IEEE 802.11 family

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Description

The 802.11 family includes over-the-air modulation techniques that use the same basic protocol.

The most popular are those defined by the 802.11b and 802.11g protocols and are amendments to the 802.11a standard.

802.11a was the first wireless networking standard even though 802.11b was the first to be widely adopted.

Following 802.11b were the 802.11g and 802.11n standards.

802.11n is a new multi-streaming modulation technique that is still under development, however products currently implementing it's Draft 2.0 specifications are available.

Protocol summary

Protocol	Release Date	Frequency (GHz)	Throughput (Typ.) (Mbit/s)	Data Rate (Max) (Mbit/s)	Modulation Technique	Range (Radius Indoor) (Meters)	Range (Radius Outdoor) (Meters)
Legacy	1997	2.4	0.9	2		~20	~100
802.11a	1999	5	23	54	OFDM	~35	~120
802.11b	1999	2.4	4.3	11	DSSS	~38	~140
802.11g	2003	2.4	19	54	OFDM	~38	~140
802.11n	Oct. 2008	2.4 and/or 5	144	600	MIMO	~70	~250

Protocols

802.11-1997 (802.11 legacy)

It's original version, released in 1997 and clarified in 1999, specified data rates of 1Mbps and 2Mbps to be transmitted via IR signals or by either frequency hopping or direct-sequence spread spectrum using the Industrial Scientific Medical frequency band at 2.4 GHz. Although IR remains a part of the standard,

it has no implementations.

Legacy 802.11 was rapidly supplemented and popularized by 802.11b.

802.11a

Release Date	Op. Frequency	Data Rate (Typ)	Data Rate (Max)	Range (Indoor)
October 1999	5 GHz	23 Mbit/s	54 Mbit/s	~35 meters

Technical description

Data rate *(Mbit/s)*	Modulation	Coding rate	Bits/Symbol	1472 byte transfer duration *(µs)*
6	BPSK	1/2	24	2012
9	BPSK	3/4	36	1344
12	QPSK	1/2	48	1008
18	QPSK	3/4	72	672
24	16-QAM	1/2	96	504
36	16-QAM	3/4	144	336
48	64-QAM	2/3	192	252
54	64-QAM	3/4	216	224

General Description

Since the 2.4GHz band is used excessively, using the 5GHz band gives 802.11a a considerable advantage. However, since higher frequencies are absorbed more easily, 802.11a has a smaller signal range than 2.4GHz protocols.

802.11b

Release Date	Op. Frequency	Data Rate (Typ)	Data Rate (Max)	Range (Indoor)
October 1999	2.4 GHz	4.5 Mbit/s	11 Mbit/s	~35 meters

Technical description

Data rate *(Mbit/s)*	Modulation	Bits/Symbol	1472 byte transfer duration *(µs)*
1	BPSK	1	1

2	QPSK	2	0.5
5.5	QPSK	4	0.1818175
11	QPSK	8	0.09090875

General Description

802.11b's dramatic increase in throughput along with price reductions led to it's immediate acceptance as the standard WLAN technology.

Although, due to CSMA/CA protocol overhead the maximum throughput an application can achieve is approximately 5.9Mbps (TCP) and 7.1Mbps (UDP).

802.11b hardware can suffer interference from other devices operating in the 2.4GHz band (Bluetooth devices, microwave ovens, cordless telephones, baby monitors etc.).

802.11g

Release Date	Op. Frequency	Data Rate (Typ)	Data Rate (Max)	Range (Indoor)
June 2003	2.4 GHz	19 Mbit/s	54 Mbit/s	~35 meters

Technical description

Data rate *(Mbit/s)*	Modulation	Coding rate	Bits/Symbol
6	BPSK	1/2	24
9	BPSK	3/4	36
12	QPSK	1/2	48
18	QPSK	3/4	72
24	16-QAM	1/2	96
36	16-QAM	3/4	144
48	64-QAM	2/3	192
54	64-QAM	3/4	216

General Description

802.11g was a great breakthrough for wireless technologies operating at a maximum speed of 54Mbps and also retaining backward compatibility with 802.11b hardware.

This lead to it's fast adoption by consumers, even before it's official ratification, due to the need for higher speeds and low manufacturing costs.

By summer 2003, most dual-band 802.11a/b products became dual-band/tri-mode, supporting a and b/g in a single mobile adapter card or access point. Details of making b and g work well together occupied much of the lingering

technical process; in an 802.11g network, however, the presence of a legacy 802.11b participant will significantly reduce the speed of the overall 802.11g network.

802.11n (Draft 2.0)

Release Date	Op. Frequency	Data Rate (Typ)	Data Rate (Max)	Range (Indoor)
October 2008 (est.)	5 GHz and/or 2.4 GHz	144 Mbit/s (20MHz channel width, 2x2[1])	600 Mbit/s (40MHz channel width, 4x4[2])	~70 meters

[1] 2x2 denotes a two-transmitter/two-receiver

[2] 4x4 denotes a four-transmitter/four-receiver

Technical description

(The following table is not a part of the standard but a test of currently available 802.11n hardware.)

Data rate ***(Mbit/s)***	Modulation	Coding rate	Bits/Symbol
13.5	BPSK	1/2	54
27.0	QPSK	1/2	108
40.5	QPSK	3/4	162
54	16-QAM	1/2	216
81	16-QAM	3/4	324
108	64-QAM	2/3	432
121.5	64-QAM	3/4	486
135	64-QAM	5/6	540

General Description

802.11n is a suggested amendment which is based on the previous 802.11 standards by adding multiple-input multiple-output (MIMO) support.

Even though there are products implementing the 802.11n specifications based on Draft 2.0, the amendment is expected to be approved on the October of 2008.

Unlike previous standards, 802.11n supports one, two, three or four spatial streams enabling it to reach significantly higher throughput rates.

Moreover, it can operate at both 20MHz and 40MHz channel widths.

This plethora of features enables it to be backward compatible with 802.11a/b/g.

At the the time of writing 802.11n's latest draft is Draft 2.07

and the Task Group N is preparing Draft 3.0 which will become available at the end of this month (October 2007).

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