



Vše, co potřebujete vědět o Wi-Fi

Dominik Soukup, SE, CCIEW# 68153
Jaroslav Čížek, CX CSS, CCIEW# 68187

4/2024

News

Wi-Fi Alliance® applauds Automated Frequency Coordination (AFC) system approval by Federal Communications Commission (FCC)



6 GHz

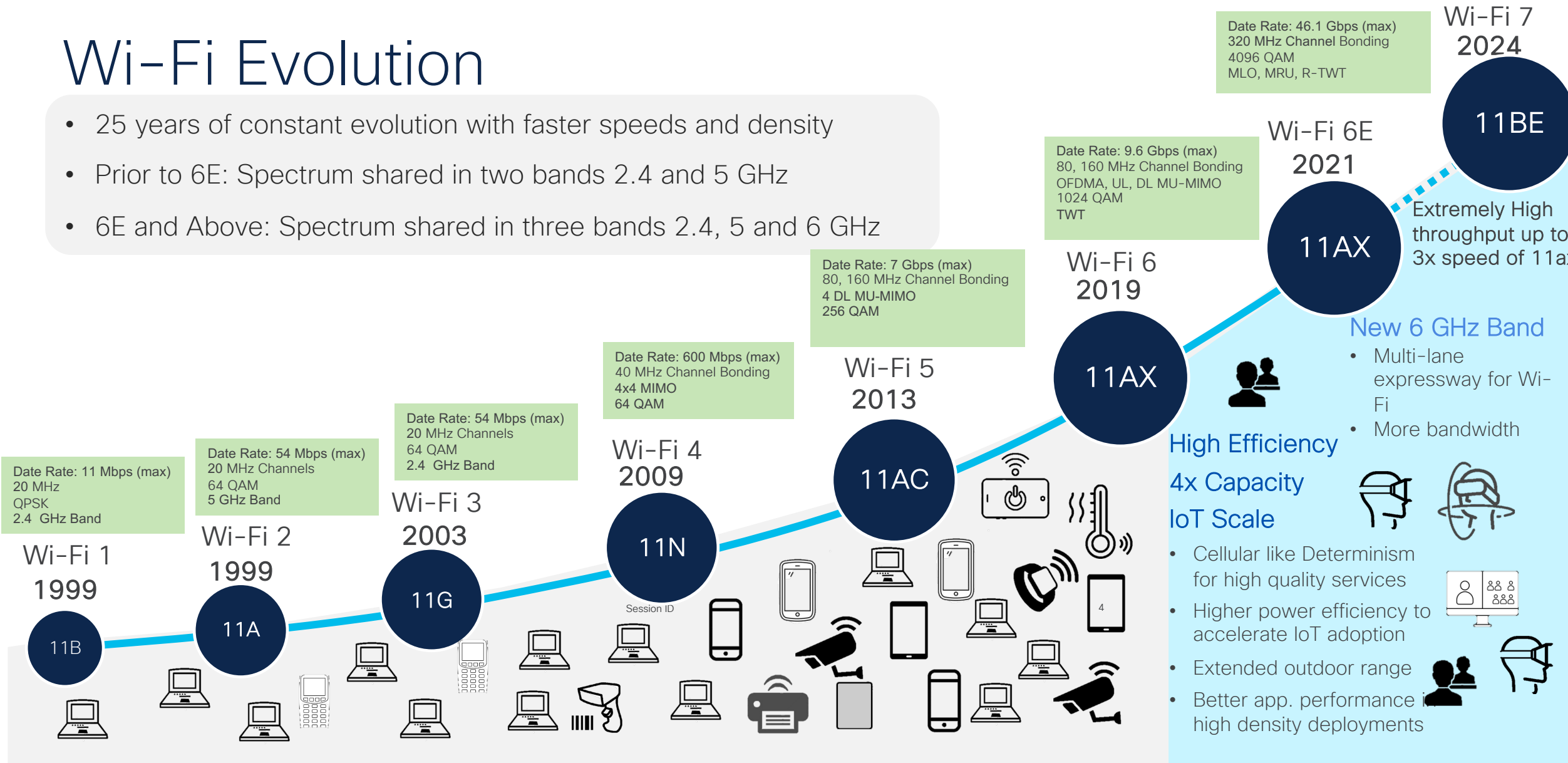


Agenda

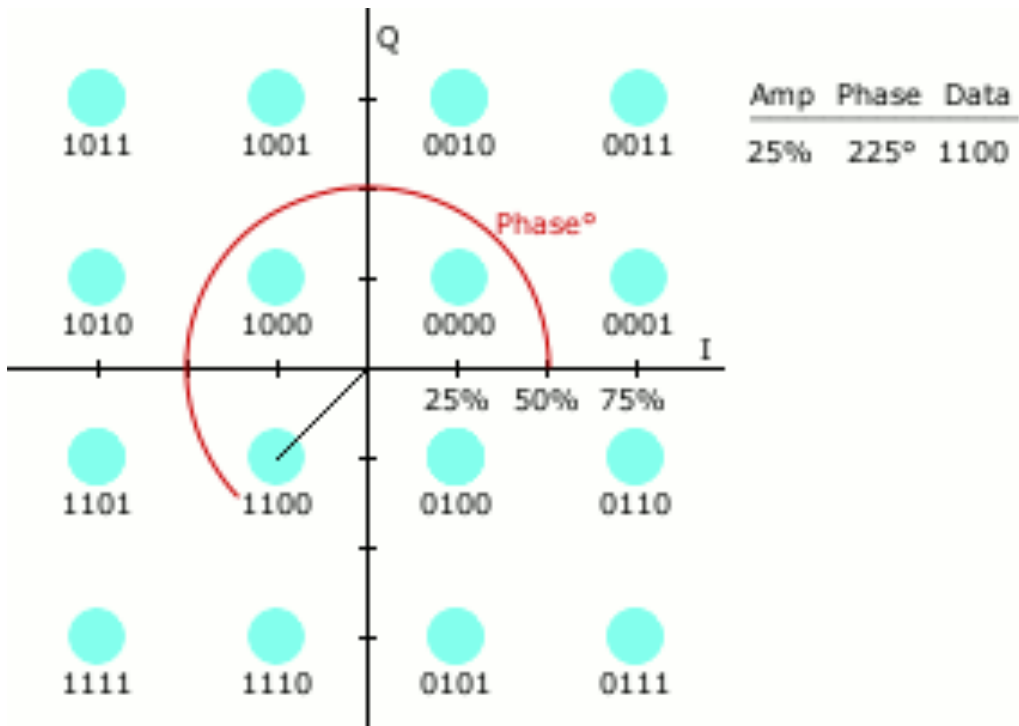
- Vlastnosti Wi-Fi
- Nasazení nových funkcí Wi-Fi
- Možnosti využití Cisco nástrojů

Wi-Fi Evolution

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

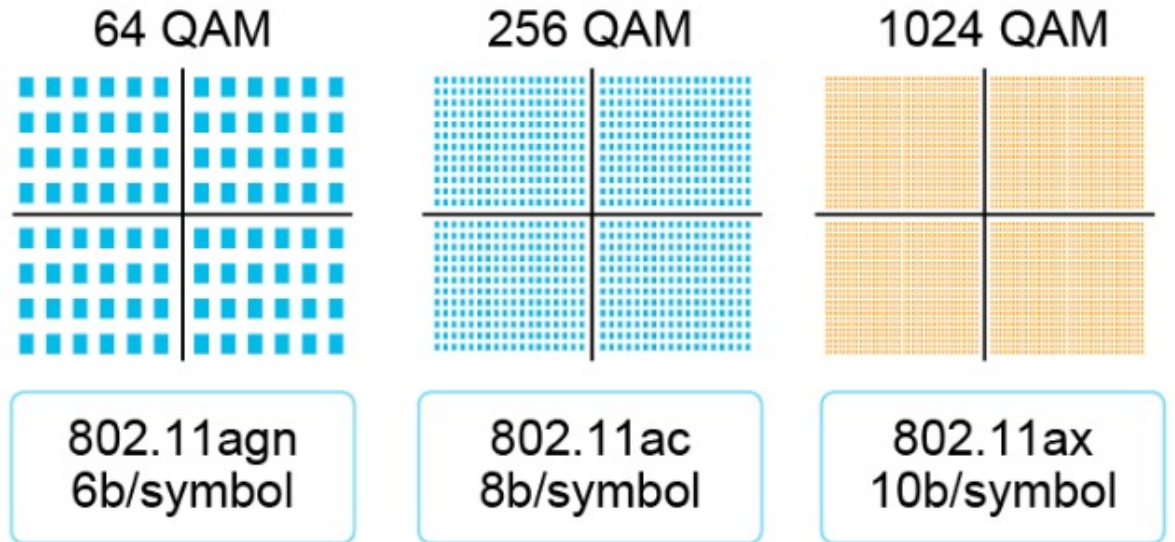


Modulation - QAM (Quadrature amplitude modulation)

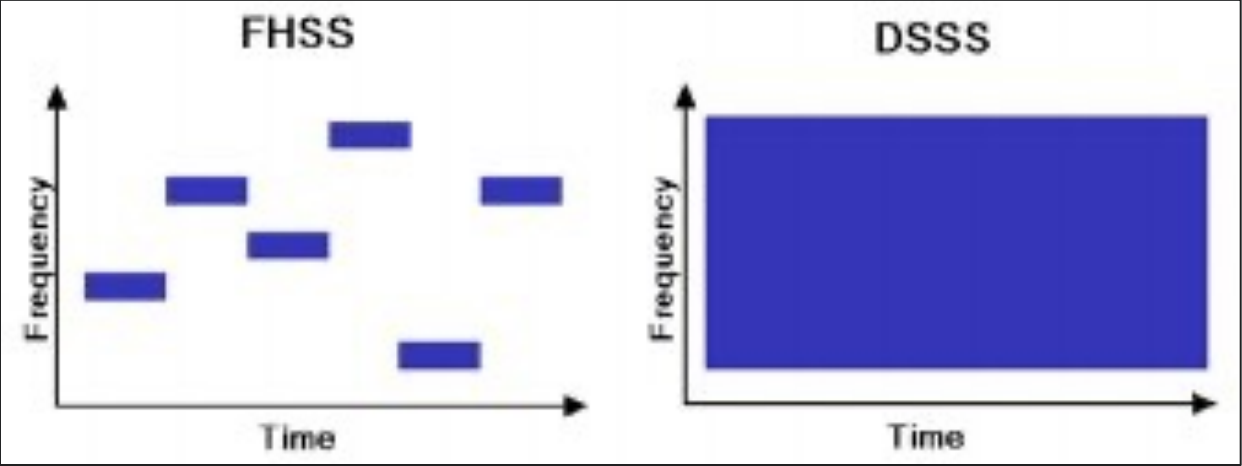


Source: [Wikipedia](https://en.wikipedia.org/wiki/Quadrature_amplitude_modulation)

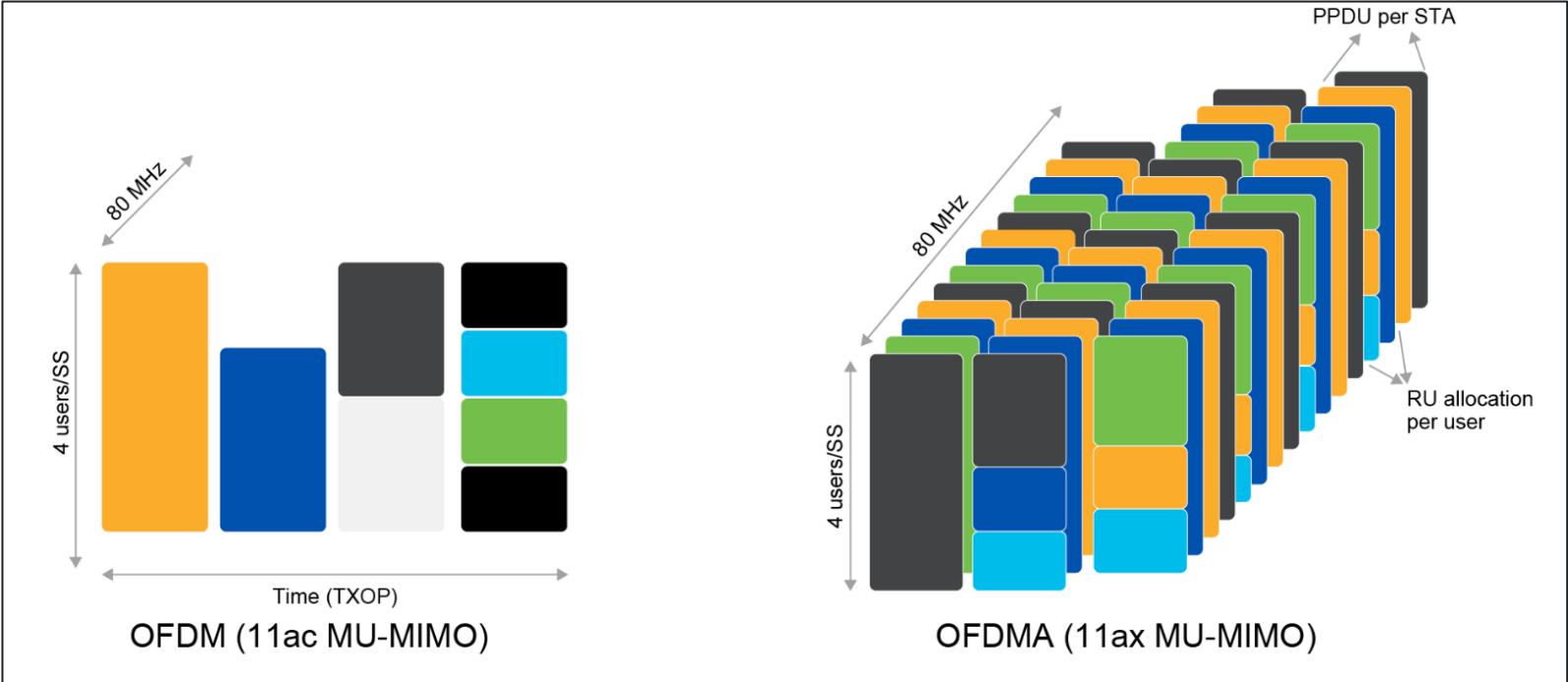
Modulation density gains



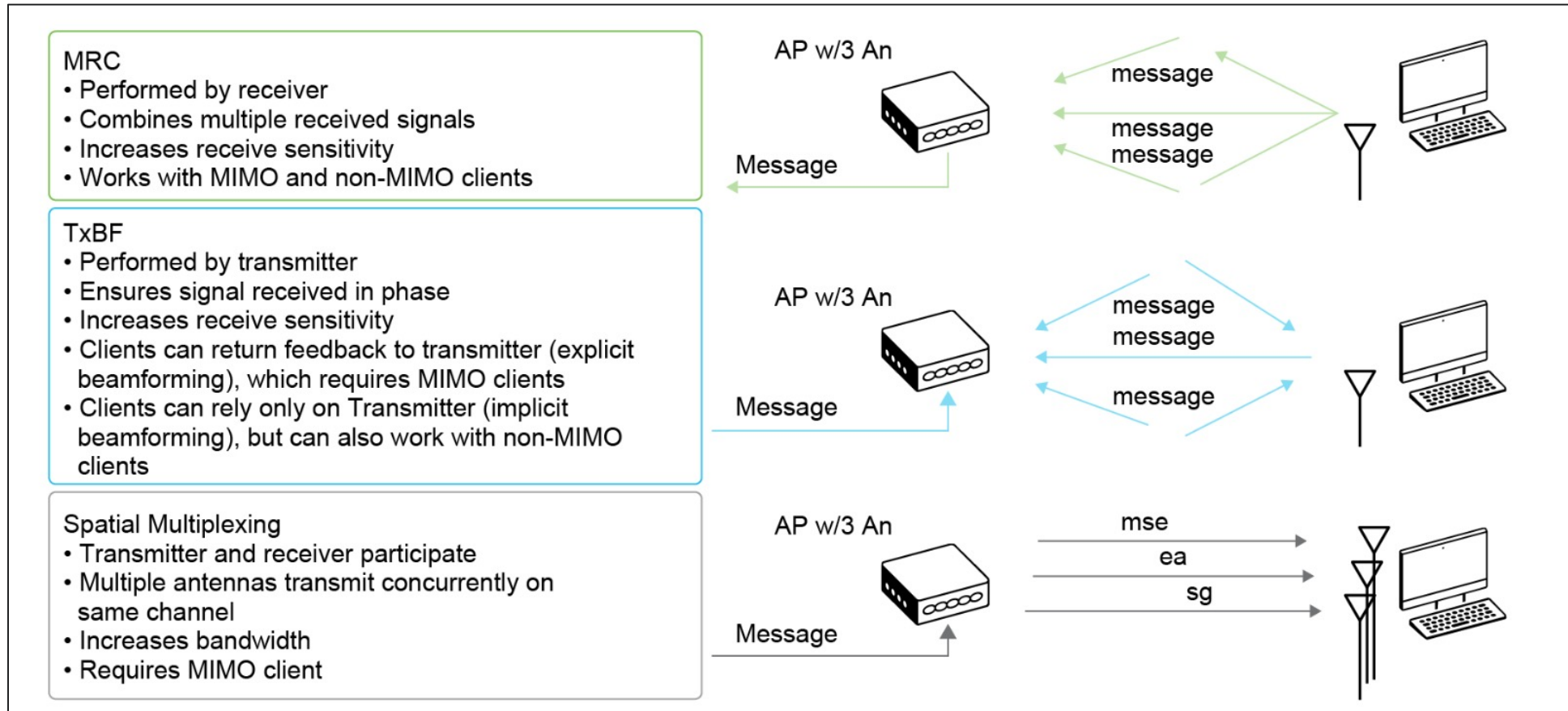
Transmission



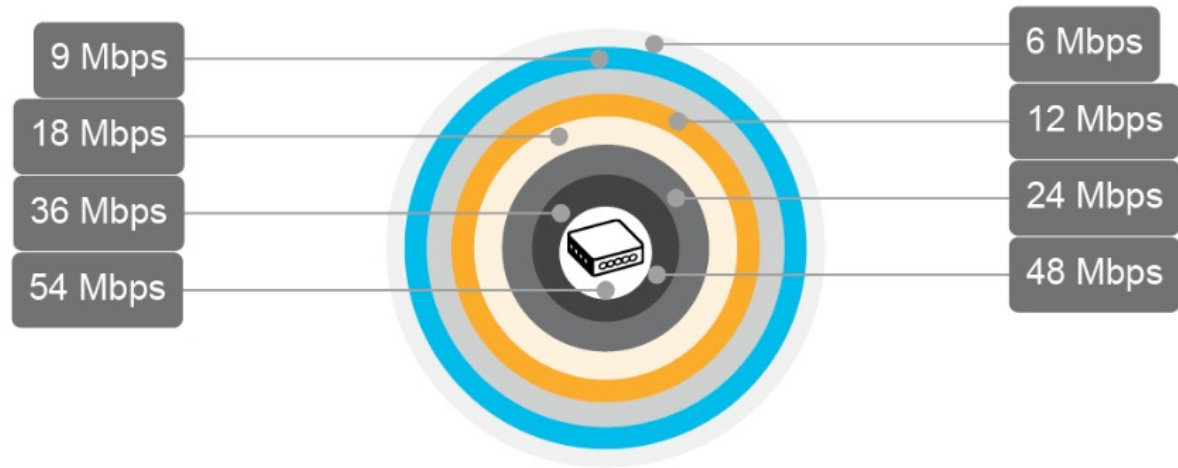
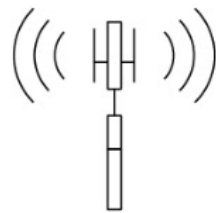
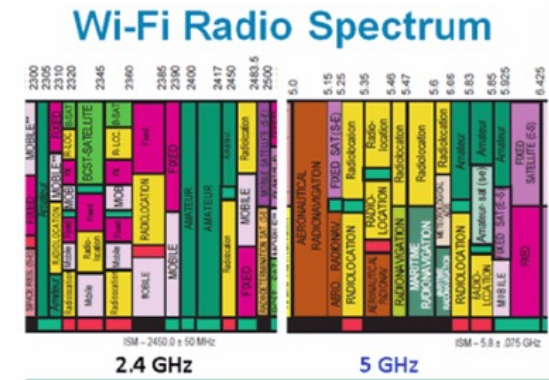
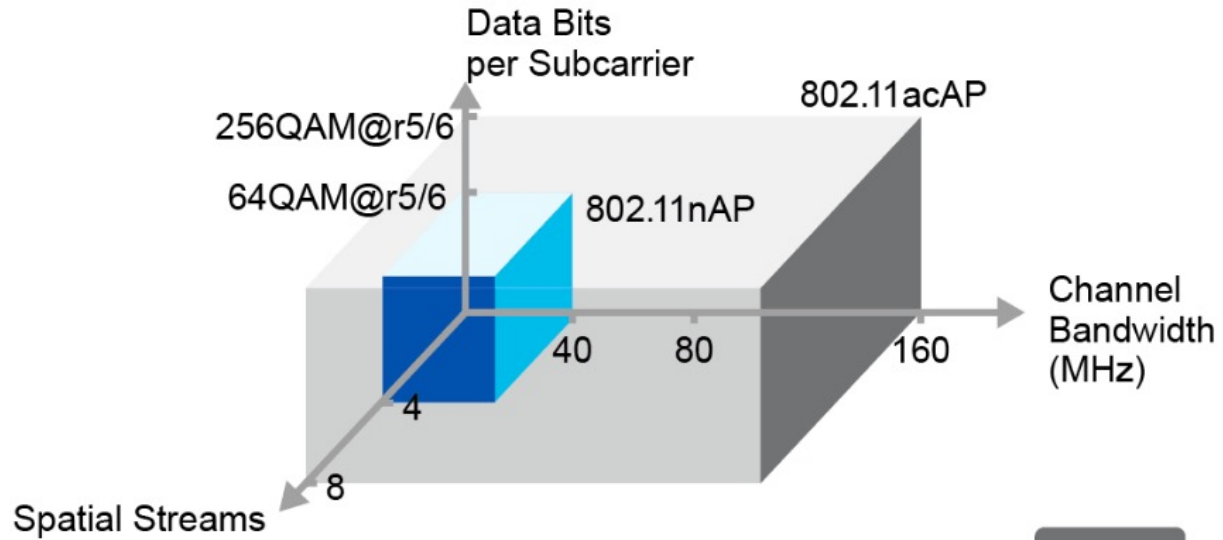
Source: [ResearchGate](#)



SISO, MIMO, MU-MIMO



Kombinace jednotlivých vlastností



Wi-Fi Evolution

$$\text{Data Rate Max} = \text{1SS speed} * \#20\text{Mhz} * \#\text{SS} = 576 \text{ Mbps}$$

Date Rate: 11 Mbps (max)
20 MHz
QPSK
DSSS
2.4 GHz Band

Wi-Fi 1
1999

11B

Date Rate: 54 Mbps (max)
20 MHz Channels
64 QAM
OFDM
5 GHz Band

Wi-Fi 2
1999

11A

Date Rate: 54 Mbps (max)
20 MHz Channels
64 QAM
OFDM
2.4 GHz Band

Wi-Fi 3
2003

11G

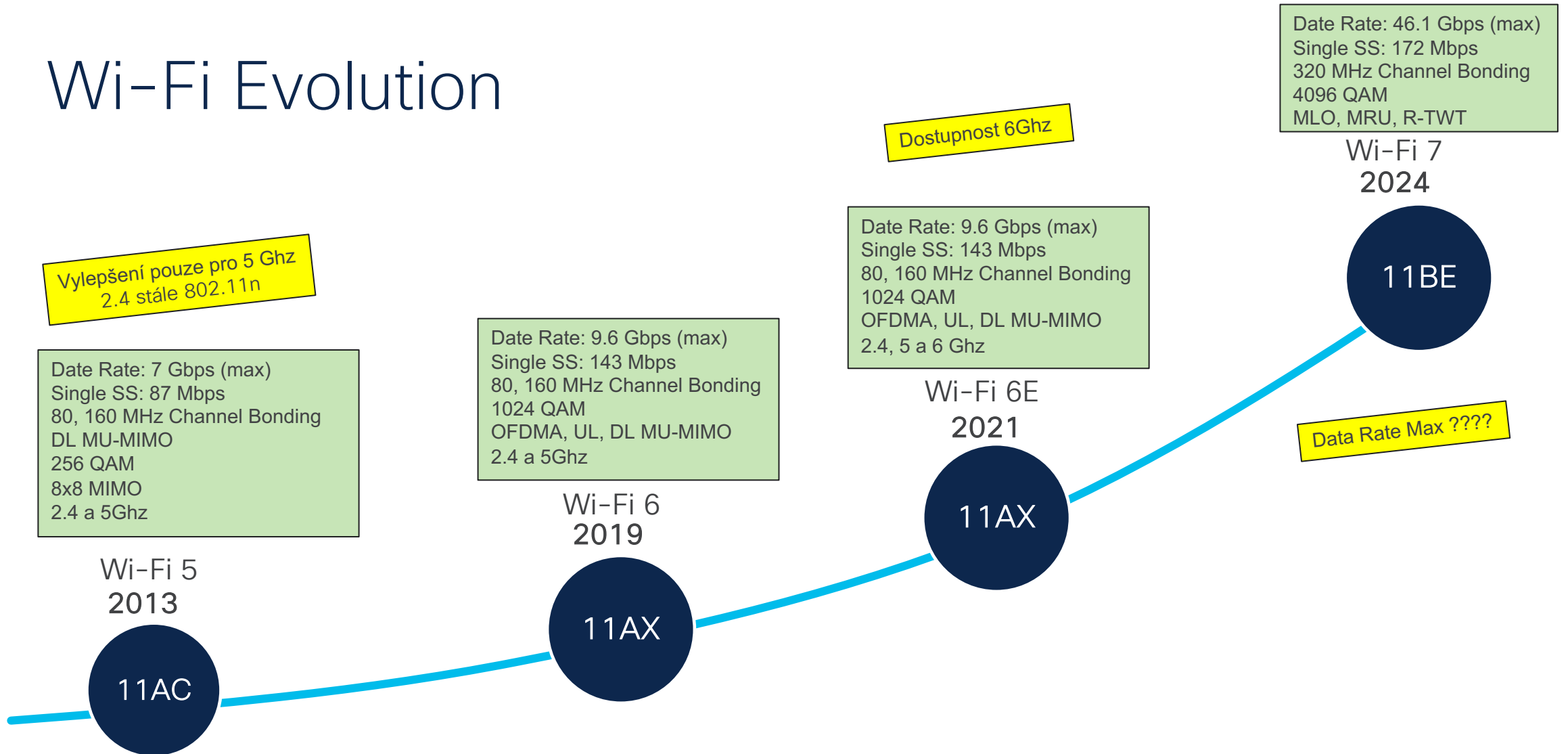
Date Rate: 600 Mbps (max)
Single SS: 72 Mbps
40 MHz Channel Bonding
4x4 MIMO
64 QAM
OFDM
2.4 Ghz & 5 Ghz Band

Wi-Fi 4
2009

11N



Wi-Fi Evolution



MCS Table

							OFDM (Prior 11ax)							
MCS Index				Spatial Stream	Modulation	Coding	20MHz		40MHz		80MHz		160MHz	
HT	VHT	HE	EHT				0.8µs GI	0.4µs GI	0.8µs GI	0.4µs GI	0.8µs GI	0.4µs GI	0.8µs GI	0.4µs GI
0	0	0	0	1	BPSQ	1/2	6.5	7.2	13.5	15	29.3	32.5	58.5	65
1	1	1	1	1	QPSK	1/2	13	14.4	27	30	58.5	65	117	130
2	2	2	2	1	QPSK	3/4	19.5	21.7	40.5	45	87.8	97.5	175.5	195
3	3	3	3	1	16-QAM	1/2	26	28.9	54	60	117	130	234	260
4	4	4	4	1	16-QAM	3/4	39	43.3	81	90	175.5	195	351	390
5	5	5	5	1	64-QAM	2/3	52	57.8	108	120	234	260	468	520
6	6	6	6	1	64-QAM	3/4	58.5	65	121.5	135	263.3	292.5	526.5	585
7	7	7	7	1	64-QAM	5/6	65	72.2	135	150	292.5	325	585	650
	8	8	8	1	256-QAM	3/4	78	86.7	162	180	351	390	702	780
	9	9	9	1	256-QAM	5/6	N/A	N/A	180	200	390	433.3	780	866.7
		10	10	1	1024-QAM	3/4								
		11	11	1	1024-QAM	5/6								
			12	1	4096-QAM	3/4								
			13	1	4096-QAM	5/6								

Wi-Fi 7



Wi-Fi 7 spec just finalized in Jan '24. 802.11be is still not ratified

IEEE Project and Final Document	Final Doc Type	Project Authorization Request (PAR)	Task Group and Activity	Documentation		Current Status	PAR Approved, Modified, or Extended [Expires]	WG Letter Ballots			Form Standards Association (SA) Ballot Pool / Reform	MEC / MDR Done	IEEE SA Ballots			Final 802.11 WG Approval	Final or Conditional 802 EC Approval	RevCom & Standards Board Final or Continuous Process Approval	ANSI Approved	Superseded or Withdrawn by Standards Board
				Session End Snapshot				Draft	Date	Result			Draft	Date	Result					
				Format & Version	Incorporated Baselines															
IEEE Std P802.11be	A	Extremely High Throughput	TGbe	PDF D5.01	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023 802.11bc-2023 802.11-2020/Cor2-2024 802.11me 802.11bh	Actual	2019-03-21 [2025-12-31]	D2.0 D3.0 D4.0 D5.0	2022-07-04 2023-03-02 2023-08-13 2023-12-16	64% 80% 90% 95%	2023-10-01	2023-09-01	D5.0	2024-02-02	82%					
						Predicted	C	C	C	C	C	C	Mar 2024	Sep 2024	Oct 2024	Dec 2024	N/A			

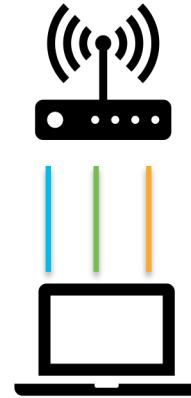
Wi-Fi 7 - 04/2024



320 MHz in 6 GHz
(optional)
160 MHz in 5 GHz
(optional)



4K QAM
(optional)



MLO



Enhanced Security



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



Multi-RU



Triggered UL-OFDMA

6 GHz is the biggest Wi-Fi spectrum expansion ever



2.4 and 5GHz = 22x 20MHz Channel

↓
6GHz = 24x 20MHz Channel

Band Channels Bandwidth

2.4 GHz

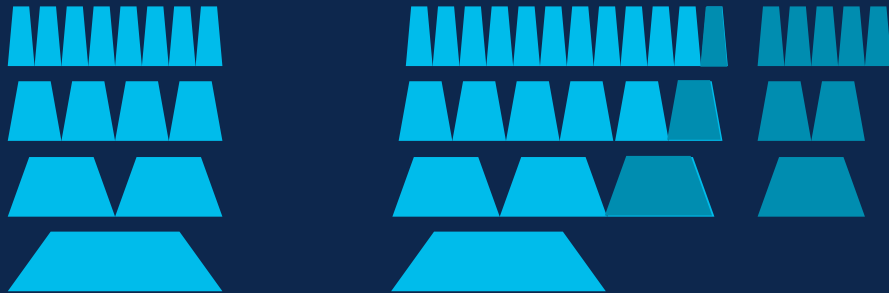
3 20 MHz
1 40 MHz



60 MHz of spectrum and
3x 20-MHz channels

5 GHz

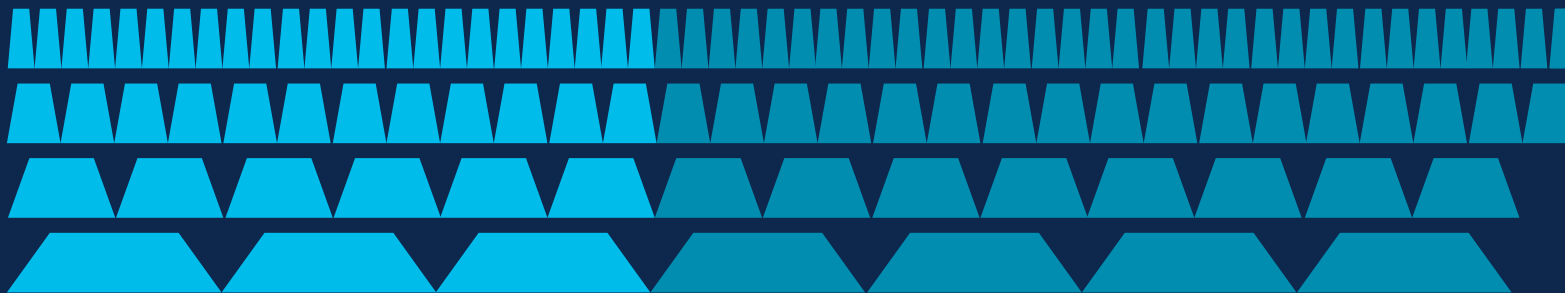
25 20 MHz
12 40 MHz
6 80 MHz
2 160 MHz



555 MHz of spectrum and
25x 20-MHz channels in US
455 MHz of spectrum and
19x 20-MHz channels in EU

6 GHz

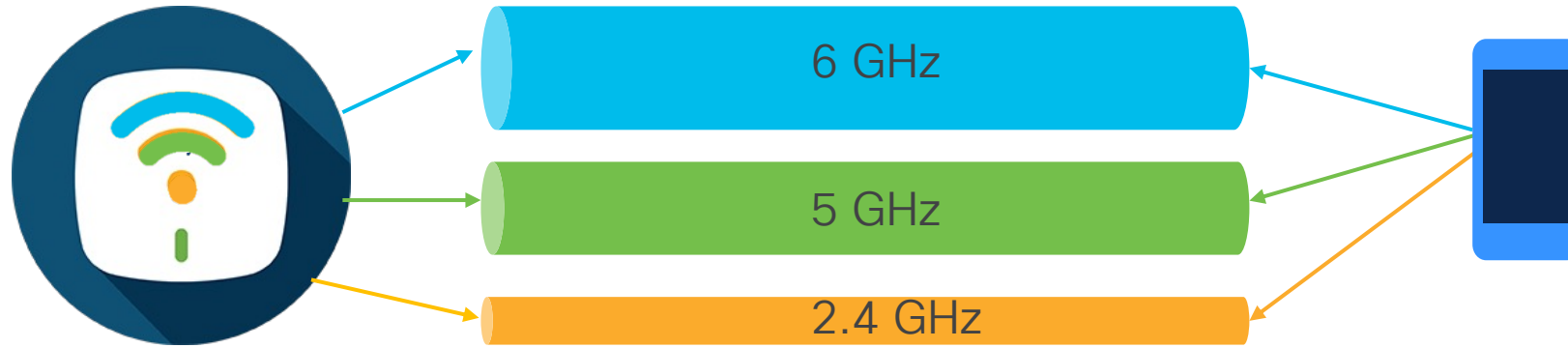
59 20 MHz
29 40 MHz
14 80 MHz
7 160 MHz



1200 MHz of spectrum and
59x 20-MHz channels in US
500 MHz of spectrum and
24x20-MHz channel in EU

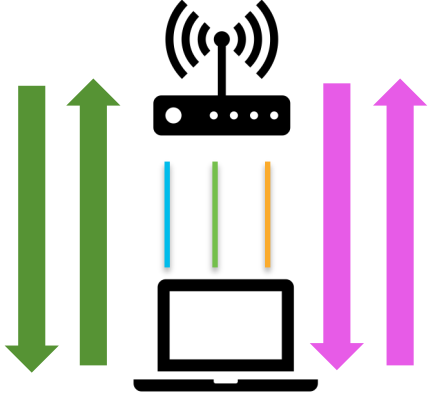


Wi-Fi 7 – Multilink (MLO)



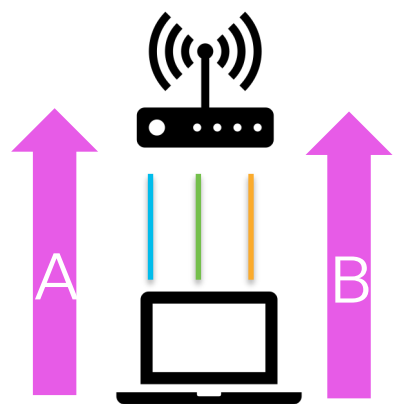
Method	Benefit
Aggregation	Throughput
Steering	Latency
Redundancy	Reliability

The many “modes” of MLO



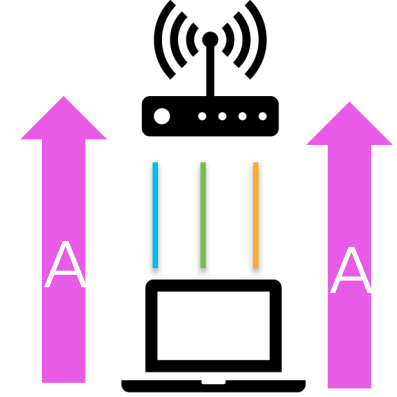
Each link operating independently

Simultaneous TX+RX (STR)



Links sending at the same time

Non-Simultaneous TX+RX (n-STR)

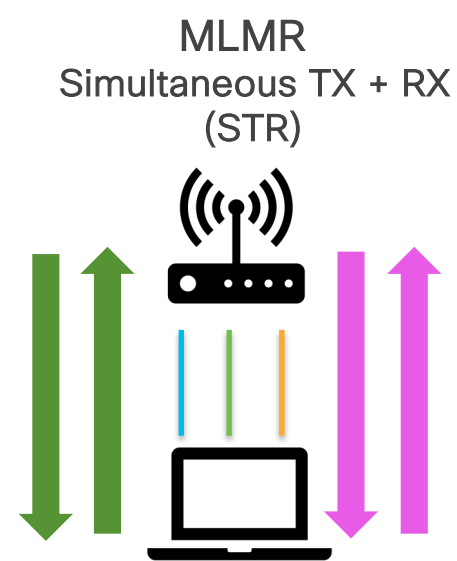


Links sending the same data, at the same time

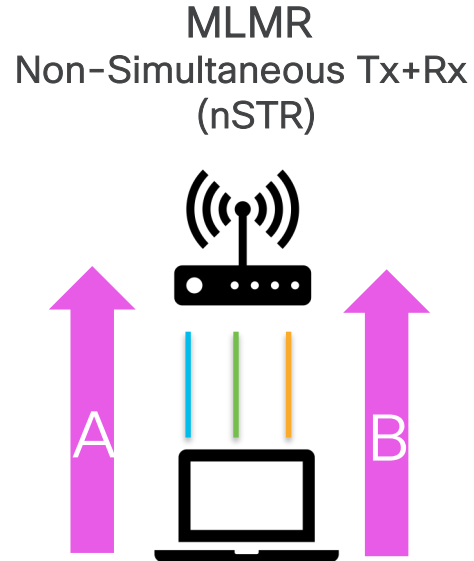
Not actually an MLO mode (yet), but a cool idea!

This is the one to pay attention to

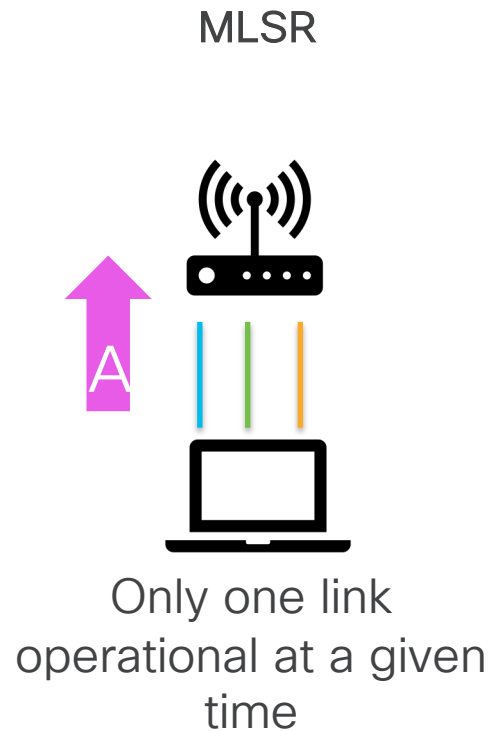
The many “modes” of MLO



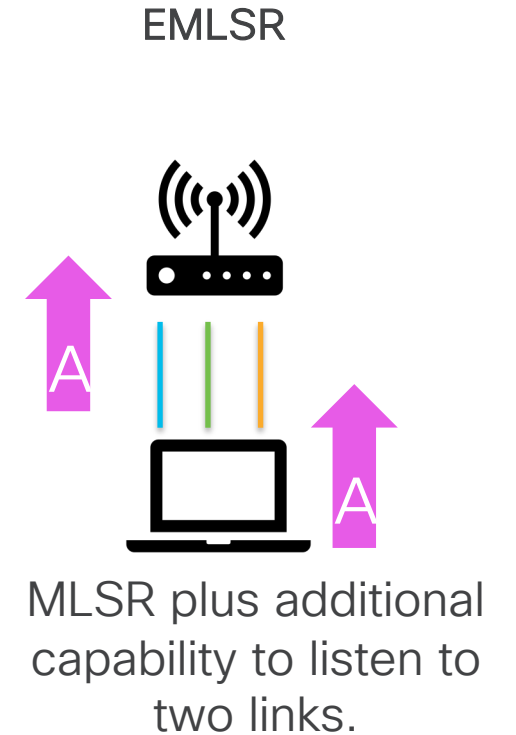
Each link operating independently



Links sending at the same time



Only one link operational at a given time



MLSR plus additional capability to listen to two links.

This is the one to pay attention to

Acronyms:

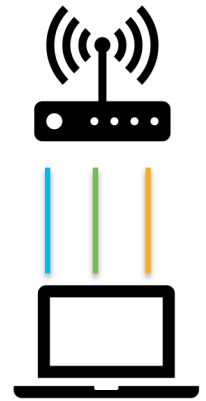
MLMR – Multi-link Multi Radio

MLSR – Multi-link Single Radio

EMLSR – Enhanced Multi-link Single Radio

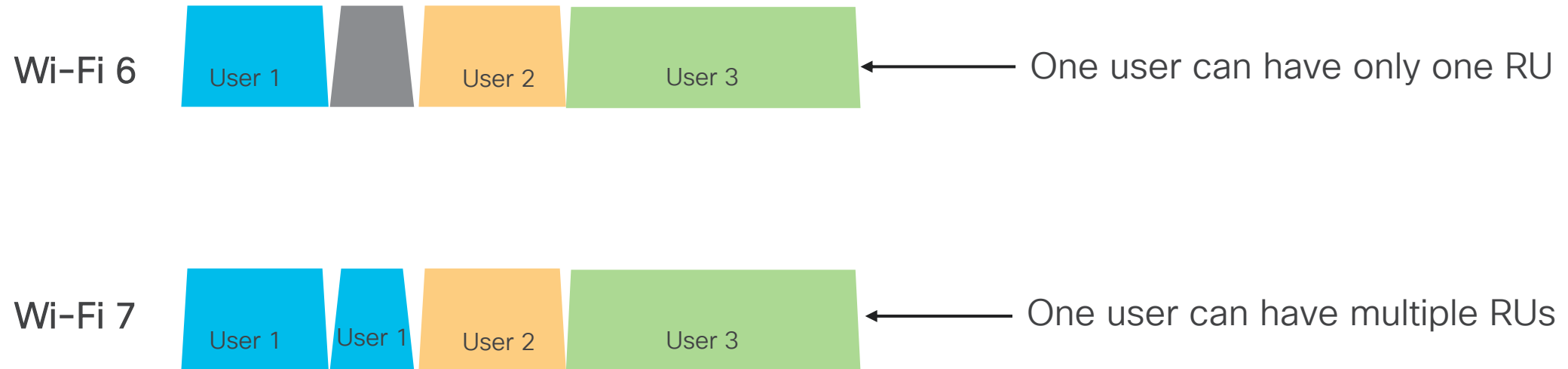
On Multilink Operation (MLO)

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



MLO

Wi-Fi 7 Multiple Resource Unit (MRU)



Multiple RUs make efficient use of spectrum

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

Wi-Fi 7 Preamble Puncturing

Without Preamble Puncturing:



With Preamble Puncturing:



Puncturing allowed for 80 MHz channel width or wider

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

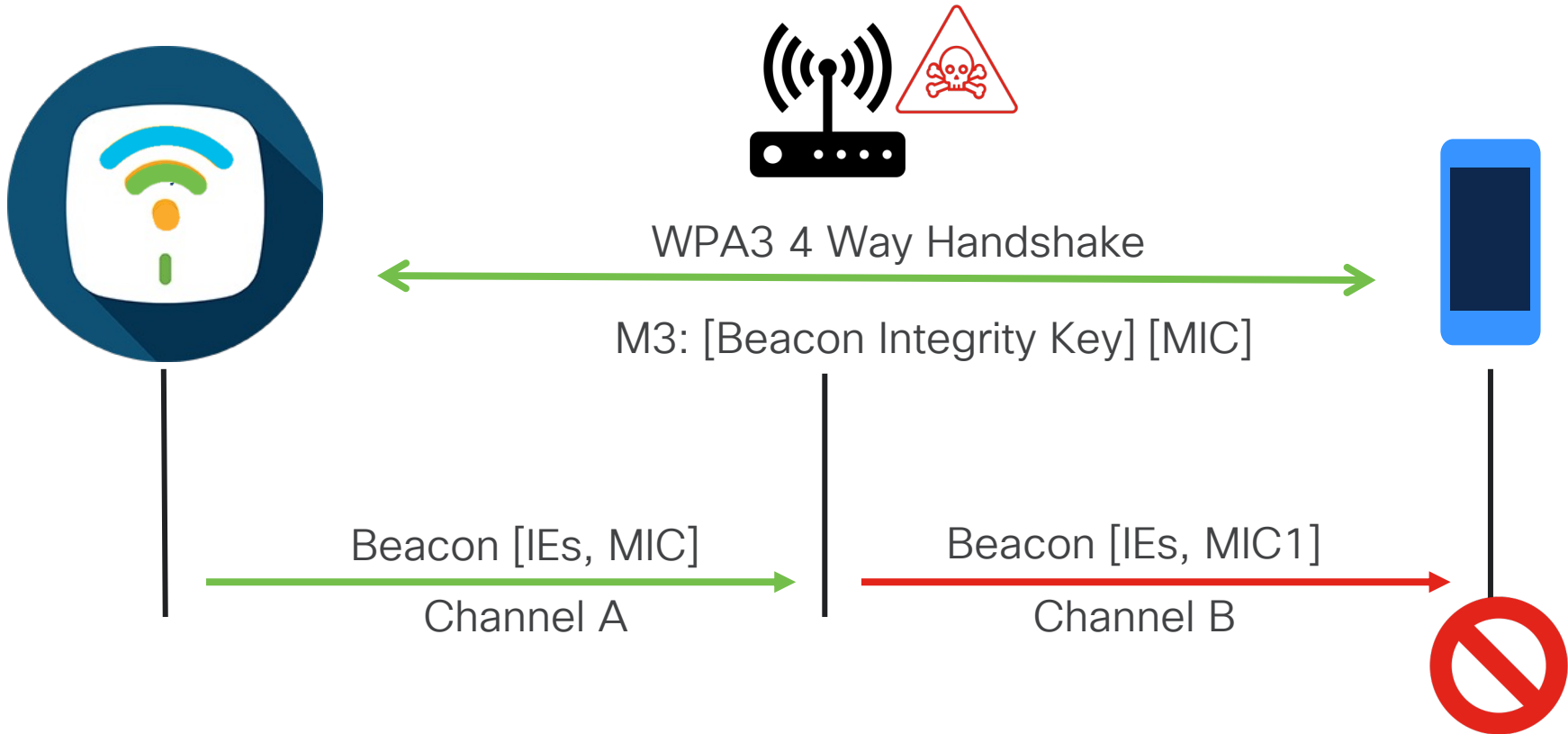
16 Spatial Streams



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

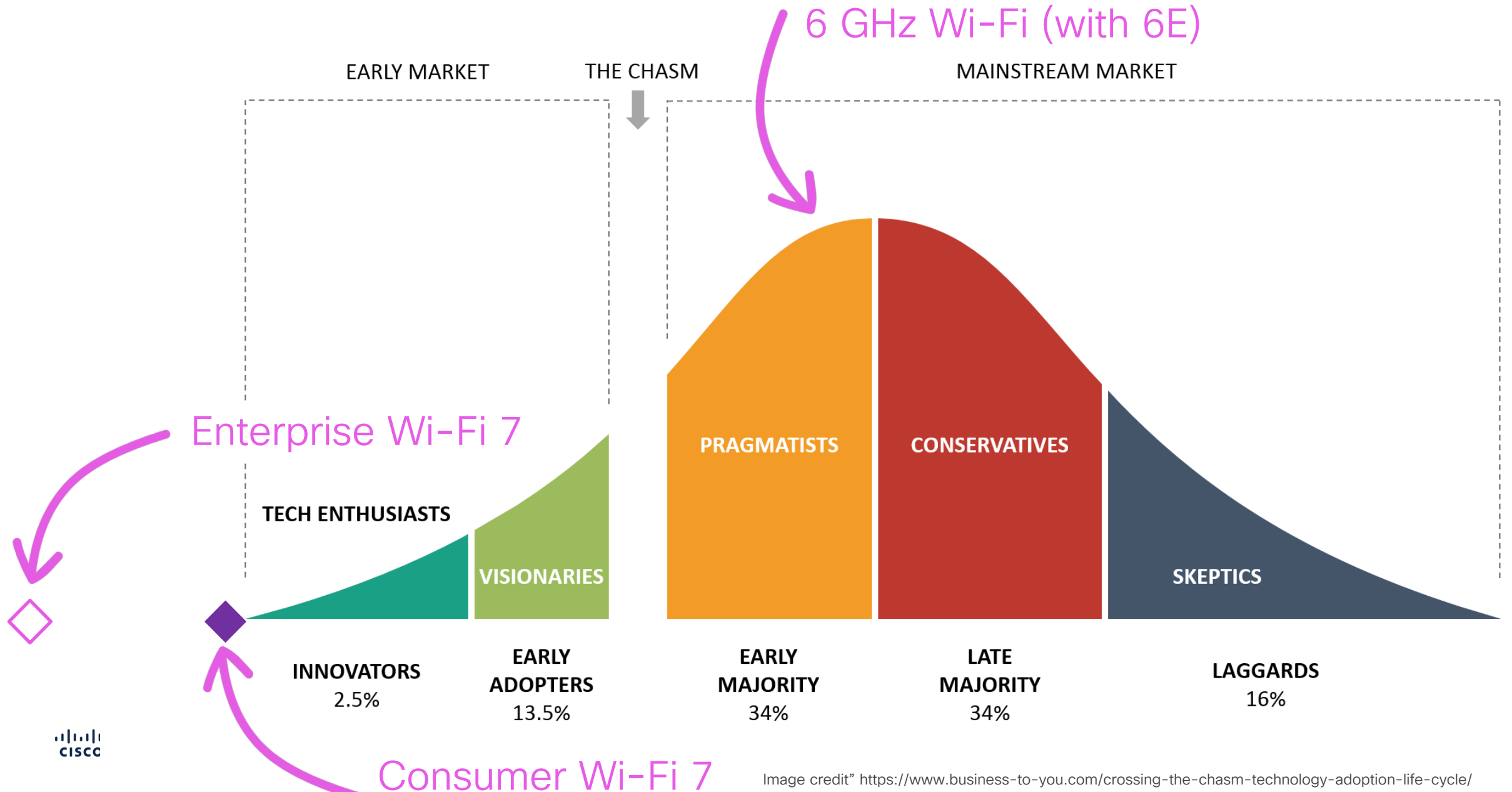
Wi-Fi 7 AP Beacon Protection

Beacons protected with an Integrity Check



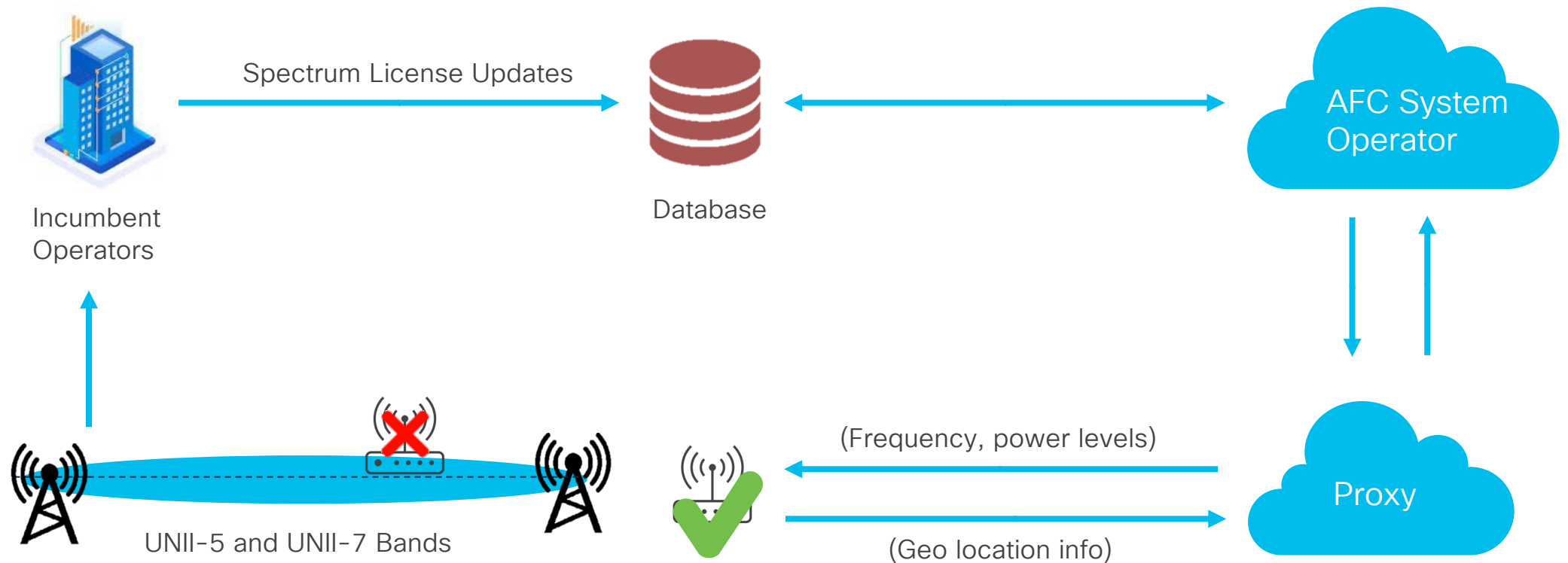
Prevents beacon forging by attacker

Wi-Fi 7 for enterprise ...



Automated Frequency Coordination (AFC)

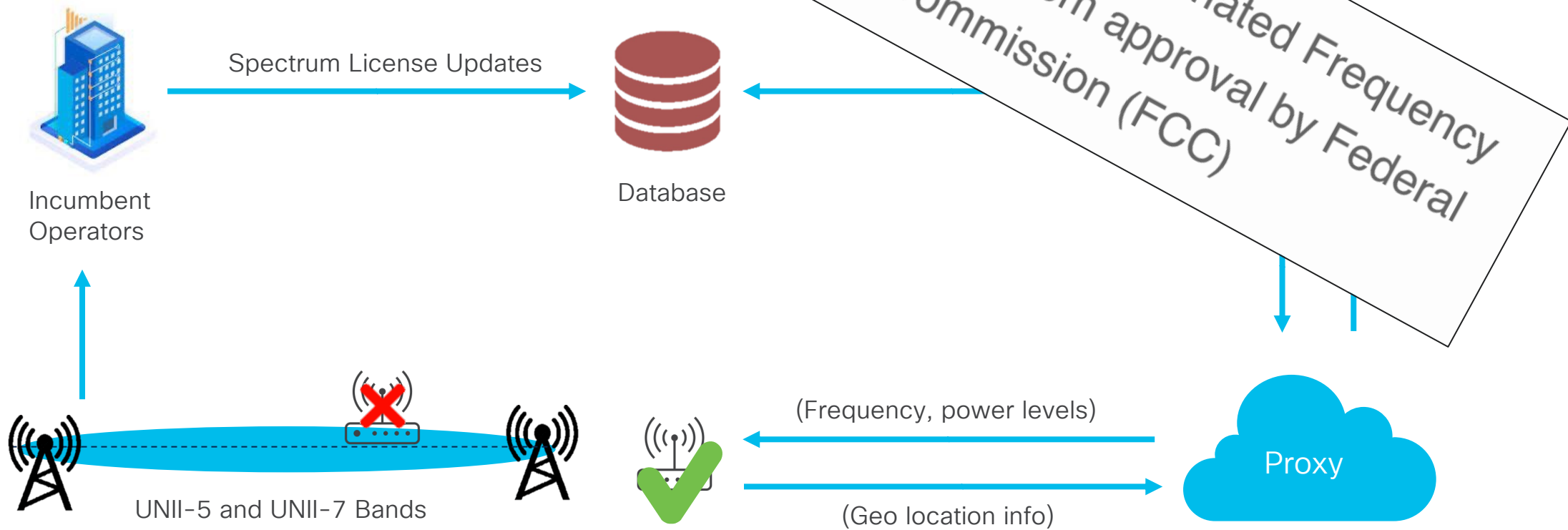
- Standard-power devices are required to check an automated frequency coordination (AFC) system prior to operating to avoid causing harmful interference to incumbent operations.



AFC rules are still to be finalized by FCC

Automated Frequency Coordination (AFC)

- Standard-power devices are required to have a frequency coordination (AFC) system prior to operating to avoid causing interference.



AFC rules are still to be finalized by FCC

7 poznatků

1. Klíčová je adopce 6GHz.
2. Cisco má kompletní 6GHz portfolio
3. Stále se pracuje na úpravě spektra pro venkovní prostředí a venkovní antény
4. Wi-Fi 7 certifikace je dostupná pro oznámení vlastností.
5. Rychlost není vše. Více je spokojený uživatel
6. Pro nasazení Wi-Fi standard myslete i na drátovou část (PoE, mgig)
7. Wi-Fi 7 má své výhody, ale je potřeba větší vývoj



Wi-Fi Protected Access 3 (WPA3)





Wireless Protected Access

WPA

- A snapshot of the 802.11i Wireless Security Standard
- Commonly used with TKIP encryption

WPA2

- Final version of 802.11i Wireless Security Standard
- Commonly used with AES encryption

Authentication Mechanisms

- Personal (PSK – Pre-Shared Key)
- Enterprise (802.1X/EAP)

WPA3

- Wi-Fi Alliance security update
- Includes new capabilities and new certification requirements

Wi-Fi Alliance Security Program History

Security Enhancements have typically taken a reactive approach (something was broken and then we fixed it):

- **WEP – first exploits 2001**
- **WPA (2003)**
 - attempted to bridge security gap from WEP to 802.11i
 - 2008 – Beck-Tews attacks shows vulnerabilities in TKIP (compromises confidentiality)
 - WPA-PSK brute force attacks (compromises network access and confidentiality)
- **WPAv2 (2004)**
 - Integrated security enhancements from 802.11i (added AES)
 - WPA2-PSK: brute force attacks still exist
 - Still maintains a TKIP only mode of operation
 - Inconsistent cryptography strength (SHA-1 <80 bits of security)
- **WPS (2006) – not really security**
 - Created for the consumer to easily adopt Security
 - 2011 – Brute force pin attack (compromises network access)
 - 2014 – Weak Random Number Generator implementations compromises WPS
- **KRACK(2017)**
- **WPA2 Security Enhancements (2018)**
- **WPA3 certification (2018)**
- **Enhanced Open (2018) – privacy not security**
- **Dragonblood (2019)**
- **WPA3 mandatory for "Wi-Fi CERTIFIED™" devices (2020)**



Wi-Fi Protected Access 3 (WPA3)

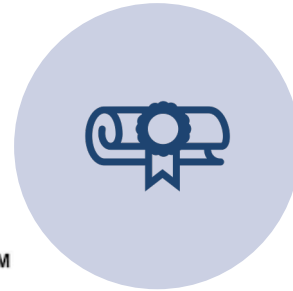
- **Mandatory for Wi-Fi 6 Certification**
- **Remove insecure legacy protocols**
 - WEP
 - TKIP
 - SHA1
- **Negative Testing**
 - KRACK
- Protected Management Frames (802.11w)
 - Protection for unicast and multicast management action frames
 - Mandatory for both WPA3-Enterprise and WPA3-Personal
- Simultaneous Authentication of Equals (SAE)
 - WPA3-Personal – "new PSK"
- Wi-Fi Certified Enhanced Open
 - Opportunistic Wireless Encryption (OWE) – Encryption and Privacy for Guest Networks

How many of you are using WPA3?

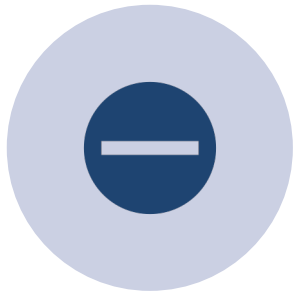
Wi-Fi 6E & 7 Security



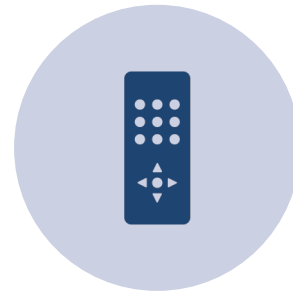
Wi-Fi 6E&7 up levels security with WPA3 and OWE



WPA3 and Enhanced Open Security made mandatory for Wi-Fi 6E&7 certification.



No backward compatibility with Open and WPA2 Security.



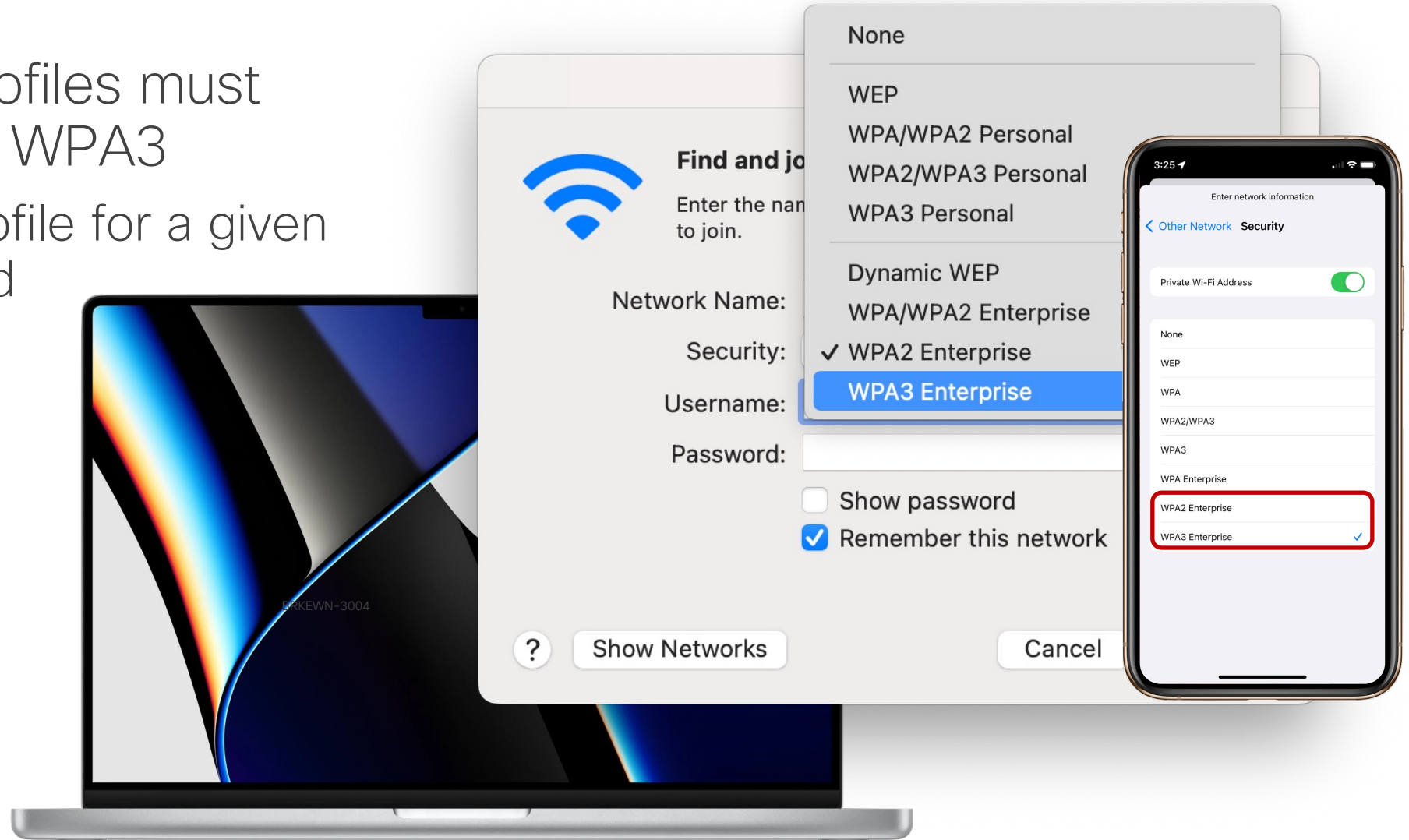
Requires Protected Management Frame (PMF) in both AP and Clients.

Client Devices

Wi-Fi 6E and Wi-Fi 7 Security



- Client device profiles must select WPA2 *or* WPA3
- And only one profile for a given SSID is permitted



WPA3 (& 6GHz) WLAN Design Considerations

Most likely your current WLAN design would prevent it from being supported on 6GHz

6GHz SSID Requirements

- L2 Security: **WPA3** or **OWE**
- Any other L2 security method is not allowed – no mixed mode possible
- Protected Management Frame (PMF) enabled

What options would you have?

1. Reconfigure the existing WLAN and move to WPA3 → one SSID for all radio policies (2.4/5/6 GHz) – **NOT RECOMMENDED**
2. Redesign your SSIDs, adding specific SSID/WLAN with specific security settings. (Most Safe)
3. Use single SSID WLAN Profile and enable WPA3 Transition Mode (supported in 17.12+ for 6GHz) (Most Flexible)

WPA3 Modes

Because a mode is different than the brand

WPA3-Personal

- WPA3-SAE Only Mode
 - PMF Required
- **WPA3-SAE Transition Mode**
 - Whenever WPA2-PSK is enabled, the WPA3-SAE Transition Mode must also be enabled by default
 - Same passphrase share between WPA2 and WPA3 Personal

WPA3-Enterprise

- WPA3-Enterprise Only Mode
 - PMF *required*
- **WPA3-Enterprise Transition Mode**
 - PMF shall be negotiated for a WPA3 connection
 - PMF optional for a WPA2 connection
- WPA3-Enterprise “192-bit” mode (CNSA)
 - More than just for the Federal Government
 - Consistent cryptographic cipher suites to avoid misconfiguration
 - Addition of GCM & ECC for crypto and better hash functions (SHA384)
 - PMF Required



WPA3 Transition Mode (IOS-XE 17.12+)

Single WLAN Profile for 2.4/5 and 6 GHz

Add WLAN

General Security Advanced

Profile Name* Blizzard

SSID* Blizzard

WLAN ID* 8

Status **ENABLED**

Broadcast SSID **ENABLED**

Radio Policy ⓘ

Show slot configuration

6 GHz Status **ENABLED**

5 GHz Status **ENABLED**

2.4 GHz Status **ENABLED**

802.11b/g Policy 802.11b/g

WPA3 Enabled

Dot11ax Enabled

Auth Key Mgmt

802.1X

CCKM ⚠️

FT + SAE

FT + PSK

PSK-SHA256

PSK

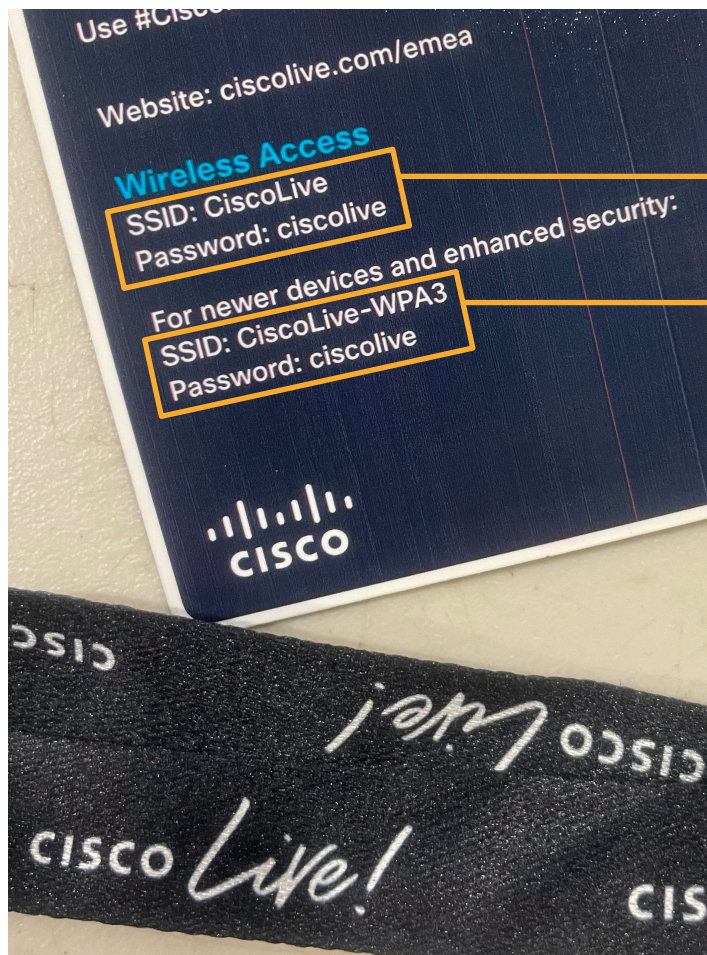
SAE

FT + 802.1X

802.1X-SHA256

- ✓ L2 Security would be WPA2+ WPA3.
- ✓ AKM should be set to **802.1x-SHA256** and **802.1x (SHA1)** for Enterprise + FT; SAE and PSK for Personal.
- ✓ PMF as **Optional**
- ✓ **Fast Transition Enabled**
- ✓ How to configure the client side?
 - For clients that don't support 6 GHz, configure a **WPA2 profile** or **WPA3 Enterprise with PMF as Optional** depending on the client support.
 - For clients that support 6 GHz, configure **WPA3 Enterprise**. They will use these settings to connect to both 2.4/5 GHz and 6GHz

Cisco Live - The SSIDs



Main SSID: WPA2 PSK only, no WPA2 + WPA3 transition mode because our devices remembered it from last year as WPA2 PSK only

WPA3 SSID: for higher security and because 6 GHz mandate WPA3

OpenRoaming: for seamless first-time association and higher security (WPA2 + WPA3 Enterprise)

eduroam: for seamless first-time association of education and research accounts

Fast Transition

Status	Enabled
Over the DS	<input type="checkbox"/>
Reassociation Timeout *	20

Protected Management Frame

PMF	Required *
Association Comeback Timer*	1
SA Query Time*	200

Assisted Roaming (11k)

11v BSS Transition Support

Device Analytics

Advertise Support	<input checked="" type="checkbox"/>
Advertise PC Analytics Support ⓘ	<input checked="" type="checkbox"/>
Share Data with Client	<input type="checkbox"/>

* PMF optional for “eduroam”

WPA3 Deployment Guide

<https://www.cisco.com/c/en/us/products/collateral/wireless/catalyst-9100ax-access-points/wpa3-dep-guide-og.html>



... / Cisco Catalyst 9100 Access Points / Sales Resources /

WPA3 Deployment Guide

Updated: December 2, 2023

Bias-Free Language

- Introduction to WPA3
- Table of Contents
 - Introduction to WPA3
 - Supported WPA3 modes
 - Road-mapped WPA3 features
 - Cisco device compatibility
- WPA3-Enterprise
- WPA3-Personal
- OWE
- Client interoperability matrix
- Useful Catalyst WLC CLI com...
- Useful Catalyst AP CLI comma...
- References

Save Download Print

Introduction to WPA3

WPA3 is the third and latest iteration of the Wi-Fi Protected Access standard developed by the Wi-Fi Alliance and replaces the previous standard, WPA2. The WPA standard was created by the Wi-Fi Alliance security technical task group, chaired by Cisco's Stephen Orr, with the purpose of standardizing wireless security. WPA3 introduces new features on enterprise, personal, and open security networks through an increase in cryptographic strength, allowing for a more secure authentication process for all WPA3-supported endpoints. The WPA3 Enterprise form extends the solid foundation provided by WPA2 Enterprise by making it mandatory to use Protected Management Frames (PMF) on all connections. This security feature protects against such dangerous attacks as Denial of Service, honeypots and eavesdropping.

Over the next few years, Cisco expects the industry to see an exponential increase in WPA3 adoption, especially in government and financial institutions. With the number of internet-connected devices forecasted to reach 41.6 billion in four years, there is an implicit need for better security, and WPA3 is the answer.

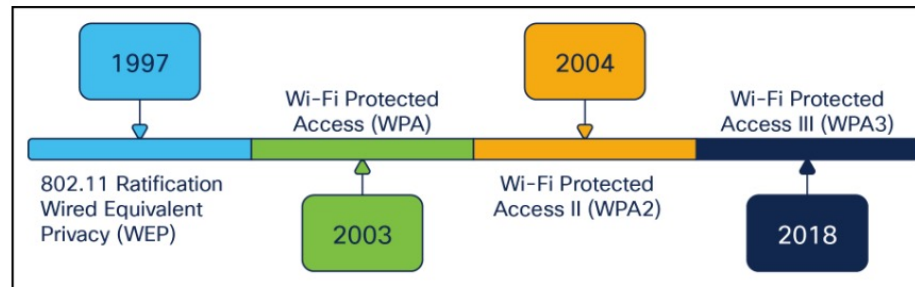
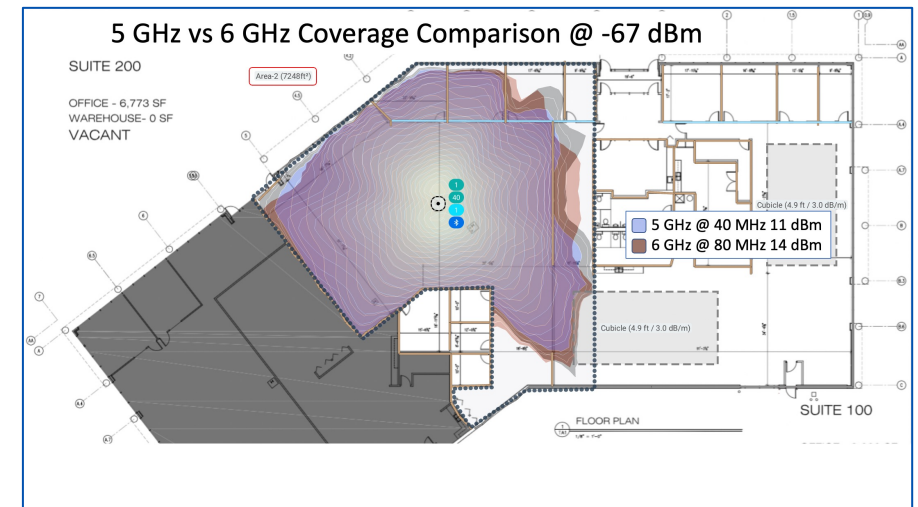


Figure 1.
Wi-Fi security standards timeline



RF Design a nasazení 6GHz / Wi-Fi 6E & 7



Yes, for real!

Pre Wi-Fi 6E



- Limited reusable **channels**
- Channels congestion
- Interference

6GHz - Wi-Fi 6E & 7

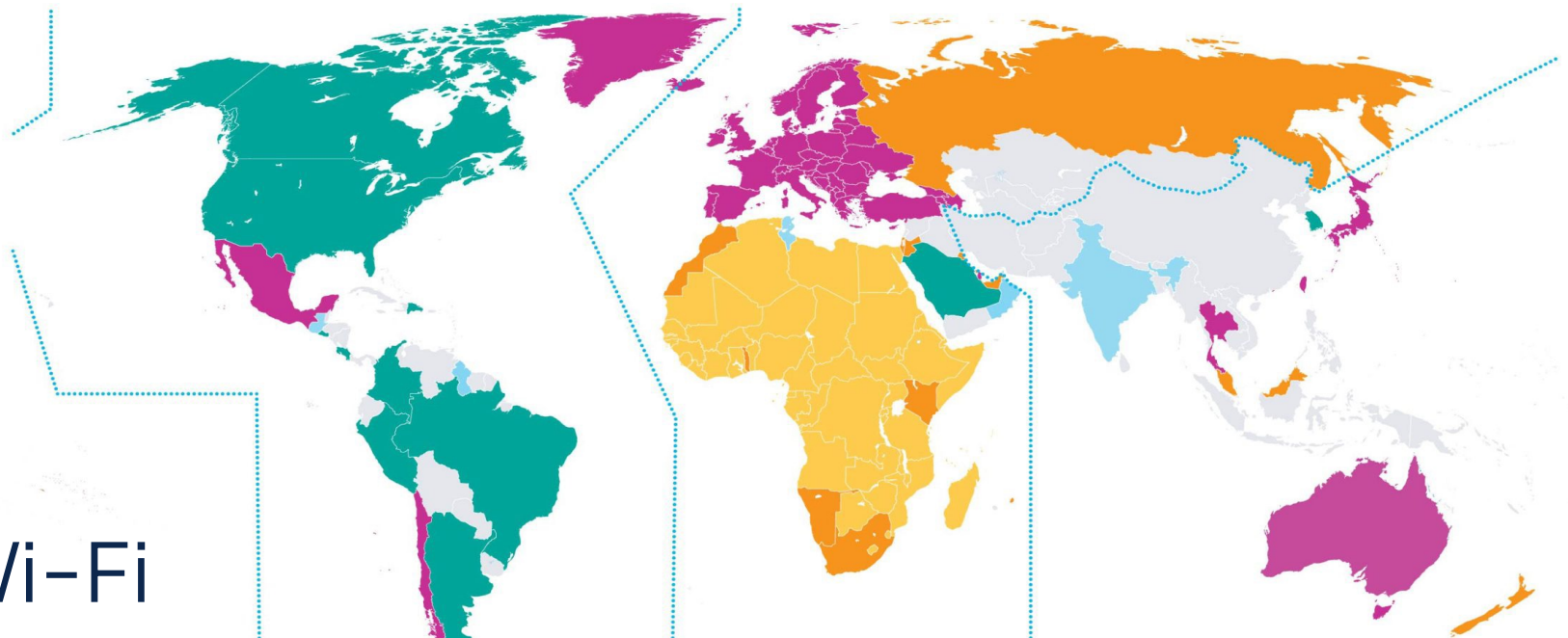


- More spectrum
- Wider Channels
- Clean RF

This results in faster speeds, lower latency, and better overall experience

Global availability of 6 GHz band for Wi-Fi

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



Region 2

- 1200 MHz
 - Canada
 - USA
 - Honduras
 - Costa Rica
 - Brazil
 - Peru
 - Dominican Republic
 - Colombia
 - Argentina
 - El Salvador
- 500 MHz (& evaluating 1200 MHz)
 - Chile
 - Mexico

Region 1

- 1200 MHz
 - Saudi Arabia
- 500 MHz (& evaluating 1200 MHz)
 - CEPT Area
 - European Union (480 MHz)
 - Qatar
 - United Kingdom
- 500 MHz
 - Morocco
 - UAE
 - Jordan
 - Kuwait
 - Kenya
 - Israel
 - Mauritius (480 MHz)
 - Bahrain
 - Togo
 - Russia
 - South Africa
 - Namibia
 - Africa / ATU

Region 3

- 1200 MHz
 - South Korea
- 500 MHz (& evaluating 1200 MHz)
 - Australia
 - Japan
 - Taiwan
 - Thailand
- 500 MHz
 - Hong Kong
 - Malaysia
 - New Zealand
 - Singapore

Source: <https://6ghz.info>

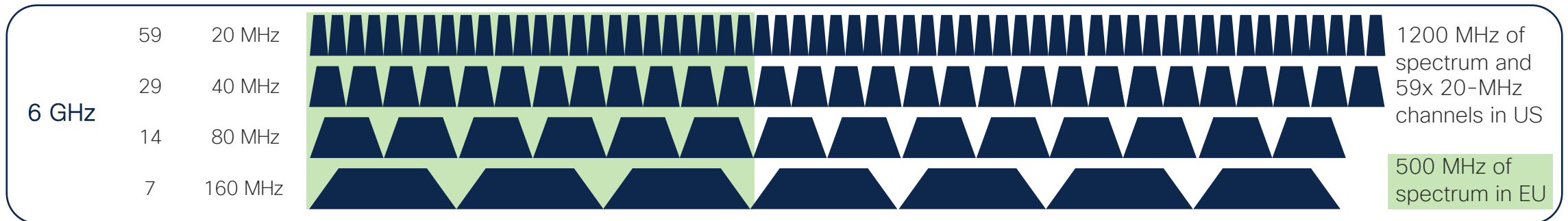
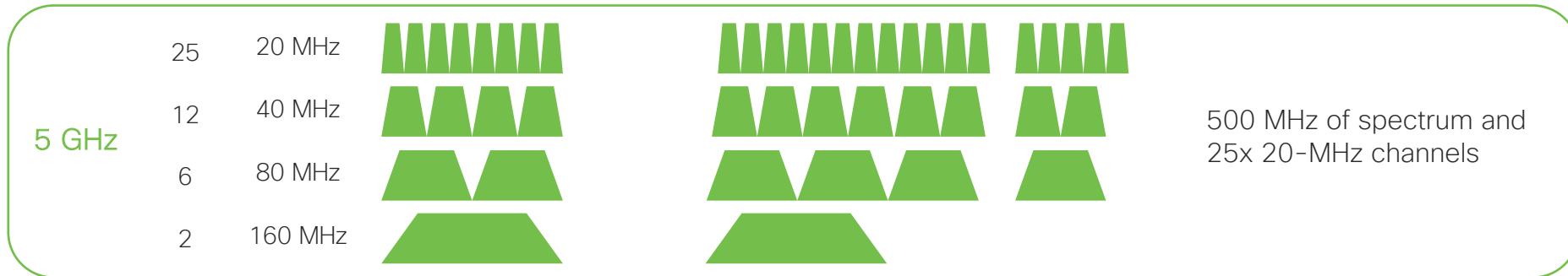
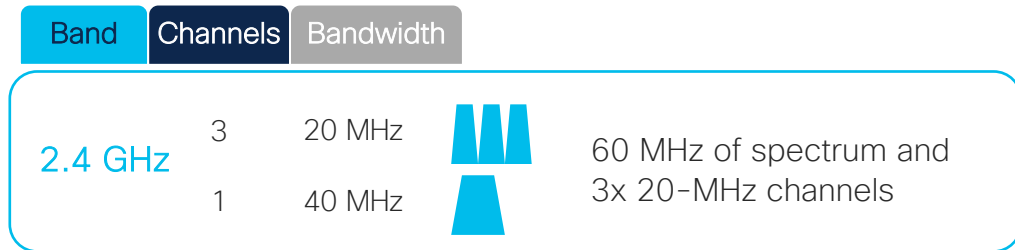


6 GHz – Available Channels

New 24x 20MHz Channels in Europe



2.4 and 5GHz = 22x 20MHz Channel
 6GHz = 24x 20MHz Channel



6 GHz - Tx Power and Antennas

New Device Classes

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



Low Power Indoor AP

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



Standard Power AP

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



Very Lower Power AP

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



Client Devices

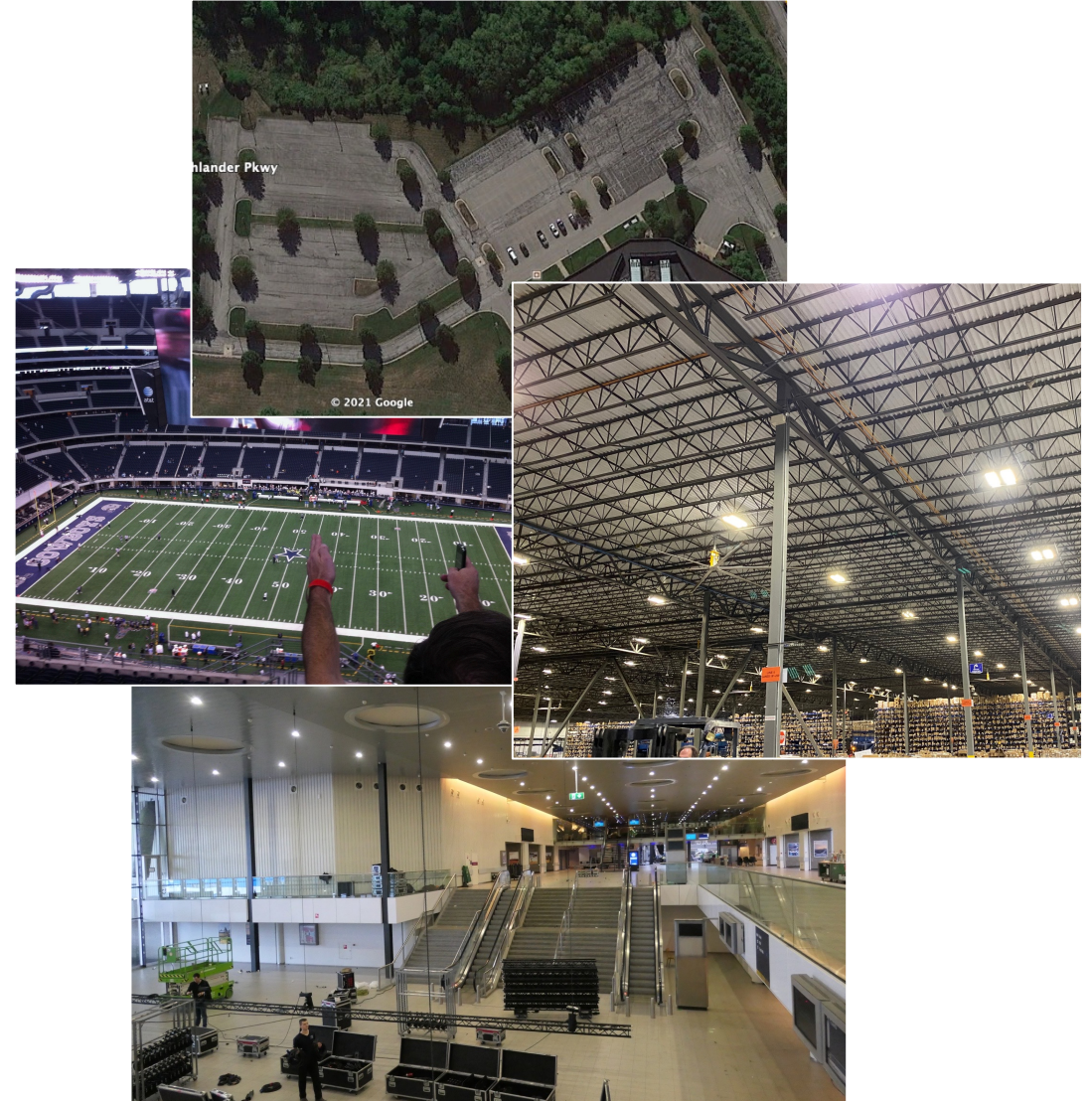
- Indoor or Outdoor
- Only Indoor under control of LPI AP
- 6 dBm lower power than AP

Regulations vary by country

6 GHz Tx Power and Antennas

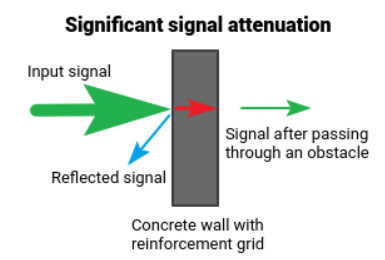
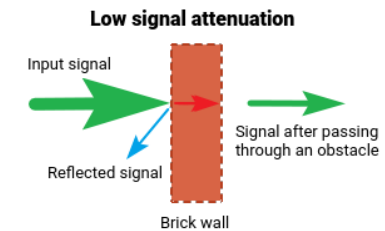
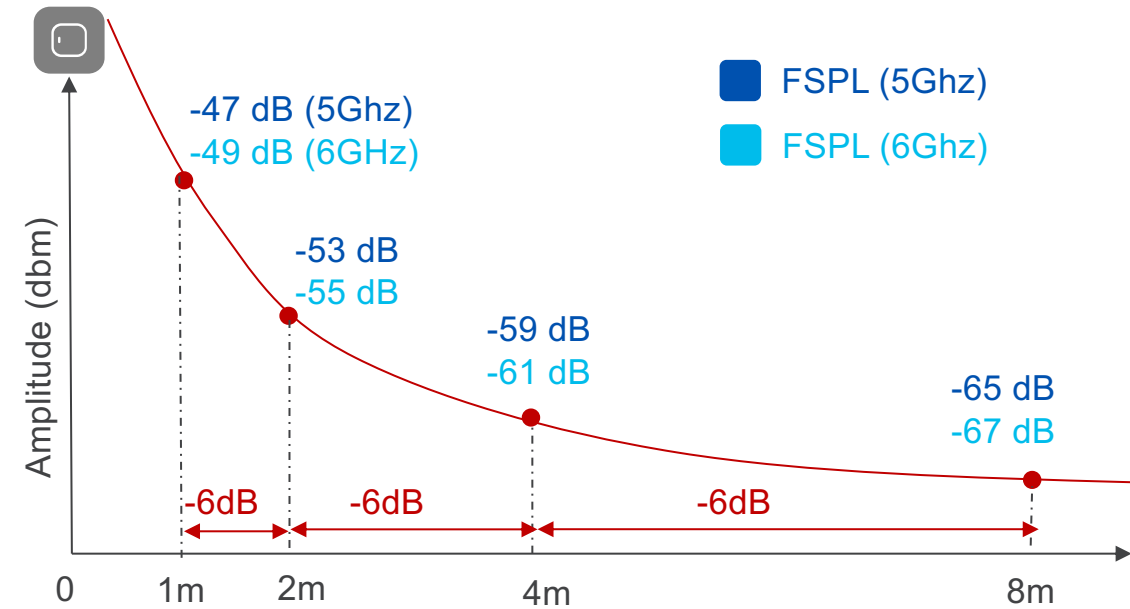
What are the downsides of LPI Rules (for Europe)?

- No outdoor operation – Period
 - No 6 GHz for outdoor public/private spaces
- No External antenna's
 - Many use cases exist (warehouse high ceiling, lecture hall, atriums, large public venues and convention centers) require high gain directional antennas to build for coverage and capacity



What you need to consider?

- **Path Loss (FSPL)*** - Path loss in the first meter is on average 2dB higher at 6GHz vs. 5GHz. After that, the 6 dB rule applies: doubling the distance results in a 6 dB loss, regardless of the frequency
- **Cell Size** - At 6 GHz @ same power level cell is smaller vs. cell size at 5 GHz
- **Absorption/Reflectance** - 6 GHz will be attenuated more through wall or other surface
- **Noise floor** at 6 GHz is much lower than 5 GHz, at least for some time 😊
- **Coverage type**: Today 6GHz is indoor only

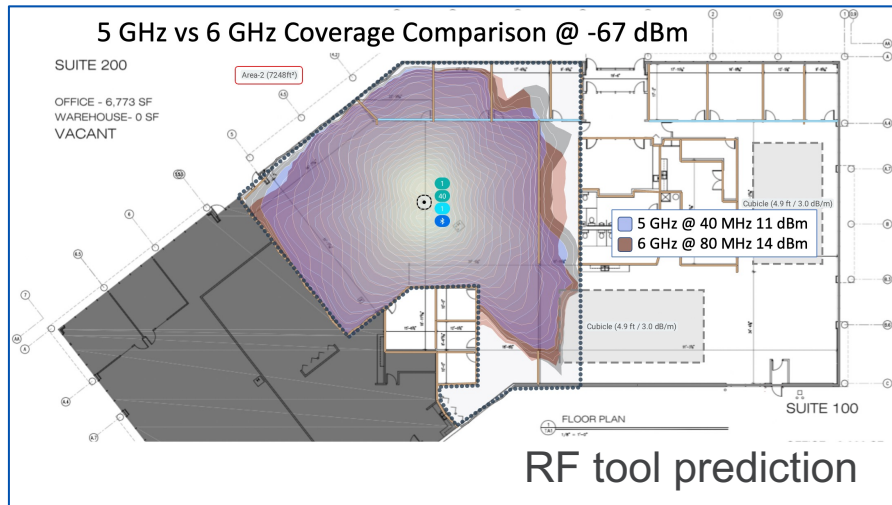


(*) FSPL = Free Space Path Loss: https://en.wikipedia.org/wiki/Free-space_path_loss

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

RF Design considerations

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



- 5GHz @40 MHz 11dbm
- 6GHz @80 MHz 14 dbm

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

RF Design considerations

Site Survey with Wi-Fi 6E Measurement!

Ekahau Sidekick 2

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

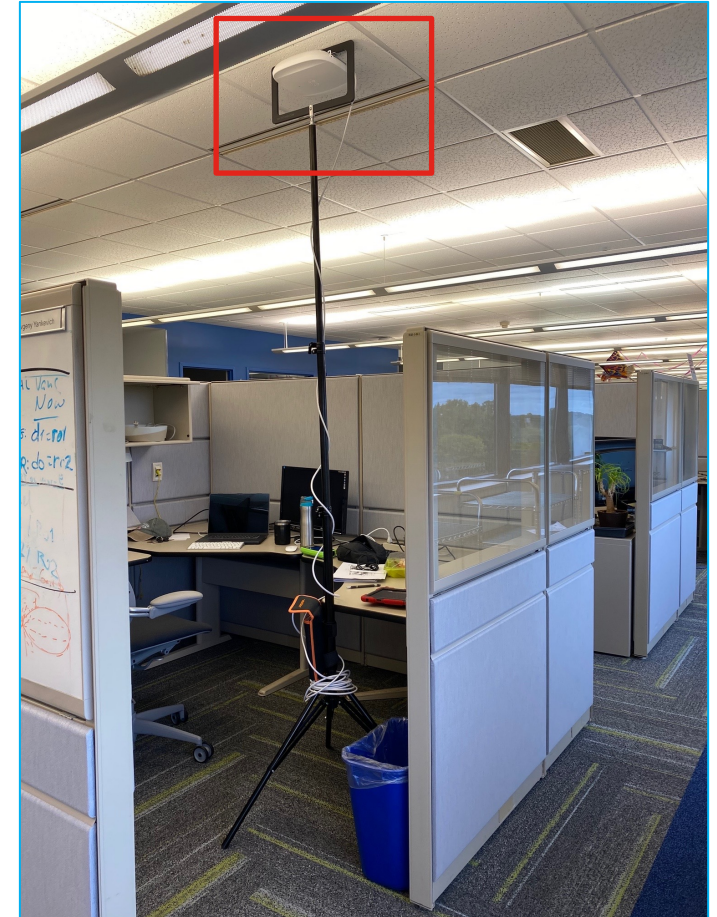


NetAlly Aircheck G3 Pro

- 2.4, 5, 6 GHz
- NetAlly Link-Live



Hamina Integration – Work in progress!



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



9162 



9164 



9166D1 



9136



GPS/GNSS 



9166I 



MR57

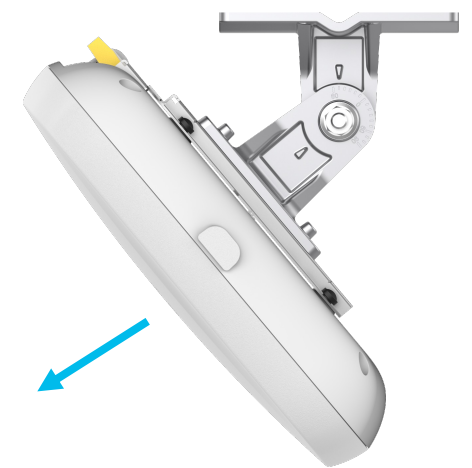
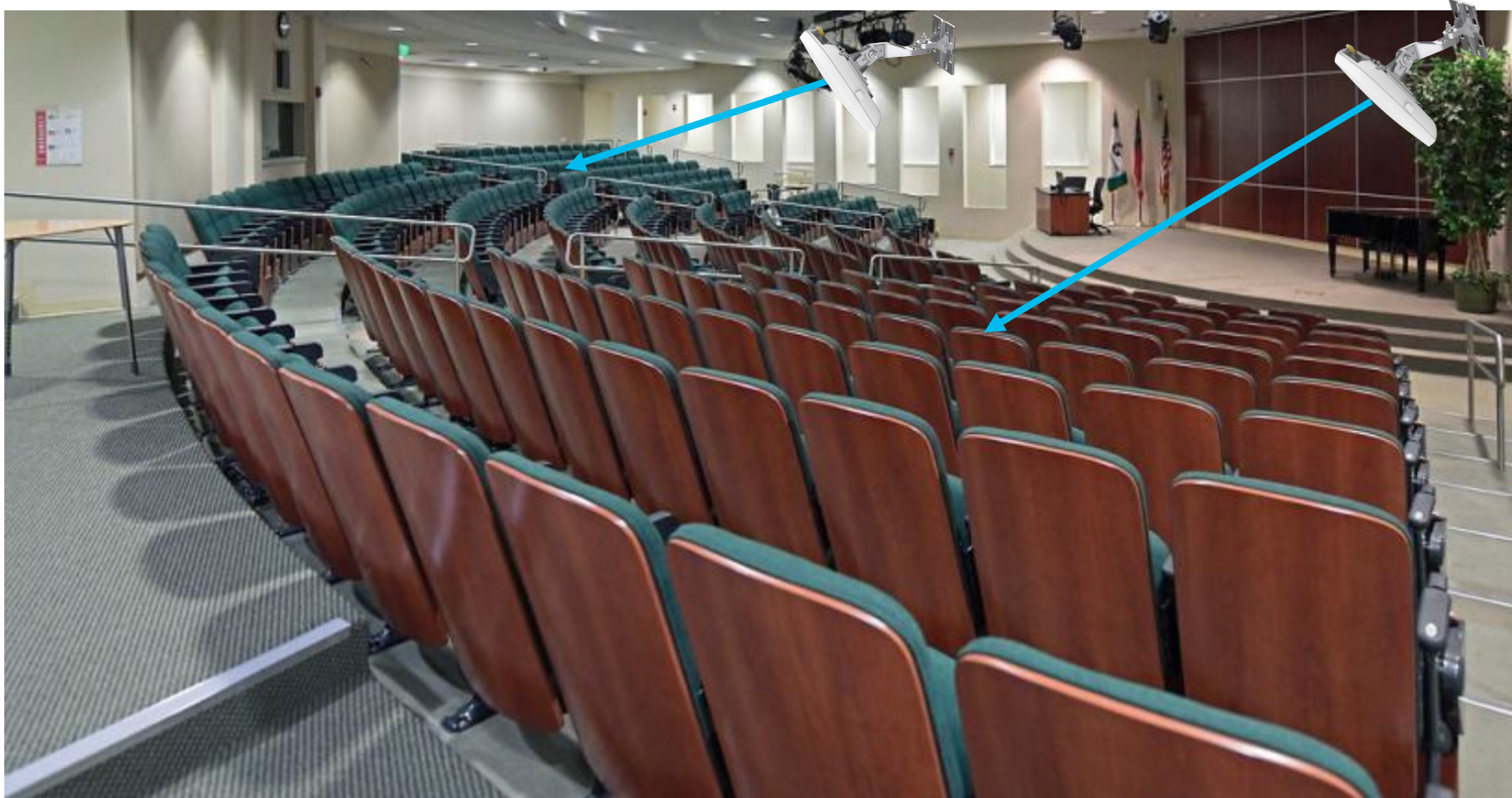


9163E 

Indoor Access Points

Outdoor Access Points

Use cases – Auditoriums, Halls, ...



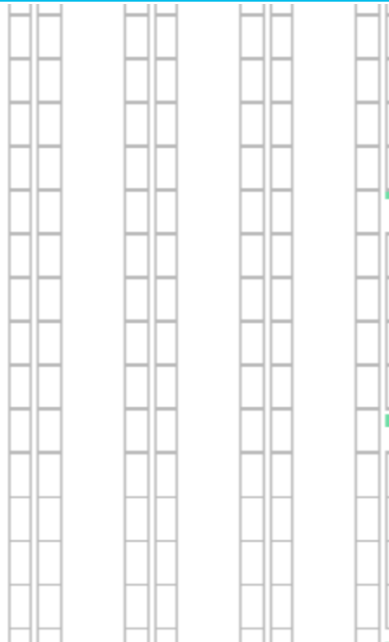
Focusing the direction of the signal improves range, increases signal strength and reduces retries improving overall performance

While an Omni-Directional would work, in this fashion, RF connectivity is optimized as each AP is focused into a specific area

Use cases - Warehouse (High ceilings / long aisles)

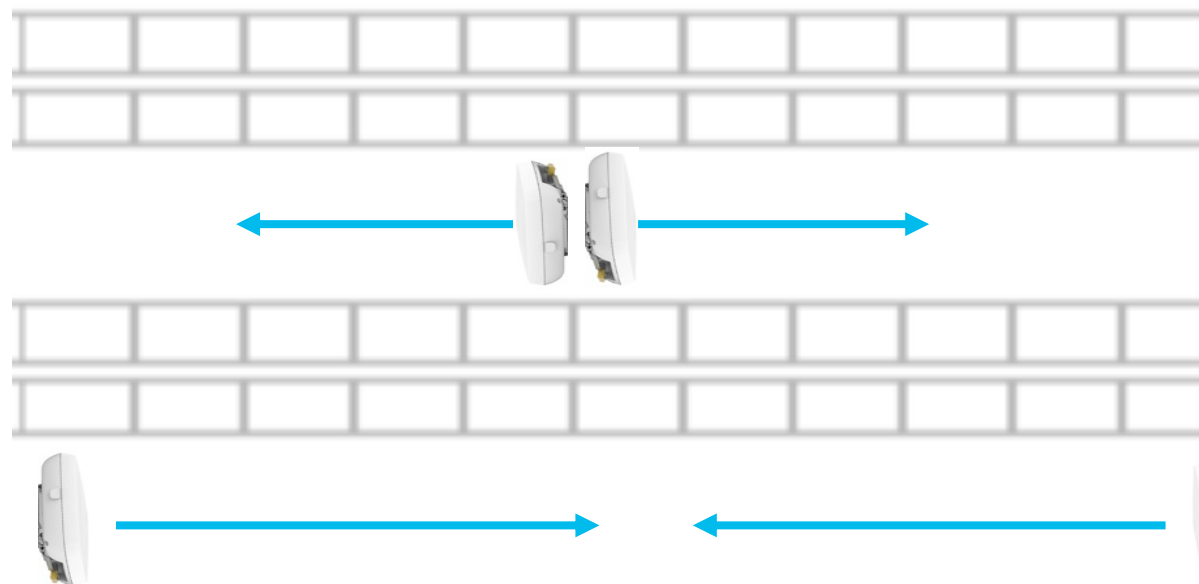
Warehousing challenges

- High Ceilings
- Long aisles
- Stock material changes (seasonal)
- AP (distance to client) & mounting



BRKEWN-2024

Back-to-Back units in center of aisle covering long aisles (Ability to adjust tilt)



Or perhaps at each end of the aisle shooting down the aisle

Omni-directional pattern is problematic in these areas as AP should be directional and located high to avoid tow motors, changing stock material etc.

Wi-Fi 6E Client Device Eco System

Wide range of client support ..

*Upgrade to Windows 11!
Update the Wi-Fi driver and Bios!!*



Samsung Galaxy Ultra S21/S22 & Up



Samsung Galaxy Z Fold



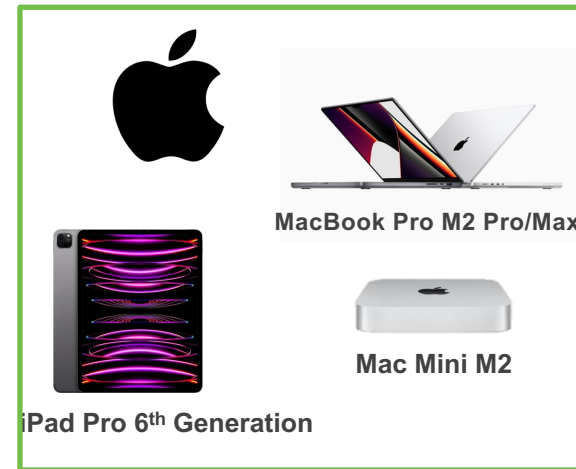
Google Pixel 6 /Pro & Up



XIAOMI



Xiaomi Mi 11 /Ultra



iPad Pro 6th Generation

MacBook Pro M2 Pro/Max

Mac Mini M2



ASUS Zenfone 8 and 8 Flip ROG Phones*

Samsung Galaxy Tab S8 series



Laptops with Intel AX210/AX211/AX411 Chipset



Chromebook



Redmagic 6s Pro & Up

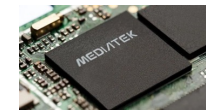


Zebra TC53/58



Motorola Edge (2021 & up)

Wi-Fi 6E Chipsets



And more getting added.....

Getting clients to join 6E - from bad to better

Bad: Early days of 6E

6E Capable clients *always* preferred 5 GHz



Better: Now

More of 6E-capable clients join 6 GHz*



Working closely with client device vendors

Recommendations:

1. Upgrade to the Latest Driver
2. Configure Client Steering Feature
(to move 6 GHz capable clients to 6 GHz Radio)

* Assuming latest driver

Clients finally prefer 6 GHz!



Reference

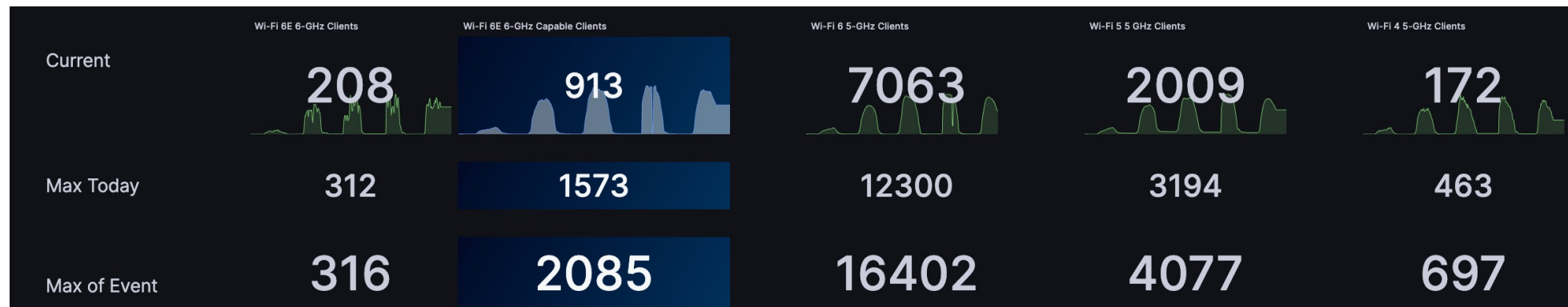
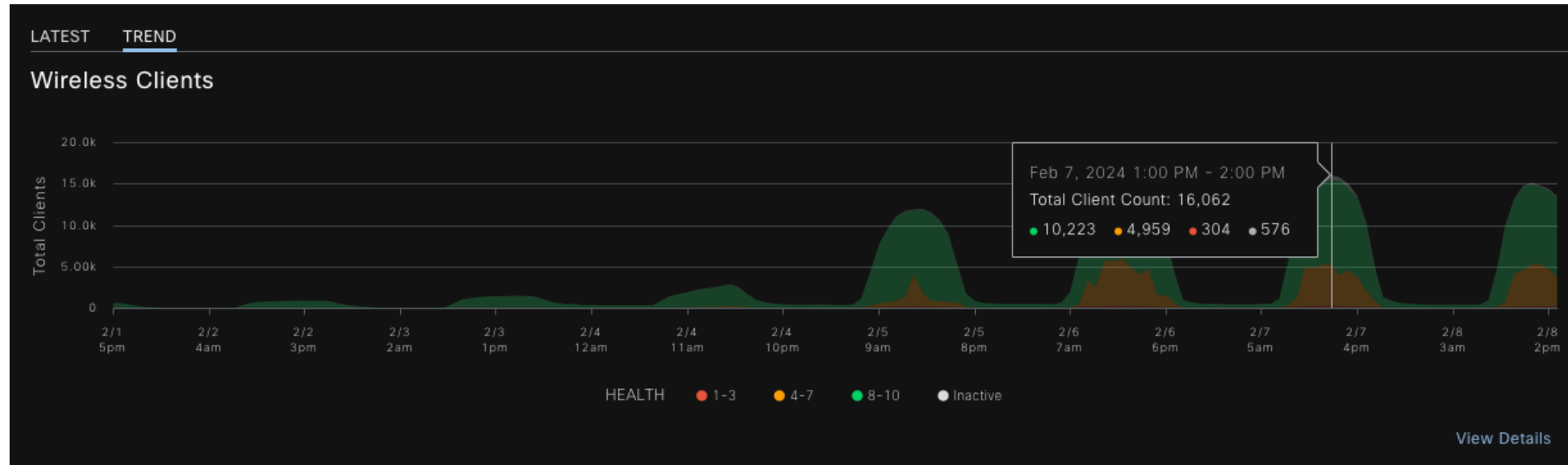
Client Vendor	6E Clients	Version Tested	6E Preference
Apple	iPad Pro, MacBook Pro M2	iPad OS 16.4, MacOS:13.5.2	Prefers 6G
	iPhone 15 Pro (under testing)	iOS 17	
Samsung	S21 Ultra, Galaxy Z Fold, S22+, S23	Android 13	Prefers 6G
Intel	AX210, AX211, AX411	22.250.1	Prefers 6G
Google-Pixel	Pixel 6, 6 Pro, 7 and 8	Android 13	Prefers 6G
Google Chrome OS	ChromeOS with Intel AX211	116.0.5845.120	Prefers 6G
	ChromeOS with Mediatek MT7922	116.0.5845.120	
	ChromeOS with QCA WCN6856	116.0.5845.120	
Zebra	TC22, TC53, TC58, TC73, TC78	Android 13	Prefers 6G
Other Clients	Broadcom, Qualcomm, NXP, Xiaomei, Asus , Redmagic,	QCA: 2.0.0.1016	Prefers 6G

Broad support across Windows, MacOS, Android!

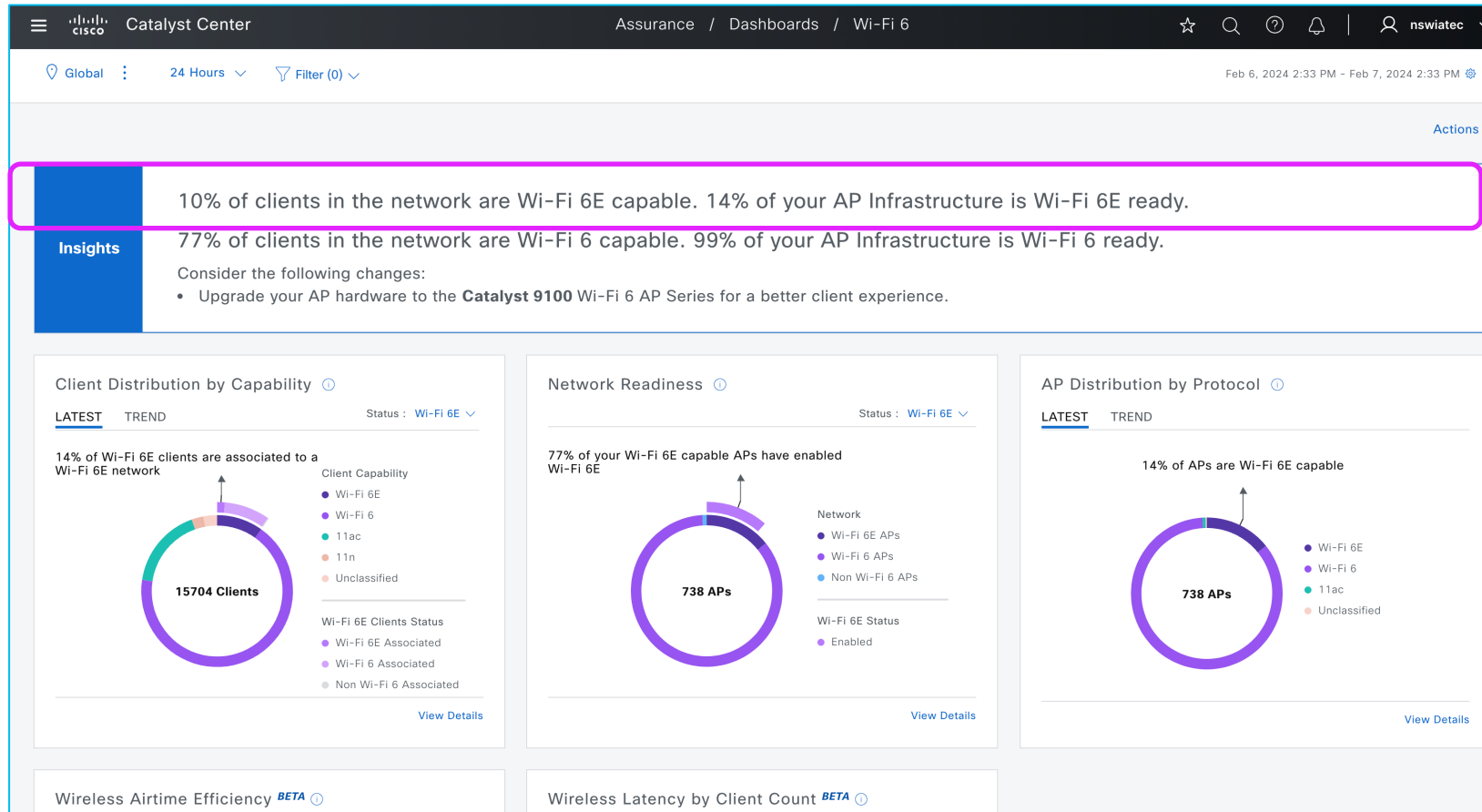


Cisco Live Amsterdam 2024

Wireless Clients Details



Are my clients 6E capable?



Ask Catalyst Center!

Wi-Fi 6E

How do I start adopting
6GHz?

Wi-Fi 6E, are you ready?

Deploying and Migrating to Wi-Fi 6E



Security requirements

Mandatory:

WPA3 is required for Wi-Fi 6E networks to be enabled.

WPA3 was not required for prior Wi-Fi generations; hence, it must be top of mind.

Switching Considerations

Recommendation:

Use a Multigigabit switch with 2.5/5G capability.

Better user experiences with speeds beyond 1 Gbps on existing cabling

Power Considerations

Recommendation:

802.3bt (Cisco UPOE®) is the suggested power input.

Full radio capability with 802.3at for 9166 I/D & 9164
Full ap operation with 802.3at for 9162/9163

RF Design

Recommendation:

Site survey recommended for Greenfield deployment.

Co-resident 6 GHz radio can provide the same coverage as 5 GHz, when 5 GHz radios operate at pwr level 3-4*

References:

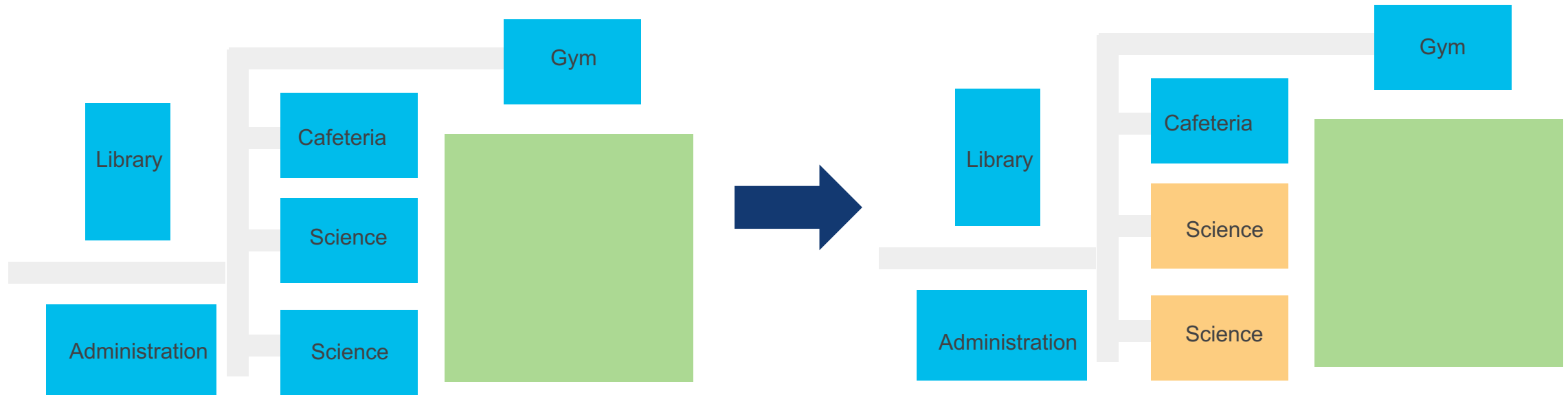
[WLAN Design and Migration into 6 GHz Migrating to 6 GHz](#)

Note:

- 5 GHz network with RRM operating at power levels 3-4? >then equal 5 and 6 GHz coverage is possible with a one for one AP replacement in both ETSI and FCC. Assuming 80 MHz channel in FCC and 40 MHz channel in ETSI/UK
- If the power level is in 1-2, then you may need around 10 to 20% additional access points.
- Assuming 1.2 – 2k f² (140-190 m²) of average AP density, carpeted office normal ceiling (3 m /10 ft)

RF Design – Migration Scenarios

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



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

Wi-Fi 6E - New AP Discovery Mechanisms

Out of Band

Reduced Neighbor Report
Co-located Discovery

802.11k Neighbor Report



In Band

Passive Scan:

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

Active Scan:

Preferred Scanning Channels (PSC)



Multiple BSSID

Reduced Neighbor Report (RNR)

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

Wi-Fi 6E AP

SSID: **employee**
5GHz Channel: **36**
2.4GHz Channel: **1**



Probe Request

Probe Response:
blizzard
RNR :
employee6
channel 69 (6 GHz)

SSID: **employee6**
6GHz Channel: 69



No.	Time	Source	Destination	Protocol	Length	Signal	Strength	Authentication	Info
5	14:31:03.851	68:7d:b4:5e:5f:4f	68:2c:7b:cb:42:d6	802.11	525	-35dBm			Probe Response, SN=9, Flags=.....C, BI=100, SSID=cvoice
8	14:31:03.871	68:7d:b4:5e:5f:4f	68:2c:7b:cb:42:d6	802.11	525	-35dBm			Probe Response, SN=10, Flags=.....C, BI=100, SSID=cvoice
10	14:31:03.910	68:7d:b4:5e:5f:4f	98:01:a7:ec:5f:b6	802.11	525	-34dBm			Probe Response, SN=11, Flags=.....C, BI=100, SSID=cvoice
11	14:31:03.912	68:7d:b4:5e:5f:4f	98:01:a7:ec:5f:b6	802.11	525	-34dBm			Probe Response, SN=11, Flags=.....R...C, BI=100, SSID=cvoice
12	14:31:03.913	68:7d:b4:5e:5f:4f	98:01:a7:ec:5f:b6	802.11	525	-34dBm			Probe Response, SN=11, Flags=.....R...C, BI=100, SSID=cvoice
13	14:31:03.913	68:7d:b4:5e:5f:4f	98:01:a7:ec:5f:b6	802.11	525	-35dBm			Probe Response, SN=11, Flags=.....R...C, BI=100, SSID=cvoice
14	14:31:03.914	68:7d:b4:5e:5f:4e	98:01:a7:ec:5f:b6	802.11	514	-34dBm			Probe Response, SN=5, Flags=.....C, BI=100, SSID=cal-psk
15	14:31:03.915	68:7d:b4:5e:5f:4e	98:01:a7:ec:5f:b6	802.11	514	-35dBm			Probe Response, SN=5, Flags=.....R...C, BI=100, SSID=cal-psk
16	14:31:03.916	68:7d:b4:5e:5f:4e	98:01:a7:ec:5f:b6	802.11	514	-34dBm			Probe Response, SN=5, Flags=.....R...C, BI=100, SSID=cal-psk
17	14:31:03.917	68:7d:b4:5e:5f:4e	98:01:a7:ec:5f:b6	802.11	514	-35dBm			Probe Response, SN=5, Flags=.....R...C, BI=100, SSID=cal-psk

▼ Tag: Reduced Neighbor Report
Tag Number: Reduced Neighbor Report (201)

▼ neighbor AP information
.....00 = TBTT Information Field: 0
.....1.. = TBTT Filtered Neighbor AP: 1
0000 = TBTT Information Count: 0
0000 1101 .. = TBTT Information Length: 1
Neighbor AP TBTT Offset subfield, the BSSID subfield, the Short SSID subfield, the BSS Parameters subfield and the PSD Subfield

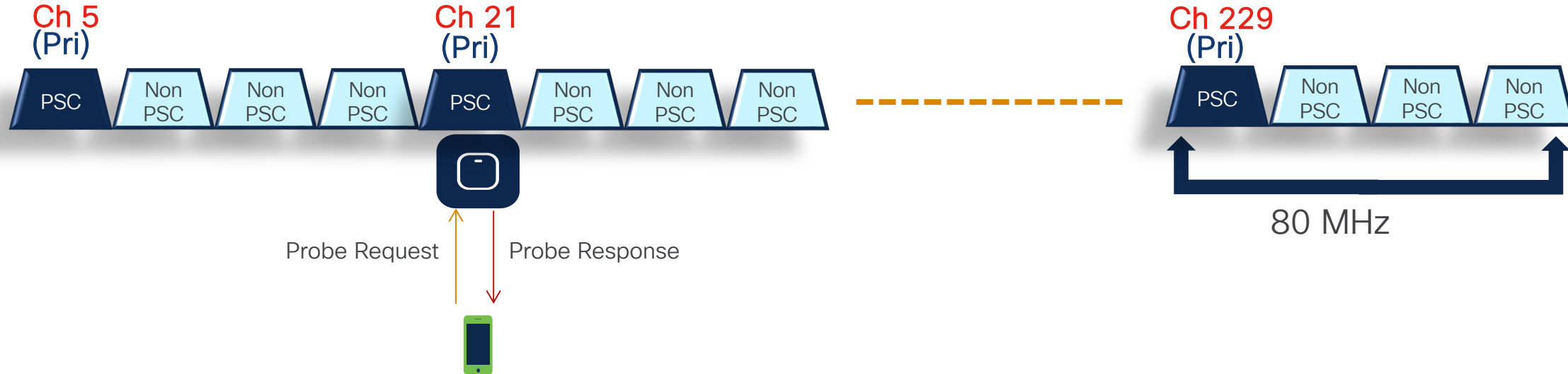
Channel Number: 69

▼ TBTT Information
Neighbor AP TBTT Offset: 255
BSSID: 687db45e5f40
Short SSID: 0x4f27e7b9
▼ BSS Parameters: 0x4e
.....0 = OCT Recommended: False
.....1. = Same SSID: True
.....1.. = Multiple BSSID: True
.....1... = Transmitted BSSID: True
.....0 = Member of ESS with 2.4/5 GHz Co-located AP: True
.....0 = Unsolicited Probe Responses: False
.....1. = Co-located AP: True
0... = Reserved: 0x0
PSD Subfield: 254dBm/MHz

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

Preferred Scanning Channels (PSC)

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



PSC Channel List:

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

Možnosti využití Cisco nástrojů

News

Wi-Fi Alliance® applauds Automated Frequency Coordination (AFC) system approval by Federal Communications Commission (FCC)



6 GHz



News

Wi-Fi 4,5,6,6E



Wi-Fi Alliance® applauds Automated Frequency Coordination (AFC) system approval by Federal Communications Commission (FCC)

802.11k,v,r,w

802.11u,e

WPA, WPA2, 802.11i



SNR, Speed, Radio

6 GHz



DOH!

IT'S SO COMPLEX

makeameme

Cisco Networking Cloud

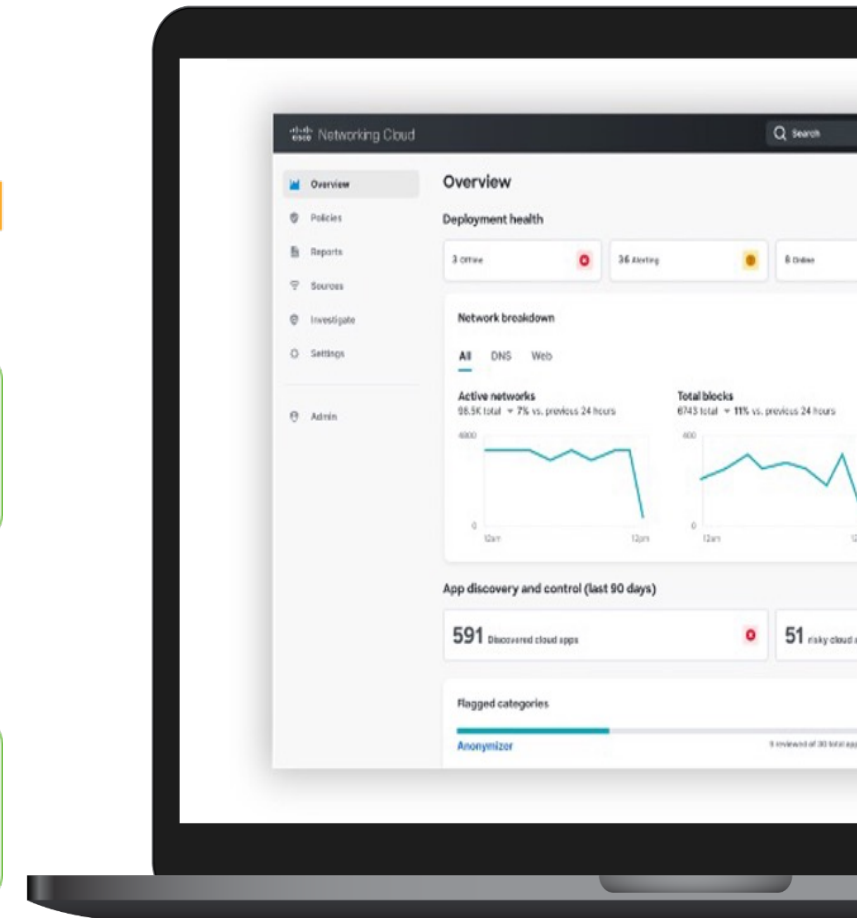
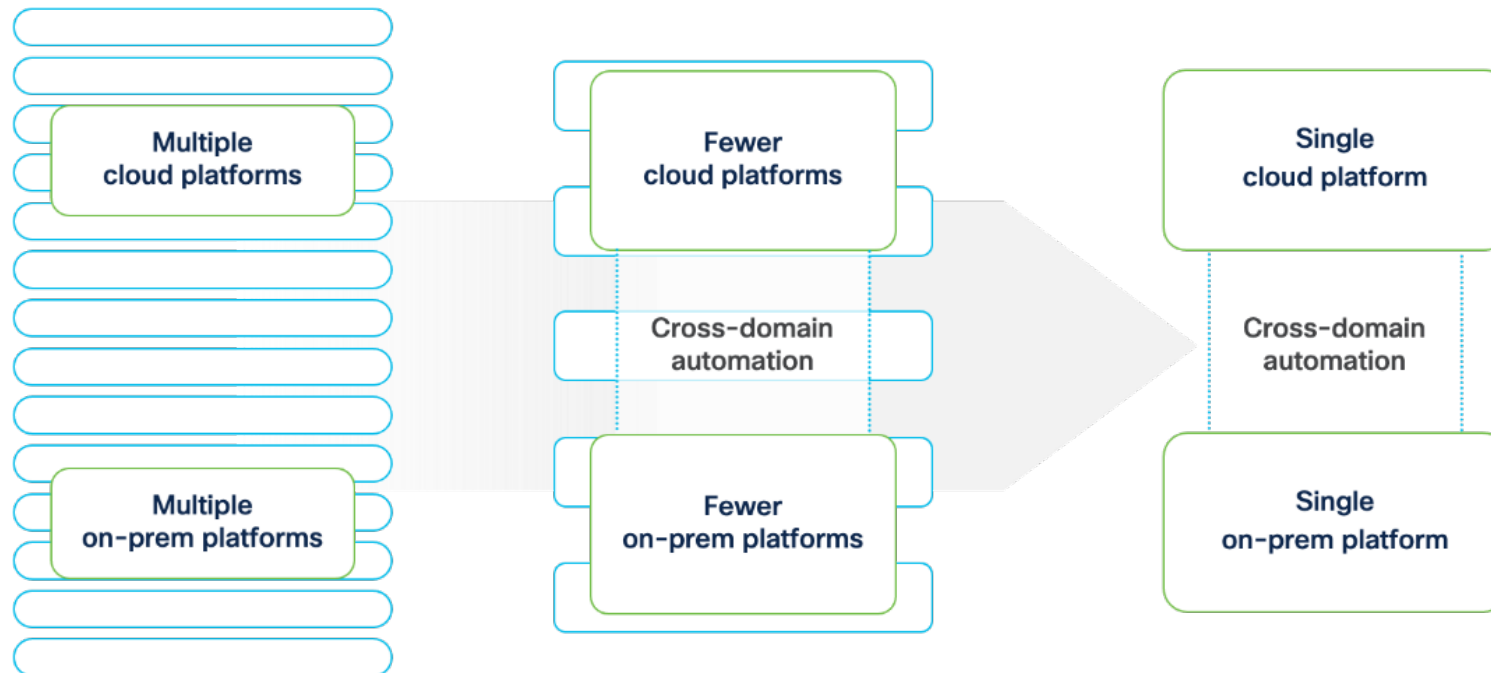
Integrating on-prem and cloud operating models

Unified Experiences

RELY ON

Your Platform Architecture

Consumption Model Considerations



Greater simplicity, everywhere, at every scale

Unifying AI Technology for Cisco Wireless



Industry's Largest Data Lake



Catalyst Cloud Monitoring



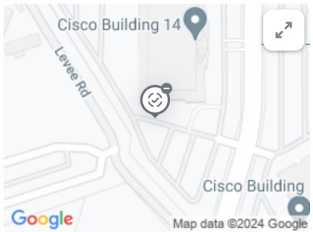
Catalyst APs

CW & MR APs

Cisco Catalyst 9800 Controllers

CLOUD-MON-C9800-40-DEMO Online Monitor Only

C9800-40-K9 4c:42:1e:3d:0c:80 **Summary** Ports Redundancy APs



Address
3625 Cisco Way, San Jose, CA 95134

HA/Redundancy
SSO

LAN IP
10.14.3.2

Type
statically assigned

Link aggregate
-


Public IP
128.107.234.14

Gateway
10.14.3.1

DNS
10.10.105.7

LAN IPv6
-

Serial number



Port key

Live Data

Access Points 12 total 📶


All
Online 🟢

Clients 4 total 💻

All
Online 🟢

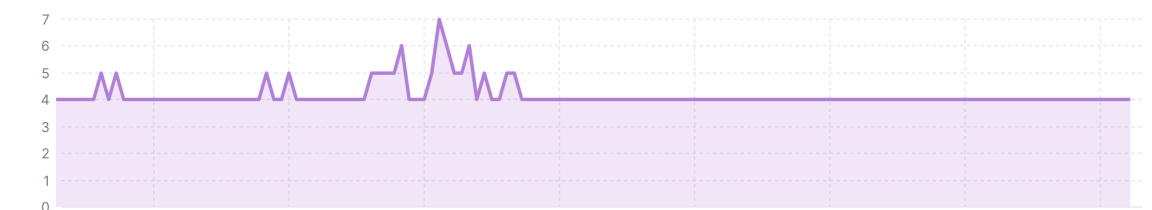
Historical Data 🕒 Last day

Connectivity



12:33 PM 3:20 PM 6:06 PM 8:53 PM 11:40 PM 2:26 AM 5:13 AM 8:00 AM 10:46

Clients



7
6
5
4
3
2
1
0

Supported Hardware¹

C9800-80
C9800-40
C9800-L-C
C9800-L-F

IOS-XE Software

17.12.3 / 17.15.1 or later

¹ C9800-CL support is on the roadmap



Access Points

Wi-Fi 6E

C9136 CW9163
 CW9166I/D1 CW9162
 CW9164

Wi-Fi 6

C9130 C9117
 C9124 C9115
 C9120 C9105

Wave 2

AP4800
 AP3800
 AP2800

AP-Bldg-14-HQ-01
 CW9164I-B cc:9c:3e:f1:e2:5f
 Monitor Only

ADDRESS

WIRELESS CONTROLLER
 ● C9800-L-B14-HQ-SSO

WIRELESS CONTROLLER TAGS
 Site tag: Building 14 HQ SSO
 Policy tag: CLUS-SSIDs
 RF tag: Building 14 HQ SSO RF TAG

AP MODE
 local-mode

SSIDS
 CLUS
[BSSID Details](#)

RADIO SETTINGS
 2.4 GHz: 1 (20 MHz; 2 dBm)
 5 GHz: 161 (40 MHz; 23 dBm)
 6 GHz: 117 (80 MHz; 2 dBm)

Summary Location

Live data

Ports

AP port profile
 use network default (none currently set) [\(edit\)](#)
[\(see/edit all profiles\)](#)

Current clients 200

Description	IP address	VLAN	MAC address	Usage	Associated for	SSID
2c:33:11:7a:2b:20	10.14.140.76	140	2c:33:11:7a:2b:20	5.6 MB	17 minutes	CLUS
2c:33:11:7a:2b:21	10.14.140.75	140	2c:33:11:7a:2b:21	39 KB	18 minutes	CLUS
2c:33:11:7a:2b:22	10.14.140.93	140	2c:33:11:7a:2b:22	39 KB	18 minutes	CLUS

3 results per page

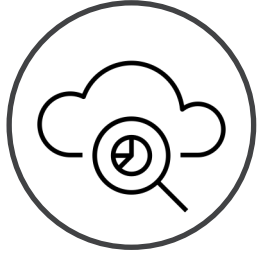
Utilization on current channels

Channel 1 (2.4 GHz): 100% (Very high, likely a problem)

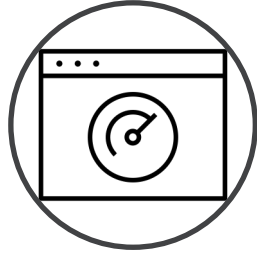
Channel 161 (5 GHz): 30% (Acceptable)

Channel 5 (6 GHz): 1% (Acceptable)

Cisco AIOps Capabilities & Data Powered Insights



AI-Enhanced RRM



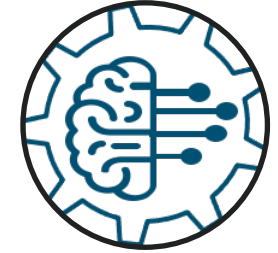
Peer & Network Comparison



Network Health, Trends and Insights



AI/ML based Issue Detection



Machine Reasoning Engine



Visibility & Improved Serviceability

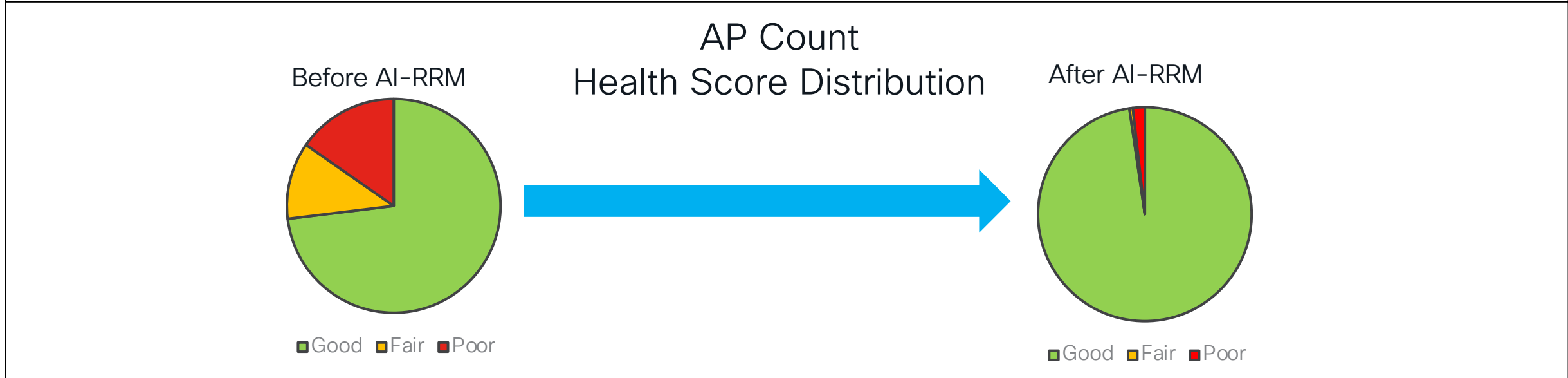
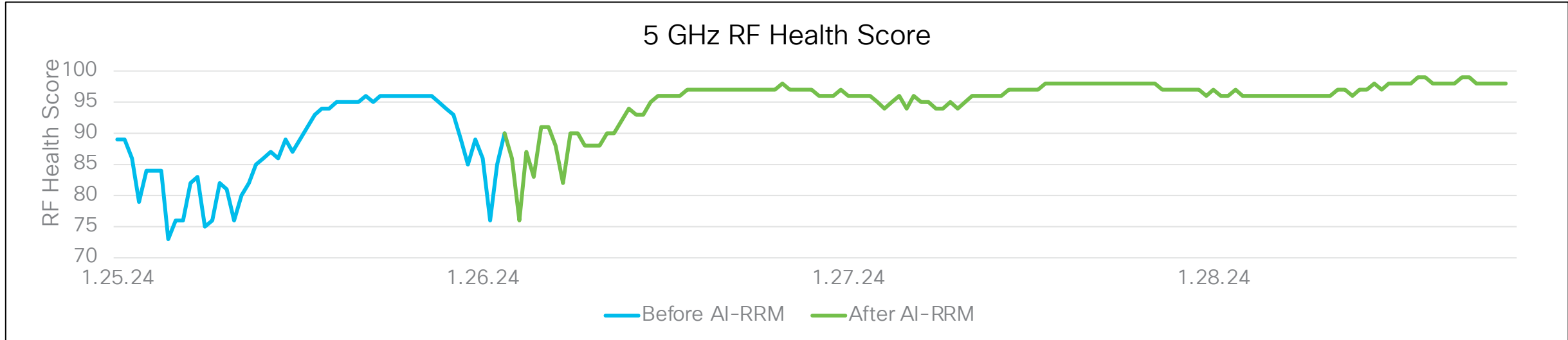
Compare to Peer Networks using different KPI

Time evolving long term trends

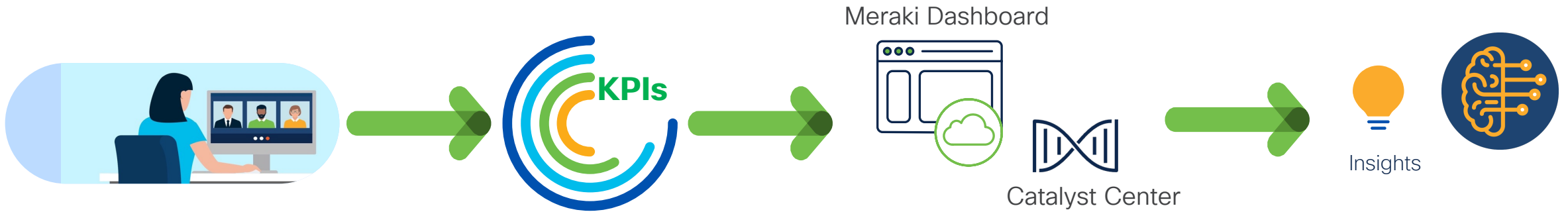
Dynamic Baselines

Example: Device Analytics

Trend-Based RRM Improved a Large Japanese University 5 GHz Network of 776 APs in Just Three Days!



Network & Peer Comparison: Compare your network performance with peer networks

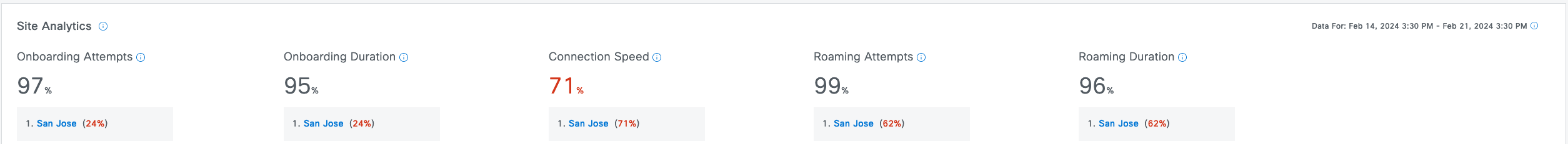
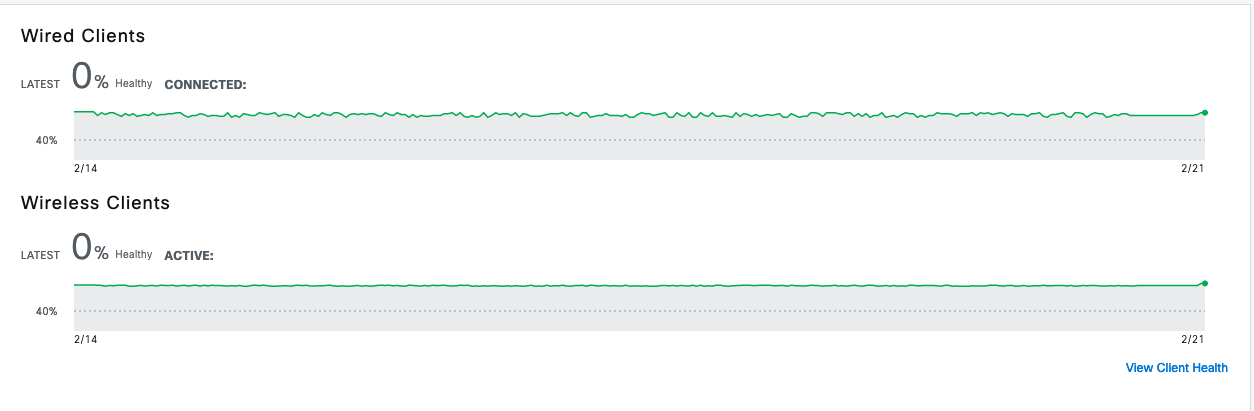
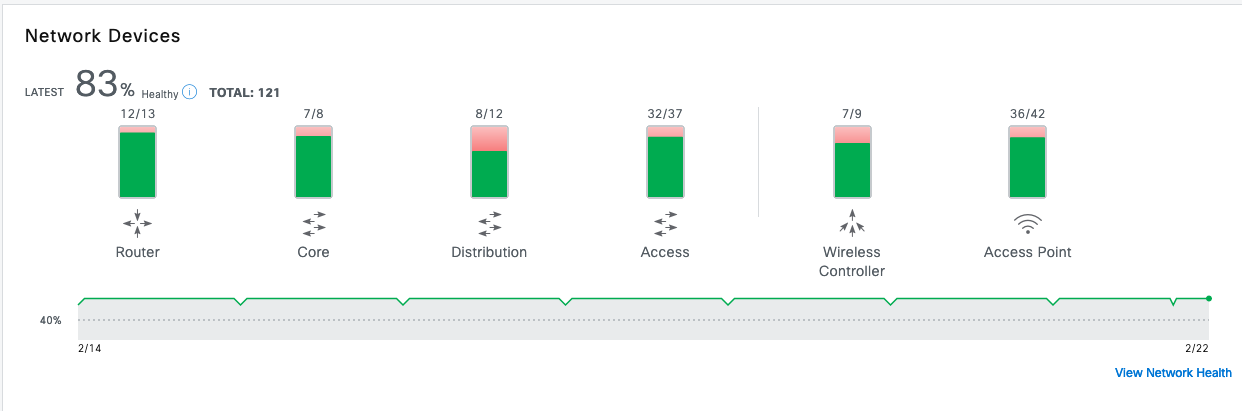


- IT admins may want to check how their network is performing compared to their industry peers across different KPIs
- identify performance improvement opportunities in the network
- IT admins may want visibility into below KPIs compared to their peers,
 - RSSI
 - Interference
 - Radio throughput etc.
 - Buildings
 - Endpoints
- Network & Peer Comparison allows you to determine how your network is performing in comparison to your peer networks or a selected Key Performance Indicators (KPI).
 - Note: All Peer information data is anonymized and aggregated to ensure we take care of data privacy requirements
- Peer comparison is an easy way to understand the effectiveness of your deployed network with respect to how peer organizations are operating
- The insights you gain helps to make changes or modifications to enhance network performance across different KPIs

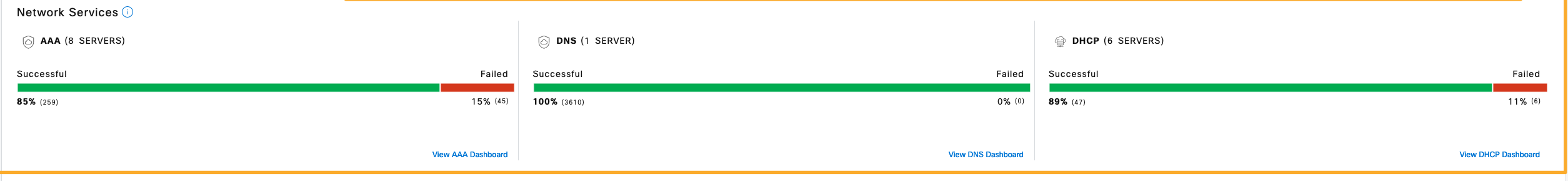
Outcomes

Visualizing how your network is performing compared to your industry peers & take necessary actions to enhance performance

Actions



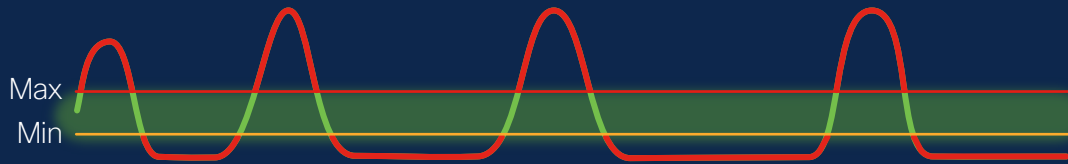
Correlate Client and Network Service related issues (e.g. AAA/DNS/DHCP)!



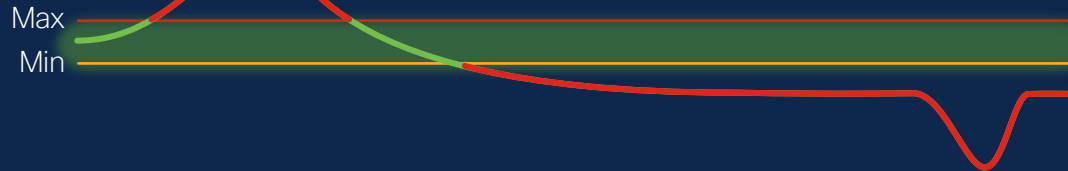
AI-Driven Dynamic Baseline: Focus on Issues that Really Matter

Custom Thresholds = False Positives

Environment 1



Environment 2

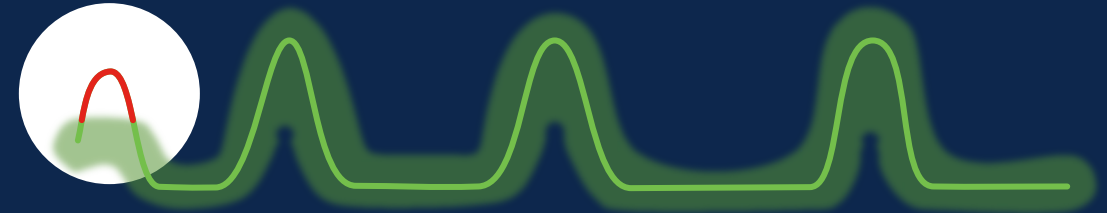


Environment 3

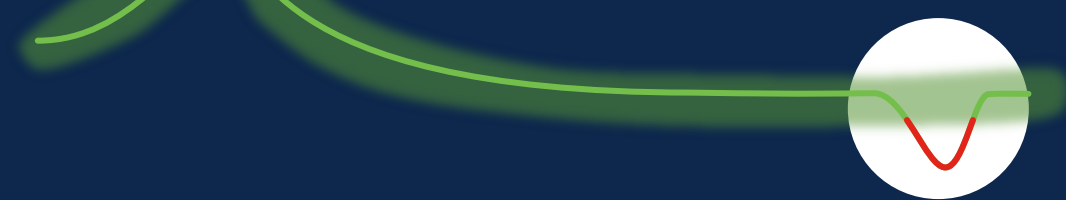


AI-Driven Dynamic Baselines = Relevant Anomalies

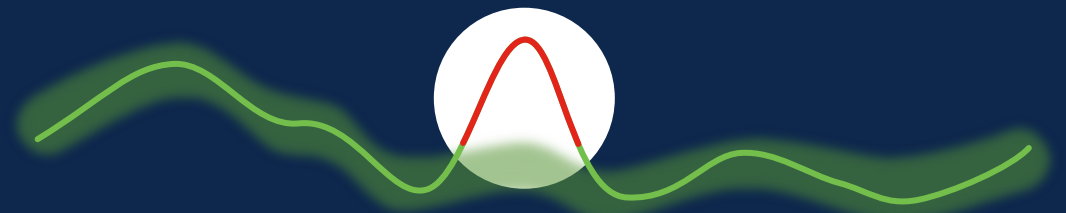
Environment 1



Environment 2



Environment 3



Cisco brings to your customer the client view

Cisco is the *only* company with the size and power to partner with client vendors



SAMSUNG

 Microsoft



 intel

Clients send exclusive messages to Cisco APs

What is this client?

- Form factor (phone/tablet/laptop) - Helps learn behavior
- HW (what chipset), SW (what drivers, what OS)
- Spot bugs / specific behavior overrides

How does the client see the RF?

- AP RSSI, neighbor APs signal, Retries, problems

Why did it leave?

- 802.11 has 'standard' reasons
- what if you click another SSID in your client OS?
- User reasons, upper layer reasons, deeper 802.11 reasons

Next: let's exchange further

- Bring the 'view from the ceiling' to the client
- Clients roam faster, find the best cell, optimize its traffic

Example: Catalyst Center Intel Connectivity Analytics

Event Viewer

Filter Export Go to Global Event Viewer

Event is Roam Report

May 9, 2022

>	●	Intel	Roam Report	9:25:35.935 PM	RSSI: -47 dBm AP: OTA-9136B-17E0	Reason Code: Low RSSI	Type: Device Analytics - Intel
>	●	Intel	Roam Report	8:55:33.628 PM	RSSI: -47 dBm AP: OTA-9136B-17E0	Reason Code: Better AP	Type: Device Analytics - Intel
>	●	Intel	Roam Report	8:25:32.200 PM	RSSI: -47 dBm AP: OTA-9136B-17E0	Reason Code: Other	Type: Device Analytics - Intel
>	●	Intel	Roam Report	7:55:30.066 PM	RSSI: -47 dBm AP: OTA-9136B-17E0	Reason Code: 11v force	Type: Device Analytics - Intel
∨	●	Intel	Roam Report	7:25:28.241 PM	RSSI: -47 dBm AP: OTA-9136B-17E0	Reason Code: Other	Type: Device Analytics - Intel
	●	Intel	Roam Report	7:25:28.241 PM	RSSI: -47 dBm AP: OTA-9136B-17E0	Reason Code: Low RSSI	Type: Device Analytics - Intel
>	●	Intel	Roam Report	6:55:27.112 PM	RSSI: -46 dBm AP: OTA-9136B-17E0	Reason Code: Better AP	Type: Device Analytics - Intel
>	●	Intel	Roam Report	6:25:26.366 PM	RSSI: -47 dBm AP: OTA-9136B-17E0	Reason Code: Other	Type: Device Analytics - Intel
>	●	Intel	Roam Report	5:55:24.129 PM	RSSI: -46 dBm AP: OTA-9136B-17E0	Reason Code: Other	Type: Device Analytics - Intel

Showing 1 - 9 of 48

Roam Reasons

Detailed Report

Roam Report

May 9, 2022 7:25:28 PM

Detailed Information

Status:

● Report Received

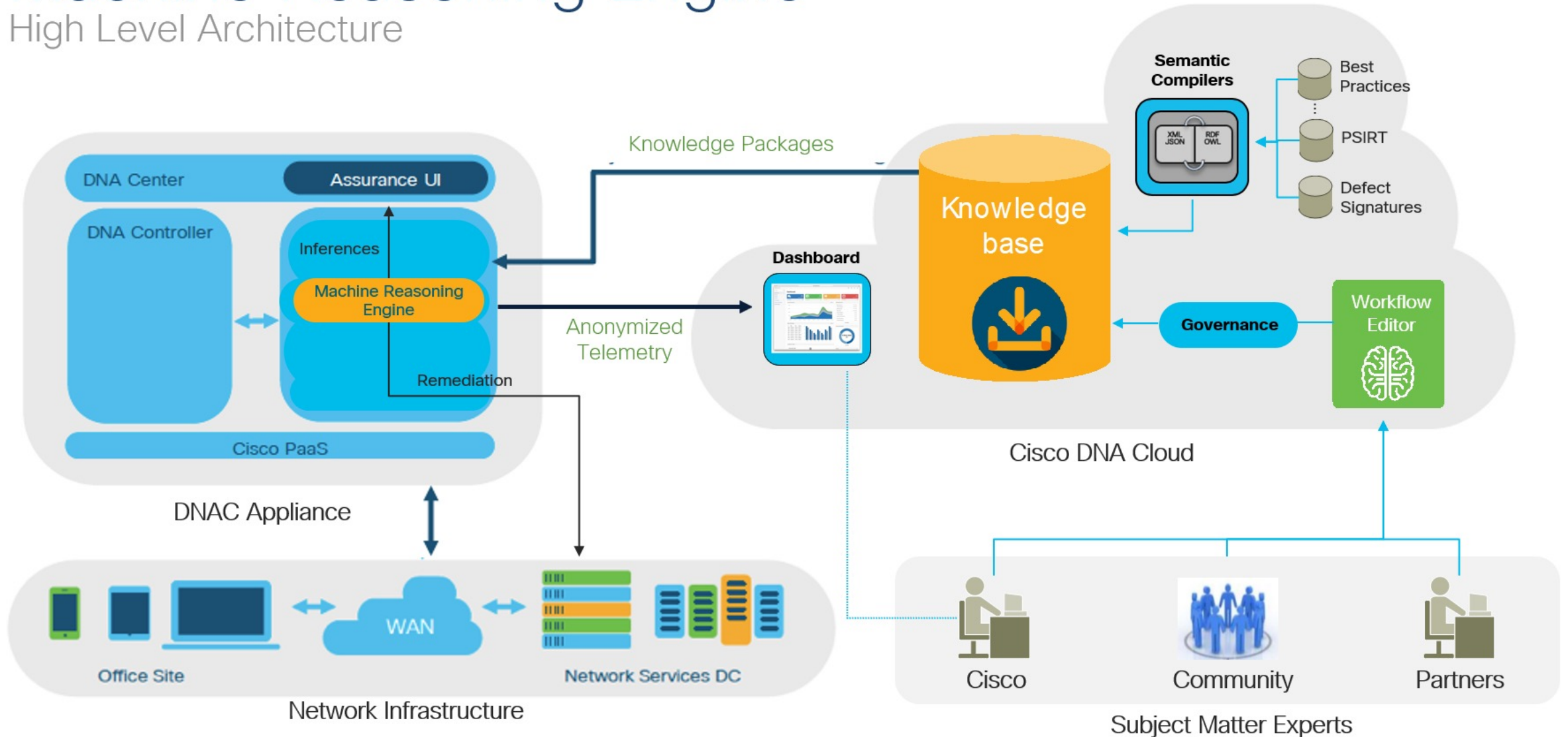
Details:

AP Name	OTA-9136B-17E0
AP Mac	68:7D:B4:5F:1D:60
BSSID	68:7D:B4:5F:1D:68
Type	Device Analytics - Intel
Reason Code	Low RSSI
RSSI	-47 dBm
Candidate APs	Access Point: OTA-9136B-17FC
76	BSSID: 68:7D:B4:5F:1E:B8
	RSSI: -61 dBm

Low RSSI

Machine Reasoning Engine

High Level Architecture



Shrnutí

- Adopce nových vlastností a standardů je klíčová
- Wi-Fi již není jen o rychlosti, ale primárně o spokojených klientech
- Cisco poskytuje kompletní řešení pro aktuální i budoucí výzevy



The bridge to possible