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Wireless Standards 802.11a, 802.11b/g/n, and 802.11ac

The 802.11 family explained

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Home and business owners looking to buy networking gear face an array of choices. Many products conform to the *802.11a*, *802.11b/g/n*, and/or *802.11ac* wireless standards collectively known as Wi-Fi technologies. (Bluetooth and various other wireless (but not Wi-Fi) technologies also exist, each designed for specific networking applications.

This article describes the Wi-Fi standards and related technologies, comparing and contrasting them to help you better understand the evolution of Wi-Fi technology and make educated network planning and equipment buying decisions.

802.11

In 1997, the Institute of Electrical and Electronics Engineers (IEEE) created the first WLAN standard. They called it *802.11* after the name of the group formed to oversee its development. Unfortunately, 802.11 only supported a maximum network bandwidth of 2 Mbps – too slow for most applications. For this reason, ordinary 802.11 wireless products are no longer manufactured.

802.11b

IEEE expanded on the original 802.11 standard in July 1999, creating the *802.11b* specification. 802.11b supports bandwidth up to 11 Mbps, comparable to traditional Ethernet.

802.11b uses the same *unregulated* radio signaling frequency (2.4 GHz) as the original 802.11 standard. Vendors often prefer using these frequencies to lower their production costs. Being unregulated, 802.11b gear can incur interference from microwave ovens, cordless phones, and other appliances using the same 2.4 GHz range. However, by installing 802.11b gear a reasonable distance from other appliances, interference can easily be avoided.

Pros of 802.11b - Lowest cost; signal range is good and not easily obstructed

Cons of 802.11b - Slowest maximum speed; home appliances may interfere on the unregulated frequency band

802.11a

While 802.11b was in development, IEEE created a second extension to the original 802.11 standard called *802.11a*.

Because 802.11b gained in popularity much faster than did 802.11a, some folks believe that 802.11a was created after 802.11b. In fact, 802.11a was created at the same time. Due to its higher cost, 802.11a is usually found on business networks whereas 802.11b better serves the home market.

802.11a supports bandwidth up to 54 Mbps and signals in a regulated frequency spectrum around 5 GHz. This higher frequency compared to 802.11b shortens the range of 802.11a networks. The higher frequency also means 802.11a signals have more difficulty penetrating walls and other obstructions.

Because 802.11a and 802.11b utilize different frequencies, the two technologies are incompatible with each other. Some vendors offer hybrid *802.11a/b* network gear, but these products merely implement the two standards side by side (each connected devices must use one or the other).

Pros of 802.11a - Fast maximum speed; regulated frequencies prevent signal interference from other devices.

Cons of 802.11a - Highest cost; shorter range signal that is more easily obstructed.

802.11g

In 2002 and 2003, WLAN products supporting a newer standard called *802.11g* emerged on the market. 802.11g attempts to combine the best of both 802.11a and 802.11b.

802.11g supports bandwidth up to 54 Mbps, and it uses the 2.4 GHz frequency for greater range. 802.11g is backward compatible with 802.11b, meaning that 802.11g access points will work with 802.11b wireless network adapters and vice versa.

Pros of 802.11g - Fast maximum speed; signal range is good and not easily obstructed.

Cons of 802.11g - Costs more than 802.11b; appliances may interfere on the unregulated signal frequency.

802.11n

802.11n (also sometimes known as "Wireless N") was designed to improve on 802.11g in the amount of bandwidth supported by utilizing multiple wireless signals and antennas (called *MIMO* technology) instead of one.

Industry standards groups ratified 802.11n in 2009 with specifications providing for up to 300 Mbps of network bandwidth. 802.11n also offers somewhat better range over earlier Wi-Fi standards due to its increased signal intensity, and it is backward-compatible with 802.11b/g gear.

Pros of 802.11n - Fastest maximum speed and best signal range; more resistant to signal interference from outside sources.

Cons of 802.11n - Standard is not yet finalized; costs more than 802.11g; the use of multiple signals may greatly interfere with nearby 802.11b/g based networks.

802.11ac

The newest generation of Wi-Fi signaling in popular use, 802.11ac utilizes dual-band wireless technology, supporting simultaneous connections on both the 2.4 GHz and 5 GHz Wi-Fi bands. 802.11ac offers backward compatibility to 802.11b/g/n and bandwidth rated up to 1300 Mbps on the 5 GHz band plus up to 450 Mbps on 2.4 GHz.

What About Bluetooth and the Rest?

Aside from these five general-purpose Wi-Fi standards, several other related wireless network technologies exist.

IEEE 802.11 working group standards like 802.11h and 802.11j are extensions or offshoots of Wi-Fi technology that each serve a very specific purpose.

Bluetooth is an alternative wireless network technology that followed a different development path than the 802.11 family. Bluetooth supports a very short range (approximately 10 meters) and relatively low bandwidth (1-3 Mbps in practice) designed for low-power network devices like handhelds. The low manufacturing cost of Bluetooth hardware also appeals to industry vendors. You can readily find Bluetooth in the networking of PDAs or cell phones with PCs, but it is rarely used for general-purpose WLAN networking due to the range and speed considerations.

WiMax also was developed separately from Wi-Fi. WiMax is designed for long-range networking (spanning miles or kilometers) as opposed to local area wireless networking.

The following IEEE 802.11 standards exist or are in development to support the creation of technologies for wireless local area networking:

802.11a - 54 Mbps standard, 5 GHz signaling (ratified 1999)

802.11b - 11 Mbps standard, 2.4 GHz signaling (1999)

802.11c - operation of bridge connections (moved to 802.1D)

802.11d - worldwide compliance with regulations for use of wireless signal spectrum (2001)

802.11e - Quality of Service (QoS) support (not yet ratified)

802.11F - Inter-Access Point Protocol recommendation for communication between access points to support roaming clients (2003)

802.11g - 54 Mbps standard, 2.4 GHz signaling (2003)

802.11h - enhanced version of 802.11a to support European regulatory requirements (2003)

802.11i - security improvements for the 802.11 family (2004)

802.11j - enhancements to 5 GHz signaling to support Japan regulatory requirements (2004)

802.11k - WLAN system management

802.11l - skipped to avoid confusion with 802.11i

802.11m - maintenance of 802.11 family documentation

802.11n - 100+ Mbps standard improvements over 802.11g (2009)

802.11o - skipped

802.11p - Wireless Access for the Vehicular Environment

802.11q - skipped

802.11r - fast roaming support via Basic Service Set transitions

802.11s - ESS mesh networking for access points

802.11T - Wireless Performance Prediction - recommendation for testing standards and metrics

802.11u - internetworking with 3G / cellular and other forms of external networks

802.11v - wireless network management / device configuration

802.11w - Protected Management Frames security enhancement

802.11x - skipped (generic name for the 802.11 family)

802.11y - Contention Based Protocol for interference avoidance

The Official IEEE 802.11 Working Group Project Timelines page is published by IEEE to

indicate the status of each of the networking standards under development.

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