Computer Networks and Communication

Lecture 13

Wireless Networks

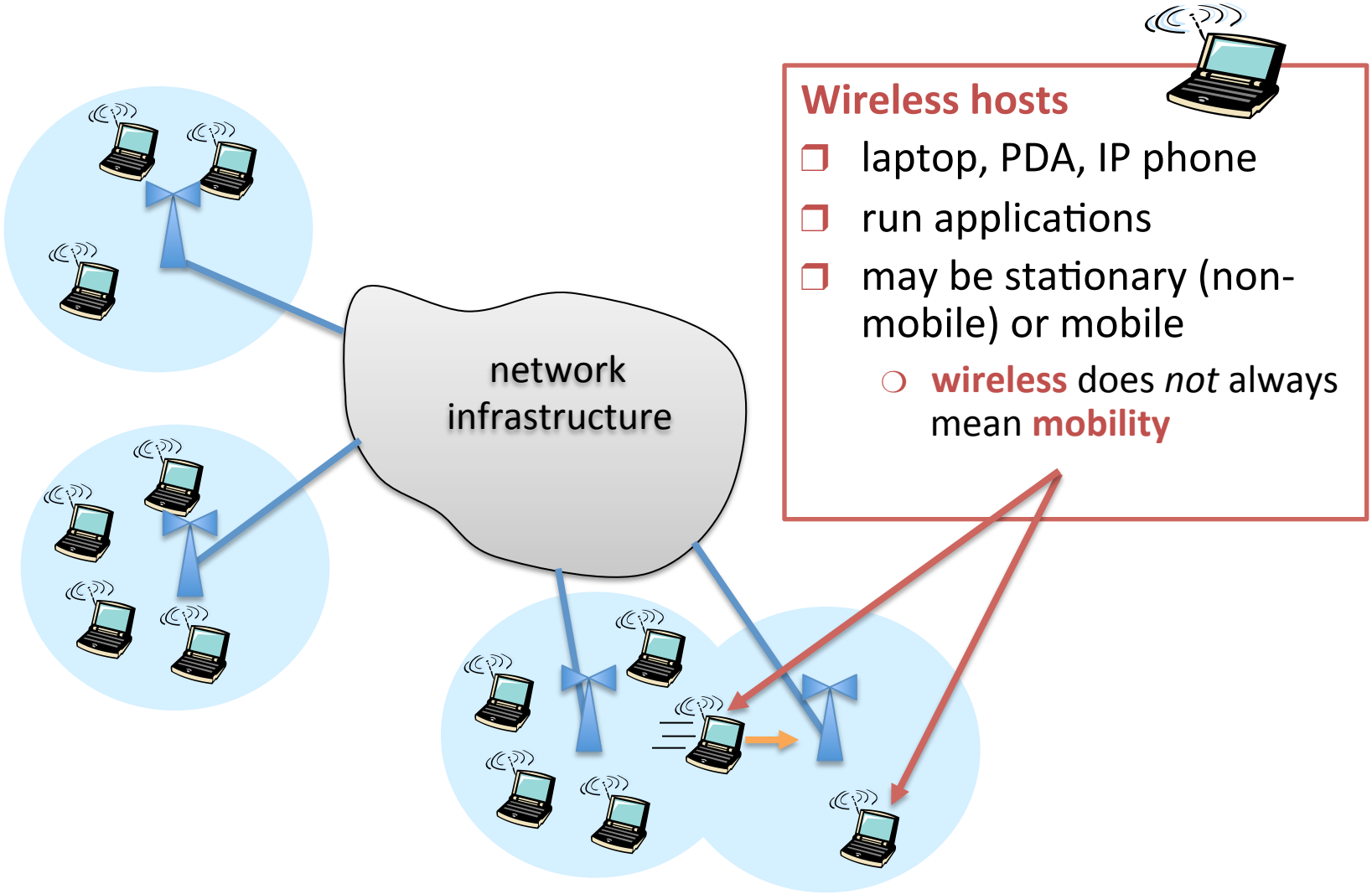
What we have learned so far

- Application layer
  - Network / Internet applications
  - Application-layer protocols: HTTP, SMTP, DNS, etc.
- Transport layer
  - UDP and TCP
  - Reliable data transfer
  - Flow and congestion control
- Network layer
  - IP
  - Routing protocols
  - Host addressing: Subnet and IP address
- Link layer
  - Multiple access to network links
  - Error detection: Checksum, parity check and CRC code
  - Network topologies
  - Ethernet and beyond

Wireless Networks

- Background
  - Mobile phone subscribers are now exceeding wired phone (landline) subscribers
  - Mobile devices such as laptops, tablet computers, smartphones are getting more popular
    - They require constant network access!
- Challenges in wireless network
  - Communication over wireless link
  - Handling mobile moving users

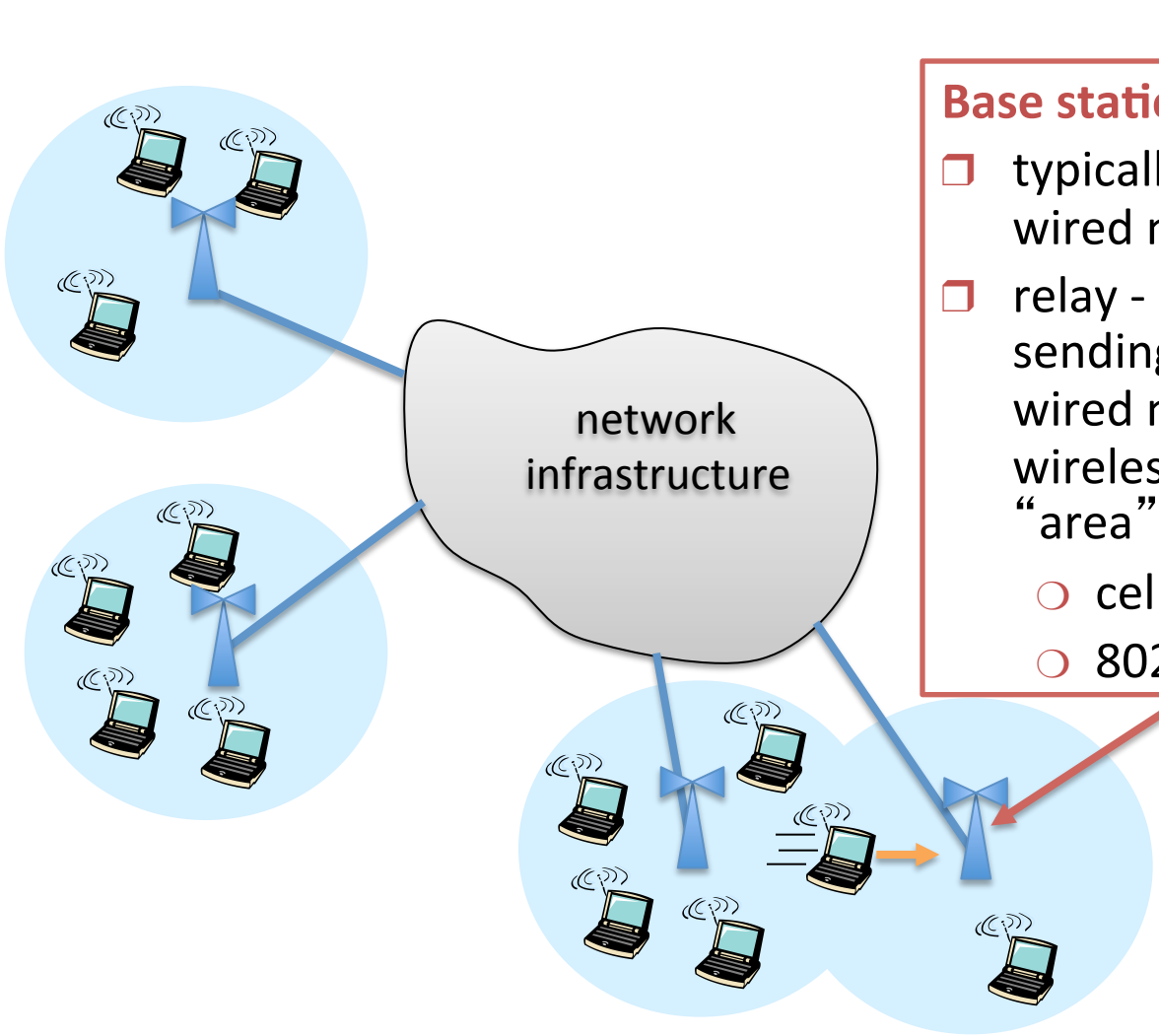
Elements of a Wireless Network



Wireless hosts

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

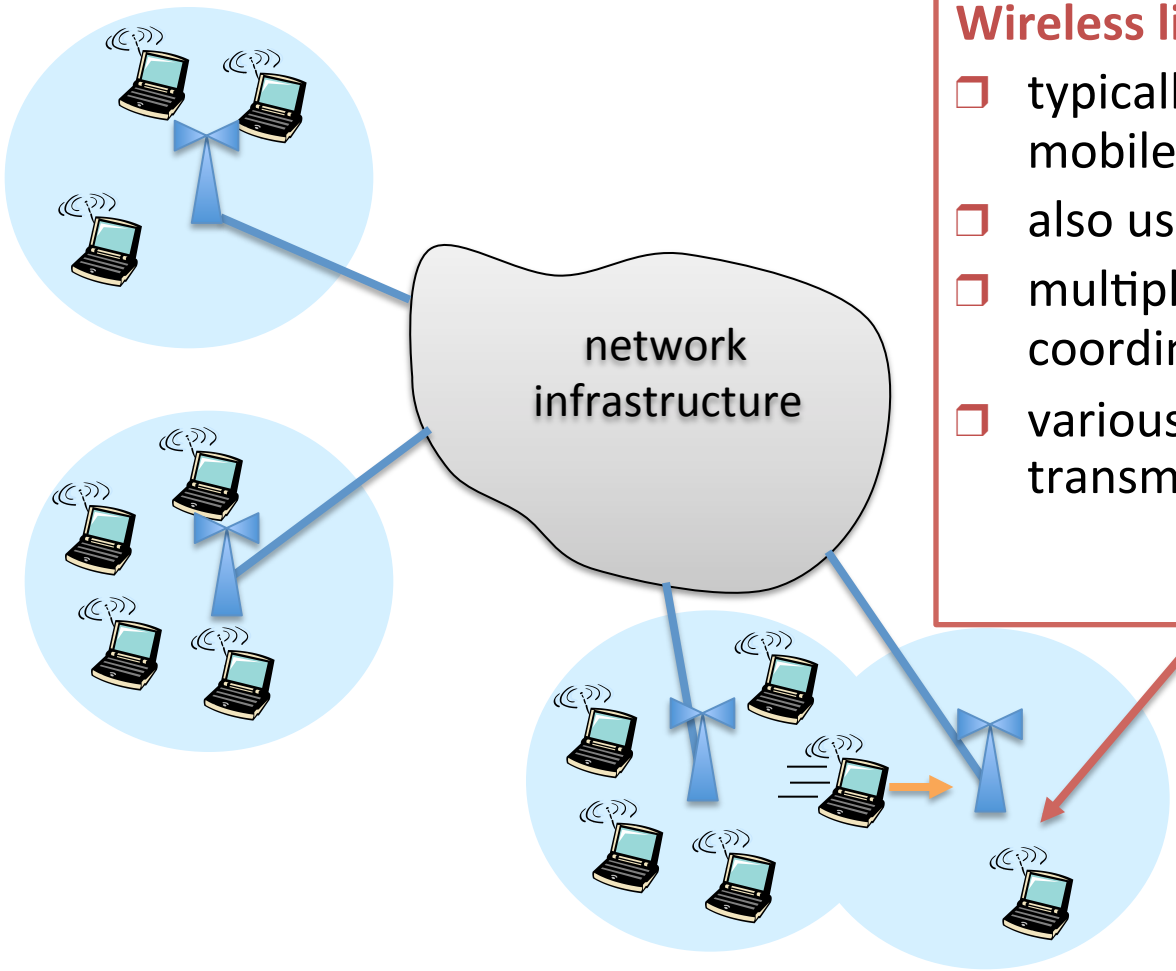
Elements of a Wireless Network (2)



Base station

- typically connected to wired network
- relay - responsible for sending packets between wired network and wireless host(s) in its "area" such as
  - cell towers
  - 802.11 access points

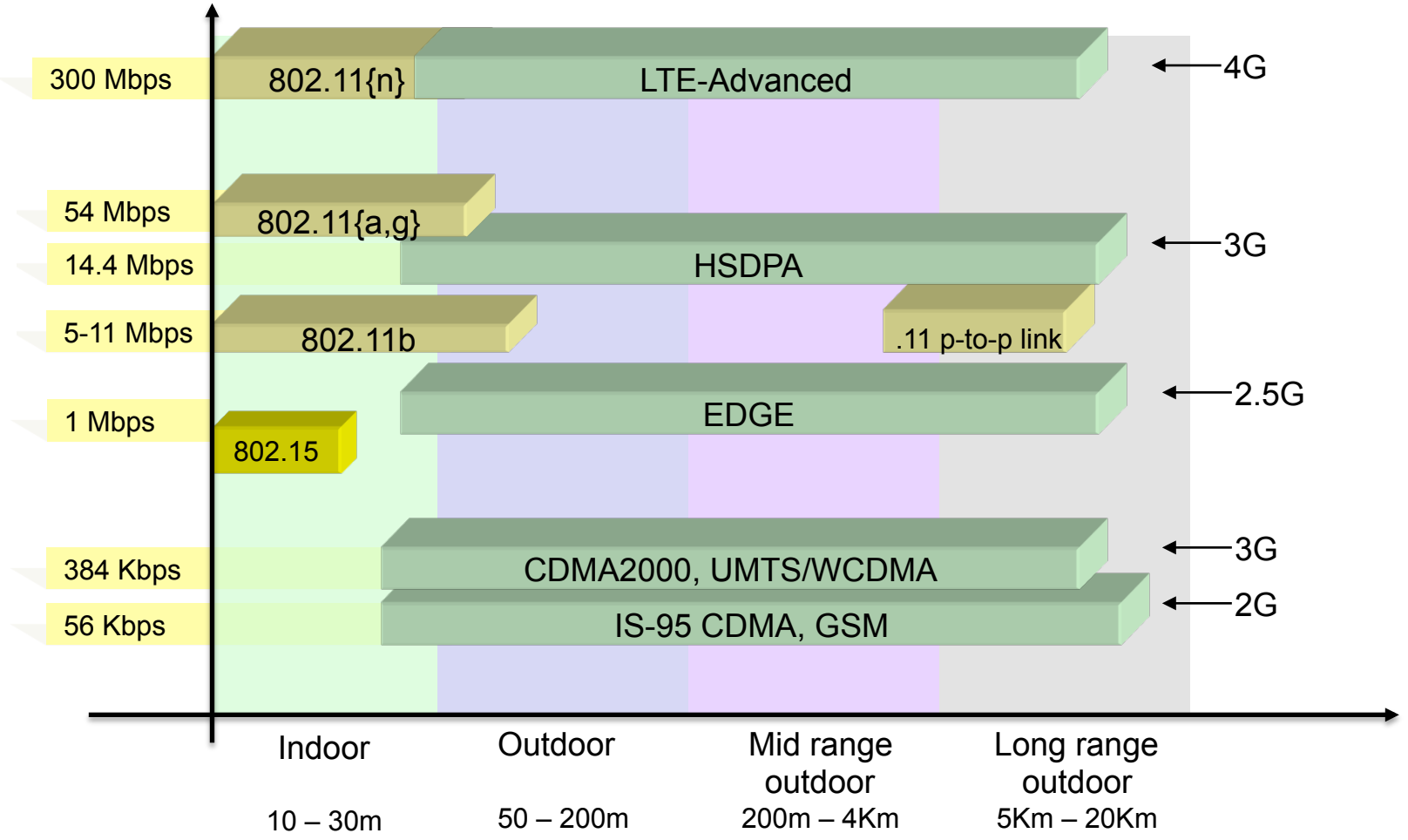
Elements of a Wireless Network (3)



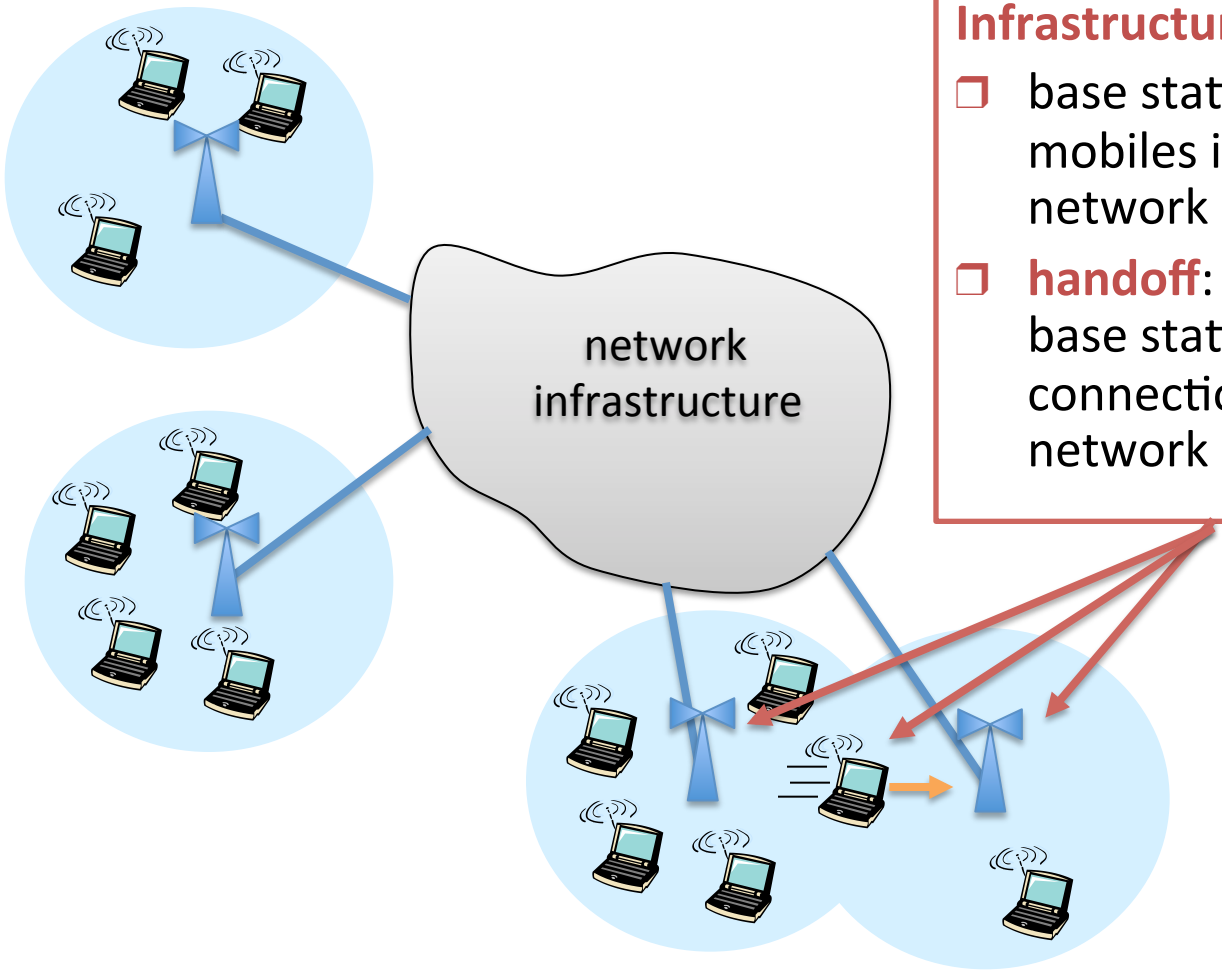
Wireless links

- 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

Wireless Link Standards



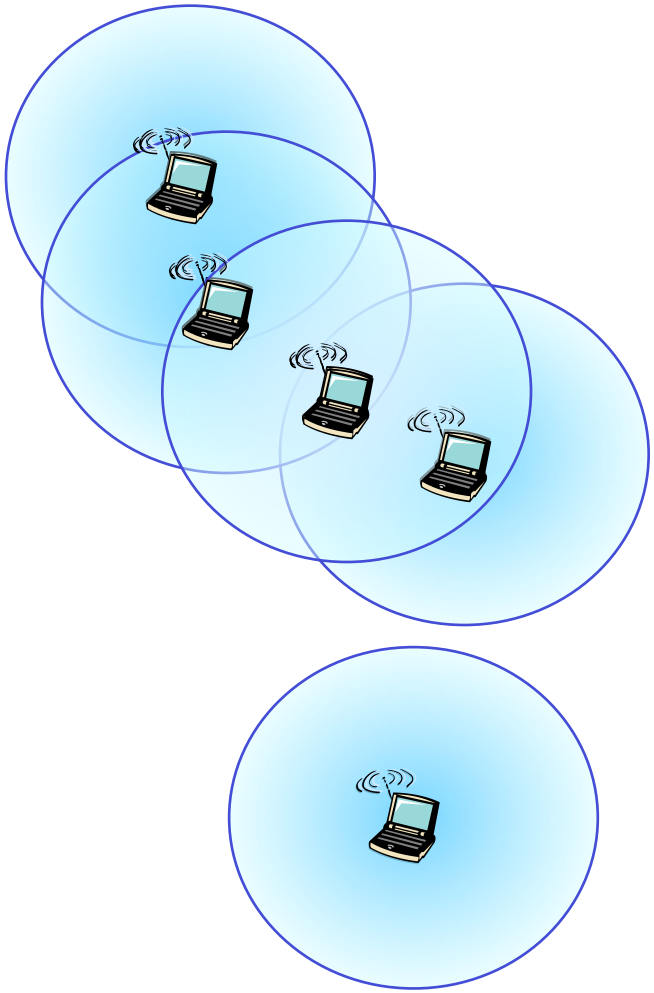
Wireless Infrastructure Mode



Infrastructure Mode

- base station connects mobiles into wired network
- **handoff**: mobile changes base station providing connection into wired network

Wireless Ad hoc Mode



Ad hoc Mode

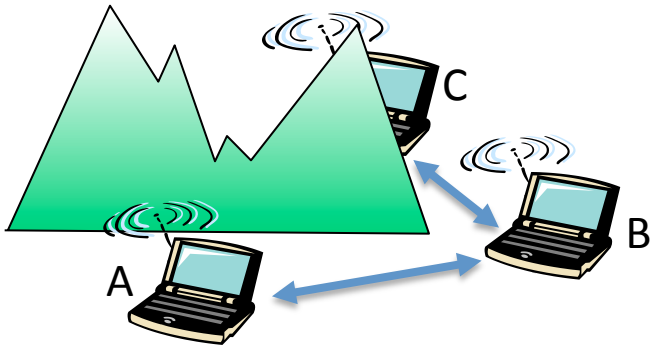
- no base stations
- nodes can only transmit to other nodes within link coverage
- nodes organize themselves into a network: route among themselves

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 ad destination at slightly different times
- These issues make communication across (even a point to point) wireless link much more "difficult"

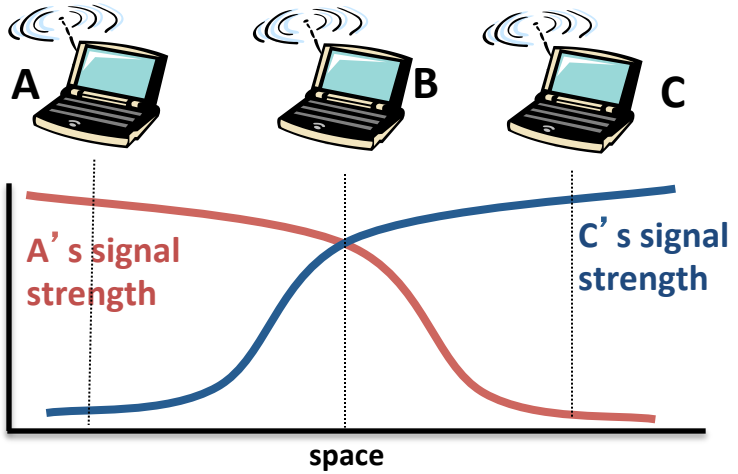
Wireless Link Issues

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



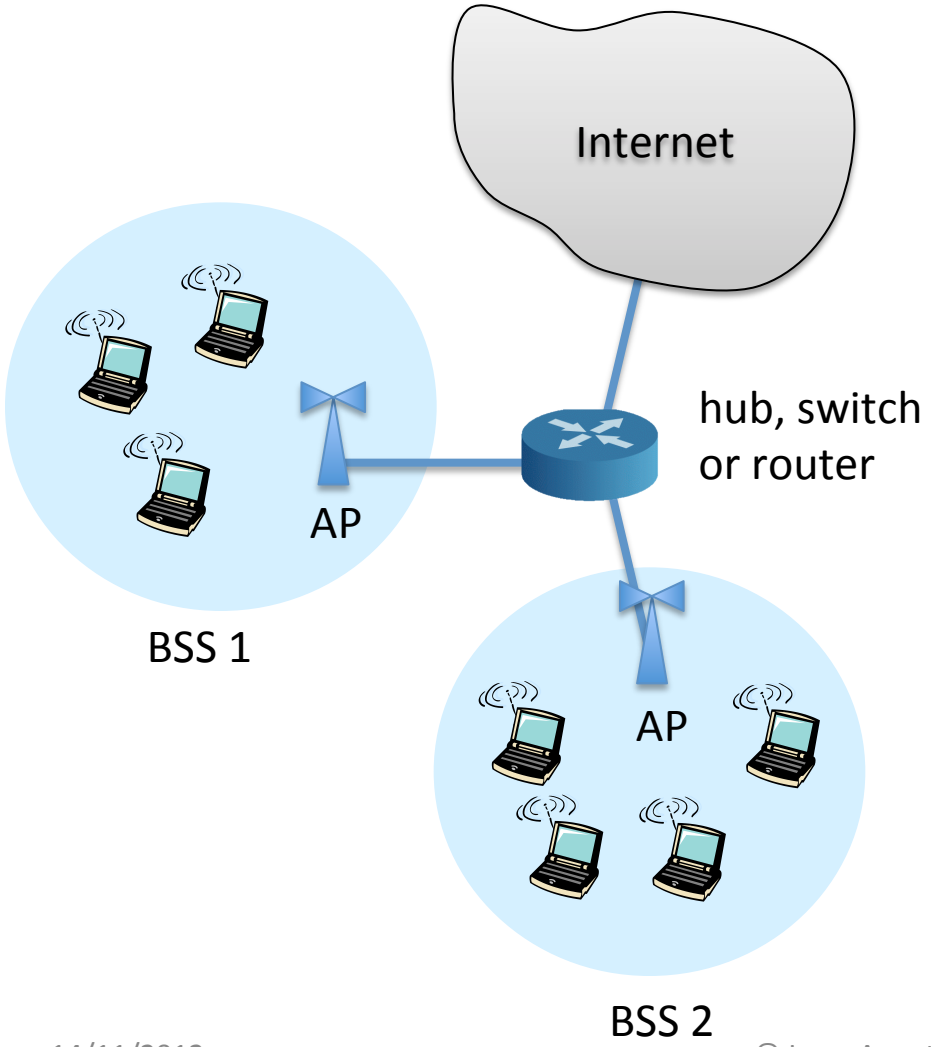
Signal fading

- 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)** or **cell** in infrastructure mode contains:
  - wireless hosts
  - Access Point (AP): base station
  - ad hoc mode: hosts only

802.11 Access Point

- 802.11b: 2.4GHz-2.485GHz spectrum divided into 11 channels at different frequencies
  - AP admin chooses frequency of the 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
  - Will typically run DHCP to get IP address in AP's subnet

802.11 Multiple Access

- 802.11 employs CSMA but **no collision detection (CD)**
  - Difficult to receive (sense collisions) when transmitting due to weak received signals (fading)
  - Can't sense all collisions in any case: hidden terminal, fading
- Solution, just try to **avoid collisions**: **CSMA/CA – (Collision Avoidance)**

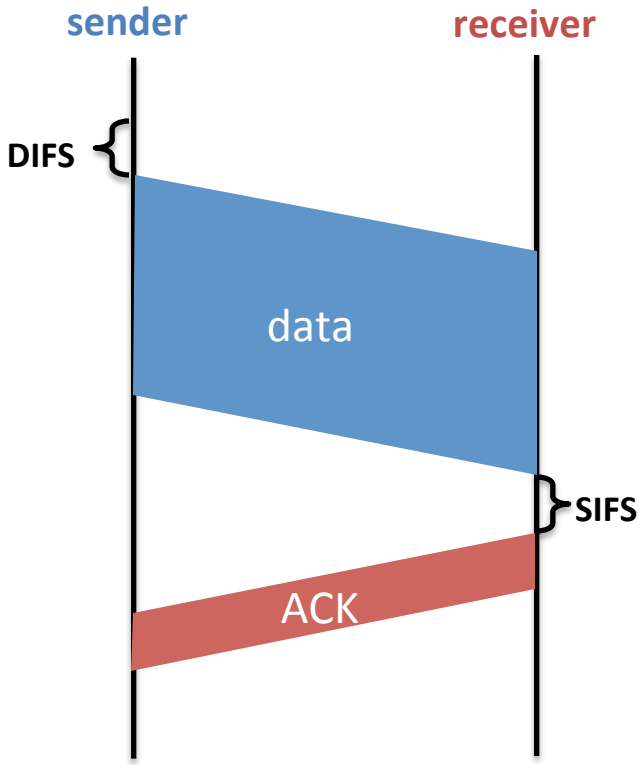
CSMA/CA

sender

- Sense the channel for **DIFS**
- If the channel is idle then
  - transmit entire frame (no CD)
- If the channel is 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

receiver

- if frame received OK
  - return ACK after **SIFS** (ACK needed due to hidden terminal problem)

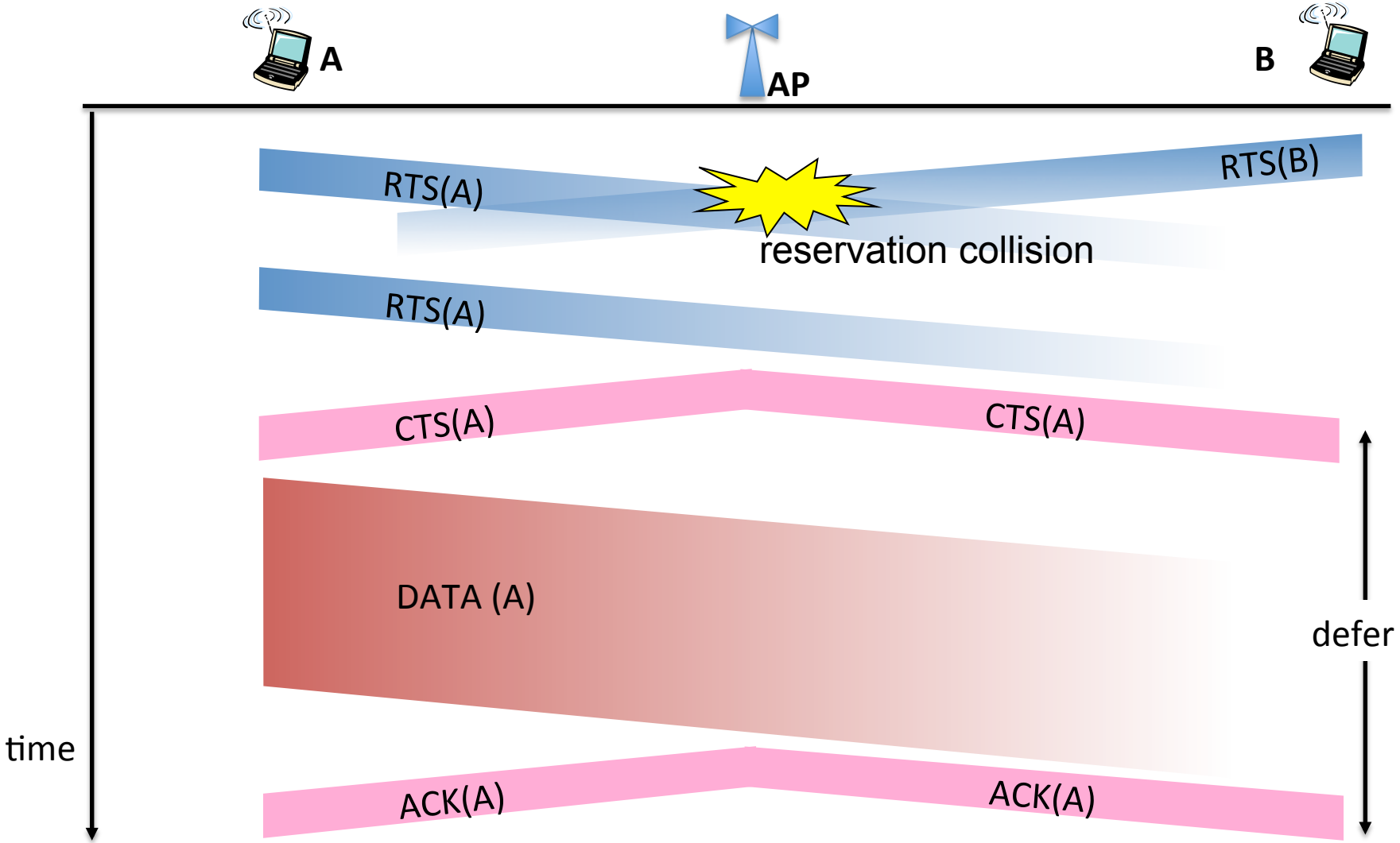


CSMA/CA (2)

- 802.11 also employs another collision avoidance scheme
  - 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 the base station
  - RTSs may still collide with each other (but they're short)
- Base station broadcasts **clear-to-send CTS** in response to RTS
  - RTS heard by all nodes
  - Sender transmits data frame
  - Other stations defer transmissions

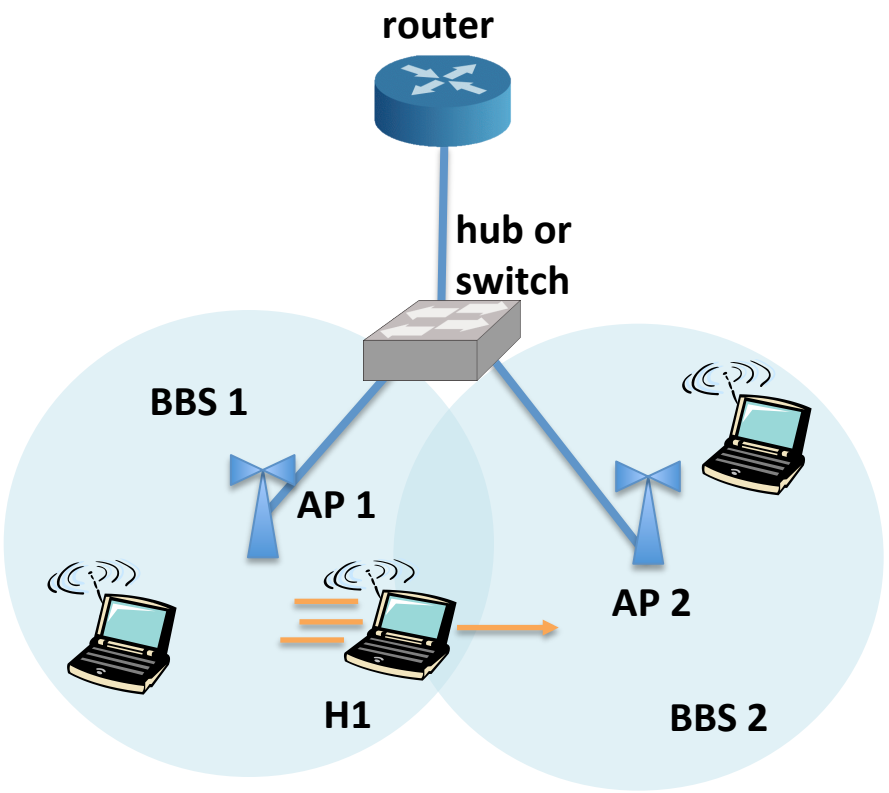
Avoid data frame collisions completely using small reservation packets!

RTS-CTS exchange



Mobility in 802.11 Network

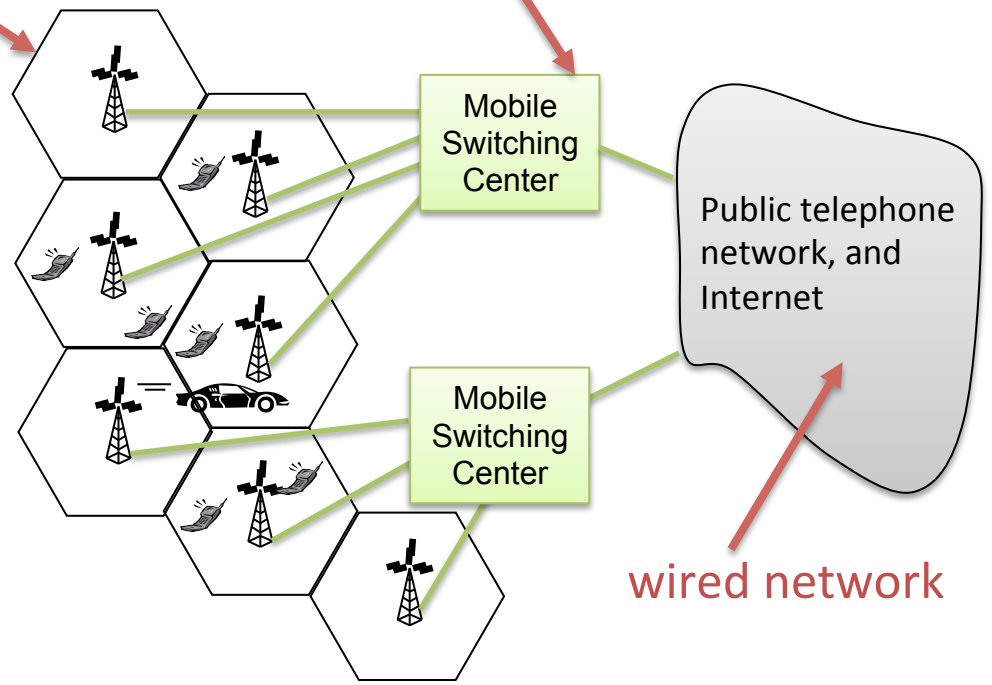
- H1 remains in same IP subnet
  - IP address can remain the same
- Switch has to determine which AP is associated with H1
- With self-learning, switch will see frame from H1 and remember which switch port can be used to reach H1



Cellular Network Architecture

MSC
connects cells to wide area net
manages call setup
handles mobility

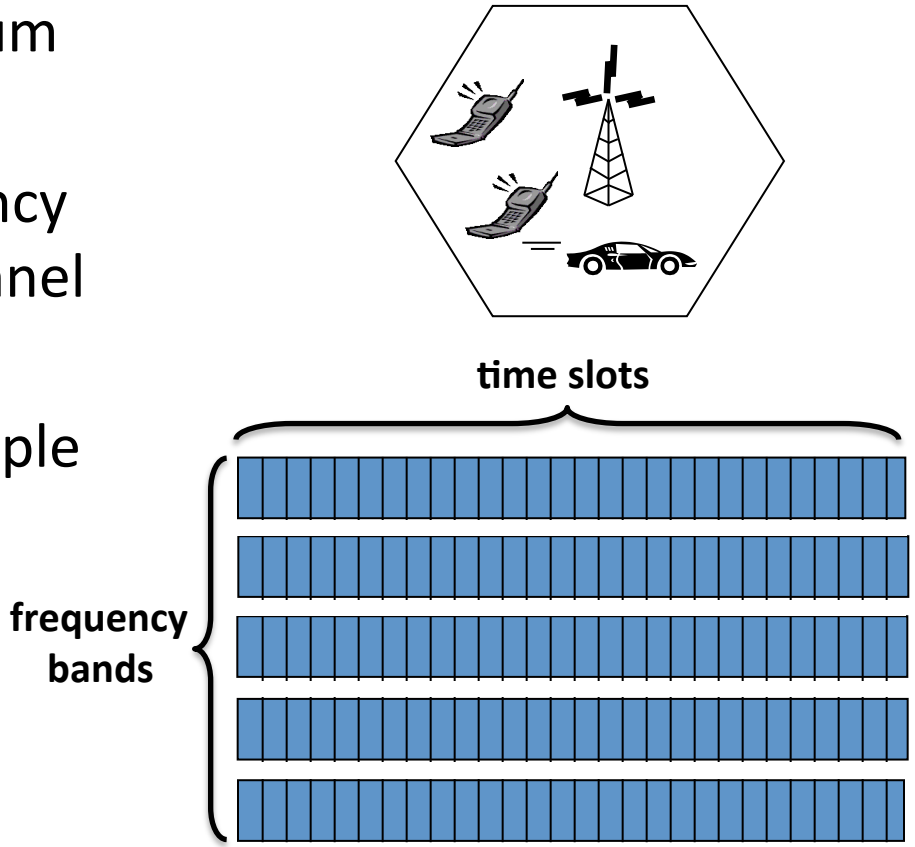
cell
covers geographical region
base station (BS)
analogous to 802.11 AP
mobile users attach to network through BS
air-interface: physical and link layer protocol between mobile and BS



Cellular Cell

Two techniques for sharing mobile-to-BS radio spectrum

- **Combined FDMA/TDMA:** divide spectrum in frequency channels, divide each channel into time slots
- **CDMA:** code division multiple access



Cellular Standards (2G)

- **2G Systems**: Voice channels
  - **IS-136 TDMA**
    - Combined FDMA/TDMA
    - Used in North America. Now obsolete
  - **IS-95 CDMA**
    - First CDMA standard
    - Developed by Qualcomm
    - It is promoted as cdmaOne
  - **GSM (Global System for Mobile communications)**
    - Combined FDMA/TDMA
    - Most widely deployed

Cellular Standards (2.5G)

- **2.5G Systems**: Voice and data channels
  - **General packet radio service (GPRS)**
    - evolved from GSM
    - data sent on multiple channels (if available)
  - **Enhanced data rates for global evolution (EDGE)**
    - also evolved from GSM,
    - Uses enhanced modulation
    - Date rates up to 384K
  - **CDMA-2000** (phase 1)
    - Data rates up to 144K
    - Evolved from IS-95

Cellular Standards (3G)

- **3G Systems**: Voice and data channels
  - Specified by ITU in **IMT-2000** standard
    - Faster: 144 kbps – 2Mbps
    - Support more services
    - Use CDMA scheme
    - Use licensed channel
  - First deployed my NTT DoCoMo in Japan
  - **Universal Mobile Telecommunications Service (UMTS)**
    - Based on GSM network but using CDMA within TDMA frames
    - Upgraded with **High-Speed Downlink Packet Access (HSDPA)** protocol to be even faster (up to 42-84 Mbps)
  - **CDMA2000**
    - Based on original CDMA technology

Cellular Standards (4G)

- 4G Systems: All IP
  - Specified in **IMT Advanced** standard by ITU
    - **FASTER**: 100-1000 Mbps
    - **LTE Advanced**
  - Use **Orthogonal frequency-division multiple access (OFDMA)** to access wireless links