Ethernet Uses CSMA/CD

- Carrier sense: wait for link to be idle
  - Channel idle: start transmitting
  - Channel busy: wait until idle
- Collision detection: listen while transmitting
  - No collision: transmission is complete
  - Collision: abort transmission, send jam signal
- Random access: exponential back-off
  - After collision, wait a random time before trying again
  - After $m^{th}$ collision, pick $K$ randomly from $\{0, \ldots, 2^m-1\}$
  - … and wait for $K*512$ bit times before trying again
Ethernet Frame Structure

- Sending adapter encapsulates packet in frame

- **Preamble**: synchronization
  - Seven bytes with pattern 10101010, followed by one byte with pattern 10101011
  - Used to synchronize receiver, sender clock rates
Ethernet Frame Structure (Cont.)

- **Addresses**: source and destination MAC addresses
  - Adaptor passes frame to network-level protocol
    - If destination address matches the adaptor
    - Or the destination address is the broadcast address
  - Otherwise, adapter discards frame

- **Type**: indicates the higher layer protocol
  - Usually IP
  - But also Novell IPX, AppleTalk, …

- **CRC**: cyclic redundancy check
  - Checked at receiver
  - If error is detected, the frame is simply dropped
CSMA/CD (Collision Detection)

• Human analogy: the polite conversationalist
• CSMA/CD: carrier sensing, deferral if busy
  – Collisions detected within short time
  – Colliding transmissions aborted, reducing waste
• Collision detection
  – Easy in wired LANs: measure signal strengths, compare transmitted, received signals
  – Difficult in wireless LANs: receiver shut off while transmitting
CSMA/CD Collision Detection
Elements of a wireless network

- **network**
- **infrastructure**

**wireless hosts**
- laptop, PDA, IP phone
- run applications
- may be stationary (non-mobile) or mobile
  - wireless does *not* always mean mobility
Elements of a wireless network

- Network
- Infrastructure

Base station
- Typically connected to wired network
- Relay - responsible for sending packets between wired network and wireless host(s) in its “area”
  - E.g., cell towers
  - 802.11 access points
Elements of a Wireless Network

- network
- infrastructure

wireless link
- typically used to connect mobile(s) to base station
- also used as backbone link
- multiple access protocol coordinates link access
- various data rates, transmission distance
Elements of a Wireless Network

- network
- infrastructure

infrastructure mode
- base station connects mobiles into wired network
- handoff: mobile changes base station providing connection into wired network
Elements of a Wireless Network

Ad hoc mode
• no base stations
• nodes can only transmit to other nodes within link coverage
• nodes organize themselves into a network: route among themselves
Wireless Link Characteristics

Differences from wired link ....

- **decreased signal strength**: radio signal attenuates as it propagates through matter (path loss)
- **interference from other sources**: standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone); devices (motors) interfere as well
- **multipath propagation**: radio signal reflects off objects ground, arriving at destination at slightly different times

.... make communication across (even a point to point) wireless link much more “difficult”
Wireless Network Characteristics

Multiple wireless senders and receivers create additional problems (beyond multiple access):

- Hidden terminal problem
- B, A hear each other
- B, C hear each other
- A, C can not hear each other
- means A, C unaware of their interference at B

- Signal fading:
  - B, A hear each other
  - B, C hear each other
  - A, C can not hear each other interfering at B
IEEE 802.11 Wireless LAN

- **802.11b**
  - 2.4-5 GHz unlicensed radio spectrum
  - up to 11 Mbps
  - direct sequence spread spectrum (DSSS) in physical layer
    - all hosts use same chipping code
    - widely deployed, using base stations

- **802.11a**
  - 5-6 GHz range
  - up to 54 Mbps

- **802.11g**
  - 2.4-5 GHz range
  - up to 54 Mbps

- All use CSMA/CA for multiple access
- All have base-station and ad-hoc network versions
802.11 LAN architecture

- Wireless host communicates with base station
  - Base station = access point (AP)

- Basic Service Set (BSS) (aka “cell”) in infrastructure mode contains:
  - Wireless hosts
  - Access point (AP): base station
  - Ad hoc mode: hosts only
802.11: Channels, association

- 802.11b: 2.4GHz-2.485GHz spectrum divided into 11 channels at different frequencies
  - AP admin chooses frequency for AP
  - interference possible: channel can be same as that chosen by neighboring AP!
- host: must *associate* with an AP
  - scans channels, listening for *beacon frames* containing AP’s name (SSID) and MAC address
  - selects AP to associate with
  - may perform authentication [Later Lectures]
  - will typically run DHCP to get IP address in AP’s subnet
IEEE 802.11: multiple access

- avoid collisions: $2^+$ nodes transmitting at same time
- 802.11: CSMA - sense before transmitting
  - don’t collide with ongoing transmission by other node
- 802.11: no collision detection!
  - difficult to receive (sense collisions) when transmitting due to weak received signals (fading)
  - can’t sense all collisions in any case: hidden terminal, fading
  - goal: avoid collisions: CSMA/C(ollision)A(voidance)
IEEE 802.11 MAC Protocol: CSMA/CA

802.11 sender
1 if sense channel idle for DIFS then
   transmit entire frame (no CD)
2 if sense channel busy then
   start random backoff time
   timer counts down while channel idle
   transmit when timer expires
   if no ACK, increase random backoff interval, repeat 2

802.11 receiver
- if frame received OK
  return ACK after SIFS (ACK needed due to hidden terminal problem)
Avoiding collisions (more)

**idea:** allow sender to “reserve” channel rather than random access of data frames: avoid collisions of long data frames

- sender first transmits *small* request-to-send (RTS) packets to BS using CSMA
  - RTSs may still collide with each other (but they’re short)
- BS broadcasts clear-to-send CTS in response to RTS
- RTS heard by all nodes
  - sender transmits data frame
  - other stations defer transmissions

• Avoid data frame collisions completely
  • using small reservation packets!
Collision Avoidance: RTS-CTS Exchange

- RTS(A)
- RTS(B)
- CTS(A)
- DATA (A)
- ACK(A)
- ACK(A)
- reservation collision
- defer
- time
What’s Next

• Read Chapter 1 and 2
• Next Lecture Topics from Chapter 3.1 and 3.2
  – Switching and Forwarding
• Homework
  – Due Thursday in Recitation
• Project 1
  – Due Friday