



# (IN)NUUG

Indiana Networking User Group

## WiFi 7, More Bandwidth More Black Magic

Presented By:

(US)NUA

US Networking User Association

Nathan White

RF “Nerd”

Networking Enthusiast

Local “Musician”

Jeep Junkie

Presented By:

**(US)NUA**

US Networking User Association

Wi-Fi Brief History

6 GHz Overview

Wi-Fi 7 Goals

Wi-Fi 7 Major Enhancements

What does this all Mean???

Presented By:

**(US)NUA**

US Networking User Association



## The IEEE:

# Institute of Electrical and Electronics Engineers

- Creates standards for compatibility and coexistence between networking equipment
- The technical standard for Wi-Fi communications is the 802.11
- The 802.11 Standard 1997

<http://standards.ieee.org>

Presented By:

(US)NUA  
US Networking User Association

## Wi-Fi Alliance

- Wi-Fi technology builds on IEEE 802.11 standards. The IEEE develops and publishes these standards, but does not test equipment for compliance with them. The non-profit Wi-Fi Alliance formed in 1999 to fill this void.
- The Wi-Fi Alliance, a global association of companies.
- As of 2009 the Wi-Fi Alliance consisted of more than 300 companies from around the world.
- Manufacturers with membership in the Wi-Fi Alliance, whose products pass the certification process, gain the right to mark those products with the Wi-Fi logo.

Presented By:

## Wi-Fi Alliance

Industry Consortium  
Founded 1999

**900+** Member Companies

**60K+** Certified Devices

**25+** Years Active

### What Does the Wi-Fi Alliance Do?

#### Device Certification

Tests and certifies that Wi-Fi devices from different vendors interoperate correctly. The Wi-Fi CERTIFIED™ logo is the standard signal of compliance.

#### Branding & Naming

Created the consumer-friendly Wi-Fi 4/5/6/6E/7 naming convention — replacing the confusing 802.11 IEEE nomenclature used by engineers.

#### Security Standards

Owns and certifies WPA2 and WPA3 security protocols. All Wi-Fi 7 certified devices must pass WPA3 certification.

#### AFC Governance

Operates the AFC system for Standard Power 6 GHz deployments, providing frequency and power coordination to protect licensed incumbents.

*IEEE writes the rules • FCC regulates the spectrum • Wi-Fi Alliance ensures interoperability*

Presented By:

**(US)NUA**

US Networking User Association

## FCC & Wi-Fi

Federal Communications Commission

**1.2 GHz**

of new spectrum opened

**2020**

6 GHz rules adopted

**3**

operating power classes

## FCC's Role in Wi-Fi 7 & the 6 GHz Band

### Spectrum Allocation

In 2020, the FCC opened 5.925–7.125 GHz (1.2 GHz of spectrum) for unlicensed Wi-Fi use — the largest spectrum allocation in FCC history. This is the foundation of Wi-Fi 6E and Wi-Fi 7.

### Protecting Incumbents

Licensed services already occupied the 6 GHz band — fixed microwave links, broadcast auxiliaries, and public safety systems. The FCC required interference protection mechanisms before allowing Wi-Fi to share it.

*More power = more range, but requires stricter interference controls • AFC is mandatory for all outdoor 6 GHz use*



- |   |   |   |
|---|---|---|
| 4 | 802.11n (HT)  | - High Throughput                         |
| 5 | 802.11ac (VHT)                                      | - Very High Throughput                    |
| 6 | 802.11ax (HE)                                       | - High Efficiency                         |
| 7 | 802.11be (EHT)<br>High Speed<br>Spectral Efficiency | - Extremely High Throughput               |
| 8 | 802.11bn (UHR)                                      | - Ultra High Reliability<br>- late 2020's |

Presented By:

The logo for US Networking User Association, featuring the letters '(US)NUA' in a stylized font. The 'U' and 'S' are in white, and 'NUA' is in orange.

US Networking User Association

# Wi-Fi 7: Who Cares?

HD Streaming, Video Conferencing

AR/VR/XR

Gaming/ESports

Immersive Learning

Healthcare

IoT

Bridge/Mesh Backhaul

Presented By:

(US)NUA

US Networking User Association

Speeds – up to 46Gbps, 4096 (4K) QAM, 16SS

320MHz channel bonding

Preamble Puncturing

MLO

Multi-RU

Enhanced Security

512 Compressed block Ack

Emergency Preparedness Communication Services (EPCS)

Triggered UL Access Optimization (Cisco Fastlane+ standardized)

Managed QoS and QoE (Stream Classification Service)



Presented By:

(US)NUA

US Networking User Association

## Reality???

### Config

320MHz, 4SS

320MHz, 2SS

160MHz, 2SS

80 MHz, 2SS

40 MHz, 2 SS

### Connection Speed

11Gbps

5.7Gbps

2.5Gbps

1.4Gbps

0.7Gbps



## What Channel Width should you use?

- Consumer devices enable 320MHZ by default
- Some do NOT have the ability to change

### 5Ghz Rule of Thumb

40MHz channel width when you can

20MHz when you need to

### 6Ghz Rule of Thumb

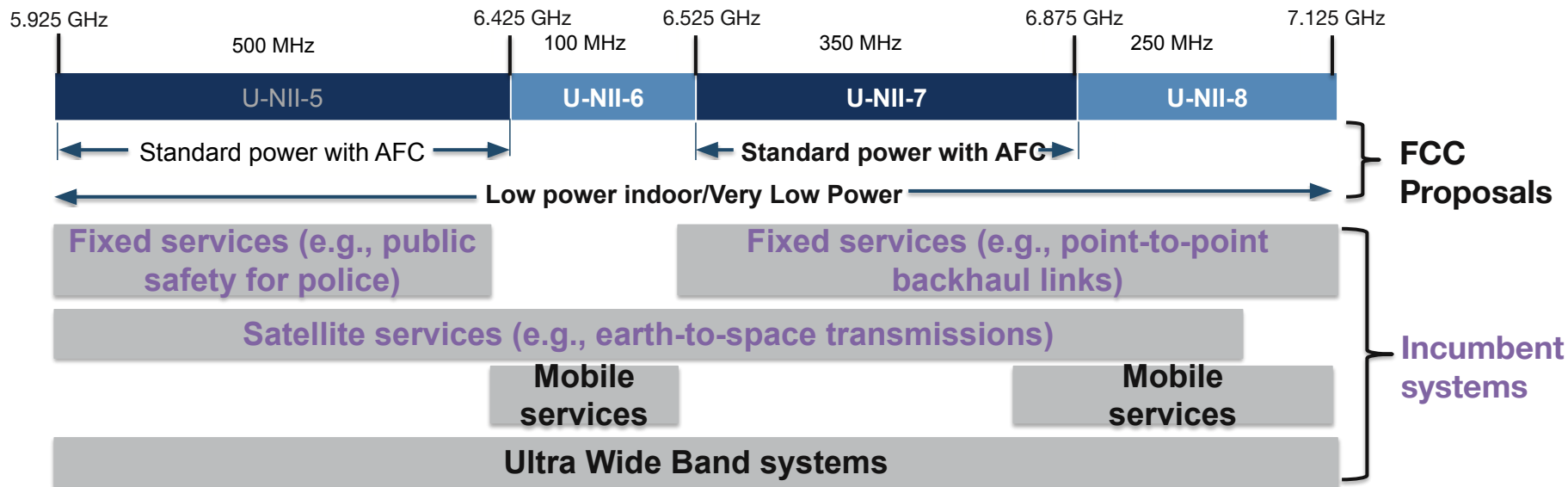
80MHz channel width when you can

40MHz when you need to

Presented By:

 (US)NUA

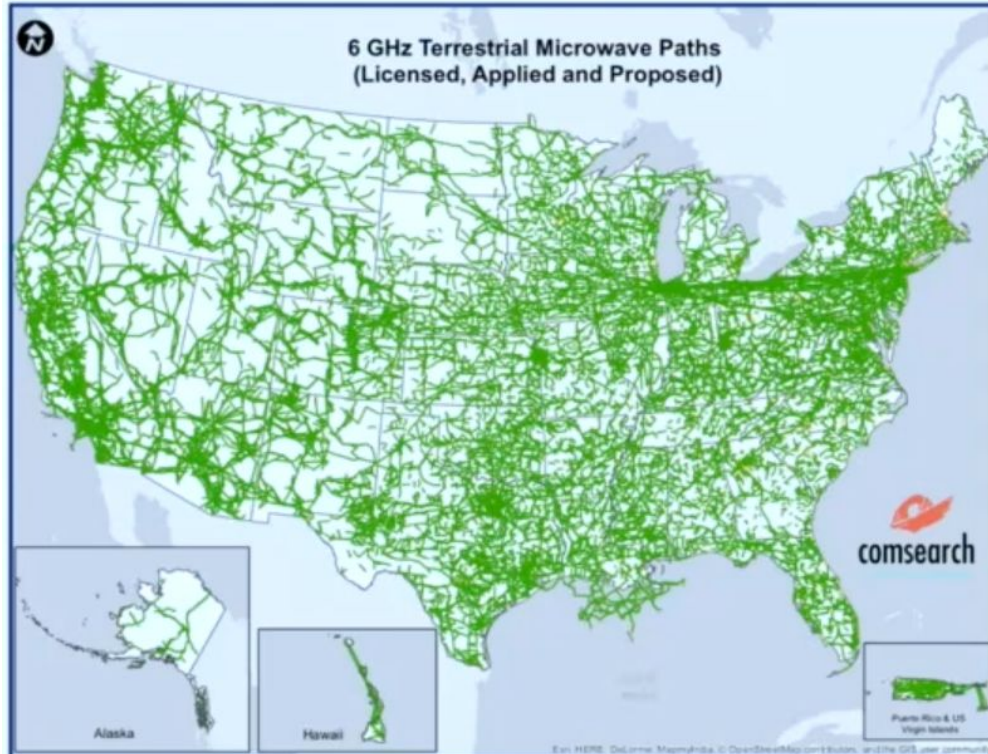
US Networking User Association



Presented By:

(US)NUA

US Networking User Association



Presented By:

(US)NUA

US Networking User Association

## Low Power Operations

A wireless access point (AP) operating under the below guidelines is said to be in LPI mode:

- Operates across the entire 6GHz band (UNII-5, UNII-6, UNII-7, and UNII-8) for indoor deployments.
- Maximum EIRP of 30 dBm and 5 dBm/MHz PSD (power spectrum density).
- Not battery operated.
- Does not have an external antenna,
- Not mobile,
- Does not use ruggedized enclosures.

Clients connecting to LPI AP will have a maximum allowed EIRP of 24 dBm (with PSD of -1 dBm/MHz) and can operate in the entire 6GHz band.

## Standard Power Operations

A wireless AP operating under the below guidelines is said to be in SP mode:

- Operates in UNII-5 & UNII-7 bands indoors or outdoors at full power.
- Operates with a maximum allowed EIRP of 36 dBm and maximum PSD of 23 dBm/MHz.
- May use external antennas.
- May use ruggedized enclosures.

Clients connecting to SP AP will have a maximum allowed EIRP of 30dBm.

Presented By:

 (US)NUA

US Networking User Association

# FCC LPI rules

Channel Width	Max EIRP	Max Tx Power (4 dBi antenna)
20 MHz	18 dBm	14 dBm
40 MHz	21 dBm	17 dBm
80 MHz	24 dBm	20 dBm
160 MHz	27 dBm	23 dBm
320 MHz (Wi-Fi 7)	30 dBm	26 dBm

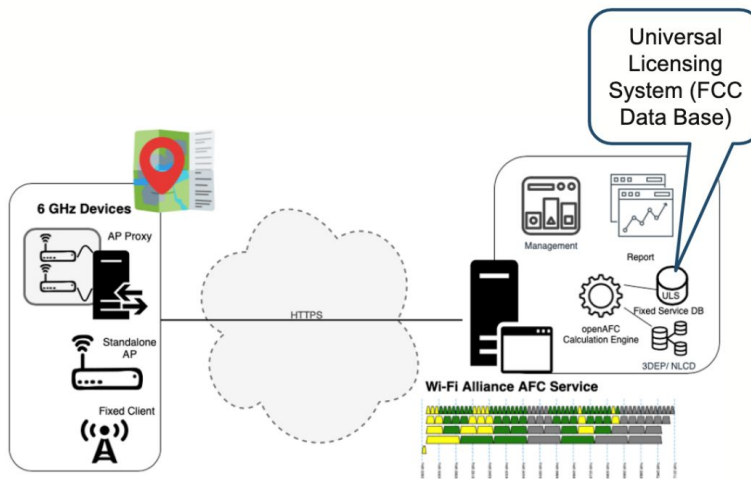
Presented By:

**(US)NUA**

US Networking User Association

## FCC guidelines on AP Geolocationing

- Non-LPI APs coordinate with a “AFC service provider” by providing
  - Identity
  - Latitude, longitude and height
  - With GPS: Location uncertainty with 95% confidence level
  - Without GPS: distance separation from GPS reference with 95% confidence level
- Lat/long must be **obtained automatically**
- When must AP geolocate itself
  - Before first operation
  - At least once every 24 hours
  - On power up/change of location
- AP must adhere to allowed channels and max Tx power
- If no valid response is available, **AP to fall back to LPI/turn off the 6 GHz radio**



Source:  
<https://www.wi-fi.org/beatcon/the-beacon/wi-fi-alliancer-demonstrates-afc-service-seoul>

# Multi-Link Operation

Communicate over multiple links at same time.

“Link aggregation feature”.

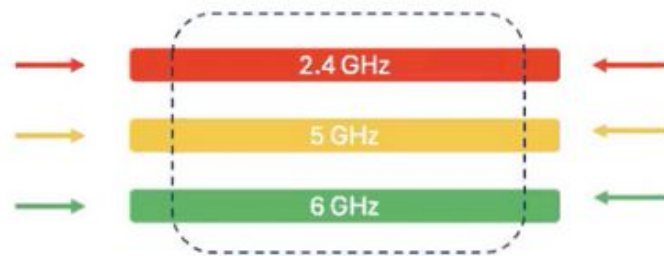
Throughput & aggregation.

Low latency steering (VR/AR/XR).

Reliability & Redundancy.



Wireless Client  
(non-AP MLD)



Presented By:

(US)NUA

US Networking User Association

## Requirements for MLO Operation

- **Wi-Fi 7 only**
- **Must use WPA3**
- MFP - Management Frame Protection

## MLO caveats

- **Not Multi-AP** (Wi-Fi 8?)
- Not Full-Duplex (medium access rules did not change)
- Windows 11 - 24H2+ Required
- WPA3-Enterprise not supported in all chipsets

## For MLO, MAC Layer Has to Change

MAC change details beyond the scope of this talk but...

MAC layer has to split into:

Upper (MLD/Non-MLD)

Lower (MLD)

Multiple MAC addresses

Multiple client-to-AP connections

Multiple RSNAs

MLD Management frames

Multi-link Element



Wi-Fi 8 is promising MLO to different APs

Presented By:

(US)NUA

US Networking User Association

# Types of MLO

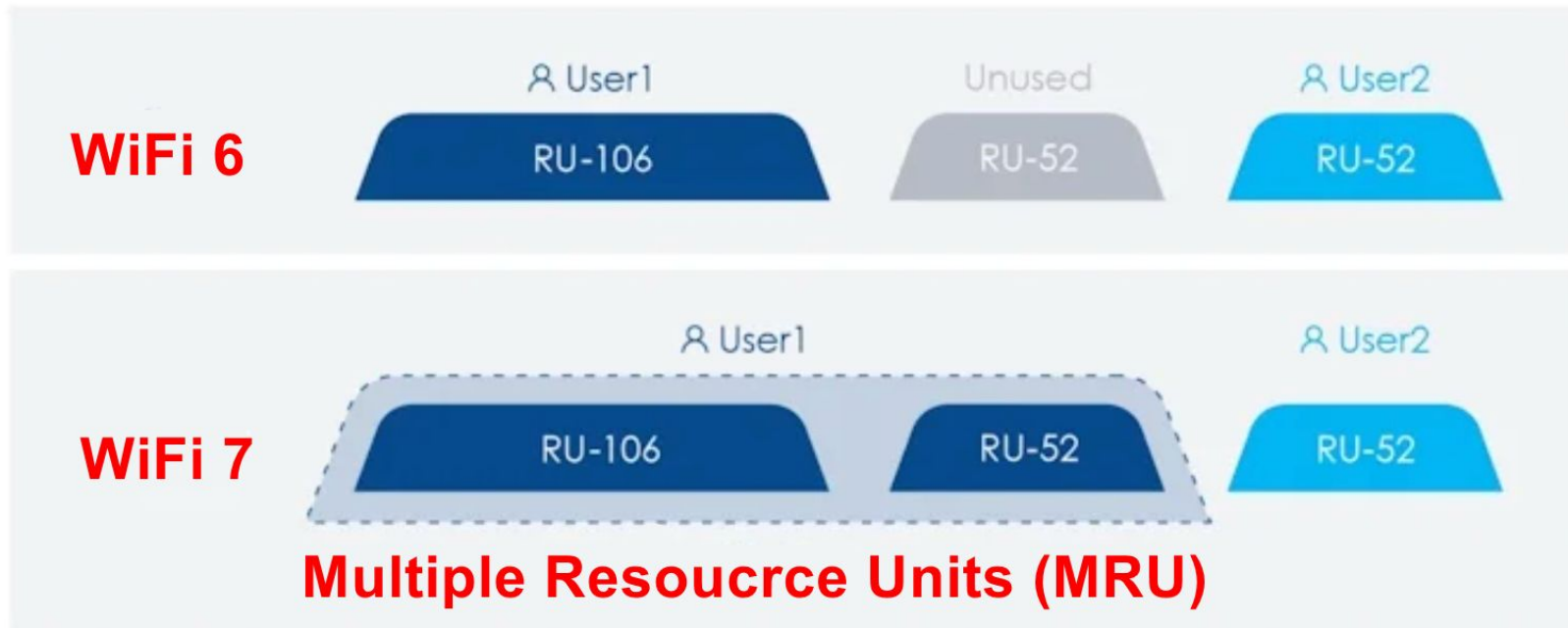
MLO Type	Number of Radios	Characteristics
Multi-link single radio (MLSR)	1	TX/RX over one link at a time.
Enhanced multi-link single radio (EMLSR)	1	MLSR with additional capability to listen to two links simultaneously.
Nonsimultaneous transmit and receive multi-link multi-radio (NSTR MLMR)	$\geq 2$	Simultaneous TX/TX, RX/RX over multiple links.
Simultaneous transmit and receive multi-link multi-radio (STR MLMR)	$\geq 2$	Simultaneous TX/TX, RX/RX, and TX/RX over multiple links.
Enhanced multi-link multi-radio (EMLMR)	$\geq 2$	MLMR with additional capability to dynamically reconfigure spatial multiplexing capability on each link.

Complexity & performance

Presented By:

US Networking User Association

# Wi-Fi 7 Enhancements: Multiple Resource Units



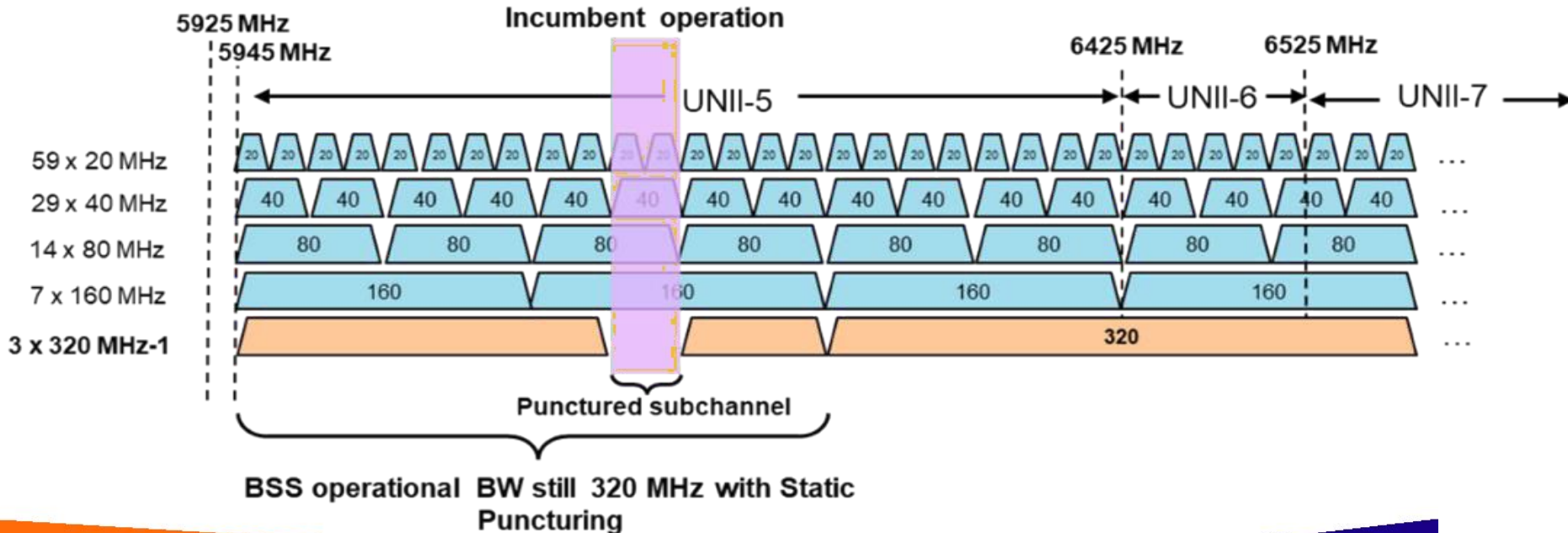
Presented By:

(US)NUA

US Networking User Association

# Spectrum Puncturing

AKA – Pre-Amble Puncturing / Static Puncturing

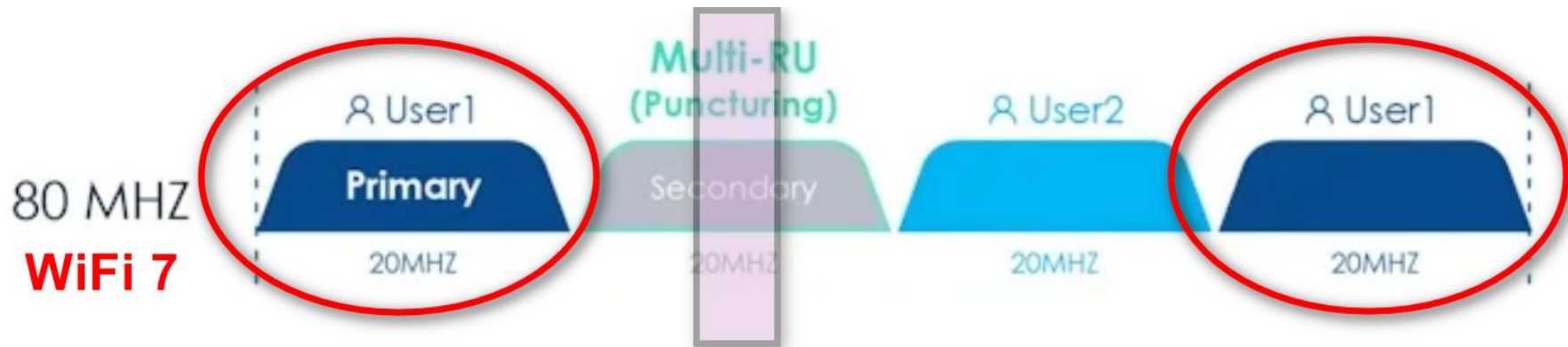


Presented By:

(US)NUA

US Networking User Association

# Wi-Fi 7 Enhancements: Spectrum Puncturing w/MRU



Presented By:

(US)NUA

US Networking User Association

	Intel BE200 23.120	Qualcomm NCM865 3.1.0.1323	MediaTek 7927 5.4.0.2974	iPhone 16 iOS 18.4.1
Operational Mode	EMLSR (5/6)	STR-MLMR (2.4/6)	STR-MLMR / MLSR (2.4/6)	NSTR-MLMR (2.4/5/6) / STR-MLMR (2.4/6)
6 GHz Width	320	320	320 (160 if MLO)	160
4096 QAM Achieved				
# Links - Windows 24H2	2 - w/MLO	2 - w/MLO	2 - w/MLO	3
# Links - Ubuntu 24 / 16.4	3 - w/MLO	No Driver	1 - No MLO	
MLO "Dynamic Shift"	✓	✗	✗	✗ ✗ ✗
Simultaneous Rx/Tx	✗	✓	✓	✓
Puncturing	TBD	TBD	TBD	TBD
WPA3-Enterprise w/MLO	NO	NO	NO	YES
WPA3-Personal w/MLO	✓	✓	✓	✓

Presented By:

## Wi-Fi Design “Rules” and Best Practices

**It  
Depends!!!!!!**

Presented By:

(US)NUA

US Networking User Association

## Wi-Fi Design “Rules” and Best Practices

Design for most critical least capable device

Presented By:

**(US)NUA**  
US Networking User Association

- Lots more features I did not specifically cover!  
MLO and Spectrum Puncturing are very beneficial and key features of WiFi 7
- 6 GHz for 6e or 7 is ready today - Even if clients don't support MLO
- Client adoption will catch up – Quick!
- WPA3 and Required for clients in 6 GHz
- 4096 QAM not likely to be achieved in most situations
- Test your clients for WPA3 support – If good, enable WPA3 on Prod SSID and turn it up on all 3 Bands
- Start with High Density Areas - Auditorium / Cafe / Gym
- Outdoor 6 GHz requires additional considerations for connectorized APs
  - o Standard Power
- 320 MHz wide channel not advisable - Plan for 40 or 80

## Wi-Fi 8 Teaser

802.11bn Ultra High Reliability

100Gbps (10Gbps 2SS)

8K – QAM

16 Spatial Streams

Multi-AP coordination

Multi-AP MLO

Even greater deterministic latency

Unicorns and rainbows...



Presented By:

(US)NUA

US Networking User Association

Thank  
You!!

Presented By:

(US)NUA

US Networking User Association