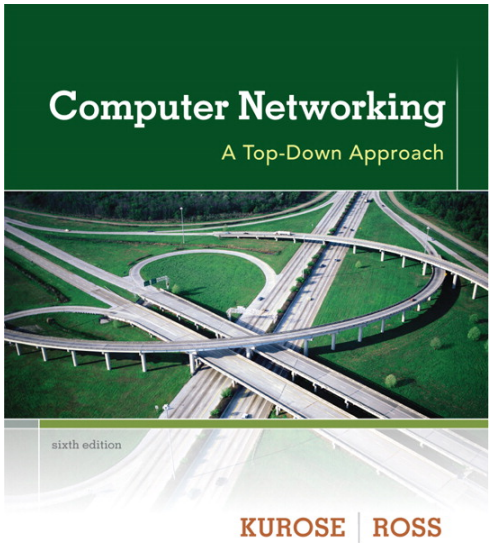
Chapter 6
Wireless and Mobile Networks



Reti degli Elaboratori
Canale AL
Prof.ssa Chiara Petrioli
a.a. 2014/2015

Computer Networking: A Top Down Approach
6th edition
Jim Kurose, Keith Ross
Addison-Wesley
March 2012

We thank for the support material Prof. Kurose-Ross

Chapter 6: Wireless and Mobile Networks

Background:

- # wireless (mobile) phone subscribers now exceeds # wired phone subscribers!
  - With the introduction of mobile broadband technologies AND the evolution of mobile devices from conventional phones to smart-phones, laptops and devices such as itouch, Mobile Internet traffic is changing, with multimedia traffic becoming dominant.
  - Bandwidth demanding, energy demanding applications and limited available spectrum are driving development of wireless technologies
- computer nets: laptops, palmtops, PDAs, Internet-enabled phone promise anytime untethered Internet access
- two important (but different) challenges
  - *wireless:* communication over wireless link
  - *mobility:* handling the mobile user who changes point of attachment to network

Chapter 6 outline

6.1 Introduction

Wireless

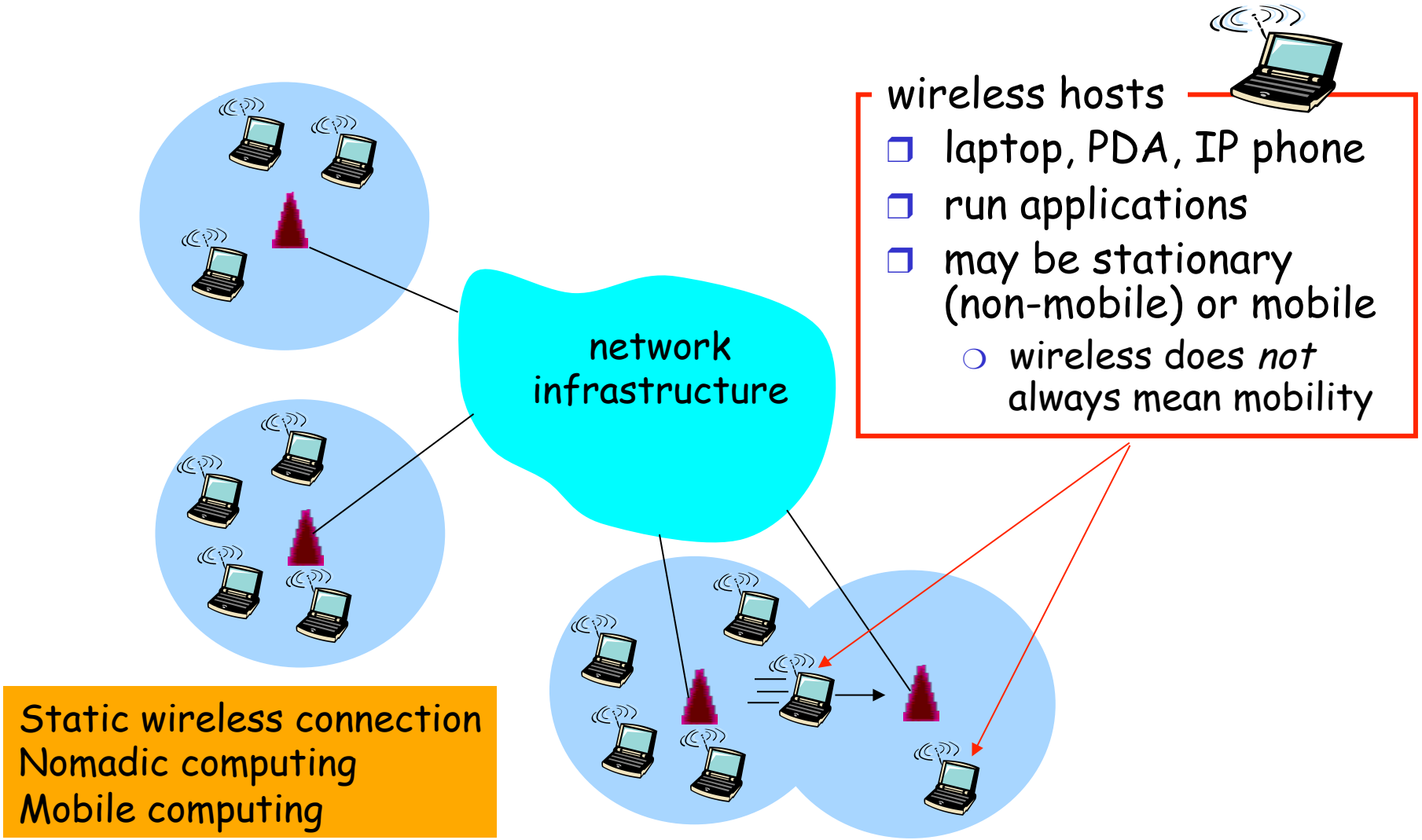
- 6.2 Wireless links, characteristics
  - CDMA
  - FDMA/TDMA
  - OFDMA
  - Different modulations and phy layers
- 6.3 IEEE 802.11 wireless LANs ("wi-fi")
- 6.4 Cellular Internet Access
  - architecture
  - standards (e.g., GSM)

Mobility

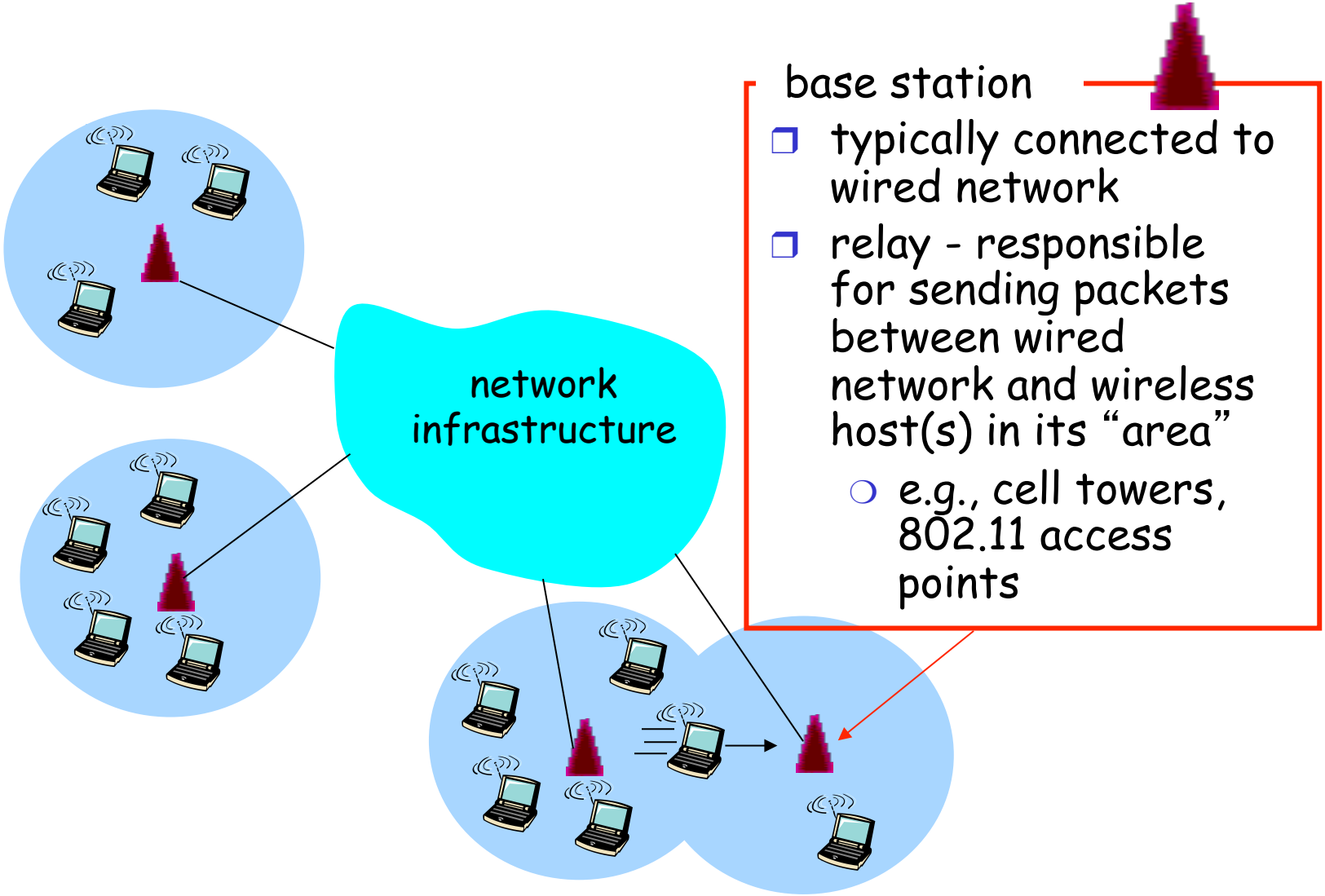
- 6.5 Principles: addressing and routing to mobile users
- 6.6 Mobile IP
- 6.7 Handling mobility in cellular networks
- 6.8 Mobility and higher-layer protocols

6.9 Summary

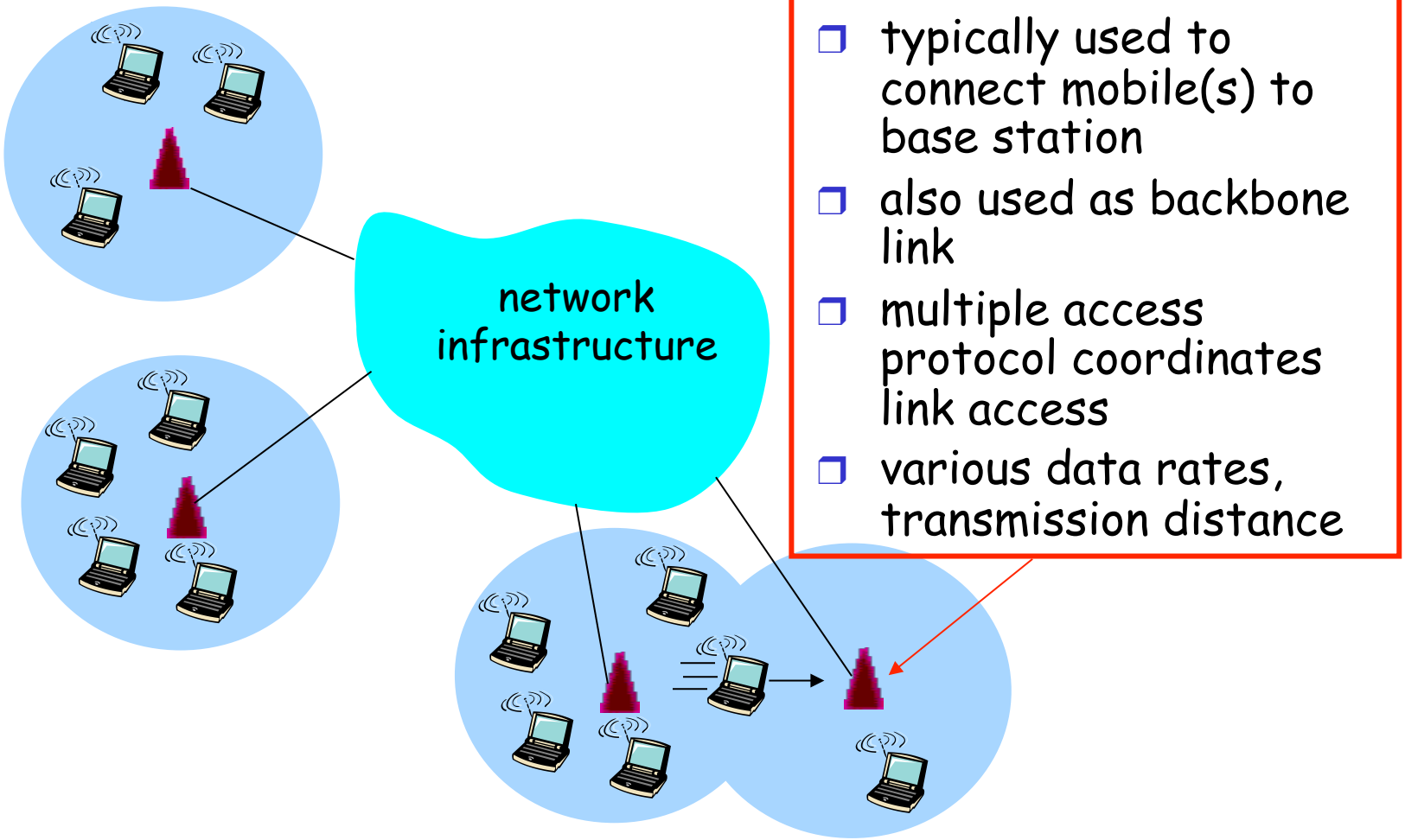
Elements of a wireless network



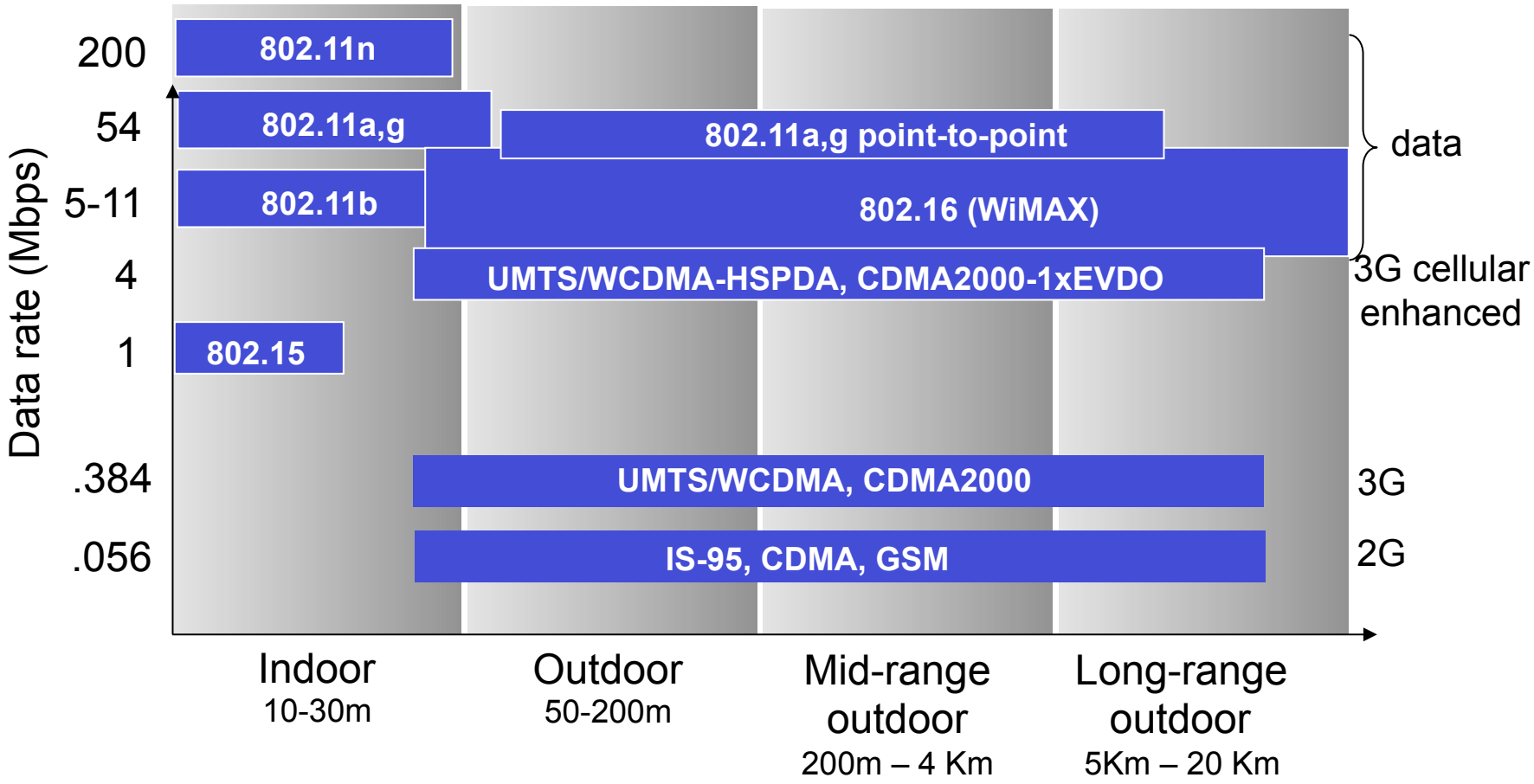
Elements of a wireless network



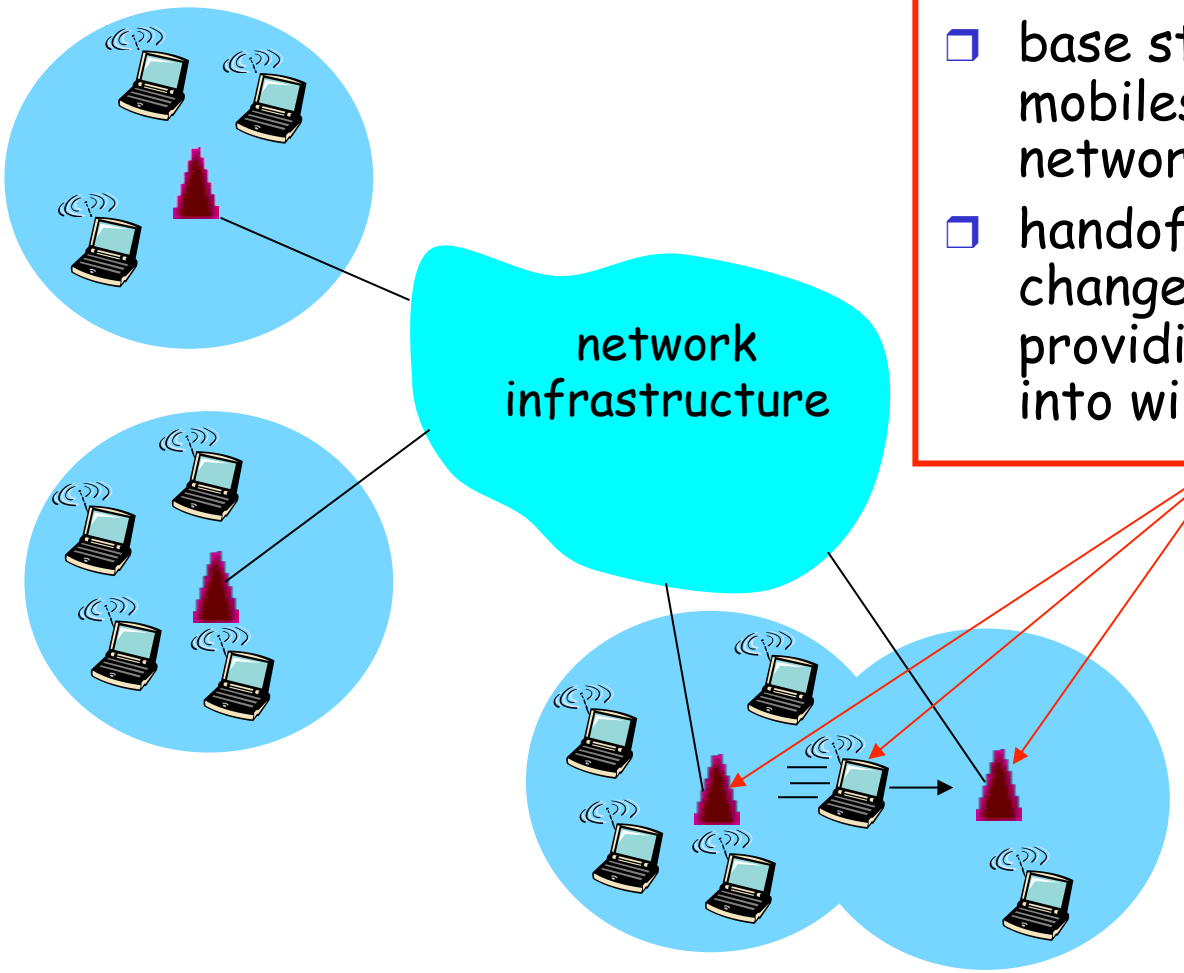
Elements of a wireless network



Characteristics of selected wireless link standards



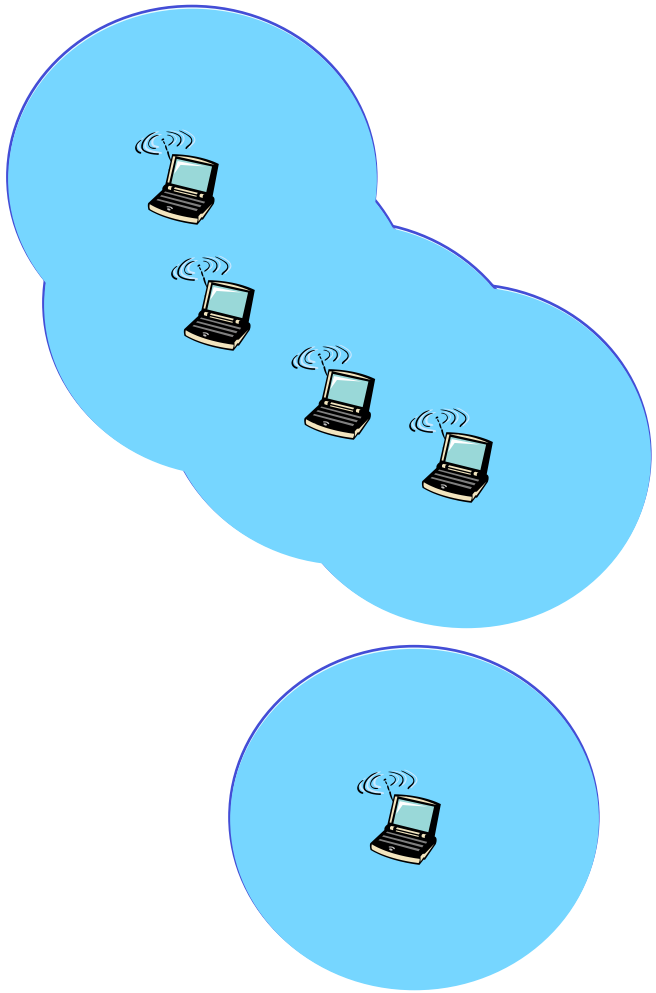
Elements of a wireless network



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 network taxonomy

	single hop	multiple hops
infrastructure (e.g., APs)	host connects to base station (WiFi, WiMAX, cellular) which connects to larger Internet	host may have to relay through several wireless nodes to connect to larger Internet: *mesh net*
no infrastructure	no base station, no connection to larger Internet (Bluetooth)	no base station, no connection to larger Internet. May have to relay to reach other a given wireless node MANET, VANET

Wireless Link Characteristics (1)

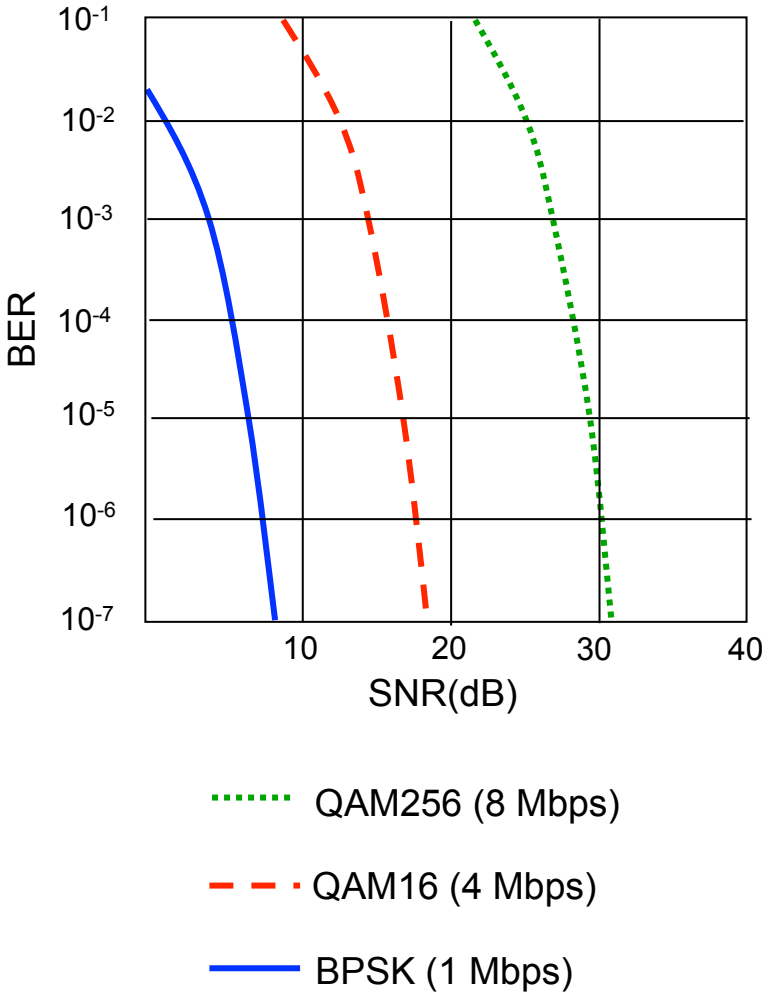
Differences from wired link ….

- 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., microwaves); 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 Link Characteristics (2)

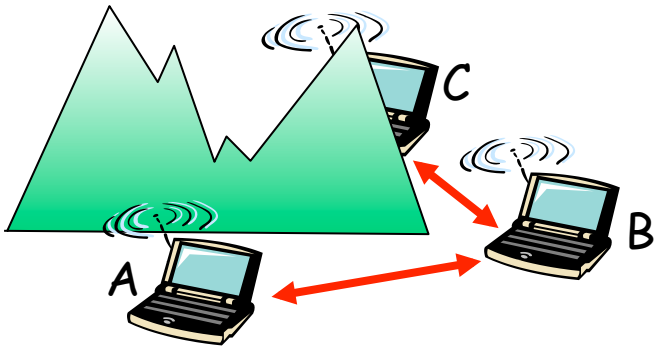
- SNR: signal-to-noise ratio
  - larger SNR – easier to extract signal from noise (a "good thing")
- *SNR versus BER tradeoffs*
  - *given physical layer:* increase power -> increase SNR->decrease BER
  - *given SNR:* choose physical layer that meets BER requirement, giving highest throughput
    - SNR may change with mobility: dynamically adapt physical layer (modulation technique, rate)



Wireless network characteristics

The wireless link is a broadcast channel

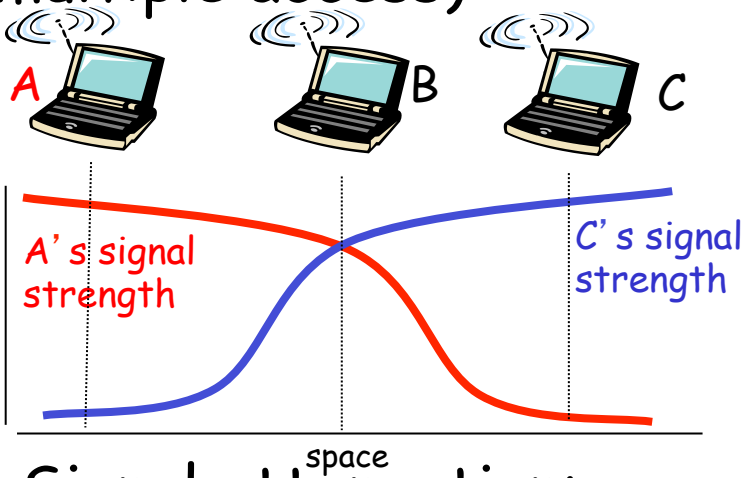
Multiple wireless senders and receivers create additional problems (beyond multiple access):



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 attenuation:

- B, A hear each other
- B, C hear each other
- A, C can not hear each other interfering at B

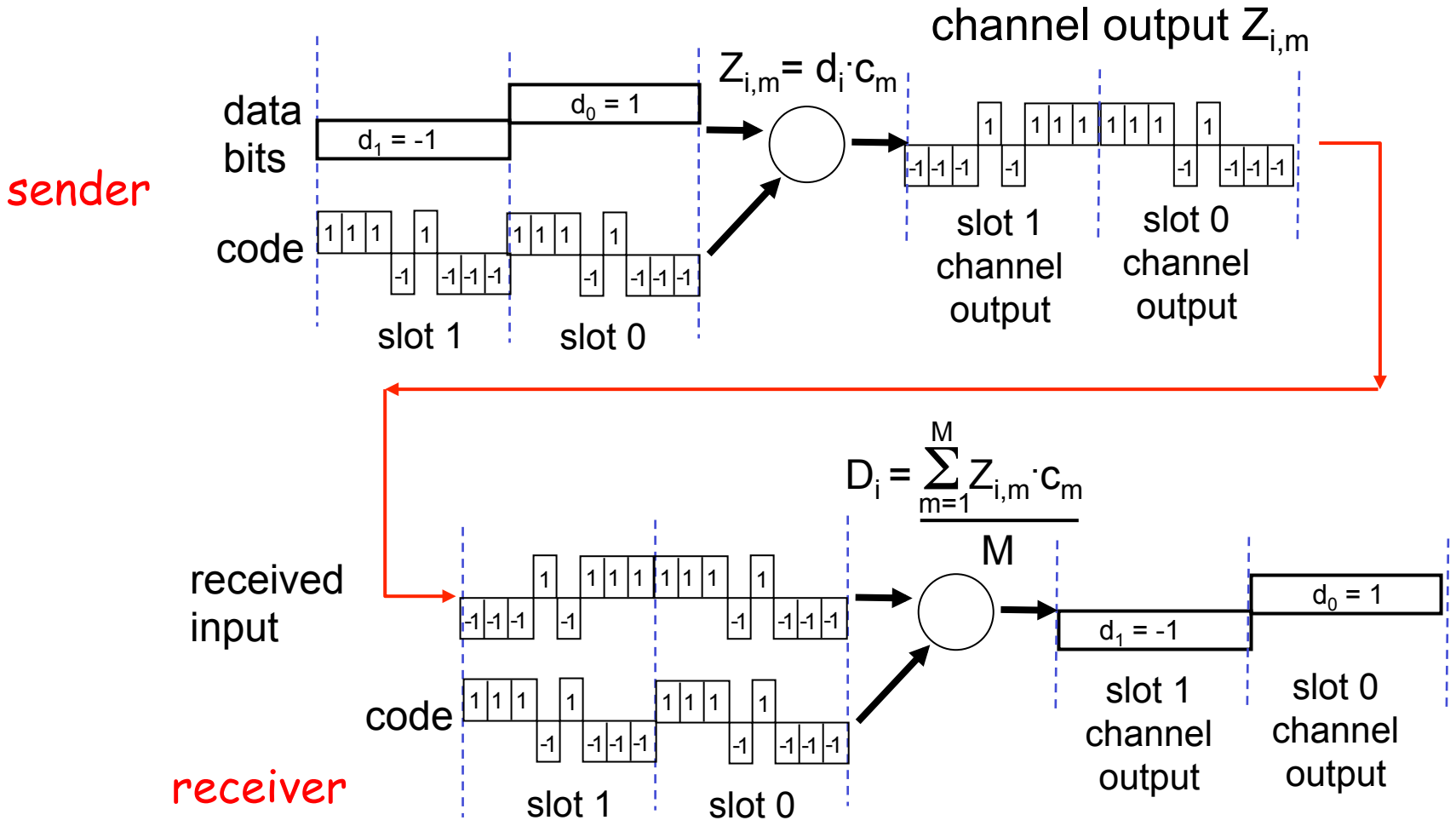
Explains why we cannot use CSMA/CD
Additional difference: typical devices cannot hear and transmit simoultaneously

Code Division Multiple Access (CDMA)

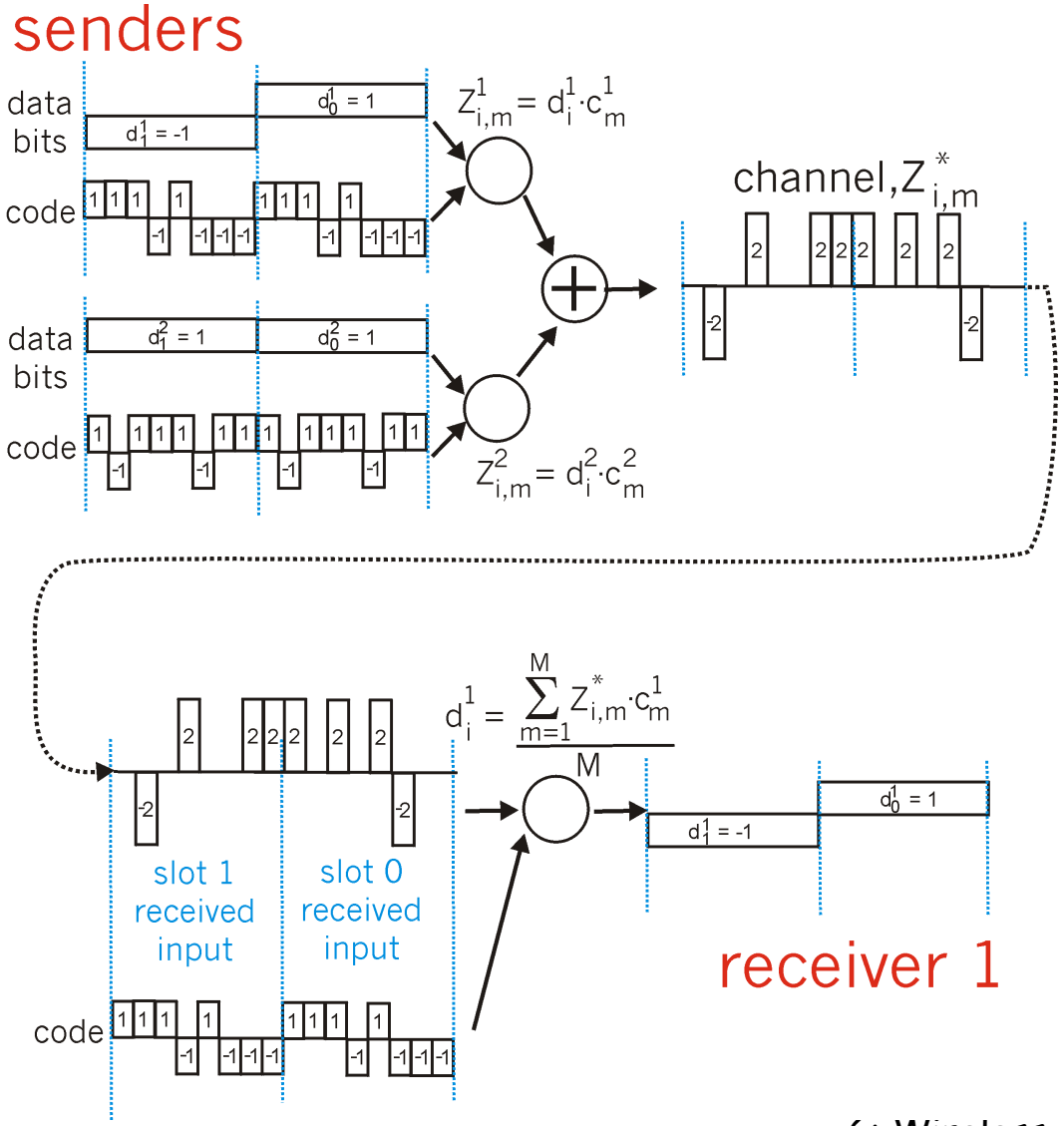
As an example of more efficient access techniques which have been developed to do a better use of the available spectrum

- used in several wireless broadcast channels (cellular, satellite, etc) standards
- unique "code" assigned to each user; i.e., code set partitioning
- all users share same frequency, but each user has own "chipping" sequence (i.e., code) to encode data
- *encoded signal* = (original data) X (chipping sequence)
- *decoding:* inner-product of encoded signal and chipping sequence
- allows multiple users to "coexist" and transmit simultaneously with minimal interference (if codes are "orthogonal")

CDMA Encode/Decode



CDMA: two-sender interference



Chipping codes must be orthogonal

Other requirements such as the fact signals arrivere with comparable power

Chapter 6 outline

6.1 Introduction

Wireless

- 6.2 Wireless links, characteristics
- 6.3 IEEE 802.11 wireless LANs ("wi-fi")
- 6.4 cellular Internet access
  - architecture
  - standards (e.g., GSM)

Mobility

- 6.5 Principles: addressing and routing to mobile users
- 6.6 Mobile IP
- 6.7 Handling mobility in cellular networks
- 6.8 Mobility and higher-layer protocols

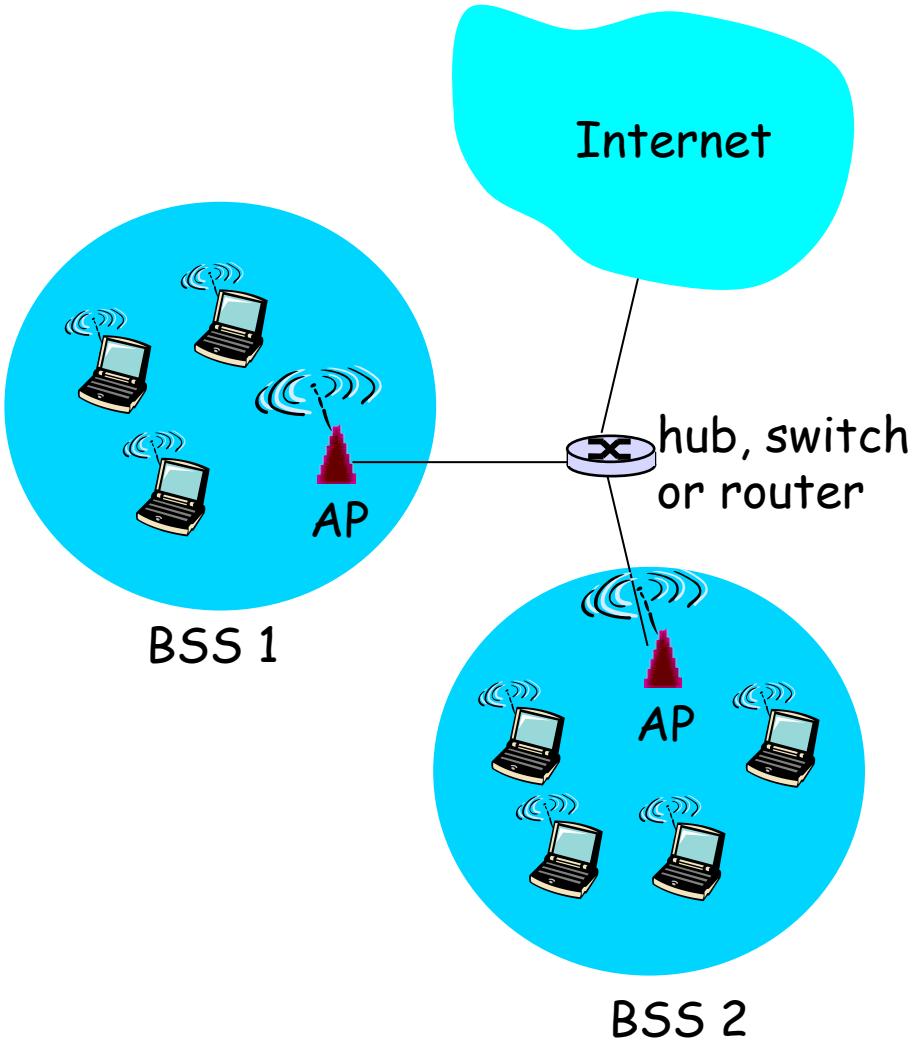
6.9 Summary

IEEE 802.11 Wireless LAN

- 802.11b
  - 2.4-5 GHz unlicensed spectrum
  - up to 11 Mbps
  - direct sequence spread spectrum (DSSS) in physical layer
    - all hosts use same chipping code
- 802.11a
  - 5-6 GHz range
  - up to 54 Mbps
- 802.11g
  - 2.4-5 GHz range
  - up to 54 Mbps
- 802.11n: multiple antennae
  - 2.4-5 GHz range
  - up to 200 Mbps

- all use CSMA/CA for multiple access
- all have base-station and ad-hoc network versions

802.11 LAN architecture

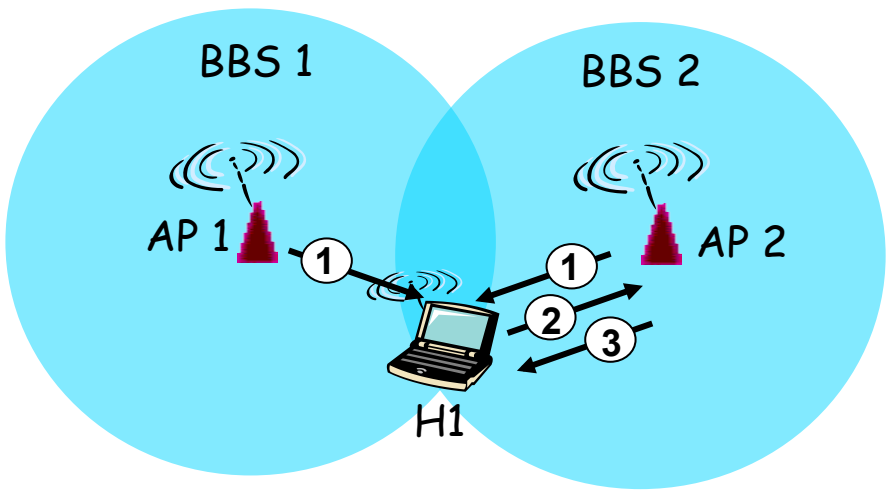


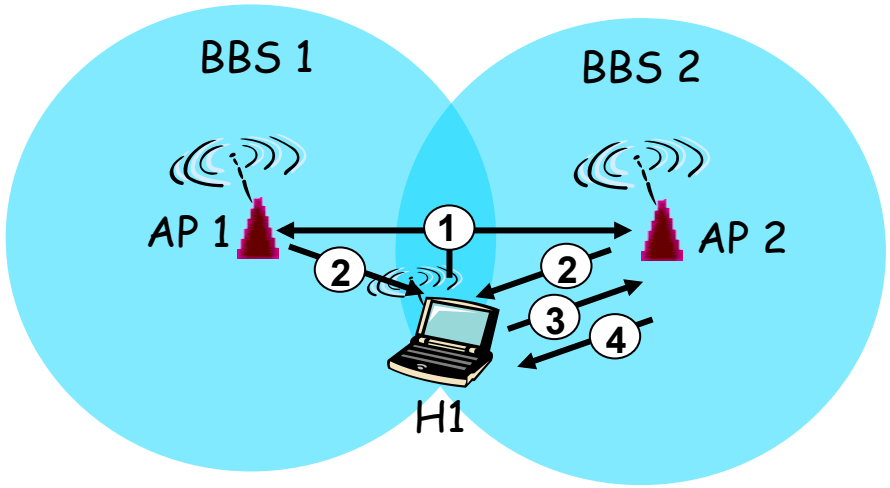
- wireless host communicates with base station
  - base station = access point (AP)
- Basic Service Set (BSS) (aka "cell") in infrastructure mode contains:
  - wireless hosts
  - access point (AP): base station
  - ad hoc mode: hosts only

802.11: Channels, association

- 802.11b: 2.4GHz-2.485GHz spectrum is divided into 11 partially overlapping channels at different frequencies
  - AP admin chooses frequency for AP
  - interference possible: channel can be same as that chosen by neighboring AP!
  - maximum number of non interfering co-located AP: 3 (using channels 1,6,11), as channels are non overlapping only if they are separated by four or more channels
- host: must *associate* with an AP (usually many available, the WiFi jungle)
  - Passive scanning:
    - scans channels, listening for *beacon frames* containing AP's name (SSID) and MAC address
      - AP periodically sends a beacon frame
    - active scanning
      - a probe is sent by the user, APs with the range of the wireless host answer the probe
  - selects AP to associate with, sends an association request to which the AP answers
  - may need to perform authentication
  - will typically run DHCP to get IP address in AP's subnet

802.11: passive/active scanning





Passive Scanning:

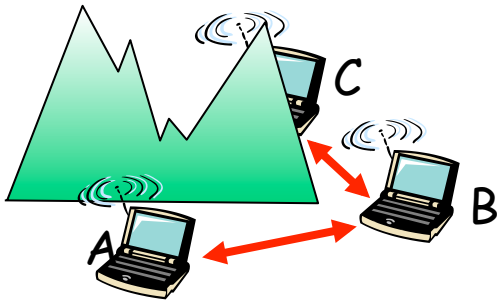
(1) beacon frames sent from APs
(2) association Request frame sent: H1 to selected AP
(3) association Response frame sent: H1 to selected AP

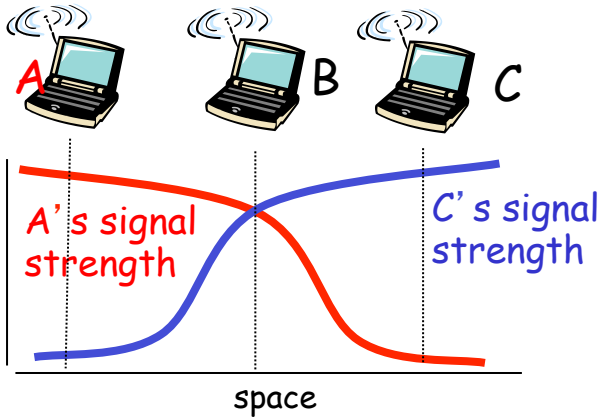
Active Scanning:

(1) Probe Request frame broadcast from H1
(2) Probes response frame sent from APs
(3) Association Request frame sent: H1 to selected AP
(4) Association Response frame sent: H1 to selected AP

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

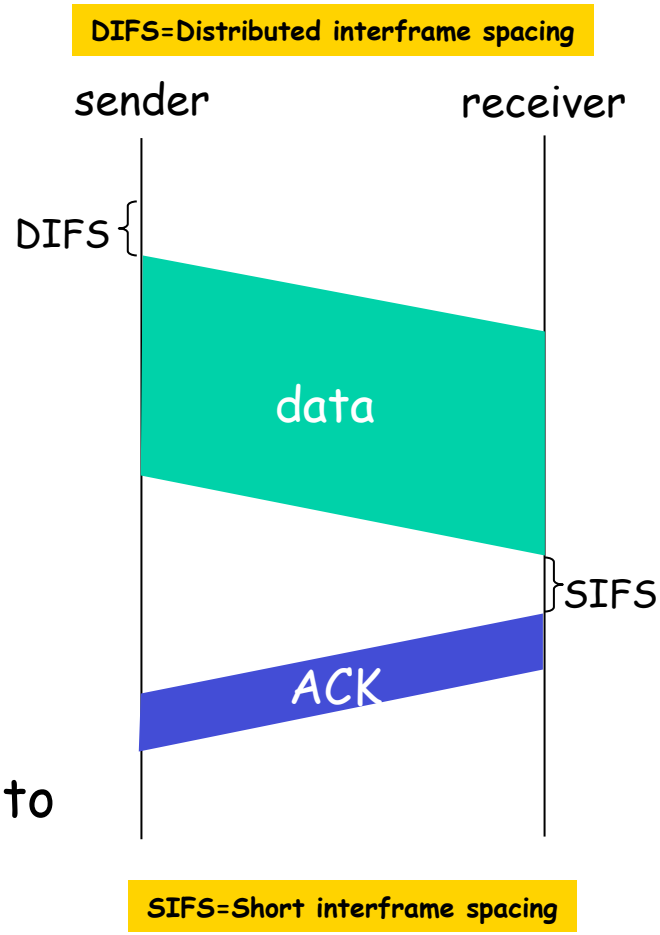
802.11 sender

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)
  - **SIFS <<DIFS**



Avoiding collisions (virtual carrier sensing)

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
- CTS 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