The bridge to possible

High Density Wi-Fi Design, Deployment, and Optimization

Matt Swartz - Cisco Customer Experience, Distinguished Engineer, CCIE #13232
Josh Suhr - Cisco Customer Experience, Principal Architect, CCIE #39980

BRKEWN-2087

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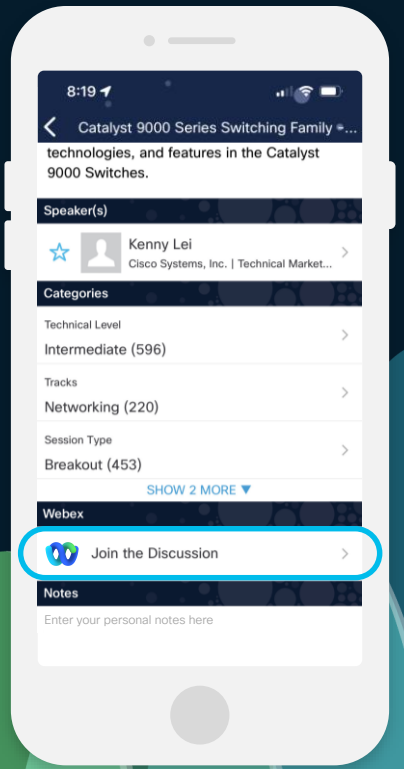


Agenda

- Designing RF for High Client Densities
- HD Wi-Fi Configuration Tips
- HD Wi-Fi Engineering Toolkit

Josh Suhr

Principal Architect, Cisco CX

CCIE #39980 (Wireless)

First HD WiFi Project: Sporting Kansas City, 2011

Husband, recent dad, soccer fan, beer & pizza connoisseur

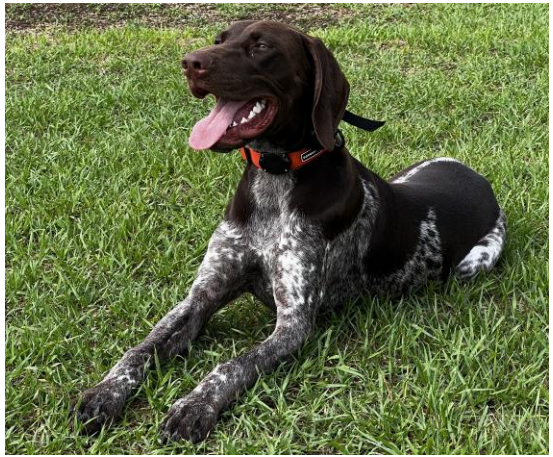
Matt Swartz

Distinguished Engineer, Cisco CX

CCIE #13232 (R/S, Wireless)

First HD WiFi Project: New York Yankees, 2008

Husband, dad, mountain biker, beer connoisseur

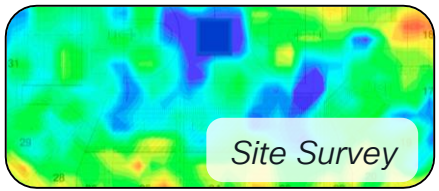


Key Trends in High Density Wi-Fi

- Software-defined antenna (C9104)
- 6GHz / Wi-Fi 6E: More Spectrum / AFC is here!
  Including Standard Power (SP) vs Low Power Indoor (LPI) modes & caveats
- More usage & more devices per user
- Auto authentication & OpenRoaming

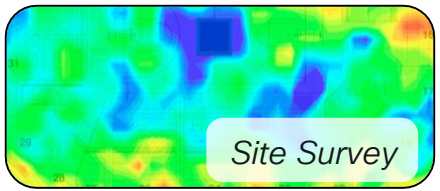
Designing for the 3 Key RF Relationships

1 AP to Client



Designing for the 3 Key RF Relationships

1 AP to Client



2 Client to AP

Device Type	iPhone 12
Device OS	iOS 15.4.1
Client Performance	Signal Strength: -66 dBm Signal Quality: 30 dB Ch BW(Negotiated/Capable): 20 MHz/80 MHz
Capabilities	802.11ax - 2.4 GHz
Fabric Status	Disabled

WLC UI / CLI

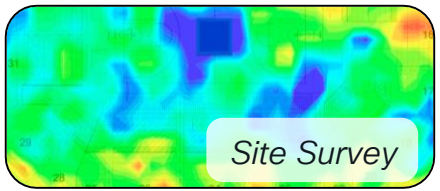
Designing for the 3 Key RF Relationships

Name	Slot	Channel	Power Level	Power dBm	Neigh. Name	Neigh. Slot	Neigh. Channel	Neigh. Power	Compensated Power
AP12	1	112	6	4	AP1	1	52	-42	-57
AP12	1	112	6	4	AP2	1	144	-51	-66
AP12	1	112	6	4	AP3	1	120	-53	-65
AP12	1	112	6	4	AP4	1	100	-53	-65
AP12	1	112	6	4	AP5	1	124	-57	-66
AP12	1	112	6	4	AP6	1	60	-61	-73
AP12	1	112	6	4	AP7	1	136	-62	-74
AP12	1	112	6	4	AP8	1	44	-69	-69
AP12	1	112	6	4	AP9	1	104	-79	-85
AP12	1	112	6	4	AP10	1	60	-80	-89
AP12	1	112	6	4	AP11	1	153	-81	-84

WCAE

3 AP to AP

1 AP to Client



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WLC UI / CLI

Bonus points: Client <-> Client – harder to influence

It All Starts with Layer 1: RF Design

Antenna Selection:

Decide which antenna is right for the job.

Consider:

- Density of clients to be served
- Available mounting assets
  - Within 65'/20m of furthest client (or 200'/60m with C-ANT9104)

Antenna Placement:

Where will this antenna provide the best throughput and most reliable service?

Consider:

- Line of sight
- Isolation from ambient RF
- Angle of incidence to client devices

Catalyst Directional Antenna Selection

		Beamwidth	Use Case
	Dual-Band “Narrow” 8x8 Patch Antenna AP: 9130AXE Antenna: C-ANT9103	2.4/5GHz 75/70° Az 70/70° Elev	Augmentation and short-distance HD coverage (15’/5m – 30’/10m to clients)
	Dual-Band “Wide” Patch Antenna AP: 9120AXE/P, 9130AXE Antenna: AIR-ANT2566P4W-R	2.4/5GHz 105/125° Az 70/60° Elev	Augmentation and short-distance HD coverage (< 30’ / 10m to clients)
	Dual-Band “Narrow” Patch Antenna AP: 9120AXE/P, 9130AXE Antenna: AIR-ANT2566D4M-N	2.4/5GHz 65/65° Az 65/65° Elev	Augmentation and short-distance HD coverage (15’/5m – 30’/10m to clients)
	Dual-Band High Density Antenna C-ANT9104 (Antenna + Integrated AP)	70/70° 2.4GHz 80/25° 5GHz (Wide) 25/25° 5GHz (Narrow)	Primary overhead coverage (i.e. seating areas; > 30’/10m, <200’/60m to clients)

IW9167E
6E (SP) - Soon

70w x 30h

9166D1 Wi-Fi 6 Access Point

Cisco® Catalyst® 9166D1-x

Directional, Tri-Radio with 12 Spatial Streams!

Note: for LPI (Indoor) Use Only

Penta-Radio Architecture

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

Directional antenna architecture

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

Internet of Things Capabilities

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

5 Multigigabit (mGig) PoE Port

- Optional DC Power

Meraki AP & Antenna Selection: Directional

Wi-Fi 6E

CW9166D1

6E (LPI)

CW9163E

6E (SP)

CW-ANT-D1-NS-00

Wi-Fi 6

MR86

MA-ANT-25

MA-ANT-27

AIR-ANT2513P4M-N

Part No.	Type	Beam (Az)	Beam (Elev.)
MA-ANT-25	Patch	75 deg	84 deg
MA-ANT-27	Sector	65 deg	18 deg
AIR-ANT2513P4M-N	Array	31 deg	27 deg
CW9166D1	Integrated Directional	70 deg (5ghz) 60 deg (6ghz)	70 deg (5ghz) 60 deg (6ghz)
CW-ANT-D1-NS-00 & CW9163E (6E)	Patch	70 deg	30 deg

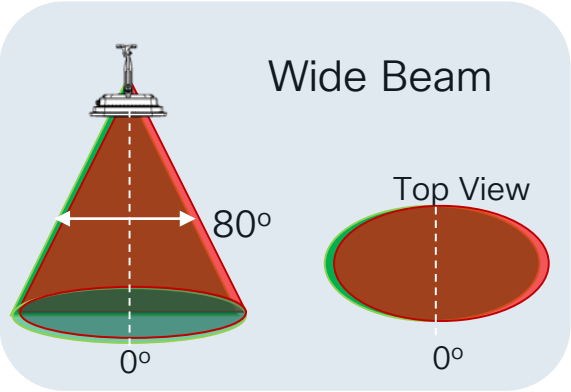
Cisco Catalyst C-ANT9104 – Stadium Antenna + Integrated AP

- The C-ANT9104 antenna is designed specifically to solve challenges encountered in stadium/Large Public Venue/High Client Density environments.
- Dual 5 GHz on two individual 5 GHz 4x4 Arrays
- Configurable electronic beam steering as well as Narrow and Wide modes of the antenna
- Catalyst C9800 release 17.6.1 adds configuration support for these new controls

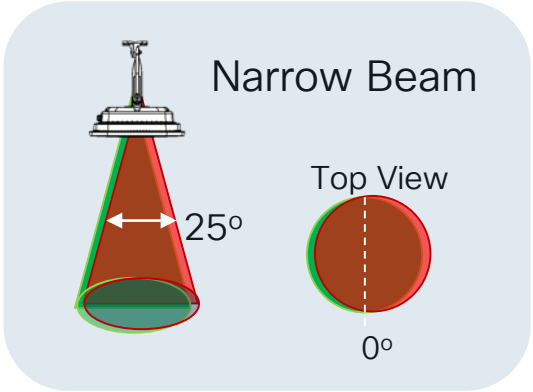
C-ANT9104: Key Things to Know

Antenna Design Improvements	Cover Clients from Longer Distances (up to 200’ / 60m line-of-sight)
Integrated Unit, Outdoor-Rated	AP + Antenna all-in-one, no enclosures required, outdoor-rated
Deployment Flexibility	Beam Switching & Beam Steering; switch between narrow/wide, meet needs of multiple different coverage types
Important Notes	Band-Locked Slots & Tx Power Implications Tight RF patterns, minimal sidelobes, RF Isolation = no RRM

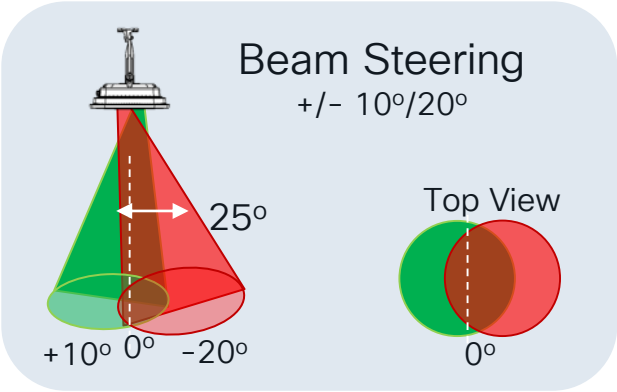
C-ANT9104: Software-Configurable Beams



Wide sector beamwidth
Dual 4x4 5GHz (80ºx25º)
2.4 GHz (75ºx85º)
8 dBi gain



Narrow sector beamwidth
Dual 4x4, 5 GHz (25ºx25º)
10 dBi gain



Software defined beam steering
Each 5GHz 4x4 can steer
+/- 10º,20º off center

5GHz Software Defined Beamwidth and Direction

C-ANT9104: Deployment Checklist

- ✅ Physical Install:
  - ✅ All-In-One – no enclosures needed
  - ✅ Portrait vs landscape
  - ✅ Physical orientation of higher-power slot
- ✅ Channel & power planning
- ✅ Determine initial beam configuration (surveys / prediction)
- ✅ Define Radio Profiles & RF Tags
- ✅ Less (or no) RX-SOP optimization needed
- ✅ Validate & optimize

C-ANT9104 Power Table Summary

[Slot 1]	[Slot 2]
UNII-2e / 12 channels: 17dBm	UNII-1 / 4 channels: 21dBm
UNII-3 / 5 channels: 23dBm	UNII-2 / 4 channels : 17dBm

Award-Winning Indoor & Outdoor Wi-Fi 6E portfolio

Indoor Access Points

Outdoor Access Points

Introducing the Catalyst IW9167E with Wi-Fi 6E stadium antenna

Catalyst IW9167E with
Wi-Fi 6E stadium antenna

Wide beam | 30° V /70° H | 8-10 dBi gain

High performance in high-density environments

High performance **directional panel antenna** delivers high-quality experience in high-density environments.

Simplified deployment and improved aesthetics

Pre-assembled antenna and access point simplifies and shortens deployment time, and improves aesthetics

Protected against the elements

IP67 design and extreme temperature support makes it ideal for deployment outdoors.

Supports wide-range of use cases

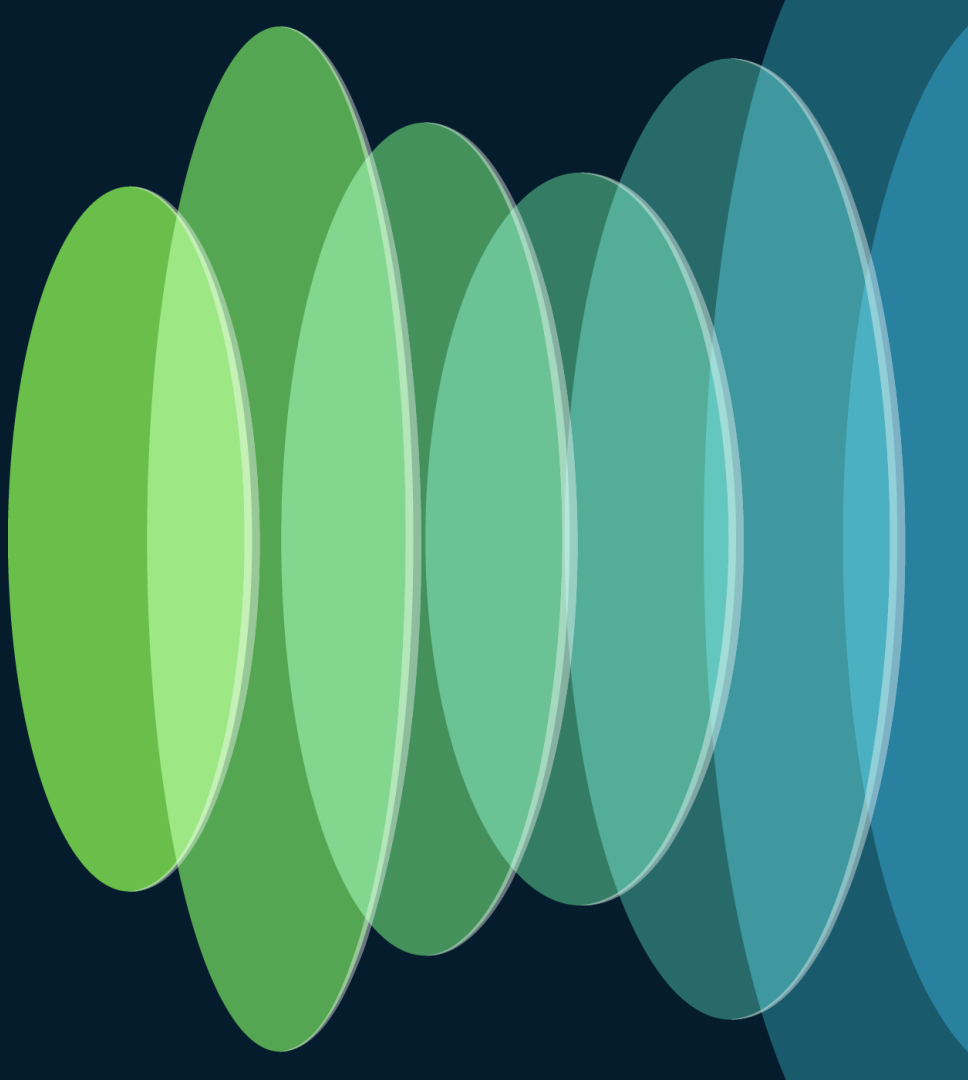
Large public venues, sports & entertainment, parks, city centers, lawn areas, theme parks and more

Available in two options:

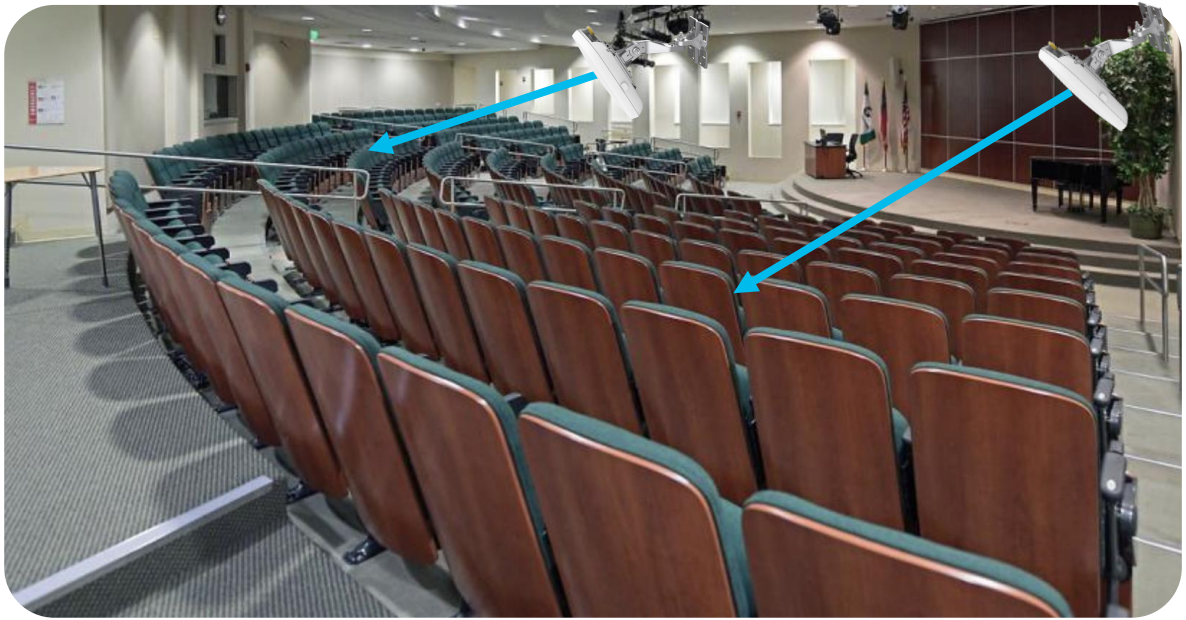
- Assembled unit (antenna + IW9167E) – US only
- Standalone antenna for custom deployments

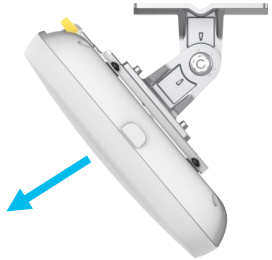
Orderable Aug 2024
Available Sep 2024

Antenna Placement



Classrooms & Auditoriums



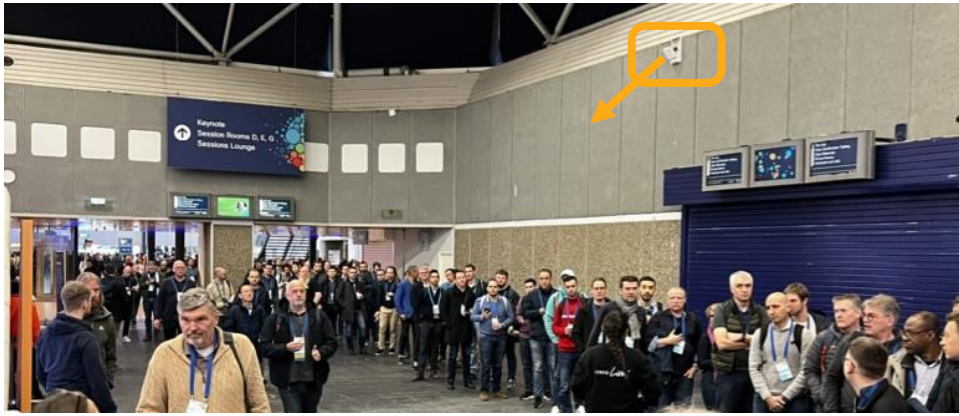


Directional antennas: more coverage cells in the same physical area, better control of the RF environment

Directional antennas (e.g., 9166D1) strongly preferred over omnis

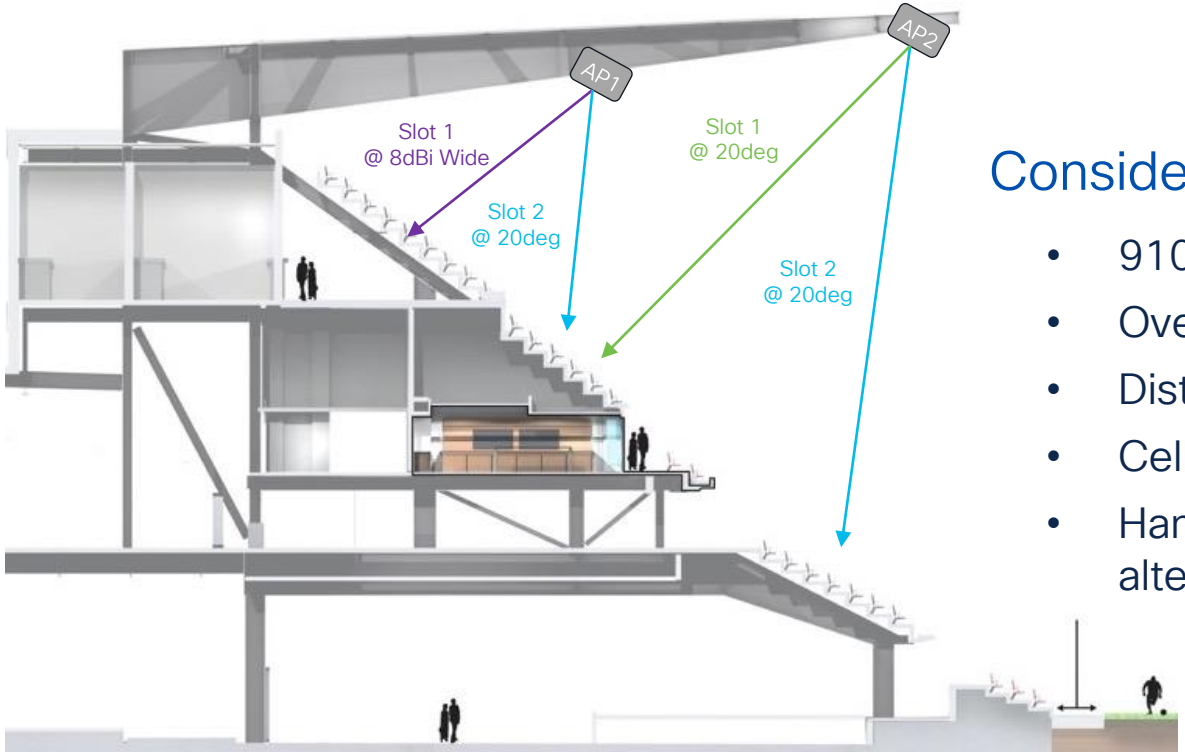
Conference Halls, Airports, Open Atriums

High Density Open Areas – Conference Halls, Classrooms



- Omnis not preferred for open areas where high capacity is needed
- Create smaller cells with directional antennas mounted above, aimed directly downward
- Understand RRM implications of this type of design – it may not work as you expect

Stadiums, Theaters, & Other Large Public Venues



Consider:

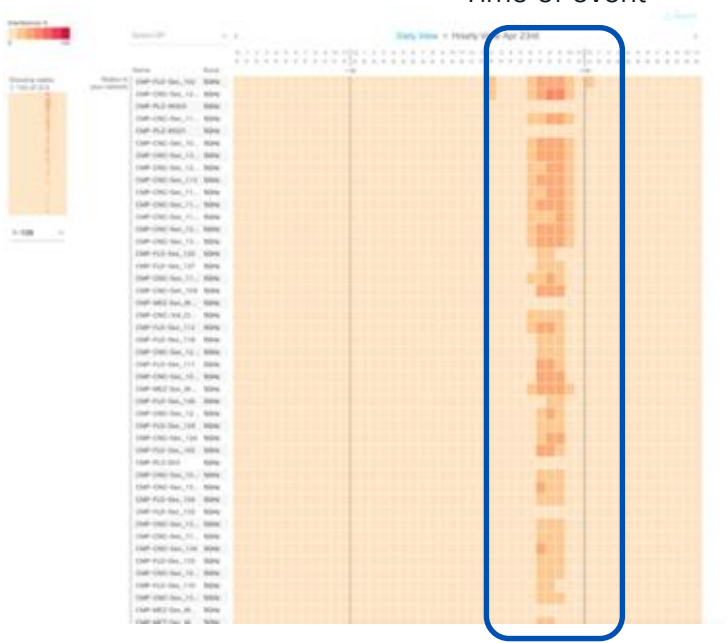
- 9104: Dual-Slot Orientation
- Overhead / Line-of-Sight
- Distance to Clients
- Cell Size & Overlap
- Handrail or Under-seat as alternative options

Performance Comparison: Overhead / Under Seat

Time of event

Under Seat / Omni

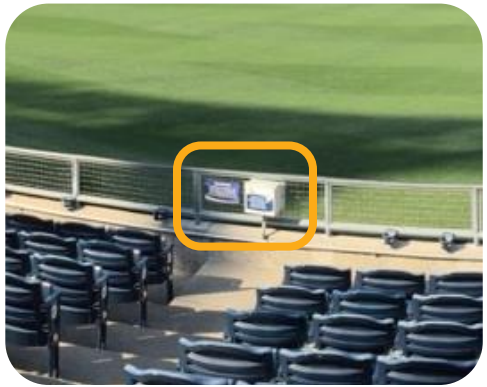
Time of event

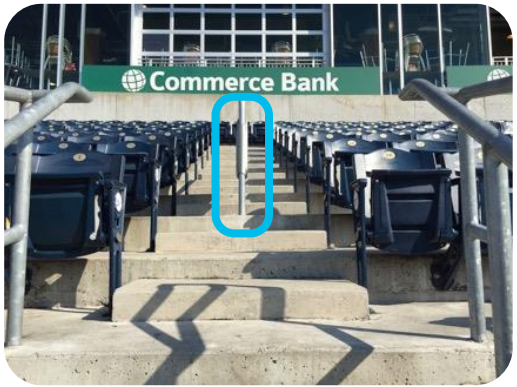


Overhead/Directional

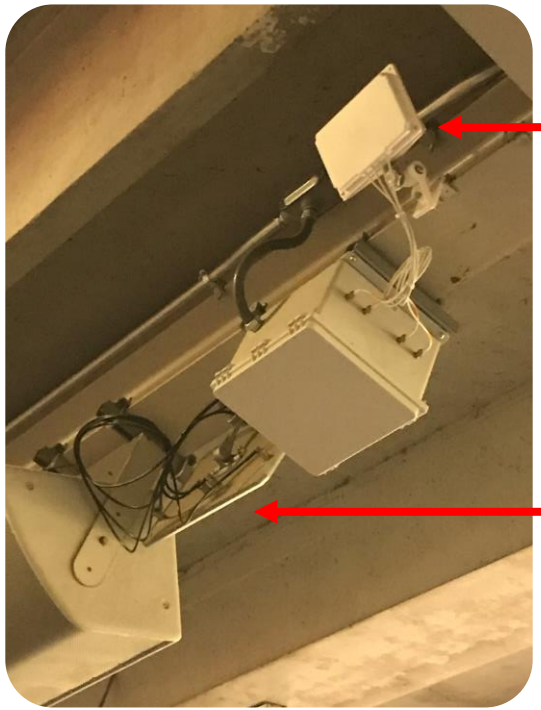
Red = High CCI / Poor Performance

Creative AP/Antenna Mount Examples





Multiple Coverage Areas with 1 AP



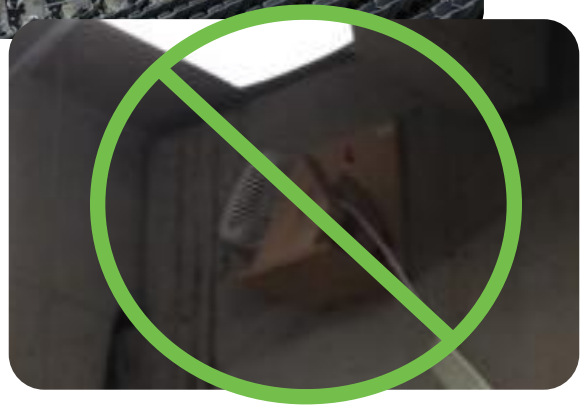
“Wide” Patch Antenna

“Narrow” High-Gain Antenna

Antenna Placement: What Not To Do

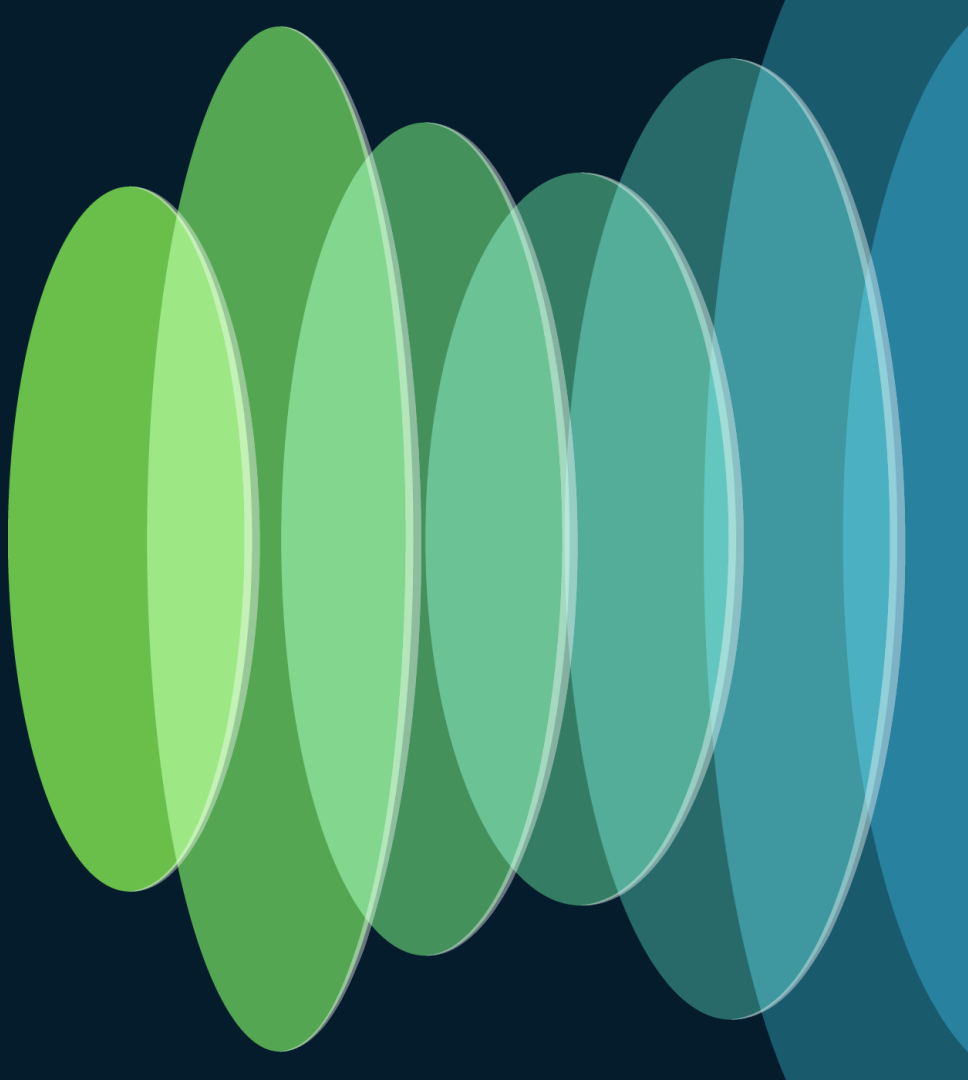
Challenging Areas

Avoid long-distance shots with poor angle of incidence / line of sight to each client



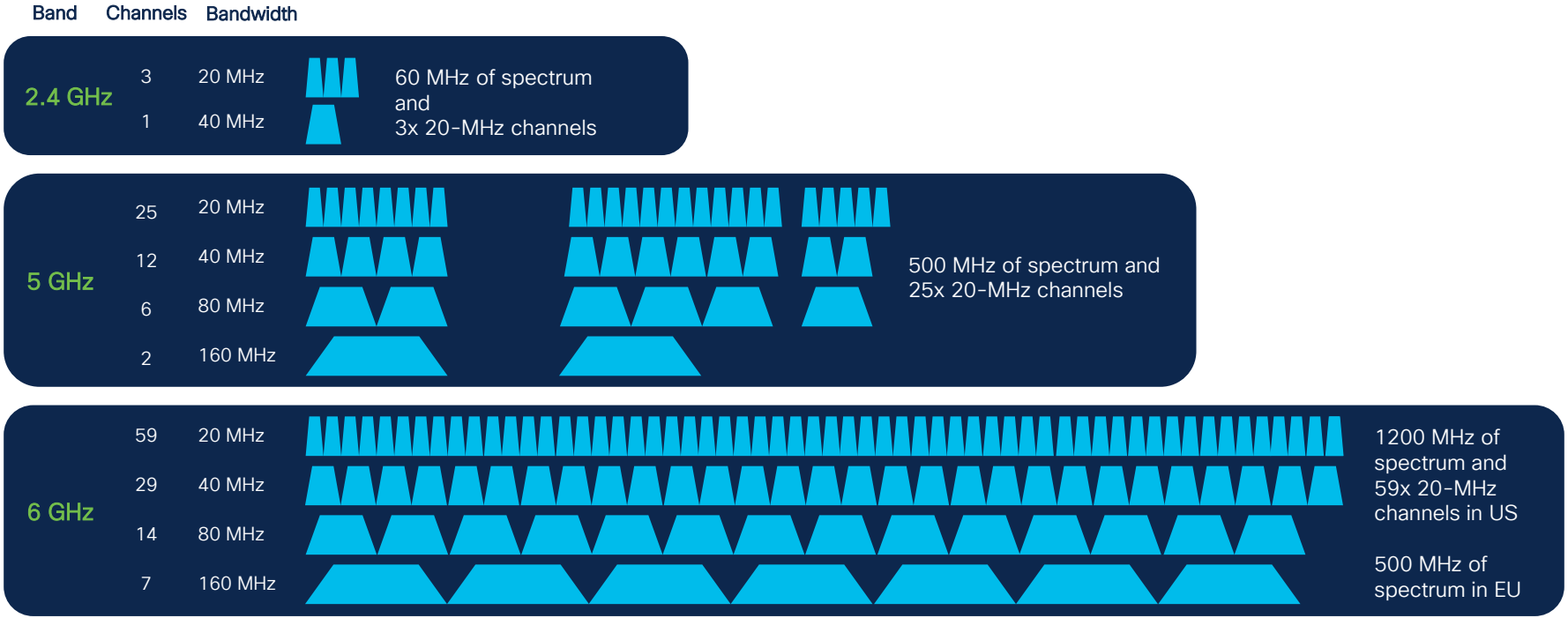
Avoid obstructions in front of your antennas

Wi-Fi 6E Deployment Considerations



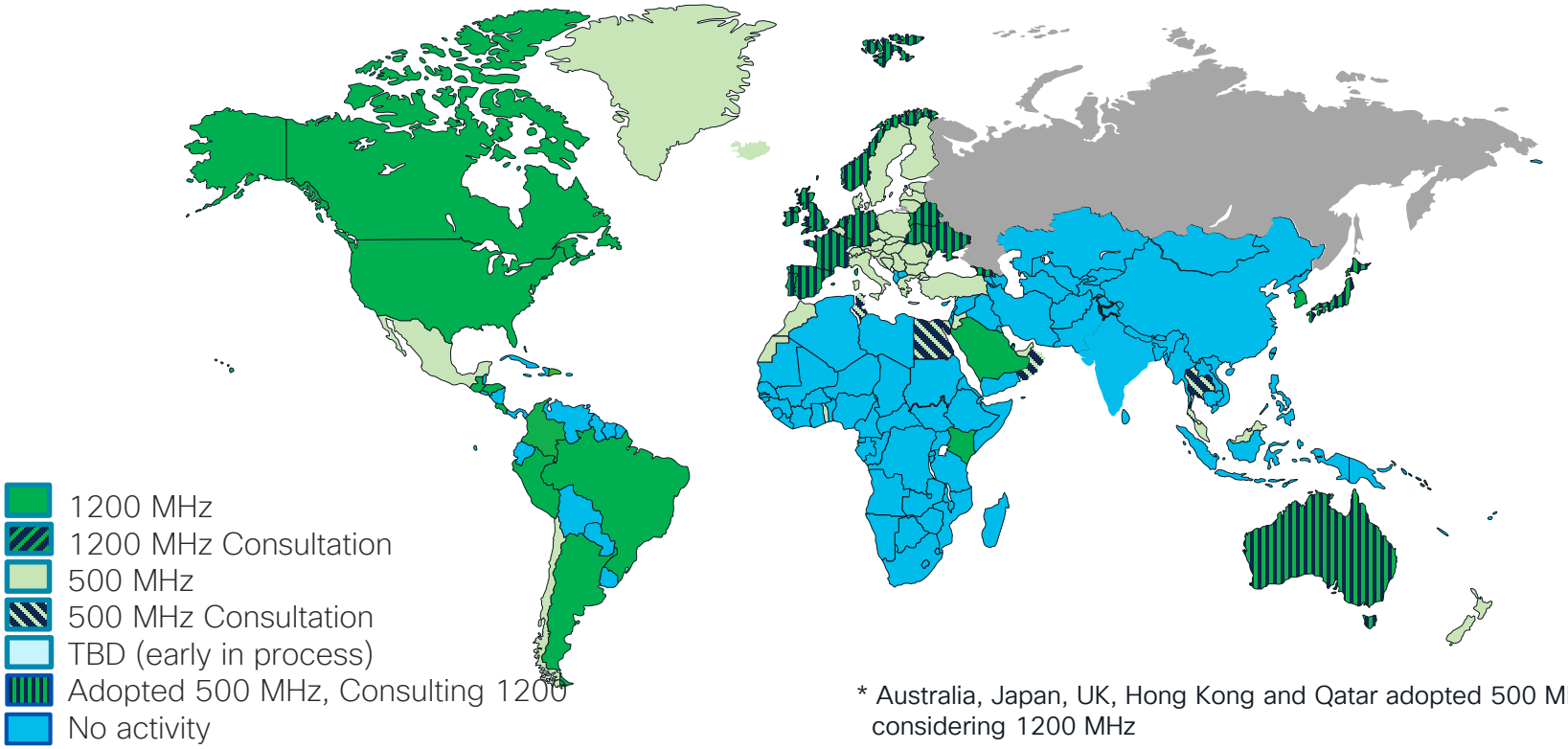
cisco Live!

6 GHz is the biggest Wi-Fi spectrum expansion ever



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

Deploying and migrating to Wi-Fi 6E
Key Considerations

6GHz SSID Discovery	Active Scanning is less practical – too many channels Reduced Neighbor Report (RNR) offers “passive” detection Device behavior varies - testing is important!
AFC – Standard Power & LPI	Indoor / LPI AP’s **cannot be used outdoors** or within enclosures Outdoor AP’s must be Standard-Power Certified and have some special requirements (re: antenna aim, channel limitations)
Avoid “Salt & Pepper” Scenarios	Deploying small pockets of 6E amongst existing 5GHz deployments will cause client disruption
Understand Client & Security Requirements	E.g., WLAN configurations - WPA3 is required for Wi-Fi 6E networks

AFC & Standard Power in 6GHz

Ready for Outdoor Use

April 8, 2024 — 1 Comment

Networking

Cisco Access Points among the First to Be Standard-Power Certified by the FCC

4 min read

Brett Shore

It's an exciting time in the world of Wi-Fi. The Federal Communication Commission (FCC) recently approved Automated Frequency Coordination (AFC) for service providers. Adding to this momentum, the FCC granted standard-power certification to a range of Cisco Wireless Wi-Fi 6E access points. This means you'll be able to take full advantage of the 6 GHz band to support your wireless-first strategy. But what exactly is AFC and standard power, who requires it, and how can it benefit you and your organization?

https://blogs.cisco.com/networking/cisco-access-points-among-the-first-to-be-standard-power-certified-by-the-fcc

Why we need 6GHz Standard Power and AFC

jiflorwi — Cisco Employee — 04-19-2024 03:32 PM

By now everyone should have heard the news on 6 GHz and Wi-Fi 6E that was announced initially back in April of 2020. Customers have been deploying and turning up these networks on Wi-Fi 6E AP's operating under LPI (Low Power Indoor) rules for many months now. LPI operating rules limit operations to Indoor only, and no external antenna's, no weatherproof enclosures, and a limit on the power of 5 dBm /MHz PSD (Power Spectral Density). Like any new technology, there were many concerns about the new technology and its frequencies. Would it even be useful with the restricted power limits, or how will the propagation differ from 5 GHz (how far the signal goes). Would the power mismatch produce un-even 5 and 6 GHz cell sizes? In spite of all the initial concerns it turns out it is all quite useful- in an indoor carpeted office space it is very easy to deploy co-located 5/6 GHz cells and maintain even coverage for both. Indoor densification (capacity increases) of Wi-Fi requires relatively small (lower power) cells and for this - LPI has been perfect.

https://community.cisco.com/t5/wireless-mobility-blogs/why-we-need-6ghz-standard-power-and-afc/ba-p/5074158

Deploying and migrating to Wi-Fi 6E
Deep Dive

FULL CONFERENCE | IT LEADERSHIP | FULL CONFERENCE PLUS

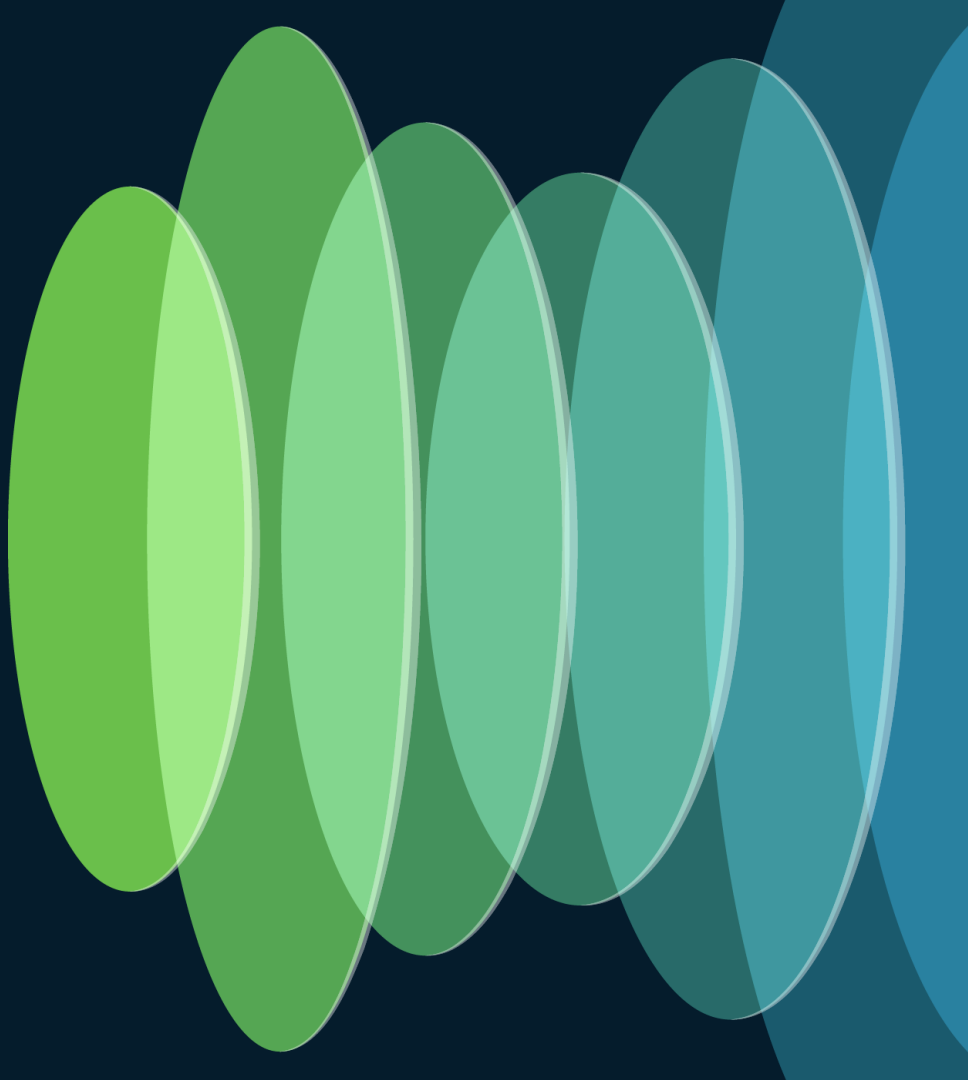
Wi-Fi 6E Adoption and a Sneak Peek into the Future with Wi-Fi 7 - BRKEWN-2024

ANAND Gurumurthy, Sr. Technical Leader, Technical Marketing, Cisco

Schedule **Wednesday, Jun 5 | 2:30 pm - 4:00 pm PDT | L3, South Seas E**

Wi-Fi standards continuously evolve to cater to the needs of the latest applications and use cases. 6 GHz in Wi-Fi, termed Wi-Fi 6E, was a paradigm shift, almost like Wi-Fi reborn. While the adoption of Wi-Fi 6E has picked up momentum, the Wi-Fi alliance has introduced the next generation of Wi-Fi -i.e., Wi-Fi 7, which has created a lot of buzz. Many end users are in a dilemma if they've to deploy Wi-Fi 6E or wait for Wi-Fi 7. This session begins with an overview of Wi-Fi 6E and walks through the design, deployment, and migration considerations the Wi-Fi administrators need to know regarding Network Infrastructure, RF Design, Security, and WLAN Design. The session will then deep-dive into the technical aspects of Wi-Fi 7, walk through the features and benefits, and conclude with the readiness of Wi-Fi 7 for enterprise deployment today..

Maximizing the Spectrum

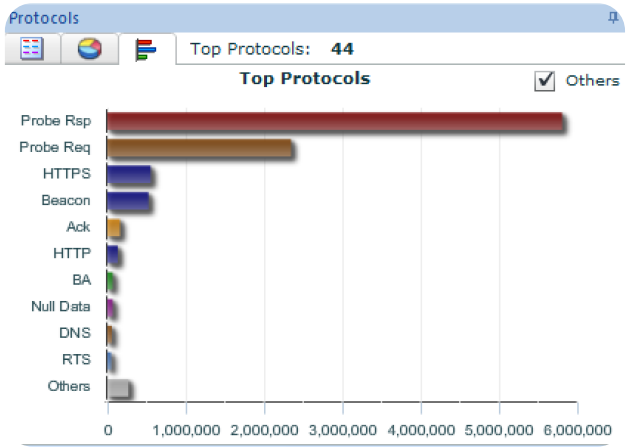


Maximize your Spectrum

- Limit SSIDs (reduce management traffic)
- Integrate existing networks
- Optimize PHY Rates
- Monitor Noise Floor & use power adjustments
- Remove barriers to entry

Maximizing the Spectrum

Avoiding Excessive Management Traffic

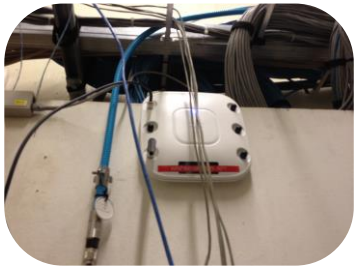


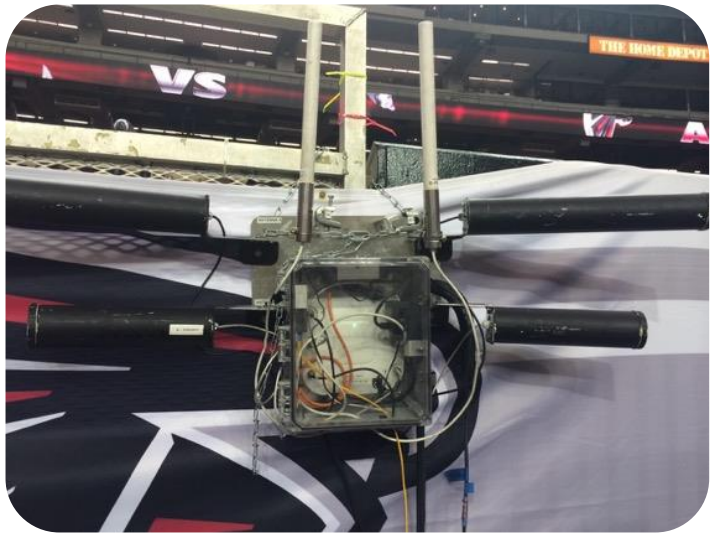
- Always aim for 1 SSID
  - Especially in high density areas
- More SSID's = Worse Performance
- Why?
  - Each SSID requires a separate beacon
  - Each SSID will beacon at the minimum mandatory data rate
  - Radios will respond to null probe requests for each broadcast SSID
  - Exponential amounts of airtime wasted!

Maximizing the Spectrum

Integrate Existing WLANs

- Common to see various existing WiFi deployments in venues
- Efficient HD WLANs are deployed holistically – one infrastructure
- Benefits?
  - Configuration consistency
  - Airtime efficiency
  - Legacy management traffic that once chewed up 30-40% of airtime typically drops to < 1% of airtime



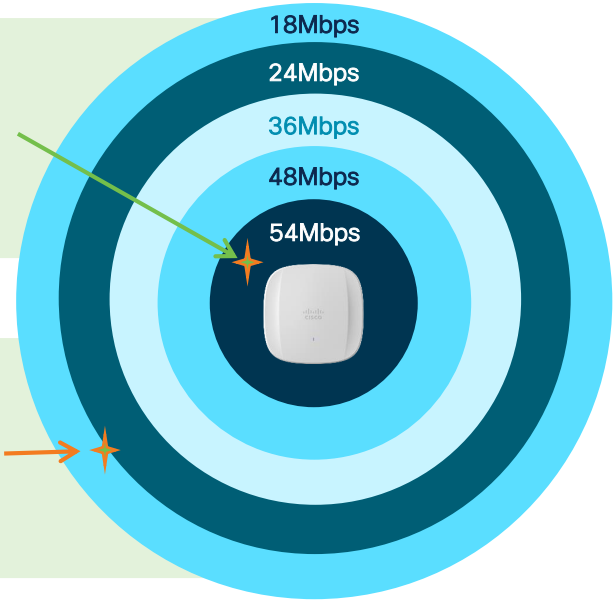


Maximizing the Spectrum

PHY Rate Tuning: Why PHY Rates Matter

Client near AP:
Higher PHY Rate
More Efficient
(high signal-to-noise ratio)

Client far from AP:
Lower PHY Rate
Less Efficient
(lower signal-to-noise ratio)

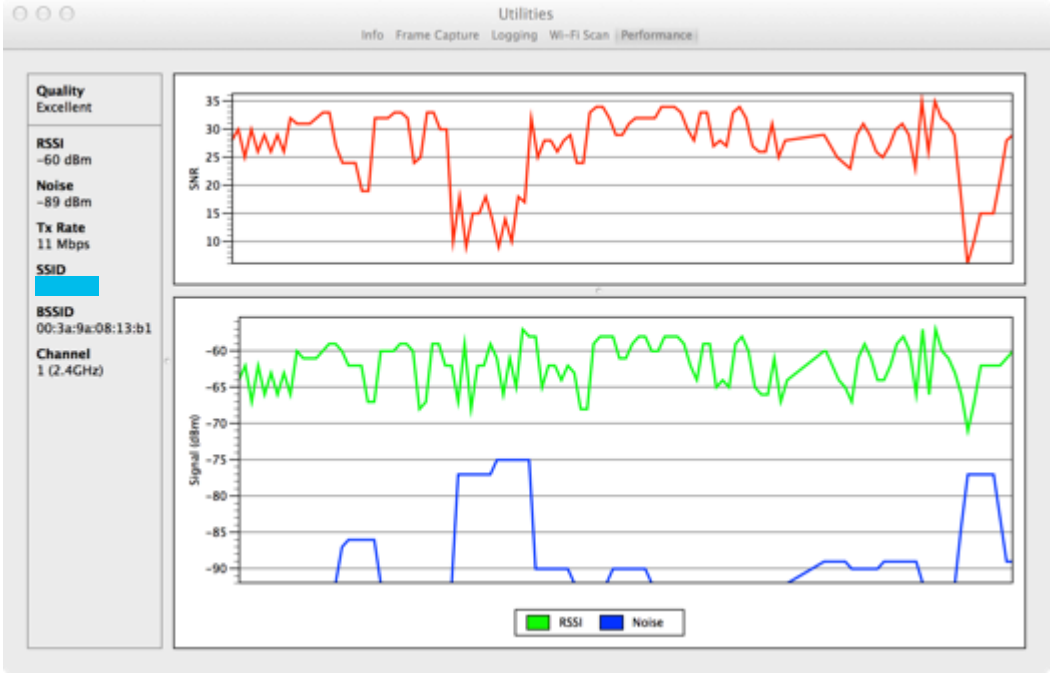


- Tune your Minimum Mandatory and Supported data rates to optimize airtime
- Higher rates require higher SNR – don't be too aggressive
- Leave 1 or 2 rates below your Minimum Mandatory rate as "supported" to provide a "soft landing" and allow some SNR flexibility
- Generally, no need to adjust MCS rates (client compatibility)
- Common starting points (5ghz): 18mbps Minimum Mandatory, 12mbps Supported, <12 disabled, >18 Supported

Maximizing the Spectrum

RSSI vs. SNR

- Check your noise floor in each band during peak usage
  - Packet captures with a NIC that you trust (MacBook Pro, etc.)
  - Fluke AirCheck
  - Spectrum Expert
  - Metageek Chanalyzer for Clean Air



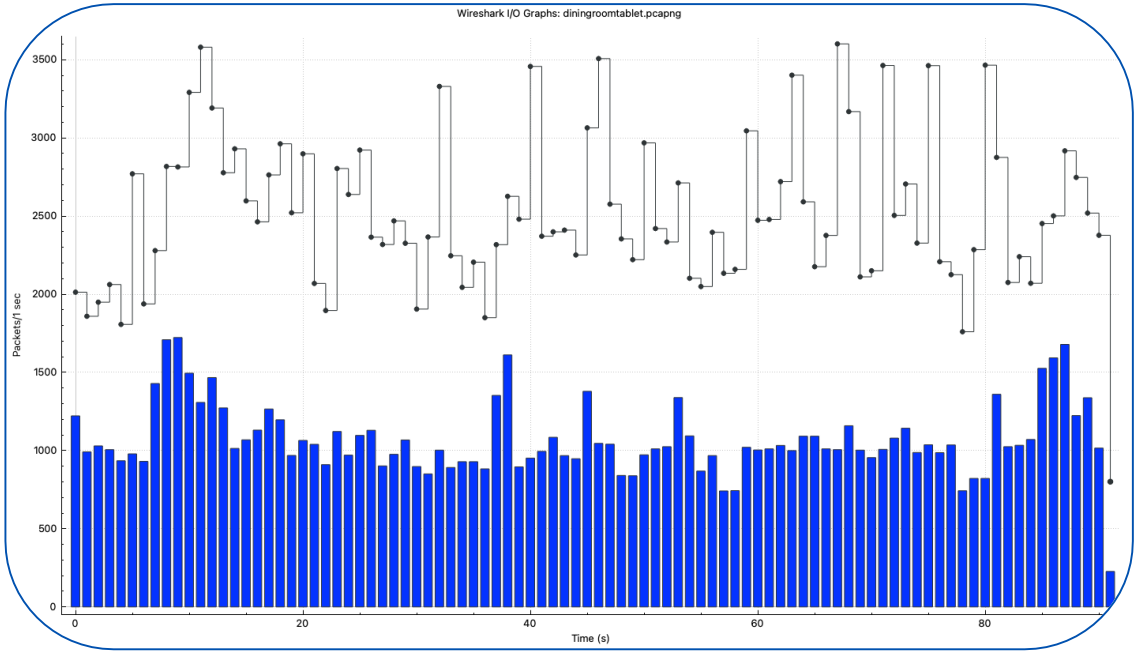
Maximizing the Spectrum

Ease-of-Use & Client Induced Interference

- Ask yourself - how difficult is it to get on your WiFi network?
- Ease-of-use directly impacts airtime efficiency
- Low take rate = lots of probe request noise (1mb, max power, all channels)
  - Results in Client Induced Interference
- A device on the network is far less damaging than a device off the network!
- Make captive portals easy, implement OpenRoaming, etc.

Maximizing the Spectrum

Eliminating unnecessary traffic over the air



Propagation of mDNS & IPv6 traffic consuming **>40%** of airtime across all channels

Maximizing the Spectrum

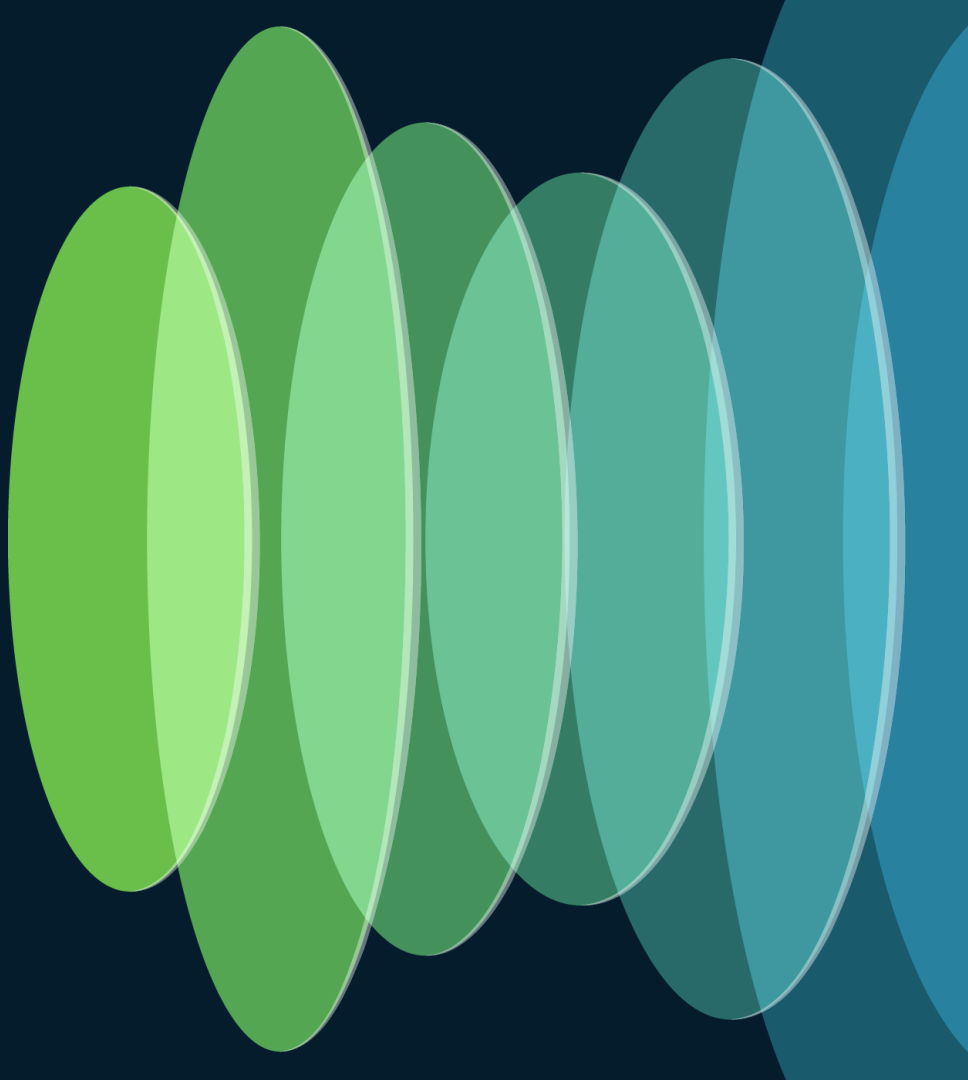
Eliminating unnecessary traffic over the air

	Before Optimization	*After Optimization*
	Slot 1 (5 GHz)	Slot 1 (5 GHz)
Radio Type	802.11ax - 5 GHz	802.11ax - 5 GHz
Radio Role (Radio Mode)	Automatic (Local)	Automatic (Local)
Admin Status	Enabled	Enabled
Number of Clients	1	1
Current Channel	153	153
Power Level	*6/8 (8 dBm)	*6/8 (8 dBm)
Channel Utilization	34%	17%
Transmit Utilization	29%	17%
Receive Utilization	0%	0%

Agenda

- Designing RF for High Client Densities
- HD Wi-Fi Configuration Tips
- HD Wi-Fi Engineering Toolkit

The Basics: RF Profiles, TPC, DCA



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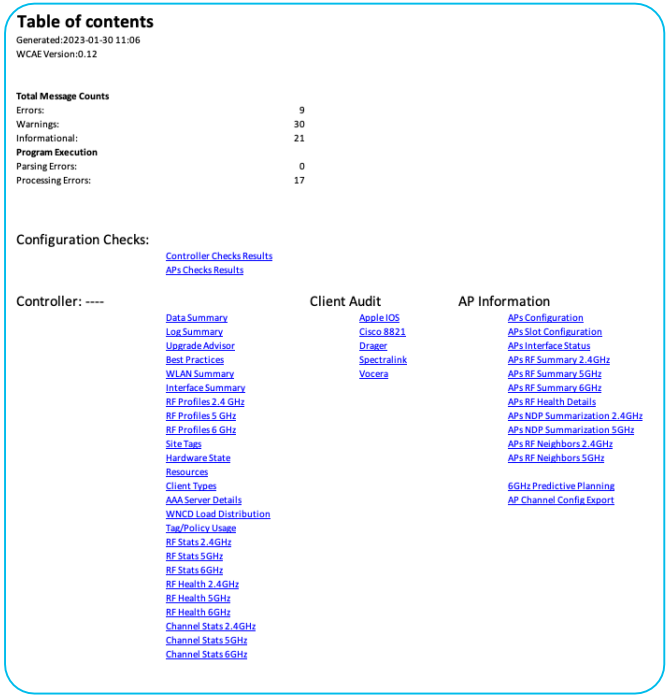
First – a handy (free!) tool: WCAE

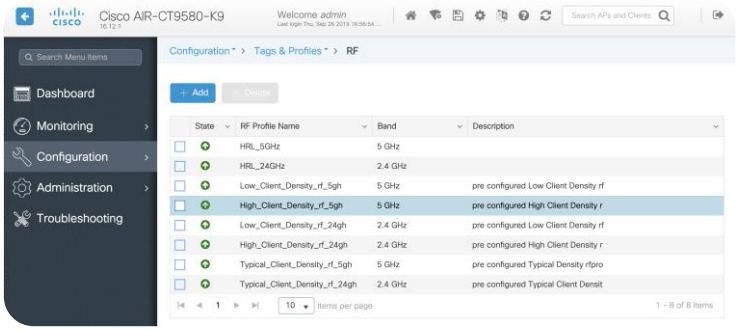
- Wireless Config Analyzer Express (WCAE) is an extremely valuable tool when validating and optimizing a Cisco Wi-Fi deployment
- Feed your WLC config output to WCAE and it will help you:
  - Find and troubleshoot problems quickly
  - Identify top areas for RF optimization
  - Check configs against best practices
  - RRM overview with the RF Summary

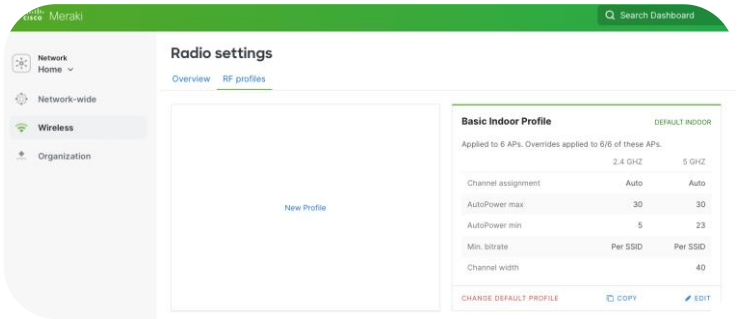


Download: https://developer.cisco.com/docs/wireless-troubleshooting-tools/

More info: Cisco Live US 2022 – BRKEWN-3006

High Density WLAN Features & Configurations

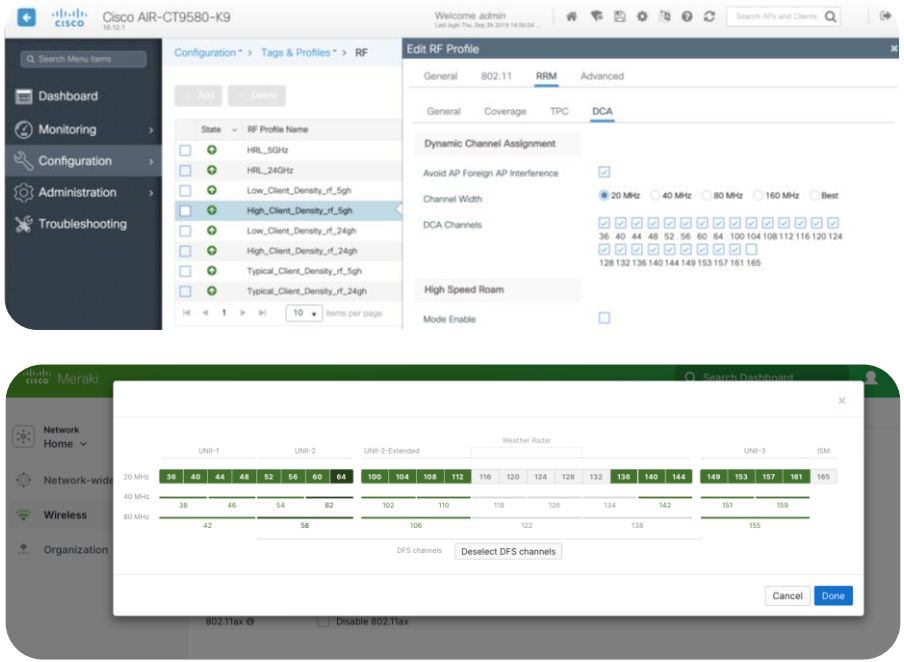




- WiFi deployments **are not "one-size-fits-all"**
- **Use RF Profiles** on both Catalyst and Meraki deployments for granular RF control
  - **Configure network-wide channel parameters:** remove channels as needed, set channel widths
  - **Configure transmit power min/max:** ensure balance, avoid "client magnets"
  - **Configure RX-SOP thresholds** to selectively reduce radio sensitivity where needed
- On C9800, **plan Site Tags** to balance APs across processes

Channel Planning with RF Profiles

- Plan channels with Dynamic Channel Allocation (Catalyst) or AutoChannel (Meraki) via RF Profile
- If needed – **eliminate unusable channels** for business-critical areas (DFS, etc)
- Reserve channels for use by other systems



Catalyst Tip: Identifying Potentially Unhealthy Channels

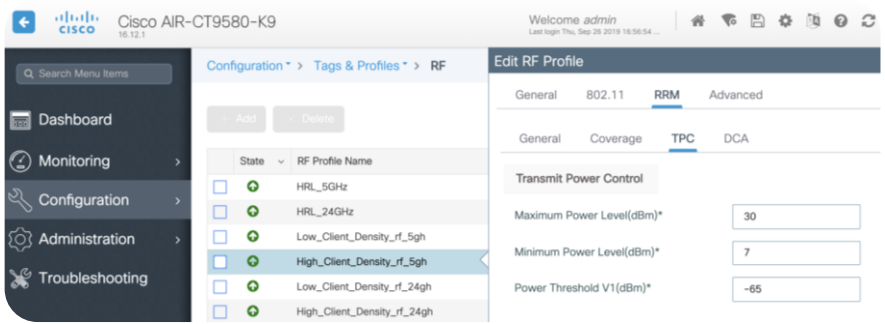
WCAE – 'APs RF Summary' tab – "High Channel Changes" column

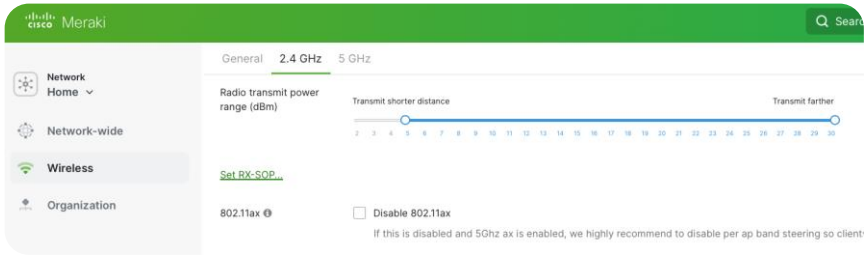
C	D	G	H	I	J	K	L	M	N	O	V
Model	Mode	Chann	TX Pow	TX Power dB	Total Clients	RX SOP	CH Util%	CH TX Util%	CH RX Util%	Channel Changes	High Channel Chang
C9130AXI-B	Client Serving	108	3	9	18	medium(-78)	50	3		18	Yes
C9130AXI-B	Client Serving	140	2	12	8	medium(-78)	73	50		20	Yes
C9130AXI-B	Client Serving	52	2	11	17	medium(-78)	46	5		20	Yes
C9130AXI-B	Client Serving	64	2	11	4	medium(-78)	11	0		25	Yes
C9130AXI-B	Client Serving	100	3	9	12	medium(-78)	49	2		30	Yes
C9130AXI-B	Client Serving	44	5	9	7	medium(-78)	47	8		23	Yes
C9130AXI-B	Client Serving	100	3	9	13	medium(-78)	38	7		19	Yes
C9130AXI-B	Client Serving	56	2	11	22	medium(-78)	46	17		28	Yes
C9130AXI-B	Client Serving	132	3	9	14	medium(-78)	37	8		32	Yes
C9130AXI-B	Client Serving	52	2	11	15	medium(-78)	45	1		18	Yes
C9130AXI-B	Client Serving	56	2	11	23	medium(-78)	42	7	1	25	Yes
C9130AXI-B	Client Serving	116	3	9	9	medium(-78)	24	3		22	Yes
C9130AXE-B	Client Serving	52	2	15	0	medium(-78)	2	0		19	Yes
C9130AXE-B	Client Serving	36	2	19	0	medium(-78)	1	0		20	Yes
C9130AXE-B	Client Serving	56	2	15	0	medium(-78)	1	0		30	Yes
C9130AXE-B	Client Serving	149	2	20	0	medium(-78)	2	0		22	Yes
C9130AXE-B	Client Serving	124	2	15	88	medium(-78)	78	19	1	70	Yes
C9130AXE-B	Client Serving	48	2	20	0	medium(-78)	2	0		66	Yes
C9130AXE-B	Client Serving	36	2	19	0	medium(-78)	2	0		19	Yes
C9130AXE-B	Client Serving	44	2	20	0	medium(-78)	2	0		21	Yes
C9130AXE-B	Client Serving	108	2	15	0	medium(-78)	1	0		25	Yes
C9130AXE-B	Client Serving	149	2	20	0	medium(-78)	1	0	0	21	Yes

"High Channel Change: Yes" triggered for radios with more than 4 channel changes per day

Balancing Transmit Power with RF Profiles

- **TPC** (Catalyst) and **AutoPower** (Meraki)
- **Ensures AP-to-AP consistency** (no “client magnets”) and 2.4GHz to 5GHz balance (5GHz hotter, 2.4GHz cooler)
- **TPC/AutoPower Min** – lower power limit specified for a given radio. TPC/AutoPower will never adjust power below this level.
- **TPC/AutoPower Max** – upper power limit specified for a given radio. TPC/AutoPower will never adjust power above this level.





Identifying Possible Power Imbalance

WCAE – 'APs RF Summary' tab – "TX Power dBm" and "Total Clients" columns

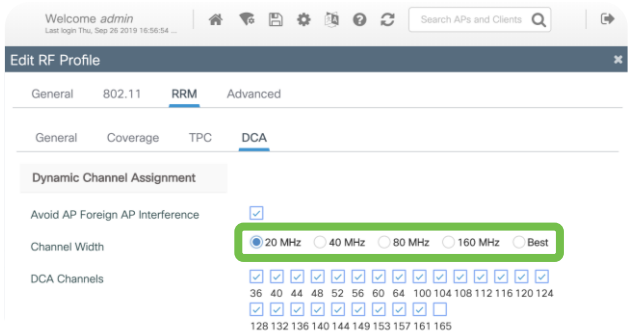
Name	Slot	Band	Channel	TX Power	TX Power dBm	Total Clients
AP1	1	5	100	1	17	21
AP1	2	5	48	1	23	70

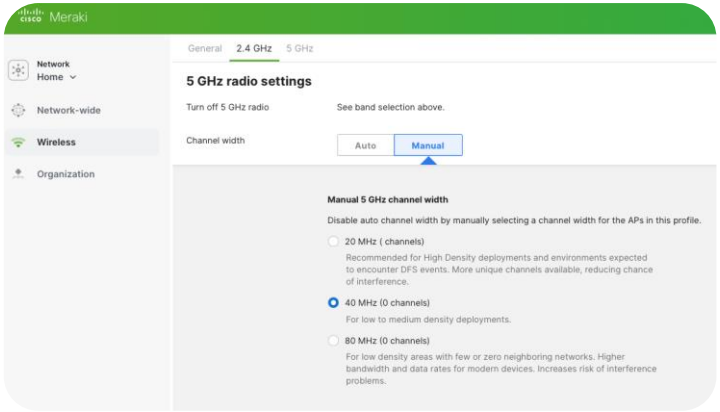
6dB power difference = client imbalance

Refer to AP power tables to determine max TX power per UNII band

Use "show controller" on a sample AP for all details

Selecting Channel Width with RF Profiles





5GHz

- In general, **20MHz channels** provide the most channel reuse (capacity) for high density environments
- **Wider channels may be used selectively** in more isolated areas – smaller classrooms, lobbies, conference rooms, etc.

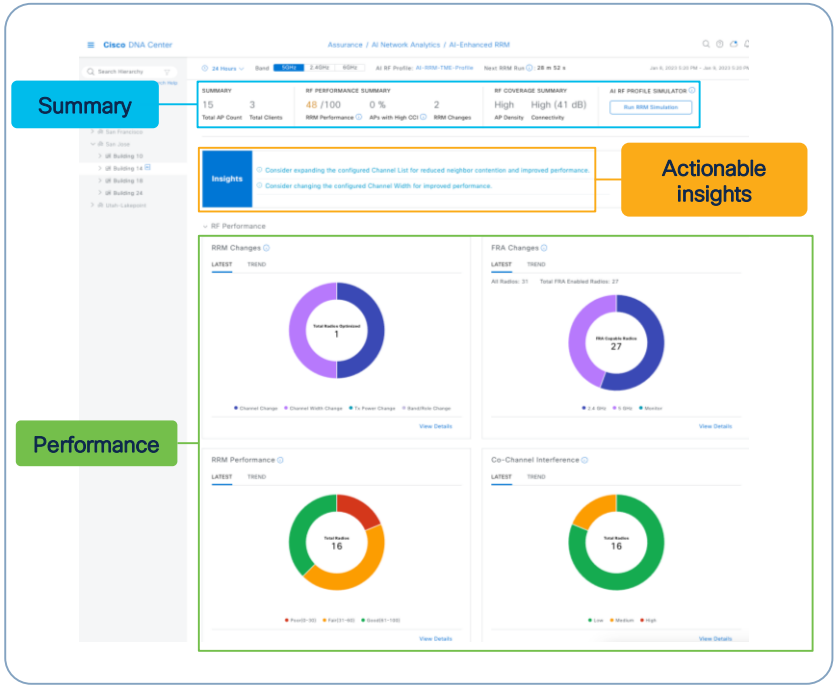
6GHz

- Heavily dependent on regulatory domain
- Note! Higher channel width results in higher max Tx power for data frames (but not beacons – remember when surveying!)

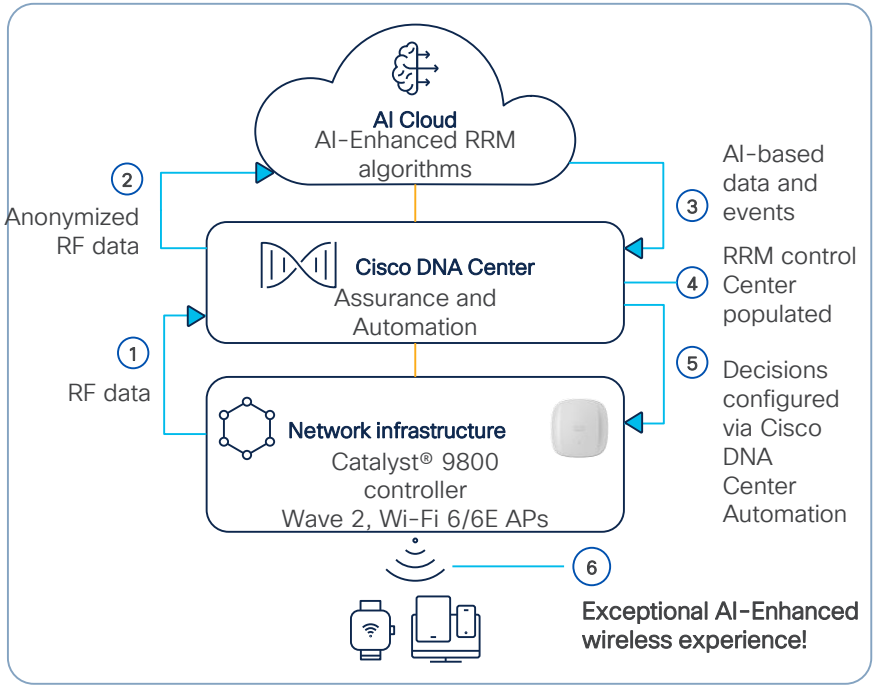
What is AI-Enhanced RRM?

AI-Driven RRM solution

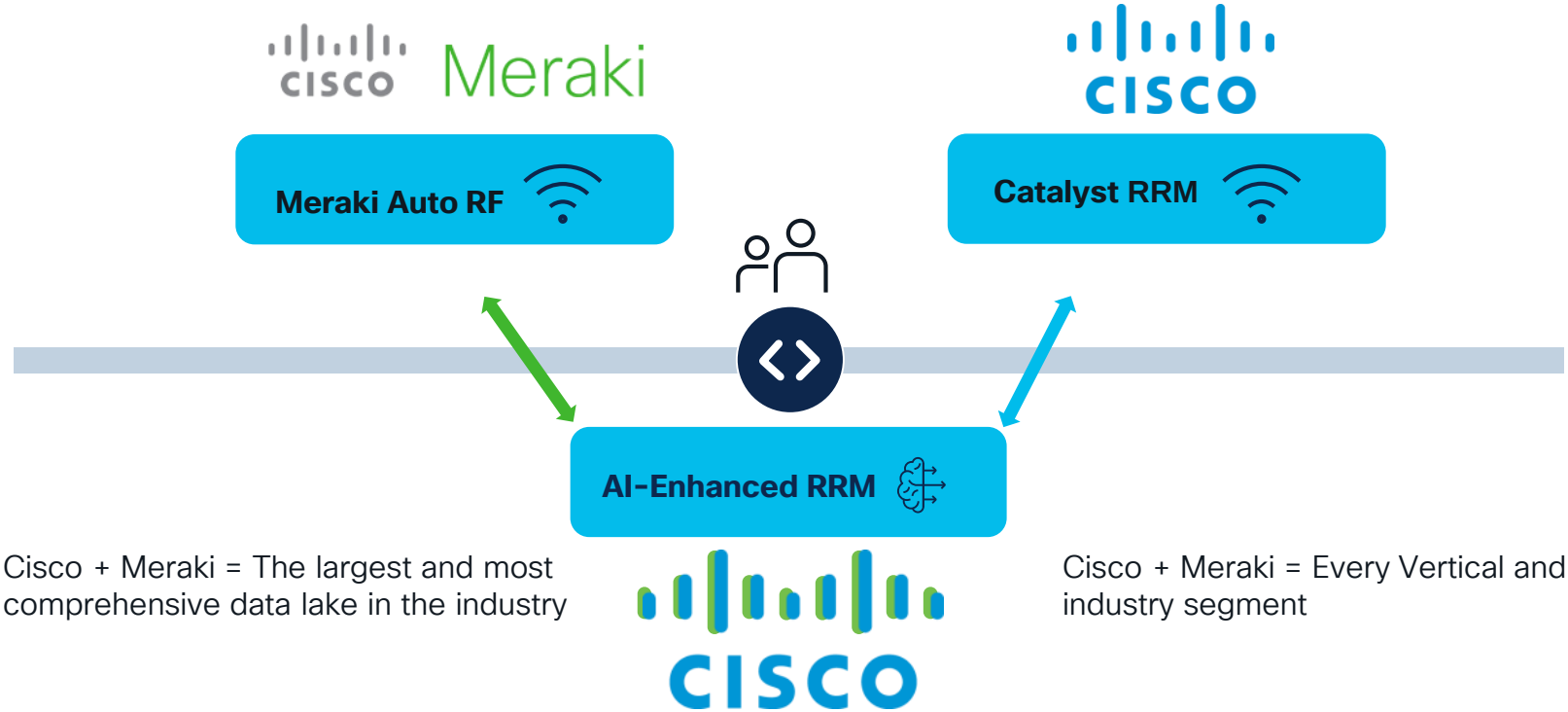
Deep RF visibility & advanced control



Proactive optimizations for all deployment sizes



AI RRM: Meraki + Catalyst



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

Cisco + Meraki = Every Vertical and Every industry segment

AI-RRM: Hear from an expert!

FULL CONFERENCE | IT LEADERSHIP | FULL CONFERENCE PLUS

Advanced RF Tuning for Wi-Fi 6E with Catalyst Wireless: Become an Expert While Getting a Little Help from AI - BRKEWN-3413

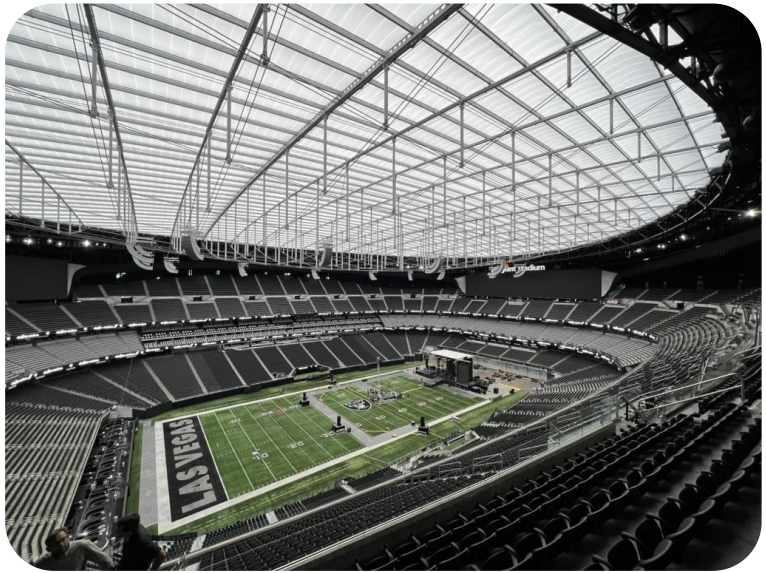
Jim Florwick, Technical Marketing Engineer, Cisco - **Distinguished Speaker, Hall of Fame Elite Speaker, Hall of Fame Speaker**

Schedule **Wednesday, Jun 5 | 10:30 am - 12:00 pm PDT | L2, Mandalay Bay G**

Participants will learn the RF design and implementation guidelines necessary to plan, configure, and implement Wi-Fi networks that meet the evolving regulatory (6 GHz) and customer RF demands. Wi-Fi is changing, and there has never been a more exciting time to be in RF technologies. In this session, you will learn about Cisco's newest Catalyst wireless access points and antennas, including the latest Wi-Fi 6E access point and the new Wi-Fi 6 stadium antenna. Participants will learn and understand the current coverage and design best practices as well as what this means to the evolving RF landscape around the world. Everything we know is evolving. This session will provide a deep dive on how to think about and manage Wi-Fi 6E, RRM, spectrum intelligence, and the evolution of multi-band operations within the infrastructure. The evolution to Wi-Fi 6E brings amazing RF capacity gains. Wi-Fi 6E also means new pressures on the wired infrastructure capacity and power that supports it. Attendees will learn what to expect and how to manage and plan for future needs now. Session attendees will be able to successfully use the information to navigate and understand today's fluid RF and mobility landscapes and articulate the benefits to their customers, enabling the best wireless and mobility experiences yet.

Site Tags & Balancing AP Load on 9800

Key Considerations



In High Density Deployments – **balance your APs across Site Tags.** Do not use the default site tag.

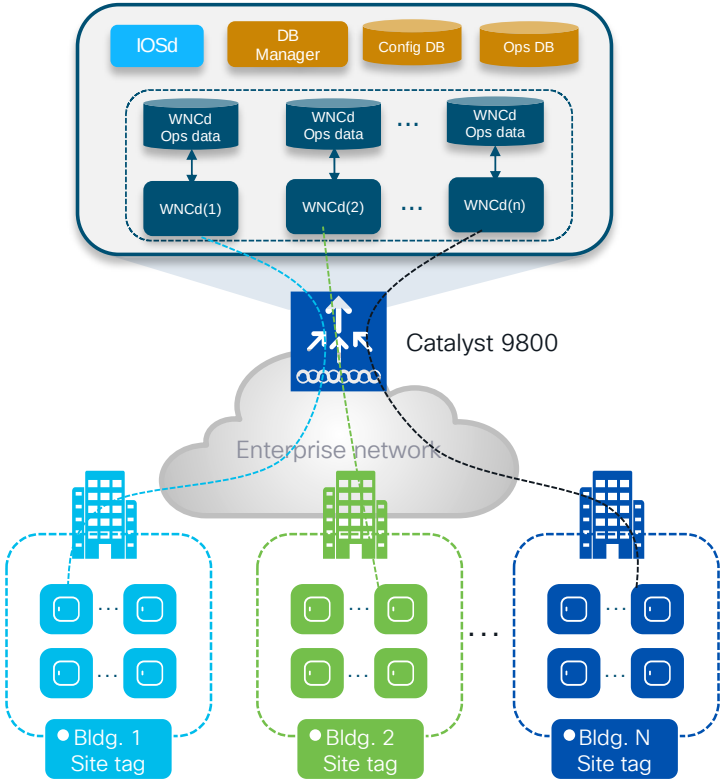
Site Tag does not necessarily equate to a physical “Site”

Site Tag assigns an AP to a WNCd (9800 process)
(# of available WNCd’s differs per HW platform)

Organize Site Tags into approximate roaming domains

Refer to the C9800 Best Practices guide for the latest guidance

Site Tags – Design considerations



A few more important suggestions:

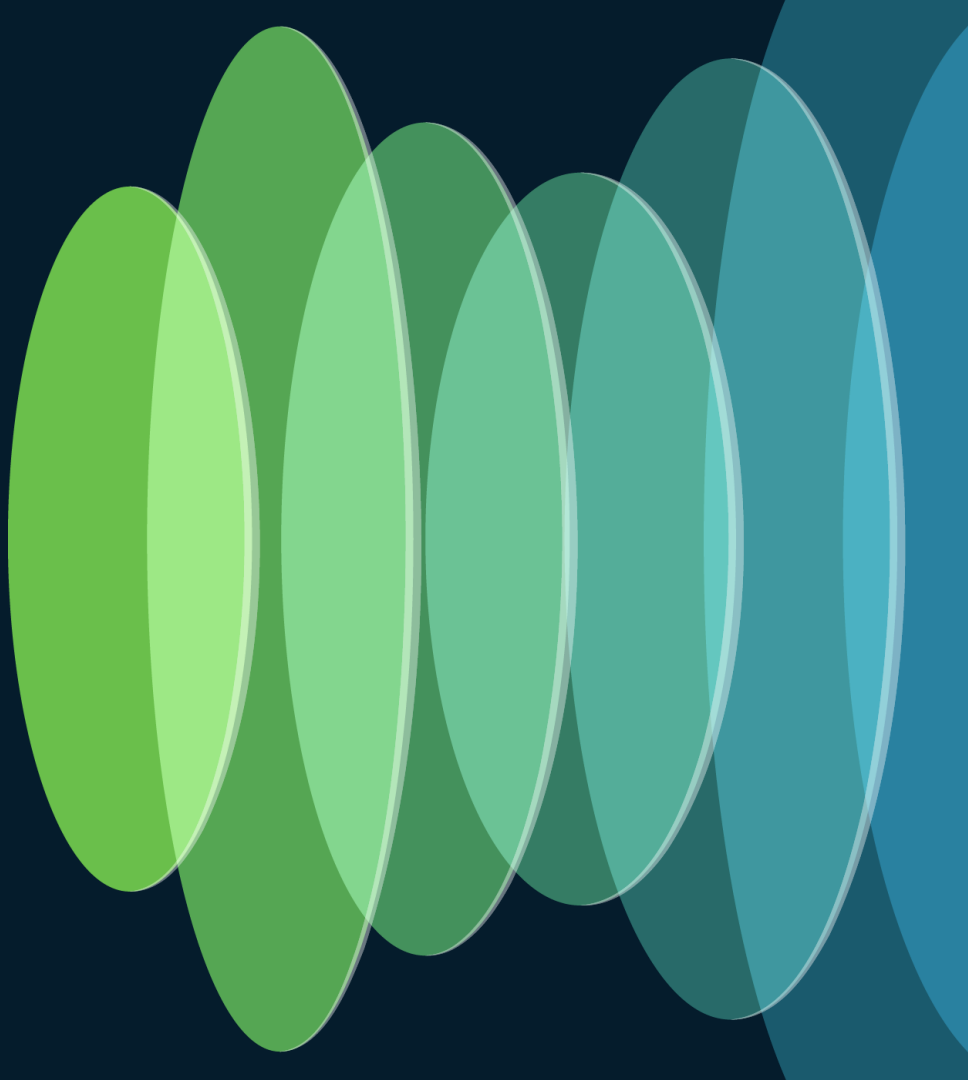
- Distributing APs (and clients) across custom Site Tags (and thus WNCd's) gives better scale and performance
- In large public venues, avoid having more Site Tags than # of WNCd's
- The number of WNCd varies from platform to platform:

Platform	# of WNCD instances
EWC (on AP or C9k switch)	1
C9800-L	1
C9800-CL (small)	1
C9800-CL (medium)	3
C9800-40	5
C9800-CL (large)	7
C9800-80	8

The following command shows the # of WNCDs processes:

```
9800#sh processes platform | inc wncd
```

The (Not So) Secret High Density Weapon: RX-SOP



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Receive Sensitivity Threshold (RX-SOP)

What if…

I put AP's wherever I needed them…
I used all the right antennas…
I surveyed and optimized and surveyed and optimized again…

…but my Channel Utilization is still really high, with almost no "real" traffic?

Vendor	Signal	Noise	SNR	Channel	Channel Utilization	Clients
Cisco Sys…	-85 dBm	-96 dBm	11 dB	48	90%	
Cisco Sys…	-70 dBm	-96 dBm	26 dB	153	89%	
Cisco Sys…	-74 dBm	-96 dBm	22 dB	153	89%	7
Cisco Sys…	-74 dBm	-96 dBm	22 dB	153	89%	
Cisco Sys…	-74 dBm	-96 dBm	22 dB	153	89%	
Cisco Sys…	-90 dBm	-96 dBm	6 dB	144	87%	
Cisco Sys…	-78 dBm	-96 dBm	18 dB	157	86%	2
Cisco Sys…	-64 dBm	-96 dBm	32 dB	1	84%	
Cisco Sys…	-70 dBm	-96 dBm	26 dB	153	82%	
Cisco Sys…	-76 dBm	-96 dBm	20 dB	153	80%	
Cisco Sys…	-86 dBm	-96 dBm	10 dB	161	80%	
Cisco Sys…	-80 dBm	-96 dBm	16 dB	153	80%	
Cisco Sys…	-64 dBm	-96 dBm	32 dB	44	79%	3
Cisco Sys…	-62 dBm	-96 dBm	34 dB	44	79%	
Cisco Sys…	-64 dBm	-96 dBm	32 dB	44	79%	2
Cisco Sys…	-80 dBm	-96 dBm	16 dB	153	78%	
Cisco Sys…	-74 dBm	-96 dBm	22 dB	153	77%	
Cisco Sys…	-70 dBm	-96 dBm	26 dB	153	76%	
Cisco Sys…	-80 dBm	-96 dBm	16 dB	153	76%	
Cisco Sys…	-80 dBm	-96 dBm	16 dB	153	76%	
Cisco Sys…	-80 dBm	-96 dBm	16 dB	153	76%	
Cisco Sys…	-70 dBm	-96 dBm	26 dB	153	76%	
Cisco Sys…	-80 dBm	-96 dBm	16 dB	153	75%	
Cisco Sys…	-78 dBm	-96 dBm	18 dB	153	75%	
Cisco Sys…	-78 dBm	-96 dBm	18 dB	153	74%	2

Receive Sensitivity Threshold (RX-SOP)

What does it do?

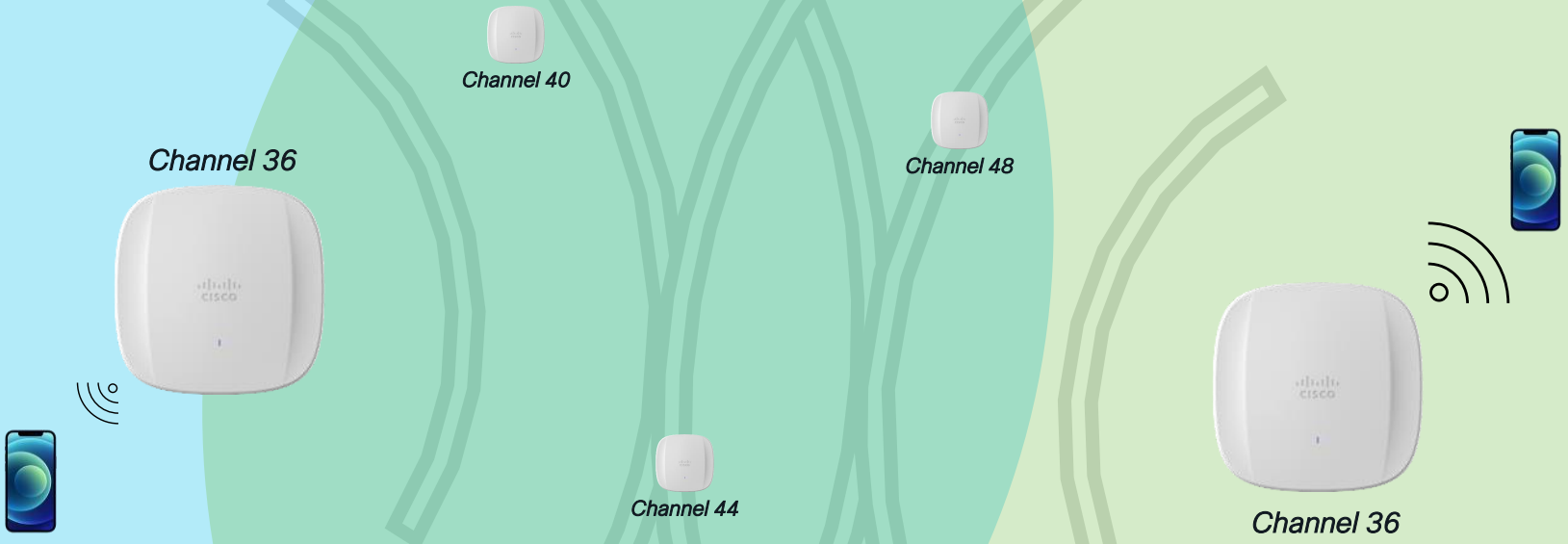
Reduces “receive” sensitivity of the AP to a pre-determined power level

> Example: ignore everything coming into the radio at lower than -80dBm, because those devices are unlikely to be in our cell

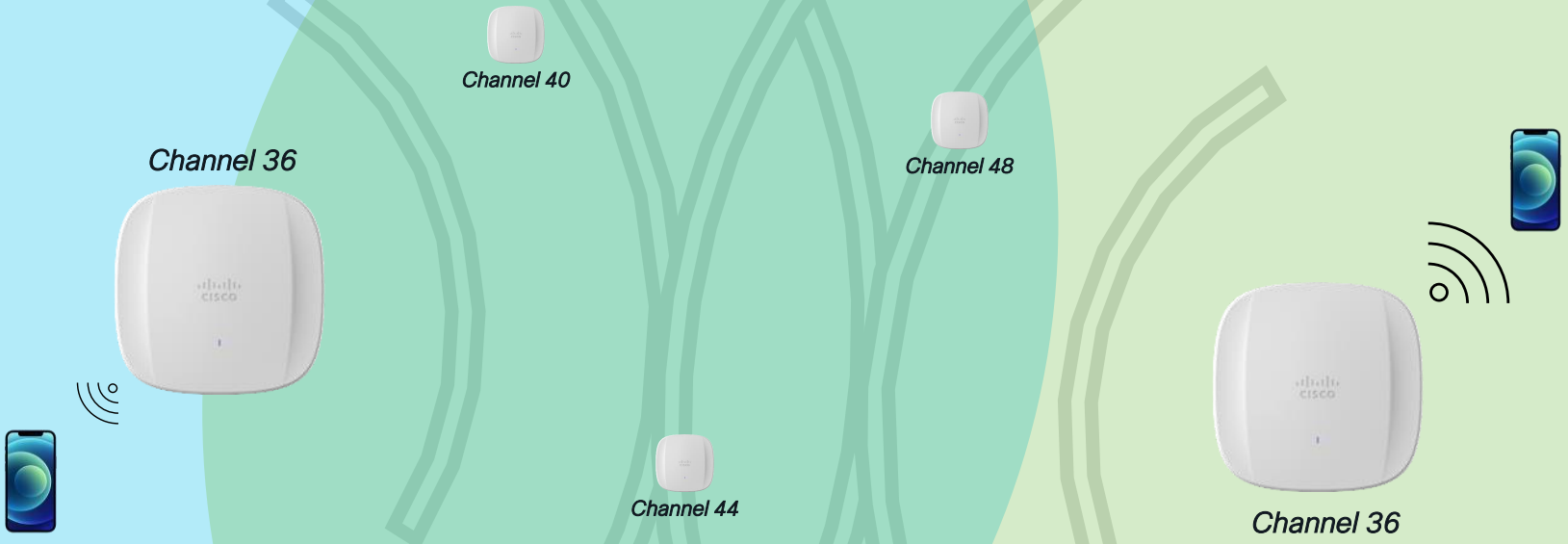
Why is it helpful?

Allows us to transmit more often to clients in our intended cell

- *802.11 is a “polite” protocol*



- *802.11 is a “polite” protocol*
- *I must listen before I start to talk - I will not talk until it’s “quiet” on my channel*



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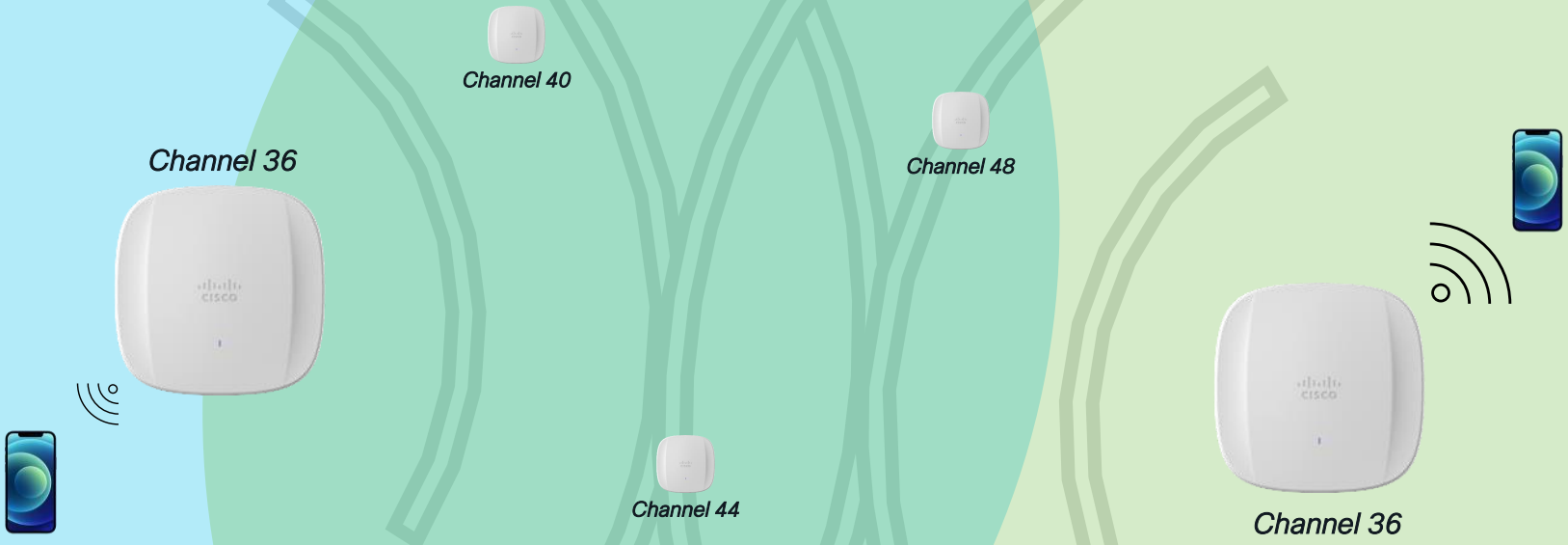
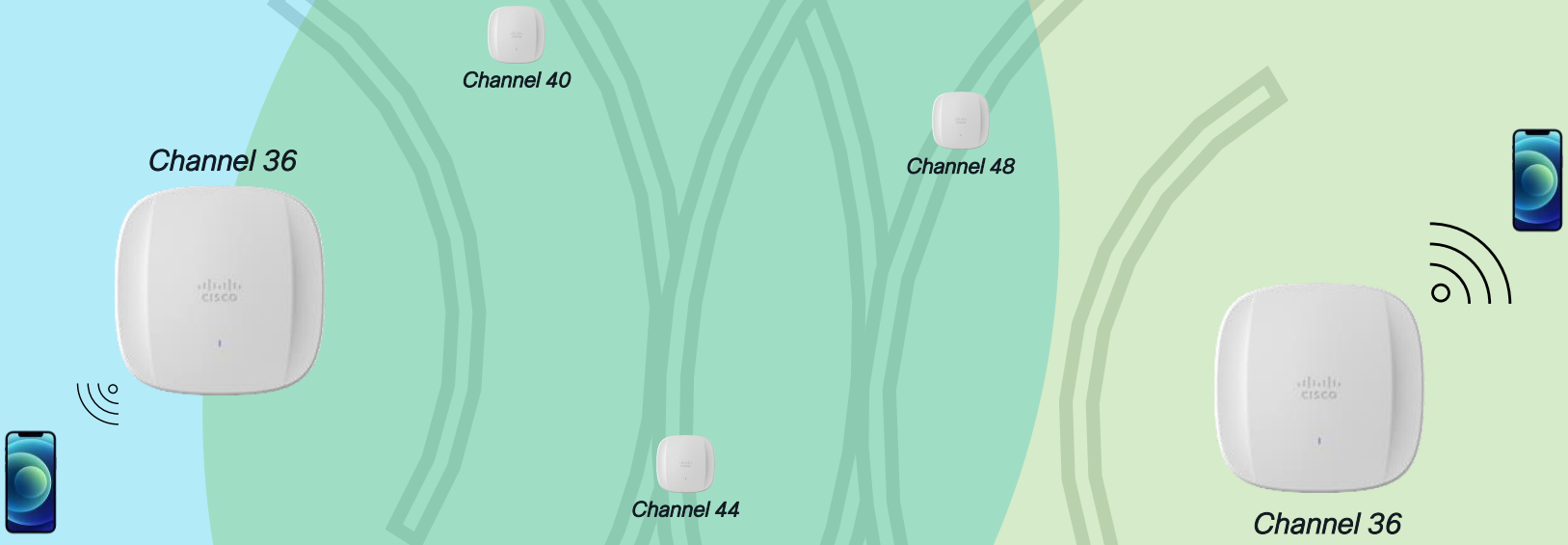
- *In dense deployments, you <u>will</u> have co-channel AP’s in range of each other*



- *802.11 is a “polite” protocol*
- *I must listen before I start to talk - I will not talk until it’s “quiet” on my channel*
- *In dense deployments, you will have co-channel AP’s in range of each other*
- *RX-SOP optimization helps us tune out the most distant co-channel transmissions*



Receive Sensitivity Threshold (RX-SOP)

- Be careful and make small adjustments
  - Generally, start in the -80's

Receive Sensitivity Threshold (RX-SOP)

- **Be careful and make small adjustments**
  - Generally, start in the -80's
- Remember – adjusting the RX-SOP threshold **doesn't impact the actual RF energy on the channel**, but it does impact APs' sensitivity to it
  - High Channel Utilization still affects all clients

Receive Sensitivity Threshold (RX-SOP)

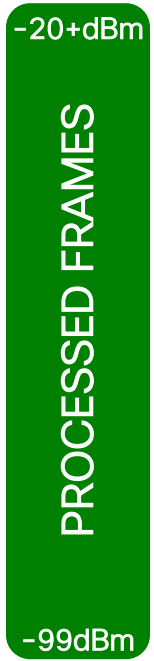
- **Be careful and make small adjustments**
  - Generally, start in the -80's
- Remember – adjusting the RX-SOP threshold **doesn't impact the actual RF energy on the channel**, but it does impact APs' sensitivity to it
  - High Channel Utilization still affects all clients
- **WiFi6, WiFi6E, and/or use of C9104 may reduce the need for RX-SOP** in some environments; continue to monitor your Channel Utilization and adjust as needed

Receive Sensitivity Threshold (RX-SOP)

Without Custom RX-SOP Threshold

(Default / “Auto” Radio Sensitivity)

Radio processes everything that it can hear – any frame with enough SNR



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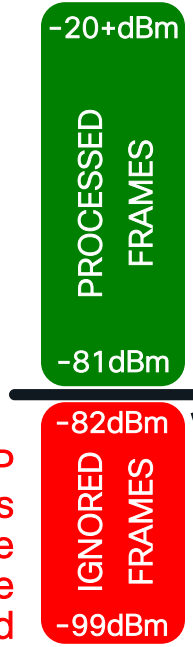
With Custom RX-SOP Threshold



The AP radio processes *only* the frames heard above the threshold

Frames where SOP (start of packet) is heard below the threshold are ignored

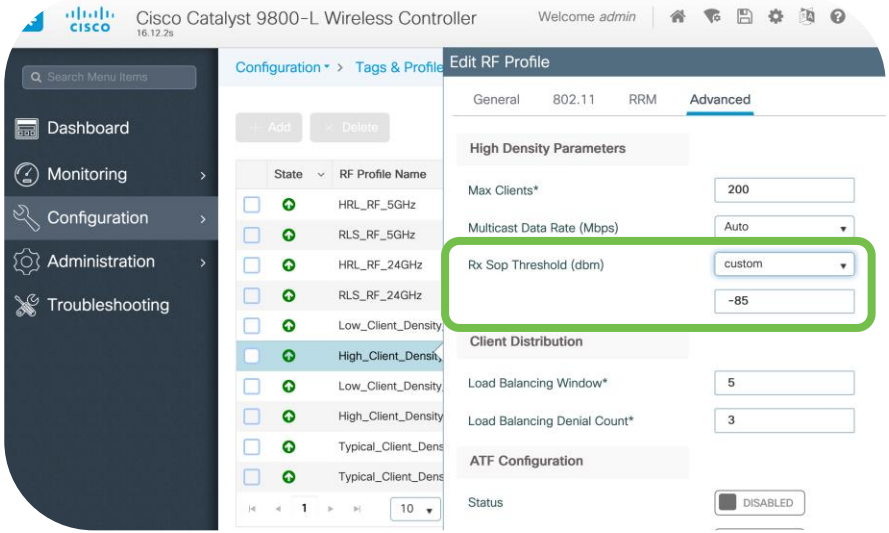
-82dBm RX-SOP Threshold

Ignored frames are now considered “Noise” and I can talk over them

HOW TO: Optimize RX-SOP Thresholds

1. Choose client devices and representative areas to test
2. Create a temporary SSID on one AP in the test area so your client doesn't roam
   (see hidden slides for tips on AireOS / 9800)
3. Monitor the AP's view of test clients throughout the cell
   (from WLC UI, WLC CLI, or AP CLI)
4. Pad the worst reading by another 15dB or more = initial RX-SOP threshold

Example: Worst AP-observed RSSI value is -72; initial RXSOP threshold with 15dB cushion = -87 (or higher)

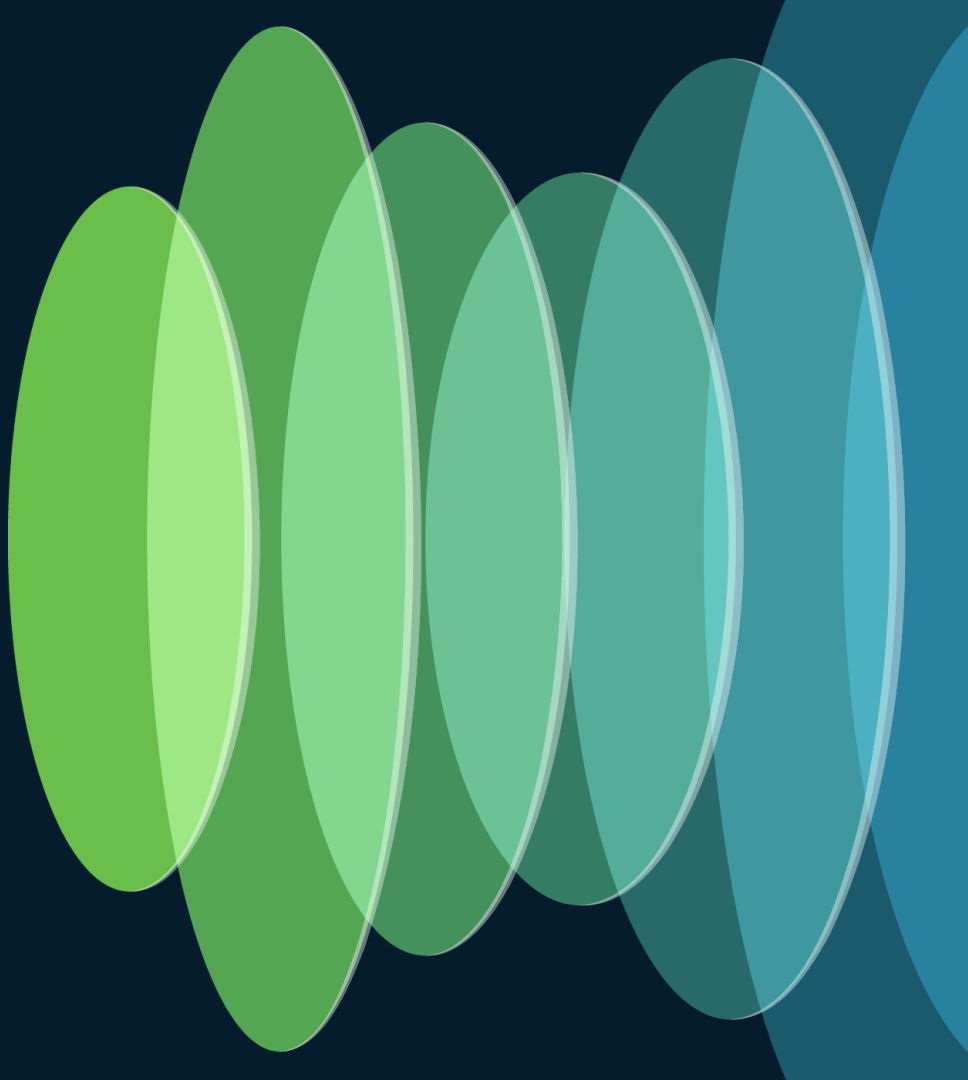


HOW TO: Optimize RX-SOP Thresholds

A key takeaway:

Be **conservative** and make **small adjustments**!

Cloud-Managed High Density



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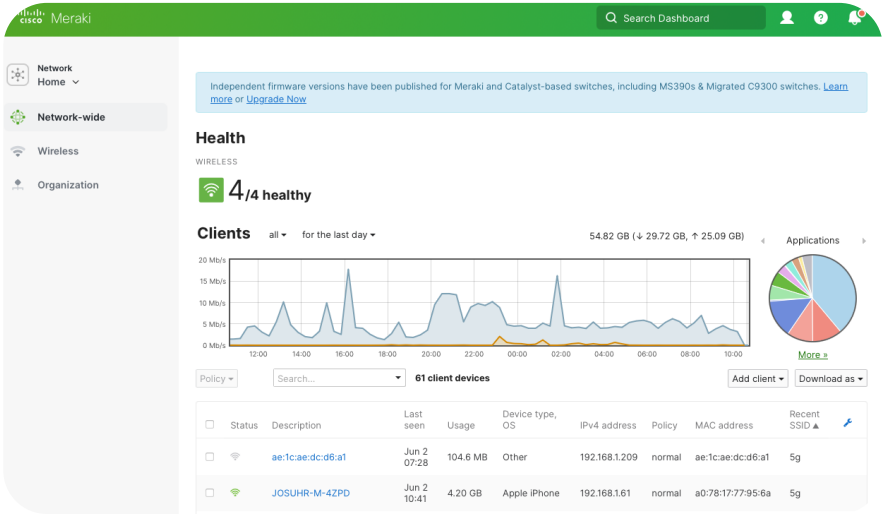
Cloud-Managed High Density



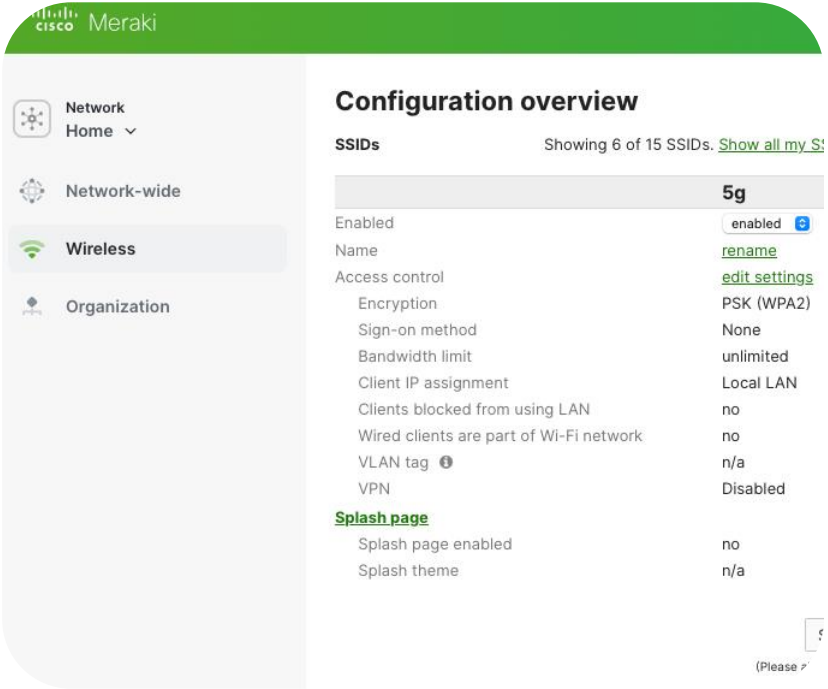
Can be ideal for:

- Classrooms
- Theaters & Auditoriums
- Hotspots

Be aware of:

- Switched Network Capacity (L2 / L3)
- Roaming Domains & Expected Roaming Experience

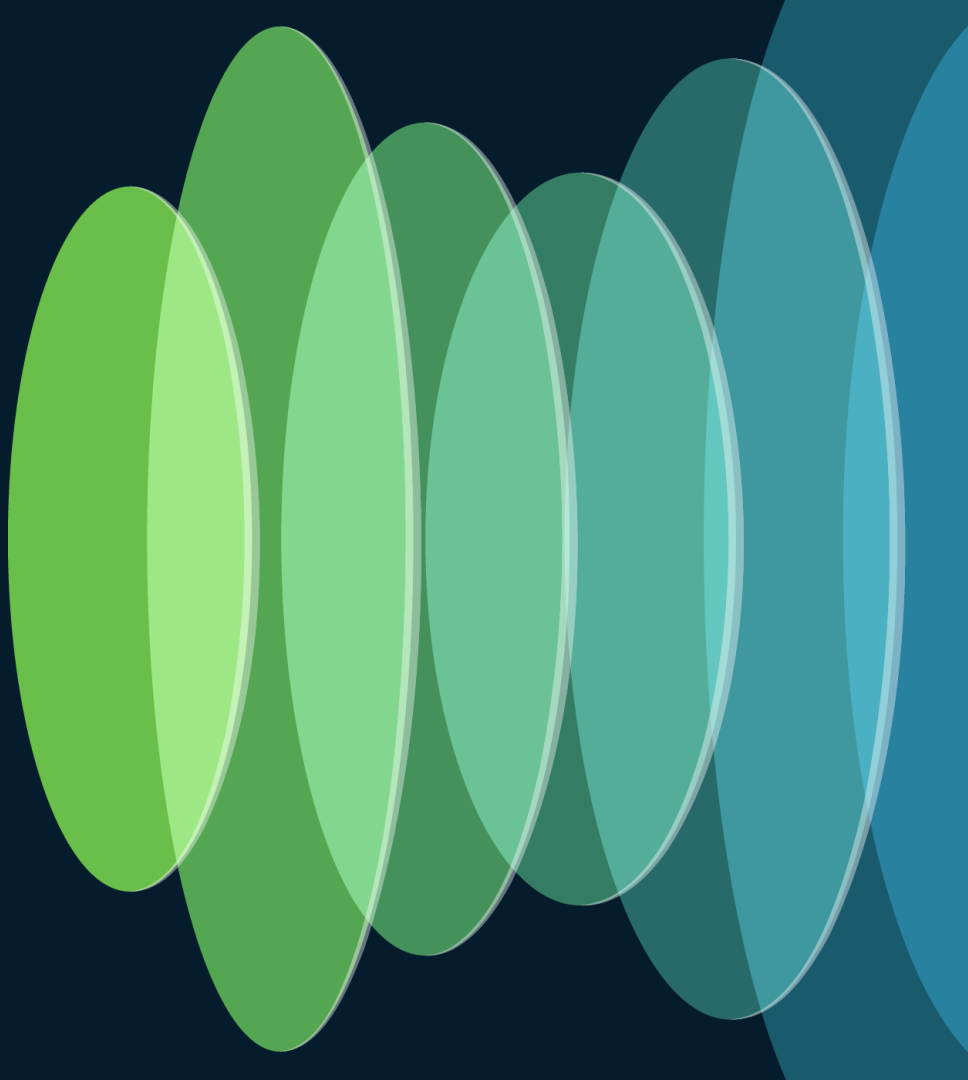
Cloud-Managed High Density



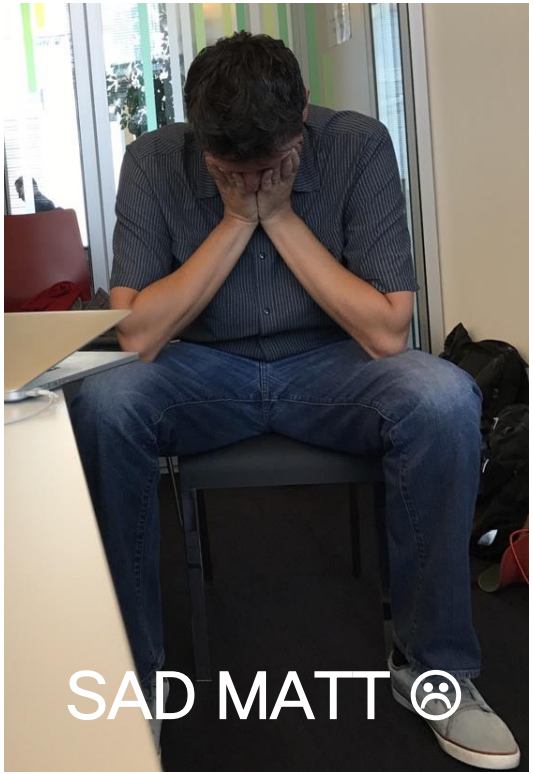
Similarly to “traditional” Catalyst networks:

- Manage AP Tx power appropriately
- Tune PHY rates
- Limit SSID count per AP as much as possible
- Optimize channels
- Leverage RX-SOP (carefully, when needed)

Common High Density Mistakes



Common High Density Optimization Mistakes



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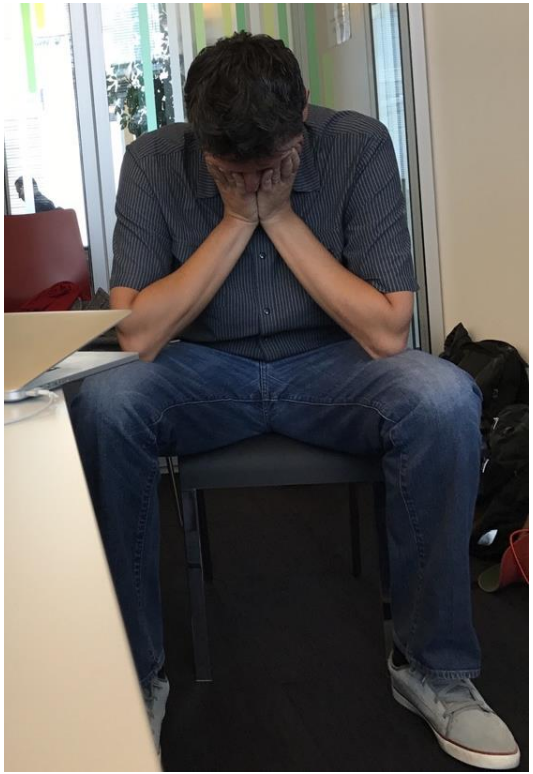


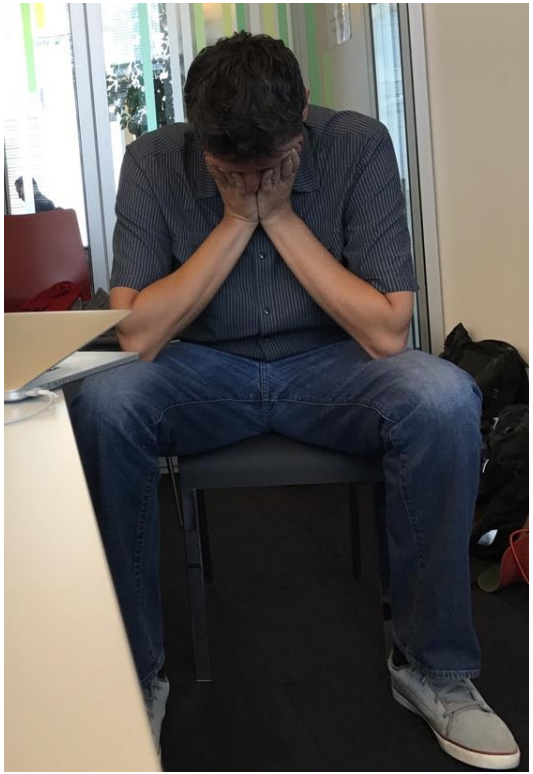
- AP-to-AP transmit power imbalance (causes “Magnet” / overloaded AP’s)

5GHz TX Power: 7dB
2 clients

5GHz TX Power: 17dB
50 clients

Note: This also applies to the dual-5GHz C9104!

Common High Density Optimization Mistakes

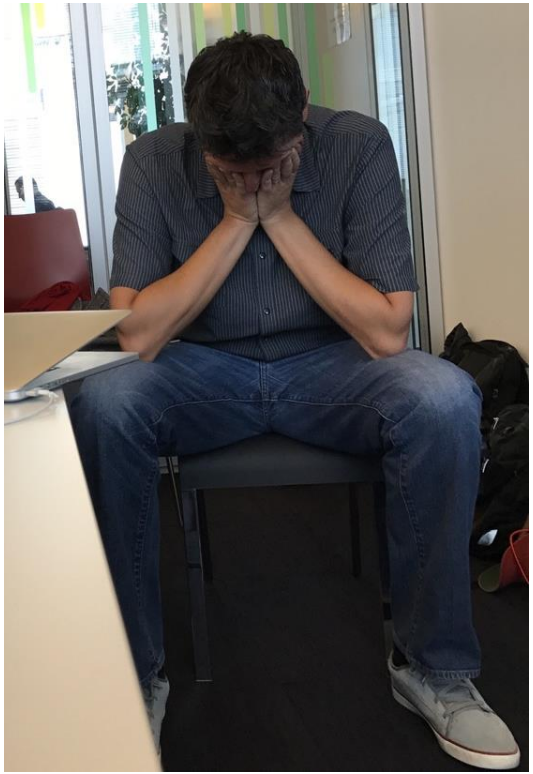


- AP-to-AP transmit power imbalance (causes “Magnet” / overloaded AP’s)
- 2.4GHz to 5GHz transmit power imbalance (draws dual-band clients to 2.4GHz)

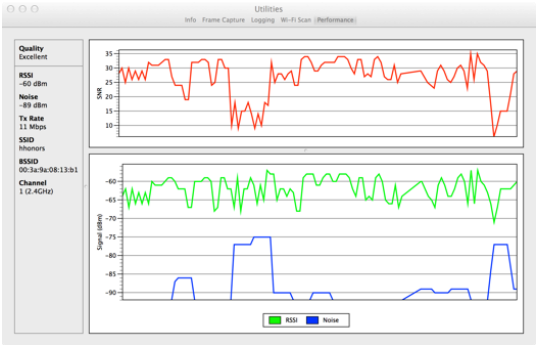
2.4GHz: 13dB
20 dual-band clients

5GHz: 7dB
0 dual-band clients

Common High Density Optimization Mistakes



- AP-to-AP transmit power imbalance (causes “Magnet” / overloaded AP’s)
- 2.4GHz to 5GHz transmit power imbalance (draws dual-band clients to 2.4GHz)
- Transmit power too low to overcome noise floor



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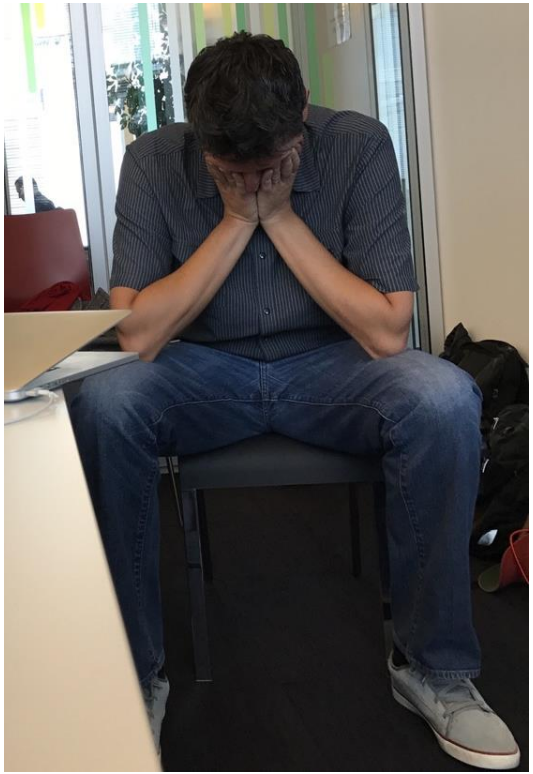

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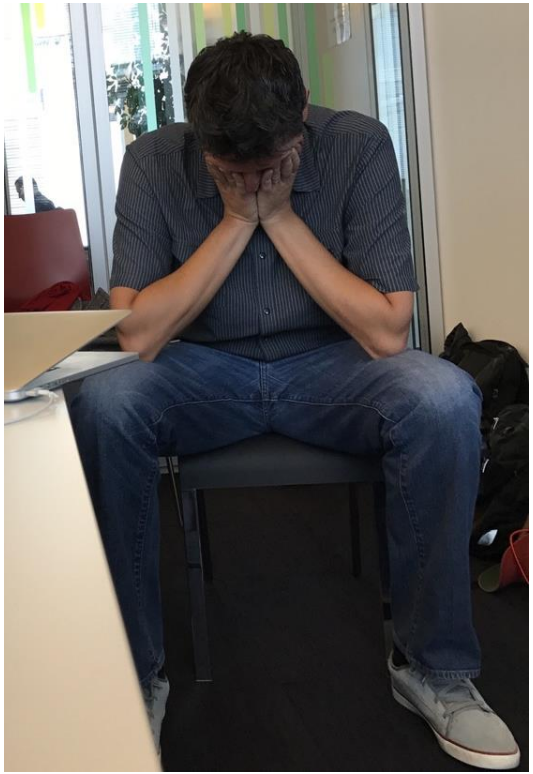

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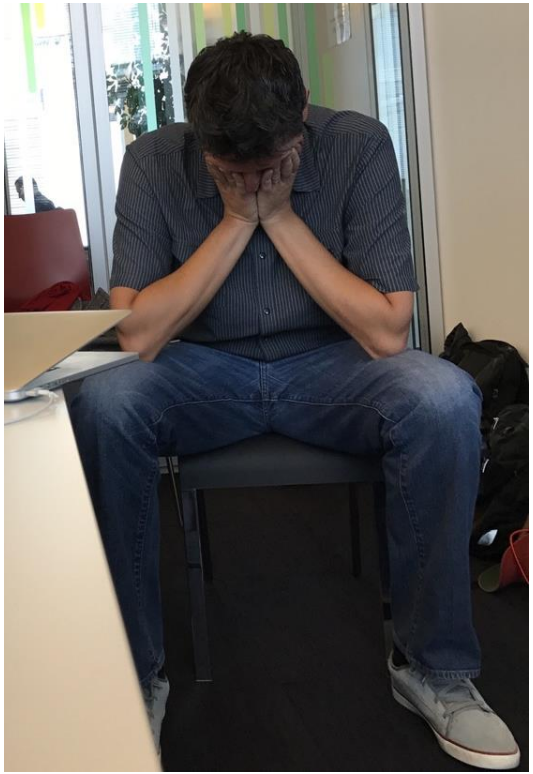
Common High Density Optimization Mistakes



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- Unusable channels (especially 5GHz)

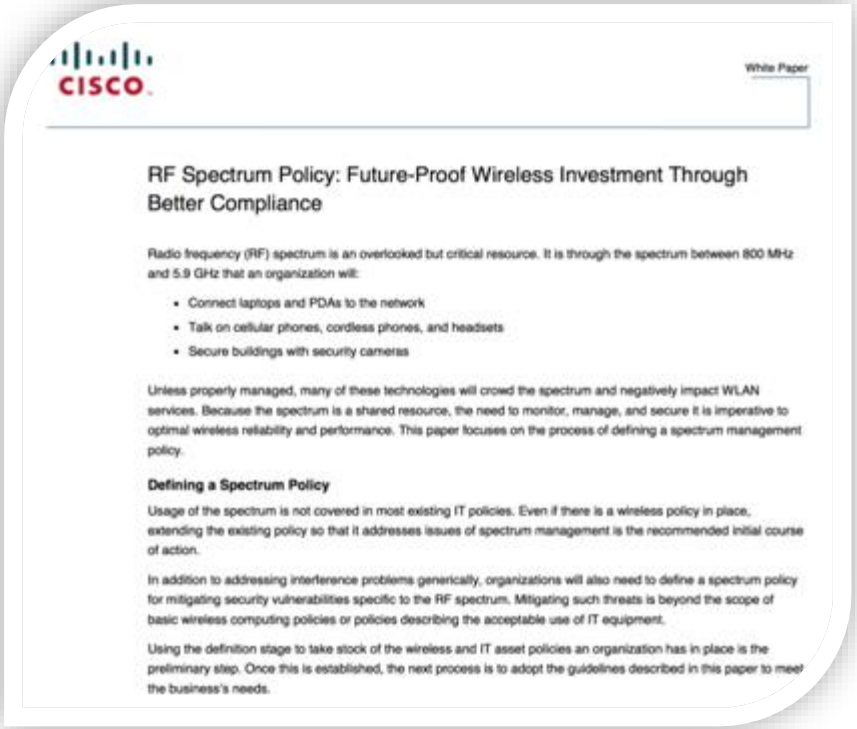
Common High Density Optimization Mistakes

- AP-to-AP transmit power imbalance (causes “Magnet” / overloaded AP’s) **TPC**
- 2.4GHz to 5GHz transmit power imbalance (draws dual-band clients to 2.4GHz) **TPC**
- Transmit power too low to overcome noise floor **TPC**
- Channel Utilization too high **Env. Cleanup / RXSOP**
- Minimum mandatory PHY rate improperly tuned (too high or too low) **PHY Rate tuning**
- Too many SSID’s enabled (not using AP Groups to control where SSID’s are enabled) **Policy Tags**
- Unusable channels (especially 5GHz) **DCA**

What can we do?

- Develop and Enforce an RF Policy

- Employ an effective RF policy
- Identify:
  - what's permitted in your environment
  - what is not permitted in your environment
  - whom to contact for further information



White Paper

RF Spectrum Policy: Future-Proof Wireless Investment Through Better Compliance

Radio frequency (RF) spectrum is an overlooked but critical resource. It is through the spectrum between 800 MHz and 5.9 GHz that an organization will:

- Connect laptops and PDAs to the network
- Talk on cellular phones, cordless phones, and headsets
- Secure buildings with security cameras

Unless properly managed, many of these technologies will crowd the spectrum and negatively impact WLAN services. Because the spectrum is a shared resource, the need to monitor, manage, and secure it is imperative to optimal wireless reliability and performance. This paper focuses on the process of defining a spectrum management policy.

Defining a Spectrum Policy

Usage of the spectrum is not covered in most existing IT policies. Even if there is a wireless policy in place, extending the existing policy so that it addresses issues of spectrum management is the recommended initial course of action.

In addition to addressing interference problems generically, organizations will also need to define a spectrum policy for mitigating security vulnerabilities specific to the RF spectrum. Mitigating such threats is beyond the scope of basic wireless computing policies or policies describing the acceptable use of IT equipment.

Using the definition stage to take stock of the wireless and IT asset policies an organization has in place is the preliminary step. Once this is established, the next process is to adopt the guidelines described in this paper to meet the business's needs.

Agenda

- Designing RF for High Client Densities
- HD Wi-Fi Configuration Tips
- HD Wi-Fi Engineering Toolkit

Our Favorite Tools

Cisco Wireless Troubleshooting & Analysis Tools (Free)

- Wi-Fi Hawk
- WCAE
- WLAN Poller

Intuitibits Tools (Mac)

- WiFi Explorer
- AirTool
- WiFi Signal

Intuitibits Tools (Windows)

- WiFi Explorer Lite

Packet Capture & Analysis Tools

- Metageek Chanalyzer
- Wireshark
- *(Article)* Analyzing Wireless Packet Captures

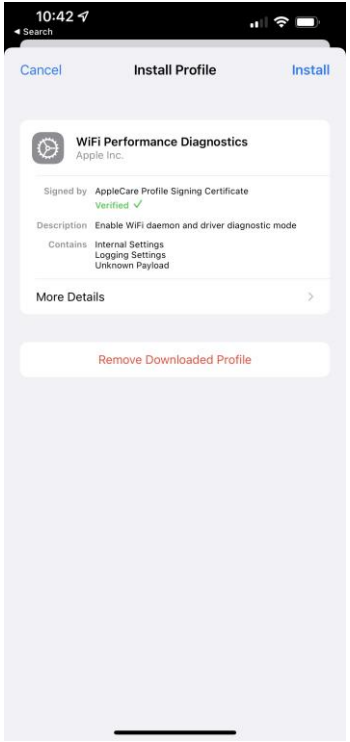
Site Survey Tools

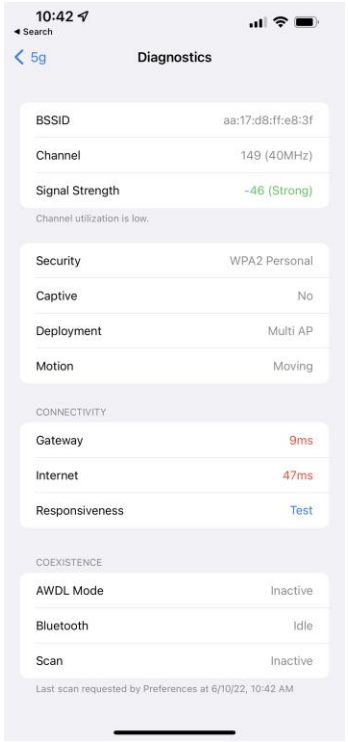
- Hamina
- Ekahau Pro

NetOps, AIOps, DevOps Tools

- Cisco DNA Center Assurance

iOS Wi-Fi Diagnostics with iOS





Diagnostics Profile for installation on iOS devices extends on-device WiFi diagnostics capabilities

More Info:

https://tidbits.com/2022/04/22/use-apples-networkquality-tool-to-test-internet-responsiveness/

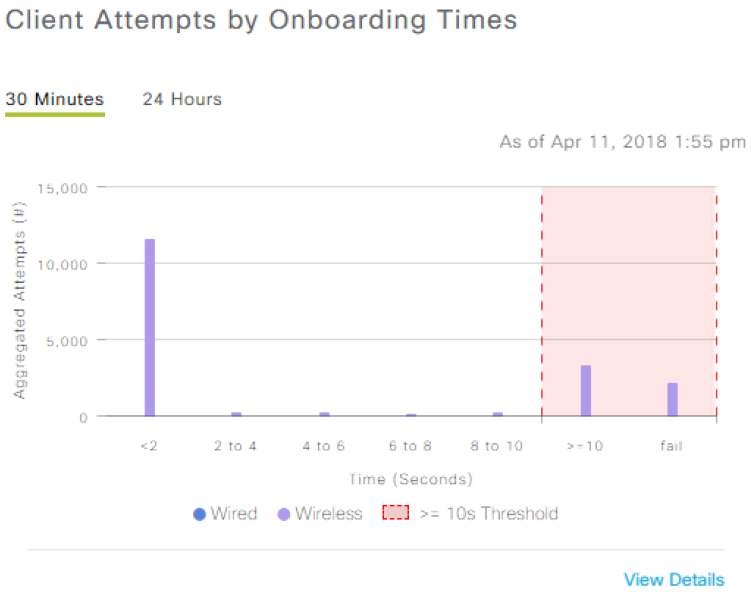
Profile Download:

https://developer.apple.com/services-account/download?path=/iOS/iOS_Logs/MegaWifiProfile.mobileconfig

Note: Profile auto-expires after 7 days and must be re-installed when needed

Catalyst Center Assurance

Broad applicability to High Density deployments



- iOS Analytics
- Detailed client onboarding analysis
- Aironet Active Sensor support
- Intelligent Capture
- Network Time Travel

...and much more!

https://www.ciscolive.com/c/dam/r/ciscolive/emea/docs/2024/pdf/BRKEWN-2029.pdf

Key Takeaways

- Design the RF environment with appropriate antennas and sensible physical placements
- Employ HD-focused WLC feature configurations such as RF Profiles for more flexible and robust designs
- Understand the key outside factors that may impact a live HD WLAN, including enemies of performance
- Get comfortable with Wi-Fi analysis and optimization tools to make informed, data-driven decisions

Complete Your Session Evaluations

Complete a minimum of 4 session surveys and the Overall Event Survey to be entered in a drawing to **win 1 of 5 full conference passes** to Cisco Live 2025.

Earn 100 points per survey completed and compete on the Cisco Live Challenge leaderboard.

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Complete your surveys in the **Cisco Live mobile app.**

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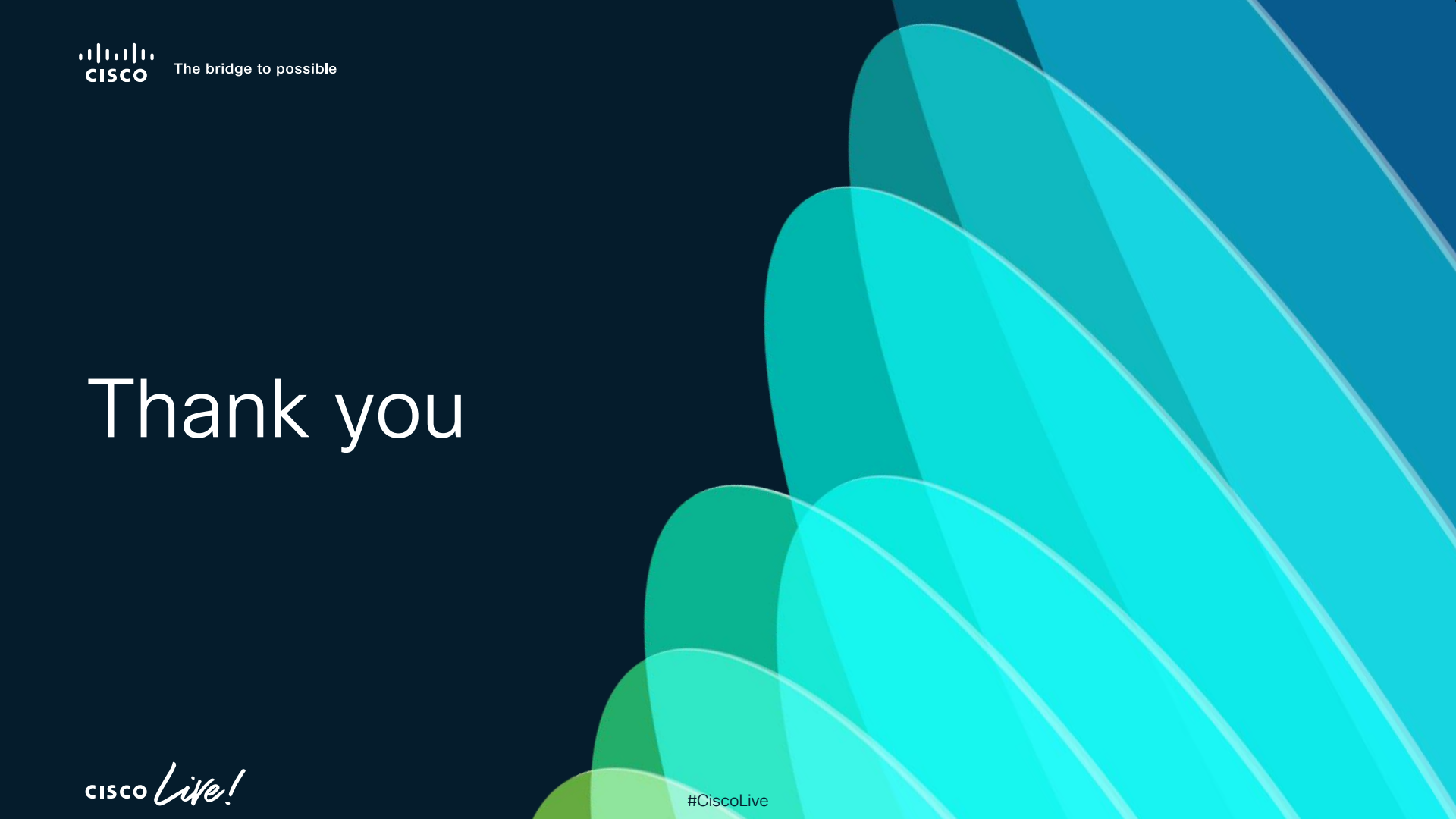
- Book your one-on-one Meet the Engineer meeting
- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
- Visit the On-Demand Library for more sessions at www.CiscoLive.com/on-demand

Contact us at:
josuhr@cisco.com and mswartz9@cisco.com


The bridge to possible
Thank you
cisco Live!
#CiscoLive