Scaling Wi-Fi Mesh Coverage in Dense MDUs

Service providers can improve Wi-Fi coverage and performance in MDUs by using open-source, intelligent mesh software and incorporating backhaul technologies with existing wiring infrastructure.

By Livia Rosu, prpl Foundation / *HomeGrid Forum*

Multiple-dwelling-unit (MDU) deployments continue to get denser. More buildings are closer together and taller than they used to be. At the same time, homes have more-sophisticated Wi-Fi devices of all sorts, requiring more reliable and faster broadband service. HD video streaming and home monitoring, videoconferencing, home networks, always-connected intelligent devices: the list seems endless.

Residents' expectations for good Wi-Fi coverage (rate-at-range) everywhere in homes have increased accordingly. The quality of service promise can only be kept if translated into a quality of experience (QoE) perception. However, the Wi-Fi spectrum is a limited public resource – a shared medium. Overuse results in congestion, poor performance and user dissatisfaction. How can dense MDUs optimally share the finite amount of Wi-Fi spectrum? What strategies and technologies can address the challenges of ever-increasing requirements?

1. Use intelligent Wi-Fi mesh software, such as prpl free, open-source software.
2. Preserve Wi-Fi channels for use as fronthaul links by employing wired backhaul technologies wherever possible.
3. Select wired backhaul technologies (e.g., G.hn or MoCA) that leverage existing wiring deployed in MDUs.

Let's explore what all that means.

WI-FI MESH

Wi-Fi mesh solutions have become very popular in the last few years because they provide good coverage throughout a dwelling by deploying multiple Wi-Fi "extender" devices throughout a home. Wi-Fi extenders act like Wi-Fi sprinklers to cover what otherwise might be "dead" spots. Each extender access point covers a portion of a dwelling, represented in Figure 1 by the gray coverage circles. With Wi-Fi mesh, each user/device in the home enjoys better signal quality by being closer to an extender access point than expected from a single Wi-Fi access point.

One might think that MDUs would not need mesh Wi-Fi, being generally smaller than single-dwelling homes. However, MDUs are often constructed from steel-reinforced concrete, which is relatively opaque to Wi-Fi signal penetration compared with wooden structures often used in single-dwelling homes. A single Wi-Fi access point could have difficulty providing good coverage after penetrating reinforced concrete walls. There could be a small, low-cost, low-power Wi-Fi extender within each room with a mesh deployment.

As good as they are, however, mesh Wi-Fi solutions can *increase* the usage of finite Wi-Fi spectrum. Each mesh extender likely occupies different Wi-Fi channels. Fortunately, in MDUs, low-power extender devices and attenuation from concrete walls both help reduce unwanted signal interference into neighboring dwellings.

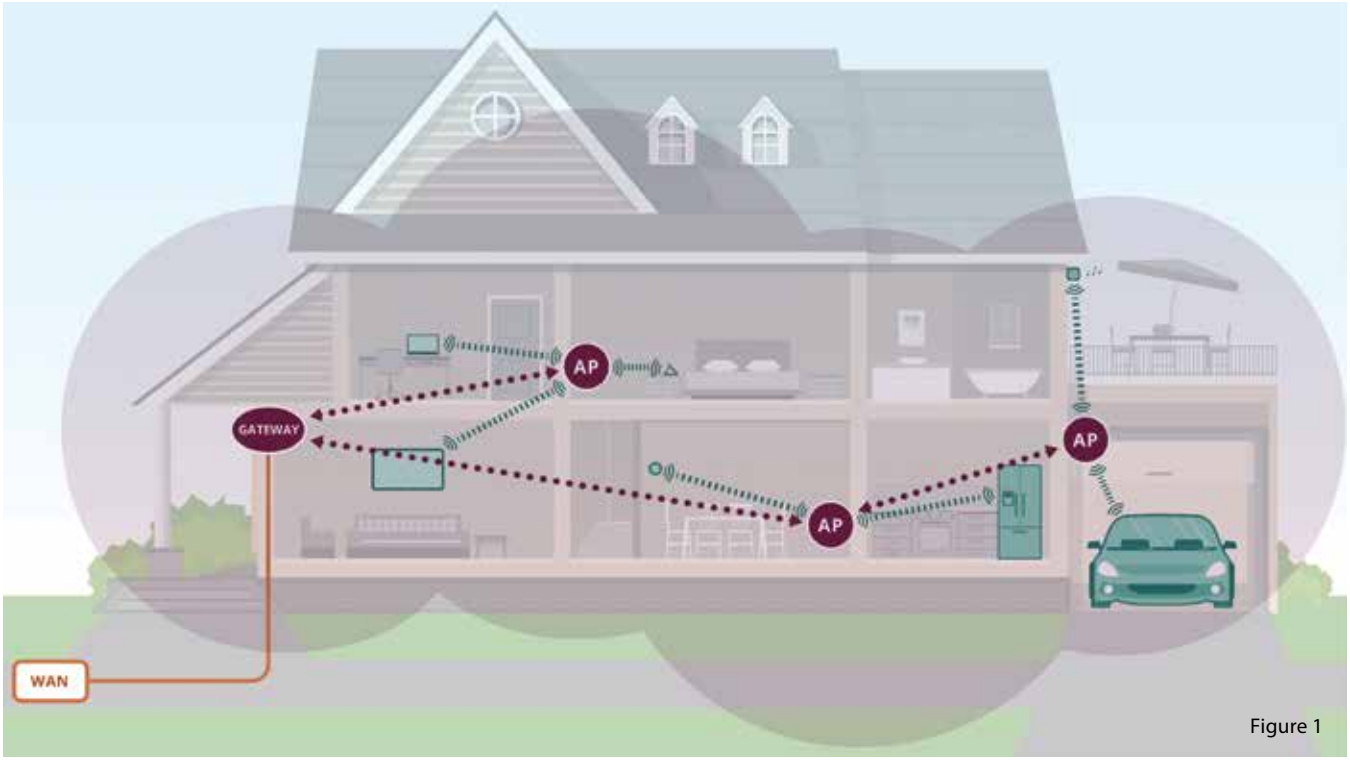

Figure 1

Such mitigation of undesired signal interference among neighbors is one tool that enables Wi-Fi channels to be reused by other homes in the MDU, thereby allowing effective sharing of precious Wi-Fi spectrum resources.

BACKHAUL AND FRONTHAUL LINKS

As shown in Figure 1, an internet service provider (ISP) typically provides gateway customer premises equipment (CPE) to access an internet wide area network (WAN). The connection is shared throughout a single dwelling over a Wi-Fi mesh network that serves as a distribution system.

Data traffic is distributed among the Wi-Fi extender access points (labeled "AP" in Figure 1) over "backhaul" links represented by the dotted purple arrows. The most remote extender (the rightmost AP) is positioned out of range from the gateway and requires a double-hop through one of the less remote extenders (over two different backhaul links). Backhaul links can use wired or wireless connections.

The dotted green arrows in Figure 1 represent the "fronthaul" links. Fronthaul links are almost always Wi-Fi connections because Wi-Fi is the universal wireless interface standard for all consumer devices in a home. The fronthaul links are the Wi-Fi connections that individual devices "see" and connect to from their location in a dwelling. Mobile devices that roam with a user from one location in the home to another will similarly have their Wi-Fi connection walk from one extender AP to another.

PRPLMESH SMART WI-FI

prplMesh is a free, open-source software implementation of a carrier-grade mesh Wi-Fi solution for managing Wi-Fi access points in CPE gateways and Wi-Fi mesh extenders. The prplMesh software stack was developed and released by the prpl Foundation, a community-driven consortium dedicated to harmonizing open-source network architecture.

prplMesh software implements an industry-standard mesh protocol called EasyMesh from the Wi-Fi Alliance, but it goes further. It includes controller software with intelligent, decision-making algorithms to make the mesh network self-organizing. In this self-organizing network, backhaul and fronthaul links are automatically selected, arranged and optimized by controller algorithms that make such decisions based on the capabilities of individual devices and the traffic load environment they measure locally. For example, the controller can assess the unique environment in each MDU unit, then automatically select lightly loaded Wi-Fi channels for fronthaul links that offer users the best performance and QoE. The controller can also expose diagnostic and other metadata to the cloud for optimal remote management of the mesh network.

Several top-tier ISPs expect to deploy prplMesh software, so the stack includes features for analytics to facilitate remote troubleshooting.

Several top-tier ISPs expect to deploy prplMesh software, so the stack includes features for analytics to facilitate remote troubleshooting.

The use of intelligent prplMesh free, open-source software, with its support for Ethernet, MoCA and G.hn backhaul technologies, provides an excellent strategy for service providers to scale mesh Wi-Fi deployments into dense MDUs.

stack includes features for analytics to facilitate remote troubleshooting. It also includes a carrier-grade management interface for remote configuration and management of the software stack.

For more information about prplMesh software, see https://tinyurl.com/hxpzw5kw.

PRPL BACKHAUL STRATEGY

The prplMesh software includes a backhaul manager, which monitors, chooses and optimizes the backhaul links used in the mesh. They can themselves be Wi-Fi connections, which is convenient for placing extenders in a dwelling – but that would further occupy and load the available Wi-Fi channels. Recall that an important strategy for dense MDUs is to preserve Wi-Fi channels for use as fronthaul links, so it is preferable to employ wired connections for backhaul links, wherever possible.

The prplMesh software supports Wi-Fi backhaul links and various wired backhaul technologies, such as Ethernet, MoCA and G.hn.

- **Ethernet:** This standard wired technology is suitable for backhaul links, but it requires dedicated cables between the gateway and extender apps, which are not commonly deployed in MDUs. Fortunately, other backhaul technologies function very much like Ethernet but use existing wiring widely found in MDUs, thereby avoiding the expense and headache of installing dedicated Ethernet cables.
- **MoCA:** This technology uses existing coaxial cables, which typically distribute cable television signals. MoCA shares those cables to transport backhaul traffic between mesh Wi-Fi devices at Ethernet-like throughput speeds.
- **G.hn:** G.hn technology operates over almost any type of wiring available in residential environments, such as AC power lines, coaxial cables and twisted-pairs (e.g., phone-line cables). Transporting backhaul traffic over the existing AC powerlines with G.hn technology is particularly convenient because mesh Wi-Fi devices (i.e., gateway and extenders) are all AC-powered. Instead of consuming Wi-Fi channels to carry backhaul, the mesh devices can use their powerline connection. Any power socket can become a potential location for a high-performance mesh Wi-Fi access point.

Using MoCA and G.hn technologies over existing wiring is so convenient to solve problems that may arise in home networking applications that the technologies also find widespread use in other adjacent applications, such as distributing high-speed internet access within MDUs (e.g., where installing new optical fiber is prohibitively expensive).

Mesh Wi-Fi networks provide whole-home coverage with no dead spots by leveraging backhaul and fronthaul links to relay traffic to ever-increasing numbers of end-user Wi-Fi devices.

Poor signal penetration through steel-reinforced concrete walls is one challenge with Wi-Fi in MDUs. Service providers can address this by using an MDU's existing wiring infrastructure to carry backhaul traffic between Wi-Fi extenders in different rooms. MoCA and G.hn technologies capitalize on the existing wired infrastructure of MDUs to transport data traffic for efficient backhaul to support ever-growing data services such as IPTV, video-on-demand and web applications.

Intelligent, self-organizing mesh Wi-Fi networks can self-optimize their Wi-Fi channel selections to provide good service to all users while minimizing signal interference into neighboring MDU units.

The use of intelligent prplMesh free, open-source software, with its support for Ethernet, MoCA and G.hn backhaul technologies, provides an excellent strategy for service providers to scale mesh Wi-Fi deployments into dense MDUs. ❖

Livia Rosu is president of the HomeGrid Forum. Previously, she was chair of the Marketing Working Group and member of the board of directors for HomeGrid Forum for more than six years.