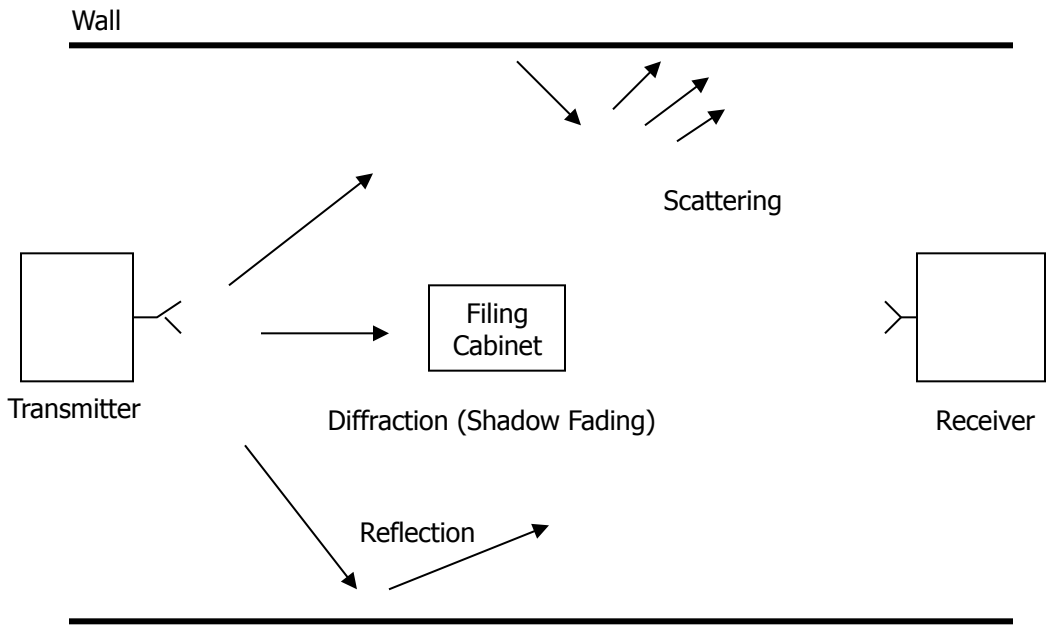
MAC Layer - WiFi Case Study

IEEE 802.11 Wireless LAN

- 802.11b
  - 2.4-5 GHz unlicensed radio spectrum
  - up to 11 Mbps
  - direct sequence spread spectrum (DSSS) in physical layer
    - all hosts use same chipping code
  - widely deployed, using base stations
- 802.11a
  - 5-6 GHz range
  - up to 54 Mbps
- 802.11g
  - 2.4-5 GHz range
  - up to 54 Mbps
- All use CSMA/CA for multiple access
- All have base-station and ad-hoc network versions

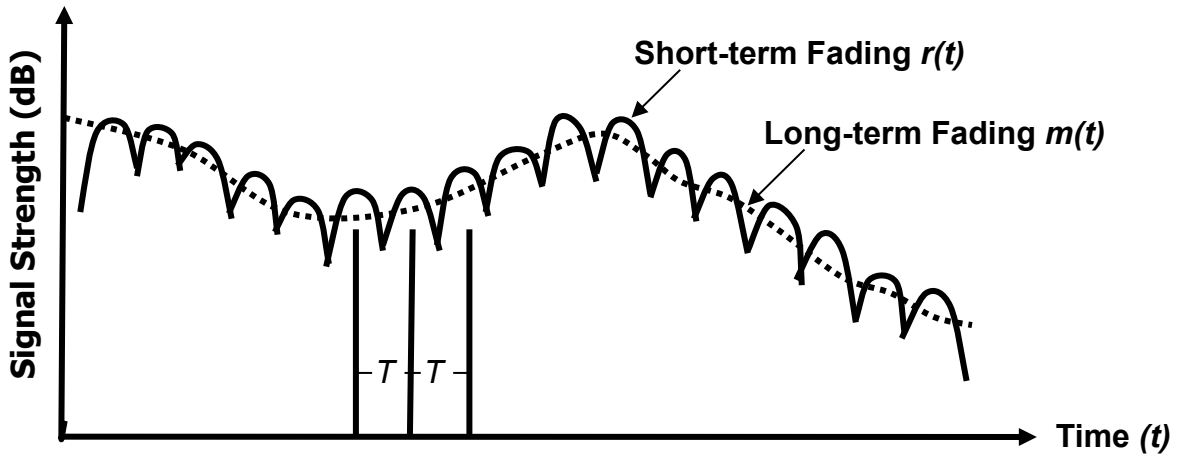
Multipath propagation

- The radio signal can get severely distorted at the receiver
  - Reflection (objects larger than wave length), diffraction (shadow fading) and scattering (objects smaller than wave length)



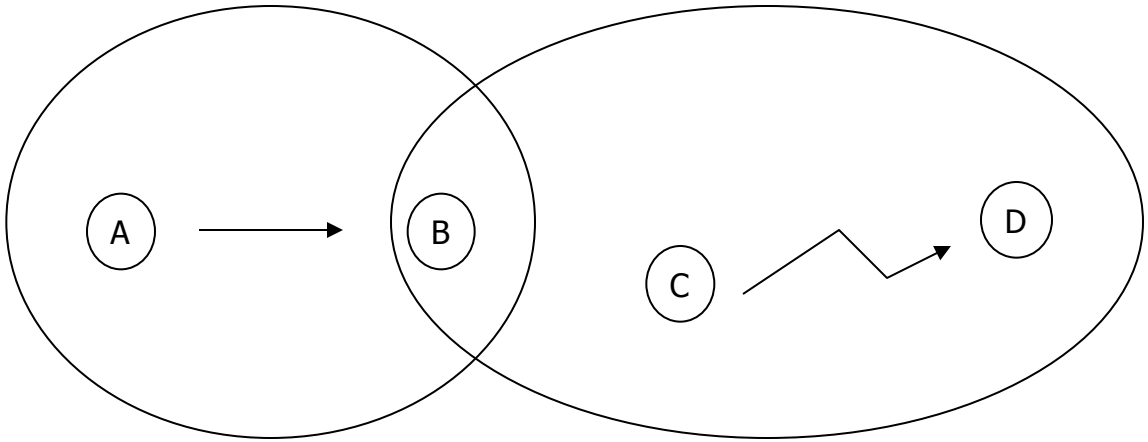
Signal fading

- The following received signal power results in higher BER
  - Path loss
    - determines how the average received signal power decreases with distance between the transmitter and receiver
  - Shadow fading
    - characterizes the signal attenuation due to obstructions from building and other objects
  - Raleigh fading (fast fading):
    - the rapid fluctuation caused by local multipath



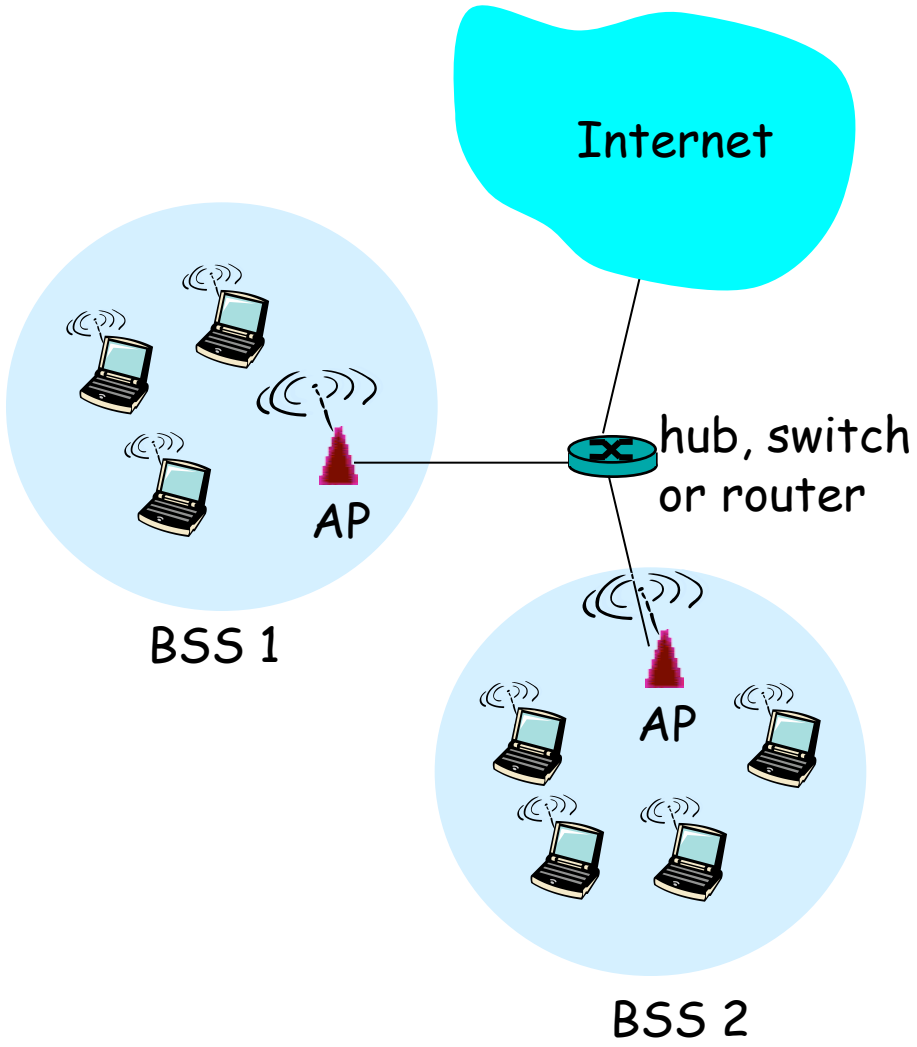
Sharing the air using media access

- CSMA (carrier sensing media access) is widely used
- Problems
  - Hidden terminal problems, near-far



Cell: Coverage Range, range over which a node can transmit and receive data reliably.

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) and MAC address
  - selects AP to associate with
  - may perform authentication
  - will typically run DHCP to get IP address in AP's subnet

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(voidance)

CSMA/CA MAC Protocol

IEEE 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

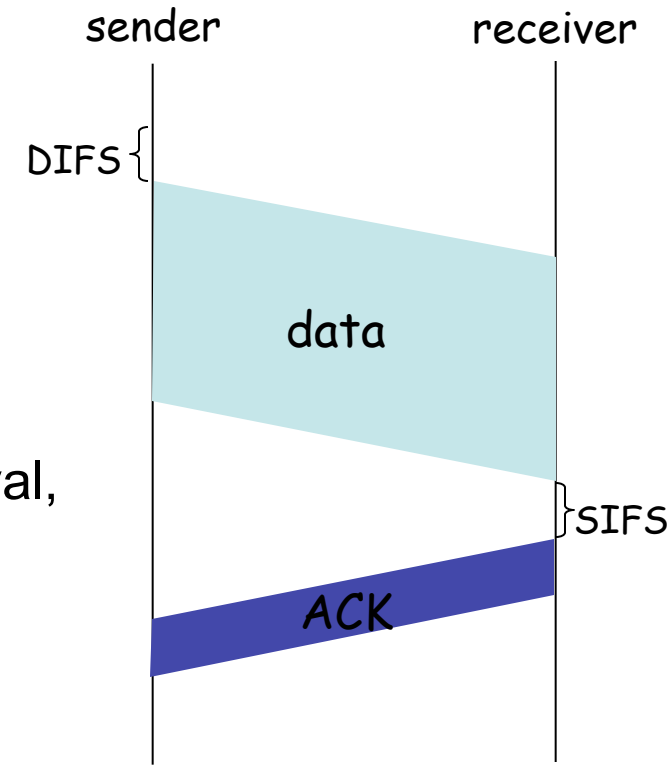
transmit when timer expires

if no ACK, increase random backoff interval, repeat 2

IEEE 802.11 receiver

- if frame received OK

return ACK after **SIFS** (ACK needed due to hidden terminal problem)

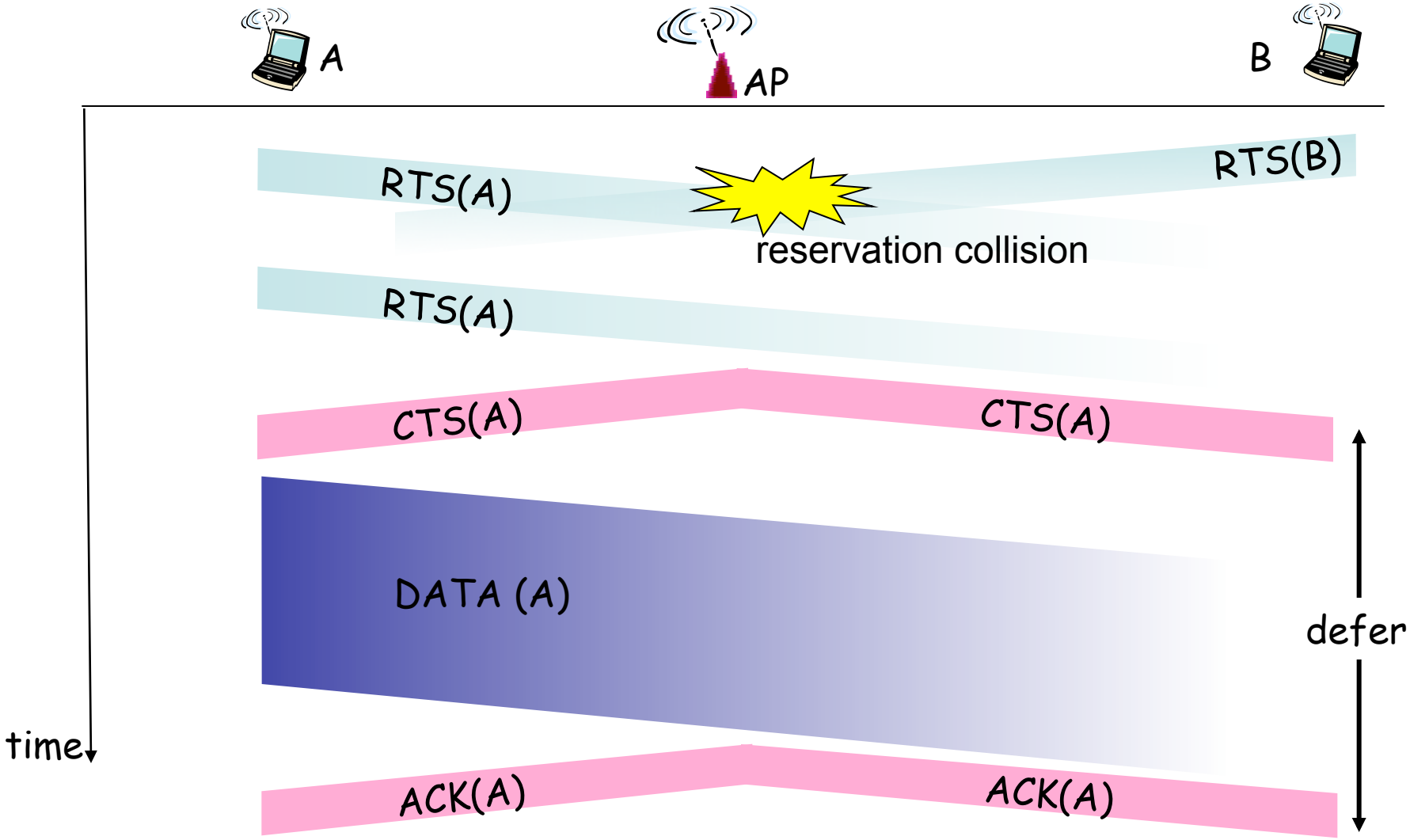


Avoiding collisions

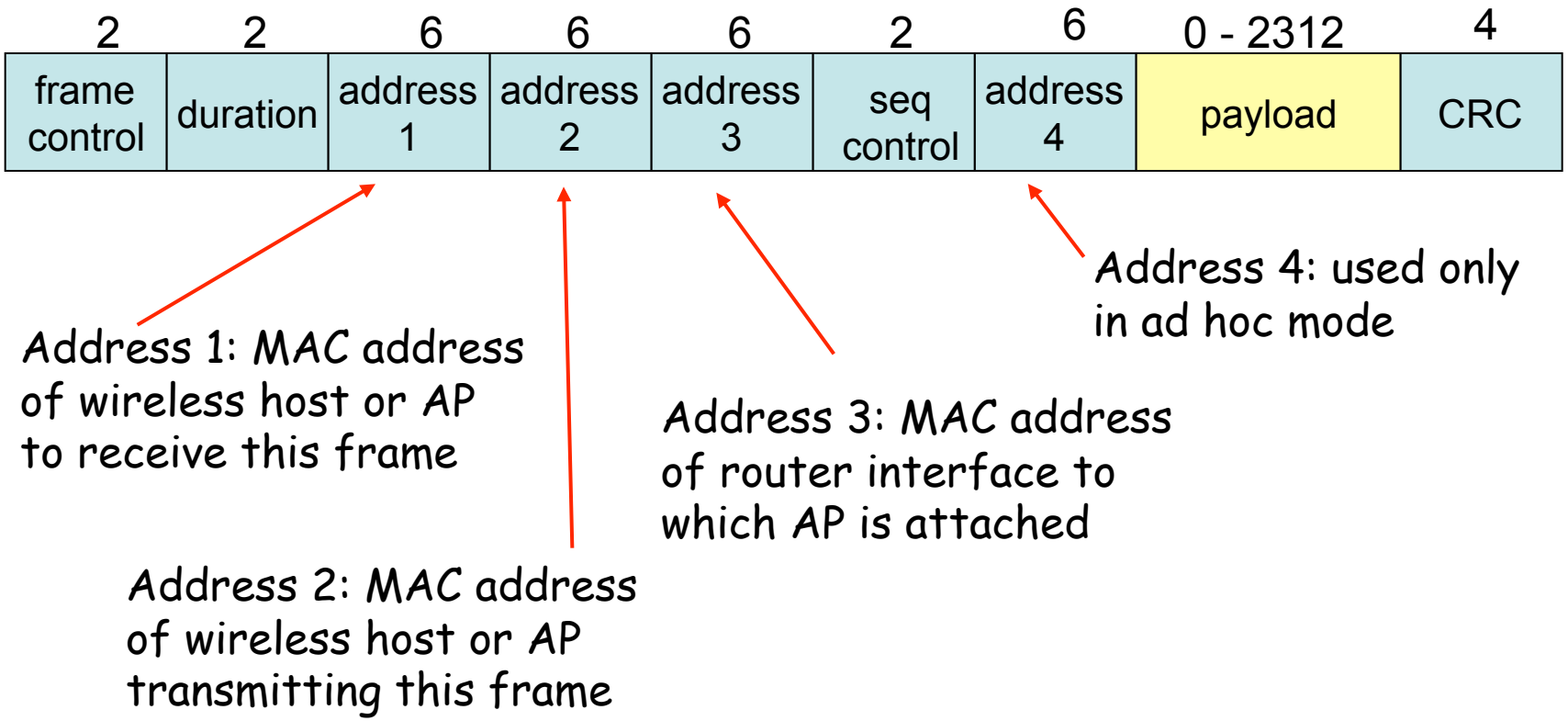
- Idea: allow sender to "reserve" channel rather than random access of data frames: avoid collisions of long data frames
- sender first transmits small request-to-send (RTS) packets to BS using CSMA
  - RTSs may still collide with each other (but they're short)
- BS broadcasts clear-to-send CTS in response to RTS
- RTS heard by all nodes
  - sender transmits data frame
  - other stations defer transmissions

Avoid data frame collisions completely using small reservation packets

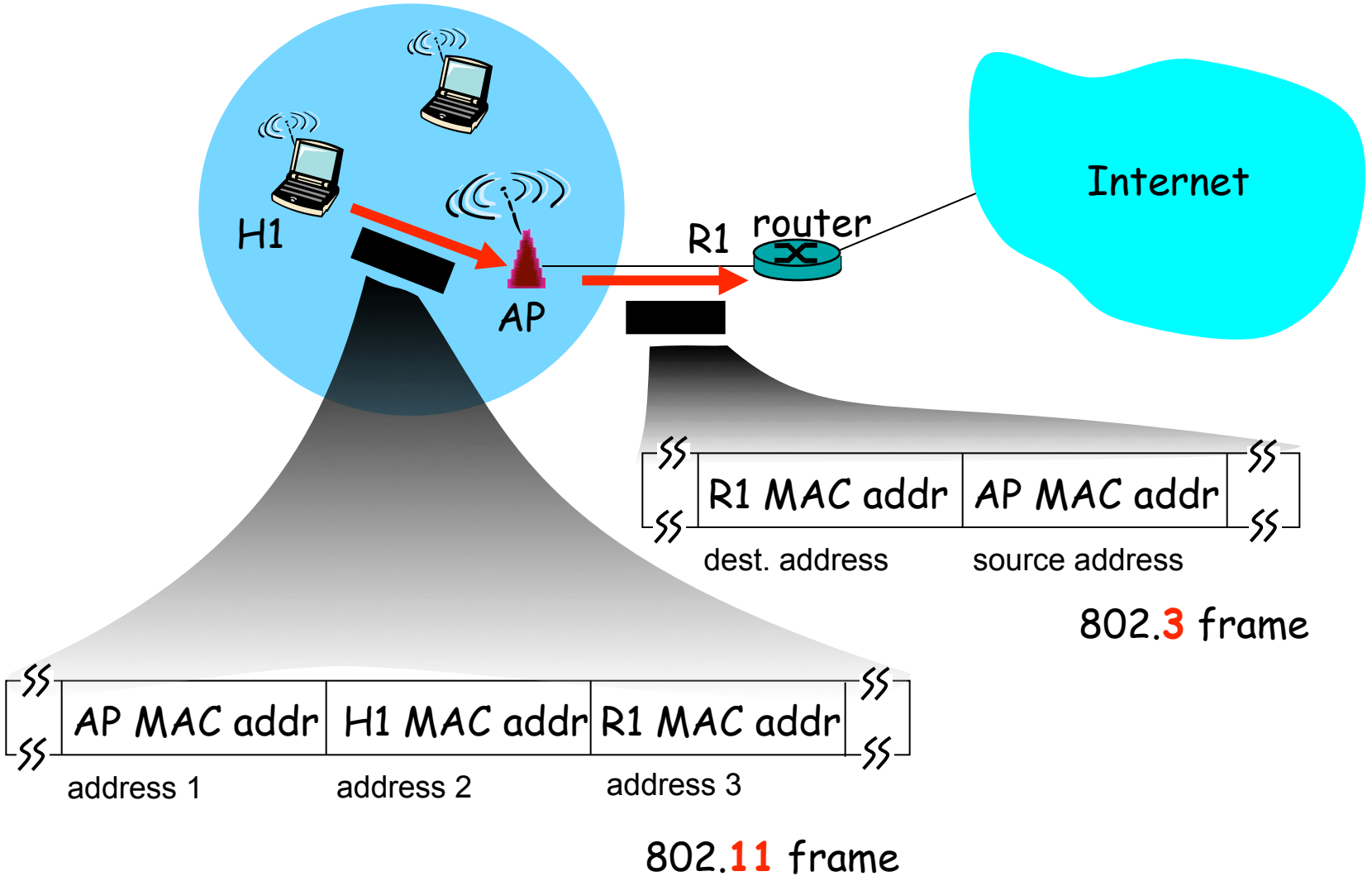
Collision Avoidance: RTS-CTS



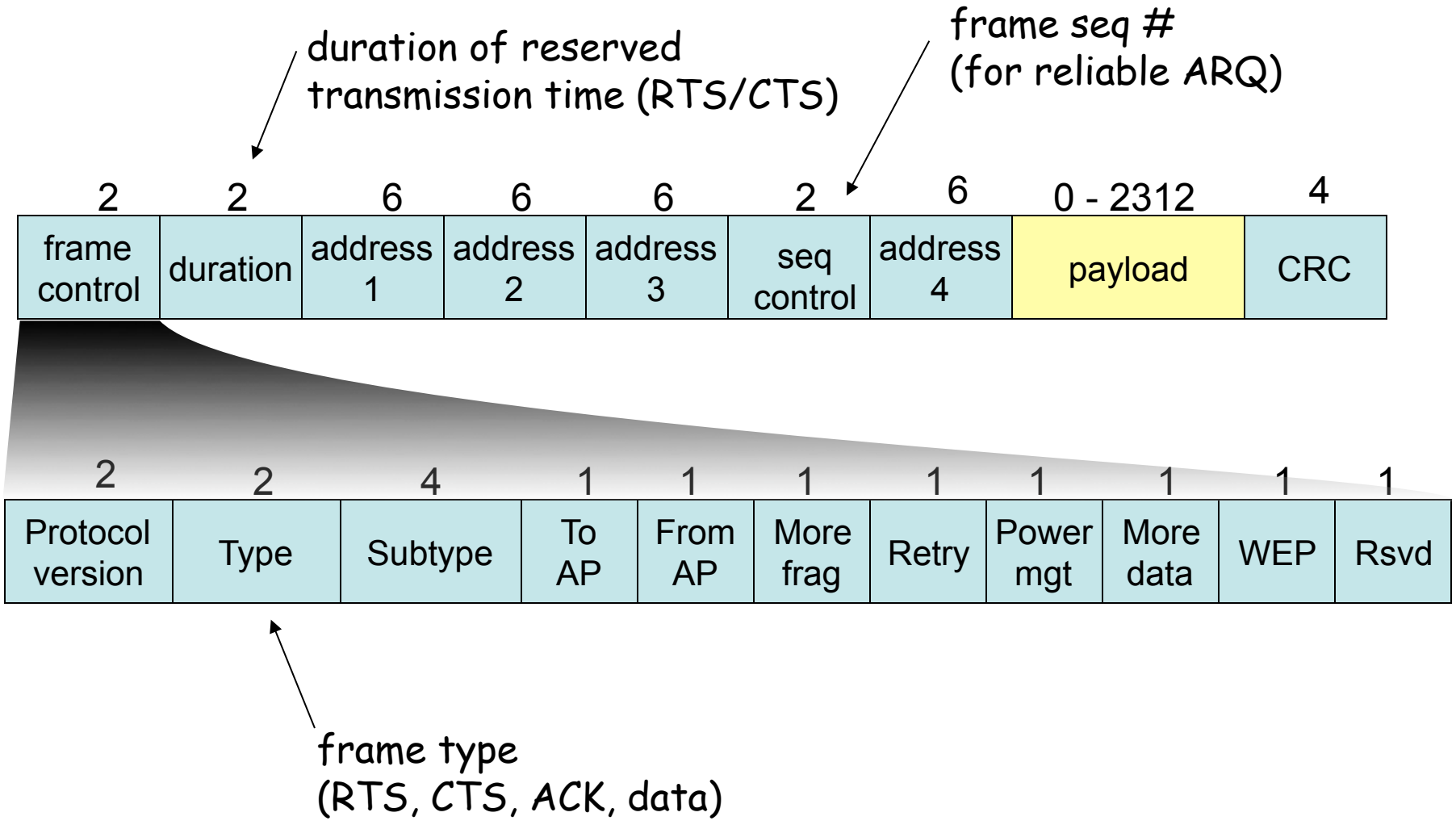
Addressing


2
2
6
6
6
2
6
0 - 2312
4
frame control
duration
address 1
address 2
address 3
seq control
address 4
payload
CRC
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

Addressing

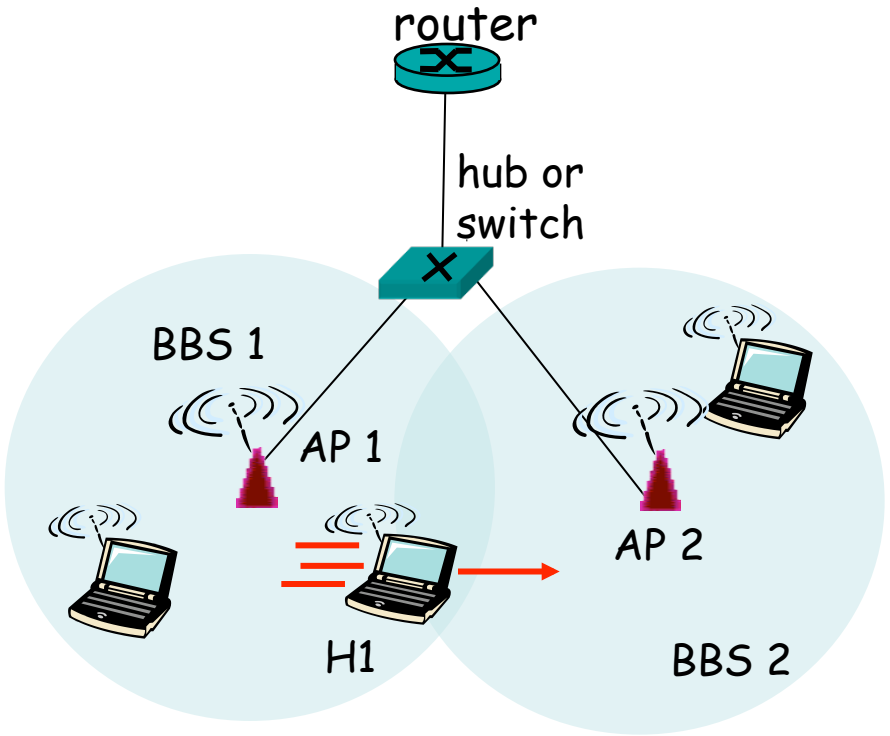

H1
AP
R1
router
Internet
R1 MAC addr
AP MAC addr
dest. address
source address
802.3 frame
AP MAC addr
H1 MAC addr
R1 MAC addr
address 1
address 2
address 3
802.11 frame

802.11 frame


duration of reserved transmission time (RTS/CTS)
frame seq # (for reliable ARQ)
2
2
6
6
6
2
6
0 - 2312
4
frame control
duration
address 1
address 2
address 3
seq control
address 4
payload
CRC
2
2
4
1
1
1
1
1
1
1
1
Protocol version
Type
Subtype
To AP
From AP
More frag
Retry
Power mgt
More data
WEP
Rsvd
frame type (RTS, CTS, ACK, data)

Mobility within same subnet

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



802.15: personal area network (PANs)

- 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
- IEEE 802.15: evolved from Bluetooth specification
  - 2.4-2.5 GHz radio band
  - up to 721 kbps