Lecture 25: 802.11

CSE 123: Computer Networks

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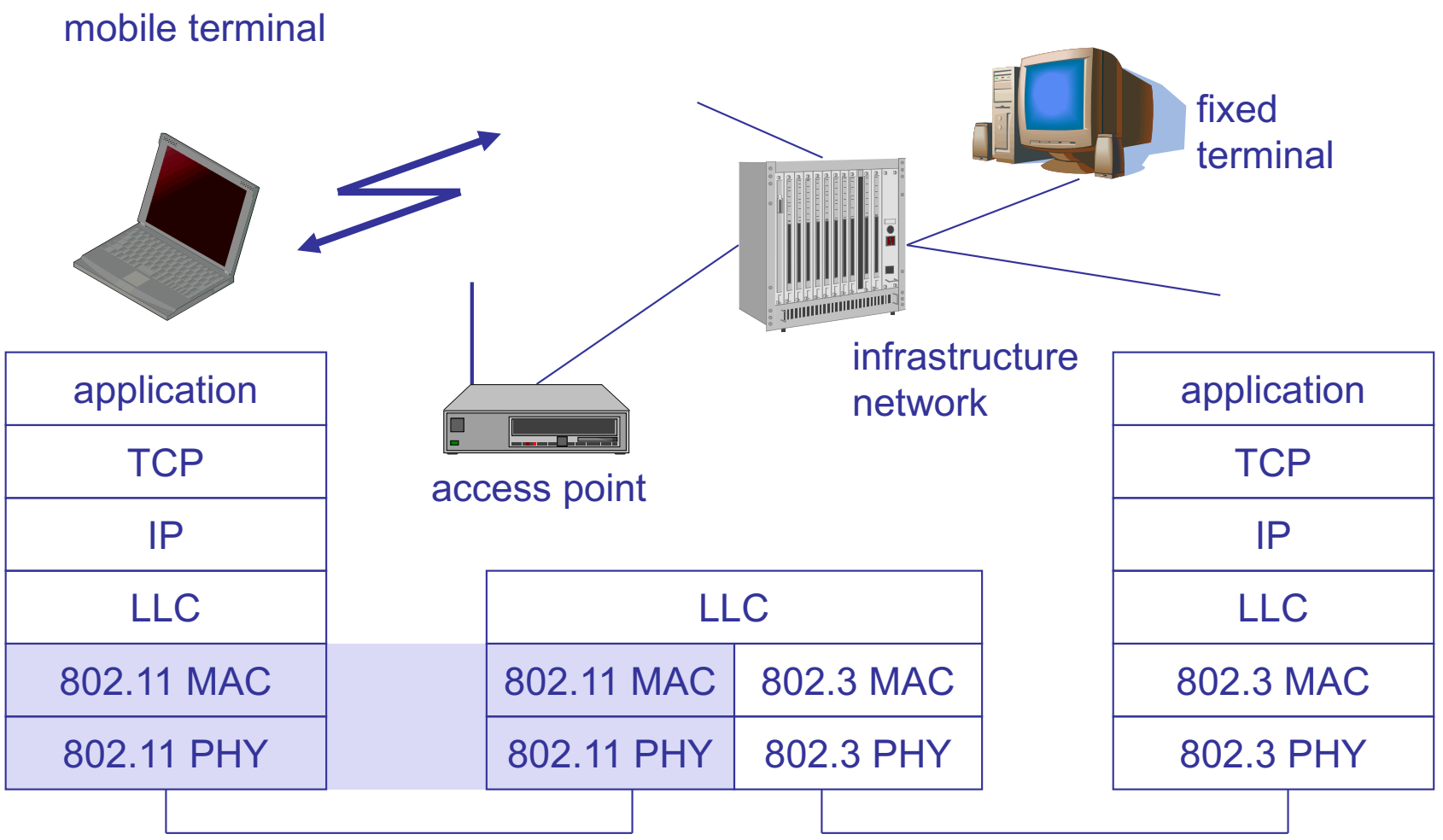
UCSDCSE

HW3 due NOW

Lecture 25 Overview

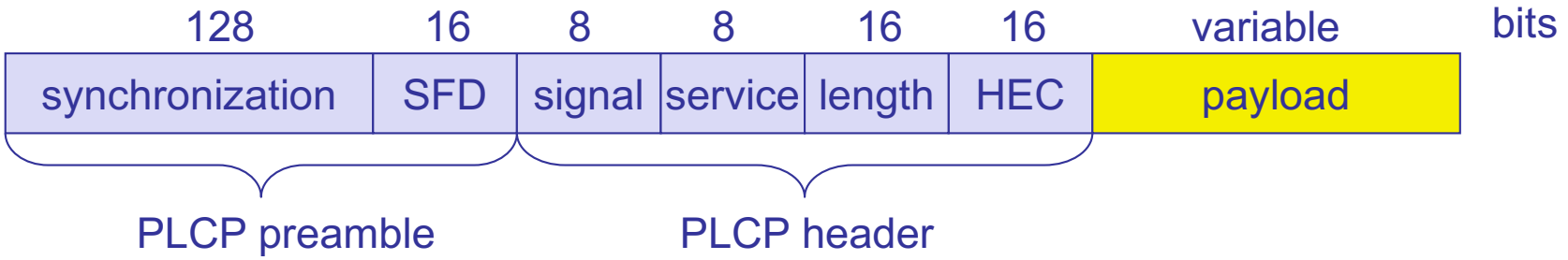
- 802.11 Wireless
  - PHY layer overview
- Hidden Terminals
  - Basic wireless challenge
- RTS/CTS
  - Virtual carrier sense
- CSMA/CA
  - Limits of half-duplex radios

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



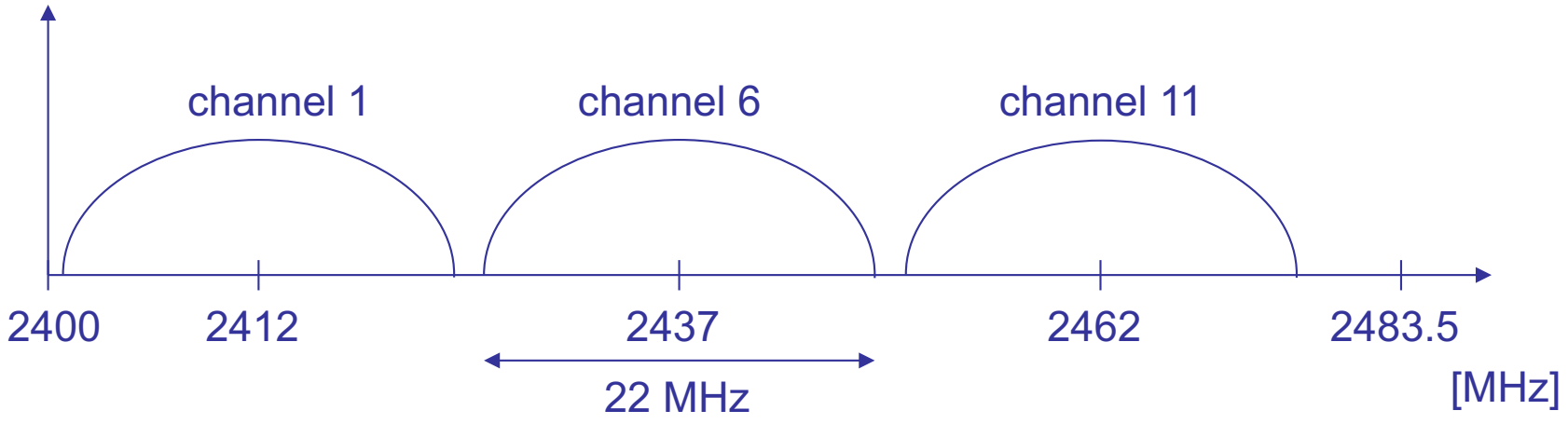
WLAN: IEEE 802.11b

- Data rate
  - 1, 2, 5.5, 11 Mbit/s
  - User data rate max. approx. 6 Mbit/s
- 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)

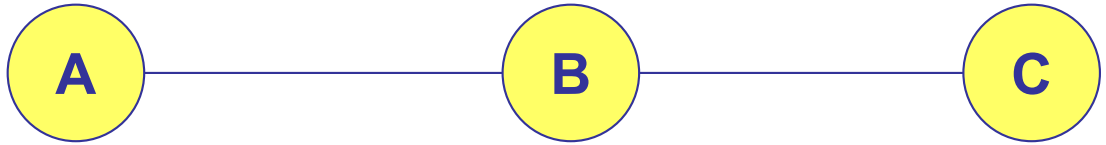


Carrier Sense Multiple Access

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

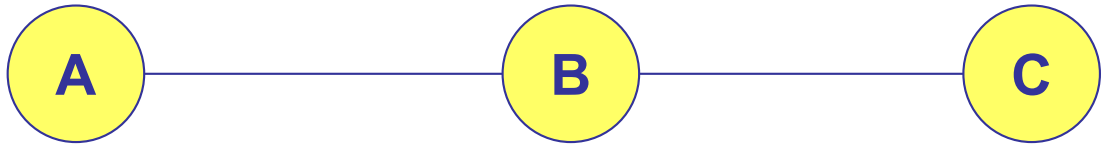


- B can communicate with both A and C
- A and C cannot hear each other – not a single shared channel
- Problem
  - When A transmits to B, C cannot detect the transmission using the carrier sense mechanism
  - If C transmits, collision will occur at node B
- Solution
  - Hidden sender C needs to defer

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)

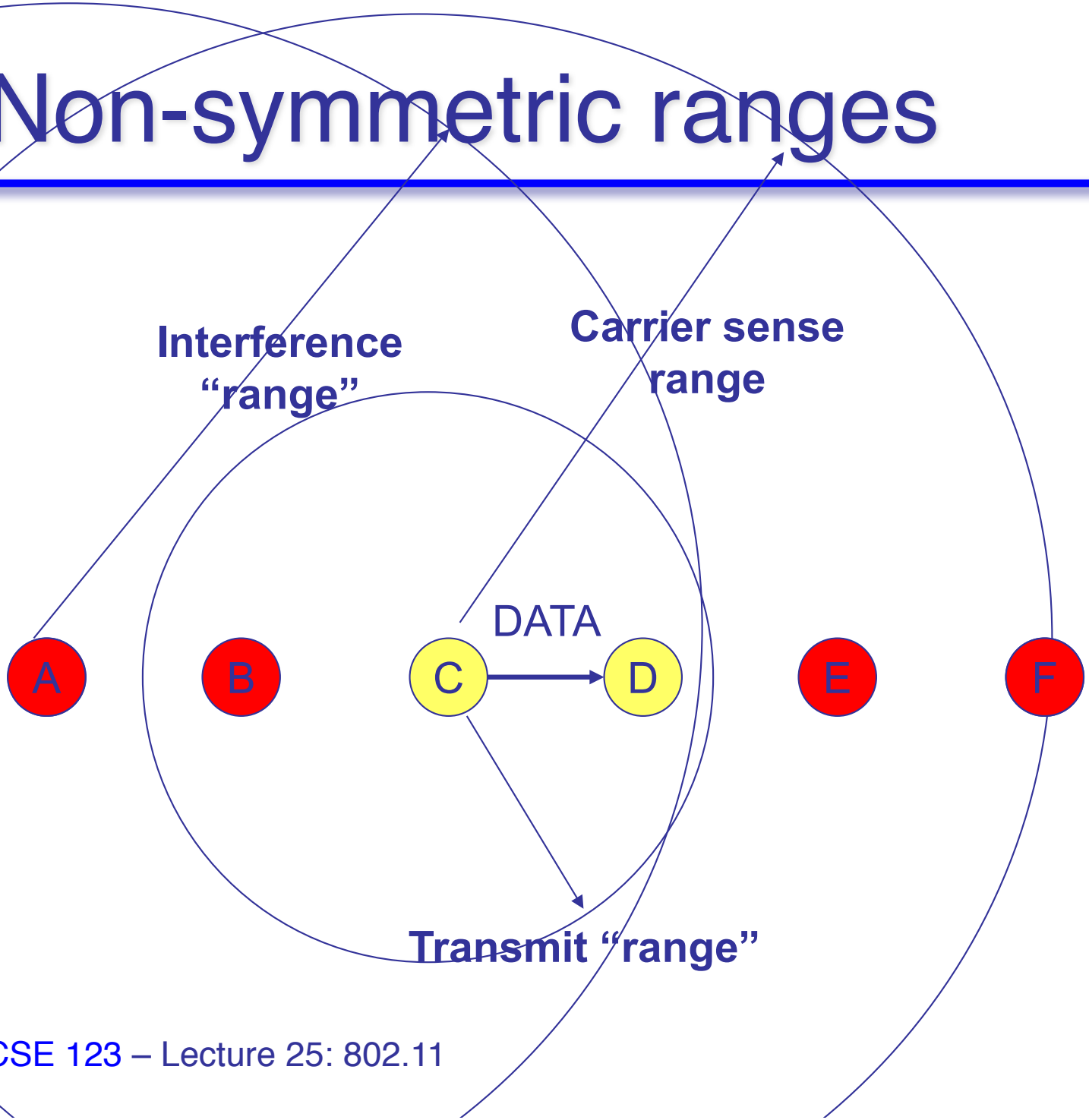


- When A wants to send a packet to B, A first sends a Request-to-Send (RTS) to B
- On receiving RTS, B responds by sending Clear-to-Send (CTS), provided that A is able to receive the packet
- When C overhears a CTS, it keeps quiet for the duration of the transfer
  - Transfer duration is included in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



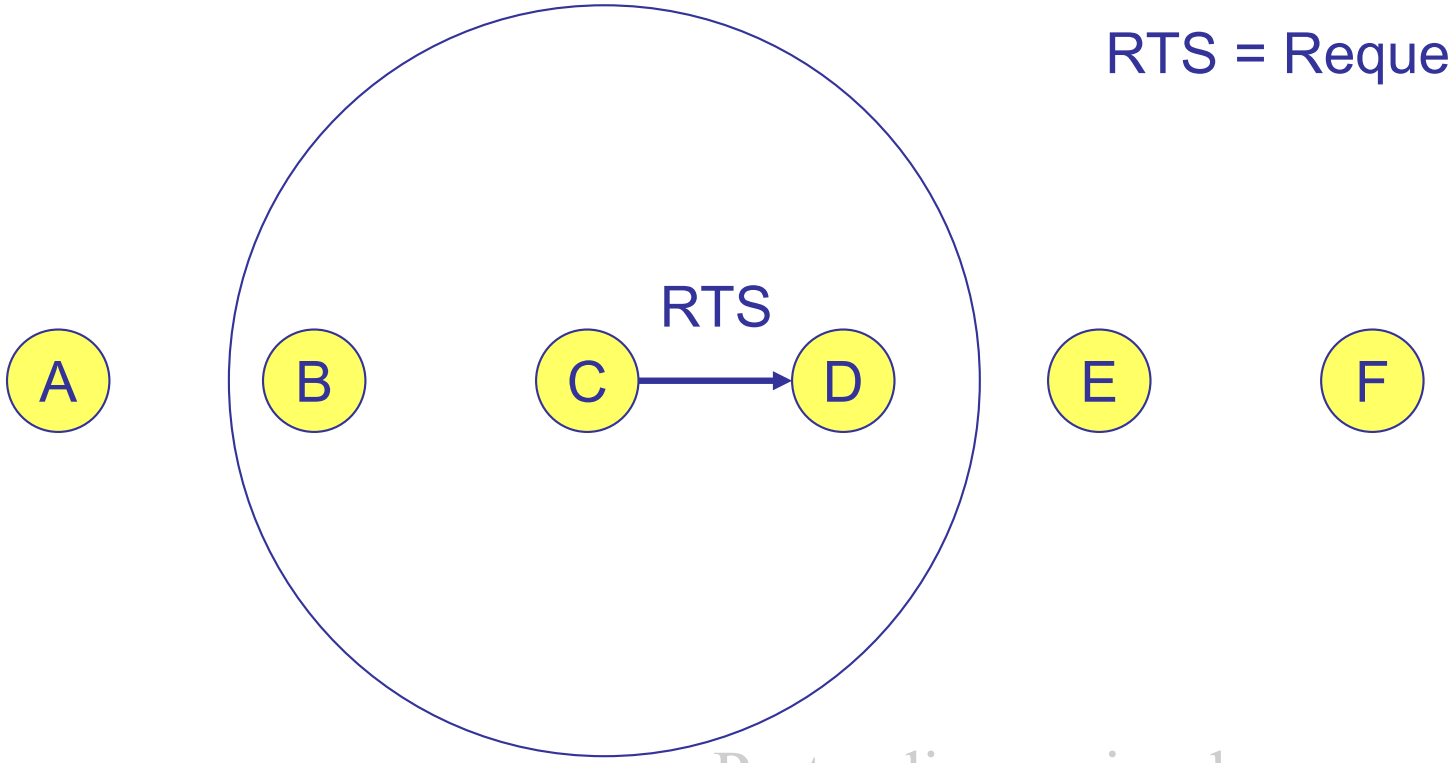
802.11 MAC Modes

- 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 Fuction (PCF) - *optional*
  - Access point polls terminals according to a list
  - We're not going to discuss…

IEEE 802.11 DCF

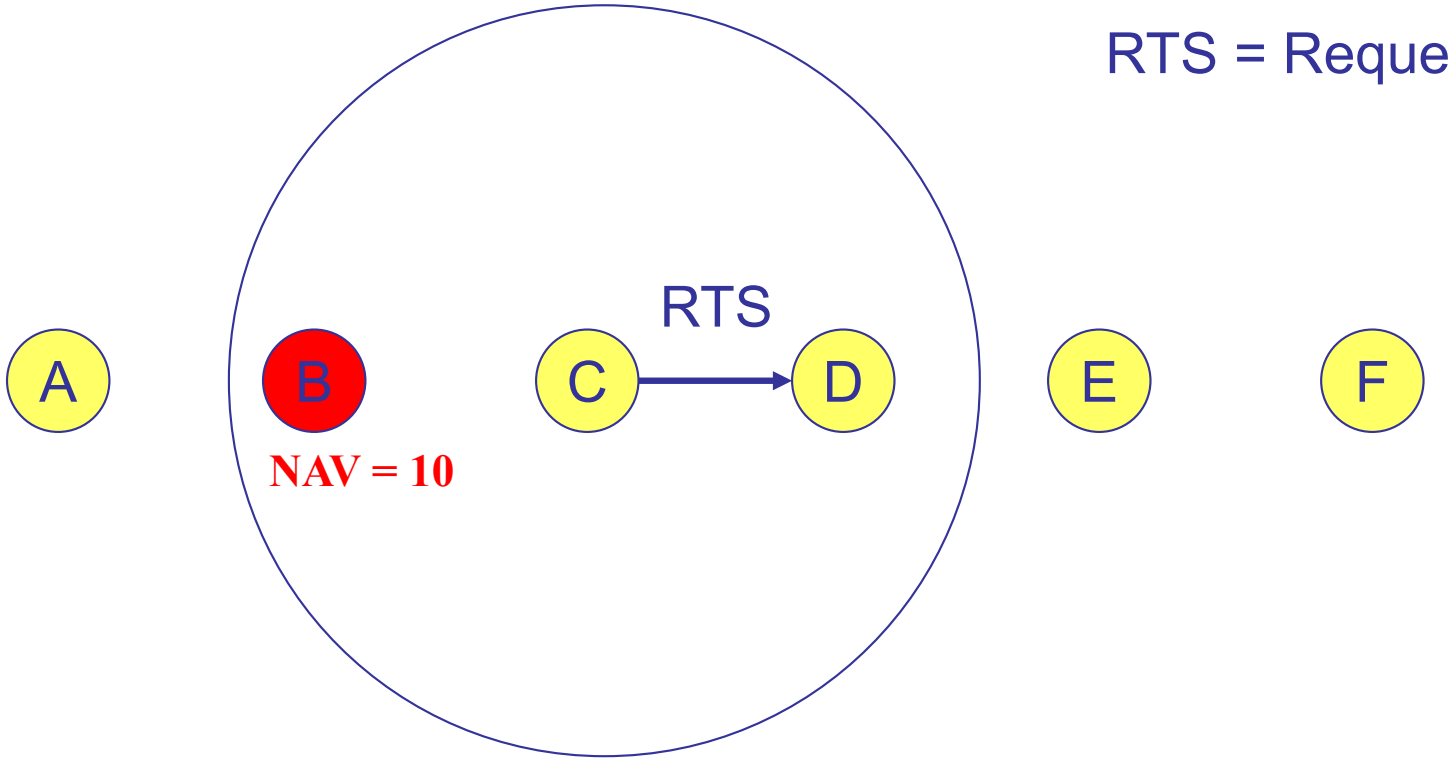
- DCF is CSMA/CA protocol
  - Uses a Network Allocation Vector (NAV) to implement collision avoidance (pkt specifies duration in header)
- Optionally uses RTS/CTS exchange to avoid hidden terminal problem
  - Any node overhearing a CTS cannot transmit for the duration of the transfer
- Uses ARQ to provide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

IEEE 802.11

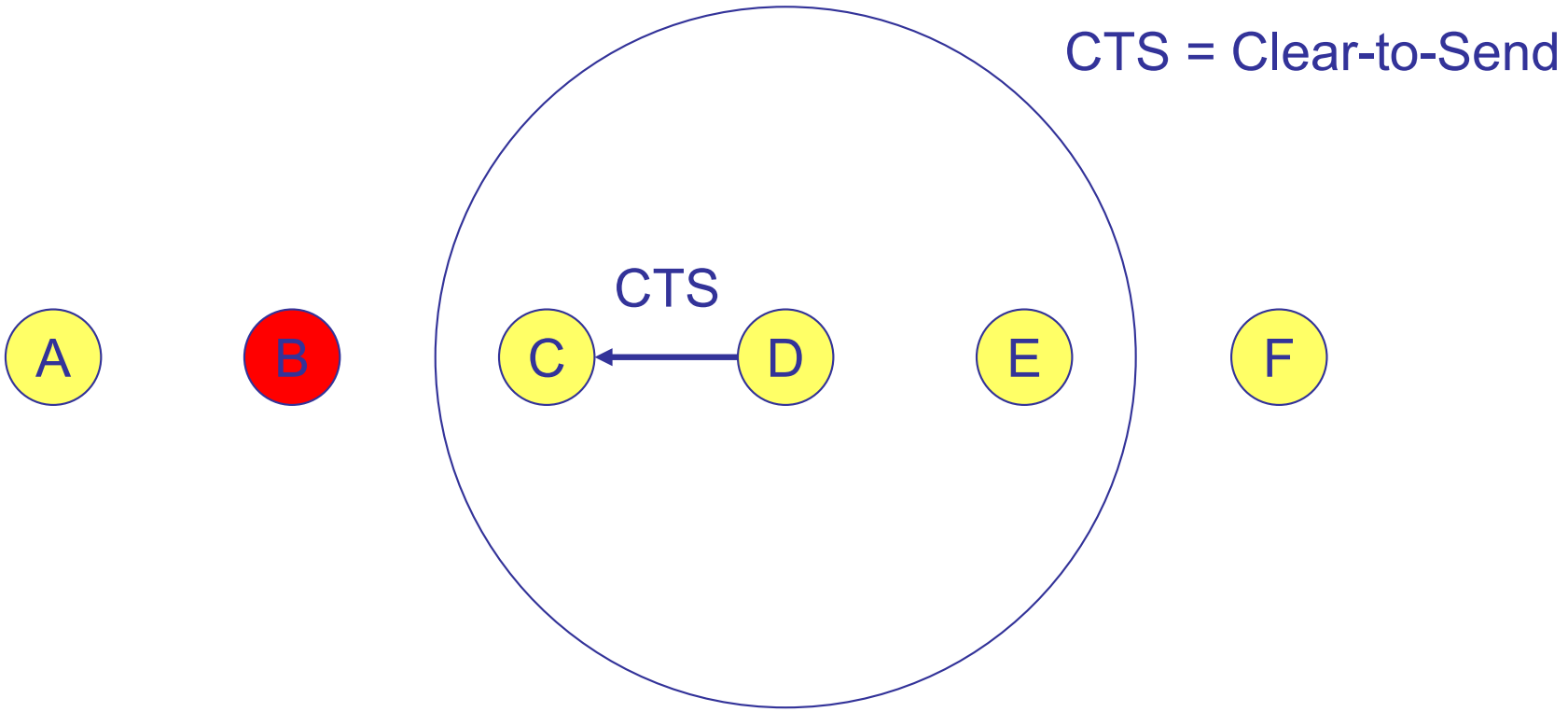


IEEE 802.11

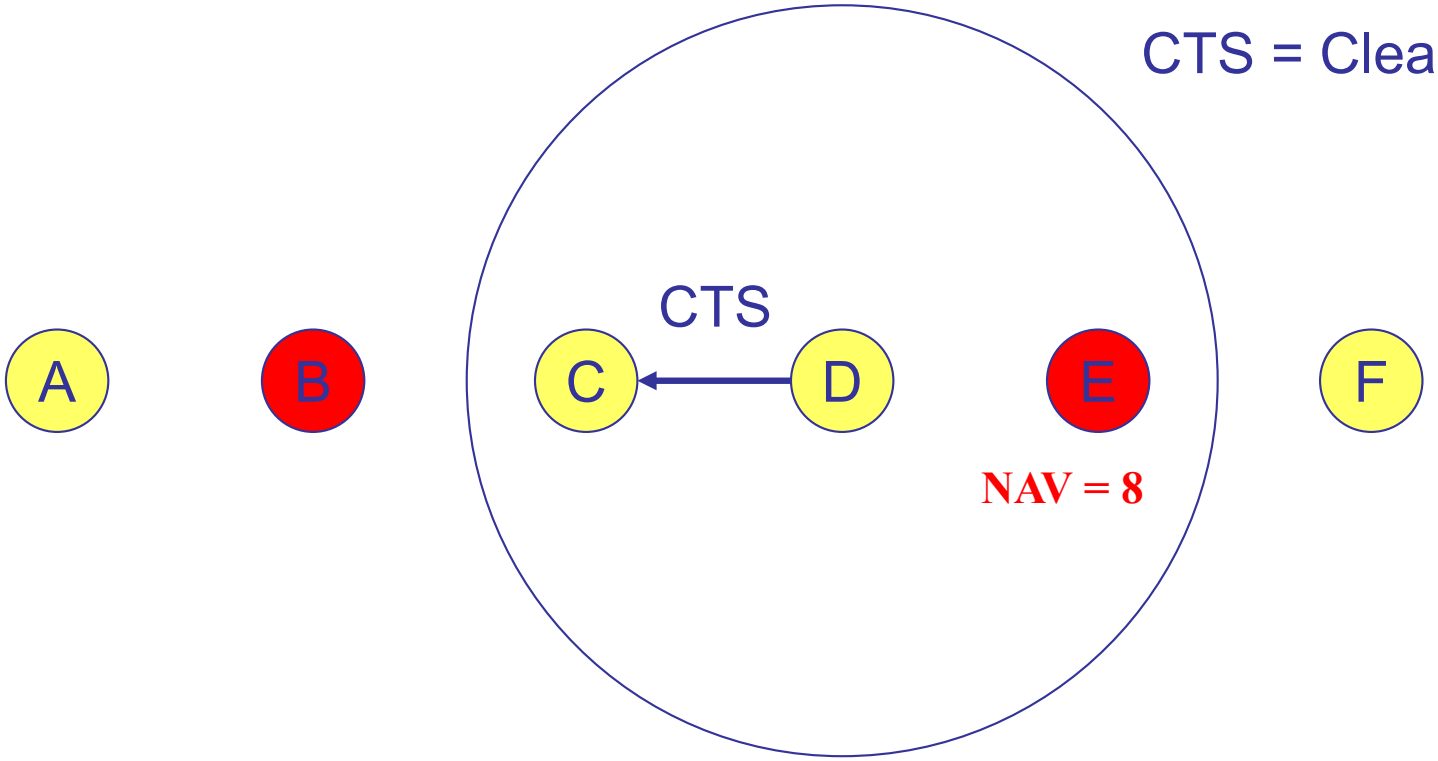
NAV = remaining duration to keep quiet



IEEE 802.11

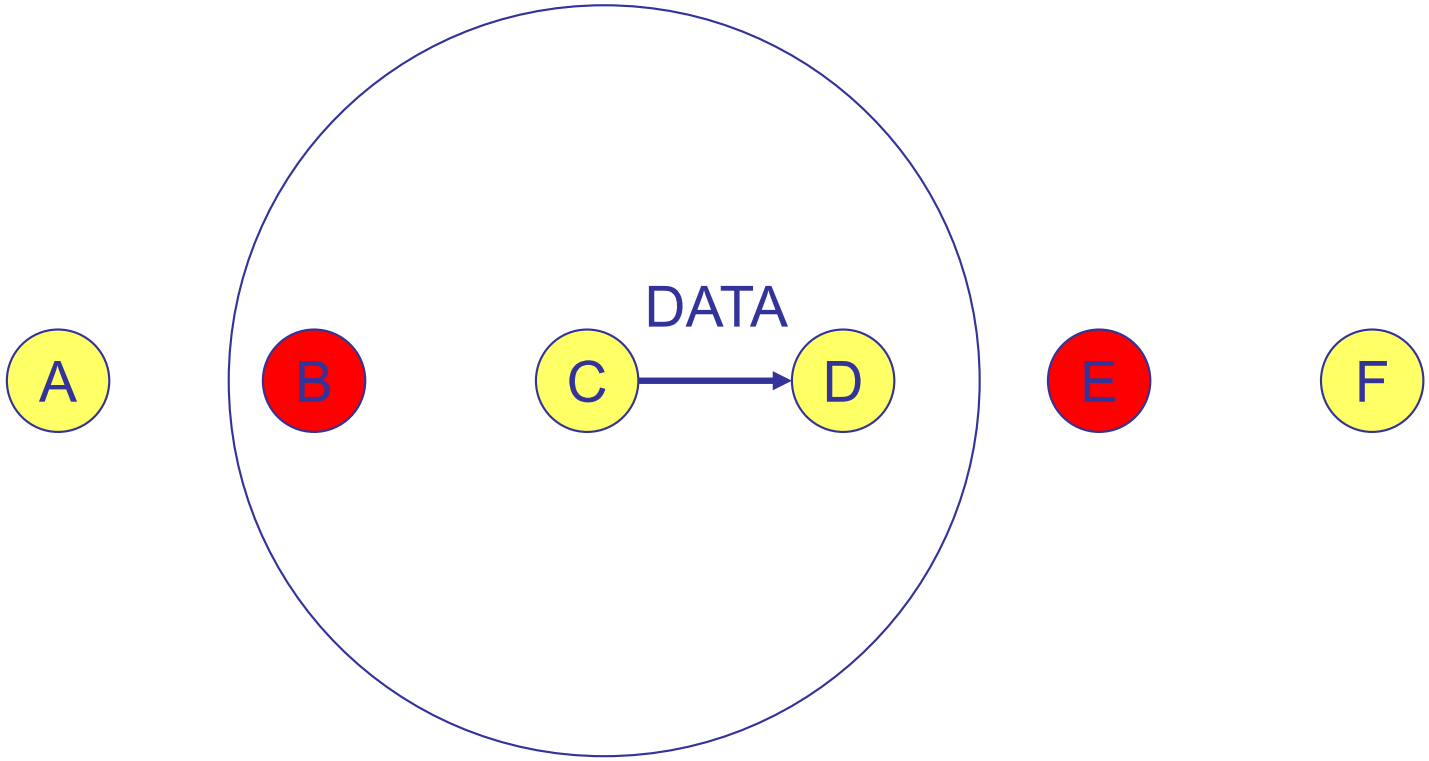


IEEE 802.11

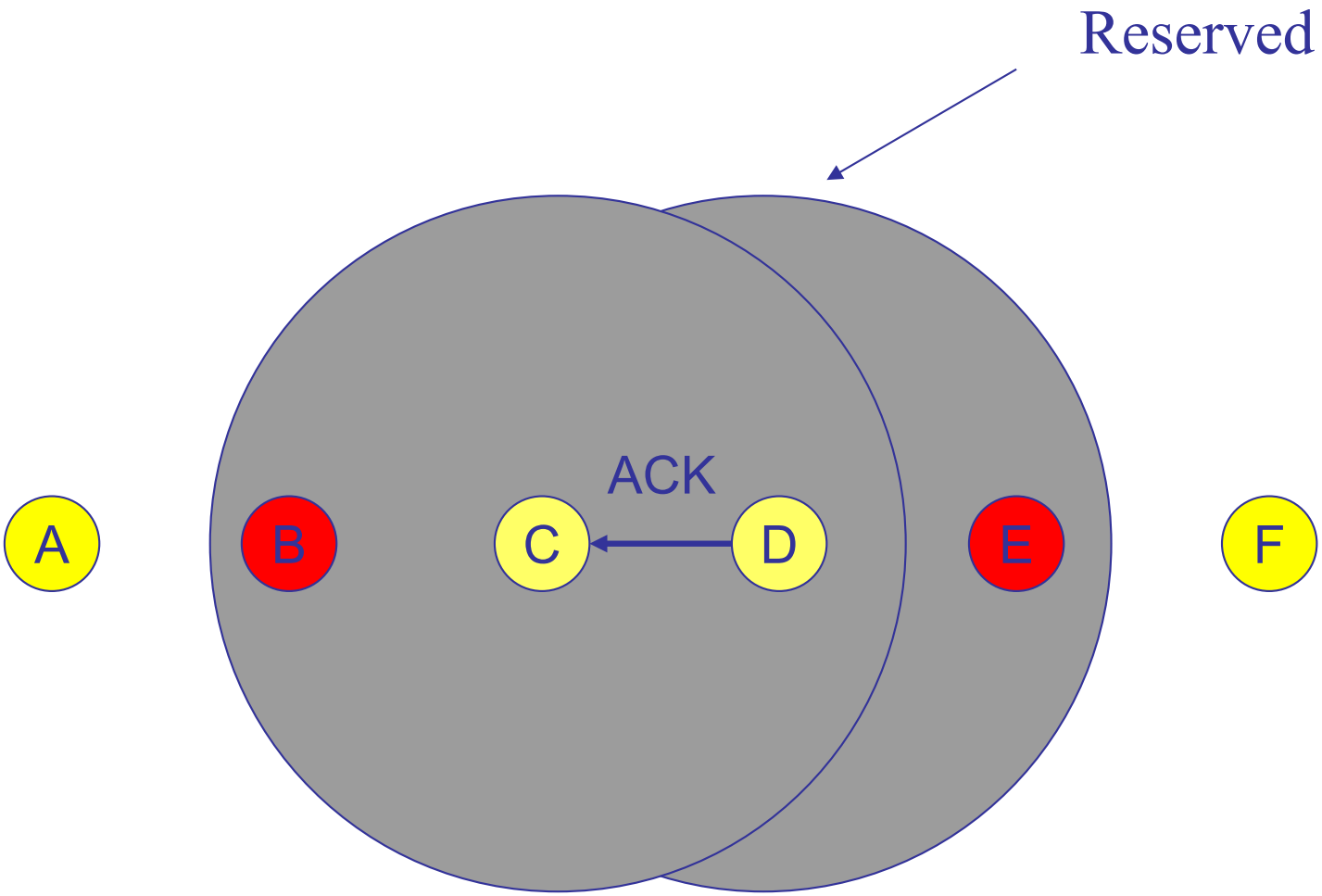


IEEE 802.11

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



IEEE 802.11



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 > 1Gbps

That's all folks

- No more new material…
- Remember to turn in Project 2 on time!
  - Espresso Prize awarded at Final
  - Letter grade for each day late
- Final review on Friday
  - During regular class period