WIRELESS FIDELITY(WI-FI) IEEE 802.11

CDAC-Mumbai

Governing Standards Body

- Formed in 1999
- Founding Companies:
  - 3Com
  - Aironet
  - Harris Semi Conductor
  - Lucent
  - Symbol Technologies
  - Nokia
- The term Wi-Fi was created by the Wireless Ethernet Compatibility Alliance (WECA).
- Products certified as Wi-Fi compliant are interoperable with each other even if they are made by different manufacturers.

IEEE 802.11 Standard

- The standard for wireless local area networks (WLANs) and Personal Area Networks.
- Operates in the 2.4 GHz industrial, scientific and medical (ISM) band
- Standard defines the physical (PHY) and medium access control (MAC) layers
- DSSS, FHSS or OFDM
- Extensions (IEEE 802.11b, IEEE 802.11a, etc.) allow for operation at higher data rates.

IEEE 802.11(Physical Medium Specifications)

- **D**irect-**S**equence **S**pread **S**pectrum**(DSSS)**
  - Used in 802.11, 802.11b, 802.11g standard
  - Operating in 2.4 GHz ISM band
  - Data-rates of 1 Mbps or 2 Mbps(Optional)
- **O**rthogonal **F**requency **D**ivision **M**ultiplexing(OFDM)
  - Used in 802.11a, 802.11g standard
  - Operating in 5GHz or 2.4 GHz ISM band
  - Data rates of 54Mbps
- **F**requency-**H**opping **S**pread **S**pectrum**(FHSS)**
  - Used in 802.11 standard
  - Operating in 2.4 GHz ISM band
  - Data rates of 1 or 2 Mbps(Optional)

DSSS(Direct Sequence Spread Spectrum

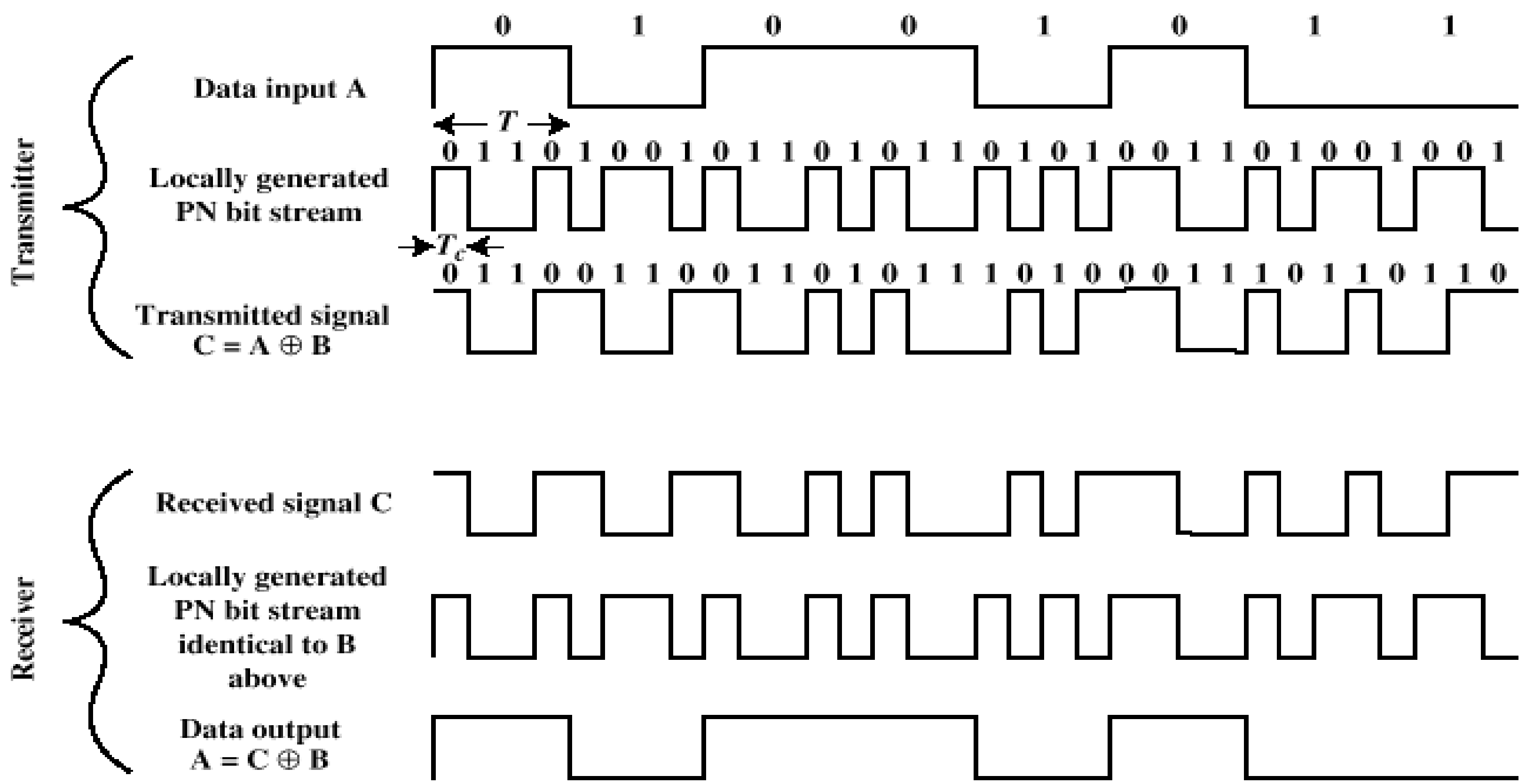


Figure 7.6 Example of Direct Sequence Spread Spectrum

IEEE 802.11

- uses **2.4 – 2.483 GHz band or 5.15 - 5.825 GHz band**

- Specifically, the frequencies used by 802.11 fall in the unlicensed bands, these are frequency bands which anyone can use for radio communication (without a license) as long as their radio waves do not radiate too much power.

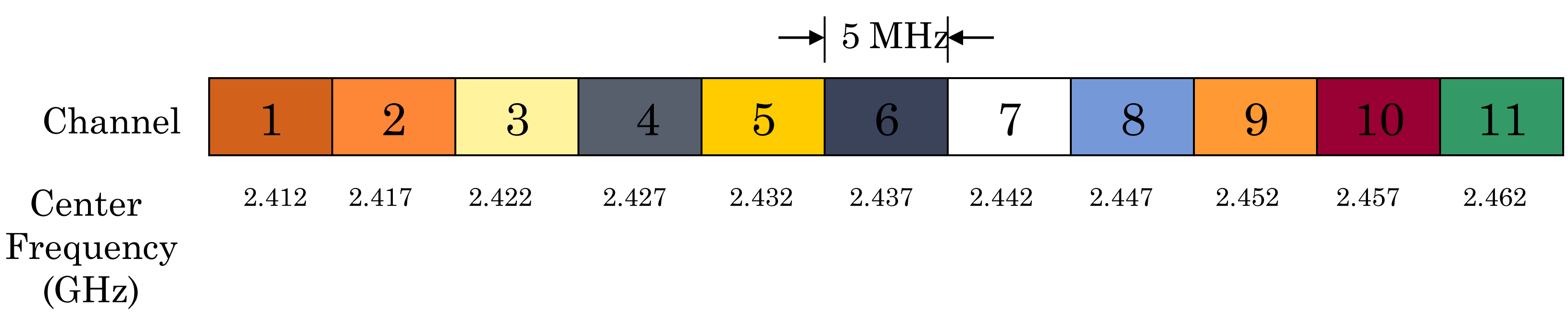
- The exact frequencies used (and how they are used) depends on whether the system follows 802.11b, 802.11a, or 802.11g.

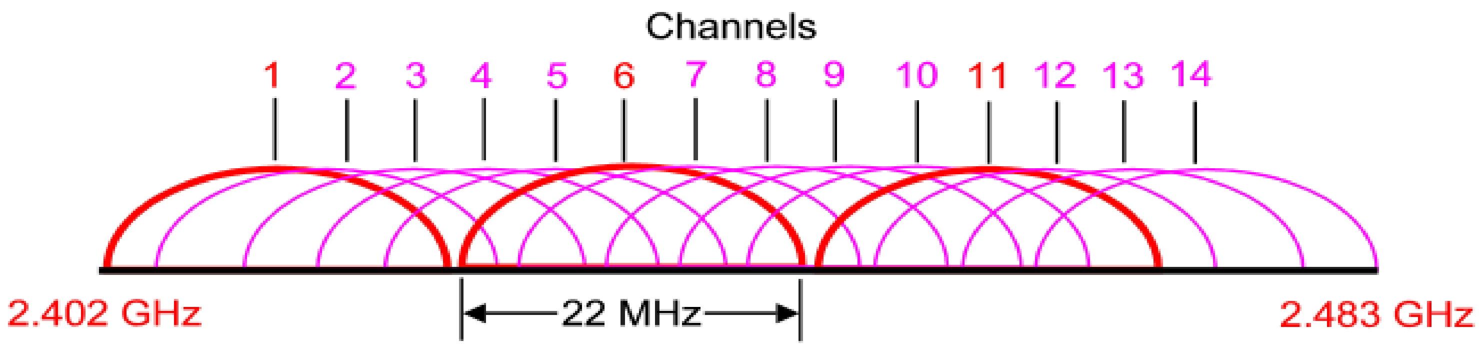
802.11 A/B/G

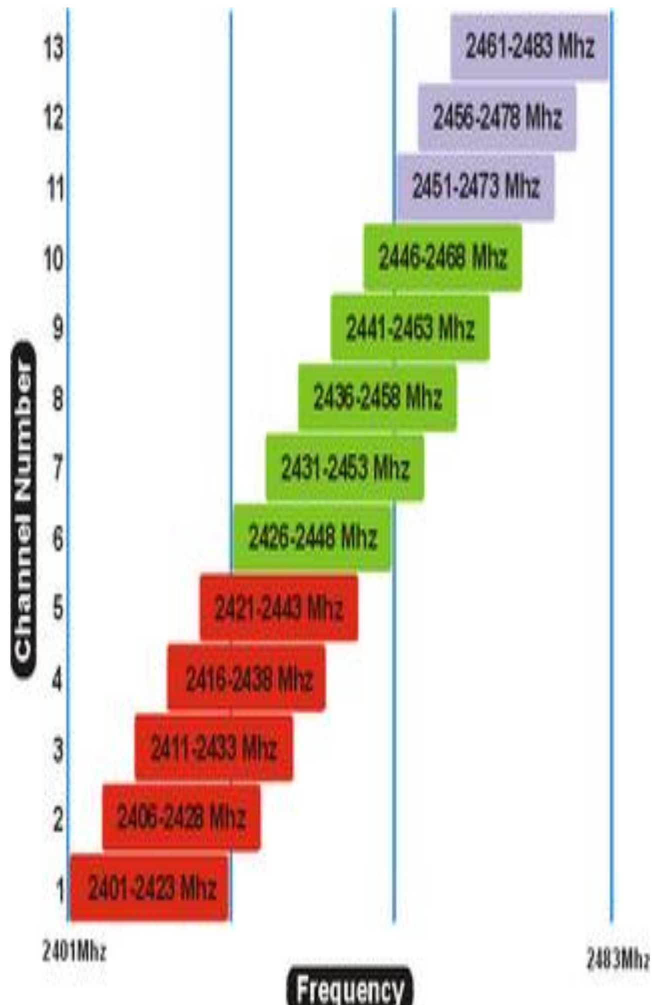
Standard	Frequency	Speed	Range
WiFi A (802.11a)	5 GHz	54 Mbit/s	10 m
WiFi B (802.11b)	2.4 GHz	11 Mbit/s	100 m
WiFi G (802.11g)	2.4 GHz	54 Mbit/s	100 m

802.11B

- The 802.11b standard defines a total of 14 frequency channels.
- FCC(Federal Communication Commission)allows channels 1 through 11 within the U.S. Most of Europe can use channels 1 through 13. In Japan, only 1 choice: channel 14.
- Channel represents a center frequency. Only 5 MHz separation between center frequencies of channels.




Channels
1 2 3 4 5 6 7 8 9 10 11 12 13 14
2.402 GHz
22 MHz
2.483 GHz

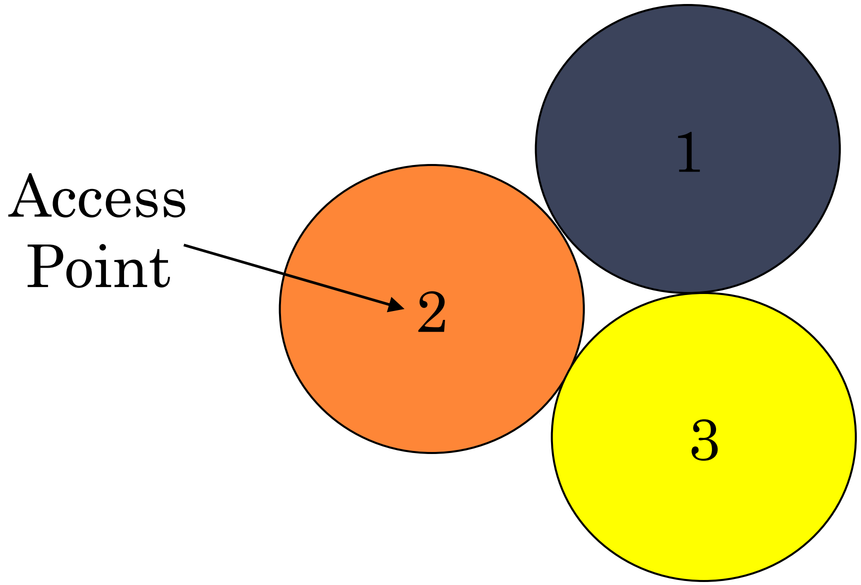

Channel Number
13
2461-2483 Mhz
12
2456-2478 Mhz
11
2451-2473 Mhz
10
2446-2468 Mhz
9
2441-2463 Mhz
8
2436-2458 Mhz
7
2431-2453 Mhz
6
2426-2448 Mhz
5
2421-2443 Mhz
4
2416-2438 Mhz
3
2411-2433 Mhz
2
2406-2428 Mhz
1
2401-2423 Mhz
2401Mhz
2483Mhz
Frequency

802.11b (Cont'd)

- Any 802.11b signal occupies approximately 30 MHz.
- Thus, 802.11b signal overlaps with several adjacent channel frequencies.
- Only three channels (channels 1, 6, and 11 for the U.S.) that can be used without causing interference between access points.
- Any given area can therefore support at most 3 access points (operating on different channels) at once. Equivalently, it can at most support three local ad-hoc connections.

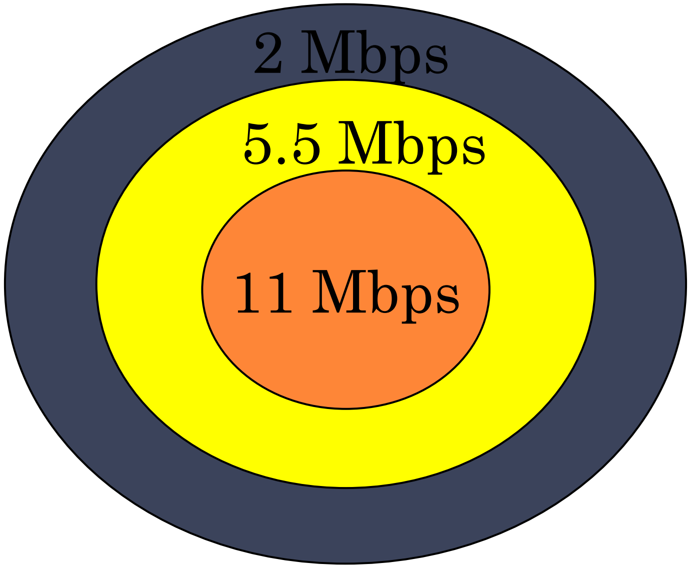
802.11B (CONT'D)

Neighboring AP's use different channels to reduce interference. "Reuse cluster" size is equal to 3.



802.11b (Cont'd)

- Ideally, 802.11b supports wireless connections between an access point and a wireless device at four possible data rates: 1 Mbps, 2 Mbps, 5.5 Mbps, and 11 Mbps.
- Specifically, as terminal travels farther from its AP, the connection will remain intact but connection speed decreases (falls back).



802.11A

- 802.11a specification operates at radio frequencies between 5.15 and 5.825 GHz, i.e. 802.11a utilizes 300 MHz bandwidth in Unlicensed National Information Infrastructure (U-NII) band.

- The FCC has divided total 300 MHz in this band into three distinct 100 MHz bands: low, middle, and high, each with different legal maximum power.

	Band	Channel	Max Power
High band	5.725-5.825 GHz	9-12	1000 mW
Middle band	5.25-5.35 GHz	5-8	250 mW
Low band	5.15-5.25 GHz	1-4	50 mW

802.11a (Cont'd)

- Because of high power output, high band used for building-to-building products. Lower two bands suitable for in-building wireless products.

- In 802.11a, radio signals are generated using a method called Orthogonal Frequency Division Multiplexing (OFDM).

- OFDM is defined over the lower two bands (low and middle).

802.11A (CONT'D)

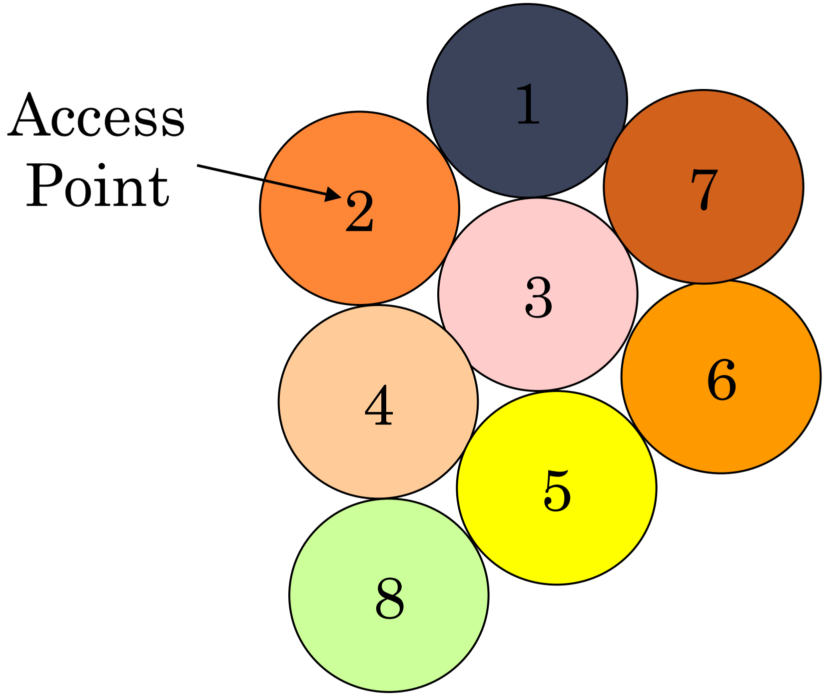
- The low and middle bands have a total of 200 MHz of frequency.
- This 200 MHz supports 8 non-overlapping channels.
- Each channel is split in 52 bands, each approximately 300 kHz wide.
- Each of these smaller bands is called a subcarrier in OFDM terminology.
- In OFDM, a transmitter can select some number of subcarriers to transmit a signal over.

802.11a (Cont'd)

- Depending on the number of subcarriers chosen, the transmitter can achieve transmission rates of 6, 9, 12,18, 24, 36, 48, or 54 Mbps.
- Since there are eight non-overlapping channels, 802.11a can support 8 different access-point to wireless device links in a given location. Or equivalently, it can support at most 8 ad hoc connections simultaneously.
- This is an improvement over 802.11b, where only 3 could be supported.

802.11a (Cont'd)

Neighboring AP's use different channels to reduce interference. "Reuse cluster" size is equal to 8.

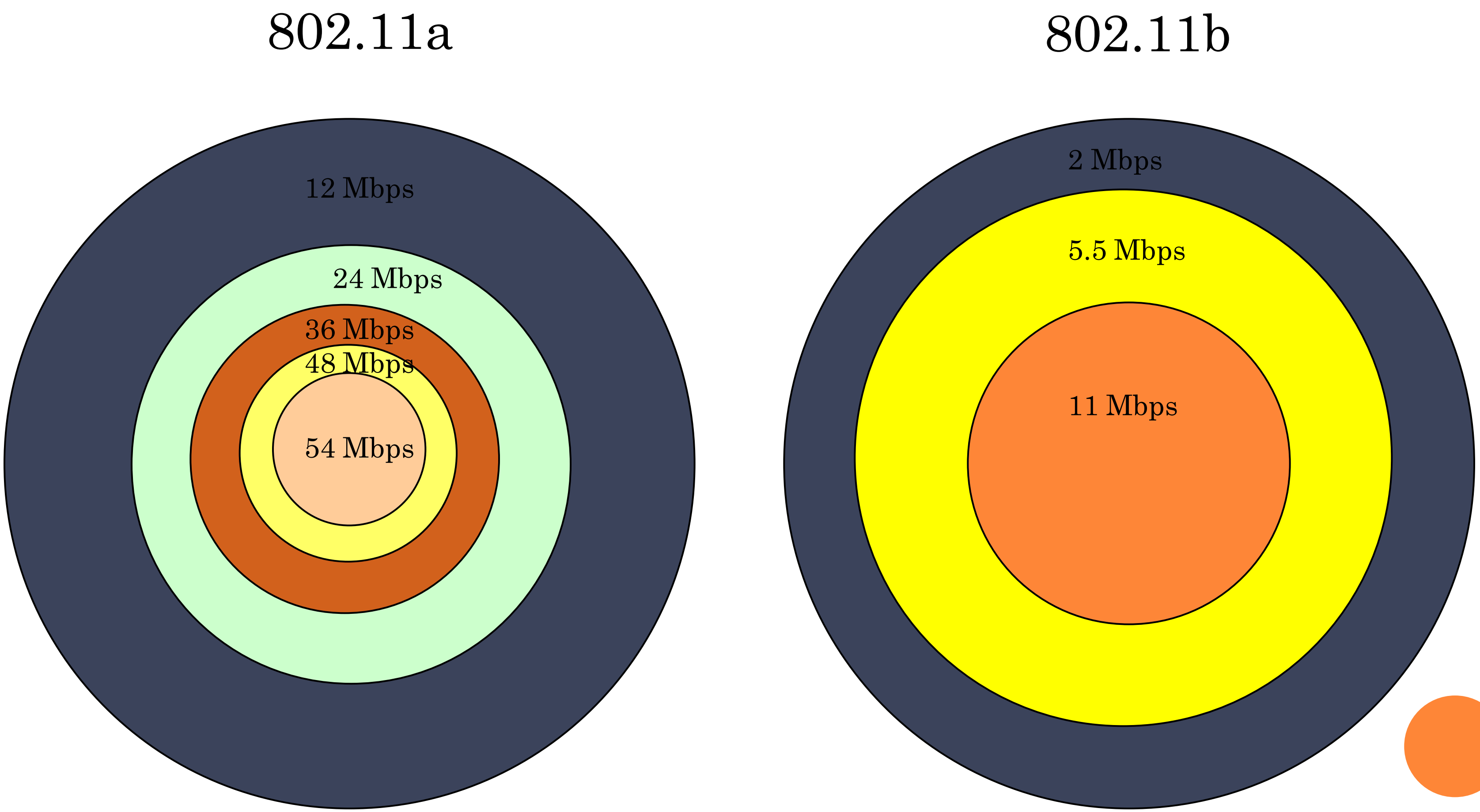


802.11a (Cont'd)

- The various data rates are supported in 802.11a by varying the number of subcarriers, the modulation scheme, etc.

- 802.11a (like 11b) has a rate fall back mechanism, i.e., as the distance between the transmitter and receiver increases, the supported data rate decreases.

802.11a (Cont'd)



802.11G

- 802.11g offers throughput of 802.11a with backward compatibility of 802.11b.
- 802.11g operates over 3 non-overlapping channels.
- 802.11g operates in 2.4 GHz band but it delivers data rates from 6 Mbps to 54 Mbps.
- 802.11g also uses OFDM but supports spread-spectrum capabilities if any one component of the system has older equipment, i.e., 802.11b equipment.

802.11G

- Once again, 802.11g's "backward compatibility" with 802.11b means that when a mobile 802.11b device joins an 802.11g access point, all connections on that access point slow down to 802.11b speeds.
- So both 11a and 11g offer the same data rates. Which is better?

802.11 (Cont'd)

Generally, 802.11a is the most expensive of the three options.

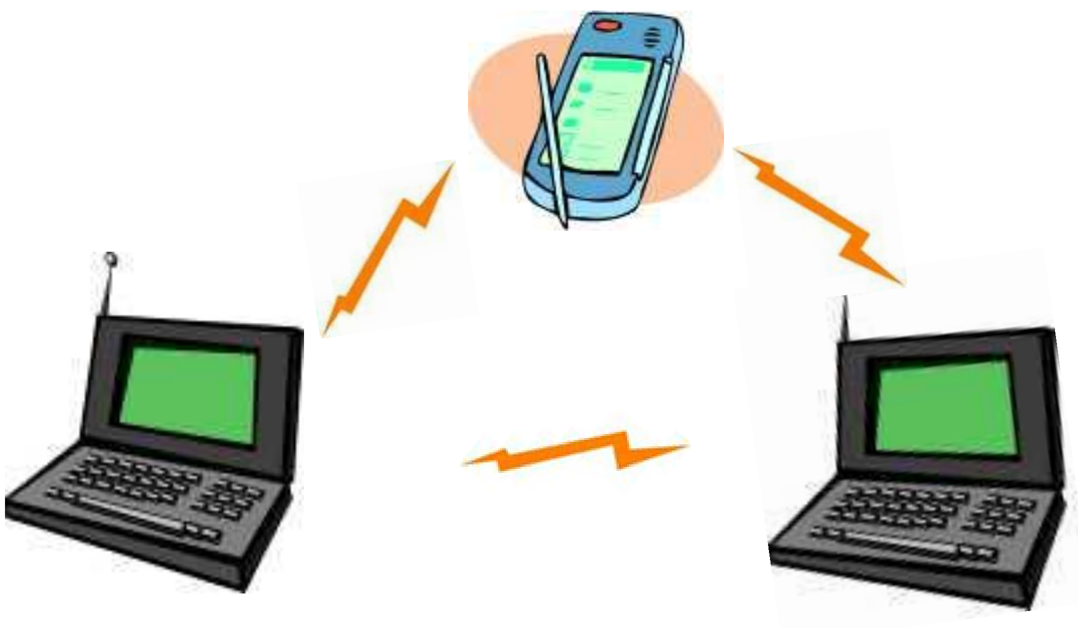
802.11b is the cheapest and most popular WLAN option.

802.11g is more expensive than 11b but cheaper than 11a.

Because of its smaller range, 11a requires more Access Points to a region, thereby increasing cost.

WLAN Architecture—Ad Hoc Mode

- **Ad-Hoc mode:** Peer-to-peer setup where clients can connect to each other directly. Generally not used for business networks.

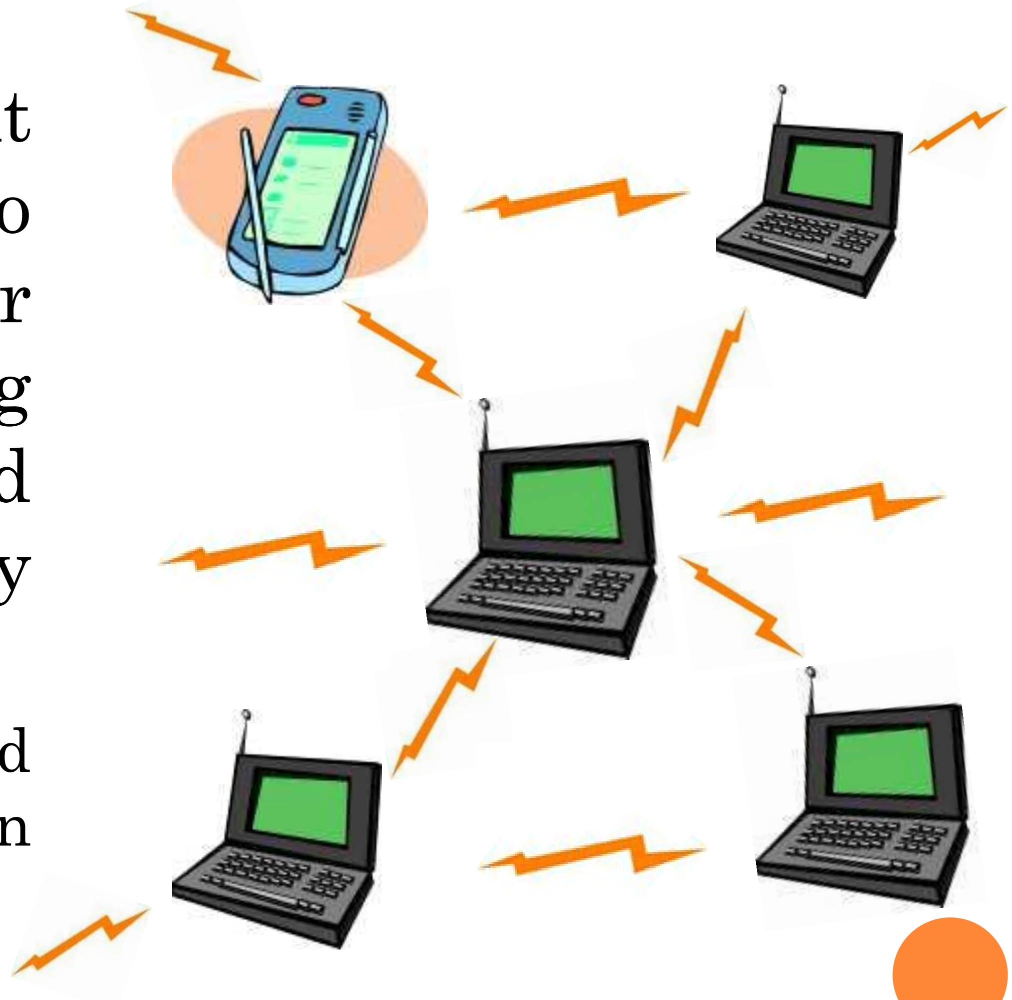


Ad Hoc Structure

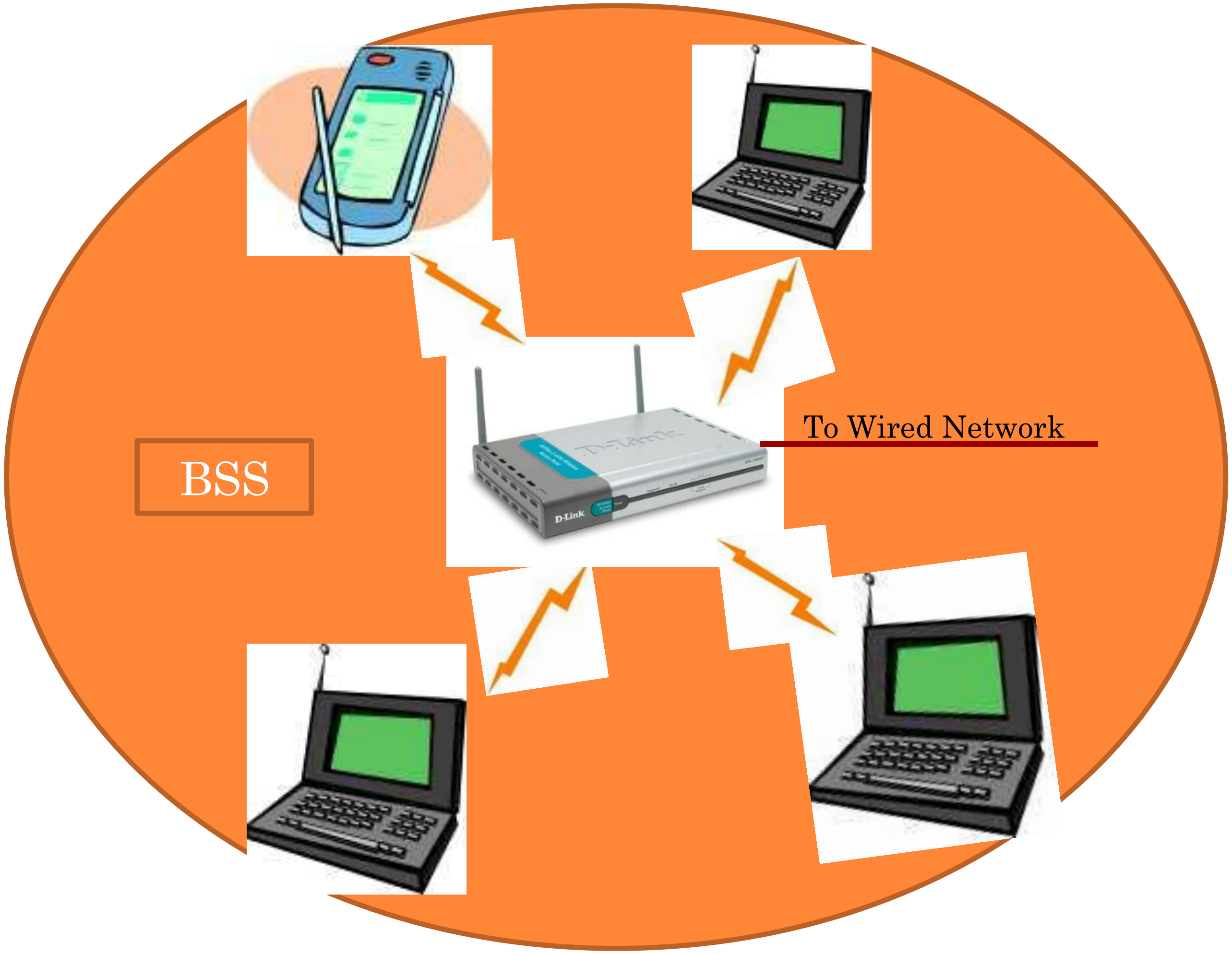
- Mobile stations communicate to each other directly.
- It's set up for a special purpose and for a short period of time. For example, the participants of a meeting in a conference room may create an ad hoc network at the beginning of the meeting and dissolve it when the meeting ends.

WLAN ARCHITECTURE--MESH

- **Mesh:** Every client in the network also acts as an access or relay point, creating a "self-healing" and (in theory) infinitely extensible network.
  - Not yet in widespread use, unlikely to be in homes.



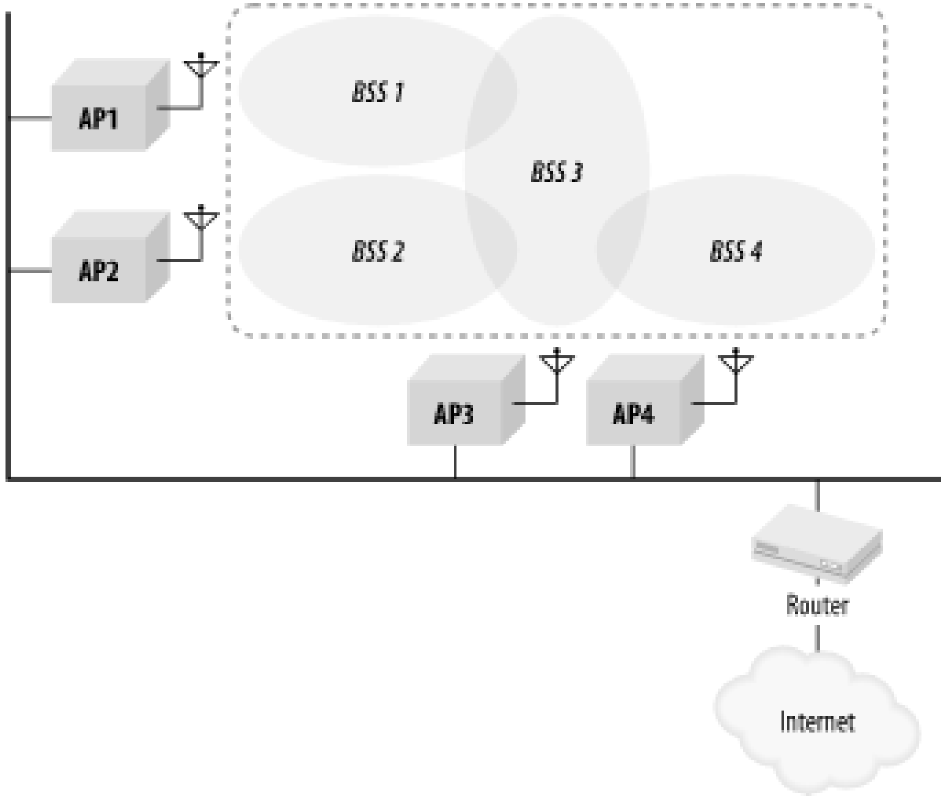
WLAN Architecture—Infrastructure Mode



Infrastructure network

- There is an Access Point (AP), which becomes the hub of a "star topology."
- Any communication has to go through AP. If a Mobile Station (MS), like a computer, a PDA, or a phone, wants to communicate with another MS, it needs to send the information to AP first, then AP sends it to the destination MS
- Multiple APs can be connected together and handle a large number of clients.
- Used by the majority of WLANs in homes and businesses.

Extended Service Area



Roaming

- In an extended service area, a mobile station (MS) can roam from one BSS (Basic Service Set) to another.
- Roughly speaking, the MS keeps checking the beacon signal sent by each AP and select the strongest one and connect to that AP.
- If the BSSs overlap, the connection will not be interrupted when an MS moves from one set to another. If not, the service will be interrupted.
- Two BSSs coverage areas can largely overlap to increase the capacity for a particular area. If so, the two access points will use different channels.

CSMA/CA(MAC Layer Protocol)

- Before a station transmits, it "listens" to the medium to determine if another station is transmitting. If the medium is quiet, the station recognizes that this is an appropriate time to transmit.
- If the Channel is busy the node keep sensing the channel and if it is free for a period of DIFS , the node waits for some random back-off interval and transmits its frame.
- When the destination receives the frame, it has to send an acknowledgement(ACK).
- To send ACK, the destination will sense the medium and if it is free for a pre-defined short time(Short inter frame space SIFS), the ACK is sent.

CSMA/CA(MAC Layer Protocol)

- What we need is a polite contention method to get access to the medium; this is the collision avoidance part of CSMA/CA.
- 802.11 has come up with two ways to deal with this kind of collision.
- One uses a two-way handshake when initiating a transmission.
- The other uses a four-way handshake.

2 Way Handshake

- Node with packet to send monitors channel.
- If channel idle for specified time interval called DIFS, then node transmits.
- If channel busy, then
  - node continues to monitor until channel idle for DIFS.
  - At this point, terminal backs-off for random time (collision avoidance) and attempts transmitting after waiting this random amount of time.

2 Way Handshake

- If the node does not back-off the random time, then it will definitely collide with another node that has something to send.
- Reason for **random** back-off time is that if I choose a random time and you choose a random time, the probability that we choose the same random time is slim.
- This way we both back-off transmitting and will therefore will probably not interfere with each other when we are ready to transmit.

2 Way Handshake (Cont'd)

- First way of the 2 way handshake was for the transmitter to send its information packet to the destination node, after following the collision avoidance method described above.

- If the packet reaches the destination without problems, the destination sends a short packet over the wireless medium acknowledging the correct reception.

- This packet is typically called an ACK packet. ACK is the second way of the 2 way handshake.

4 Way Handshake

- "Listen before you talk"
- If medium is busy, node backs-off for a random amount of time after waiting DIFS, just as before.
- But now, instead of packet, sends a short message: Ready to Send (RTS). This message is basically attempting to inform others that "I have something to send."

4 Way Handshake (Cont'd)

- RTS contains destination address and duration of message.
- RTS tells everyone else to back-off for the duration.
- If RTS reaches the destination okay (no one else collides with this message), the destination sends a Clear to Send (CTS) message after waiting a prescribed amount of time, called SIFS.

4 Way Handshake (Cont'd)

- After getting the CTS, the original transmitter sends the information packet to its destination.

- In these systems, the transmitter cannot detect collisions. The receiver uses the CRC to determine if the packet reached correctly. If it does then, it sends out an ACK packet.

- If the information packet not ACKed, then the source starts again and tries to retransmit the packet.

Bluetooth vs WiFi

	BLUETOOTH	WI-FI
Frequency:	2.4 Ghz	2.4 Ghz
Security:	It is less secure	It is more secure
Standard	IEEE 802.15	IEEE 802.11
Cost	Low	High
Bandwidth	Low(800Kbps)	High (11Mbps)
Range:	10 meters	100 meters
Power	Low	High