



High-Speed Wireless LAN Options 802.11a and 802.11g

The Wireless Local Area Network (WLAN) industry has emerged as one of the fastest-growing segments of the communications industry. WLAN equipment shipments grew to almost 12 million units in 2001 and market research firm Cahners In-Stat expects sales of wireless network cards and WLAN base stations to grow from \$1.9 billion in 2001 to \$5.2 billion in 2005.

This growth was due, in large part, to the introduction of standards-based WLAN products. These products – based on the 802.11b standard – are faster, lower in cost, and simpler to setup and use than previous generation products. The majority of WLAN products today communicate at speeds up to 11 megabits per second (Mbps).

Two new WLAN standards are now emerging and will deliver higher speeds, up to 54 Mbps, to WLAN users. These new standards are known as 802.11a and 802.11g. To help you to better understand these new technologies, the Wireless LAN Association (WLANA) has developed this white paper as an introduction to high-speed WLAN options.

The Road to High-Speed Wireless LAN

You may be wondering why 802.11b products came before 802.11a. The letters after the number “802.11” indicate the order in which standards were first proposed, not the order in which products appear. The first wireless LAN standard, 802.11, was approved by the Institute of Electrical and Electronics Engineers (IEEE) in 1997 and supported speeds up to 2 Mbps.

In 1999, the IEEE approved both the 802.11a and 802.11b standards. 802.11a specified radios transmitting at 5 GHz and at speeds up to 54 Mbps using orthogonal frequency division multiplexing (OFDM) modulation technology. The 802.11b standard – now popularly known as Wi-Fi – specified operation in the 2.4 GHz band (also known as the ISM band) and could achieve speeds up to 11 Mbps using direct sequence spread spectrum (DSSS) technology.

Because DSSS is easier to implement than OFDM, 802.11b products appeared on the market first, starting in late 1999. Since then, 802.11b products have been widely deployed in corporations, small offices/home offices (SOHO), in residential home and in public locations (Wi-Fi “hotspots”). Products bearing the Wi-Fi logo conform to the 802.11b standard, have passed an interoperability certification test defined by the Wireless Ethernet Compatibility Alliance (WECA) and have received permission from WECA to use the logo.

In early 2002, the first end-users products based on the 802.11a standard were

Frequency Fundamentals

Today’s WLAN products transmit and receive information using radio waves. Multiple, simultaneous transmissions can exist without interference if the radio waves are transmitted on different radio frequencies, known as channels. To extract data, a radio receiver tunes in (or selects) one channel while rejecting all other radio signals on different channels. WLAN products operate inside a collection of frequencies, known as a frequency band: 2.4 GHz for 802.11b/g and 5 GHz for 802.11a.

To transmit data over radio waves, WLAN devices must superimpose the data being transmitted onto the radio wave, also known as a carrier wave because it carries data. This process is called modulation. Different modulation types exist and each has its benefits and tradeoffs in terms of efficiency and power requirements. DSSS modulations are used in 802.11b/g. OFDM modulations are used in 802.11a/g.

Together, the frequencies of operation and the modulation types define the Physical Layer (PHY) of the IEEE standard. Products are compatible at the PHY layer when they use the same frequencies and modulation. A second data layer, the Medium Access Control Layer (MAC) has been standardized across 802.11a, b and g.

shipped. Currently, these products are all based on chipsets from a single vendor. WECA has announced that it is defining an interoperability certification test for 802.11a products, which will be used as soon as the products are available based on a second vendor's chipset. Products passing this test will be known as Wi-Fi5 compatible.

In early 2001, the FCC announced new rules allowing additional modulations in the 2.4GHz range. This allowed IEEE to extend 802.11b to support higher data rates, resulting in the 802.11g standard, which is now in draft stage and expected to be completed and approved by the end of 2002. 802.11g defines new data rate, up to 54 Mbps, at 2.4Ghz using OFDM, while at the same time providing backward compatibility with 802.11b at speeds up to 11 Mbps using DSSS.

Table 1 summarizes the IEEE WLAN standards:

	802.11	802.11a	802.11b	802.11g
Standard Approved	July 1997	September 1999	September 1999	Draft stage. Completion expected in 2002.
Available Bandwidth	83.5 MHz	300 MHz	83.5 MHz	83.5 MHz
Unlicensed Frequencies of Operation	2.4-2.4835 GHz DSSS, FHSS	5.15-5.35 GHz OFDM 5.725-5.825Ghz OFDM	2.4-2.4835GHz DSSS	2.4-2.4835GHz DSSS, OFDM
Number of Non-Overlapping Channels	3 (Indoor/Outdoor)	4 Indoor (UNII1) 4 Indoor/Outdoor (UNII2) 4 Outdoor (UNII3)	3 (Indoor/Outdoor)	3 (Indoor/Outdoor)
Data Rate per Channel	2, 1 Mbps	54, 48, 36, 24, 18, 12, 9, 6 Mbps	11, 5.5, 2, 1 Mbps	54, 36, 33, 24, 22, 12, 11, 9, 6, 5.5, 2, 1 Mbps
Modulation Type	DQPSK (2 Mbps DSSS) DBPSK (1 Mbps DSSS) 4GFSK (2Mbps FHSS) 2GFSK (1Mbps FHSS)	BPSK (6, 9 Mbps) QPSK (12, 18 Mbps) 16-QAM (24, 36 Mbps) 64-QAM (48, 54 Mbps)	DQPSK/CCK (11, 5.5 Mbps) DQPSK (2 Mbps) DBPSK (1 Mbps)	OFDM/CCK (6,9, 12,18,24,36,48,54) OFDM (6,9,12,18, 24,36,48,54) DQPSK/CCK (22, 33, 11, 5.5 Mbps) DQPSK (2 Mbps) DBPSK (1 Mbps)
Compatibility	802.11	Wi-Fi5	Wi-Fi	Wi-Fi at 11Mbps and below

Table 1: IEEE WLAN Standards

802.11a – High-Speed, High Capacity

By moving to the 5 GHz frequency band and by using OFDM modulation, the 802.11a standard provides two key benefits over 802.11b. It increases the maximum speed per channel (from 11 Mbps to 54 Mbps) and increases the number of non-overlapping channels. The 5 GHz band (also known as the UNII band) is actually made up of three sub-bands, UNII1 (5.15-5.25 GHz), UNII2 (5.25-5.35 GHz) and UNII3 (5.725-5.825 GHz). Up to 8 non-overlapping channels are available when UNII1 and UNII2 are both used, versus 3 in the 2.4 GHz band. The total bandwidth available in the 5 GHz band is also higher than in the 2.4 GHz band – 83.5 MHz versus 300 MHz. Thus, an 802.11a-based WLAN can support a larger number of simultaneous high-speed users without the potential for conflict.

These benefits come, however, with some tradeoffs in terms of compatibility and range.

Because they operate in different frequency bands, 802.11a and 802.11b products are not compatible. A 2.4 GHz 802.11b access point, for example, won't work with a 5 GHz 802.11a network card. However, both standards can certainly co-exist. For example, an 802.11a user and an 802.11b user, using separate access points and clients for each, connected to the same LAN, can operate in the same physical space and share network resources including broadband and internet access.

The higher operating frequency of 802.11a equates to a relatively shorter range. You will need a larger number of 802.11a access points to cover the same area. The FCC requires a max 6dB antenna attached to the radio when UNII1 and UNII2 are both used to get a full 8 indoor channels, reducing range. However, initial tests show that 802.11a products still maintain about a 3 to 1 performance improvement versus 802.11b over typical indoor ranges.

802.11g – High-Speed in the 2.4 GHz Band

The 802.11g standard brings the benefits of higher speeds, while maintaining backward compatibility with existing 802.11b equipment. 802.11g specifies operation in the same 2.4 GHz frequency band and with the same DSSS modulation types as 802.11b at speeds up to 11 Mbps, while adding more efficient OFDM modulation types at higher speeds.

An 802.11g network card, for example, will work with an 802.11b access point and an 802.11g access point will work with 802.11b network cards – at speeds up to 11 Mbps. To benefit from higher speeds up to 54 Mbps, both the access point and network card must be 802.11g compliant. The draft standard also specifies optional modulation types (OFDM/CCK) that are intended to improve efficiency in an all-802.11g installation.

The tradeoff with 802.11g is in a lower capacity, versus 802.11a, to serve a large number of high-speed WLAN users. The OFDM modulations allow for higher speed but the total available bandwidth in the 2.4 GHz frequency band remains the same because 802.11g is still restricted to three channels in the 2.4 GHz band, unlike the eight that are available in the 5GHz band.

Choosing a High-Speed WLAN Standard

Each WLAN deployment is unique. It is impossible to provide a simple answer to choosing between 802.11a or 802.11g. In some cases, it may even make sense to mix both, especially as the industry introduces dual-mode (two radio) solutions that support all three standards. In the next few years, the industry is even expected to ship multi-mode devices that support 11a, 11b and 11g.

It is important to evaluate both your anticipated needs and your current installation. Some key criteria for choosing a high-speed WLAN standard are:

- **Total Capacity Requirements:** For installations that call for high-density populations of mostly high-speed WLAN users, 802.11a may be a better choice. If a smaller number of high-speed users are being added to an existing 802.11b installation, 802.11g may be the better choice.
- **Timing of High-Speed Need:** If high-speed is needed immediately, 802.11a would be the way to go, since 802.11g products are not expected to be shipped until the second half of 2002.
- **Migration Plan for Existing Installation:** If you have a large 802.11b installation and simply want add a few high-speed users in the next year, it may make sense to try both options now and plan to deploy dual-mode products in the following year.
- **Interference Concerns:** If you are currently experience interference in the 2.4 GHz frequency band from products like Bluetooth and cordless phones, it may make sense to move to the less crowded (for now) 5 GHz band with 802.11a.

For More Information

Wireless LAN Association

<http://www.wlana.org>

IEEE 802.11 WLAN Working Group

<http://grouper.ieee.org/groups/802/11/>

IEEE 802.11g Explained – Intersil

http://www.intersil.com/design/prism/papers/WP_IEEE802gExpla_12_06.pdf

Abbreviations and Acronyms

BPSK – binary phase shift keying

CCK – complementary code keying

DSSS – direct sequence spread spectrum using the Long Preamble and header

OFDM – orthogonal frequency division multiplexing

OFDM/CCK – orthogonal frequency division multiplexing/complimentary code keying

IEEE – Institute of Electrical and Electronics Engineers

ISM - Industrial, Scientific, and Medical, refers to 2.4 GHz unlicensed frequency band

QAM – quadrature amplitude modulation

QPSK – quadrature phase shift keying

UNII – Unlicensed National Information Infrastructure, refers to 5 GHz unlicensed frequency band

Contact WLANA

Wireless LAN Association (WLANA)

P.O. Box 9097

San Jose, CA 95157

Phone: 650-352-4709

Fax: 650-649-2305

email: info@wlana.org

website: www.wlana.org