

IEEE (Institute of Electrical and Electronics Engineers) Standard 802.11 defines wireless LANs. Although wireless data transmission has been available for years, 802.11 opened the door for enterprises to start deploying and using wireless LANs in buildings and over short ranges between buildings. This white paper is designed as a guide to help you through the alphabet soup of 802.11. More information on IEEE 802.11 and the working groups which set the wireless LAN standards is available at the IEEE 802.11 web page <http://grouper.ieee.org/groups/802/11/>.

Since 1997, when 802.11 was first released, the IEEE has been busily extending 802.11. Over 50 vendors supply hundreds of different products which are compatible with the 802.11 specifications. The Wi-Fi Alliance (<http://www.wi-fi.org/>) has helped to ensure interoperability by creating the "Wi-Fi" brand, given to products which have passed a rigorous testing program for 802.11 compatibility.

The IEEE is not the only standards organization involved in wireless communications. In both Europe and Japan, specific industry segments have created their own standards for special-purpose wireless communications. And wireless communications are not only defined with IEEE 802.11. For example, IEEE 802.16 defines standards for metropolitan area wireless networks. However, the clear leader in enterprise LANs is 802.11.

It is easy to be confused by all of the addenda to the original 802.11 Standard. Names such as 802.11a, 802.11b, and more are all being thrown around by vendors and users. Unfortunately, the order of the letters does not map to the order in which products were introduced. For example, 802.11b products were available in 2000 and 2001, while 802.11a products just started shipping in volume at the beginning of 2002.

Note: l and o are not used because it would be confusing

## **802.11**

**Importance and status:** Critical. Standard completed 1997. Contains base for all 802.11 specifications.

**What is it:** The 1997 version of the standard specifies the operation of wireless LANs, including the media access control (MAC) and wired equivalent privacy (WEP). It also includes three physical layers which have been superseded by revisions to the specification: the infrared (IR) PHY, which was never widely implemented; the frequency hopping spread spectrum (FHSS), which is no longer used; and the direct sequence spread spectrum (DSSS) PHY, which has been superseded by 802.11b.

## **802.11a**

**Importance and status:** Critical. Standard completed 1999. Products shipping today in volume at low cost.

**What is it:** Physical layer that operates within the 5 GHz radio band. Offers up to 12 non-overlapping channels (as opposed to three with 802.11b). Uses orthogonal frequency division multiplexing (OFDM) to offer maximum standardized data rate of 54 Mbps.

## **802.11b**

**Importance and status:** Critical. Standard completed 1999. Products shipping today at very low cost.

**What is it:** Physical layer operating within the 2.4 GHz radio band. Offers only three non-overlapping channels. Uses complementary code keying (CCK) to achieve maximum standardized rate of 11 Mbps per channel, shared among all users.

## **802.11d**

**Importance and status:** Minor, unless your country was not in 802.11. Standard completed 2001.

**What is it:** Radio emissions are subject to regulatory limits. 802.11 was written to comply with the regulatory limits in the U.S., Canada, and Europe. New regulators may specify different constraints for transmit power and allowed frequencies. Rather than revise the specification when new regulators issue rules, 802.11d allows an access point to "describe" allowed configurations to clients to make deployment easier.

**802.11e**

**Importance and status:** Minor. Standard not yet completed; may be finished in 2003.

**What is it:** Quality of Service (QoS) enhancements for 802.11 networks. QoS may be critical for new applications, such as voice over 802.11. Given the underwhelming appetite for QoS on the LAN, it is unlikely that 802.11e will be widely deployed soon.

**802.11f**

**Importance and status:** Unknown. Could be critical to large mobile wireless LANs, but may be irrelevant. Standard still in progress, completion was predicted last year.

**What is it:** 802.11 defines how a clients work with access points, but does not define how a network of access points provides a single seamless network. Not relevant now because most large networks are single vendor; may be more important as multi-vendor networks become more common.

**802.11g**

**Importance and status:** Could be Critical or Irrelevant for Europe. Estimated publication of standard in July 2003. Products already shipping based on current drafts.

**What is it:** Physical layer for the 2.4 GHz band. Uses OFDM and packet binary convolutional coding (PBCC) to bring 54 Mbps speeds using the frequency band of 802.11b. Critical for locations where 5 GHz band is not available but higher speed is necessary. Politically motivated by a reaction to radio regulation. Likely irrelevant to enterprise deployment in North America; may also be irrelevant in Europe if 802.11h is widely adopted.

**802.11h**

**Importance and status:** Could be Critical for Europe if accepted. Standard to be completed mid 2003.

**What is it:** European radio regulations for the 5GHz band require products to have transmission power control (TPC) to limit RF energy and dynamic frequency selection (DFS) to minimize interference with other systems. If pan-European regulators accept 802.11h, this will be the "European alternative" to 802.11a.

**802.11i**

**Importance and status:** Important. Standard ongoing; estimated completion September 2003.

**What is it:** 802.11i will offer additional security for 802.11. Builds on 802.1X to replace WEP. Acronyms to look out for: TKIP (Temporal Key Integrity Protocol), which will synchronize key changes between clients and APs. AES (Advanced Encryption Standard), a relatively new cipher, will replace RC4. WPA takes components available in September 2002 and calls them an "interim standard".

**802.11j**

**Importance and status:** Important for Japan. Irrelevant for other areas. Schedule unpublished.

**What is it:** Japan has authorized a slightly different frequency band (4.9 GHz - 5 GHz) for 802.11a-like functionality. 802.11j brings OFDM PHY speeds to the authorized Japanese band.

**802.11k**

**Importance and status:** Important. Recently formed, no schedule available.

**What is it:** 802.11 equipment does not report much about the health and status of the radio link, and network managers have little insight into its performance. This project will make low-level data available to management systems so that equipment can dynamically change radio channels, power levels, and load balance clients across APs.

**802.11m**

**Importance and status:** Minor. Letter not officially assigned yet; schedule unknown.

**What is it:** "Maintenance" update to 802.11 that will "roll up" changes made to 802.11-1999 by 802.11a, 802.11b, and 802.11d into the 2003 revision of the 802.11 standard.

**802.11n**

**Importance and status:** Important. Letter not officially assigned; completion anticipated 2005 or 2006.

**What is it:** Pending project that will focus on increasing the speed of 802.11 beyond 100 Mbps. Some proposals reportedly offer speeds of up to 320 Mbps.