

Lecture 5-6

WIRELESS NETWORKS

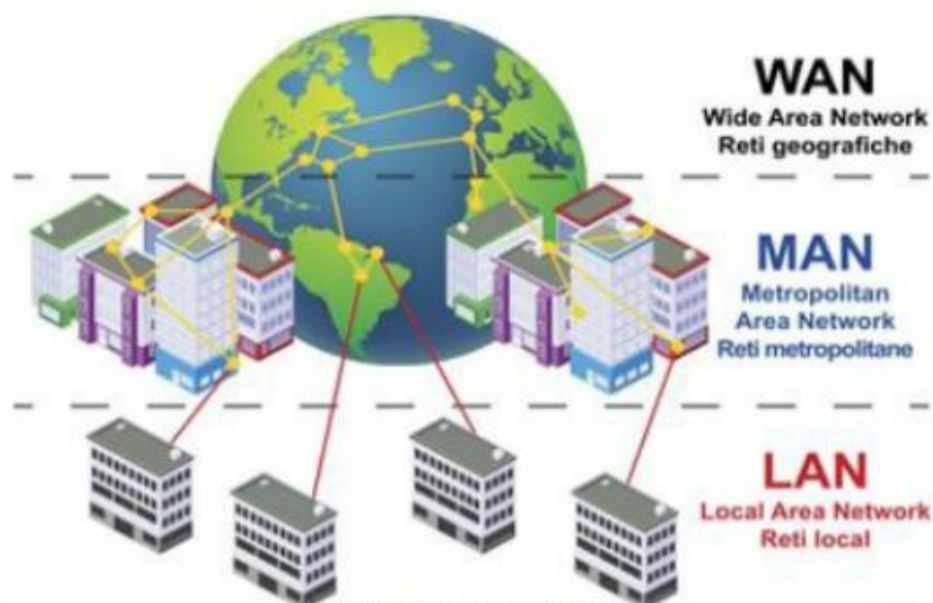
Reference

"INTRODUCTION TO WIRELESS AND MOBILE SYSTEMS", *DHARMA ARAVIAL*."

Contents

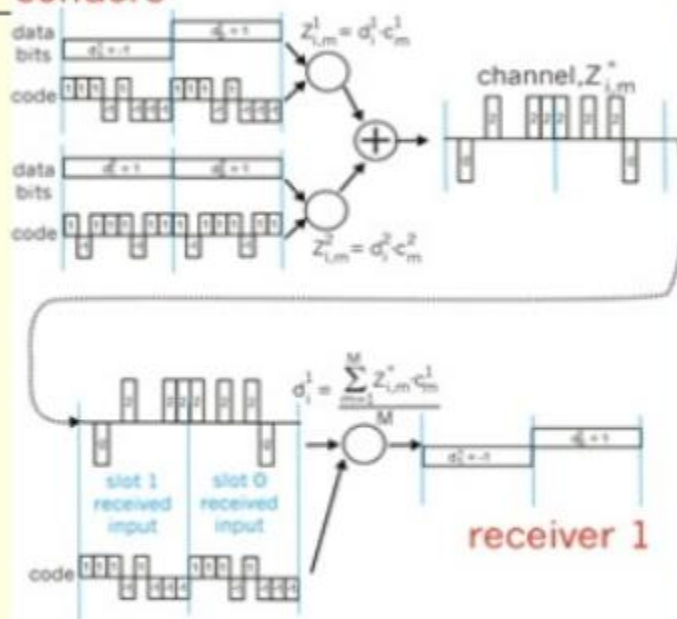
1. Introduction to satellite systems
2. Characteristics of satellite systems
3. GPS, Wireless LAN
4. Overview of IEEE802.11
5. Location management

3. Overview of Wireless Networks



CDMA: two-sender interference

senders



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

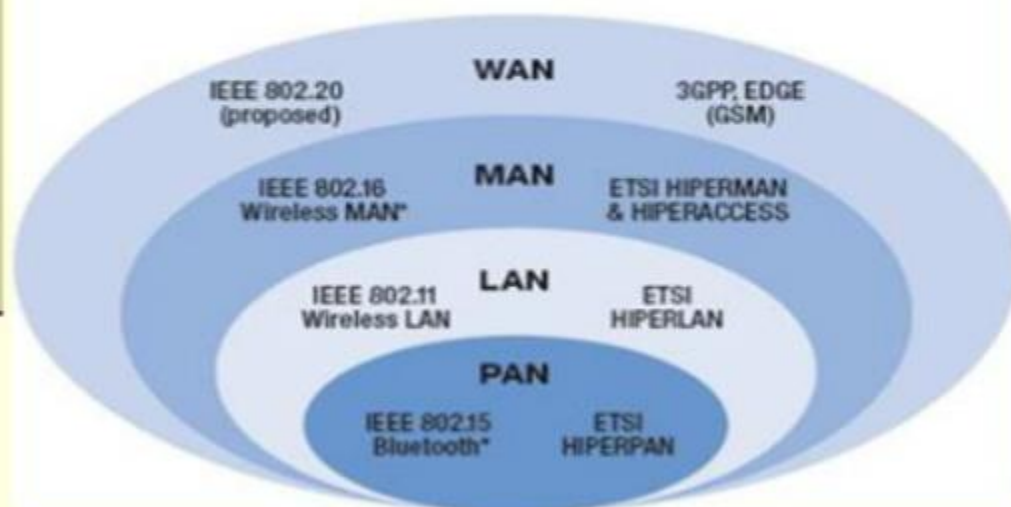
■ 802.11n: multiple antennae

- 2.4-5 GHz range
- up to 200 Mbps

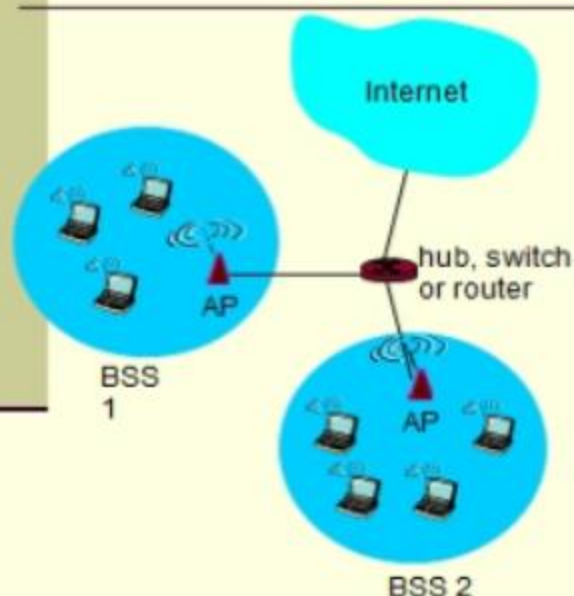
- ❑ all use CSMA/CA for multiple access
- ❑ all have base-station and ad-hoc network versions

continued

Global Wireless Standards



802.11 LAN architecture

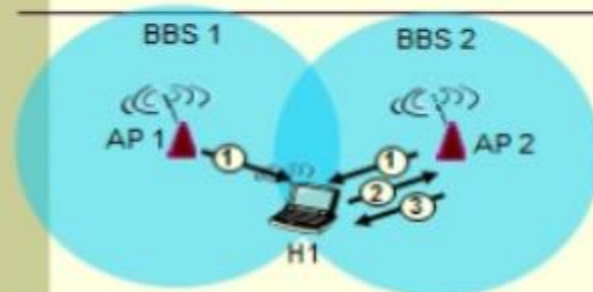


- ❑ wireless host communicates with base station
 - base station = access point (AP)
- ❑ Basic Service Set (BSS) (aka "cell") in infrastructure mode contains:
 - wireless hosts
 - access point (AP): base station
 - ad hoc mode: hosts only

802.11: Channels, association

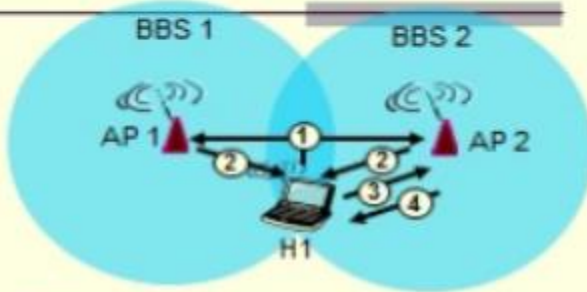
- 802.11b: 2.4GHz-2.485GHz spectrum divided into 11 channels at different frequencies
 - AP admin chooses frequency for AP
 - interference possible: channel can be same as that chosen by neighboring AP!
- host: must **associate** with an AP
 - scans channels, listening for *beacon frames* containing AP's name (SSID) and MAC address
 - selects AP to associate with
 - may perform authentication 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

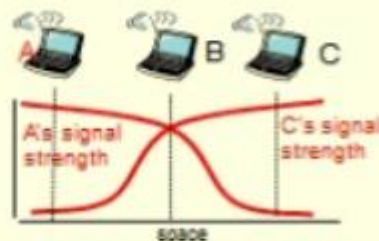


Active Scanning:

- (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)



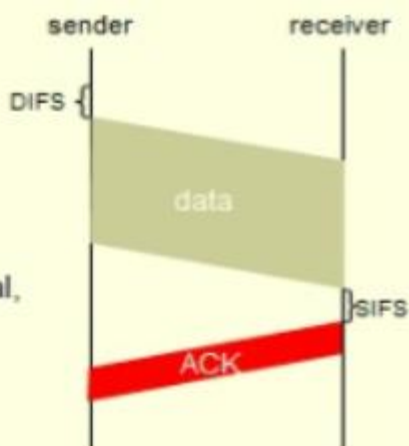
IEEE 802.11 MAC Protocol: CSMA/CA

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)



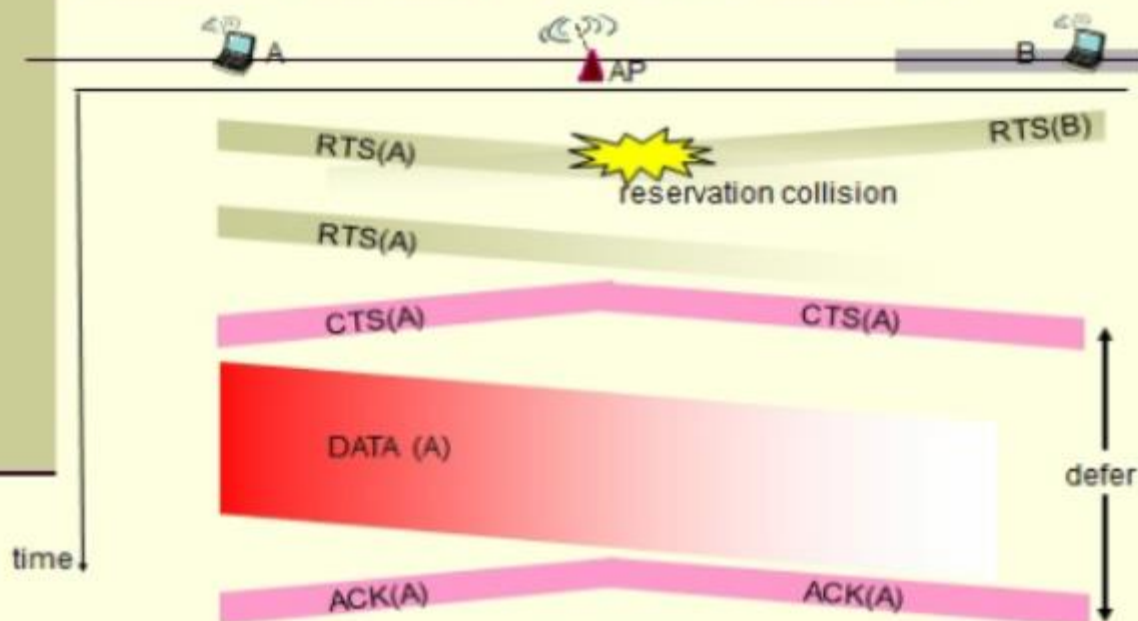
Avoiding collisions (more)

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

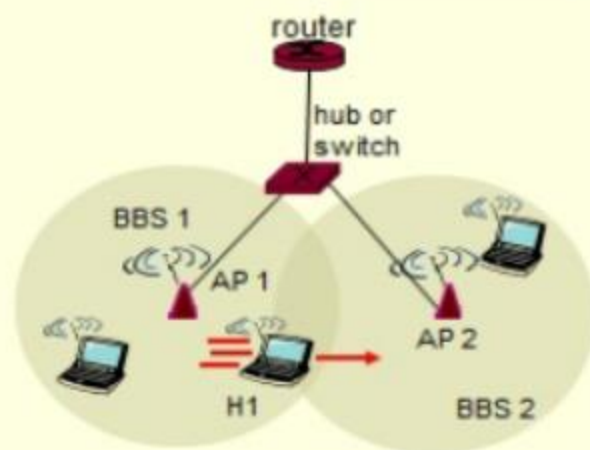
avoid data frame collisions completely
using small reservation packets!

Collision Avoidance: RTS-CTS exchange



802.11: mobility within same subnet

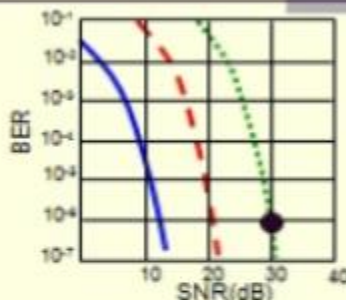
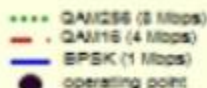
- H1 remains in same IP subnet: IP address can remain same
- switch: which AP is associated with H1?
 - self-learning (Ch. 5): switch will see frame from H1 and "remember" which switch port can be used to reach H1



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

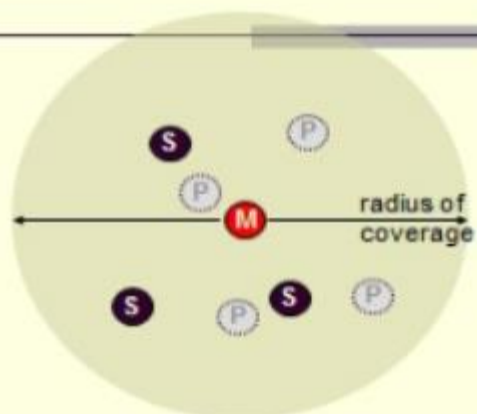
802.11: advanced capabilities

Power Management

- node-to-AP: "I am going to sleep until next beacon frame"
 - AP knows not to transmit frames to this node
 - node wakes up before next beacon frame
- beacon frame: contains list of mobiles with AP-to-mobile frames waiting to be sent
 - node will stay awake if AP-to-mobile frames to be sent; otherwise sleep again until next beacon frame

802.15: personal area network

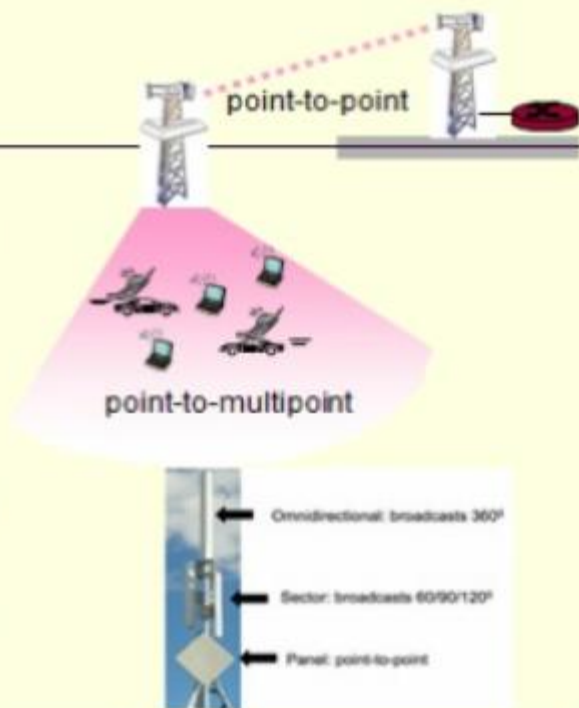
- less than 10 m diameter
- replacement for cables (mouse, keyboard, headphones)
- ad hoc: no infrastructure
- master/slaves:
 - slaves request permission to send (to master)
 - master grants requests
- 802.15: evolved from Bluetooth specification
 - 2.4-2.5 GHz radio band
 - up to 721 kbps



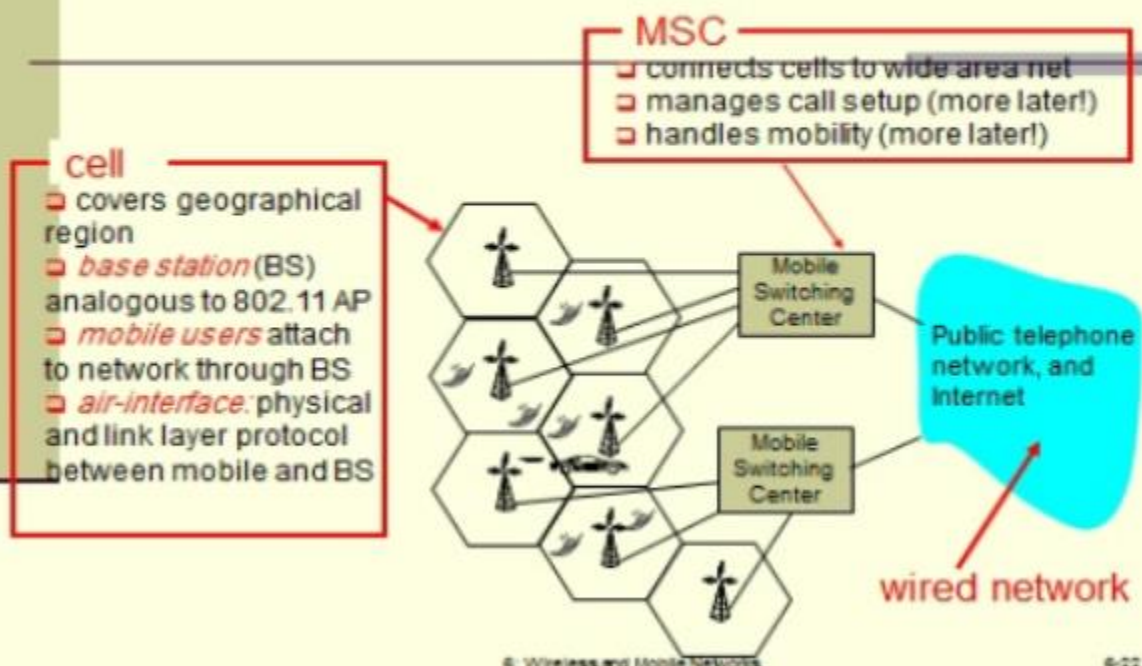
- Master device
- Slave device
- Parked device (inactive)

802.16: WiMAX

- like 802.11 & cellular:
base station model
 - transmissions to/from base station by hosts with omnidirectional antenna
 - base station-to-base station backhaul with point-to-point antenna
- unlike 802.11:
 - range ~ 6 miles ("city rather than coffee shop")
 - ~14 Mbps



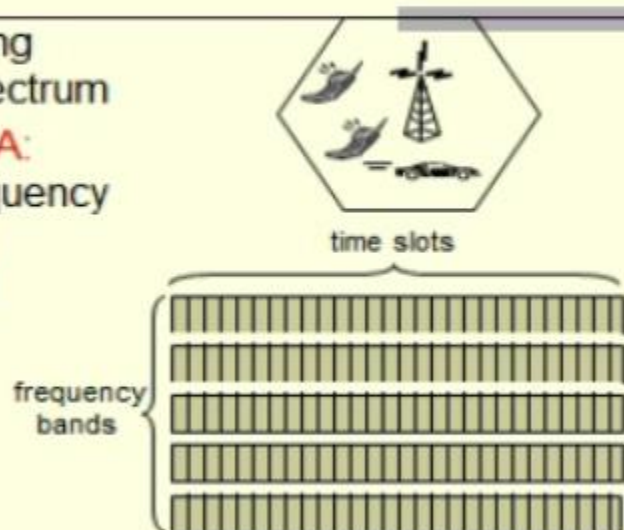
Components of cellular network architecture



Cellular networks: the first hop

Two techniques for sharing mobile-to-BS radio spectrum

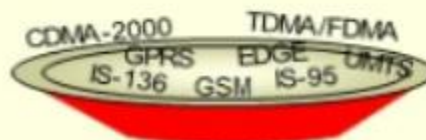
- combined FDMA/TDMA**: divide spectrum in frequency channels, divide each channel into time slots
- CDMA**: code division multiple access



Cellular standards: brief survey

2G systems: voice channels

- IS-136 TDMA: combined FDMA/TDMA (north america)
- GSM (global system for mobile communications): combined FDMA/TDMA
 - most widely deployed
- IS-95 CDMA: code division multiple access



Don't drown in a bowl of alphabet soup; use this for reference only

Cellular standards: brief survey

2.5 G systems: voice and data channels

- for those who can't wait for 3G service: 2G extensions
- 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, using enhanced modulation
 - data rates up to 384K
- CDMA-2000 (phase 1)
 - data rates up to 144K
 - evolved from IS-95

Cellular standards: brief survey

3G systems: voice/data

- Universal Mobile Telecommunications Service (UMTS)
 - data service: High Speed Uplink/Downlink packet Access (HSDPA/HSUPA): 3 Mbps
- CDMA-2000: CDMA in TDMA slots
 - data service: 1xEvolution Data Optimized (1xEVDO) up to 14 Mbps

..... more (and more interesting) cellular topics due to mobility (stay tuned for details)

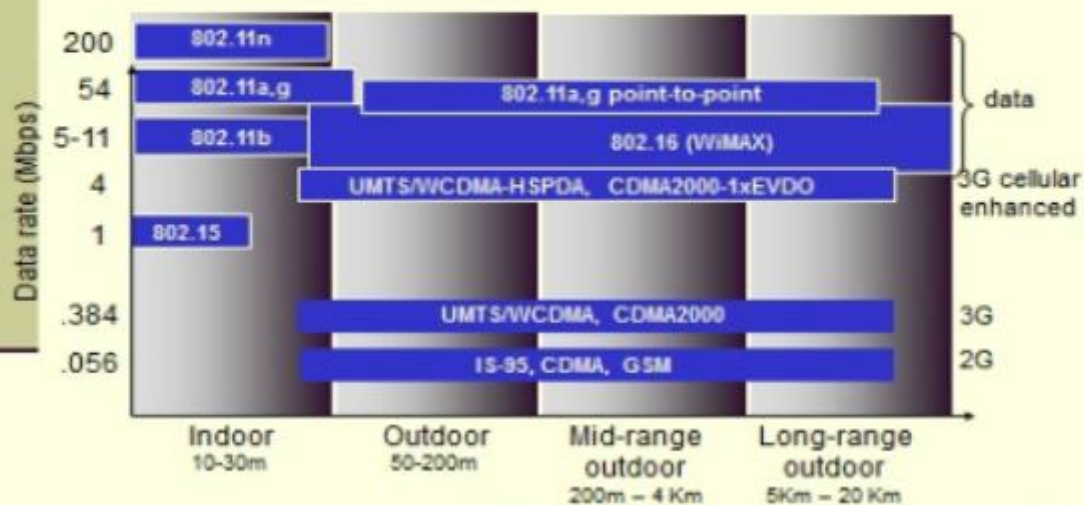
Cellular standards: brief survey

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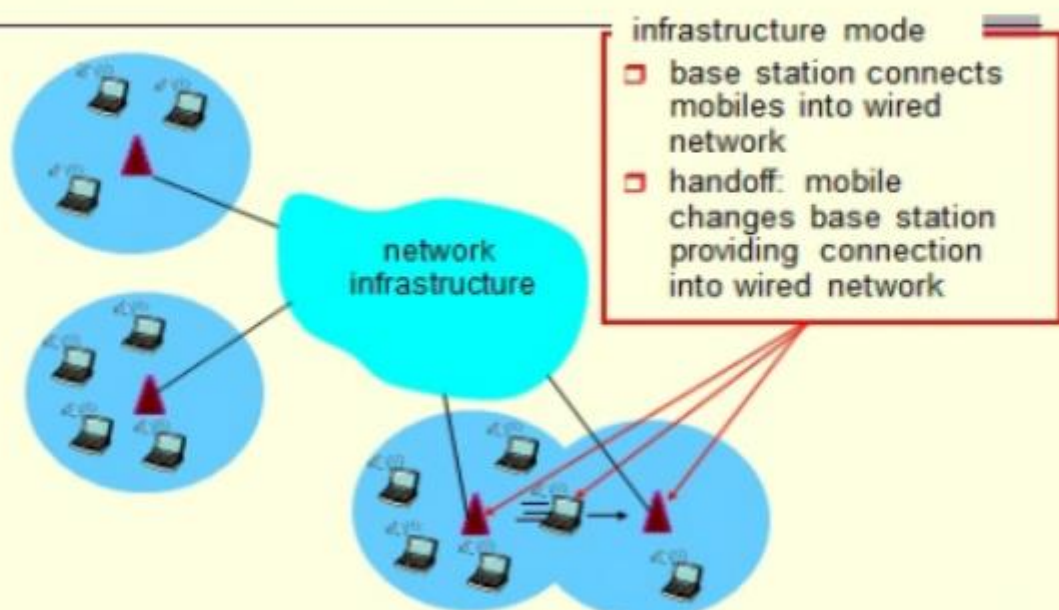
Characteristics of selected wireless link standards



6: Wireless and Mobile Networks

6-27

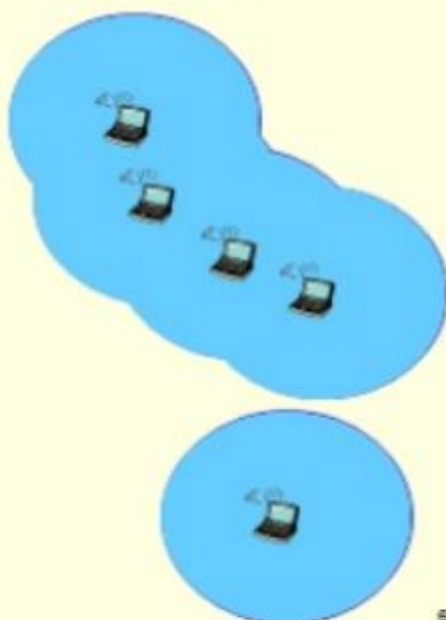
Elements of a wireless network



6: Wireless and Mobile Networks

6-28

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: <i>mesh net</i>
no infrastructure	no base station, no connection to larger Internet (Bluetooth, ad hoc nets)	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

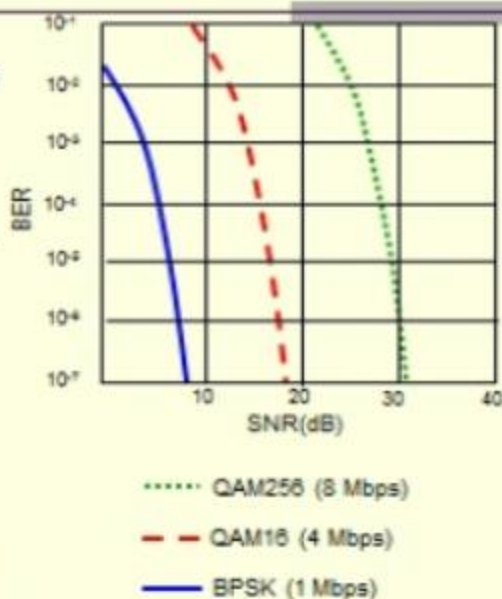
- **decreased signal strength:** radio signal attenuates as it propagates through matter (path loss)
- **interference from other sources:** standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone); devices (motors) interfere as well
- **multipath propagation:**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

6-21

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 \rightarrow increase SNR \rightarrow 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)



6: Wireless and Mobile Networks

6-22

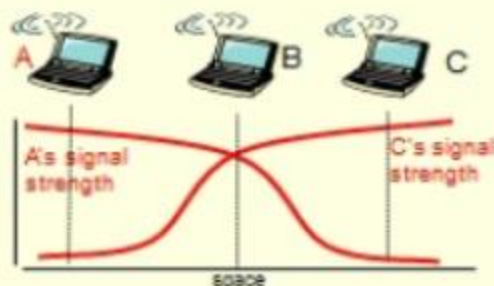
Wireless network characteristics

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



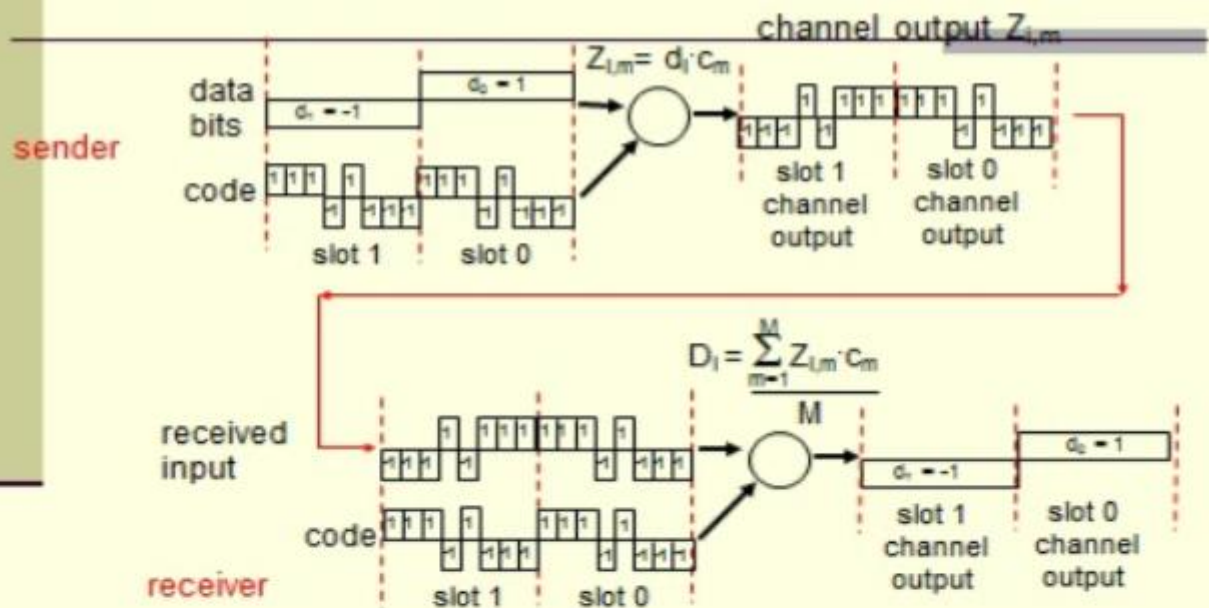
Signal attenuation:

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

Code Division Multiple Access (CDMA)

- 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



Thanks- Questions !