Introduction to Wi-Fi (802.11 or WiFi)

Introduction to Wi-Fi (802.11)

The IEEE 802.11 specification (ISO/IEC 8802-11) is an international standard describing the characteristics of a wireless local area network (WLAN). The name **Wi-Fi** (short for "Wireless Fidelity", sometimes incorrectly shortened to WiFi) corresponds to the name of the certification given by the Wi-Fi Alliance, formerly WECA (Wireless Ethernet Compatibility Alliance), the group which ensures compatibility between hardware devices that use the 802.11 standard. Today, due to misuse of the terms (and for marketing purposes), the name of the standard is often confused with the name of the certification. A Wi-Fi network, in reality, is a network that complies with the 802.11 standard. Hardware devices certified by the Wi-Fi Alliance are allowed to use this logo:

With Wi-Fi, it is possible to create high-speed wireless local area networks, provided that the computer to be connected is not too far from the access point. In practice, Wi-Fi can be used to provide high-speed connections (11 Mbps or greater) to laptop computers, desktop computers, personal digital assistants(PDAs) and any other devices located within a radius of several dozen metres indoors (in general 20m-50m away) or within several hundred metres outdoors.

Wi-Fi providers are starting to blanket areas that have a high concentration of users (like train stations, airports, and hotels) with wireless networks. These access areas are called "**hot spots**".

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The 802.11 standard reserves the low levels of the OSI model for a wireless connection that uses electromagnetic waves, i.e.:

- The physical layer (sometimes shortened to the "PHY" layer), which offers three types of information encoding.
- The data link layer, comprised of two sub-layers: **Logical Link Control** (or **LLC**) and **Media Access Control** (or **MAC**).

The physical layer defines the radio wave modulation and signalling characteristics for data transmission, while the data link layer defines the interface between the machine's bus and the physical layer, in particular an access method close to the one used in the Ethernet standard and rules for communication between the stations of the

network. The 802.11 standard actually has three physical layers, which define alternative modes of transmission:

<table>
<tr><td rowspan="2">Data Link Layer (MAC)</td><td>802.2</td></tr>
<tr><td>802.11</td></tr>
<tr><td>Physical Layer (PHY)</td><td><table><tr><td>DSSS</td><td>FHSS</td><td>Infrared</td></tr></table></td></tr>
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Any high-level protocol can be used on a Wi-Fi wireless network the same way it can be used on an Ethernet network.

The various Wi-Fi standards

The IEEE 802.11 standard is actually only the earliest standard, allowing 1-2 Mbps of bandwidth. Amendments have be made to the original standard in order to optimize bandwidth (these include the 802.11a, 802.11b and 802.11g standards, which are called 802.11 physical standards) or to better specify components in order to ensure improved security or compatibility. This table shows the various amendments to the 802.11 standard and their significance:

Name of standard	Name	Description
802.11a	Wifi5	The 802.11a standard (called WiFi 5) allows higher bandwidth (54 Mbps maximum throughput, 30 Mbps in practice). The 802.11a standard provides 8 radio channels in the 5 GHz frequency band.
802.11b	WiFi	The 802.11b standard is currently the most widely used one. It offers a maximum thoroughput of 11 Mbps (6 Mbps in practice) and a reach of up to 300 metres in an open environment. It uses the 2.4 GHz frequency range, with 3 radio channels available.
802.11c	Bridging 802.11 and 802.1d	The 802.11c bridging standard is of no interest to the general public. It is only an amended version of the 802.1d standard that lets 802.1d bridge with 802.11-compatible devices (on the data link level).

802.11d	Internationalization	The 802.11d standard is a supplement to the 802.11 standard which is meant to allow international use of local 802.11 networks. It lets different devices trade information on frequency ranges depending on what is permitted in the country where the device is from.
802.11e	Improving service quality	The 802.11e standard is meant to improve the quality of service at the level of the *data link layer*. The standard's goal is to define the requirements of different packets in terms of bandwidth and transmission delay so as to allow better transmission of voice and video.
802.11f	Roaming	The 802.11f is a recommendation for access point vendors that allows products to be more compatible. It uses the *Inter-Access Point Roaming Protocol*, which lets a roaming user transparently switch from one access point to another while moving around, no matter what brands of access points are used on the network infrastructure. This ability is also simply called *roaming.*
802.11g		The 802.11g standard offers high bandwidth (54 Mbps maximum throughput, 30 Mbps in practice) on the 2.4 GHz frequency range. The 802.11g standard is backwards-compatible with the 802.11b standard, meaning that devices that support the 802.11g standard can also work with 802.11b.
802.11h		The *802.11h* standard is intended to bring together the 802.11 standard and the European standard (HiperLAN 2, hence the *h* in 802.11h) while conforming to

		European regulations related to frequency use and energy efficiency.
802.11i		The *802.11i* standard is meant to improve the security of data transfers (by managing and distributing keys, and implementing encryption and authentication). This standard is based on the *AES* (Advanced Encryption Standard) and can encrypt transmissions that run on 802.11a, 802.11b and 802.11g technologies.
802.11Ir		The *802.11r* stadard has been elaborated so that it may use infra-red signals. This standard has become technologically obsolete.
802.11j		The *802.11j* standard is to Japanese regulation what the 802.11h is to European regulation.

It is also useful to note the existence of a standard called "*802.11b+*". This is a proprietary standard with improvements in data flow. However, this standard also suffers from gaps in interoperability due to not being an IEEE standard.

Range and data flow

The 802.11a, 802.11b and 802.11g standards, called "physical standards" are amendments to the 802.11 standard and offer different modes of operation, which lets them reach different data transfer speeds depending on their range.

Standard	**Frequency**	**Speed**	**Range**
WiFi a (802.11a)	5 GHz	54 Mbit/s	10 m
WiFi B (802.11b)	2.4 GHz	11 Mbit/s	100 m
WiFi G (802.11b)	2.4 GHz	54 Mbit/s	100 m

802.11a

The 802.11 standard has a maximum theoretical data flow of 54 Mbps, five times that of 802.11b, but at a range of only about thirty metres. The 802.11a standard relies on

a technology called OFDM (*Orthogonal Frequency Division Multiplexing*). It broadcasts in the 5 GHz frequency range and uses 8 non-overlapping channels.
Because of this, 802.11a devices are incompatible with 802.11b devices. However, there are devices that incorporate both 802.11a and 802.11b chips, called "**dual band**" devices.

Hypothetical speed (indoors)	Range
54 Mbits/s	10 m
48 Mbits/s	17 m
36 Mbits/s	25 m
24 Mbits/s	30 m
12 Mbits/s	50 m
6 Mbits/s	70 m

802.11b

The 802.11b standard allows for a maximum data transfer speed of 11 Mbps, at a range of about 100 m indoors and up to 200 metres outdoors (or even beyond that, with directional antennas.)

Hypothetical speed	Range (indoors)	Range (outdoors)
11 Mbits/s	50 m	200 m
5.5 Mbits/s	75 m	300 m
2 Mbits/s	100 m	400 m
1 Mbit/s	150 m	500 m

802.11g

The 802.11g standard allows for a maximum data transfer speed of 54 Mbps at ranges comparable to those of the 802.11b standard. What's more, as the 802.11g standard uses the 2.4GHz frequency range with OFDM coding, this standard is compatible with 802.11b devices, with the exception of some older devices.

Hypothetical speed	Range (indoors)	Range (outdoors)

54 Mbits/s	27 m	75 m
48 Mbits/s	29 m	100 m
36 Mbits/s	30 m	120 m
24 Mbit/s	42 m	140 m
18 Mbit/s	55 m	180 m
12 Mbit/s	64 m	250 m
9 Mbit/s	75 m	350 m
6 Mbit/s	90 m	400 m

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