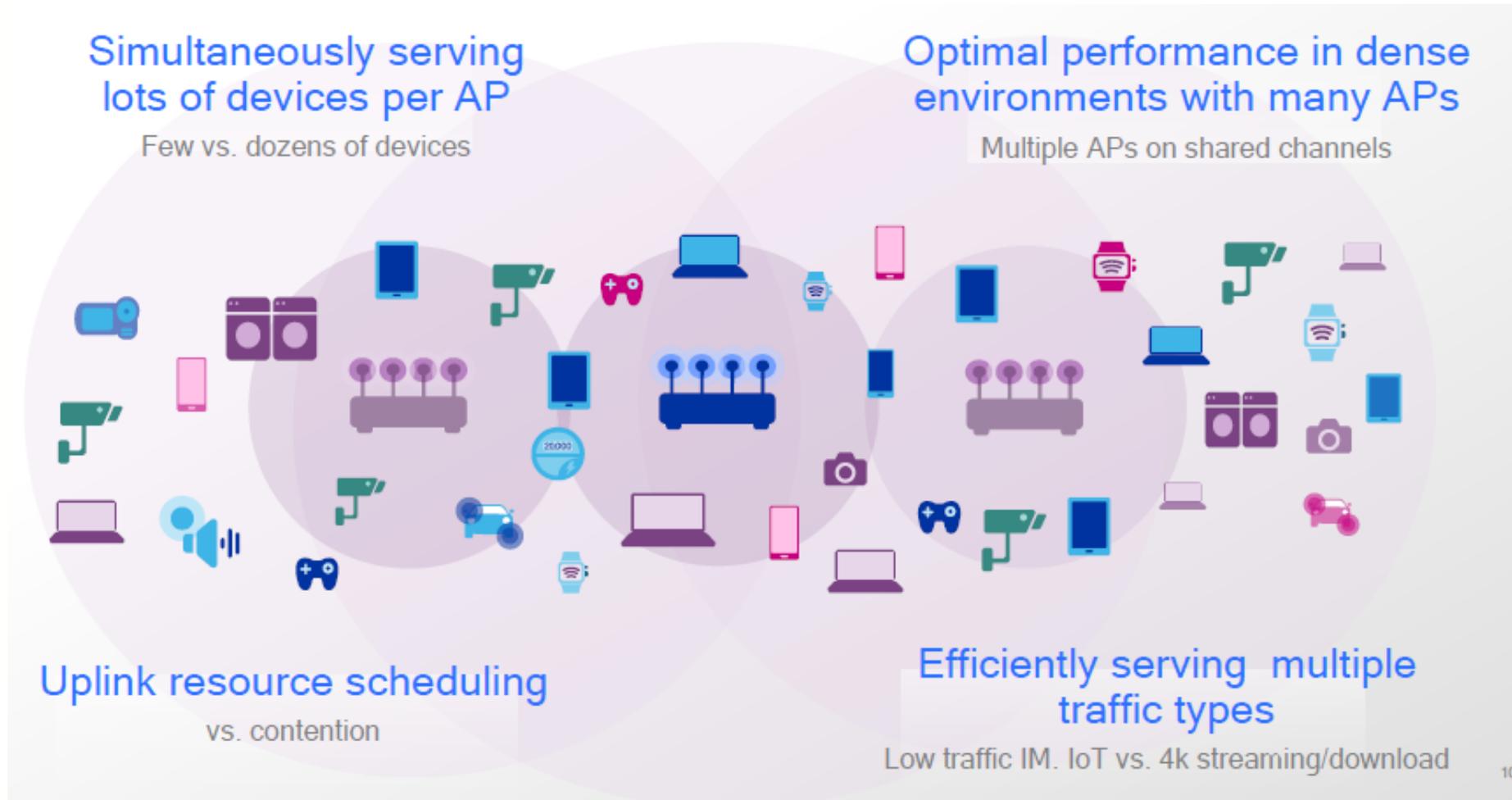


802.11ax: High Efficiency WLAN

Nadeem Akhtar

WiFi Consulting Services Team

802.11ax Requirements



Source: Qualcomm

802.11ax Enhancements

Spectral Efficiency

- 1024-QAM
- 8x8 MIMO
- Longer OFDM Symbol

High Density

- OFDMA
- Spatial Reuse

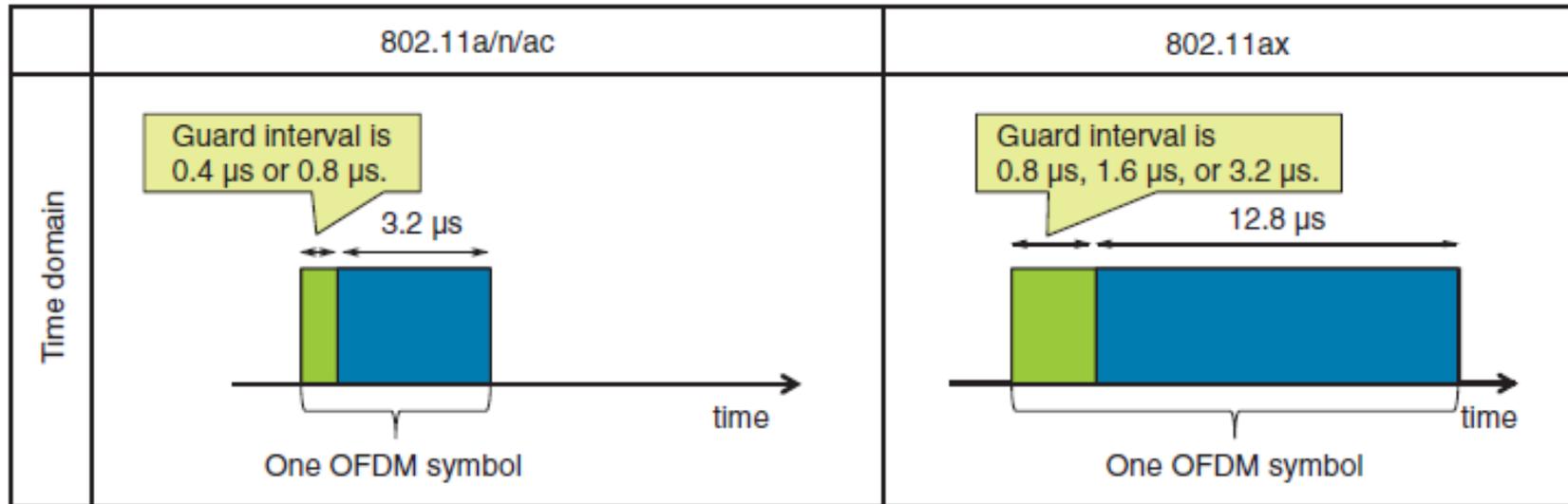
Long Range

- Longer Cyclic Prefix

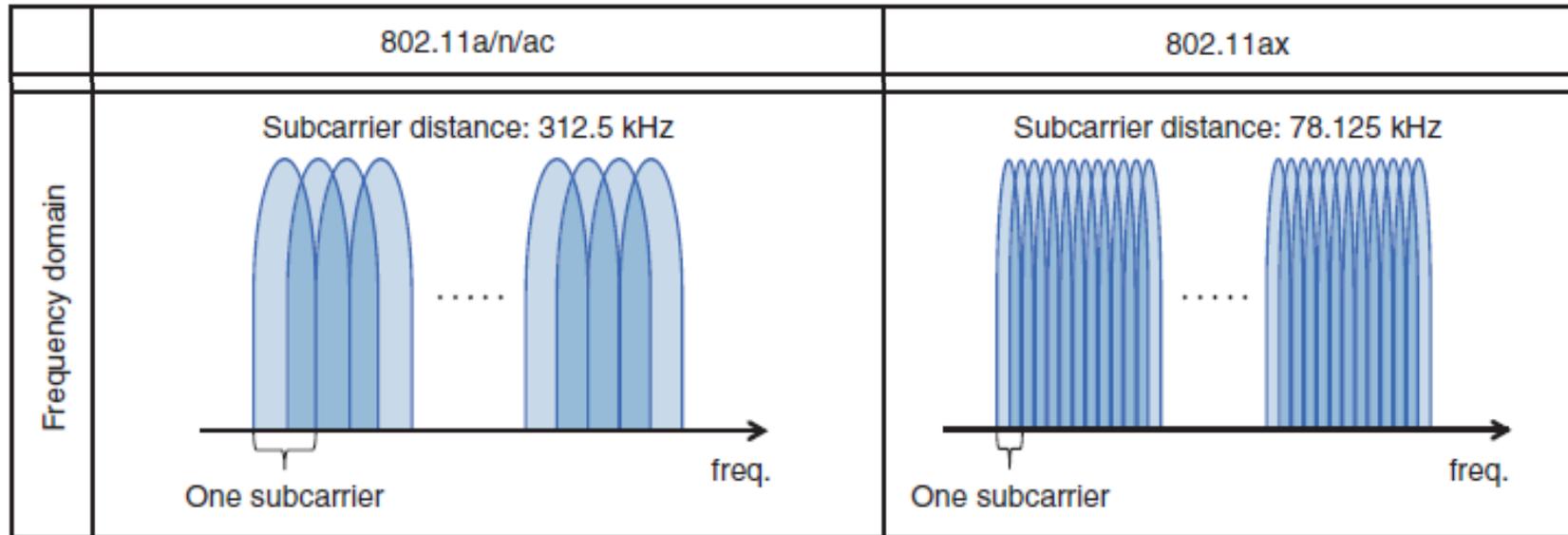
Power Save

- Scheduled sleep and wake times

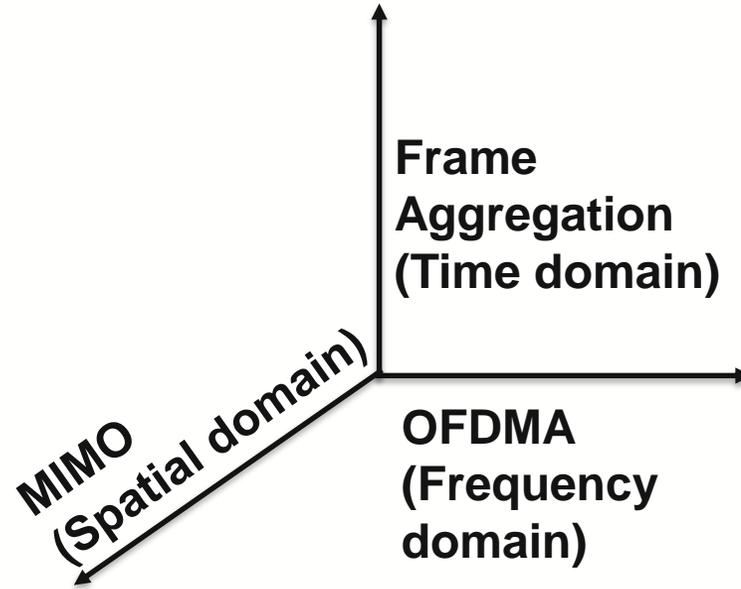
Symbol Duration



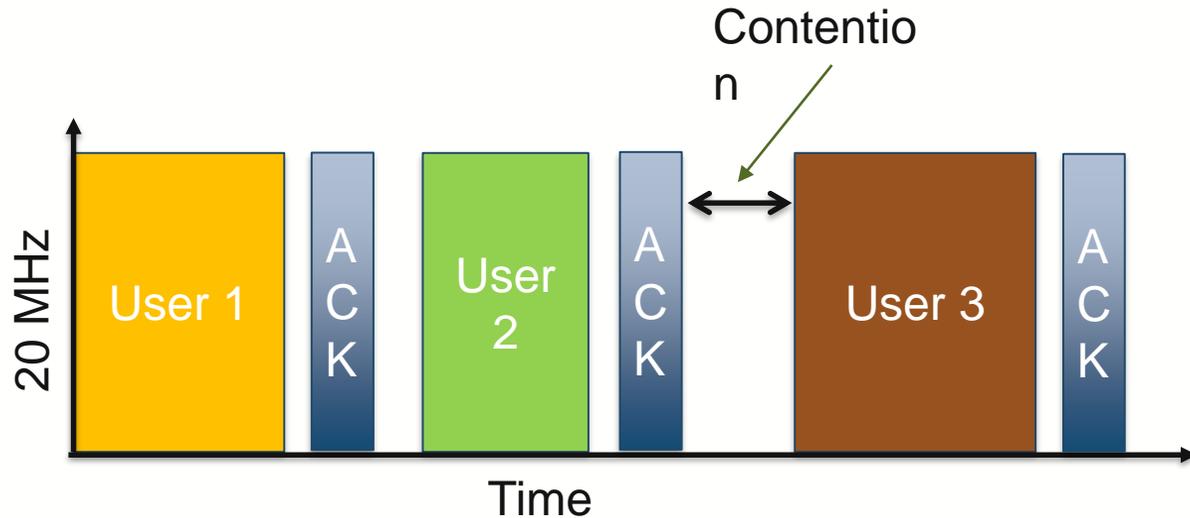
Sub-carrier Spacing



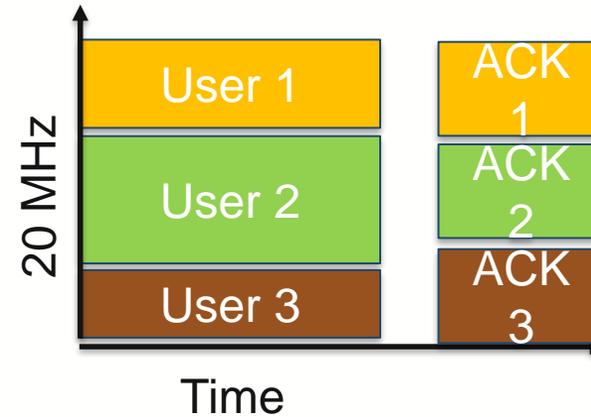
OFDMA



OFDM vs OFDMA



- **Fixed overhead independent of payload size**
- **Uses full channel bandwidth per user**



- **Overhead amortized among users**
- **Efficient use of resources**
- **Scales resources for different types of traffic (e.g. IM vs large download)**
- **Increases overall efficiency**

OFDMA

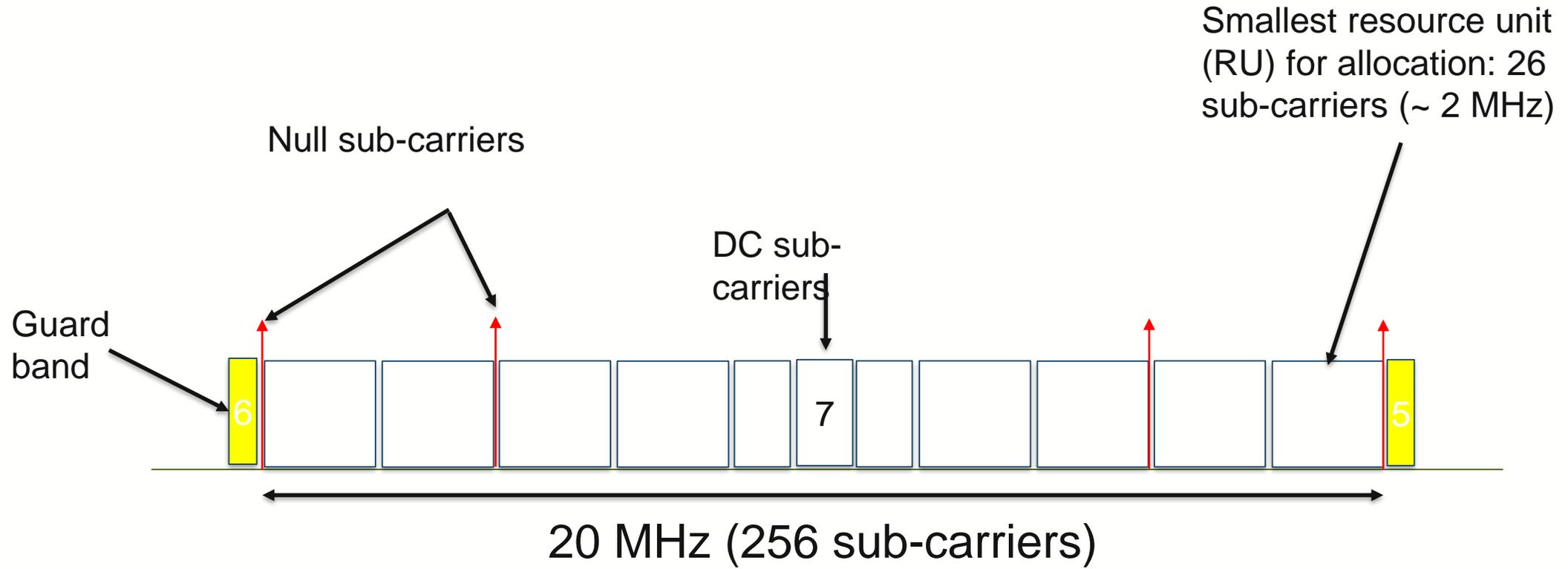
Downlink OFDMA

- AP groups users to maximize downlink transmission efficiency

Uplink OFDMA

- Users are grouped together and transmit in sync to AP to maximize uplink transmission efficiency

Resource Units

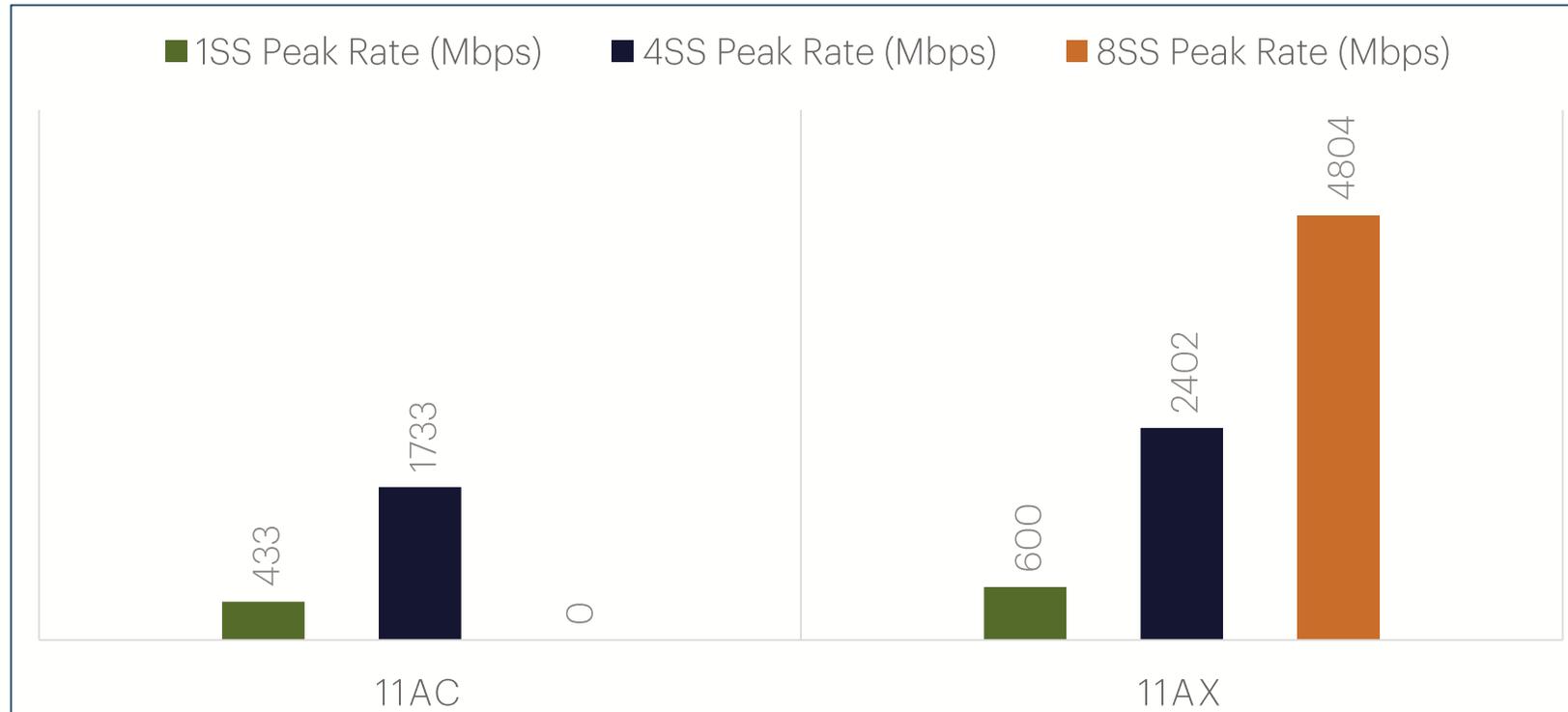


RU per Bandwidth

RU type	CBW20	CBW40	CBW80	CBW160 and CBW80+80
26-subcarrier RU	9	18	37	74
52-subcarrier RU	4	8	16	32
106-subcarrier RU	2	4	8	16
242-subcarrier RU	1 SU/ MU-MIMO	2	4	8
484-subcarrier RU	N/A	1 SU/ MU-MIMO	2	4
996-subcarrier RU	N/A	N/A	1 SU/ MU-MIMO	2
2x996 subcarrier RU	N/A	N/A	N/A	1-SU/ MU-MIMO

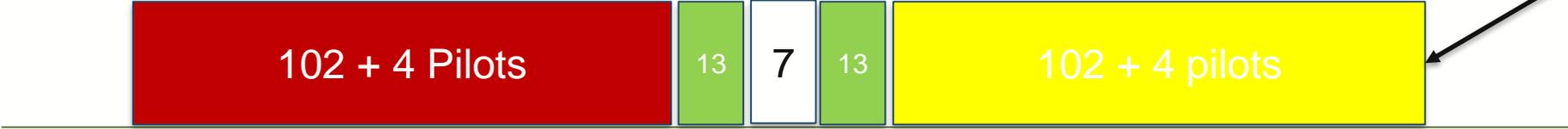
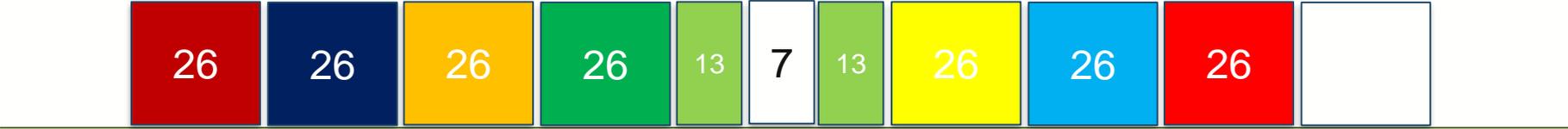
Source: Agilent

Peak Rate Calculation



Standard	BW (MHz)	Data Sub-carriers	Max bits per Symbol	Code Rate	Data bits per sub-carrier	OFDM Symbol Duration (us)	1SS Peak Rate (Mbps)	4SS Peak Rate (Mbps)	8SS Peak Rate (Mbps)
11ac	80	234	8	5/6	6.67	3.6	433	1733	NA
11ax	80	980	10	5/6	8.333333	13.6	600	2402	4804

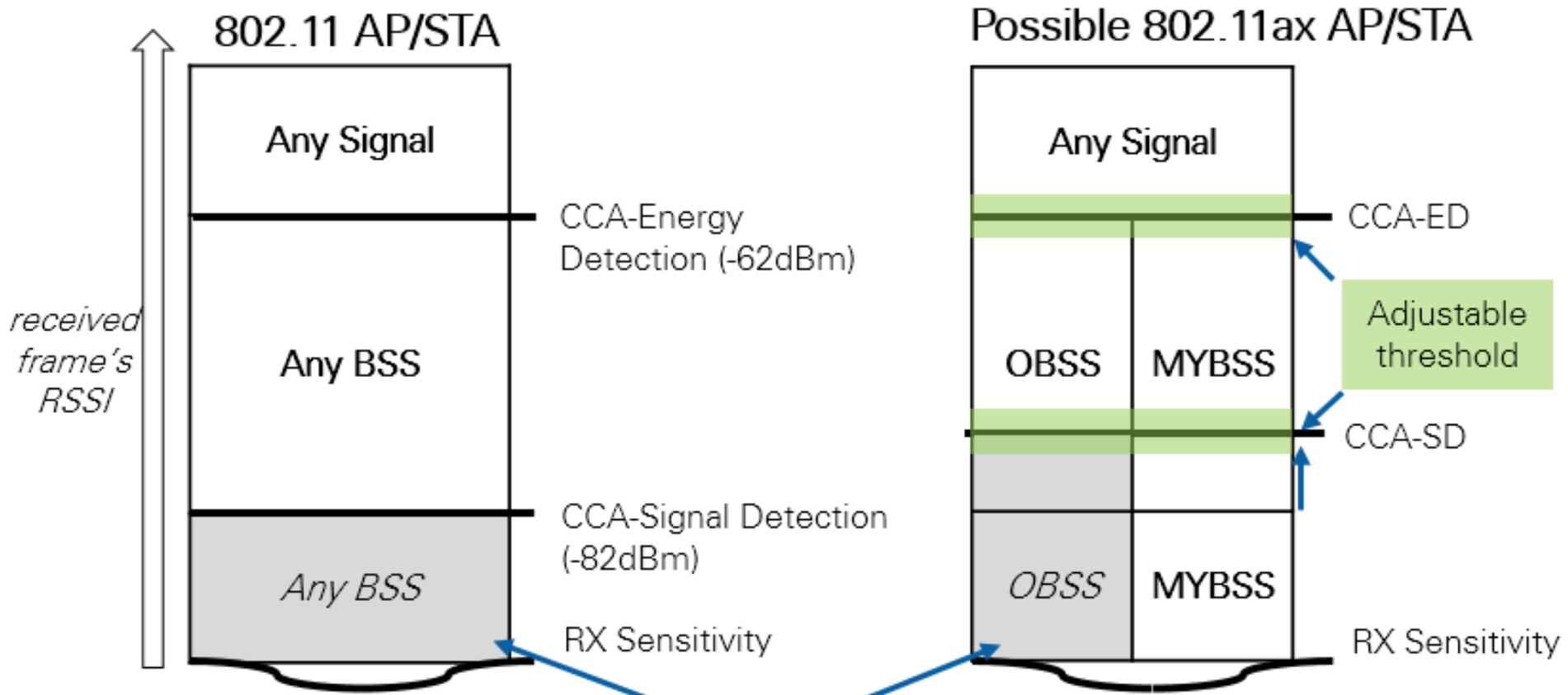
Resource Allocation



Minimum
RU size
for MU-
MIMO



Spatial Reuse



BSS: Basic Service Set
OBSS: Overlapping BSS

Source: NI