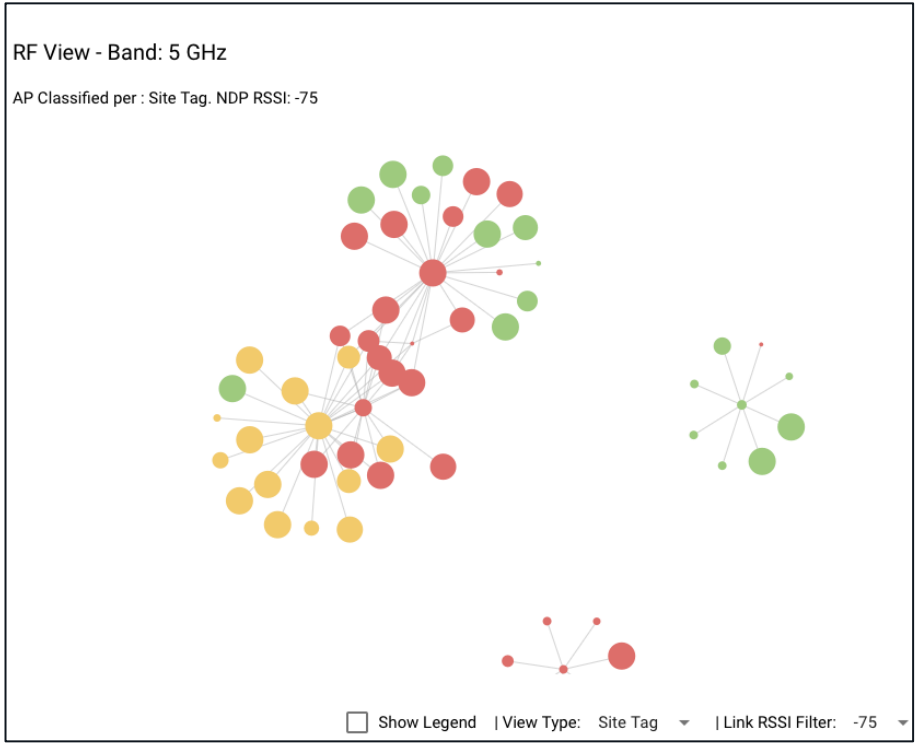
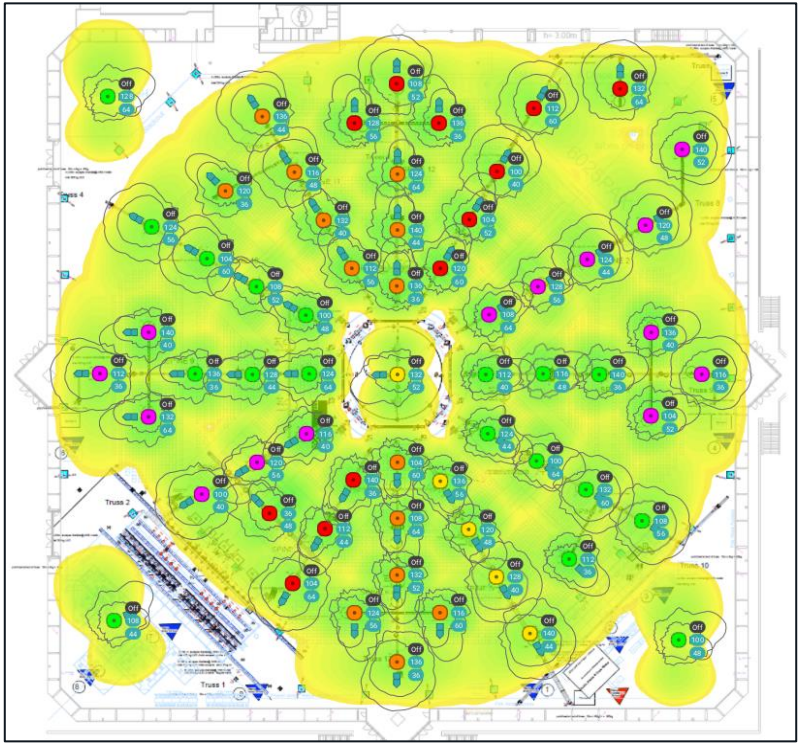
The view From the keynote – AND The C9104 antenna





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

- 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
- All Modern APs have RF-Asic and Scanning Radio

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

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

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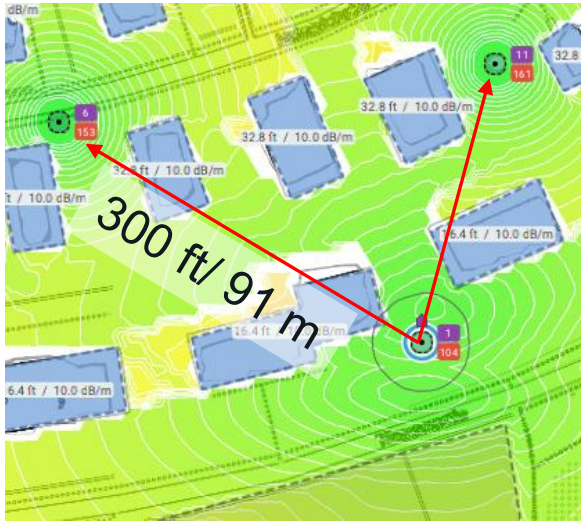
On-Channel NDP

C9124 and the New Neighbor Discovery Protocol

cisco Live!

Catalyst C9124AX and Optimized Neighbor Discovery

- The Catalyst family of APs introduced the world to the power of the Cisco RF -ASIC
- In the Catalyst C9120/C9130 series APs the RF-ASIC is responsible for all off channel intelligence including the NDP protocol which offloads the serving radios duty
- This boosts performance under full load by as much as 25% against legacy APs and with increased resolution as well – more for less!
- The outdoor AP and MESH use cases differ with lower AP density and greater distances between nodes than indoor
- 6 GHz adds an additionally 1200 MHz to scan and increasing time between updates as a result
- Time to Innovate!



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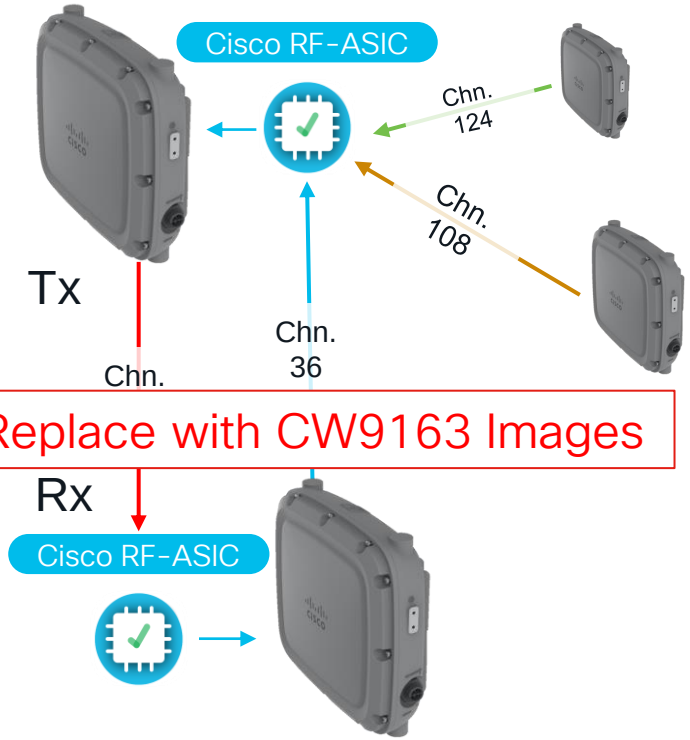
Cisco On-Channel NDP

- NDP frames transmitted on channel by the serving radio
  - Serving radio transmits NDP frames once every 450ms
- Received on the RF-ASIC
  - Dedicated scanning
    - 925ms dwell on 5Ghz (in FCC, 23 sec)
    - 1130ms on 2.4Ghz (in FCC, 3.2 sec)
  - Neighbor discovery within ~46 seconds of RF-ASIC Rx scan for both bands



Faster Neighbor Acquisition/Updates!

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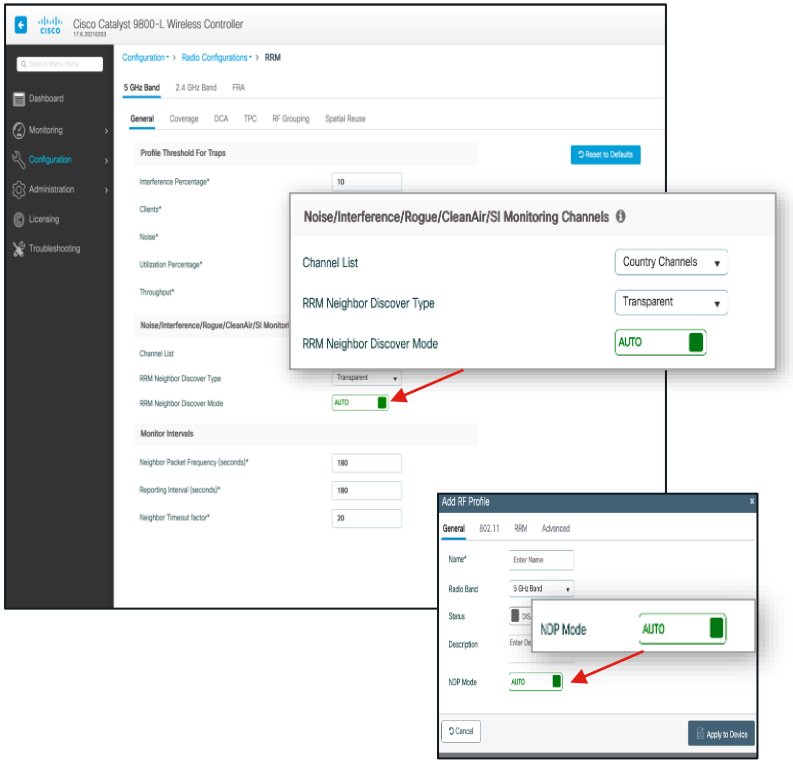
Cisco On-Channel NDP

- Two Ways to NDP – Not interchangeable!
- Mixed Mode Operation?
- RF-ASIC required for on-Channel
- NDP "Type" Configuration at the Global and RF Profile levels
  - Auto = WLC chooses based on RF-ASIC
  - Off Channel = Legacy off-channel NDP
    - RF-ASIC if present, will Tx/Rx NDP



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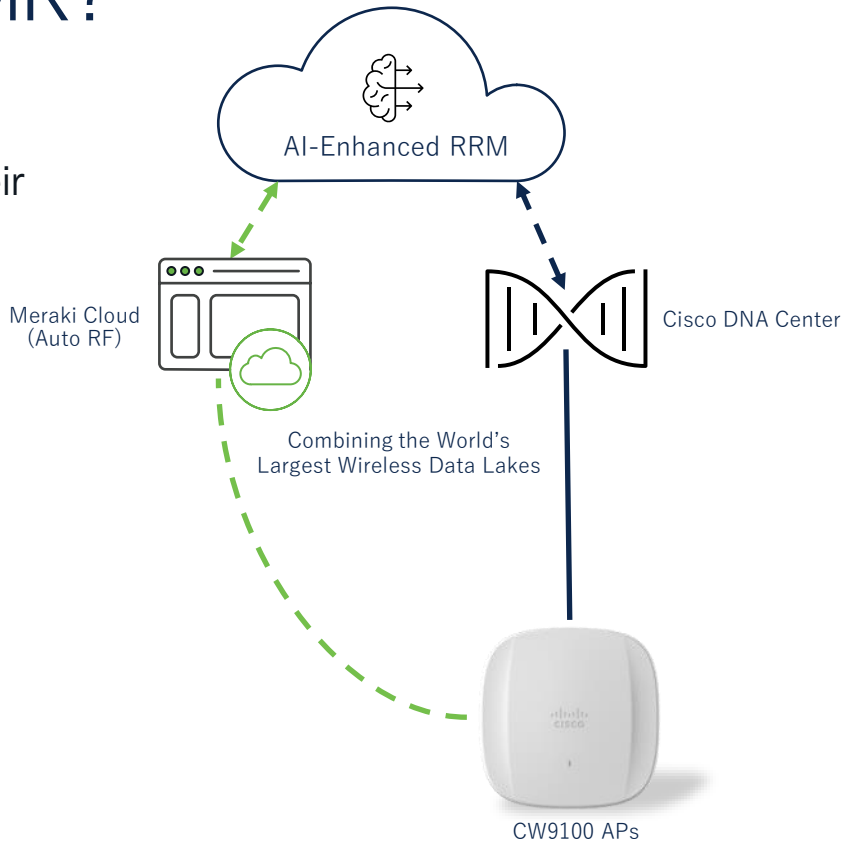
Cisco Meraki – NDP for MR?

- Coming in release R31, Meraki networks will have the options to have NDP enabled on their APs
- Many additional metrics are being added to power AI-Enhanced RRM
- Stay tuned



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AP Isolation, Operating Density, and Performance

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

Available ETSI channels by Width	
20 MHz	19
40 Mhz	10
80 Mhz	4
160 MHz	2

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Very Dense = 1K ft2 / 93 m2 @40 MHz

1 AP every 36 ft / 11 m

The Channel Plan requires:

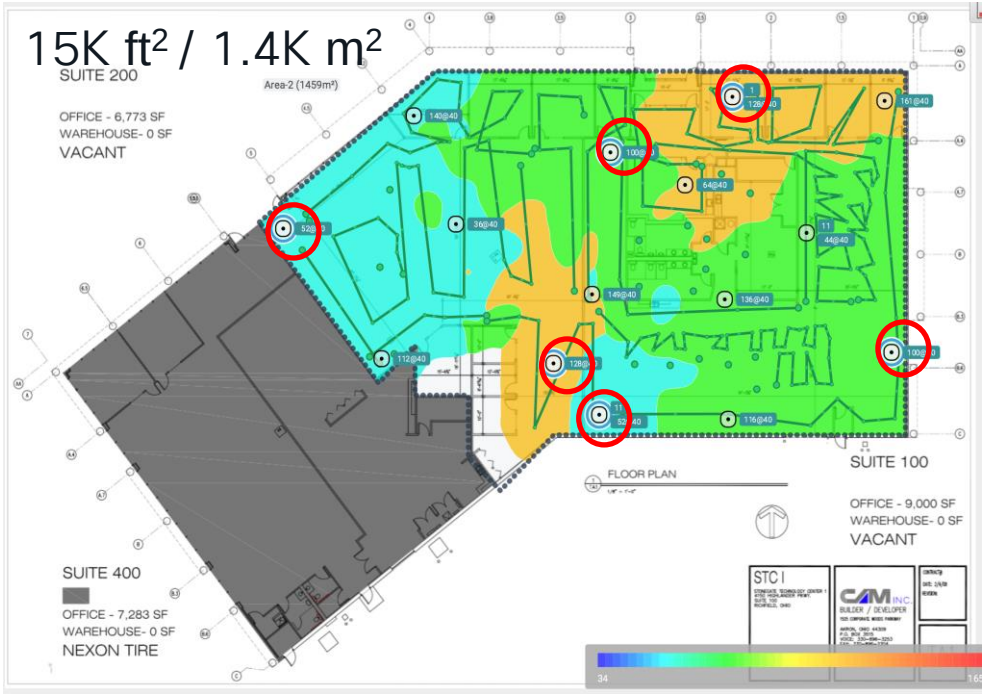
15x 5 GHz interfaces @ 40 MHz

12 x 40 MHz Channels Available in US

15 (APs)/12(Channels)=Plan reused 1.25 times

3 APs needed to re-use channels

- Channel power between these pairs was high at -70 dBm, -64 dBm and -54 dBm
  - Well above the -78 required for isolation
- To evaluate we chose a co-channel pair and tested both simultaneously
- We used the -64 dBm pair, and loaded each cell with 8 Clients ea.
  - As expected, the results show that each cell received roughly half the bandwidth



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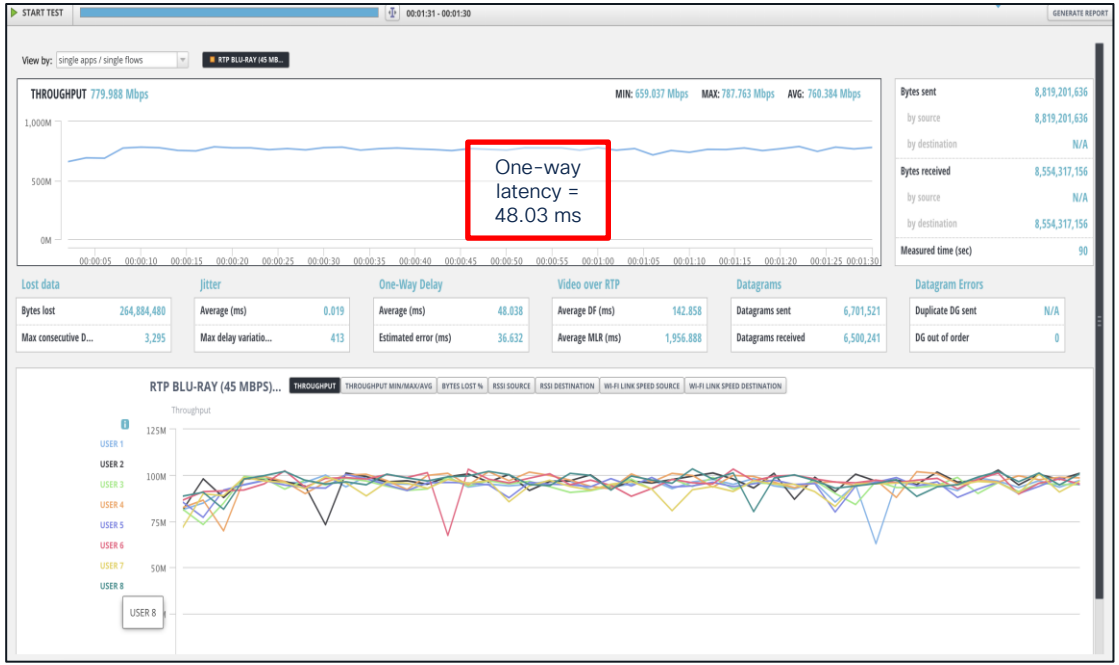
TEST: 40 MHz, 8 x 8K Video Client – Single AP

Throughput / Latency reference

- 40 MHz single cell throughput for 8x 8K video clients performed very well
- 760 Mbps or > 90 Mbps supported for all 8 clients
- One-Way latency <50 ms
- No issues – excellent performance



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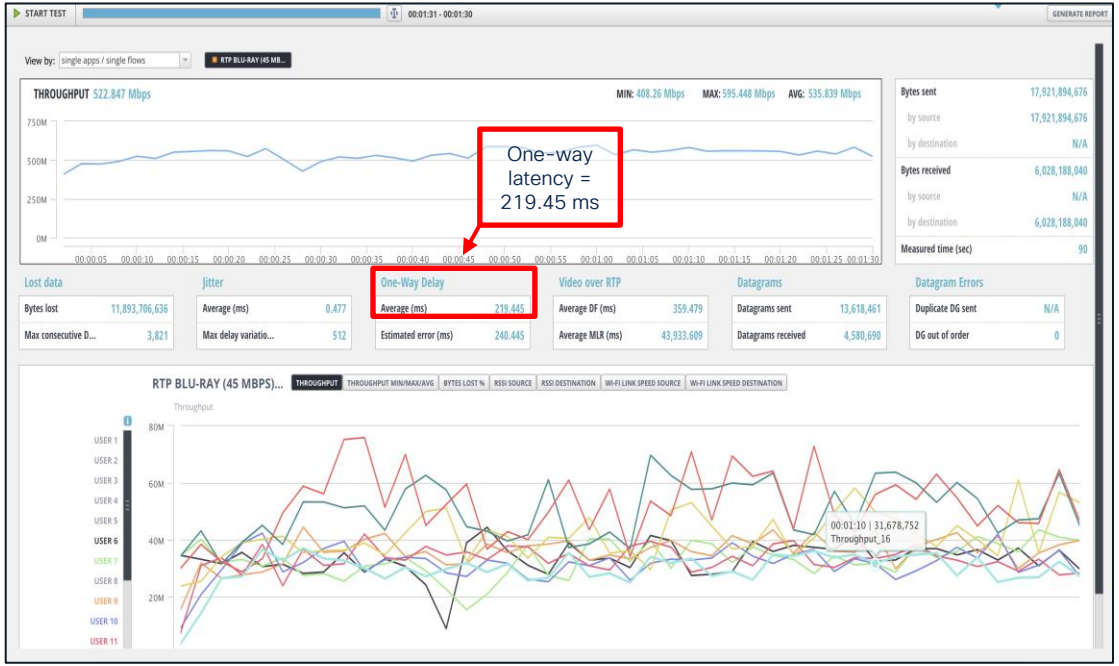
TEST: 40 MHz, 16 x 8K Video Client x 2 APs

C0-Channel interference = Reduced QOE

- Total bandwidth is 535 Mbps or 33 Mbps /client avg.
- Latency quadruples 219.44 ms One-Way avg. unacceptable for RT Video/Voice
- Individual Client experience ranged anywhere from 20 Mbps to 60 Mbps, not smooth
- Quality of Experience suffers



NOTE: RX-SOP is only effective down to -78 dBm

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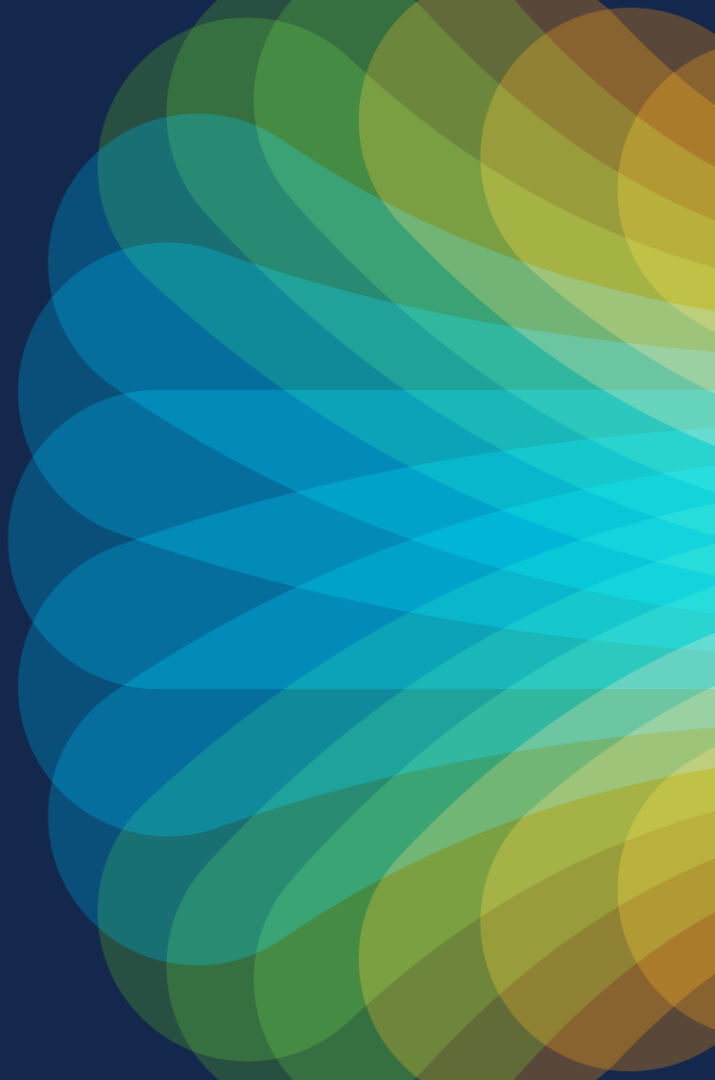
AI Enhanced RRM



That’s it for History

- Why does this matter?
  - Cisco has been collecting neighbor and Auto-RF RRM data since 2004 (Anonymized)
  - AI-Enhanced RRM Algorithms were trained on this data lake
  - AI Analytics Cloud - continues to grow today with the onboarding of more AI-Enabled systems
  - More data than even since telemetry was mainstream and manageable
  - All in All, that’s a pretty deep lake.

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What mitigates RF pain points?

Radio Resource Management
Catalyst AI-Enhanced RRM
Meraki AI-Powered Auto RF

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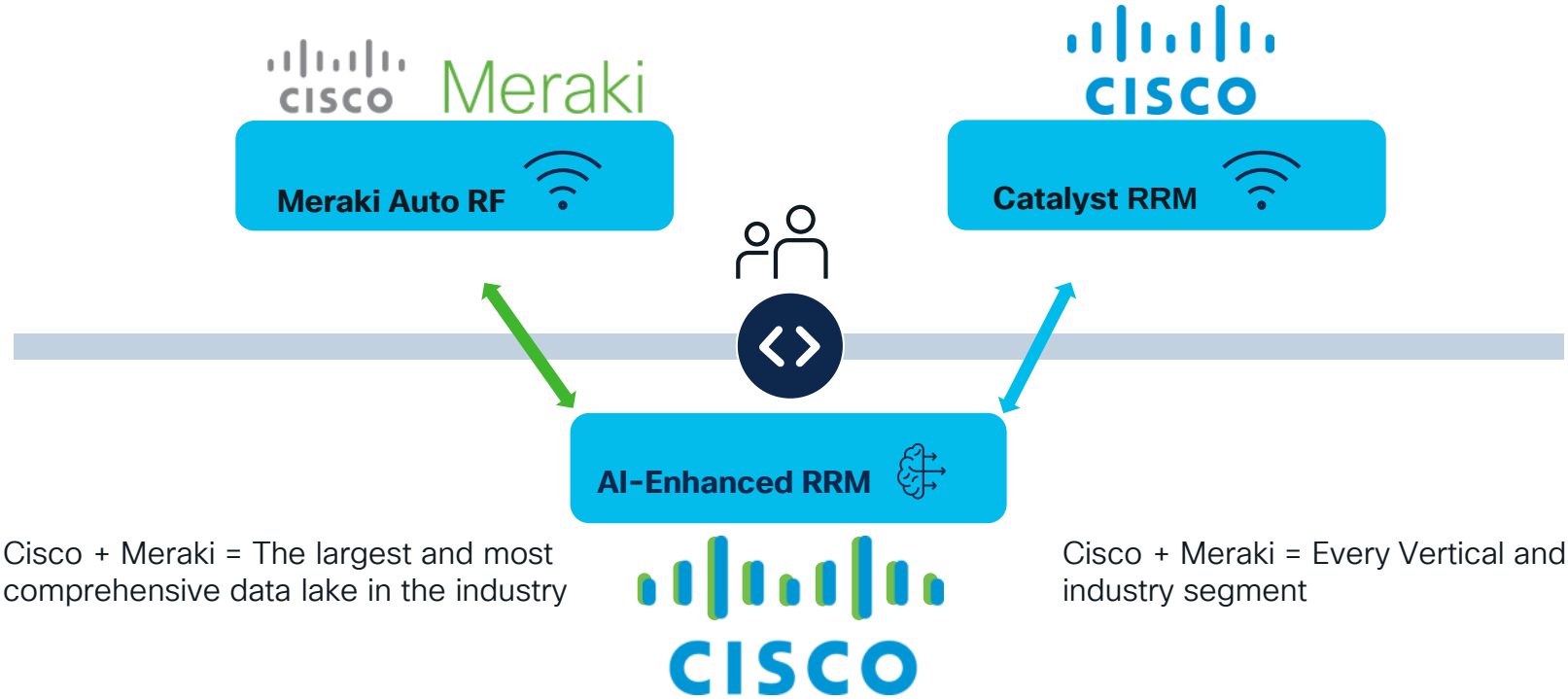
Customer Choices – Outcomes Matter Experience Matters



Cisco + Meraki = The largest and most comprehensive data lake in the industry

Cisco + Meraki = Every Vertical and Every industry segment

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The benefits of AI-Power

First steps towards an intelligent autonomous network!

Maximize

efficiency with AI-driven optimizations

Reduce

interruptions by up to 50%

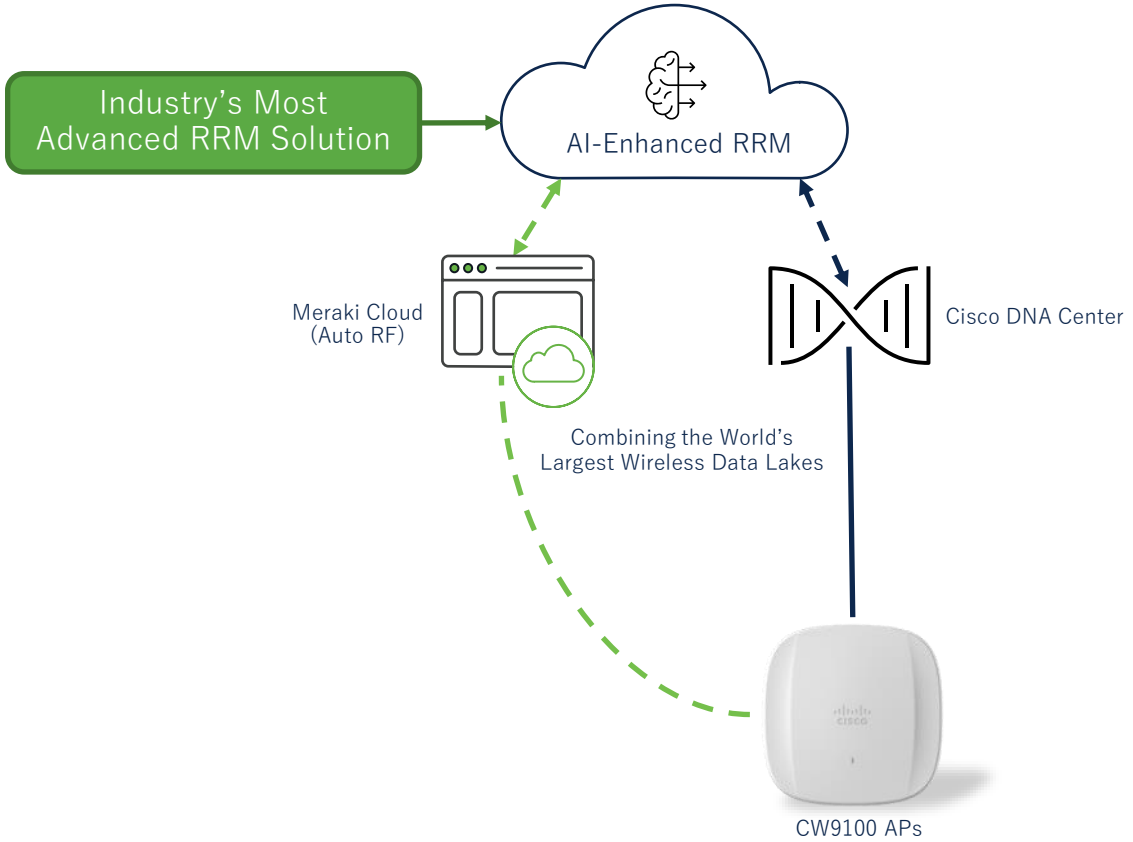
Minimize

channel changes in busy hours

In Progress

Maximize

Efficiency by integrating AI-Enhanced RRM



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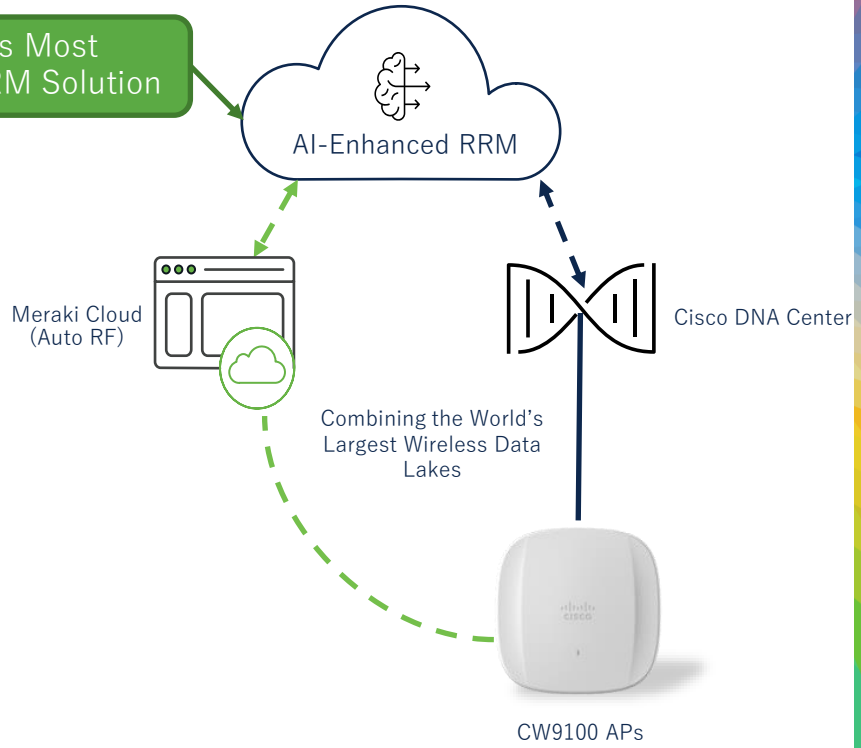
Integrating Meraki's Auto RF with AI-Enhanced RRM
Driving Cisco Meraki's RF Excellence Towards an Enterprise Vision

RRM North Star Vision

Cisco Wireless deployments regardless if it's Cloud or on-prem, must have capability to support wireless deployments of any scale and complexity.

Benefits and Outcomes

Customers will get a unified, and consistent RF automation and recommendations engine in hybrid, cloud and on-prem deployments.



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Top 3 Priorities for Auto RF after Integrating with AI-Enhanced RRM Priority is focused on improving the end user's wireless experience

1 Trend Based RRM Optimization

Promotes RF Convergence Efficiency

Allows RRM to understand and avoid spikes within the ingested RF telemetry (e.g., nF), which allows for RRM changes only when needed, allowing a network to achieve system convergence more efficiently.

2 Flexible Radio Assignment

Mitigates Congestion, Increases Coverage

When optimal, change a radio's band between monitor/2.4/5 GHz or monitor/5/6 GHz. FRA will provide instant benefits to the network, especially in the 2.4 GHz band, where the spectrum is often overutilized.

3 Actionable RF Insights

Optimizes RF/RRM Configurations

Good wireless experience stems from a properly configured RF profile. RF Insights will use data-driven analysis to recommend to users the optimal RRM settings such as DCA channel list, DBS width, TPC threshold, and FRA enablement with can be inherited from AI-Enhanced RRM.

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Legacy Controller based RRM vs AI Enhanced

Areas	Traditional RRM	AI Enhanced RRM
RF Telemetry Inputs	Snapshot [10 mins]	RF Trends [14 days]
Config Workflow	Manual [50+ RF Savvy knobs]	Automated (AI Assisted) [Minimal Config Knobs]
Segment Services	No [Cannot Segment within WLC]	Yes [Service Segmentation by Buildings]
Visualization	Controller UI [List View/ Does not group radios by site]	RRM Control Center [Group collocated radios by Building/Site]
Interrupt Cognizant	No [Reactive optimizations]	Yes [Scheduled RF Tuning]
Reward Based Decisions	No [Decisions based on composite RRM Metrics]	Yes [Maximize WCAE Performance Score]
Emulate What-If Scenarios	No [Doesn't support emulation mode]	Yes [RRM Simulator]
Troubleshooting	Complex [Requires multiple service logs from WLC/AP]	Simplified [Integrated One-Click Service Bundle]

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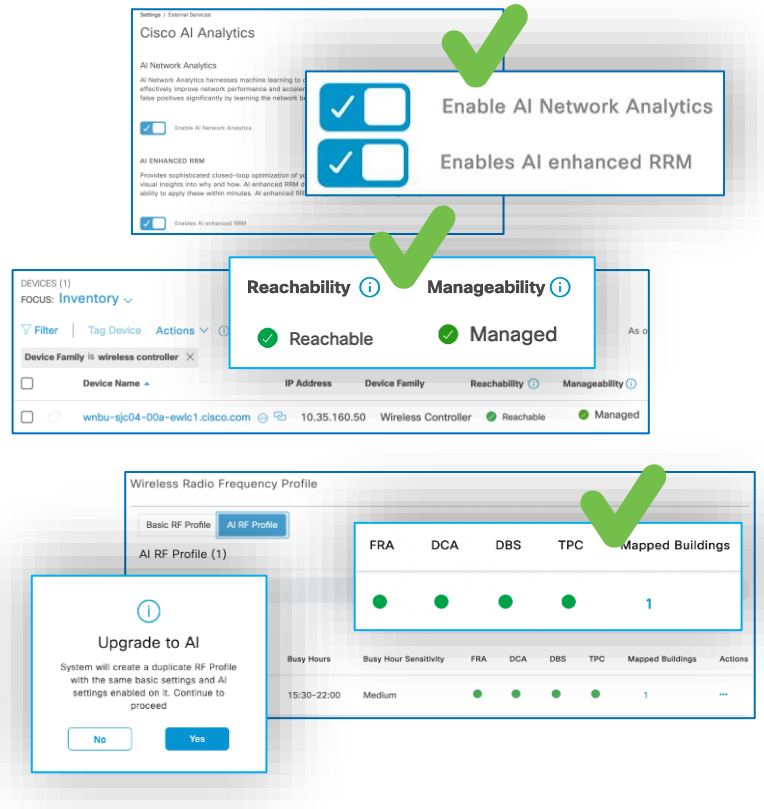
Onboarding a Site to Cisco DNA Center

AI Enhanced RRM Onboarding

- Subscribe to the Cisco AI Analytics Cloud
  - Ad AI Enhanced RRM Service
- Add the Sites C9800 WLC and APs into the DNAc Inventory
  - Provision the Site C9800 WLC and APs
- Create and Assign an AI RF Profile to the controller/site (s)
  - When applied, the system creates a duplicate RF Profile with the same Basic Settings Enabled
  - Reverting, simply applies the Duplicate Basic profile (i.e. RF Tag) back to the WLC



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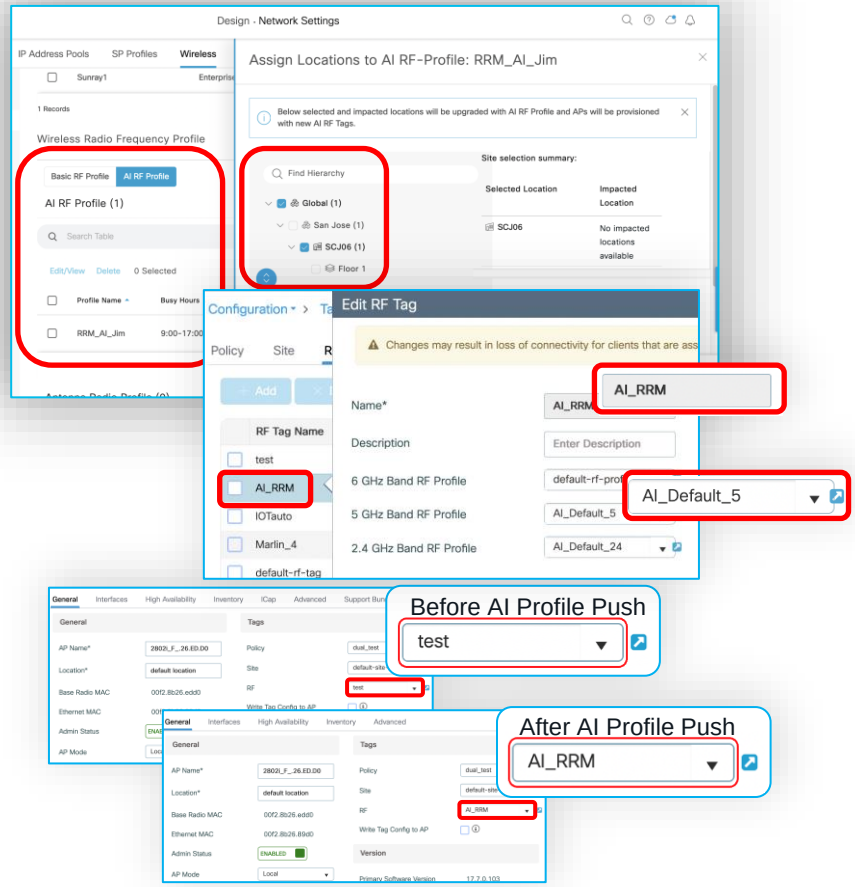
Onboarding the WLC

AI Enhanced RRM Onboarding

- On the DNA Center console, Select the site to apply the AI Profile that was created
- When the site gets assigned, the AI RF Profile gets pushed to the WLC and replaces the legacy RF Tag/Profile
- All of the APs on the WLC are assigned the AI RF Profile (small interruption)
- All the sites on a controller must be assigned. A WLC can either run legacy RRM or AI Enhanced RRM but not both



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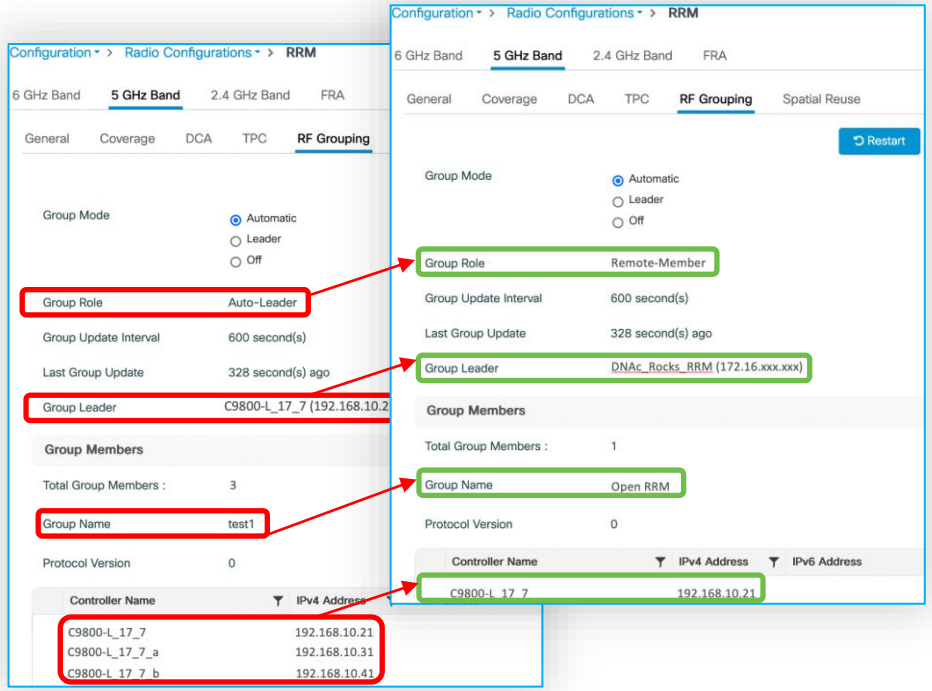
What Happens at the WLC ?

AI Enhanced RRM Onboarding

- When the AI RF Profiles are updated on the WLC, the RF Group Leader Role changes from Auto-Leader to “Remote-Member”
- The RF group Group Leader Changes from “C9800-L_17_7” to “DNAc_Rocks_RRM”
- The RF Group Name changes from “test1” to “Open RRM”
- Other WLCs that were a member of this WLCs RF group as Members will assign a new RF group leader and continue using the existing configurations

Before AI RF Profile

After AI RF Profile



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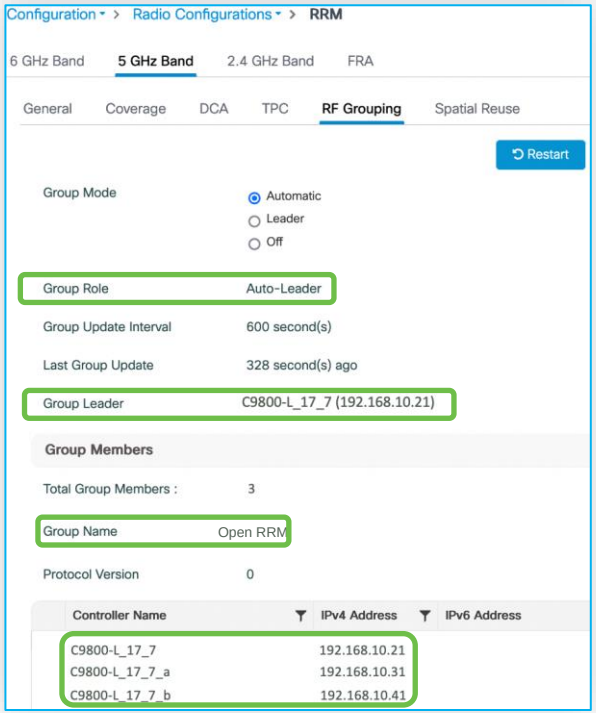
What Happens if the AI-RF Group Leader is lost?

AI Enhanced RRM Operations

- So, what does it mean if the RF Group leader is in the cloud for AI-Enhanced RRM systems?
- What Happens if the cloud gets interrupted?
  - AI Enhanced RRM has a keepalive timer that runs every 20 minutes
  - If interrupted the WLC simply assumes Auto-Leader role and RRM runs locally with the AI Profiles!

Graceful Recovery!



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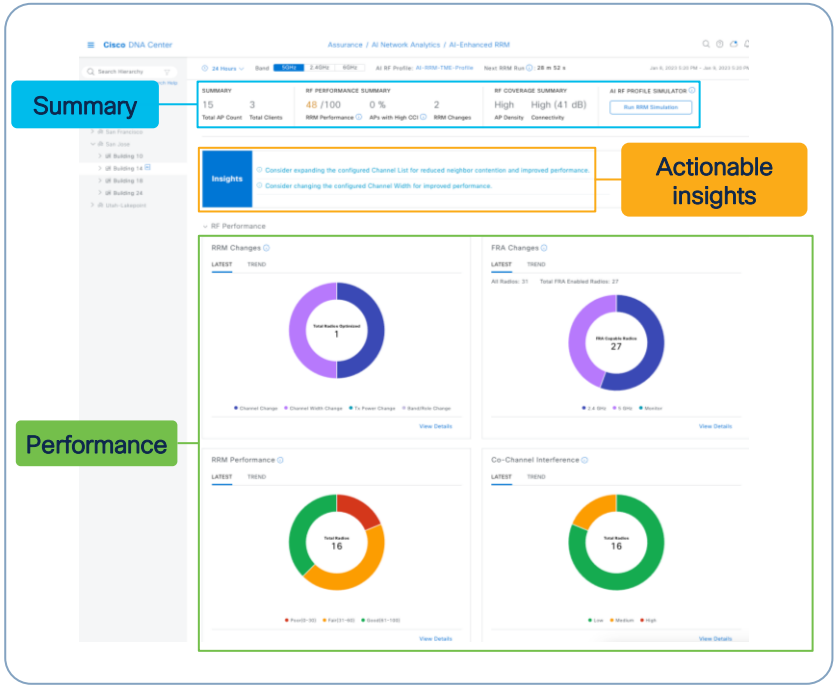
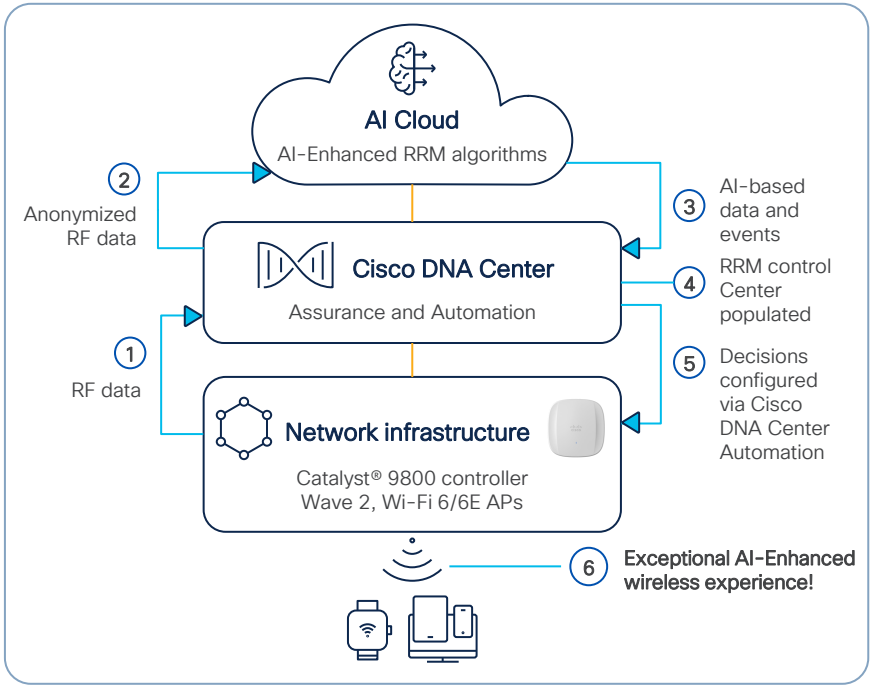
What is AI-Enhanced RRM?

Catalyst's AI-Driven RRM solution

Deep RF visibility & advanced control **Proactive optimizations for all deployment s**





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North Star Vision of Cisco Wireless's AI-Driven RRM Solution

RRM should be Designed for Wireless Deployments of All Sizes and Complexities (SMB to Enterprise)

Wireless Client Disruption

RRM Services Ready at Any Scale

Supports RRM services, DCA, DBS, TPC, FRA, and AP zone-level configurations for deployments of all sizes and use cases.

Trend, Reward, Client-Based RRM

Uses AI to optimize based on historical trends, RF performance, and client-side telemetry.

Interrupt Cognizant RF Tuning

Defers optimizations after peak hours to minimize disruptions but uses peak hour data for relevance to clients' activity times.

Trust & Visibility

Config Simplification

RF Visibility Widgets

Provides org-to-AP level visibility of RF health, RRM changes, co-channel interference, etc.

RF Insights and Recommendation

AI reviews customer config against intended outcomes and provides insight recommendations to ensure goals are met.

Predictive RF Simulator

Uses historical data to predict outcomes of RRM config changes, giving admins peace of mind before applying them.

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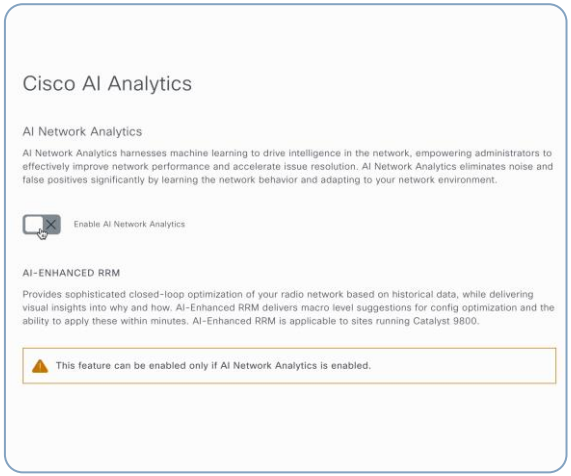
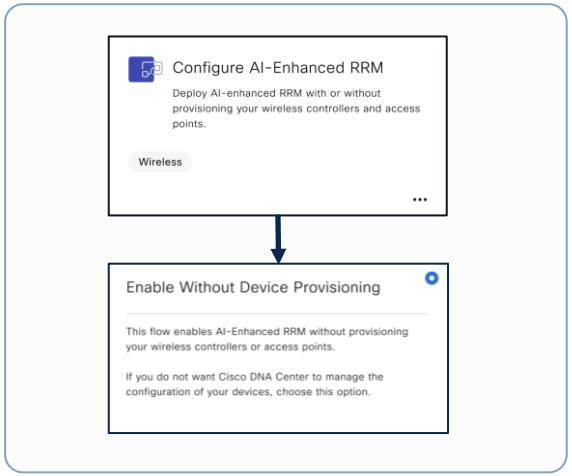
AI-Enhanced RRM Supports Assurance-Only Users

Newly redesigned and simplified deployment workflow for an improved user experience!

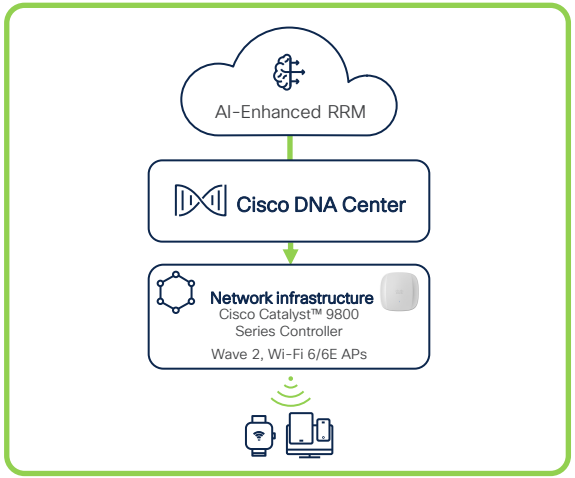
1 Enable AI-Enhanced RRM cloud access in Settings



2 Select the newly designed workflow and deployment option!



3 AI-Enhanced RRM is enabled without device provisioning!



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Software and Hardware Support Matrix

for AI-Enhanced RRM's Workflow for Assurance-Only Deployments

Cisco IOS XE WLC Software	Cisco Catalyst Center Software and Licensing
17.9.3 or newer (17.12.1 recommended)	2.3.7.4 (Patch 2) with DNA Advantage License

Cisco Access Point Hardware
Wave 1, Wave 2, Catalyst Wi-Fi 6 and 6E Access Points

Cisco IOS XE WLC Hardware
C9800-CL
C9800-L
C9800-40
C9800-80

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Cisco IMPACT Las Vegas 2023 Deployment with AI-Enhanced RRM Displayed the Power of AIOps in High-Density Wireless!

Busy Hour reduced the number of channel changes by 83% during peak hours!

Average SNR was 25 dB before AI-Enhanced RRM and was improved to 29 dB after!

% of APs with High CCI was at 43% before AI-Enhanced RRM and was improved to 15% after!

AI-Enhanced RRM Deployment

- **Location:** Mandalay Bay, MGM Grand, Delano
- **Contiguous Square Footage:** 3 m ft/2 (280 Km/2)
- **Market Segment:** Convention Center
- **WLC Count:** 2 x C9800-80 in HA
- **WLC Version:** 17.9.3
- **AP Type:** 3800s and 9130E with RP-TNC connector Antenna
- **AP Count:** 2352 (with 2526 enabled radios)
- **Catalyst Center:** 1 Running 2.3.3.7
- **Spectrum:** 5 GHz

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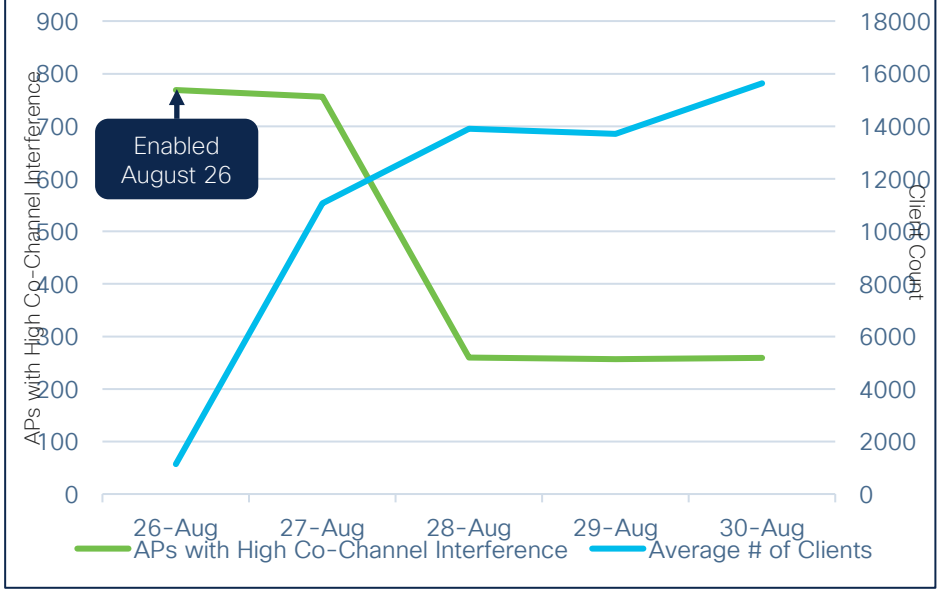
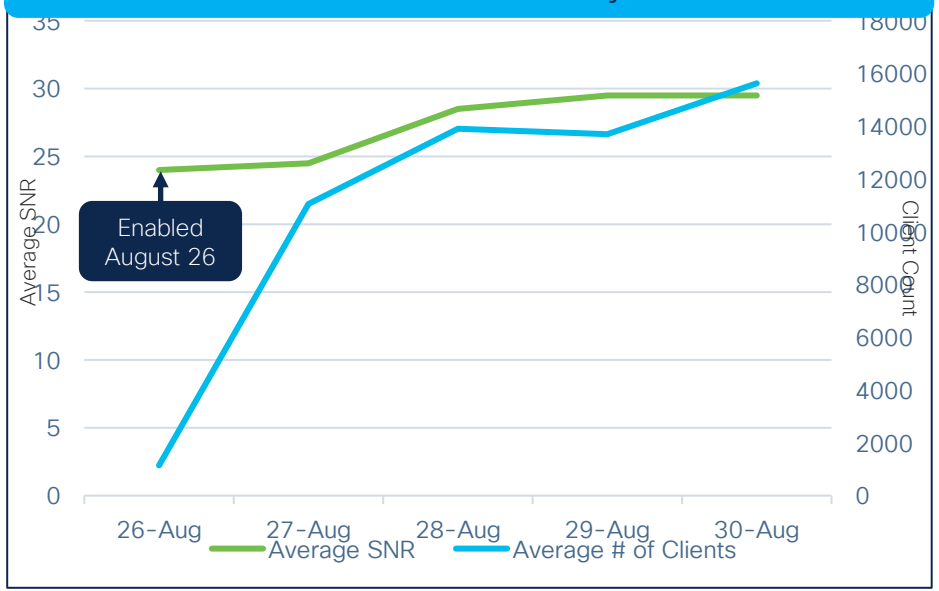
AI-Enhanced RRM Significantly Improved the Wireless Experience at Cisco IMPACT in August 2023

APs with High Co-Channel Interference Decreased by 28%!



Client SNR Increased by ~4dB!



AI-Enhanced RRM converged the wireless network within 6 hours and continued to improve the wireless experience in the high-density environment after a large influx of clients began to join.

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Cisco IMPACT 2022 Analysis

Cisco Impact (GSX) Site

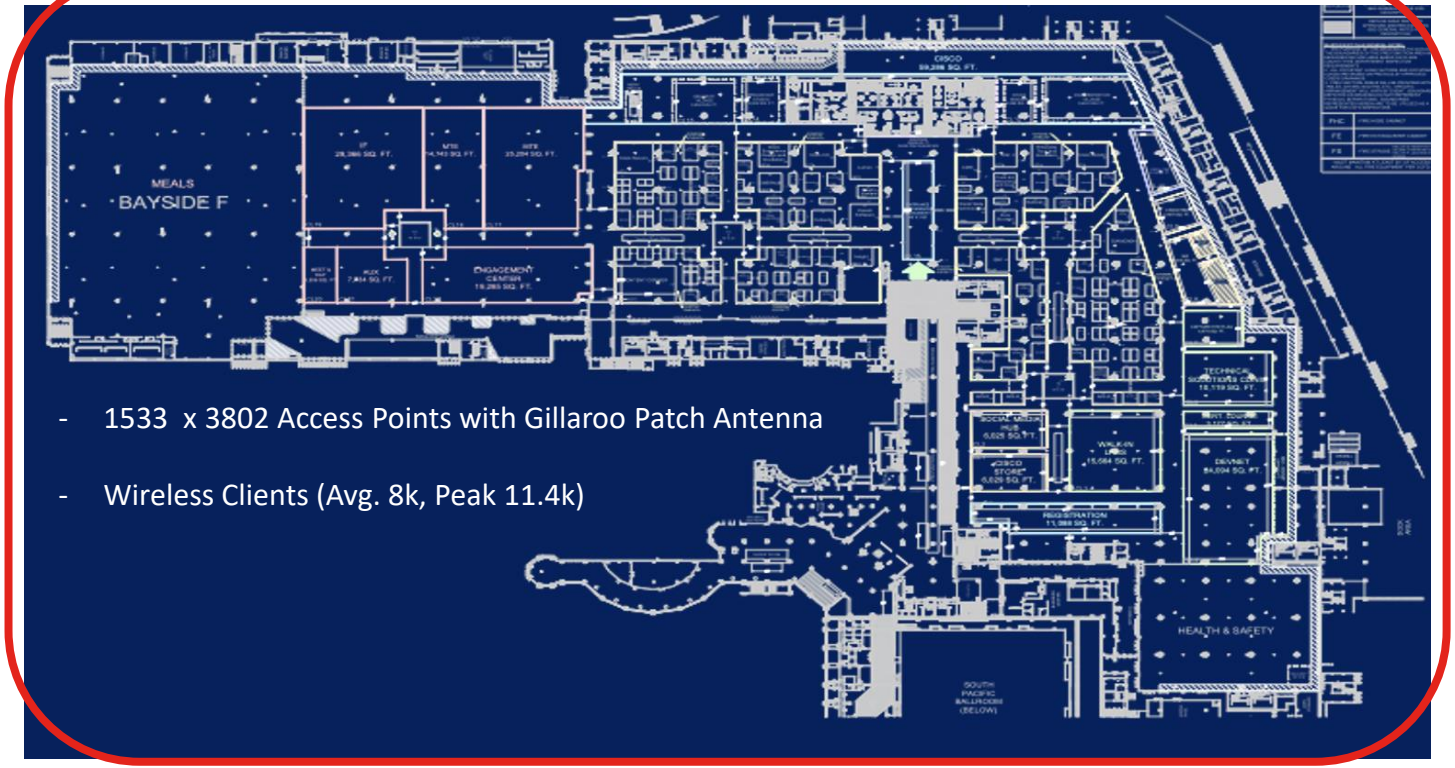
AI-Enhanced RRM Managed

Guardian GA / 17.8.1

Legacy RRM Managed

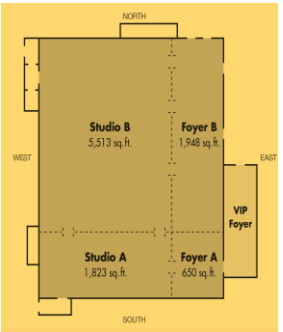
17.6.3

Mandalay Bay South Convention Center



- 1533 x 3802 Access Points with Gillaroo Patch Antenna
- Wireless Clients (Avg. 8k, Peak 11.4k)

MGM GRAND



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Instantly Understand the Cisco Impact Wireless The AI-Enhanced RRM Control Center

- Stable Performance throughout event
- 0% co-channel interference
- Understand increase in load between 10am – 4pm

- Solid Wi-Fi coverage for more than 11K clients

- Non-Busy hour minimizes RRM changes at the crucial hours
- Sticky clients in hallway impacted health score on 6% of radios
- Majority of the APs operated at low CCI even at the traffic peak

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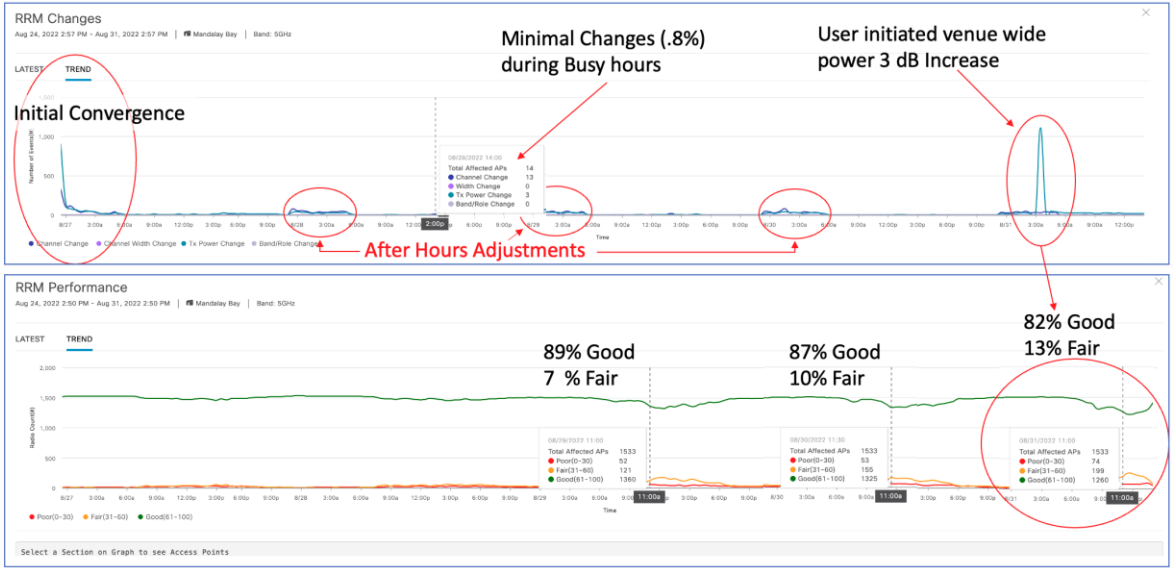
Cisco Impact August 2022

AI-Enhanced RRM In Action

- Initial Convergence ~3 Hours
- Changes made at Night
- Health stayed above 85% (very good with load)
- Manual Changes made last day, easy to spot the decrease in efficiency



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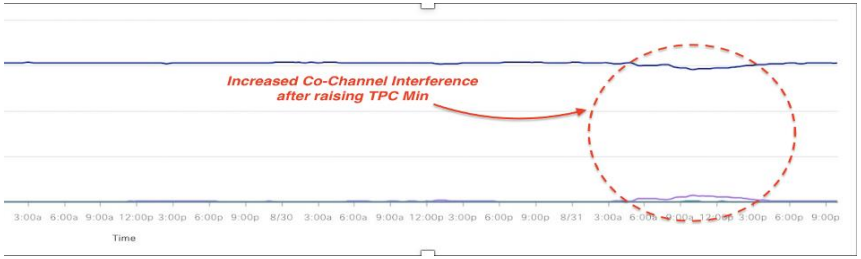
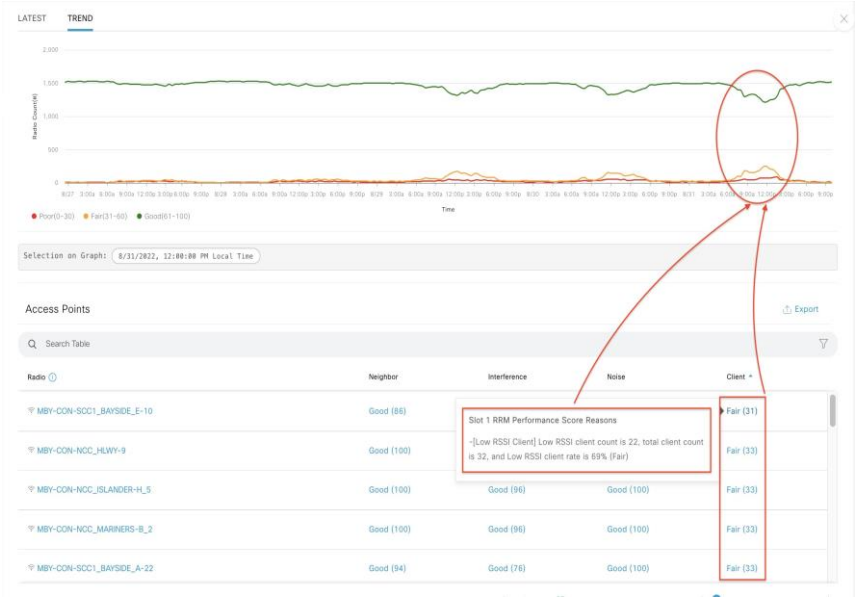
Leave Wireless Optimization to AI-Enhanced RRM!

- Motivation:
  - On Third Day – NOC admins made config changes at off-hours to increase radio cell size to match configurations with last years' RF profile.
- Resulting Impact:
  - Detrimental impact to the wireless performance
    - 74% of the radios increase Tx Power by 3dB
    - Co-Channel interference increased by 8%
    - Performance dropped 9% due to increased sticky clients
  - AI-Enhanced RRM reverted the changes.





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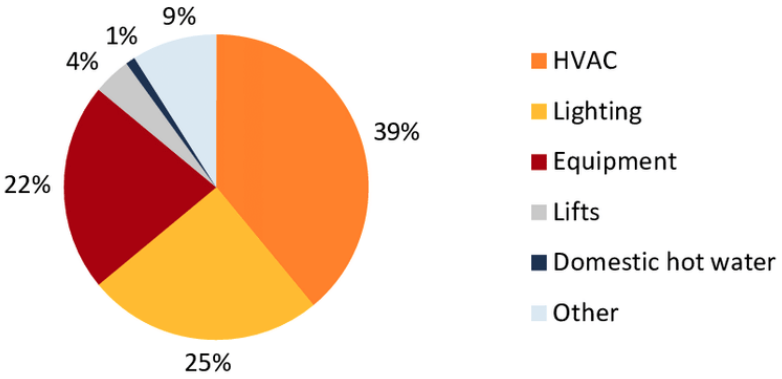
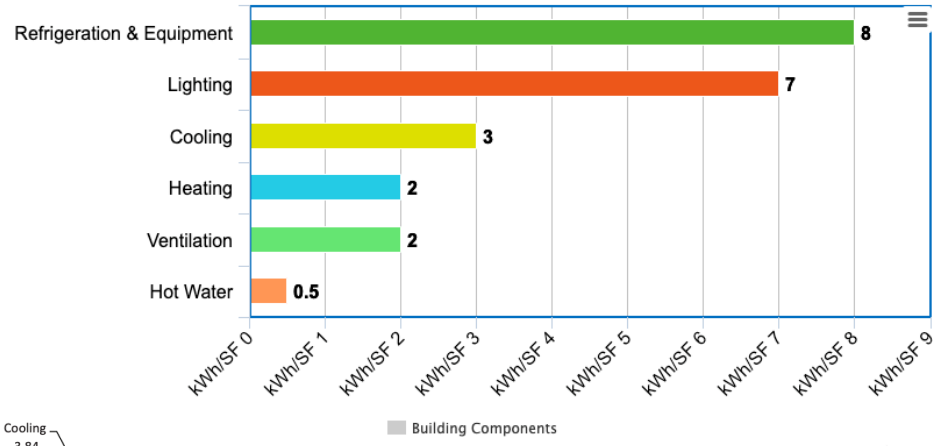
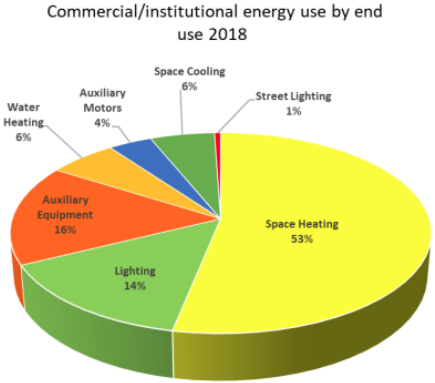
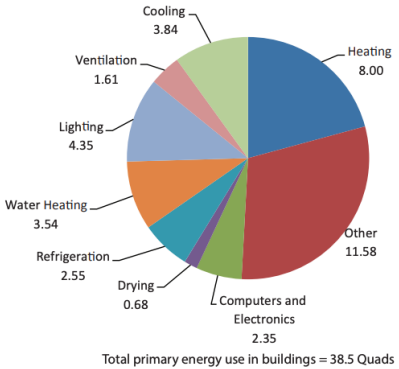
Sustainability

Network Energy Consumption
Is not the first concern for customers...









Different views of Energy consumption breakdown in office building

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So...

1. In order to provide some tangible energy savings to customers, the network needs to help save on other resources like HVAC and lighting >
2. The network can provide valuable information in terms of occupancy, environmental data (temperature, humidity, etc.) that can be passed to the Building Management system (Cloud/API integration)
3. Need to maximize network energy saving in order to be relevant

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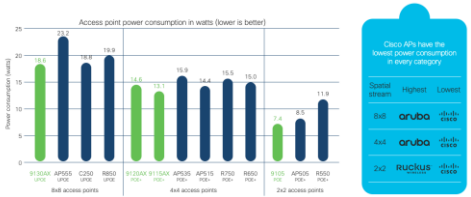
Calculating AP energy savings

If you want calculate AP energy savings, you need to consider four different tiers/modes of operations for the APs when it comes to energy consumption:

- AP is fully operational/full power > Catalyst Wi-Fi 6 and 6E APs have the highest power efficiency in the market thanks to the Cisco hardware and software innovation



Source: Miercom

- AP in idle mode (no clients) > Power save mode optimizations apply and can save an additional 20% in energy cost vs. regular idle mode

- AP on degraded power (e.g., C9166 with .3at power) > Power distribution (starting release 17.10) allows you to allocate available power to the functions you need most

- AP is off > Automating the power off/on of the switchport during off-peak, you can maximize your energy savings

MAX savings

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Why not just turning off the radios?

- Turning off all radios with “ap name <> shutdown” command gives 0.5-0.8 W max saving (I guess it depends on AP model, see next slide)
- C9164 AP in idle with radios up:

```
3560-CX#sh power inline gig 1/0/3 detail | i Mea
Measured at the port: 11.7 <<this is an average as with this command, I see a LOT of fluctuations
```

- C9164 AP in shut down:

```
3560-CX#sh power inline gig 1/0/3 detail | i Mea
Measured at the port: 11.1
```


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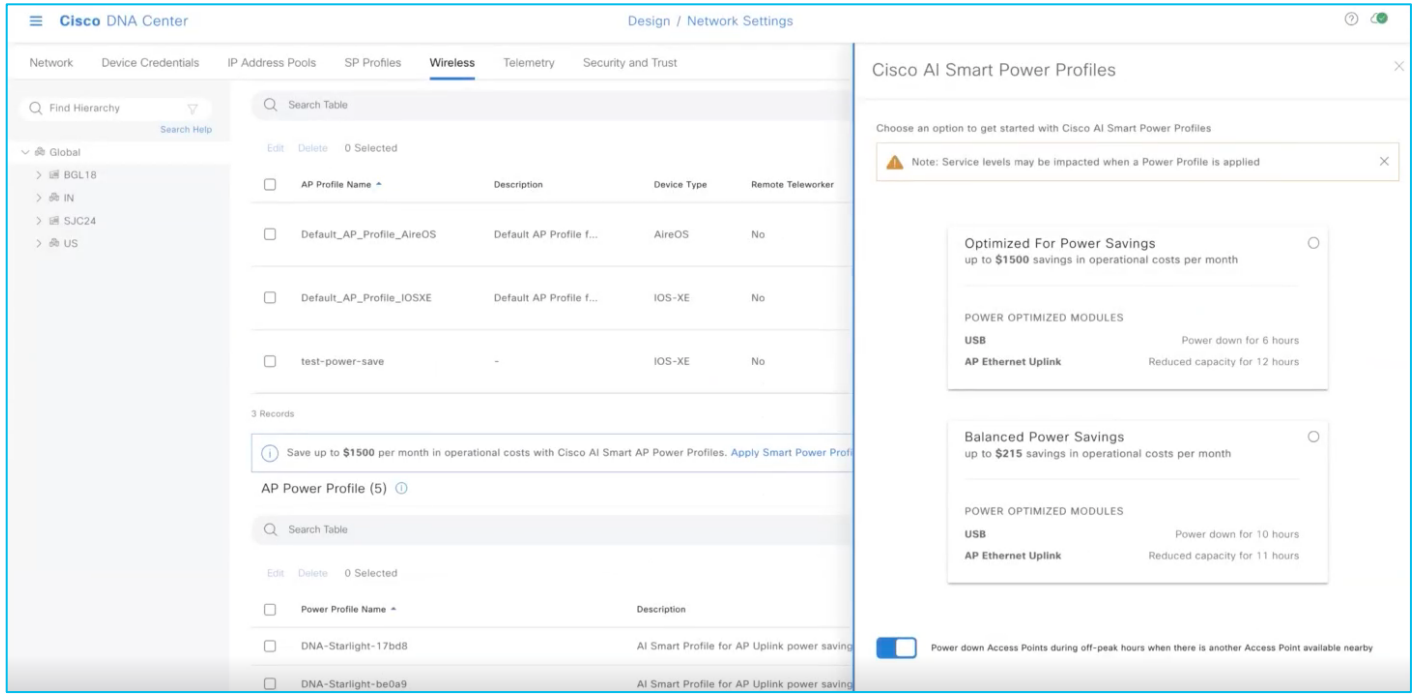
AI Power Profiles – Hackathon winner



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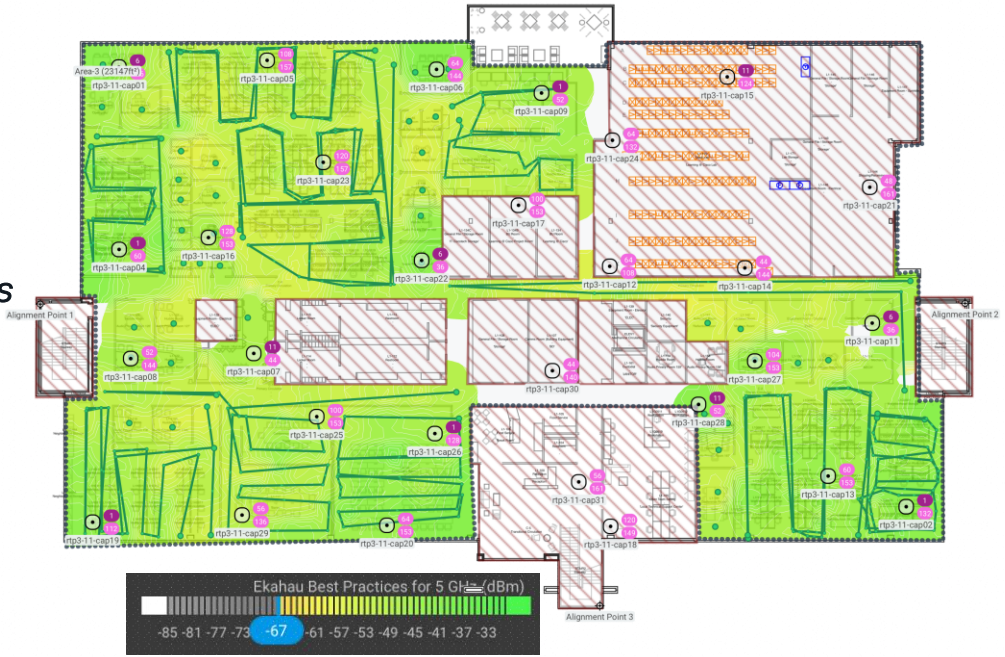
Designing for Sustainability

Capacity vs Coverage

- Enterprise networks are built to provide capacity over coverage
  - An Access Point (AP) represents a finite amount of bandwidth
  - That bandwidth will be shared with every device on that cell
  - Multiple Cells are needed to handle the numbers of users required ***during business hours***
- What about afterhours?
- How do you get the information to make that determination?
- Can you shut down portions of your network to optimize consumption?



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Designing for Sustainability

Capacity vs Coverage

- What are the requirements?
  - Complete Lights out?
  - Partial Shutdown/Skeleton coverage?
- What hours?
  - Do you know your Busy Hours?
  - Do you know it for every Campus?
- Speaking of hours, how long before its needed, do you have to turn it back on?
- Is that a blanket answer?

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Designing for Sustainability

Capacity vs Coverage

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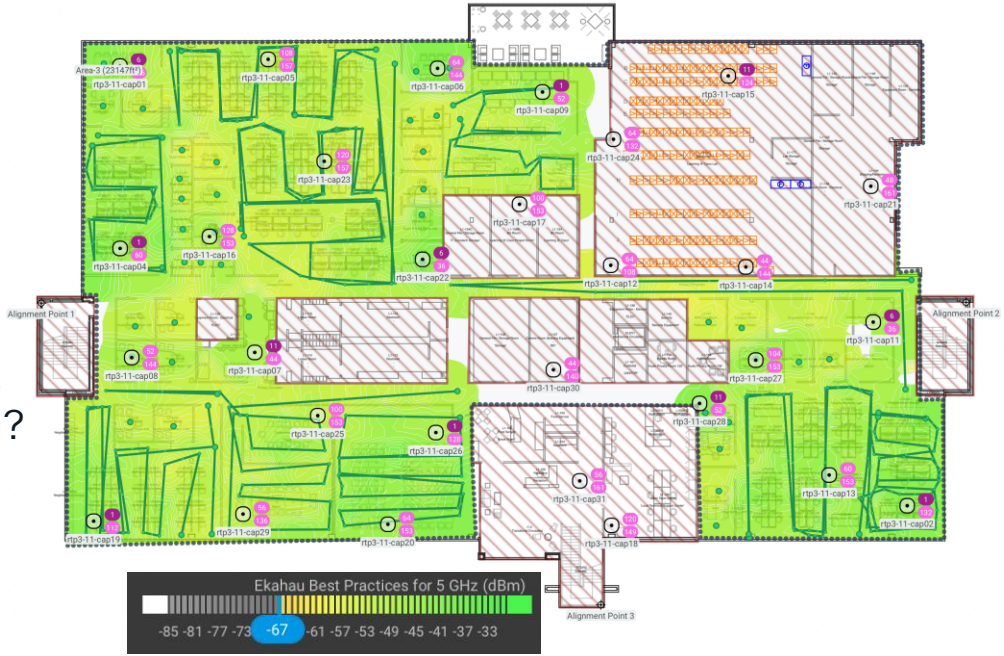

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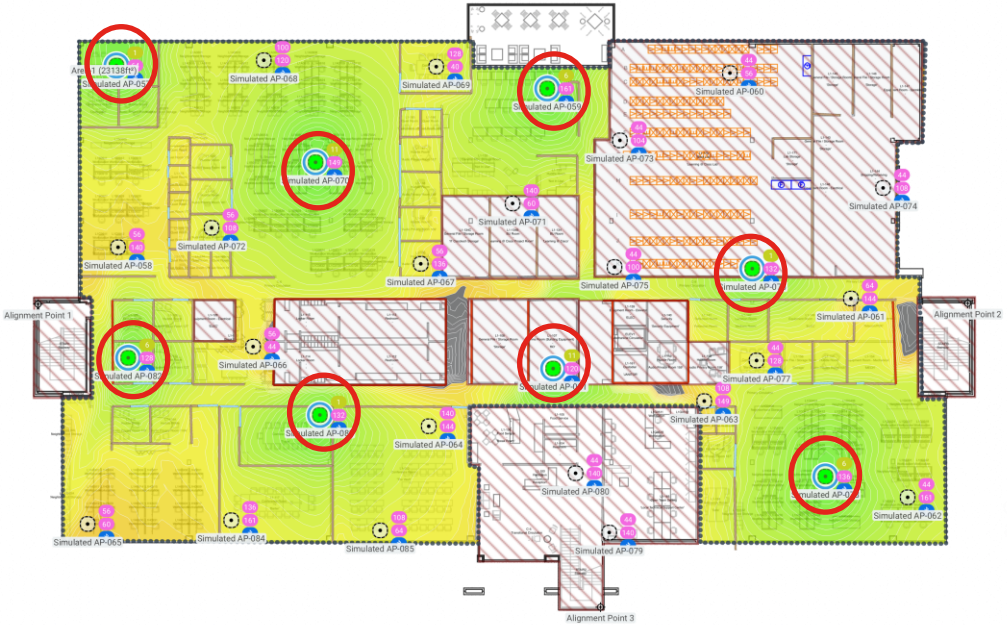
Designing for Sustainability

Capacity vs Coverage

- Survey reveals a normal high-density enterprise office space, well covered at -60 dBm
- With an SNR of 30 dB or better
- A Project plan is created to model solutions, the measured Survey is used to calibrate the model
- 29 Active APs are considered, 8 are selected for the bare coverage model
- At the original 11 dBm, coverage isn't adequate
- Increasing the power to 14 dBm provides coverage at -67 to near 100%, with a 70% fewer APs



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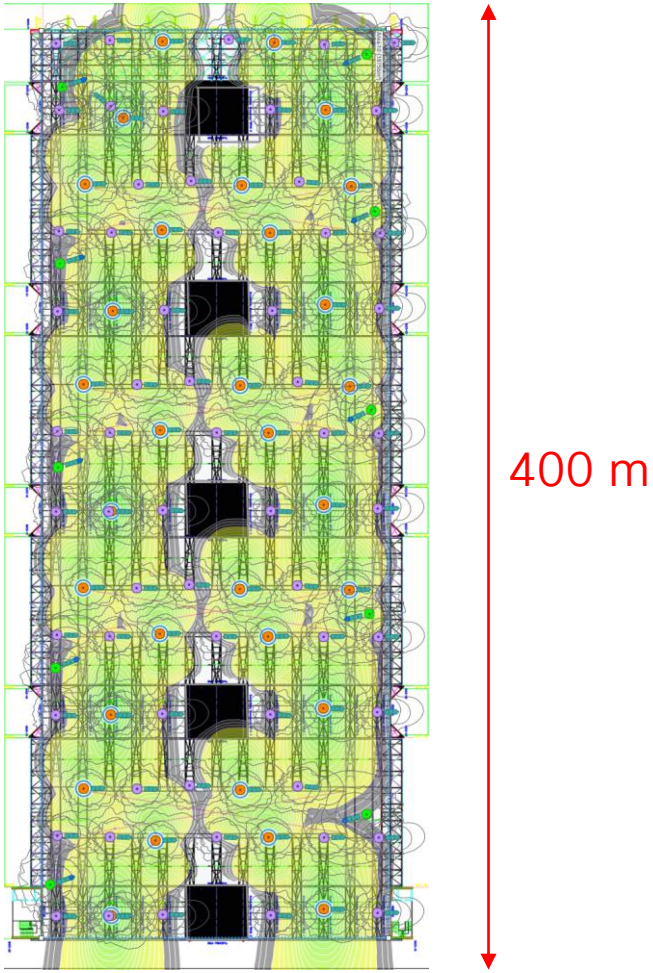
At Scale Sustainability = Versatility

- A Prime opportunity to optimize power usage exists particularly in LPV environments.
- Halls often sit idle for significant periods of time
- If all of the AP's are on, this constitutes a tremendous amount of power wasted.
- Shows of different sizes do not need all of the capacity that can be provided, its possible to re-configure the C9104 to cover in different densities without having to move the antennas with careful design.



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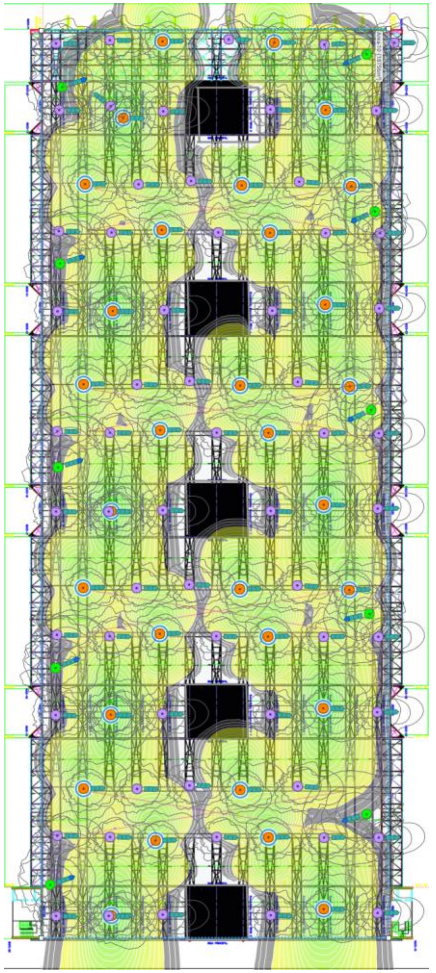
At Scale Sustainability = Versatility

- By reconfiguring (Software) the beamwidth to 20 degrees off center for interface 1 and 2, (Orange AP's)
- Most of the hall is well covered with 31 APs each supporting 2x 5 GHz interfaces
- For reference, shutting off an AP saves ~15 W at rest. Shutting of a single interface only saves roughly .8 watts.
- Relying on dual 5 GHz to back fill for another AP and shutting it off, nets a much higher return



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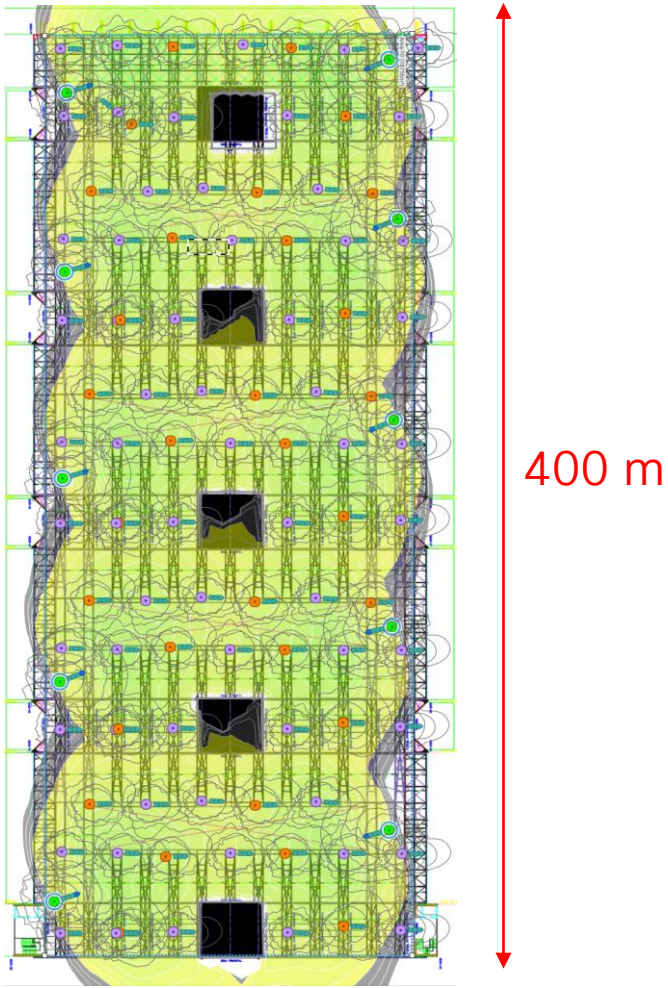
Sustainability – Off Peak Coverage

- Another way to ensure minimal coverage is to install APs strictly for afterhours coverage.
- These would be running when the main hall APs are not
- Installed specifically to cover the entire floor with a large practical low density cell design.
- In this drawing, 10 APs provide viable high speed, low capacity (10-20 per interface) coverage for the entire hall



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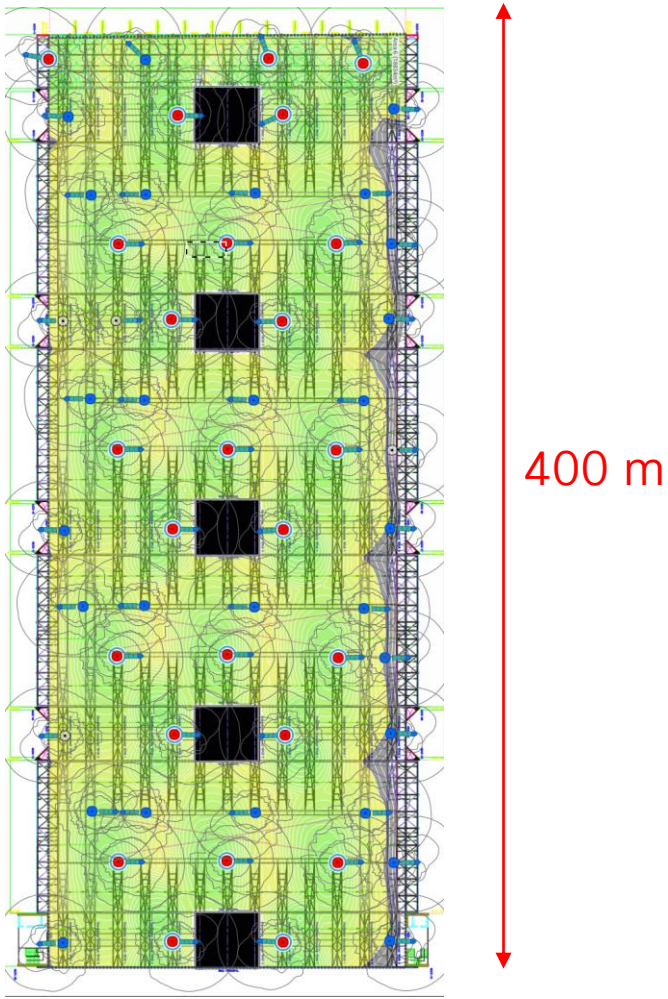
C9104, for Lower Density

- There are multiple options to provide the right balance between coverage and sustainability
- In this design, we reduced the AP count to 85 by tilting the AP angle 15 degrees
- After hours coverage can be configured using the wide Settings and medium to Medium high Capacity can be provided with just 25 APs (red) with the remaining APs shut down.



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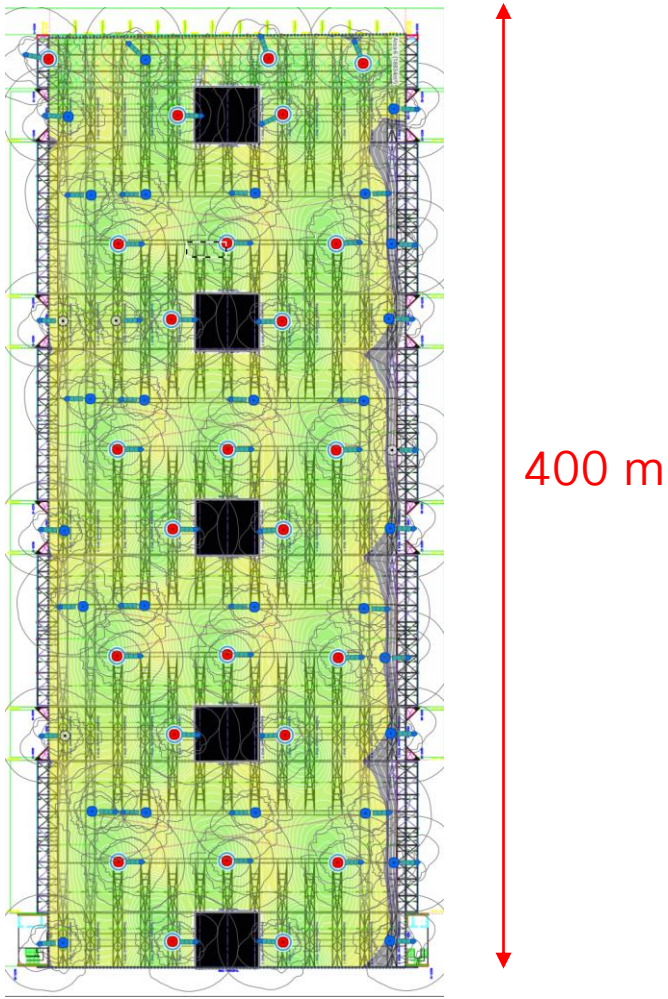

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So...

- See BRKEWN-2043 Simone Arena - *Saving Money and Energy with Cisco Wireless Networks*
- Be creative
- Look for more on this – lots more

Wi-Fi 6E Design Guidance

Best Practices

Complete Wi-Fi 6E portfolio

Indoor Access Points

Outdoor Access Points

Management mode can be changed

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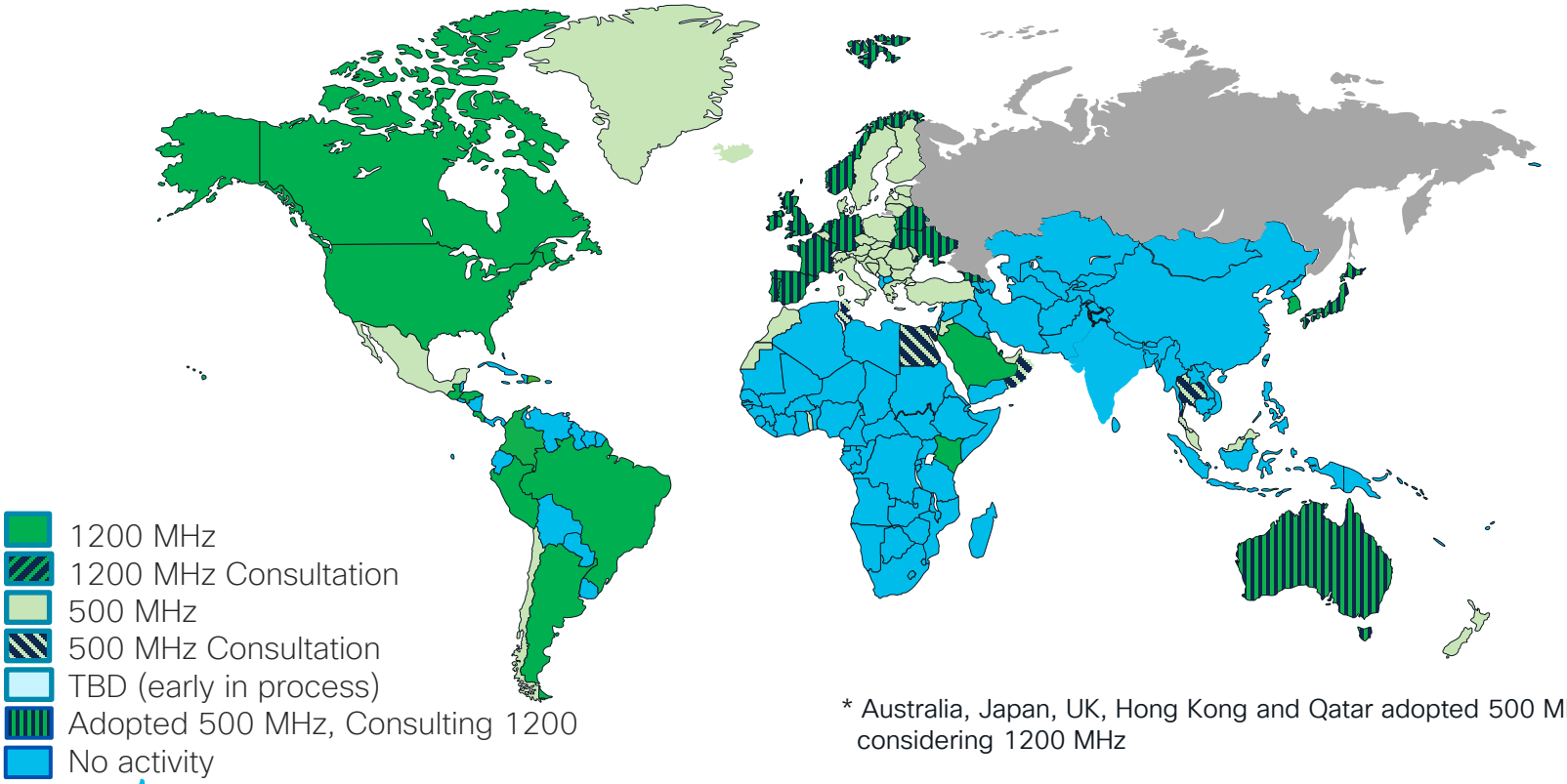
Global availability of 6 GHz band for Wi-Fi

(https://www.wi-fi.org/countries-enabling-wi-fi-6e)



* Australia, Japan, UK, Hong Kong and Qatar adopted 500 MHz and now considering 1200 MHz

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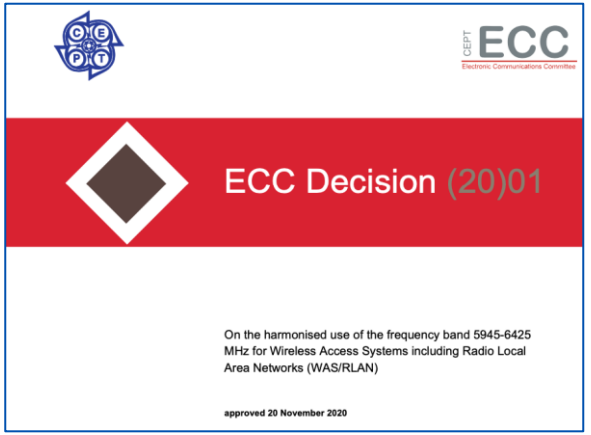
What are the important rules?

- 6 GHz Rules
- The requirements for low power use are as follows:
  - Must be indoors (the AP is not allowed to be “weatherized”).
  - Must have a permanently attached antenna.
  - May not be battery powered.
  - Must employ a contention-based protocol.
  - Maximum EIRP is 5 dBm/MHz
  - Client maximum power is 6 dB below the AP maximum allowed EIRP (power)
- There is only one option possible outdoors: Standard Power w/AFC

Federal Communications Commission



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Summary Wi-Fi 6E/6GHz Tx Requirements*

Mode	Country	Max Tx Power EIRP		Max PSD EIRP		Max Ch BW
	(Frequency Range MHz)	AP (dBm)	Client (dBm)	AP (dBm)	Client (dBm)	(MHz)
LPI	FCC (5925-7125)	30	24	5	-1	320
	ETSI (5945-6425)	23	23	10	10	
	UK (5925-6425)	24	24	11	11	No Max
	S Korea (5925-7125)			2	2	160
	Malaysia (5925-6425)	23	23	10	10	
	Brazil (5925-7125)	30	24	5	-1	
	ISED (5925-7125)	30	24	5	-1	
	Chile (5925-7125)	30	24	5	-1	
	Peru (5925-7125)	30	24	5	-1	
	UAE (5925-6425)	24	24			
	Saudi Arabia (5925-7125)	30	24	10	10	
	ATU (5945-6425) (Kenya/Uganda/Congo/Niger/Ghana)	23	23	10	10	
	Morocco (5945-6425)	23	23			
SP	FCC (U-NII-5/7)	36 (21<30°)	30	23	17	320

* Includes only the countries and regions that approved the allocation; Empty cell means regulation is silent

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Summary 6GHz Tx Requirements*

Mode	Country (Frequency Range MHz)	Max Tx Power EIRP AP (dBm)	Max Tx Power EIRP Client (dBm)	Max PSD EIRP AP (dBm)	Max PSD EIRP Client (dBm)	
	FCC (5925-7125)	30	24			
	ETSI (5945-6425)	23				
	UK (5925-6425)					
	S Korea (5925-7125)					
	Mal					
					-1	
			24	5	-1	
		30	24	5	-1	
		24	24			
	(5925-7125)	30	24	10	10	
	ATU (5945-6425) (Kenya/Uganda/Congo/Niger/Ghana)	23	23	10	10	
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	UK (5925-6425)	24	24	11	11

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Summary 6GHz Tx Requirements

- Breaking down the PSD Values vs Max TX EIRP
  - FCC = 3 dB more power per channel width doubling and MAX TX EIRP of 30 dBm
  - ETSI/UK = PSD value = MAX TX EIRP at 20 MHz, remaining channel widths = Max TX EIRP

Mode	Country	Max Tx Power EIRP		Max PSD EIRP	
	(Frequency Range MHz)	AP (dBm)	Client (dBm)	AP (dBm)	Client (dBm)
	FCC (5925-7125)	30	24	5	-1
	ETSI (5945-6425)	23	23	10	10
	UK (5925-6425)	24	24	11	11

	20 MHz	40 MHz	80 MHz	160 MHz
FCC 5 dBm/MHz	18 dBm	21 dBm	24 dBm	27 dBm
ETSI 10 dBm/MHz	23 dBm	26>23 dBm	29>23 dBm	32>23 dBm
UK 11 dBm/MHz	24 dBm	27>24 dBm	30>24 dBm	33>24 dBm

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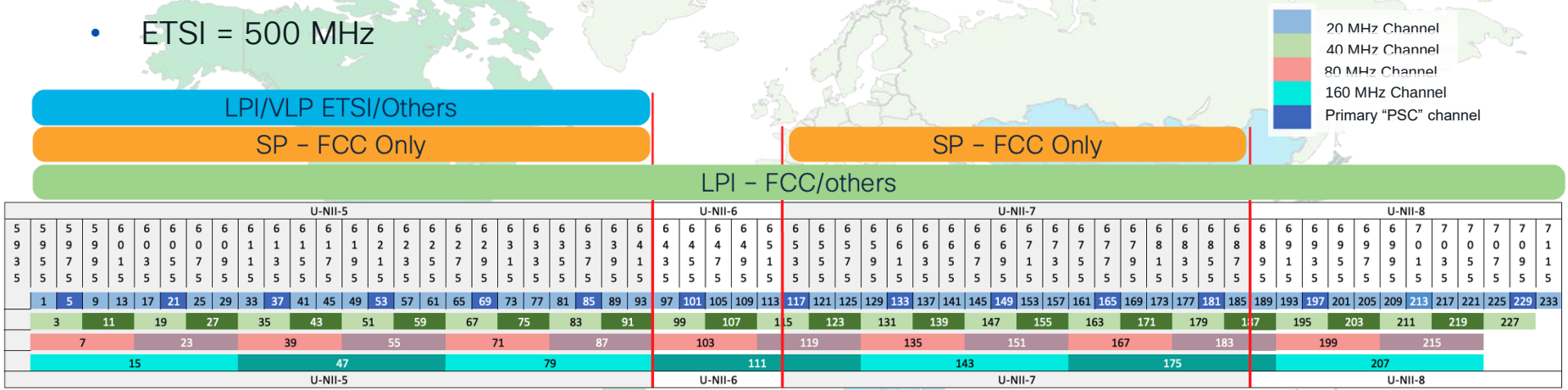
The new 6 GHz band :

- Two main proposals being reviewed or accepted by world regulators
  - FCC = 1200 MHz
  - ETSI = 500 MHz



59 FCC, 24 ETSI @20 MHz

29 FCC, 12 ETSI @40 MHz

14 FCC, 6 ETSI @80 MHz

7 FCC, 3 ETSI @160 MHz

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Site Survey @6GHz: Something to think about…

- On the definition of Low Power Indoor AP, there is the following technical conditions regarding the use of batteries to power the device: May **not** be **battery powered**

=

- Cisco legal recommends the surveyor to attach a physical label that says something like “Indoor RF survey use only”

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Catalyst AP: Site Survey mode configuration steps

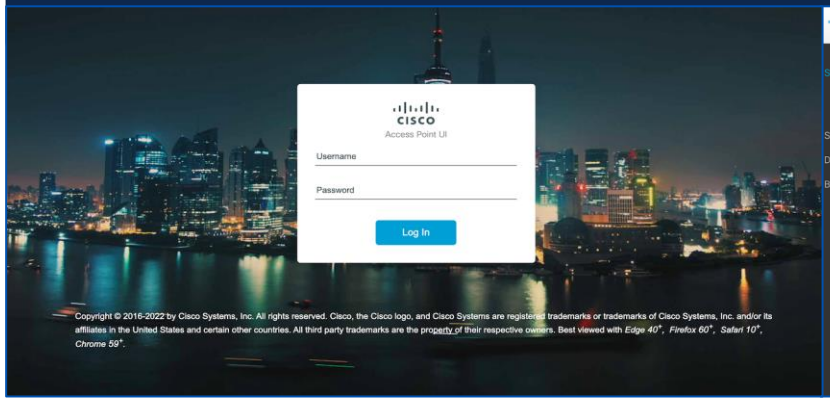
1. Change AP to site survey mode > exec command “ap site-survey”

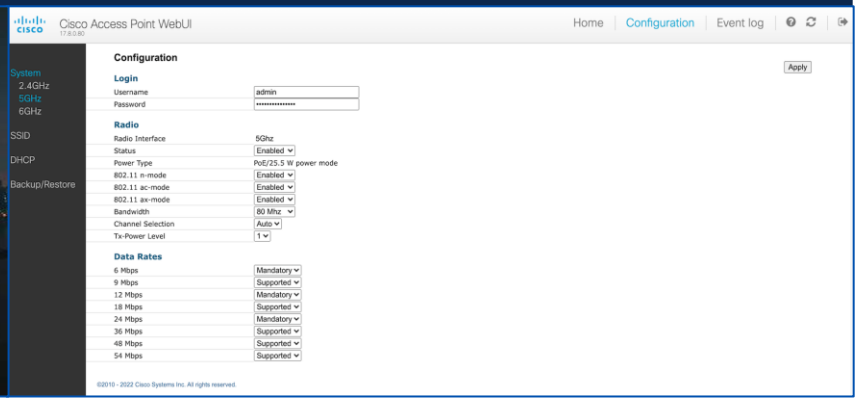
```
C9136#ap ?
  capwap       Switch to CAPWAP AP type
  site-survey  Switch to Site Survey AP type
```

2. After bootup, the AP is automatically assigned a static IP of 10.0.23.1. CLI prompt changes

   `site-survey-AP#` *(default credentials Cisco/Cisco)*

3. AP will start broadcasting the CiscoAirProvision SSID with open authentication security
4. Connect your wireless client with the CiscoAirProvision SSID and it’ll receive an IP from 10.0.23.0/24.
5. Access the Catalyst Site Survey WebUI via 10.0.23.1 (*default credentials admin/admin*)





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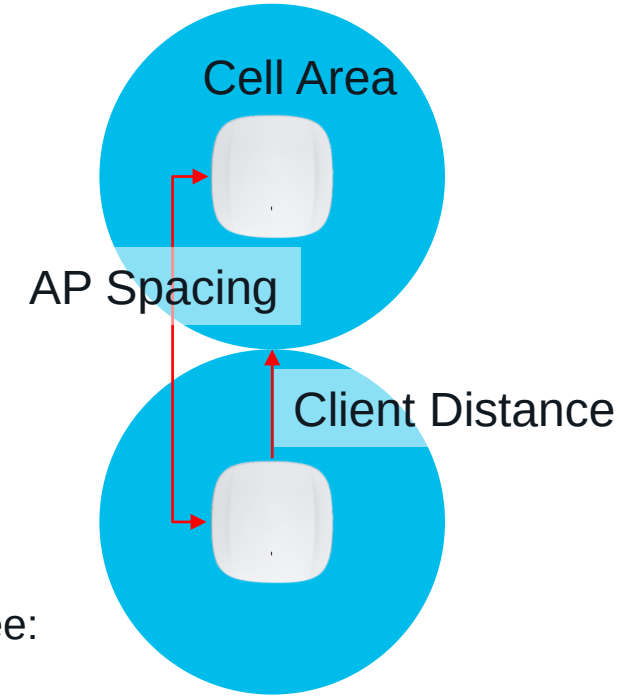
Dimensioning 5 GHz

Cell Area/Coverage	AP Spacing 1 AP every	Max Client Distance to AP
1k ft^2/92m^2	36 f /11 m	18 f / 5.5 m
1.2k ft^2/111m^2	40 f /12 m	20 f / 6 m
1.5k ft^2/140 m^2	44 f /13.5 m	22 f / 6.7 m
2K ft^2/185 m^2	50 f /15.2 m	25 f / 7.6 m
2.8K ft^2/260 m^2	60 f /18.2 m	60 f / 18.2 m

Cell Edge/ Clients 20-25 feet (6-7.5 meters)



For more information on channel planning and AP density see:
Cisco High Density AP/Deployment
https://www.youtube.com/watch?v=c8w6Mfck0nQ

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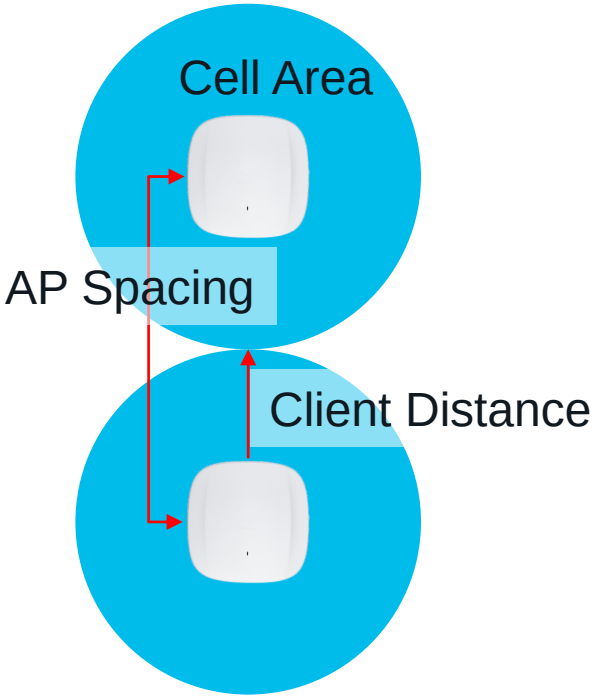
5 GHz Design Considerations

- Most modern Carpeted Enterprise 5 GHz Wi-Fi are installed at an AP Density between 1.2-2K f^2 /110-185 m^2
- The Spatial Reuse factors are:
  - # Channels (dual 5 GHz =minimum 2 channels/AP)
  - The density of the AP's (how close together they are)
  - TX Power (Same Channel Interference range)
- Enterprise/healthcare/Higher Education networks are operating with **Tx powers 11-15 dBm** (PL3-4) depending on density.



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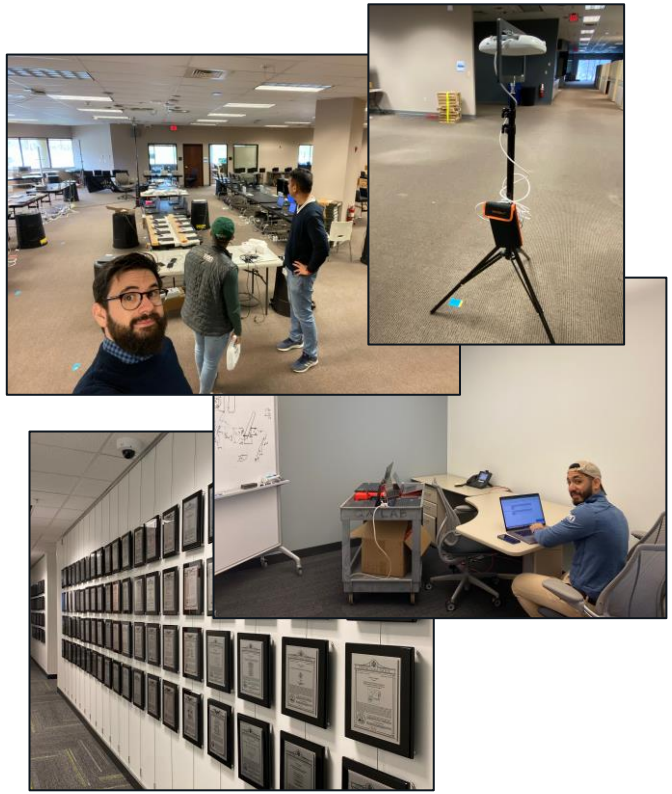
What we Tested

1. Propagation for 6 GHz as it compares to 5 GHz propagation – Using Clients
   - Use clients to record RSSI @ 5 and 6 GHz measuring at 12 points across the Richfield, OH Cisco offices
   - Compare 5 GHz and 6 GHz readings from each device at each point
2. Compare Ekahau AI-Pro Site Survey/Sidekick 1 and 2 and NetAlly AirCheck G3 Measurements
3. Range vs Rate testing for 5 GHz vs 6 GHz
   - Compare 5 vs 6 GHz implementation on Various clients
   - Demonstrate effectiveness of a practical coverage plan



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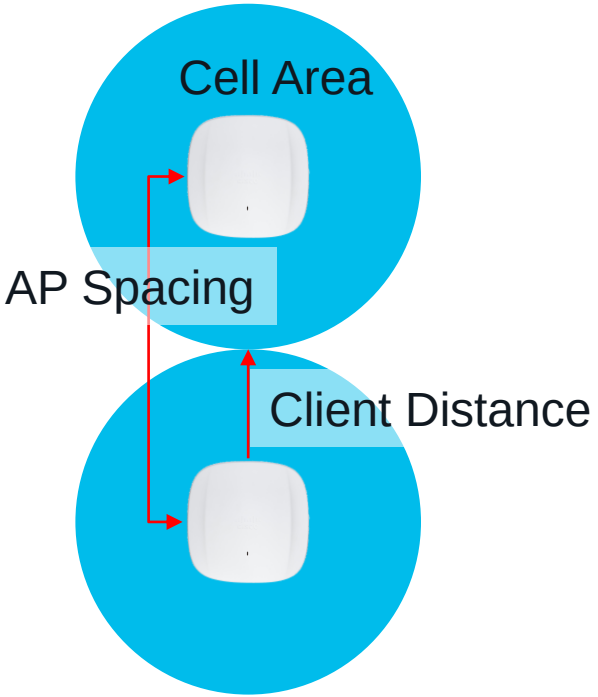

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1. Propagation Comparison 5/6 GHz

- Multiple Test Points 1-12 with 5 Tri band Client Devices
  - 1 Lenovo, 2x Samsung and 1 MSI Laptops
  - Samsung S-21 Phone
- Record and Compare Measurements between clients @ both 5 and 6 GHz
- Compare 5 GHz Measurements with Ekahau site survey
  - Validate Survey vs Client observation
  - Ekahau Sidekick – Mobile Device mode

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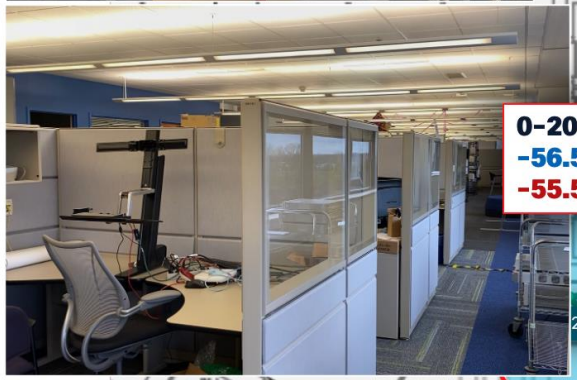

Empty for My Access Points on 2.4 5 Both Options

35-40 Feet
-58.5 dBm 5 GHz
-58.5 dBm 6 GHz

50-70 Feet
-60 to -65 dBm 5 GHz
-60 to -66 dBm 6 GHz

25-30 Feet
-57.5 dBm 5 GHz
-55.5 dBm 6 GHz

0-20 Feet
-56.5 dBm 5 GHz
-55.5 dBm 6 GHz

#8 @59 ft
#9 @70 ft
#7 @50 ft
#6 @35 ft
#5 @28 ft
#11 @40 ft
#10 @55 ft
#4 @17 ft
2 @18 ft
#12 @30 ft
#3 @9 ft
1
36@40
#1 @25 ft

5 GHz PL 3 (15 dBm), 36 @ 40

6 GHz PL 1 (17 dBm), 5 @ 80

*RSSI values = Average of all 5 devices

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Raw Data – Client RSSI

5 GHz Clients (6E AX210)	RSSI Value (From Client - 1)	RSSI Value (From Client - 2)	RSSI Value (From Client - 3)	RSSI Value (From Client - 4)	RSSI Value (From Client- 5)	RSSI Value (From Client - 6)	RSSI Value (From Client- 7)	RSSI Value (From Client- 8)	RSSI Value (From Client-9)	RSSI Value (From Client-10)	RSSI Value (From Client-11)	RSSI Value (From Client-12)
Ekahau – Mobile Device	**-62**	**-62**	**-56**	**-58**	**-60**	**-63**	**-65**	**-67**	**-69**	**-63**	**-62**	**-58**
Distance from AP	25	18	9	17	28	35	50	59	70	55	40	30
Lenovo	-56	-57	-57	-57	-57	-59	-60	-60	-59	-58	-58	-58
Samsung Book	-60	-58	-59	-60	-60	-60	-63	-70	-74	-64	-60	-60
MSI	-58	-59	-59	-59	-59	-60	-60	-63	-63	-63	-60	-58
Samsung S21	-56	-50	-51	-52	-53	-52	-59	-64	-67	-60	-58	-58
Samsung Notebook	-56	-58	-58	-58	-58	-58	-60	-60	-64	-61	-60	-58
Average	-57.2	-56	-56.7	-56.92	-57.2	-57.4	-60	-63.2	-65.2	-61	-59	-58.1

6 GHz Clients (6E AX210)	RSSI Value (From Client - 1)	RSSI Value (From Client - 2)	RSSI Value (From Client - 3)	RSSI Value (From Client - 4)	RSSI Value (From Client- 5)	RSSI Value (From Client - 6)	RSSI Value (From Client- 7)	RSSI Value (From Client- 8)	RSSI Value (From Client-9)	RSSI Value (From Client-10)	RSSI Value (From Client-11)	RSSI Value (From Client-12)
Distance(f) from AP	25	18	9	17	28	35	50	59	70	55	40	30
Lenovo	-56	-56	-56	-56	-56	-56	-57	-60	-59	-59	-59	-57
Samsung Book	-57	-57	-57	-57	-59	-58	-65	-79	-59	-58	-58	-58
MSI	-64	-56	-55	-55	-57	-59	-60	-63	-59	-59	-59	-66
Samsung S21	-60	-52	-57	-57	-61	-63	-71	-75	-64	-65	-58	-61
Samsung Notebook	-59	-56	-56	-57	-56	-58	-59	-59	-57	-59	-57	-57
Average	**-59.1**	**-55.4**	**-56.1**	**-56.3**	**-57.7**	**-58.8**	**-62.4**	**-66.9**	**-59.4**	**-59.6**	**-58.2**	**-59.5**

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- *Conclusion 1 –*
  With an appropriate power offset (~2 dB), 5 and 6 GHz LPI Cells can be made co-resident at normal Enterprise Densities.

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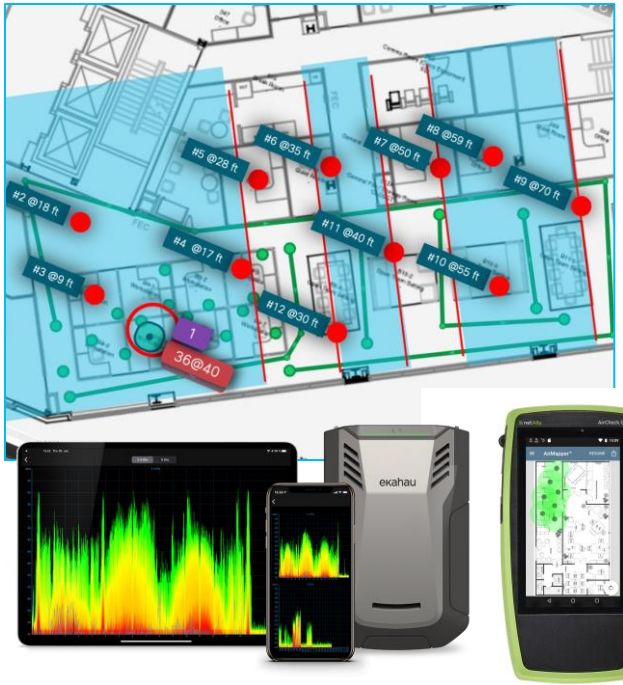
2. Characterize New Test tools

- Using the same Test points in the setup, Validate New test hardware against the client's truth
- Measurements made using:
  - Ekahau Sidekick 2
    - 2.4, 5, 6 GHz
    - Ekahau AI Pro
    - Ekahau Analyzer
  - Ekahau Sidekick 1
    - Compared 5 GHz only w SK2
  - NetAlly Aircheck G3
    - 2.4, 5, 6 GHz
    - NetAlly Link-Live



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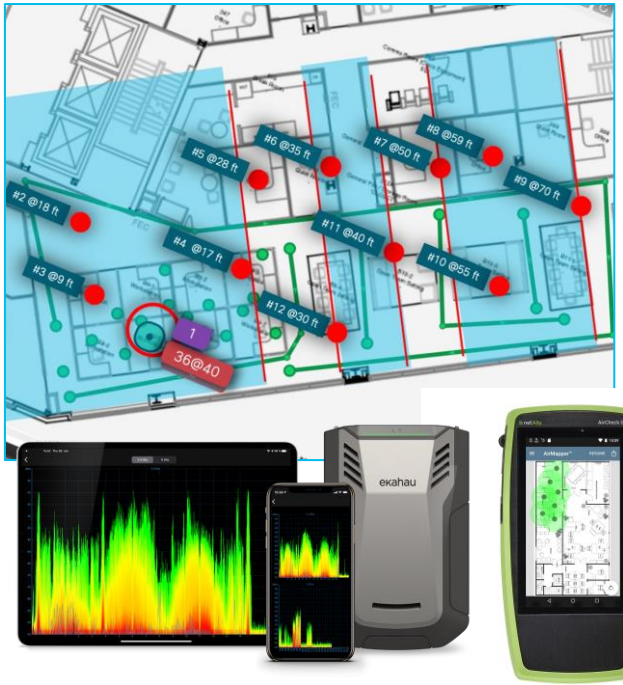

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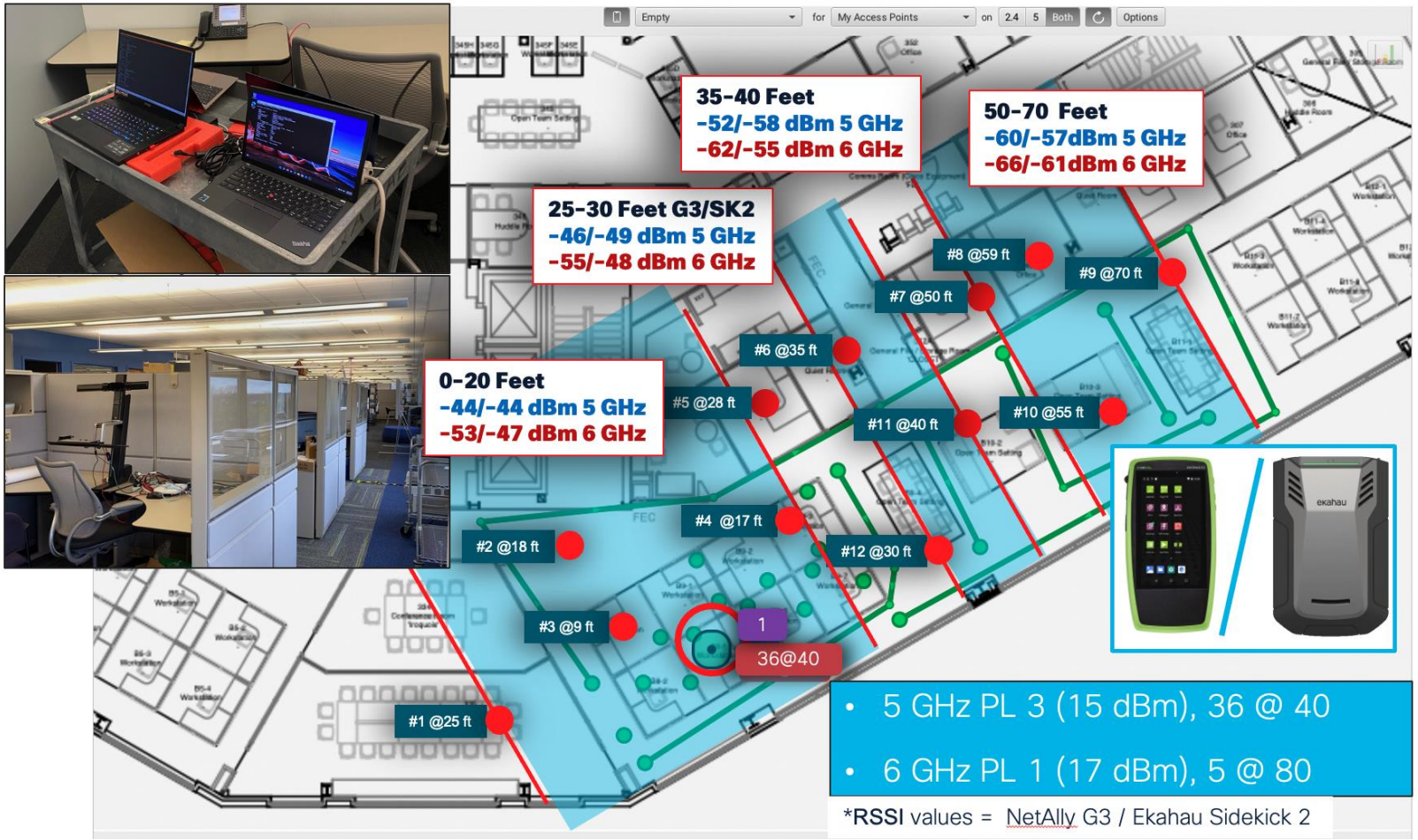

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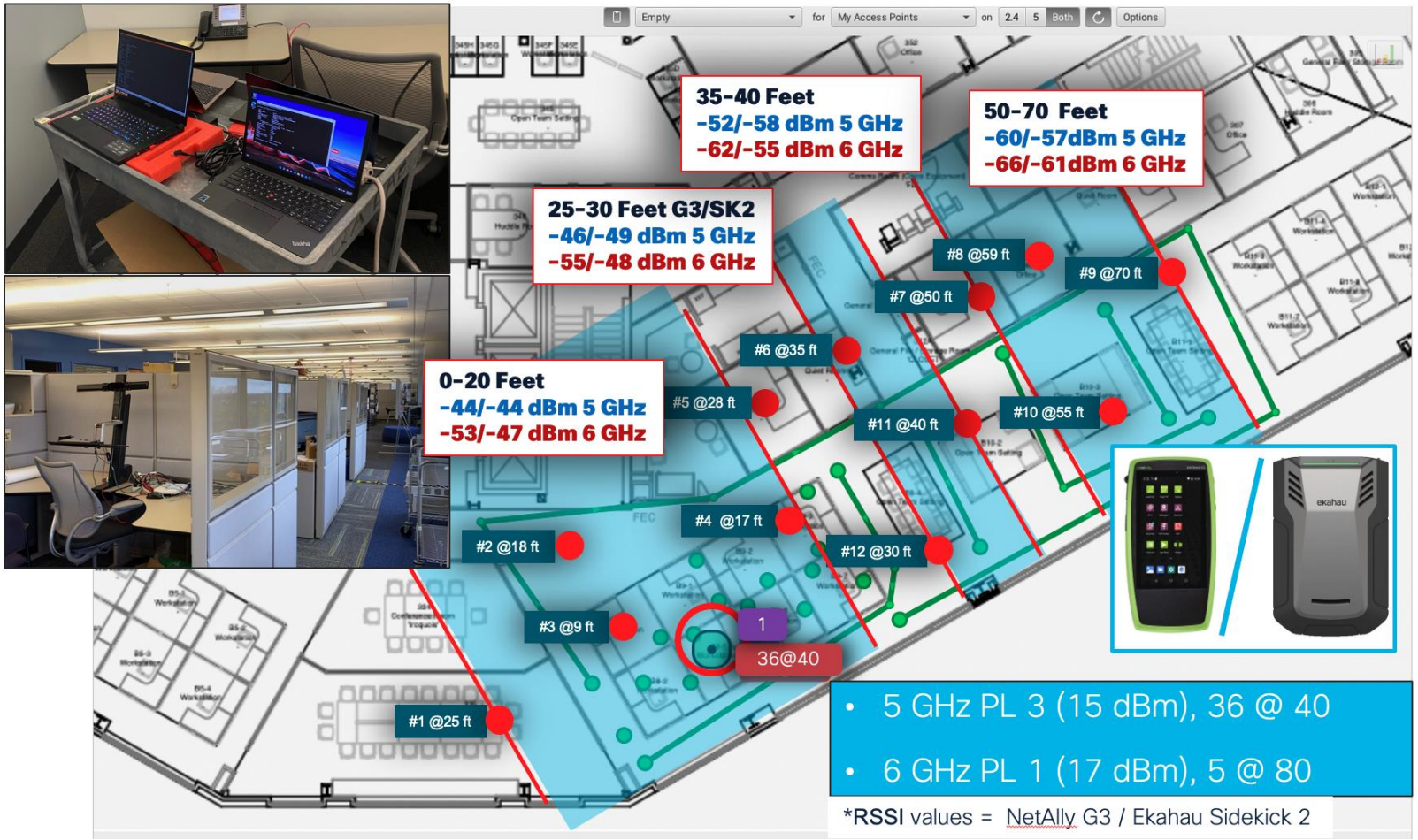

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Raw Data – Client/Test Set RSSI

Clients WI-Fi 6E **5 GHz**	RSSI Value Point 1	RSSI Value Point 2	RSSI Value Point 3	RSSI Value Point 4	RSSI Value Point 5	RSSI Value Point 6	RSSI Value Point 7	RSSI Value Point 8	RSSI Value Point 9	RSSI Value Point10	RSSI Value Point 11	RSSI Value Point 12
Ekahau Sidekick1	-62	-62	-56	-58	-60	-63	-65	-67	-69	-63	-62	-58
Lenovo	-56	-57	-57	-57	-57	-59	-60	-60	-59	-58	-58	-58
Samsung Book	-60	-58	-59	-60	-60	-60	-63	-70	-74	-64	-60	-60
MSI	-58	-59	-59	-59	-59	-60	-60	-63	-63	-63	-60	-58
Samsung S21	-56	-50	-51	-52	-53	-52	-59	-64	-67	-60	-58	-58
Samsung Notebook	-56	-58	-58	-58	-58	-58	-60	-60	-64	-61	-60	-58
Client Average	-57	-56	-57	-57	-57	-57	-60	-63	-65	-61	-59	-58
NetAlley G3	-45	-47	-45	-51	-51	-57	-63	-64	-57	-58	-47	-41
Ekahau Analyzer/SideKick2	-43	-44	-44	-45	-52	-55	-59	-61	-59	-51	-61	-45
Ekahau AI Pro/SideKick2 Mob	-55	-57	-51	-56	-57	-64	-70	-72	-70	-68	-61	-60

Clients WI-Fi 6E **6 GHz**	RSSI Value Point 1	RSSI Value Point 2	RSSI Value Point 3	RSSI Value Point 4	RSSI Value Point 5	RSSI Value Point 6	RSSI Value Point 7	RSSI Value Point 8	RSSI Value Point 9	RSSI Value Point10	RSSI Value Point 11	RSSI Value Point 12
Lenovo	-56	-56	-56	-56	-56	-56	-57	-60	-59	-59	-59	-57
Samsung Book	-57	-57	-57	-57	-59	-58	-65	-79	-59	-58	-58	-58
MSI	-64	-56	-55	-55	-57	-59	-60	-63	-59	-59	-59	-66
Samsung S21	-60	-52	-57	-57	-61	-63	-71	-75	-64	-65	-58	-61
Samsung Notebook	-59	-56	-56	-57	-56	-58	-59	-59	-57	-59	-57	-57
Average Client	-59.1	-55.4	-56.1	-56.3	-57.7	-58.8	-62.4	-66.9	-59.4	-59.6	-58.2	-59.5
NetAlley G3	-50	-54	-52	-56	-57	-62	-67	-70	-65	-62	-61	-54
Ekahau Analyzer/SideKick2	-46	-47	-49	-48	-50	-56	-60	-64	-63	-57	-54	-45
Ekahau AI Pro/SideKick2 Mob	-59	-57	-56	-59	-67	-67	-70	-70	-72	-69	-64	-61

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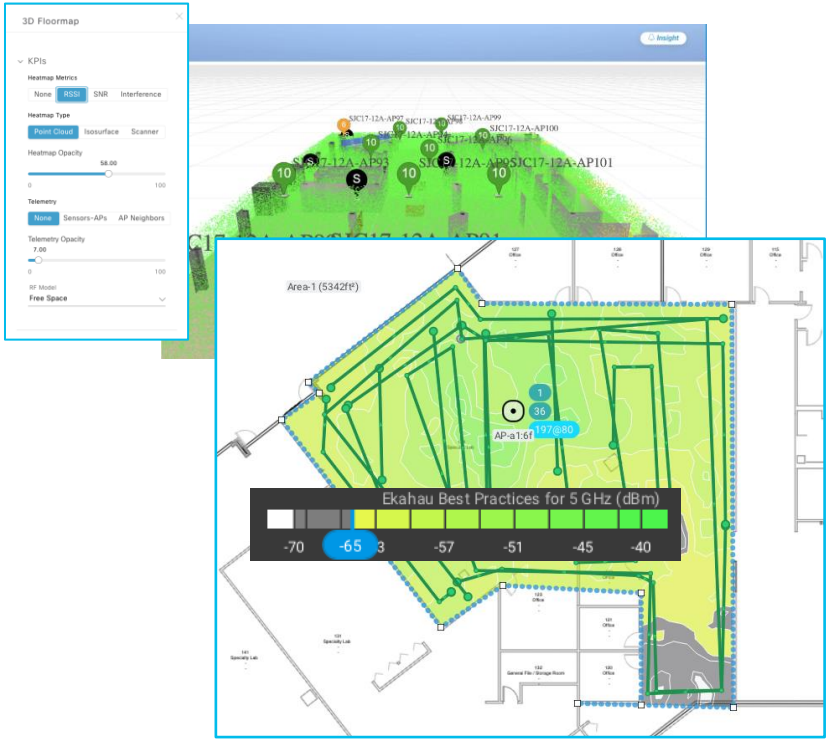
Predictive vs Measured

When is good enough, good enough?

- A “Predictive Survey” is an RF design created using a predictive modeling tool, specific to RF
- Using scale floor plan, antenna patterns provided by manufacturers, the predicted RF coverage can be visualized in a heatmap as coverage
- Available tools can be quite sophisticated and provide good visualizations



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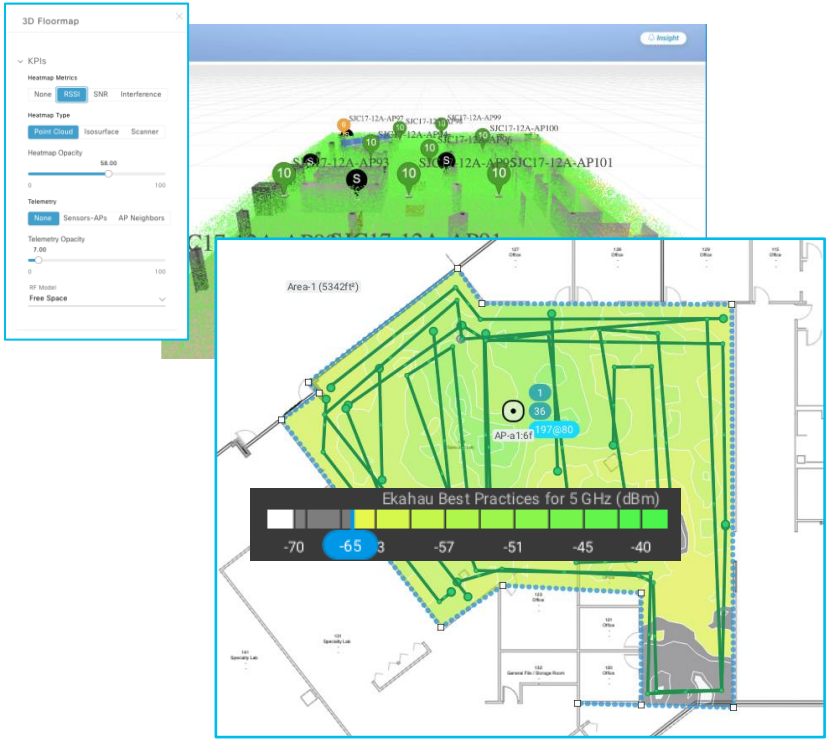

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Predictive vs Measured

When is good enough, good enough?

- A Measured Site Survey is an actual measurement of the RF Coverage in each space
- Measurement tools range from off the shelf client devices to specialized scanning radios and applications
- Ekahau and NetAlly both have Instruments specifically for measuring Wi-Fi at 2.4 => 6 GHz

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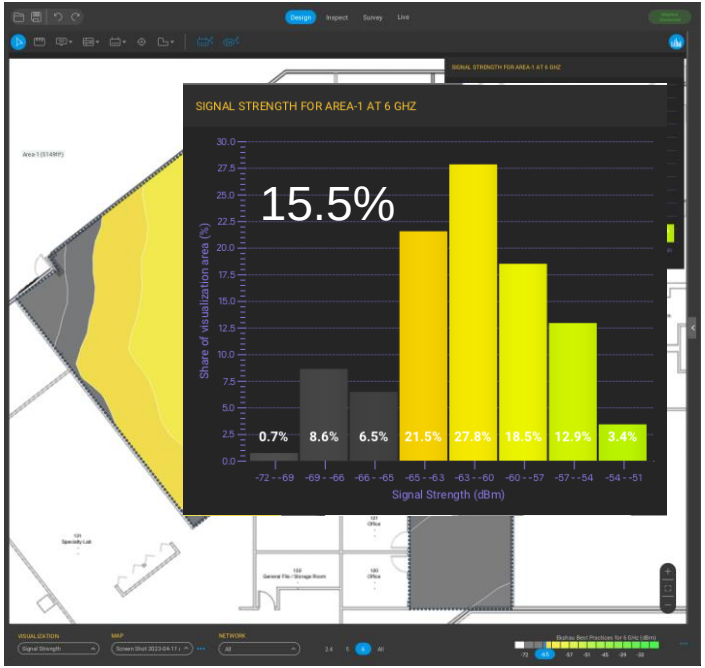
How to Calibrate
Ekahau AI Pro 11.2

A measurement, is the ground truth

1. A Catalyst C9166 AP was measured on channel 37@80 MHz, 2 dBm power
2. Using the Signal Strength for Area tool in Ekahau – The measured coverage that's below -65 = 15.5 %
3. Modeling a Catalyst 9166 @ 2 dBm channel 37@80 MHz Measures 41% below -65 dBm
4. Adjust the power in the model until the same approximate coverage area is reached – adding 3 dB to make TX power 5 dBm



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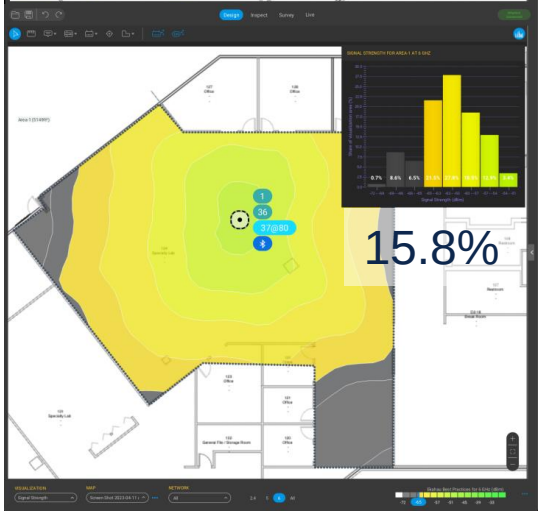
How to Calibrate
Ekahau AI Pro 11.2

A measurement, is the truth

- The Measured coverage is more complex, but this is measured in a room full of tables filled with wi-fi devices to measure
- The Model covers more smoothly, but looks pretty good with a +3 dB TX power increase and measures 15.8% to the actual measured 15.5% above -65 dBm
- Then for the C9166 in 6 GHz in an open office space - add 3 dB to the TX power and design with confidence

Measured

Simulated



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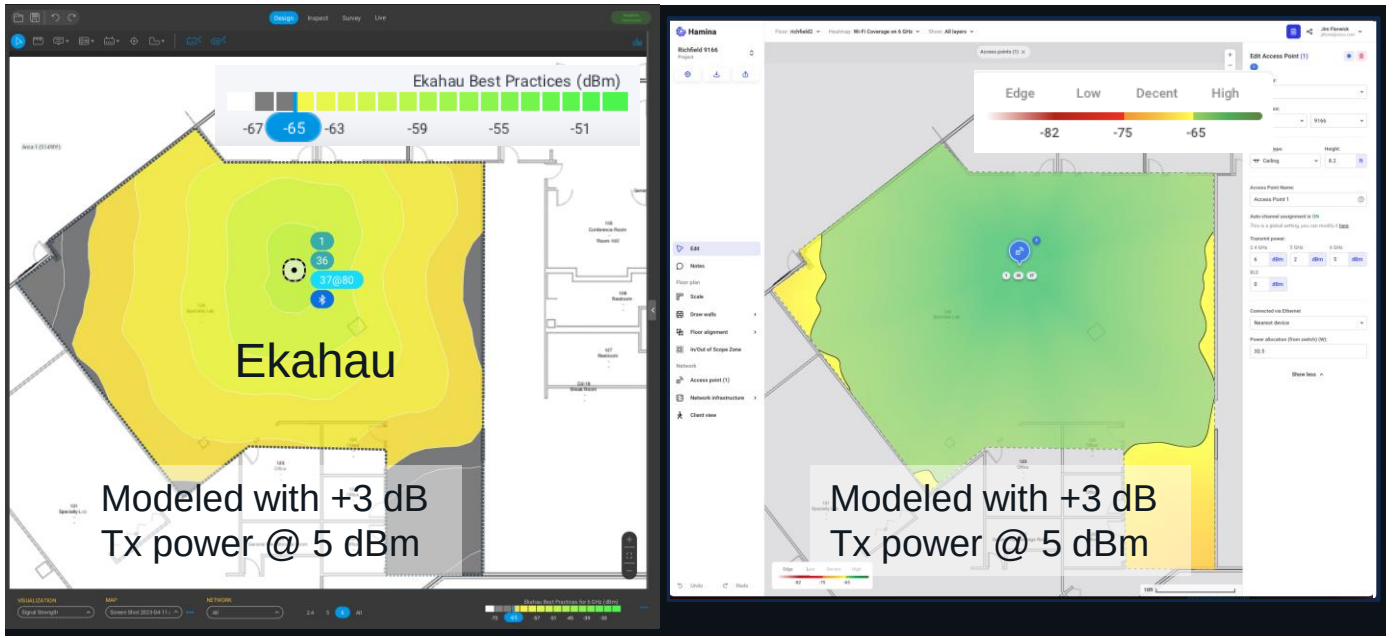
Referencing Predictive Models

Ekahau AI Pro 11.2 And Hamina Wireless

Once there is a scale Predictive Model, can be used to reference other tools



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Referencing Predictive Models

Ekahau AI Pro 11.2 And Hamina Wireless

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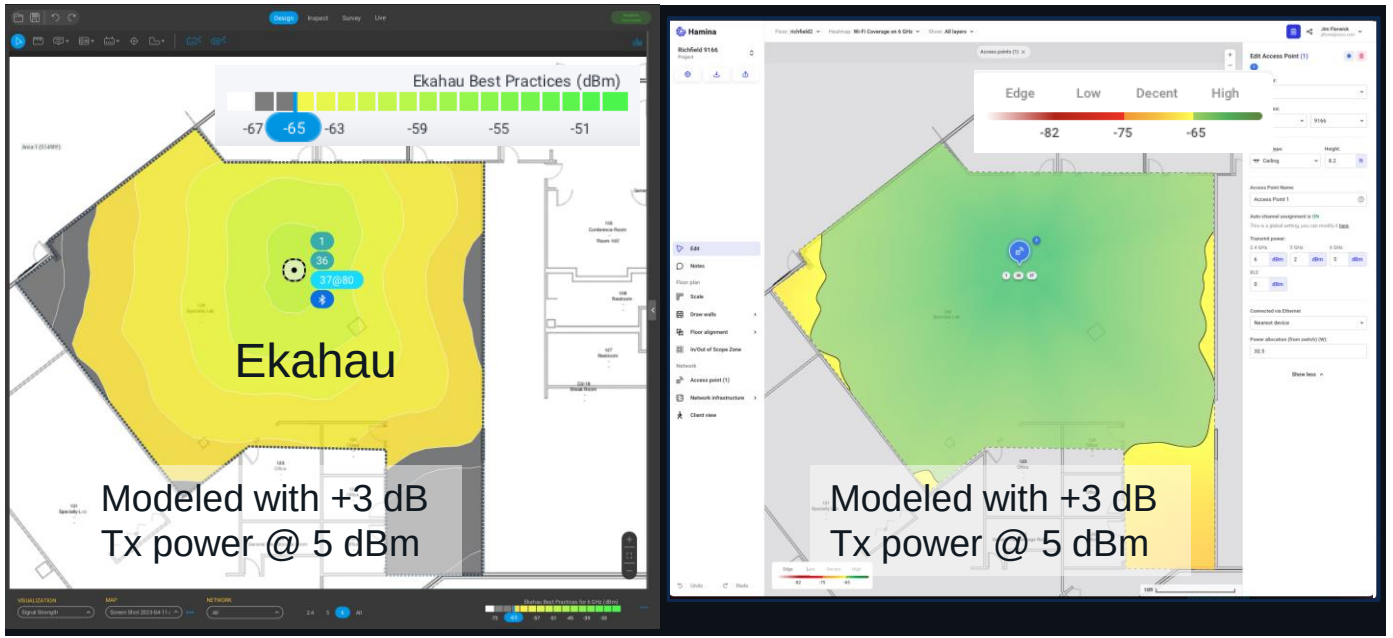

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- *Conclusion 2*

Know your Tools – and Calibrate!

Using Ekahau tools note that SK1 and SK2 are both fine tools, SK1, more sensitive than SK2 and overestimates Client level RF, SK2 better

Know the measurement differences and how to employ View as Mobile Device mode and why
AI Pro and Analyzer applications both have View s Mobile Device mode

NetAlly G3 Is a bit more sensitive and does not have an automatic offset to get it closer to Client Device reality.

It does have Manual offsets that can be entered in dB to compensate – BUT – Calibrate

See BRKEWN-2024 – Anand Gurumurthy Architecting
Next Generation Wireless Networks with Catalyst Wi-Fi 6E AP's

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2. Range vs Rate Performance

- At Enterprise densities (1.2-2K f^2) Cell boundary is ~25 Feet max from AP
- Testing 5 clients TCP throughput @ 5 and 6 GHz
- Test Range uses Cisco C9136 -B configured for 5 GHz PL 4 (17 dBm EIRP), chn 36@40 and 6 GHz PL 2 (20 dBm EIRP), chn 5@80
- Data gathered at 5,10,20,25, and 30 foot distances from the AP
- All devices 2ss @ 5 and 6 GHz

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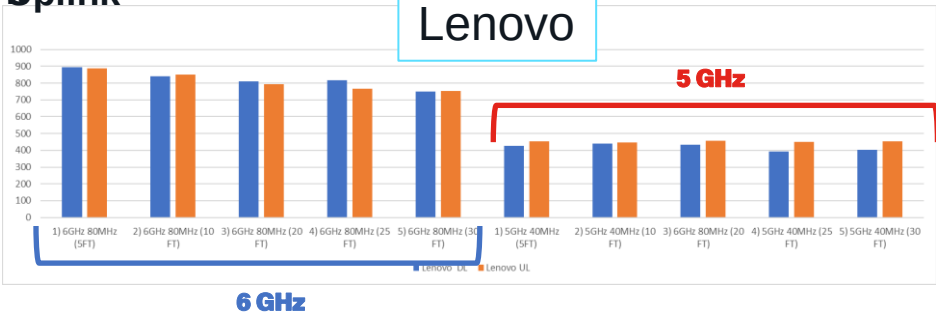
UL and DL compared – 6 GHz and 5 GHz

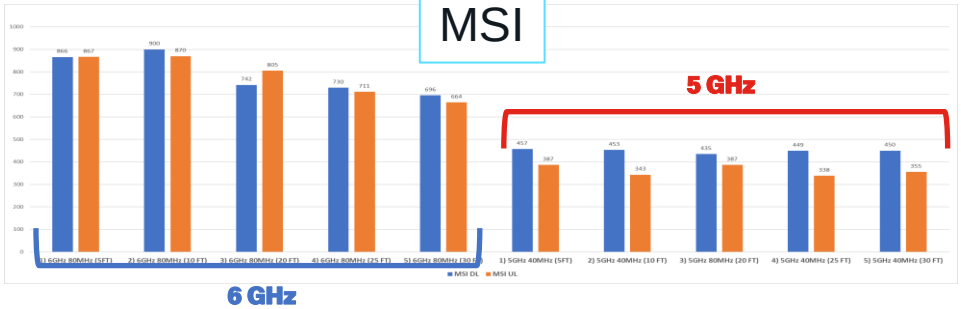
Downlin
Uplink

Google Pixel 6

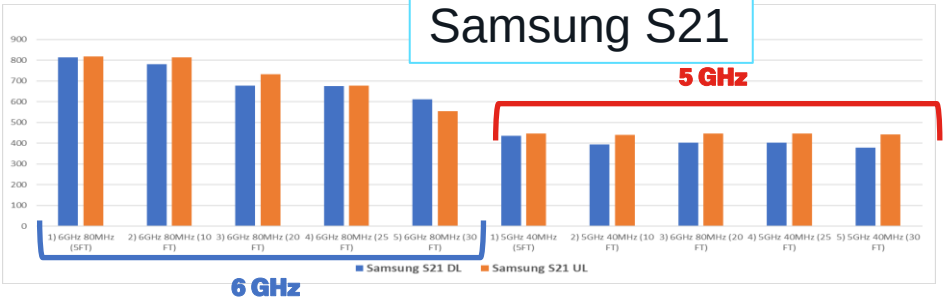
Lenovo



MSI



Samsung S21



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- *Conclusion 3*

  Throughput UL/DL almost equal in Each band 5-6 GHz for the devices tested

  More than adequate throughput for each at the distances tested (111-270 $m^{2)}$

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Where are we then on 5 and 6 GHz assumptions?

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

A1: Yes!

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

A2: Yes. *Assuming 1.2 – 2k f^2 average AP density, carpeted office normal ceiling (3 m /10 ft)

Q3: If network is less dense 3-5 f^2 Then 15-20% increase in density to accommodate 6 GHz coverage expected

- 5 GHz network with RRM operating at power levels 3-4? >then equal 5 and 6 GHz coverage is possible with a one for one AP replacement in both ETSI and FCC. Assuming 80 MHz channel in FCC and 40 MHz channel in ETSI/UK
- Edges and less dense Areas need to be identified and augmented.

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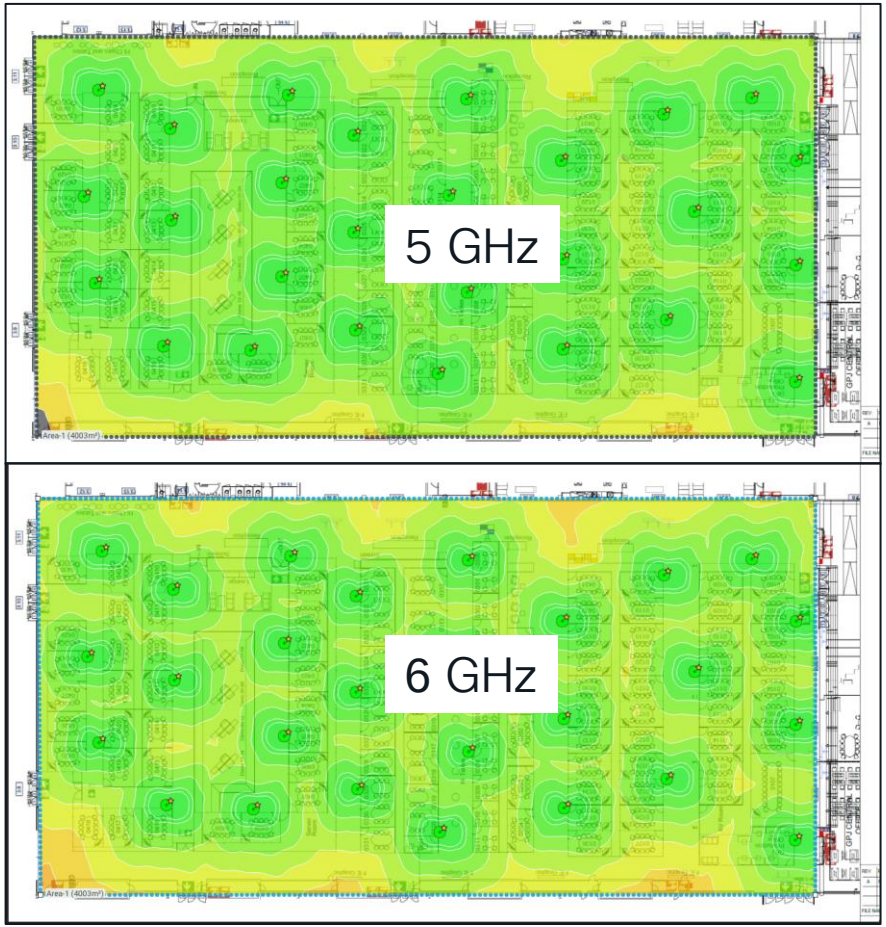
And, How does it work?

- Comparing 5 and 6 GHz coverage after RRM did its thing, 6 GHz needed to come up ½ dB
- Or did it?
- We were able to hold the 6 GHz connection into the next hall, why?
- Low noise floor – high SNR



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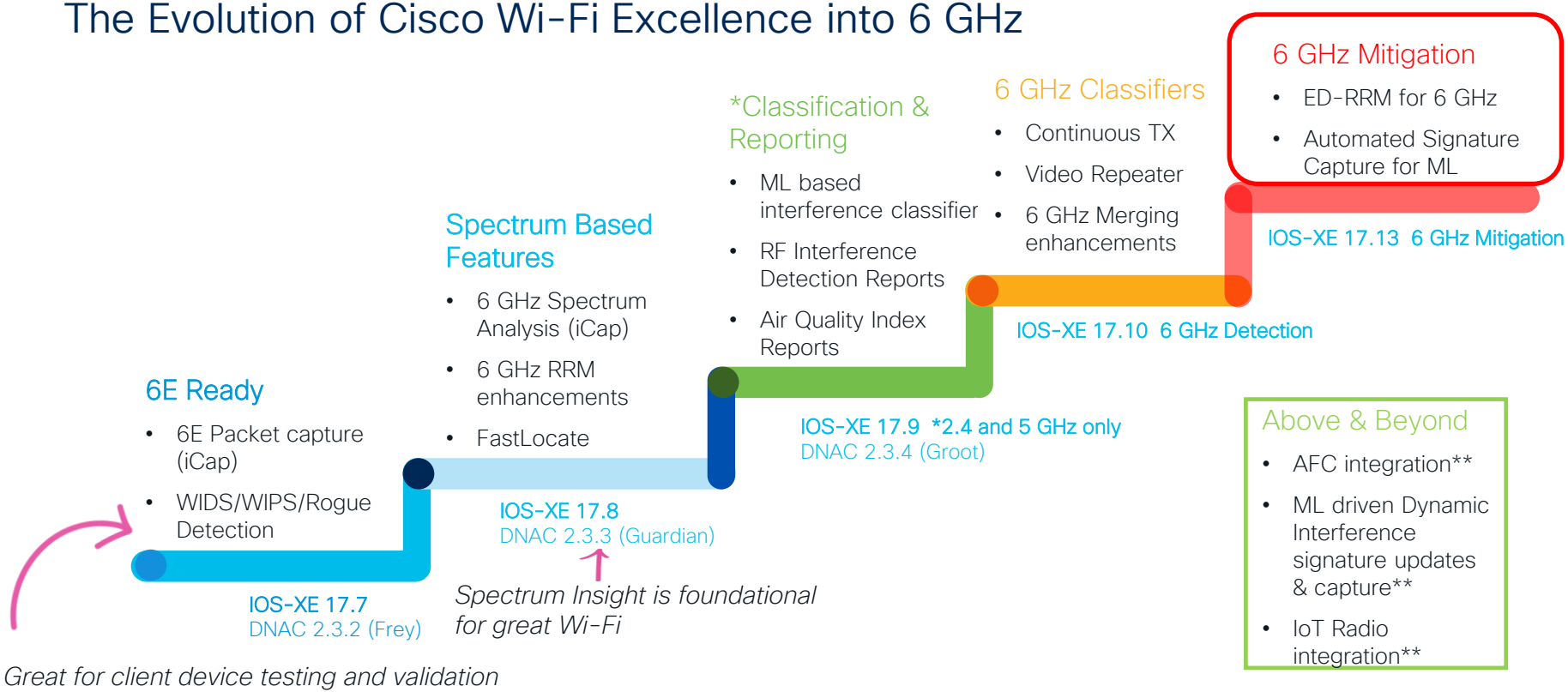
CleanAir™ Pro

RF Excellence

Cisco CleanAir Pro™

The Evolution of Cisco Wi-Fi Excellence into 6 GHz



** Still to be committed

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Cisco CleanAir Pro™

The Evolution of Cisco Wi-Fi Excellence into 6 GHz

Is Cisco CleanAir **Pro** still CleanAir ?

	CleanAir	CleanAir Pro
Detect and Classify Non – Wi-Fi interference To Wi-Fi, if it's not Wi-Fi – then its noise	✓	✓
Set Severity Metric per Interferer Important to identify which source is causing the most harm	✓	✓
Establish Air Quality for all interfaces on the AP Track how much the combined impact is affecting Wi-Fi service in the cell	✓	✓
Merge same Type interferers Correlation of duplicate alarms from other neighboring APs of same event	✓	✓

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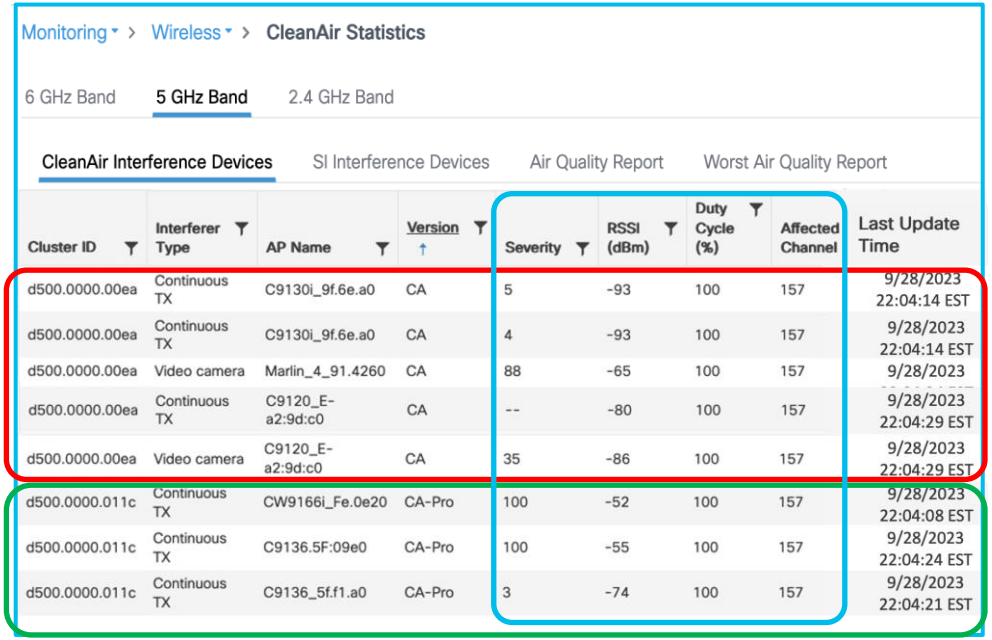
Cisco CleanAir Pro™ Detect and Classify

CleanAir Pro =CA-Pro

5 GHz Video Camera is on Channel 157

- All the CleanAir and CleanAir Pro radios agree – channel 157 is messed up
- Depending on RSSI, Duty Cycle and persistence a Severity is assigned
- Some Disagreement on device type
- All agree on the Duty Cycle



Cluster ID	Interferer Type	AP Name	Version	Severity	RSSI (dBm)	Duty Cycle (%)	Affected Channel	Last Update Time
d500.0000.00ea	Continuous TX	C9130i_9f.6e.a0	CA	5	-93	100	157	9/28/2023 22:04:14 EST
d500.0000.00ea	Continuous TX	C9130i_9f.6e.a0	CA	4	-93	100	157	9/28/2023 22:04:14 EST
d500.0000.00ea	Video camera	Marlin_4_91.4260	CA	88	-65	100	157	9/28/2023
d500.0000.00ea	Continuous TX	C9120_E-a2:9d:c0	CA	--	-80	100	157	9/28/2023 22:04:29 EST
d500.0000.00ea	Video camera	C9120_E-a2:9d:c0	CA	35	-86	100	157	9/28/2023 22:04:29 EST
d500.0000.011c	Continuous TX	CW9166i_Fe.0e20	CA-Pro	100	-52	100	157	9/28/2023 22:04:08 EST
d500.0000.011c	Continuous TX	C9136.5F:09e0	CA-Pro	100	-55	100	157	9/28/2023 22:04:24 EST
d500.0000.011c	Continuous TX	C9136_5f.f1.a0	CA-Pro	3	-74	100	157	9/28/2023 22:04:21 EST

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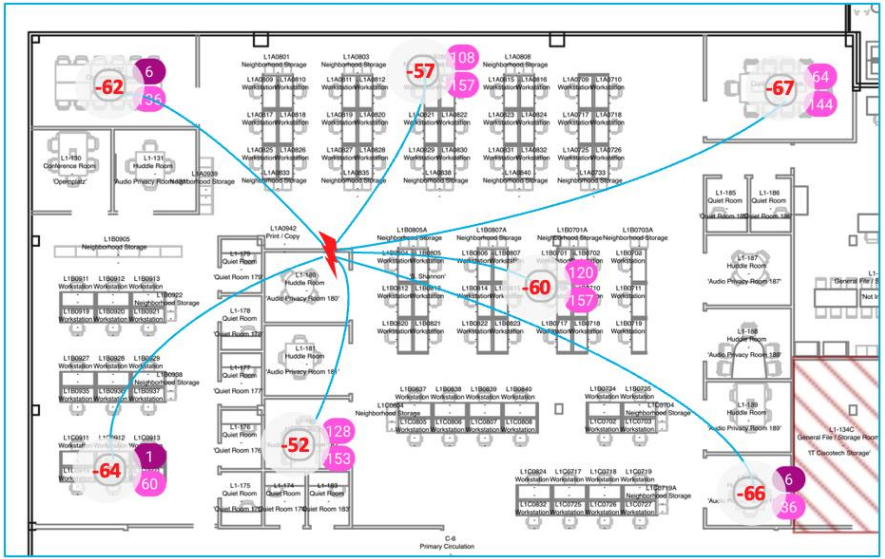
CleanAir Pro™ – Merging
The Challenge

- A non Wi-Fi device in a Wireless office will be heard at more than one AP
- Multiple detections = multiple reports of the same device from different sources.
- Only Cisco's CleanAir Pro can Identify individual devices
- CleanAir Pro Merging Algorithms Correlate and identify individual Interference devices



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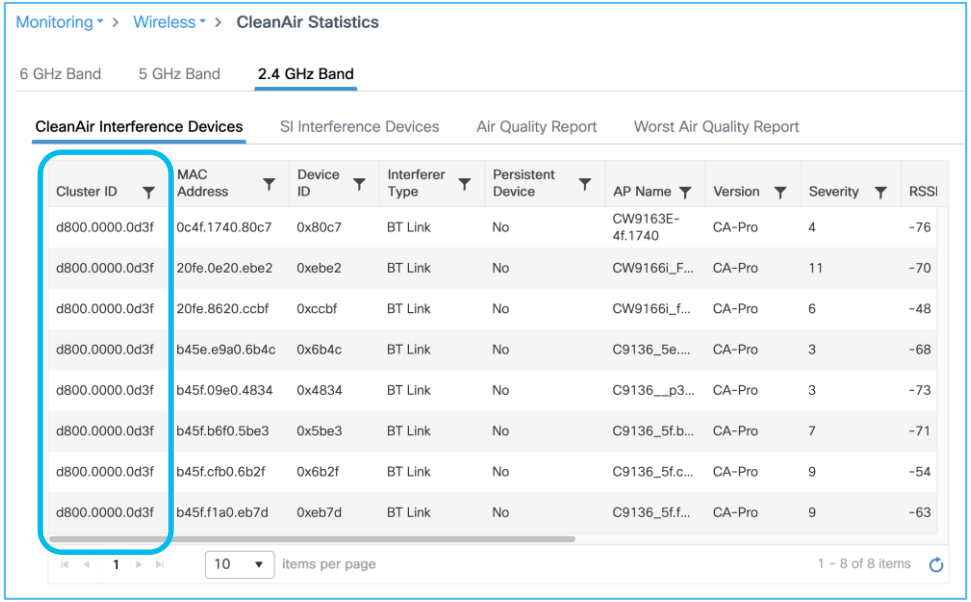
CleanAir Pro™ – Cluster ID Merging

- Is it 8 Bluetooth devices or some number being reported multiple times?
- CleanAir Pro – like CleanAir's Patented technology is able to tell the difference
- Merged devices share a unique Cluster ID which Identifies the closest AP, as well as all other AP's detecting the same device



Actionable Information!

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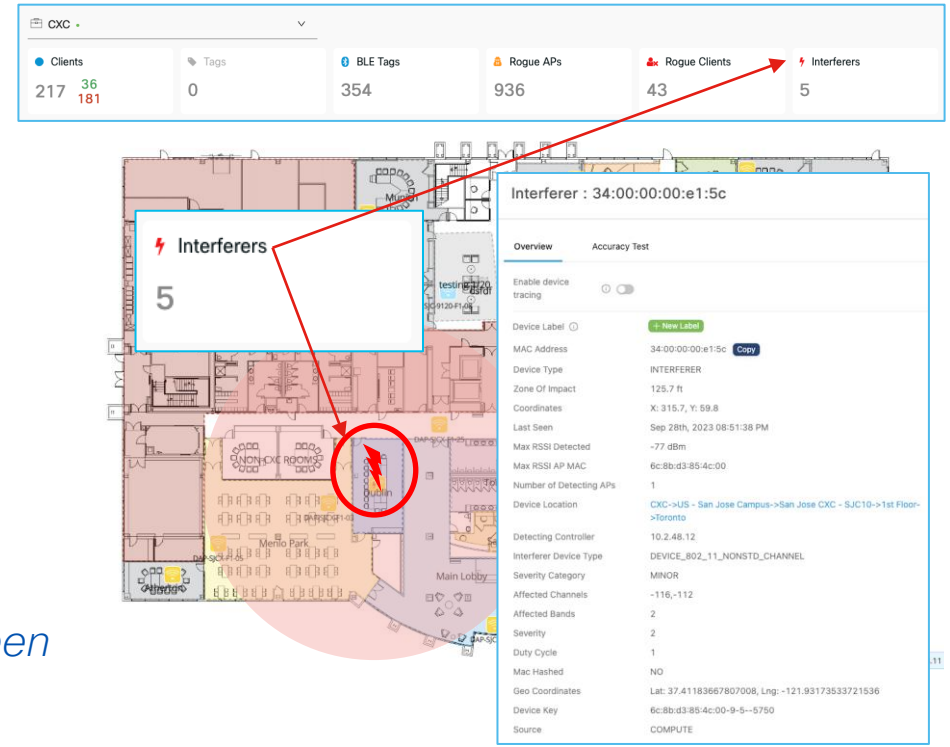
CleanAir Pro™ – Cisco Spaces Location

- In the merging process, the RF coordinates for geospatial location are shared with Cisco Spaces Detect and Locate application
- Cluster telemetry data are processed and placed on the map
- An interference radius is calculated
  - The RSSI determines the size of the zone
  - The severity determines the opacity darker = worse



"Actionable Information is the difference between knowing there is a problem and Mitigating it"

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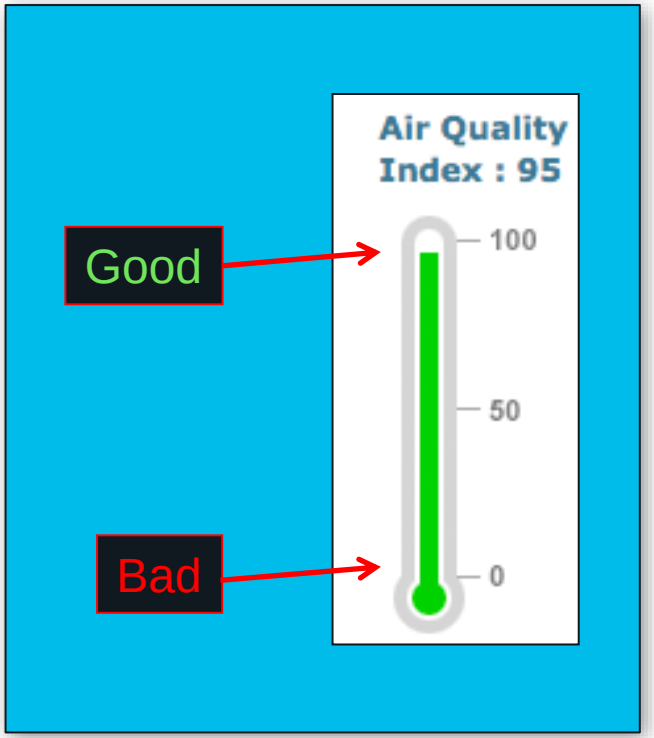
CleanAir Pro™ – Severity and Air Quality

- CleanAir Pro Identifies non Wi-Fi interference devices, but it also characterizes the impact
- **Severity** is assessed for individual devices by detecting APs. Based on its RSSI, Duty Cycle and waveform a severity from 1-100 is assigned (1 is good, 100 is very bad).
- **Air Quality (AQ)** measures air time lost to an AP's cell from the cumulative interference sources being detected
- **The AQI (Air Quality Index)** begins at 100% and decrements based on the cumulative Non Wi-Fi interference severity subtracted from AQ



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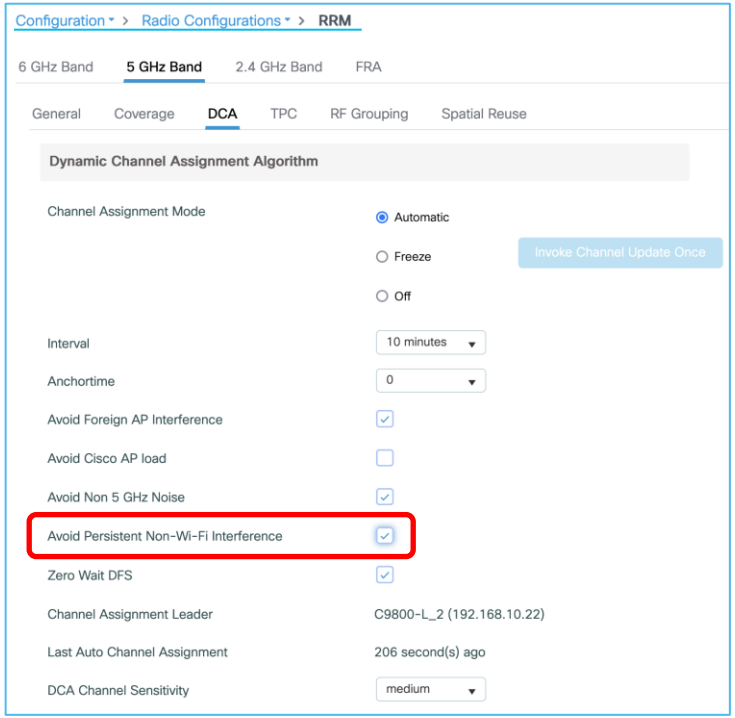
CleanAir Pro™ – Mitigation
Persistent Device Avoidance

- A microwave oven is incredibly bad for Wi-Fi, but only when in operation.
- RRM will react if its on long enough. Worse though, it can disappear for hours and RRM may need those channels.
- Persistent Device integrates with RRM to intelligently avoid, and monitor for reoccurrence allowing the RF environment to be proactive and simply plan around it
- Telemetry maps the impacted APs and RRM does the rest.
- Cisco Best Practice = Enabled



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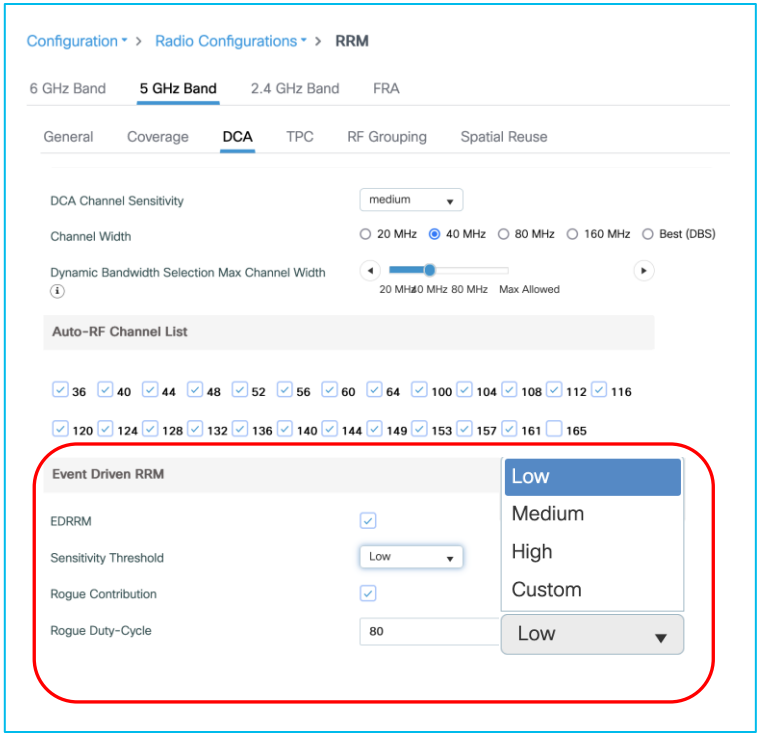
CleanAir Pro™ – Mitigation
Energy Detect - RRM

- Because Wi-Fi is Listen to Talk, it will politely not try as long as something else is using the frequency.
- A high Duty Cycle device can shut down and Access Point and all clients connected.
- ED-RRM allows CleanAir Pro to positively ID a Non Wi-Fi interference signal and change the APs channel within 30 seconds
- Triggered by a low AirQuality (AQ) alert. Thresholds are Low = 35, Medium=50, High=60.



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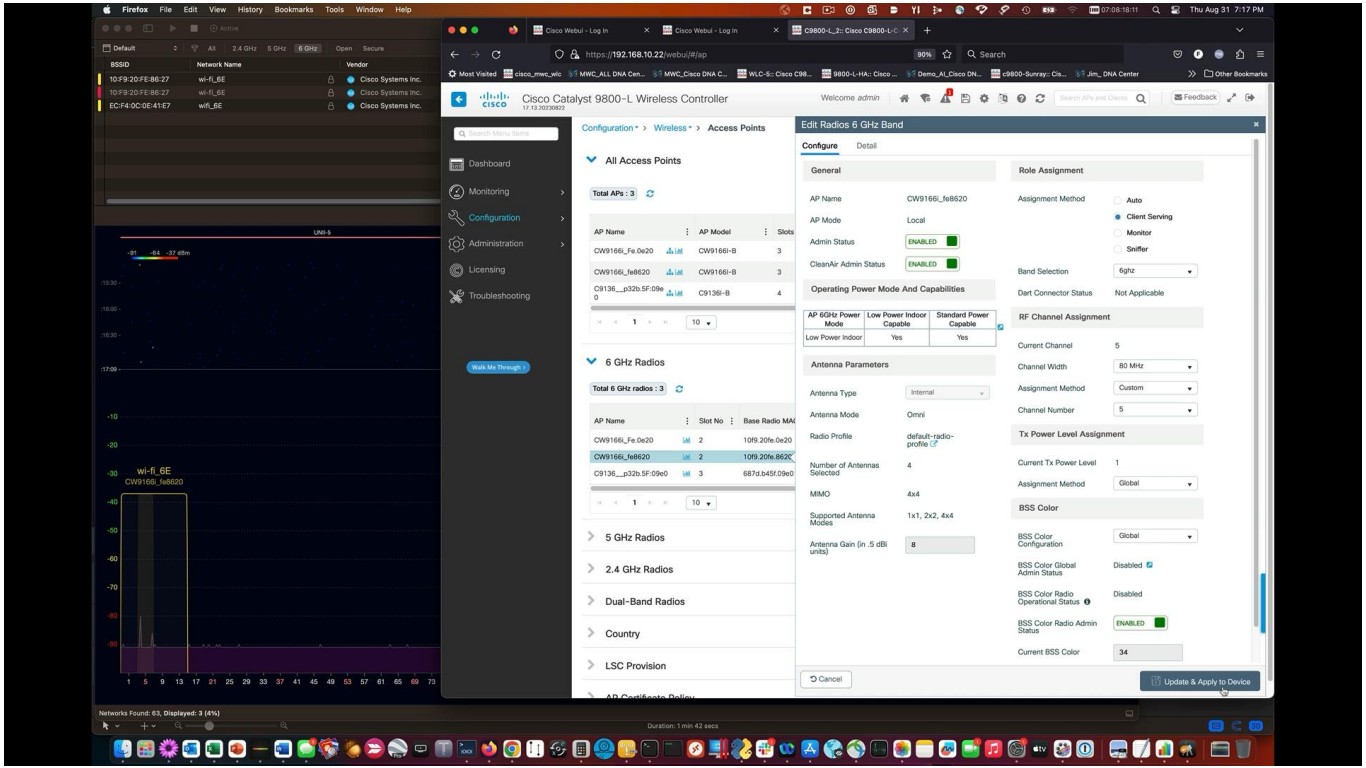
CleanAir™ Pro ED-RRM 6 GHz demo



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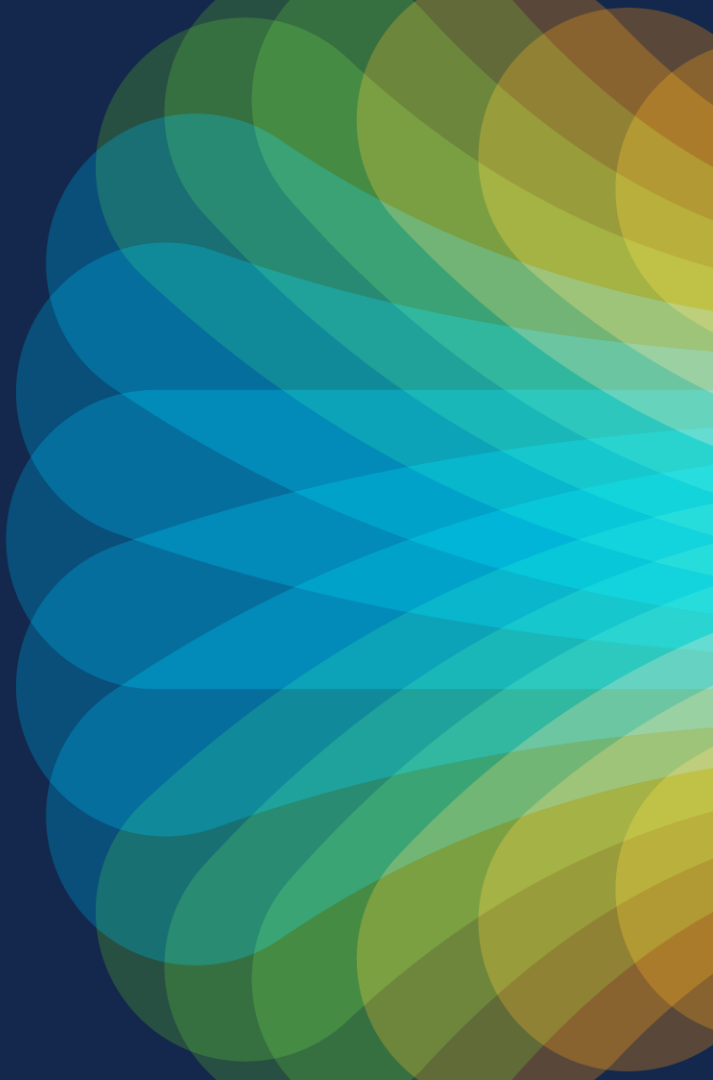
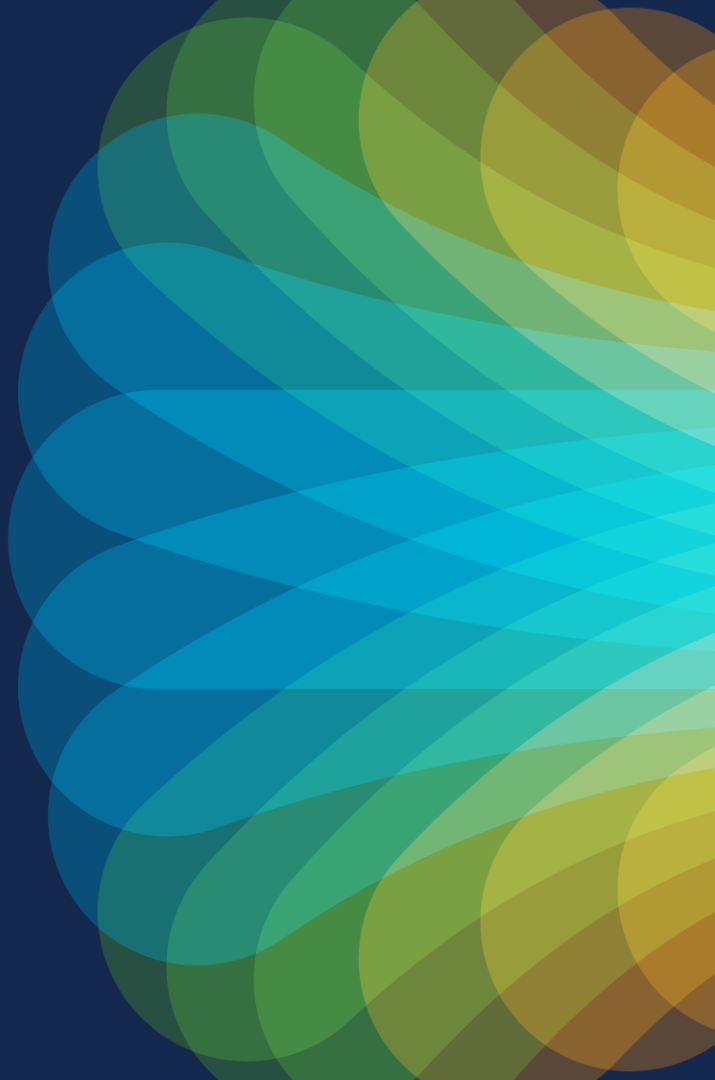
CleanAir Pro ED-RRM Demo



Zero Wait DFS

Avoid service outage when switching on DFS channels



Zero Wait DFS*

Without Zero Wait DFS:

- An AP on Wi-Fi Channels 52-144 (16 channels) must NEVER interfere with Radar
- Are required to scan a channel for 60-600s before transmitting
- Must immediately abandon the channel if radar detected
- And require minimum 60s scan before resuming operations

With Zero Wait DFS:

- An AP pre-scans one to many of the channels on power up
- After scan is completed – AP can use any of the channels on the list with no delay
- Eliminating 60-600s delay before Clients can use the network again

*Supported on Catalyst C9130AX and CW9166AXI -B and -E running IOS-XE 17.10 and later
C9130AX only in 17.9

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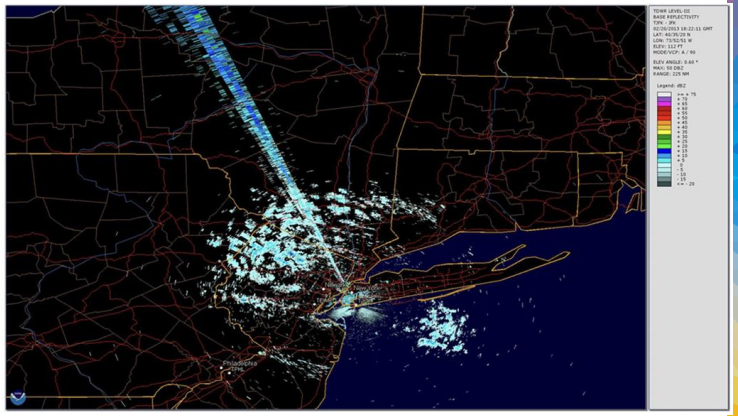
What's a DFS and Why do I need it?

- Dynamic Frequency Selection – DFS allows Wi-Fi to use frequencies in the U-NII-2 and 2c
- A Wi-Fi AP must comply with the rules
  - Able to detect radar
  - Perform a CAC – Clear Channel Assessment before actively transmitting on any DFS channel
  - Shutting down operations within .5 ms of detection
- CAC must be performed for 60s (up to 600s) and puts a heavy delay burden on a loaded AP that needs to change channels
- DFS impacts a sizeable number of channels, ETSI would have 4 channel without DFS



Citation: Bulletin of the American Meteorological Society 97, 7; 10.1175/BAMS-D-15-00048.1

New York based Weather Radar showing The impact of a Wi-Fi AP operating in its Range. Weather radar operates with signals far lower than Wi-Fi

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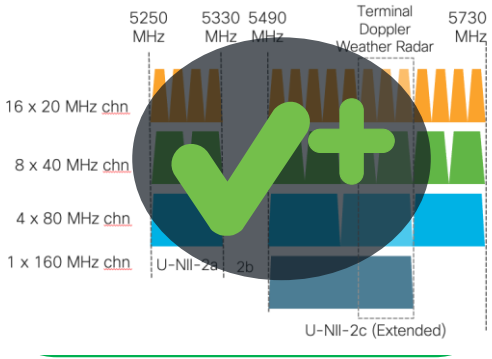
Zero Wait DFS

- Zero Wait DFS does exactly what it says, give immediate access to a channel upon Tuning
- It isn't as simple as providing a scanning radio, and simply pre-scanning all the channels though
- This feature is heavily dependent on Regulatory Bodies rules
- Presently, only supported in -B and -E domains (FCC/ETSI) on C9130AX APs

DFS Channel
Inclusion list : 52,132,56,60,64,100,
104,108,112,116,136,140



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Two Methods to Clear Future Channels

- Pre-CAC Europe – ETSI
  - AP does continuous 60s CAC on each channel sequentially for as many as we want to keep in the buffer
  - CAC is considered valid until radar detected on the channel, or AP rebooted
  - If Channel change needed, and an un-CAC'd channel is needed, Pre-CAC will be performed BEFORE channel Change
  - If radar is detected, any channel in the buffer may be used without delay

- Rolling-CAC US-FCC
  - AP performs continuous CAC on single selected off-channel
  - This channel is considered available for future use as long as no radar are detected during continuous scan
  - Future Channel is DCA selected next best

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Zero Wait DFS – Channel Allocation

S1 @ Ch 52/56
S2 @ Ch 124/128
Dual 5 GHz

Reserve Channel Allocation	
Dual 5 GHz = No	Find a Channel assignment that matches bandwidth
Dual 5 GHz = Yes, find a Ch good for both radios	Ch 52/56 @ 5260 MHz, Ch 124/128 @ 5620 MHz Ch 100/104 @ 5490 MHz > 100 MHz from Both
If can't solve for both – pick one	Choose the slot with the highest client count and select a reserve.
In ETSI – 2 reserve channels are possible	If all else is equal, change the channel and CAC before using

NOTE: On SSO, All Channel lists, reserved channel state and pre-CAC state maintained on failover

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Zero Wait DFS – Radar Event Handling

S1 @ Chn 52/56
S2 @ Chn 124/128
Dual 5 GHz

Radar Event Handling Priority	
Use Flex DFS	Ch. 56 radar detect, reduce Channel Width to 20 and run on ch 52
Use DCA Alt channel – if no CAC required	Radar Detected Ch. 52, is Primary. Mini DCA = Chn 44 = No CAC needed; AP is assigned 44/48
Use Reserve Channel	If Mini DCA Ch needs CAC, Use the reserve Channel
Else –Assign Channel to Radio and CAC	If all else is equal, change the channel and CAC before using

NOTE: On SSO, All Channel lists, reserved channel state and pre-CAC state maintained on failover

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Zero Wait DFS – Maintaining Channel Lists

S1 @ Chn 52/56
S2 @ Chn 124/128

In FCC

- Inclusion List = Serving Channels and Reserve Channels on CAC completion
- On Radar Detection, Channel removed from inclusion added to exclusion list

For ETSI

- AP is provided with Channel list to scan, when pre-CAC status complete it adds all channels scanned to the Inclusion list
- All channels remain in the inclusion list itil radar detected, or AP rebooted
- Radar Detection adds channel to the exclusion list

```
#sh ap name C9130i_9f.6e.a0 config slot 1 | s Zero
  Zero Wait DFS Parameters
    Zero Wait DFS Capable        : Yes
    CAC Domain                   : FCC
    Zero Wait DFS Enabled        : Enabled
    DFS Channel Inclusion list   : 52,56,108,112
                                   124,128
    DFS Channel Exclusion list   : 60,64,100,104,
                                   116,120,132, 136
                                   140,144
    Pre-CAC Status               : NA
    Reserved Channel CAC Status  : Complete
    Reserved Channel             : 108
    Reserved Channel Width       : 40 MHz
```


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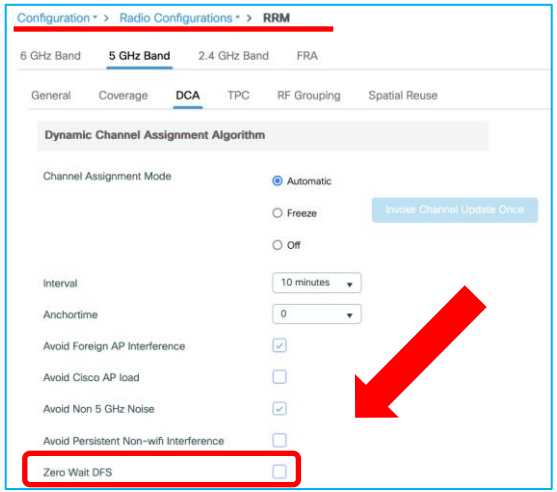
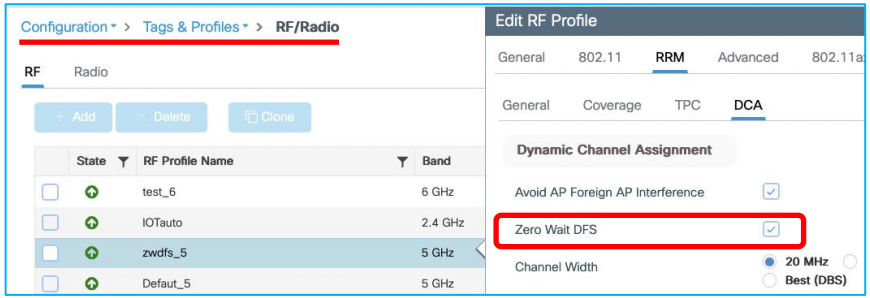
Configuring Zero Wait DFS

- Zero Wait DFS is configured under Dynamic Channel Assignment (DCA) at both the Global and the RF Profile levels

Global



RF Profile



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Zero Wait DFS WLC Show Commands

FCC

```
#sh ap name C9130i_9f.6e.a0 config slot 1 | s
Zero
  Zero Wait DFS Parameters      Zero Wait DFS
   Capable                        : Yes
   CAC Domain                     : FCC
   Zero Wait DFS Enabled          : Enabled
   DFS Channel Inclusion list     :52,56,108,112
                                   124,128
   DFS Channel Exclusion list     :60,64,100,104,
                                   116,120,132,136
                                   140,144
   Pre-CAC Status                 : NA
   Reserved Channel CAC Status    : Complete
   Reserved Channel               : 108
   Reserved Channel Width         : 40 MHz
```

ETSI

```
#sh ap name C9130E-E-53.4e.20 config slot 1 | s
Zero
  Zero Wait DFS Parameters     Zero Wait DFS
  Capable                        : Yes
  CAC Domain                     : ETSI
  Zero Wait DFS Enabled          : Enabled
  DFS Channel Inclusion list     :52,132,56,60,64
                                 100,104,108,112
                                  116,120,124,128
                                  132,136,140
  DFS Channel Exclusion list     :
  Pre-CAC Status                 : Complete
```

```
#sh ap dot11 5ghz channel | i Zero
  Zero Wait DFS
: Disabled
```

```
#sh ap rf-profile name new5g detail | i Z
Zero Wait DFS                    : Enabled
```


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Zero Wait DFS – CLI – sh and config

Global Status

```
C9800-L_17_10#sh ap dot11 5ghz channel | i Zero
  Zero Wait DFS                                : Enabled
```

RF-Profile Status

```
C9800-L_17_10#sh ap rf-profile name zwdfs_5 detail | i Zero
Zero Wait DFS                    : Enabled
```

Global Enable/Disable

```
C9800-L_17_10(config)#ap dot11 5ghz rrm channel zero-wait-dfs
C9800-L_17_10(config)#no ap dot11 5ghz rrm channel zero-wait-dfs
```

RF Profile Enable/Disable

```
C9800-L_17_10(config)#ap dot11 5ghz rf-profile zwdfs_5
C9800-L_17_10(config-rf-profile)#channel zero-wait-dfs
C9800-L_17_10(config-rf-profile)#no channel zero-wait-dfs
```


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Zero Wait DFS – CLI – sh and config

Global Status

```
C9800-L_17_10#sh ap dot11 5ghz channel | i Zero
  Zero Wait DFS                              : Enabled
```

RF-Profile Status

```
C9800-L_17_10#sh ap rf-profile name zwdfs_5 detail | i Zero
Zero Wait DFS                        : Enabled
```

Global Enable/Disable

```
C9800-L_17_10(config)#ap dot11 5ghz rrm channel zero-wait-dfs
C9800-L_17_10(config)#no ap dot11 5ghz rrm channel zero-wait-dfs
```

RF Profile Enable/Disable

```
C9800-L_17_10(config)#ap dot11 5ghz rf-profile zwdfs_5
C9800-L_17_10(config-rf-profile)#channel zero-wait-dfs
C9800-L_17_10(config-rf-profile)#no channel zero-wait-dfs
```


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2. Catalyst 9800 on 17.9.2+ (Wi-Fi 6E support).
3. CW 9100, Catalyst 9100 (Wi-Fi 6/6E) and 802.11ac (Wave2) only.
4. Willing to use Cisco DNA Automation.

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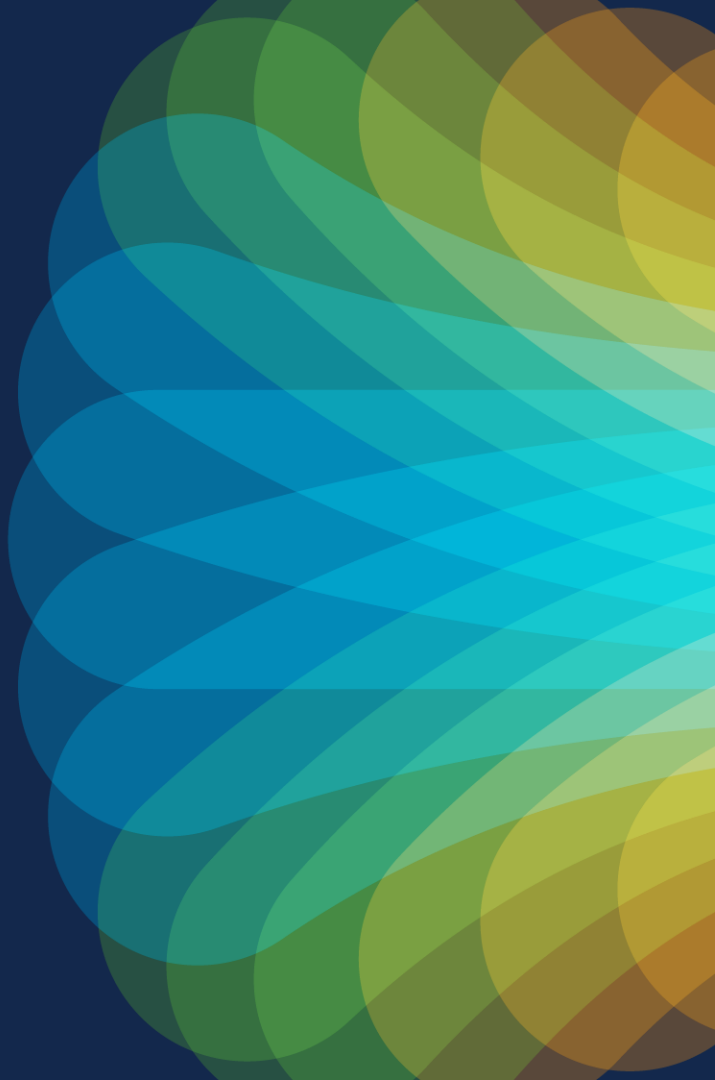
The bridge to possible

Thank you



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Let's go