

Chapter 6: Wireless and Mobile Networks

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Chapter 6

Wireless and Mobile Networks

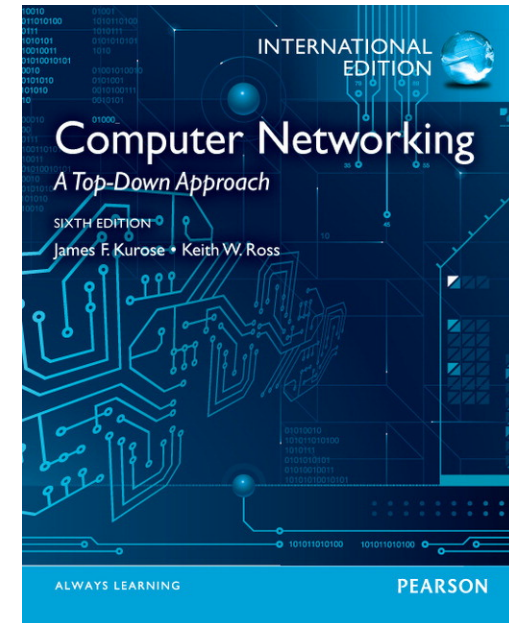
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Computer Networking: A Top Down Approach

6th edition

Jim Kurose, Keith Ross
Addison-Wesley
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Ch. 6: Wireless and Mobile Networks

Background:

- ❖ number of wireless (mobile) phone subscribers now exceeds number of wired phone subscribers (5-to-1)!
- ❖ number of wireless Internet-connected devices equals number of wireline Internet-connected devices
 - laptops, Internet-enabled phones 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

"I have always wished that my computer would be as easy to use as my telephone. My wish has come true. I can no longer figure out how to use my telephone."

—Bjarne Stroustrup

Chapter 6 outline

6.1 Introduction

Wireless

6.2 Wireless links, characteristics

- CDMA

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

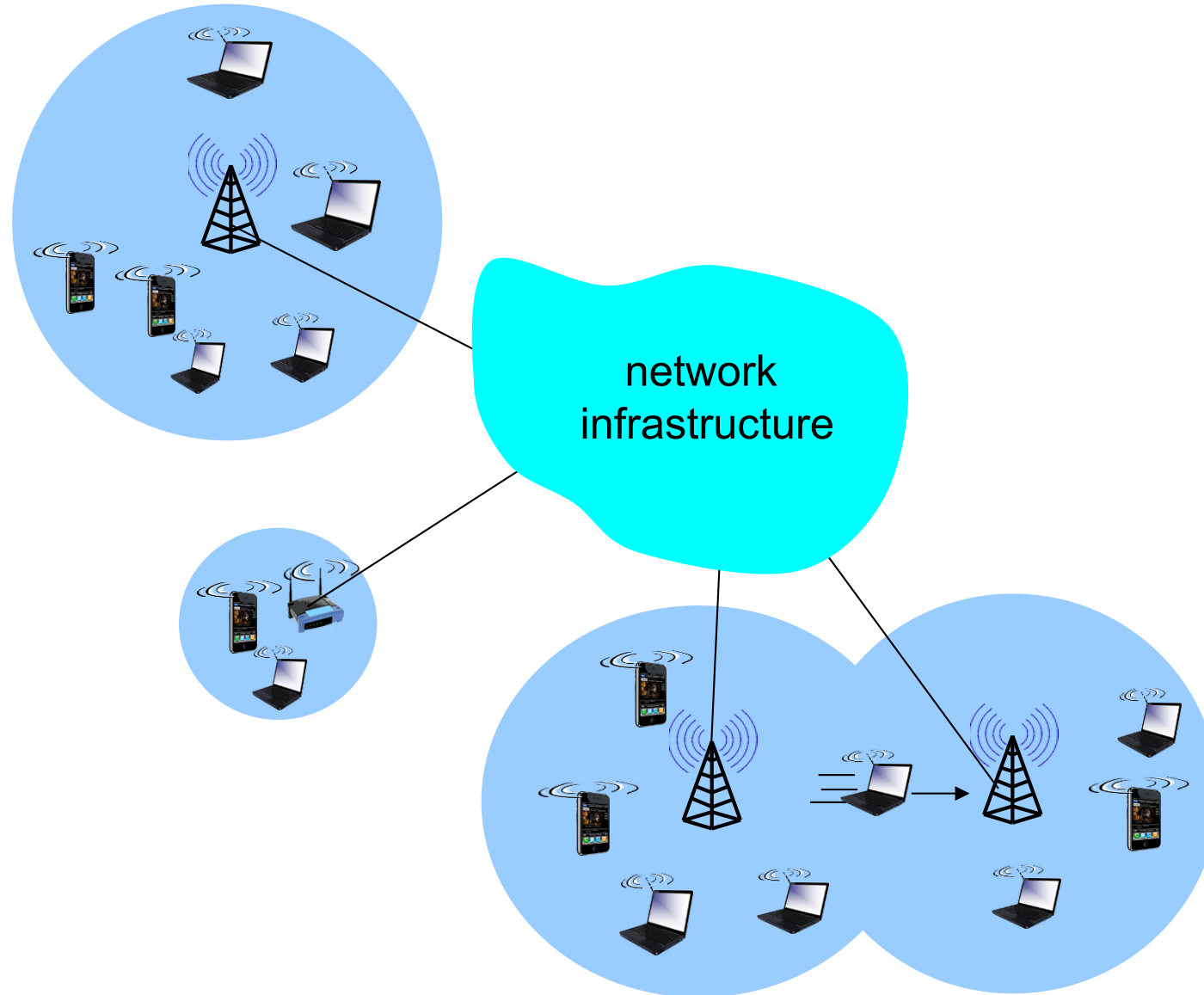
6.6 Mobile IP

6.7 Handling mobility in cellular networks

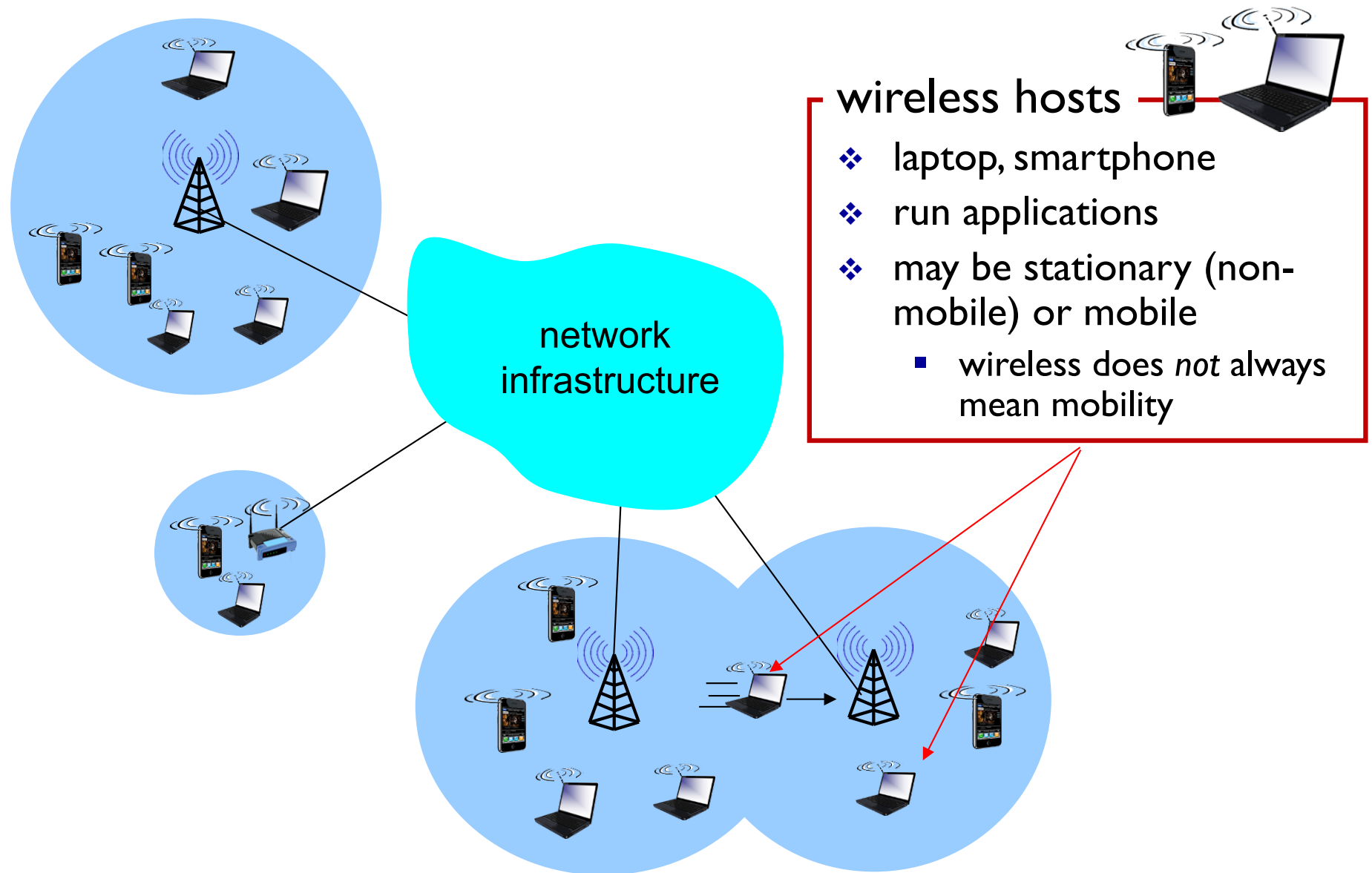
6.8 Mobility and higher-layer protocols

6.9 Summary

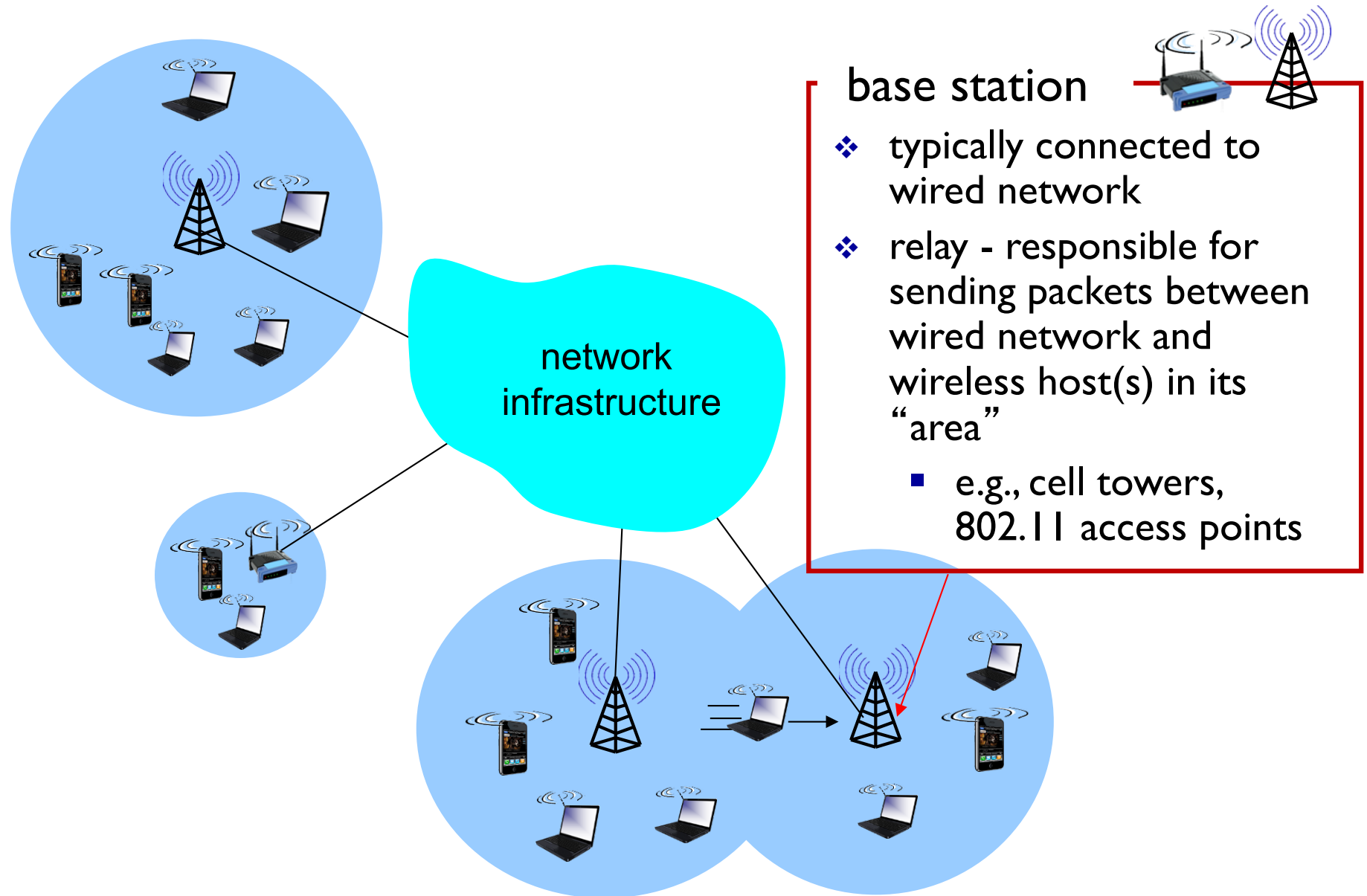
Elements of a wireless network



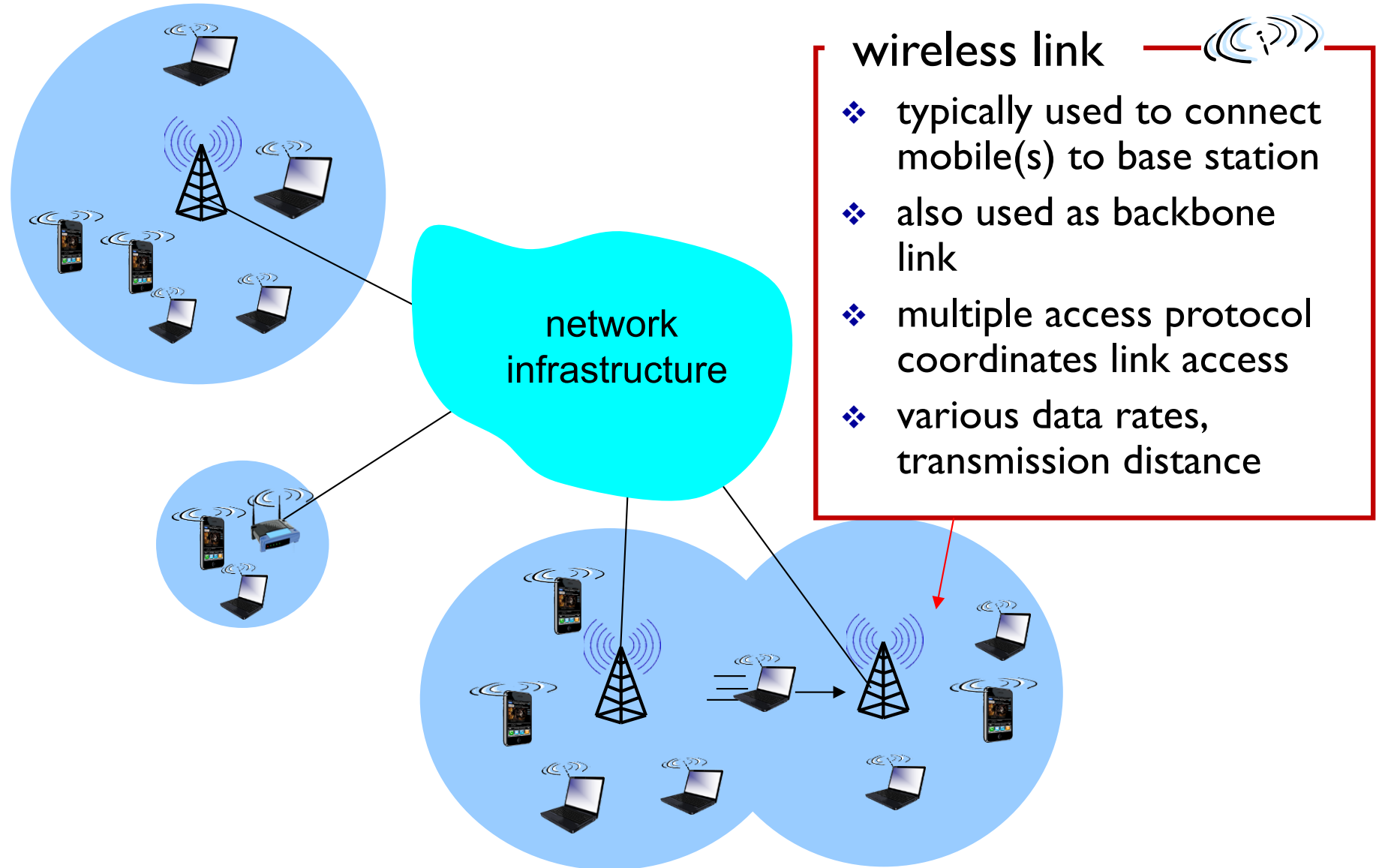
Elements of a wireless network



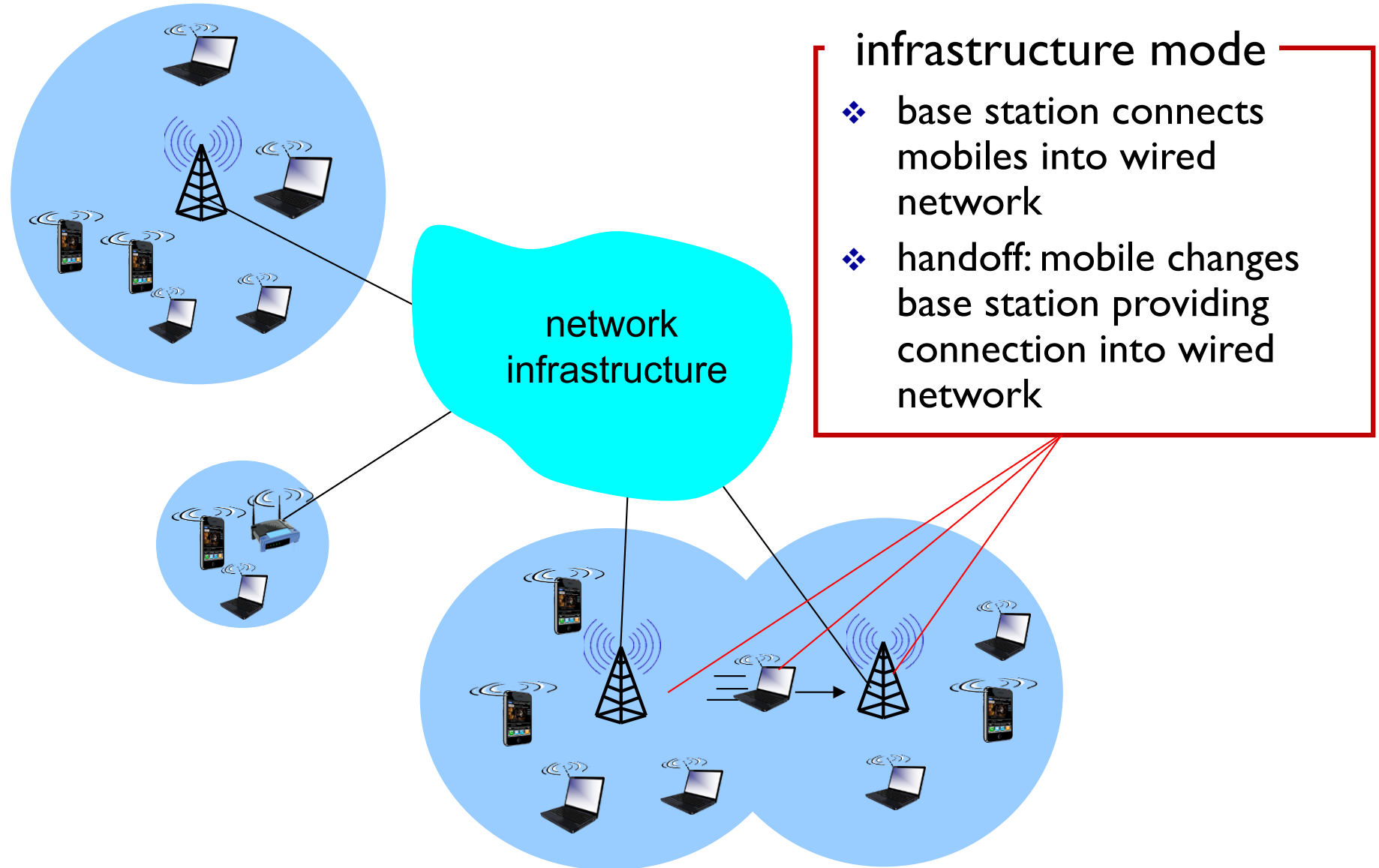
Elements of a wireless network



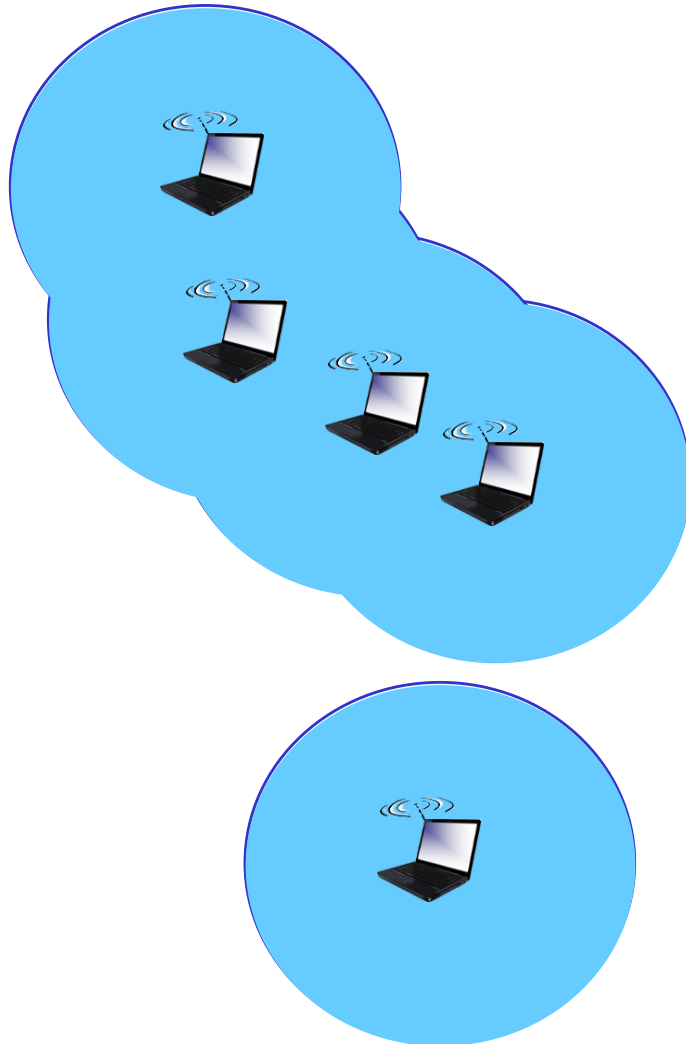
Elements of a wireless network



Elements of a wireless 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

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Wireless Link Characteristics (I)

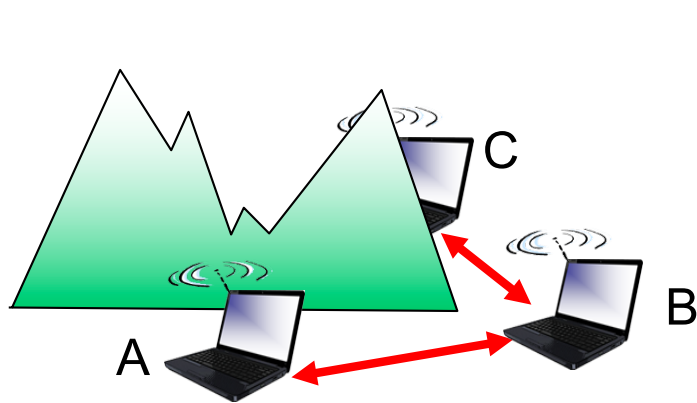
important differences from wired link

- *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”

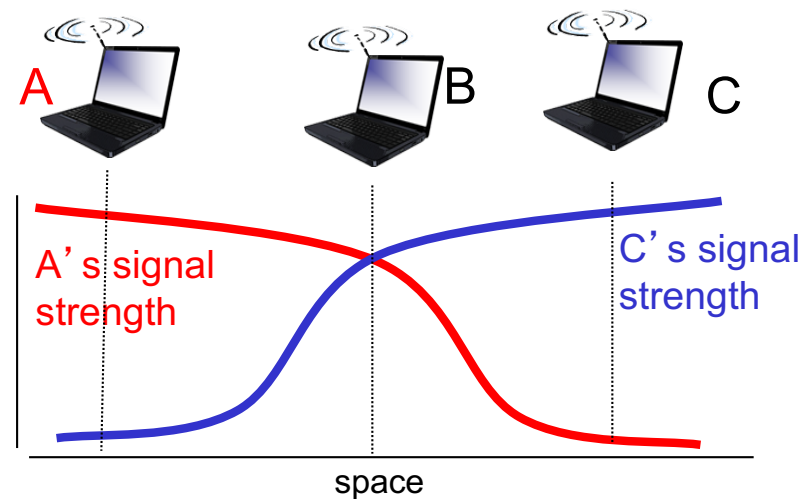
Wireless network characteristics

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 cannot 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 cannot hear each other interfering at B

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IEEE 802.11 Wireless LAN

802.11b

- ❖ 2.4-5 GHz unlicensed spectrum
- ❖ up to 11 Mbps

802.11g

- 2.4-5 GHz range
- up to 54 Mbps

802.11n: multiple antennae

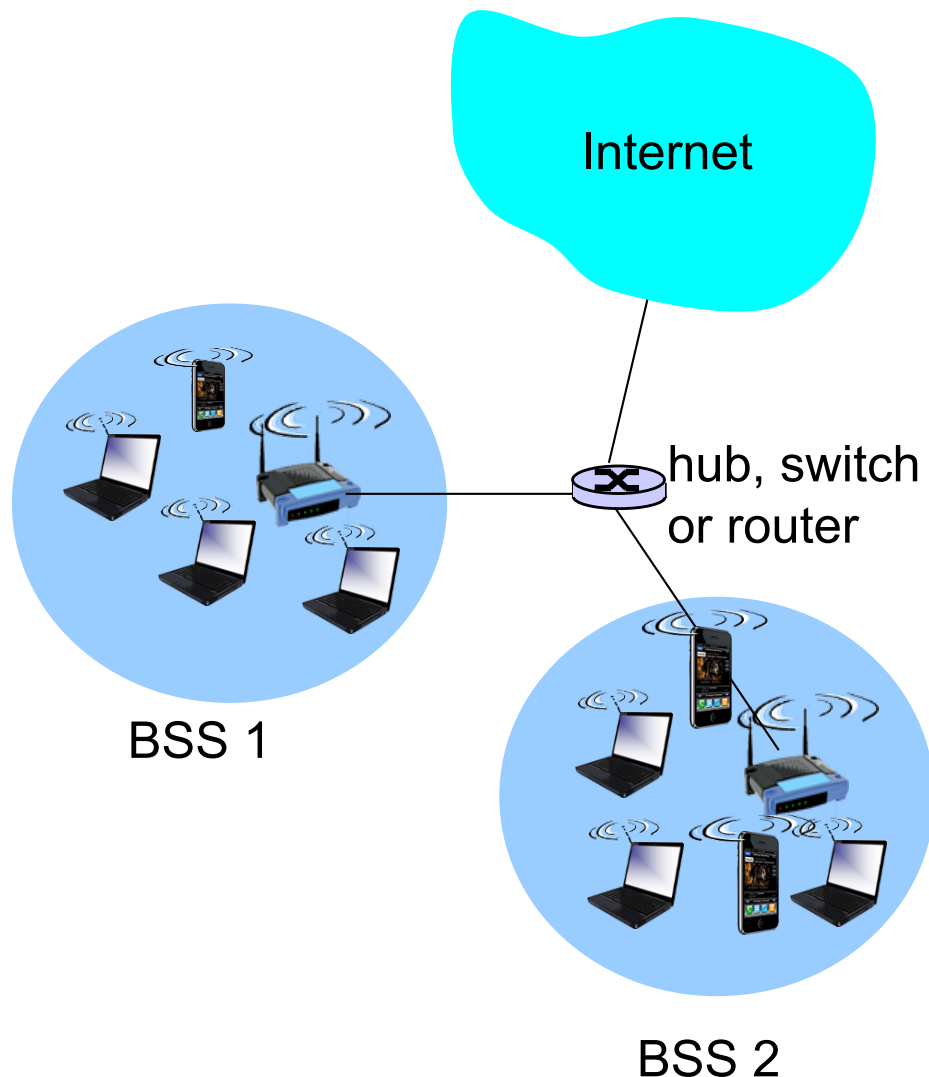
- 2.4-5 GHz range
- up to 200 Mbps

802.11ac: multiple antennae, multi-user

- 5 GHz range
- At least 1000 Mbps multi-station (500 Mbps single link)

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

802.11 LAN architecture



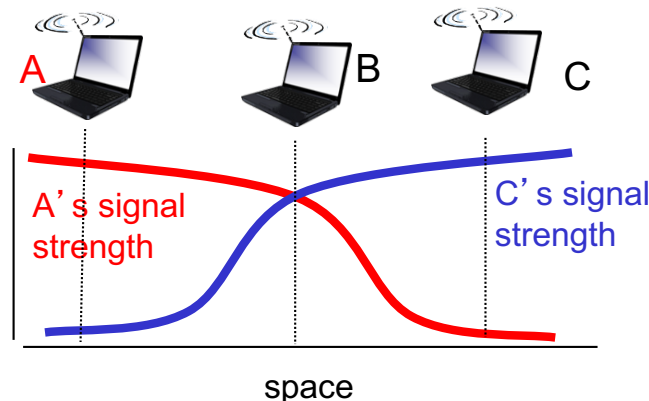
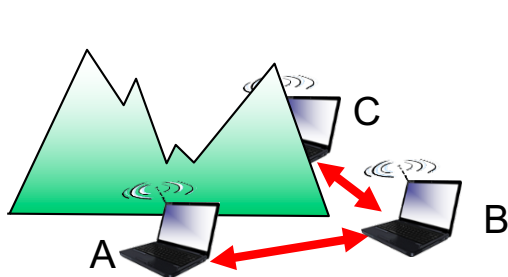
- ❖ wireless host communicates with base station
 - base station = access point (AP)
- ❖ **Basic Service Set (BSS)** (aka “cell”) in infrastructure mode contains:
 - wireless hosts
 - access point (AP): base station
 - ad hoc mode: hosts only

802.11: Channels, association

- ❖ 802.11b: 2.4GHz-2.485GHz spectrum divided into 11 channels at different frequencies
 - AP admin chooses channel 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 [Chapter 8]
 - will typically run DHCP to get IP address in AP's subnet

IEEE 802.11: multiple access

- ❖ avoid collisions: 2 nodes or more 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(avoidance)



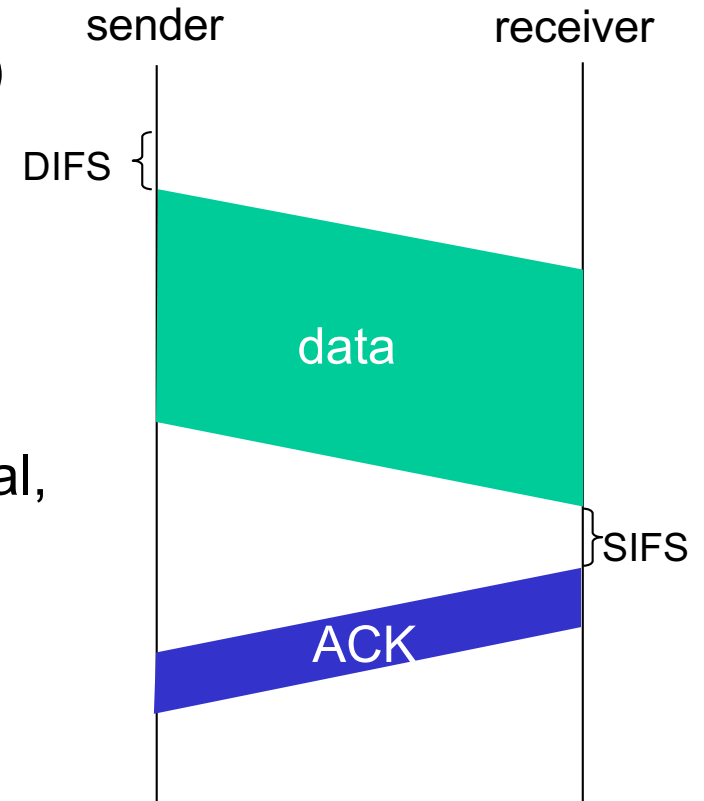
IEEE 802.11 MAC Protocol: CSMA/CA

802.11 sender

- 1 if sense channel idle for **DIFS** then
transmit entire frame (no Collision Detect!)
- 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)



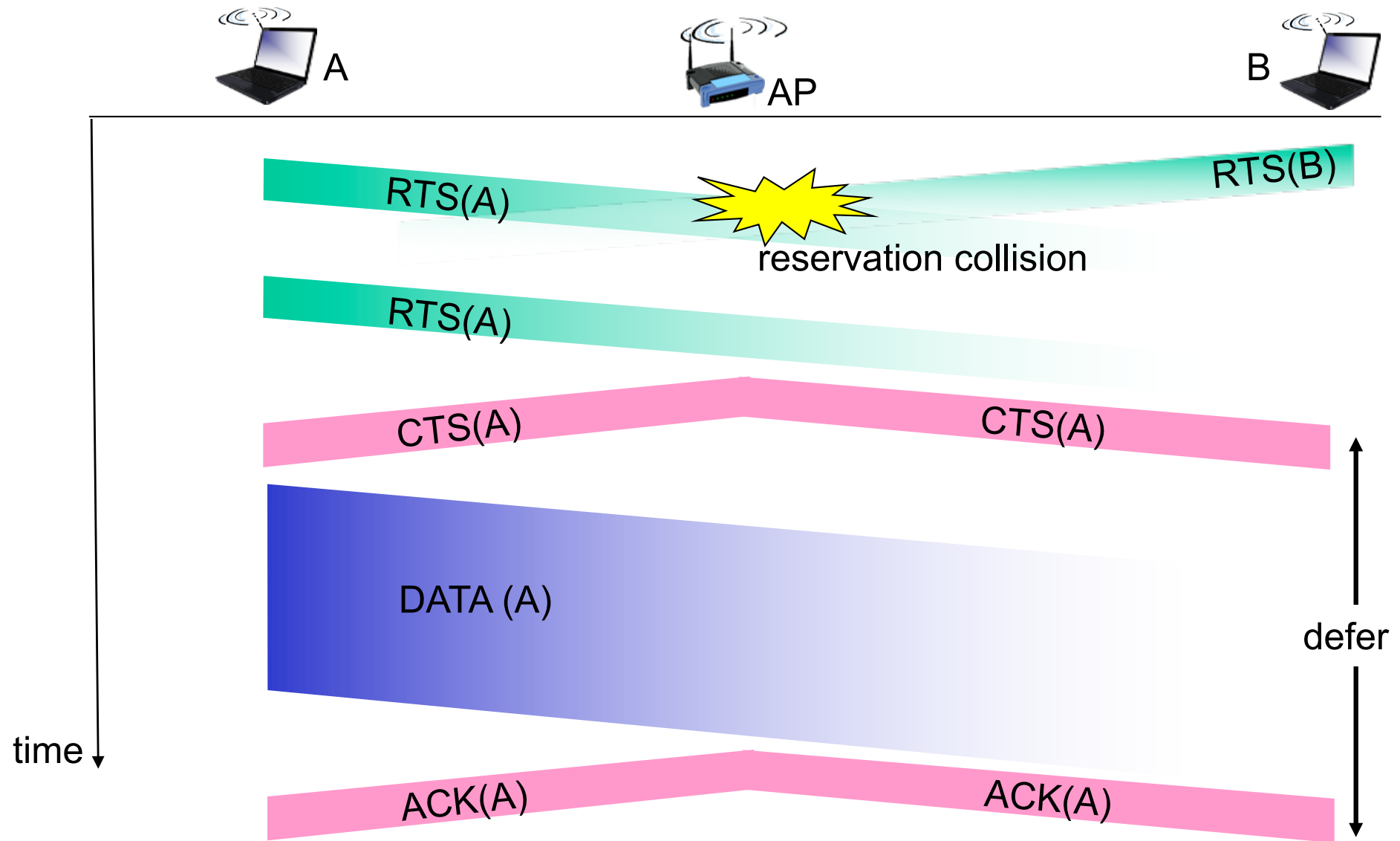
Avoiding collisions (more)

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

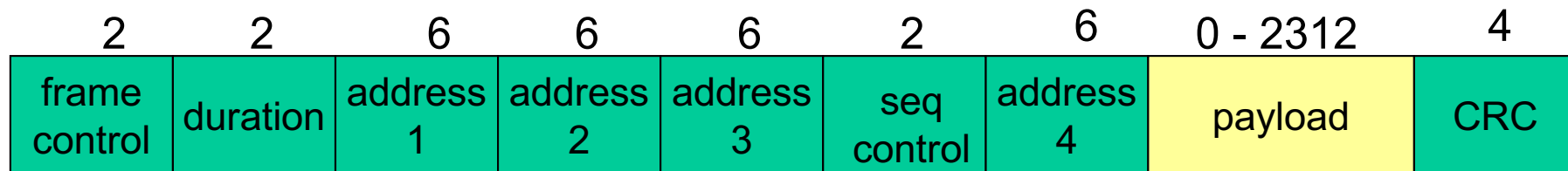
- ❖ sender first transmits *small* request-to-send (RTS) packets to BS using CSMA
 - RTSs may still collide with each other (but they’re short)
- ❖ BS broadcasts clear-to-send CTS in response to RTS
- ❖ CTS heard by all nodes
 - sender transmits data frame
 - other stations defer transmissions

*avoid data frame collisions completely
using small reservation packets!*

Collision Avoidance: RTS-CTS exchange



802.11 frame: addressing



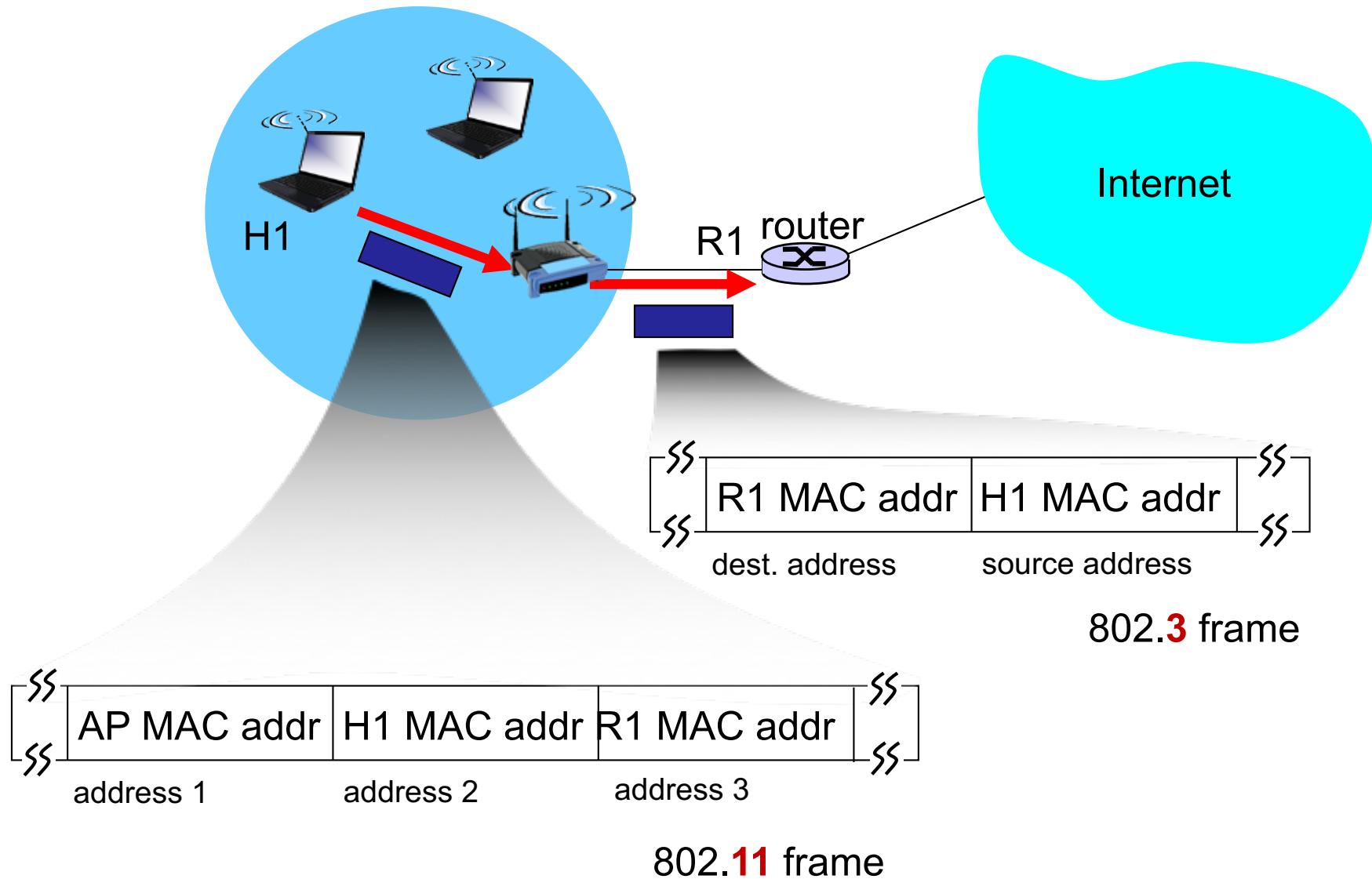
Address 1: MAC address of wireless host or AP to receive this frame

Address 2: MAC address of wireless host or AP transmitting this frame

Address 3: MAC address of router interface to which AP is attached

Address 4: used only in ad hoc mode

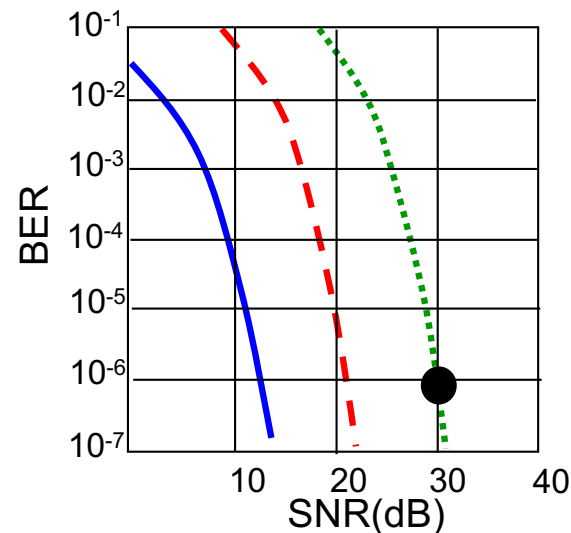
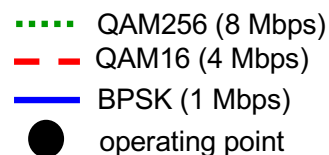
802.11 frame: addressing



802.11: advanced capabilities

Rate adaptation

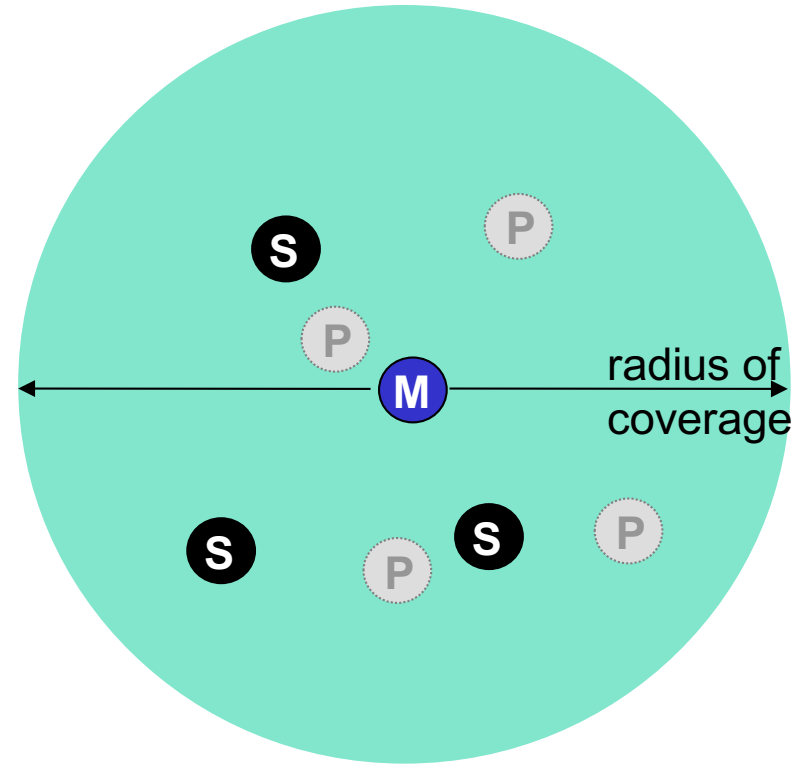
- ❖ base station, mobile dynamically change transmission rate (physical layer modulation technique) as mobile moves, SNR varies



1. SNR decreases, BER increase as node moves away from base station
2. When BER becomes too high, switch to lower transmission rate but with lower BER

802.15: personal area network

- ❖ less than 10 m diameter
- ❖ replacement for cables (mouse, keyboard, headphones)
- ❖ ad hoc: no infrastructure
- ❖ master/slaves:
 - slaves request permission to send (to master)
 - master grants requests
- ❖ 802.15: evolved from Bluetooth specification
 - 2.4-2.5 GHz radio band
 - up to 721 kbps



- M** Master device
- S** Slave device
- P** Parked device (inactive)

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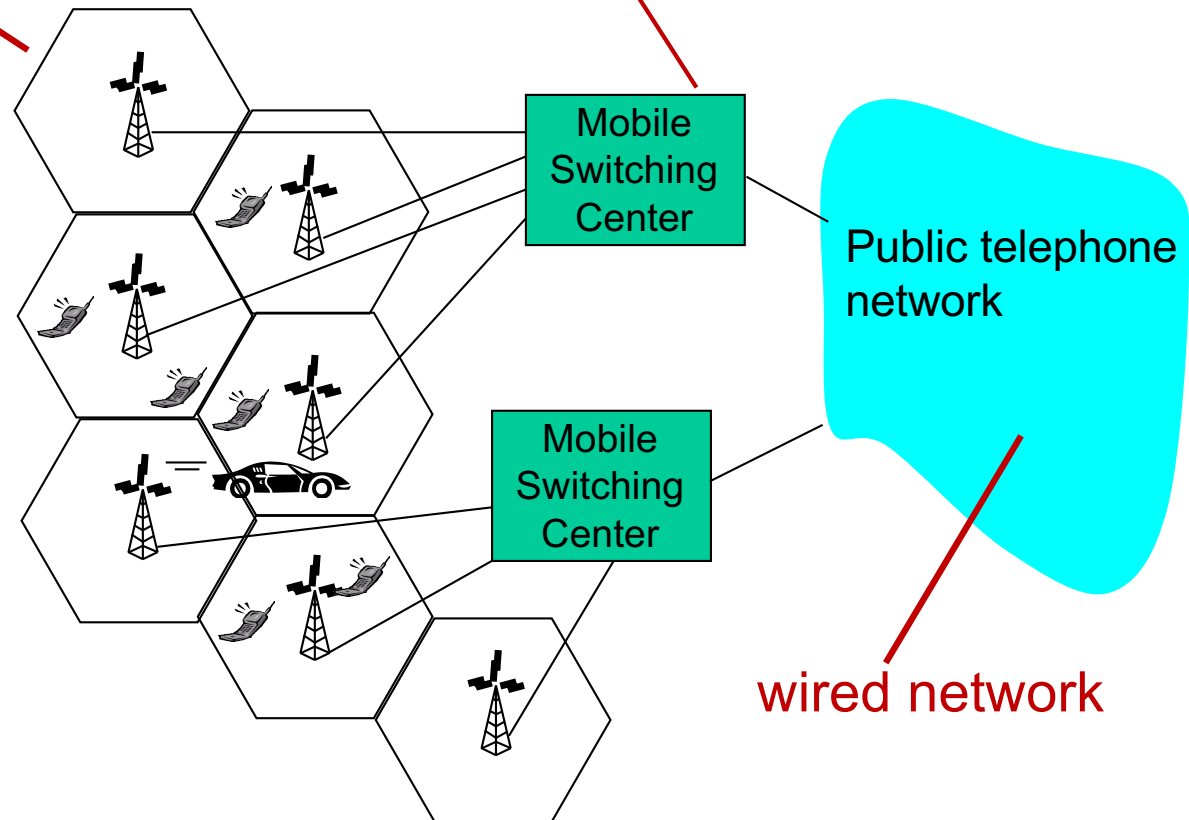
Components of cellular network architecture

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

MSC

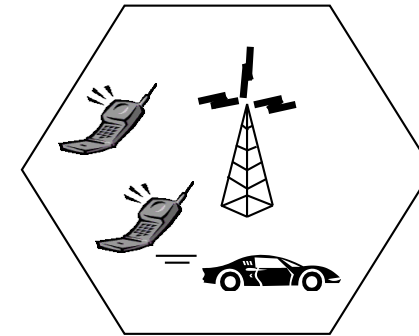
- ❖ connects cells to wired tel. net.
- ❖ manages call setup (more later!)
- ❖ handles mobility (more later!)



Cellular networks: the first hop

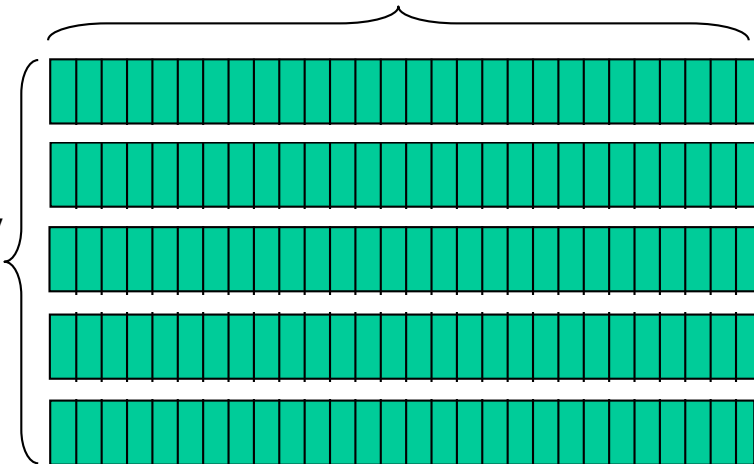
Two techniques for sharing
mobile-to-BS radio spectrum

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

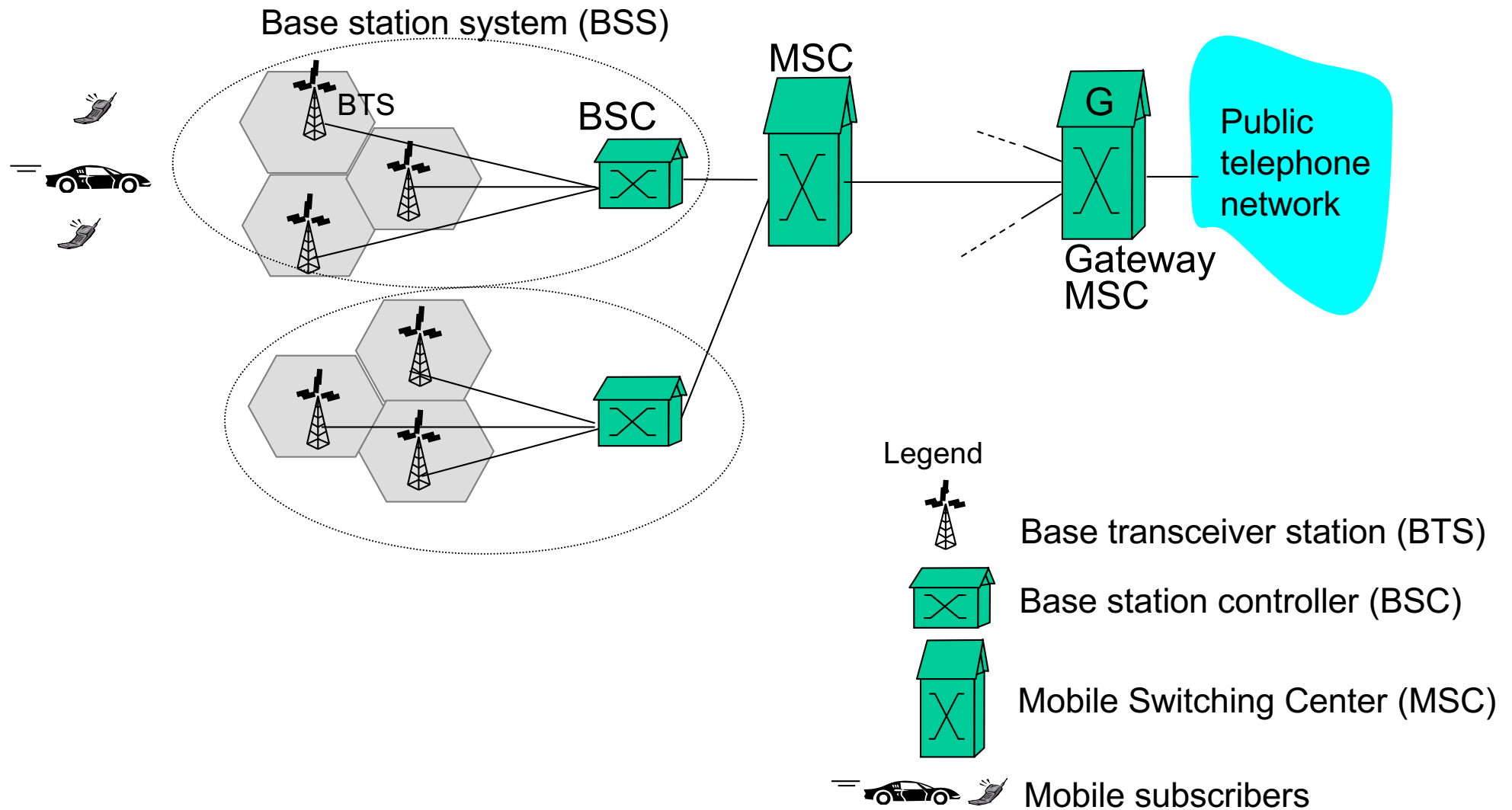


time slots

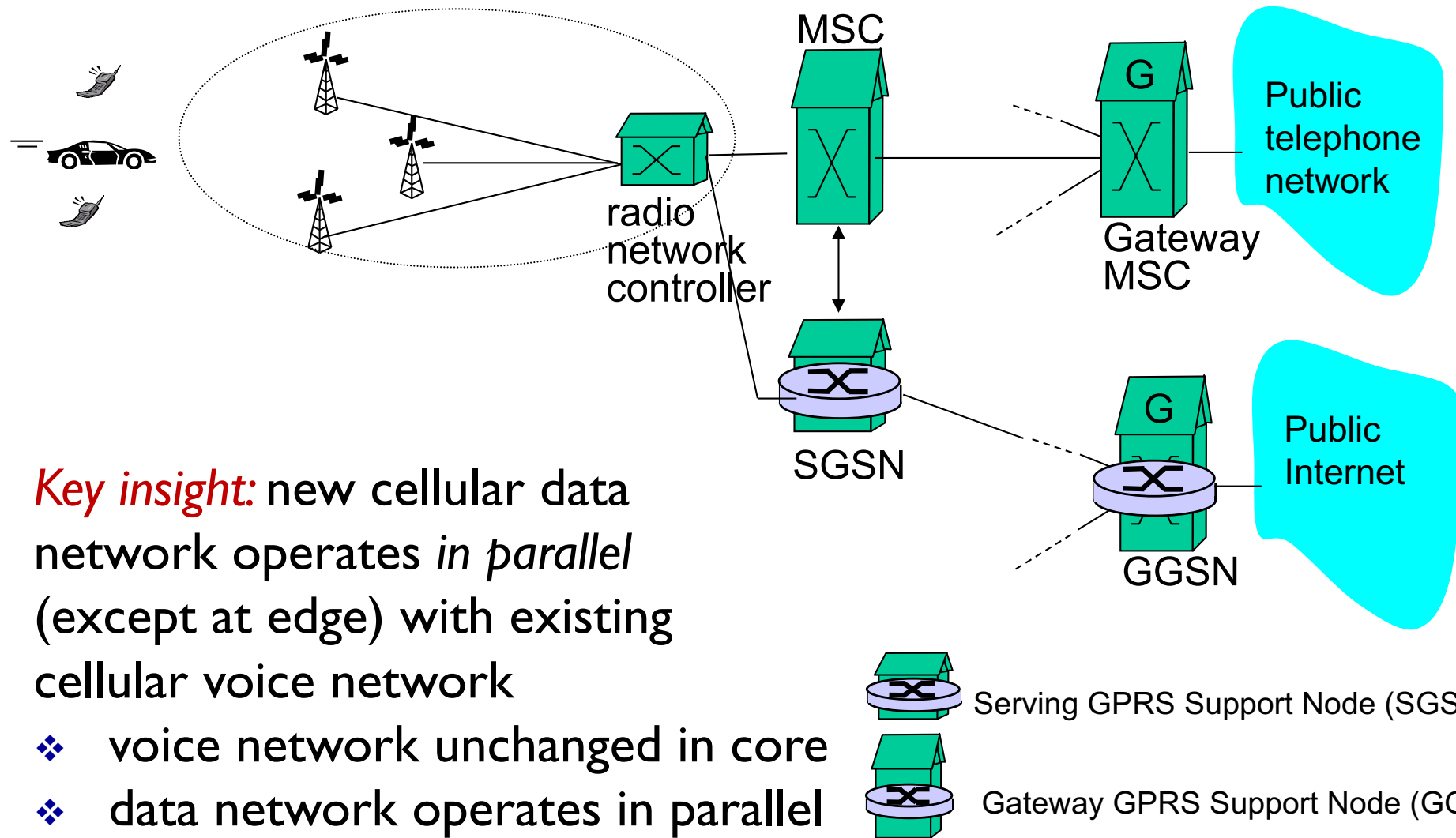
frequency
bands



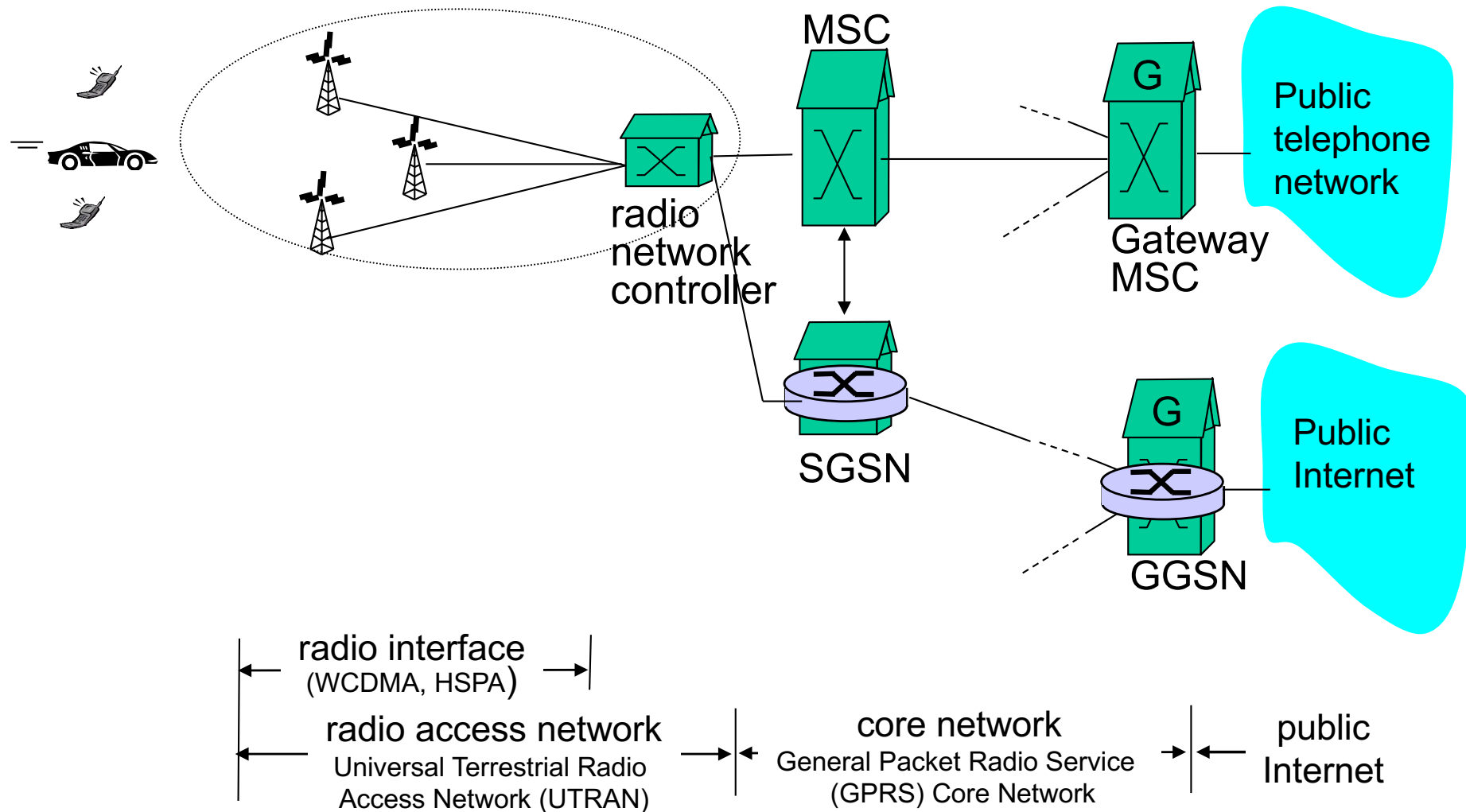
2G (voice) network architecture



3G (voice+data) network architecture



3G (voice+data) network architecture



Chapter 6 summary

Wireless

- ❖ wireless links:
 - capacity, distance
 - channel impairments
 - CDMA
- ❖ IEEE 802.11 (“Wi-Fi”)
 - CSMA/CA reflects wireless channel characteristics
- ❖ cellular access
 - architecture
 - standards (e.g., GSM, 3G, 4G LTE)

Mobility

- ❖ principles: addressing, routing to mobile users
 - home, visited networks
 - direct, indirect routing
 - care-of-addresses
- ❖ case studies
 - mobile IP
 - mobility in GSM
- ❖ impact on higher-layer protocols