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# Troubleshooting Wi-Fi Performance

## Technical Guide

# Troubleshooting Wi-Fi Performance

There are many reasons why your wireless network may not be optimised, causing performance to suffer. In this guide, we outline the probable causes of performance problems.

**Note:** ***Items in this guide are listed in order (most severe impact to least severe impact)***

## *Interference*

If you are experiencing poor performance on your Wi-Fi network despite being within range of the access point, the most likely cause is interference. The spectrum that Wi-Fi operates within is unlicensed and everyone is free to use it. The RF energy used by microwave ovens falls within the 2.4 GHz frequency band, which was the initial reason that the spectrum was unlicensed. Wi-Fi is designed to inter-operate with competing RF energy sources and devices, but their presence may affect the data rates and range of the Wi-Fi network by periodically blocking users and access points from accessing the shared air medium, sometimes dramatically.

Adaptations to the modulation type and coding by the Wi-Fi access point to improve data quality impacts performance of over-the-air transmission, and these adaptations are reflected in the PHY rate. In addition, the 802.11 protocol allows for retransmissions of data packets. These retransmissions are independent of the 802.3 Ethernet networking protocol and will exist whether the data is TCP or UDP. Interference triggers 802.11 retransmissions and, if severe enough, communication ceases, regardless of the PHY rate. High interference levels create a "catch-22" where the radio slows its data rate, which in turn exposes the data transfer to even longer periods of interference. This is another benefit of optimising the throughput rate as much as possible, because it minimises transmission time in the air medium.

The 2.4 GHz band is subject to the most interference due to its heavier Wi-Fi usage (co-channel and adjacent channel interference) and wider range of non-802.11 interference. Understanding interference and procedures for minimising their effects on your wireless network are also covered here. Keep in mind that the implementation of the 802.11 protocol can be sophisticated and very adaptive, and has many mechanisms for mitigating interference. The performance of wireless networks even in the presence of interference is improving all of the time as the technology evolves.

## *Co-channel Interference*

Co-channel interference refers to the reduction in capacity of a channel due to the number of other users sharing the channel. Having multiple clients on the same channel competing for transmit time is called "interference" but is in fact a cooperative exchange, with the competing clients taking their turns communicating to the access point – much like a conversation within a group of people. In 802.11 these are not interferers, per se, because the 802.11 protocol allows for a cooperative and reasonably fair sharing of the airtime. The more users that are sharing the channel, the less time allocated to any one particular user -- so the individual user's access to the network is reduced. This is a well-managed function of 802.11 and is much less an impairment than the other forms of interference.

Co-channel interference can be minimised by choosing the channel with the least number of users on it. There are several utilities available to help you choose a lightly used channel. Refer to the 'Further Reading' section of this guide for assistance.

# *Overlapping Channel Interference*

Radios operating on an overlapping channel generate what is called "overlapping channel interference" and are in fact truly interfering with other channels on the Wi-Fi network. An example of this is one network operating on 2.4 GHz channel 1, and another network on channel 2. These channels overlap in terms of their RF spectrum use, but clients on channel 1 cannot decode frames from clients on channel 2.

No one is taking turns, and the transmissions of each of the radios simply trample the transmissions of the other. The data transmission of both networks is seriously degraded. For this reason, co-channel interference is much preferable to overlapping channel interference. In some cases, even adjacent (non-overlapping) channels may cause interference if the adjacent signals are high enough that the receiver filter cannot eliminate the interference.

Overlapping channel interference is avoided by adhering to the regimen of operating all access points that are sharing the local environment only on channels 1, 6, or 11. For a complete explanation, refer to the Wi-Fi Fundamentals guide.

Another type of interference, Adjacent Channel Interference, refers to non-overlapping channels (2.4 GHz channels 1, 6, and 11) where strong signals present on one channel may leak into another channel due to insufficient filtering. This type of interference will present similar symptoms as Overlapping Channel Interference, namely, higher noise present on the adjacent channels.

# *Interferers in the 2.4 GHz Frequency Band*

The 2.4 GHz unlicensed ISM band has a wide variety of interferers that may affect the operation of your Wi-Fi network or devices. Some of these may or may not be 802.11-based.

Some examples include:

- Microwave oven (major offender)
- 2.4 GHz cordless phones
- Proximity sensors
- Wireless mouse
- Wireless bridge
- Set top boxes
- Wireless audio devices: headsets, headphones or speakers
- Bluetooth devices
- Wireless video/surveillance cameras
- Outdoor microwave links
- Wireless game controllers
- Fluorescent lights

- WiMAX
- Bad electrical connections
- RF leakage from Direct Satellite Service (satellite TV)
- Baby monitors
- Neighbour’s wireless devices
- Certain external monitors and LCD displays (may emit harmonic interference, especially in the 2.4GHz band near Channel 11)
- Fluorescent bulbs
- Elevator motors
- Wireless Internet Service Providers (WISPs)

Using one of the following strategies can help minimise the effect of these interferers on your Wi-Fi network:

- Set the channel selection on your Fibre Router to "auto" via the EWI and reset the unit. Upon start up, the radio scans for and uses the channel with the lowest amount of interference.
- Manually change the channel selection to see if another channel improves your performance.
- Operate your Fibre Router on the 5 GHz band (if your client devices are 5 GHz capable).
- Minimise the number of nearby Bluetooth wireless devices. These could include a wireless mouse or printer.
- Avoid proximity to any suspected interference generator such as a microwave oven – for both the access point and the client. Particular care should be taken near the access point as it generally stays in a fixed location. This location should be as optimal for your wireless network as possible.

# *Interferers in the 5 GHz Frequency Band*

The 5 GHz bands also have their share of interferers, although the list is much shorter and their presence is less likely. Potential sources of interference in the 5 GHz bands include:

- 5 GHz cordless phones
- Radar (weather or military), limited to the DFS channels
- Perimeter sensors
- Digital satellite
- Nearby 802.11a or 802.11n WLANs
- Outdoor wireless 5 GHz bridges

# Attenuation and Weak Signals

Wi-Fi signals experience attenuation due to distance from their source just like any other radio. This signal attenuation subsequently causes the radio to be less effective and throughput suffers. Eventually, connectivity is lost when the signal becomes too weak. There are essentially two factors that affect signal attenuation between the access point and the client, and those are range (or distance), and attenuation due to obstructions.

# Range

The amount of distance or range that can be tolerated between an access point such as the Fibre Router and any client device is affected by several factors. Some of these factors are built into the hardware of the receiving and sending devices, such as power amplifiers on transmitters to boost power, and low noise amplifiers on the receivers to make them more sensitive. Transmit power can only be increased so far due to regulation, in which case most access points operate at the maximum power legally allowed for transmission. An overly sensitive receiver also picks up more interference, so there is a balance point where transmit power and receiver sensitivity are optimised for a specific application whether it be in a business environment or a subscriber's home.

# Physical Obstruction Interference

To maximise range and reception, it is helpful to know what structures and materials affect Wi-Fi signals. Fibre Router Placement, Orientation, and Turn-up details common building materials and their effect on Wi-Fi signals. Understanding these variables and building your network with an awareness of the effects of physical obstructions will minimise problems in this area. HCN recommends following these guidelines when optimising your Wi-Fi signal path:

- Metal structures reflect and scatter Wi-Fi signals. These can include anything with metal framing, like ductwork, electrical panels, metal roofs, mirrors, cubicle walls, metal furniture, or less obvious materials like concrete or stucco that are reinforced with metal mesh. Transmission through building structures that have continuous walls that are lined with metal coatings or foil may be extremely limited. Metal is most problematic when it is located in close proximity to the access point as it may also affect the radiation pattern of the antennas. Wi-Fi signals will not penetrate metal enclosures.
- Your wireless connection may have a shorter range or a slower speed through walls made of non-porous materials.
- Tinted glass panes (such as low e windows) have metallic coatings and can attenuate Wi-Fi signals.

# About Client Device Limitations

Client devices generally have less sophisticated Wi-Fi capabilities than the access point due to size and cost limitations. While an access point may have multiple antennas, MIMO technology, and the ability to support both frequency bands (resulting in a high available throughput rate), client devices are often limited to a single antenna and the 2.4 GHz frequency band. Wi-Fi throughput rates are determined by the least-capable device in the link which is usually the client. Because of their compact construction and (usually) single antenna, client devices such as smartphones and tablets can be more sensitive to device orientation and may suffer slow throughput because of poor reception. This is inherent in the design of these devices and needs to be accommodated by the user by staying within a reasonable range of the access point.

More capable Wi-Fi clients such as laptop computers often have multiple antennas, MIMO technology, and dual band radios. These clients are specifically designed to operate effectively over a wireless network, and will be able to take best advantage of the data throughput provided by the access point.

# *Summary 2.4 GHz Optimisation*

From a best practices' standpoint, HCN recommends following the procedure below to optimise 2.4 GHz Wi-Fi performance.

**Optimising performance**

- From the Fibre Router EWI, navigate to Wireless > 2.4 GHz > Radio Setup
- Ensure the Wireless Radio is "On"
- Ensure Wireless Channel is set to "Auto" **Note:** If interference persists, manually selecting channels is recommended until you achieve the best performance.
- Ensure your "mission critical" applications are using the 5 GHz band. **Note:** Ensure any sub-tended wireless devices are 5 GHz band compatible (802.11ac)
- Avoid proximity to suspected *interferers:*
  - Bluetooth Printers
  - Microwave Ovens
  - Ensure the Fibre Router is in an optimal location and is not susceptible to random movement.

# *Sample Throughput Rates*

Real world throughput rates will be dictated by the type of client that is communicating with the Fibre Router. The move to 802.11ac clients with higher levels of MIMO will certainly increase over the next few years however, many consumers still have older devices that may negatively impact their user experience. In theory, a 3x3 client can expect about 75% of the speeds demonstrated with 4x4 based client; a 2x2 client can expect 50%; and a 1x1 25% of the 4X4 speed. The table below summarises best case speed expectations for 802.11n and 802.11ac networks over the 5 GHz band for each level of MIMO client.

| Maximum Client Performance at 5 GHz (optimal) | | |
|---|---|---|
| **MIMO Level** | **802.11n (40 MHz Channel)** | **802.11ac (80 MHz Channel)** |
| 1 x 1 | 65 Mbps | 190 Mbps |
| 2 x 2 | 130 Mbps | 375 Mbps |
| 3 x 3 | 195 Mbps | 560 Mbps |
| 4 x 4 | 258 Mbps | 730 Mbps |
| **Note:** Values shown above are estimated and may vary based on your specific environment. | | |

The results above reflect a maximum expected performance level since Wi-Fi is impacted by both distance and the physical environment of the house. Wi-Fi performance over distance depends heavily on the transmit power and receive sensitivity of the clients. Maximum coverage is achieved when both the Fibre Router and the client are transmitting at maximum regulatory levels and both use high performance LNAs (low noise amplifiers) to obtain maximum receiver sensitivity. This is generally not the case for battery operated devices due to battery life issues and the added cost to support the maximum regulatory levels. With the lower power clients, the Wi-Fi range may be dictated by the failure to acknowledge uplink requests (ACKS). Client sensitivity is also important and by using LNAs, improved sensitivity of 5-6dB is generally obtained. Again, this consumes more power and has increased cost, and as a result, may not be available on many clients, particularly battery-operated devices. Moreover, these compact designs may not have the adequate package size to support multiple antennas or placement of the antennas in the most advantageous configuration. If a particular house still requires better coverage due to reinforced concrete, stucco, in-floor heating systems or other challenging Wi-Fi environments, HCN recommends the use of Wi-Fi devices available with Ethernet or USB connections that use high performance 3x3 or 4x4 radios.

## ***Additional Reading***

The Wi-Fi Alliance (a trade association promoting and certifying Wi-Fi technology) has articles and videos about understanding 802.11n — go to https://www.wi-fi.org/