Wireless Local Area Networks (WLANs) Part I

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IEEE 802.11

1. Features
2. MAC
3. Physical Layers

WiFi

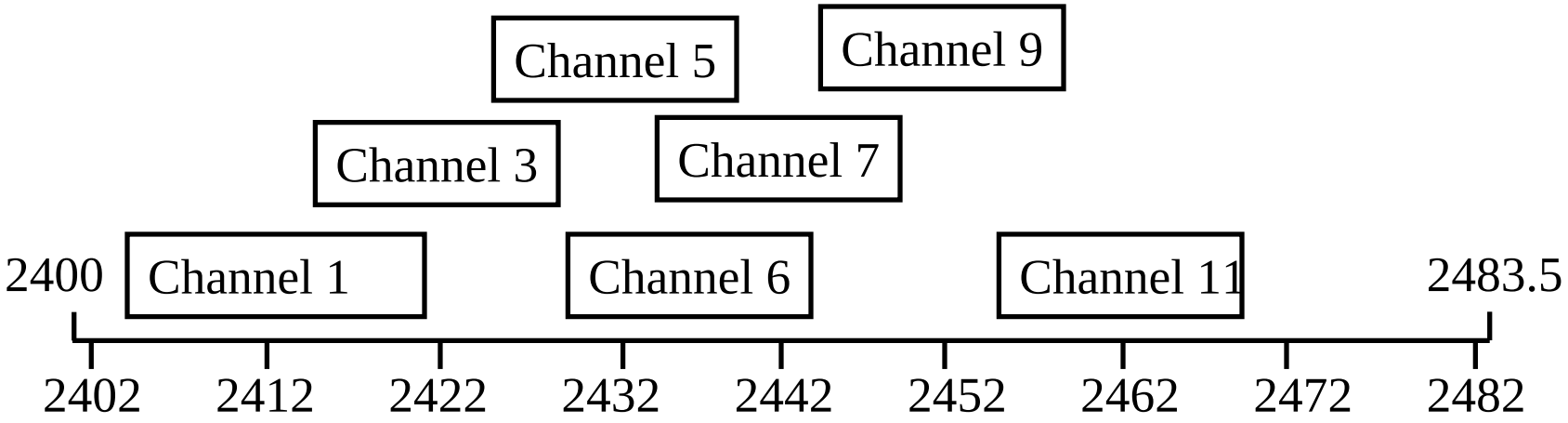
- Almost all wireless LANs now are IEEE 802.11 based
- Competing technologies, e.g., HiperLAN can't compete on volume and cost
- 802.11 is also known as WiFi = "Wireless Fidelity"
- Fidelity = Compatibility between wireless equipment from different manufacturers
- WiFi Alliance is a non-profit organization that does the compatibility testing (WiFi.org)

IEEE 802.11 Features

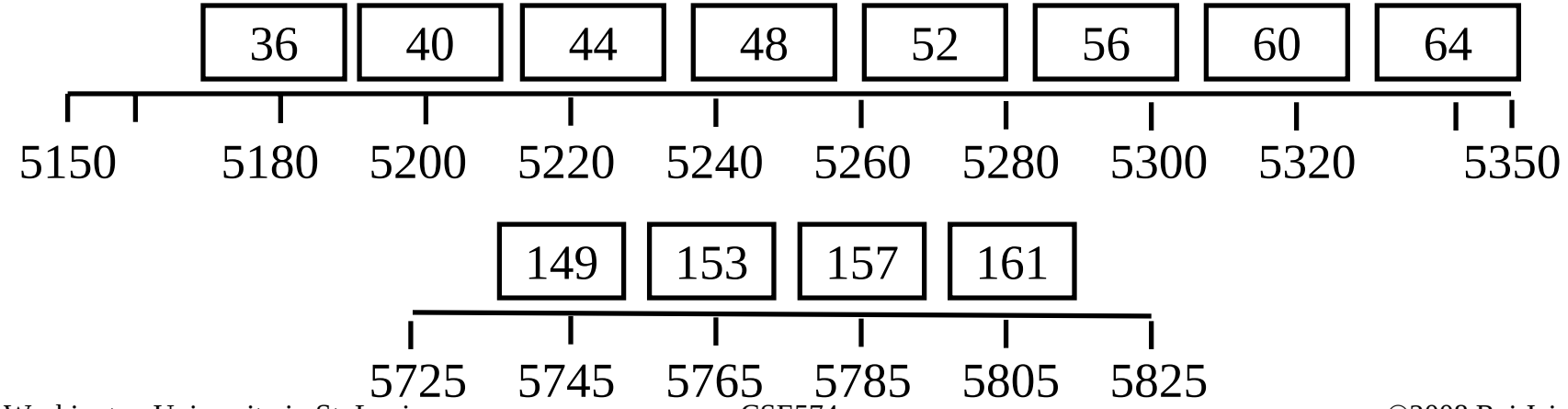
- Original 802.11 was at 1 and 2 Mbps.
  Newer versions at 11 Mbps and 54 Mbps
- Supports both Ad-hoc and base-stations
- Spread Spectrum ⇒ No licensing required.
  Three Phys: Direct Sequence, Frequency Hopping, 915-MHz, **2.4 GHz** (Worldwide ISM), 5.2 GHz, and Diffused Infrared (850-900 nm) bands.
- Supports multiple priorities
- Supports time-critical and data traffic
- Power management allows a node to doze off

North American Channels

2.4 GHz Band: Only 3 non-overlapping channels



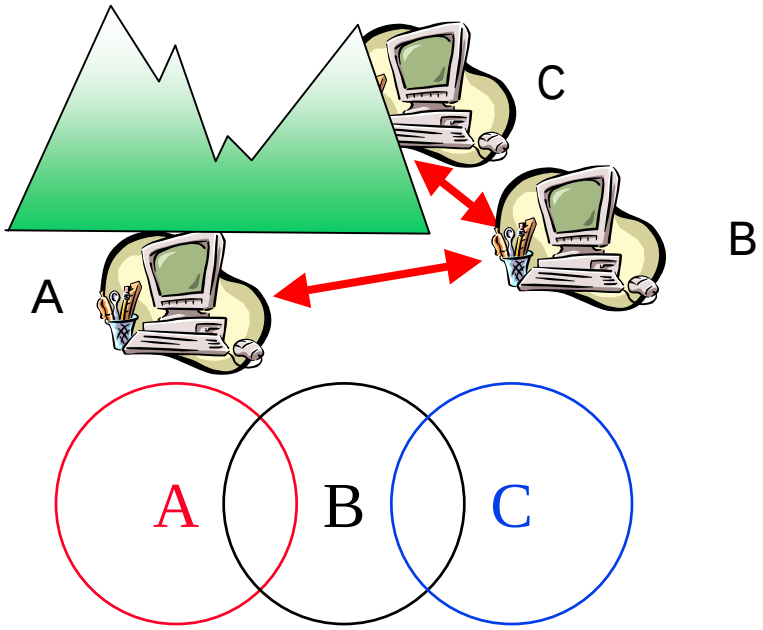
5 GHz Band: 12 non-overlapping channels



IEEE 802.11 Physical Layers

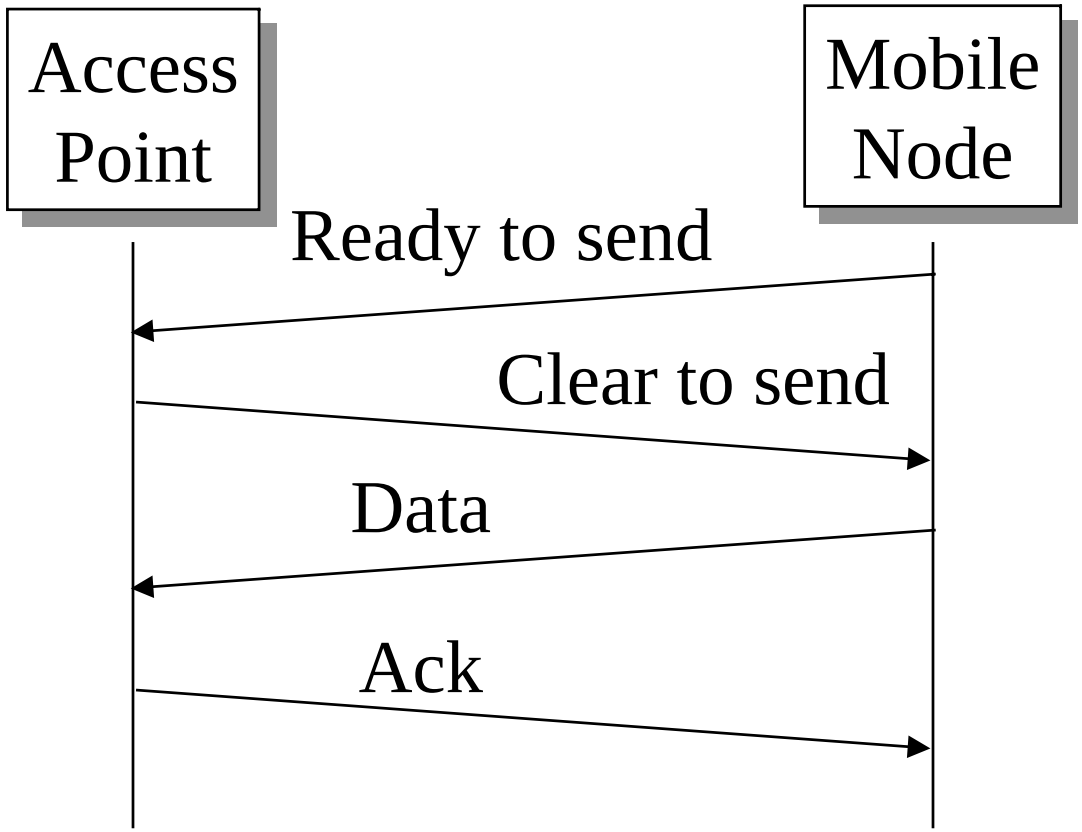
- Issued in four stages
- First part in 1997: IEEE 802.11
  - Includes MAC layer and three physical layer specifications
  - Two in 2.4-GHz band and one infrared
  - All operating at 1 and 2 Mbps
- Two additional parts in 1999:
  - IEEE 802.11a-1999: 5-GHz band, 54 Mbps/20 MHz, OFDM
  - IEEE 802.11b-1999: 2.4 GHz band, 11 Mbps/20 MHz
- Fourth part:
  - IEEE 802.11g-2003 : 2.4 GHz band, 54 Mbps/20 MHz, OFDM

Hidden Node Problem



- A can hear B, B can hear C, but C cannot hear A.
- C may start transmitting while A is also transmitting ⇒ A and C can't detect collision.
- Only the receiver can help avoid collisions

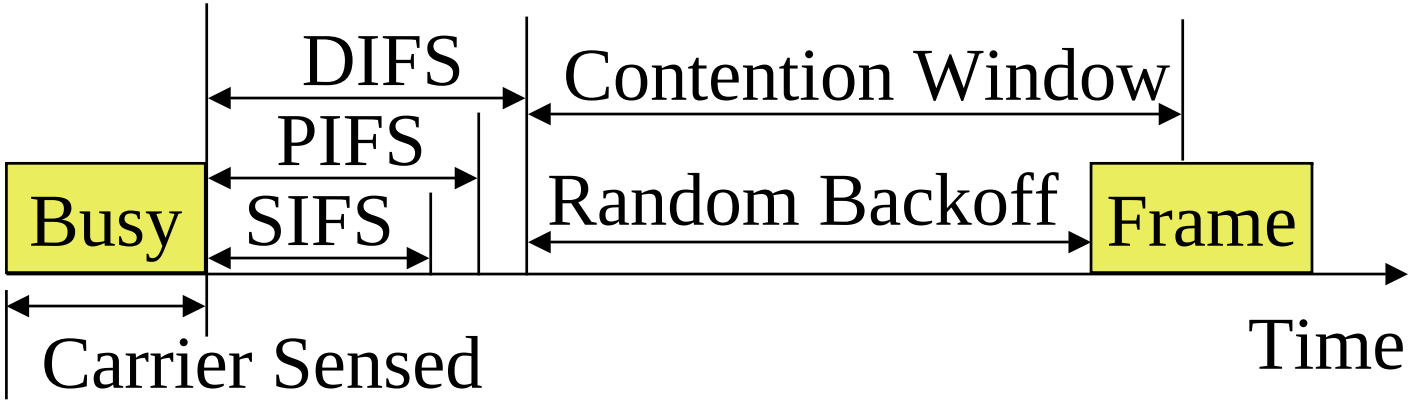
4-Way Handshake



IEEE 802.11 MAC

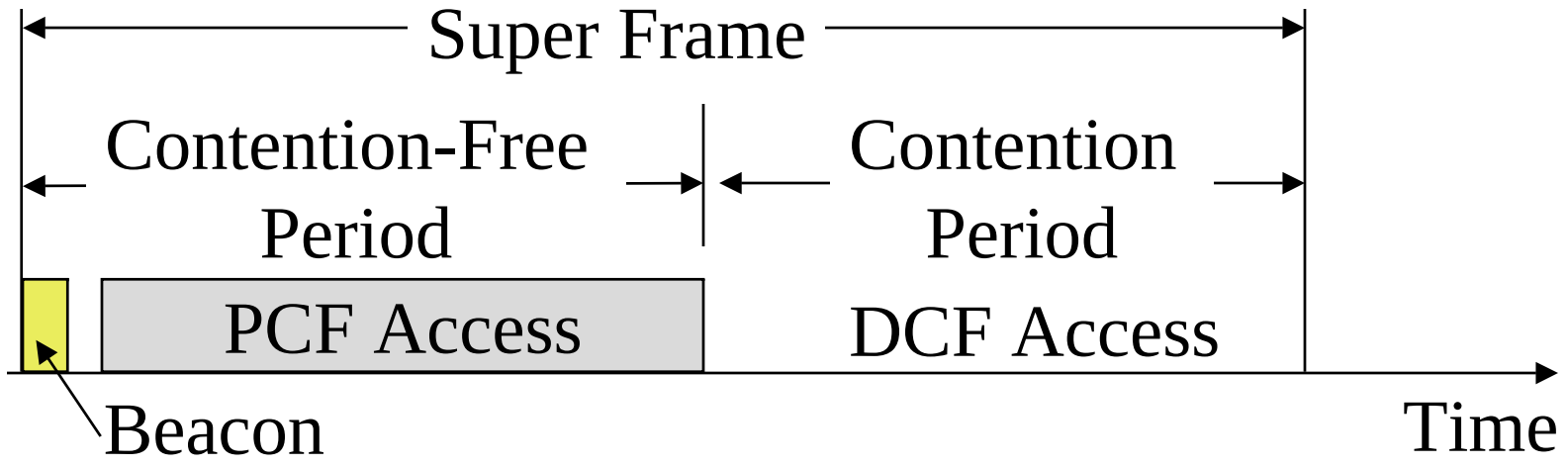
- Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)
- Listen before you talk. If the medium is busy, the transmitter backs off for a random period.
- Avoids collision by sending a short message:
  Ready to send (RTS)
  RTS contains dest. address and duration of message.
  Tells everyone to backoff for the duration.
- Destination sends: Clear to send (CTS)
  Other stations set their network allocation vector (NAV) and do not transmit for that duration
- Can not detect collision $\Rightarrow$ Each packet is acked.
- MAC level retransmission if not acked.

IEEE 802.11 Priorities



- Initial interframe space (IFS)
- Highest priority frames, e.g., Acks, use short IFS (SIFS)
- Medium priority time-critical frames use "Point Coordination Function IFS" (PIFS)
- Asynchronous data frames use "Distributed coordination function IFS" (DIFS)

Time Critical Services



- Timer critical services use Point Coordination Function
- The point coordinator allows only one station to access
- Coordinator sends a beacon frame to all stations. Then uses a polling frame to allow a particular station to have contention-free access
- Contention Free Period (CFP) varies with the load.

IEEE 802.11 DCF Backoff

- MAC works with a single FIFO Queue
- Two variables:
  - Contention Window (CW)
  - Backoff count (BO)
- BO is a pseudorandom integer in [0, CW]
- Initially and after each successful transmission:

$$CW = CW_{min}$$

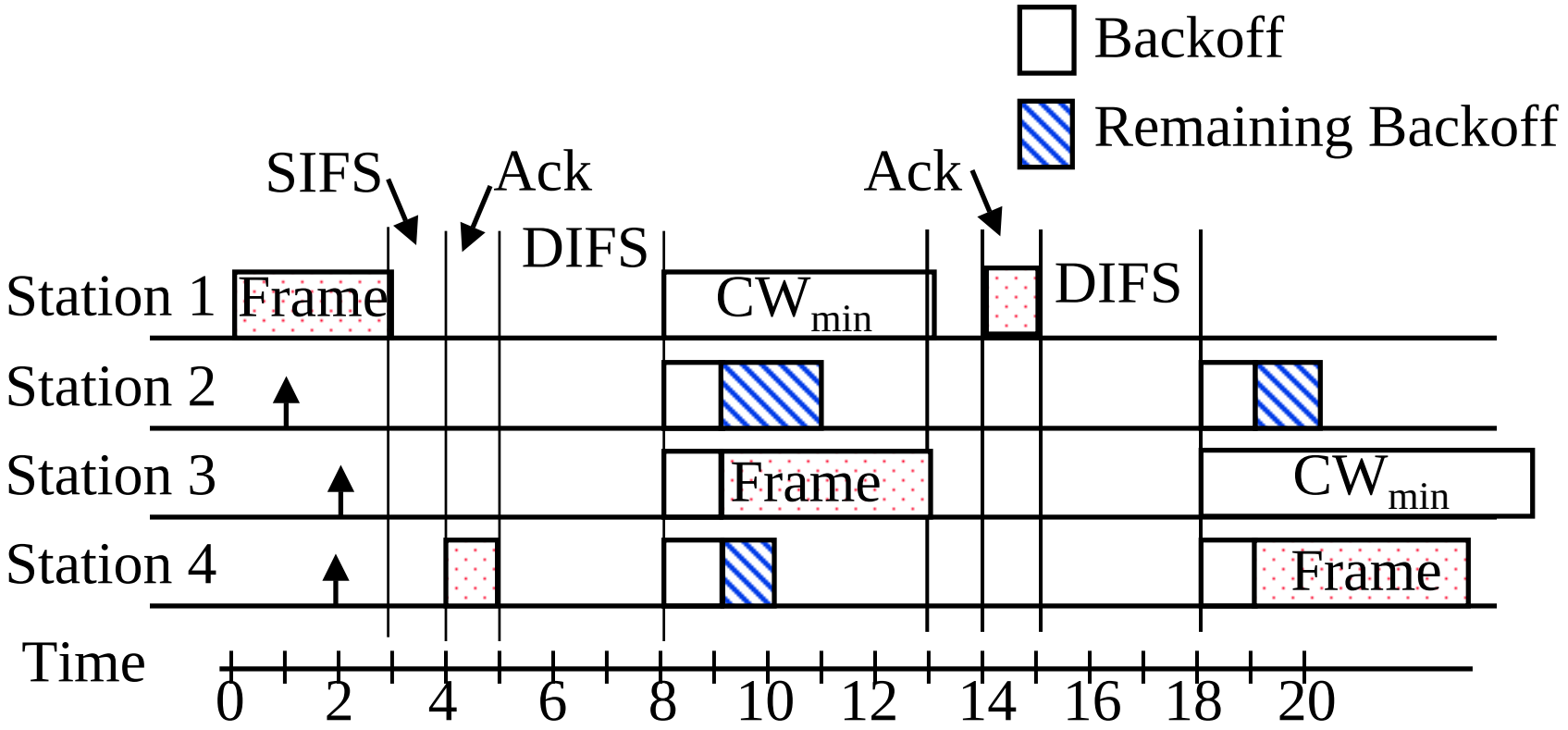
- After each unsuccessful attempt

$$CW = \min\{2CW+1, CW_{max}\}$$

- The stations wait for BO. If another station starts transmitting, the waiting stations pause their backoff counter and restart it DIFS after the end of frame again.

DFS

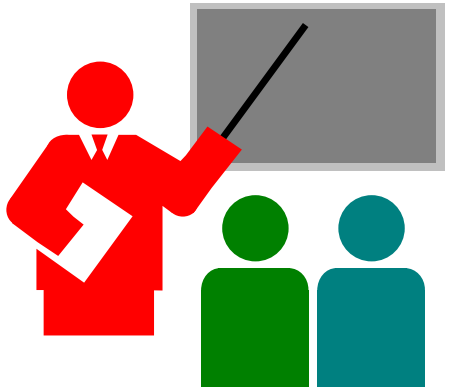
- Example: Slot Time = 1, CW = 5, DIFS=3, PIFS=2, SIFS=1,



DFS: Example (Cont)

- T=1 Station 2 wants to transmit but the media is busy
- T=2 Stations 3 and 4 want to transmit but the media is busy
- T=3 Station 1 finishes transmission.
- T=4 Station 1 receives ack for its transmission (SIFS=1)
- T=5 Medium becomes free
- T=8 DIFS expires.
  Stations 2, 3, 4 draw backoff count between 0 and 5.
  The counts are 3, 1, 2
- T=9 Station 3 starts transmitting.
  Station 2 and 4 pause backoff counter at 2 and 1 resp.
- T=13 Station 3 finishes transmission
- T=14 Station 3 receives Ack.
- T=15 Medium becomes free
- T=18 DIFS expires
  Stations 2 and 4 start their backoff counter
- T=19 Station 4 starts transmitting

Summary



1. 802.11 uses Frequency hopping, Direct Sequence CDMA, OFDM
2. 802.11 PHYs: 802.11, 802.11a, 802.11b, 802.11g
3. Allows both: Ad-Hoc vs Infrastructure-based
4. BSS, ESS, AP
5. 802.11 supports single FIFO Q. Uses SIFS, PIFS, DIFS

Homework 6

- Two 802.11 stations get frames to transmit at time t=0. The 3rd station has just finished transmitting a long packet at t=0. The transmission parameters are: Slot time=1, SIFS=1, DIFS=3, Cwmin=5, Cwmax=7. Assume that the pseudo-random number generated are 1, 3. The frame size is 3 slots. Draw a transmission diagram. How many slots before the two packets will get acknowledged assuming no new arrivals.