THE ANATOMY OF 802.11ac

802.11ac Technology Enhancements

802.11ac technology addresses challenges that apply tremendous stress on the WLAN - such as high density environments driven by BYOD proliferation and high bandwidth intensive applications such as video streaming - by delivering Gigabit speeds. 802.11ac builds on many of the techniques introduced with 802.11n to further improve WLAN performance.

These techniques include:

- Wider RF channels
- More antennas in MIMO configurations
- Multi-user MIMO
- Higher Modulation and Coding Schemes (MCS)
- Standardized beamforming using explicit feedback
- 802.11ac operates only in the 5GHz band, and is backwards compatible with 802.11a/n clients.

FORMULA

The maximum PHY data rate for 802.11ac is calculated with this formula:

PHY Data Rate (Mbps)

PHY data rates refer to the physical-layer connection rates at which Wi-Fi can operate under optimal conditions. Actual user throughput will be lower due to the shared RF medium, and transmission, management and control overhead.

- 802.11n delivers a maximum PHY data rate of 600 Mbps.
- 802.11ac delivers a maximum PHY data rate of 6933 Mbps, with all specified enhancements enabled.
- With more common 3x3 Access Points operating 80MHz channels, a PHY date rate of 1300Mbps is common for the first wave of 802.11ac deployments.

Spatial Streams	802.11ac MCS Index	Guard Interval	20MHz Channel PHY Data Rate	40MHz Channel PHY Data Rate	80MHz Channel PHY Data Rate	160MHz Channel PHY Data Rate
1	0	LGI	6.5	13.5	29.3	58.5
1	0	SGI	7.2	15.0	32.5	65.0
1	1	LGI	13.0	27.0	58.5	117.0
1	1	SGI	14.4	30.0	65.0	130.0
1	2	LGI	19.5	40.5	87.8	175.5
1	2	SGI	21.7	45.0	97.5	195.0
1	3	LGI	26.0	54.0	117.0	234.0
1	3	SGI	28.9	60.0	130.0	260.0
1	4	LGI	39.0	81.0	175.5	351.0
1	4	SGI	43.3	90.0	195.0	390.0
1	5	LGI	52.0	108.0	234.0	468.0
1	5	SGI	57.8	120.0	260.0	520.0
1	6	LGI	58.5	121.5	263.3 A	526.5
1	6	SGI	65.0	135.0	292.5 A	585.0
1	7	LGI	65.0	135.0	292.5	585.0
1	7	SGI	72.2	150.0	325.0	650.0
1	8	LGI	78.0	162.0	351.0	702.0
1	8	SGI	86.7	180.0	390.0	780.0
1	9	LGI	86.7 B	180.0	390.0 C	780.0 D
1	9	SGI	96.3 B	200.0	433.3 C	866.7 D

A. Not valid for 3, 7 spatial streams
B. Not valid for 1, 2, 4, 5, 7, 8 spatial streams
C. Not valid for 6 spatial streams
D. Not valid for 3 spatial streams

Number of Spatial Streams

802.11ac supports from 1 to 8 spatial streams

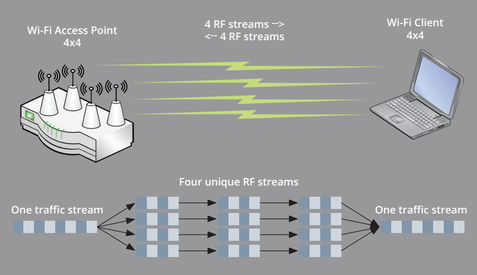
Multiple Input Multiple Output (MIMO) refers to using multiple antennas for receiving and transmitting multiple RF streams simultaneously. This allows a single traffic stream to be inverse-multiplexed over multiple simultaneous RF spatial streams to increase bit rates. This also allows a single traffic stream to be transmitted redundantly over multiple paths to improve RF reception and frame error rates; this is known as Space Time Block Coding (STBC).

MIMO nomenclature:
(Number of transmit antennas) x (number of receive antennas) : (number of unique spatial streams)

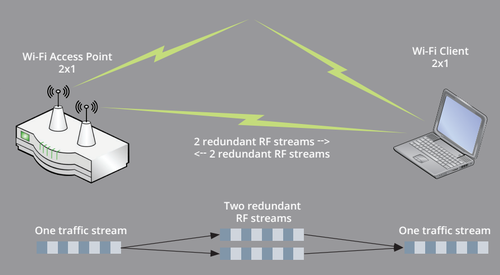
For example:

- 2x2:2 means that 2 antennas are used to transmit, and 2 antennas are used to receive, 2 unique spatial streams.
- 4x2:2 means that 4 antennas are used to transmit, and 2 antennas are used to receive, 2 unique spatial streams.

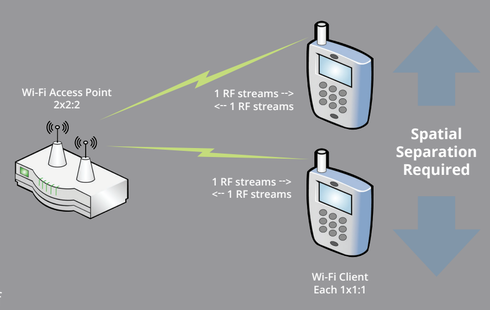
Spatial Multiplexing
A signal stream is broken down into multiple signal streams, each of which is transmitted in a separate spatial stream. Each of these streams arrives at the receiver with different amplitude (signal strength) and phase (delay).



Space Time Block Coding (STBC) is the technique of using more antennas than spatial streams to redundantly transmit a single traffic stream over multiple RF paths. This optional feature increases the reliability of the signal at the receiver. It uses more transmit antennas than receive antennas, and is designated by the MIMO comfit MxN where M > N. 802.11ac defines STBC codes for 2×1, 4×2, 6×3, and 8×4.



Multi-User Multiple Input/Output (MU-MIMO)
Traditional MIMO is used to transmit multiple spatial streams between an AP and a client radio. Multi-user MIMO (MU-MIMO) is specified in 802.11ac for an AP to use a multiple antenna array to steer beams and transmit simultaneously to multiple clients. For example, a 4x4 AP can transmit simultaneously to four 1x1 clients. In another example, a 3x3 AP can transmit 2x2:2 to one 2x2 client and 1x1:1 to another 1x1 client. This effectively increases the number of users that an 802.11ac AP can support.

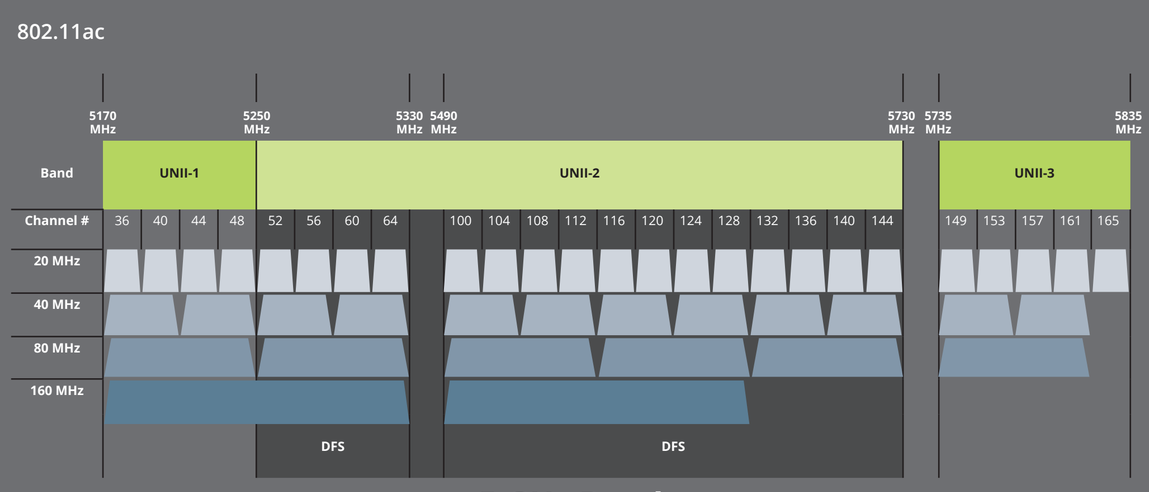


Channel Width Factor

Aggregating multiple channels increases throughput. Where 802.11n adds 40MHz channels in addition to the 20MHz channels used by legacy Wi-Fi, 802.11ac adds 80MHz and 160MHz channels to the 5GHz band.

If channel width is:	Use this value:
20MHz	52
40MHz	108
80MHz	234
160MHz	468

80MHz channel	Must be allocated from 4 adjacent 20MHz channels
160MHz channel	Can be allocated from 2 adjacent 80MHz channels, or from 2 non-adjacent 80MHz channels (designated 80+80)
Rate Improvements	Approximately proportional to bandwidth. For example, an 80MHz channel can achieve about twice the speed as a 40MHz channel
Dynamic Frequency Selection (DFS) channels	Allocated by the FCC and other regulatory bodies as those channels in which air control, weather and other official radar may be in use.



5 GHz Band

MCS Factor

Use the multiplier from the table below based on the Modulation and Coding Scheme (MCS) employed. The MCS determines how many bits can be encoded on an RF sub-carrier using phase shift and amplitude. Higher orders of MCS can encode more bits, thereby resulting in higher bit rates.

802.11ac MCS Index	MCS	MCS Factor
0	BPSK 1/2	0.5
1	QPSK 1/2	1
2	QPSK 3/4	1.5
3	16 QAM 1/2	2
4	16 QAM 3/4	3
5	64 QAM 2/3	4
6	64 QAM 3/4	4.5
7	64 QAM 5/6*	5
8	256 QAM 3/4	6
9	256 QAM 5/6	6.67

**Maximum MCS supported in 802.11n*

MCS nomenclature: 256 QAM 5/6 means that 256 different combinations of phase shift / amplitude are used to modulate an 8-bit sequence onto a single wave, and the 5/6 coding rate means for 5 bits of useful data, 6 bits are transmitted.

- 802.11ac introduces 256 QAM, and specifies 10 MCS indices.
- No support for unequal MCS for multiple spatial streams.
- Because of the higher MCS indices offered by 802.11ac, it can deliver a 6.67 / 5 = 33% improvement in rates over 802.11n, with all other things being equal.
- 256 QAM is very sensitive to noise, and is effective at close range only.

Guard Interval

Shorter guard interval increases data rates – use the table below to insert the correct factor.

Long or Short GI	Use this value:
LGI	4
SGI	3.6

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