Wi-Fi CERTIFIED™ Voice-Enterprise

Delivering Wi-Fi® voice to the enterprise

Wi-Fi Alliance®
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Executive summary

The proliferation of Wi-Fi networks, along with voice over internet protocol (VoIP) technologies, has fueled explosive growth in the number and variety of voice-enabled handheld devices. As proponents of this growth, the Wi-Fi Alliance has taken the leadership role by creating certification programs for voice over Wi-Fi that meets both the interoperability and performance requirements necessary for an acceptable end-user experience.

The Wi-Fi CERTIFIED Voice-Enterprise program defines the requirements necessary to deliver enterprise-grade voice quality, mobility, power saving and security. The certification program facilitates multi-vendor solutions across a range of Wi-Fi-enabled devices with enterprise-class WLAN infrastructure. The Wi-Fi Voice-Enterprise program establishes industry-wide interoperability, enterprise-grade performance, and security requirements. Products must meet rigorous protocol adherence and performance metric testing to achieve Wi-Fi Voice-Enterprise certification.

Wi-Fi CERTIFIED™ Voice-Enterprise program benefits
Wi-Fi Voice-Enterprise certified access points (APs) give priority to voice packets over data packets, optimizing performance in mixed traffic environments where data, voice and video traffic coexist.
Test measurement of real-time performance parameters for voice applications—such as latency, jitter, and packet loss—ensure the priority for voice is performing correctly, even in wireless local area networks (WLAN) with a heavy data traffic load.
Voice connectivity is preserved as the user moves within the enterprise network, with seamless mobility from one access point to the next.
Multi-vendor interoperability allows APs and mobile devices to be combined to meet a variety of IT manager's needs.
WPA2™ advanced security protections help ensure integrity of communication.

The Wi-Fi Voice-Enterprise certification program is the latest addition in a series of certification programs that have extended the functionality of Wi-Fi to provide full support for voice applications in enterprise environments. With the Wi-Fi Voice-Personal certification program as a foundation, Wi-Fi Voice-Enterprise certification testing adds support for mobility within large Wi-Fi networks. It leverages the Wi-Fi Multimedia™ (WMM®), WMM-Power Save, and WMM-Admission Control certification programs for quality of service (QoS) and the advanced security provided by Wi-Fi Protected Access® 2 (WPA2) Enterprise.

With Wi-Fi Voice-Enterprise devices and access points, IT managers can be confident that multi-vendor solutions will deliver good voice performance even in the most complex Wi-Fi networks.

Background

VoIP has become mainstream technology that users expect on Wi-Fi networks. Multiple factors have driven the increase in adoption of voice over Wi-Fi applications, including:

- Proliferation of voice-capable handheld devices with cellular and Wi-Fi radios
- Expanded voice-capabilities in data-centric devices like laptop and desktop PCs
- Increased use of VoIP and unified communications, making the transition to mobile devices increasingly seamless in terms of features and functionality
- Optimized bandwidth in Wi-Fi CERTIFIED n networks, enabling a higher number of devices to share a network

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Voice over Wi-Fi in general has proliferated, bringing new opportunities and challenges. IT managers are asked to support voice over Wi-Fi in an increasing variety of client devices, to integrate them within their end-to-end enterprise network, and meet enterprise-grade requirements for performance and security. Employees also want the flexibility to use most of their Wi-Fi devices for voice, regardless of where they are—in the office, at home, or on the road.

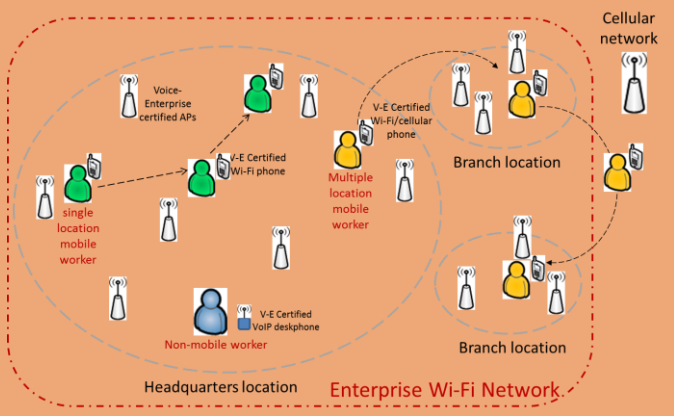
The Wi-Fi CERTIFIED Voice-Enterprise program establishes interoperability across vendors and common performance requirements for enterprise-grade voice-capable Wi-Fi equipment. The new certification program was developed based on existing Wi-Fi Alliance certification programs including WMM, WMM-Power Save, and WMM-Admission Control and WPA2-Enteprise, then adds applicable features from Institute of Electrical and Electronics Engineers (IEEE) standards for radio resource measurement, fast basic service set (BSS) transition, and wireless network management, to provide a solid foundation for industry-wide interoperability and enterprise-grade performance.

The introduction of the Wi-Fi Voice-Enterprise program furthers the commitment of the Wi-Fi Alliance to enable a high-quality voice experience using Wi-Fi technology. It follows the 2008 introduction of the Wi-Fi CERTIFIED Voice-Personal program, which established core requirements to support voice applications, with a focus on single AP Wi-Fi networks prevalent in homes and small businesses. The Wi-Fi Voice-Enterprise program was designed to meet the additional requirements of enterprise networks that are larger in size, require support for advanced WPA2-Enterprise security mechanisms, support fast transitions between APs and provide for voice applications.

This white paper outlines usage models that the Wi-Fi Voice-Enterprise certification program addresses. It also provides a technical overview of the certification program, its key functionality and relationship to other certification programs.

Enterprise usage models

Wi-Fi technology can be used in voice-capable devices by users in a variety of scenarios. Three common usage models show how the technology can be used in an enterprise environment.



Multiple-location mobile worker (yellow figures)

The device of choice for multiple-location mobile workers is typically a Wi-Fi/cellular dual-mode smartphone. While connected to the company's Wi-Fi network the worker has access to enterprise voice applications and the unified communication system. When they are out of the Wi-Fi coverage area, they can make calls using their selected carrier's cellular network.

Single-location mobile worker (green figures)

Nurses, teachers, hotel catering staff, retail clerks, and manufacturing technicians spend most of their working day at the company's work site, but away from a desk. Because in most cases their work takes place at a single location, these employees use a Wi-Fi handset optimized for voice applications. The employees have full access to the enterprise voice network and the IT department has complete control of device usage.

Non-mobile employee (blue figure)

Voice over Wi-Fi is also an attractive solution for many non-mobile employees. Untethered devices lead to easier and faster deployment, cost savings in cabling, and simplified configuration of the workspace. Call center agents, for example, can take a Wi-Fi desk phone, a softphone application on a laptop, or a handheld device to the desk they have been assigned for the day.

Market overview: Driving growth for voice over Wi-Fi in the enterprise

As enterprises have increasingly deployed Wi-Fi networks for data applications, IT managers have begun to look at how voice over Wi-Fi could not only lower their cellular and wireline telecommunications bills, but also increase employee effectiveness, flexibility, and satisfaction. As the demand grows for anytime, anywhere connectivity, enterprise IT managers are rapidly adopting or expanding support for voice over Wi-Fi within their offices, campuses, retail stores and warehouses.

IEEE 802.11 was originally designed for best-effort traffic such as email, internet browsing, or large file downloads. Unlike best-effort data applications on an internet protocol (IP) network, voice has to meet tight latency, jitter, and packet loss requirements to provide a good user experience. When this is accomplished, the voice quality in a Wi-Fi network is comparable to that of a fixed, cellular, or cordless voice network. To ensure that the required network resources were available to voice applications, vendors previously developed proprietary mechanisms that could support good voice quality in mixed-use data and voice WLANs.

The Wi-Fi Voice-Enterprise program enables the growing range of voice-capable devices to consistently meet enterprise requirements and provide a positive user experience. The program provides a solution that is secure, reliable, and manageable for IT managers when both the client devices and APs are Wi-Fi CERTIFIED.

It is important to recognize that the Wi-Fi Voice-Enterprise program is focused on the device-to-AP interface. End-to-end voice quality is affected by multiple factors across different network elements. The Wi-Fi Voice-Enterprise program optimizes the Wi-Fi link, but it does not provide a remedy if voice quality is compromised elsewhere in the end-to-end network.

Enterprise-grade voice requirements

Running voice applications in heavily-used data networks can be challenging. To achieve consistently high voice quality, stringent requirements must be met, and therefore, voice traffic must to be handled differently from data traffic.

Effective enterprise-grade voice over Wi-Fi solutions must address the following requirements:

1. **Voice quality.** Voice quality has to be consistently good throughout the call, in all load conditions. To ensure that client devices maintain good voice quality, latency, jitter and packet loss have to be consistently low.
2. **Data traffic coexistence.** In most enterprises, the Wi-Fi network will be used for both voice and data applications. As a result, voice calls must coexist and share network resources with data traffic, which often accounts for the largest portion of the network load.

To meet these two requirements, the following features are required:

- **Prioritization.** AP and client devices are required to support WMM, which enable the AP to recognize and prioritize voice traffic over "video and best effort" traffic, such as internet browsing, email reading, or large file downloads. The QoS functionality supported by WMM enables APs and client devices to manage different traffic types (i.e., voice, video, or data) depending on their characteristics and requirements. When using WMM, the AP puts voice packets in the highest-priority queue, namely Access Category Voice (AC_VO).
- **Bandwidth management.** Real-time availability of AP resources has to be known in order to determine if sufficient resources are available to admit a new voice call at the required performance level. WMM-Admission Control optimizes traffic management by admitting only those traffic streams that an AP can support at a given time. WMM-Admission Control also enables load balancing, supplying a consistent experience to connected users.
- **Seamless transitions across the Wi-Fi network.** A voice call has to be maintained as the user moves across areas in the Wi-Fi network that are covered by different APs. IEEE standards for radio resource measurement, fast BSS transition, and wireless network management bring essential functionality to the Wi-Fi Voice-Enterprise certification program to optimize voice applications, by allowing fast AP handoffs (known as BSS transitions), and by managing radio network resources effectively.
- **Security.** The solution must accommodate the WPA2-Enterprise security mechanisms that protect against intrusion and unauthorized usage.
- **Battery life.** APs must support power save mechanism WMM-Power Save, which optimizes power consumption to extend the battery life of handheld devices. Support of WMM-Power Save is optional for client devices.

The Wi-Fi Voice-Enterprise certification program

The Wi-Fi Voice-Enterprise certification program is intended for APs and endpoints used in enterprise networks that cover facilities such as office buildings, campuses, hospitals, warehouses, or manufacturing sites. All Wi-Fi CERTIFIED products can be submitted for certification under the Wi-Fi Voice-Enterprise program.

Both the AP and client device must have Wi-Fi Voice-Enterprise certification to ensure operation in a manner that meets Wi-Fi Alliance requirements. A certified client device associated to an AP that lacks this certification may support voice over Wi-Fi, but the performance has not been tested to meet Wi-Fi Voice-Enterprise standards.

Enterprise networks that intend to support voice over Wi-Fi should select both client devices and APs that are Wi-Fi CERTIFIED Voice-Enterprise.

Protocol adherence testing

Protocol testing ensures that WLAN infrastructure and endpoint end-user devices operate as expected in a multi-vendor Wi-Fi CERTIFIED network. Protocol adherence testing specific to Wi-Fi Voice-Enterprise certification includes the following, which are described in detail below:

- **Radio resource measurement:** 802.11k elements, mandatory for AP and client devices
- **Fast BSS transition:** 802.11r elements, mandatory for AP and client devices
- **Wireless network management:** 802.11v BSS Transition Management, optional for APs and client devices

Performance metric testing

Performance metric testing verifies that the Wi-Fi devices on each end of the link can provide good voice quality. Performance is measured under simulated, but realistic, network conditions. Performance of equipment submitted for Wi-Fi Voice-Enterprise certification has to meet the following thresholds to ensure that the Wi-Fi network preserves good voice call quality (with commonly used voice codecs):

- **Latency** (including during BSS fast transitions)**:** one-way delay <50 ms
- **Jitter**: <50 ms
- **Packet loss**: <1%
- **Consecutive lost packets:** no more than three

Performance testing is conducted in a simulated network environment, with four (802.11b) or ten (802.11a/g/n) concurrent voice calls, a high speed video stream, and sustained data traffic loads, designed to represent a fully loaded network. Two types of voice streams are tested, the equivalent of G.711 and G.729 codecs.

Performance testing and mobility

Certification testing includes transition within and between mobility domains. A mobility domain includes a group of APs with the same functionality from a single vendor. Enterprise Wi-Fi networks may have multiple mobility domains, including those using APs from different vendors.

As the user moves within a mobility domain, the voice connection is maintained. The Wi-Fi device continuously scans the environment and associates itself with the AP that provides the best link, using a BSS fast transition (Figure 1) that results in no noticeable audio gaps. When moving between from different vendors' mobility domains (Figure 2), the voice call is still maintained, but the user may in some cases notice a short delay as the mobile device makes a BSS transition to an AP in the second mobility domain. Typically, enterprises deploy Wi-Fi using a single mobility domain.

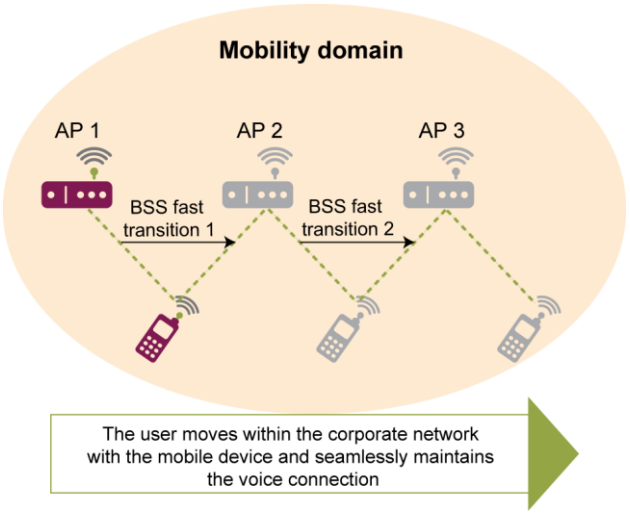


Figure 1. BSS fast transitions as a Wi-Fi device moves within a mobility domain

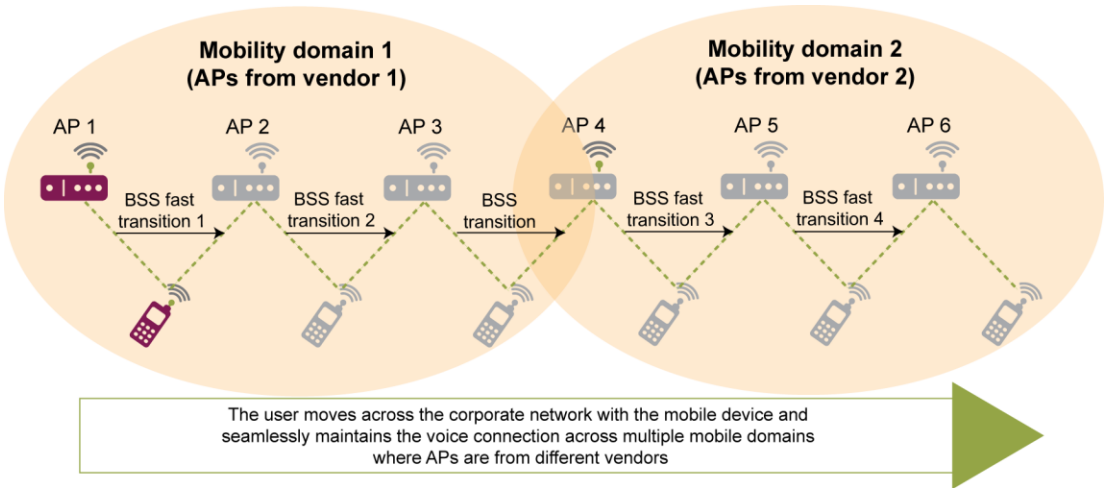


Figure 2: BSS transitions between multi-vendor mobility domains

A two-tier approach is used to test BSS transitions:

- **BSS transition within the same mobility domain.** The APs within the mobility domain are from the same vendor and support the same functionality. BSS fast transitions are supported in this environment, as the client device changes its association from one AP to another. In this test case, the communication break has to be <50 ms.
- **BSS transition between multi-vendor mobility domains.** This test case tests a BSS transition across APs from different vendors. In this case, a BSS fast transition is not mandated, because typically the client device requires an 802.1X re-authentication after associating with a new AP. Voice applications are still supported when the device moves to an AP in a new mobility domain, but the transition may introduce a short delay that is noticeable by the user.

Certification dependencies

Wi-Fi Voice-Enterprise certification testing leverages functionality provided by other certification programs of the Wi-Fi Alliance. To receive Wi-Fi Voice-Enterprise certification, equipment has to meet these prerequisites:

- **Baseline certification** for the physical (PHY) layer—namely, 802.11a, b, g, or n. Wi-Fi Voice-Enterprise certification is PHY independent and any combination of PHY interfaces is allowed.
- **Security certification** through WPA2-Enterprise with support for WPA2 supplicants, Remote Authentication Dial In User Service (RADIUS) authentication servers, and a variety of Extensible Authentication Protocol (EAP) methods.
- **QoS and bandwidth management** through WMM and WMM-Admission Control. WMM is required by the Wi-Fi Voice-Enterprise certification testing to identify voice traffic and assign it a higher priority than other data traffic. WMM-Admission Control further enhances WMM by providing bandwidth management tools. With WMM-Admission Control, the Wi-Fi network is capable of maintaining consistently high performance levels for all the connected client devices, and admits only traffic streams that can be supported by the AP.
- **Power conservation for mobile devices** – WMM-Power Save is mandatory for APs, in order to support any WMM-Power Save device connected to them. However, it is an optional feature for client devices, in order to accommodate client devices that do not require advanced power management, such as non-mobile phones.

A detailed description of these certification programs and the features they bring to Wi-Fi equipment can be found in white papers available from the Wi-Fi Alliance.

Protocol requirements specific to Wi-Fi Voice-Enterprise

Radio resource measurement

In Wi-Fi networks, client devices identify available APs, and usually connect to the AP with the strongest signal. In some cases, the location of devices leads to an uneven distribution of traffic, resulting in underutilization of some access points and congestion on others. To prevent this, features in 802.11k enable client devices to take into account both signal strength and real-time resource availability when choosing an AP to be associated with. This may result in a client device being connected to an AP that does not have the strongest link, but that nevertheless provides the best performance because they carry less traffic. Within the Wi-Fi Voice-Enterprise program, the ability of the endpoint to select the best-performing AP is crucial to managing BSS transitions effectively.

The Wi-Fi Voice-Enterprise program requires that the following features of 802.11k be supported by the AP and client device:

- Neighbor reports provide information on BSS availability to the client device, reducing the time needed for client devices to discover APs.
- Radio measurements from client devices provide information to the APs to generate and update the neighbor report. They include the following:
    - Transmit Power Control (TPC) information enables the client device to calculate the link budget prior to association.
    - Power capability elements allow the client device to compute range data as part of the monitoring of neighboring APs during an active call.
    - QoS metrics provide troubleshooting data.
    - Client device statistic measurements include voice diagnostics and management for QoS.
    - Power constraint element (2.4 GHz and 5 GHz) provides information that reduces co-channel interference.
    - Quiet-time announcement (2.4 GHz and 5 GHz) permits the collection of measurements for diagnostics and troubleshooting.
- Beacon report gathers information from client devices that the AP uses to generate and update the neighbor report.
- 802.11e QoS Basic Service Set (QBSS) Load provides data that is used to choose the AP that provides the best performance and for troubleshooting by the enterprise network manager.

Fast BSS transitions

802.11r makes the transition from one AP to another faster when WPA2-Enterprise is used. As the network environment changes or the client device moves, the client device may need to associate with another AP. Prior to 802.11r,the new AP association requires a new 802.1X authentication and, if WMM-Admission Control is enabled, additional messaging for the AP to grant the admission request to the client device.

802.11r accelerates the association process, provided that the new AP is within the same mobility domain (Figure 1). 802.11r achieves this goal by allowing APs and client devices to re-use an

802.1x derived security key across APs and, therefore, enables a new security association to be established without a complete 802.1X/EAP authentication process.

BSS Transition Management

Support for 802.11v BSS Transition Management is optional for AP and client devices. It builds on 802.11k capabilities to improve the management of AP handoffs, and to leverage the information about network resources that is exchanged between the AP and the client devices.

The Wi-Fi Voice-Enterprise program uses an 802.11v feature to enable an AP to send a client device a recommendation that it move to another AP. The recommendation is based on information about the network topology and network load, and, if available, on preferences set by the Wi-Fi network administrator. The client device is still responsible for deciding whether to move to the new AP, but the recommendation from the first AP can streamline and improve the assessment of available APs. This is particularly valuable in a scenario in which the client device continuously moves within the network, because minimizing the time required for the client device to assess its network environment can lead to an improvement in performance.

Wi-Fi CERTIFIED Voice-Enterprise Certificate of Interoperability

Equipment that is Wi-Fi CERTIFIED Voice-Enterprise receives a Certificate of Interoperability that lists Wi-Fi Voice-Enterprise under the Convergence category. The Certificate of Interoperability assists enterprise and residential users in determining whether the equipment supports the functionality they need and in making their purchasing decisions.

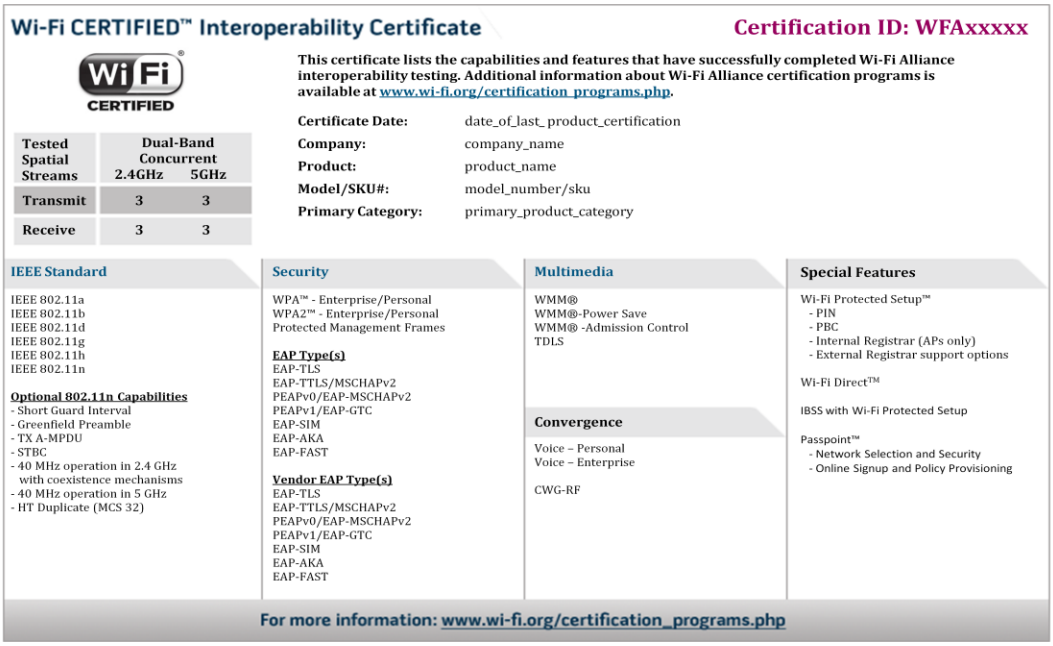


Figure 3. Wi-Fi CERTIFIED Interoperability Certificate

Summary

The Wi-Fi CERTIFIED Voice-Enterprise program from the Wi-Fi Alliance supports enterprise-grade voice over Wi-Fi applications. It does so by leveraging functionality provided by other certification programs, including WPA2-Enterprise for security, WMM for QoS, WMM-Admission Control, and WMM-Power Save. The Wi-Fi Voice-Enterprise certification relies on features of more recently approved 802.11 amendments, including radio resource measurement, fast BSS transition, and wireless network management. A network that includes both AP and client devices that are Wi-Fi CERTIFIED Voice-Enterprise gives enterprise customers consistently good voice quality without compromising security.

Wi-Fi Voice-Enterprise products operate within demanding enterprise environments, typically coexisting with heavy data traffic. Users need the flexibility to use a wide range of client devices and move freely within the enterprise network, and advanced voice applications must be integrated within the end-to-end enterprise network. Wi-Fi Voice-Enterprise equipment delivers the interoperability, performance, and security that enterprise customers require.

About the Wi-Fi Alliance

The Wi-Fi Alliance is a global non-profit industry association of hundreds of leading companies devoted to seamless connectivity. With technology development, market building, and regulatory programs, the Wi-Fi Alliance has enabled widespread adoption of Wi-Fi worldwide.

The Wi-Fi CERTIFIED™ program was launched in March 2000. It provides a widely-recognized designation of interoperability and quality and it helps to ensure that Wi-Fi-enabled products deliver the best user experience. The Wi-Fi Alliance has completed more than 13,000 product certifications, encouraging the expanded use of Wi-Fi products and services in new and established markets.

Acronyms

AC_VO	Access Category Voice
AP	Access Point
BSS	Basic Service Set
EAP	Extensible Authentication Protocol
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
PHY	Physical [layer]
QBSS	QoS Basic Service Set
QoS	Quality of Service
RADIUS	Remote Authentication Dial-In User Service
RF	Radio Frequency
SSID	Service Set Identifier
WLAN	Wireless Local Area Network
WMM®	Wireless Multimedia™
WPA2™	Wi-Fi Protected Access® 2