Cisco Networking Academy
Mind Wide Open

Introduction to Wireless Technologies

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Agenda

1. Why is Wireless More and More important?
2. Wireless Technologies
3. CSMA/CA
4. Wireless Standards – 802.11 a/b/g/n
5. The new kid on the block – 802.11ac

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Why is Wireless More and More important?

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John, 10 years ago

Wi-Fi laptop

I can use Wi-Fi in the meeting room, but I lose signal if I move away

Everything else is wired

Wired Phone

I heard that some phones have Wi-Fi capabilities, but where would I use them?

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Jim, 2010

I get Wi-Fi from home, the office, most public places, some streets

Multi Wi-Fi

Like most people, have 2 or 3 Wi-Fi devices

More Applications

I rely on Wi-Fi for critical applications… and do not see why video is so slow…

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Sam, today in Barcelona

802.11ac
802.11n
Everything uses Wi-Fi…
Everything?

Far Reaching Wi-Fi

I get Wi-Fi from
almost everywhere

More Applications

Everyone uses Wi-Fi…
for almost everything

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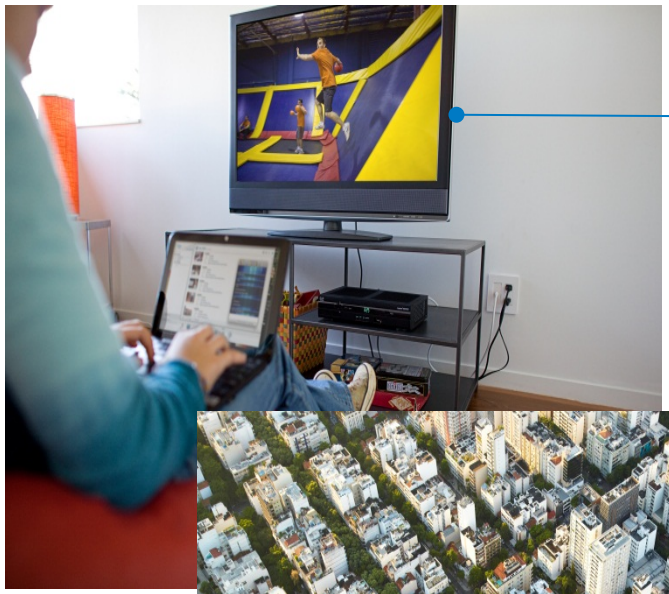
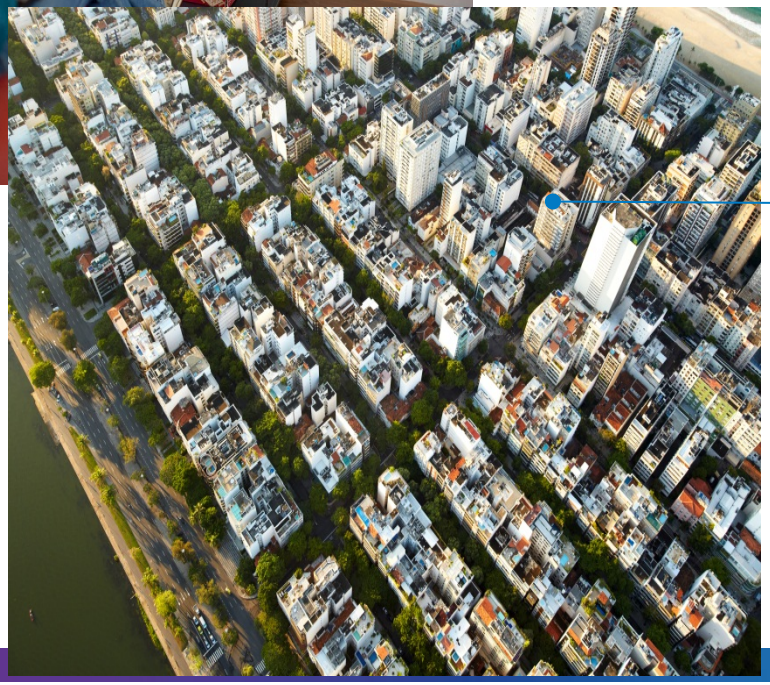
In 2017…



802.11ac -> 802.11ad

Your media server can stream to your TV, your laptop, your phone, your tablet… multiple streams everywhere in the house



802.11ah – Wireless for IoT

Wi-Fi is used to monitor your electricity, gas meters, industrial sensors (wind-mills etc.), hospital remote patients vitals, etc.

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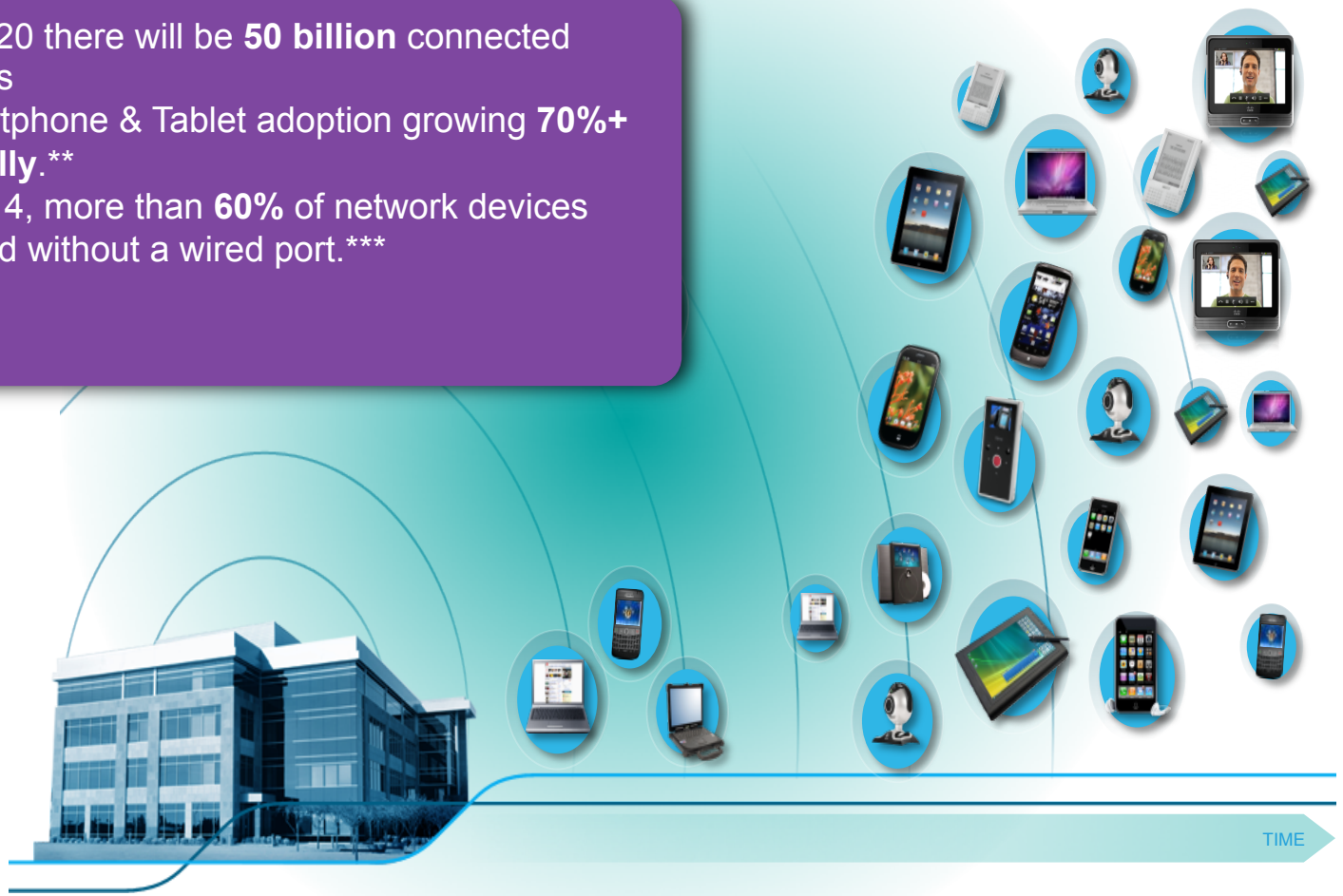
Explosive Mobile Device Growth

- In 2020 there will be **50 billion** connected devices
- Smartphone & Tablet adoption growing **70%+ annually**.**
- In 2014, more than **60%** of network devices shipped without a wired port.***



*Source: *ABI Research, **IDC, *** Morgan Stanley Market Trends

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Wireless Technology

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Wireless Technologies

- PAN/WPAN (Personal Area Network)
  Bluetooth, IEEE 802.15.4
- **LAN (Local Area Network)**
  IEEE 802.11
- MAN (Metropolitan Area Network)
  IEEE 802.11, IEEE 802.16, IEEE 802.20
- WAN (Wide Area Network)
  GSM, CDMA, Satelite
- http://www.ieee.org/index.html

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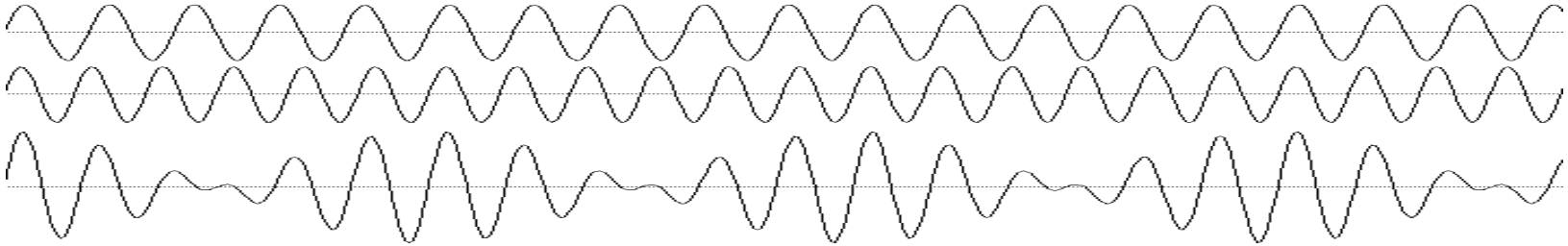
Electromagnetic waves

- Wireless technologies use electromagnetic waves



- What types of communication mediums do we have in wired networks?

  Coper, Fiber

- What communication medium do we have in wireless?

  The Earth's Athmosphere

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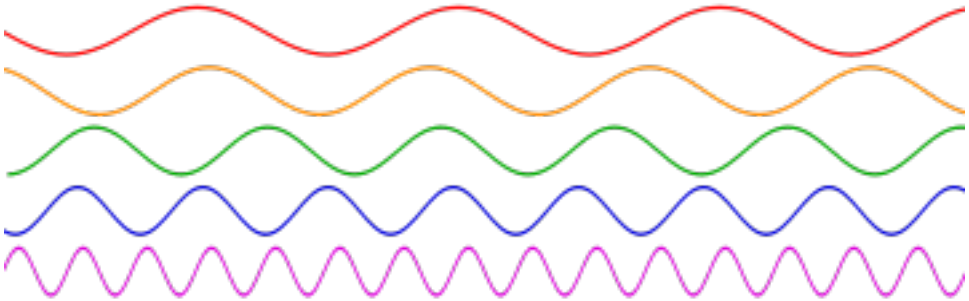
Where it starts

- Frequency (*f* - Hz)

  Frequency is the number of occurrences of a repeating event per unit time.



- Higher frequency:
  - Greater speed
  - Shorter range
  - High reflection rate
  - Higher absorption in the Earth's atmosphere
  - Higher costs

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Frequency in LAN?

- ISM – Industrial Scientific Medical

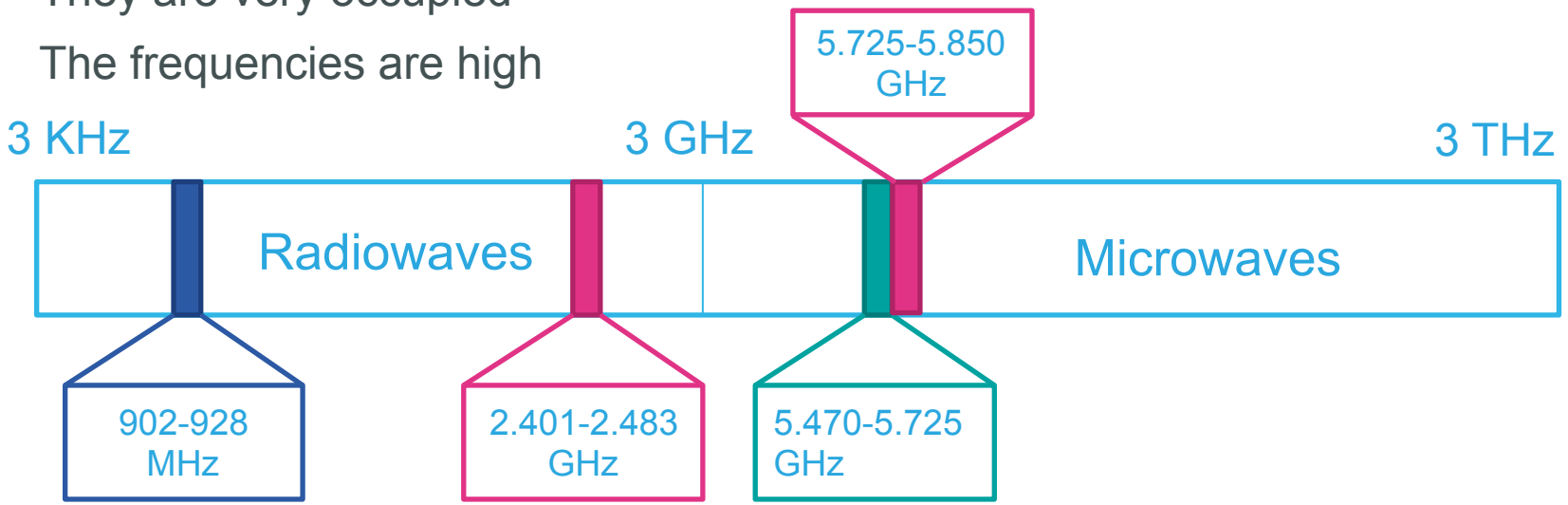
  Free to transmit

  http://en.wikipedia.org/wiki/ISM_band

- 2,4 and 5 GHz bands
- Disadvantage:

  They are very occupied

  The frequencies are high



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Modulation and Multiplexing

- Encoding digital data into wireless signals (OFDM)
- Higher bandwidth requires higher modulation techniques
- Analog modulation: AM, FM, PM etc
- Digital modulation: ASK, APSK, QAM-64 etc
- Spread Spectrum: DSSS, FHSS, OFDM

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CSMA/CA

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The problem of accessing the medium

- Wireless will always be half-duplex because of the communication environment
  - Similar to the 10-Base5 and 10-Base2 implementations
- If 2 stations transmit at the same time, a collision will occur
  - Detectable by unsteady frequencies and incorrect modulation
- The conclusion?
  - An access control method is needed for the wireless environment

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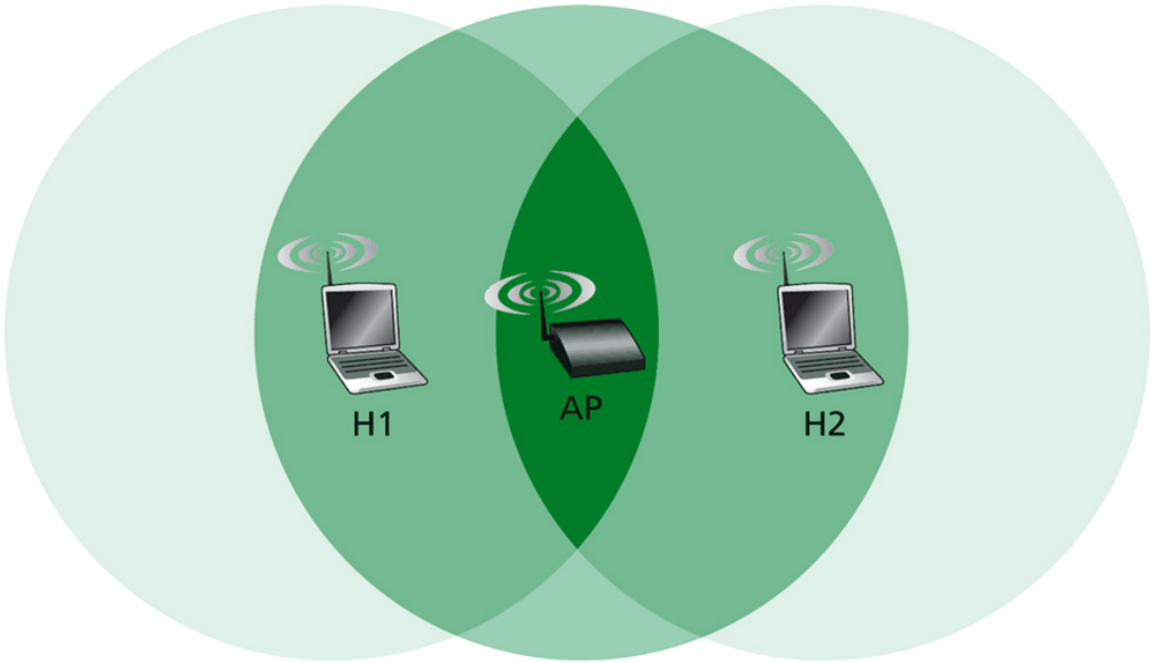
Access control

- Why not use CSMA/CD?



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Access control

- With ACK messages
  - For each frame sent an ACK message is required
  - If no ACK message is received, retransmission is done
- With the RTC/CTS mechanism

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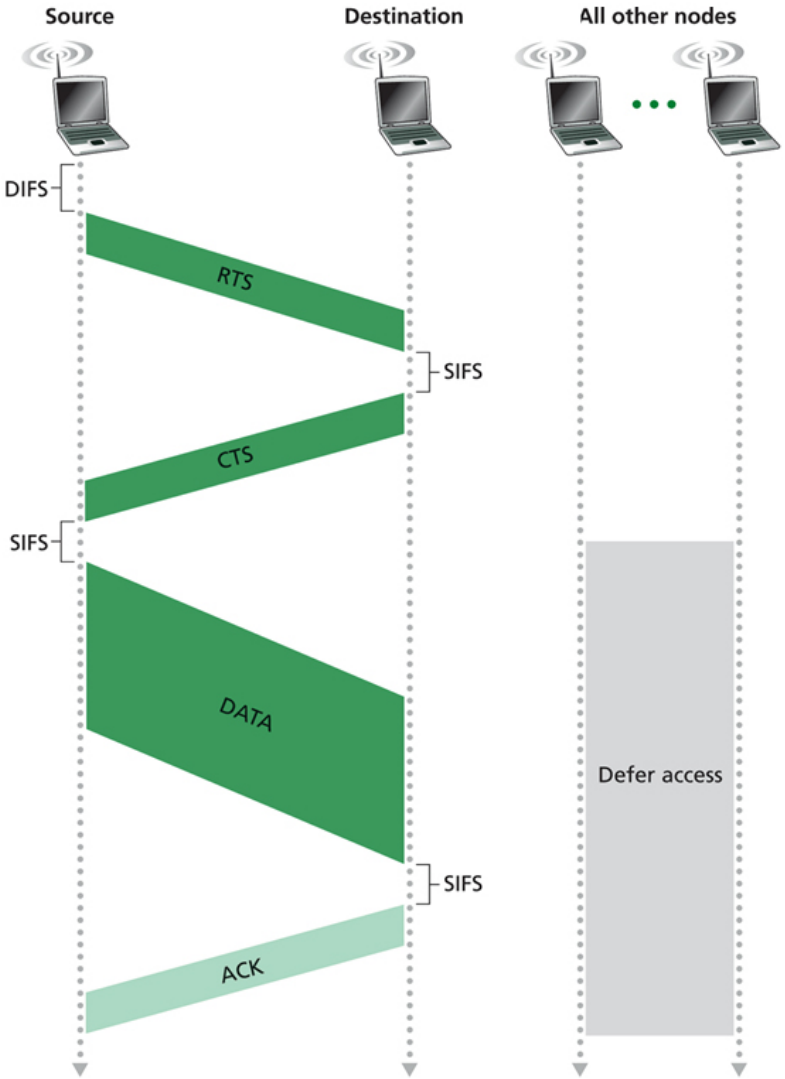
Access control



CSMA/CA

Carrier-Sense Multiple Access with Collision Avoidance

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Communication channel

- The wireless transmition medium is shared
- It is not possible to transmit in the exact same frequency without collisions
- How many Hz do we need to transmit 54 Mbps in 802.11g?

  Answer: **22 Mhz**
- Solution: we could split the ISM band into channels and map each WLAN/SSID on a single channel, thus having multiple networks in the same band

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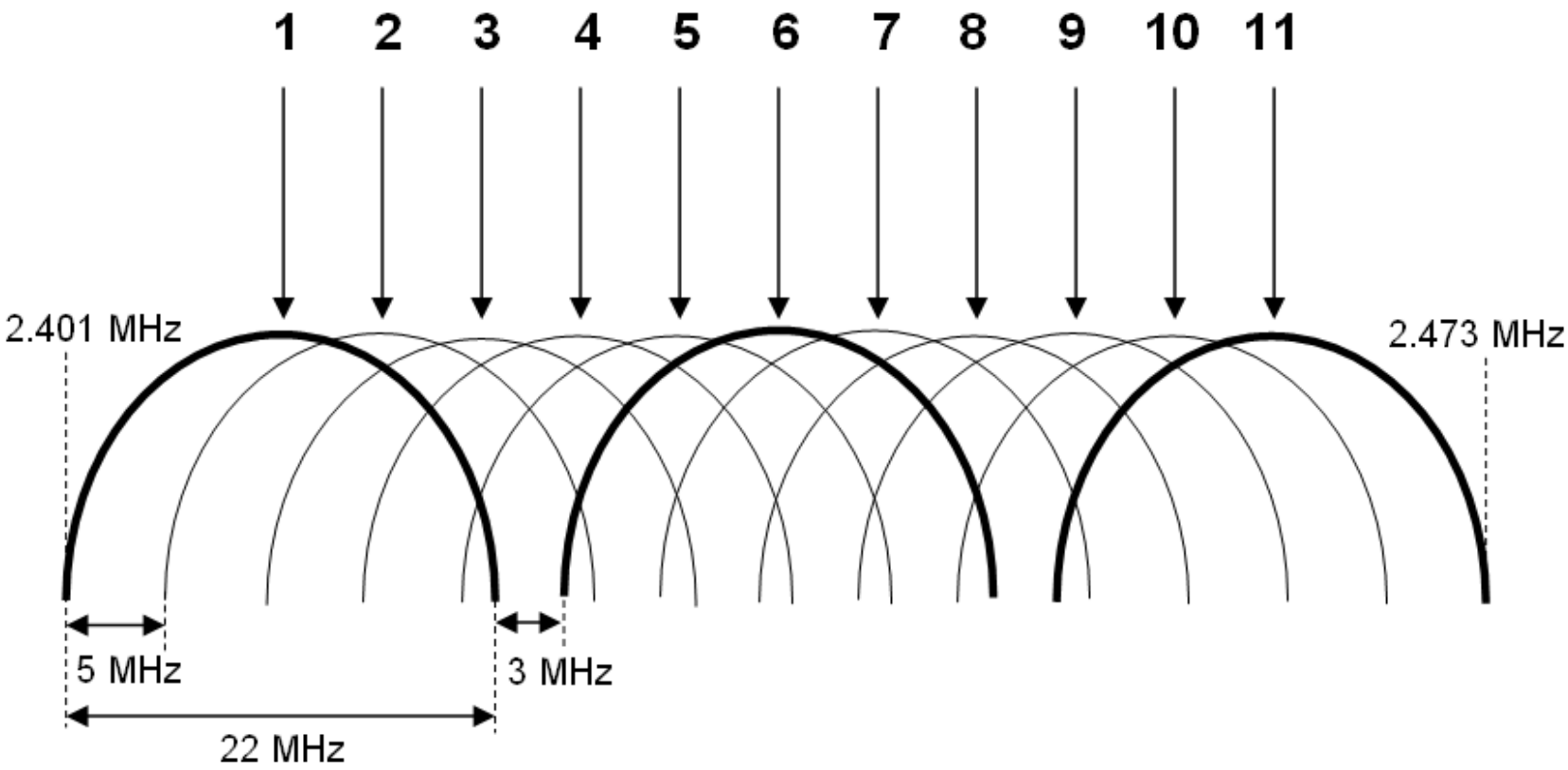
Multiple channels



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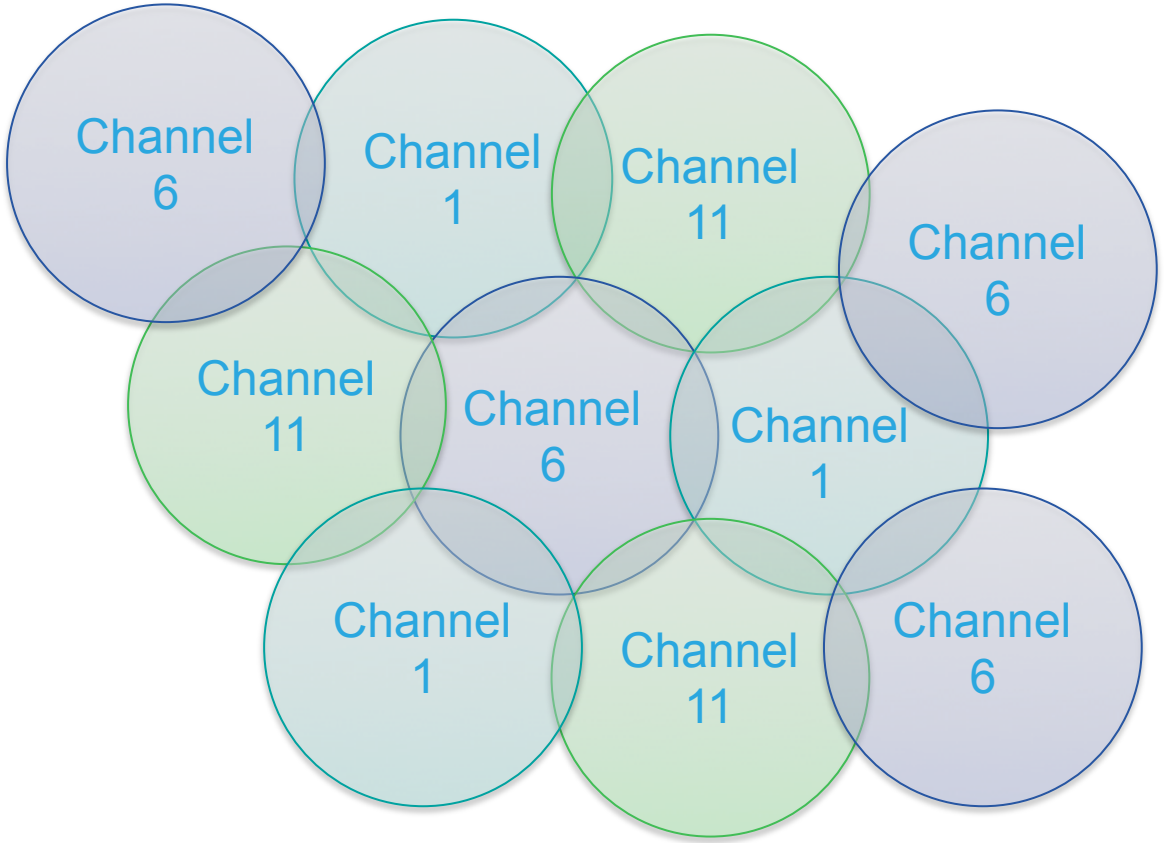
Multiple channels



It is possible to cover any surface using just 3 channels

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Wireless LAN Standards

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802.11

- Legacy – released in 1997
- Specified in infrared and wireless
- Spread Spectrum – FHSS/DSSS
- Speed: 1-2 Mbps
- Frequency: 2.4 Ghz and 900 Mhz

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802.11 a&b

- Both standards appeared about the same time - 1999
- 802.11a
  - Introduces OFDM and takes speed up to 54 Mbps
  - Frequency band: 5 GHz
  - Distance to transmit signal: 25m
- 802.11b
  - Bandwidth: 11 Mbps
  - Frequency band: 2.4 GHz
  - Became very popular – called WiFi

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802.11g

- Standardized in 2003
- Best of both worlds (a & b)
- Frequency band: 2.4 GHz
- Bandwidth: 54 Mbps
- Modulation: OFDM
- Used for a long time and can still be found in networks

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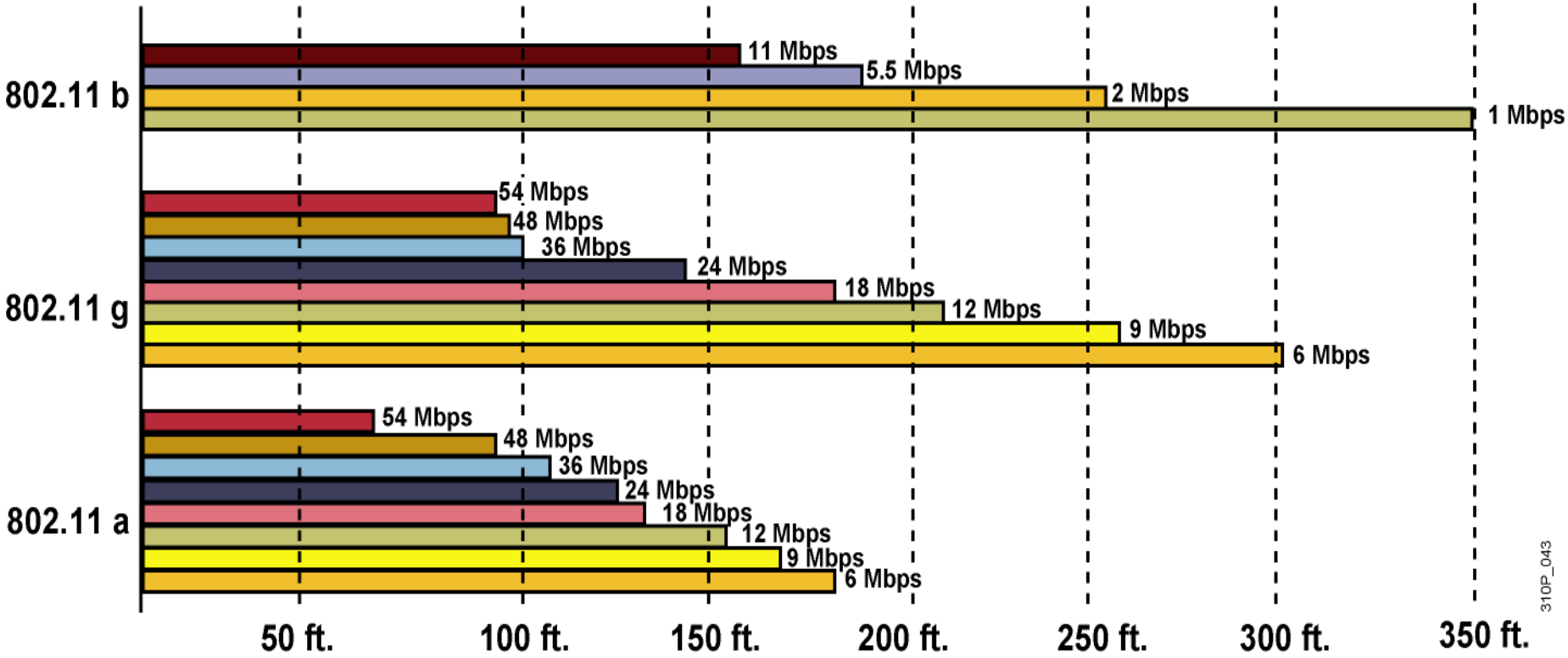
802.11a/b/g – Area coverage

The measurement was made in indoor office spaces



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802.11n

- 802.11n – standardized 29 October 2009
- Far greater speeds: theoretical maximum 600 Mbps
- Better coverage and density of the signal
- Backwards compatible with 802.11 a/b/g
- Uses multiple antenaes and MIMO technology
- Increased channel width to 40 Mhz
- Improved imunity to noise using complex modulation techniques
- Support packet aggregation (one header for multiple data packets)

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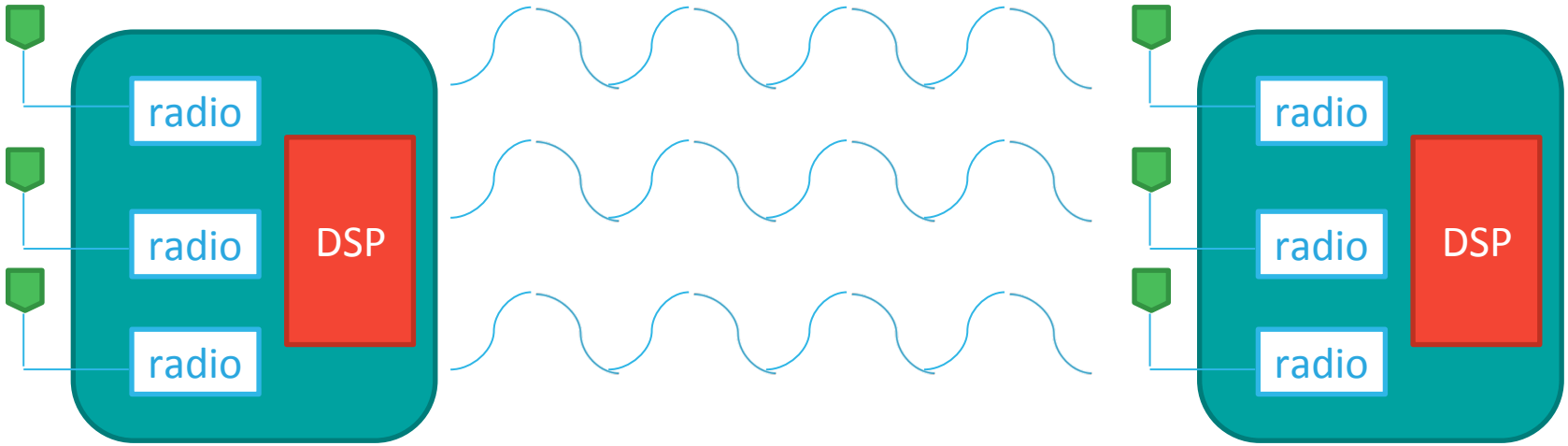
802.11n - MIMO

- MIMO uses DSP processors to multiplex and demultiplex the signal



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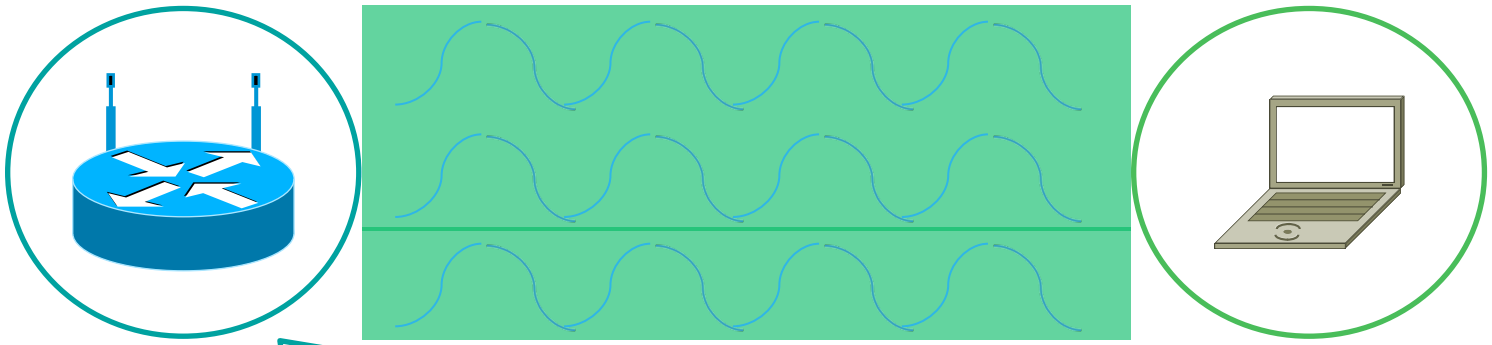
802.11n – Maximum Ratio Combining

- The multipath effect = the process in which many waves carrying the same information are reflected differently from surfaces and with varying clarity
- In 802.11g, the DSP chose the wave with the best signal to noise ratio



Although I receive multiple waves, I am going to chose the one with the best quality and interpret it

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802.11n – Maximum Ratio Combining

- Problem description: some weaker SNR waves are ignored even if there is the possibility that they contain relevant information
- In 802.11n, MRC is implemented in the NIC's DSP so that it takes all the waves and composes just one high-quality wave, thus increasing throughput
- Concluding:

  MRC is a client-side technology

  If you have an 802.11n board in a 802.11g network, you will have higher-than-ordinary through

  It's like having a cat with multiple ears

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General comparison of standards

Standard	802.11a	802.11b	802.11g	802.11n
Published	1999	1999	2003	2009
Frequency	5GHz	2.4GHz	2.4GHz	2.4GHz / 5GHz
Bandwidth	54Mbps	11Mbps	54Mbps	160-600 Mbps
Modulation	OFDM	DSSS	OFDM, DSSS	OFDM
Coverage Interior Exterior	35m 120m	38m 140m	38m 140m	70m 250m
Advantages	Strong signal in a small office	Low price	Good speed and good coverage	Very big speed Very big coverage
Disatvantages	Incompatible with g and b	Interference	Interference	More expensive

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Faster than 802.11n – 802.11ac

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Faster Than 802.11n

- How to Increase Speed Without Making it Impossibly Difficult?
  - Increase channel width… beyond 40 MHz
  - Increase number of spatial streams… more than 4
  - Improve the modulation? Is 64-QAM the best we can do?
  - Better manage the cell
  - 5 Ghz band – in 2015 it's the perfect thing to have
    - Cost does not vary with freq anymore
    - It's not as populated as 2.4
    - It's a bigger space
  - Why would only one device send at a time?
    - If we can have one device send 3 streams at the same time on the same frequency, why not have 3 devices send 1 stream at the same time on the same frequency instead?

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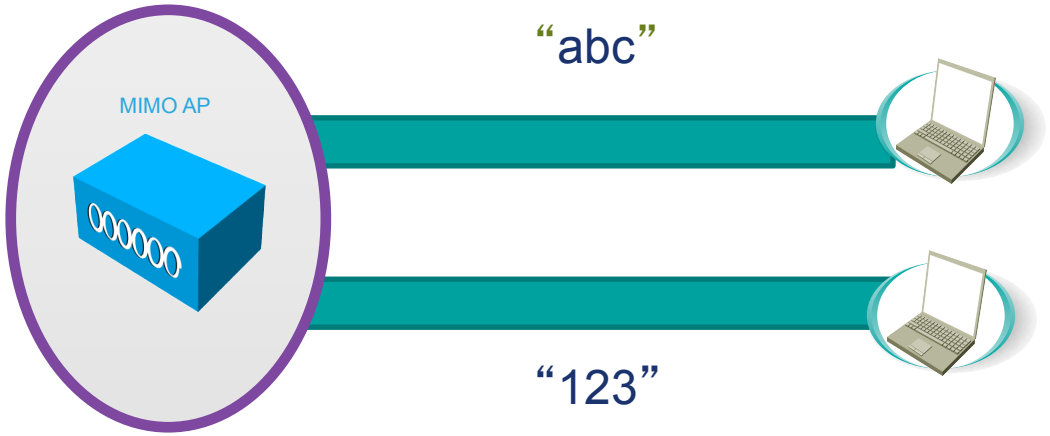
Faster Than 802.11n: 802.11ac

- MU-MIMO
  - 2 clients can receive signals at the same time, on the same frequency
    - Each client has a dedicated spatial stream
    - No collisions anymore
    - “Full-duplex” becomes possible



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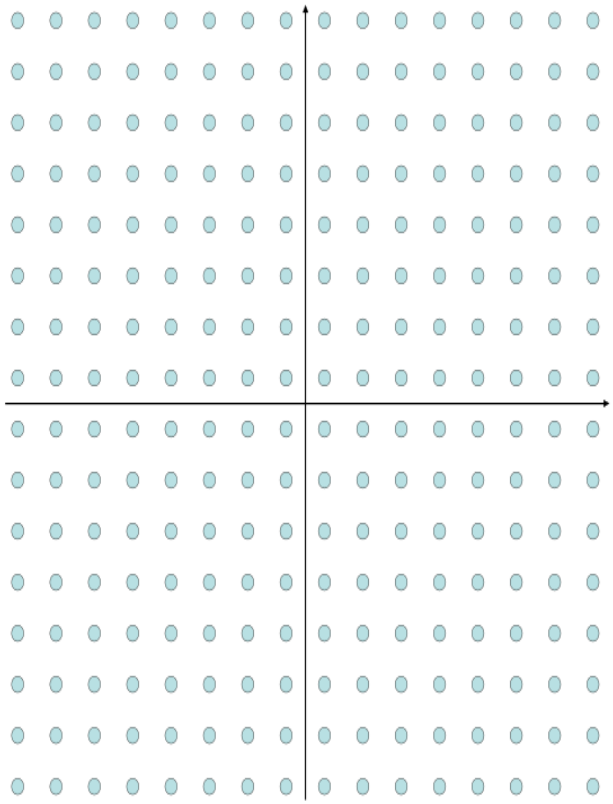
Faster Than 802.11n: 802.11ac

- Beyond the 1 Gbps Bar

  - 160 MHz-wide channel width…
    - Up to 160 MHz for APs
    - 80 MHz for stations, 160 MHz optional
  - More spatial streams
    - Up to 8 spatial streams
    - 8 radio circuits sending or receiving
  - Better modulation
    - QAM-256
      (8 bits per symbol vs. 6 bits for QAM-64)
      Up to 4 times faster



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802.11ac Max Speeds

(Modulations Coding Schemes – MCS), Mbps, 1 SS

MCS	Modulation	Ratio	20 MHz channel		40 MHz channel		80 MHz channel		160 MHz channel	
			800 ns GI	400 ns GI	800 ns GI	400 ns GI	800 ns GI	400 ns GI	800 ns GI	400 ns GI
0	BPSK	1/2	6.5	7.2	13.5	15	29.3	32.5	58.5	65
1	QPSK	1/2	13	14.4	27.	30	58.5	65	117	130
2	QPSK	3/4	19.5	21.7	40.5	45	87.8	97.5	175.5	195
3	16-QAM	1/2	26	28.9	54	60	117	130	234	260
4	16-QAM	3/4	39	43.3	81	90	175.5	195	351	390
5	64-QAM	2/3	52	57.8	108	120	234	260	468	520
6	64-QAM	3/4	58.5	65	121.5	135	263.3	292.5	526.5	585
7	64-QAM	5/6	65	72.2	135	150	292.5	325	585	650
8	256-QAM	3/4	78	86.7	162	180	351	390	702	780
9	256-QAM	5/6	N/A	N/A	180	200	390	433.3	780	866.7

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Thank you.

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