

Lecture 24:

802.11

CSE 123: Computer Networks
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HW4 due NOW

UCSD CSE



About the final

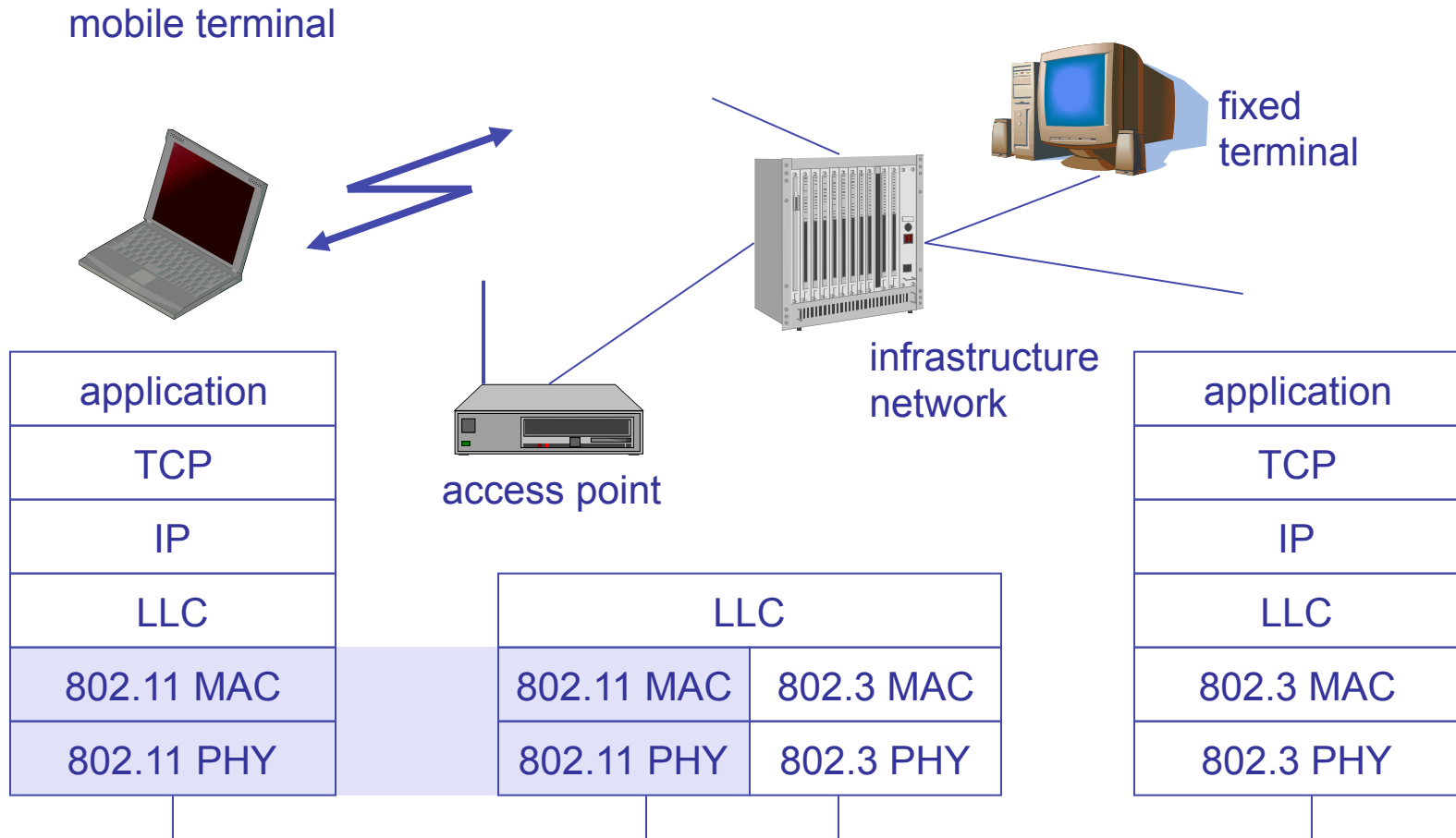
- Similar in style to midterm
 - ◆ Some combination of easy questions, short answer and more in-depth questions
 - ◆ Sample final from 2010 on the Web site
- Closed book/notes, but one note sheet is fine
- Will focus more on second half of class
 - ◆ Up until link-state lecture, material will probably only appear in TF or short-answer questions
 - ◆ Link-state and on is fair game for more in-depth questions (esp TCP)
- Review session:
 - Saturday at 2pm
 - Pepper Canyon 122



Lecture 24 Overview

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

IEEE 802.11 Infrastructure



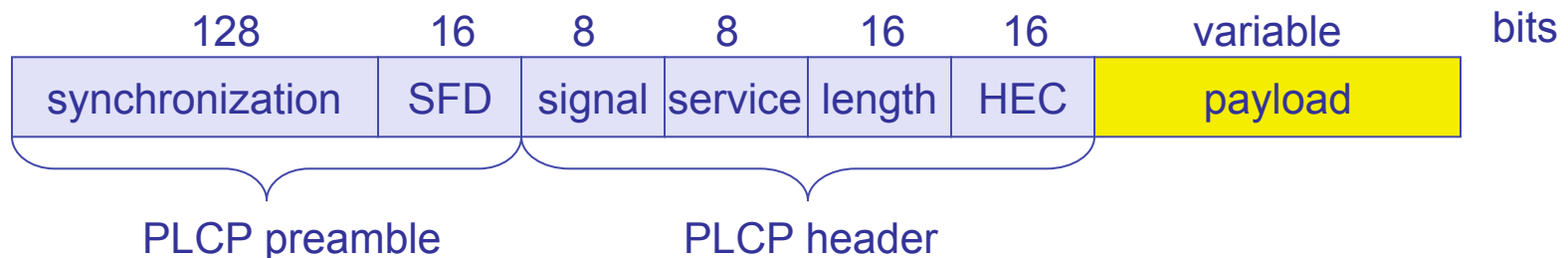


802.11 Frame Format

- 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
- HEC (Header Error Check)
 - ♦ protection of signal, service and length, $x^{16}+x^{12}+x^5+1$

Length

□ payload length





WLAN: IEEE 802.11b

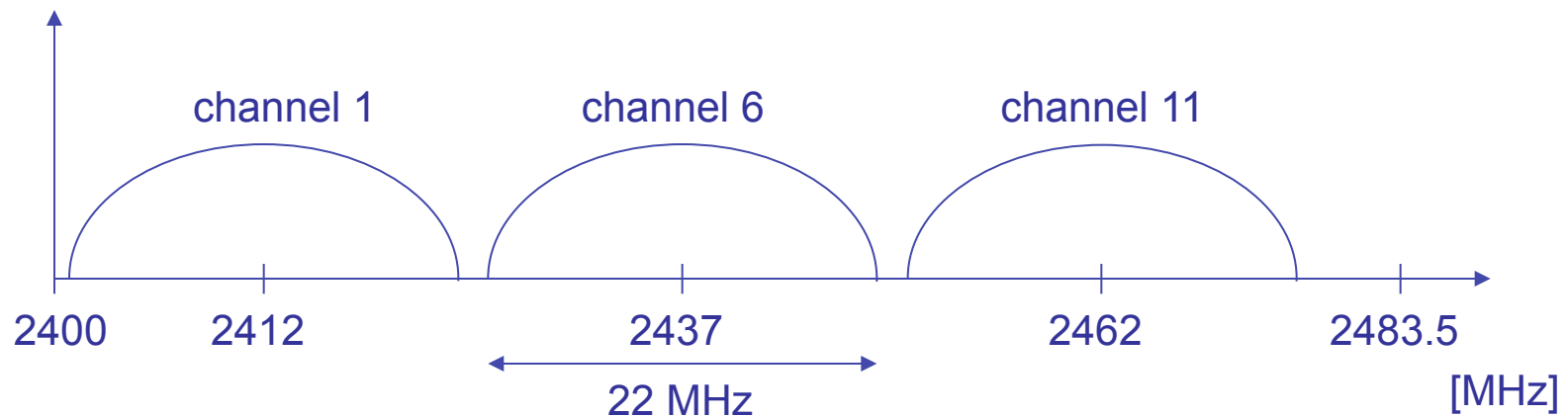
- Data rate
 - ◆ 1, 2, 5.5, 11 Mbit/s
 - ◆ User data rate max. approx. 6 Mbit/s
- Transmission range
 - ◆ 300m outdoor, 30m indoor
 - ◆ Max. data rate ~10m indoor
- Frequency
 - ◆ Free 2.4 GHz ISM-band



Physical Channels

- 12 channels available for use in the US
 - ◆ Each channel is 22 MHz wide
 - ◆ Only 3 orthogonal channels
 - ◆ Using any others causes interference

US (FCC)/Canada (IC)



Carrier Sense Multiple Access

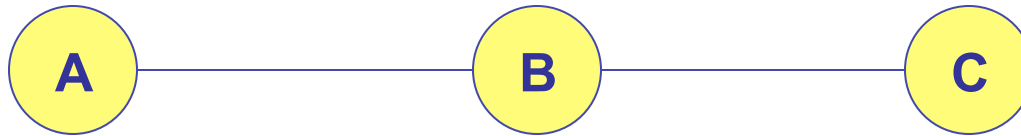


CSMA: listen before transmit:

- If channel sensed idle: transmit entire pkt
- If channel sensed busy, defer transmission
 - ◆ Persistent CSMA: retry immediately with probability p when channel becomes idle (may cause instability)
 - ◆ Non-persistent CSMA: retry after random interval



Hidden Terminal Problem



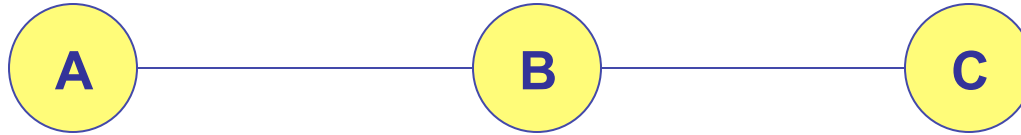
- B can communicate with both A and C
- A and C cannot hear each other – not a single shared channel
- Problem
 - ♦ When A transmits to B, C cannot detect the transmission using the **carrier sense** mechanism
 - ♦ If C transmits, collision will occur at node B
- Solution
 - ♦ Hidden sender C needs to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

CSMA/CA



- Cannot detect collision w/half-duplex radios
- 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.
 - ◆ Once channel becomes idle, the node waits for a randomly chosen duration before attempting to transmit.

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

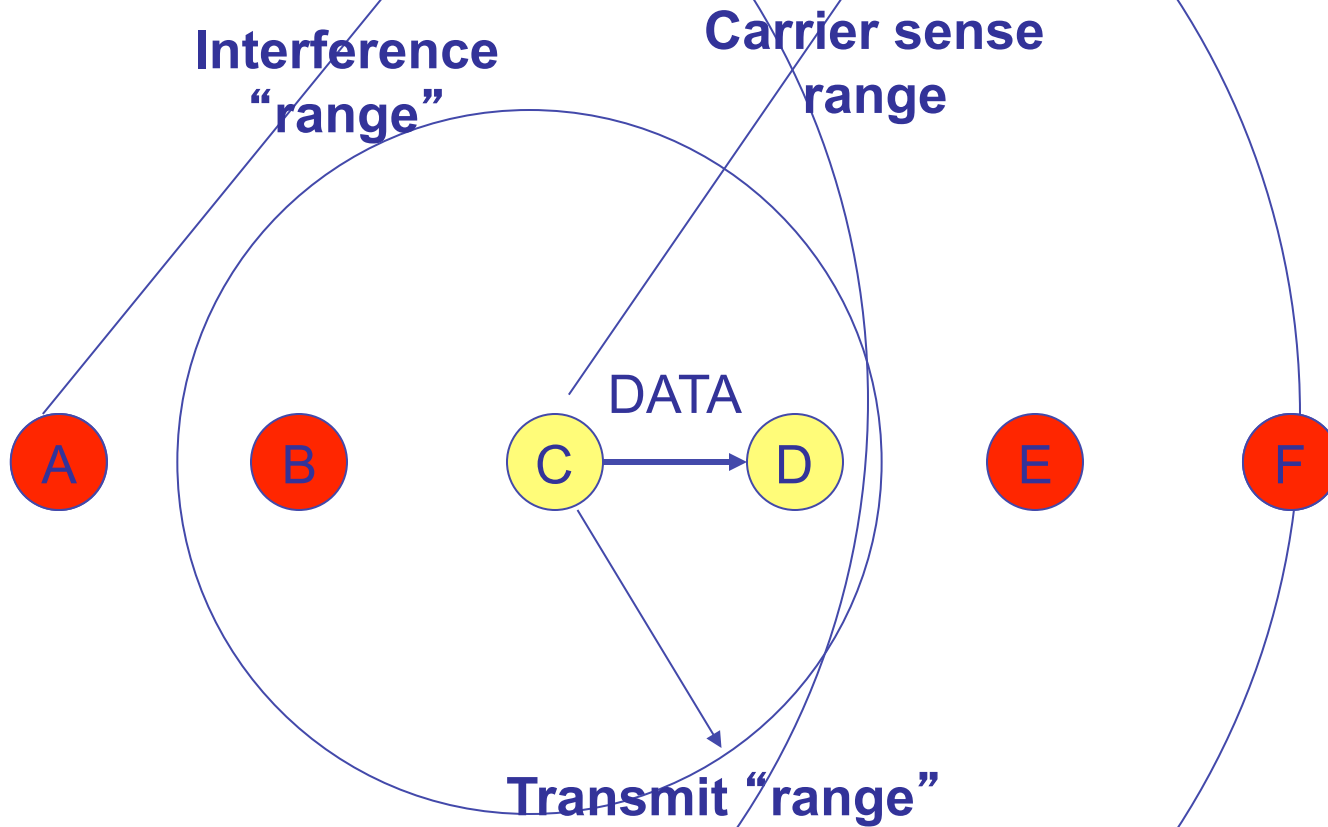


Backoff Interval

- **Problem:** With many contending nodes, RTS packets 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
 - ◆ Similar in spirit to Ethernet backoff



Non-symmetric ranges





802.11 MAC Modes

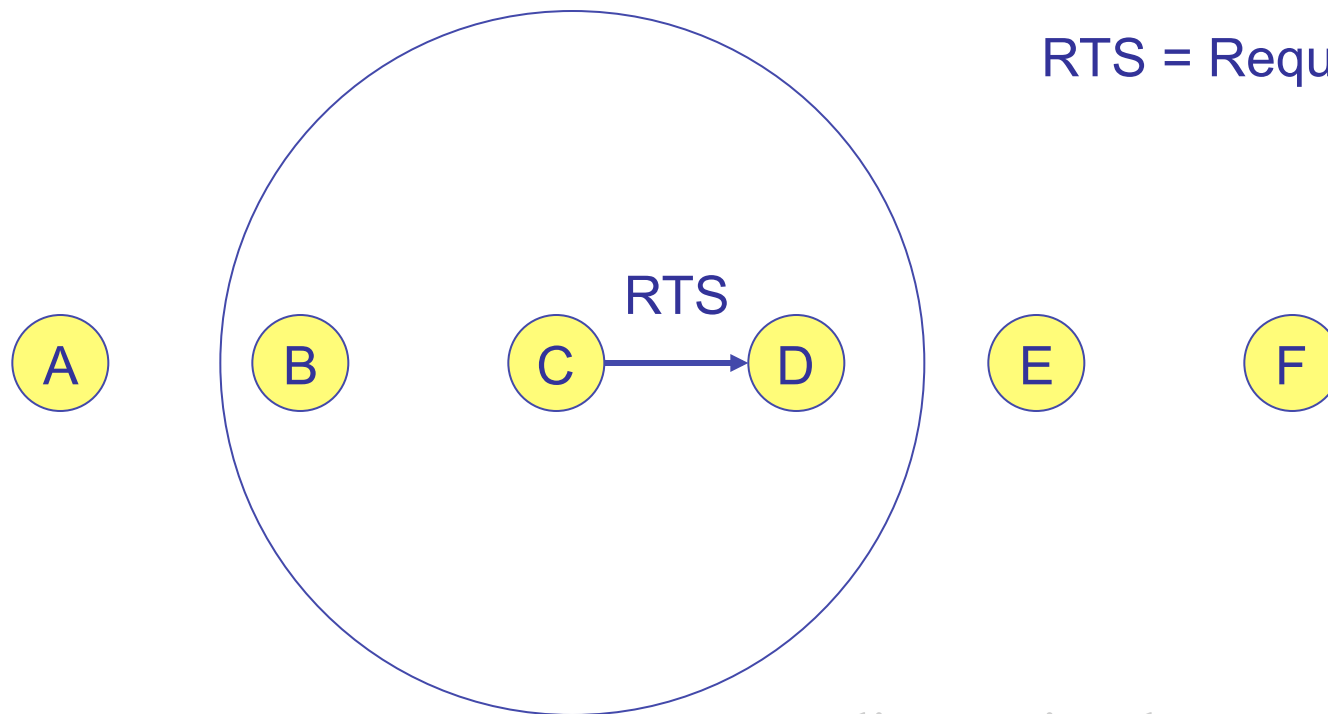
- Distributed Coordination Function (DCF) CSMA/CA
 - ◆ collision avoidance via randomized “back-off” mechanism
 - ◆ minimum distance between consecutive packets
 - ◆ ACK packet for acknowledgements (not for broadcasts)
- DCF w/ RTS/CTS
 - ◆ Distributed Foundation Wireless MAC
 - ◆ avoids hidden terminal problem
- Point Control Function (PCF) - *optional*
 - ◆ Access point polls terminals according to a list
 - ◆ We’ re not going to discuss...



IEEE 802.11 DCF

- DCF is CSMA/CA protocol
 - ◆ Uses a Network Allocation Vector (NAV) to implement collision avoidance (pkt specifies duration in header)
- Optionally uses RTS/CTS exchange to avoid hidden terminal problem
 - ◆ Any node overhearing a CTS cannot transmit for the duration of the transfer
- Uses ARQ to provide reliability

IEEE 802.11



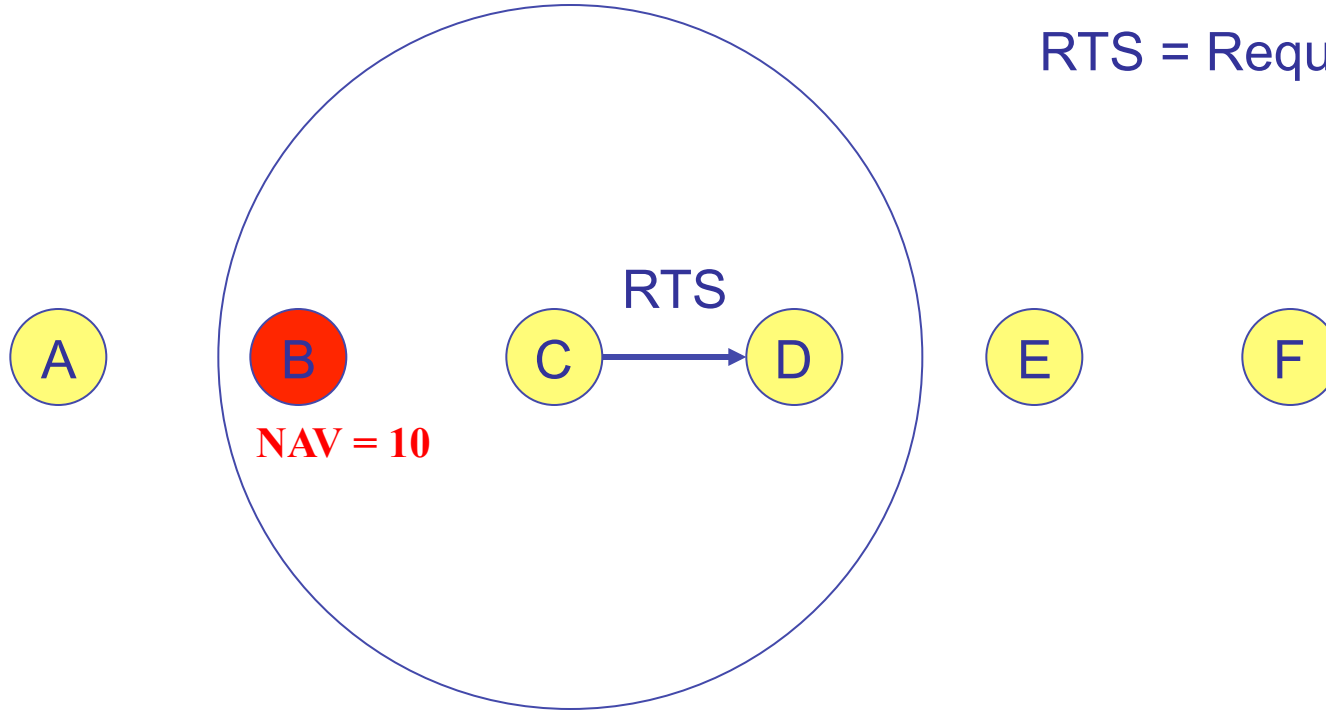
RTS = Request-to-Send

Pretending a circular range

IEEE 802.11

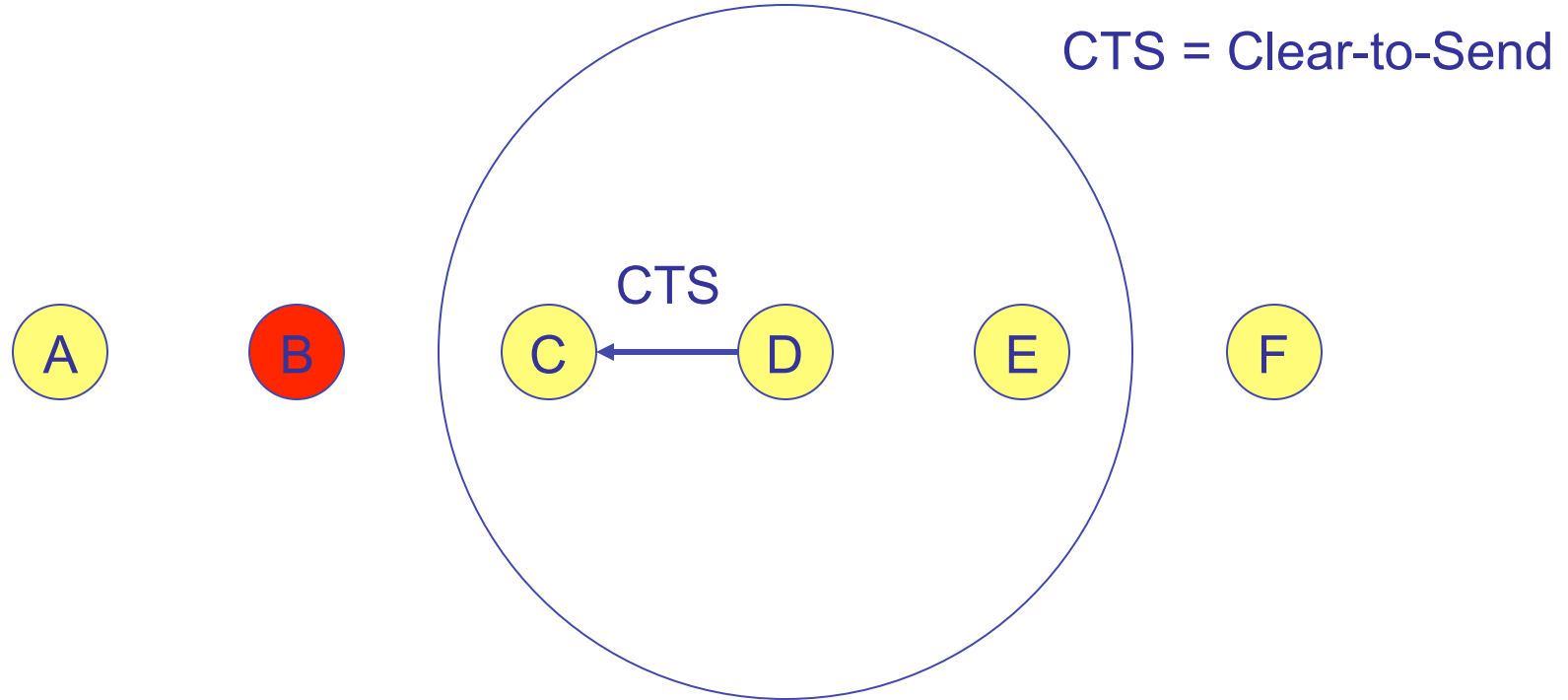


NAV = remaining duration to keep quiet

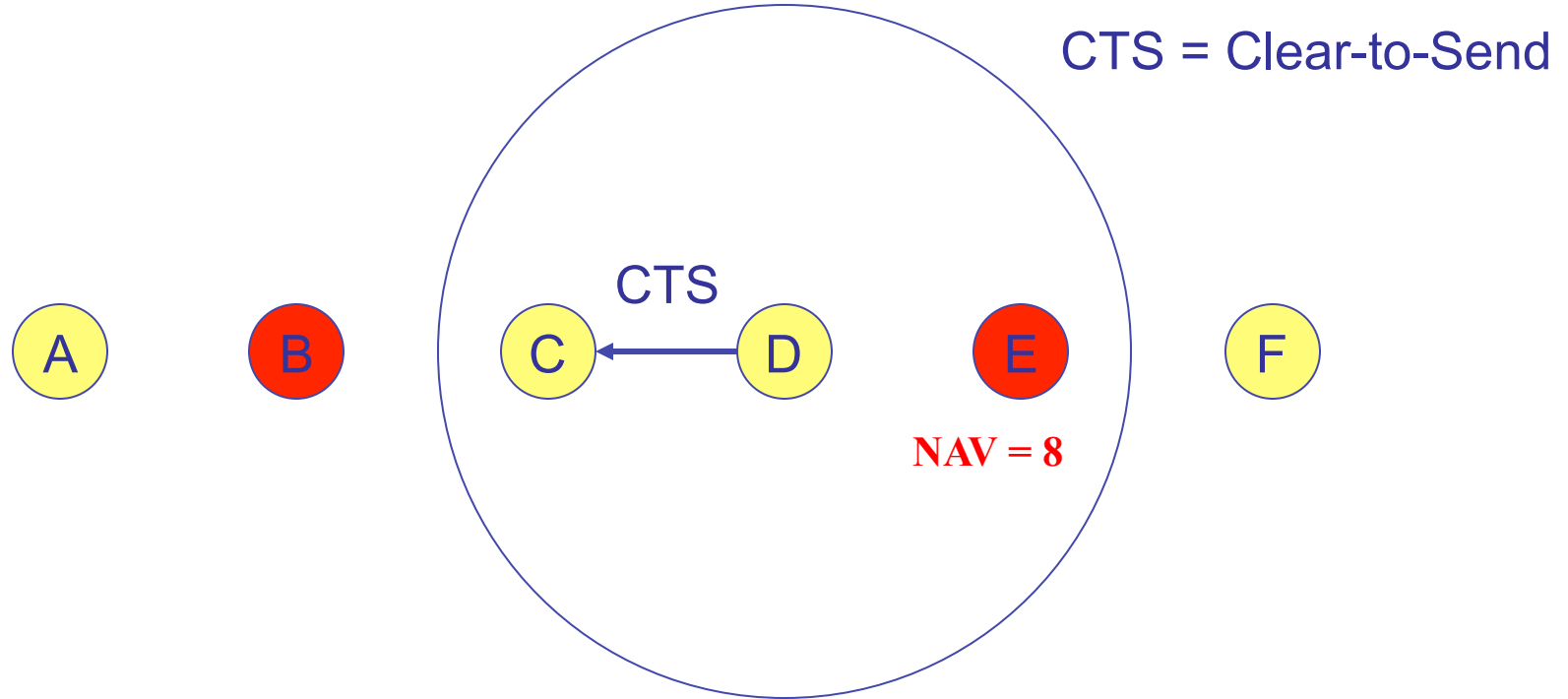


RTS = Request-to-Send

IEEE 802.11



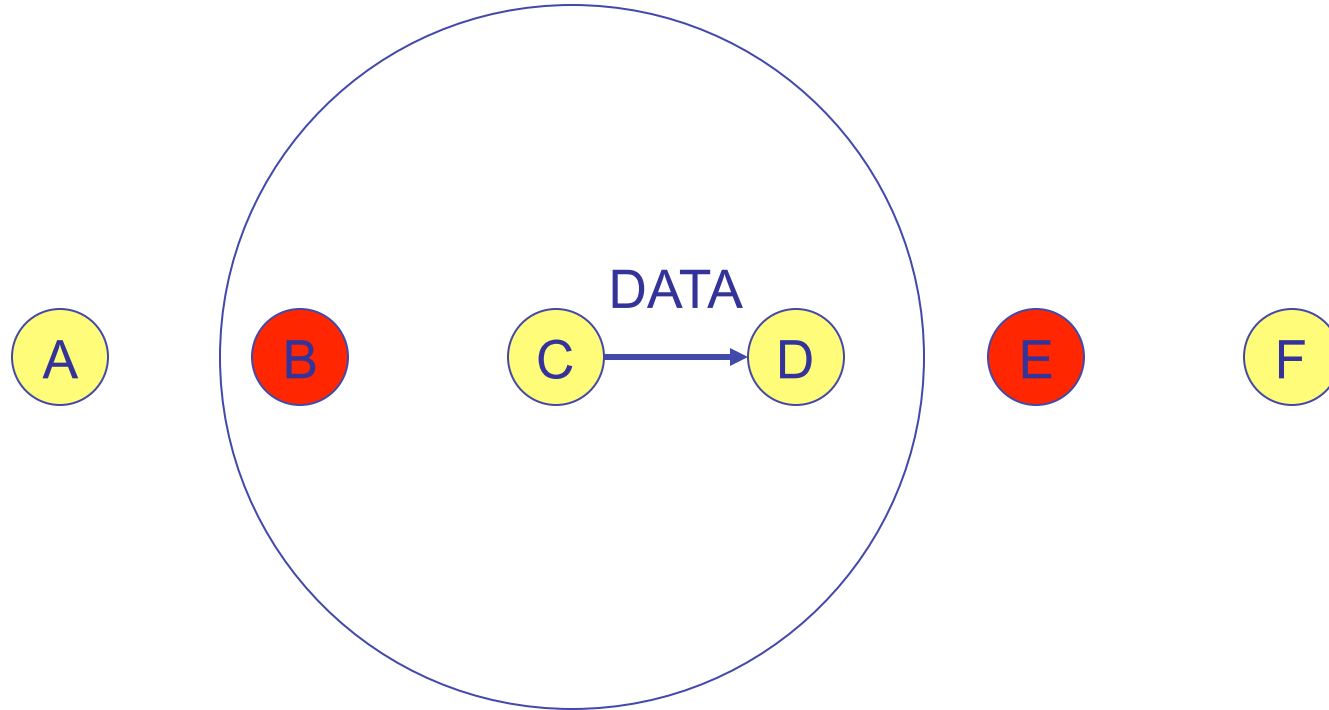
IEEE 802.11



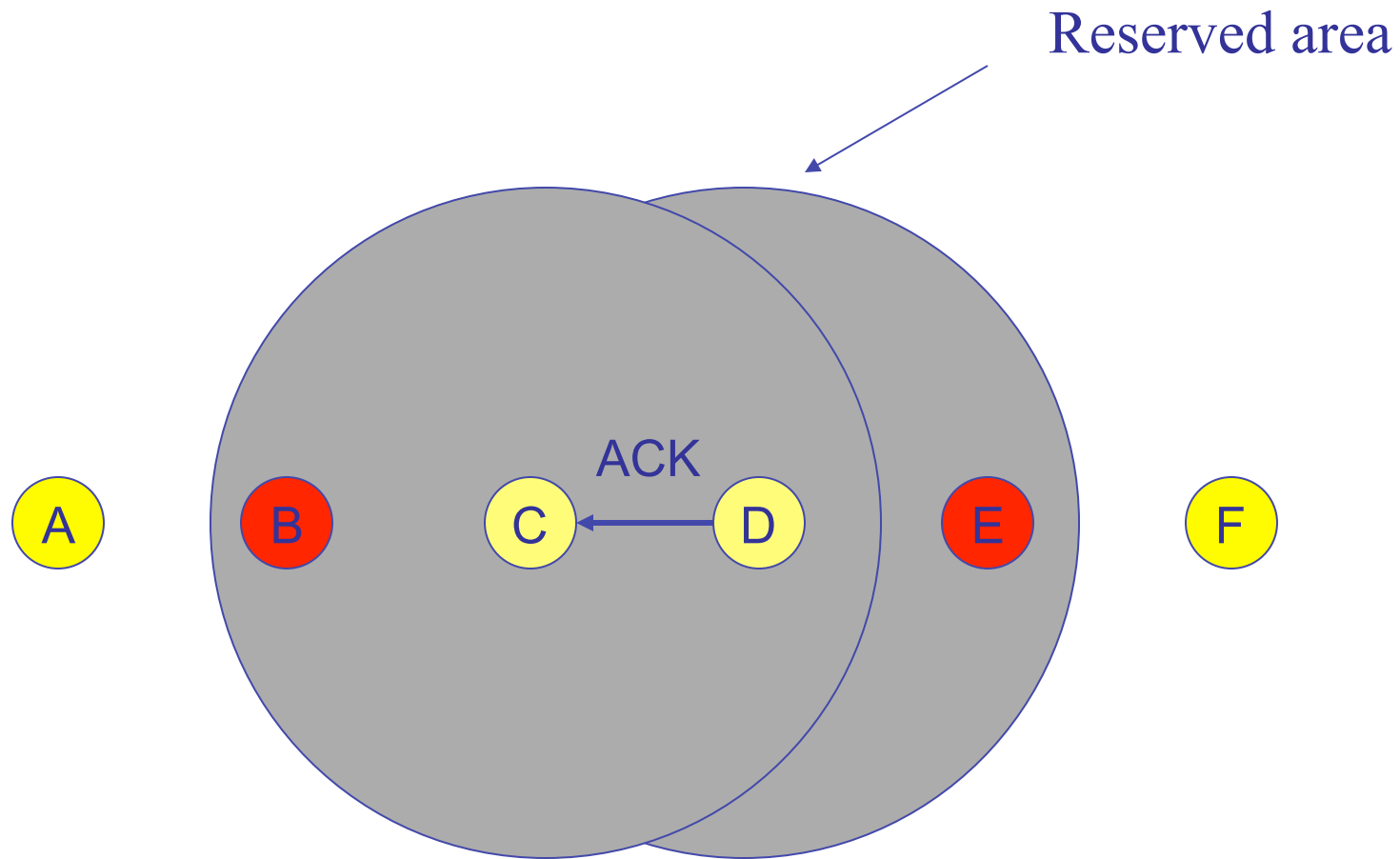
IEEE 802.11



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



IEEE 802.11





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



- Remember to turn in Project 2
- See you at the final