Why is my WiFi slow? Why does my WiFi keep dropping out?

By Steve Biddle, in General, posted: 5-Oct-2014 14:28

Complaints about poor WiFi performance are one of the biggest issues facing the average internet user right now. With most people now relying on phones, tablets and laptops for their Internet fix, the days of a cabled Ethernet connection being the norm is well and truly over. Unlike a cabled Ethernet connection which offers a guaranteed level of performance, WiFi is incredibly complex with many variables that will impact performance and reliability. Dealing with wireless performance issues is a nightmare for the helpdesk of the average Internet Service Provider (ISP), with poor speeds being one of the biggest complaints from customers, and something they can do very little about as it's something they have absolutely no control over.

First off lets be very clear with one thing. WiFi is not, and never will be a replacement for a cabled Ethernet connection. It will always be a convenient, complementary solution. Unless the laws of physics are changed at some point in the future there will never be an exception to this rule.

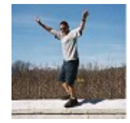
The first WiFi capable devices first appeared in the market in the late 90s with a standard known as 802.11b, offering headline theoretical speeds of up to 11Mbps. From the 802.11b standard the 802.11g standard was created, delivering an improved headline theoretical speed of 54Mbps. By 2009 the 802.11n standard was ratified, delivering headline speeds of up to 300Mbps, and by 2011 we were seeing the first 802.11ac gear promising headline speeds of up to 867Mbps (or even greater from some vendors).

The issue of theoretical vs real world throughput is something that we need to cover here. Every headline wireless speed you see mentioned, whether it be 11Mbps, 54Mbps, 150Mbps, 300Mbps or 867Mbps is a theoretical maximum speed. For various reasons it's impossible for these sorts of speeds to ever be achieved in in the real world, primarily because they don't take into account any overheads that exist in the WiFi protocol at Layer 1, and overheads at Layer 2 and Layer 3 in the open systems interconnection (OSI) model which form the basis of all data communications. They also don't factor in WiFI being a half duplex medium, meaning that a WiFi device can't transmit and receive data at the same time. It has to (very quickly) alternate between both, much like two people talking on a walkie talkie. This differs to an Ethernet connection which is full duplex and can transmit and receive data at the same time like two people having a real world conversation. As you're transferring data across your WiFi connection you'll be using one of two data protocols, Transmission Control Protocol (TCP) or User Datagram Protocol (UDP). Because TCP relies on an acknowledgement (ACK) packet (think of a walkie talker user responding to every message saying they're received it before the other person can send their next message), TCP performance over WiFi will typically be significantly less than UDP performance as UDP does not rely on ACK packets.

In the real world a 802.11b network will deliver maximum speeds of around 5Mbps, a 802.11g network will typically deliver maximum speeds of around 20Mbps, a 802.11n network will with 20Mhz channels (N150) will typically deliver maximum speeds of around 40Mbps, a 802.11n network with 40Mhz channels (N300) will typically deliver maximum speeds of around 80Mbps, and a 802.11ac network will typically deliver between 100Mbps and 350Mbps depending on channel width and the brand of hardware you're using. These are all maximum real world speeds, and in the real world issues such as signal strength and congestion from other wireless networks will mean you may not get speeds anywhere near these - these issues are exactly what I'll get onto next. Understanding what impacts WiFi performance isn't straight forward as many of the key factors rely on a level of radio frequency (RF) engineering and protocols, however I'll attempt to try to explain a few of the major concepts in something resembling simple English.

Lets start by explaining the most important principal of radio communications - noise floor. Unless you live somewhere with no neighbours within a 20km radius (or live inside a faraday cage), you're continually being exposed to a myriad of radio

sbiddle's profile



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I'm an engineer who loves building solutions to solve problems.

My interests and skillset include:

*VoIP (Voice over IP). I work with various brands of hardware and PBX's on a daily basis
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  -Polycom
  -Cisco
  -Linksys
  -Patton
  -Zyxel
  -Snom
  -Sangoma
  -Audiocodes

*Telecommunications/Broadband
  -xDSL deployments
  -WiMAX
  -GSM/WCDMA

*Structured cabling
  -Home/office cabling
  -Phone & Data

*Computer networking
  -Mikrotik hardware
  -WAN/LAN solutions

*Wireless solutions
  -Motel/Hotel hotspot deployments
  -Outdoor wireless deployments, both small and large scale
  -Temporary wireless deployments

*CCTV solutions
  -Analogue and IP

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waves from other wireless networks along with other sources of RF interference such as microwave ovens, cordless phones, mobile phones, video senders, baby monitors, and Bluetooth devices. Noise floor (like signal strength) is measured in dBm. dBm uses a logarithmic scale for measurement.

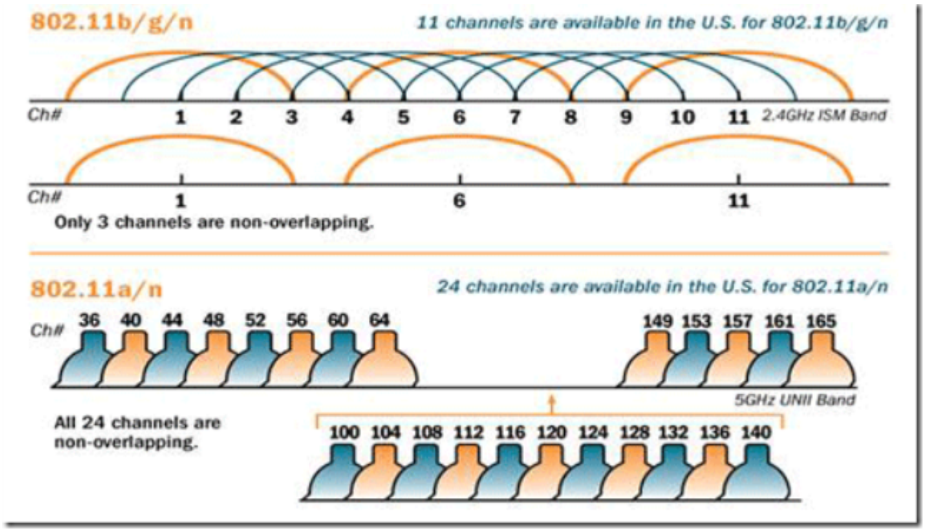
A typical noise floor value in the 2.4GHz band can be anywhere from -80 dBm to -110 dBm depending on the level of background noise in your environment from other sources. When you connect a WiFi device to a WiFi access point or router you'll likely see an indication of signal strength on your device, typically showing bars. This shows a good approximation of signal strength, but isn't telling you the full story. Many WiFi devices and access points also show the signal strength of the connected device, which will be shown in dBm. If you're within close proximity of your WiFi access point you'll potentially see a signal level of -50 dBm, as you start moving away from the access point this level will increase downwards. Once your signal level approaches the noise floor, link quality (and overall WiFi performance) will be affected. Once the signal strength reaches the noise floor, maintaining a WiFi connection will be impossible as each device is unable to "hear" the other device due to the level of background noise. All building materials cause a drop in signal strength which can be anywhere from a few dBm upwards - a regular plasterboard wall at home may reduce WiFi signal strength by 5 dBm, whereas a steel reinforced concrete wall with can easily impact signal levels by 20dBm.

To maintain a good quality WiFi connection you need to ensure your signal level is stronger than the noise floor. This is known as the signal to noise ratio (SNR). A SNR of 20 dBm or greater is recommended, meaning that if your noise floor is in the range of –90 to -95 dBm you'll need to ensure your signal strength is at least –70 to –75 dBm to ensure a good connection. If you live in a very crowded inner city apartment block with a large amount of background noise and interference from other WiFi networks, you may find your noise floor is well below this figure and it could easily be in the vicinity of –80dB. This type of environment is when major problems start to occur, as it means you will need to be very close to your WiFi access point or router to maintain a good connection – but even then maintaining good performance may be difficult due to the way the WiFi protocol works, which is something I'll discuss later on.

I like to explain noise floor in a very simple way by comparing it to people talking in a room. If you're in a large room with one other person you'll easily be able to have a conversation with them. If 300 other people and a DJ turn up playing music, they're all creating noise. As this level of background noise increases you'll find that maintaining a conversation with the person next to you becomes very difficult, and even when you shout you may not be heard. This pretty much mirrors what happens to WiFi when background RF noise effectively creates an environment where maintaining a reliable WiFi connection can be very difficult.

Now that I've explained the concept of noise floor, we'll now look at the issue of frequencies. Two frequency bands are used by WiFi – 2.4GHz and 5GHz. Today 2.4GHz is still the primary frequency used by WiFi devices. Most tablets, phones and laptops sold within the past 1-2 years will also support the 5GHz band, however the number of access points and home routers that support this band is still small. Both of these bands use blocks of spectrum that are openly usable by anybody in most countries in the world without a licence, meaning that there are other devices out there that also use these same frequency bands. In the 2.4GHz band, Bluetooth devices, baby monitors, older cordless phones, video senders and microwave ovens all use the same frequency band as WiFi which means they all have the potential to cause interference and impact the performance of your WiFi. Most modern cordless phones use the DECT standard which uses the 1800Mhz band and will not cause interference with 2.4GHz WiFi, however in New Zealand in particular Uniden sold tens of thousands of 2.4GHz cordless phones until they stopped selling these a few years ago. A 2.4GHz cordless phone is a significant cause of interference with 2.4GHz WiFi and should be replaced with a modern DECT phone to eliminate the issue. Likewise turning on your microwave oven can cause a jump in noise that can impact WiFi.. Baby monitors and video senders that use the 2.4GHz or 5GHz band will also impact WiFi performance.

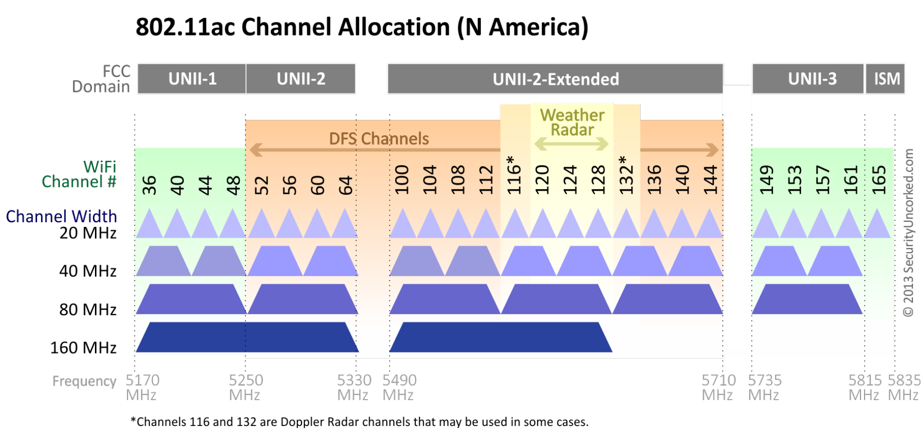
In the 2.4GHz band there are 13 channels available for use in New Zealand. In many other countries (including the USA) only 11 channels are available. Each of these channels is 10MHz apart. This in itself creates a major problem for 2.4GHz WiFi, as from 802.11g onwards 20MHz channels are now the norm, meaning that to avoid interfering with other WiFi networks, only 3 channels are actually available for use that don't overlap with other channels. These are 1, 6 and 11. Using channel 13 in New Zealand is often a good idea as it is often less crowded, however it creates plenty of problems as many WiFi capable devices are configured for the US market where only channels 1-11 are allowed, and such devices will not be able to connect to a network transmitting on channel 13.



(Picture borrowed from www.xirrus.com)

Using a 20MHz channel meant a maximum theoretical throughput of 150Mbps with the Wireless N 150 standard, which for many people wasn't fast enough - people wanted faster speeds. How did they achieve that? They simply moved to 40MHz wide channels, and Wireless N 300 was born. It doesn't require a genius to realise that suddenly the 2.4GHz spectrum became a lot more crowded, and that overlapping channels from different networks became a major problem.

In the 5GHz band channels are placed 20MHz apart so overlaps don't exist like they do in the 2.4GHz band if you're using standard 20MHz channels, however recent additions such as the new 802.11ac standard can use channels up to 80MHz wide (and the standard allowing up to 160MHz channels), meaning the same challenges that exist in the 2.4GHz band will eventually occur in the 5GHz band as the number of devices using this band increases.



Due to the simple way WiFi works all other WiFi networks out there using the same channel or overlapping channels are creating interference which will ultimately impact the performance of your WiFi network. The WiFi standard uses something known as Clear Channel Assessment (CCA) to determine if other nearby WiFi networks on the same channel(s) are transmitting or receiving data. If it detects activity from another network it may not be able to transmit or receive data. Likewise when you're transmitting or receiving data on your WiFi network, CCA on nearby WiFi networks will detect this activity. Think of this as like multiple conversations in a room with multiple people, where only two people are able to have a conversation at a time and all other conversations must stop before you can talk – in the WiFi world the impact of overlapping networks is a significant slow down in WiFi speeds and/or other performance issues.

For this very reason 2.4GHz WiFi performance in many urban environments is now significantly degraded. If you're living in an environment such as an inner city apartment where there may be hundreds of nearby networks, you're basically living in the worst possible environment possible for WiFi, and in some cases really have to be thankful your WiFi even works at all. The harsh reality is that fixing the 2.4GHz WiFi band isn't possible – the solution is to upgrade your equipment to support the 5GHz band if reliable WiFi performance is important to you. While the 5GHz band will offer better performance, it also doesn't propagate (travel) through open air and building materials as well due to the higher frequency. This is both the biggest benefit, and also the biggest downside of 5GHz WiFi – your 5GHz signal probably won't leave your house and cause interference with your neighbours WiFi network, but you will also find that in your home a 5GHz signal will not travel through internal walls as well as a 2.4GHz signal. As we move towards even higher frequency bands for WiFi with a 60GHz standard now in place, we're moving towards a future where individual access points in each room of your house either cabled back via Ethernet cabling or using Ethernet over Power adapters will become the standard way of providing WiFi coverage in the home.

Now that I've explained a few of the reasons why your WiFi can be impacted, I'll offer a few tips on how to improve your WiFi connection.

First up is placement of your modem/router or access point. Many people are going to have this located next to their primary PC. The simple reality is that a WiFi connection will always work best the closer you are to your router or access point; so if this is located at one end of your home, you could easily have poor coverage at the other end of your home. As explained above, WiFi signals degrade as they travel though building materials within your home so placing your modem/router or access point in a central location is typically going to deliver the best outcome. If you have a big house the reality is that a single WiFi access point will probably not be sufficient to deliver adequate coverage. In this situation the best solution is a secondary access point that's cabled back to your primary modem/router via Ethernet cable or Ethernet over Power adapters. Different brands of equipment have different levels of performance so upgrading your equipment can also significantly improve your performance. Discussing the pros and cons of different hardware isn't something I'm going to write about though, so opening a discussion thread in a forum site such as Geekzone is the best place to discuss such things. Newer hardware that supports the 802.11ac standard will also likely use antennas that support beamforming which can deliver significantly improved performance. Ruckus (who arguably make some of the best WiFi equipment on the market) have a great white paper on beamforming that you can read here.

The next step is to ensure that your WiFi network is operating on the best available channel. What determines "best" isn't something that's easy to answer. If your WiFi hardware has it's channel set to auto rather than having a channel manually configured there is a good chance it has probably picked what it believes is the best channel to use. Auto mode does have it's downsides though, and if you're in a very noisy environment your device may change channels regularly and performance may be impacted. If you have a 802.11n 300Mbps device it's probably defaulting to 40Mhz channels, and if you live in a noisy environment with lots of other networks you may find your WiFi performance improves if you drop this back to using 20Mhz channels. There are various applications (my favourite is inSSIDer) for Android mobile phones and PC's that will show you surrounding networks, and let you see what channels are the least crowded. If you're using an iPhone you're out of luck – Apple won't allow applications such as this in the App Store.

You also need to be aware that not all hardware is created equal – it's not uncommon to find home routers that can only support somewhere in the vicinity of 10 wireless devices. If you connect more WiFi devices than your router can support, you'll start to encounter problems. You will also encounter problems if you have lots of devices connected with poor signal strength – if you have devices connected at one end of the house with very low signal strength, this will affect the performance of WiFi devices that are closer and have good signal strength.

And lastly ensure that power levels are set lower, not higher. Many people assume that more power = better, but in reality this is not the case. Turning your router or access point to maximum power settings will typically result in reduced maximum throughput and reduced receive sensitivity, meaning your level of performance may actually be worse. High power devices also mean more noise is being created, and this simply makes the 2.4GHz band worse for others. Setting your power level to a lower setting in many situations will actually improve your WiFi performance.

One common piece of hardware people are buying these days in an attempt to improve performance is a so called "WiFi extender". These devices work by picking up a WiFi signal and rebroadcasting it, meaning it can improve performance in your home if you have low coverage areas. There are two major issues with these devices however – the first being that they will typically halve the maximum speed of your WiFi network as they have to pick up and then rebroadcast the network, and the second being that they are often not installed correctly. As the extender needs to connect wirelessly to your main access point or router, it's no good placing it where there is poor coverage – the device needs to be placed in a location where coverage is good such as a mid way point between these areas.

In summary, WiFI is far from simple. These days people have an expectation that just because a WiFI network exists, that it should work, and work well - in reality nothing can be further from the truth.

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Comment by *Kyhwana*, on 5-Oct-2014 15:20

As a real world example, we have 57/10mbit VDSL.(sync rate)On 2.4ghz 802.11n, I can get ~21mbit/8mbit to the local spark speedtest.net server, with 5ghz 802.11n, I can get ~53mbit/10mbit.

Comment by *RunningMan*, on 5-Oct-2014 15:23

No longer out of luck on an iPhone. Airport utility under iOS8 will identify channel and signal strength of nearby networks in scan mode.

Comment by *donkey*, on 5-Oct-2014 15:52

Also, inSSIDer is available for OSX.

Comment by *DarthKermit*, on 5-Oct-2014 19:00

My neighbour two doors down has UFB installed, then running all his gadgets through a wifi connection. I tried to explain to him why he won't get the full speed benefit of UFB that way to no avail.

Comment by *Rikkitic*, on 5-Oct-2014 19:41

Excellent overview. As a wi-fi novice, I wish I had seen this a few weeks ago. Well done sbiddle and thanks.

Comment by *Kyhwana*, on 6-Oct-2014 20:30

Opp, after auckland power outage, now getting this:http://www.speedtest.net/my-result/3811643309(62/9.7 mbit, still over 5ghz 802.11n wifi, ~67mbit sync)

Comment by *gcorgnet*, on 7-Oct-2014 11:19

Great article, thanks for sharing

Comment by *Koko Kodina*, on 7-Oct-2014 13:52

Devices with poor link quality should have little effect on devices with good signal strength provided that the device manufacturer has implemented a proper "Air Fairness" algorithm. Most of the cheap WiFi equipment on the market is awful because the rate algorithms, "Air Fairness", and "interference mitigation" algorithms are poorly implemented.Also, 5GHz WiFi if deployed properly can easily beat cabled connections; 802.11ac with 4x4 multi-user mimo can easily outperform a gigabit ethernet without breaking a sweat!People having having WiFi issues at home; buy a good 5GHz access point (or two) and you solve most of your connectivity issues.

Comment by *mdf*, on 7-Oct-2014 21:38

Awesome explanation. I'm one of The people you've previously helped with wifi issues on geekzone, so thanks for posting!

Comment by *John S*, on 7-Oct-2014 23:22

Good article and makes the argument that if you truly want performance use a cable. The security issue is another drag on wireless. Encryption drags on a wireless network and yet if you are paranoid about privacy and not sharing your network. You must use encryption in order to protect your network. The trouble with any wireless is two fold. One is range and how a signal degrades as it travels. Digital has somewhat helped this as we saw with digital TV signals. The other of course is bandwidth which all we have really done there is just keep piling on more channels in a bonding system to augment more bandwidth. This is truly not unlimited and not efficient. If wireless data transmission was so great, how come no ISP can provide a decent speed service with wireless? Its because they not only fight the bandwidth problem, but also the degrading effects of the surrounding area. In my house we pretty use wireless connections and except for the wired connection between router and cable modem. We connect through wireless as a convenience. But not without accepting that the priority is convenience and not speed or security. This is why if your set on using a mostly wireless local network. You need to buy the best equipment for that purpose. All the way from a good router, to devices that have good wireless hardware. This of course is not always the case. But try plugging a LAN cable into your iPad? Right?

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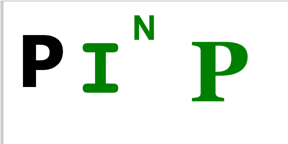

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