802.11 Wireless Standards
Explained

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Introduction

The explosion of mobile devices continues to drive not only digital transformation of businesses, but also how those businesses' employees work. According to a 2017 Gartner survey, 50% of employers require employees to supply their own devices for work and 89% of employees access business applications through personal mobile devices.

Wireless has changed our lives over the past twenty years—a relatively short period of time in terms of technology. Wireless mobility has forever impacted how we work and where we work. End-users now demand anytime, anywhere, any device connectivity—fast and with high availability. Think about it: what device do you have with you all the time? Your phone. But you probably also have a tablet and laptop that you use to access work applications. Most people have three mobile devices and Wi-Fi* is a critical component of how we connect at the edge, whether that edge is the office, your car, the airport, or even your kitchen table.

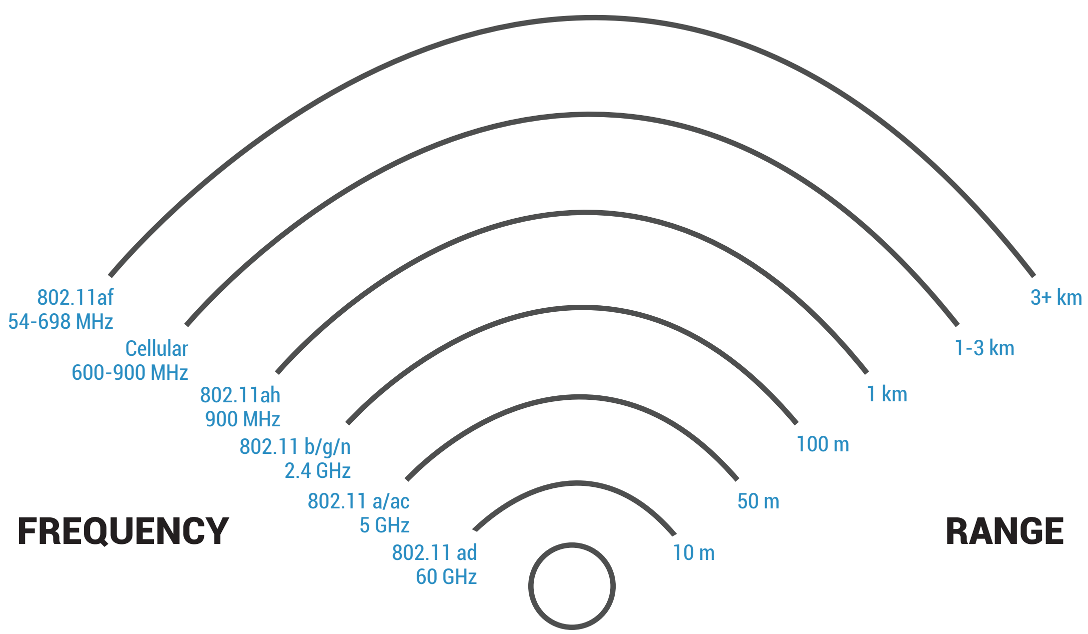
There are multiple wireless technologies, such as DAS and small cell, and enterprises usually use a combination of them for unrestricted mobility. But people are most familiar with Wi-Fi. It's the term used for IEEE 802.11 family of standards that provide wireless "hotspots", like the one you use in your home and in shops, restaurants, hotels, and more. IEEE stands for the Institute of Electrical and Electronics Engineers association which creates the standards and protocols used for communications in industries such as telecommunications and IT. 802 is the prefix used for any protocol that entails networking, such as Ethernet LANs (802.3). Wireless networks fall under the 802.11 protocol.

This whitepaper will decipher the alphabet soup of the most common IEEE 802.11 standards and describe how they have evolved over the years. Now you can see the difference between standards and understand better why you've upgraded your wireless router at home every few years or so. We'll also take a look at the newest standard, 802.11ax and why it will be a game changer in wireless connectivity.

*The term Wi-Fi is trademarked by the Wi-Fi Alliance, a group that certifies that products meet the IEEE 802.11 standards.

Overview

IEEE 802.11 Standards				
Standard	Released	Freqeuncy	Speed	Range
IEEE 802.11	1997	2.4 GHz	2 Mbps	Indoors: 20 m Outdoors: 100 m
IEEE 802.11a	1999	5/3.7 GHz	54 Mbps	Indoors: 35 m Outdoors: 120/5000 m
IEEE 802.11b	1999	2.4 GHz	11 Mbps	Indoors: 35 m Outdoors: 120 m
IEEE 802.11g	2003	2.4 GHz	54 Mbps	Indoors: 38 m Outdoors: 140 m
IEEE 802.11n (WiFi 4)	2009	2.4/5 GHz	600 Mbps	Indoors: 70 m Outdoors: 250 m
IEEE 802.11ac (WiFi 5)	2013	2.4/5 GHz	450 Mbps/1300 Mbps	Indoors: 35 m
IEEE 802.11ad (WiGig)	2012	60 GHz	6.7 Gbps	3.3 m
IEEE 802.11ah (HaLow)	2016	900 MHz	347 Mbps	1 km
IEEE 802.11af (WhiteFi)	2014	6–8 MHz	24 Mbps	Several km
IEEE 802.11ax (WiFi 6)	2019 est.	2.4/5 GHz	450 Mbps/10.53 Gbps	TBD



These are the approximate maximum ranges of 802.11 wireless technologies. Environment, obstacles, etc. can shorten or lengthen these ranges.

802.11 Standards

802.11
802.11. This was the original standard created in 1997. It only provided data throughput of 2 Mbps in the 2.4 Ghz frequency, which was too slow for most applications.

802.11a
Also created in 1997, this provided data rates up to 54 Mbps. Because of the 5 GHz frequency, the signals have more difficulty penetrating walls.

802.11b
Released in 1999, 802.11b operates in the unregulated 2.4 GHz frequency and provides a data rate up to 11 Mbps. Operation can be affected by interference from microwave ovens and other appliances using the same frequency. Your first home router was probably 802.11b.

802.11g
Released in 2003, this was the next significant wireless standard. It could achieve 802.11a speeds of 54 Mbps but in the lower 2.4 GHz frequency. It is also backward compatible with 802.11b.

802.11n (Wi-Fi 4)
Approved in 2009, 802.11n enables operation in both the 2.4 and 5 GHz frequencies. It was the first standard to use MIMO (Multiple In, Multiple Out) technology that supported multiple wireless signals and antennas. It offered better speed, 300—450 Mbps, better range due to its increased signal intensity, more resistance to interference, and backward compatibility with 802.11b/g.

802.11ac (Wi-Fi 5)
This is what we use now for Wi-Fi connectivity. Introduced in 2013, 802.11ac was the beginning of what we consider Gigabit Wi-Fi. It provides speeds of 1300 Mbps in the 5 GHz frequency, which is approximately twenty times faster than 802.11n. 802.11ac is specified for 5 GHz although many vendors provide support for the 2.4 GHz frequency, which ensures backward compatibility with n/g/b. In the 2.4 GHz frequency, it can reach speeds of 450 Mbps. 802.11ac Wave23 enables MU-MIMO or multi-user, multiple input, multiple output. In other words, access points can talk to multiple devices simultaneously. 802.11ac access points are widely used in large enterprise networks to complement DAS and small cell wireless networks. 802.11ac access points also provide the primary wireless connectivity in smaller businesses, retail establishments, and, most likely, your home.

802.11ad
Approved in December 2012, 802.11ad is designed to be very fast with a very high throughput over a very short range. At 7 Gbps and operating in the 60 GHz frequency, 802.11ad is fifty times faster than 802.11n and was created for multi-gigabit speeds and high-performance networking. With a range of only 3.3 meters, its use is limited although it is well suited to streaming raw video.

802.11ah (HaLow)
Published in May 2017, this standard specifies the operation of license-exempt networks in frequency bands below 1 GHz, typically 900 MHz. Lower frequencies provides a longer range. 802.11ah can be used for extended distance networks of up to one kilometer with speeds up to 347 Mbps. Another characteristic of the 900 MHz frequency is the ability to penetrate walls and other obstructions providing non-line-of-sight operation. It also provides lower energy consumption by having devices wake up for very short times to accept data at defined intervals making it useful for applications with short bursts of data. Together, all these characteristics make 802.11ah ideal for enabling IoT devices to communicate, particularly in industrial, retail, or agricultural applications. It's also well suited for smart building and smart city applications.

802.11af (WhiteFi)
Also known as Super Wi-Fi, 802.11af (2014) is designed to use TV white spaces or the unused VHF and UHF TV bands from 54 to 698 MHz. Similar to 802.11ah, WhiteFi supports long-range and non-line-of-sight transmissions and provides lower power consumption making it useful for IoT and industrial applications. It uses cognitive-radio technology and geolocation database access to ensure that there's no interference to local TV signals. It works with TV channels that have bandwidths of 6, 7, or 8 MHz. The maximum data rate for a 6-Hz channel is about 24 Mbps. Range depends on the frequency. Several kilometers can be achieved at higher frequencies. Longer distances of several miles can be achieved at lower VHF frequencies. Note: this standard is not part of the Wi-Fi Alliance family.

802.11ax (Wi-Fi 6)

Let's take a look at the proposed IEEE standard that will blow all previous standards out of the water. Expected to be released in 2019, 802.11ax is a game changer in terms of Wi-Fi.

802.11ax will be able to accommodate a large number of users and IoT devices accessing the network simultaneously. While 802.11ax will be used everywhere, it's especially intended to solve wireless connectivity problems in high-density edge environments such as transportation hubs, office buildings, sports venues, etc.

Significantly faster
Because of its speed (four to ten times faster than 802.11ac) and capacity (wider, multiple channels), 802.11ax is going to become a critical component of mobile-first strategies. Theoretically, one stream can deliver a data rate of 3.5 Gbps. Multiply that by four and you have a potential capacity of 14 Gbps.

To achieve the significant speed and capacity increase and reduce network congestion, 802.11ax will layer MU-MIMO (multi-user, multiple input, multiple output) with OFDMA (orthogonal frequency division multiple access) technology. This enables a large number of devices to use the same access point at the same time rather than sequentially. Imagine a cashier in a store being able to wait on four people at the same time. While Customer One pulls out the credit card, Customer Two is being rung up, etc.

In addition, 802.11ax is truly next-generation Wi-Fi with the ability to accommodate an equal amount of simultaneous uploads and downloads. Previous generations of Wi-Fi were based on the premise that there would be mostly downloads rather than uploads, which was true. Not anymore.

802.11ax and the Internet of Things
802.11ax will be a boon for IoT sensors and devices in congested environments, such as hospitals and smart buildings, where you'll have tens, hundreds, maybe even thousands of devices demanding simultaneous access. It won't just increase the speed of the network, it will also quadruple the speeds of the individual wireless clients.

Extend battery life
A side benefit of 802.11ax is that it will improve battery life of devices. A time-wake feature enables access points to tell devices when to go to sleep and when to wake. Although these may be very short periods of time, just seconds, it adds up over time and results in extended battery life. If you're enabling hundreds of IoT sensors, that's a big deal.

When to upgrade
The answer is to upgrade when you need to, which could be now in terms of accommodating more users and improving wireless capacity. Although the IEEE 802.11 releases new standards approximately every five to six years (g in 2003, n in 2009 and ac in 2013), forward-thinking IT administrators typically upgrade their wireless networks every three years. It's estimated that 802.11ax will have wide-spread adoption by 2020, but manufacturers are already producing equipment with ax chipsets. Once 802.11ax is ratified, compliance can be as simple as a firmware update. So if you need more speed, bandwidth and capacity, don't wait.

If you're thinking about your mobile-first strategy, talk to Black Box now. We can help you make mobility happen with the right intelligent edge foundational technology including DAS, small cells, two-way radio as well as Wi-Fi. When you enable mobility, you enable connectivity at the digital edge.

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