New Generation of Wireless Network Standards

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Overview

Challenges faced by the previous generation of wireless networks(802.11ac)

- How to improve the diffraction capability of WiFi signals?
  - 802.11ac works in the 2.4GHz and 5GHz frequency bands. The wavelengths corresponding to these two frequency bands are usually smaller than the size of obstacles.
- How to significantly extend the wireless network range？
- How to address dense scenarios?
- How to achieve higher signal quality?

Solutions of the challenges by New Generation Wireless Network Standards

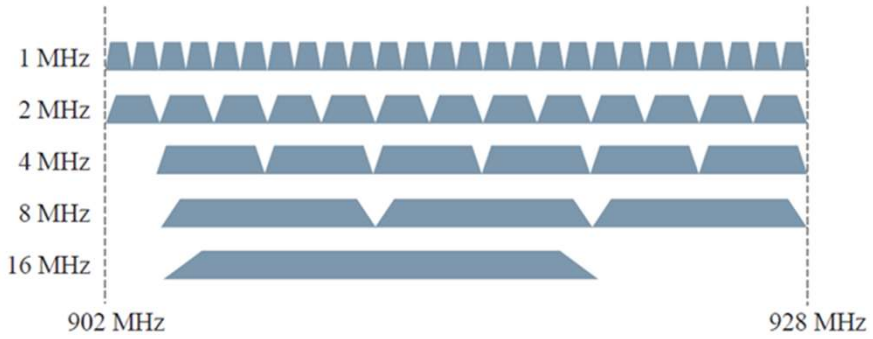
- Diffraction and Long range
  - 802.11ah(HaLow)
- Dense scenario and Higher throughput
  - 802.11ax(WiFi6)

Overview of 802.11ah features

- **Long distance and diffraction**: using the frequency band below 1GHz, the transmission distance will reach 1000m
- **Big connection**: each wireless access point can connect 8191 IoT devices
- **High reliability**: introduce a variety of innovative mechanisms to improve the reliability of the system
- **Easy to popularize**: Inherit the usage habits and management methods of WiFi, which is convenient for end users to deploy and manage
- **Application fields**: IoT Sensor

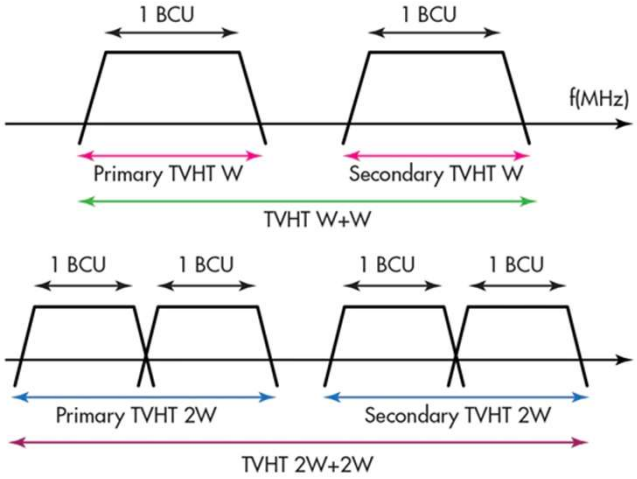
Key of 802.11ah: Sub-1GHz frequency band

802.11ac supports 80MHz, 160MHz, 80+80MHz channel bandwidth, and also supports 20/40MHz channel bandwidth of 802.11n. 802.11ah defines 2MHz, 4MHz, 8MHz, and 16MHz channel bandwidth, which is exactly 1/10 of the previous standard. In addition, 802.11ah also defines a 1MHz channel bandwidth for longer-distance wireless transmission.



Another Standard works on Sub-1GHz: 802.11af

- Especially for TV White Space Spectrum Sharing
- Unlike 802.11ah, 802.11af uses licensed band
- Physical Layer features
  - OFDM
  - MU-MIMO

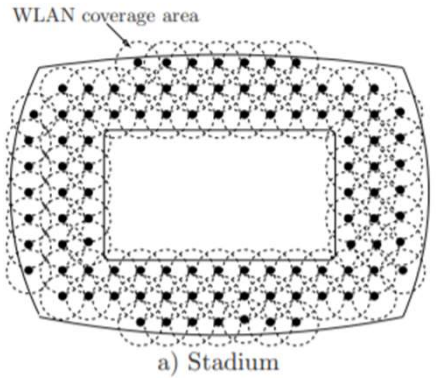


Overview of 802.11ax(WiFi 6)

- Whole throughput increases
- Speed up to 9.6Gbps
- Supporting 8T8R at the same time
- Lower Latency
- Ability to respond various needs
- Lower energy use

Challenges addressed by 802.11ax

- Addressing dense scenarios (Using the example of stadium)
- High-definition audio and video content support (Higher throughput)



a) Stadium

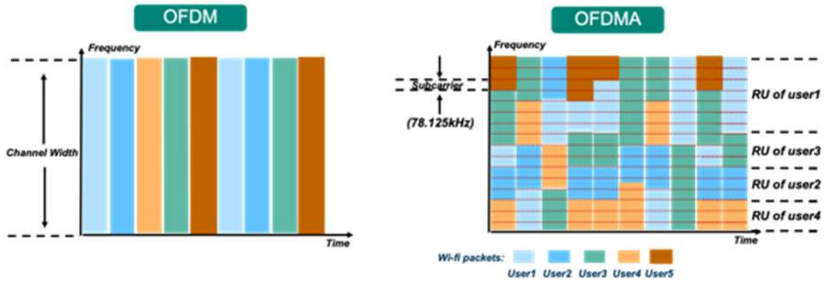
Literature Review

Core features of 802.11ax

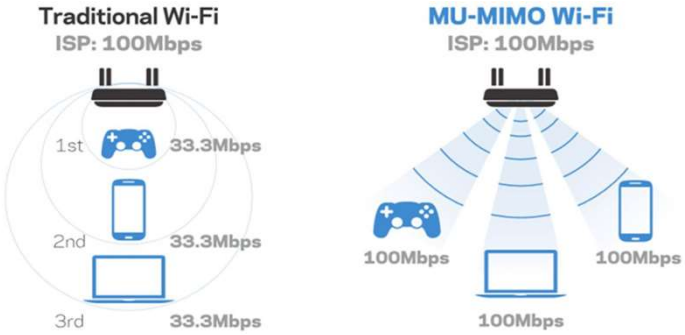
- Frequency use: 2.4GHz and 5GHz (Option: 6GHz)
- Collision-free MAC protocols
- Multi-User Multiple-Input Multiple-Output (MU-MIMO) for both upload and download
- Orthogonal Frequency Division Multiple Access (OFDMA) supports lower latency
- Spatial reuse

OFDMA based MAC

- Different form traditional OFDM
- Use of spectrum resources by dividing the channel width into multiple narrow channels
- Dynamic Channel Bonding with different users using the same channel during OFDM
- 802.11ax standard terms the smallest subchannel as a resource unit (RU) which contains at least 26 subcarriers



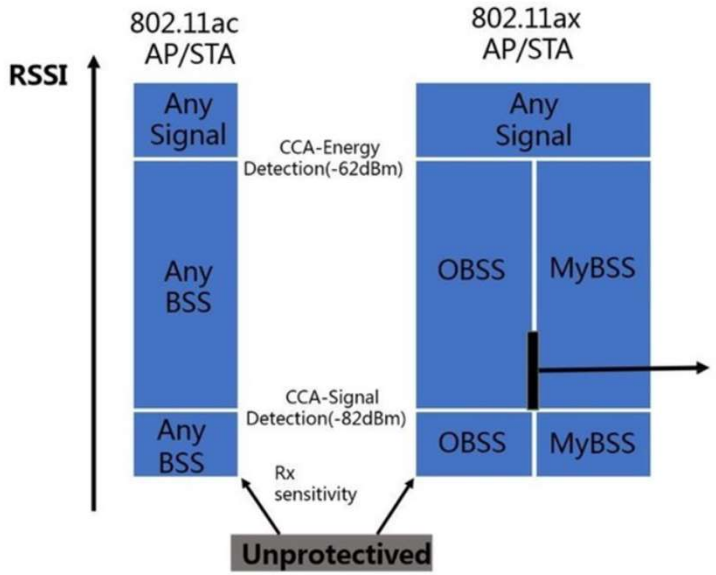
MU-MIMO



- Downlink MU-MIMO already used in 802.11ac
- Using the collected CSI, the AP has to select the specific STAs that will take part in next MU-MIMO transmission
- Example: If the router has three antennas, but the receiving device has only one, then only the transmission rate of a single antenna can be used. The other two antennas will produce idle waste.

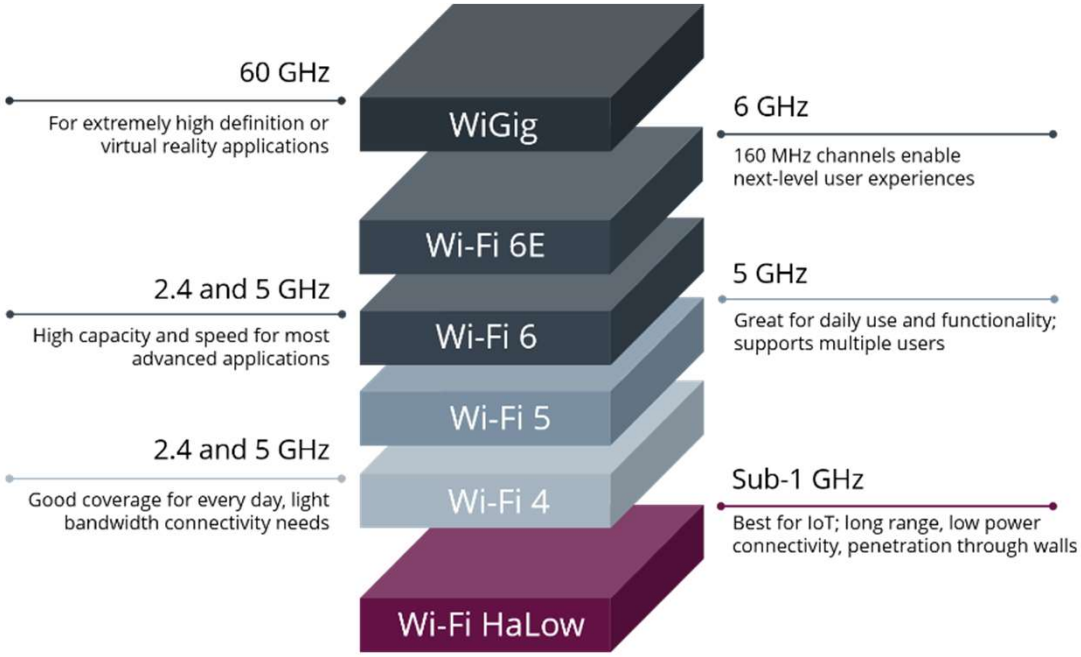
Spatial Reuse

- Intro of spatial reuse
- Physical Clear Channel Assessment (PHYCCA) modules
- BSS color (core, with picture)
- Dynamic adaptation of the transmit power and CCA levels
- Multiple NAVs for Spatial Reuse
- 3 min

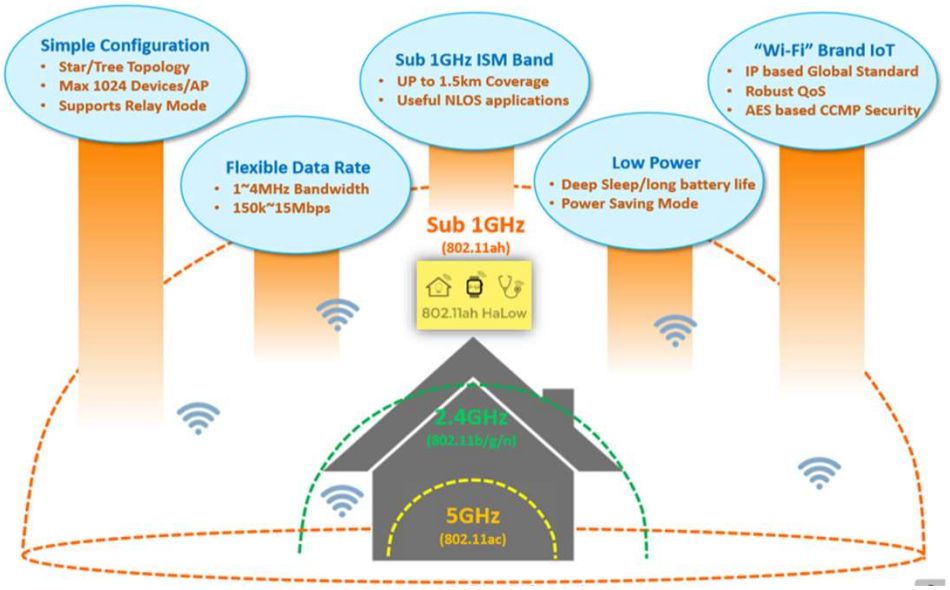


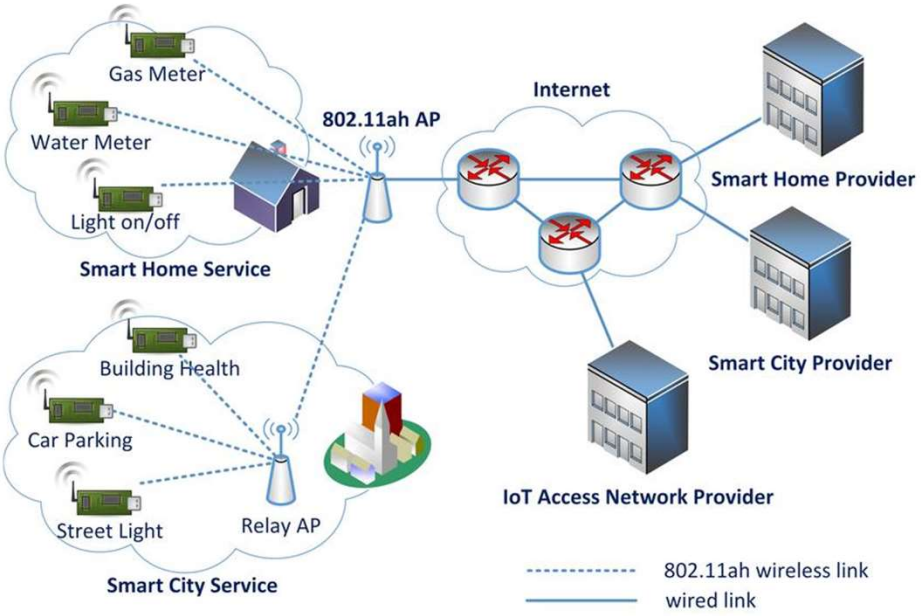
Current Wifi Standards

- WiFi A/B/G/N/AC operate on 2.4 GHz or 5 GHz
- High Data Rates + Low Range
- IOT Devices
  - Floors, walls, structures
  - Long distances
  - Small data transmission
  - Low power



802.11ah - WiFi HaLow



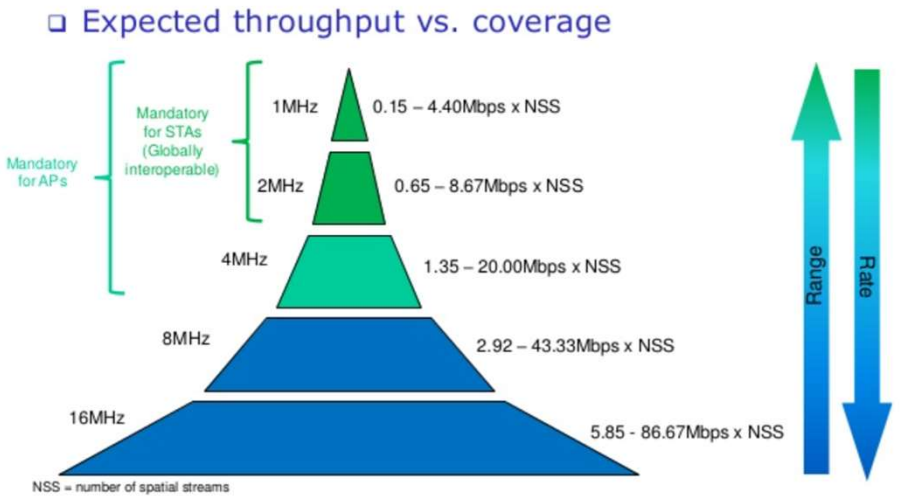


Longer range / Low Power consumption / IOT Data Rates

Connect multiple smart devices with remote servers

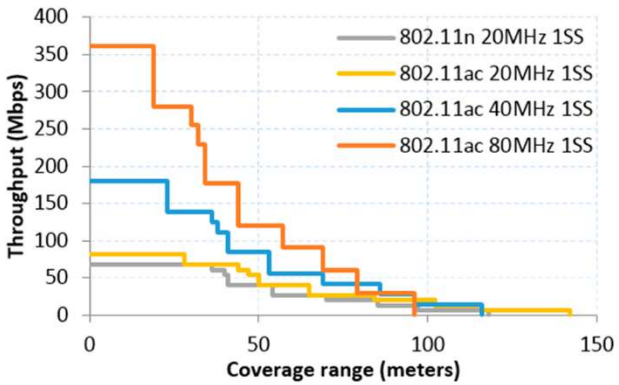
802.11ah - WiFi HaLow

- 900 MHz license-exempt bands
- New 802.11ah physical layer
  - 1/2/4/8/16 MHz channel bandwidths
  - OFDM modulation scheme
- New 802.11ah MAC layer
  - Increased Association IDentifiers (AID) → up to 8191 connected devices
  - Compact MAC headers
  - Removal of ACK overhead with new medium access scheme
  - Target Wake Time and Power Saving Mode

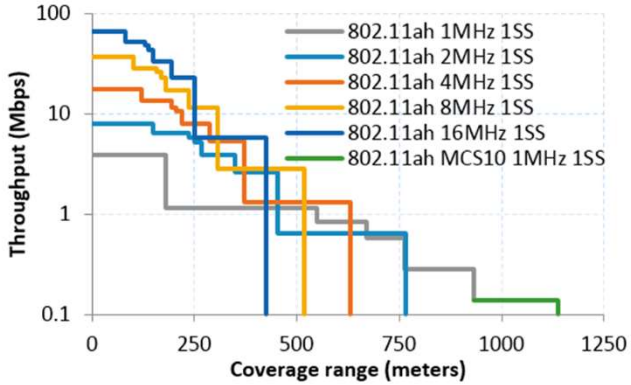


802.11ah - Assessment

- Pros
  - Low Power Consumption
  - Much Longer Range
  - Thousands of Devices
- Cons
  - Unlicensed Band
  - Differing sub 1 GHz spectra
  - Congestion



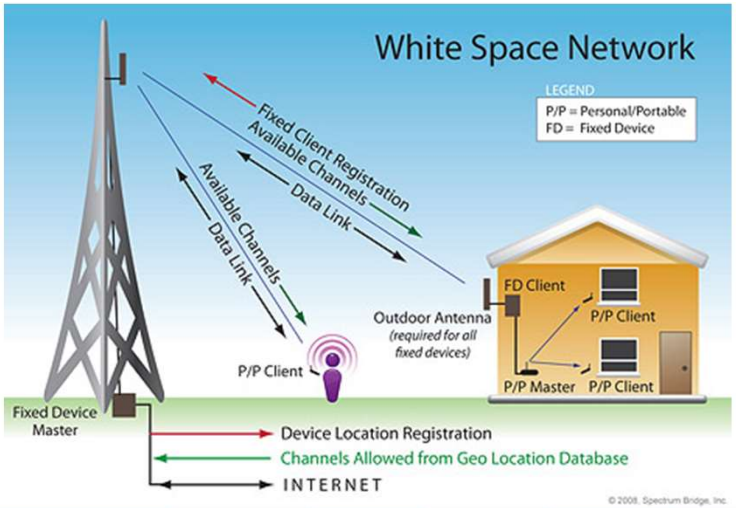
(a)



(b)

802.11af -WhiteFi

- Unused TV white space spectrum (TVWS) from 54 to 790 MHz
- Spectrum Regulation
  - Geolocation Database from GPS
  - Channel Availability Query
- Physical Layer
  - OFDM
  - 6 or 8 MHz channel bandwidths
  - MU-MIMO possible

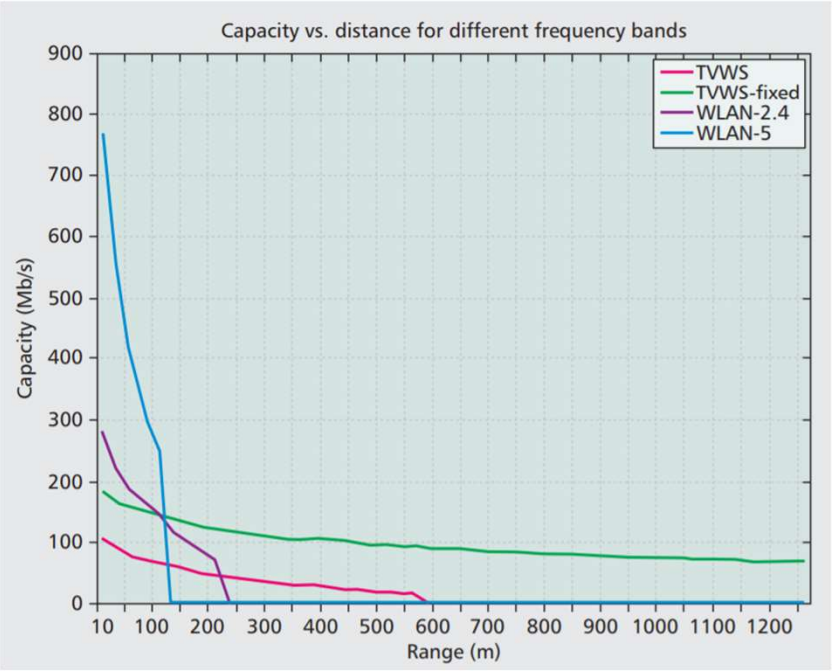


Materials	0.57 GHz (dB)	1 GHz (dB)	2 GHz (dB)	5.7 GHz (dB)	0.57 to 5.7 GHz (ΔdB)
Brick 89 mm	–1.5	–3.5	–5.4	–15	13.5
Brick 267 mm	–4.8	–7	–10.5	–38	33.2
Composite Brick 90 mm/ Concrete Wall 102 mm	–12	–14	–18	–42	30
Composite Brick 90 mm/ Concrete Wall 203 mm	–21.5	–25	–33	–71.5	50
Masonry 203 mm	–9.5	–11.5	–11	–12.75	3.25
Masonry 610 mm	–26.5	–27.5	–30	–46.5	20

Received signal magnitude gain in dB (0.0 dB = no attenuation) [7].

802.11af - Assessment

- Pros
  - Extreme range
  - Low Power
  - Limits channel interference
- Cons
  - Variable frequency → transmit power and range
  - Expensive and specific hardware
  - Competition



Conclusion

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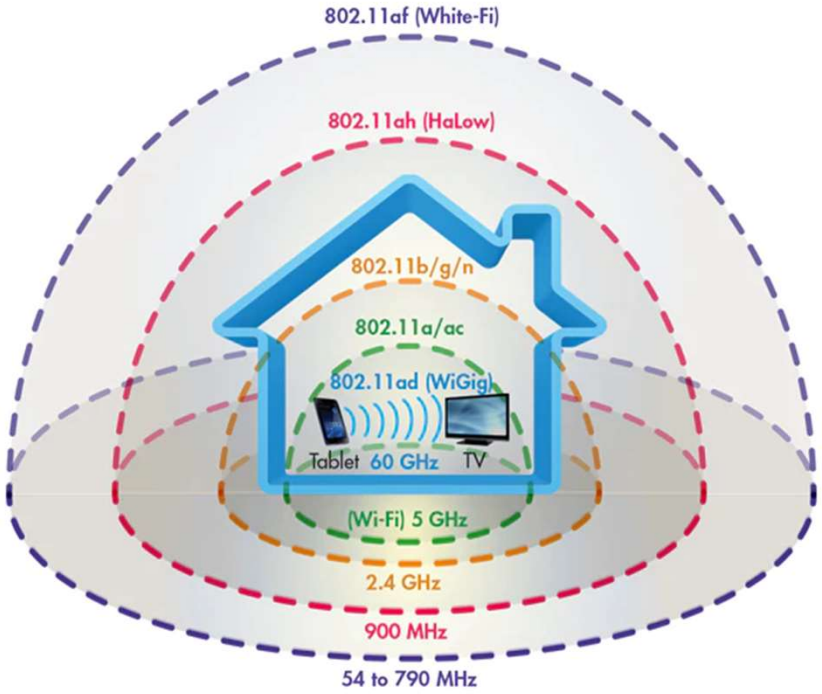
- Very active research area
- Range vs data rate tradeoff
- Increased smart devices in future
  - Average home → 14.5 connected devices
  - 31 Billion IOT devices by 2025
- Cheaper, cost effective, robust connections, easily deployable
- Wifi 6E ratified in December 2019



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