Announcements:
- Assign 4 is due this Thursday
- Lab 4 is due next Tuesday
- Assignment 5 posted soon...
Wireless and Mobile Networks

Background:
- success of wireless: # wireless (mobile) phone subscribers now exceeds # wired phone subscribers!
- Internet: anytime & anywhere: laptops, PDAs, tablets, iPhones, MagicJack, IP-enabled devices
- two important (but different) challenges
  - wireless: communication over wireless link
  - mobility: handling the mobile user who changes point of attachment to network
Elements of a wireless network

- **Network infrastructure**
- **Wireless hosts**
  - e.g.: laptop, iPhone
  - run: applications
  - stationary or mobile
    - wireless does *not* always mean mobility
Elements of a wireless network

- **base station**
  - bridge: typically connected to wired network
  - relay: responsible for sending pkts between backbone network and wireless host(s)
  - e.g., cell towers, 802.11 access points

network infrastructure
Elements of a wireless network

- **Network infrastructure**
  - Connects: mobiles to base station
  - Multiple access protocol: coordinates link access
  - Various data rates, transmission distance

- **Wireless link**
Elements of a wireless network

- **Infrastructure mode**
  - **Bridge**: 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
- limited range: nodes can only transmit to other nodes within link coverage
- multi-hop: nodes organize themselves into a network: route among themselves
## Wireless network taxonomy

<table>
<thead>
<tr>
<th>Single Hop</th>
<th>Infrastructure</th>
<th>Infrastructure-less</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. hosts connect to base station</td>
<td>1. no base station</td>
</tr>
<tr>
<td></td>
<td>2. base station connects to larger Internet</td>
<td>2. no connection to larger Internet</td>
</tr>
<tr>
<td></td>
<td>E.g.: WiFi/Cellular</td>
<td>E.g.: Bluetooth</td>
</tr>
<tr>
<td>Multiple hops</td>
<td>1. hosts may have to relay via multiple nodes (multi-hop)</td>
<td>1. no base station</td>
</tr>
<tr>
<td></td>
<td>2. connects to larger Internet</td>
<td>2. no connection to larger Internet</td>
</tr>
<tr>
<td></td>
<td>E.g.: mesh network</td>
<td>3. may have to relay via others to reach a given node</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E.g.: MANET</td>
</tr>
</tbody>
</table>
Outline

Wireless
- wireless characteristics
- multiple access schemes
  - TDMA/FDMA
  - CDMA
- Wi-Fi wireless LANs
  - CSMA/CA
  - IEEE 802.11

Mobility
- principles:
  - addressing
  - routing to mobile users
- mobile IP
Wireless Link Characteristics

Differences from wired link ….

- decayed 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)

- 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, meaning that A, C are unaware of their interference at B

Signal attenuation:
- B, A hear each other
- B, C hear each other
- A, C can not hear each other ➔ can interfere at B
Outline

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Multiple Access Schemes

Q: How can multiple users share the medium?

- **FDMA**: Frequency Division Multiple Access
  (seen before)

- **TDMA**: Time Division Multiple Access
  (seen before)

- **CDMA**: Code Division Multiple Access
  (will be discussed next)

- **CSMA/CA**: Carrier-Sense Multiple Access (i.e., Wi-Fi)
  (will be discussed later)
FDMA and TDMA (review)

FDMA

Example:
4 users

TDMA

4 users
CDMA

- all users use all frequency (like TDMA)
- all users send at all time (like FDMA)
- allows multiple users to “coexist” and transmit simultaneously

- a unique “code” assigned to each user
- encoding at sender: (original data) \times (code)
- decoding at receiver: (encoded signal) \times (code)
Each user is assigned a unique code: 
\[ c_m = [-1 -1 -1 1 -1 1 1 1] \]
(length of \( c_m \) is \( M = 8 \) in this example)

We use “-1” to mean “0”

Channel output
\[ Z_{i,m} = d_i \cdot c_m \]

Decoding at receiver:
\[ d_i = (Z_{i,m} \cdot c_m)/8 = (d_i \cdot c_m \cdot c_m)/8 = d_i \]

Note that \( c_m \cdot c_m = 8 \)
CDMA: two-senders and interference

\[ Z_{i,m} = d_i \cdot c_m \]

\[ Z_{i,m}^2 = d_i^2 \cdot c_m^2 \]
CDMA: two-senders and interference

\[ Z_{i,m}^1 = d_i^1 \cdot c_m^1 \]

\[ Z_{i,m}^2 = d_i^2 \cdot c_m^2 \]

\[ M = \text{length of } c_m \]
CDMA: Example of multiple users

- See board notes for a CDMA example.