Lecture 25: 802.11

Project 2 due FRIDAY
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

mobile terminal

fixed terminal

application
TCP
IP
LLC
802.11 MAC
802.11 PHY

access point

infrastructure network

application
TCP
IP
LLC
802.3 MAC
802.3 PHY

802.11 PHY

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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
  - Length
    - future use, 00: 802.11 compliant
    - 00: 802.11 compliant

- 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

802.11b beat out 802.11a, a contemporaneous standard, in the market. In which of the following ways was 802.11b superior?

A. Higher maximum speed
B. Larger usable range
C. Less interference
D. All of the above
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

802.11ac supports 20, 40, and even 80-MHz channels. What do you think it gains from increased channel width?

A. Higher maximum speed
B. Larger usable range
C. Less interference
D. All of the above
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 short, 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 \([0, \text{CW}]\)
  - \(\text{CW}\) 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 \(\text{CW}\) as contention varies
  - 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
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)

- 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

RTS = Request-to-Send

Pretending a circular range
IEEE 802.11

NAV = remaining duration to keep quiet

RTS = Request-to-Send

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CTS = Clear-to-Send
IEEE 802.11

CTS = Clear-to-Send

A

B

C

D

E

F

NAV = 8
• **DATA** packet follows CTS. Successful data reception acknowledged using **ACK**.
Non-symmetric ranges

Interference “range”

Carrier sense range

Transmit “range”

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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

- Final review on Friday
  - During regular class period