Optimizing Home IoT with Wi-Fi CERTIFIED®

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Introduction

Connected homes are replete with a variety of smart objects collectively known as the Home Internet of Things (IoT). Due to Wi-Fi®'s ubiquity throughout the world, its wide-ranging technology portfolio, and its strong legacy of interoperability, Wi-Fi is certain to play a role in almost every Home IoT environment. The nature of Home IoT is that a wide range of products, manufactured by different companies, need to work in unison. Wi-Fi is designed for interoperability at its core by adhering to IEEE standards, and as such, it offers pervasive connectivity across control devices, like smartphones, as well as access points (APs) and connected objects. Personal data exchanged through the Home IoT network is safe with Wi-Fi due to its inherent security protocols, and the high performance that Wi-Fi offers ensures that IoT devices remain consistently connected and operational, which is especially important for high-stakes situations such as eldercare.

Wi-Fi Alliance® offers Wi-Fi CERTIFIED® testing and certification to ensure interoperability with other Wi-Fi CERTIFIED devices. While companies may create products based on the IEEE 802.11 standard that are not certified, they do not carry the Wi-Fi brand or certification logo. This is a serious detriment to a product's credibility as the Wi-Fi CERTIFIED seal of approval means that a product has been tested in a variety of ways to validate its quality and reliability. Certification is especially important for IoT devices as they often must interoperate with numerous products in order to provide the Home IoT experience that homeowners and renters are looking for. Wi-Fi CERTIFIED also benefits device vendors by giving confidence to consumers, solution integrators, and service providers that products perform well and are backward compatible with earlier versions of Wi-Fi. In addition to the many benefits of Wi-Fi CERTIFIED described above, it is also a mandatory requirement for Matter certification, which further ensures device compatibility.

Wi-Fi Alliance offers certification for over 20 technology programs, many of which offer specific advantages for Home IoT. These certification programs can be categorized as core Wi-Fi connectivity or additional Wi-Fi capabilities:

- **Power saving features:** Innovations that increase Wi-Fi device power efficiency
- **Core Wi-Fi connectivity:** Certification programs based on specific key versions of the IEEE 802.11 connectivity standard, each of which incorporates a range of technical features and capabilities
- **Additional Wi-Fi capabilities:** Certification programs that optimize Wi-Fi networks or support particular applications and services. These programs offer capabilities such as advanced security, easier onboarding, interoperable meshes, and integration/coexistence with other network technologies

Power saving features

Always innovating and evolving, Wi-Fi is now even better suited for battery-powered applications. Wi-Fi Alliance has introduced additional power saving features as a part of Wi-Fi CERTIFIED programs that enable devices to benefit from native connectivity to Wi-Fi networks and the Internet without concern for power consumption. Power saving features can drastically increase battery life for Wi-Fi enabled devices in smart home, smart city, industrial, and healthcare environments.

- **Longer sleep periods:** Devices stay asleep longer while remaining associated with the network
- **Improved network efficiency:** Network traffic and exchanges to keep devices connected are drastically reduced
- **Extended battery life:** Mechanisms in APs enable lower-power operation for all connected devices
- **Easily applicable:** Features may be delivered to networks, including existing networks, via software update

Core Wi-Fi connectivity

Core Wi-Fi connectivity is the basis for IoT devices to connect to a home network and ultimately to internet applications. Wi-Fi Alliance has introduced simple numerical designators to identify major Wi-Fi connectivity releases, such as Wi-Fi 6, and its associated certification program, Wi-Fi CERTIFIED 6®. This enables each major release to combine both the new, better-performing radio protocol standards for enhanced capacity, range, latency, etc., as well as certain other foundational and mandatory capabilities, such as WPA3™ security. From a Home IoT perspective, newer generation technologies offer capabilities that go beyond raw throughput speed. It is worth noting that the addition of 6 GHz to Wi-Fi CERTIFIED 6 is a special case, as it marks the point at which a whole new spectrum band became applicable. In addition to the major Wi-Fi releases, Wi-Fi also offers application-specific Wi-Fi connectivity, such as Wi-Fi CERTIFIED HaLow™, providing long range, low-power Wi-Fi in the sub-gigahertz spectrum.

Wi-Fi 7

Wi-Fi 7, based on IEEE 802.11be technology, is the latest Wi-Fi standard that enhances Wi-Fi performance in the 2.4 GHz, 5 GHz, and 6 GHz bands, bringing cutting-edge capabilities to enable innovations that require high throughput, lower latency, and greater reliability across home, enterprise, and industrial environments. As video use cases gain prevalence in the home, Wi-Fi 7 supports ultra-high definition video streaming and conferencing and key AR/VR/XR applications that provide immersive, interactive experiences including social gaming. Wi-Fi 7 delivers extremely high throughputs, low latency, and low jitter by leveraging new features that support wideband, high-speed communication with more nimble and robust use of spectrum in the presence of interference. The newest products are also starting to adopt Wi-Fi 7 to access the 6 GHz band, which is being released (with a few different rules and frequency widths) in many regulations around the world. Wi-Fi in 6 GHz can support faster speeds using larger channel widths that bring extra capacity to the Wi-Fi universe with relatively low interference and congestion. Initial APs and devices appeared during 2021, with the total number of devices certified for 6 GHz exceeding 1,300 in mid-2024. While the initial targets for 6 GHz devices are mostly at the high end (for instance, laptops and top-tier smartphones), it is also suitable for high-throughput IoT devices such as video-based fitness machines, security cameras, and telemedicine products.

Wi-Fi 7 offers significant advancements that balance high performance with reduced power consumption, addressing the growing user demand for high-throughput, low-latency applications. One of its key features, Multi-link Operation (MLO), allows devices to combine different channels across frequency bands together, enabling concurrent transmission and reception of data over multiple links for increased efficiency. This flexibility optimizes both performance and power usage based on network conditions. Additionally, Wi-Fi 7's use of 4K QAM and Multiple Resource Units to a single STA enhances data transmission rates and efficiency, both of which are crucial for power-saving. These features make Wi-Fi 7 particularly beneficial for battery-operated devices in automotive and Industrial IoT applications, where efficient power usage is essential for extending operational life and reducing maintenance costs.

Initially introduced in Wi-Fi 6, Target Wake Time (TWT) assists in delivering extended battery life and reduced power consumption by allowing a device to "sleep" for extended periods of time between connections to the network, rather than being permanently connected. Wi-Fi 7 has expanded on this feature with Restricted Target Wake Time (R-TWT). R-TWT allows client devices to effectively reserve a channel, scheduling specific times for their own use. This further enhances power efficiency, a crucial component of the operational life of IoT devices.

Wi-Fi 6 and 6 GHz

Based on the IEEE 802.11ax standard, Wi-Fi 6 operates in the 2.4 GHz, 5 GHz, and 6 GHz frequency bands. Wi-Fi 6 provides greater capacity, multi-gigabit data rates, better power efficiency, and high performance even in densely populated environments. Wi-Fi 6 has mostly been deployed in mid-to-high end APs, primarily where ISPs have ultra-high speed broadband offers of 300 Mbps or above, such as FTTx fiber or DOCSIS3+ generations of cable. Some 5G fixed wireless access (FWA) modems also use Wi-Fi 6 for in-home connectivity.

On the device side, Wi-Fi 6 and 6 GHz are now fairly common in mid-to-high end laptops, mid-tier smartphones, and other devices such as certain TVs and gaming consoles.

Wi-Fi 6 is particularly relevant when devices have high bandwidth or low latency requirements such as cameras and screens, but there are also additional benefits around power consumption and reliability. Wi-Fi 6 contains a number of features that have significant benefits for Home IoT applications, with Target Wake Time (TWT) being one of the most influential in terms of power saving. TWT allows a device to "sleep" for extended periods of time between connections to the network rather than being permanently connected. APs and end devices negotiate and pre-schedule timing – either individually or in groups – which is key for extending battery life and reducing power consumption. Additional features include multi-user multiple-input and multiple-output (MU-MIMO), beamforming, and basic service set (BSS) coloring. Wi-Fi 6 also mandates WPA3 security mechanisms.

Wi-Fi 4

Wi-Fi 4 is the "baseline" for modern Wi-Fi networks. Wi-Fi CERTIFIED™ n is based on the 802.11n standard originally published in 2009, and can operate in both the 2.4 and 5 GHz bands and provides good coverage across the home for devices that do not require extensive bandwidth, such as smart thermostats and connected lighting. Owing to its stability and relatively low cost, it is still widely used today in many IoT devices as well as some wearables and smart televisions. Its power saving features are also particularly valuable for IoT devices, which require long battery life and may not need to communicate with infrastructure too frequently.

Wi-Fi HaLow™

Wi-Fi HaLow is the first version of Wi-Fi specifically designed for the IoT marketplace, with longer range and lower power connectivity than other Wi-Fi connectivity technologies. It has applications for Home IoT as well as enterprises, agriculture, and smart cities. Based on IEEE 802.11ah technology, it operates in unlicensed spectrum below 1 GHz using narrowband channels. The exact bands vary by region of the world but are the same frequencies used for other low-power wide-area network (LPWAN) technologies such as LoRa and SigFox.

Wi-Fi CERTIFIED HaLow™ for IoT

Features	Benefits
Sub-1 GHz spectrum operation	Long range: approximately 1 km
Narrow band OFDM channels	Penetration through walls and other obstacles
Several device power saving modes	Supports coin cell battery devices for months or years
Native IP support	No need for proprietary hubs or gateways
Latest Wi-Fi® security	

In the context of Home IoT, the ability to penetrate walls and other barriers better than 2.4 GHz technologies is an important consideration. Wi-Fi HaLow implements new sleep and management modes (using the same TWT protocol outlined above) to deliver energy-efficient, multi-year battery operation. This makes it suitable for connecting devices such as door locks, lighting, cameras, and heating, ventilation, and air conditioning (HVAC) components. It can also link appliances to each other or to Internet resources without running additional signaling wires. Home doorbells or multi-dwelling unit (MDU) access control systems can use Wi-Fi HaLow's higher data rates to support real-time video and biometric authentication schemes.

Similar to Wi-Fi 6 and Wi-Fi 7, Wi-Fi HaLow is underpinned by modern security protocols, including WPA3 and Wi-Fi CERTIFIED Enhanced Open™. For Home IoT applications, these protocols encrypt valuable or confidential data sent between IoT devices and the AP. The comparatively higher data rates also allow for additional security layers, such as tunneled IP traffic sent to trusted cloud platforms. Firmware updates can be downloaded quickly and securely via over-the-air refresh, improving functionality and security without extra user intervention.

WPA3

WPA3 is now a mandatory certification for all devices. It provides cutting-edge security protocols to simplify Wi-Fi security, enable more robust authentication, deliver increased cryptographic strength for highly sensitive data markets, and maintain resiliency of critical networks.

For Home IoT, WPA3 gives increased protection from password guessing attempts — an important upgrade given the threats emerging around IoT devices. It also allows users to choose passwords that are easier to remember,

which, given the input and display constraints for many Home IoT devices or even smartphones used for companion apps, provides a better user experience.

Additional Wi-Fi capabilities

In addition to the core Wi-Fi connectivity generations, Wi-Fi 7, Wi-Fi 6, and Wi-Fi 4, plus the IoT-centric Wi-Fi HaLow, there is also a growing portfolio of Wi-Fi capabilities directly relevant to Home IoT developers. The Wi-Fi CERTIFIED portfolio includes certifications that can improve lifecycle management functions (such as IoT device onboarding) and help service providers manage and monitor the home Wi-Fi environment on behalf of their customers. Wi-Fi QoS Management™, for example, enables the network to prioritize traffic to ensure a positive experience with demanding applications including lower latency, reduced lag time, and prevention of outages to deliver consistent end-to-end QoS. uses a standards-based approach to create Wi-Fi networks with multiple APs suitable for whole-home coverage, including outdoor spaces, giving users greater flexibility in device choice through interoperable products. And when consumers need to know where their devices are, allows devices to know their indoor location with sub-meter-level accuracy using only Wi-Fi, while also ensuring the privacy of data on a station device. When attempting to design for reduced power consumption, Wi-Fi devices may also be tested and certified for power saving features.

Conclusion

Wi-Fi Alliance offers several certification programs that help enable different use cases, services, and applications. Wi-Fi CERTIFIED testing and certification is one of the most effective ways to optimize Home IoT device performance because IoT is so dependent on both Wi-Fi and interoperability. Homeowners and renters purchase devices with the expectation that they have been evaluated according to the highest standard available. When it comes to connectivity, reliability, and security, there is no standard more stringent yet easy to attain than Wi-Fi CERTIFIED.

While all the certifications listed here can effectively enable and enhance a device's Home IoT capabilities, the most exciting and monumental shift comes from the expansion into the 6 GHz band in Wi-Fi 6 and Wi-Fi 7, and the sub-1 GHz band with the low power, long-range capabilities offered through Wi-Fi HaLow. Because the world is only producing more and more data at faster and faster speeds, with no end in sight, it is a dramatic improvement to have more spectrum allocated for Wi-Fi, given its utmost importance to the connected society.

About Wi-Fi Alliance®

www.wi-fi.org
Wi-Fi Alliance® is the worldwide network of companies that brings you Wi-Fi®. Members of our collaboration forum come together from across the Wi-Fi ecosystem with the shared vision to connect everyone and everything, everywhere, while providing the best possible user experience. Since 2000, Wi-Fi Alliance has completed more than 80,000 Wi-Fi certifications. The Wi-Fi CERTIFIED® seal of approval designates products with proven interoperability, backward compatibility, and the highest industry-standard security protections in place. Today, Wi-Fi carries more than half of the internet's traffic in an ever-expanding variety of applications. Wi-Fi Alliance continues to drive the adoption and evolution of Wi-Fi, which billions of people rely on every day.

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