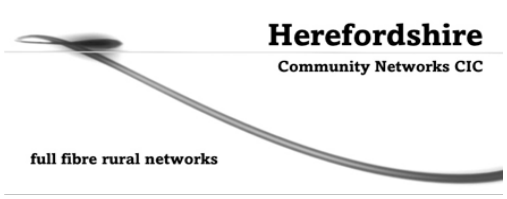


**Herefordshire Community Networks CIC**

phone: 01432 617306
e: hereford.cic@gmail.com
w: www.hereford-cic.net

# Extending and Enhancing your Home Network

## Technical Guide

# Extending and Enhancing your Home Network

## *Choosing the Proper Environment Based on Device Type*

Choosing what type of network to use in various environments is a critical step during in-home network planning.

**Wired Network**
While wireless connectivity is approaching the performance of wired connections, wired connections are typically superior where speed, reliability, and security are concerned.

Whenever an Ethernet port is accessible, or devices that are to be interconnected are within the reach of an Ethernet cable, the Ethernet network connection should be your first choice even if Wi-Fi capability exists. This also minimises the number of wireless clients, ensuring optimum performance of the wireless network.

If the device, such as a laptop, has dual network adapters and is experiencing network instability and/or slow connectivity, the Wi-Fi adapter should be disabled. Windows does not automatically disable the Wi-Fi port when the Ethernet port is active and may not prioritise between Wi-Fi or cabled connections.

**Wireless Network**
The wireless network is ideal for connecting mobile network devices such as smartphones, laptops, and tablets, or other Wi-Fi enabled devices that may be remotely located from the residential gateway without nearby wired Ethernet access. Wireless connectivity should be reserved for "best effort" network access where reliability and security are not critical or where the device itself is inherently "mobile" by design but still requires network connectivity.

**Fibre Router**
The HCN Fibre Router provides Wi-Fi connectivity via either an 802.11n 2x2 MIMO radio or an 802.11ac 4x4 MIMO radio with beam-forming gain. Fibre Routers support both 2.4 GHz and 5 GHz Wi-Fi bands (simultaneously) - configuration is accomplished using the Fibre Router's EWI.

Many devices can be operated in the 5 GHz band, which has more available channels and tends to have better performance if the Wi-Fi environment becomes congested in the 2.4 GHz band.

To ensure peak performance, use the 5 GHz band for higher bandwidth applications, such as IPTV.

## Expanding Wi-Fi Coverage/Reach

One of the primary considerations when deploying Internet capable devices in the home is the cost and inconvenience of hardwiring connections to each device’s location. Wi-Fi removes this obstacle and enables the deployment of smart devices without wires to simplify network setup. These devices are deployed in every possible location inside and outside the home and users expect these devices to connect seamlessly wherever they are deployed. In the past, when the end user had less than a handful of Wi-Fi devices on the home network, the location of the Wi-Fi enabled Router/Gateway was easily optimised. Now, with the proliferation of wireless devices, along with interferers such as appliances, radio interference from other devices, and factors as seemingly benign as adjacent street lights, it can be a challenge to provide coverage in all

environments. To make matters worse, not all homes are the same size or use the same construction materials/methods and the preferred demarcation point for the ONT/Wi-Fi Gateway within the home may not always coincide with the best location for Wi-Fi coverage.

The ability to establish a connection via Wi-Fi is directly associated with the strength of the Wi-Fi signal. It is affected by many factors including distance and the type of materials that it must pass through. Low or no signal strength can lead to dead zones where the Wi-Fi enabled device cannot connect to the home Wi-Fi enabled gateway/router. As end users migrate outside, they expect these mobile devices (iPad, Smart Phone, Laptops) to remain connected to the Wi-Fi network, eliminating the need to rely on more expensive 3G/4G data plans. Newer Wi-Fi devices with up to 4x4 Multiple Input, Multiple Output (MIMO) and beam-forming features (such as the HCN Fibre Router) have greatly expanded the coverage within the home, however a certain percentage of the homes may still have dead zones. To eliminate these dead zones and give coverage to these expanded spaces, additional Wi-Fi elements may be needed.

There are multiple ways to build an expanded Wi-Fi network. Two currently accepted practices are:

- An additional Wi-Fi Repeater/Extender
- One or more Wireless Access Points (WAP) or Wi-Fi bridges (existing Wi-Fi Router reconfigured as a WAP).

A brief discussion follows on these two technologies.

## Wireless Repeaters or Extenders

A wireless repeater or extender is a device that receives the Wi-Fi signal from the Wi-Fi enabled Router/Gateway, and retransmits it. On the far end, the repeater receives the Wi-Fi signal from the mobile client(s) and retransmits the signal back to the Wi-Fi enabled Router/Gateway.

**Note:** Wi-Fi by its nature is half-duplex, which means the single channel is used for both Transmit and Receive, however both cannot occur simultaneously.

When a Repeater is introduced into the network, transmissions will double and delays are potentially introduced. This occurs due to the nature of the repeaters catch and forward design. In other words, for every packet it receives, the repeater must process it, and then forward it out its internal transmitter. This has the effect of cutting the performances in half for traffic going through the repeater. Depending upon the nature of the application, this may or may not be an issue and is considered to be a better alternative than providing no connectivity at all.

Depending upon the capabilities of the repeater, it can use the same Service Set Identifier (SSID) or a different SSID. The SSID is the name that uniquely identifies one Wi-Fi network from any neighbouring networks. The SSID allows users to control what network they want to connect to.

Both Single and multiple SSID deployments are supported with the following differences:

- A single SSID allows the mobile client to access only configuration info for the main Wi-Fi enabled Router/Gateway, including all other mobile devices that are connected. A single SSID may enhance the client's ability to roam from the extender to the AP and back depending on movement of the client within the home.

- When two SSID's are used, the user can control and know which wireless host they are connected to. In addition, some of the units that support a second SSID will use a different channel for that second SSID. To accomplish this, the repeater must have dual radios. The use of a second channel allows the repeater to receive and transmit simultaneously and eliminates the halving of the bandwidth.

There are many varieties of Wi-Fi repeater and extenders available however they all are designed to support the basic repeater function. As an alternative to wireless repeaters, there are devices with the ability to support additional wired interfaces such as:

- Ethernet
- Multi-Media Over Cable Alliance (MOCA)
- Powerline Networks
- Home Phone Network Alliance (HPNA)

These higher end devices are used to inter-connect hardwired devices and backhaul the traffic to the Wi-Fi enabled router/gateway over a Wi-Fi channel. These higher end repeaters or extenders closely resemble WAPs/Routers and are available in a similar price range.

***Gateway/Repeater Physical Deployment***

Communications to and from the repeater is accomplished via a Wi-Fi channel (through the air) and as such, it is important to correctly place this equipment. For optimal performance, the repeater should be located where it has the highest possible connectively to the Wi-Fi enabled Router/Gateway. If placed at the outer limits of effective communication with respect to the Router/Gateway, there may be a tendency for increased performance issues due to retransmissions caused by the low signal strength.

***Managing Repeater Capabilities***

The management capabilities associated with this class of repeaters fall into the following categories:

- Wi-Fi Protected Setup (WPS) - Enters set-up mode via a "learn" button that is temporarily open for setup.
- Embedded Web Interfaces - May include a full suite of management features for all devices on the network.
- Remote Management via TR-069 - 3rd party management utilities are supported using standards-based TR-069 to monitor, configure, and remotely re-boot network devices.

Given the nature of what repeaters are designed to do, most of them do not include or need extensive management interfaces, with vendors typically highlighting how simple the devices are to deploy. From a service provider perspective, the best practice is to recommend an additional WAP or Wireless bridge, however if a Repeater/Extender is needed, the recommendation is to select a repeater with TR-069 capabilities. This allows the service provider to configure the repeater as another network element, being visible in network architecture diagrams.

The benefits of this network architecture are:

- Since all communication is done via Wi-Fi, no additional infrastructure is needed.
- Plug-n-Play nature - manageable elements are typically auto-detected.

Conversely, this network architecture poses a few challenges:

- By their nature, repeaters or extenders insert twice as much traffic onto the airways which effects throughput.
- The client may attach to the repeater (inefficient at one-half the speed) when attaching directly to the gateway would be more efficient (better).
- Physical obstructions in the home may exist blocking the Wi-Fi signal (such as embedded radiant floor heaters)
- By their nature they add delay and some applications (typically video) are very sensitive to packet delay and jitter.
- Most commercial repeaters or extenders are typically not robust from a management perspective (more difficult to know that these elements exist in the network, making troubleshooting more difficult).
- Solution does not scale well for multiple reasons:
- Potential channel re-use
- Distance limitations
- Cascading of repeaters or extenders is typically not allowed
- Puts the burden on end users to manage the complexity of dual SSID networks when needed.

## WAPs or Wi-Fi Bridges

As opposed to wireless repeaters or extenders, one of the fundamental differences when using Wireless Access Points (WAPs) or Wi-Fi bridges is how the additional Wi-Fi elements are connected to the Wi-Fi enabled Router/Gateway. With WAPs or Bridges, the elements are hard-connected via CAT5. Alternatively, the WAP may be connected to the gateway using Ethernet to MoCA/HPNA, or Powerline adapters. This additional infrastructure can be costly and is certainly more complex than "over-the-air" Wi-Fi circuits. However, for the additional cost and complexity, users typically enjoy increased performance, network simplicity, flexibility, and control.

To support this architecture, additional network configuration is needed but once configured, this high-performance network uses a single SSID end-to-end.

The benefits of this network architecture are:

- Each of the two Wi-Fi devices (Router/Gateway and WAP/Wi-Fi Bridge) use different channels, maximising throughput and minimising interference.
- Packets to and from the mobile clients are always a single wireless link away and therefore are not transmitted twice.
- End users only see a single SSID. Mobile client can seamlessly roam between the two wireless spaces.
- Extremely scalable solution - can easily add more WAPs as needed.
- Given the hardwired nature of the backhaul from the remote WAP to the primary Router/Gateway, link speeds between them are not limited by Wi-Fi a/b/g/n/ac speeds.
- To handle the complexity of configuring and administering the network, TR-069 management solutions can be leveraged. This greatly simplifies network administration for both the end user and the service provider.

The challenges of this network include:

- If re-purposing an existing Router/Gateway as a Wi-Fi Bridge, it must be set up as a bridge and any Layer-3 features such as Network Address Translation (NAT) and DHCP must be disabled.

- There is the additional cost of the wired backhaul and additional WAP/Router/Gateway. In some cases these costs may be minimal or zero provided the infrastructure already exists on site.
- If devices are not TR-069 manageable, the end user must configure and administer these devices manually.

## About Client Roaming and Sticky Clients

Regardless of the wireless LAN standard you plan to deploy, a potential problem exists in that Access Point (AP) to AP roaming for Wi-Fi has historically been the decision of the client with no clear rules defined as to which host to connect to. With the introduction of 802.1n, additional capabilities were added where the Wi-Fi WAP can give guidance to the mobile Wi-Fi client and suggest that they roam to a different AP.

These additional capabilities are further confined to deployments incorporating the 802.11n standard since 802.1a/b/g devices are not currently supported. The good news is that these older mobile clients will eventually be retired and replaced with new devices that support the latest wireless standards, mitigating the issue. In addition, the standards bodies are introducing support for controls that allows a network of WAPs to communicate between themselves. This allows roaming decisions to be made at multiple points in the network. This will prove beneficial in that signal strength decisions can then be considered as well as packet load and channel capacity decisions on individual WAPs in the network.

The problem of the sticky client is worse with the Repeater/Extender approach since the client has no way of knowing that communication through the repeater is less efficient as compared to directly connecting to the gateway. As a result, a connected may be selected based on signal strength alone which may not always be the desired approach.

Until these new capabilities are prevalent within your network, HCN recommends using only the single SSID model in your configurations.

## What to Deploy?

The decision as to what type of Wi-Fi network to deploy is not always cut and dried, however from a best practices' standpoint, the following variables must be considered:

- What system provides the overall highest value?
- What system provides the best performance?
- What solution provides the least amount of risk?
- What deployment gives the service provider the highest degree of control?
- What system provides for remote management via TR-069?

Taking into account the above variables, it is clear that a Wi-Fi network incorporating hard-wired Wireless Access Points or Wired is the de-facto best practice model as opposed to the Repeaters or Extender model. Whether an enterprise network or a simple home network, building a distributed Wi-Fi network using standards-based functionality with additional capabilities (such as WAP directed client steering and enhanced roaming) is highly desirable.

In addition, most of these devices support TR-069 clients which allow the service provider a view of what is connected to the home network and how the end users' mobile resources are utilising

the Wi-Fi infrastructure. This allows service providers who have home networking TR-069 ACS solutions (such as HCN) to offer managed services with access to a set of tools for troubleshooting, configuring and maintaining these resources.

In general, better throughput, better coverage, and increased interoperability are the benefits of an 802.11ac system.

- 802.11n is limited to 40 MHz wide channels, while the Fibre Router can use 80 MHz wide channels for much higher throughput in nearby areas where beam-forming is not used.

- 802.11ac also supports 160 MHz channels, although HCN has not implemented this on the Fibre Routers as chip sets have yet to be introduced that simultaneously support both 160 MHz and 4 spatial streams, although this no doubt will change soon.

- 802.11ac supports explicit and inter-operable beam-forming, doubling the amount of gain from beam-forming compared to 802.11n. This significantly increases coverage in hard to reach places at the edge of the home network.

- 802.11ac supports higher QAM (256 vs 64) levels for higher throughput.