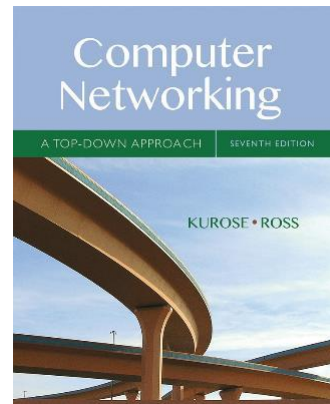


Chapter 7 Wireless and Mobile Networks

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Computer Networking: A Top Down Approach

7th edition

Jim Kurose, Keith Ross

Pearson/Addison Wesley

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Wireless and Mobile Networks 7-1

Ch. 6: Wireless and Mobile Networks

Background:

- # wireless (mobile) phone subscribers now exceeds # wired phone subscribers (5-to-1)!
- # wireless Internet-connected devices equals # 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

Wireless and Mobile Networks 7-2

Chapter 7 outline

7.1 Introduction

Wireless

7.2 Wireless links, characteristics

- CDMA

6.73 IEEE 802.11 wireless LANs (“Wi-Fi”)

6.74 Cellular Internet Access

- architecture
- standards (e.g., 3G, LTE)

Mobility

7.5 Principles: addressing and routing to mobile users

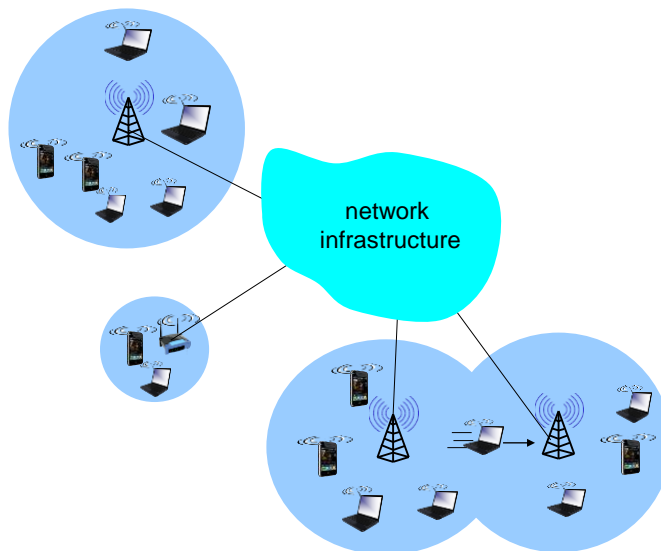
7.6 Mobile IP

7.7 Handling mobility in cellular networks

7.8 Mobility and higher-layer protocols

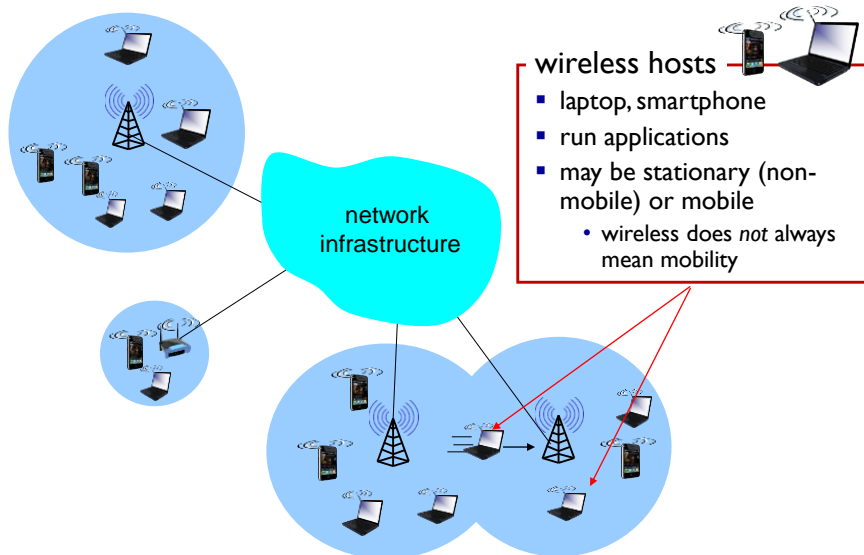
Wireless and Mobile Networks 7-3

Elements of a wireless network



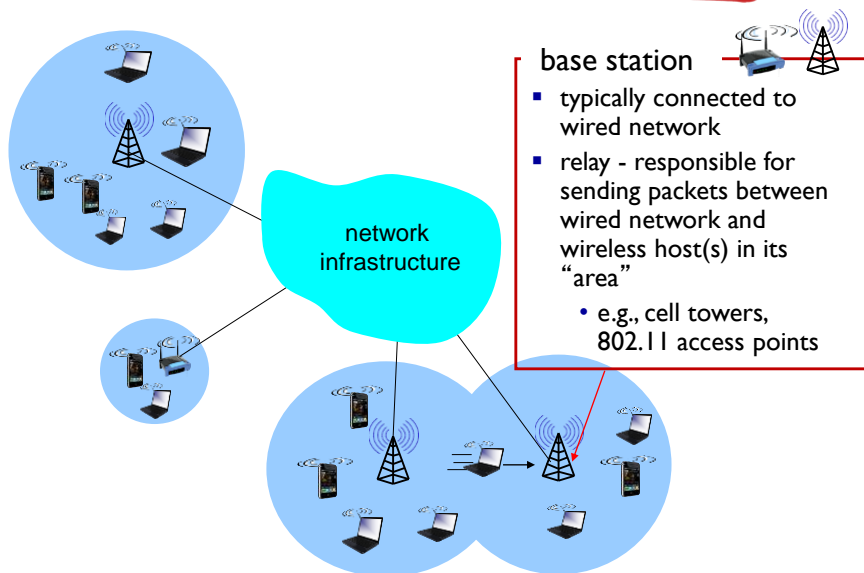
Wireless and Mobile Networks 7-4

Elements of a wireless network



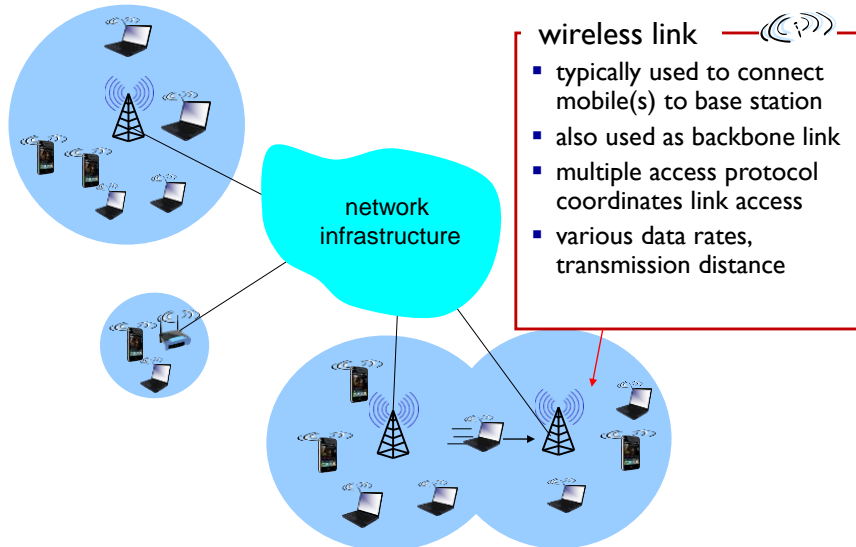
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Elements of a wireless network



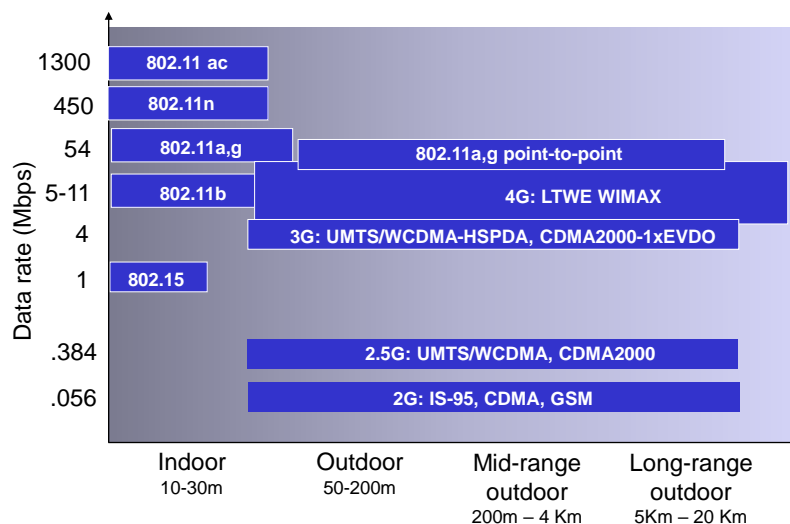
Wireless and Mobile Networks 7-6

Elements of a wireless network



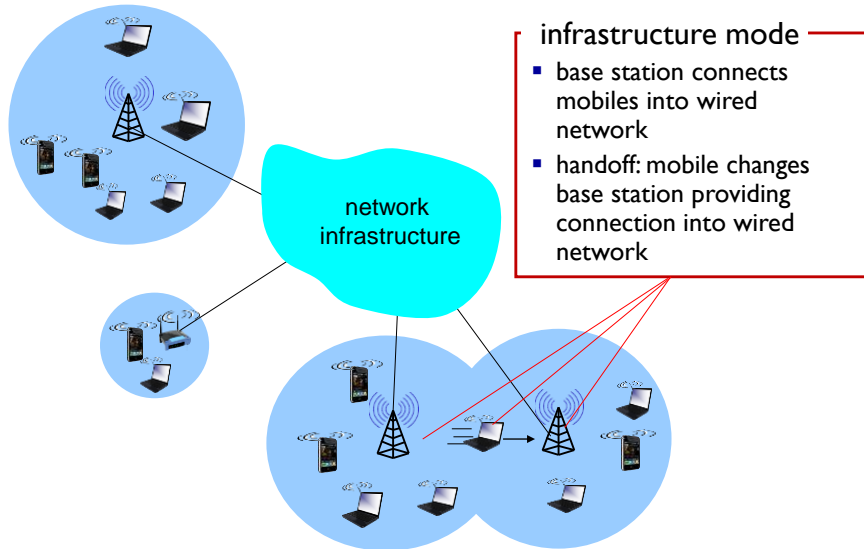
Wireless and Mobile Networks 7-7

Characteristics of selected wireless links



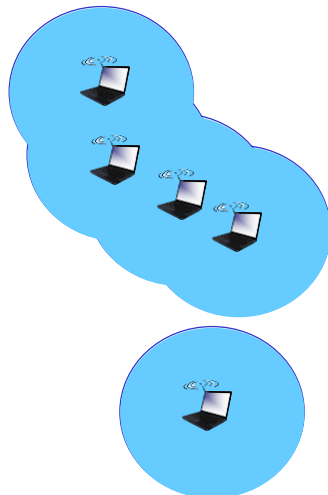
Wireless and Mobile Networks 7-8

Elements of a wireless network



Wireless and Mobile Networks 7-9

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 and Mobile Networks 7-10

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 and Mobile Networks 7-11

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Wireless and Mobile Networks 7-12

Wireless Link Characteristics (I)

important differences from wired link

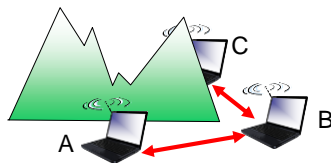
- *decreased signal strength*: radio signal attenuates as it propagates through matter (path loss)
- *interference from other sources*: standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone); devices (motors) interfere as well
- *multipath propagation*: radio 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 and Mobile Networks 7-13

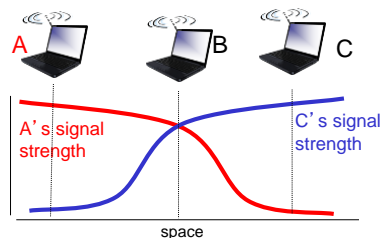
Wireless network characteristics

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

Wireless and Mobile Networks 7-15

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Wireless and Mobile Networks 7-19

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

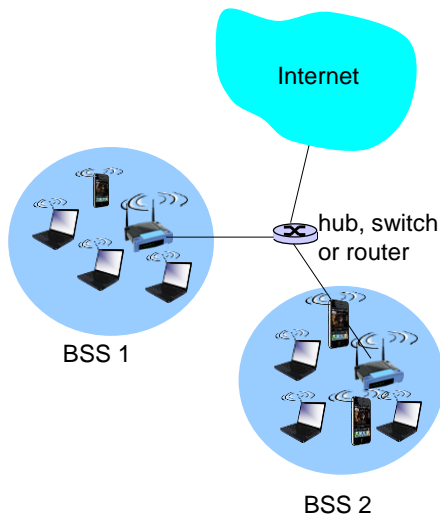
802.11n: multiple antennae

- 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

Wireless and Mobile Networks 7-20

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

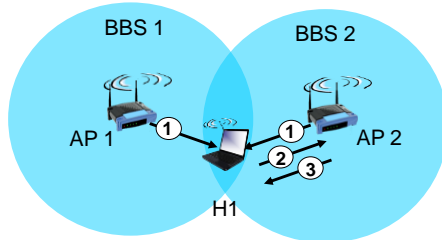
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802.11: Channels, association

- 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 [Chapter 8]
 - will typically run DHCP to get IP address in AP's subnet

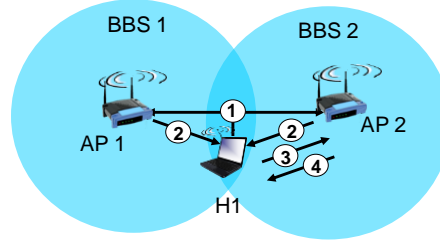
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802.11: passive/active scanning



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



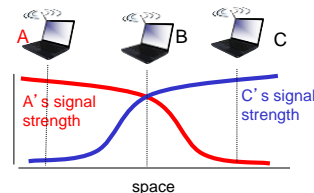
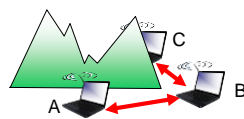
active scanning:

- (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

Wireless and Mobile Networks 7-23

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(avoidance)



Wireless and Mobile Networks 7-24

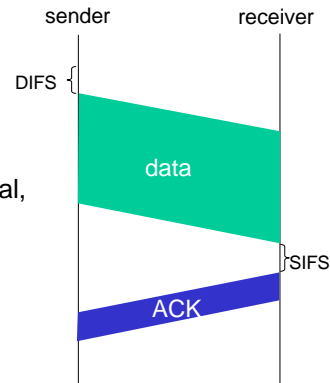
IEEE 802.11 MAC Protocol: CSMA/CA

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)



Wireless and Mobile Networks 7-25

Avoiding collisions (more)

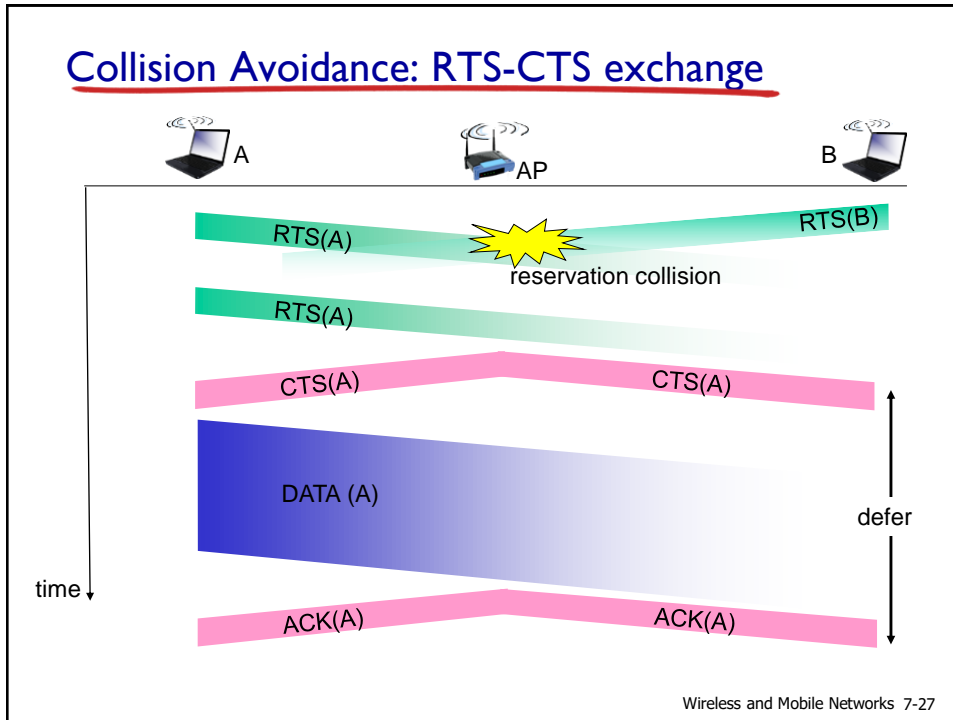
idea: allow sender to “reserve” channel rather than random access of data frames: avoid collisions of long data frames

- 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

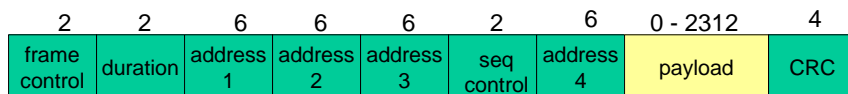
*avoid data frame collisions completely
using small reservation packets!*

Wireless and Mobile Networks 7-26

Collision Avoidance: RTS-CTS exchange



802.11 frame: addressing



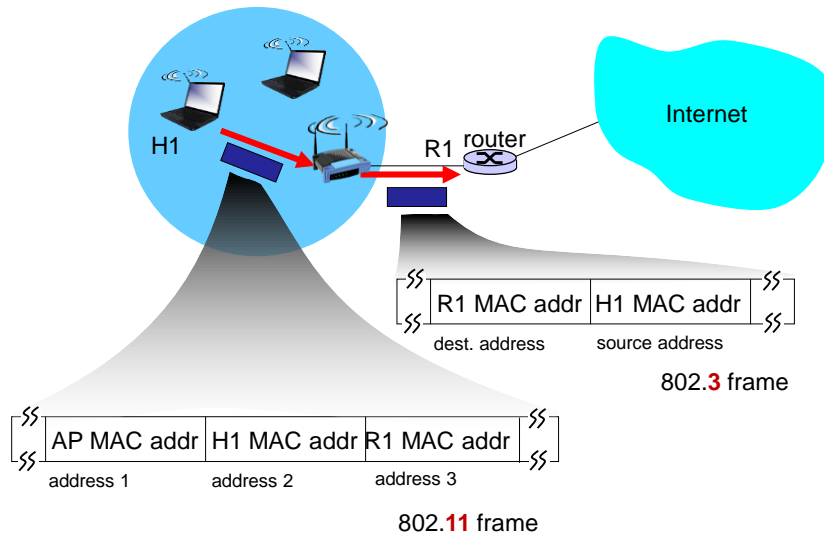
Address 1: MAC address of wireless host or AP to receive this frame

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

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

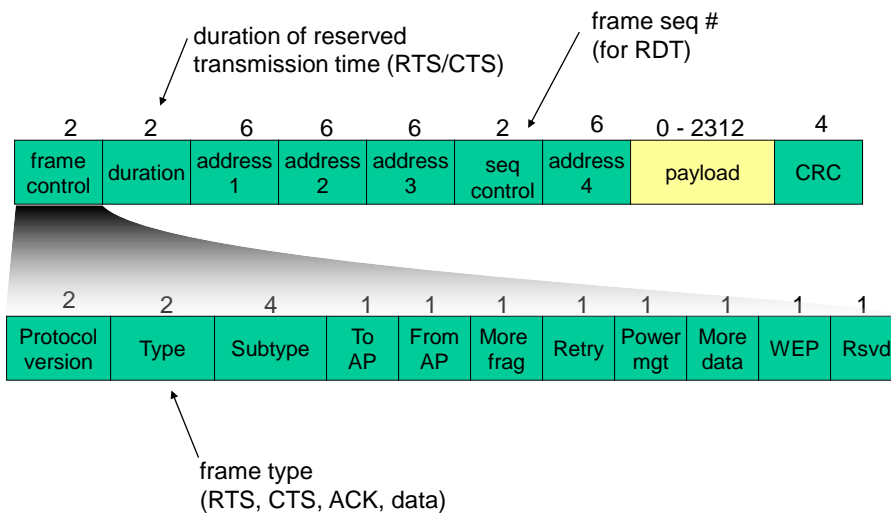
Address 4: used only in ad hoc mode

802.11 frame: addressing



Wireless and Mobile Networks 7-29

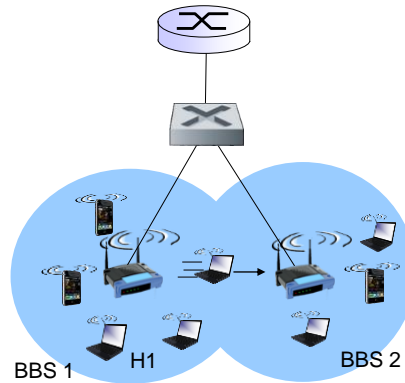
802.11 frame: more



Wireless and Mobile Networks 7-30

802.11: mobility within same subnet

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



Wireless and Mobile Networks 7-31

Chapter 7 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., 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, LTE
- impact on higher-layer protocols

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