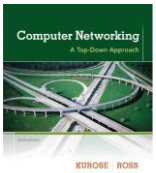
# Chapter 6
# Wireless and Mobile Networks




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

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Thanks and enjoy! JFK/KWR



The course notes are adapted for Bucknell's CSCI 363
Xiannong Meng
Spring 2016



# Ch. 6: Wireless and Mobile Networks

*Background:*

- Number of wireless (mobile) phone subscribers now exceeds number wired phone subscribers (5-to-1)!
  - World has about 6 billion cell phone subscribers (2011 statistics) (http://www.huffingtonpost.com/2012/10/11/cell-phones-world-subscribers-six-billion_n_1957173.html)
  - China has about 1.2 billion mobile phones (2014), India 1.1 billions (2016), U.S. 327 millions (2014) (http://en.wikipedia.org/wiki/List_of_countries_by_number_of_mobile_phones_in_use)
- Though not all are digital/network ready, they potentially will be.



# Ch. 6: Wireless and Mobile Networks

*Background:*

- # wireless 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



# Chapter 6 outline

6.1 Introduction

Wireless
6.2 Wireless links, characteristics
- CDMA

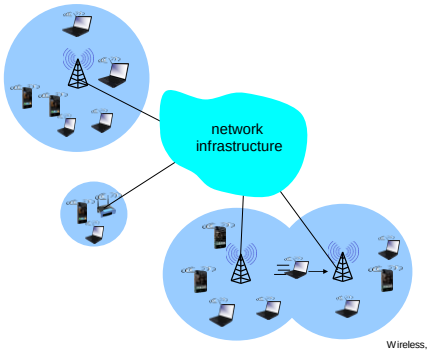
6.3 IEEE 802.11 wireless LANs ("Wi-Fi")
6.4 Cellular Internet Access
- architecture
- standards (e.g., GSM, 4G LTE)

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



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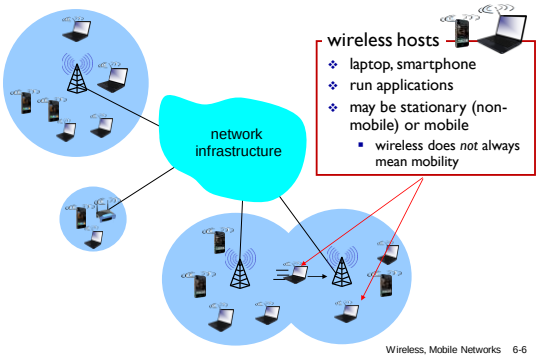

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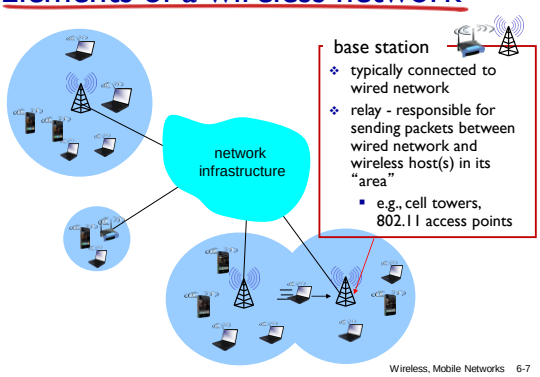




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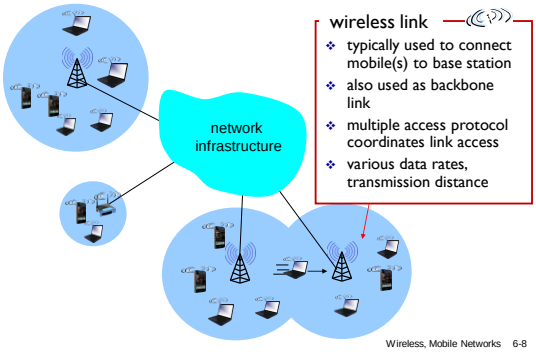
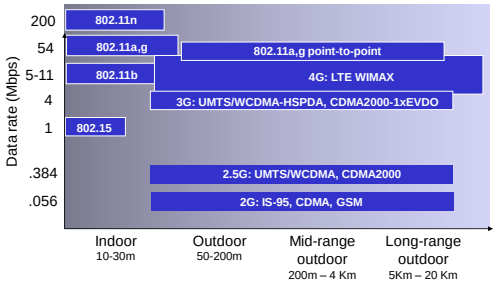





## Characteristics of selected wireless links



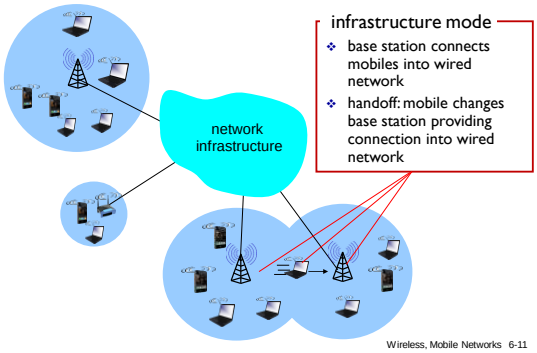



## Acronym in wireless communication

- 4G LTE: 4th Generation Long Term Evolution
- UMTS: Universal Mobile Telecommunications System
- HSPDA: High-Speed Downlink Packet Access
- EVDO: Enhanced Voice-Data Optimized
- GSM: Global System for Mobile Communications



## Elements of a wireless network



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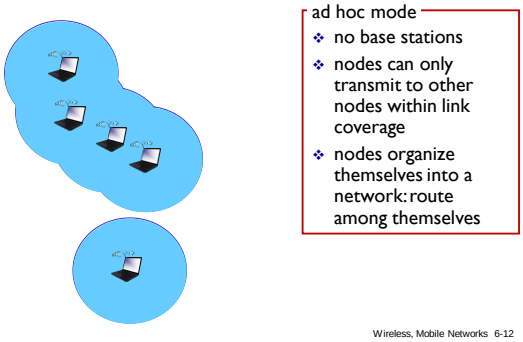

# Wireless network taxonomy

| | 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, ad hoc nets) | no base station, no connection to larger Internet. May have to relay to reach other a given wireless node MANET, VANET |



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# Wireless Link Characteristics (1)

*important* differences from wired link ….

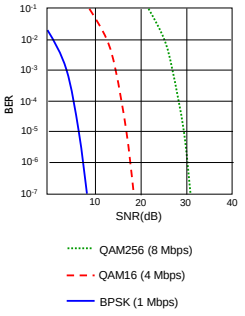
- *decreased signal strength:* radio signal attenuates as it propagates through matter (path loss)
- *interference from other sources:* standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone); devices (motors) interfere as well
- *multipath propagation:* radio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

…. make communication across (even a point to point) wireless link much more "difficult"



# Wireless Link Characteristics (2)

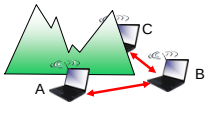
- SNR: signal-to-noise ratio
  - larger SNR – easier to extract signal from noise (a "good thing")
- *SNR versus BER tradeoffs*
  - *given physical layer:* increase power -> increase SNR->decrease BER
  - *given SNR:* choose physical layer that meets BER requirement, giving highest thruput
    - SNR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



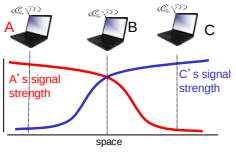



# Wireless network characteristics

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



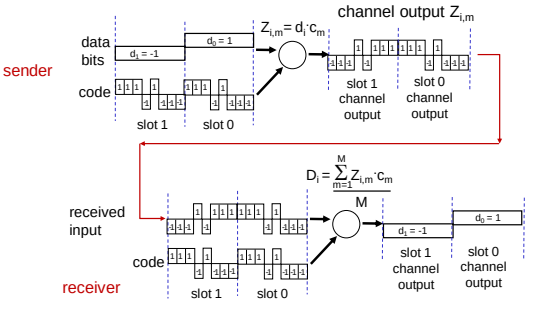

*Signal attenuation:*
- B, A hear each other
- B, C hear each other
- A, C can not hear each other interfering at B



# Code Division Multiple Access (CDMA)

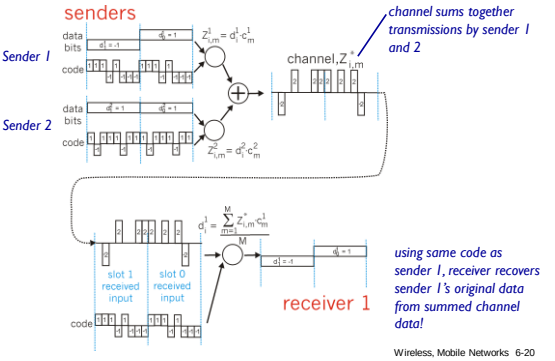
- unique "code" assigned to each user; i.e., code set partitioning
  - all users share same frequency, but each user has own "chipping" sequence (i.e., code) to encode data
  - allows multiple users to "coexist" and transmit simultaneously with minimal interference (if codes are "orthogonal")
- *encoded signal* = (original data) • (chipping sequence)
- *decoding:* (encoded signal) • (chipping sequence)
  - Note: operator • means inner product

# CDMA encode/decode






# CDMA: two-sender interference






# Exercises

- Compute and make sure you understand that the chipping codes used in the example are orthogonal [1,1,1,-1,1,-1,-1,-1], [1,-1,1,1,1,-1,1,1]
- What are the data bits 1 and -1 sent if the chipping code is [1,-1,1,-1,1,-1,1,-1]?
- Can you recover the same data bits using the given chipping code?