

**Wi-Fi CERTIFIED™ Voice-Personal:
Delivering the Best End-User Experience
for Voice over Wi-Fi**

**Wi-Fi Alliance®
June 2008**



Executive Summary

Voice over Wi-Fi allows users to make and receive voice calls over their Wi-Fi networks. It is rapidly gaining popularity as voice over internet protocol (VoIP) gains popularity and as more voice-capable devices, such as dual-mode phones with cellular and Wi-Fi technology, become widely available. Growth in the widespread use of voice over Wi-Fi in the consumer market is expected to accelerate over the next few years, driven by the forthcoming availability of Wi-Fi CERTIFIED™ equipment that supports good voice quality.

A program developed by the Wi-Fi Alliance, named Wi-Fi CERTIFIED Voice-Personal, will strengthen support for voice applications in Wi-Fi equipment. With certifications awarded to more than 170 phones for baseline interoperability and security, the Wi-Fi Alliance is seeing an increased need to address voice and multimedia applications across a wide range of product types. The Wi-Fi CERTIFIED Voice-Personal program includes performance testing focused on the unique characteristics of voice. The new certification program is a key step in the Alliance's efforts to further enhance the Wi-Fi user experience.

The Wi-Fi CERTIFIED Voice-Personal program demonstrates that Wi-Fi has evolved to meet the specific requirements of voice applications, while providing the same great experience that users are accustomed to from Wi-Fi data applications. It tests the performance of voice applications in network configurations that are common in home and small office environments. To achieve certification, client devices and access points must perform below set thresholds for packet loss, latency, jitter and call capacity while maintaining good voice quality.

Products that have undergone the certification offer users, manufacturers, operators and application developers additional confidence that Wi-Fi CERTIFIED Voice-Personal products will support an improved and consistent experience of voice quality performance, while preserving interoperability with existing Wi-Fi CERTIFIED equipment. To take advantage of the enhanced support for voice applications, both the client device and the access point must be Wi-Fi CERTIFIED Voice-Personal. Users can still use voice over Wi-Fi applications in devices that are not Wi-Fi CERTIFIED Voice-Personal, but in this case the user cannot be as confident about the voice performance.

Wi-Fi CERTIFIED Voice-Personal is an optional program open to Wi-Fi Alliance members with client devices or access points that have already been Wi-Fi CERTIFIED for 802.11a, 802.11b, or 802.11g; Wi-Fi Protected Access™ 2-Personal (WPA2™); Wi-Fi Multimedia™ (WMM®); and, WMM Power Save (required for access points, optional for client devices).

Wi-Fi CERTIFIED products have undergone rigorous tests for interoperability, security and Quality of Service that are defined by the Wi-Fi Alliance and executed by independent Authorized Test Laboratories.

To address the additional features necessary for multiple access point-networks common in large enterprises and campus-wide networks, the Wi-Fi Alliance plans to expand its support for voice applications in 2009 with a Wi-Fi CERTIFIED Voice-Enterprise program. This program will enhance support for voice applications in higher-density networks, where voice users can roam across multiple access points while maintaining high voice quality and enterprise-class security.

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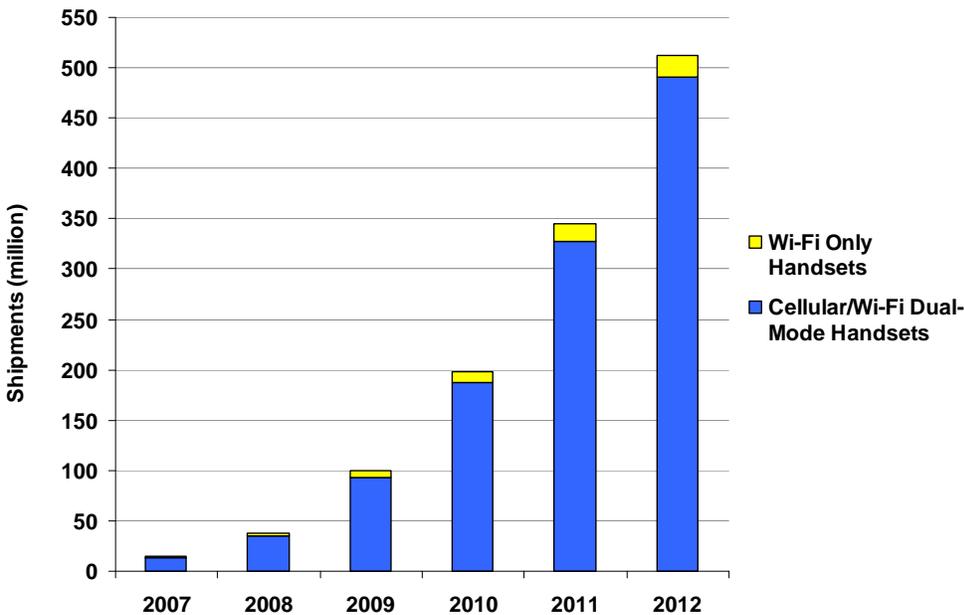
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Introduction

With half a billion estimated users worldwide, Wi-Fi has quickly moved beyond its beginnings as a data-centric technology for PCs and has evolved into a wireless technology that supports a wide range of devices and applications. A few more than 300 million Wi-Fi chipsets were shipped in 2007. Annual chipset shipments are expected to reach one billion by 2011¹. The most exciting new trend in the market is the increased availability and adoption of Wi-Fi in mobile phones, gaming devices, printers, cameras, TVs, audio players, and other consumer electronics devices.

At the same time, the growing popularity of Voice over Internet Protocol (VoIP) solutions, such as those offered by Vonage™ and Skype™, has increased demand for client devices that can support these voice-based applications in the home and small office. Users require the same level of performance and quality from VoIP applications to which they have become accustomed with traditional voice devices and applications. These expectations can be a challenging since voice applications are highly sensitive to latency, jitter and packet loss and must coexist with bandwidth-intensive data applications in the same network.

Users have embraced Wi-Fi for delivering wireless data and expect this positive experience to extend to voice applications. More than 500 million Wi-Fi enabled handsets are predicted to be sold in 2012² driven by the inherent flexibility and performance of Wi-Fi combined with the increased popularity of VoIP applications.



¹ ABI Research, 2007 NBED

² ABI Research, 2007 NBED

Figure 1. Embedded Wi-Fi handset shipments by category. Source: ABI Research

A 2007 study³ by ABI Research of more than 1,200 U.S. wireless subscribers found that one in four respondents would switch mobile carriers if offered a Wi-Fi/cellular converged service. Further evidence of user-driven demand for Wi-Fi handsets comes from an In-Stat survey⁴ of U.S. early adopters which showed that almost half of the respondents who plan to replace their mobile phones want to have Wi-Fi capabilities in their new handsets.

Over the last few years, manufacturers have expanded and enhanced voice functionality in their new Wi-Fi-enabled devices to meet user demand and to accelerate the growth of the market for voice over Wi-Fi. There are already more than 150 Wi-Fi-only and dual-mode Wi-Fi/cellular phones that are Wi-Fi CERTIFIED for baseline Wi-Fi interoperability and security and many other Wi-Fi CERTIFIED devices (including notebook computers) that support voice applications. In addition, certification programs for WMM and WMM-Power Save have introduced advanced Quality of Service (QoS) features that have improved the voice capability of Wi-Fi networks.

The Wi-Fi Alliance is now taking a further step in helping to ensure good voice quality in Wi-Fi CERTIFIED equipment by introducing the Wi-Fi CERTIFIED Voice-Personal program. The program addresses the specific requirements of voice applications in home and small office environments, requiring client devices and access points to meet the appropriate performance levels for packet loss, latency and jitter to at ensure good voice quality. The Wi-Fi CERTIFIED Voice-Personal program helps users identify handsets and access points with this certified level of performance.

Voice is a compelling application for many users with a home or small office Wi-Fi network, for several reasons:

- **Voice-capable devices.** Wi-Fi technology offers users a wide choice of devices with support for voice applications, which includes, but is not limited to, mobile phones. Laptop computers have been among the first devices to support voice over Wi-Fi, but the number of single- and dual-mode (Wi-Fi and cellular) phones is growing rapidly, offering users wire-free VoIP. Other consumer electronics devices will also increasingly support voice functionality.
- **Convenience.** Voice over Wi-Fi operates within an affordable, trusted network that users know how to manage. Wi-Fi equipment is easy to set up and can be used by a wide array of devices throughout the home or office (e.g. phones, laptops, game consoles, printers, etc.).
- **Good voice quality.** The Wi-Fi CERTIFIED Voice-Personal testing of devices and access points supports the delivery of good voice quality within a Wi-Fi network that is shared by multiple devices (e.g. phones, laptops, game consoles and printers).
- **Cost savings.** Voice over Wi-Fi widens the choice of services available to users through their current or a new service provider, which can result in cost savings.

³ ABI Research, 2007. See http://www.wi-fi.org/pressroom_overview.php?newsid=507

⁴ In-Stat, 2007.

The remainder of this white paper provides background on the Wi-Fi Alliance and existing certification programs, and provides details of the Wi-Fi Alliance's Wi-Fi CERTIFIED Voice-Personal program.

What is Wi-Fi CERTIFIED™?

The Wi-Fi CERTIFIED programs are developed and managed by the Wi-Fi Alliance, a non-profit international trade association representing the entire Wi-Fi ecosystem with a membership exceeding 300 companies in more than 20 countries.

From the launch of the program in 2000 until June 2008, more than 4,500 products achieved Wi-Fi CERTIFIED designation from testing conducted in one of 12 independent Authorized Test Laboratories worldwide. Wi-Fi CERTIFIED programs cover basic connectivity, security, authentication and Quality of Service (QoS), bringing interoperability between different manufacturers' products and a great user experience. In addition, the certification programs test for backward compatibility with Wi-Fi CERTIFIED products already in the market, helping to ensure that the latest generation of client devices and access points will work with previously purchased Wi-Fi equipment in the same network.

Products bearing the Wi-Fi CERTIFIED logo benefit from carrying a recognized mark of interoperability that has been a key driver of the adoption of Wi-Fi by both consumer and enterprise users. In a U.S. survey⁵, 88% of respondents indicated they would be more likely to buy a Wi-Fi product that had been tested and certified by an independent third party such as the Wi-Fi Alliance. Moreover, in a recent brand awareness study⁶, 70% of U.S. respondents and 68% of United Kingdom respondents were aware of Wi-Fi CERTIFIED as an indicator of interoperability, reliability and product quality.

Users can easily identify Wi-Fi CERTIFIED equipment by locating the Wi-Fi CERTIFIED logo (Figure 2) on the product packaging, which includes information about the baseline certification received. Choosing a product that is Wi-Fi CERTIFIED helps to ensure the best user experience, a wide choice of interoperable brands, and the confidence that security protections are in place.



Figure 2. Wi-Fi CERTIFIED logo

Each Wi-Fi CERTIFIED device or access point has a corresponding Interoperability Certificate (Figure 3) that provides detailed information about the product's Wi-Fi certifications. These certificates are available on the Wi-Fi Alliance web site and may also be included with product documentation.

⁵ Kelton Research and Wi-Fi Alliance, 2006

⁶ Survey conducted for the Wi-Fi Alliance by Alliance/Millward Brown, July 2007.

Wi-Fi® Interoperability Certificate
Certification ID: WFAxxxx



This certificate indicates the capabilities and features that successfully completed interoperability testing by the Wi-Fi Alliance. You may find detailed descriptions of these features at www.wi-fi.org/certification_programs.php.

Certificate Date: date_of_product_certification
Category: primary_product_category
Company: company_name
Product: product_name
Model/SKU #: model_number/sku

This product has the following Wi-Fi Certifications:

IEEE Standard	Security	Multimedia	Convergence
IEEE 802.11a IEEE 802.11b IEEE 802.11g IEEE 802.11n draft 2.0 IEEE 802.11d IEEE 802.11h	WPA™ - Enterprise, Personal WPA2™ - Enterprise, Personal EAP Type(s) EAP-TLS EAP-TTLS/MSCHAPv2 PEAPv0/EAP-MSCHAPv2 PEAPv1/EAP-GTC EAP-SIM Vendor EAP Type(s) EAP-TLS EAP-TTLS/MSCHAPv2 PEAPv0/EAP-MSCHAPv2 PEAPv1/EAP-GTC EAP-SIM	WMM © WMM Power Save <div style="background-color: #cccccc; padding: 2px;">Special Features</div> Wi-Fi Protected Setup™ PIN PBC NFC	Voice – Personal CWG-RF Profile (contact manufacturer for results)

For more information: www.wi-fi.org/certification_programs.php

Figure 3. Wi-Fi Interoperability Certificate

Wi-Fi CERTIFIED programs are constantly evolving to support and accelerate new technology and market developments, as well as to encourage the emergence of new devices and applications. The Wi-Fi Alliance recognizes the need to go beyond protocol adherence and interoperability by introducing performance-based testing to help to ensure that the same high level of user experience is preserved across devices and applications.

All Wi-Fi CERTIFIED products receive certification under mandatory programs that cover basic functionality, such as IEEE 802.11 baseline interoperability and security. In addition, the Wi-Fi Alliance offers optional certification programs focused on the specific functionality only required by selected devices or applications. Table 1 includes a list of the existing certification programs currently offered by the Wi-Fi Alliance.

Certification programs	Category	Functionality
802.11a,b, or g	IEEE 802.11 baseline	The baseline program certifies 802.11a, b and/or g interoperability to ensure that the essential wireless data transmission works as expected. 802.11b and g utilize spectrum in the 2.4 GHz band. 802.11g has a higher data rate (54 Mbps) than 802.11b (11 Mbps). 802.11a utilizes spectrum in the 5 GHz band and has a maximum data rate of 54 Mbps. Each certified product is required to support one spectrum band as a minimum, but it can support both.
Wi-Fi Protected Access 2 (WPA2)	Security	Provides strong security mechanisms. Two versions of WPA2 exist: WPA2-Personal for residential or latency-sensitive applications, and WPA2-Enterprise for corporate networks. Each certified product is required to support Personal or Enterprise WPA2.
802.11n draft 2.0	IEEE 802.11 baseline	802.11n utilizes MIMO (Multiple-Input Multiple-Output) technology to provide dramatically improved throughput and range, and to support an even wider array of applications.
Wi-Fi Multimedia (WMM)	Multimedia	WMM enables Wi-Fi networks to prioritize traffic generated by different applications. In a network where WMM is supported by both the access point and the client device, traffic generated by voice and multimedia client applications (sensitive to small delays) is prioritized over data traffic such as email or Internet surfing. WMM is required for 802.11n draft 2.0 certification.
WMM Power Save	Multimedia	WMM Power Save helps conserve power for battery-operated devices by increasing the time the client device spends in sleep mode. Recent tests indicate a 30-60% reduction of the power usage in handheld devices using WMM Power Save, depending on the level of activity. To take advantage of power saving capabilities, both the device and the access point must support WMM Power Save.
Wi-Fi Protected Setup™	Security	Wi-Fi Protected Setup facilitates the configuration of protected home and small business networks using WPA and WPA2 mechanisms. Users can easily configure a network with security protection by using a Personal Identification Number (PIN) or a button located on the access point and the client device. In either case, the user is not required to have any knowledge of the underlying security mechanisms used.
Converged Wireless Group—RF Profile (CWG-RF)	Multimedia	Developed jointly between the Wi-Fi Alliance and the Cellular Telecommunications and Internet Association (CTIA), CWG-RF tests devices with both Wi-Fi and cellular radios to help to ensure that each performs well in the presence of the other. All CTIA-certified handsets now include this certification.
Voice-Personal	Application	The most recently introduced Wi-Fi CERTIFIED program offers enhanced support for voice applications in residential and small business Wi-Fi networks that include one access point, mixed voice and data traffic from multiple devices (such as phones, PCs, printers and consumer electronic devices), and support for up to four concurrent phone calls. Both the access point and the client device must be certified for the client device to deliver performance matching certification metrics.

Table 1. Overview of available Wi-Fi Alliance certification programs (mandatory programs are shaded in gray).

Why a Certification Program for Voice Applications?

VoIP has greatly expanded the range of voice services and devices from which users can choose. Voice services are no longer restricted to the wireline circuit-switched or cellular networks that were traditionally designed to transport voice traffic. Today, virtually any IP-based broadband connection can support voice, but the quality of the voice call is affected by the performance characteristics of the network.

Voice is an application that has unique requirements due to its high sensitivity to network delays. In particular, voice calls are extremely sensitive to latency, jitter and packet loss during transmission. By comparison, applications such as downloading a large file or Internet browsing typically require more bandwidth, but are much more flexible in accommodating high latency, high jitter and packet loss. Perceived performance in these data applications degrades gradually (i.e. a slow file download). In contrast, voice conversations simply cannot continue if the values for these key metrics are too high, as they may become too distorted to understand or inaudible. Wi-Fi devices delivering voice services must meet application-specific requirements to provide a good user experience across all applications.

In the home and small office, voice over Wi-Fi is typically used within a shared network, in which multiple data streams compete for the available network resources. For instance, a single Wi-Fi network may simultaneously support phones, laptops, gaming devices and printers, with each device transmitting data, audio, voice, video or some combination of these traffic types. To optimize the overall network performance while providing consistent support for voice applications, voice traffic has to be prioritized over data, audio, or video traffic.

The Wi-Fi CERTIFIED Voice-Personal Certification Program

Wi-Fi CERTIFIED Voice-Personal devices enable users to consistently make high-quality voice calls with the same convenience they expect from VoIP and data over Wi-Fi applications. Using voice over Wi-Fi can be as simple as turning on a Wi-Fi CERTIFIED Voice-Personal device, associating with a Wi-Fi CERTIFIED Voice-Personal access point and registering with a VoIP service provider.

The Voice-Personal program is the first application-specific program from the Wi-Fi Alliance. It builds on existing tests for protocol adherence, interoperability, security and multimedia functionality to offer enhanced support for voice applications in both client devices and access points.

To help to ensure devices and access points meet the performance requirements of real-life scenarios, certification tests are based on a typical network seen in a home or small office, with a substantial traffic load (Figure 4). The test network used for this program:

- Consists of a **single access point serving multiple clients** that may include PCs, phones, gaming devices, printers, etc. Handoffs between access points are not tested in this certification program.
- Supports at least **four simultaneous simulated voice calls** from four voice devices associated with the same access point.

- Carries **data and video traffic** to and from multiple devices, in addition to voice traffic.
- Assigns **priority to voice** over traffic from other applications.
- Provides **security-protected access** through WPA2 - Personal.
- Supports **power-saving** capabilities in the access point and in battery-operated client devices.
- Has a **single Internet connection**.

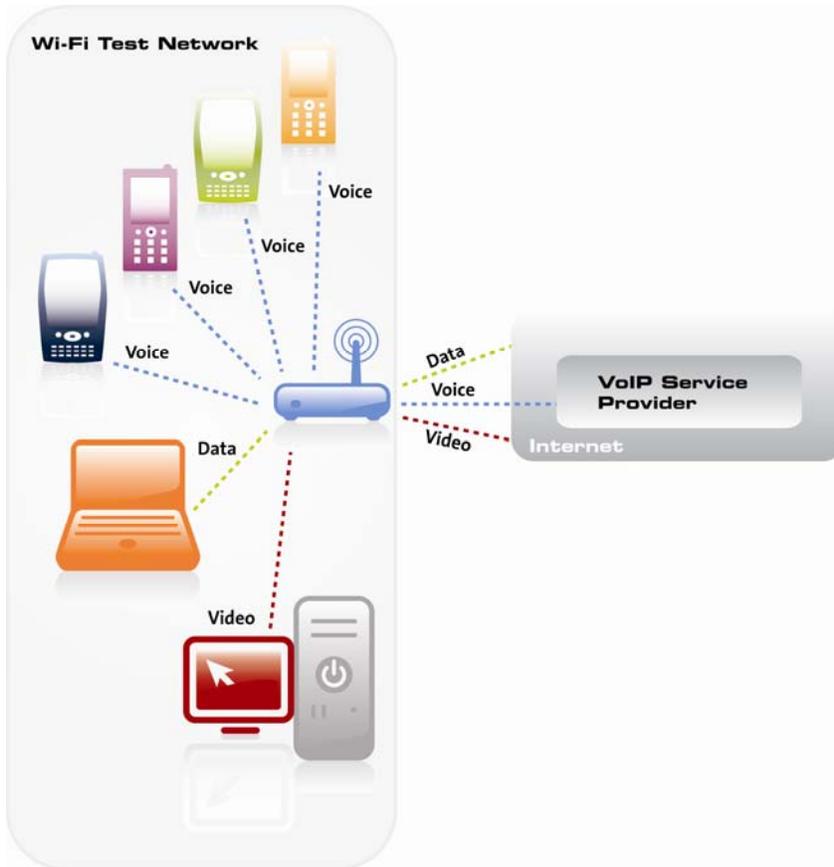


Figure 4. Personal network with mixed data and voice traffic and four concurrent voice calls

Voice-Personal performance criteria include:

- Packet loss of less than 1% with no burst losses;
- Latency of less than 50 milliseconds;
- Maximum jitter of less than 50 milliseconds.

If a device does not perform to these levels, the voice call may drop in and out, may end suddenly, or the conversation may suffer from excessive delays, making it unintelligible. Products that do not meet these requirements will not receive Voice-Personal certification.

Certification testing is aimed at establishing support for voice applications within the Wi-Fi network and preserving the quality of the call transmitted over the IP channel. All certification tests take place exclusively within a Wi-Fi network and assume the presence of a broadband Internet connection that supports VoIP applications⁷. Performance thresholds were defined in a way to ensure that the quality of the voice traffic carried over the Wi-Fi network is the same, or better than, voice traffic carried over a reliable broadband connection.

Both access points and client devices should be Wi-Fi CERTIFIED Voice-Personal in order for users to benefit from the enhanced support for voice applications. In a network in which the access point lacks Wi-Fi certification for Voice-Personal, Wi-Fi CERTIFIED devices may have access to the same voice applications, but may not meet the required performance levels that ensure good voice quality. As an example, a user with a Wi-Fi CERTIFIED Voice-Personal device can run voice applications in a hotspot or at a friend's house, but it is not possible to predict the quality of the call if the access point used is not also Wi-Fi CERTIFIED for voice.

To be eligible for certification under the Voice-Personal program, devices and access points are required to pass the following Wi-Fi Alliance certification tests:

- IEEE 802.11a, 802.11b, or 802.11g;
- WPA2-Personal;
- WMM;
- WMM-Power Save (required for access points, optional for client devices based on the need to conserve battery life)⁸.

WMM prioritizes voice over other Wi-Fi network traffic and addresses the issue of whether voice traffic is properly treated relative to other types of traffic (video, best-effort traffic and background traffic). The Voice-Personal program moves one step further and quantitatively measures the quality of the high-priority voice traffic directly for loss, delay, and jitter against performance thresholds to verify that the prioritization of voice traffic is conducive to good voice quality.

It is, however, important to clarify that the Voice-Personal program tests only the portion of the call transmitted over the local Wi-Fi network and not the overall quality of the end-to-end voice call. In particular:

⁷ A broadband connection with high packet loss, high latency, high jitter or insufficient bandwidth may indirectly affect the performance of Wi-Fi client devices. The impact of limited broadband connectivity on voice calls is excluded from certification testing as the Wi-Fi network has no control over the quality of the Internet connection.

⁸ Access points have to support WMM Power Save to enable any mobile devices in the network to benefit from extended battery life. Since WMM Power Save is specifically designed to provide extended battery life for mobile voice devices, not all Wi-Fi CERTIFIED Voice-Personal programs require this functionality.

- Baseline Wi-Fi certification and WMM address the interoperability between subscriber devices and access points.
- Voice-Personal verifies that the Wi-Fi network can carry good quality voice calls.
- Proprietary and industry voice protocols (e.g. SIP, Skype) that operate above the Wi-Fi layer are not included in the Wi-Fi Alliance certification testing, but are essential to good end-to-end quality of voice calls.

What Lies Ahead: Voice over Wi-Fi in the Enterprise

The Wi-Fi CERTIFIED Voice-Personal program addresses quality of voice over Wi-Fi applications in typical home and small office networks that normally comprise a single access point and a few Wi-Fi CERTIFIED client devices. An equally strong demand for voice over Wi-Fi comes from enterprise Wi-Fi networks that have even more stringent requirements, due to their network complexity and the mission-critical nature of applications and data.

Enterprise Wi-Fi networks generally consist of multiple access points spread between floors within an office building or across a wider company campus. They require support for handoffs across multiple access points, as users need the voice calls to stay active without noticeable interruptions as they move to an area covered by a different access point.

The Wi-Fi Alliance plans to offer a Wi-Fi CERTIFIED Voice-Enterprise certification program in 2009. Building on the Voice-Personal program, it will add support for bandwidth management, hand-offs between access points, enterprise-class security with WPA2-Enterprise, and additional features relevant to the enterprise network environment.

Conclusions

Voice over Wi-Fi is one of the most exciting areas of growth in the Wi-Fi industry. Users are keen to use their Wi-Fi CERTIFIED devices for voice applications and to explore new services that bring them additional functionality and convenience. The value proposition is compelling: voice over Wi-Fi provides users with convenient, easy access to mobile voice applications available over their broadband Internet connection through a wide choice of client devices.

The popularity of VoIP and the increased availability of Wi-Fi CERTIFIED access points and client devices that support voice are bringing voice over Wi-Fi to a broad consumer market. To further accelerate its adoption, it is crucial that Wi-Fi supports a high voice call performance that matches the rich user experience and ease of set-up that Wi-Fi already provides for data applications.

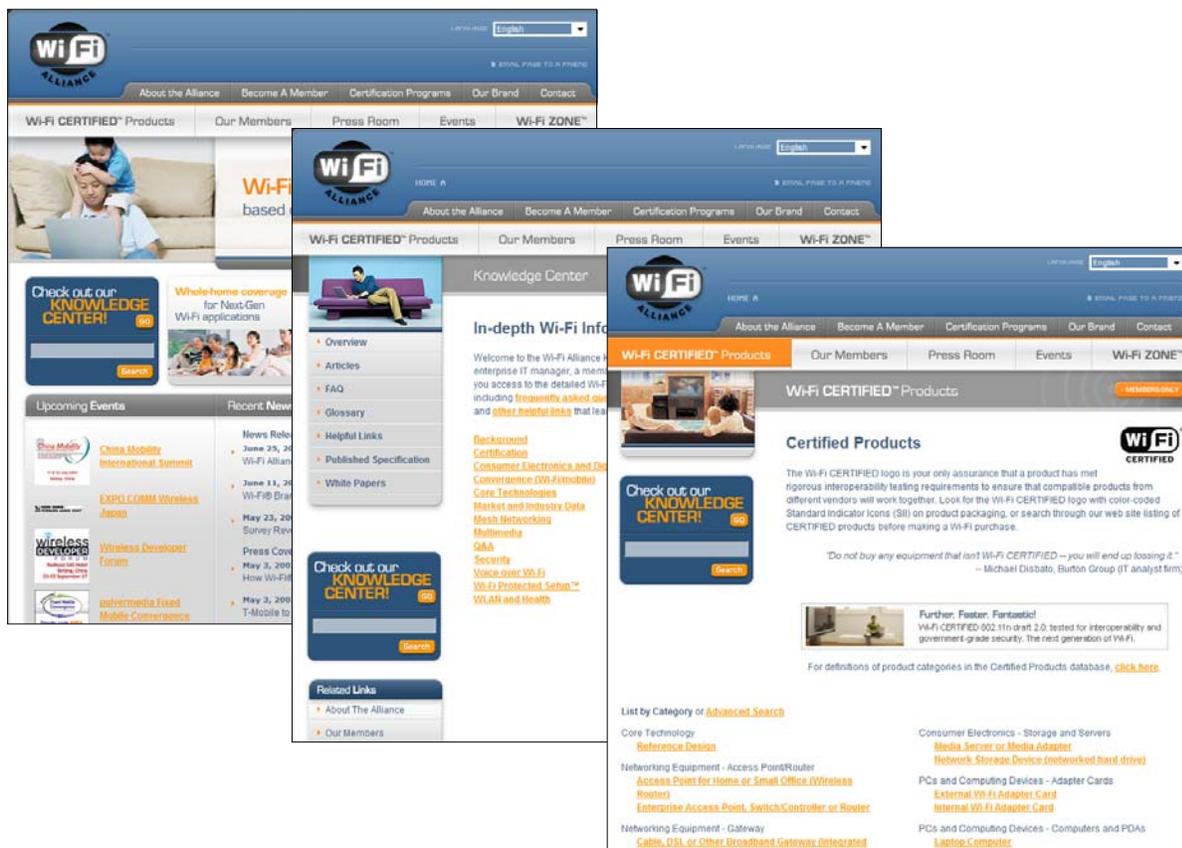
Achieving good quality voice in a mixed environment in which data and voice applications put a heavy load on the network is a challenge for any wireline or wireless network. The degradation in quality due to high latency, high jitter and high packet loss can rapidly make the quality of the voice conversation unacceptable. The network has to meet key performance requirements and prioritize voice traffic to provide the enhanced level of quality that users demand.

The Voice-Personal certification program verifies that both access points and client devices meet the specific requirements of voice applications. It complements and builds on existing certification programs for the 802.11 standard's baseline, security, and multimedia functionality. Devices that complete the Voice-Personal testing will help provide consistent, good quality voice over Wi-Fi calls in typical home and small office environments in which one access point manages multiple client devices and up to four concurrent voice calls.

Voice over Wi-Fi gives users access to the voice application service of their choice in an ever-widening range of Wi-Fi CERTIFIED devices. The Wi-Fi CERTIFIED Voice-Personal program raises the bar for Wi-Fi, taking voice over Wi-Fi beyond early adopters to the mass consumer market, and making voice a mainstream Wi-Fi application.

Additional Resources

More information about the Wi-Fi Alliance initiatives and about the Wi-Fi CERTIFIED programs is available at www.wi-fi.org. The "Wi-Fi CERTIFIED Products" section has a database that includes information about the more than 4,500 Wi-Fi CERTIFIED devices. The "Knowledge Center" section offers answers to frequently asked questions, a glossary of terms, white papers, and articles on a variety of Wi-Fi related topics.



How do you know if a product is Wi-Fi CERTIFIED™?



Wi-Fi CERTIFIED products display a logo on their package indicating they have passed rigorous certification testing in an independent Authorized Test Laboratory. Only Wi-Fi CERTIFIED products have demonstrated that they meet requirements for interoperability, security protection, and compliance to standards.

Beside the Wi-Fi CERTIFIED logo, the letters a, b, g and n indicate which IEEE 802.11 standard the product supports.

List of Acronyms

CTIA	Cellular Telecommunications and Internet Association
CWG-RF	Converged Wireless Group–RF profile
IP	Internet Protocol
IEEE	Institute of Electrical and Electronics Engineers
MIMO	Multiple-Input Multiple-Output
PC	Personal Computer
PIN	Personal Identification Number
QoS	Quality of Service
RF	Radio frequency
VoIP	Voice over Internet Protocol
WLAN	Wireless Local Area
WMM	Wi-Fi Multimedia™
WPA	Wi-Fi Protected Access™
WPA2	Wi-Fi Protected Access™ 2

About the Wi-Fi Alliance

The Wi-Fi Alliance is a global, non-profit industry association of more than 300 member companies devoted to promoting the growth of wireless Local Area Networks (WLANs). With the aim of enhancing the user experience for wireless portable, mobile, and home entertainment devices, the Wi-Fi Alliance's testing and certification programs help ensure the interoperability of WLAN products based on the IEEE 802.11 specification. Since the introduction of the Wi-Fi Alliance's certification program in March 2000, more than 4,500 products have been designated as Wi-Fi CERTIFIED™, encouraging the expanded use of Wi-Fi products and services across the consumer and enterprise markets.

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