

EXTREME NETWORKS

# Wi-Fi 7 Heaven or Wi-Fi 7 Deadly Sins?

David Coleman | 10/21/2023

Who am I?



Extreme Networks  
Office of the CTO  
Director of Wireless



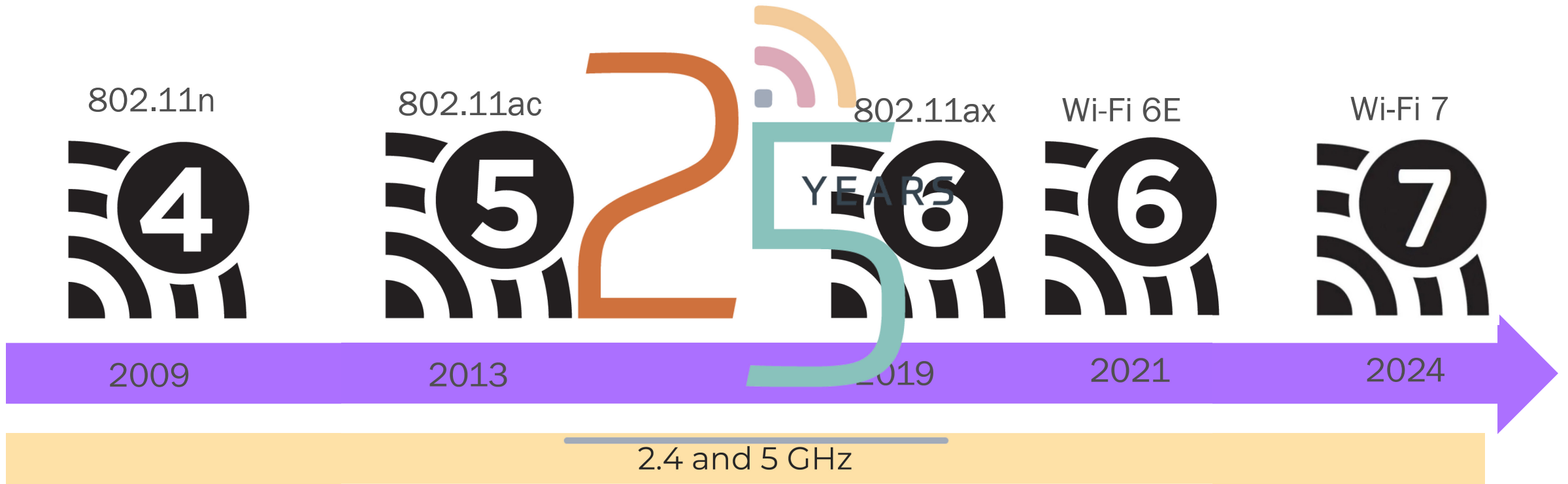
FEATURING  
**DAVID COLEMAN**  
CWNE #4

[@mistermultipath](#)

Wi-Fi is a way of Life



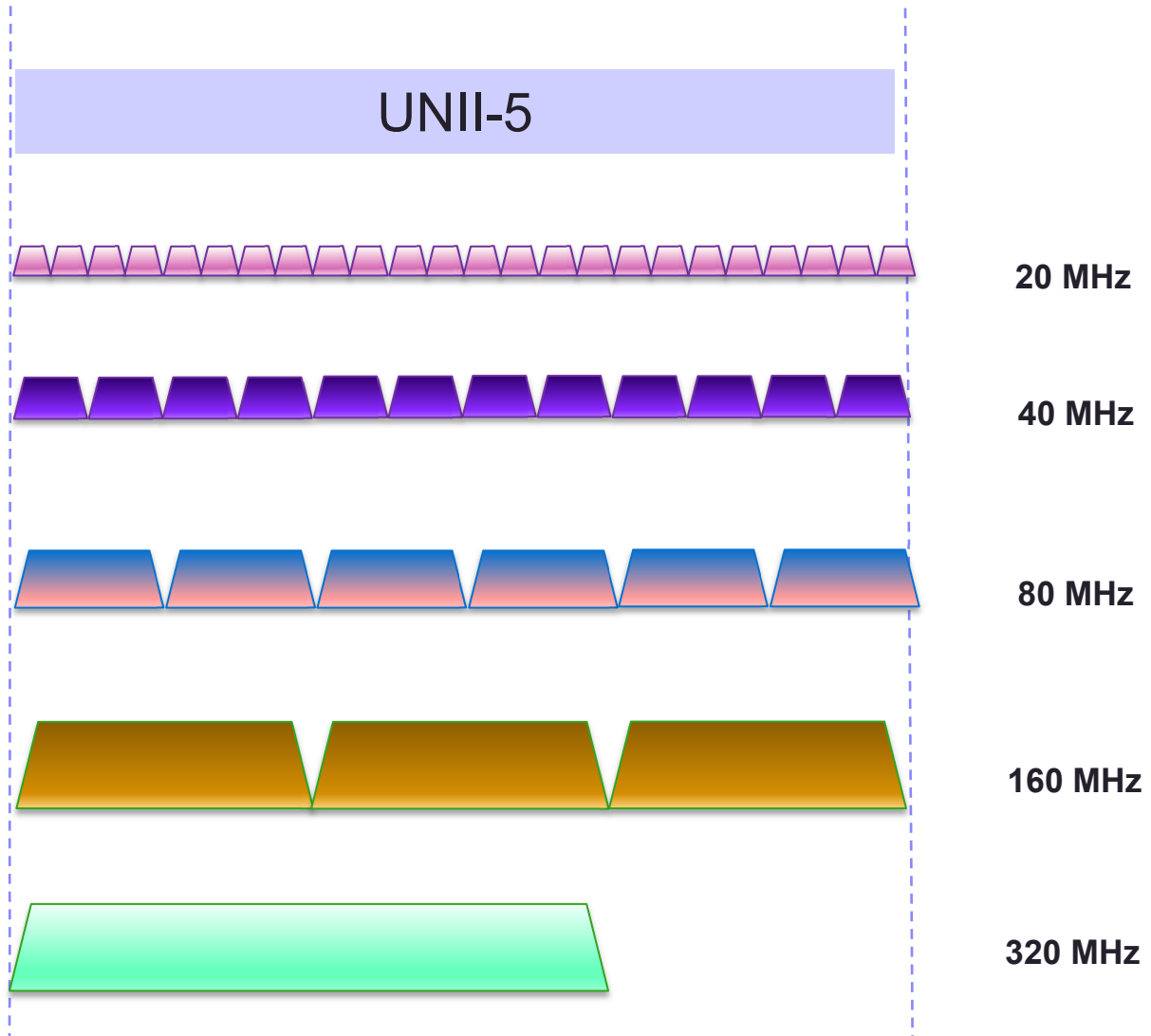
# 25 Year Anniversary of Wi-Fi



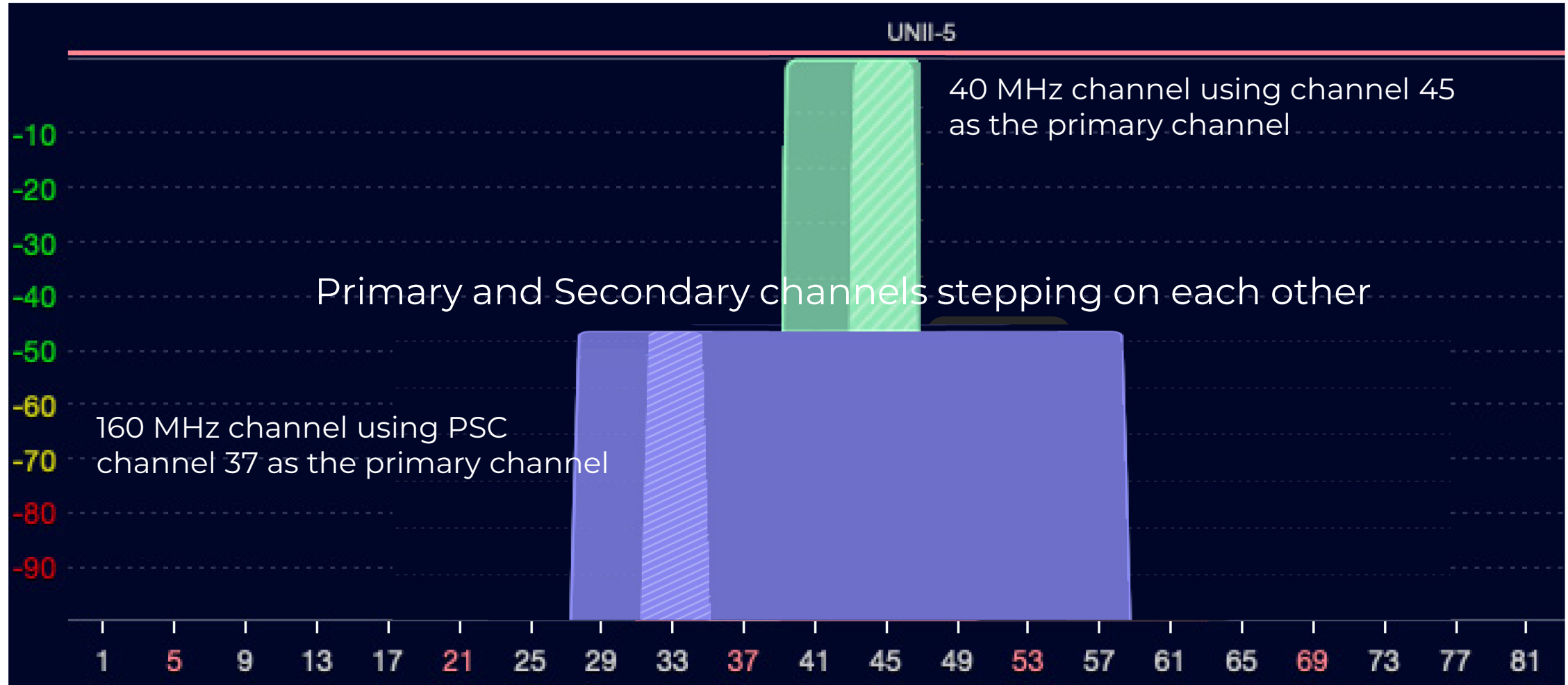


# W i-Fi 7 Bells and W histles

# 320 MHz Channels - Europe



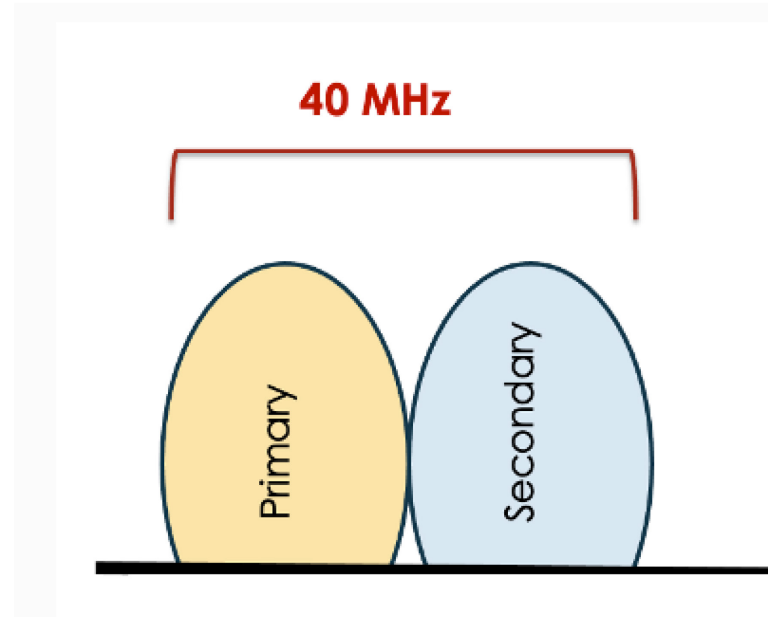
# OBSS interference



## Blog #1:



## Blog #2:



### Primary Channel

- Signal Detect (SD): 4 dB SNR
- Energy Detect (ED): SD + 20 dB

### Secondary Channel

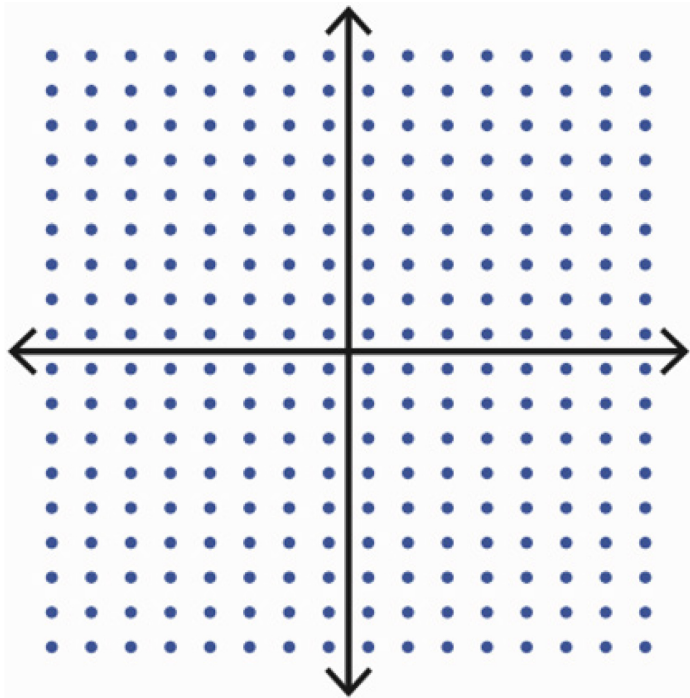
- Signal Detect (SD): -72 dBm
- Energy Detect (ED): -62 dBm



# 4K QAM – will it work?

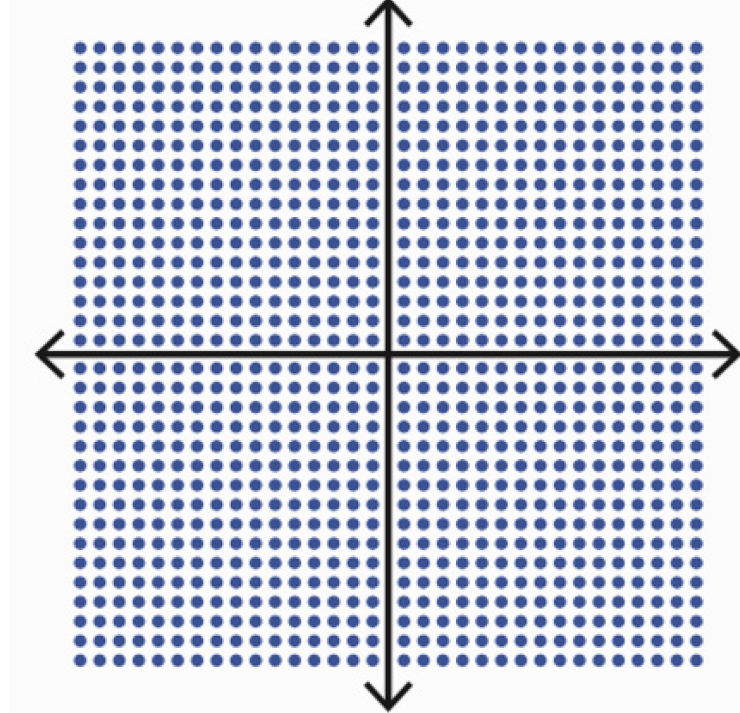


Wi-Fi 5



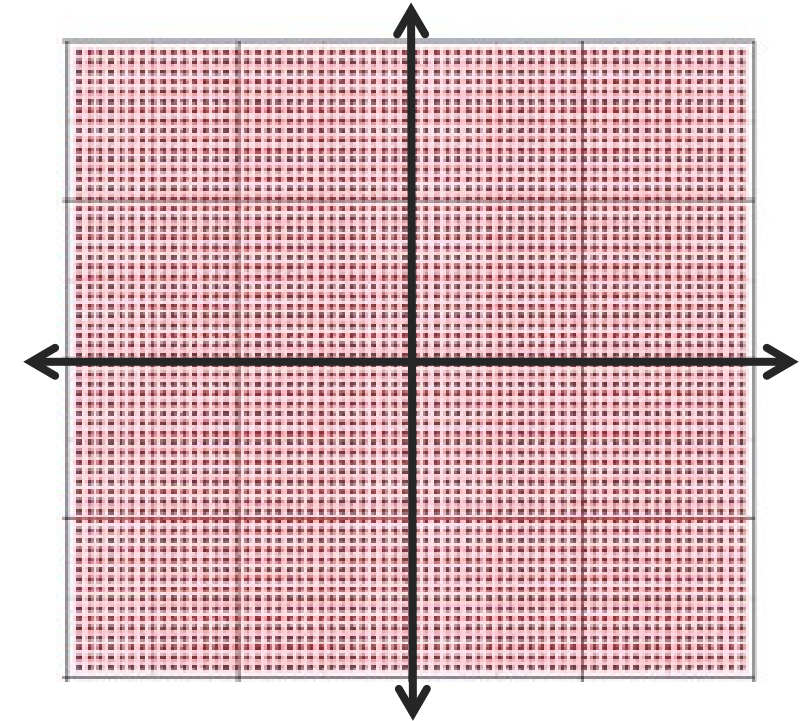
256-QAM

Wi-Fi 6/6E



1024-QAM

Wi-Fi 7

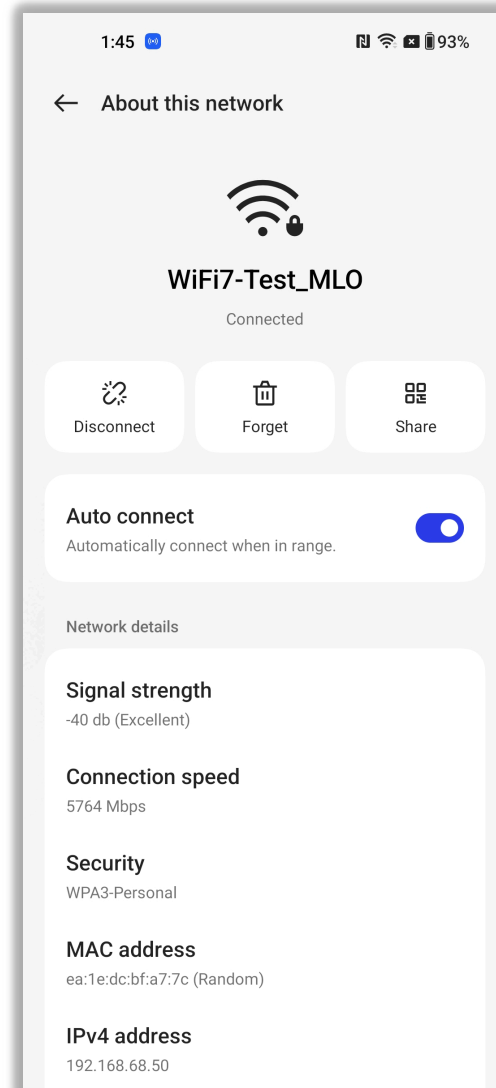


4096-QAM

## Wi-Fi 7 Client

**5764** Mbps

- MCS 13
- 2 Spatial Streams
- 4096-QAM
- 320 MHz Channel
- 0.8 $\mu$ s GI



OnePlus 11



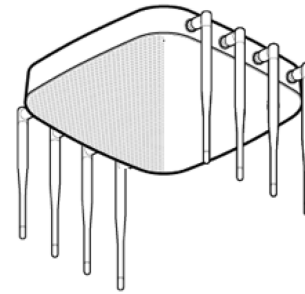
# Multi-Link Operation (MLO) – multiple bands and multiple channels



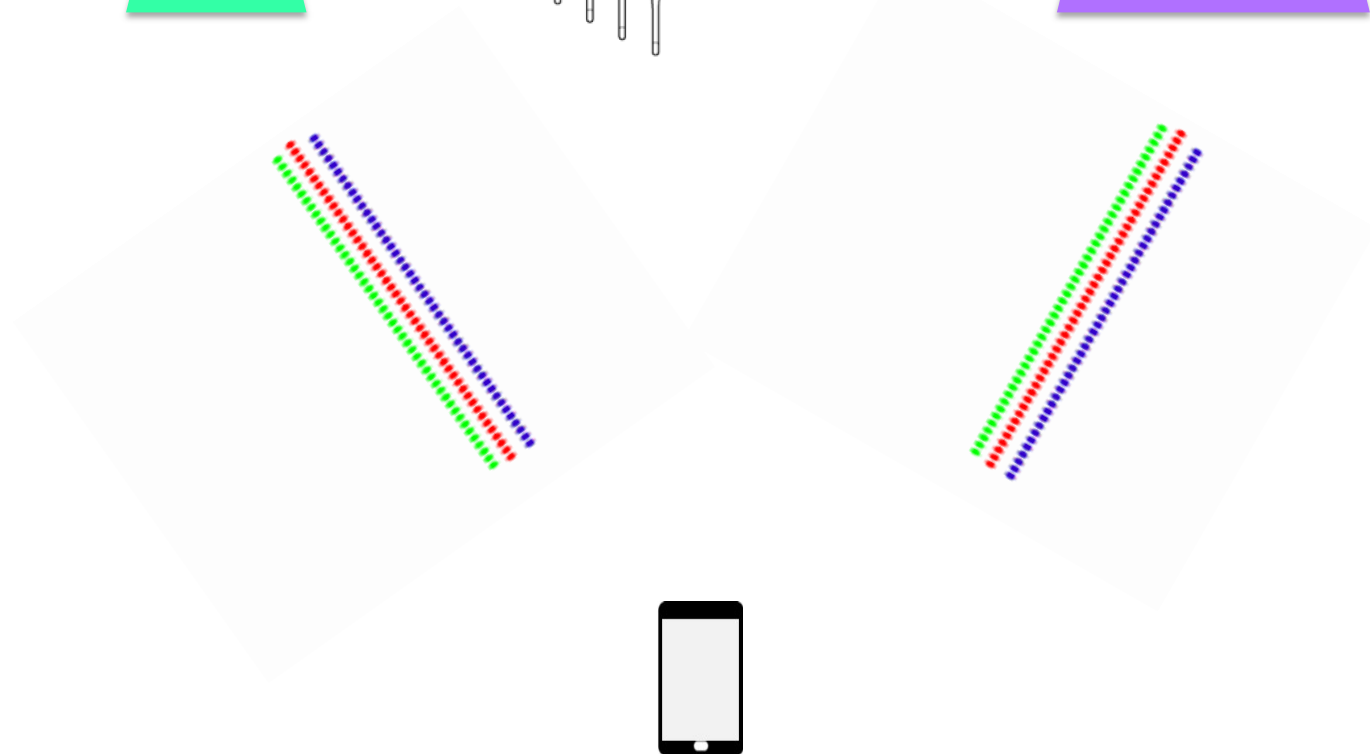
2.4 GHz – 20 MHz



5 GHz – 40 MHz



6 GHz – 80 MHz

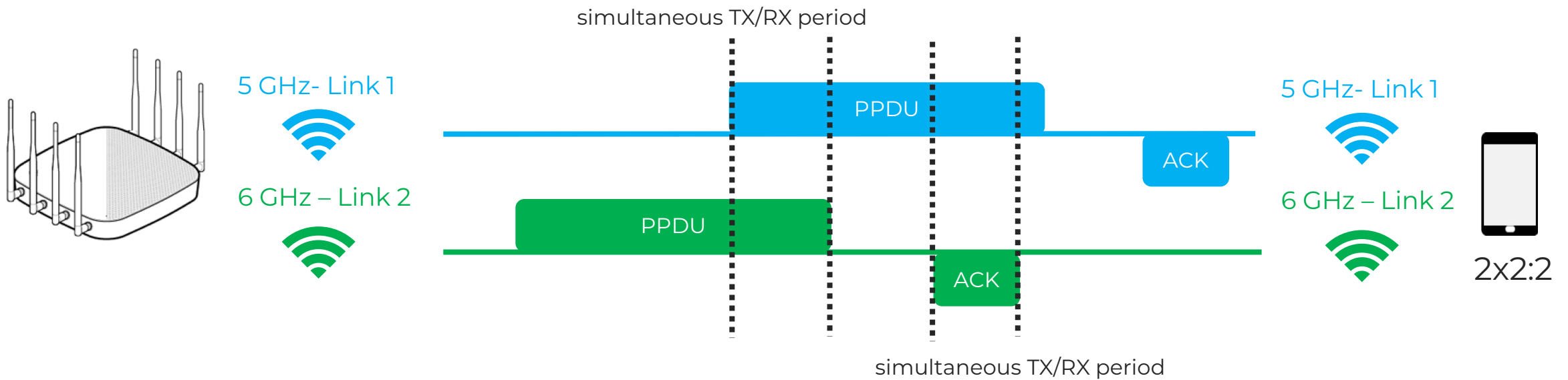


# Multi-Link Operation (MLO) – Data Aggregation



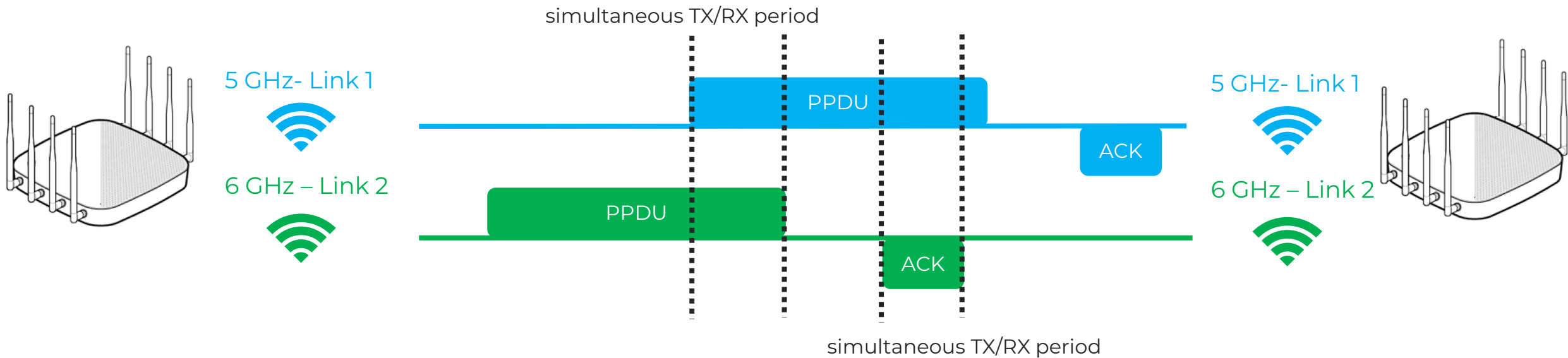


# STR MLMR channel access – MLO Aggregation



simultaneous transmit and receive multi-link multi-radio (STR MLMR)

# STR MLMR channel access – MLO Aggregation - Mesh



simultaneous transmit and receive multi-link multi-radio (STR MLMR)

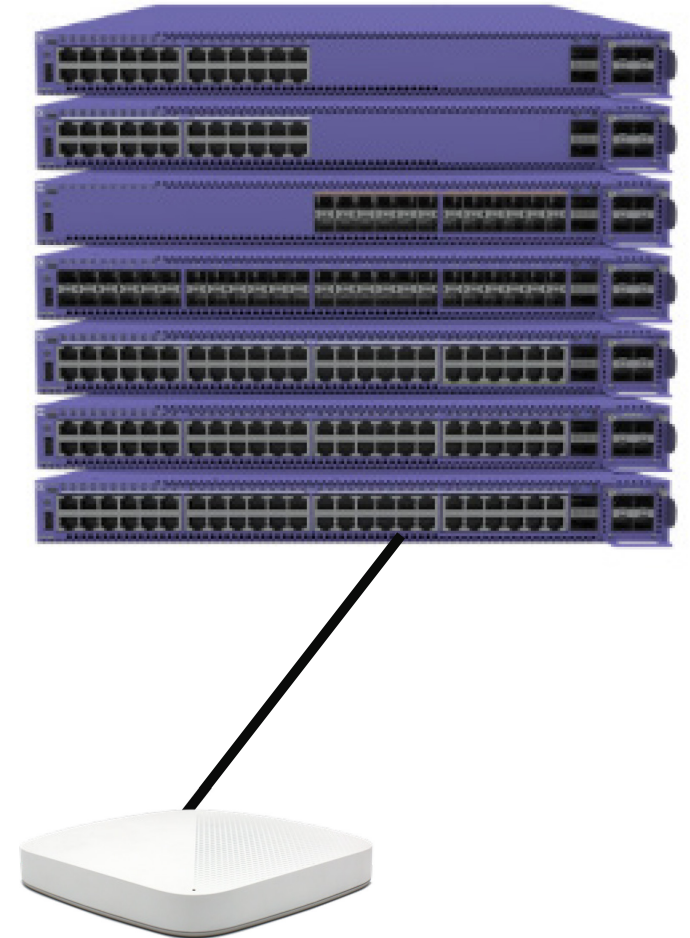
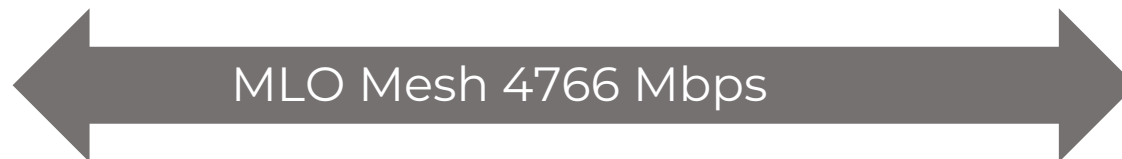
# MLO Aggregate Mesh Performance



MLO Enabled	Backhaul Interface	Bandwidth	DUT Settings	Port Used	Downstream	Upstream	Bidirectional
Yes	6 + 5 GHz	320+240MHz	Bridge mode Mesh established DFS Enabled	Master and Slave: 2.5GbE WAN Port *1 + 1GbE Port * 4	4430.933	4509.399	4766.941
No	6 GHz	320MHz			3183.355	3242.875	3689.561
No	5 GHz	240MHz			2345.161	2329.434	2515.455
				Total Throughput	5528.516	5572.309	6205.016
				Efficiency	80%	81%	77%

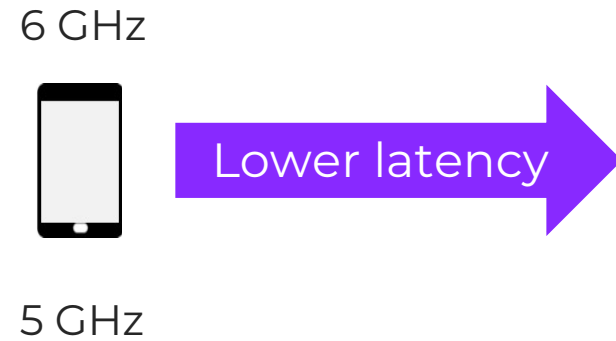
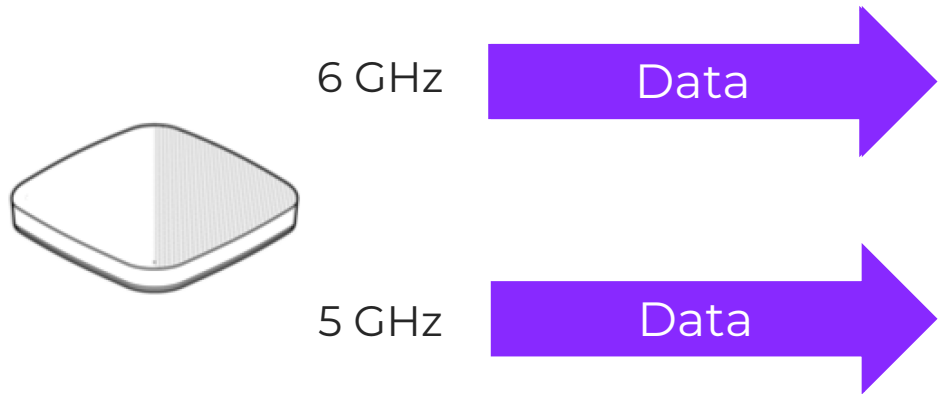


- Tri-band Wi-Fi 7 APs will make the need for **MultiGig** a requirement
- **2.5 or 5 MultiGig (802.3bz)** Ethernet ports

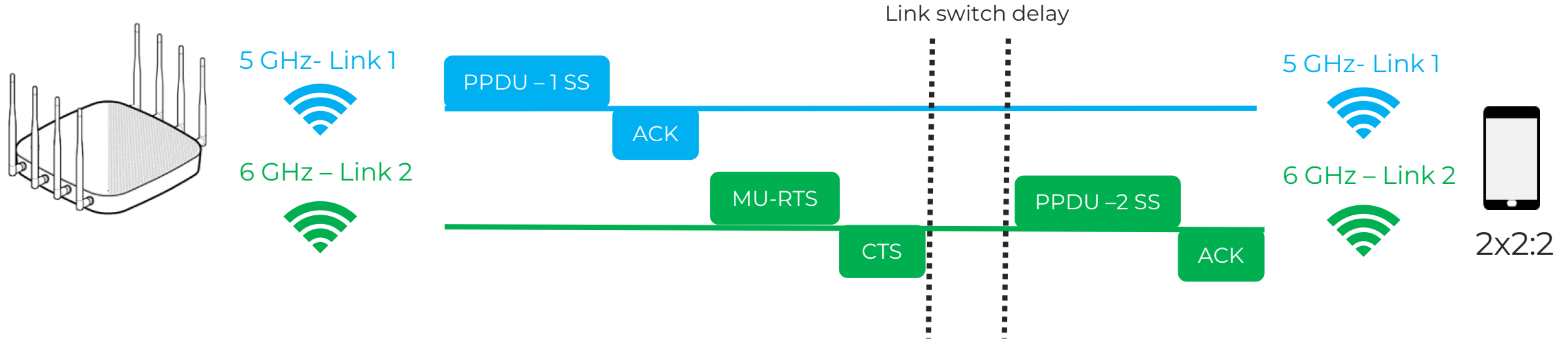




# Multi-Link Operation (MLO) – link steering



# EMLSR channel access – MLO link steering

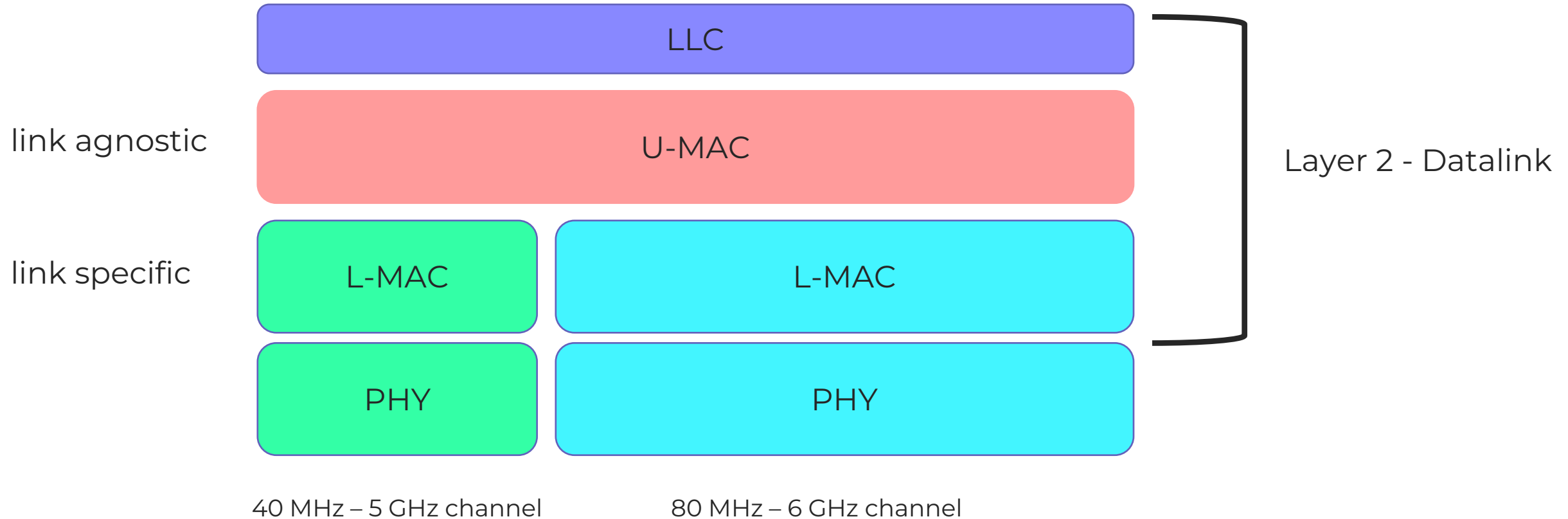


## Enhanced multi-link *single radio* (EMLSR) Channel Access

```

v Ext Tag: Multi-Link (802.11be D3.0)
  Ext Tag length: 247 (Tag len: 248)
  Ext Tag Number: Multi-Link (802.11be D3.0) (107)
  v Multi-Link Control: 0x01b0 Basic
    .... .000 = Type: Basic (0)
    .... .0... = Reserved: 0x0
    .... .1.... = Link ID Info Present: True
    .... ..1. .... = BSS Parameters Change Count Present: True
    .... .0... = Medium Synchronization Delay Info Present: False
    .... .1... = EML Capabilities Present: True
    .... .1.... = MDL Capabilities Present: True
    .... ..0. .... = AP MLD ID Present: False
    .... .0... = Extended MLD Capabilities and Operations Present: False
    0000 000. .... = Reserved: 0x00
  v Common Info
    Common Info Length: 13
    MLD MAC Address: TPLink_66:77:6d (50:91:e3:66:77:6d)
    > Link ID subfield: 0x02
    BSS Parameters Change Count: 0
    v EML Capabilities: 0x0001, EMLSR Support
      .... .1 = EMLSR Support: True
      .... .000. = EMLSR Padding Delay: 0
      .... .000 .... = EMLSR Transition Delay: 0
      .... .0... = EMLMR Support: False
      .... .000 .... = EMLMR Delay: 0
      .... .000 0... = Transition Timeout: 0
      .... .0... = Reserved: 0x0
    > MLD Capabilities: 0x0041
  
```

# Multi-Link Operation (MLO) - Two MAC layers

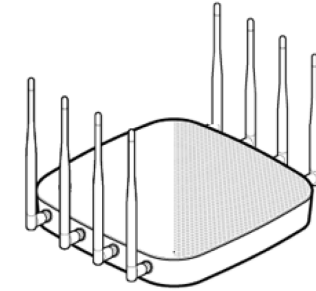
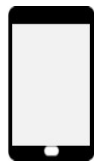





# MLD MAC Address



Extension: Multi-Link	Basic, MLD MAC Address: 50:91:E3:66:77:6D, Link ID: 2
Extension ID:	107
Length:	15 bytes
Multi-Link Control:	0x01b0
.....000	Type: Basic (0x0000)
.....0...	Reserved
.....1....	Link ID Info Present: Yes
.....1....	BSS Parameters Change Count Present: Yes
.....0....	Medium Synchronization Delay Information Present: No
.....1....	EML Capabilities Present: Yes
.....1....	MLD Capabilities And Operations Present: Yes
.....0....	AP MLD ID Present: No
.....0....	Extended MLD Capabilities And Operations Present: No
0000 0....	Reserved
Common Info	
Common Info Length:	13
MLD MAC Address:	50:91:E3:66:77:6D
Link ID Info:	0x02
BSS Parameters Change...	0
EML Capabilities:	0x0001
MLD Capabilities and Op...	0x0041





Multi-Link Element (MLE)	
MLD Common information	
client radio 1 info (2.4 GHz)	
client radio 1 info (5 GHz)	
client radio 1 info (6 GHz)	

Multi-Link Element (MLE)	
MLD Common information	
AP radio 1 info (2.4 GHz)	
AP radio 1 info (5 GHz)	
AP radio 1 info (6 GHz)	

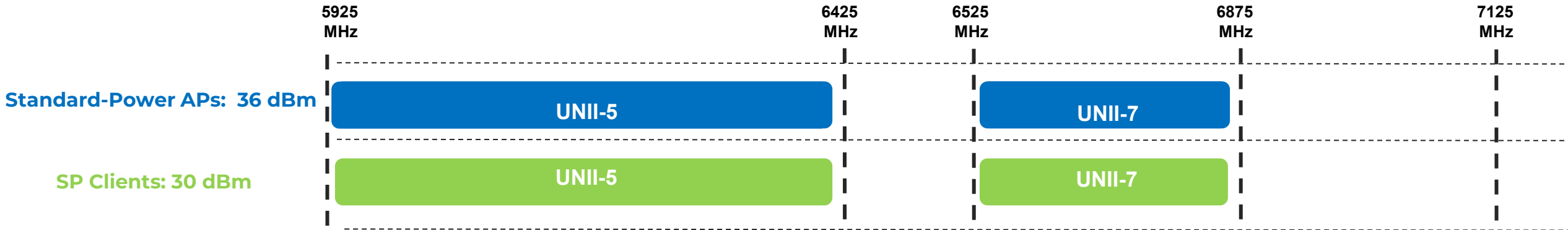


# Multi-Link Discovery and Setup



Will Wi-Fi 7 drive Standard Power?

# 6 GHz – Standard power class devices

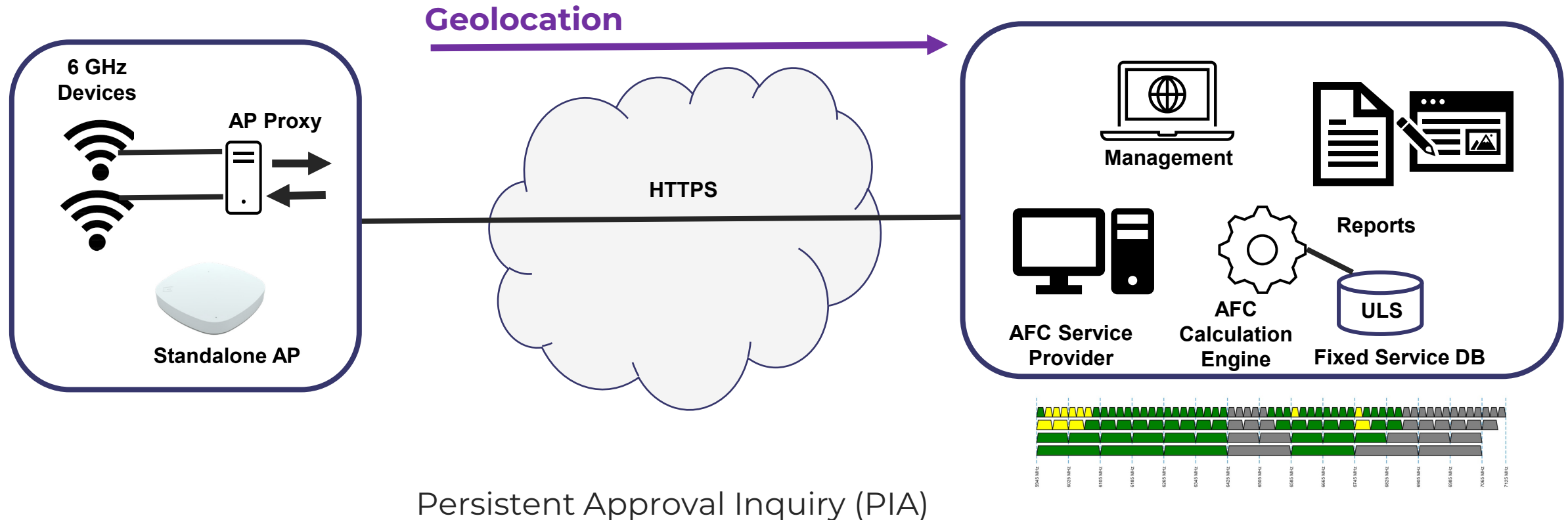


**Automated Frequency Coordination (AFC) required**



- AFC required
- External antenna connectors allowed
- Weatherized enclosure allowed

AFC Service provides maximum permissible transmission power levels that are available for use by standard power devices operating in the allowed 6 GHz sub-bands



Persistent Approval Inquiry (PIA)

# Dual Client – Standard Power and LPI



Status	MAC Address	Hostname	Device Type	Network ▲
●	96:9F:75:FC:30:D0	Galaxy-S21-Ultra-5G-Coleman	Android	Coleman-AFC
●	FE:08:9B:9E:B4:FF	Pixel-8	Android	Coleman-AFC
●	5C:1B:F4:9A:38:1A	Mac-mini	Mac OS X 10.7+	Coleman-AFC

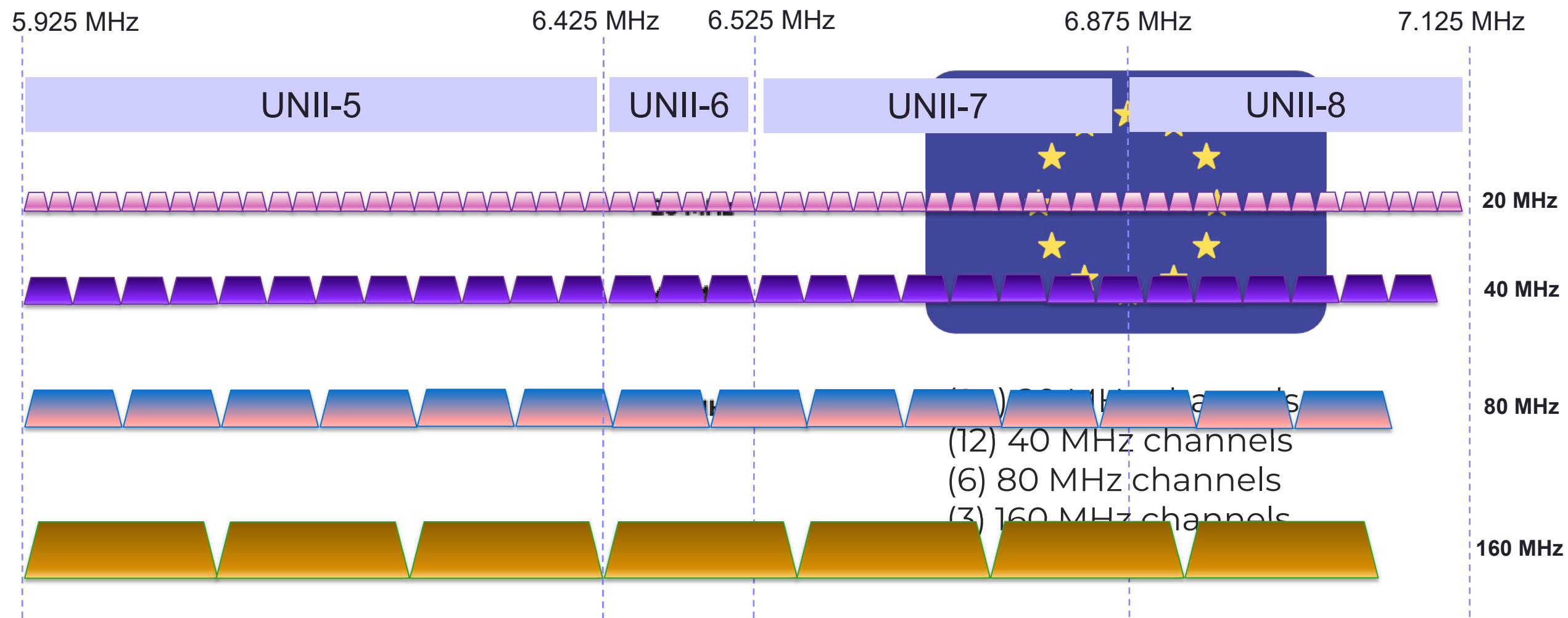
- Already 1000+ clients have been certified to use both Standard Power or LPI (Dual-Client)
- There is no guarantee that all first-generation LPI Wi-Fi 6E clients will be recertified as “Dual-Client”

Class II Permissive Change	1/17/24
Class II Permissive Change	1/17/24
Class II Permissive Change	1/17/24
Class II Permissive Change	1/17/24
Class II Permissive Change	1/17/24



Google Pixel 8

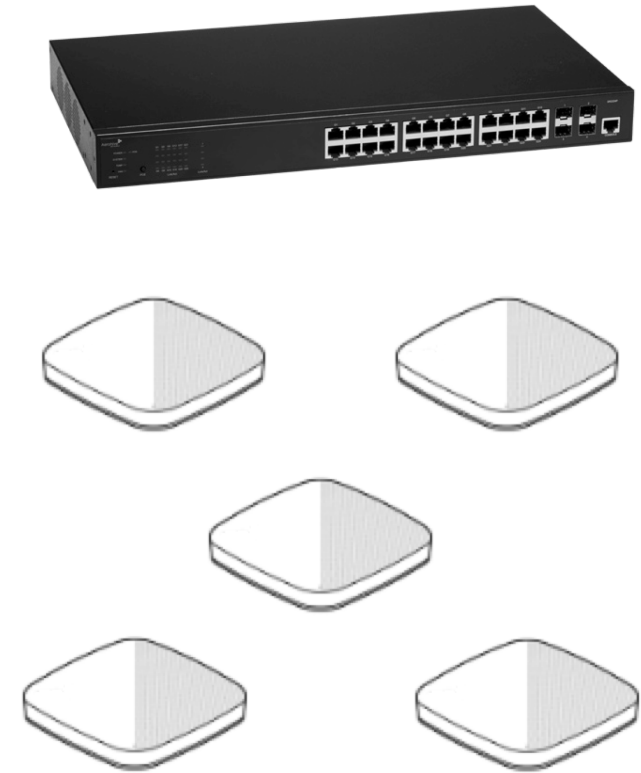
# 6 GHz – The Wi-Fi superhighway for the next 10 years and beyond



# Wi-Fi 7 and 6 GHz Design Considerations



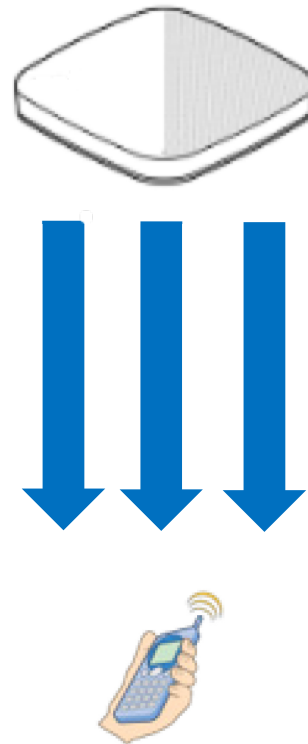
- The extra radio chains of tri-band radios require more power
- 802.3at PoE Plus power of 25 watts *will* be required in **tri-band 2x2x2** APs
- 802.3bt PoE power of 30+ watts *will* be required in **tri-band 4x4x4** APs for all the radio chains





## 5 GHz channel (100)

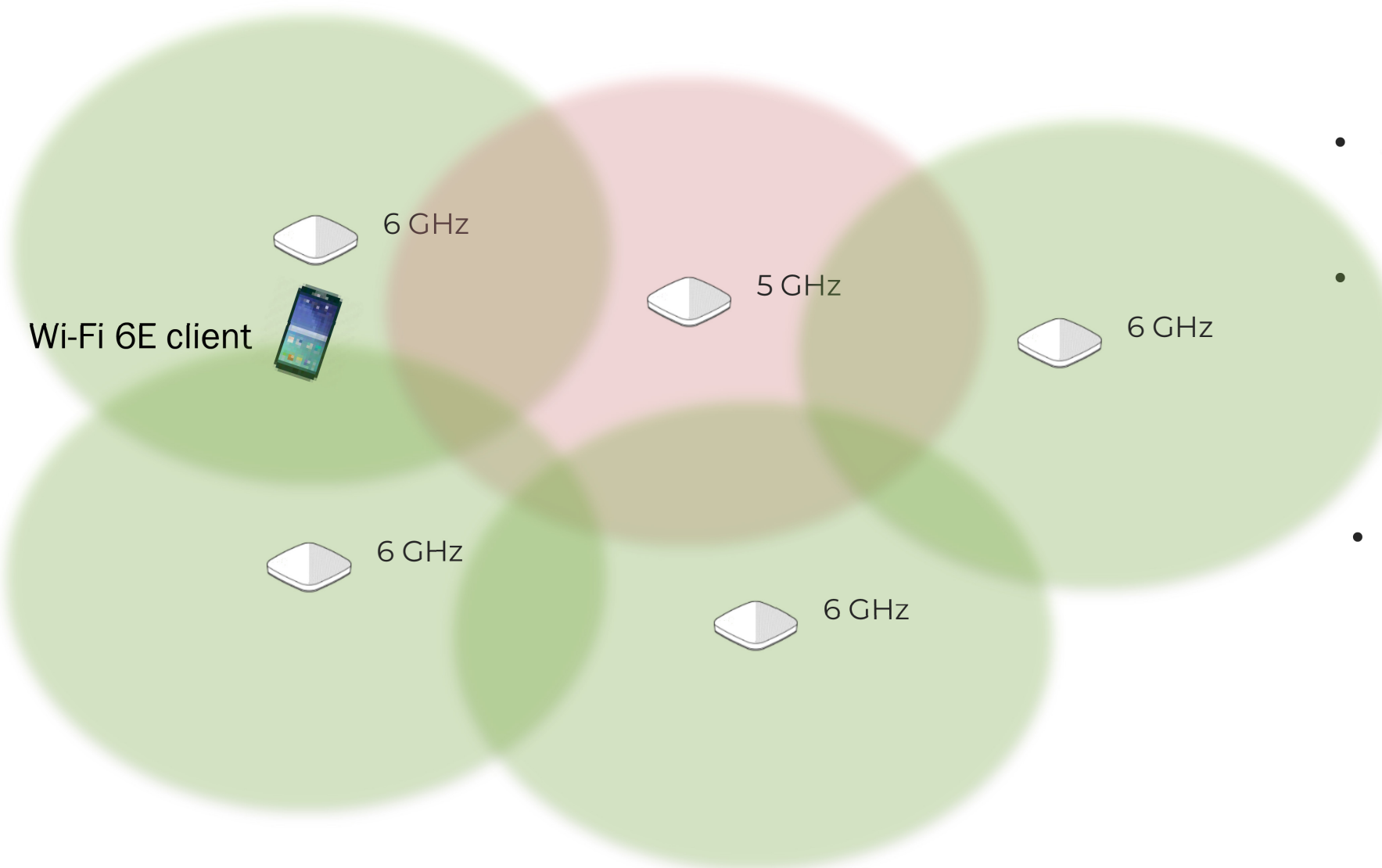
- SSID: **eduroam**
  - WPA3-Enterprise (802.1X)  
(with transition modes)
- SSID: **BYOD**
  - WPA2-Personal (PSK)
- SSID: **guest**
  - Open



## 6 GHz channel (37)

- SSID: **eduroam**
    - WPA3-Enterprise (802.1X)
  - SSID: **BYOD-6**
    - WPA3-Personal (SAE)
- MLO SSIDs (all three bands)**
- SSID: **employee-MLO**
    - WPA3-Enterprise (802.1X)

# Alternative Design – 5 GHz for roaming and 6 GHz for capacity



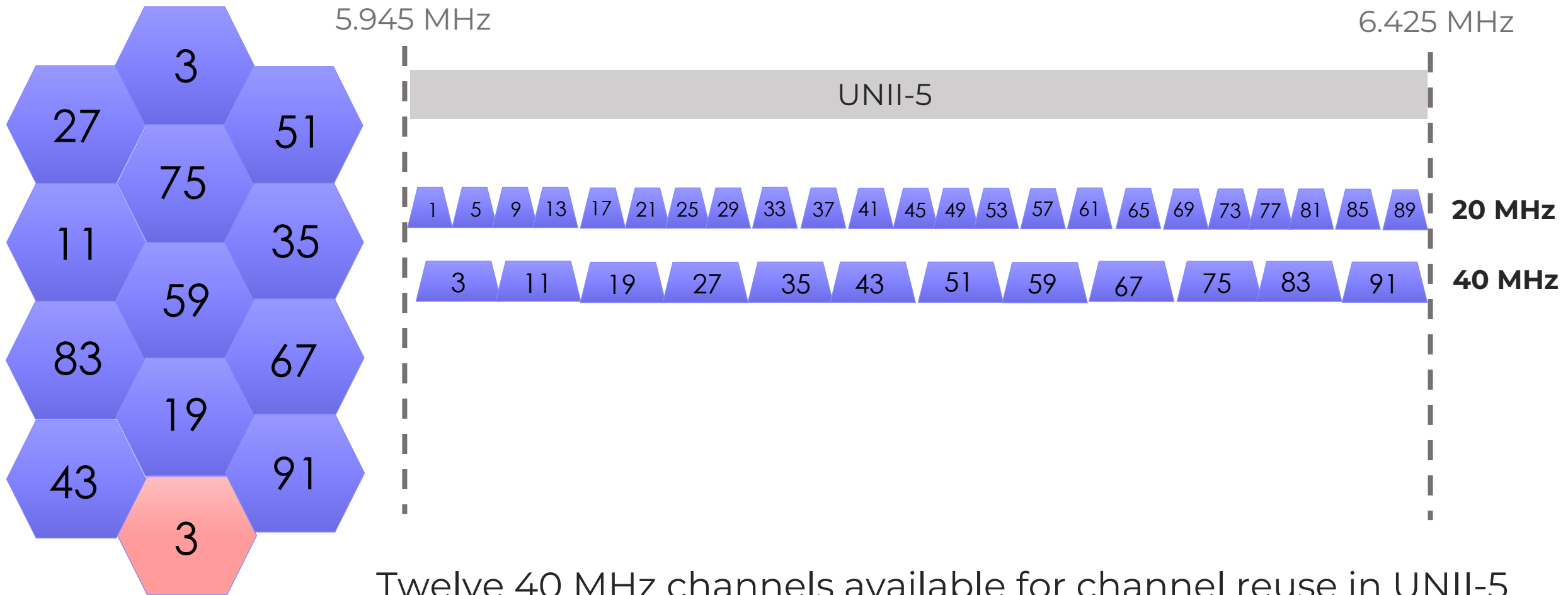
## 5 GHz

- SSID: **employee**
  - WPA2-Enterprise (802.1X)
- SSID: **Critical-APP**
  - WPA3-Enterprise (802.1X) (no transition modes)

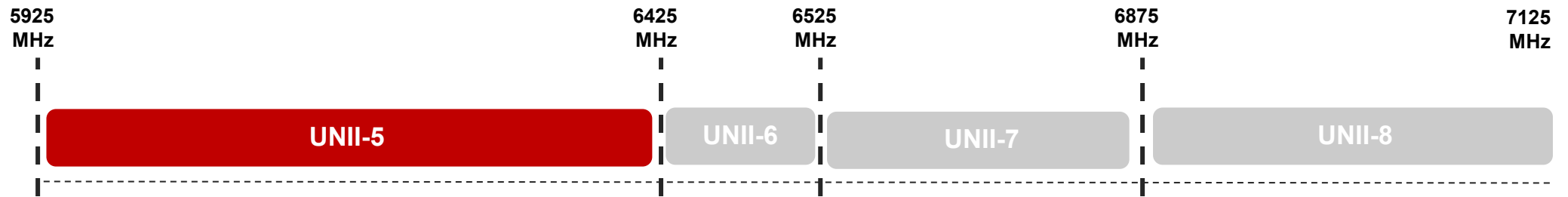
## 6 GHz

- SSID: **Critical-APP**
  - WPA3-Enterprise (802.1X)

# Europe – 40 MHz Design

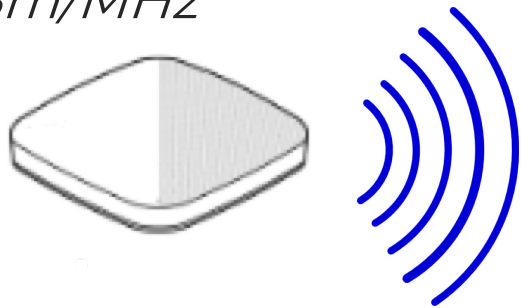


# RANGE? - Low Power Indoor (LPI) class devices – EU



## Low-Power APs: 23 dBm EIRP

*PSD is 10 dBm/MHz*



## LPI Clients: 23 dBm EIRP

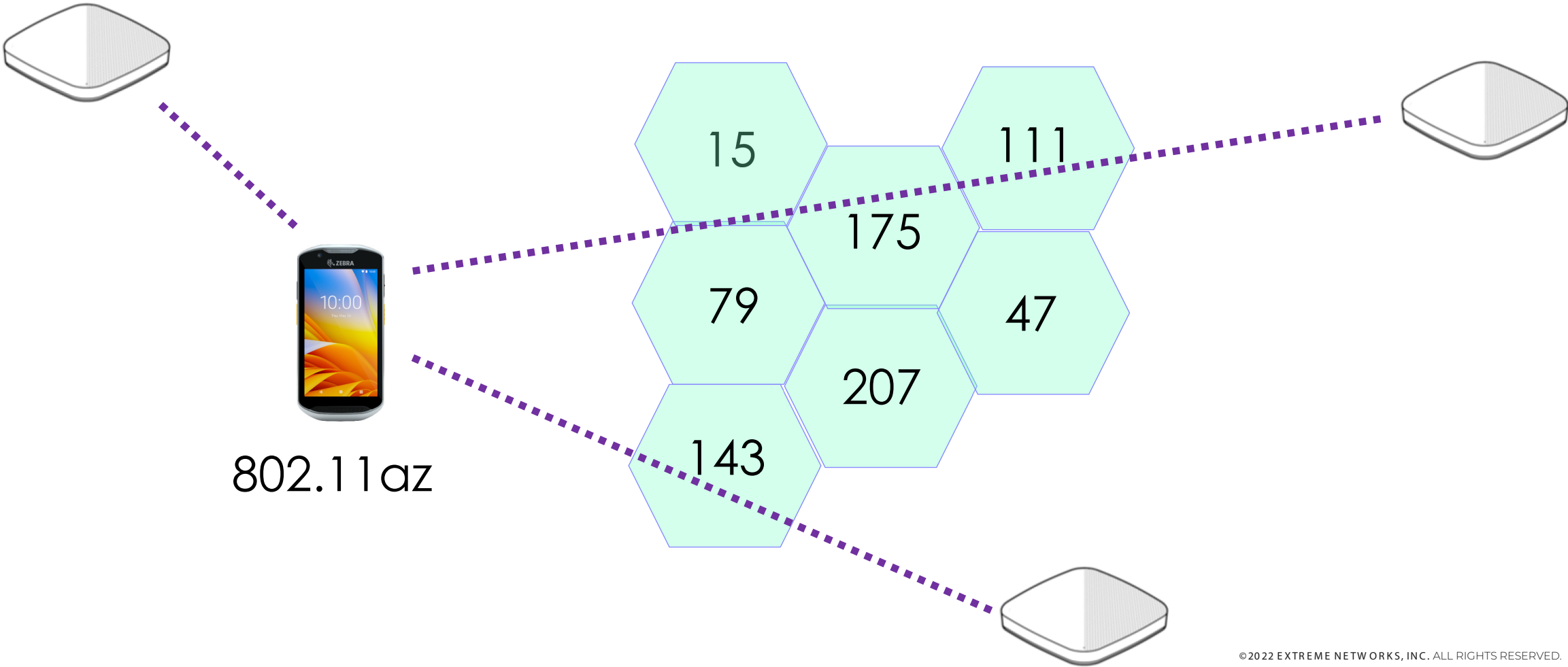
*PSD is 10 dBm/MHz*



# 160 MHz design for 802.11az device location accuracy



Seven 160 MHz channels available for channel reuse



802.11az

# 6 GHz – The Wi-Fi superhighway for Wi-Fi 6E, Wi-Fi 7, Wi-Fi 8, Wi-Fi 9....



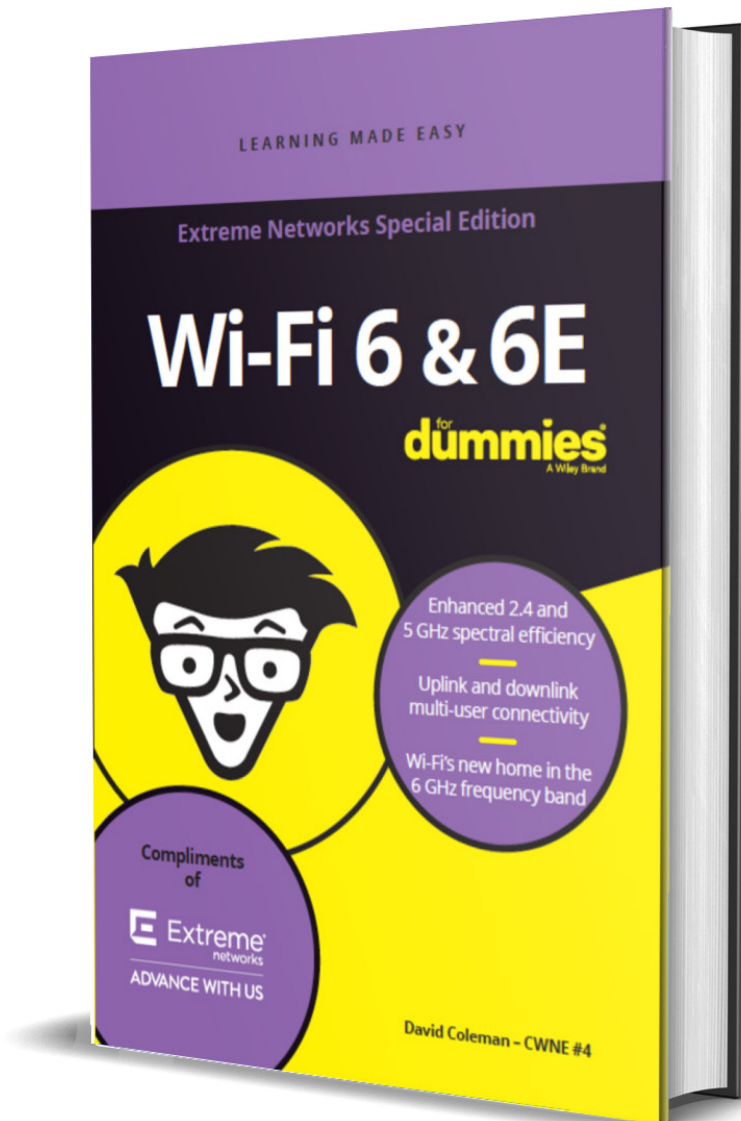
It's not the features... It's the spectrum





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# Supplemental

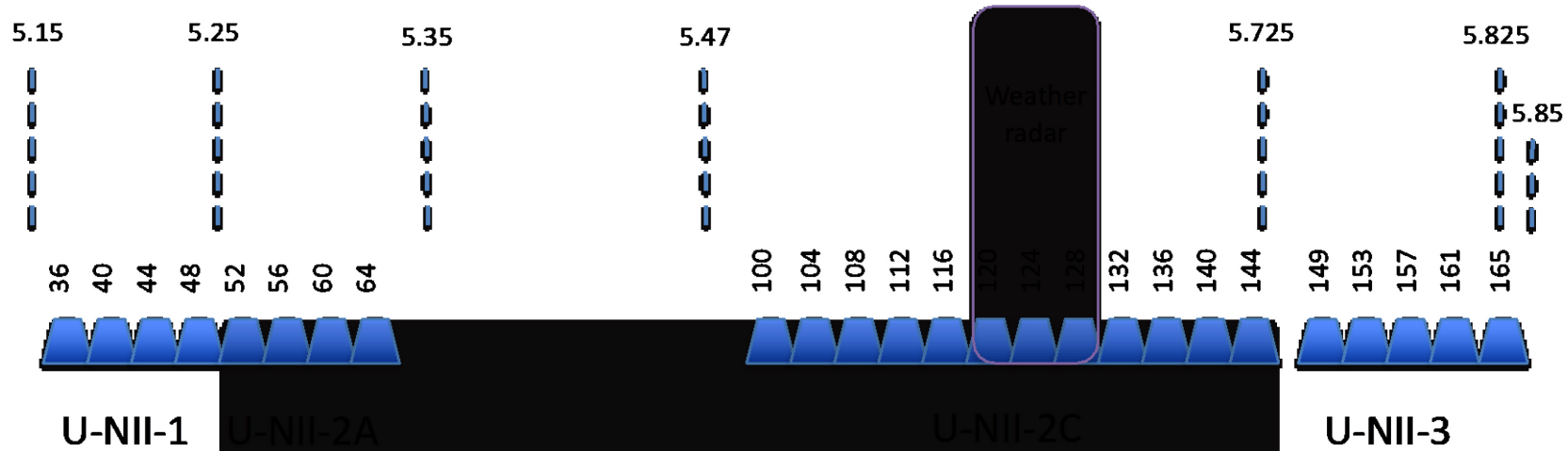


Download your free copy:

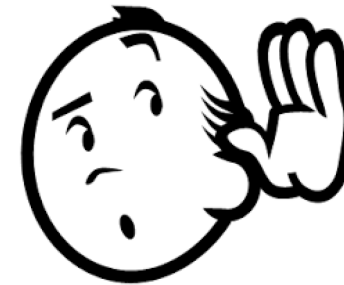
<https://bit.ly/WiFi6E-Dummies>



# MLO considerations - DFS and RRM

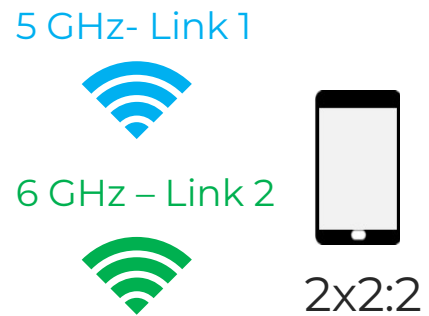
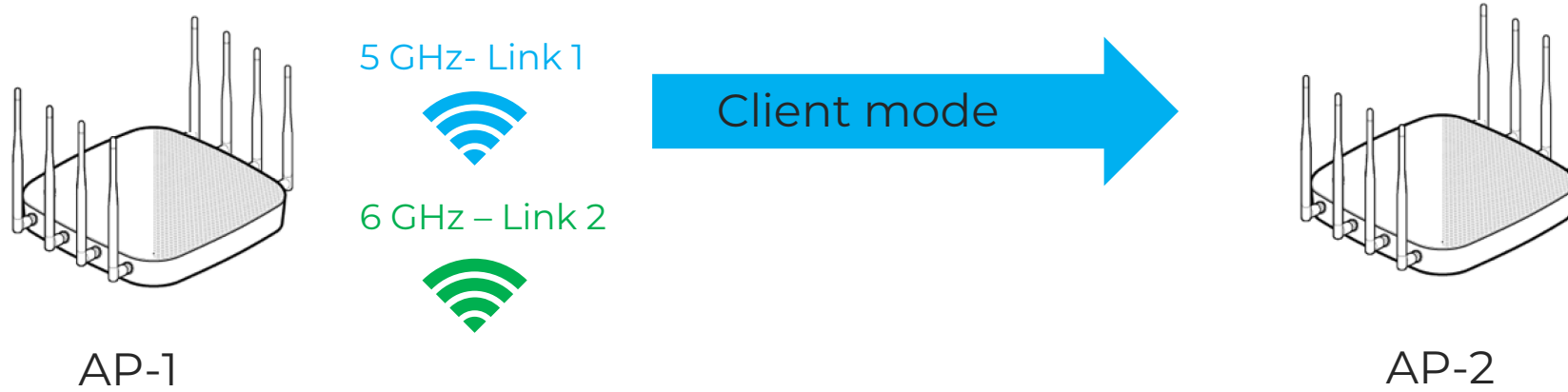


Do I hear radar pulses?

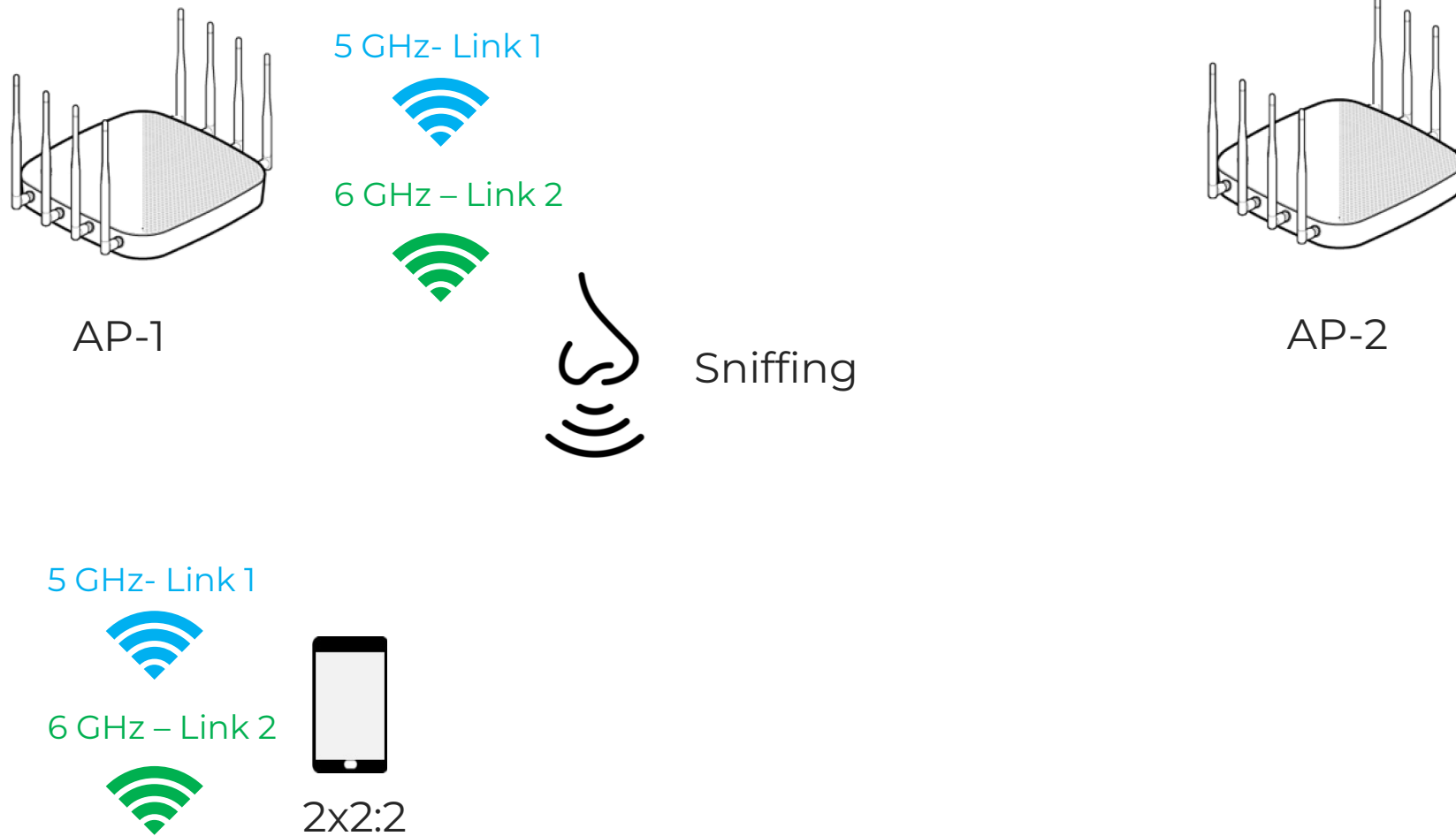


Dynamic Frequency Selection

# MLO considerations – Multilink Reconfiguration (AP Removal)



# MLO considerations – Multilink Reconfiguration (AP Removal)

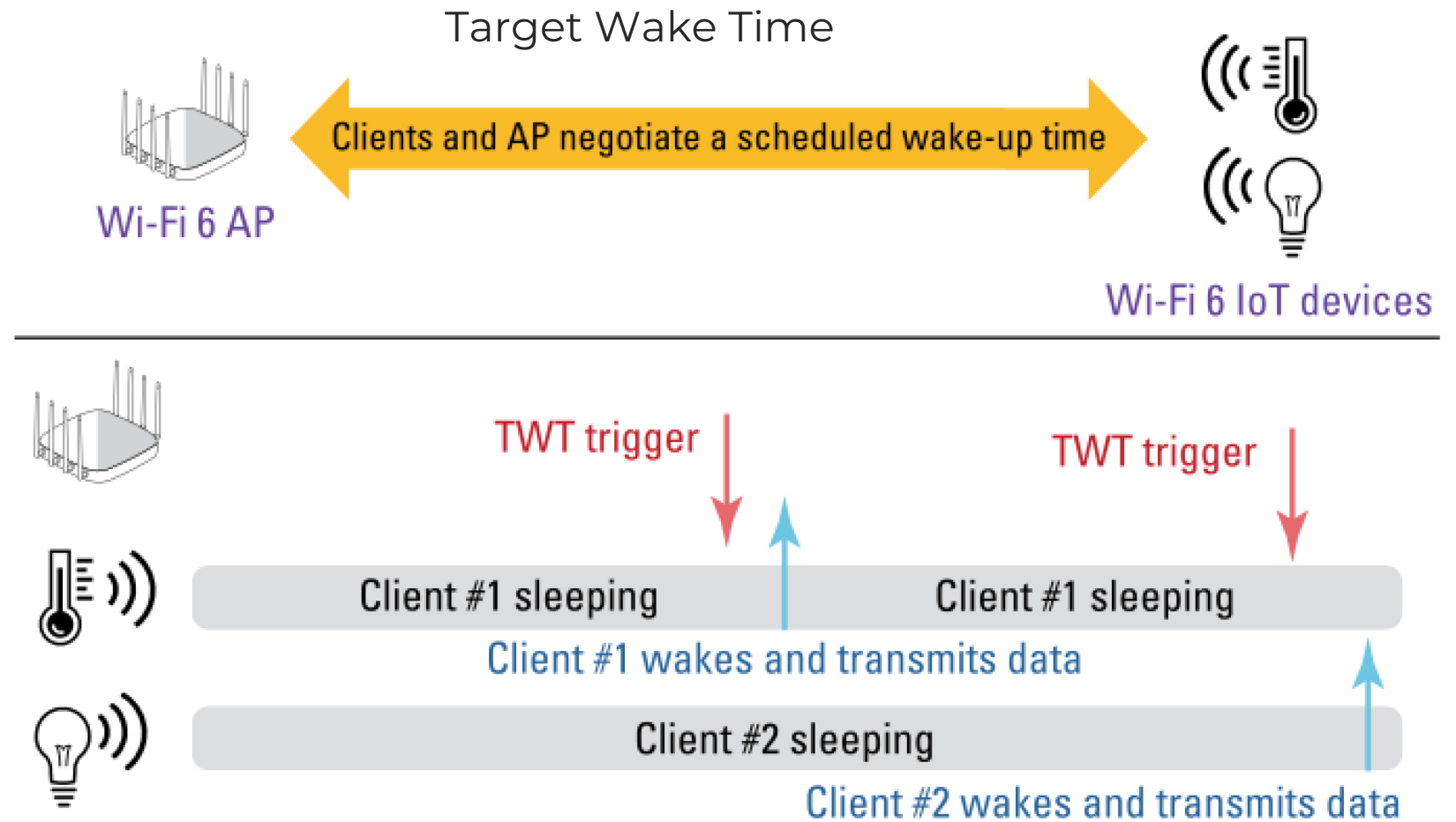


# Multi Link Power Save



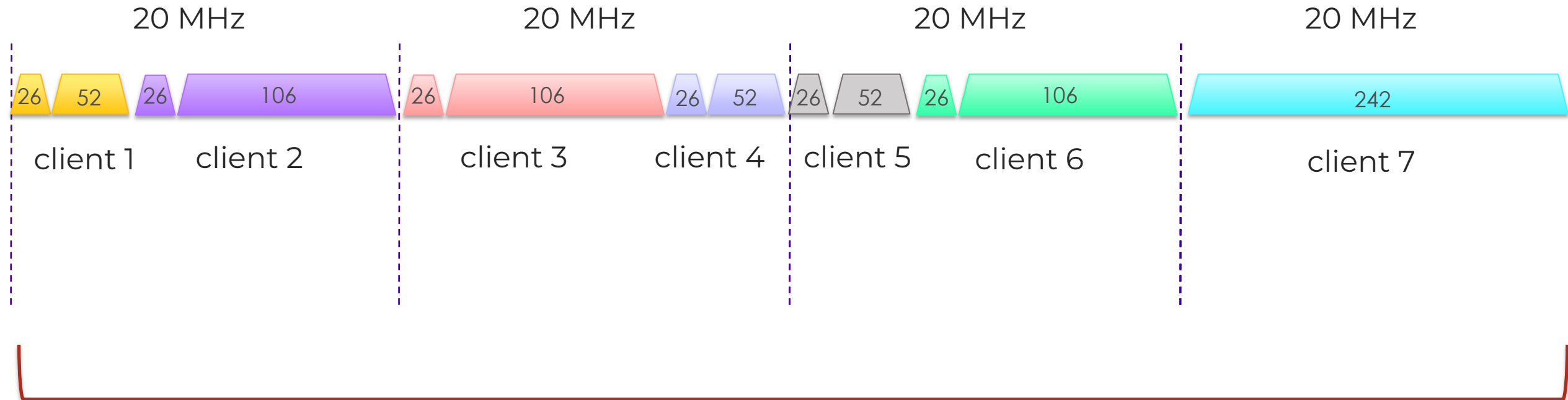
## TIM and DTIM

```
network media info
+ 802.11 MAC header
- 802.11 frame body
  timestamp : 18940888
  beacon interval : 100 TUs
+ capability info
+ info : SSID (0)
+ info : supported rates (1)
+ info : DS param set (3)
- info : TIM (5)
  length : 4
  next DTIM : 0 beacon(s)
  DTIM period : 1 beacon(s)
  AID 0 traffic indicator : 0
  TIM offset : 0
  AID 0 traffic indicator : 0
  AID 1 traffic indicator : 0
  AID 2 traffic indicator : 0
  AID 3 traffic indicator : 0
  AID 4 traffic indicator : 0
  AID 5 traffic indicator : 0
  AID 6 traffic indicator : 0
  AID 7 traffic indicator : 0
```





# Multi RU – multiple resource unit (small)



small MRU sizes:  
26 tone + 52 tone  
26 tone + 106 tone

80 MHz

# Multi RU – multiple resource units (large)



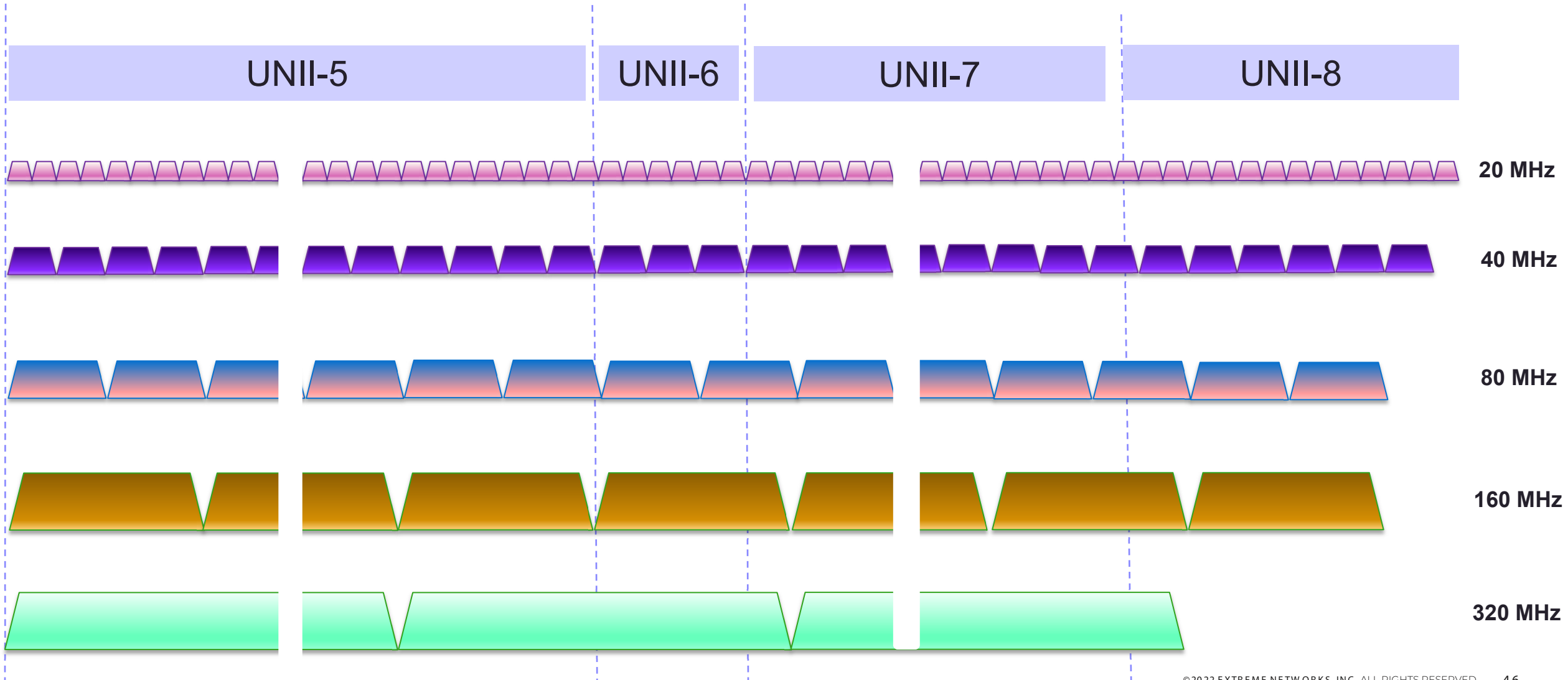
Large MRU sizes:

242 tone + 484 tone

484 tone + 996 tone

Other various combos for 160 MHz and 320 MHz channels

# Puncturing in 6 GHz.



# Wi-Fi 8 - Multiple AP Operation

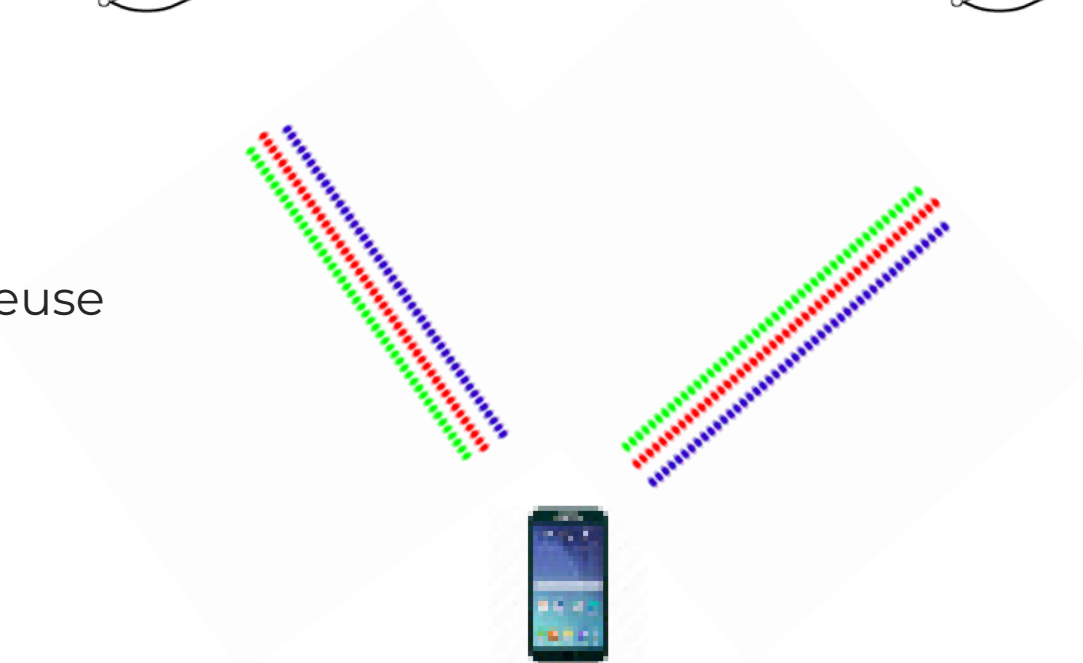


## MAC methods:

- Coordinated OFDMA
- Coordinated Spatial Reuse
- Coordinated TDMA

## PHY methods:

- Coordinated Beamforming
- Coordinated Joint Processing





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