IEEE 802.11a-1999

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IEEE 802.11a-1999 or **802.11a** was an amendment to the IEEE 802.11 wireless local network specifications that defined requirements for an orthogonal frequency division multiplexing (OFDM) communication system. It was originally designed to support wireless communication in the unlicensed national information infrastructure (U-NII) bands (in the 5–6 GHz frequency range) as regulated in the United States by the Code of Federal Regulations, Title 47, Section 15.407.

Originally described as clause 17 of the 1999 specification, it is now defined in clause 18 of the 2012 specification and provides protocols that allow transmission and reception of data at rates of 1.5 to 54Mbit/s. It has seen widespread worldwide implementation, particularly within the corporate workspace. While the original amendment is no longer valid, the term "802.11a" is still used by wireless access point (cards and routers) manufacturers to describe interoperability of their systems at 5.8 GHz, 54 Mbit/s (54 x 10^6 bits per second).

802.11 is a set of IEEE standards that govern wireless networking transmission methods. They are commonly used today in their 802.11a, 802.11b, 802.11g, 802.11n and 802.11ac versions to provide wireless connectivity in the home, office and some commercial establishments.

Contents

Description

The 802.11a amendment to the original standard was ratified in 1999. The 802.11a standard uses the same core protocol as the original standard, operates in 5 GHz band, and uses a 52-subcarrier orthogonal frequency-division multiplexing (OFDM) with a maximum raw data rate of 54 Mbit/s, which yields realistic net achievable throughput in the mid-20 Mbit/s. The data rate is reduced to 48, 36, 24, 18, 12, 9 then 6 Mbit/s if required. 802.11a originally had 12/13 non-overlapping channels, 12 that can be used indoor and 4/5 of the 12 that can be used in outdoor point to point configurations. Recently many countries of the world are allowing operation in the 5.47 to 5.725 GHz Band as a secondary user using a sharing method derived in 802.11h. This will add another 12/13 Channels to the overall 5 GHz band enabling significant overall wireless network capacity enabling the possibility of 24+ channels in some countries. 802.11a is not interoperable with 802.11b as they operate on separate bands, except if using equipment that has a dual band capability. Most enterprise class Access Points have dual band capability.

Using the 5 GHz band gives 802.11a a significant advantage, since the 2.4 GHz band is heavily used to the point of being crowded. Degradation caused by such conflicts can cause frequent dropped connections and degradation of service. However, this high carrier frequency also brings a slight disadvantage: The effective overall range of 802.11a is slightly less than that of 802.11b/g; 802.11a signals cannot penetrate as far as those for 802.11b because they are absorbed more readily by walls and other solid objects in their path and because the path loss in signal strength is proportional to the square of the signal frequency. On the other hand, OFDM has fundamental propagation advantages when in a high multipath environment, such as an indoor office, and the higher frequencies enable the building of smaller antennas with higher RF system gain which counteract the disadvantage of a higher band of operation. The increased number of usable channels (4 to 8 times as many in FCC countries) and the near absence of other interfering systems (microwave ovens, cordless phones, baby monitors) give 802.11a significant aggregate bandwidth and reliability advantages over 802.11b/g.

Regulatory issues

Different countries have different regulatory support, although a 2003 World Radiotelecommunications Conference improved worldwide standards coordination. 802.11a is now approved by regulations in the United States and Japan, but in other areas, such as the European Union, it had to wait longer for approval. European regulators were considering the use of the European HIPERLAN standard, but in mid-2002 cleared 802.11a for use in Europe. In the U.S., a mid-2003 FCC decision may open more spectrum to 802.11a channels.

Timing and compatibility of products

802.11a products started shipping late, lagging 802.11b products due to 5 GHz components being more difficult to manufacture. First generation product performance was poor and plagued with problems. When second generation products started shipping, 802.11a was not widely adopted in the consumer space primarily because the less-expensive 802.11b was already widely adopted. However, 802.11a later saw significant penetration into enterprise network environments, despite the initial cost disadvantages, particularly for businesses which required increased capacity and reliability over 802.11b/g-only networks.

With the arrival of less expensive early 802.11g products on the market, which were backwards-compatible with 802.11b, the bandwidth advantage of the 5 GHz 802.11a was eliminated. Manufacturers of 802.11a equipment responded to the lack of market success by significantly improving the implementations (current-generation 802.11a technology has range characteristics nearly identical to those of 802.11b), and by making technology that can use more than one band a standard.

Dual-band, or dual-mode Access Points and Network Interface Cards (NICs) that can automatically handle a and b/g, are now common in all the markets, and very close in price to b/g- only devices.

Technical description

Of the 52 OFDM subcarriers, 48 are for data and 4 are pilot subcarriers with a carrier separation of 0.3125 MHz (20 MHz/64). Each of these subcarriers can be a BPSK, QPSK, 16-QAM or 64-QAM. The total bandwidth is 20 MHz with an occupied bandwidth of 16.6 MHz. Symbol duration is 4 microseconds, which *includes* a guard interval of 0.8 microseconds. The actual generation and decoding of orthogonal components is done in baseband using DSP which is then upconverted to 5 GHz at the transmitter. Each of the subcarriers could be represented as a complex number. The time domain signal is generated by taking an Inverse Fast Fourier transform (IFFT).

MCS index	RATE bits	Modulation type	Coding rate	Data rate (Mbit/s)
13	**1101**	BPSK	1/2	6
16	**1111**	BPSK	3/4	9
5	**0101**	QPSK	1/2	12
7	**0111**	QPSK	3/4	18
9	**1001**	16-QAM	1/2	24
11	**1011**	16-QAM	3/4	36
1	**0001**	64-QAM	2/3	48
3	**0011**	64-QAM	3/4	54

See also

- List of WLAN channels
- OFDM system comparison table
- Spectral efficiency comparison table

802.11 network PHY standards

802.11 protocol	Release date[1]	Frequency (GHz)	Bandwidth (MHz)	Stream data rate[2] (Mbit/s)	Allowable MIMO streams	Modulation	Approximate range: Indoor (m)	Indoor (ft)	Outdoor (m)	Outdoor (ft)
802.11-1997	Jun 1997	2.4	22	1, 2	N/A	DSSS, FHSS	20	66	100	
a	Sep 1999	5	20	6, 9, 12, 18, 24, 36, 48, 54	N/A	OFDM	35	115	120	
		3.7[A]					—	—	5,000	16,
b	Sep 1999	2.4	22	1, 2, 5.5, 11	N/A	DSSS	35	115	140	
g	Jun 2003	2.4	20	6, 9, 12, 18, 24, 36, 48, 54	N/A	OFDM	38	125	140	
n	Oct 2009	2.4/5	20	400 ns GI : 7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2 [B] 800 ns GI : 6.5, 13, 19.5, 26, 39, 52, 58.5, 65 [C]	4	MIMO-OFDM	70	230	250	
			40	400 ns GI : 15, 30, 45, 60, 90, 120, 135, 150 [B] 800 ns GI : 13.5, 27, 40.5, 54, 81, 108, 121.5, 135 [C]			70	230	250	
ac	Dec 2013	5	20	400 ns GI : 7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2, 86.7, 96.3 [B] 800 ns GI : 6.5, 13, 19.5, 26, 39, 52, 58.5, 65, 78, 86.7 [C]	8		35	115[4]		
			40	400 ns GI : 15, 30, 45, 60, 90, 120, 135, 150, 180, 200 [B] 800 ns GI : 13.5, 27, 40.5, 54, 81, 108, 121.5, 135, 162, 180 [C]			35	115[4]		
			80	400 ns GI : 32.5, 65, 97.5, 130, 195, 260, 292.5, 325, 390, 433.3 [B] 800 ns GI : 29.2, 58.5, 87.8, 117, 175.5, 234, 263.2, 292.5, 351, 390 [C]			35	115[4]		
			160	400 ns GI : 65, 130, 195, 260, 390, 520, 585, 650, 780, 866.7 [B] 800 ns GI : 58.5, 117, 175.5, 234, 351, 468, 702, 780 [C]			35	115[4]		
ad	Dec 2012	60	2,160	Up to 6,912 (6.75 Gbit/s) [5]	N/A	OFDM, single carrier, low-power single carrier	60	200	100	
ah	Est. 2016[1]	0.9								
aj	Est. 2016[1]	45/60								
ax	Est. 2019[1]	2.4/5				MIMO-OFDM				
ay	2017	60	8000	Up to 100,000 (100 Gbit/s)	4	OFDM, single carrier,	60	200	1000	

- **A1 A2** IEEE 802.11y-2008 extended operation of 802.11a to the licensed 3.7 GHz band. Increased power limits allow a range up to 5,000 m. As of 2009, it is only bein licensed in the United States by the FCC.
- **B1 B2 B3 B4 B5 B6** Assumes short guard interval (SGI) enabled.
- **C1 C2 C3 C4 C5 C6** Assumes short guard interval (SGI) disabled.

References

4 "IEEE 802 11ac: What Does it Mean for Test?" (PDF) *LitePoint* October 2013
5 "WiGig and IEEE 802 11ad For Multi-Gigabyte-Per-Second WPAN and WLAN" (PDF) Tensorcom Inc

General

- "802.11a-1999 High-speed Physical Layer in the 5 GHz band" (PDF). 1999-02-11. Retrieved 2007-09-24.