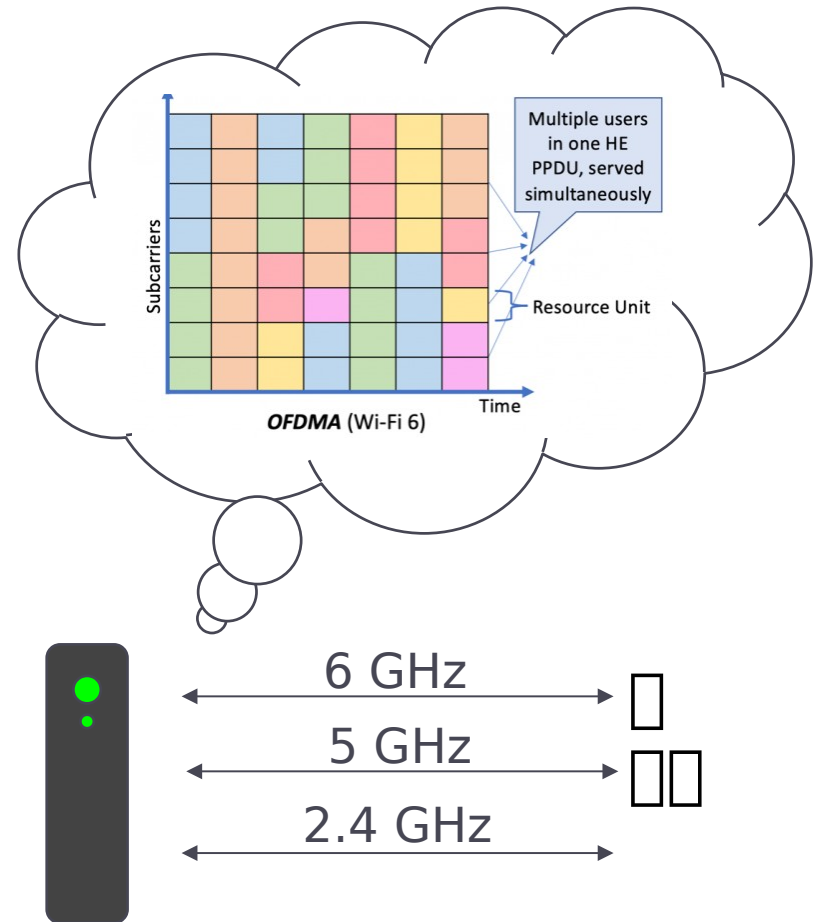


CS/ECE 439: Wireless Networking

WiFi 7

Wi-Fi 6

- ▶ 3 bands
 - ▶ 2.4, 5, 6 GHz
- ▶ OFDMA
 - ▶ Router controls scheduling
- ▶ Channels
 - ▶ Split into Resource Units (RUs)



Improvement goals

- ▶ Better data rate?
 - ▶ More frequency bands
 - ▶ Wider channel width
 - ▶ Denser modulation
 - ▶ More spatial streams



Improvement goals

- ▶ Better data rate?
 - ▶ More frequency bands
 - ▶ Wider channel width
 - ▶ Denser modulation
 - ▶ More spatial streams

Restricted by FCC!

Large channels -> more BW!

More bits per symbol

More total capacity



Improvement goals

- ▶ Better channel utilization?
- ▶ Big improvements with WiFi 6 OFDMA, but can we do better?
 - ▶ What if a section of my channel is blocked?
 - ▶ Is channel still underutilized?



Improvement goals

- ▶ Better channel utilization?
- ▶ Big improvements with WiFi 6 OFDMA, but can we do better?
 - ▶ What if a section of my channel is blocked?
 - ▶ Is channel still underutilized?

Can we work around it?

If we are clever with RUs,
what can we do?



WiFi 7 Features

- ▶ Multi-Link Operation (MLO)
- ▶ Multi-Resource Unit (multi-RU)
- ▶ Multi-RU puncturing
- ▶ General improvements
 - ▶ Wider channels
 - ▶ More MCS levels
 - ▶ More MIMO streams
 - ▶ etc.



Image: from a WiFi 7 card on Amazon

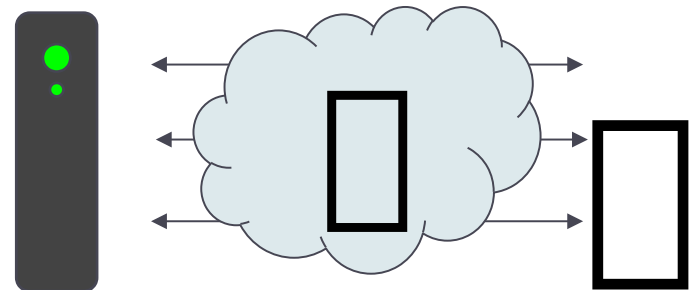
WiFi 7 Multi-Link Operation (MLO)

- ▶ Multiple links to communicate with a pair of devices
- ▶ Different configurations
- ▶ Capabilities vary from device to device



WiFi 7 Multi-Link Operation (MLO)

- ▶ Send more data
 - ▶ Simultaneously send on multiple links
- ▶ Simultaneous Tx/Rx
 - ▶ Send on one link, listen on another
- ▶ Pick band based on task
 - ▶ Demanding tasks get higher data rate?
- ▶ Pick band based on channel conditions
 - ▶ If one band is overloaded, use another
- ▶ Redundant transmission

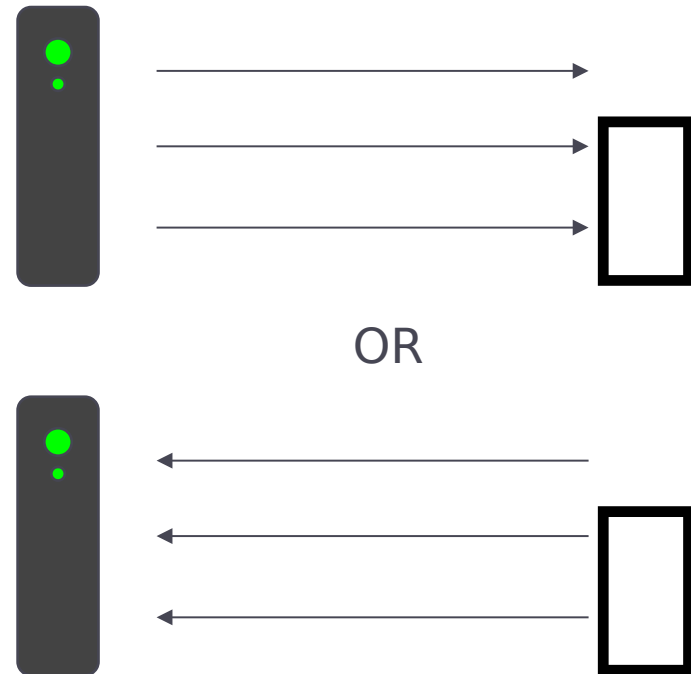


MLO w/ multiple radios: Multi Link Multiple Radio (MLMR)

- ▶ STR: Simultaneous Tx & Rx



- ▶ NSTR: Non-Simultaneous Tx & Rx



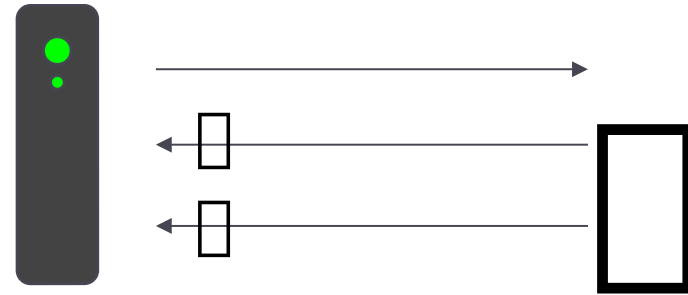
MLO w/ single radio - Multi Link Single Radio (MLSR)

- ▶ MLSR: Multi Link Single Radio

- ▶ E-MLSR: Extended MLSR



Tx or Rx on one link
at a time

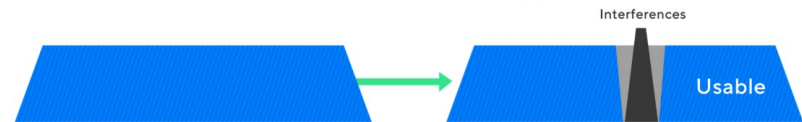


Tx on one link
Rx on (up to) two

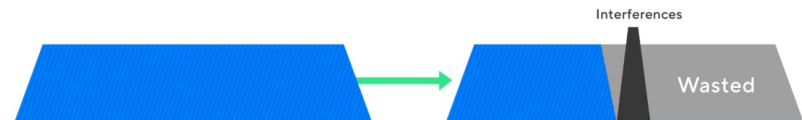
Preamble puncturing

- ▶ Now required in WiFi 7
- ▶ “Snip out” sections of channel which are in use
 - ▶ For example, by radar
- ▶ Don’t need perfectly contiguous channel
- ▶ However
 - ▶ Not supported for all channel sizes
 - ▶ May not be available on all bands

With Multi-RU Puncturing

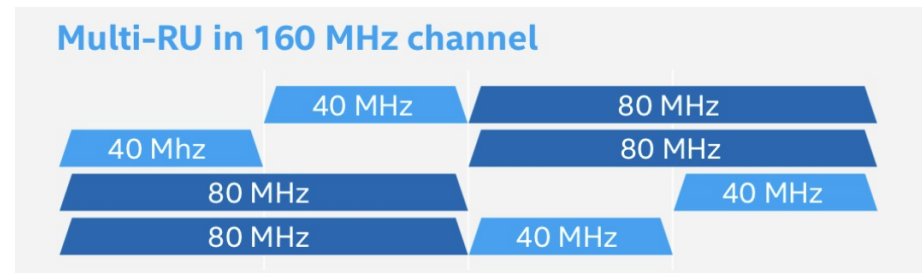
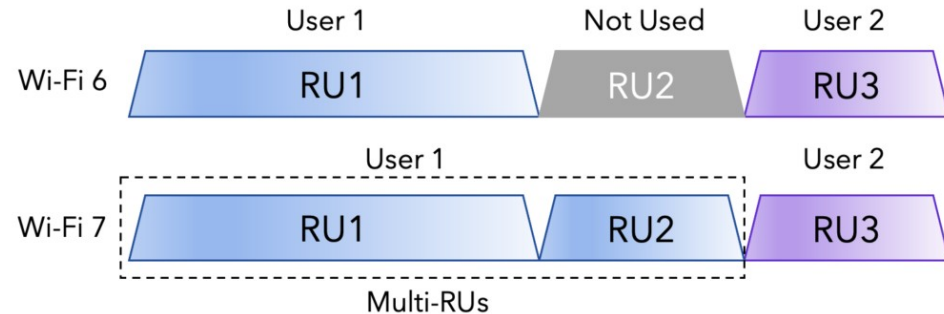


Without Multi-RU Puncturing



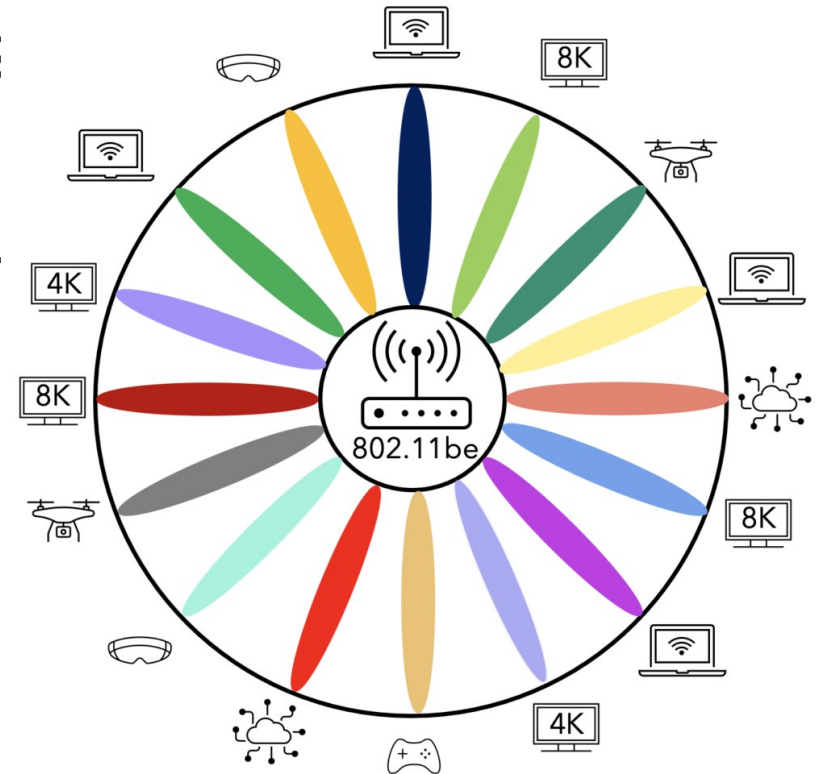
Multi-RU

- ▶ Multiple RUs can be assigned to a single user
- ▶ Potential for greater data rate and channel utilization
- ▶ RU allocation scheme dependent on the number of users to handle, channel bandwidth, etc.



Spatial streams

- ▶ WiFi 6 (802.11ax)
 - ▶ Max 8 spatial streams
- ▶ WiFi 7
 - ▶ Max 16 spatial stream



Spatial streams

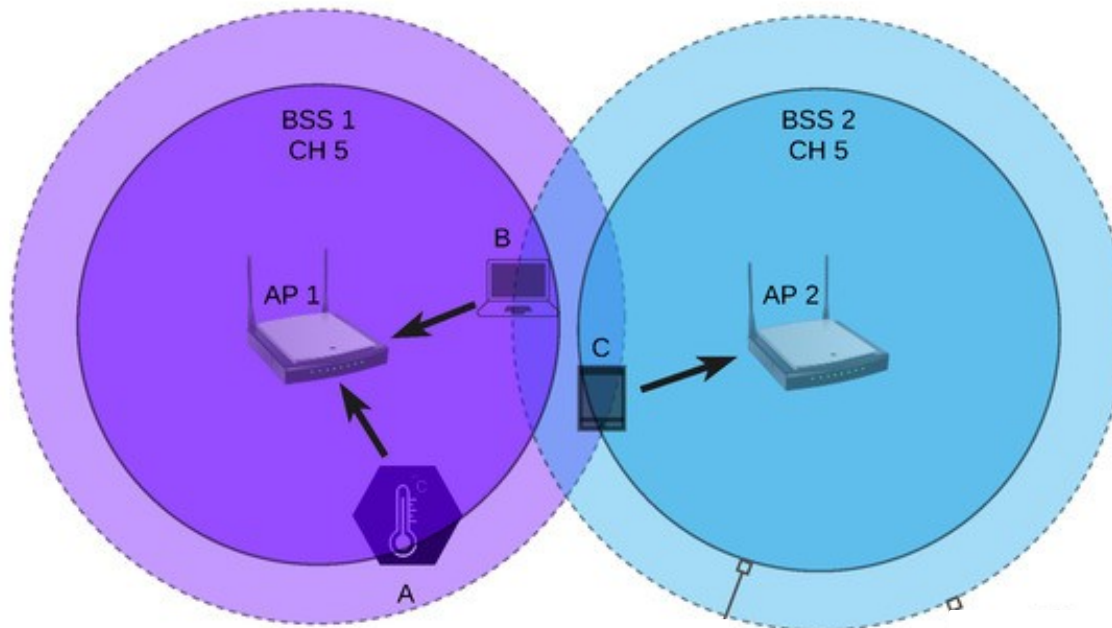
- ▶ Why it matters in practice
 - ▶ More streams = more simultaneous data paths between AP and client(s)
 - ▶ Directly boosts peak throughput
 - ▶ Combines with wider (320 MHz) channels and higher-order MIMO
 - ▶ Big throughput gains
- ▶ The catch
 - ▶ 16 streams needs 16 antennas on both ends
 - ▶ Realistically an AP-side number, not something your phone will have
 - ▶ Most of the benefit in real deployments comes from MU-MIMO
 - ▶ Splitting those streams across multiple clients
 - ▶ Not one device using all 16



Multi-AP Coordination

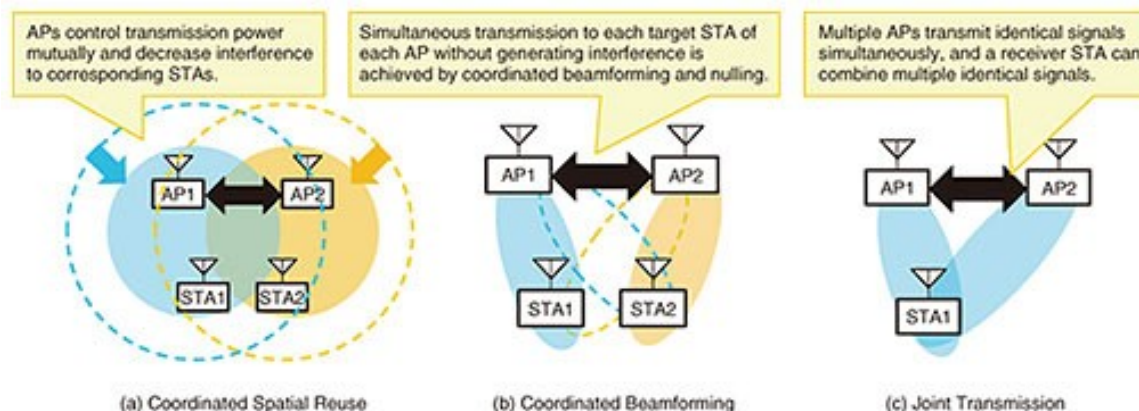
► The old way

- Neighboring APs just avoid each other's channel
- Sense the channel is busy, back off



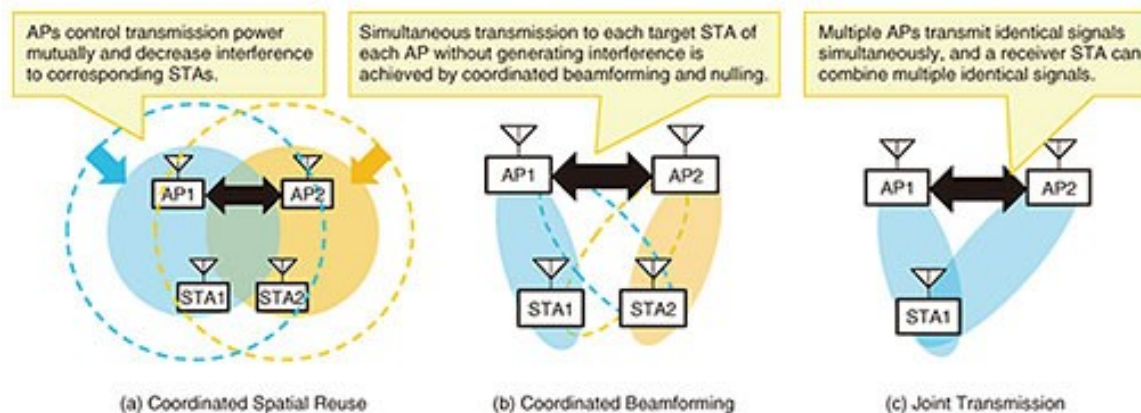
Multi-AP Coordination

- ▶ WiFi 7's new way
 - ▶ Neighboring APs coordinate directly
 - ▶ Coordinated Beamforming
 - ▶ Nearby APs steer their nulls toward each other's clients
 - ▶ Cuts interference instead of just avoiding it
 - ▶ Coordinated/Joint Transmission
 - ▶ Multiple APs jointly transmit to the same client
 - ▶ MIMO, but the antennas belong to different APs



Multi-AP Coordination

- ▶ Borrows directly from cellular's CoMP (Coordinated Multi-Point)
- ▶ Needs a low-latency backhaul link between APs
 - ▶ Not yet common in shipping hardware



Restricted TWT (R-TWT)

- ▶ Regular TWT schedules a wake time, but doesn't protect it — other traffic can still delay it
- ▶ R-TWT reserves specific time windows for latency-sensitive traffic (gaming, calls, AR/VR)
- ▶ Other stations must defer during an announced R-TWT window
- ▶ Basically: TWT tells you when to wake up, R-TWT also guarantees the channel is yours when you do



WiFi 6E vs. WiFi 7, roughly

- ▶ Max channel width: 160 MHz → 320 MHz
- ▶ Max MCS: 1024-QAM → 4096-QAM
- ▶ Links per device: 1 → up to 3 simultaneous (MLO)
- ▶ Spectrum used: single band → can span 2.4/5/6 GHz at once
- ▶ Real-world gains are usually much smaller than the on-paper numbers — see "Expectations vs reality"

