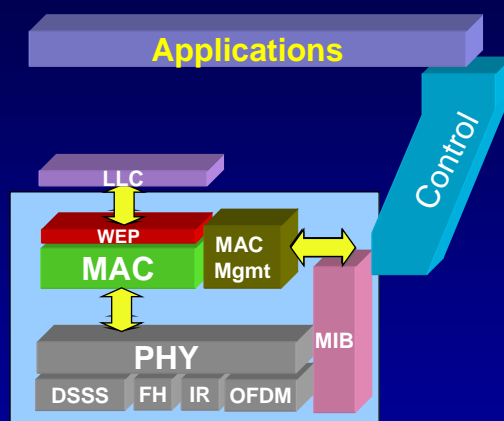
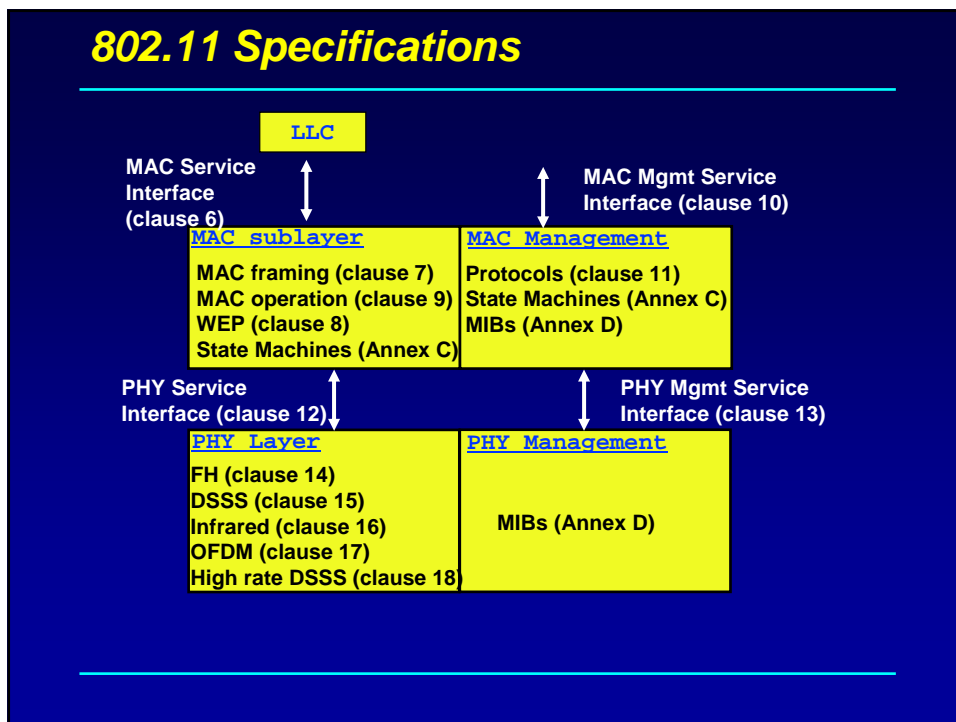
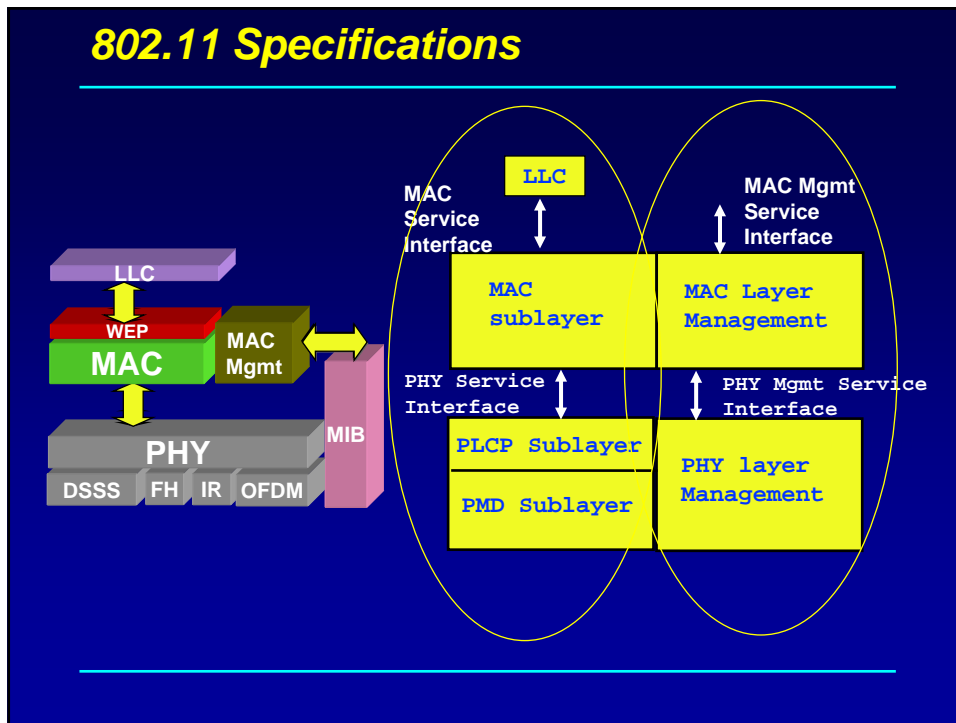


802.11 specifications overview

802.11 Specifications



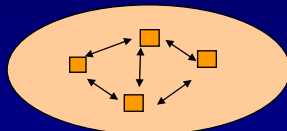
- Specification of layers below LLC
- Associated management/control interfaces



802.11 System Architecture

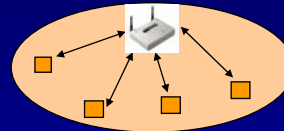
Basic Service Set (BSS): a set of stations which communicate with one another

Independent Basic Service Set (IBSS)



- only direct communication possible
- no relay function

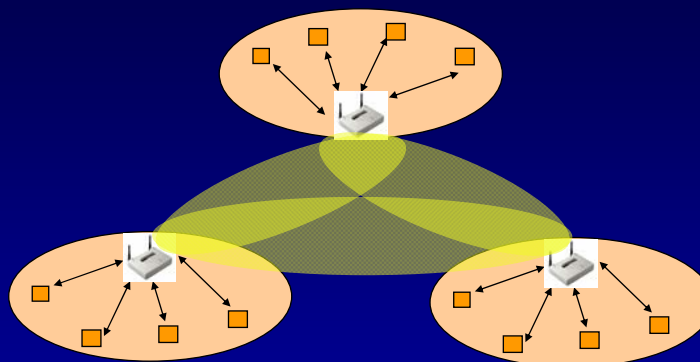
Infrastructure Basic Service Set (BSS)



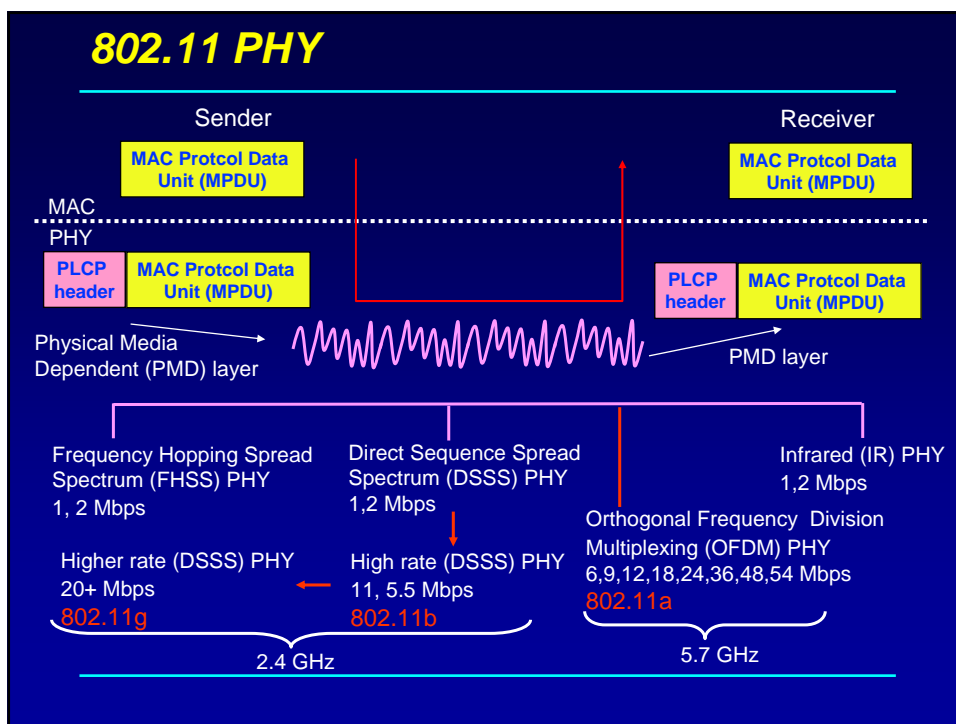
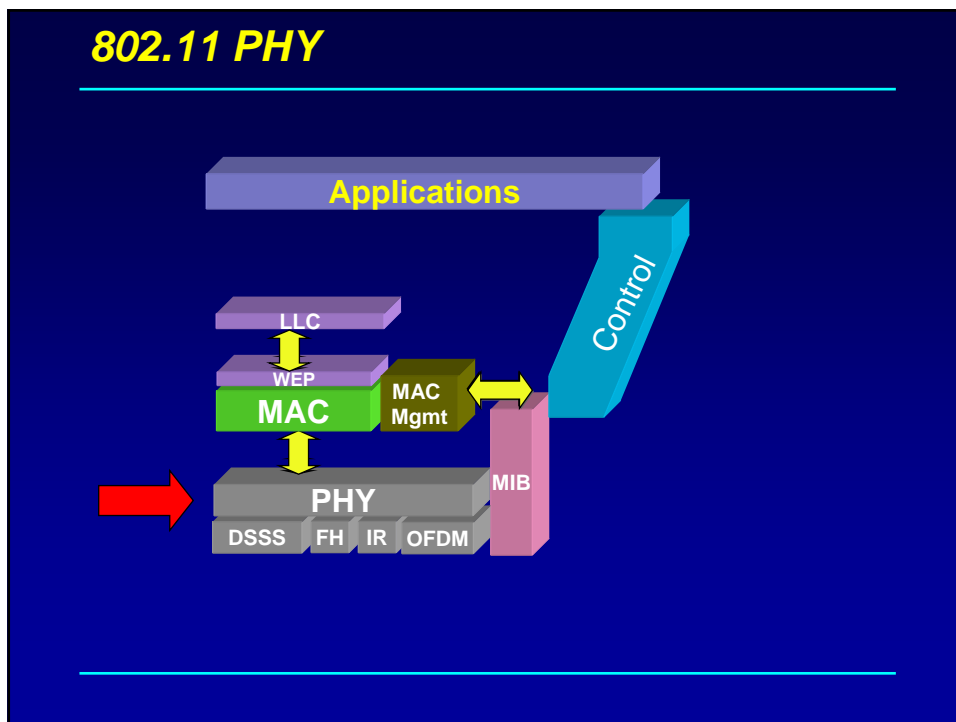
- AP provides
 - connection to wired network
 - relay function
- stations not allowed to communicate directly

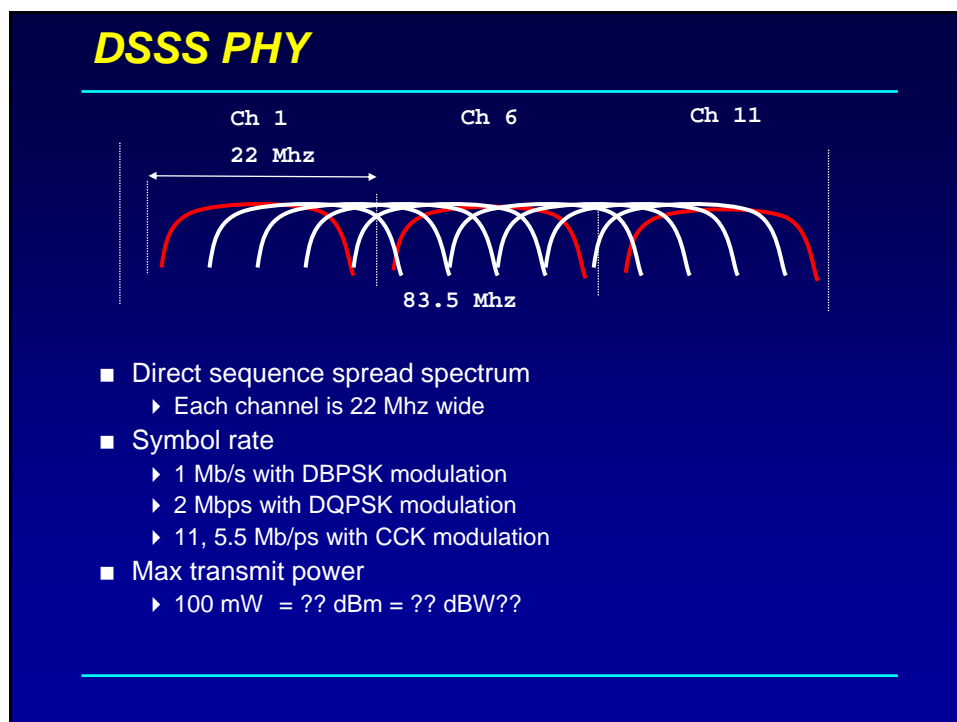
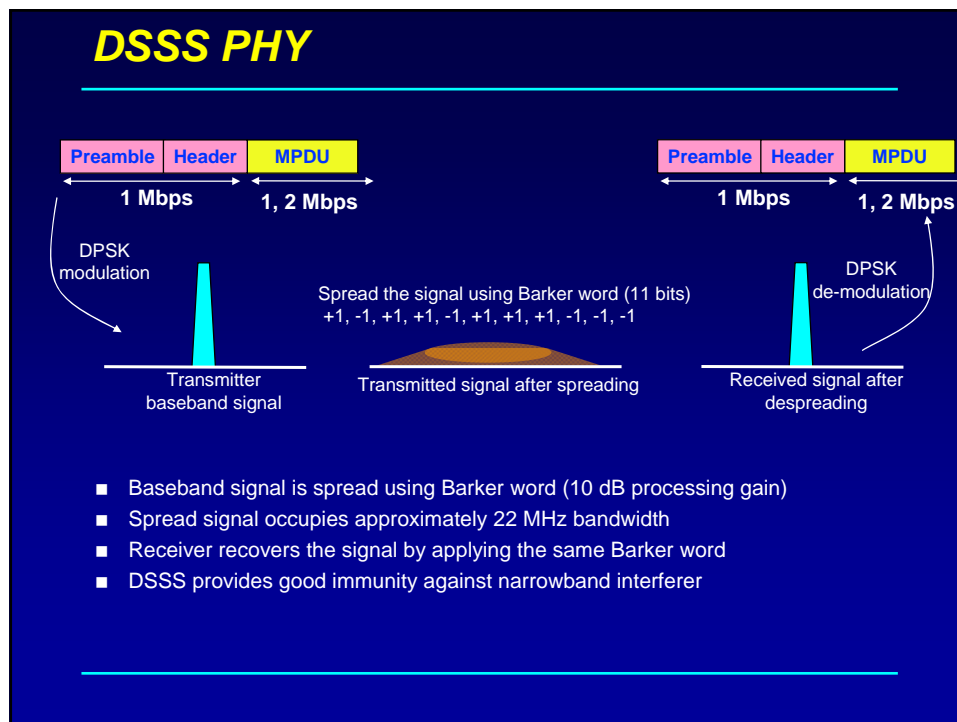
Extended Service Set

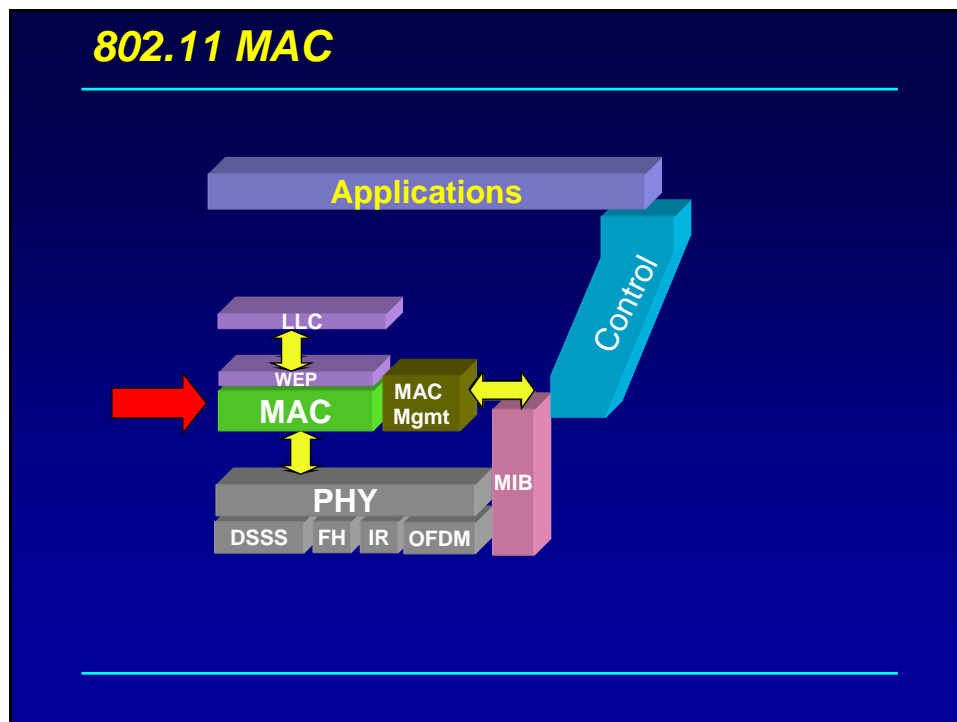
ESS: a set of BSSs interconnected by a distribution system (DS)



- ESS and all of its stations appear to be a single MAC layer
- AP communicate among themselves to forward traffic
- Station mobility within an ESS is invisible to the higher layers







802.11 MAC

■ Carrier sensing (CSMA)

▶ Rules:

- carrier ==> do not transmit
- no carrier ==> OK to transmit

▶ But the above rules do not always apply to wireless.

- Solution: RTS/CTS

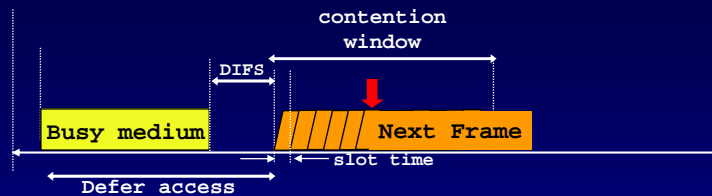
■ Collision detection (CD)

▶ Does not work over wireless

▶ Therefore, use collision avoidance (CA)

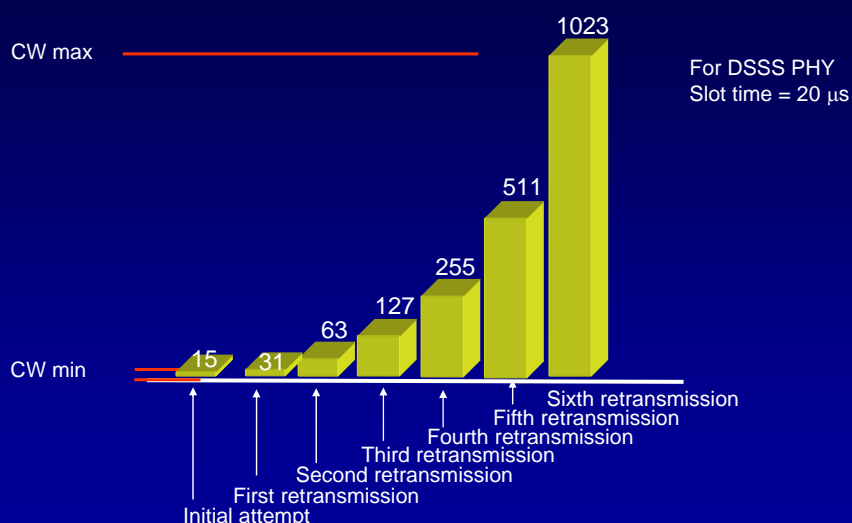
- random backoff
- priority ack protocol

802.11 MAC protocol: CSMA/CA



- Use CSMA with collision Avoidance
 - ▶ Based on carrier sense function in PHY called Clear Channel Assessment (CCA)
- Reduce collision probability where mostly needed
- Efficient backoff algorithm stable at high loads
- Possible to implement different fixed priority levels

802.11 MAC : Contention window



Exercise

- When designing the network systems, which technology would fit to those environment?
 - ▶ Cellar phone network
 - ▶ Wireless LAN
 - ▶ Point to point micro wave link
 - ▶ Satellite network using fixed earth station
 - ▶ Satellite network for mobile terminals

 - ▶ Technology
 - Pure ALOHA, Slotted ALOHA, CSMA/CD, FEC, FDMA, TDMA
 - In which case does CSMA can not work well?
 - Why collision detection (CD) does not work over wireless?
-

IEEE 802.11b and 802.11a PHY Layer Specifications

Key Resource

- **Spectrum:**
 - 802.11 operates in the unlicensed band (ISM – Industrial Scientific and Medical band) ~ 3 such bands
 - **802.11b:** 2.4 GHz
 - **3rd ISM Band:** 5.725 to 5.875 GHz
 - **802.11a:** 5GHz

Data Rates and Range

- **802.11:** 2Mbps (Proposed in 1997)
- **802.11b:** DS+CCK 1, 2, 5.5 and 11 Mbps, 100mts. range
- **802.11g:** DS+OFDM 54Mbps, 100mts. range
- **802.11a:** OFDM 6 to 54 Mbps, 50mts. range
- **802.11n:** OFDM+MIMO up to 100Mbps, 50mts. range

802.11x

- a → OFDM in the 5GHz band
- b → High Rate DSSS in the 2.4GHz band
- c → Bridge Operation Procedures
- e → MAC Enhancements for QoS to improve QoS for better support of audio and video (such as MPEG-2) applications.
- g → OFDM based 2.4 GHz WLAN.
- i → Medium Access Method (MAC) Security Enhancements: enhance security and authentication mechanisms.
- n → OFDM in the 2.4 and 5GHz band (New)

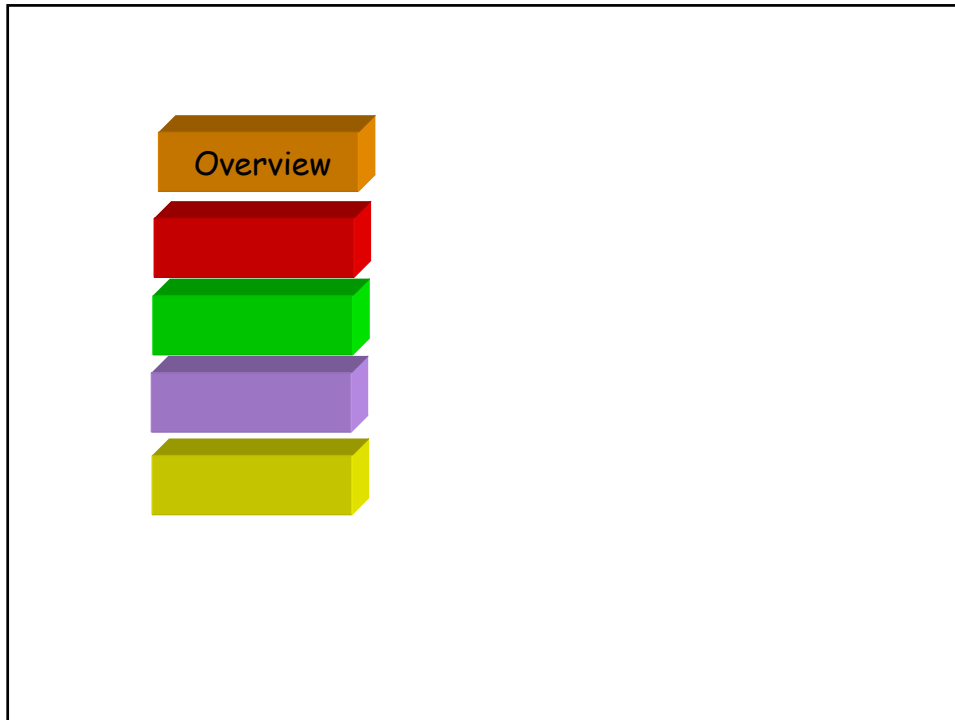
IEEE 802.11a

- 5 GHz (5.15-5.25, 5.25-5.35, 5.725-5.825 GHz)
- OFDM (Orthogonal Freq. Div. Multiplexing) ↘ ISM
- 52 Subcarriers in OFDM
- BPSK/QPSK/QAM
- Forward Error Correction (Convolutional)
- Rates: 6, 9, 12, 18, 24, 36, 48, 54 Mbps

PHY summary:

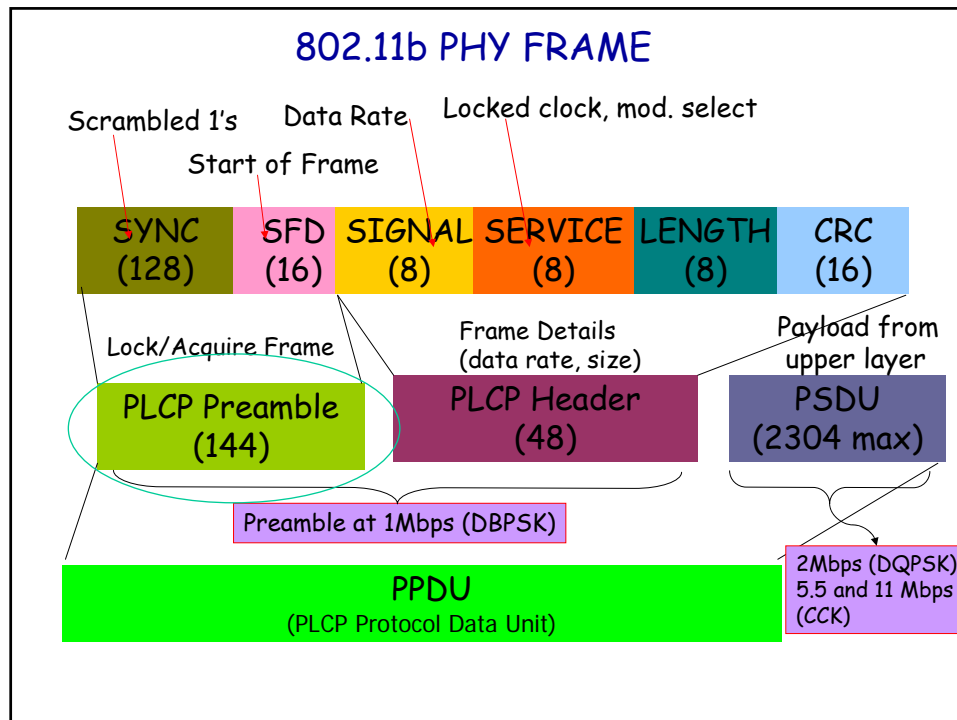
- Common MAC (Medium Access Control) for all 802.11 family
- Three Physical Layers:
 - FHSS (Frequency Hopping Spread Spectrum)
 - DSSS (Direct Sequence Spread Spectrum)
 - OFDM (Orthogonal Frequency Division Multiplexing)

802.11b Physical Layer



Data Rates

	GSM EDGE	IEEE 802.11b	HSPDA 3G
Data Rates (Mbps)	0.384	11	20
Channel Bandwidth (MHz)	0.200	22	5
Modulation Scheme	8-PSK	PSK CCK	QPSK 16 QAM
Spreading	----	Barker(11)	OVSF (16)
Access Method	TDMA	CDMA	CDMA
Frequency (MHz)	GSM	ISM (2.4)	3G



802.11b DSS Operating Channels

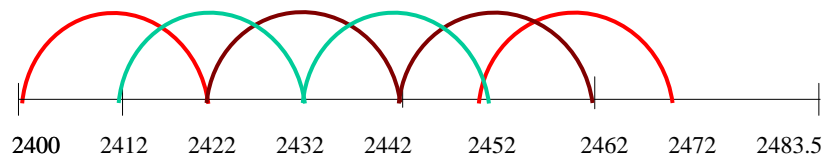
- DSS PHY has 14 channels, each 22MHz wide, placed 5MHz apart
- Channel 1 is placed at center freq. 2.412 GHz, Channel 2 at 2.417 GHz, and so on up to Channel 14 placed at 2.477 GHz
- Allowed channels
 - US/Canada 1 to 11 (2.412 – 2.462 GHz)
 - Europe (excluding France & Spain) 1 to 13 (2.412-2.472 GHz)
 - France 10 to 13 (2.457-2.462 GHz)
 - Spain 10 to 11 (2.457-2.462 GHz)
 - Japan 14 (2.477 GHz)

Operating Channels ...

Non Overlapping channels.

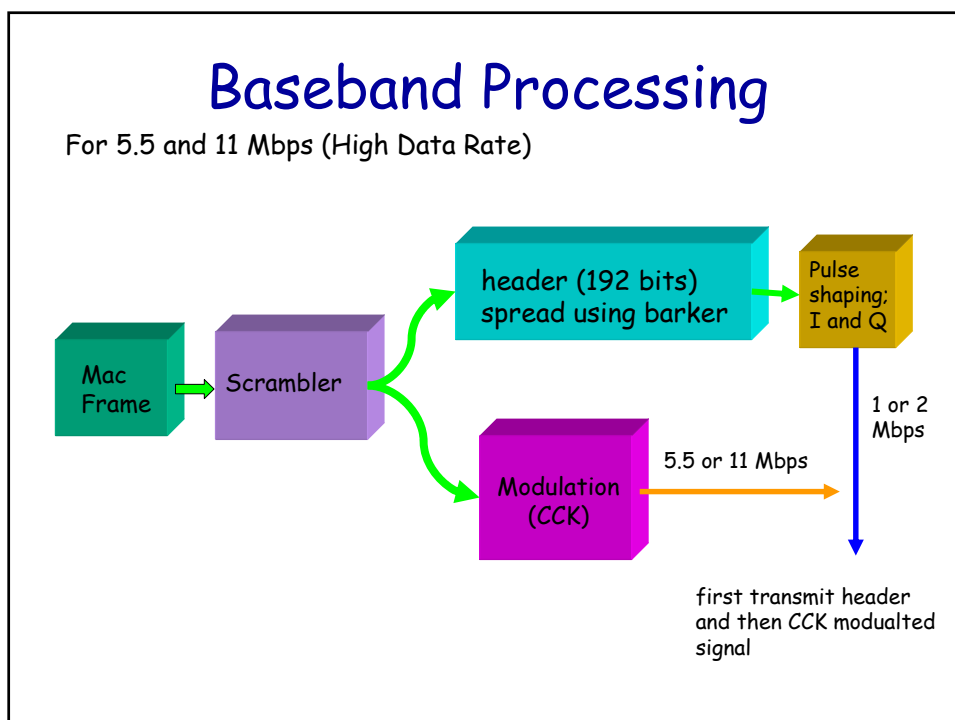
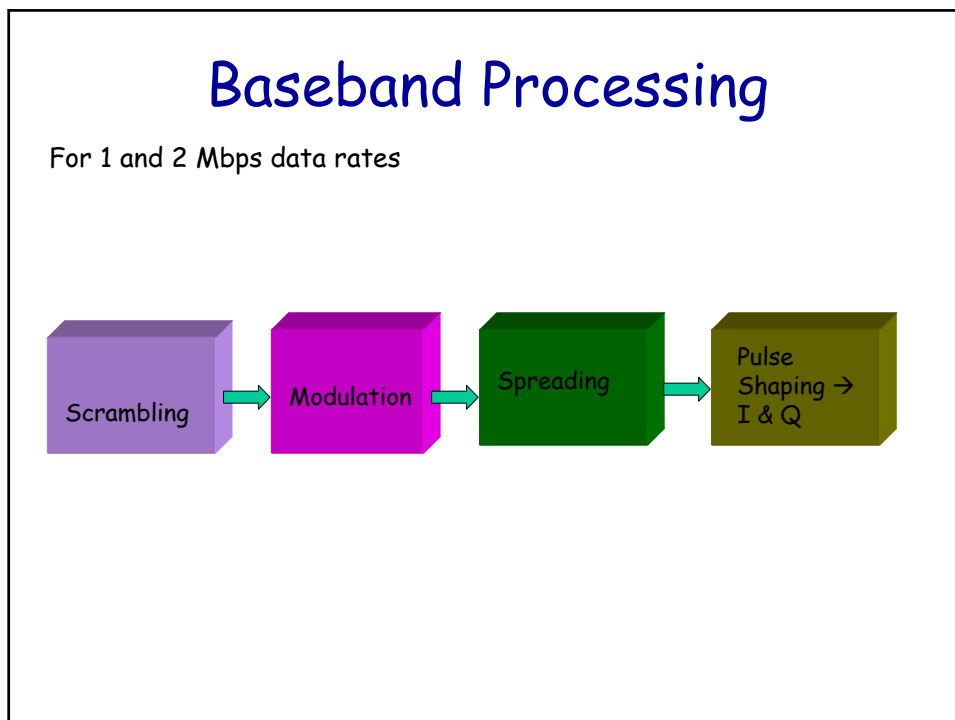


Overlapping channels.



Overview

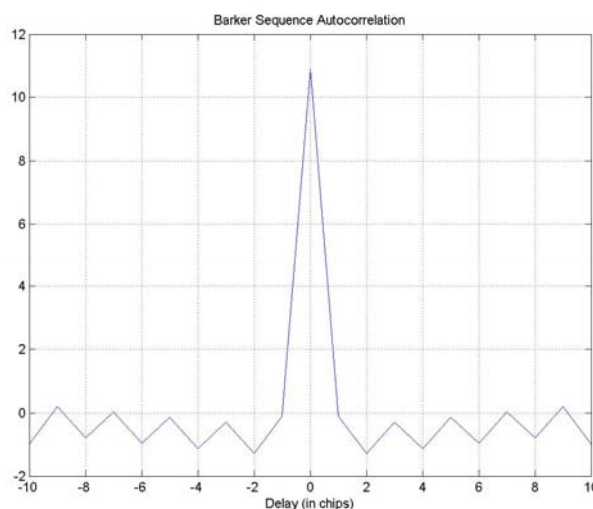
Transmitter



Spreading using Barker Sequence

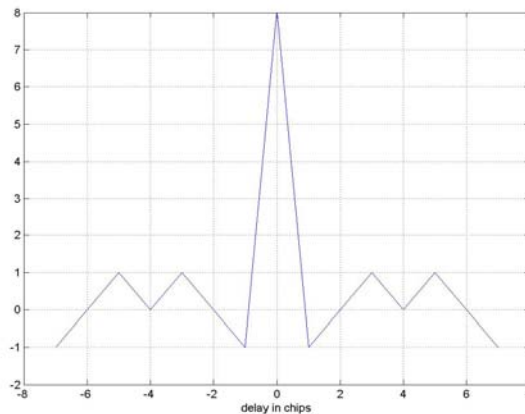
- Barker sequences are short codes (3 to 13 bits) with very good autocorrelation properties.
- Since FCC (US) defines processing gain for a SS system to be minimum 10dB, 11 bit barker sequence was chosen.

Barker Autocorrelation



Complementary codes yield very good correlation properties hence have better resilience to multipath.

It provides a coding gain of 11 dB after despreading.



The spectral masking requirements for IEEE 802.11b are not very strict.

The limits are as follows:
The power should be less than
-30dB_r (relative to $\text{sin}(x)/x$ peak) for

$$f_c - 22\text{MHz} < f < f_c - 11\text{MHz}$$

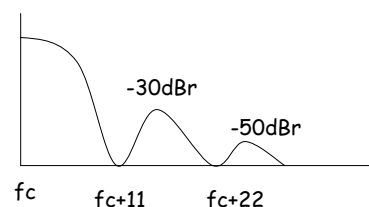
$$f_c + 11\text{MHz} < f < f_c + 22\text{MHz}$$

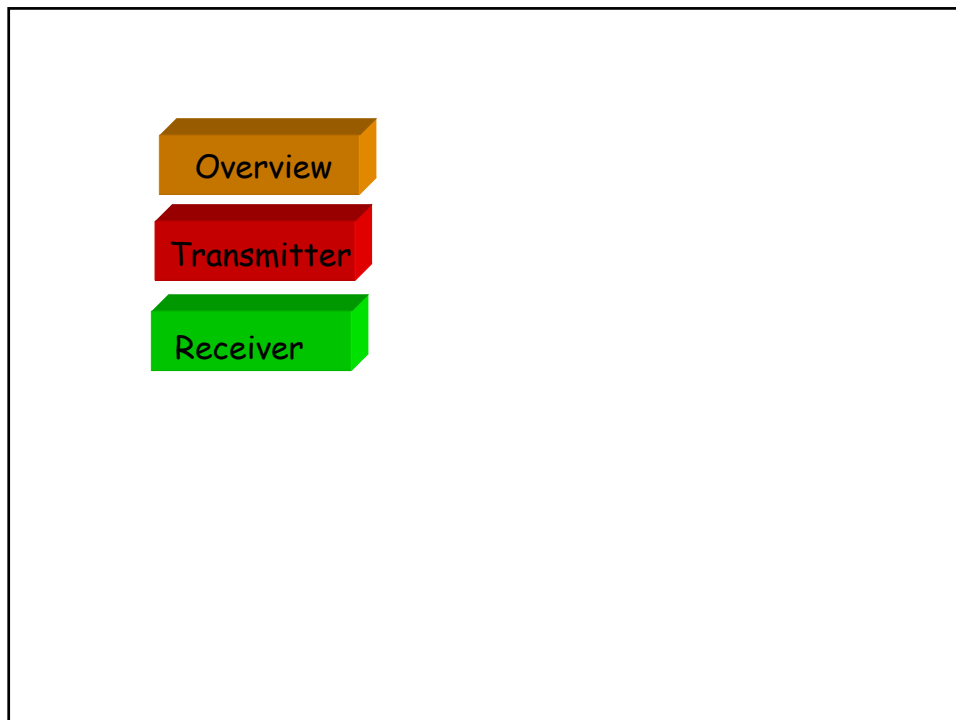
and less than -50dB_r for

$$f < f_c - 22 \text{ MHz}; \text{ and}$$

$$f > f_c + 22 \text{ MHz}$$

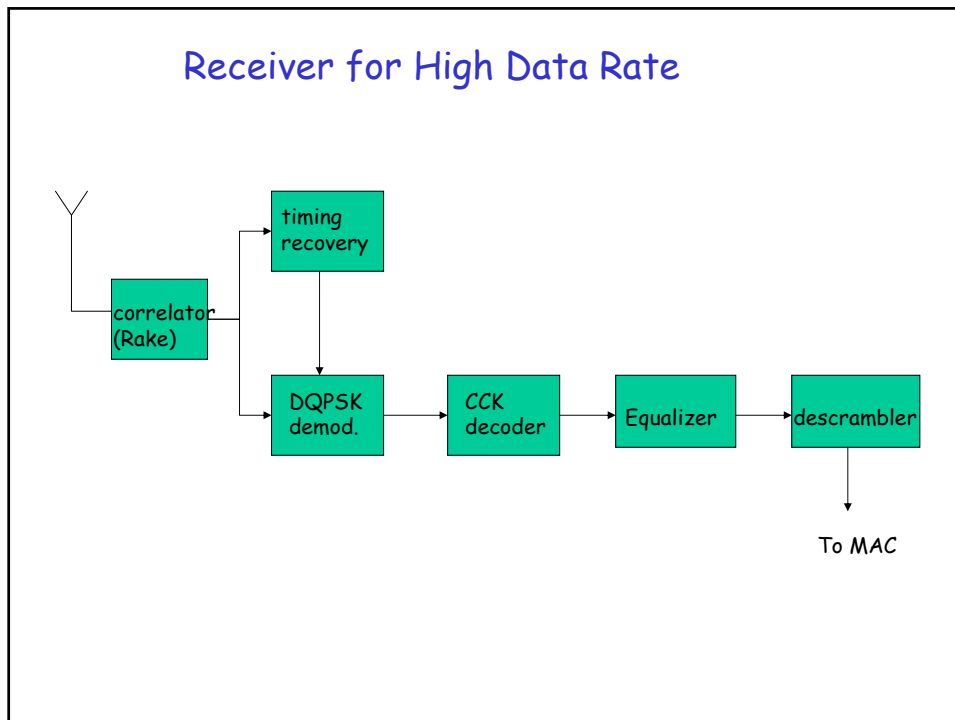
where f_c is the channel center frequency.





Receiver Structure

- Rake Combiner
- Frequency tracking
- Timing Recovery
- CCK Decoder (Fast Walsh Transform)
- Equalization (DFE ~ Decision Feedback Equalizer)



RAKE

RAKE combiner

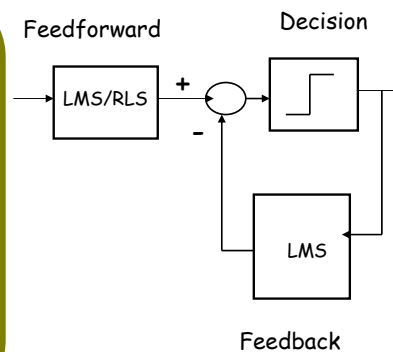
- A rake combines all the incoming paths (strong).
- A rake combiner is ideal for channels with negligible ISI. (*bit duration* \gg *delay spread*)
- For large ISI (say corresponding to 120ns delay spread), the rake output can be improved by having an equalizer

Equalization

- Performed to counter channel effects.
- Various ways of channel equalization are available. Equalization is usually achieved by transmitting a known pilot signal (training based equalization).
- Often in practice, equalization achieved with the incoming signal sampled at higher than the symbol rate. These are referred to as Fractionally Spaced Equalizer (FSE).
- A FSE has higher immunity to timing errors.

Decision Feedback Equalization

Decision Feedback Equalizer has two filters :
A feedforward and a feedback filter.
The feedback filter has as its input the sequence of decisions on previously detected symbols.
Used to remove ISI from present estimate caused by previously detected symbols.



Exercise

All 802.11 specification has maximum distance from AP to the terminal.

- What is the major factor that defines maximum range?
- If you install 802.11b or g hardware in 30km separated location in following condition. Will it work? (assuming that antenna and transmit power would be reasonably tuned)
 - As point to point link
 - Shared link by 20 stations