Lecture (02)
Introduction to Wireless Networking Concepts (II)
WLAN standard bodies

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Agenda

- WLAN modulation techniques
  - DSSS (802.11, b, g) @ 2.4Ghz
  - OFDM (a, g, n) @ 2.4 or 5Ghz (cont,..)
- WLAN common features
  - MIMO
  - Dynamic Rate Shifting
  - CSMA/CA
- Standard Bodies
  - Wireless Standards and Regulatory Committees
  - FCC
  - ETSI
- Wi-Fi Certification

Summary

Protocol	Band	Rate	Modulation
802.11	2.4G	1,2	DSSS
a	5G	54	OFDM
b	2.4G	5.5, 11	DSSS
g	2.4G	54	OFDM DSSS
n	2.4G 5G	75, 150	OFDM

DSSS (802.11, b, g) @ 2.4Ghz

- Used by 802.11b
- The transmitted signal is spread across the entire frequency spectrum
- an access point that is transmitting on channel 1 spreads the carrier signal across the 22-MHz-wide channel range of 2.401 to 2.423 GHz.
- To encode data using DSSS, you use a chip sequence.
- A chip and a bit are essentially the same thing, but a bit represents the data, and a chip is used for the carrier encoding.
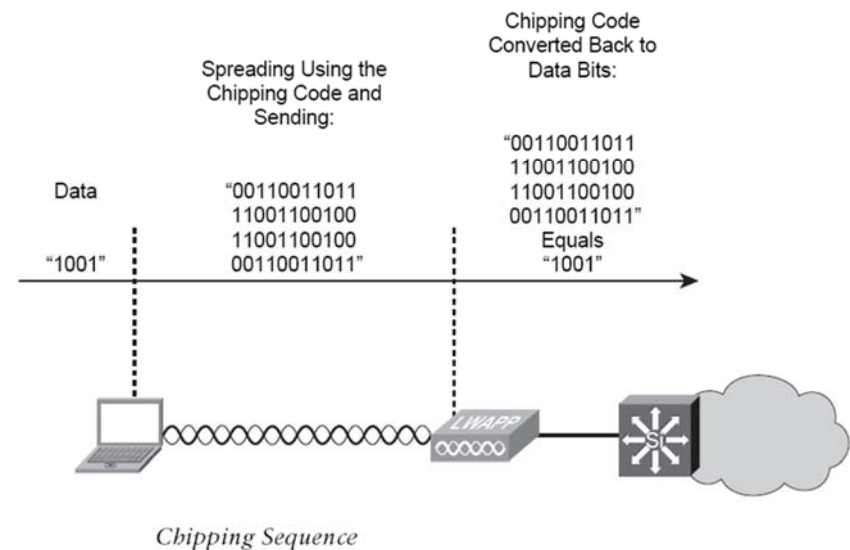
DSSS (802.11, b, g) @ 2.4Ghz (cont,..)

Chipping Codes

- The chipping code process takes each data bit and then expands it into a string of bits (*chip stream*).
- With redundant data being sent, if some of the signal is lost to noise, the data can still be understood.

DSSS (802.11, b, g) @ 2.4Ghz (cont,..)

Spreading Using the Chipping Code and Sending:

Data "1001"

"00110011011
11001100100
11001100100
00110011011"

Chipping Code Converted Back to Data Bits:

"00110011011
11001100100
11001100100
00110011011"
Equals
"1001"

Chipping Sequence

DSSS (802.11, b, g) @ 2.4Ghz (cont,..)

- the chipping code for the bit value of **1 is expanded to the chip sequence of 00110011011, and the** chipping code for the bit value of **0 is 11001100100.**
- Therefore, after the data bits are sent, 1001 creates the chip sequence.
- You can decode this chip sequence back to the value of 1001 at the receiving access point.
- Remember, because of interference, it is still possible that some of the bits in the chip sequence will be lost or inverted. This means that a 1 could become a 0 and a 0 could become a 1.

DSSS (802.11, b, g) @ 2.4Ghz (cont,..)

- This is okay, because more than five bits need to be inverted to change the value between a 1 and a 0.
- Because of this, using a chipping sequence makes 802.11 networks more resilient against interference.

00110011011	*11001100100*	*11001100100*	*00110011011*
1	0	0	1

- Also, because more bits are sent for chipping (carrier) than there is actual data, the chipping rate is higher than the data rate (data is speeded over the channel band width).

DSSS (802.11, b, g) @ 2.4Ghz (cont,..)

Chipping Codes used by DSSS in WLAN

1. Barker Code

- To achieve rates of 1 Mbps and 2 Mbps, 802.11 uses a Barker code.
- This code defines the use of 11 chips when encoding the data. The 11-chip Barker code used in 802.11 is **10110111000**.
- Certain mathematical details Barker code ideal for modulating radio waves (out of course scope)
- The basic data stream is exclusive OR'd with the Barker code to generate a series of data objects called chips.
- Each bit is "encoded" by the 11 bit Barker code, and each group of 11 chips encodes one bit of data.

DSSS (802.11, b, g) @ 2.4Ghz (cont,..)

2. Complementary Code Keying

- Barker code works well for lower data rates such as 1-Mbps, 2- Mbps.
- DSSS uses a different method for higher data rates, which allows the 802.11 standard to achieve rates of 5.5 and 11Mbps.
- Complementary code keying (CCK) uses a series of codes called complementary sequences.
- There are 64 unique code words.
- Up to 8 bits can be represented by a codeword, as opposed to the 1 bit represented by a Barker code.

DSSS (802.11, b, g) @ 2.4Ghz (cont,..)

DSSS Modulation Techniques (cont,..)

- Now that the data has been encoded using Barker code or CCK (Complementary code keying), it needs to be transmitted or modulated out of the radio antennas.

You can think of it this way:

- Encoding is how the changes in RF signal translate to the 1s and 0s.
- Modulation is the characteristic of the RF signal that is manipulated.

DSSS (802.11, b, g) @ 2.4Ghz (cont,..)

- In phase-shift keying are modulations: encoding would be that a 180-degree phase shift is a 1, and 0-degree phase shift is a 0.
- In 802.11b, the data is modulated on a carrier wave, and that carrier wave is spread across the frequency range using DSSS.
- 802.11b can modulate and encode the data using the methods seen in Table

DSSS (802.11, b, g) @ 2.4Ghz (cont,..)

DSSS Encoding Methods

Data Rate	Encoding	Modulation
1	11 chip Barker coding	DSSS Binary Phase Shift Keying
2	11 chip Barker coding	DSSS Quadrature Phase Shift Keying
5.5	8 chip encoding 8 bits CCK coding	DSSS Quadrature Phase Shift Keying
11	8 chip encoding 4 bits CCK coding	DSSS Quadrature Phase Shift Keying

OFDM (a, g, n) @ 2.4 or 5Ghz

- OFDM is not considered a spread spectrum technology, but it is used for modulation in wireless networks.
- Using OFDM, you can achieve the highest data rates with the maximum resistance to corruption of the data caused by interference.
- OFDM defines a number of channels in a frequency range. These channels are further divided into a larger number of small-bandwidth subcarriers. The channels are 20 MHz, and the subcarriers are 300 kHz wide.
- You end up with 52 subcarriers per channel.
- Each of the subcarriers has a low data rate, but the data is sent simultaneously over the subcarriers in parallel.
- This is how you can achieve higher data rates.

OFDM (a, g, n) @ 2.4 or 5Ghz (cont,..)

- OFDM is not used in 802.11b because 802.11b devices use DSSS.
- 802.11g and 802.11a both used OFDM.
- The way they are implemented is a little different because 802.11g is designed to operate in the 2.4-MHz range along with 802.11b devices.

WLAN common features

- MIMO
- Dynamic Rate Shifting
- CSMA/CA

MIMO

MIMO is a technology that is used in the new 802.11n specification.

- A device that uses MIMO technology uses multiple antennas for receiving signals (usually two or three) in addition to multiple antennas for sending signals.

- MIMO technology can offer data rates higher than 100 Mbps by multiplexing data streams simultaneously in one channel.

- In other words, if you want data rates higher than 100-Mbps, then multiple streams are sent over a bonded channel, not just one.

MIMO (cont,..)

- With the use of MIMO technology, an access point (AP) can talk to non-MIMO-capable devices and still offer about a 30 percent increase in performance of standard 802.11a/b/g networks.

Dynamic Rate Shifting (DRS)

- the farther away you get from the access point, the lower the data rates are that you can achieve, regardless of the technology.

- In 802.11 networks, operating in the 2.4-GHz range, the devices can rate-shift from 11 Mbps to 5.5 Mbps, and further to 2 and 1 Mbps, that happens without dropping your connection.

- Also, it is done on a transmission-by-transmission basis, so if you shift from 11 Mbps to 5.5 Mbps for one transmission and then move closer to the AP, it can shift back up to 11 Mbps for the next transmission.

CSMA/CA (carrier sense multiple access collision avoidance)

- Wireless networks have to deal with the possibility of collisions.

- This is because, in a wireless topology, the behavior of the AP is similar to that of a hub.

- Multiple client devices can send at the same time.

- The problem with wireless networks is that they cannot tell when a collision has occurred (half duplex).

- If you are in a wired network, a jam signal is heard by listening to the wire (CSMA/CD) it can detects collision by listing to jamming signal.

- To listen for a jam signal, wireless devices need two antennas.

CSMA/CA (carrier sense multiple access collision avoidance) (cont,..)

- They can send using one antenna while listening for a jam signal with the other.
- Although this sounds feasible, especially because MIMO technology defines the use of multiple antennas, the transmitting signal from one antenna would drown out the received signal on the other, so the jam signal would not be heard.

CSMA/CA (carrier sense multiple access collision avoidance) (cont,..)

- So WLAN need to avoid collisions as it can't detect them.
- Collision avoidance means that when a device wishes to send, it must listen first.
- If the channel is considered idle, the device sends a signal informing others that it is going to send data and that they should not send.
- It then listens again for a period before sending. Another way to supplement this is using request to send (RTS) and clear to send (CTS) packets.

CSMA/CA (carrier sense multiple access collision avoidance) (cont,..)

- With the RTS/CTS method, the sending device uses an RTS packet, and the intended receiver uses a CTS packet.
- This alerts other devices that they should not send for a period.

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Wireless Standards and Regulatory Committees

- To ensure that certain rules governing the use of wireless RF are adhered to,
- A numerous country-specific organizations and global committees monitor standards and usage of RF bands.
- Regulatory committees and organizations ensures the proper use of RF bands and interoperability of equipment.
- it's likely that people could not connect from place to place with out these organizations.
- The main organizations or committees are
  - FCC
  - ETSI
  - IEEE

FCC

- Federal Communications Commission (FCC)
- is an independent agency in the United States
- that regulates communication methods.
- It is held directly responsible by Congress.
- It is the FCC in the United States that
  - governs the frequency ranges that can be used without a license,
  - the transmit power of devices,
  - the types of devices that can be used indoors as well as outdoors,
  - and how the various types of hardware can be used

FCC (cont,..)

Samples of FCC requirements

1. FCC, Antenna Requirements

- Antennas must use a unique nonstandard connector that cannot be acquired easily, to ensure that home users and noncertified installers cannot easily deploy an antenna.
- Suppliers use a connector known as the Reverse-Polarity-Threaded Neil-Concelman (RP-TNC) connector

RP-TNC PLUG

FCC (cont,..)

2. FCC, power output rules

- Effective Isotropic Radiated Power (EIRP) is a way to measure the amount of energy radiated from an antenna.
- FCC rules state that and wireless device EIRP doesn't not exceed that mandated EIRP.
- **point-to-point scenarios**
  - You can have a maximum of 36-dBm EIRP.
  - You can have a maximum of 30-dBm transmitter power with 6-dBi gain of antenna and cable combined.
  - You are allowed a 1:1 ratio of power to gain.
- * 1:1 means could drop the transmit power by 1 dBm and increase the gain by 1 dBm

FCC (cont,..)

point-to-multipoint scenarios

- You can have a maximum of 36-dBm EIRP.
- You can have a maximum of 30-dBm transmitter power with 6-dBi gain of antenna and cable combined.
- You are allowed a 3:1 ratio of power to gain.

*3:1 means could drop the transmit power by 3 dBm and increase the gain by 1 dBm

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FCC (cont,..)

Point 2 Point EIRP

	Transmitter Power	Maximum Gain	EIRP
FCC Maximum	30-dBm	6-dBm	36-dBm

Point 2 Multi Point EIRP

	Transmitter Power	Maximum Gain	EIRP
FCC Maximum	30-dBm	6-dBm	36-dBm

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ETSI

- The European Telecommunication Standards Institute (ETSI) is the not-for-profit organization that standardizes the frequencies and power levels used in Europe as well as many countries (including Egypt)
- The European Commission (EC) recognizes ETSI as an official European Standards Organization.
- Many of the mandates for wireless usage come from the EC.
- Then, ETSI defines various standards based on these mandates.

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ETSI (cont,..)

ETSI power output rule

- For point-to-multipoint and on point-to-point scenarios
  - 20-dBm EIRP
  - 17-dBm maximum transmit power
  - 3-dBi gain.
  - You are allowed a 1:1 ratio of power to gain.
- Of course, a professional installer can increase the gain as long as he or she lowers the transmit power below 17 dBm at a ratio of 1:1.
- Therefore, a professional installer could drop the transmit power by 1 dBm and increase the gain by 1 dBm and still stay within the guidelines.

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ETSI (cont,..)

Environments   *ETSI EIRP Standards for Point-to-Point and Point-to-Multipoint*

	Transmitter Power (dBm)	Maximum Gain (dBi)	EIRP (dBm)
Governing Body Maximum	17	3	20
Cisco Integrated Antennas	17	2.2	19.2
Reduced Tx Power	15	5	20
Reduced Tx Power	13	7	20
Reduced Tx Power	7	13	20
Reduced Tx Power	0	20	20

IEEE

- The Institute of Electrical and Electronics Engineers (IEEE) is a not-for-profit organization that has more than 370,000 members globally.
- The IEEE's "Wireless Standards Zone" is dedicated to standards that are related to wireless technology.
- Here you can find information about the 802 protocols, such as the following:
■ **802.11: The Working Group for Wireless LAN (WiFi)**
■ **802.15: The Working Group for Wireless PAN (BlueTooth)**
■ **802.16: The Working Group for Broadband Wireless Access Standards (WiMax)**

IEEE (cont,..)

- IEEE defines a few protocols for WLAN (802.11)
- 802.11a, 802.11b, 802.11g, and 802.11n protocols

Wi-Fi Certification

- The Wi-Fi Alliance is a not-for-profit organization that certifies the interoperability of more than 4200 products.
- The Wi-Fi Alliance was formed in 1999 and currently has more than 300 members in more than 20 countries.
- What makes this organization different from the ETSI, FCC, and IEEE is that it gives its seal of approval to devices that plan in interoperability.
- notice that the 802.11a, 802.11b, and 802.11g protocols are certified if the device can use them as well as security protocols such as WPA and WPA2.

Thanks,

See you next Week, isA

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