Wi-Fi Technology Fundamentals

Module-5

Advanced Features and Standard Extensions

Session-5c

WiFi6E New Features- 6GHz Channels, AFC, RNR, FILS, PCS

Last Session Recap……

Module-5
Advanced Features and Standard Extensions
Session-5b
WiFi6 New Features

- ✓ OFDMA
- ✓ Mu-MIMO
- ✓ 1024 QAM
- ✓ BSS Coloring
- ✓ TWT

How to Stay Connected?

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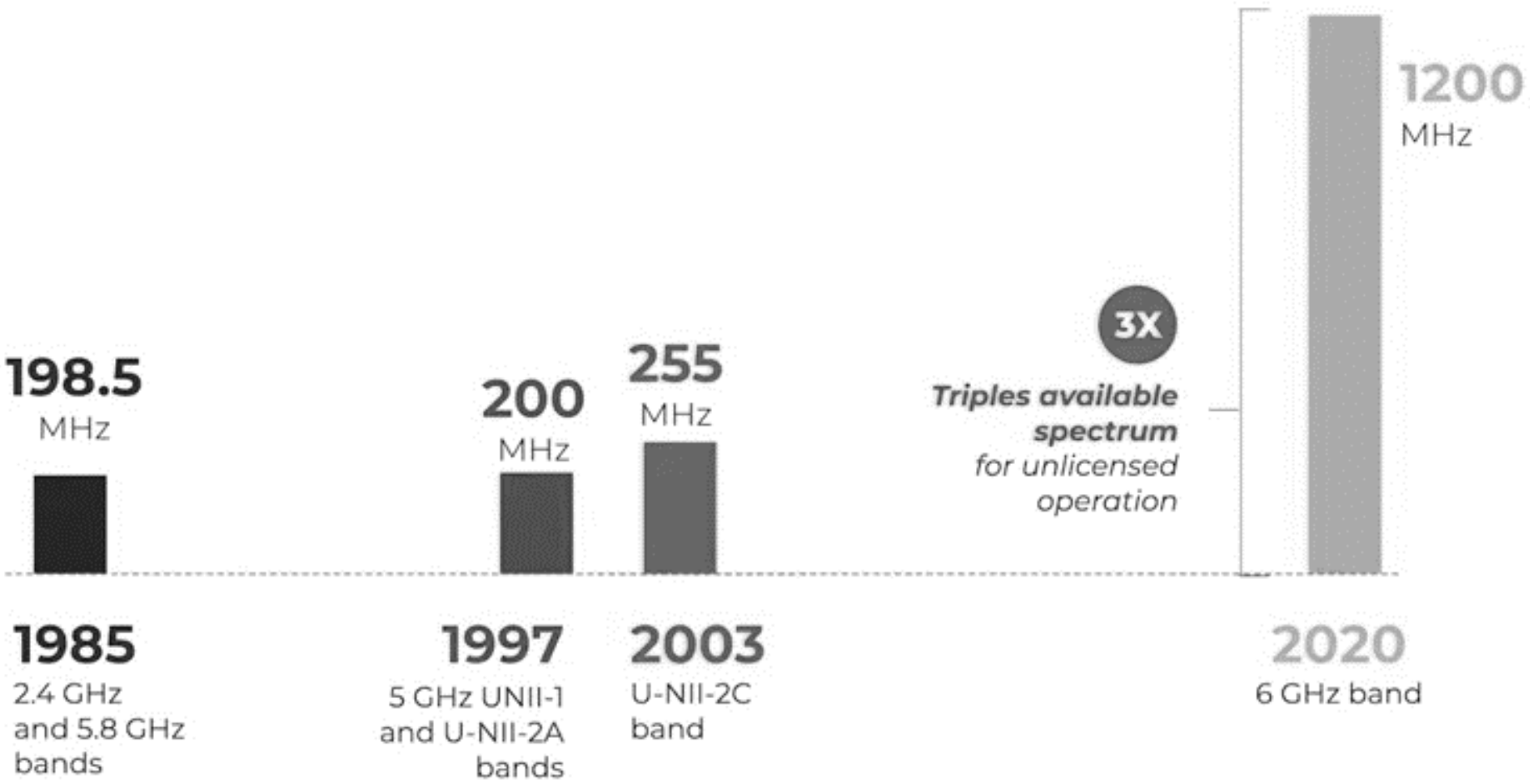
WiFi Technology Generations

	Wi-Fi 4 (IEEE 802.11n)	Wi-Fi 5 (IEEE 802.11ac)	Wi-Fi 6 (IEEE 802.11ax)	Wi-Fi 6E (IEEE 802.11ax)	Wi-Fi 7 (IEEE 802.11be)
Frequency bands operations	2.4GHz (2.402 - 2.494) 5GHz (5.030 - 5.990)	5GHz (5.030 - 5.990)	2.4GHz (2.402 - 2.494) 5GHz (5.030 - 5.990)	2.4GHz (2.402 - 2.494) 5GHz (5.030 - 5.990) 6GHz (5.925 7.125)	2.4GHz (2.402 - 2.494) 5GHz (5.030 - 5.990) 6GHz (5.925 7.125)
Maximum bandwidth per channel	2.4GHz: 40MHz 5GHz: 40MHz	2.4GHz: 40MHz 5GHz: 80MHz	2.4GHz: 40MHz 5GHz: 160MHz	2.4GHz: 40MHz 5GHz: 160MHz 6GHz: 160MHz	2.4GHz: 40MHz 5GHz: 160MHz 6GHz: 320MHz
Maximum number of non-overlapping channels	2.4GHz: 3 Channel:1,6,11	5GHz: Channels:36,52 (80MHz)	2.4GHz: 2 (40MHz) Channel:1,11 5GHz: Channel 36: 5.180 GHz to 5.340 GHz (160 MHz width) or Channel:36,52,100,116,132(80 MHz)	2.4GHz: 2 (40MHz) Channel:1,5,9,13 5GHz: Channel 36: 5.180 GHz to 5.340 GHz (160 MHz width) Channel 36,52,100,116,132 (80MHz) 6GHz: 7 (160MHz)	2.4GHz: Channel 1,5,9,13 (40MHz) 5GHz: 2 (160MHz) or Channel 36,149 (80MHz) 6GHz: Channel 31, 63, 95, 127, 159, 191 (320MHz)
Maximum MIMO configuration	4x4	4x4	8x8	8x8	16x16
Highest modulation	64 QAM	256 QAM	1024 QAM (1K QAM)	1024 QAM (1K QAM)	4096 QAM (4K QAM)
Maximum PHY datarate	600 Mbps	1.73 Gbps	9.6 Gbps	9.6 Gbps	46.1 Gbps
Multi user MIMO (MU-MIMO)	N/A	Downlink (Wave 2 only)	Downlink Uplink	Downlink Uplink	Downlink Uplink
Multi user OFDMA (bandwidth sharing)	N/A	N/A	Yes	Yes	Yes
Target Wake Time (TWT)	N/A	N/A	Yes	Yes	Yes (improved)
Multi Link Operation / Multi Resource Unit	N/A	N/A	N/A	N/A	Yes

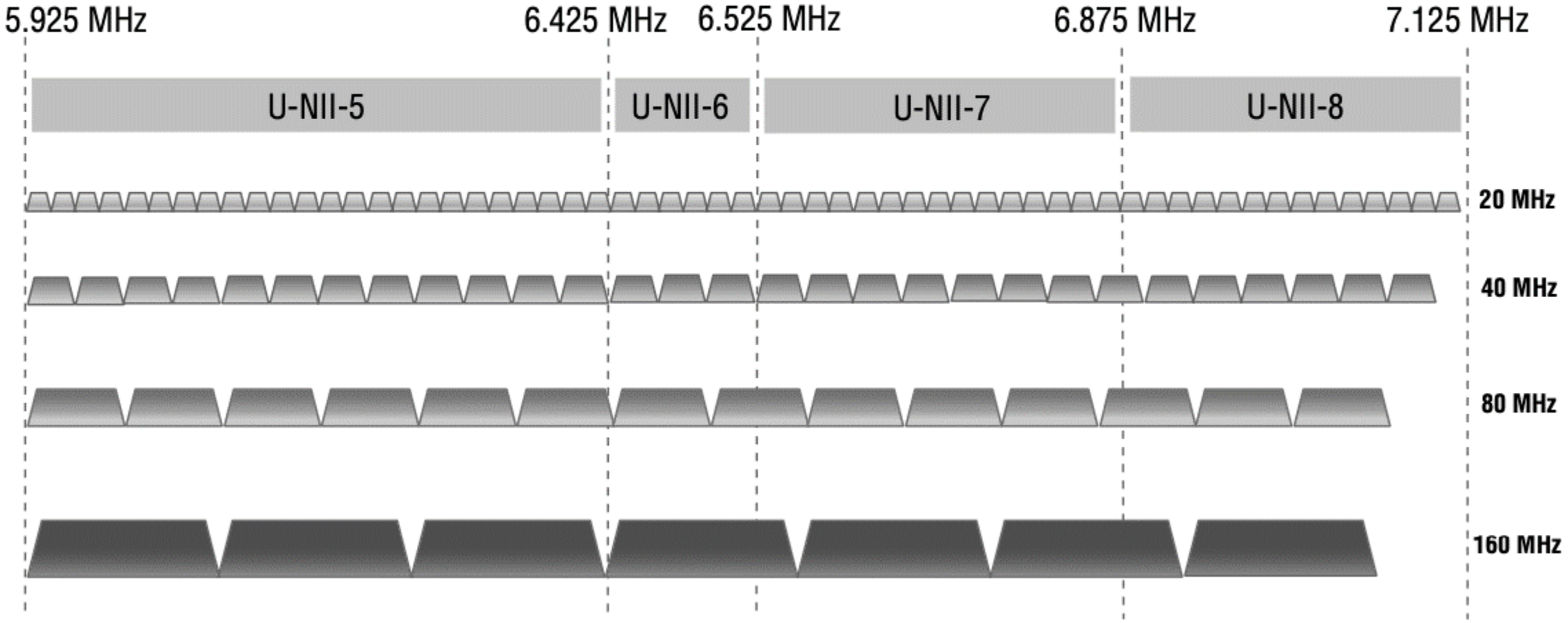
WiFi Unlicensed Spectrum Allocation History



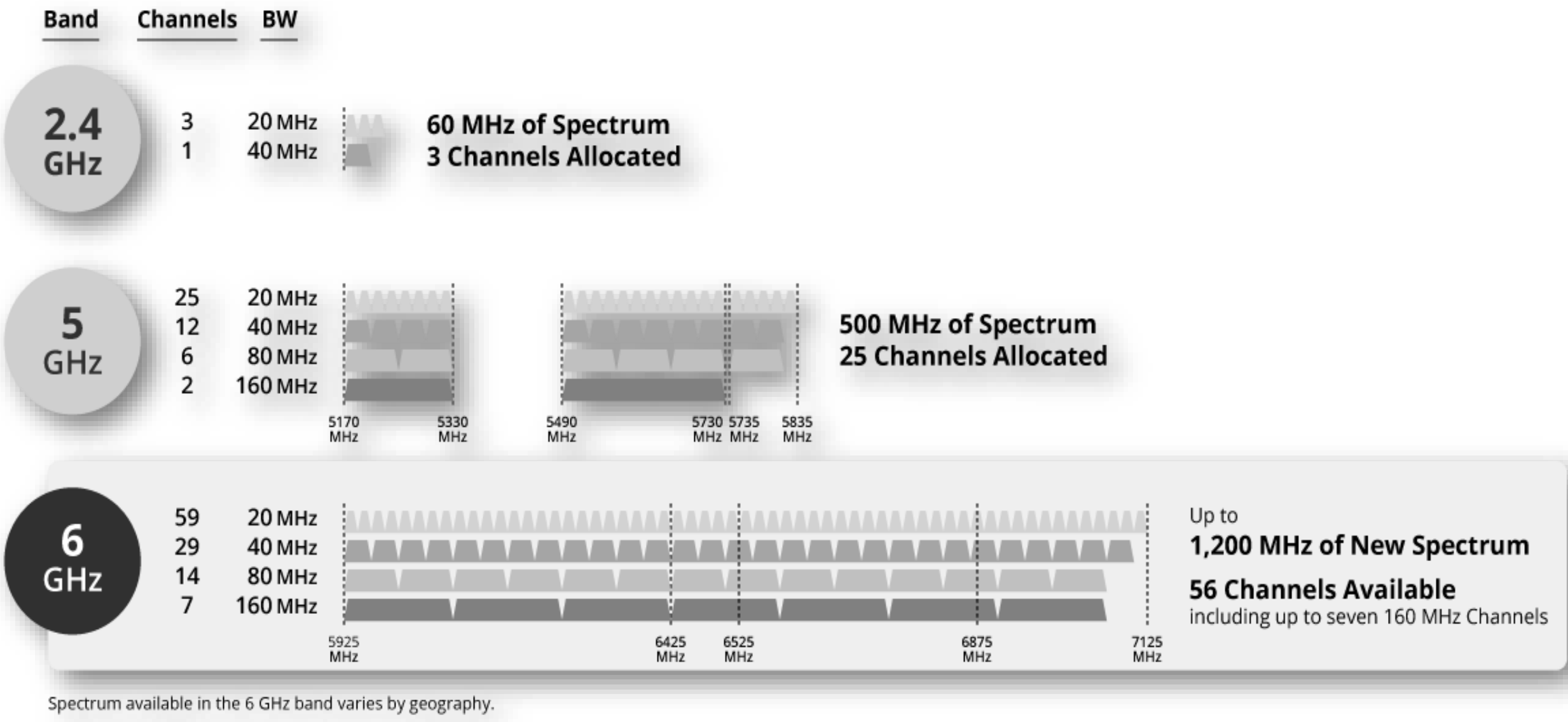
New 6GHz Spectrum for Unlicensed Use

(59) 20 MHz channels
(29) 40 MHz channels
(14) 80 MHz channels
(7) 160 MHz channels

1,200 MHz of new frequency spectrum

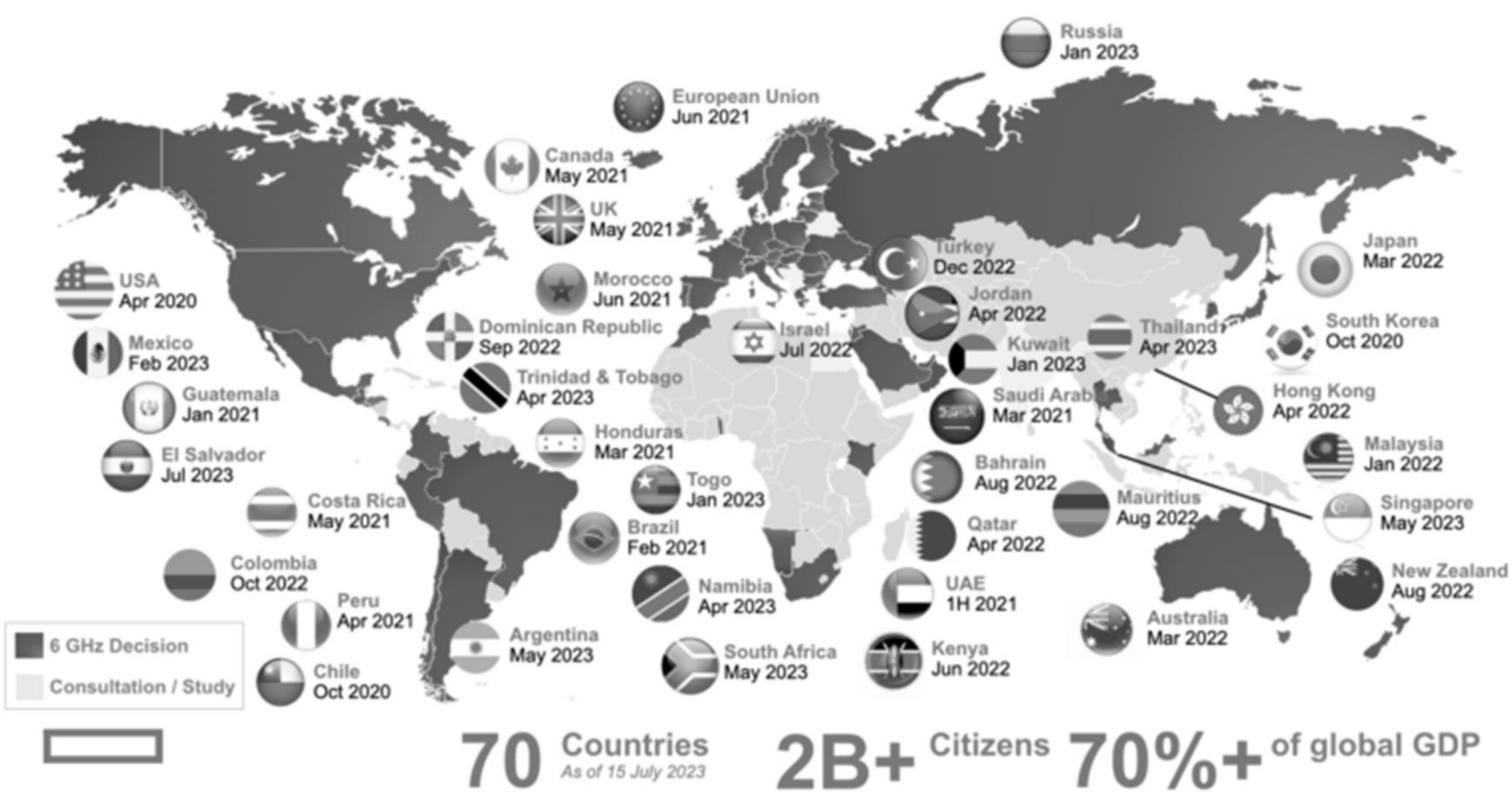


In comparison with 2.4GHz and 5GHz



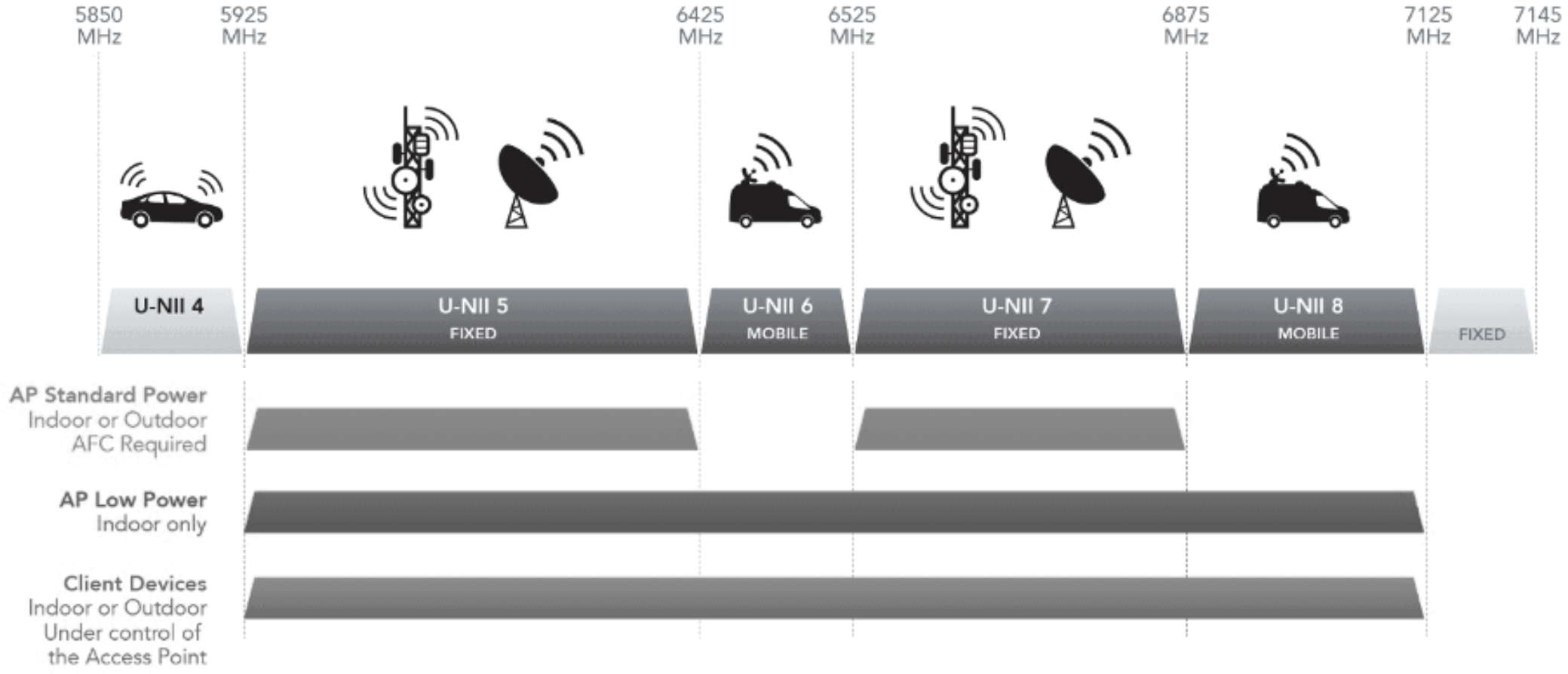
Spectrum available in the 6 GHz band varies by geography.

6GHz Global Adoption



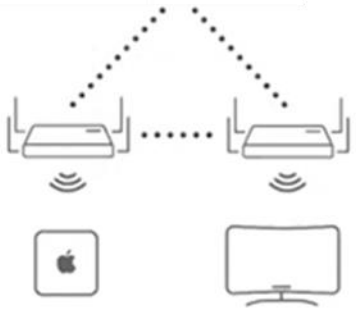
Incumbent Users of U-NII 5, U-NII 6, U-NII 7 and U-NII 8 Band

- U-NII5 and U-NII 7 bands - Satellite link communications to geostationary satellites, Point-to-Point microwave links deployed by carriers for wireless backhaul, critical services like utilities, as well as public safety and emergency services.
- U-NII 6 and U-NII 8 bands – Primarily used for mobile services, for example mobile trucks used by the news crews to relay the signal back to the TV studio.



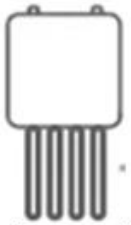
Equipment Classes for 6 GHz Unlicensed Operation

Low Power Indoor (LPI) AP
- Fixed indoor only
- Up to 63X lower energy
- No antenna connectors
- No weatherproofing
- Wired power



Subordinate Indoor Device
- Same rules as LPI AP, ***plus***:
- Under AP control
- No direct Internet connection

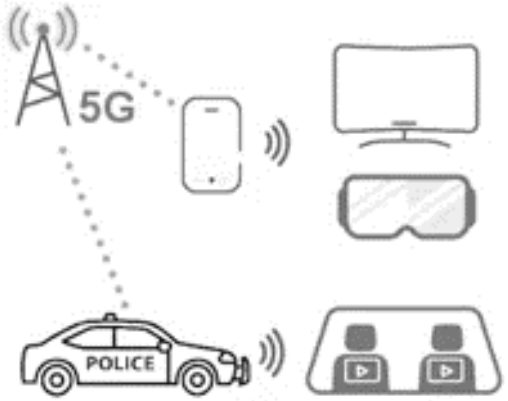
Standard Power (SP) AP
- Fixed indoor / outdoor
- Controlled by AFC database
- Automated geolocation
- Pointing angle restriction



Mobile Client
- Indoor / outdoor
- 4X less power than connected AP

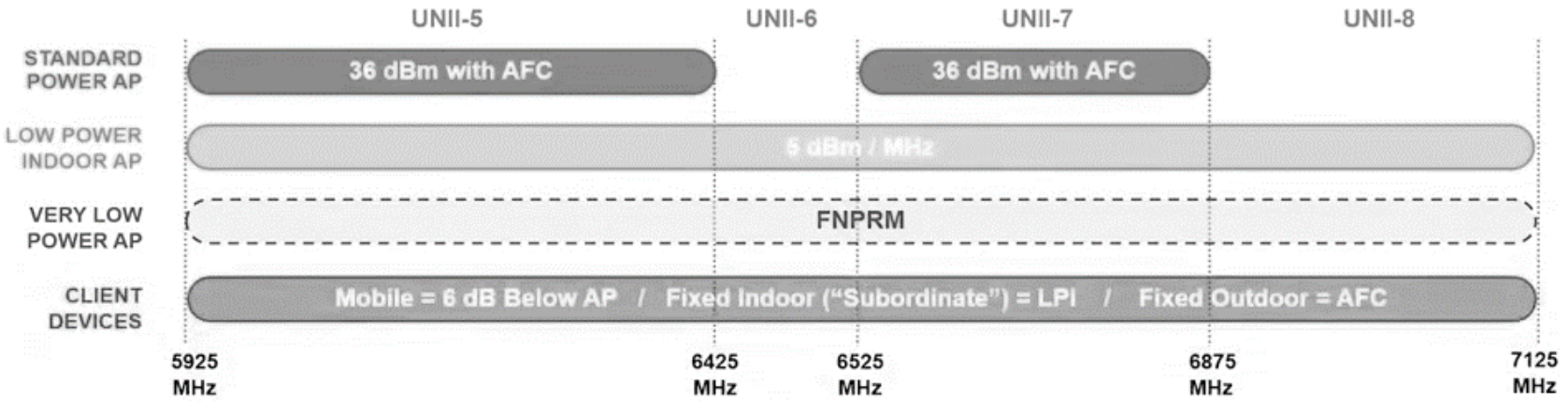
Fixed Outdoor Device
- Same rules as SP AP, ***plus***:
- Attached to structure

Very Low Power (VLP) AP
- Mobile indoor / outdoor
- 160X lower energy



~2 Gbps throughput with sub-ms latency at 3m

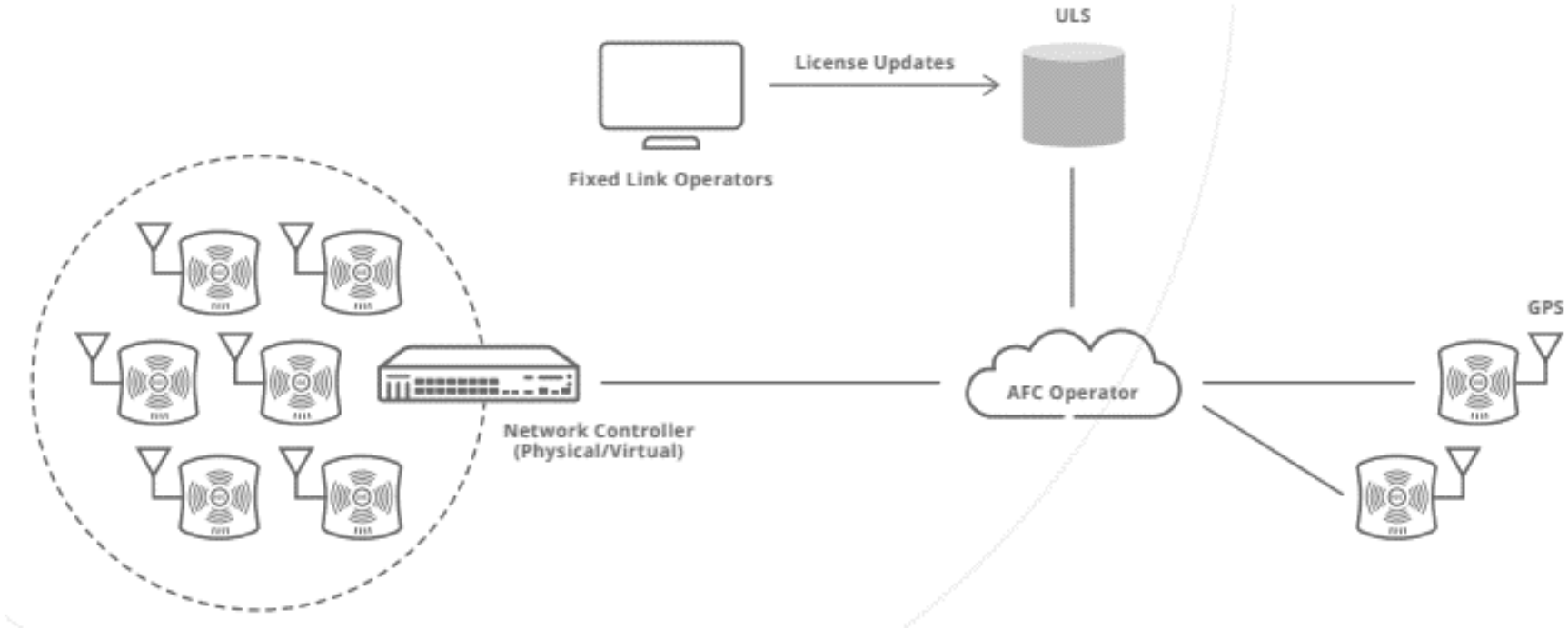
Initial 6GHz rules in the US



- Standard Power APs should be under AFC control and its not allowed in UNII-6 and UNII-8 Bands.
- Low Power Indoor can be used across the entire band without need for AFC but with max power of 5dBm/MHz, 6dB (4x) lower power than Standard power APs.

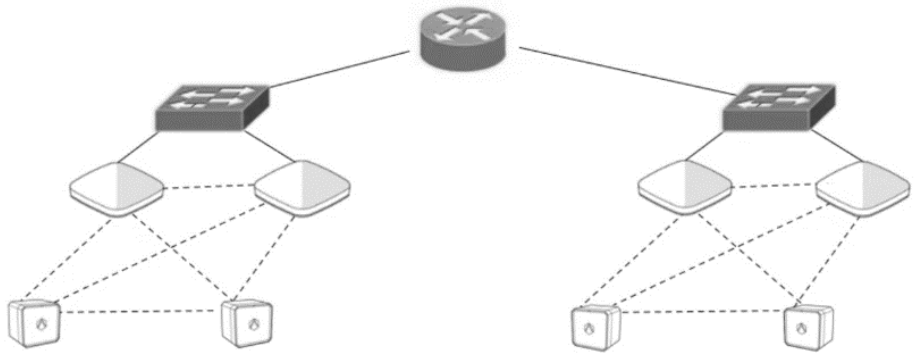
Device Class	Bands	Limitations	Maximum EIRP	Maximum PSD**
Standard Power AP Fixed Client	UNII-5 UNII-7	• **AFC Control** • **Automated geolocation** • Antenna mask (if outdoors • Attached to structure (fixed client)	36 dBm 21 dBm > 30°	23 dBm / MHz
Low Power Indoor AP Subordinate Device	UNII-5 UNII-6 UNII-7 UNII-8	• **Indoor only** • Integrated antennas only • No weatherproofing • Mains power • No battery • Labeling requirement	30 dBm	5 dBm / MHz
Mobile Client	UNII-5 UNII-6 UNII-7 UNII-8	• No mobile hotspot	30 dBm (SP) *-or-* 24 dBm (LPI)	17 dBm / MHz (SP) *-or-* -1 dBm / MHz (LPI)

Automatic Frequency Coordination(AFC)

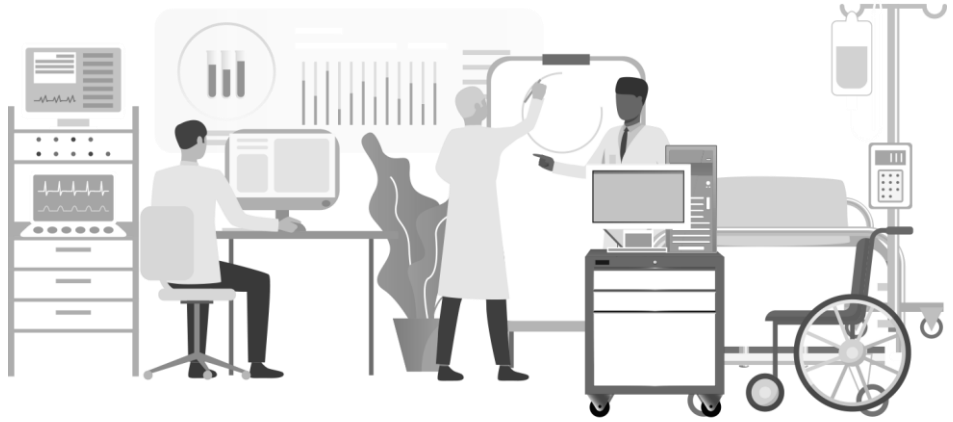


- Standard Power APs should be under AFC control.
- APs should be capable of determining their geolocation.
- They must request a list of available channel from the AFC operator once every 24 hours.
- APs must chare their geolocation,(along with error margin), their serial number and FCC ID.
- The AFC operators will manage a dynamic database on all active RF activity from fixed link operators and will make the channel availability decisions based on this data.

Most Promising WiFi 6E Use Cases

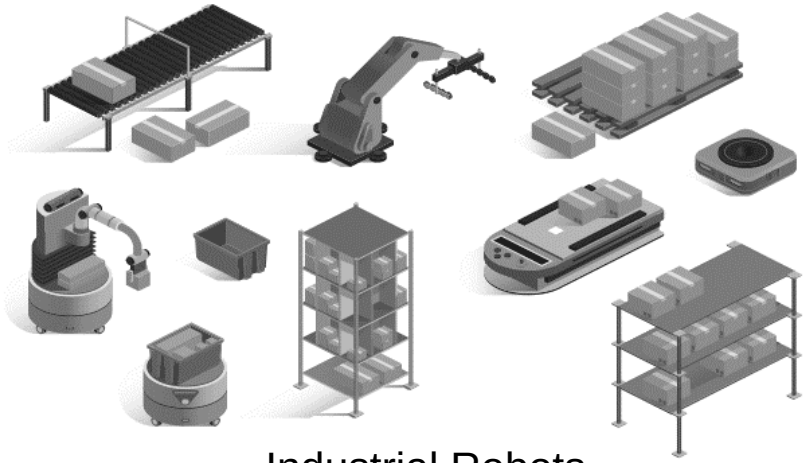


6GHz Mesh Backhaul



Hospital WiFi

Very High Bandwidth Applications



Industrial Robots

The Backward Compatibility Problem – Solved!

NO
Legacy
Devices!

New 6E Features

New Features In 6 GHz

- Native Wi-Fi 6 Transmissions
  - High-Efficiency (HE) PHY/MAC structure
  - Native HE beacons
- 3 methods for In-Band AP Discovery
  - Fast Initial Link Setup (FILS) Discovery announcements
  - Unsolicited Probe Responses
  - Active scans on preferred scanning channels
- Security Enhancements
  - WPA3 Enterprise / Personal required
  - Protected Management Frames (PMF) required
  - Enhanced Open required

Enhancements In 5 GHz & 2.4 GHz

- 2 methods for Out-of-Band AP Discovery
  - Reduced Neighbor Reports (RNR)
  - Multiple-BSSID Beacons
- Security Enhancements
  - Expanded requirements for recent WFA standards

Shortened Beacons

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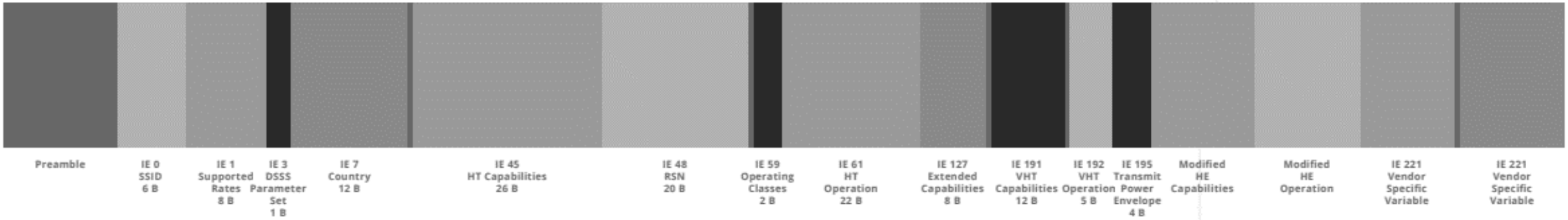
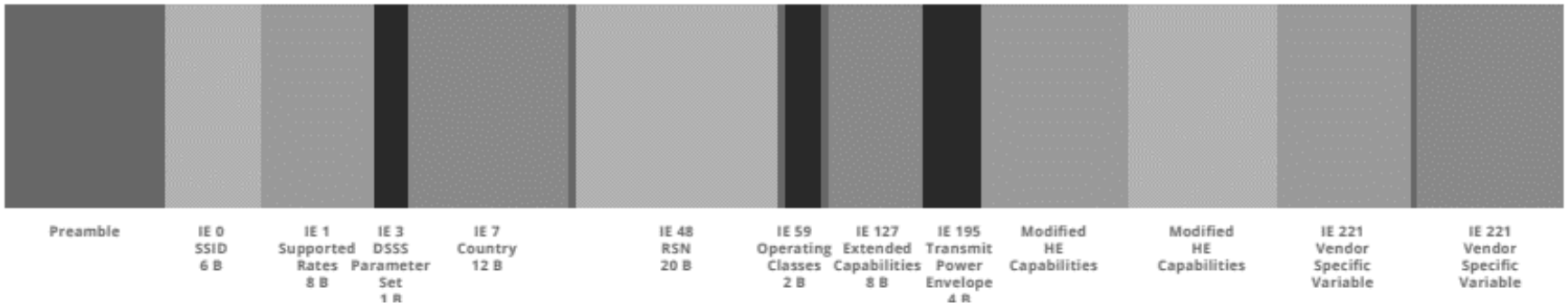
Wi-Fi 6 (802.11ax HE) beacon in 5 GHz showing with information elements (example)

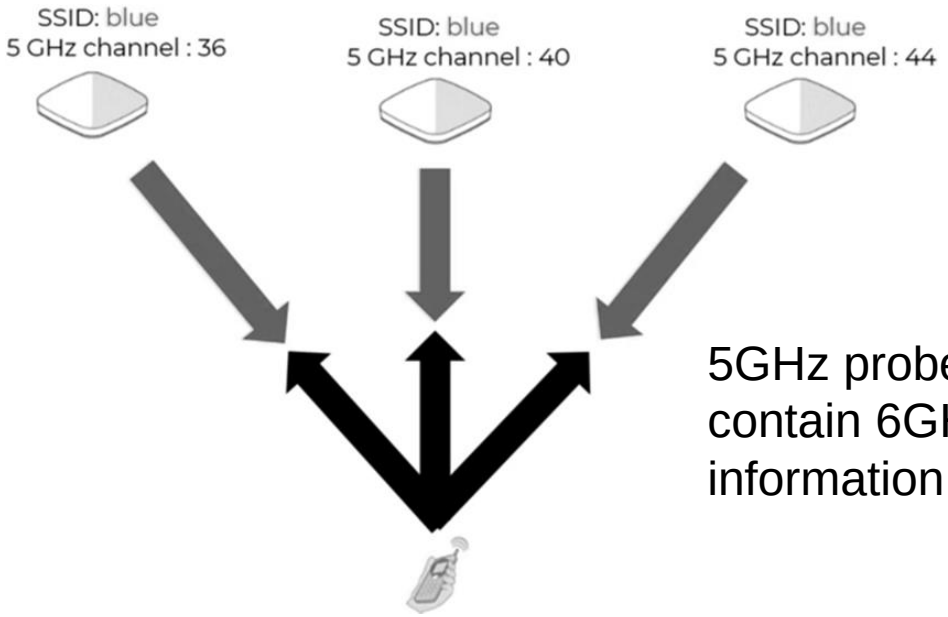


Wi-Fi 6 (802.11ax HE) beacon in 6 GHz showing information elements (example)



- There are no legacy devices in 6GHz mode and hence no need for any backward compatibly.
- Because of this most legacy WiFi4 and WiFi5 HT, VHT information elements are all removed from 6GHz Beacons
- Any important information that is supposed to be forward compatible is added to the HE information elements

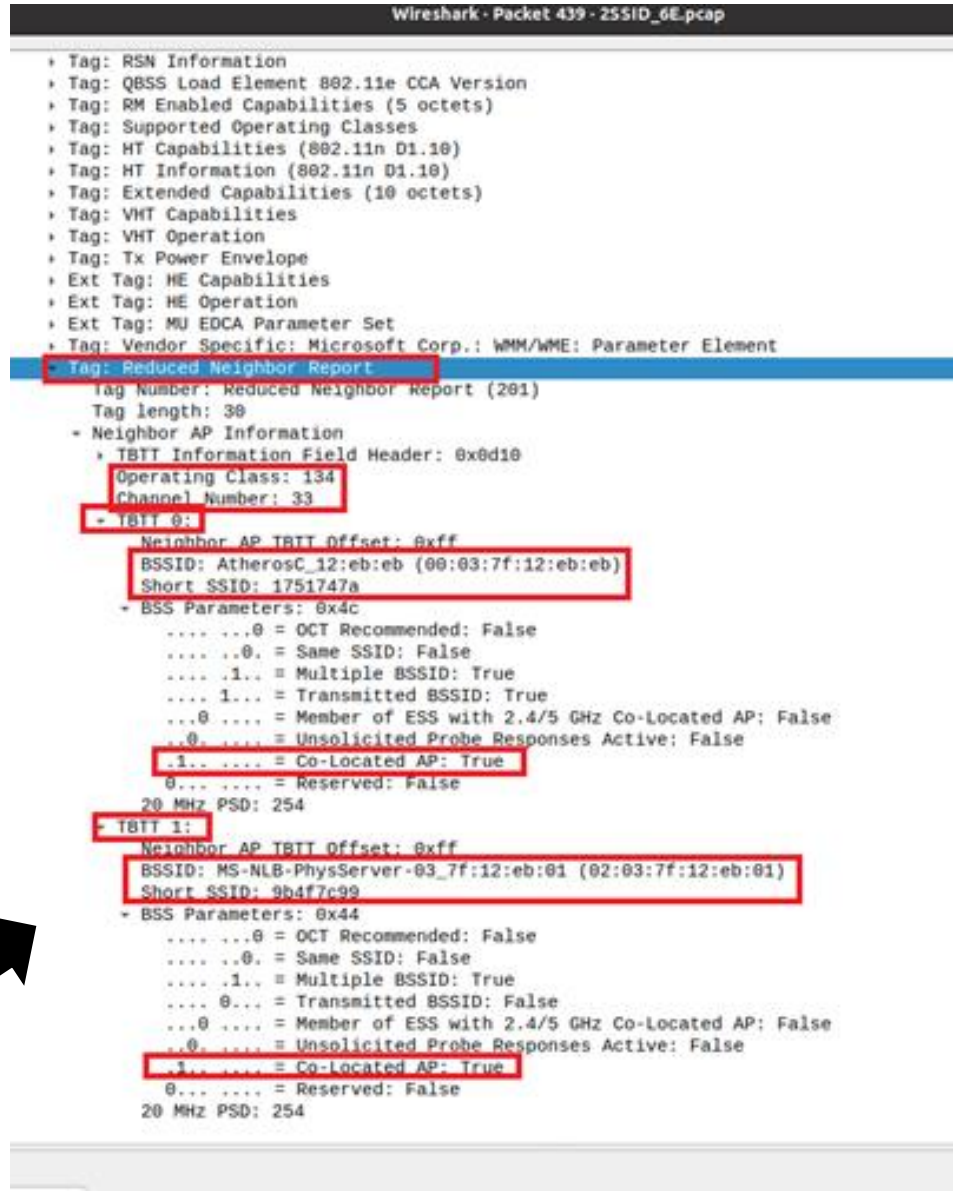
Out of Band Discovery - RNR



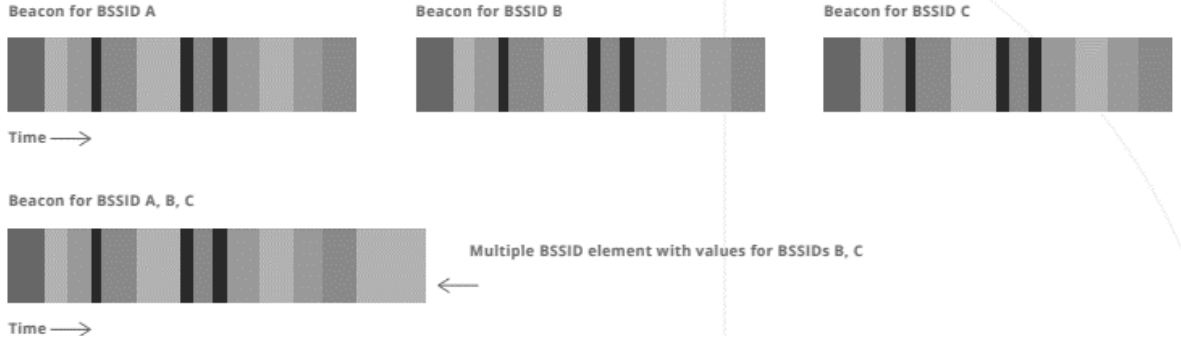
5GHz probe responses will contain 6GHz networks information

- Most APs will have both 5GHz and 6GHz radios.
- Scanning cannot be avoided on the 5GHz bands, so the idea is to use the 5GHz scan to get the 6GHz information.
- APs can respond to probed on 5GHz channels with all the information about the 6GHz networks so that the clients don't have to scan separately on 6GHz.
- After scanning the clients can create a 6GHz neighbor AP list and roam as needed to GHz AP.

Reduced Neighbor Report IE in Beacons and Probe Responses



Multiple BSSIDs in a Single Beacon




```
> Frame 1504: 295 bytes on wire (2360 bits), 295 bytes captured (2360 bits)
> Radiotap Header v0, Length 56
> 802.11 radio information
> IEEE 802.11 Beacon frame, Flags: ........
v IEEE 802.11 Wireless Management
  > Fixed parameters (12 bytes)
  v Tagged parameters (203 bytes)
    > Tag: SSID parameter set: OpenWifi-6G-1
    > Tag: Supported Rates 6(B), 9, 12(B), 18, 24(B), 36, 48, 54, [Mbit/sec]
    > Tag: DS Parameter set: Current Channel: 33
    > Tag: Traffic Indication Map (TIM): DTIM 0 of 2 bitmap
    > Tag: Country Information: Country Code US, Environment 0x04
    > Tag: Extended Supported Rates SAE Hash to Element Only, [Mbit/sec]
    > Tag: RSN Information
    v Tag: QBSS Load Element 802.11e CCA Version
        Tag Number: QBSS Load Element (11)
        Tag length: 5
        QBSS Version: 2
        Station Count: 1
        Channel Utilization: 15 (5%)
        Available Admission Capacity: 0 (0 us/s)
    > Tag: Supported Operating Classes
    > Tag: Extended Capabilities (10 octets)
    > Tag: Tx Power Envelope
    > Tag: Tx Power Envelope
    > Tag: RSN eXtension (1 octet)
    > Ext Tag: HE Capabilities
    > Ext Tag: HE Operation
```

Without MSSID Channel utilisation is 15%

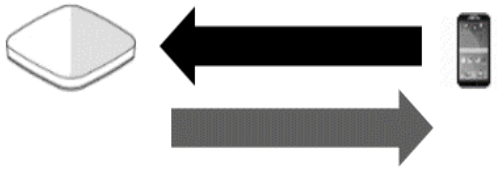
- Its very common to have several SSIDs on a single AP in modern enterprise deployments.
- MDUs scenarios may call for separate BSSIDs for each user.
- One Beacon for each SSID/BSSID will take up too much airtime.
- MBSSID feature will allow AP to advertise multiple BSSID/SSIDs in a single Beacon
- Common information will be send once and specific details for each SSID/BSSID will be sent in individual elements in the Beacon.

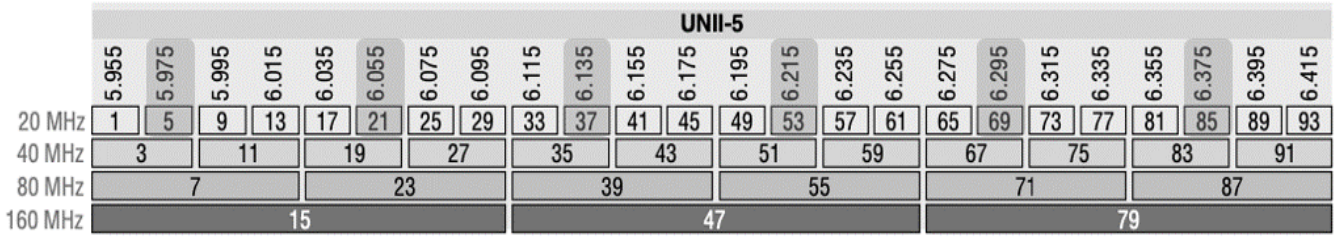
```
> Frame 16: 680 bytes on wire (5440 bits), 680 bytes captured (5440 bits)
> Radiotap Header v0, Length 56
> 802.11 radio information
> IEEE 802.11 Beacon frame, Flags: ........
v IEEE 802.11 Wireless Management
  > Fixed parameters (12 bytes)
  v Tagged parameters (588 bytes)
    > Tag: SSID parameter set: OpenWifi-6G-1
    > Tag: Supported Rates 6(B), 9, 12(B), 18, 24(B), 36, 48, 54, [Mbit/sec]
    > Tag: DS Parameter set: Current Channel: 65
    > Tag: Traffic Indication Map (TIM): DTIM 0 of 2 bitmap
    > Tag: Multiple BSSID
    > Tag: Multiple BSSID
    > Tag: Country Information: Country Code US, Environment 0x04
    > Tag: Extended Supported Rates SAE Hash to Element Only, [Mbit/sec]
    > Tag: RSN Information
    v Tag: QBSS Load Element 802.11e CCA Version
        Tag Number: QBSS Load Element (11)
        Tag length: 5
        QBSS Version: 2
        Station Count: 1
        Channel Utilization: 3 (1%)
        Available Admission Capacity: 0 (0 us/s)
    > Tag: Supported Operating Classes
    > Tag: Extended Capabilities (11 octets)
    > Tag: Tx Power Envelope
    > Tag: Tx Power Envelope
    > Tag: RSN eXtension (1 octet)
    > Ext Tag: HE Capabilities
    > Ext Tag: HE Operation
    > Ext Tag: MU EDCA Parameter Set
    > Ext Tag: HE 6 GHz Band Capabilities
    > Tag: Vendor Specific: Microsoft Corp.: WMM/WME: Parameter Element
```

With MBSSID channel utlization is reduced to 1%

In Band Scanning and Preferred Scanning Channels (PSC)

- In-band scanning is only used when we have 6GHz only APs that don't operate on 5GHz channels.
- Example: Mesh Backhaul, Point-to-Point Bridge



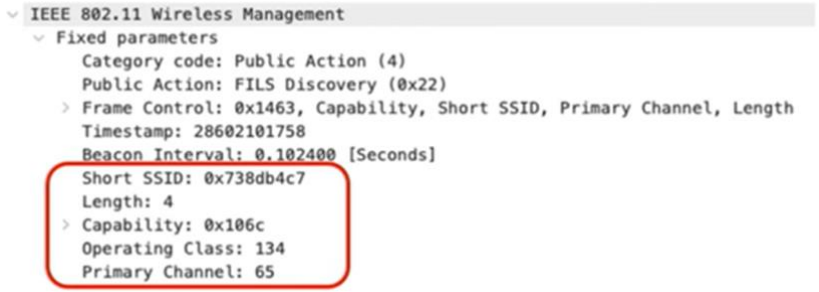


Active Scanning - PSC

- We have 59 20MHz channels in the 6GHz band and both active and passive scanning on all these channels is going to be very costly in terms of medium utilization, off channel time and battery life.
- So active scanning is only allowed on a select set of Preferred Scanning Channels (PSC)
- The complete list of all the 6 GHz PSC channels is 5, 21, 37, 53, 69, 85, 101, 117, 133, 149, 165, 181, 197, 213, 229

Passive Scanning - FILS

- Fast Initial Link Setup (FILS)
- Short Action frames sent every 20msecs
- STAs can use these action frames for in band passive scanning



References

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Wi-Fi 6E: It’s Almost Like Wi-Fi is Being Born Again!
https://www.youtube.com/watch?v=SgL53Lh5TJE&

Chuck Lukaszewski - Introducing the 6 GHz Band & Wi-Fi 6E
https://www.youtube.com/watch?v=_fHrKaEB_fk

Packet Captures

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Quiz 5b Results

WI-FI TECHNOLOGY
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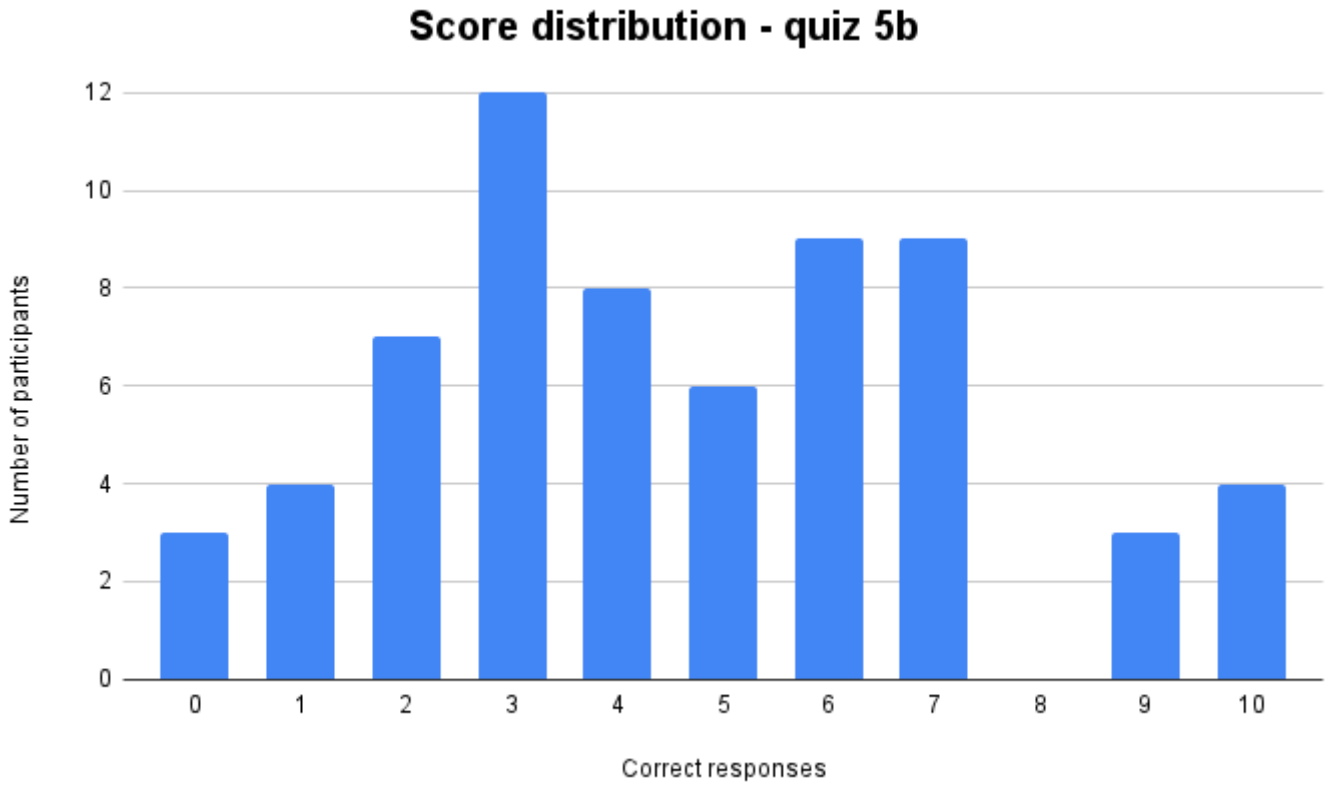
Number of participants - 65

Winner
Meghana



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QUIZ!
TIME