Wi-Fi™ REFERENCE SERIES

XIRRUS®

802.11ac DEMYSTIFIED

OVERVIEW

802.11ac is a new very high throughput Wi-Fi standard (final approval in 2014). It delivers data rates in excess of 1Gbps in its first phase of products with future iterations planned to take performance to nearly 7Gbps. 802.11ac maintains backward compatibility with existing 802.11 equipment to simplify network migration to the new technology.

The 802.11ac standard achieves its performance boost primarily via the following methods:

- Exclusive use of 5GHz spectrum
- Multi-User MIMO (MU-MIMO)
- Channel Bonding – 80MHz and 160MHz channels
- Bonding of non-contiguous channels
- Improved PHY design – 256 QAM
- Up to eight spatial streams

802.11 STANDARDS REFERENCE

Wireless LANs are implemented by a set of IEEE 802.11 standards. The first of these standards was ratified by the IEEE in 1997 and supported up to 2Mbps connectivity. The 802.11n standard provided a significant jump in data rates by moving from a SISO to MIMO radio design along with other improvements like channel bonding. The 802.11ac standards provides further improvements in data rates with MU-MIMO and channel bonding up to 160MHz.

Ratification Year	IEEE Standard	Band 2.4GHz	Band 5GHz	Channel Bandwidth	Radio Design	Max Spatial Streams	Max Data Rate
1997	802.11	X		20MHz	SISO	1	2Mbps
1999	802.11a		X	20MHz	SISO	1	54Mbps
1999	802.11b	X		20MHz	SISO	1	11Mbps
2003	802.11g	X		20MHz	SISO	1	54Mbps
2009	802.11n	X	X	20/40MHz	MIMO	4	600Mbps
2014*	802.11ac		X	20/40/80/160 MHz	MIMO	8	6.93Gbps

* Planned to be ratified

DATA RATES

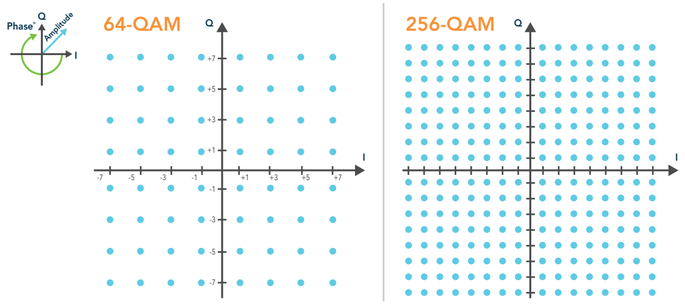
IEEE 802.11ac data rates are dependent on the number of spatial streams obtained through the use of MU-MIMO, 80 vs. 160MHz channel widths, the number of transmit antennas, and the type of modulation. This table shows the maximum data rate achievable at each level, with many additional lower rates occurring at each level dependent on signal level, SNR, etc.

Phase 1 802.11ac, first available in consumer products in 2012 and enterprise products in 2013, support up to 80MHz channels and up to 3 spatial streams for a maximum data rate of 1.3Gbps. Phase 2 and beyond products, expected starting in 2014, will add 160MHz channels and up to 8 spatial streams for a maximum data rate of 6.9Gbps.

Maximum Data Rate	# Transmit Antennas	Bandwidth (MHz)	# Streams	Modulation	
293Mbps	1	40	1	64QAM	Phase 1
433Mbps	1	80	1	256QAM	
867Mbps	2	80	2	256QAM	
1.299Gbps	3	80	3	256QAM	
1.730Gbps	4	80	4	256QAM	Phase 2+
3.470Gbps	8	80	8	256QAM	
867Mbps	1	160	1	256QAM	
1.730Gbps	2	160	2	256QAM	
3.470Gbps	8	160	4	256QAM	
6.930Gbps	8	160	8	256QAM	

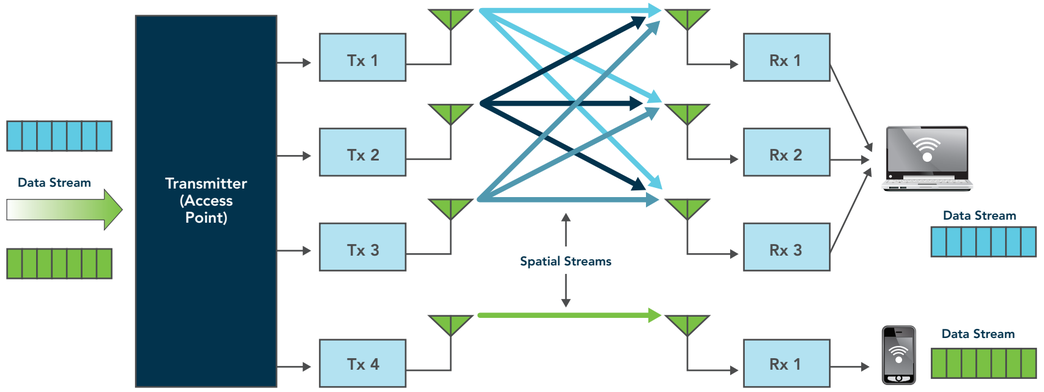
PHY

Wi-Fi utilizes several digital modulation techniques and automatically switches between them to optimize for throughput or range. The number of points in the modulation constellation determines the number of bits conveyed with each symbol. 802.11n uses 16 QAM modulation, which conveys $\log_2(16) = 4$ bits/symbol and 64 QAM, which conveys 6 bits/symbol. 802.11ac adds 256 QAM which transfers 8 bits/symbol for a 33% increase in throughput at the highest data rate over 802.11n.



MU-MIMO SIGNAL PROCESSING

MU-MIMO (multi-user multiple in multiple out) signal processing uses multiple antennas on the transmitter and receiver operating on the same channel. With spatial multiplexing in 802.11ac, up to 8 data streams may be concurrently transmitted and split between multiple devices at once. Higher data rates are achieved by splitting transmitter station streams into separate data streams; each transmitted on a different antenna. MIMO signal processing at the receiver detects and recovers each stream.

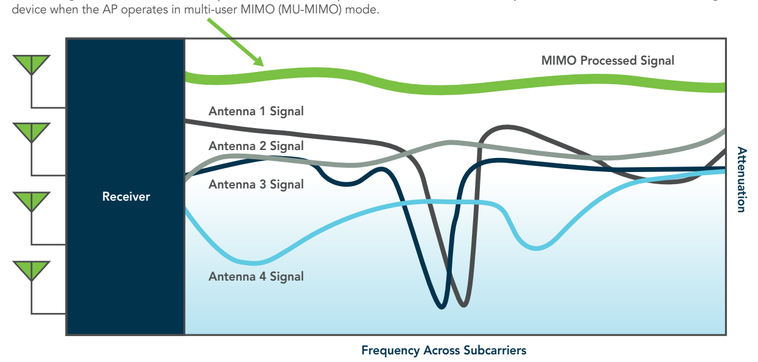


Number of AP Antennas	Possible Combinations of Receiver Antennas
2	1 station w/ 2 antennas -or- 2 stations w/ 1 antenna
3	1 station w/ 3 antennas -or- 1 station w/ 2 antennas + 1 station w/ 1 antenna -or- 3 stations w/ 1 antenna
4	1 station w/4 antennas -or- 2 stations w/2 antennas -or- 1 station w/2 antennas + 2 stations w/1 antenna -or- 4 stations w/ 1 antenna
8	1 station w/ 8 antennas -or- 2 stations w/ 4 antennas –or- 1 station w/ 4 antennas + 2 stations w/ 2 antennas -or- 2 stations w/ 2 antennas + 4 stations w/1 antenna -or- … many others …

MIMO DIGITAL SIGNAL PROCESSING

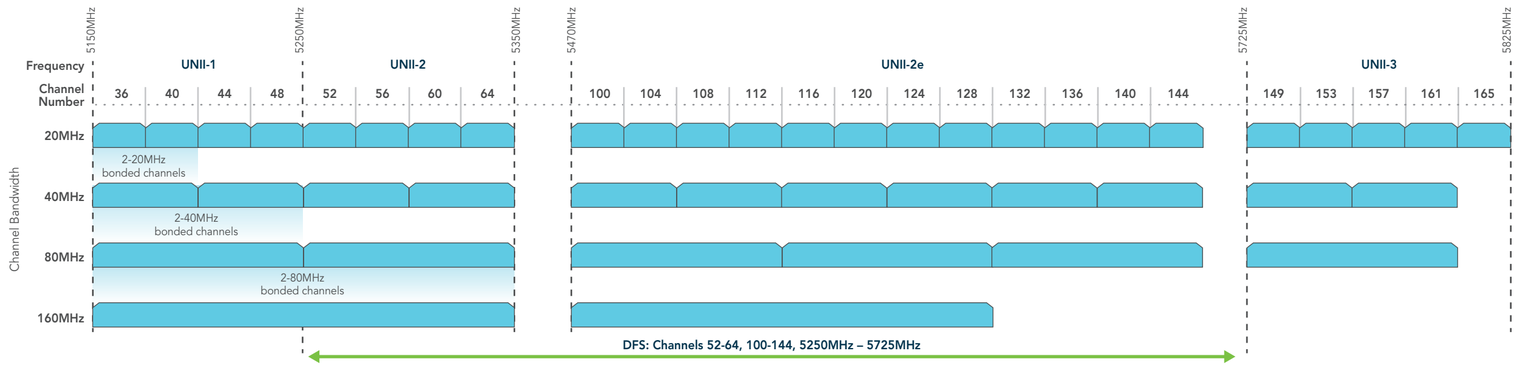
Multiple-in multiple-out (MIMO) signal processing uses multiple antennas, taking advantage of multipath reflections to improve signal coherence that greatly increases receiver sensitivity. MIMO digital signal processing creates an enhanced signal that eliminates nulls and fading.

802.11ac increases the number of antennas and spatial streams from a maximum of four in 802.11n to a maximum of eight, contributing to much higher maximum data rates (up to 6.93Gbit/s). The spatial streams can be concurrently allocated to more than one receiving device when the AP operates in multi-user MIMO (MU-MIMO) mode.



CHANNEL BONDING

Wi-Fi bandwidth can be increased by bonding multiple channels together. 802.11ac allows creation of 20, 40, 80, or 160 MHz wide channels. The 160MHz channel can also be a combination of two non-contiguous 80MHz channels (80+80). Although channel bonding increases bandwidth, wider channels are more susceptible to signal interference which may lead to reduced range and poorer signal quality.



GLOSSARY

DFS—Dynamic Frequency Selection

GI—Guard Interval

HT—High Throughput (802.11n)

MCS—Modulation and Coding Scheme

MIMO—Multiple Input, Multiple Output

MU—Multi-User

MU-MIMO—Multi-User MIMO

PHY—Physical Layer (OSI model)

QAM—Quadrature Amplitude Modulation

Rx—Receive

SISO—Single Input, Single Output

SNR—Signal-to-Noise Ratio

SS—Spatial Stream

SU—Single User

Tx—Transmit

TxBF—Transmit Beamforming

UNII—Unlicensed National Information Infrastructure

VHT—Very High Throughput (802.11ac)

WFA—Wi-Fi Alliance

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