Computer Networks

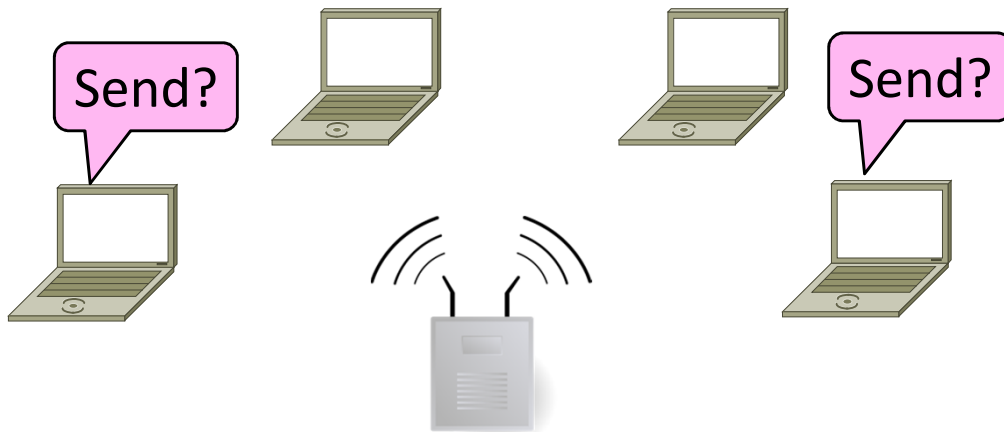## Wireless Multiple Access (§4.2.5, 4.4)

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Topic

- How do wireless nodes share a single link? (Yes, this is WiFi!)
 - Build on our simple, wired model

Wireless Complications

- Wireless is more complicated than the wired case (Surprise!)

  1. Nodes may have different areas of coverage – doesn't fit Carrier Sense **»**

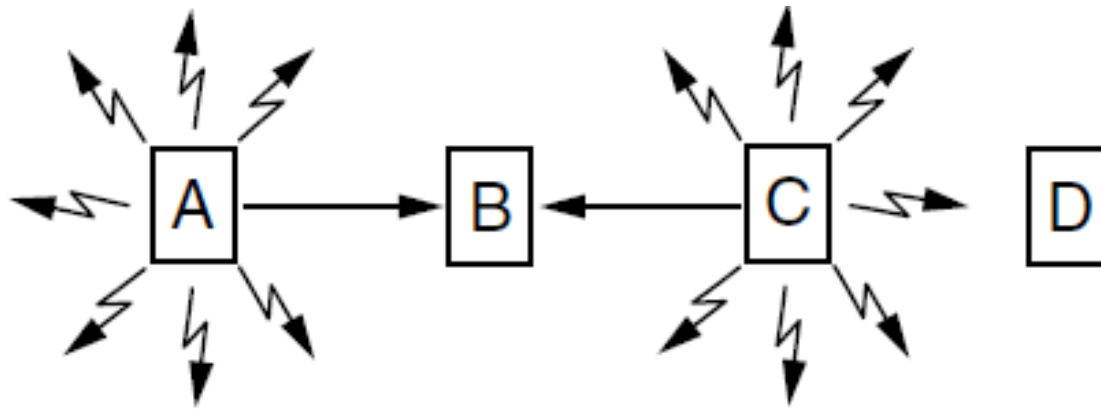 2. Nodes can't hear while sending – can't Collision Detect **»**

  ≠ CSMA/CD

Different Coverage Areas

- Wireless signal is broadcast and received nearby, where there is sufficient SNR
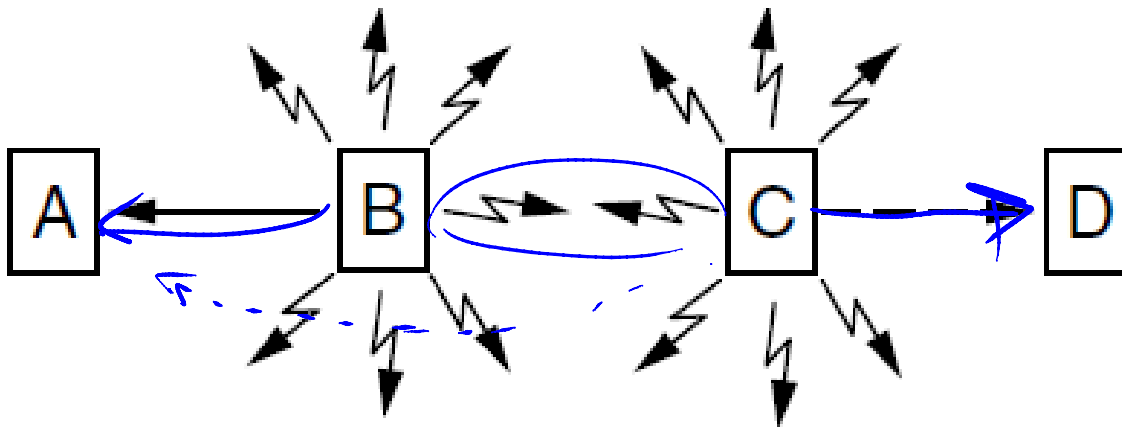

Radio range
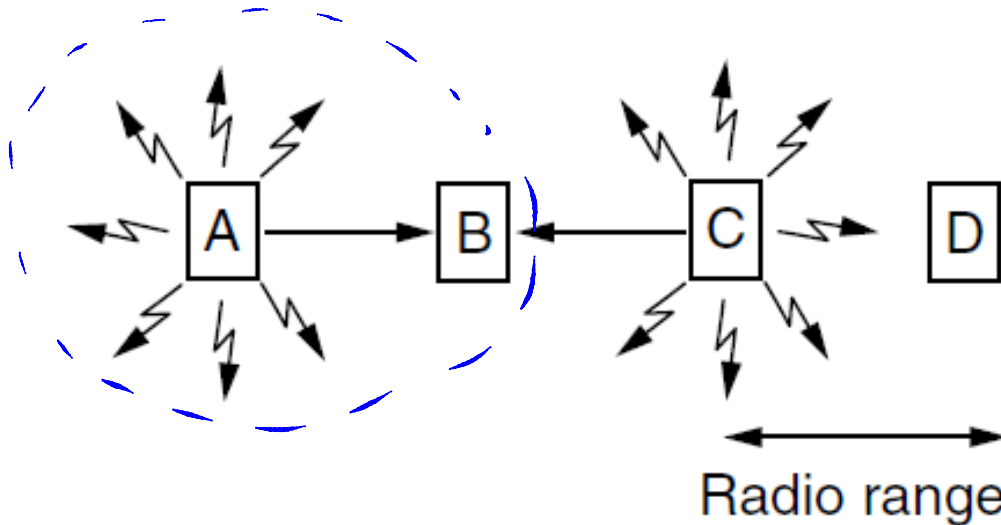
Hidden Terminals

- Nodes A and C are <u>hidden terminals</u> when sending to B
  - Can't hear each other (to coordinate) yet collide at B
 - We want to avoid the inefficiency of collisions

Exposed Terminals

- B and C are <u>exposed terminals</u> when sending to A and D
  - Can hear each other yet don't collide at receivers A and D
  - We want to send concurrently to increase performance

Nodes Can't Hear While Sending

- With wires, detecting collisions (and aborting) lowers their cost

- More wasted time with wireless

Wired
Collision

Wireless
Collision

Resend

Resend

Time
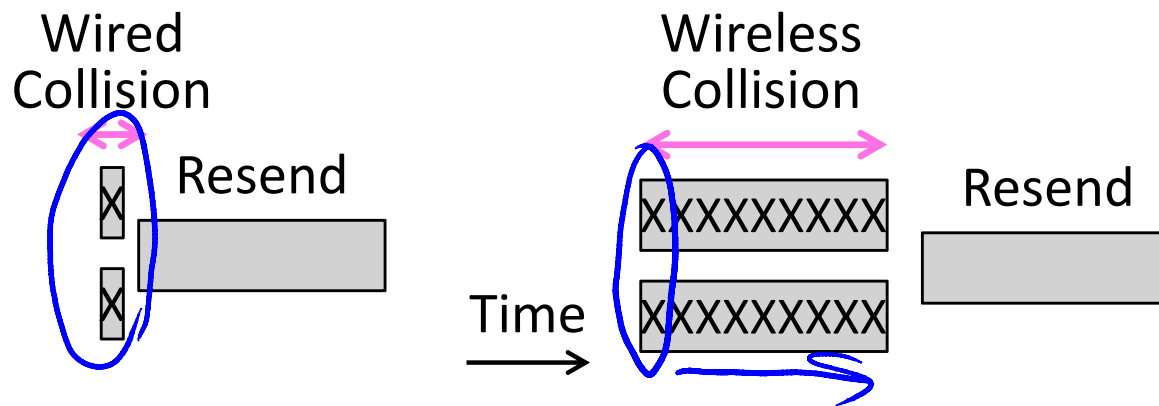
Possible Solution: MACA

- MACA uses a short handshake instead of CSMA (Karn, 1990)
  – 802.11 uses a refinement of MACA (later)

- Protocol rules:
  1. A sender node transmits a RTS (Request-To-Send, with frame length)
  2. The receiver replies with a CTS (Clear-To-Send, with frame length)
  3. Sender transmits the frame while nodes hearing the CTS stay silent
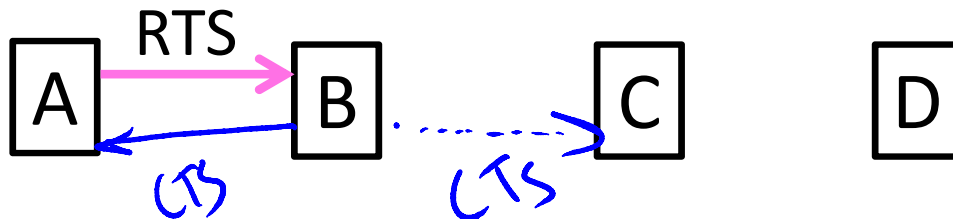   – Collisions on the RTS/CTS are still possible, but less likely

MACA – Hidden Terminals
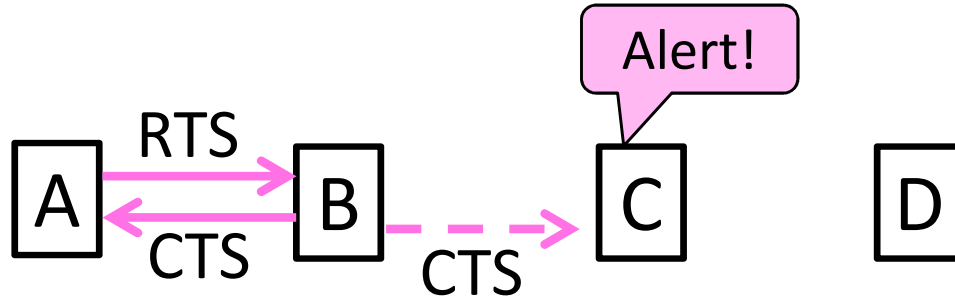
- A→B with hidden terminal C
  1. A sends RTS, to B

MACA – Hidden Terminals (2)

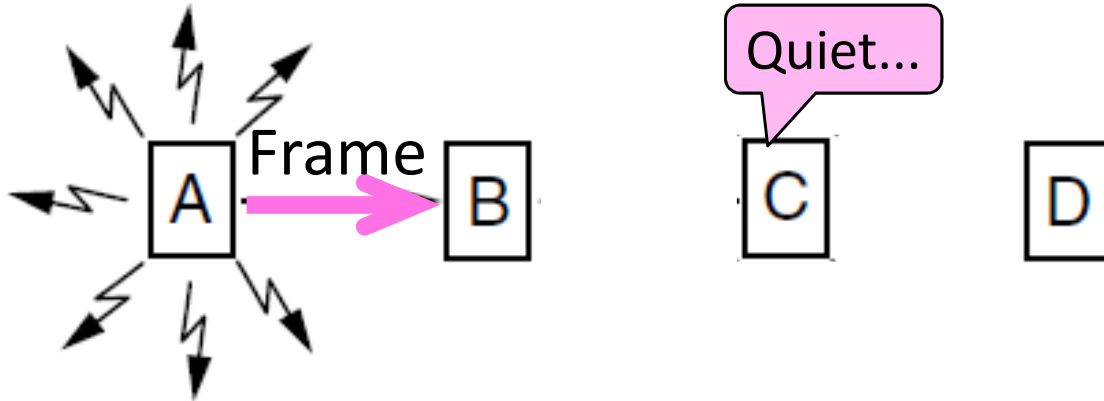- A→B with hidden terminal C

  2. B sends CTS, to A, and C too

MACA – Hidden Terminals (3)

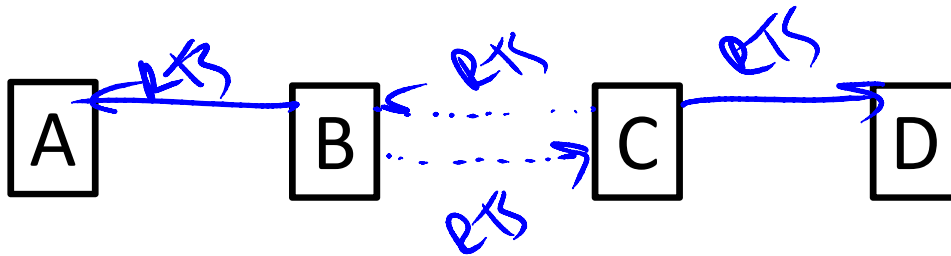- A→B with hidden terminal C

  2. B sends CTS, to A, and C too

MACA – Hidden Terminals (4)

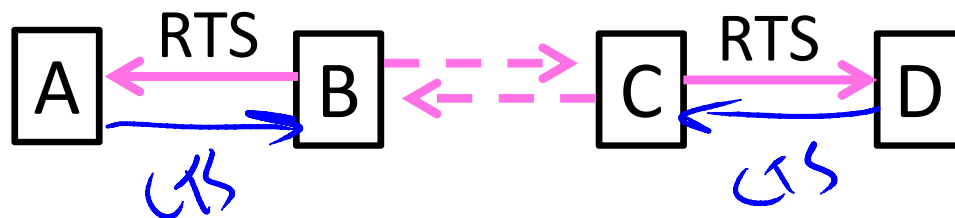- A➔B with hidden terminal C

  3. A sends frame while C defers

MACA – Exposed Terminals

- B→A, C→D as exposed terminals
  - B and C send RTS to A and D

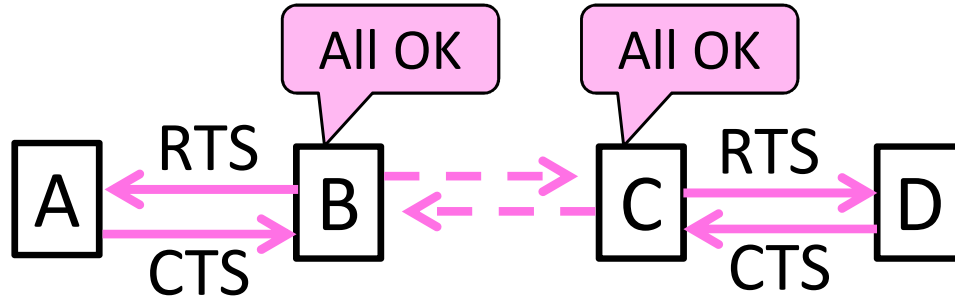# MACA – Exposed Terminals (2)

- B→A, C→D as exposed terminals
  - A and D send CTS to B and C

MACA – Exposed Terminals (3)
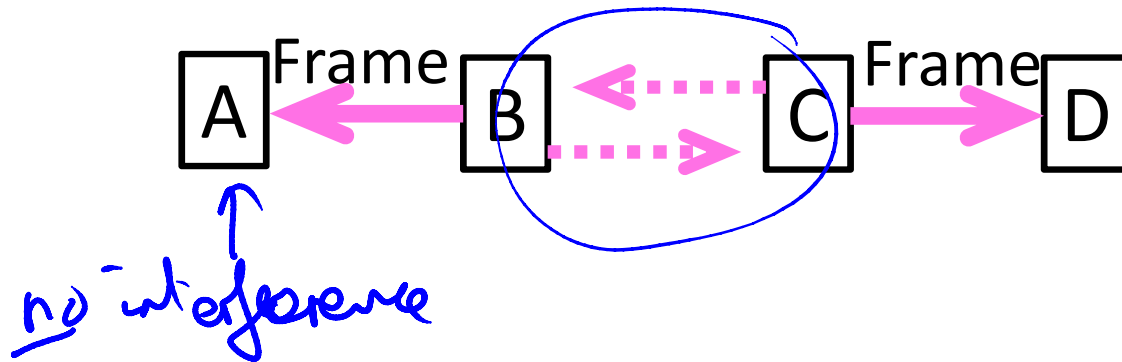
- B→A, C→D as exposed terminals
  - A and D send CTS to B and C

MACA – Exposed Terminals (4)

- B→A, C→D as exposed terminals
  - A and D send CTS to B and C

no interference

802.11, or WiFi

- Very popular wireless LAN started in the 1990s

- Clients get connectivity from a (wired) AP (Access Point)

- It's a multi-access problem ☺

- Various flavors have been developed over time
  - Faster, more features
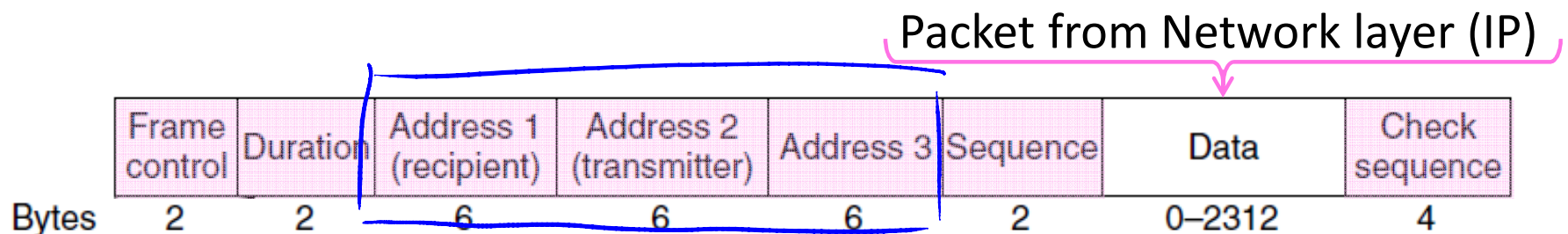

To Network

Access Point

Client
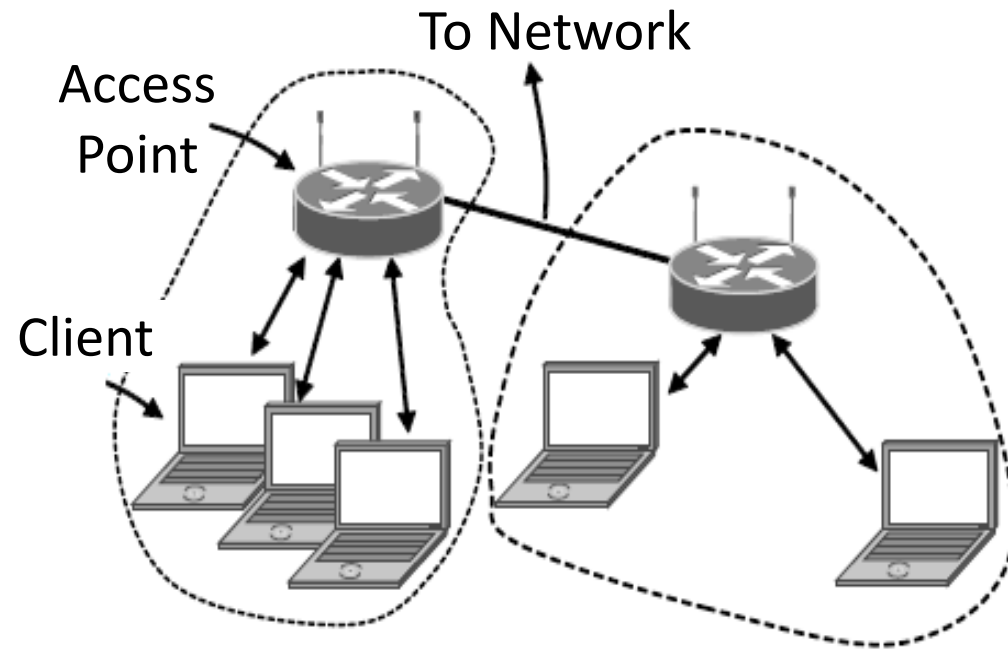
802.11 Physical Layer

- Uses 20/40 MHz channels on ISM bands
    - 802.11b/g/n on 2.4 GHz
    - 802.11 a/n on 5 GHz

- OFDM modulation (except legacy 802.11b)
    - Different amplitudes/phases for varying SNRs
    - Rates from 6 to 54 Mbps plus error correction
    - 802.11n uses multiple antennas; see "802.11 with Multiple Antennas for Dummies"

802.11 Link Layer

- Multiple access uses CSMA/CA (next); RTS/CTS optional
- Frames are ACKed and retransmitted with ARQ
- Funky addressing (three addresses!) due to AP
- Errors are detected with a 32-bit CRC
- Many, many features (e.g., encryption, power save)

Packet from Network layer (IP)

Frame control	Duration	Address 1 (recipient)	Address 2 (transmitter)	Address 3	Sequence	Data	Check sequence
Bytes 2	2	6	6	6	2	0–2312	4

802.11 CSMA/CA for Multiple Access

- Sender avoids collisions by inserting small random gaps
  - E.g., when both B and C send, C picks a smaller gap, goes first
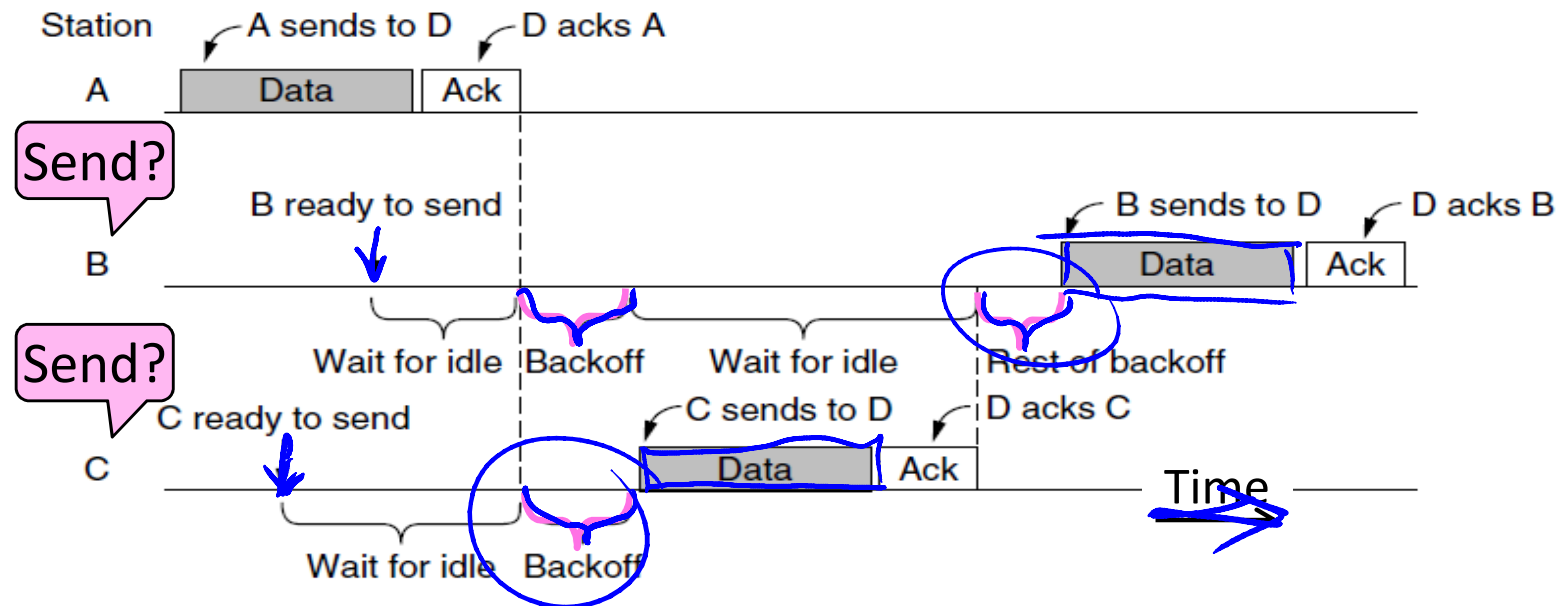
The Future of 802.11 (Guess)

- Likely ubiquitous for Internet connectivity
  - Greater diversity, from low- to high-end devices
- Innovation in physical layer drives speed
  - And power-efficient operation too
- More seamless integration of connectivity
  - Too manual now, and limited (e.g., device-to-device)

END

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