Wi-Fi® Technology presentation

Topics

- Background
- Benefits
- 802.11 Architecture
- Wi-Fi Future
- Wi-Fi® Alliance
- Certification
- More Information

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The IEEE 802.11 specification is an international standad describing the characteristics of a wireless Local Area Network

The term *Wi-Fi* suggests *Wireless Fidelity*, resembling the long-established audio-equipment classification term *high fidelity*

Background

Background

- **1990 : 802.11 development started by IEEE**
  The aim was to develop a standards for medium access control (MAC) and physical layer (PHY)

- **1997 : First version of 802.11 standard was ratified**
  First version delivered 1Mb/s and 2Mb/s data rates

- **1999 : 802.11a and 802.11b amendments were released**
  Data rates improved to 5.5Mb/s and 11Mb/s at 2.4GHz (802.11)
  Wired Equivalent Privace (WEP) introduced
  5GHz operation with OFDM modulation at 54Mb/s (802.11a)

- **2001 : FCC approved the use of OFDM at 2.4GHz**

- **2003 : OFDM modulation at 54Mb/s at 2.4GHz (802.11g)**

Background

- **2009 : 801.11n amendment were ratified**

  PHY relies heavily on multiple-input multiple-output (MIMO) technology

  Can use both 2.4Ghz and 5Ghz at the same time

  Throughput increased even up to 600Mbps

- **2009 : Bluetooth 3.0 + HS**

  802.11 selected as the Bluetooth high speed channel

- **2009 : Wi-Fi direct specification introduced**

- **2011 : 802.11ac under development**

  More throughput with wider bandwith, more MIMO streams and wider 256-QAM modulation. Provides 500-1000Mbps throughput

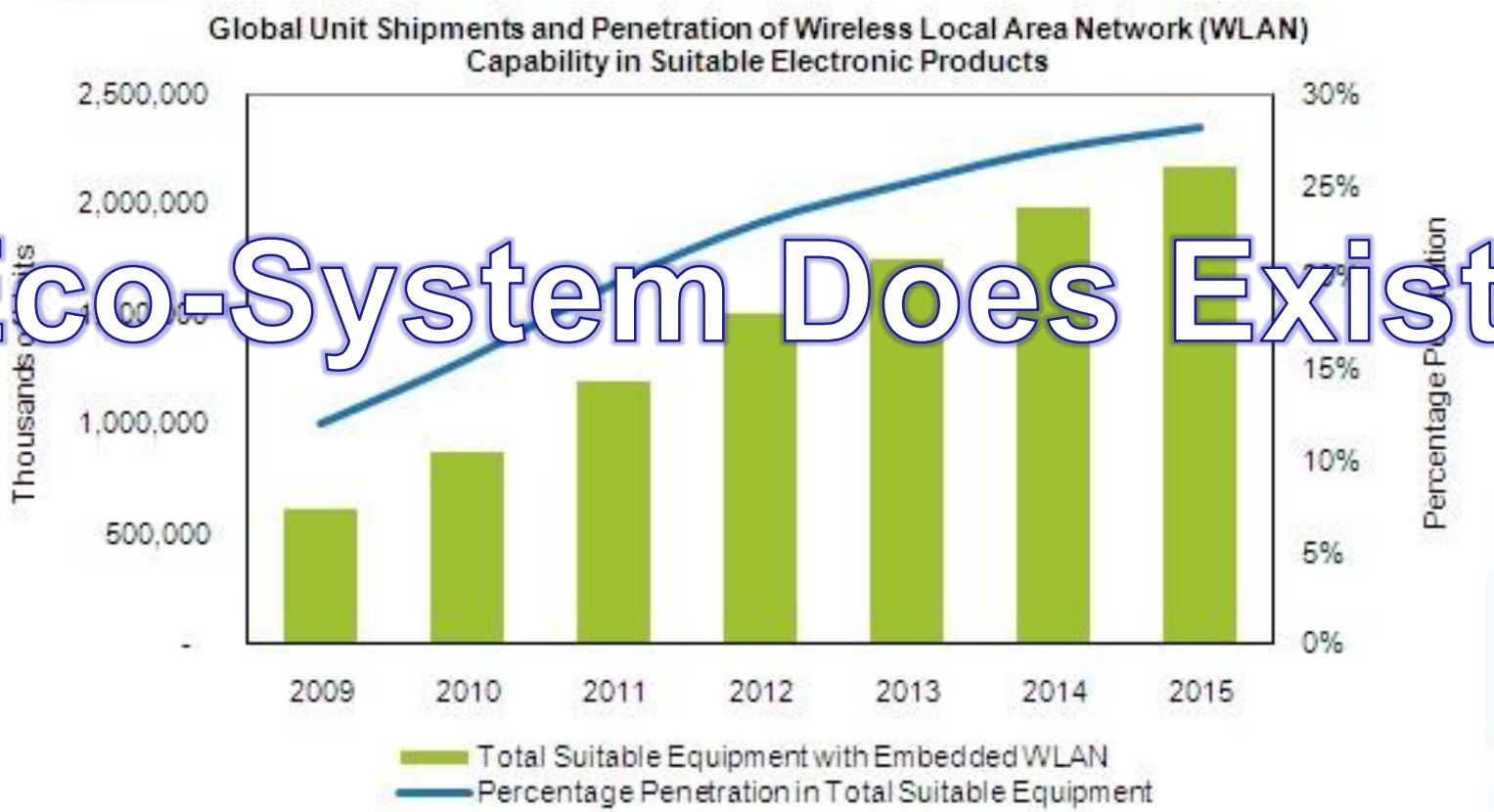
Benefits

Benefits of Wi-Fi

- Mobility
- Compatibility with IP networks
- High speed data
- Unlicenced frequencies
- Security
- Easy and fast installation
- Scalability
- Installed infrastucture
- Low cost

Eco-System Growth

- The number of Wi-Fi products is growing steadily.

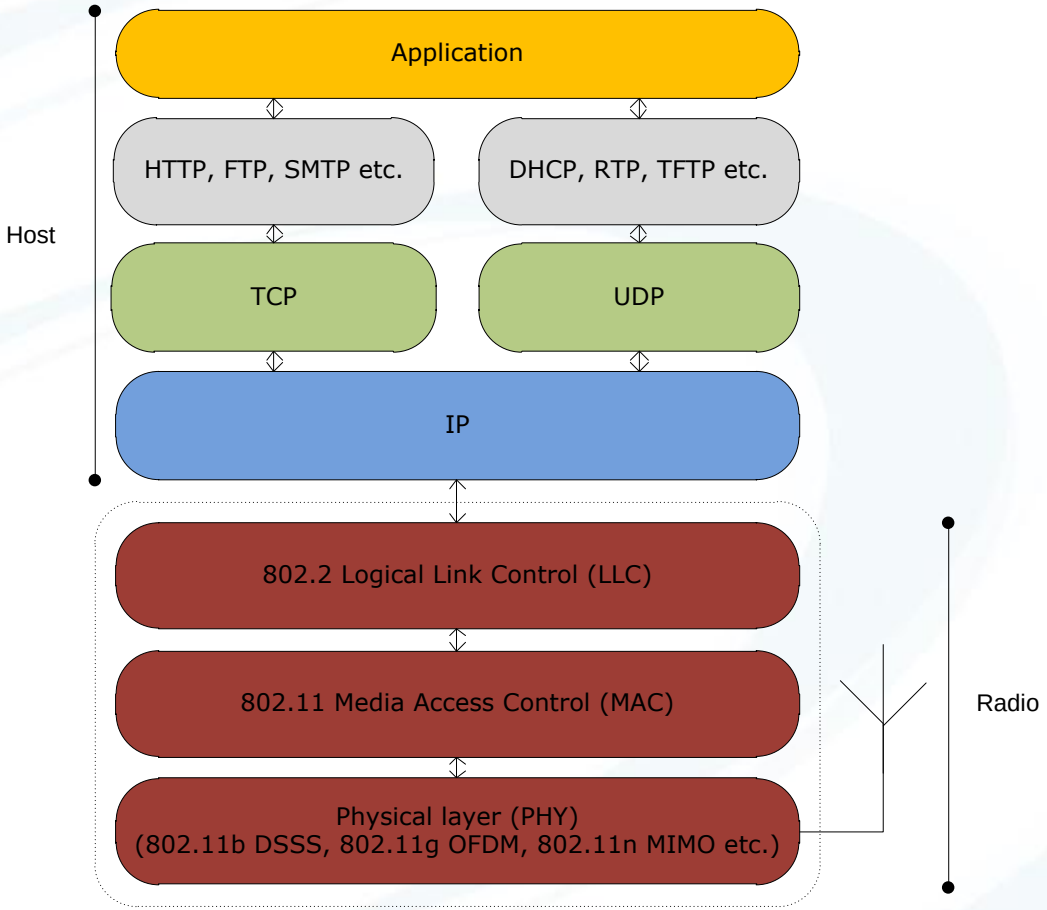


Eco-System Does Exist!

By iSuppli Market Research

802.11 Architecture

802.11 Architecture



Physical layer

2.4 GHz and/or 5GHz transciever

- Industrial Scientific Medical (ISM) band
- License free

Spread spectrum technology

- FHSS, DSSS abnd OFDM modulations

FHSS (Frequency Hopping Spread Spectrum)

- Bandwidth divided into 75 1MHz channels
- Data throughput limited to 2Mbps because of hopping overhead and FCC regulations (1 Mhz channel bandwidth)
- Obsolete

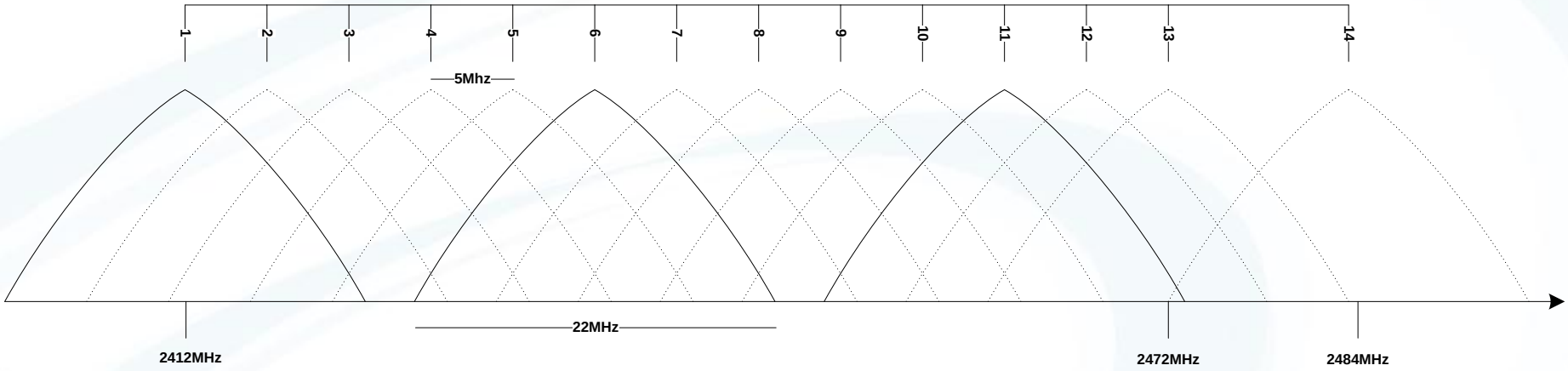
DSSS (Direct Sequency Spread Spectrum)

- Bandwidth divided into 14 22MHz channels
- Channels overlap partially

OFDM (Orthogonal Frequecy-Division Multiplexing)

- 20 or 40MHz bandwidth
- Uses several non-overlapping channels
- Channels overlap partially

Physical layer



Europe : channels 1-13

USA : channels 1-11

Japan : channels 1-14

Physical layer

Standard	Frequency	Bandwidth	Symbol rate (Mb/s)	MIMO streams	Modulation
802.11	2.4GHz	20	1, 2	1	DSSS, FHSS
802.11a	5Ghz	20	6, 9, 12, 18, 24, 36, 48, 54	1	OFDM
802.11b	2.4GHz	20	5.5,11	1	DSSS
802.11g	2.4GHz	20	6, 9, 12, 18, 24, 36, 48, 54	1	OFDM, DSSS
802.11n	2.4/5GHz	20	7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2	4	OFDM
		40	15, 30, 34, 60, 90, 120, 135, 150		

802.11 Media Access Control (MAC)

- Manages and maintains communications between 802.11 stations and clients
- Coordinates access to shared radio channels
- Uses CSMA/CA algorithm to access the media (Carrier Sense Multiple Access / Collision Avoidance)
- Similar to *Bluetooth* Link Layer

802.11 Media Access Control (MAC)

Function	Explanation
Scanning	Scanning of access points. Both active (probe) and passive (beacon) scanning are provided by the standard.
Authentication	Authentication is the process of proving identity between the client and the access point.
Association	Once authenticated, the client must associate with the access point before sending data frames.
Encryption	Encryption of payload
RTS/CTS	The optional request-to send and clear-to-send (RTS/CTS) function allows the access point to control use of the medium for stations activating RTS/CTS.
Power Save Mode	The power save mode enables the user to turn on or off enables the radio.
Fragmentation	The fragmentation function enables an 802.11 station to divide data packets into smaller frames.

Logical Link Control (LLC)

- **The LLC provides end-to-end link control over 802.11-based wireless LAN**

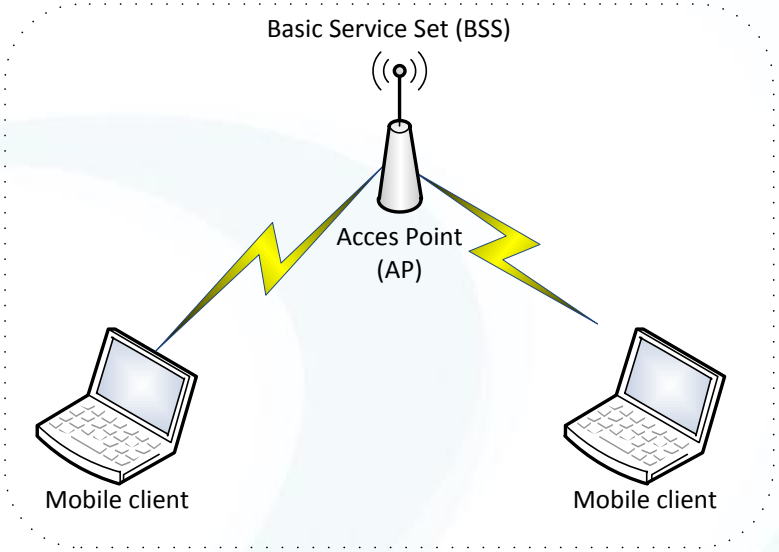
LLC services:

- **Unacknowledged connectionless service**
  - Higher layers must take care of error and flow control mechanisms
  - Peer-to-peer, multicast and broadcast communication
- **Connection-oriented service**
  - Error and flow control
  - Peer-to-peer communication
- **Acknowledged connectionless service**
  - Flow and error control with stop-and wait ARQ
  - Peer-to-peer, multicast and broadcast communication

Infrastructure

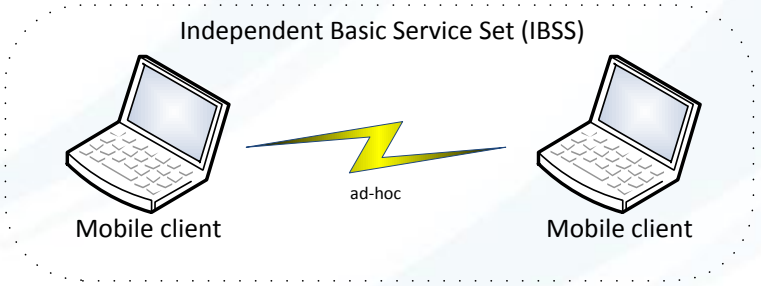
Basic Service Set (BBS)

- A set of stations controlled by a single “Coordination Function”
- Typically uses an Access Point (AP)
- All mobile stations must be accessible by the access point of the infrastructure BSS
- In the infrastructure network, stations must associate with the access point in order to get access to network services



Independet Basic Service Set (IBBS)

- A BSS without an Access-Point
- ad-hoc networking



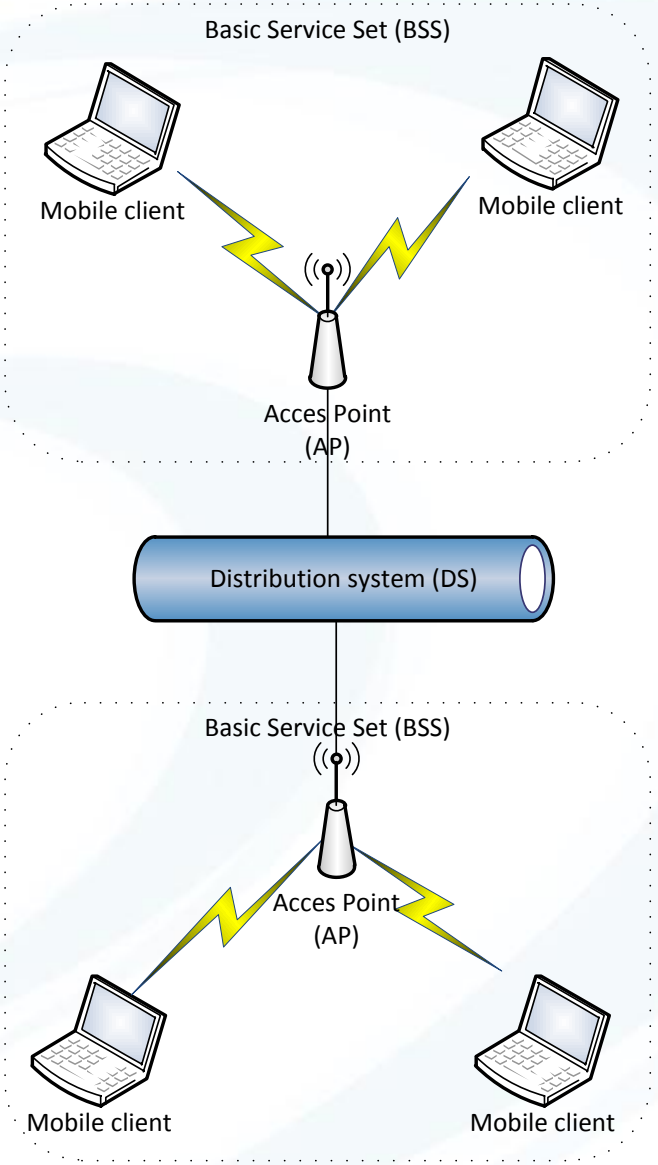
Infrastructure

Extended Service Set (ESS)

- A set of one or more Basic Service Sets interconnected by a Distribution System (DS)
- Traffic always flows via Access-Point

Distribution System (DS):

- A system to interconnect two or more BSS
- Typically wired Ethernet
- Could be also wireless like 802.11, WiMax, 3G/4G etc.



Infrastructure

AP – client services:

- Authentication : open, shared key or WPS
- De-authentication
- Privacy : WEP, WPA or WPA2

Distribution System services:

- Association : maps the client into the distribution system via access point
- Disassociation : release of association
- Distribution : used to deliver MAC frames across the distribution system
- Integration : enables delivery of MAC frames between DS and non 802.11
- Re-association : transition of association from one access point to an other

Security

Security

The 802.11 provides the following security features

- **Association**
  Client needs to associate with the Access Point

- **Authentication**
  Authentication is either open, shared key or WPS

- **Access control**
  Access Point can decide which clients are allowed to assiciate based on MAC address

  Trivial to spoof MAC address

Security

- **Encryption**

Wired Equivalent Privacy (WEP)	(insecure)
Wireless Protected Access (WPA)	(insecure)
Wireless Protected Access 2 (WPA2)	(recommended)
WAPI	(for China)

- **Data integrity**
  Data can not be modified on-the-fly. Quaranteed by encryption.

- **Data confidentiality**
  No eavesdropping with decryption of data. Quaranteed by encryption.

Security

- **Wired Equivalent Privacy (WEP)**

Wired Equivalent Privacy. This encryption standard was the original encryption standard for wireless.

Security issues known since 2001, can be cracked in <1minute

- **Wirelsss Protected Access (WPA)**

A software/firmware improvement over WEP. WPA is a trimmed-down version of the 802.11i security standard that was developed by the IEEE 802.11 to replace WEP.

WPA uses TKIP for encryption, some routers also support AES.

Security issues known since 2008 in TKIP, considered unsecure

- **WLAN Authentication and Privacy Infrastructure (WAPI)**

A wireless security standard defined by the Chinese government.

Must be supported by cell phones sold in China.

Security

Wireless Protected Access 2 (WPA2)

- WPA2 is a Wi-Fi Alliance branded version of the final 802.11i standard.
- The primary enhancement over WPA is the inclusion of the AES-CCMP algorithm as a mandatory feature.
- The CCMP/AES algorithm is considered secure, given a good enough password
- WPA2 Personal (WPA2-PSK): Uses a password, common.
- WPA2 Enterprise (WPA2-RADIUS): Certificates on server

Note: Wi-Fi Alliance will mandate Wi-Fi CERTIFIED products only to support WPA2 CCMP/AES

Wi-Fi Protected Setup

The standard for easy and secure establishment of a wireless home network, created by the Wi-Fi Alliance. It is not a security scheme but just a way to configure one.

The protocol is meant to allow home users who know little of wireless security.

- **PIN entry (mandatory)**
  - Commonly a numeric code printed on the AP needs to be fed to STA
- **Push button configuration (optional for STA)**
  - Configured by pressing physical button on both device and AP
- **A security problem with WPS devices was identified in 2011 allowing brute force attacks on the PIN**
  - It is expected that future AP will prevent brute force attacks
  - In the meanwhile, security researchers recommend turning disabling WPS
- **AOSS is Buffalo's proprietary equivalent to WPS**

Note: A major security flaw was revealed in December 2011

Upcoming technology

Wi-Fi Direct

- Allows Wi-Fi devices to talk to each other without the need for wireless access points
- Wi-Fi Direct essentially embeds a software access point, or "soft AP", into any device that wishes to support Direct.
- Requires support for Wi-Fi Protected Setup with its push-button or PIN-based setup.
- When a device enters the range of the Wi-Fi Direct host, it can connect to it

Primary use cases:

- Point-to-point file sharing (phones, picture frames, HDDs)
- Synchronization
- Wi-Fi tethering

Wi-Fi Multimedia - WMM

- Quality of Service (QoS) targeting multimedia applications
- Implemented on MAC layer as amendment (IEEE 802.11e)
- For queues or categories: **voice, video, best effort** and **background**. No guaranteed throughput.

WMM power save:

- Requires AP to buffer each queue
- Allows STA to request data from the queue or schedule delivery
- Power saving comes from sleeping while AP is buffering

IEEE 802.11ac

- **The next generation after IEEE 802.11n**
  433Mbit/s - 1Gbit/s datarates (not throughput)
- **Working in the 5GHz band**
- **Currently being drafted**
  Working group approval expected late 2013
  Demonstrations done, products released 2012-2013
- **Througput through wider channels**
  80MHz and 160MHz
- **More dense modulation**
  256-QAM

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Wi-Fi Alliance

Wi-Fi Alliance

- An open, non-profit organizaton responsible of : Wi-Fi standards development, marketing, Wi-Fi certification etc.
- Wi-Fi Alliance developed standards: WPA, WPA2, WMM, Wi-Fi Direct etc.
- Formed originally to resolve the interoperability issues between different manufacturers' 802.11 devices.
- Similar organization to Bluetooth SIG

Certification

Certification

- **Typical two step process:**
  Wi-Fi certification (optional)
  Regulatory testing (FCC, CE, IC, Telec etc.)

- **Consists of mandatory and optional certifications**

- **Mandatory**
  IEEE 802.11 based radio standards
  WPA and WPA2
  EAP

- **Optional**
  Wi-Fi Direct
  Wi-Fi Protected Setup
  WMM
  WMM Power save

- **Wi-Fi Alliance membership required to make the certification**

- **Gives right to use Wi-Fi logo on the product and marketing material**

More information

More information

- Bluegiga Technologies
  www.bluegiga.com

- IEEE 801.11
  www.ieee802.org/11
  www.en.wikipedia.org/wiki/IEEE_802.11

- Wi-Fi Alliance
  www.wi-fi.org
  www.wi-fi.org/knowledge_center_overview.php


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www.bluegiga.com