EEE4121F
Mobile and Wireless Networks

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Wireless Networks and Systems
Wireless LANs
IEEE 802.11 b, a, g, n, ac, af, ax, ah,

“In everything, therefore, treat people the same way you want them to treat you”

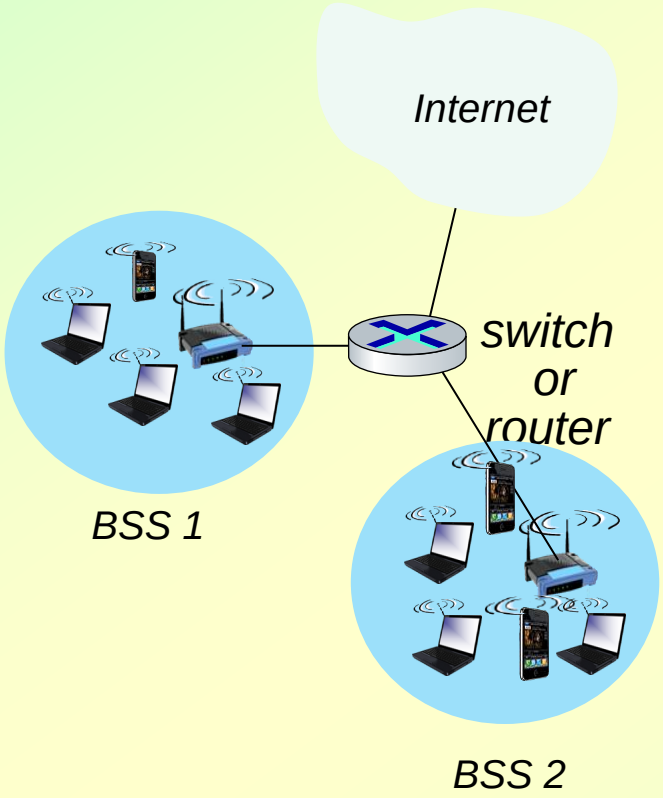
“Do not repay anyone evil for evil. Be careful to do what is right”

IEEE 802.11 Wireless LAN

IEEE 802.11 standard	Year	Max data rate	Range	Frequency
802.11b	1999	11 Mbps	30 m	2.4 Ghz
802.11g	2003	54 Mbps	30m	2.4 Ghz
802.11n (WiFi 4)	2009	600	70m	2.4, 5 Ghz
802.11ac (WiFi 5)	2013	3.47Gpbs	70m	5 Ghz
802.11ax (WiFi 6)	2020 (exp.)	14 Gbps	70m	2.4, 5 Ghz
802.11af	2014	35 – 560 Mbps	1 Km	unused TV bands (54-790 MHz)
802.11ah	2017	347Mbps	1 Km	900 Mhz

- *all use CSMA/CA for multiple access, and 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*

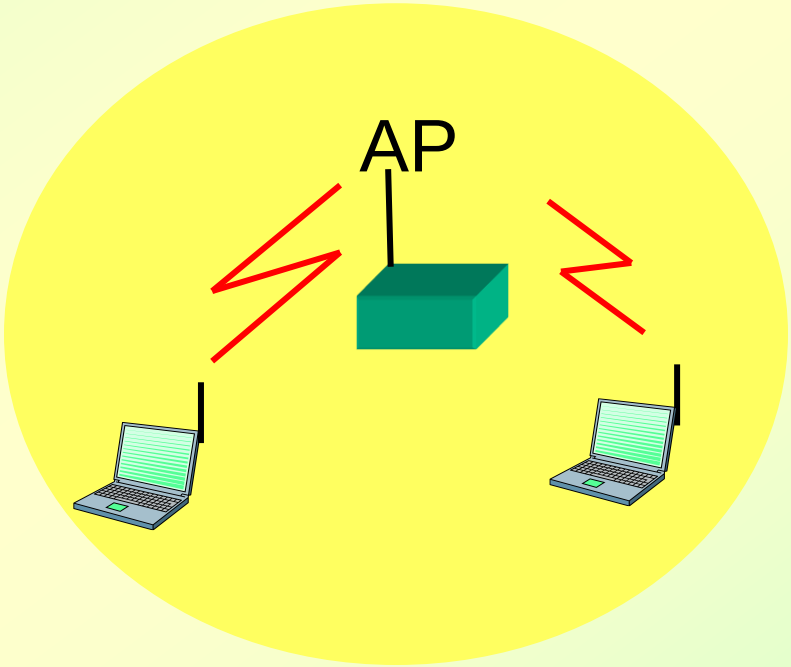
Modes of Operation of Wireless Networks

- Two modes of operation of wireless networks:

  (1) Infrastructure mode and

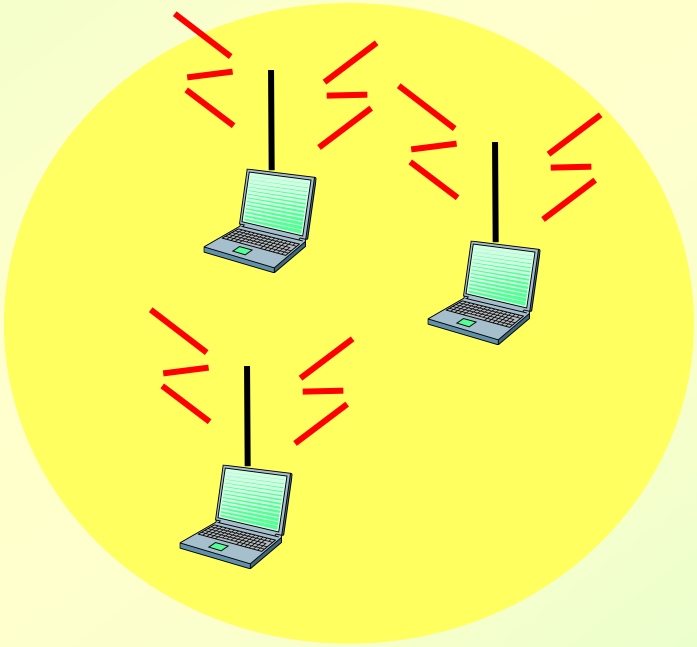
  (2) Ad hoc mode

- In infrastructure mode, the hosts communicate through a central point (base station or access point)

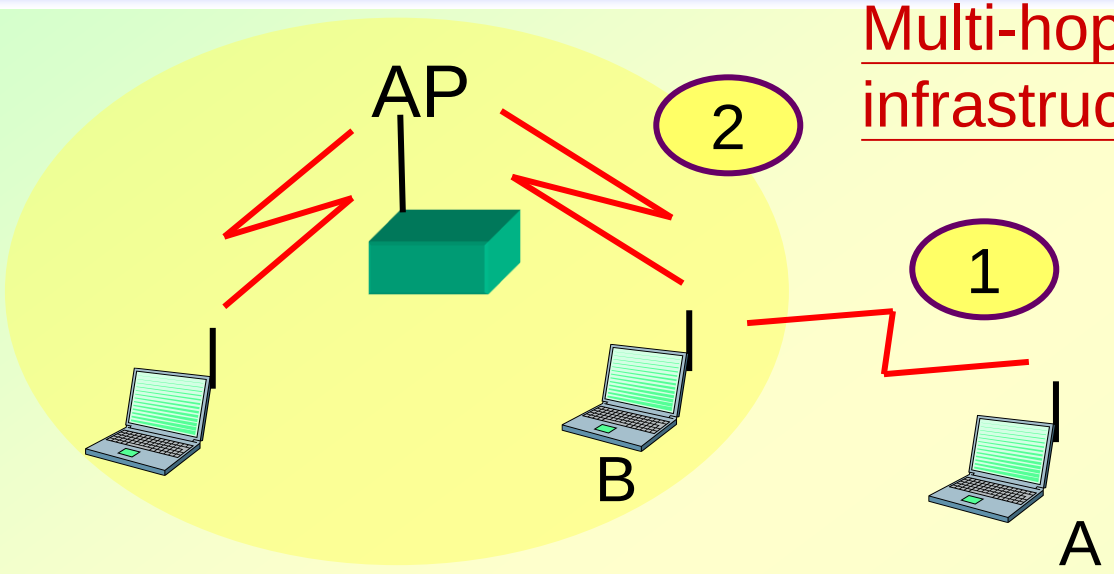


Wireless Networks

- In ad hoc mode, wireless hosts have no infrastructure with which to connect
- The hosts are directly connected to one another



Combination of Wireless Network Elements



Multi-hop, infrastructure-based

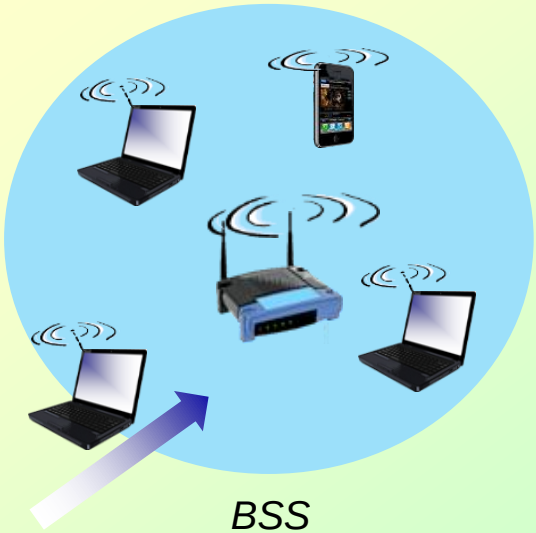
Wireless Links and Network Characteristics

- Decreasing signal strength: Electromagnetic radiation attenuates as it passes through matter- called path loss
- Interference from other sources: Radio sources transmitting in the same frequency band will interfere with each other
- Multipath propagation: Multipath propagation occurs when portions of electromagnetic wave reflects off objects and the ground – results in blurring of the received signal at the receiver

802.11: Channels, Association

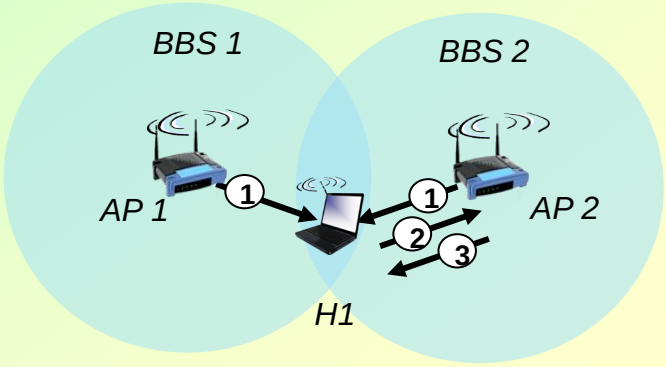
- *spectrum divided into channels at different frequencies*
  - *AP admin chooses frequency for AP*
  - *interference possible: channel can be same as that chosen by neighboring AP!*

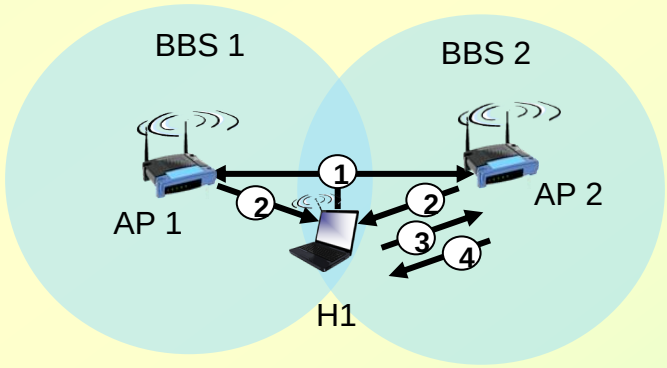
- *arriving host: must associate with an AP*
  - *scans channels, listening for beacon frames containing AP's name (SSID) and MAC address*
  - *selects AP to associate with*
  - *then may perform authentication [Chapter 8]*
  - *then typically run DHCP to get IP address in AP's subnet*



BSS

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 Media Access Control (MAC)

802.11 Media Access Control (MAC)

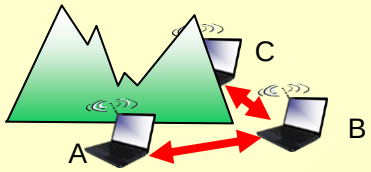
Carrier Sense Multiple Access with Collision Avoidance

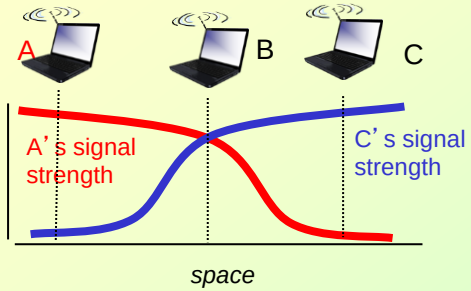
Sense Channel before Transmission

RTS
CTS
ACK
to minimize collisions

IEEE 802.11: Multiple Access

- *avoid collisions: 2+ nodes transmitting at same time*
- *802.11: CSMA - sense before transmitting*
  - *don't collide with detected ongoing transmission by another node*
- *802.11: no collision detection!*
  - *difficult to sense collisions: high transmitting signal, weak received signal due to fading*
  - *can't sense all collisions in any case: hidden terminal, fading*
  - *goal: avoid collisions: CSMA/CollisionAvoidance*





IEEE 802.11 MAC Protocol: CSMA/CA

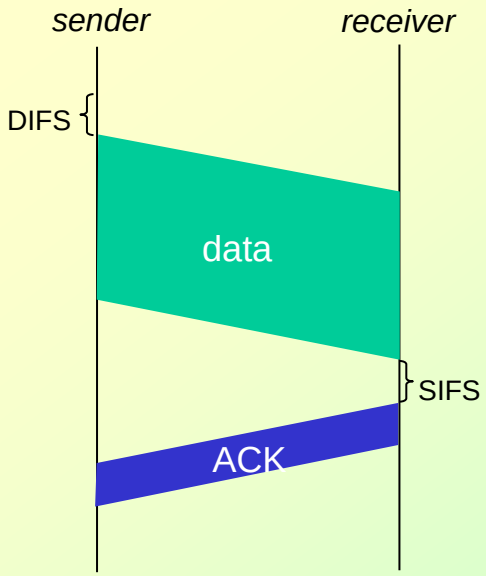
802.11 sender

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)

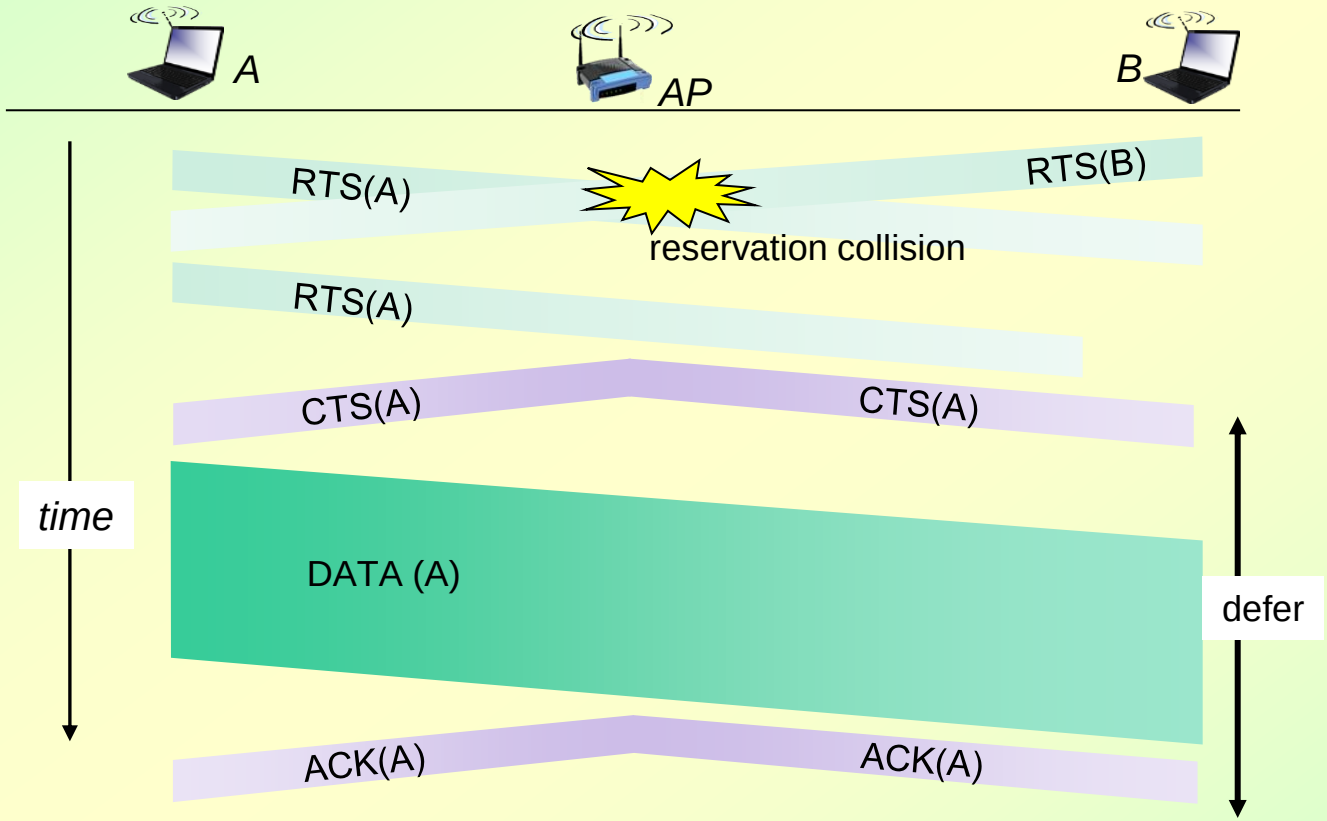


Avoiding Collisions (more)

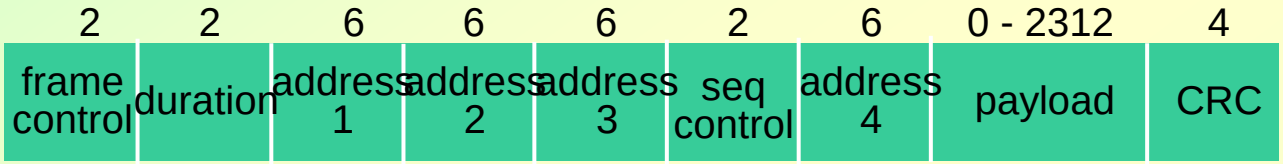
idea: sender "reserves" channel use for data frames using small reservation packets

- *sender first transmits small request-to-send (RTS) packet 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*

Collision Avoidance: RTS-CTS exchange



802.11 Frame: Addressing



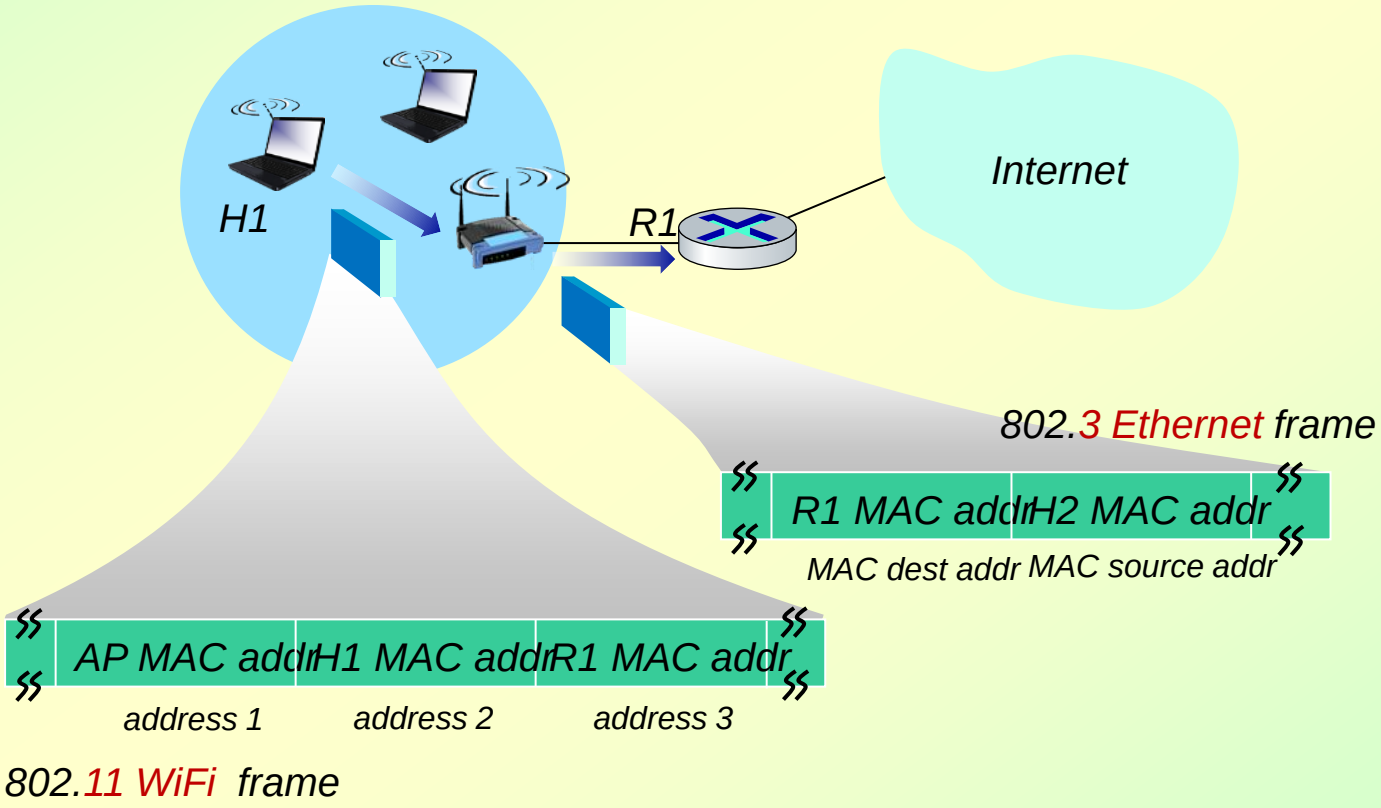
Address 1: *MAC address of wireless host or AP to receive this frame*

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

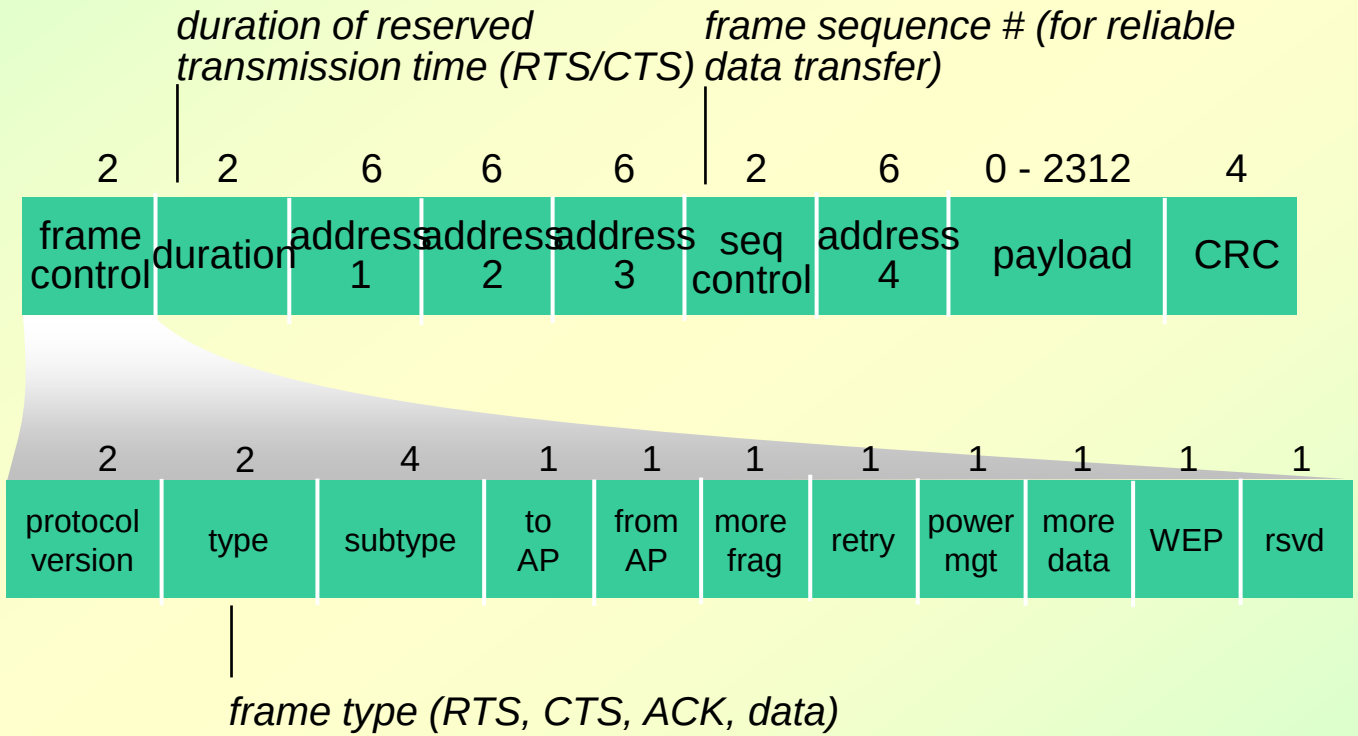
Address 3: *MAC address of router interface to which AP is attached*

Address 4: *used only in ad hoc mode*

802.11 Frame: Addressing

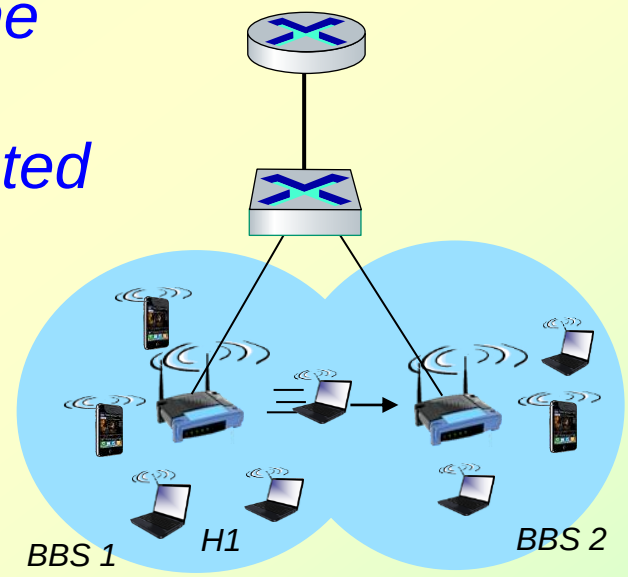


802.11 Frame: Addressing



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. 6): switch will see frame from H1 and "remember" which switch port can be used to reach H1*



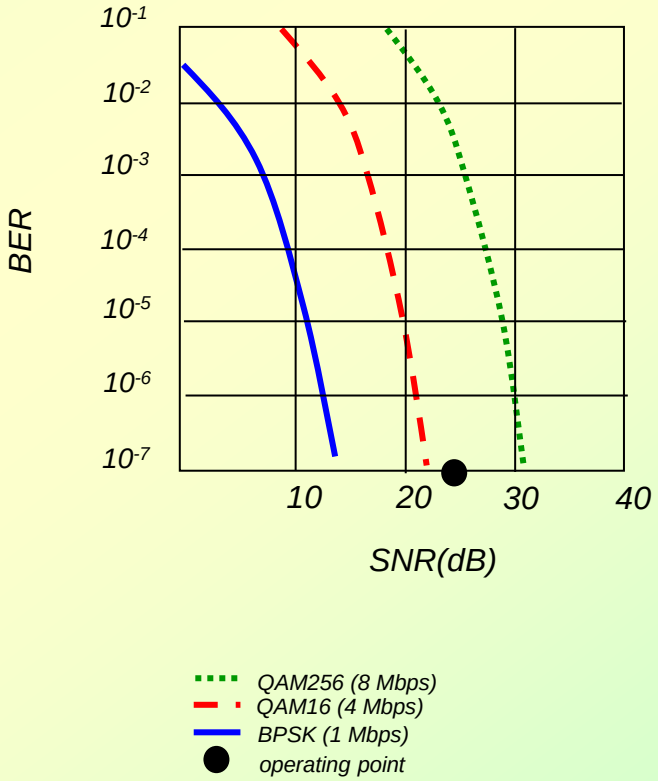
802.11: Advanced Capabilities

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



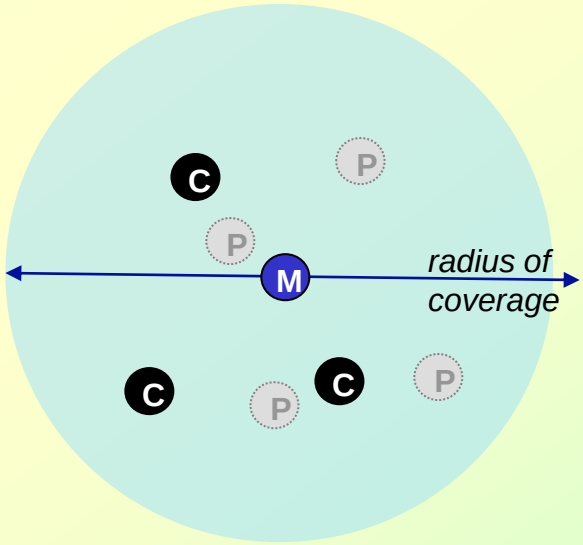
802.11: Advanced Capabilities

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*

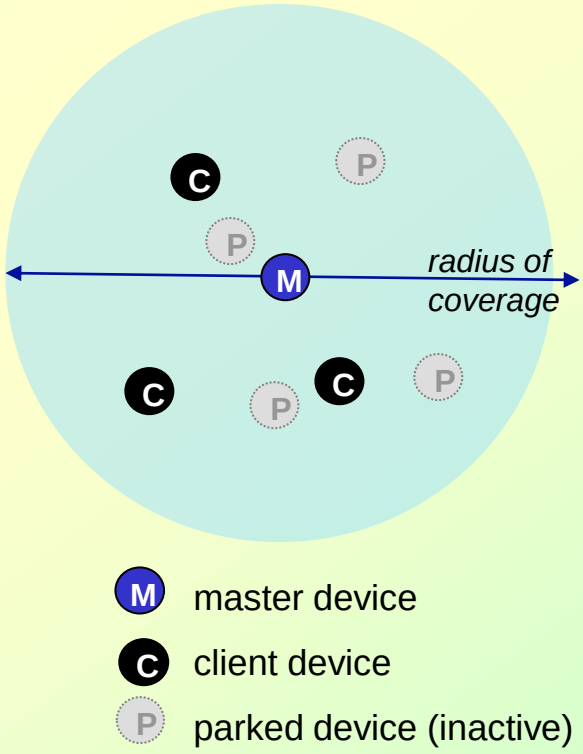
Personal area networks: Bluetooth

- *less than 10 m diameter*
- *replacement for cables (mouse, keyboard, headphones)*
- *ad hoc: no infrastructure*
- *2.4-2.5 GHz ISM radio band, up to 3 Mbps*
- *master controller / clients devices:*
  - *master polls clients, grants requests for client transmissions*



Personal area networks: Bluetooth

- *TDM, 625 μsec sec. slot*
- *FDM: sender uses 79 frequency channels in known, pseudo-random order slot-to-slot (spread spectrum)*
  - *other devices/equipment not in piconet only interfere in some slots*
- *parked mode: clients can "go to sleep" (park) and later wakeup (to preserve battery)*
- *bootstrapping: nodes self-assemble (plug and play) into piconet*



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The greatest oak was once a little nut that held its ground.

Never quit!