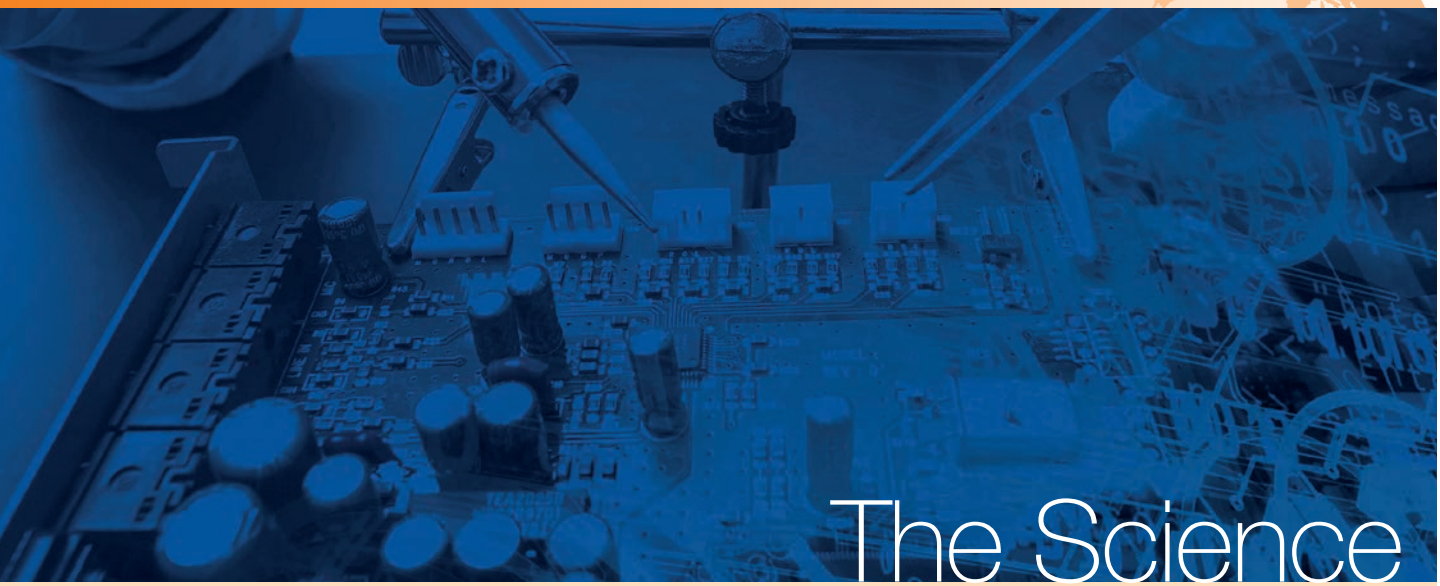

The Science of Great Wi-Fi

by Calix

Bandwidth challenges brought about by the ongoing pandemic have brought pressure to bear on residential Wi-Fi solutions. Understanding the science behind successful Wi-Fi RG is paramount to finding the right solution.

The science of great Wi-Fi

With more and more connected devices and constant online activity, most consumers want to get the fastest, most reliable Wi-Fi possible. While there are a variety of Wi-Fi residential gateway (RG) solutions available, understanding the core science behind what makes a great Wi-Fi RG is key in selecting the right solution.

Figure 1: Having Wi-Fi systems placed at a higher position will result in substantially better performance.

This technical description provides the essential scientific aspects of great Wi-Fi performance and coverage.

Wi-Fi residential gateway (RG) placement

Wi-Fi is a radio technology. As with all radio waves, obstructions can affect performance. Having Wi-Fi antennas placed at a higher position will result in substantially better transmission and performance because there are fewer chances of the radio waves being obstructed. For most residential applications, it is no surprise that most Wi-Fi RGs are placed on a desk, shelf or countertop.

In enterprise environments, by comparison, Wi-Fi RGs are typically mounted on a wall or ceiling. Wi-Fi RGs that feature integrated wall plug-ins do not allow for optimal placement, as most wall power plugs are at ground level, resulting in sub-optimal Wi-Fi performance and reach.

Wi-Fi antenna separation distance

Inside the Wi-Fi RG, it is important to have enough enclosure space to provide antenna separation. Without adequate separation, the antennae will interfere with each other. Ideal antenna separation is one wavelength apart, with ¼ wavelength as the minimum. In 2.4GHz and 5GHz radios, the wavelengths are 4.9” and 2”, respectively. Therefore, for small plug-in units, the maximum separation possible is less than one-quarter of the 2.4GHz wavelength, or about

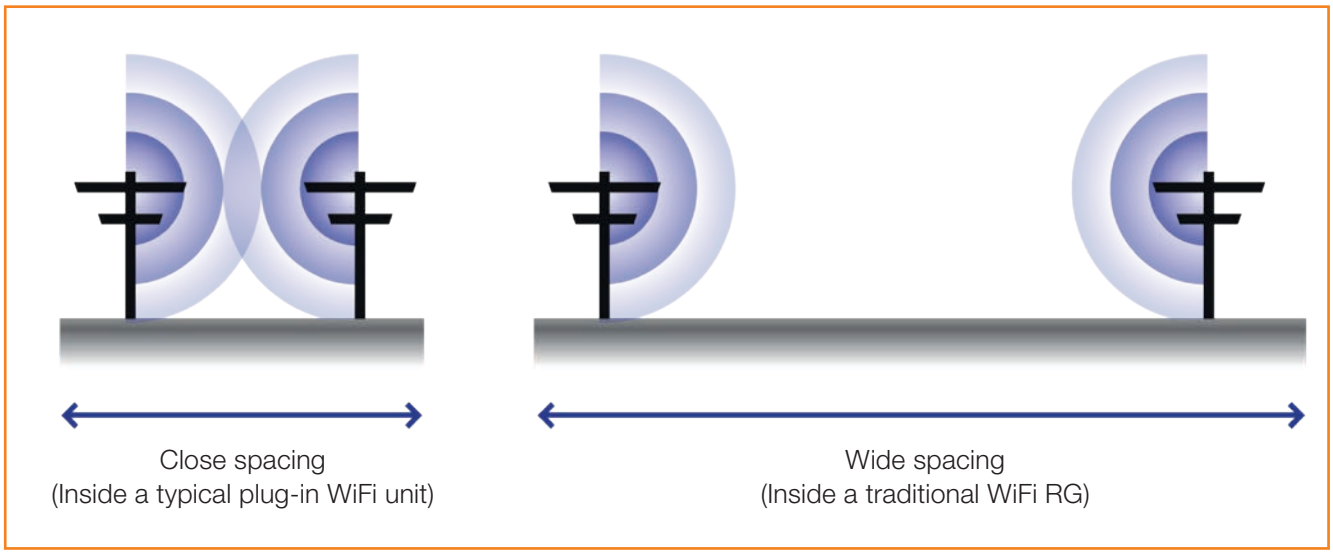

Figure 2: Without adequate antenna separation, Wi-Fi speeds will be reduced

1.2". In most traditional Wi-Fi RGs there is sufficient space to provide a full wavelength separation to provide optimal Wi-Fi performance. This can easily be observed in traditional RGs vs small wall plug-in units, as shown in Figure 2.

Packaging

The enclosure used for a Wi-Fi RG must be designed to provide adequate antenna placement and separation, as discussed above. Furthermore, enclosure design is critical for thermal ventilation. A well-designed enclosure not only offers pleasing aesthetics to the subscriber's home, but also provides essential air flow to a thermal pad; ideally, without the need for a mechanical fan. In most small Wi-Fi plug-in units, the only way to cool the electronics is to include a mechanical fan, which have inferior mean time between failure (MTBF) rates. Mechanical fans also generate ambient noise, which some consumers might find annoying. Finally, mechanical fans are less energy efficient than systems that do not require fans. As technology transitions from Wi-Fi 5 to Wi-Fi 6, the thermal requirement increases, further aggravating the wasteful power consumption associated with systems that require an internal fan.

Wi-Fi 6 Technology

The first series of carrier-class Wi-Fi 6 (802.11ax) systems were introduced in 2018. Since then, new generation Wi-Fi 6 chipsets have become available, boasting many new advanced features. As with any new technology, the learning curve takes time and experience.

Vendors that have offered Wi-Fi 6-based systems for years, report at least a 35% improvement in reach and performance, when compared to Wi-Fi 5 (802.11ac) systems. Plug-in Wi-Fi devices, which only recently started featuring Wi-Fi 6 technology, will take time to mature and tune their performance, coverage and interoperability.

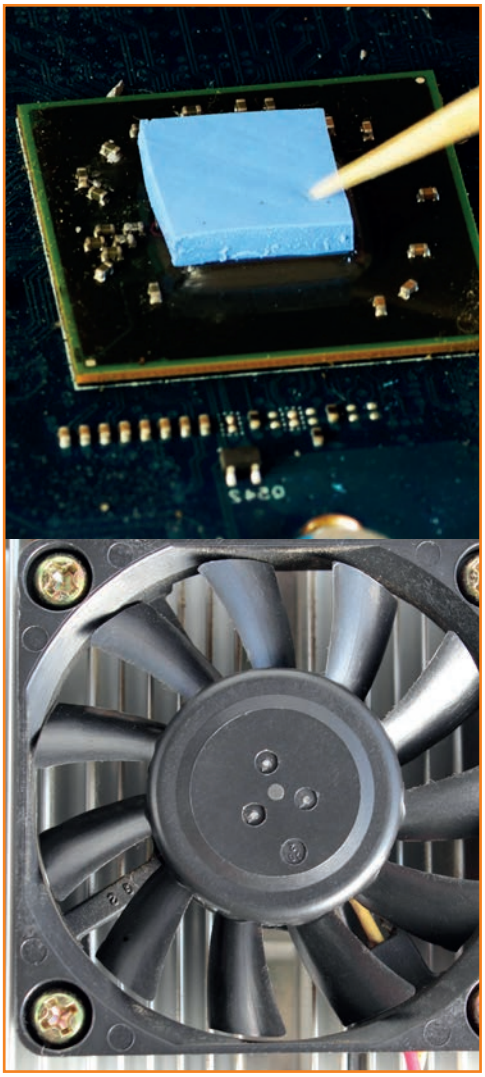

Figure 3: Enclosures for traditional Wi-Fi RGs provide essential air flow to a thermal pad (shown top). Typical plug-in Wi-Fi units require a mechanical fan, which are associated with inferior MTBF rates (shown bottom).

Figure 4: Deploying a single Wi-Fi RG with enough power to cover an entire residence (as represented by the single, large sphere that encompasses the entire house), is better than using multiple mesh Wi-Fi units (as represented by the various, smaller spheres found within the house).

Single Wi-Fi RG vs mesh deployments

Deploying a single Wi-Fi RG with enough power to cover an entire residence is better than using multiple mesh Wi-Fi units.

Managing a single RG is preferred over multiple Wi-Fi devices in terms of optimisation, analytics collection, and customer support. Having multiple, fan-cooled plug-ins decreases network reliability. In addition, node steering can be quite complex and sub-optimal in a mesh Wi-Fi environment. Solutions that require fewer APs are better than solutions that require multiple APs.

For example, some clients are "sticky" – meaning that once they connect to a Wi-Fi access point, they can refuse future steering commands; even if the signal and bandwidth is better served by another mesh unit. A single, powerful Wi-Fi RG provides uniformly high bandwidth coverage inside the sphere (as shown in Figure 4).

Other advantages of a single RG deployment include:

- Delivery of more bandwidth to each wirelessly connected device; in a Mesh Wi-Fi system, the inherent wireless backhaul that is required between Wi-Fi units translates to lower bandwidth owing to the requirement for the radio to repeat every Wi-Fi packet, even if over the air (OTA) attenuation is great.
- Wi-Fi dipole antennae found in typical RGs broadcast signals in all directions. A single, powerful Wi-Fi 6 RG provides great horizontal and vertical (shown top) and (shown bottom) coverage over a large area. In contrast, a network comprised of multiple plug-in mesh Wi-Fi units provides a series of small coverage areas, with numerous gaps in between.

Not all mesh systems are created equal

While a single, powerful, traditional RG is considered superior for the vast majority of residential applications, there are occasions where a mesh satellite system is needed, such as servicing a very large house. In these scenarios, it is important to select a mesh system that features the same advantages of a traditional RG, as discussed above, including a well-designed enclosure that allows for adequate antenna separation and sufficient airflow, without the need for a mechanical fan.

For more information, see www.calix.com/solutions/technologies/wi-fi.htm