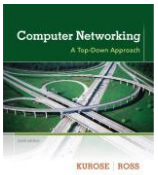
Chapter 6
Wireless and Mobile Networks



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

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

WiFi: name and history

- WiFi: any wireless network that runs IEEE 802.11 family protocol (CSMA/CA, details coming)
- Developed mid-1980s to early 1990s
- NCR and AT&T developed an early protocol (WaveLAN) for their cashier register products
- WiFi Alliance is the organization that oversees the name, protocols, and products under WiFi
- WiFi Alliance was evolved from Wireless Ethernet Compatibility Alliance, whose members include 3Com, Aironet (now Cisco), Harris Semiconductor (now Intersil), Lucent (now Alcatel-Lucent), Symbol Technologies (now Motorola), and Nokia.

Electromagnetic spectrum

- The wave length and frequency determines the characteristics of the wave,
  - E.g., 20 Hz to 20 K Hz frequency (17 m to 17 mm wave length) are audible to humans, 430 T Hz to 770 T Hz frequency (770 to 390 nm wave length) are visible to humans
- https://en.wikipedia.org/wiki/Electromagnetic_spectrum
- Relation between frequency and wavelength is f * v = c, where c is the speed of light
  - http://hubblesite.org/reference_desk/faq/answer.php.id=72&cat=light

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

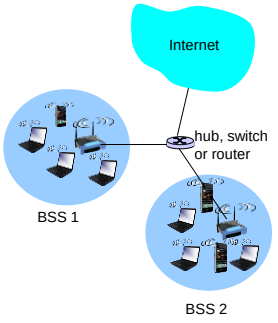
802.11a
- 5-6 GHz range
- up to 54 Mbps

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

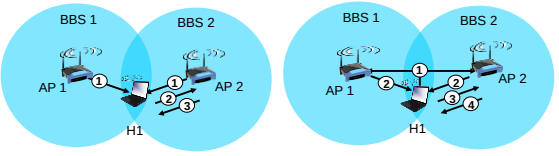


- wireless host communicates with base station
  - base station = access point (AP)
- Basic Service Set (BSS) (aka "cell") in infrastructure mode contains:
  - wireless hosts
  - access point (AP): base station
  - ad hoc mode: hosts only

802.11: Channels, association

- 802.11b: 2.4GHz-2.485GHz spectrum 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, Service Set IDentifier) 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

802.11: passive/active scanning

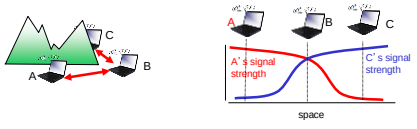


passive scanning:
(1) beacon frames sent from APs
(2) association Request frame sent: H1 to selected AP
(3) association Response frame sent from selected AP to H1

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

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/CA (collision avoidance)



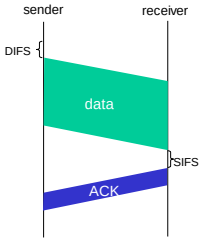
IEEE 802.11 MAC Protocol: CSMA/CA

802.11 sender

1 if sense channel idle for **DIFS(distributed inter-frame space)** 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(short inter-frame space)** (ACK needed due to hidden terminal problem)



The complete sender protocol

- When a station has a frame to transmit:
  1. If initially the state senses the channel idle, it transmits its frame after a short period of time known as *Distributed Inter-frame Space* (DIFS).
  2. Otherwise (sensing other transmission is on-going) the station chooses a random backoff value using binary exponential backoff and counts down this value when the channel is sensed idle. While the channel is sensed busy, the counter value remains frozen.
  3. When the counter reaches zero, the station transmits the entire frame and then waits for an acknowledgment.
  4. If an ack is received, the transmitting station knows that its frame has been received correctly. Continue Step 2 if more frames to send. If no ack is received, Continue Step 2 to resend the previous frame.

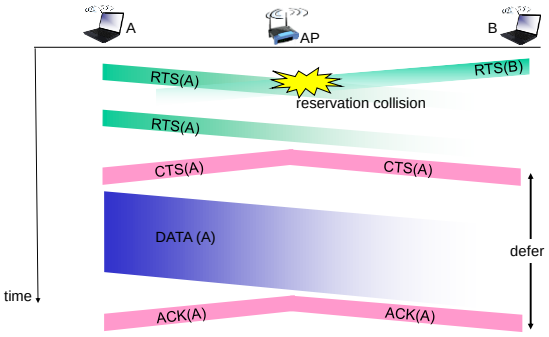
Collision avoidance mechanism

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

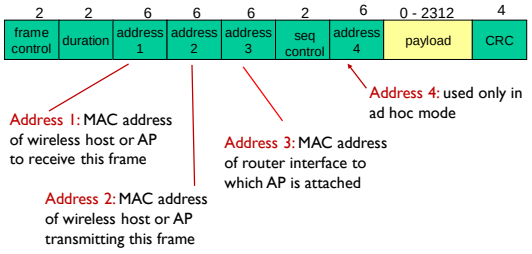
- sender first transmits *small* request-to-send (RTS) packets to base station (BS) using CSMA
  - RTSs may still collide with each other (but they're short)
- BS broadcasts clear-to-send CTS in response to RTS
- CTS heard by all nodes
  - sender transmits data frame
  - other stations defer transmissions

avoid data frame collisions completely using small reservation packets!

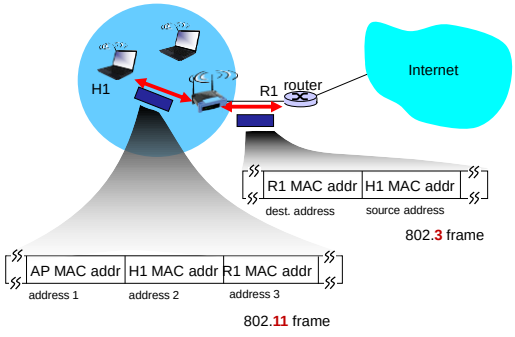
Collision Avoidance: RTS-CTS exchange



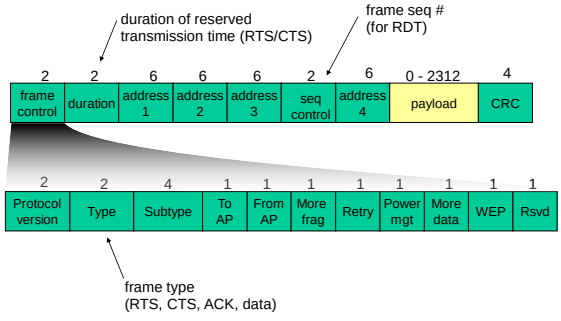
802.11 frame: addressing



802.11 frame: addressing

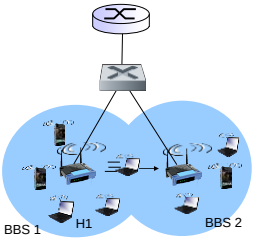


802.11 frame: more



802.11: mobility within same subnet

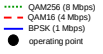
- H1 remains in same IP subnet: IP address can remain same
- switch: which AP is associated with H1?
  - self-learning (Ch. 5): switch will see frame from H1 and "remember" which switch port can be used to reach H1

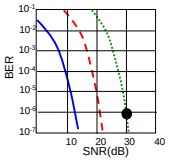


802.11: advanced capabilities

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

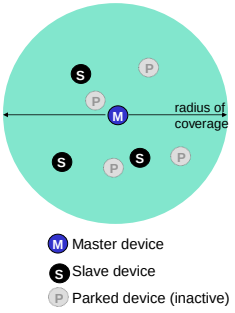
802.11: advanced capabilities

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



PAN: Bluetooth and Zigbee

- Bluetooth:
  - Operating up to 4 M bps
  - Small area (a few meters)
  - Small number of devices (up to eight)
  - Master/slave mode: the master node can transmit every odd-numbered time slot, and the slave node can transmit only when polled by the master
- Zigbee:
  - Low power, low duty cycle, low cost devices
  - Channel rates 20, 40, 100, and 250 K bps
  - Work with devices such as temperature sensors, security devices, and other wall-mounted devices