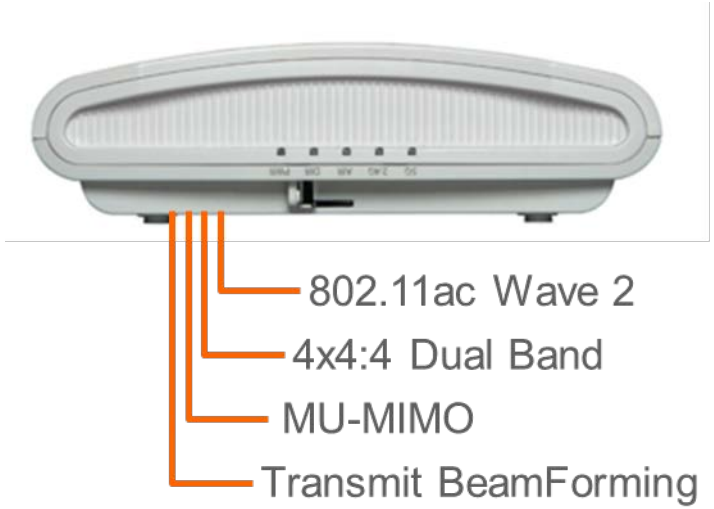
IEEE802.11ac

- **IEEE802.11ac (WiFi 5)**



Review

- IEEE802.11i
  - WPA, WPA2
- IEEE 802.11n
  - MIMO

IEEE 802.11ac – Breaking the Gigabit Barrier

Gratuitous clipart - Please ignore

IEEE802.11ac

Purpose:

- Provide significantly higher network throughput for existing WLAN application areas
- Enable new market segments for operation below 6 GHz including distribution of multiple multimedia / data streams and rapid synchronization

Scope:

Updates to both PHY and MAC to enable:

- » A multi-station network throughput of at least 1 Gbps
- » A maximum single link throughput of at least 500 Mbps
- » Below 6GHz carrier frequency operation, excluding 2.4GHz operation

I.e. 5 GHz operation generally, using same spectrum in use for .11a and .11n

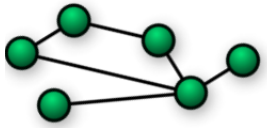
- Backward compatible with 802.11a/n.

IEEE802.11ac Categories of Usage

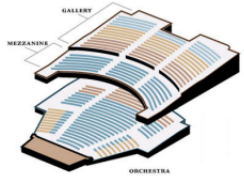
Wireless Display

In Home Distribution of HDTV and other content

Rapid Upload/Download of large files to/from server



Backhaul Traffic (e.g. Mesh, Point-to-Point)



Campus / Auditorium deployments

Manufacturing Floor Automation

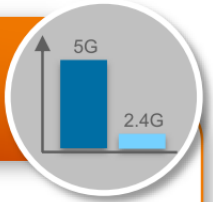
Source:
https://mentor.ieee.org/802.11/dcn/07/11-07-2988-04-0000-liaison-from-wi-fi-alliance-to-802-11-regarding-wfa-vht-study-group-consolidation-of-usage-models.ppt
also see:
https://mentor.ieee.org/802.11/dcn/09/11-09-0161-02-00ac-802-11ac-usage-model-document.ppt

IEEE802.11ac - An Overview

Optimistic Specs

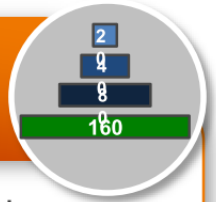
- Breaks “gigabit” barrier
- Max of 6.9 Gbps
- “Gimmick” specs that drive data rates very high
- Many features not practical for real-world enterprises

5 GHz Only



- Encourages 5G adoption
- Focuses on capacity-rich, low-interference spectrum
- Benefits entire Wi-Fi ecosystem

80/160 MHz channels

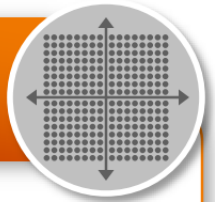


- Very wide channels
- Primary reason for 11ac’s very high data rates
- Ineffective use of spectrum in multi-AP environments
- Decreases total capacity

Up to 8 spatial streams

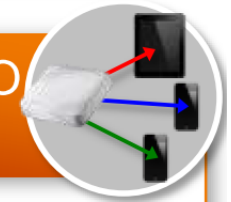
- N-fold efficiency improvement
- Increases radio complexity, power draw, and cost
- Requires client-side support
- Not possible today

256-QAM



- More efficient modulation
- 33% data rate gains
- Very short ranges only
- Requires 11ac clients

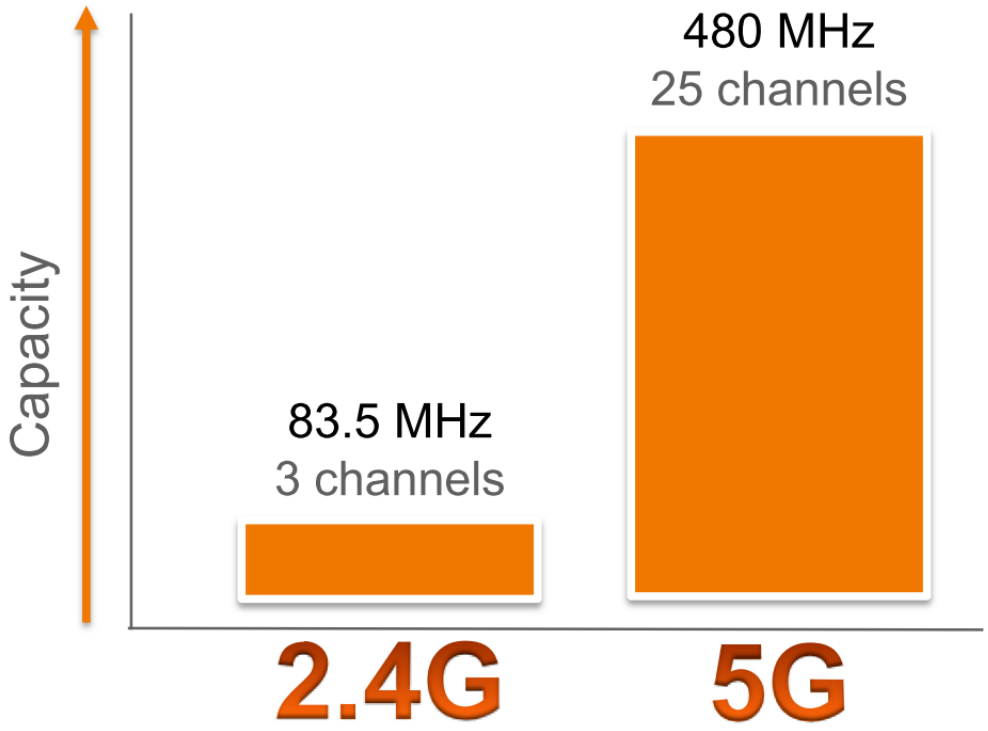
Multi-user MIMO (MU-MIMO)



- Simultaneous downlink Tx to single-stream clients
- Multiples network capacity
- Key differentiator from 802.11n

5 GHz Only

- 11ac supports 5 GHz frequencies only
  - Dual-band devices will support 11n in 2.4 GHz
- Focuses on spectrum with more bandwidth, less interference, and better scalability and capacity
- Encourages client device suppliers to adopt 5 GHz, to benefit from 11ac marketing, leaving 2.4 GHz as “best effort” spectrum



80 and 160 MHz Channels in 802.11ac

OVERVIEW

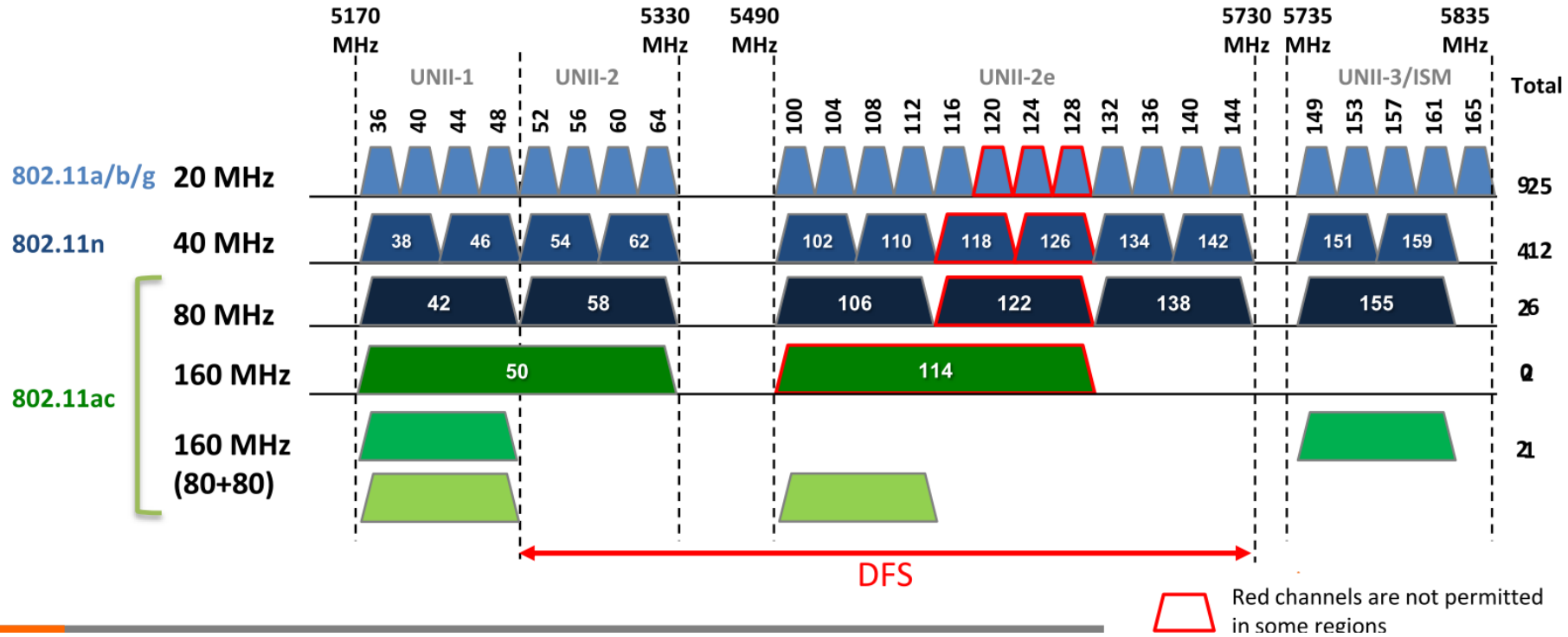
- 11ac devices must support 80 MHz channel width
- Optional support for 160 MHz
  - Contiguous or non-contiguous (80+80)
- Boosts maximum 802.11ac specs
- Appeal is for consumers with 1 AP

Pros

- Max data rate is more than doubled
- Boosts throughput in networks with few APs
- Improves backup, file transfer speeds

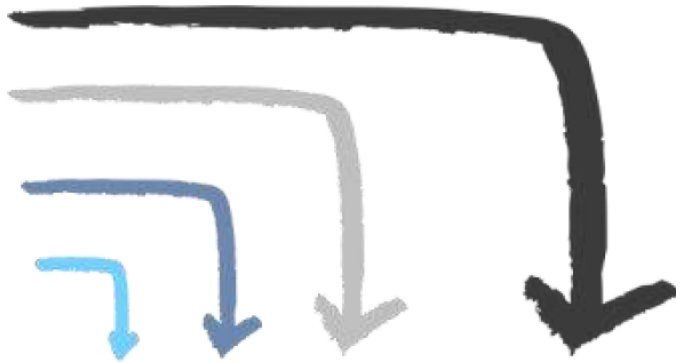
Cons

- Sub-optimal spectral reuse in multi-AP deployments
- Max of 5 non-overlapping 80 MHz channels
- Increases neighbor interference and contention
- Likely decreases aggregate capacity in enterprise



Up to 8 Spatial Streams in 802.11ac

- 802.11ac defines up to 8 spatial streams
- 802.11n defined up to 4 spatial streams
- Flagship devices today support up to 3SS
- Enterprises often prefer cost/performance of 2x2 APs



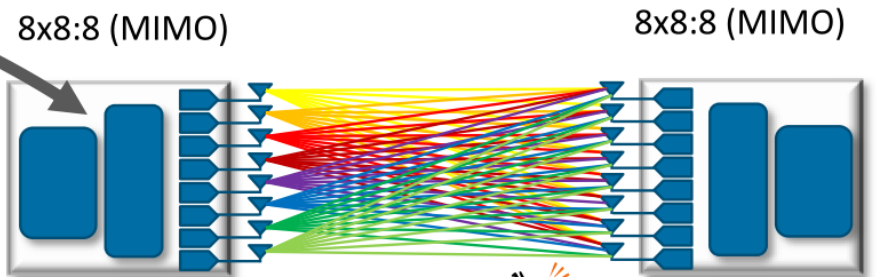
Real-World Barriers

- Business
  - Increases AP/client cost
  - Increases AP/client size
  - Decreases aesthetic appeal
  - 2x2 APs often meet the business need
- Technical
  - Short range for 4+ streams
  - More streams require RF "differentiation" (difficult with 4+ streams)
  - Adds power draw on APs (PoE power budget) and clients (battery life)

Bandwidth	1ss	2ss	3ss	4ss	...	8ss
20 MHz	78	156	260*	312	...	624
40 MHz	180	360	540	720	...	1440
80 MHz	390	780	1170	1560	...	3120

256-QAM, 800 ns GI

Artificially bloats max data rates of 802.11ac

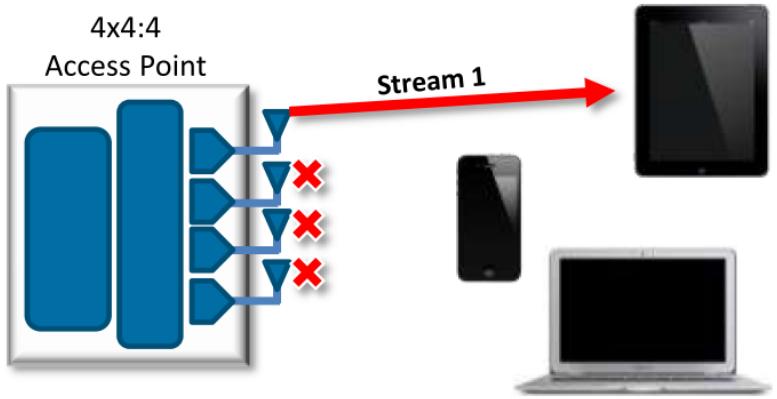


Multi-User MIMO in 802.11ac

- Transmit simultaneous downlink frames to different receivers
- Significant capacity enhancements in environments with many single-stream devices (tablets, smartphones)
- Requires 11ac client(s) with TxBF feedback/support
- Creates new challenges related to signal steering and isolation
  - How to get…
    - DataA to StaA
    - DataB to StaB
    - No DataA to StaB
    - No DataB to StaA

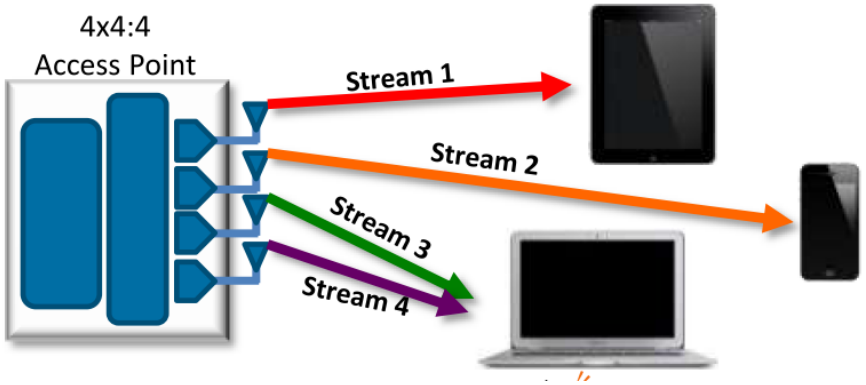
Single-User MIMO

Single downlink Tx at a time



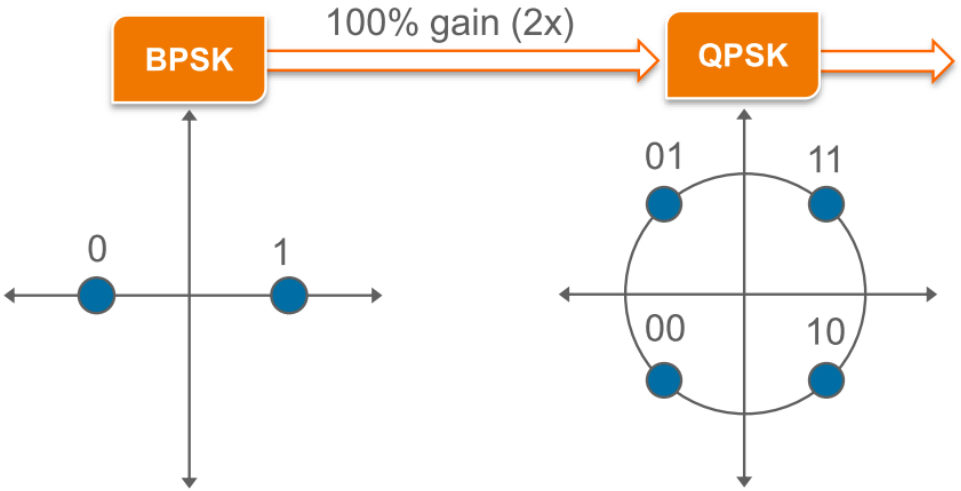
Multi-User MIMO

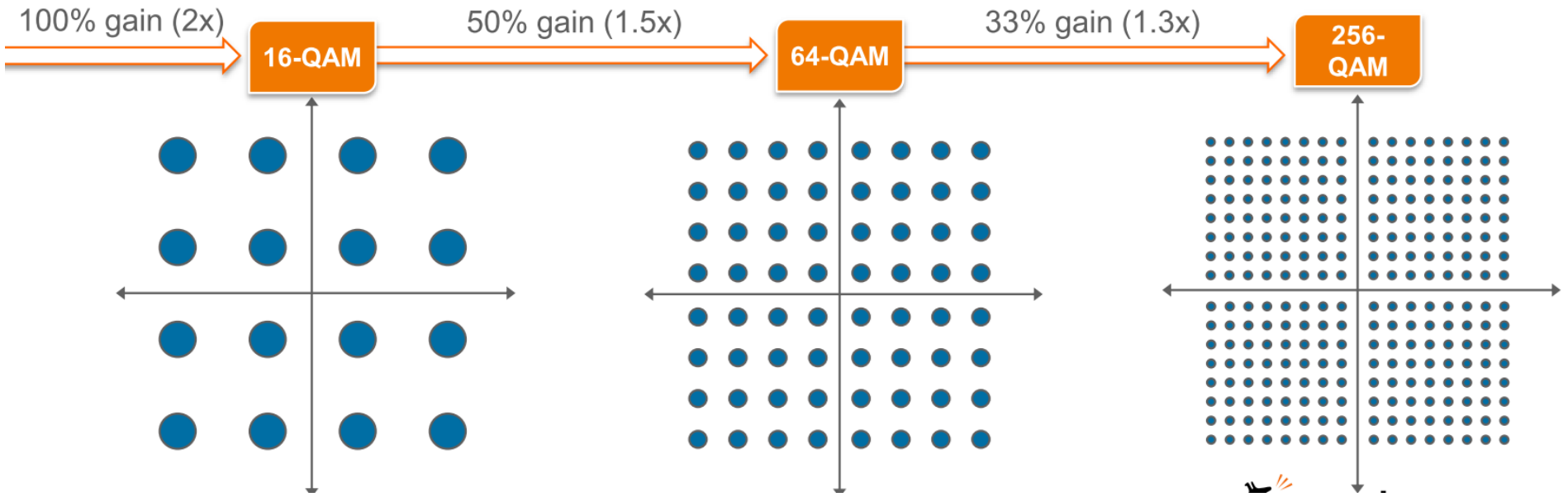
Multiple downlink Tx at same time



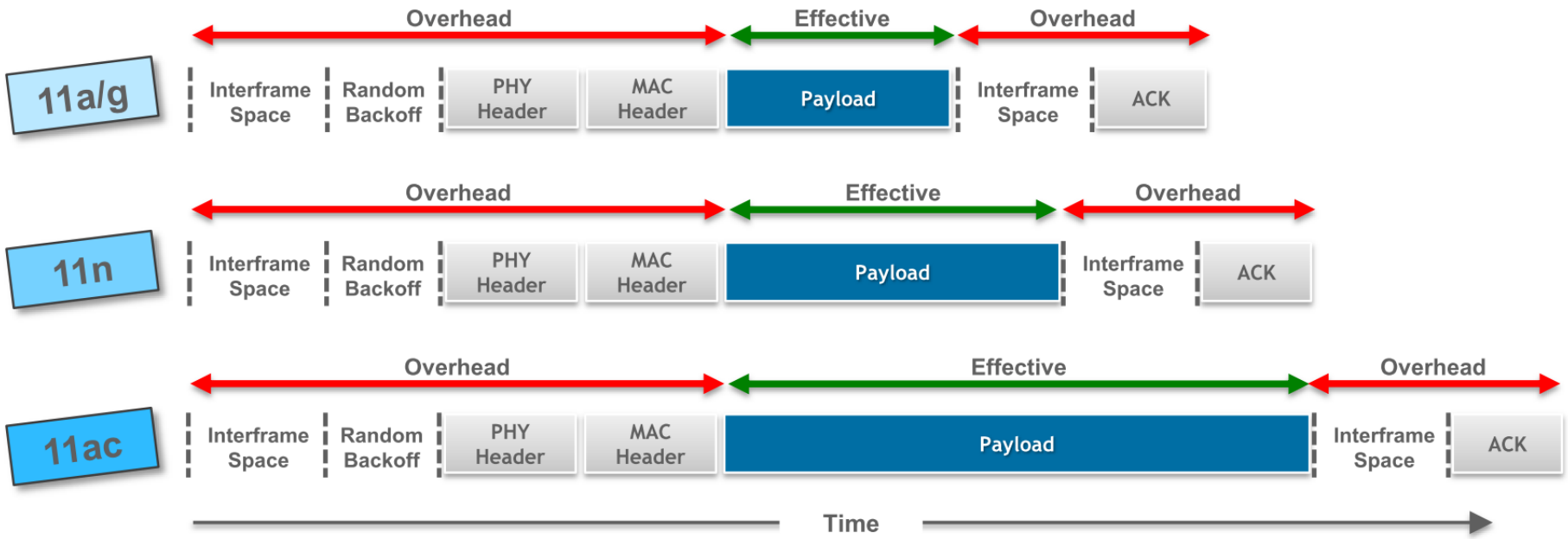
256-QAM Modulation in 802.11ac

- 256-QAM improves efficiency by 33%
- Higher-order modulation adds complexity, which requires higher SNR
  - Beneficial near the AP
- Efficiency gain from modulation does not increase linearly
- Requires 802.11ac AP and client





Large(r) Frame Size



*Note: Diagrams are not to scale and are conceptual only

PHY	Aggregation	Max Bytes (Layer 2)	Max Bytes (Layer 1)
11b	N (fragmentation often used)	2,304	~2,336
11a/g	N	2,304	~2,336
11n	Y	7,935	65,535
11ac	Y	11,454	1,048,575

The Solution: increase payload size

- Every data frame in 802.11ac is an A-MPDU
- Better spectrum efficiency enables larger frame sizes without adverse impact from interference
- Use of large frames depends on high rates

Examples of new configurations enabled by 802.11ac

Scenario*	Typical Client Form-factor	Link Rate	Aggregate Capacity
1 Tx AP, 1 Rx, 80MHz	Handheld	433 Mbps	433 Mbps
2 Tx AP, 2 Rx, 80 MHz	Tablet, Laptop	867 Mbps	867 Mbps
1 Tx AP, 1 Rx, 160MHz	Handheld	867 Mbps	867 Mbps
2 Tx AP, 2 Rx, 160 MHz	Tablet, Laptop	1.73 Gbps	1.73 Gbps
4 Tx AP, 4 1-Rx STAs,160 MHz	Handheld	867 Mbps to each STA	3.47 Gbps
8 Tx AP; 160MHz •1 4-Rx STA •1 2-RX STAs •2 1-RX STAs	DTV, STB, Tablet, PC, Handheld	**3.47 Gbps** to 4-RX STA; **1.73 Gbps** to 2-RX STA; **867 Mbps** to each 1-RX STA	6.9 Gbps
8 Tx AP; 4 2-Rx STAs, 160 MHz	DTV, Tablet, Laptop, PC	1.73 Gbps to each STA	6.9 Gbps

**** All scenarios assume 256 QAM Modulation, and rate 5/6 coding***

New technologies in 802.11ac

- **Wider channel bandwidths:**
  - **80 MHz and 160 MHz channel bandwidths**
  - **80 MHz mandatory for STA, 160 MHz optional**
- **More spatial streams:**
  - **Support for up to 8 spatial streams (vs. 4 as in 11n)**
- **Multi-user MIMO (MU-MIMO)**
  - **A technique where multiple STAs, each with potentially multiple antennas, transmit or receive independent data streams simultaneously**
    - » **"Space Division Multiple Access" (SDMA): streams not separated by frequency, but instead resolved analogously to 11n-style MIMO**
  - **Downlink MU-MIMO (one transmitting device, multiple receiving devices) included as an optional mode**
- **256-QAM Modulation**
  - **256-QAM, rate ¾ and 5/6, added as optional modes**
- **Other elements/features:**
  - **Single sounding and feedback format for beamforming (vs. multiple in 11n)**
  - **MAC modifications (mostly to adapt to above changes)**
  - **Coexistence mechanisms for 20/40/80/160 MHz channels, 11ac and 11a/n devices**

Class Quiz

- What is the drive for IEEE802.11ac?
- What is the maximum data rate in IEEE802.11ac?
- What are the new technologies in IEEE802.11ac?