



Shared Access Networks Wireless

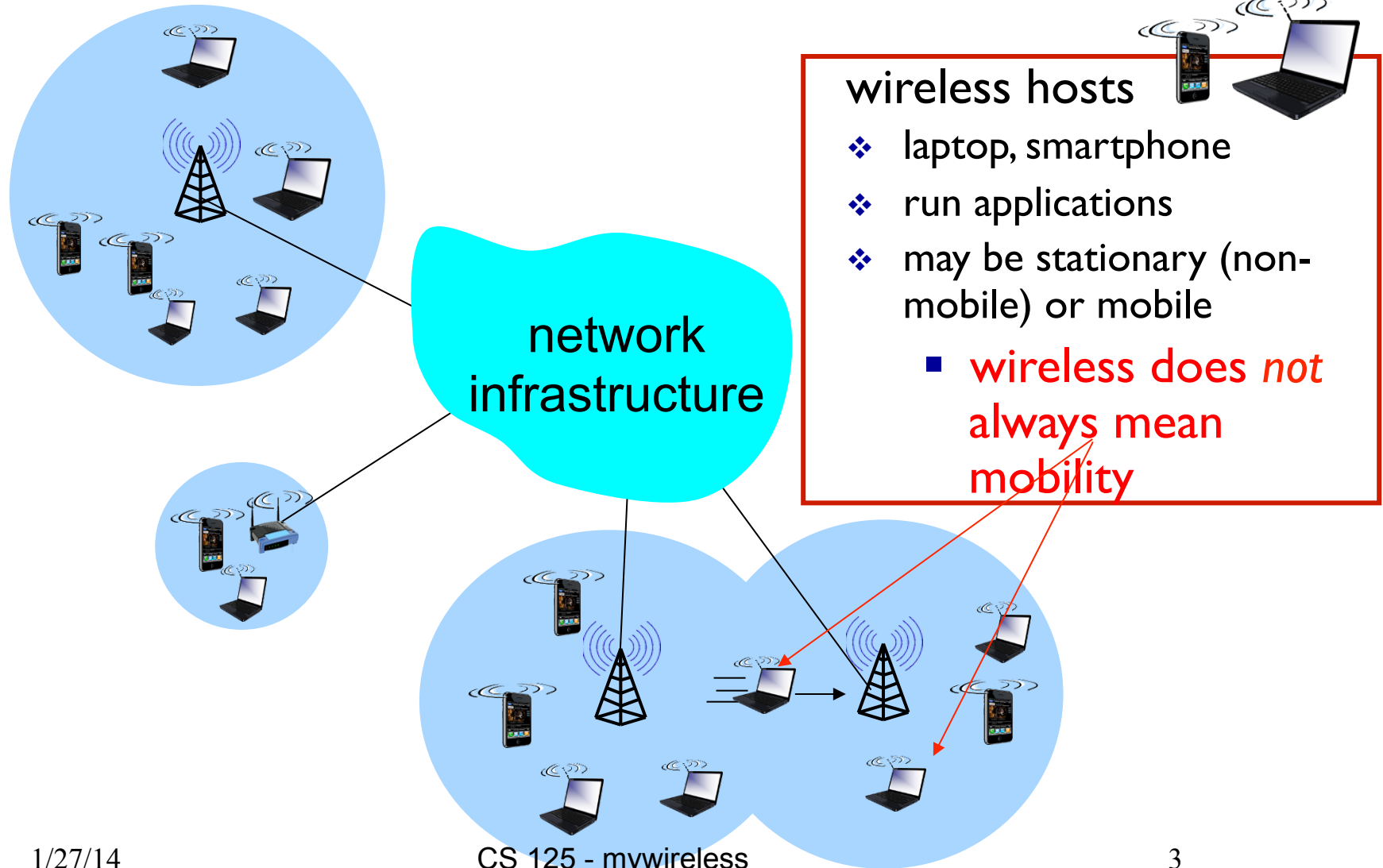
Wireless and Mobile Networks



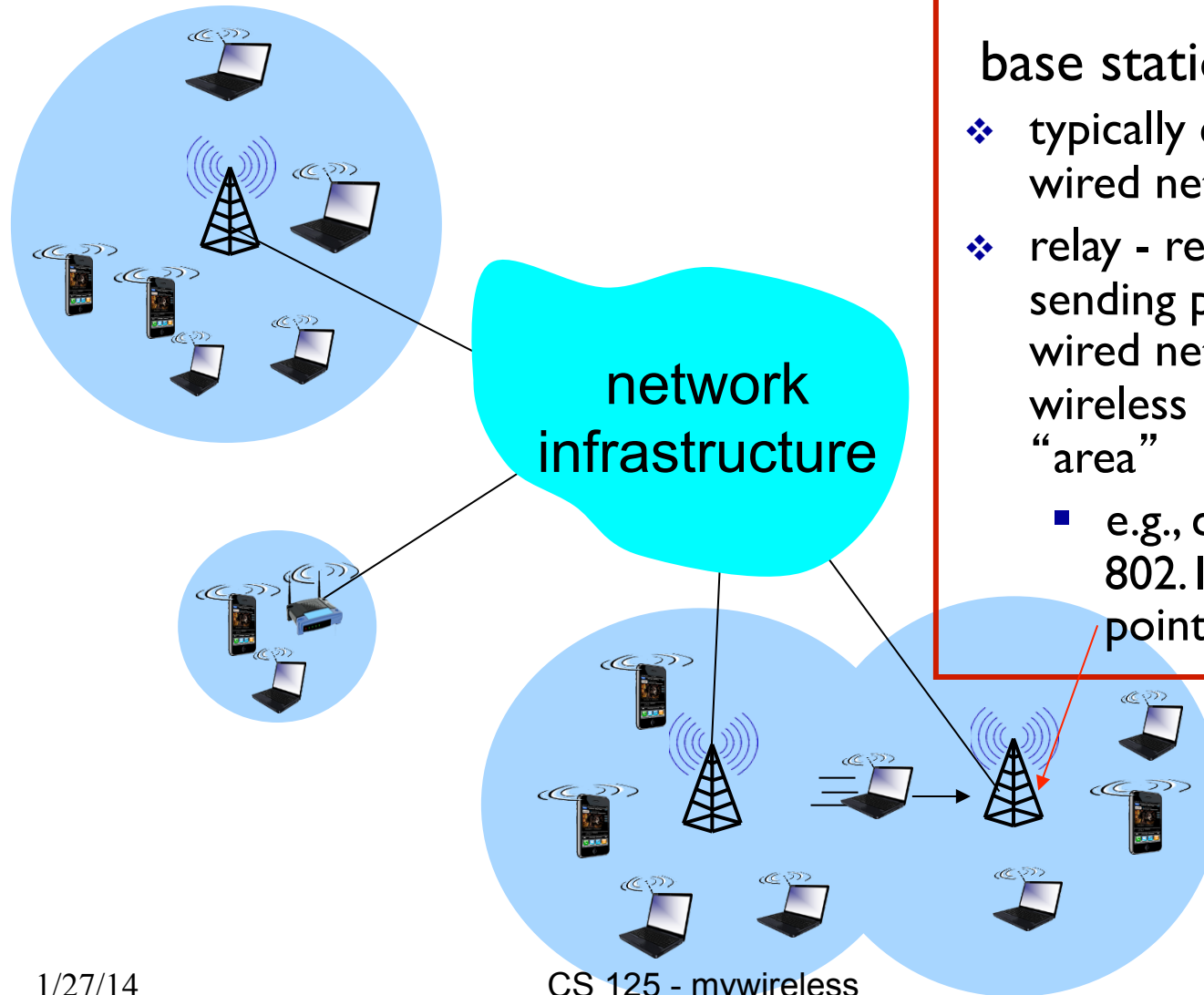
Background:


- # 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 - Now
 - *mobility*: handling the mobile user who changes point of attachment to network - Later

Elements of a wireless network



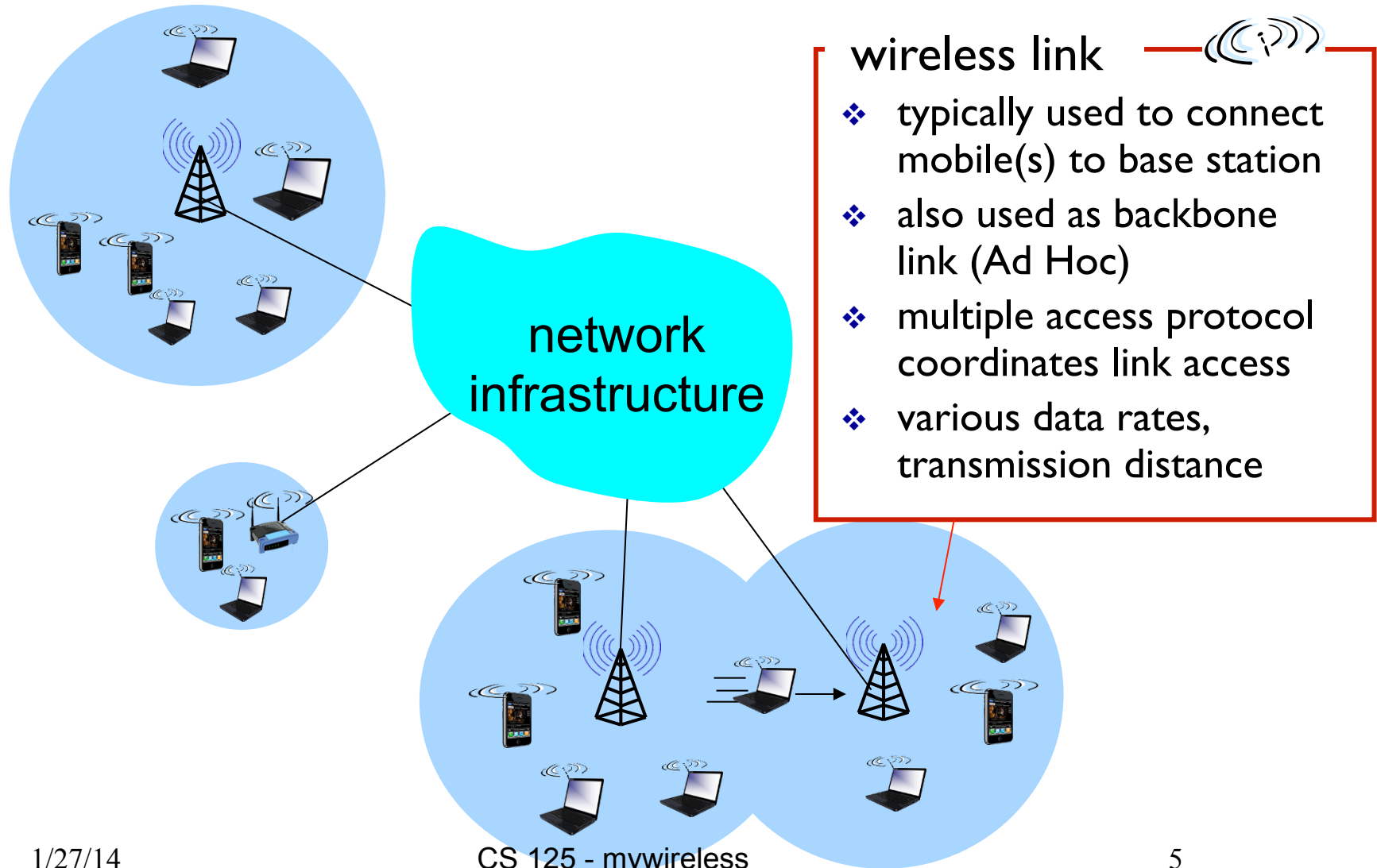
Elements of a wireless network



base station 

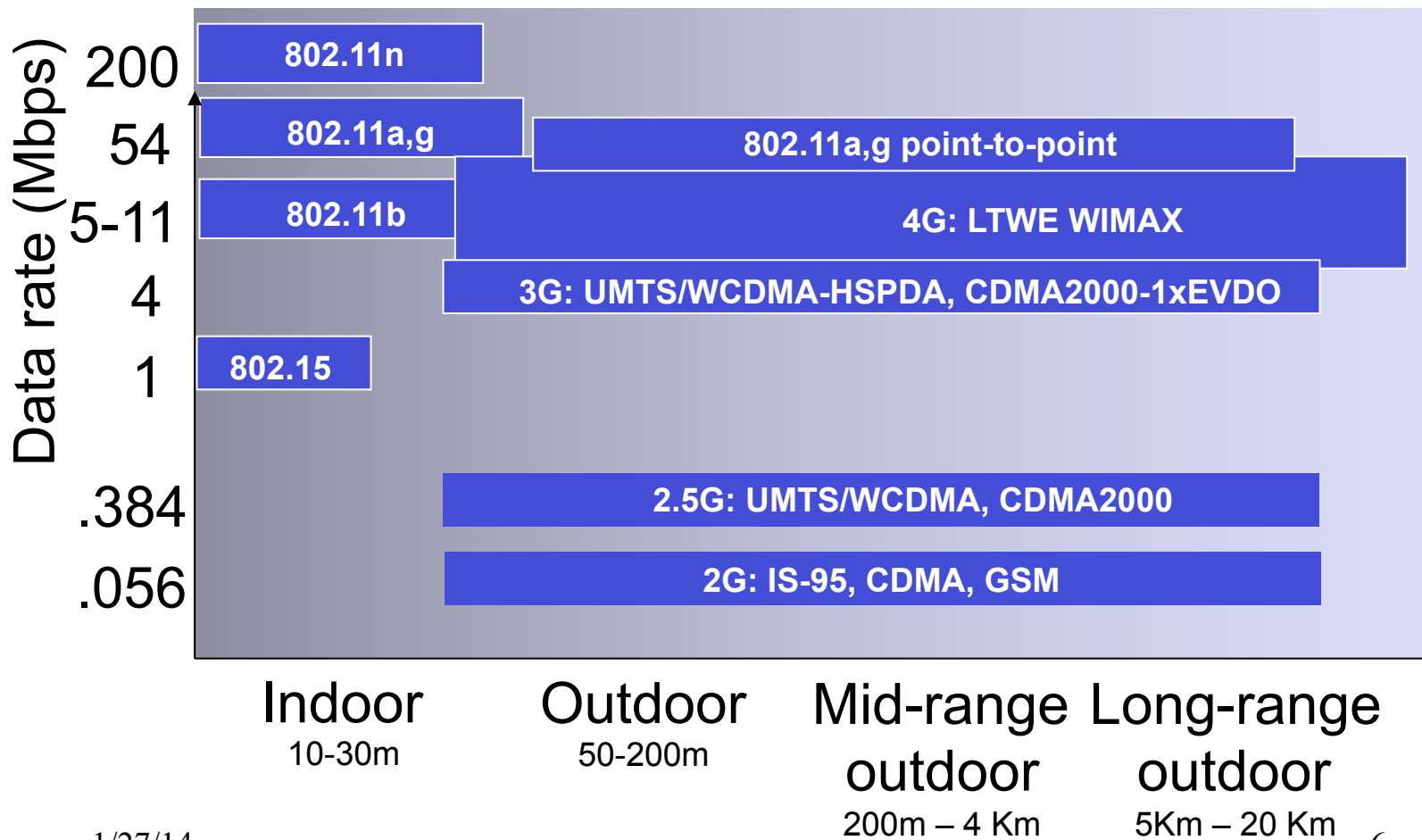
- ❖ typically connected to wired network
- ❖ relay - responsible for sending packets between wired network and wireless host(s) in its “area”
 - e.g., cell towers, 802.11 access points (AP)

Elements of a wireless network





Characteristics of selected wireless links





Wireless Link Characteristics (I)

important differences from wired link

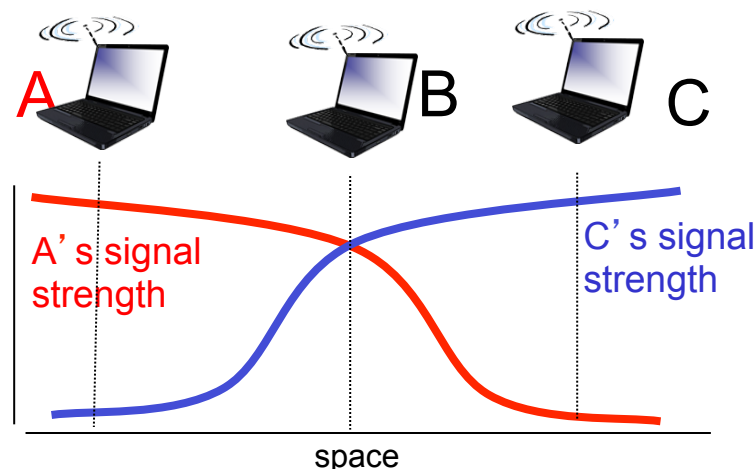
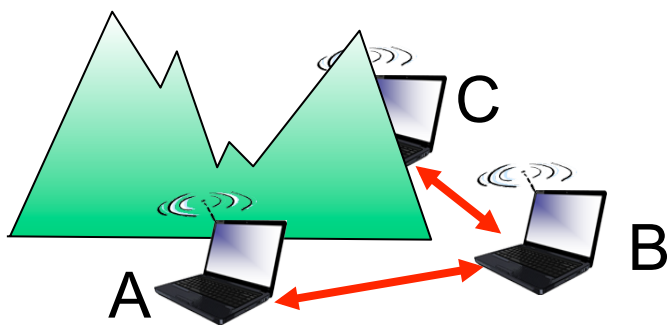
- *decreased signal strength*: radio signal attenuates as it propagates through matter (path loss)
- *interference from other sources*: standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone); devices (motors) interfere as well
- *multipath propagation*: radio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

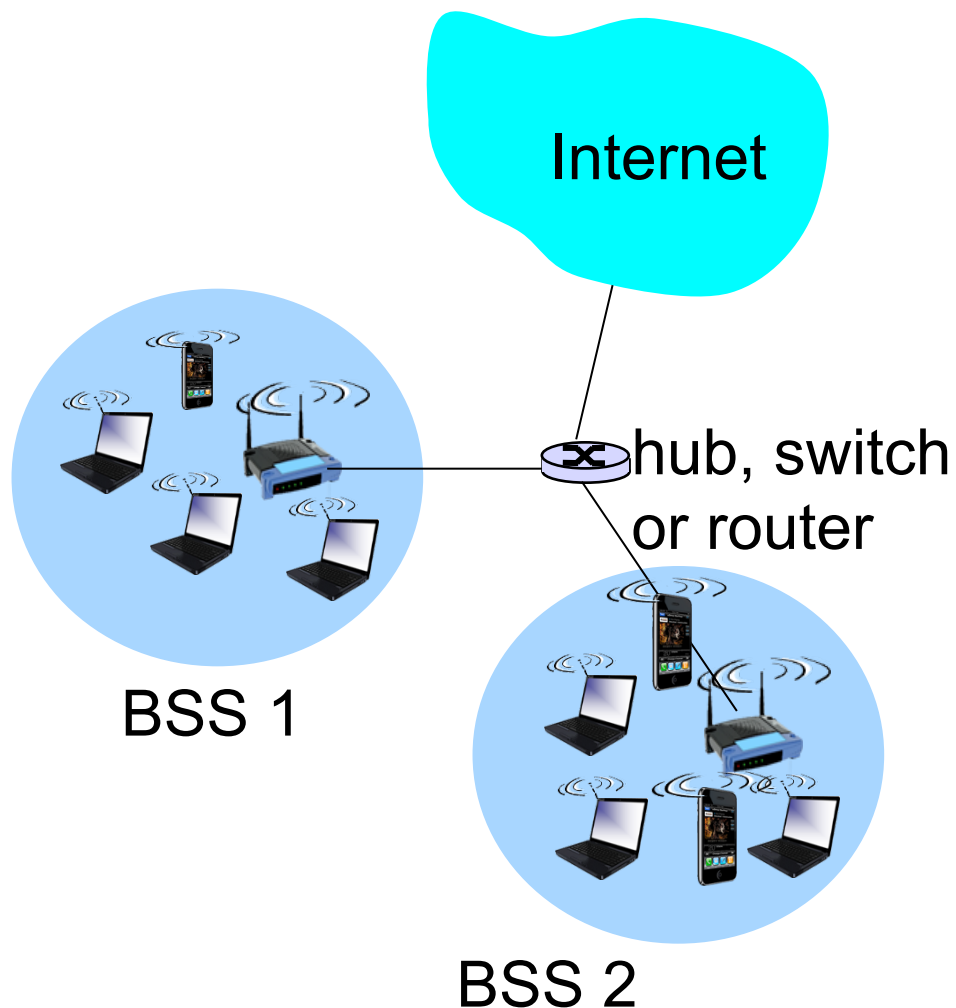
- ❖ B, A hear each other
- ❖ B, C hear each other
- ❖ A, C can not hear each other means A, C unaware of their interference at B

Signal attenuation problem???

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



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



Wireless LAN Technology

- Physical Media
 - spread spectrum radio (2.4GHz)
 - diffused infrared (10m)
- Access Challenge
 - Mediate access to shared medium that is not isolated (like a wire)
 - Channel Partitioning
 - Random Access - Ethernet
 - Taking Turns – Token Ring



IEEE 802.11 Wireless LAN Technology

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: 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

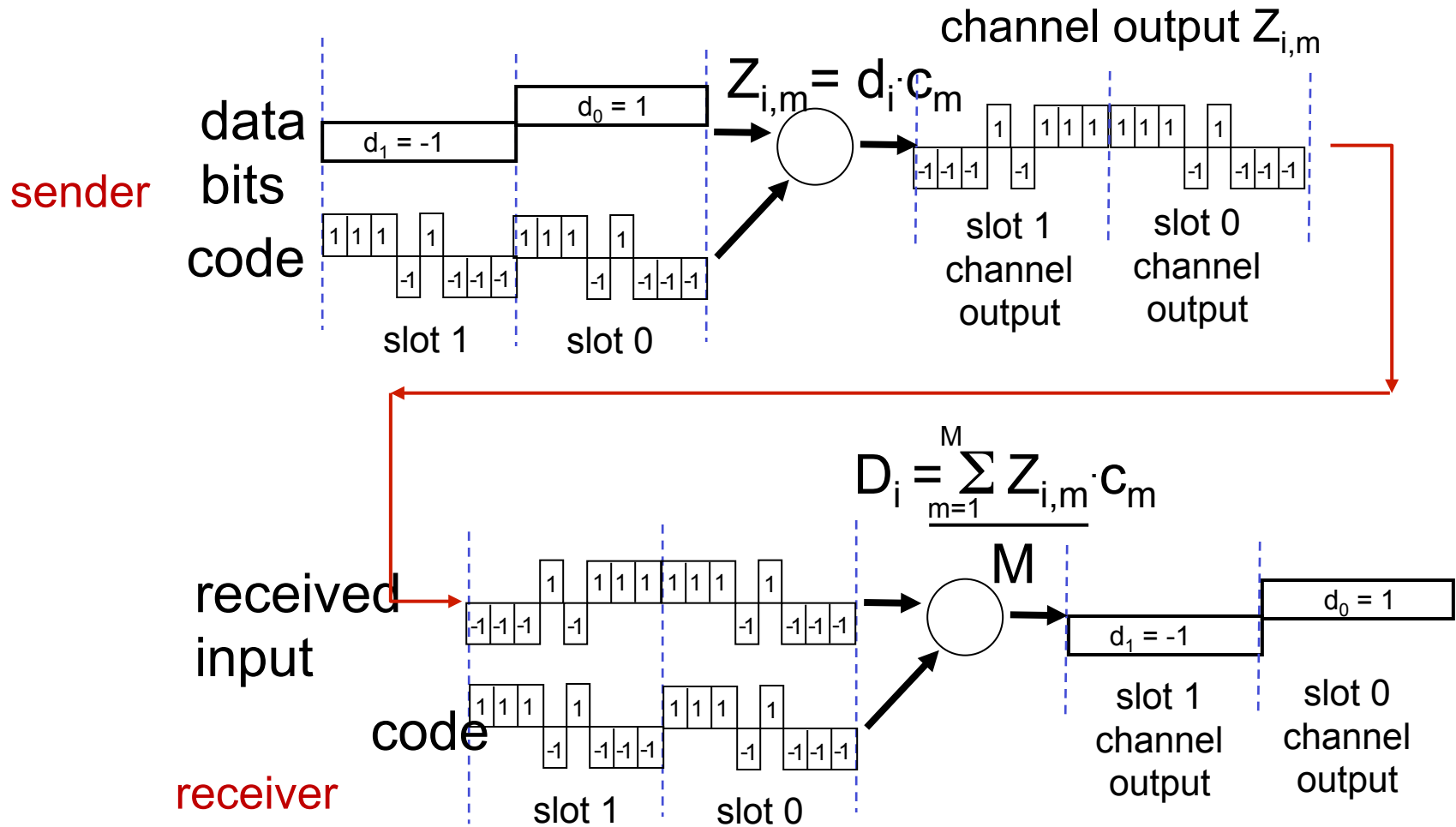
Code Division Multiple Access (CDMA)

channel partitioning



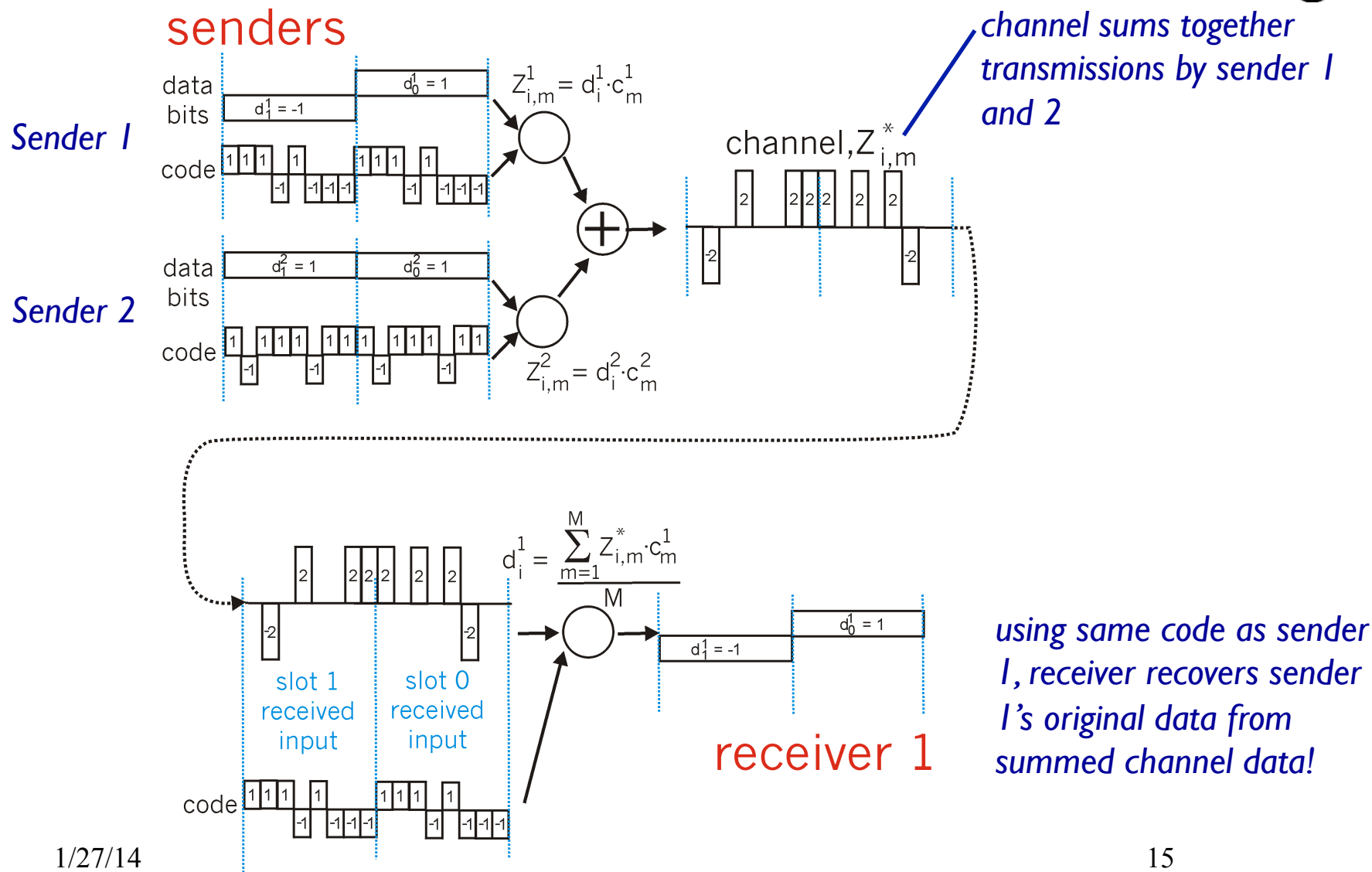
- unique “code” assigned to each user; i.e., code set partitioning
 - all users share same frequency, but each user has own “chipping” sequence (i.e., code) to encode data
 - allows multiple users to “coexist” and transmit simultaneously with minimal interference (if codes are “orthogonal”)
- *encoded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

CDMA encode/decode



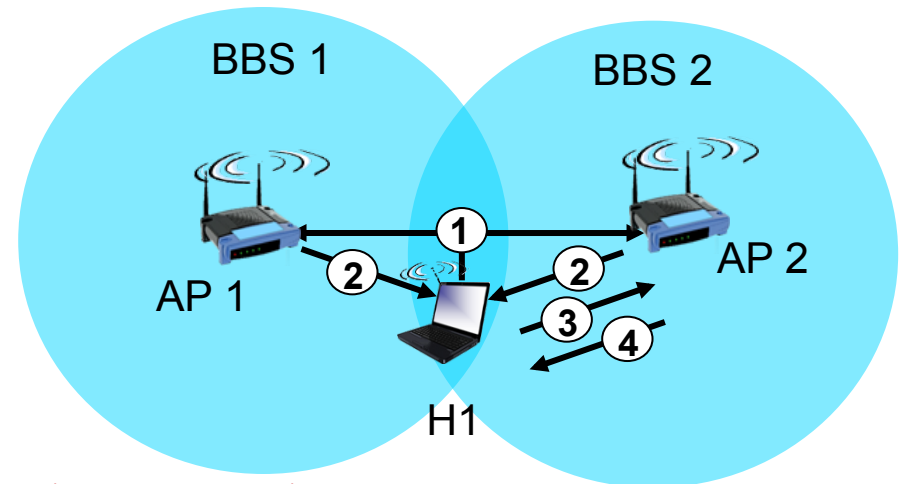
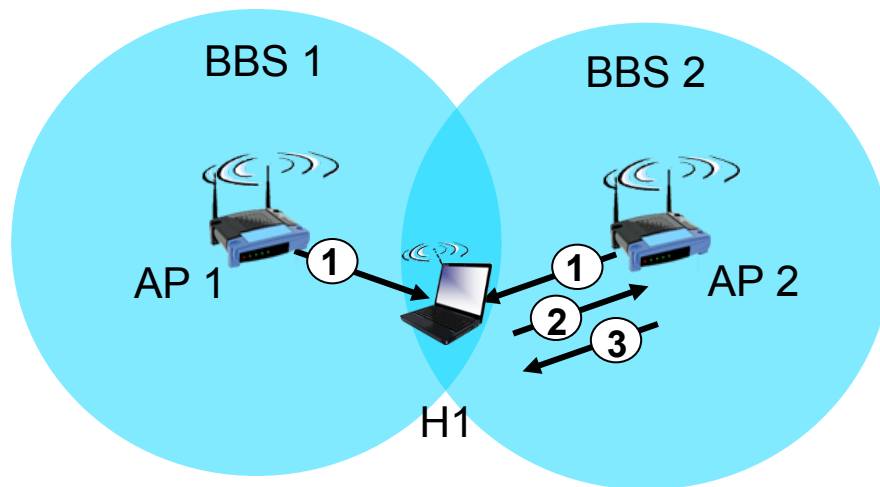


CDMA: two-sender interference



802.11: passive/active scanning

Finding an AP



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

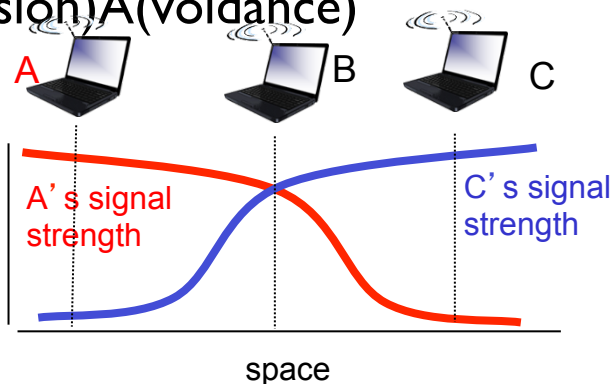
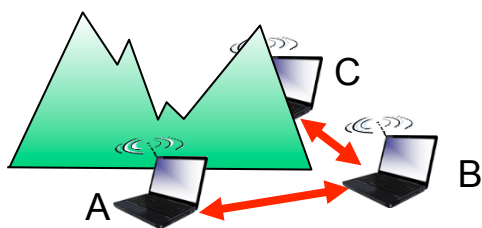
active scanning:

- (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

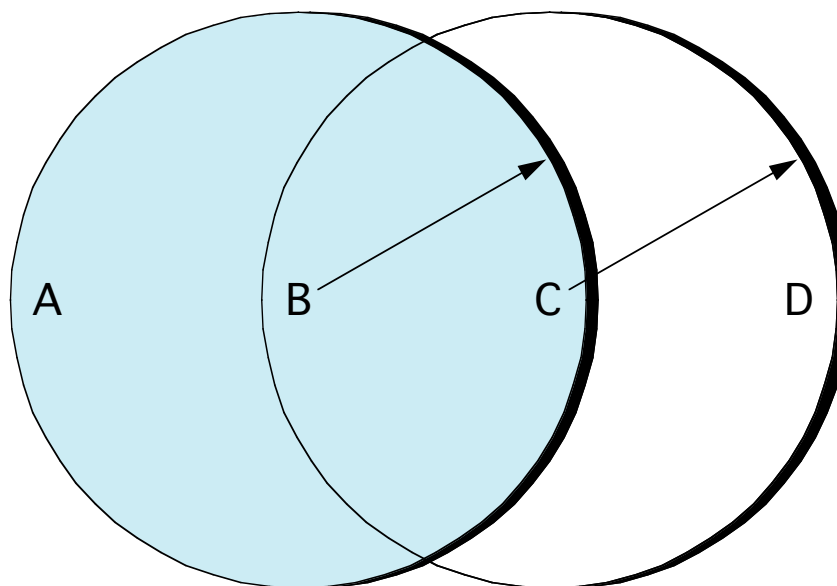
- avoid collisions: 2⁺ nodes transmitting at same time
- 802.11: CSMA - sense before transmitting
 - Carrier Sense Multiple Access
 - don't collide with ongoing transmission by other node
- 802.11: *no* collision detection!
 - difficult to receive (sense collisions) when transmitting due to weak received signals (fading)
 - can't sense all collisions in any case: hidden terminal, fading
 - goal: *avoid collisions*: CSMA/CA (Collision Avoidance)





Collision Avoidance

- Similar to Ethernet, but all nodes cannot see all nodes
- Problem: *hidden* and *exposed* nodes
- B sending to A, can C send to D? Yes





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!*



CSMA/CA

Multiple Access with Collision Avoidance

- Sender transmits **RequestToSend** (RTS) frame
- Receiver replies with **ClearToSend** (CTS) frame
- Neighbors...
 - see CTS: keep quiet
 - see RTS but not CTS: ok to transmit
 - Out of range of sender
- Receiver sends **ACK** when has frame
 - neighbors silent until see ACK
- Collisions
 - no collision detection
 - known when don't receive CTS
 - exponential backoff

IEEE 802.11 MAC Protocol: CSMA/CA

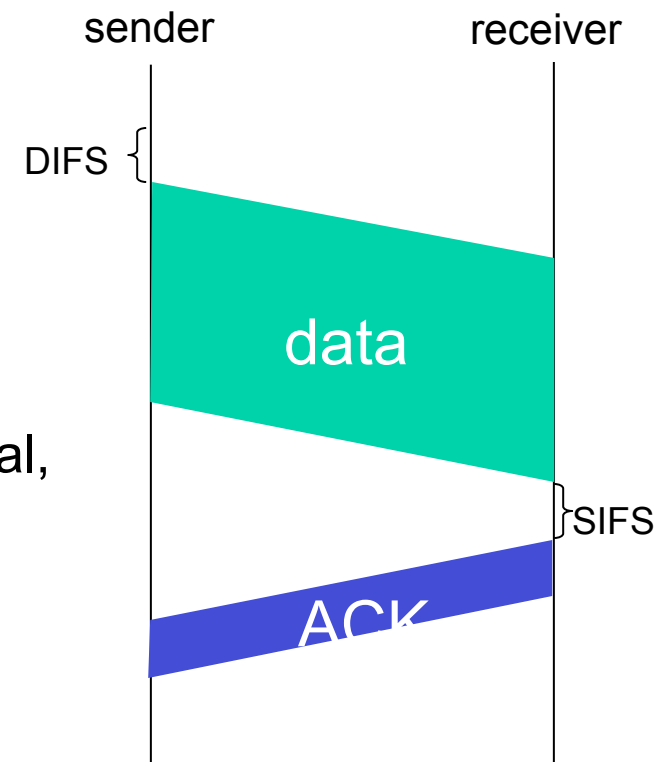


802.11 sender

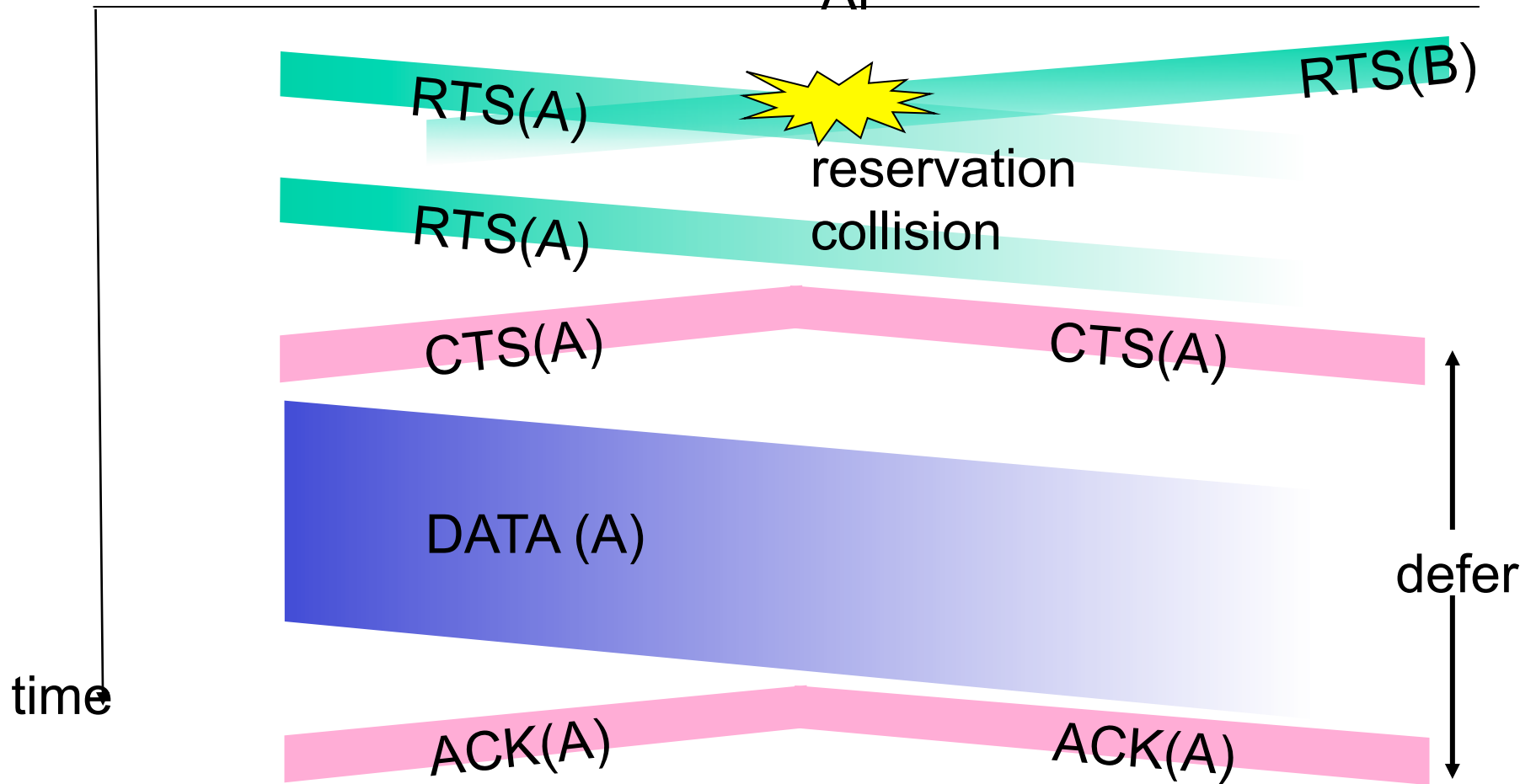
- 1 if sense channel idle for **DIFS** then transmit entire frame (no CD)
- 2 if sense channel busy then start random backoff time
timer counts down while channel idle
transmit when timer expires
if no ACK, increase random backoff interval, repeat 2

802.11 receiver

- if frame received OK
return ACK after **SIFS** (ACK needed due to hidden terminal problem)

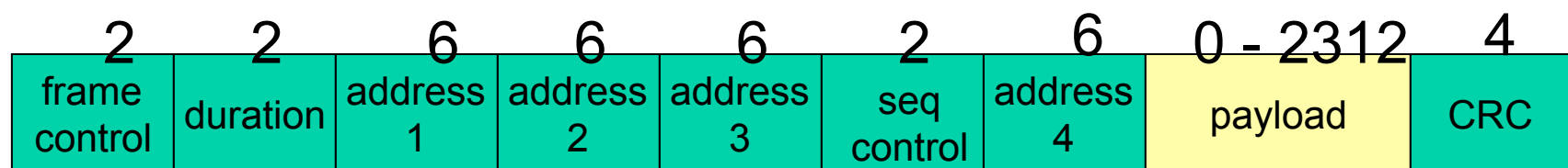


Collision Avoidance: RTS-CTS exchange





802.11 frame: addressing



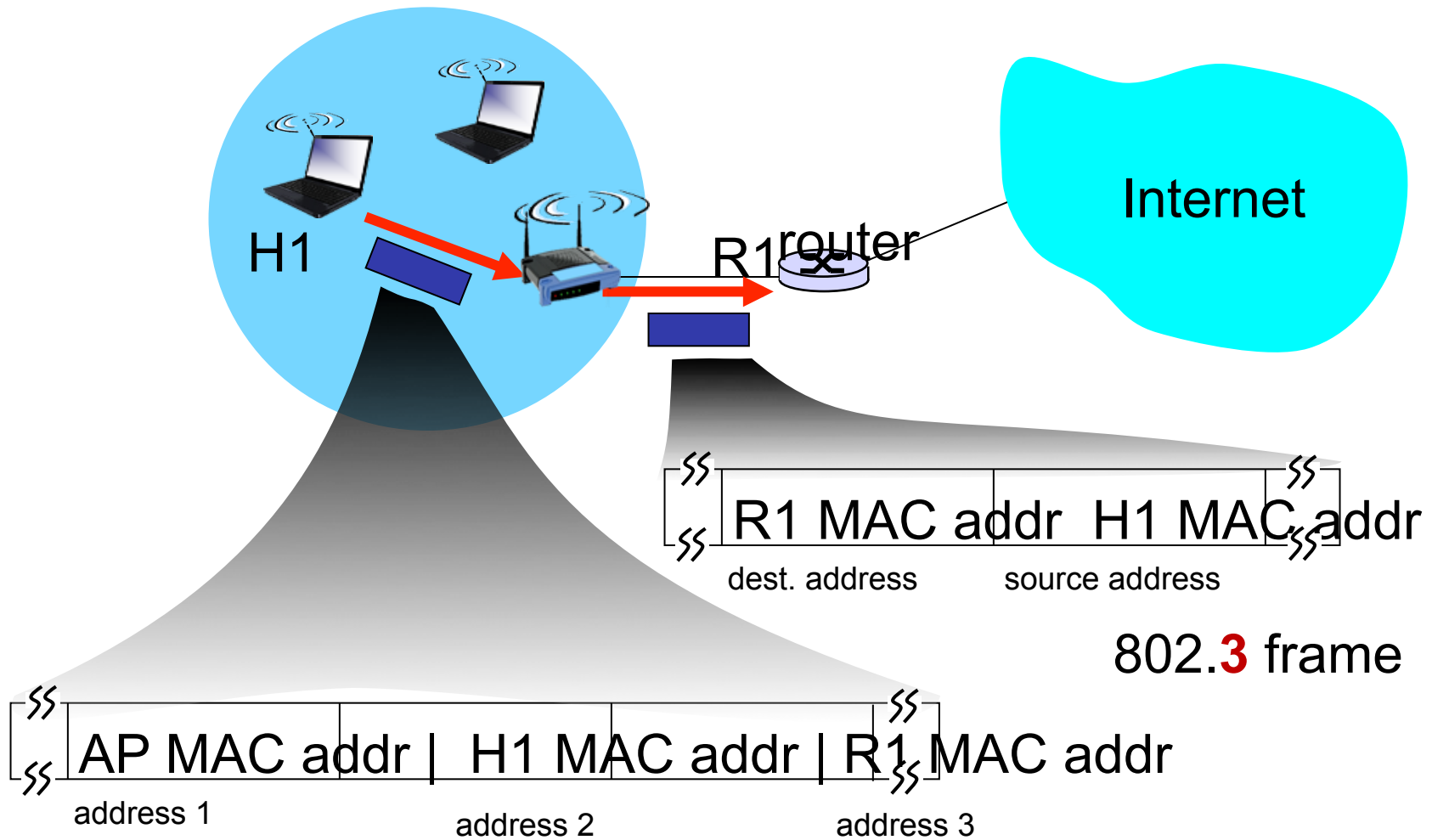
Address 1: MAC address of wireless host or AP to receive this frame

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

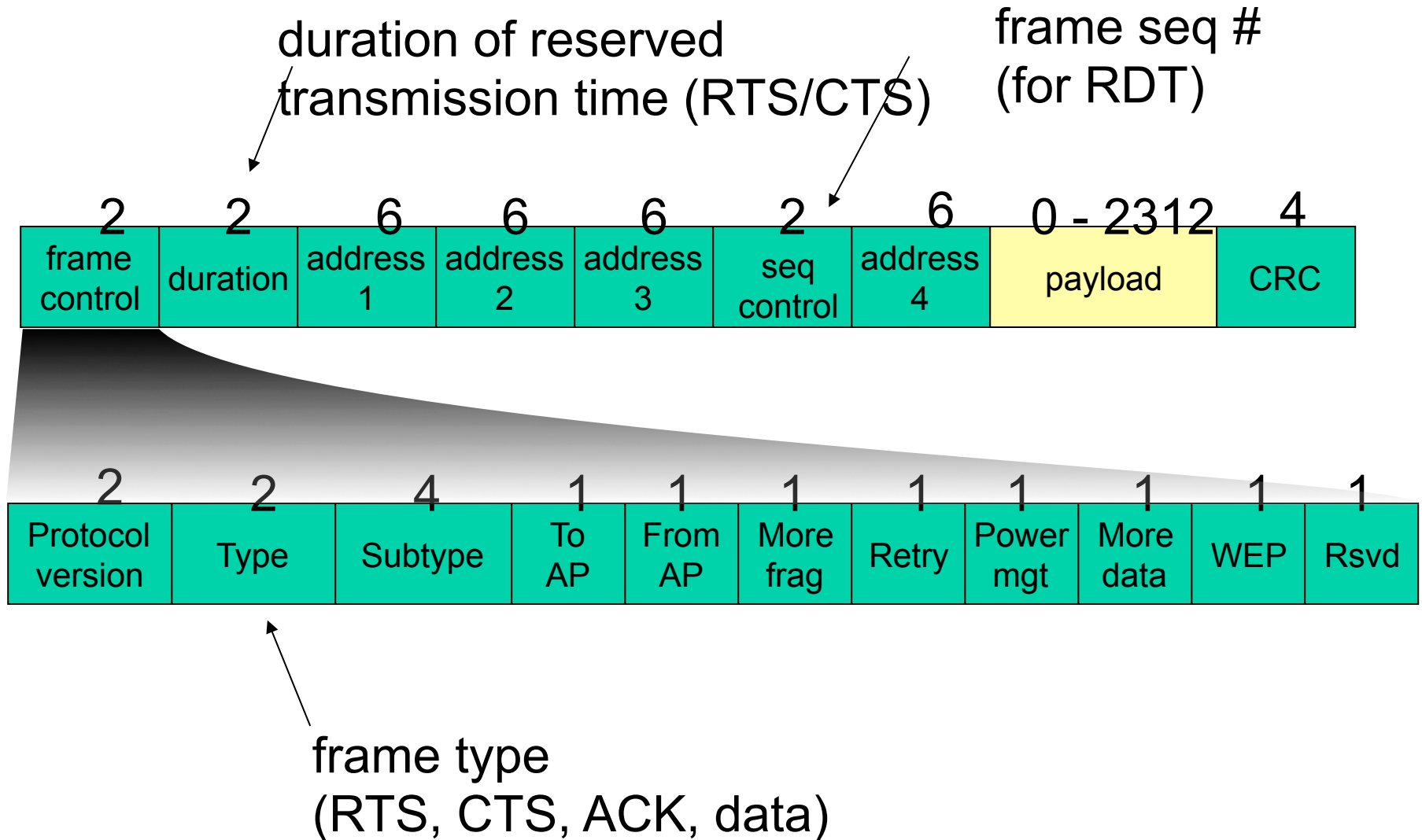
Address 3: MAC address of router interface to which AP is attached

Address 4: used only in ad hoc mode

802.11 frame: addressing



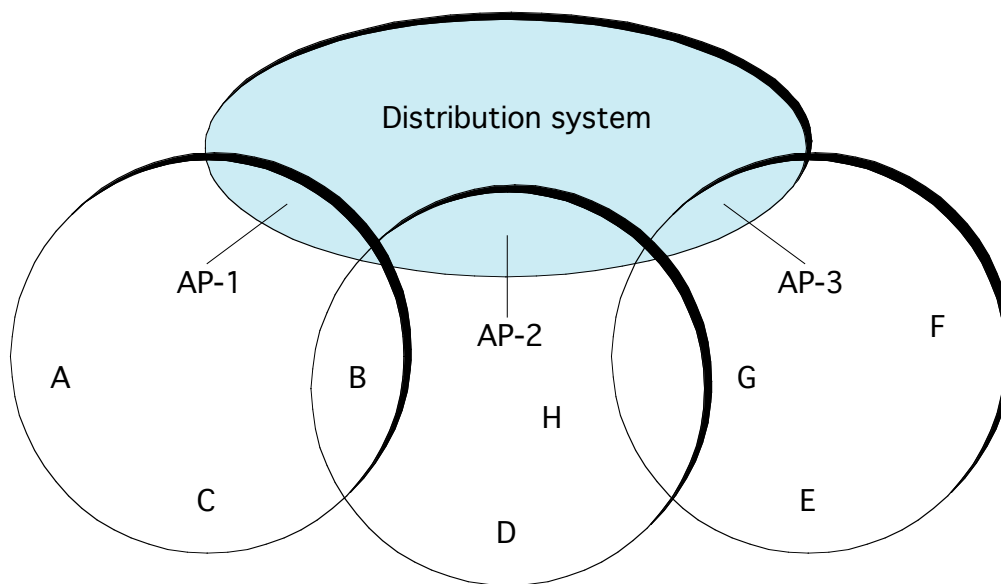
802.11 frame: more





Supporting Mobility

- Case 1: *ad hoc* networking
- Case 2: *access points (AP)*
 - tethered
 - each mobile node associates with an AP (base station)
 - AP connection/routing not a 802.11 issue





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

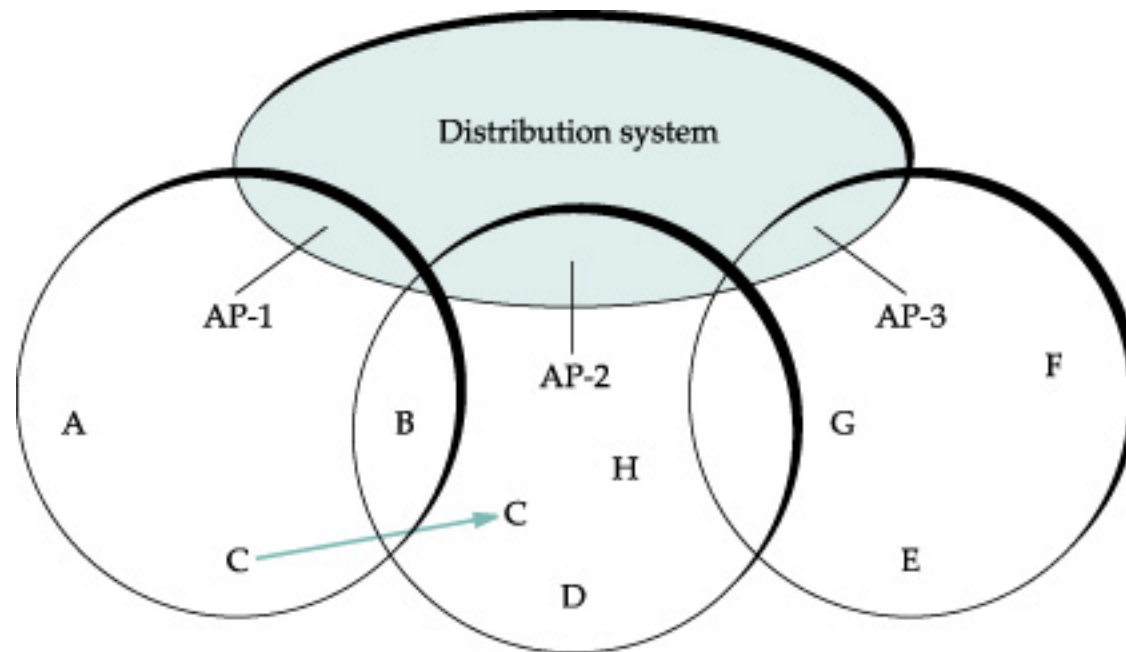




Mobility (cont)

- Scanning (selecting an AP)
 - node sends **Probe** frame
 - all AP' s within reach reply with **ProbeResponse** frame
 - node selects one AP; sends it **AssociateRequest** frame
 - AP replies with **AssociationResponse** frame
 - new AP informs old AP via tethered network (so there is a base station protocol)
- When
 - active: when join or move
 - passive: AP periodically sends **Beacon** frame

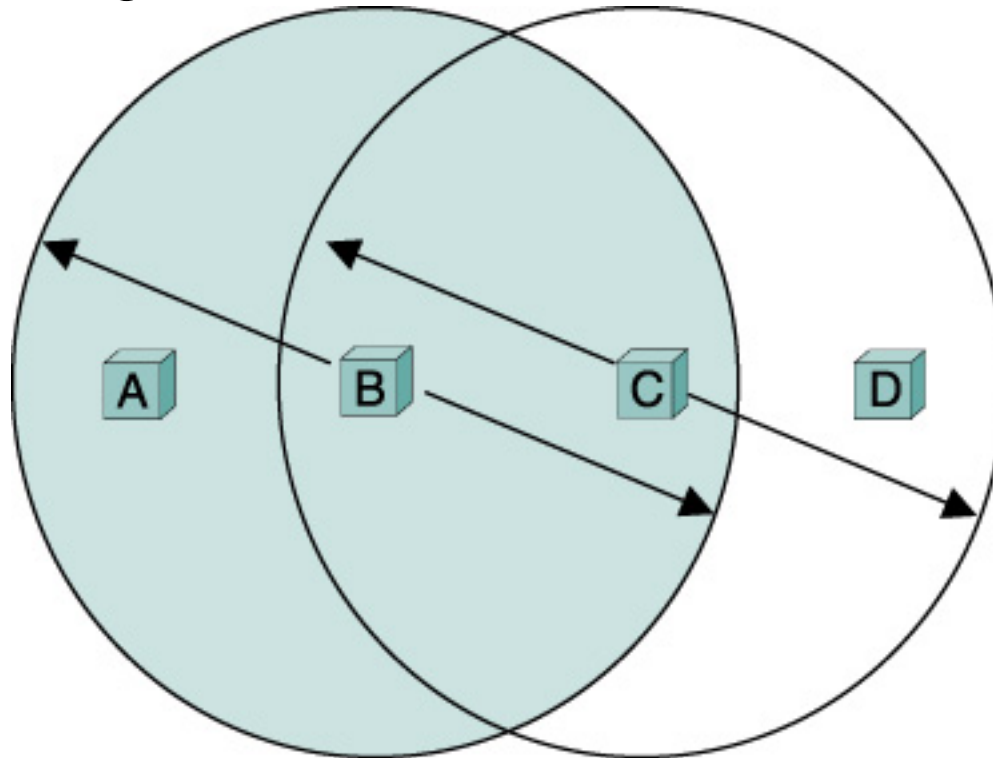
C moves and using beacon frame to join AP-2

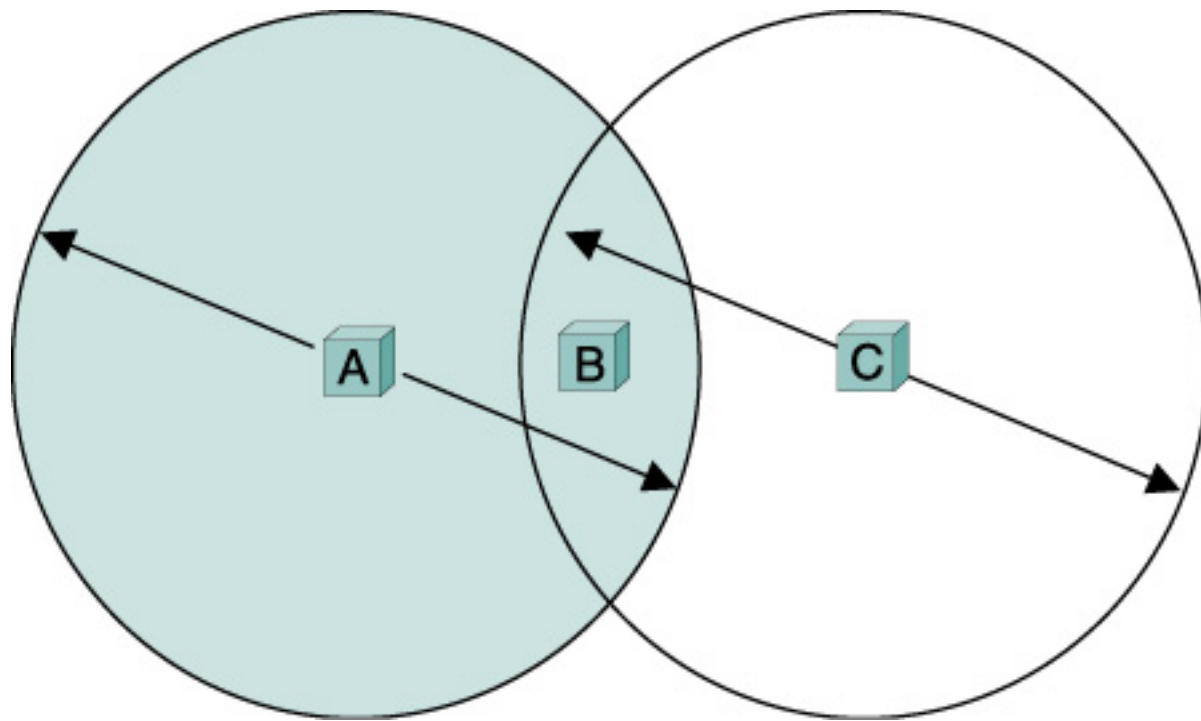


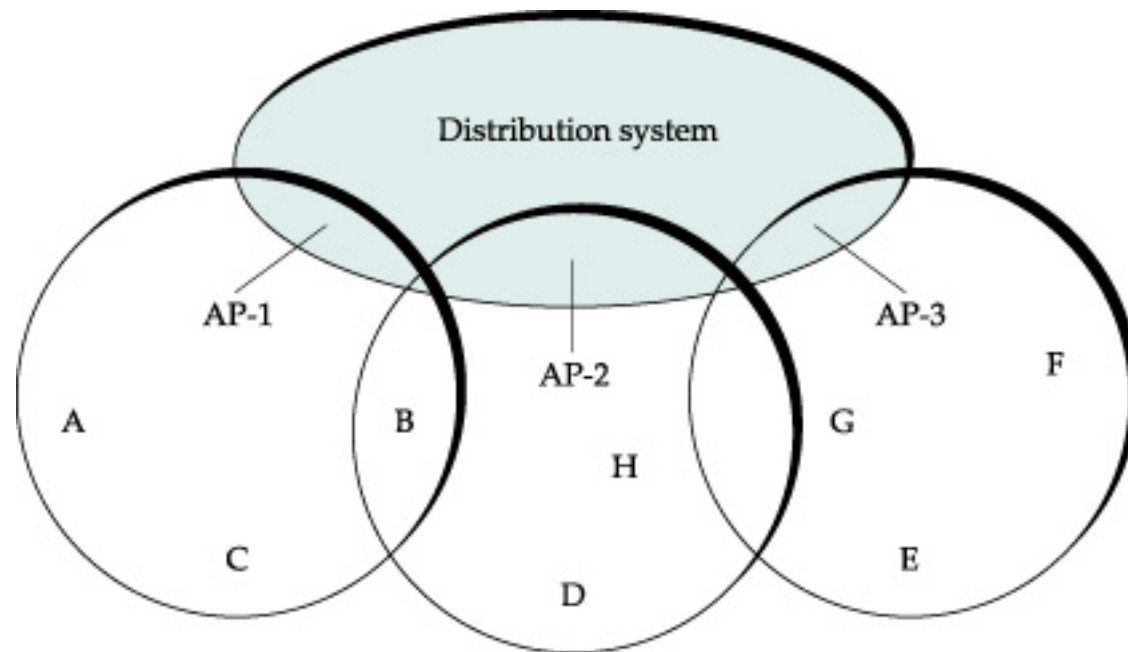


The End

What happens if A tries to send to B while C is Sending to D??









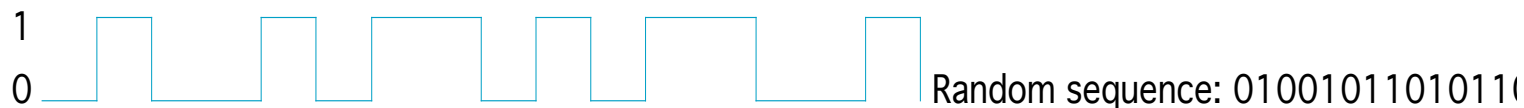
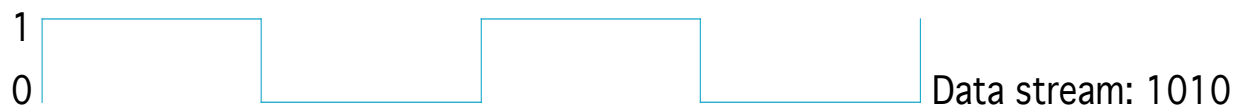
Spread Spectrum

- Idea
 - spread signal over wider frequency band than required
 - originally designed to thwart jamming
- Frequency Hopping
 - transmit over random sequence of frequencies
 - sender and receiver share...
 - pseudorandom number generator
 - seed
 - 802.11 uses 79 x 1MHz-wide frequency bands
 - 2.4 GHz frequency band



Spread Spectrum (cont)

- Direct Sequence
 - for each bit, send XOR of that bit and n random bits
 - random sequence known to both sender and receiver
 - called n -bit *chipping code*
 - 802.11 defines an 11-bit chipping code
 - How would you chose chipping code???



802.11 Frame

Control: type (data, RTS,CTS)

Addresses: host, destination, APs (control bits set meaning)

