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Wi-Fi: Basics

For home or small business

Wi-Fi is Born

In the mid 80's, the Federal Communications Commission (FCC) deemed several wireless spectrum bands to be used without a government license. These termed "garbage bands", 900MHz, 2.4GHz and 5.8GHz, were already being used by common household items, such as microwave ovens, etc. It wasn't until the late 90's, Wi-Fi-enabled devices were introduced to the consumer market. Apple's iBook being the first, in 1999. Nowadays, Wi-Fi is everywhere: on laptop computers, tablets, televisions, video game consoles, and smart phones, to name just a few. For the first time, we are liberated from a cable plugged into the wall and able to move about our lives freely. This freedom allows an extraordinary increase in abilities and an incredible expansion of uses.

The implementation of an effective Wi-Fi installation requires the selection of key system components. The component selection should not be based on manufacturer's claims, but technical performance data gathered from reputable sources. Drawing out a wiring diagram complete with system operating system parameters spelled out would be useful in aiding equipment selection.

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Can you hear me?

Wi-Fi is a two-way proposition. The Access Point (AP) must be able to hear the wireless device almost as well as the wireless device can hear the AP. Further, the wireless devices these days are usually smaller and battery-powered. Such devices are set to output the lowest power possible in order to preserve battery life. Such low power signal output is coupled with a very small antenna conspiring to make it hard for the Wi-Fi AP to hear the wireless devices. It doesn't matter how "loud" the AP is, if the AP can't hear the wireless device, throughput and coverage are compromised.

Consider, if you are trying to talk to someone across your house and one of you is yelling and the other speaking softly, can you communicate effectively? Better antenna technology, especially beamforming, proper channel choices, and low noise are far more important than signal strength, in the ability for the devices to communicate with one another other.

Router or AP?

There is a difference between a Wi-Fi Router and a Wi-Fi Access Point.

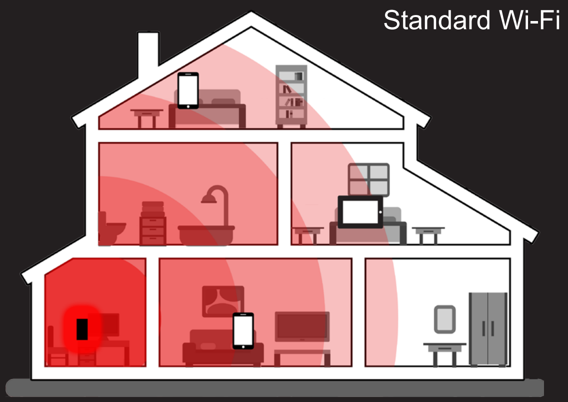
An access point (AP) simply passes along data between wired and wireless networks. A router is a specific type of network device that does IP routing, DHCP, NAT, and firewall. A Wi-Fi router is generally a single box containing an integrated router and AP. One would think the integrated router and AP (Wi-Fi router) must simply be better than just an AP in all cases – it seems to be two devices for the price of one. However, there are cases where one needs a Wi-Fi AP only, and many Wi-Fi routers cannot have their router functionality switched off (to enable only the AP). Distance between the wireless router and the user's device can also degrade the connection to the internet; the level of degradation depends on the quality of the router. For homes where a single AP is all that's needed, a Wi-Fi Router works just fine. When more than one AP is needed, Wi-Fi APs must be used/added. More than one router in a single home isn't generally necessary.

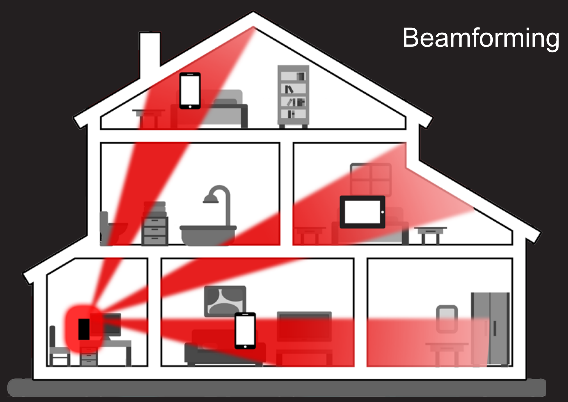
Dual-band is a must

Wi-Fi runs in the 2.4GHz and 5GHz bands. Older wireless devices run only in 2.4GHz and newer ones use both 2.4GHz and 5GHz. Any Wi-Fi AP used should operate in both bands in order to support newer and older devices. Of course, the wireless device must support dual-band Wi-Fi, but most anything purchased in the last year or two is highly likely to support dual-band. When purchasing a new laptop, dual-band Wi-Fi support should be included.

What is beamforming?

A signal processing technique used in sensor arrays for directional signal transmission or reception.





802.11 Wireless Standards

Wireless devices must conform to the 802.11a, 802.11b/g/n, and/or 802.11ac wireless standards, also known as Wi-Fi.

Release Date	Standard	Frequency	Channels	Maximum Speeds*	Actual Transmission Speeds**
1999	802.11a	5 GHz	20 MHz	54 mbps	20 mbps[1]
1999	802.11b	2.4 GHz	20 MHz	11 mbps	6 mbps[1]
2003	802.11g	2.4 GHz	20 MHz	54 mbps	20 mbps[1]
2009	802.11n	2.4Ghz 5 GHz	20 MHz, 40 MHz	600 mbps[1]	50 mbps[1]
2013	802.11ac	5 GHz	20, 40, 80, 160 MHz	1.3 Gbps[1]	100+ mbps[1]

Transmission Speeds are overstated

The packaging for a Wi-Fi Router may claim speeds like "600Mbps" or "1.2Gbps". This is a misleading claim. These numbers are theoretical and data throughput will never be close to those speeds. A good quality (802.11ac/n) AP with a good laptop using a 40MHz channel size in 5GHz band should achieve 150Mbps+ of throughput.

Placement of the Wi-Fi AP is important

In most cases, the AP or router gets buried in a cabinet or desk, back in an out-of-the-way room. The net effect is signal reduction due to absorption by all the material (wood, metal, drywall, block) between the AP or router and the wireless device. Often a single run of Cat-5 Ethernet cable to get the AP or router placed out in a more central, open area is all that's needed to drastically improve Wi-Fi performance and reliability.

Choose channels properly

Most consumer-grade Wi-Fi access points and routers default to using the largest possible channel size in both 5GHz and 2.4GHz bands. While that seems intuitive, bigger may not be better. Larger channel sizes can actually be detrimental. In the 2.4GHz band, channel sizes can be 20MHz or 40MHz, but one should never use anything except a 20MHz channel unless one live miles from anyone else and there are no other devices in the vicinity which use the 2.4GHz band. In the 5GHz band, we recommend a maximum of 40MHz channel size as it improves performance without getting too big. Channel sizes of 80MHz and 160MHz are generally worse since they just increase the amount of interference in the channel on the transmit side and they increase the probability of being interfered with on the receive side. Using an 80 or 160MHz channel generally gives lower, or higher, performance reliability. This is especially true in an urban area or when other Wi-Fi equipment is nearby.

In the 2.4GHz band, Wi-Fi equipment can use one of eleven possible channels numbered 1 through 11. Only the channels 1, 6, or 11 should ever be selected or used. Those are the only three non-overlapping channels in the band (Figure 1). If one AP is using channel 1 and another AP in the vicinity is using channel 2, they will be overlapping each other, meaning that wireless routers

* Theoretical wireless speeds (combined upstream and downstream
** Reasonable distance, low interference and small number of simultaneous clients
[1] SpeedGuide.net "What Is the Actual Real-life Speed of Wireless Networks ?" SpeedGuide. Web. 2014.
[2] "IEEE 802.11ac: What Does it Mean for Test?" (PDF). LitePoint. October 2013

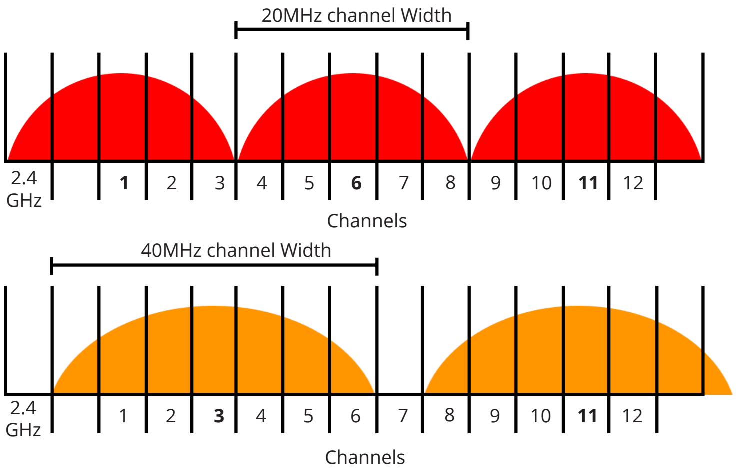


Figure 1: Non-overlapping channels

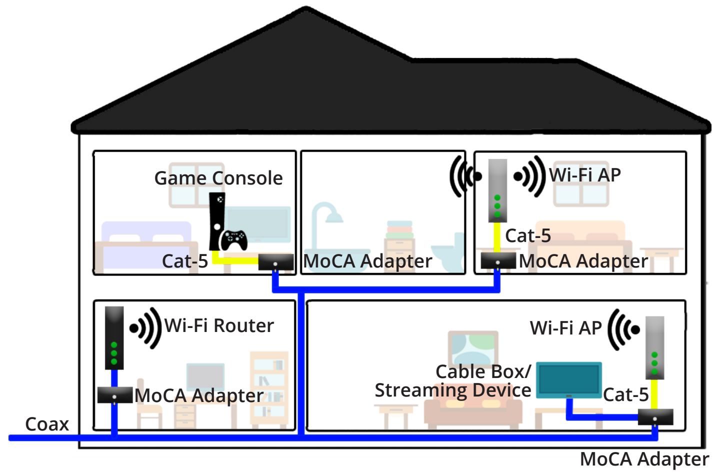


Figure 2: MoCA and Direct Cat-5

within range of one another are potentially interfering with each other. Furthermore, due to the nature of the channel assignments, the nearby AP on channel 2 is also stepping on, or competing with any AP on channel 6 in the vicinity. It sounds complicated but a picture is worth a thousand words: The rule comes down to this: if using 20MHz channels, only choose 1, 6, or 11. If using 40MHz channels – there's only one other overlapping 40MHz channel in 2.4GHz which is why we recommend that 40MHz channels never be used in the 2.4GHz band. Some access points and routers have a feature to automatically adjust channels. These features sometimes work okay and sometimes don't. With a single AP, automatic channel adjustment seems to work okay – your mileage may vary.

Extending Coverage and Covering Gaps

Depending on the size of the home, a single AP may not provide the desired coverage and it will be necessary to install more than one Wi-Fi AP to extend coverage and cover service gaps (Figure 2).

- MoCA/Coax Wi-Fi Extenders. These devices, or pair of devices, allow a second Wi-Fi AP to be placed elsewhere in a home to extend coverage. These extenders use the coax cable in the home to connect to the main home router. The only caveat here is that a single coax cable cannot simultaneously be used for data and Satellite TV applications, but are compatible with most cable TV services. If the coax cable isn't being used for anything else, it works great for Wi-Fi extending (data).

- The best solution is to use normal Cat-5 Ethernet to hard-wire in a second AP elsewhere in the home. Of course, this requires that the home has Cat-5 wiring everywhere it is needed.

Still Having Trouble?

In implementing a Wi-Fi service it is worthwhile to identify other devices in the home that could also be using the same 2.4GHz and 5GHz bands.
This competition for the airwaves can create performance and reliability problems. Not all devices allow control over the channels used. Adjusting the Wi-Fi channels to avoid the other devices can mitigate the competition. Some of the devices in a home which may be using the same frequencies are:

- Television Equipment – the installer should hook up any equipment using coax where possible. The wireless feature should only be used if coax is not available. Using Wi-Fi to stream video will consume lots of bandwidth.
- Microwave Oven
- Baby Monitors
- Cordless Phones (make sure to get a DECT cordless phone as they will never interfere)
- Wireless security cameras
- People
- Neighbors Wi-Fi signal

Simply Bits can customize a managed Wi-Fi solution for your home or business. For more information call (520) 545-0400 or email info@simplybits.com.