

Lecture 26:

802.11

CSE 123: Computer Networks
Guest starring **Aaron Schulman**



Lecture 26 Overview

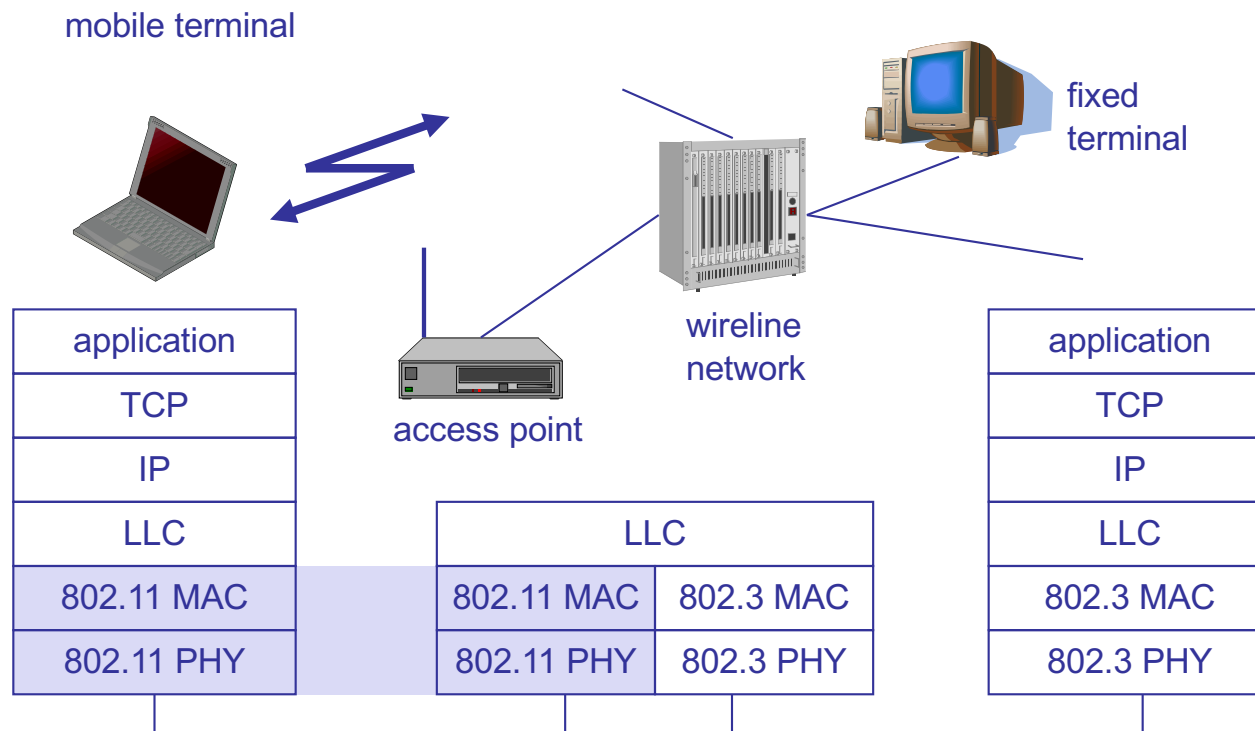


- 802.11 Wireless
 - ◆ PHY layer overview
- Hidden Terminals
 - ◆ Basic wireless challenge
- RTS/CTS
 - ◆ Virtual carrier sense
- CSMA/CA
 - ◆ Limits of half-duplex radios

No clickers or Zoom polls today...

...but stick around, you might learn something!

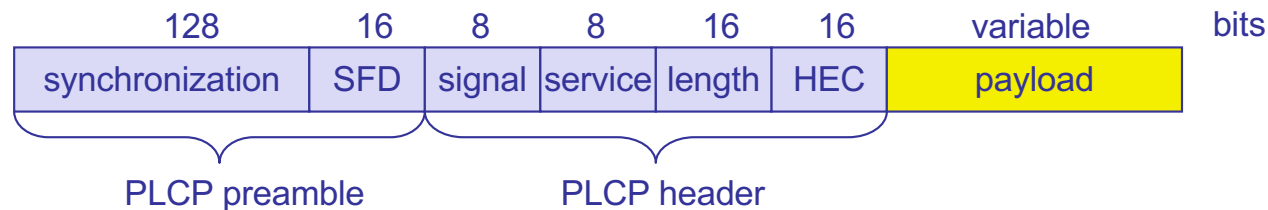
IEEE 802.11 Infrastructure





802.11 Frame Format

- Synchronization
 - ♦ synch., gain setting, energy detection, frequency offset compensation
- SFD (Start Frame Delimiter)
 - ♦ 1111001110100000
- Signal
 - ♦ data rate of the payload (0A: 1 Mbit/s DBPSK; 14: 2 Mbit/s DQPSK)
- Service
 - ♦ future use, 00: 802.11 compliant
- Length
 - payload length
- HEC (Header Error Check)
 - ♦ protection of signal, service and length, $x^{16}+x^{12}+x^5+1$



WLAN: IEEE 802.11b



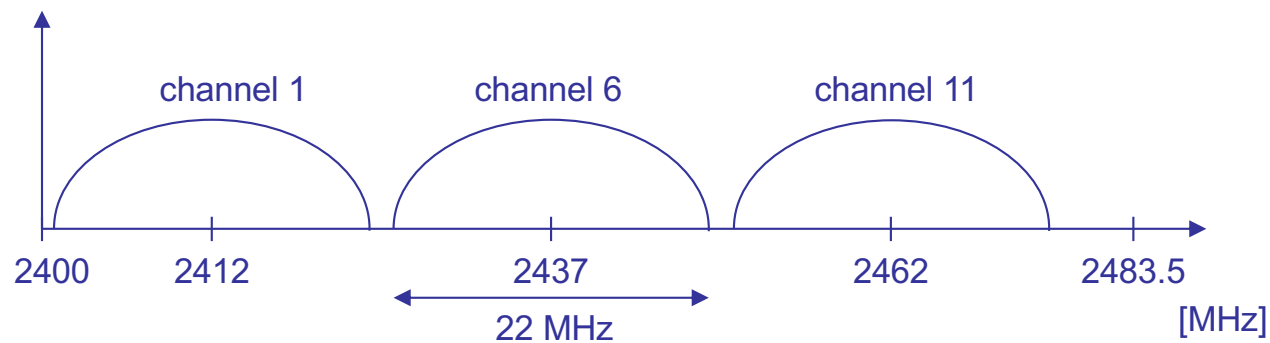
- Data rate
 - ◆ 1, 2, 5.5, 11 Mbit/s
 - ◆ User data rate max. approx. 6 Mbit/s, why?
- Transmission range
 - ◆ 300m outdoor, 30m indoor
 - ◆ Max. data rate ~10m indoor
- Frequency
 - ◆ Free 2.4 GHz ISM-band

Physical Channels



- 12 channels available for use in the US
 - ♦ Each channel is 22 MHz wide
 - ♦ Only 3 orthogonal channels
 - ♦ Using any others can cause inter-channel interference

US (FCC)/Canada (IC)





Carrier Sense Multiple Access

CSMA: listen before transmit:

- If channel sensed idle: transmit entire pkt
- If channel sensed busy, defer transmission
- Wait a randomized time after channel is idle to send
 - ◆ Called the **Contention Window**, similar to Ethernet exponential backoff
- Frames are explicitly (link-level) acknowledged by the receiver
 - ◆ Delay before sending ACK is 10 us, so unlikely to collide with packets



Backoff Interval

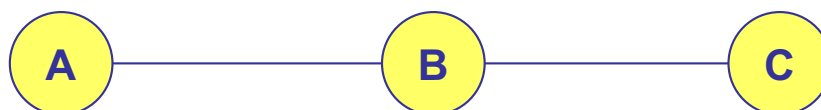
- **Problem:** With many contending nodes, frames will frequently collide
- **Solution:** When transmitting a packet, choose a backoff interval in the range $[0, CW]$
 - ◆ CW is contention window
- Wait the length of the interval when medium is idle
 - ◆ Count-down is suspended if medium becomes busy
 - ◆ Transmit when backoff interval reaches 0
- Need to adjust CW as contention varies, retransmissions increase CW
 - ◆ Similar in spirit to Ethernet backoff

CSMA/CA



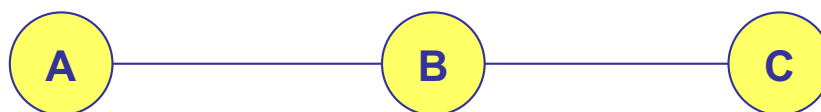
- Cannot detect collision w/half-duplex radios
 - ◆ So collisions are (much) more expensive than in CSMA/CD
- Wireless MAC protocols often use collision avoidance techniques, in conjunction with a (physical or virtual) carrier sense mechanism
- Collision avoidance
 - ◆ Nodes negotiate to reserve the channel before sending data
 - ◆ Still potential for collisions during negotiation, but they are cheaper

Hidden Terminal Problem



- Nodes have a limited range. In this example B can communicate with both A and C
 - ♦ A and C cannot hear each other – not a single shared channel
- Problem
 - ♦ When A transmits to B, C cannot detect the transmission using the **carrier sense** mechanism
 - ♦ If C transmits, collision will occur at node B
- Solution
 - ♦ Hidden sender C needs to defer

RTS/CTS (MACA)



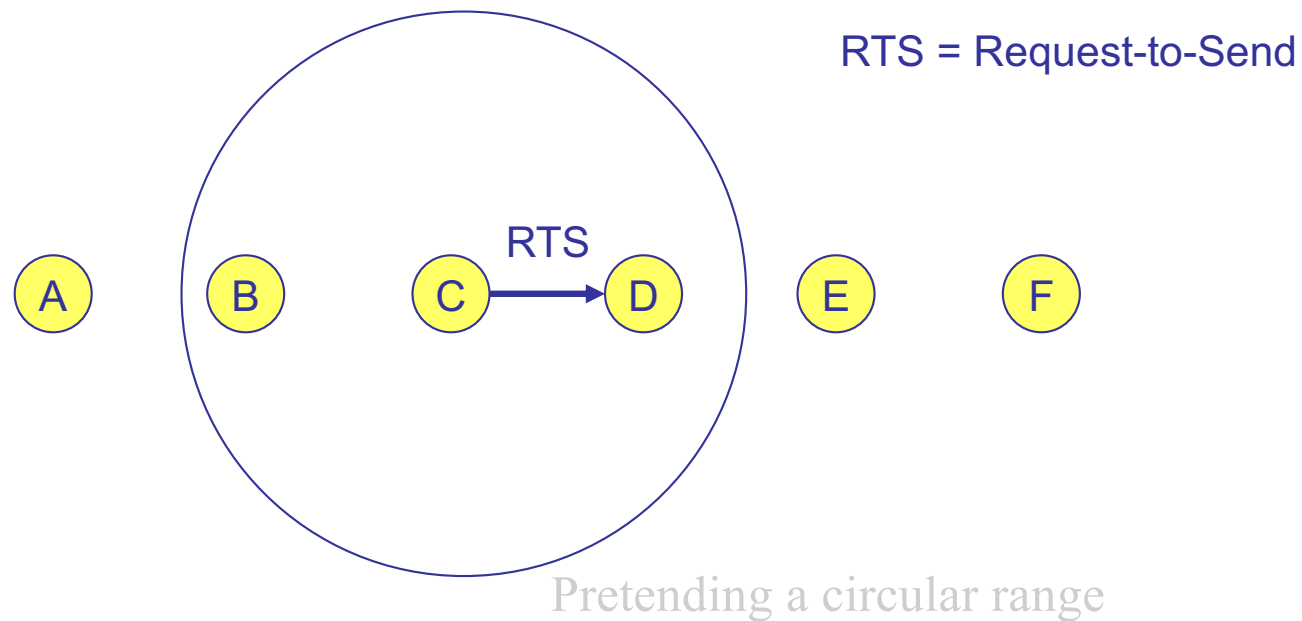
- When A wants to send a packet to B, A first sends a **Request-to-Send (RTS)** to B
- On receiving RTS, B responds by sending **Clear-to-Send (CTS)**, provided that A is able to receive the packet
- When C overhears a CTS, it keeps quiet for the duration of the transfer
 - ♦ Transfer duration is included in both RTS and CTS

IEEE 802.11 DCF



- DCF is CSMA/CA protocol
 - ◆ Uses a **Network Allocation Vector (NAV)** to implement collision avoidance (each frame specifies remaining transaction duration in header)
 - ◆ Saves energy, don't have to do carrier sense to find when a transmission is done.
- Optionally uses RTS/CTS exchange to avoid hidden terminal problem
 - ◆ Any node overhearing a CTS cannot transmit for the duration of the transfer
- Uses link-level ARQ to provide reliability

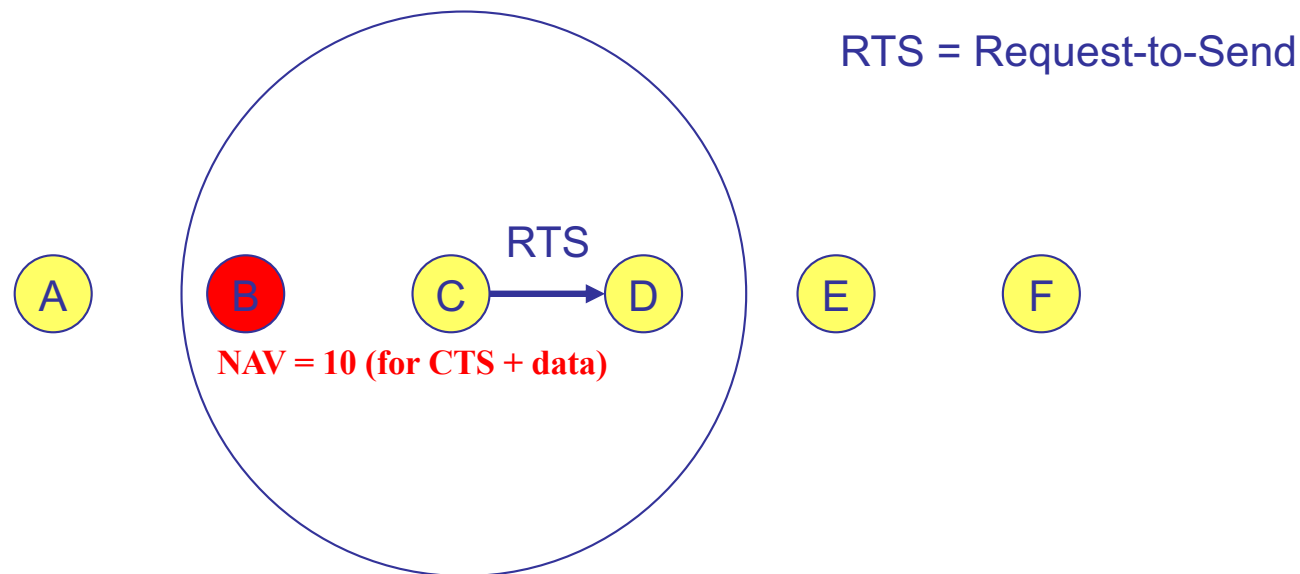
IEEE 802.11



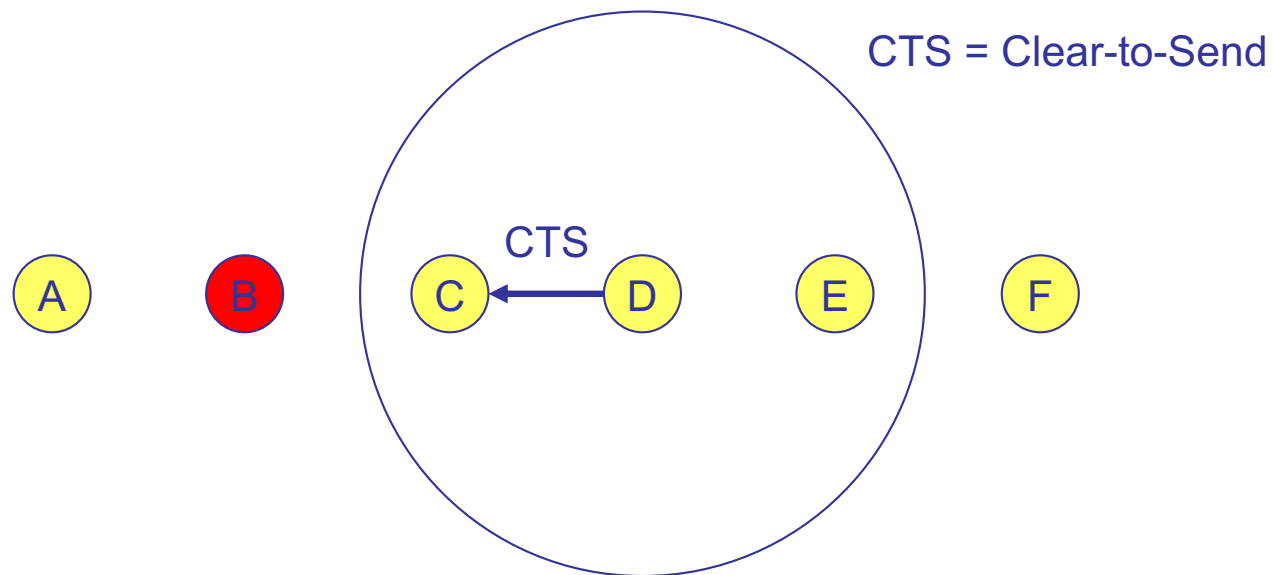
IEEE 802.11



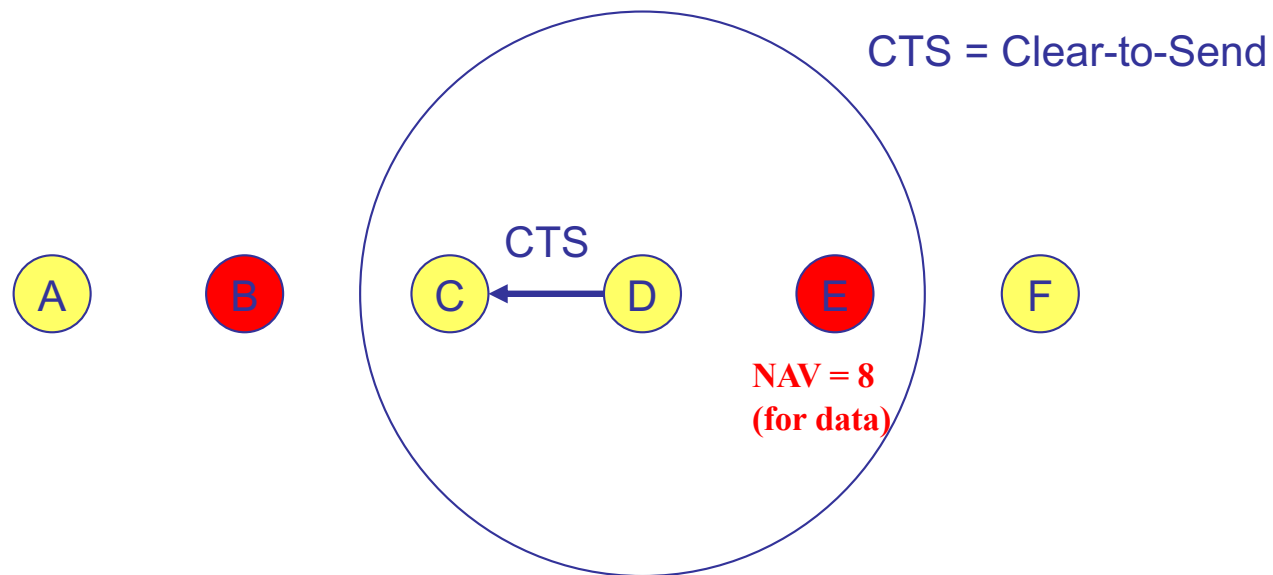
NAV = remaining duration to keep quiet



IEEE 802.11



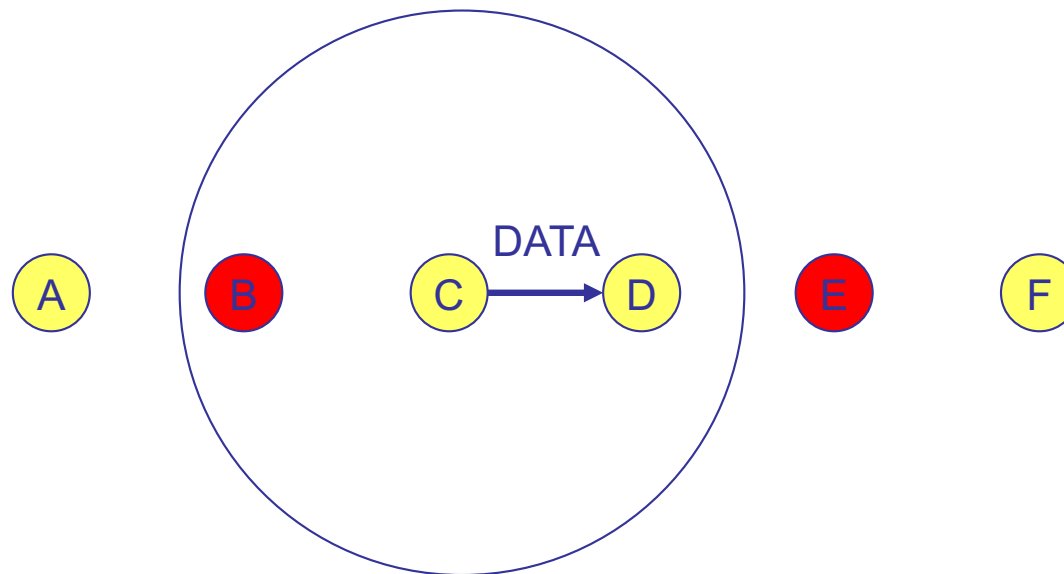
IEEE 802.11



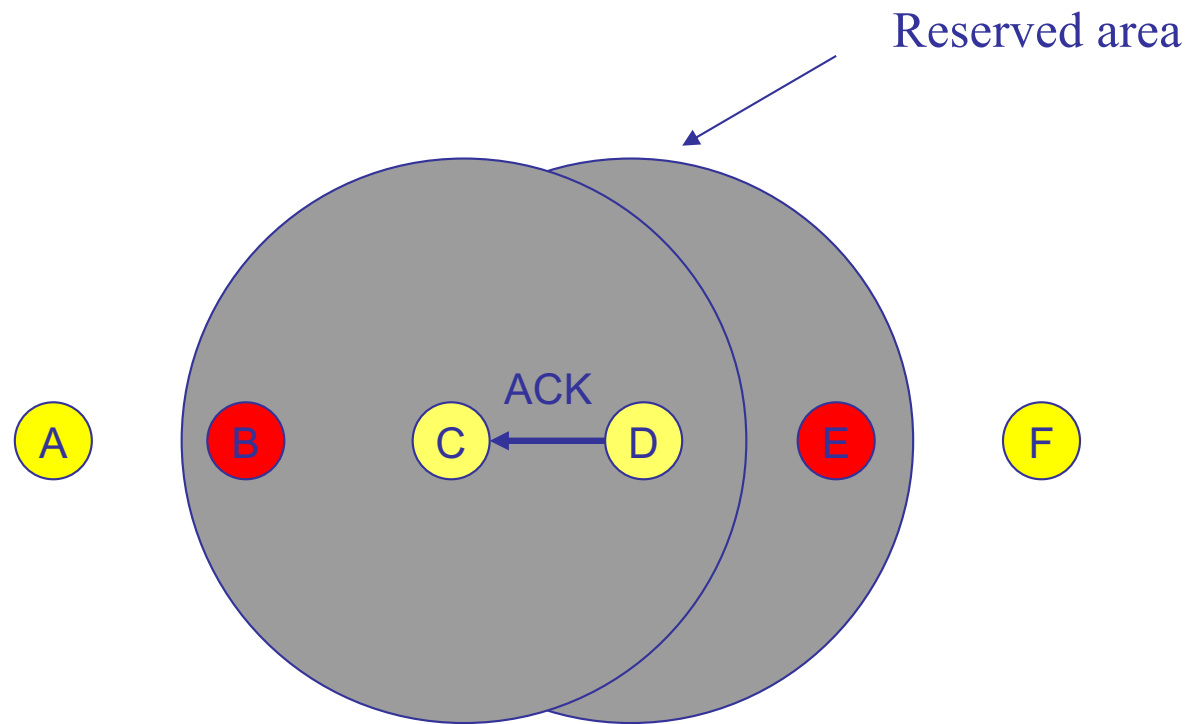
IEEE 802.11



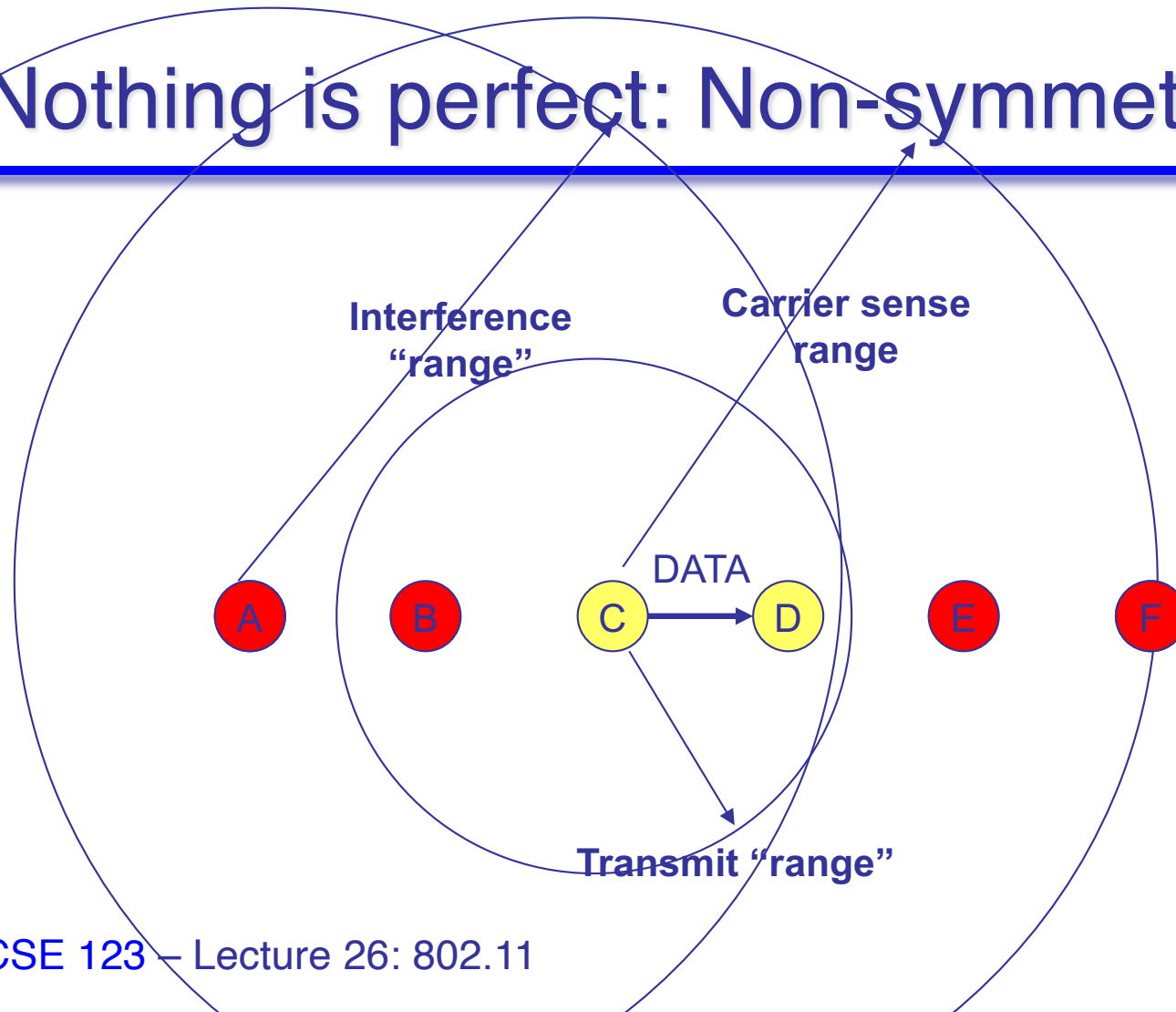
- **DATA** packet follows CTS. Successful data reception acknowledged using **ACK**.



IEEE 802.11



Nothing is perfect: Non-symmetric ranges



802.11 Summary



- Common technology for local-area wireless
- Uses CSMA/CA
- Needs to handle hidden terminal problem
- Challenges due to asymmetric ranges

- But totally works!
 - ◆ Modern versions work up to > 1Gbps

That's all folks



- No more new material...
- Final review on Friday
 - ◆ During regular class period
 - ◆ Zoom only