Mobile Computing

Lecture 6: Wireless LAN (Continue)

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Slides Credits

with modifications

Computer Networking: A Top Down Approach
6th edition
Jim Kurose, Keith Ross
Addison-Wesley
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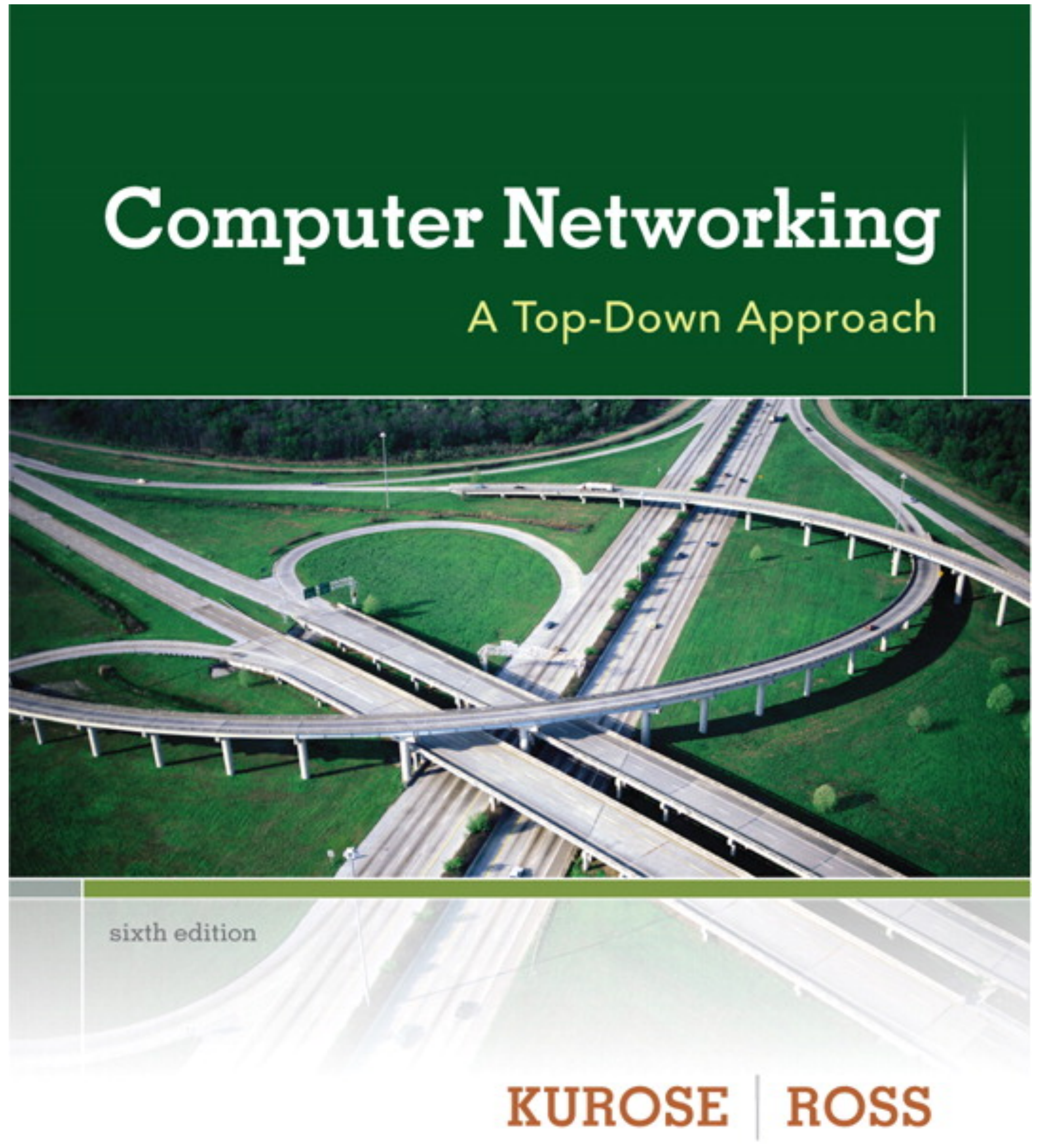
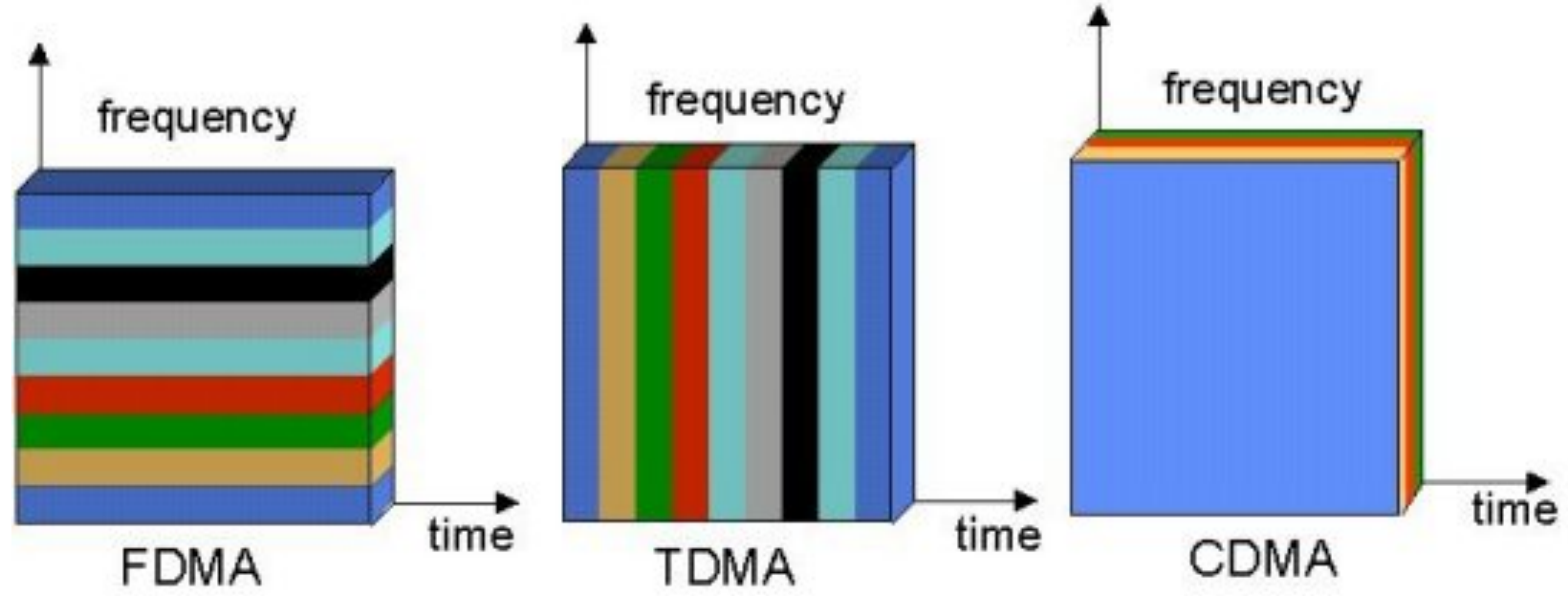
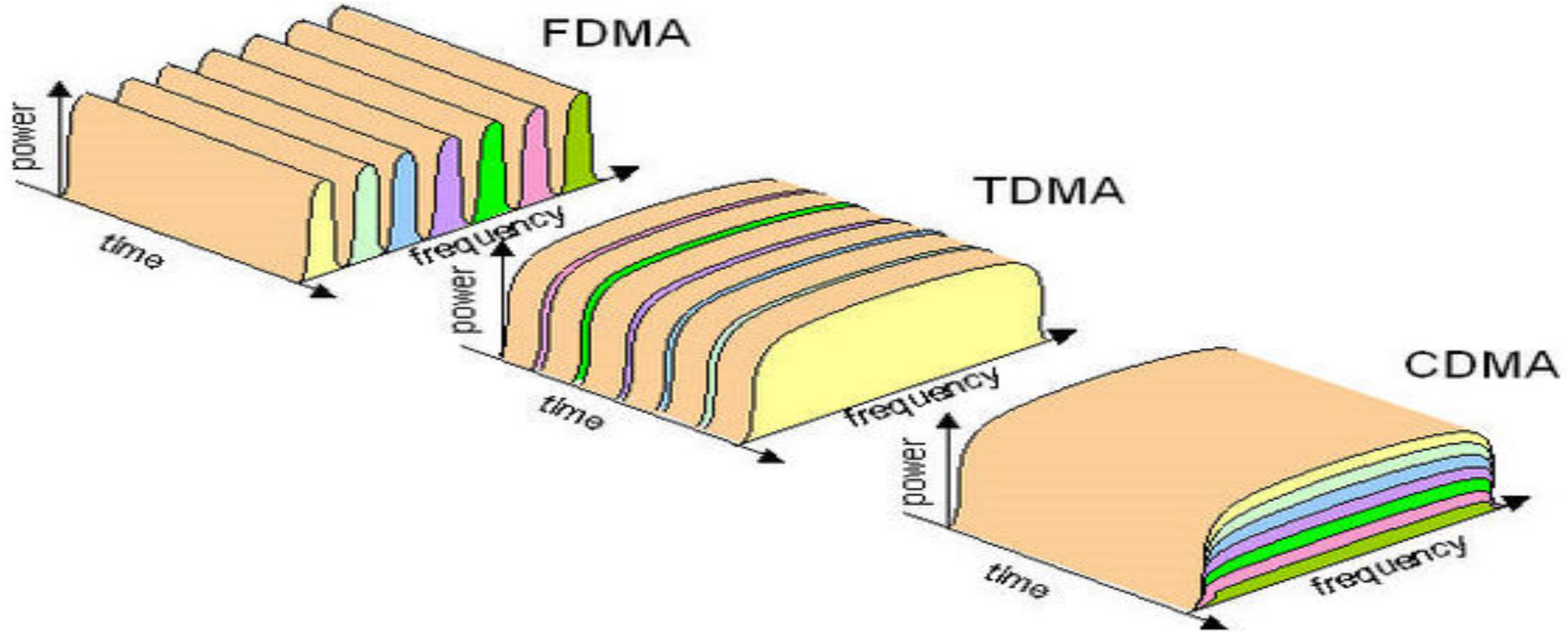


TDMA vs FDMA vs CDMA

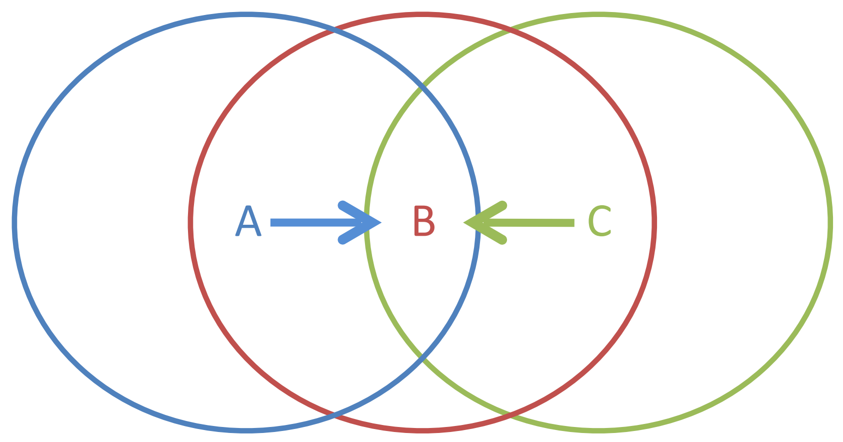
Recap





Hidden Terminal Problem

- A and C cant see each other, both send to B
- Collision will happen at B



IEEE 802.11 Wireless LAN

802.11b

- 2.4-2.485 GHz unlicensed spectrum
- up to 11 Mbps
- direct sequence spread spectrum (DSSS) modulation in physical layer.

802.11a

- 5.1-5.8 GHz range
- Uses OFDM
- **Pros**: fast speed up to 54 Mbps
- **Cons**: higher cost, shorter range

802.11g

- 2.4-2.485 GHz range
- up to 54 Mbps
- **Pros**: fast speed, good signal range, backward compatible with 802.11b devices.
- **Cons**: higher cost, interference with other appliances is possible

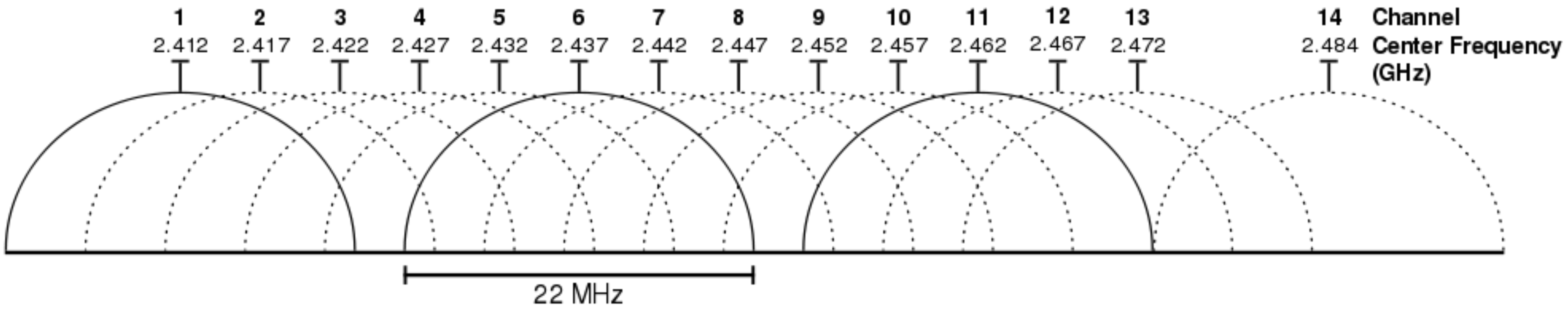
802.11n: multiple antennae

- Operates in both 2.4 GHz and (optional) 5 GHz range
- up to 200 Mbps (using MIMO)
- **Pros**: fast speed, good signal range, more resistant to interference.
- **Cons**: highest cost.

- all use CSMA/CA for multiple access
- all have base-station and ad-hoc network versions

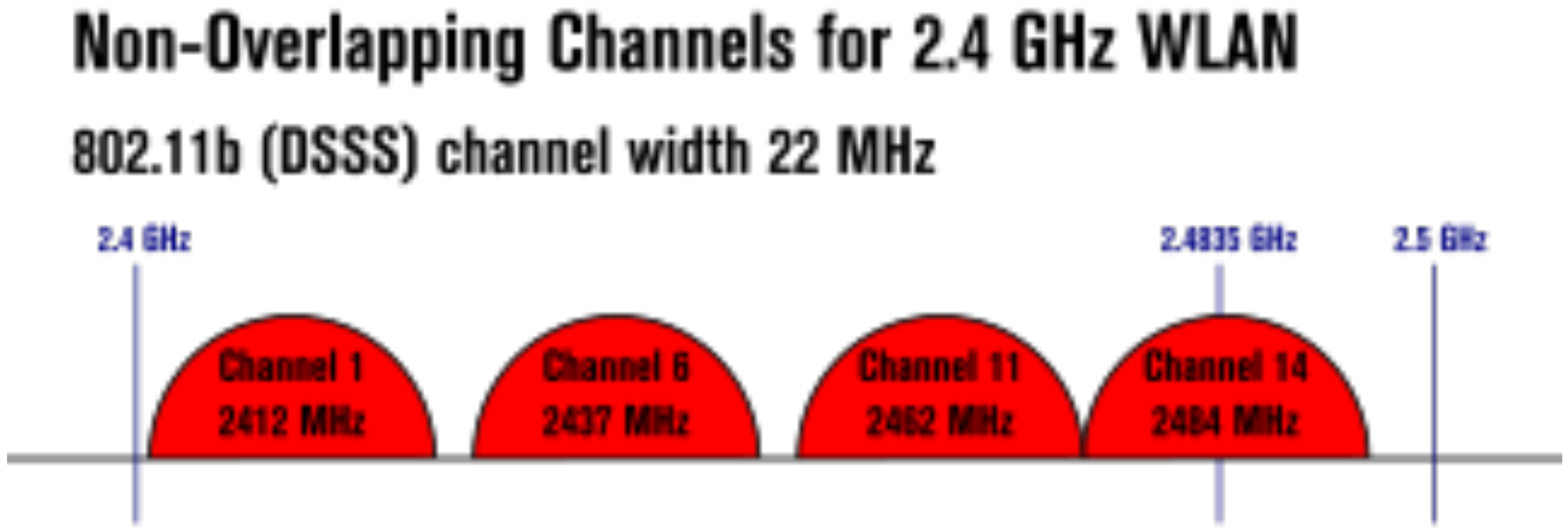
WIFI channel planning

- WIFI 802.11b/g/n uses the 2.4 ISM band.
- The 2.4 GHz frequency band is divided into 14 channels with 5 MHz spacing between them (except channel 14).
- USA uses 11 channels, Europe uses 13 and Japan uses 14.



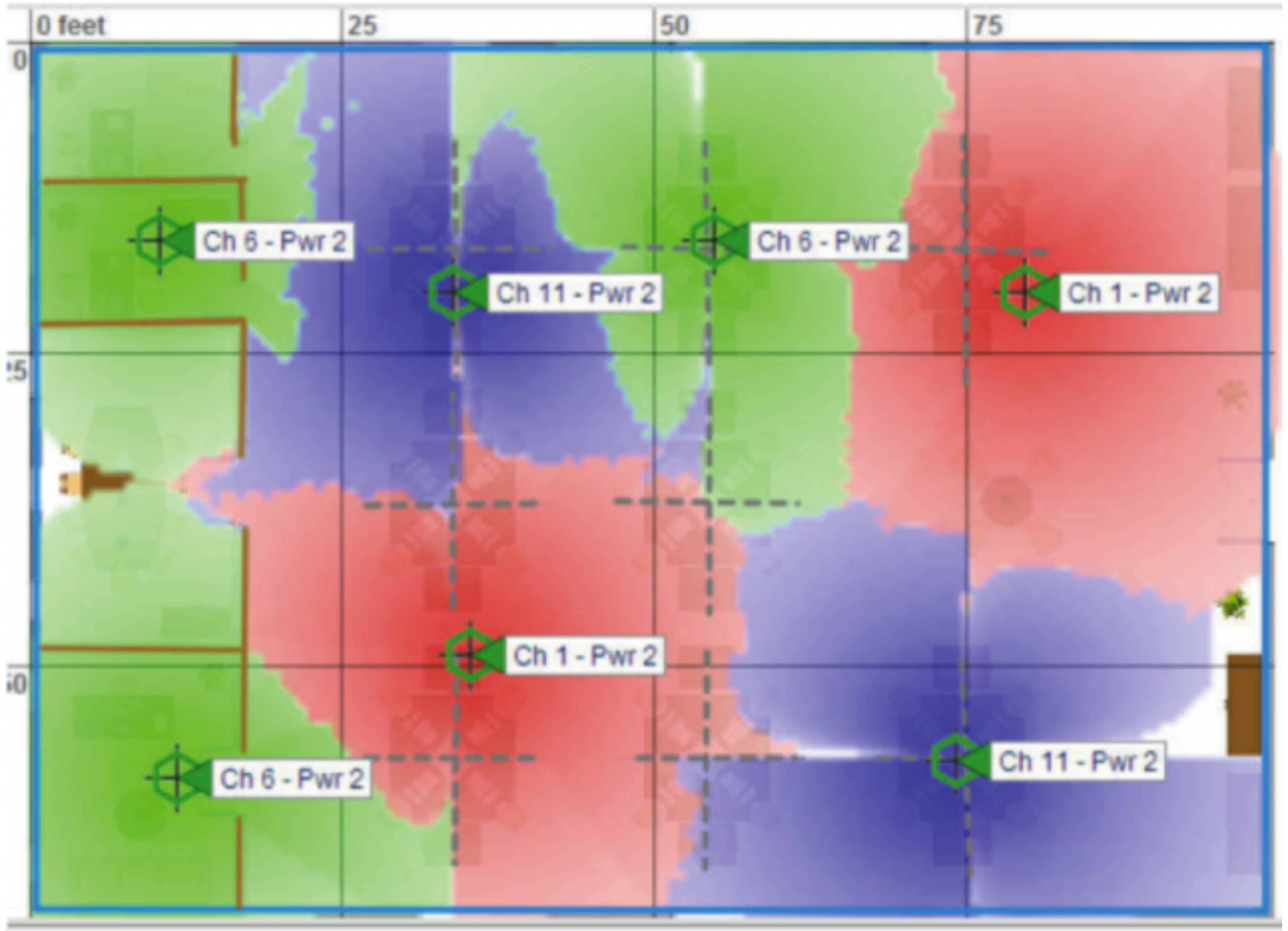
WIFI channel planning

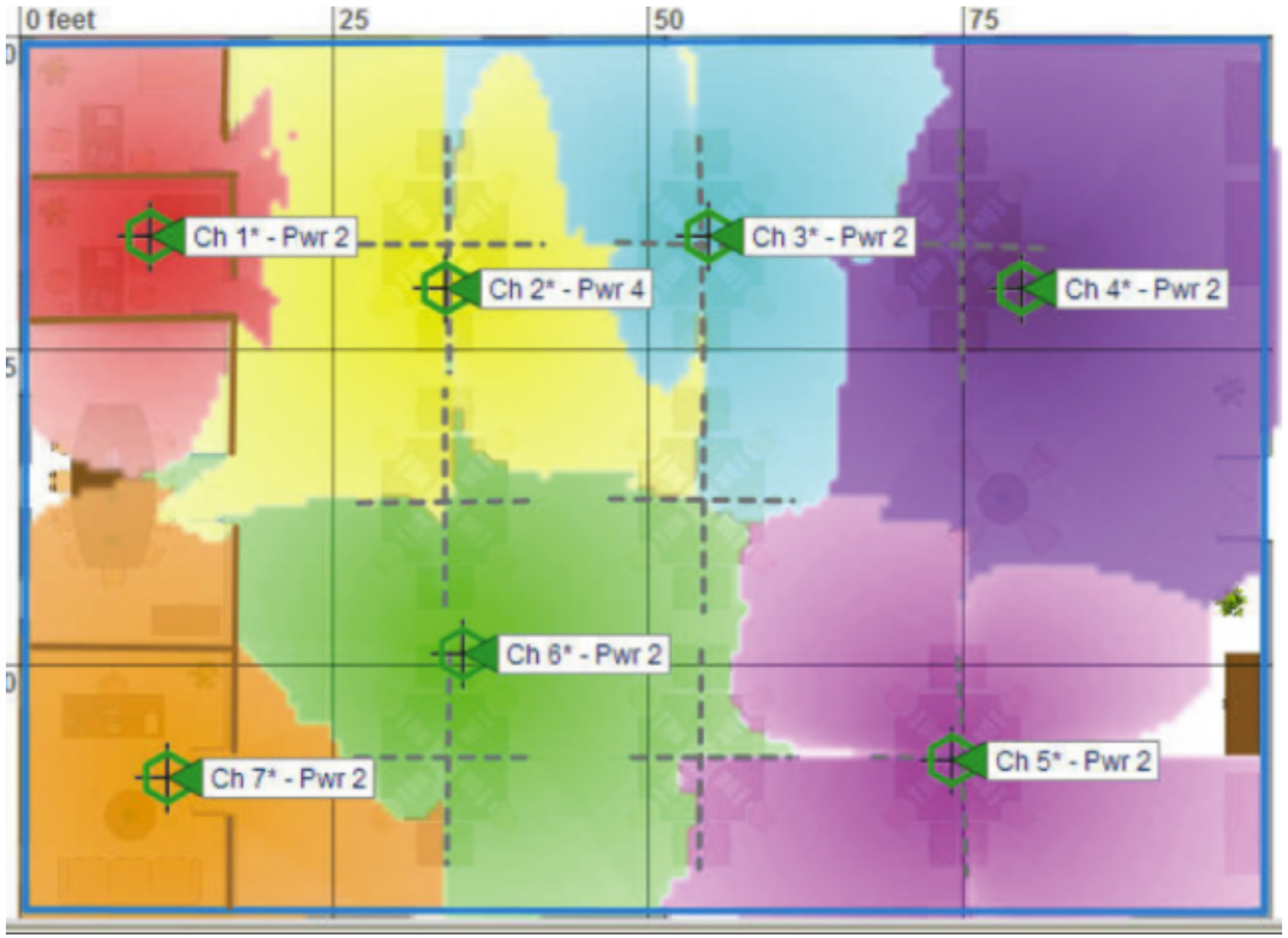
- 802.11b (DSSS) requires 22 MHz channel bandwidth for communication. This means there is a maximum of 3 channels (channel 1, 6, 11) - in USA- that are not overlapping.
- Proper choice of channel can be useful to minimize co-channel interference between neighboring devices and increase the network throughput.



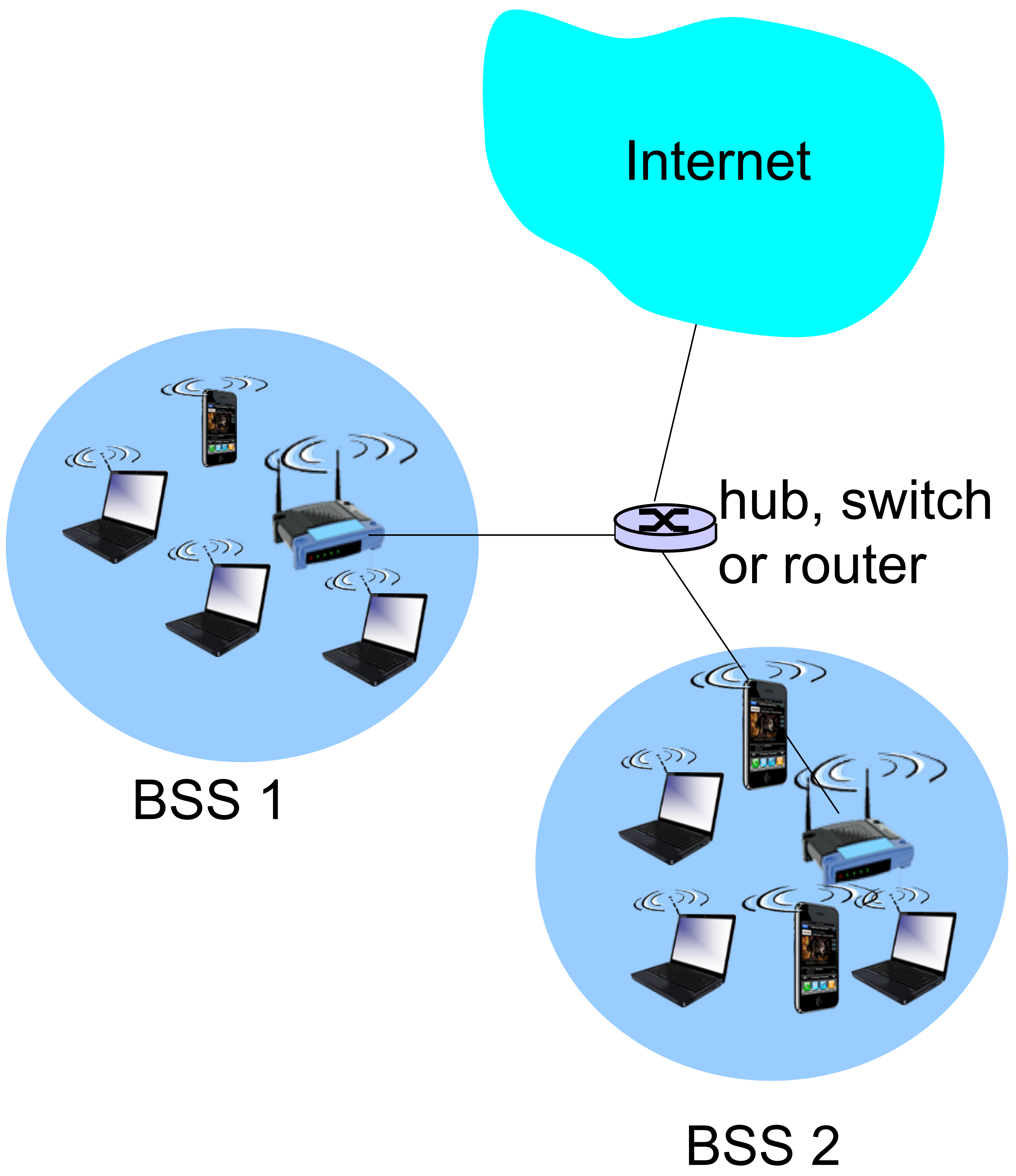
Quiz

- The figures below show channel planning to provide coverage over a floorpan with 7 APs. Which assignment is better ?





802.11 LAN architecture

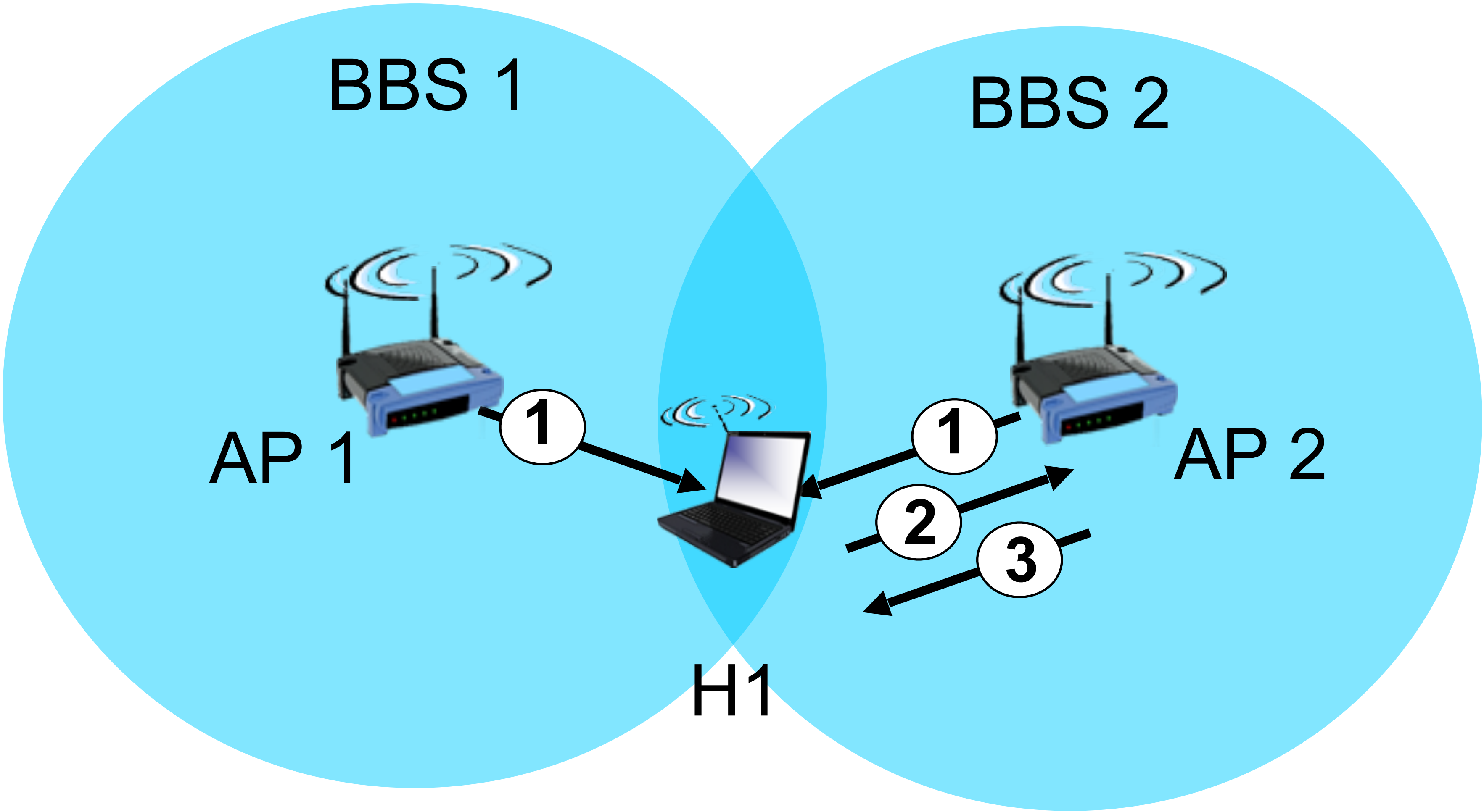


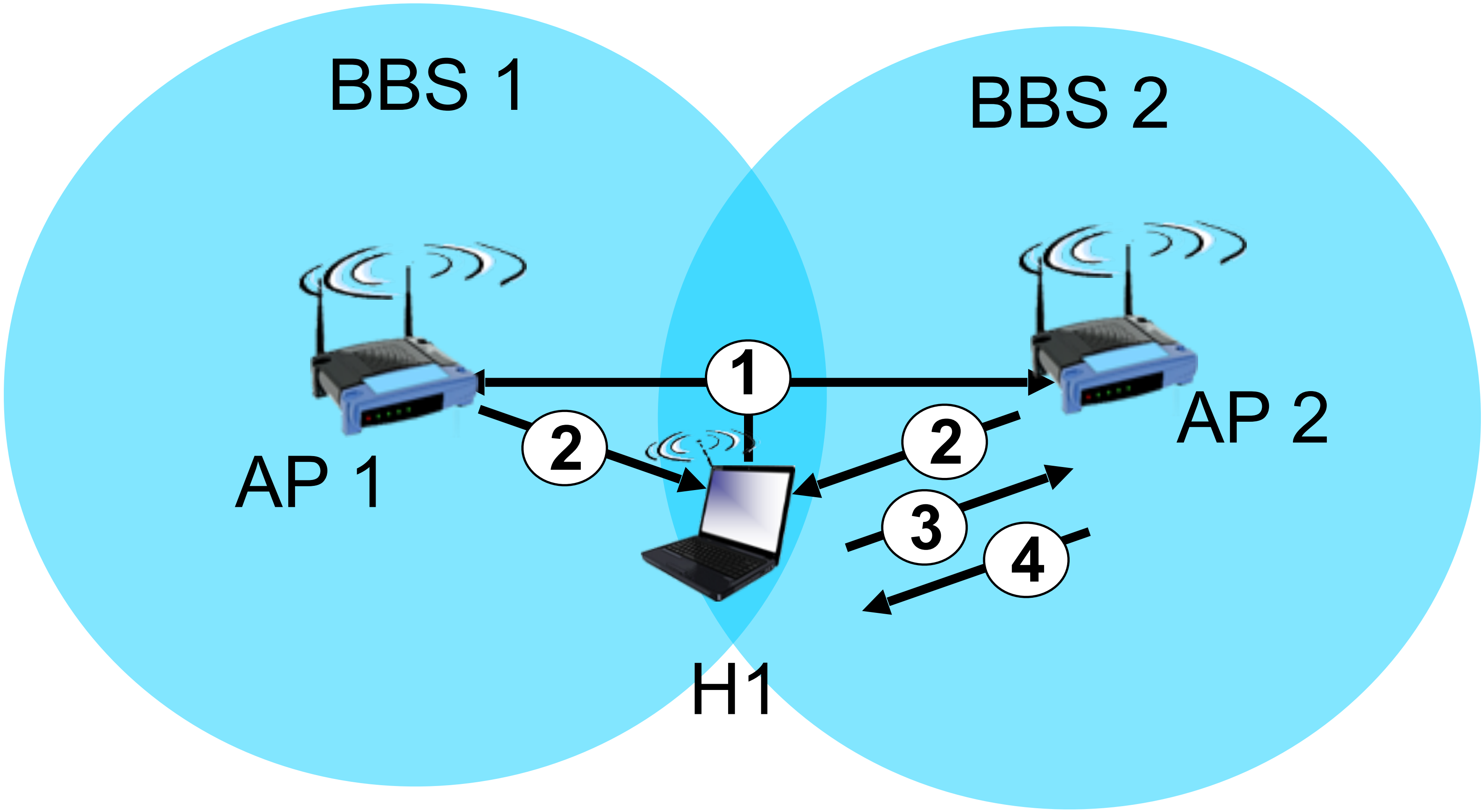
- wireless host communicates with base station
  - base station = access point (AP)
- Basic Service Set (BSS) (aka "cell") in infrastructure mode contains:
  - wireless hosts
  - access point (AP): base station
  - ad hoc mode: hosts only

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

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

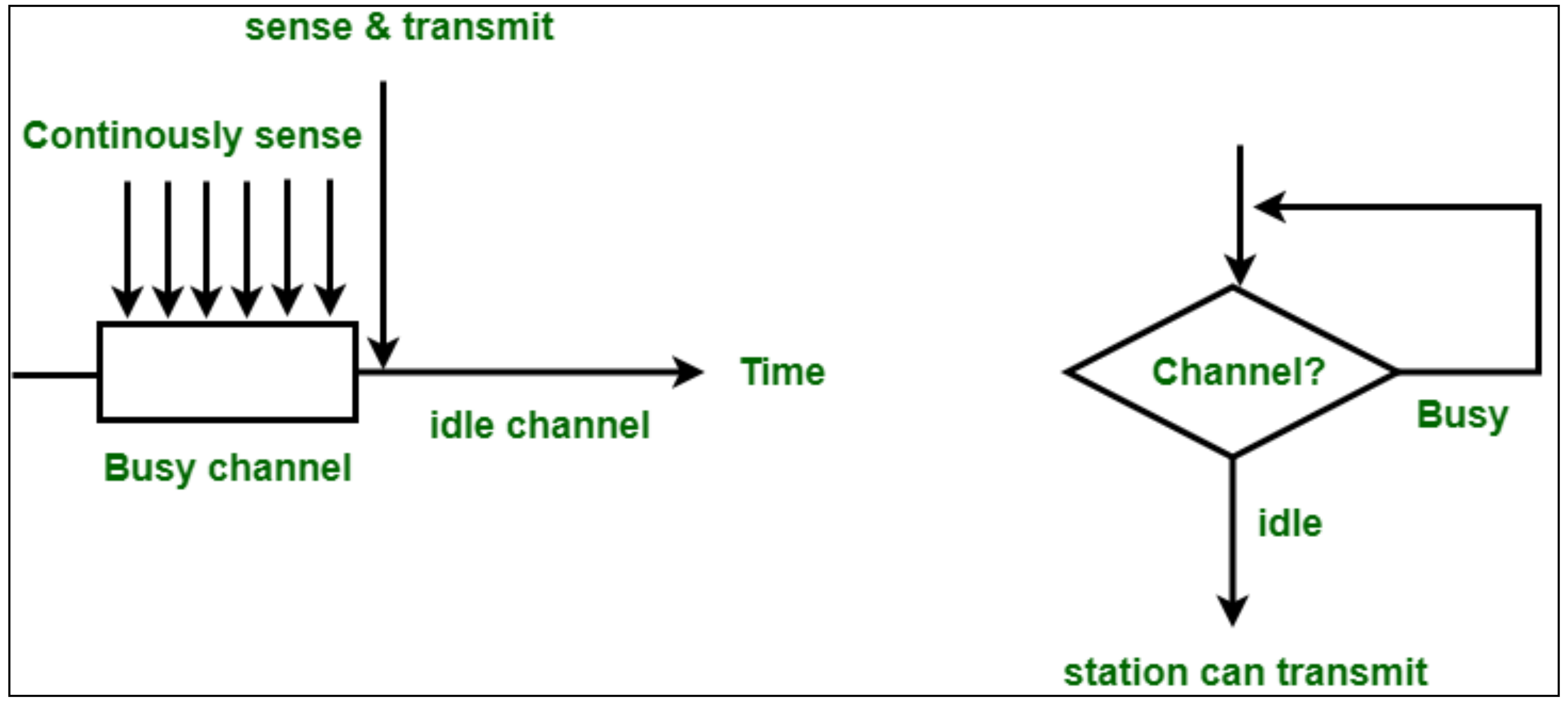
active scanning:
(1) Probe Request frame broadcast from H1
(2) Probe Response frames sent from APs
(3) Association Request frame sent: H1 to selected AP
(4) Association Response frame sent from selected AP to H1

CSMA

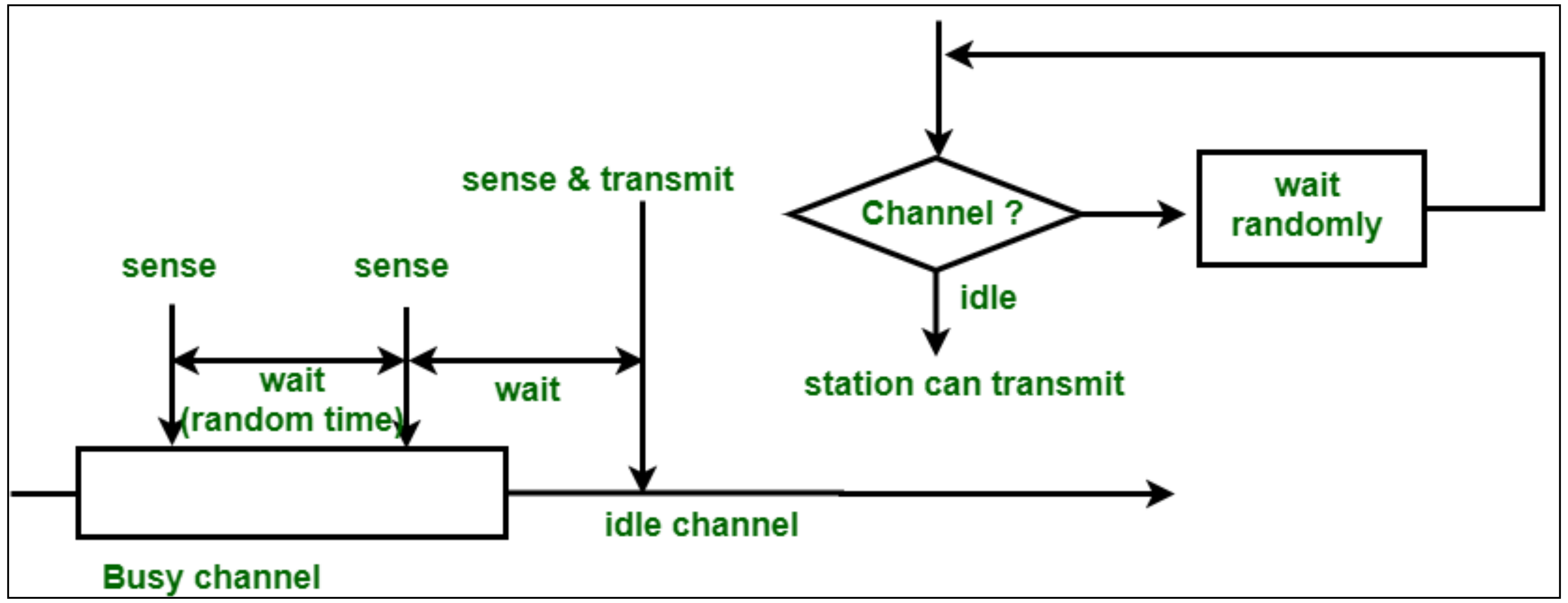
- CSMA (Carrier Sense Multiple Access):
- Listen before transmit
  - If channel sensed idle: transmit entire frame.
  - If channel sensed busy, defer transmissions.
- Analogous to humans (don’t interrupt others)

CSMA

- Different variations including :
  - **1-persistent** : aggressive transmission algorithm.
    - If idle, transmit immediately
    - If busy, keep sensing continuously until channel becomes idle.



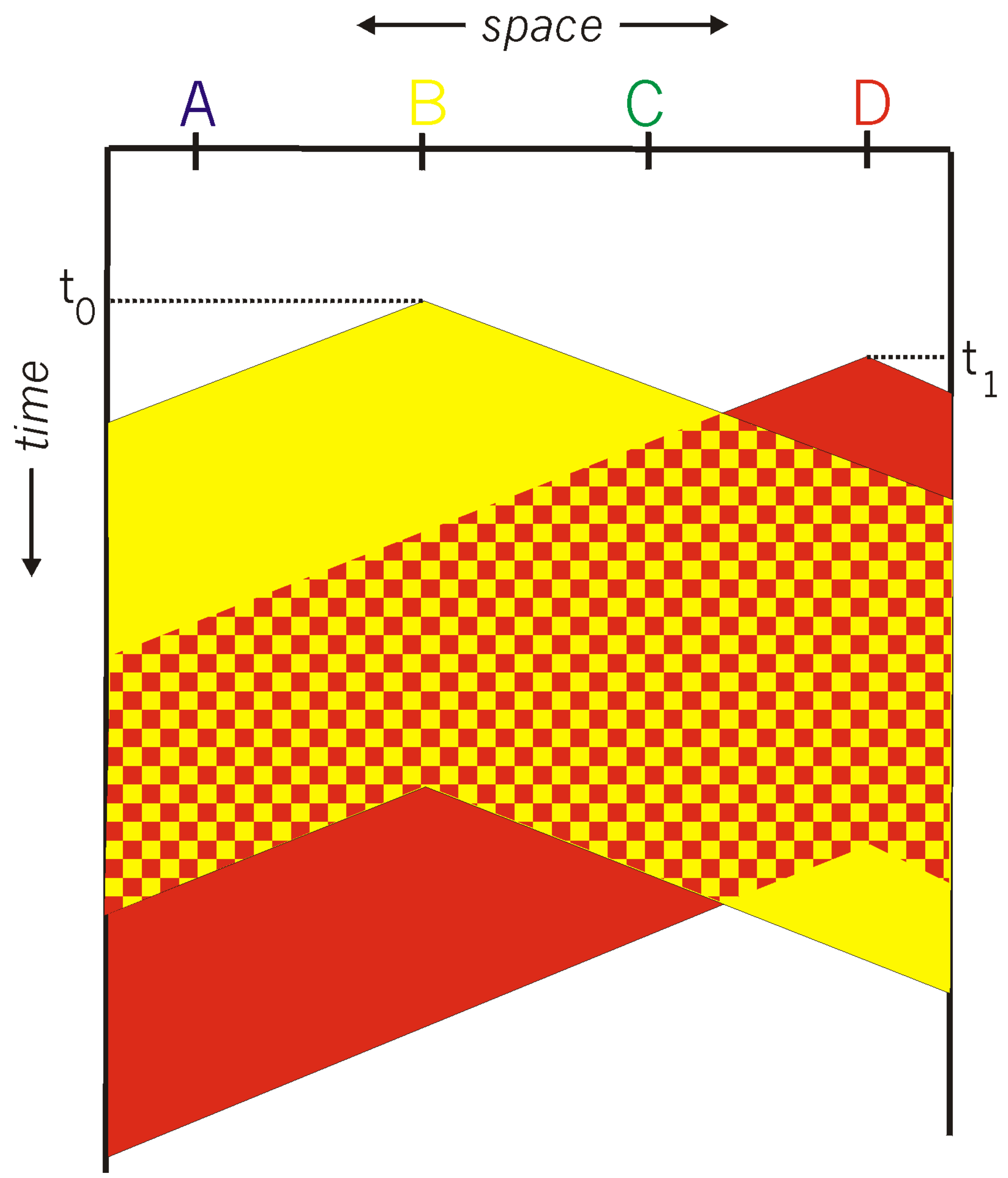
- **Non-persistent:**
  - If busy, wait for a random period of time, then repeat.
  - If idle transmit immediately.



CSMA

- Collision can still occur.
  - Propagation delays means two node may not hear each other's transmission immediately.

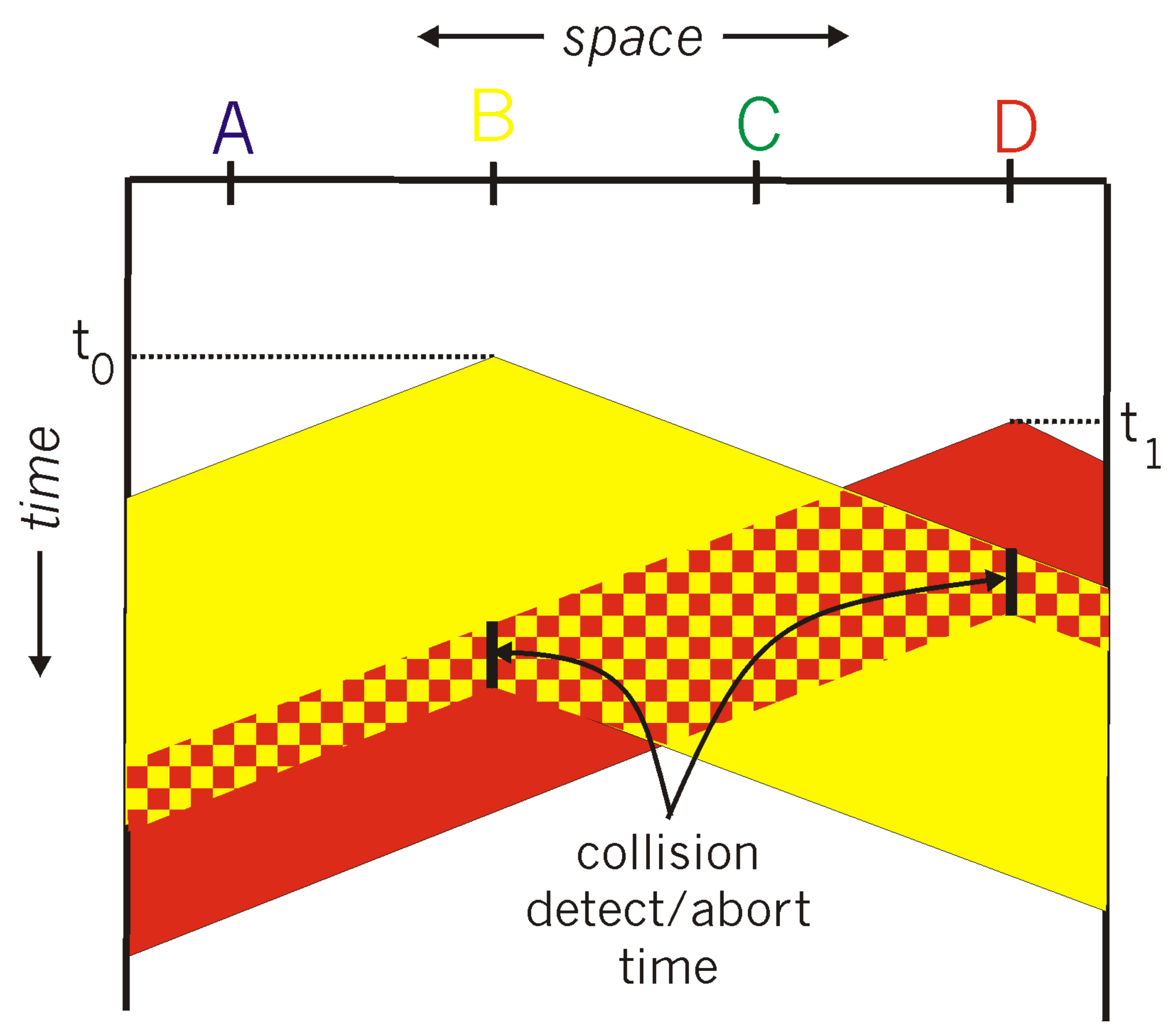
- Collision causes an entire packet transmission to be wasted.



CSMA / CD

CSMA (Carrier Sense Multiple Access / Collision Detection):

- Used in Ethernet networks.
  - If channel is sensed idle, then start transmission immediately.
  - If channel is sensed busy, the keep listening until it becomes idle then transmit.
  - While transmitting, keep listening for any collision, collision can be detected after a short time period.
  - Once collision detected at a sender, the sender will abort transmissions to reduce the channel wastage time.
  - Each sender will backoff using "*binary exponential backoff*" before re-attempt transmission.



CSMA / CD

- **Binary exponential backoff algorithm**
  - After the first collision, wait for 0 or 1 “slot time” period before retrying.
  - After the second collision, wait for 0, 1, 2, or 3 “slot times” before retrying.
  - After the n^{th} collision, wait for a number of slot times = k where is a random integer between 0 and $2^n - 1$
  - After 10 collisions, the wait time value then remains the same for 6 further attempts
  - After 16 unsuccessful attempts, station gives up and reports error

CSMA / CD

❖ **Binary exponential backoff algorithm**

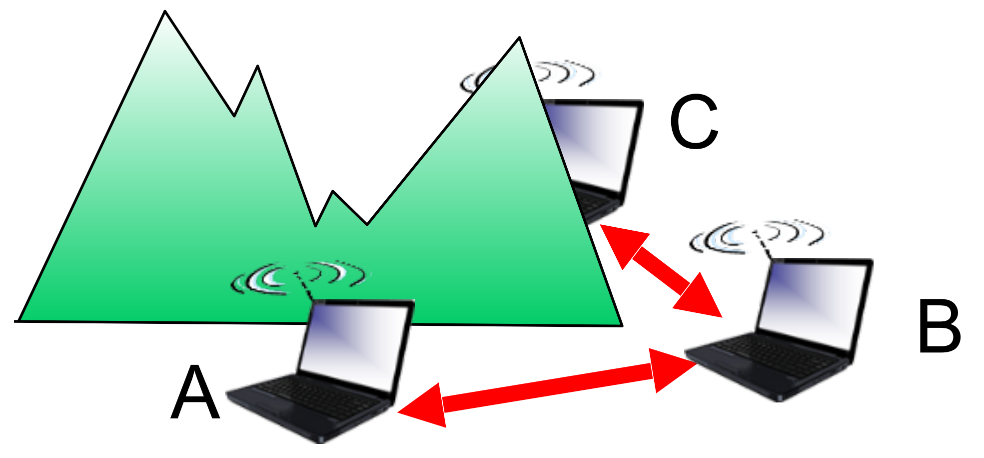
- Slot time = the times it takes to send 1 data frame on the medium.
  i.e. when frame size = 512bits and link speed is 10 Mbit/s, then
  slot time = 51.2 micro second.
- When congestion increases, stations will back off by larger amounts of time to reduce the probability of collision.
- After a maximum number of collisions, transmission is aborted.

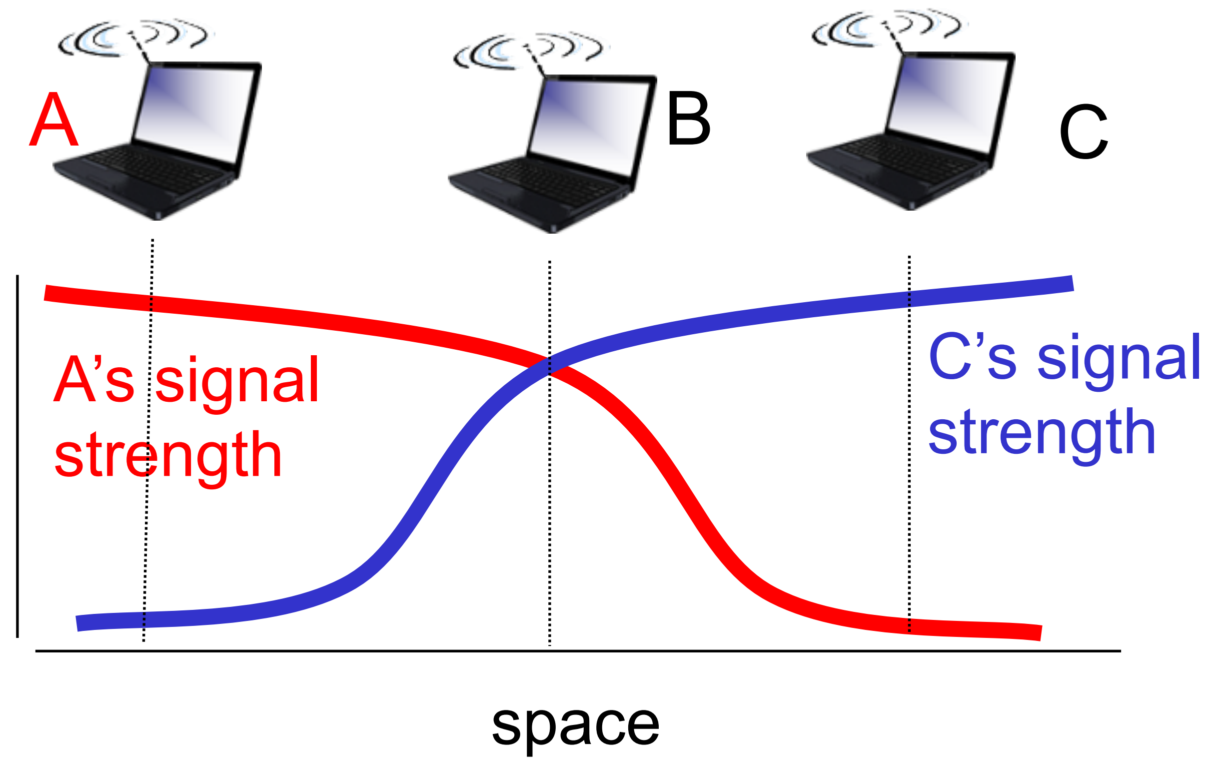
CSMA / CD

Unfortunately, collision detection can not be applied in wireless networks.

IEEE 802.11: multiple access

- 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





IEEE 802.11 MAC Protocol: CSMA/CA

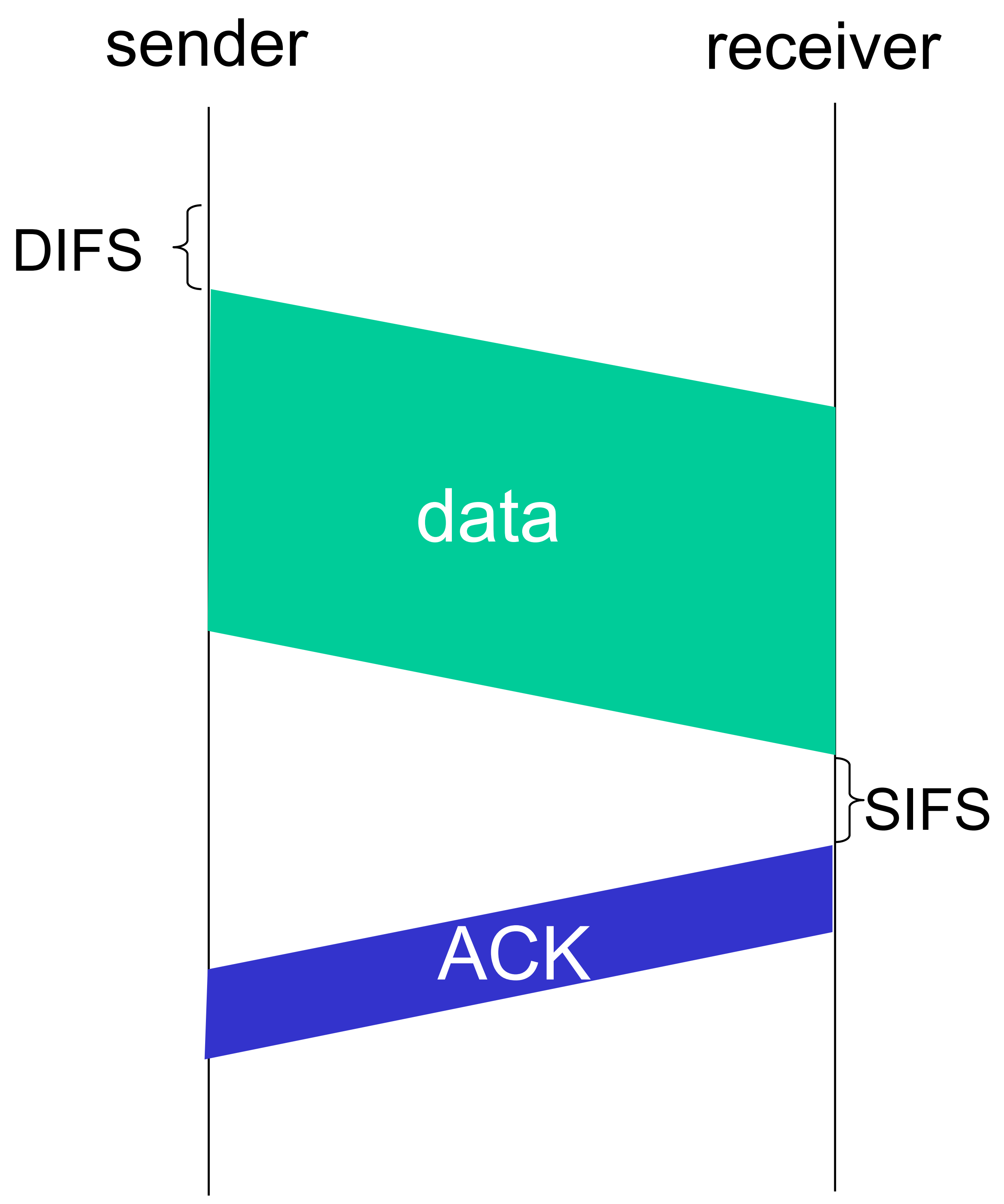
goal: avoid collisions: CSMA/C(ollision)A(voidance)

Sender transmits the entire data frame, and then start a timer to wait for ACK to be sent by receiver after SIFS interval.

What will happen if collusion occur ?

- No ACK will mean that the frame was corrupted.

In wireless network, there is a non-eligible chance of delivery failure while sending a frame to destination.



IEEE 802.11 MAC Protocol: CSMA/CA

goal: avoid collisions: CSMA/C(ollision)A(voidance)

Distributed Coordination Function (DCF)

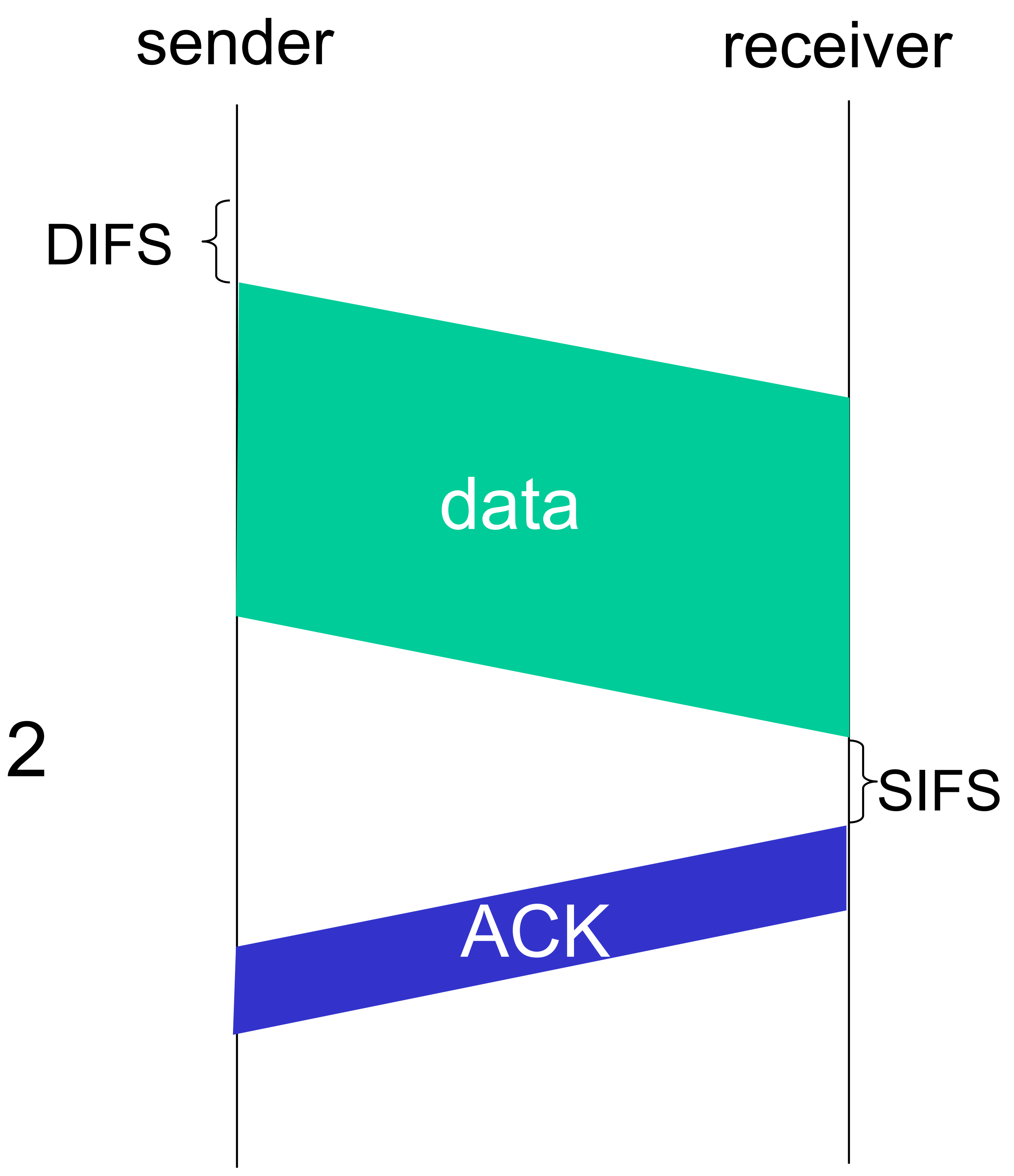
1 if sense channel idle for **DIFS** then
   transmit entire frame (no CD)

2 if sense channel busy then
   Pick a random backoff value using binary exponential timer.
   - Counter counts down while channel idle for DIFS
   - Counter is frozen when channel is busy
   - transmit when timer expires and wait for ACK.
 - if no ACK received, increase random backoff interval, repeat 2
 - If ACK received, reset the counter to 1

802.11 receiver

- if frame received OK

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



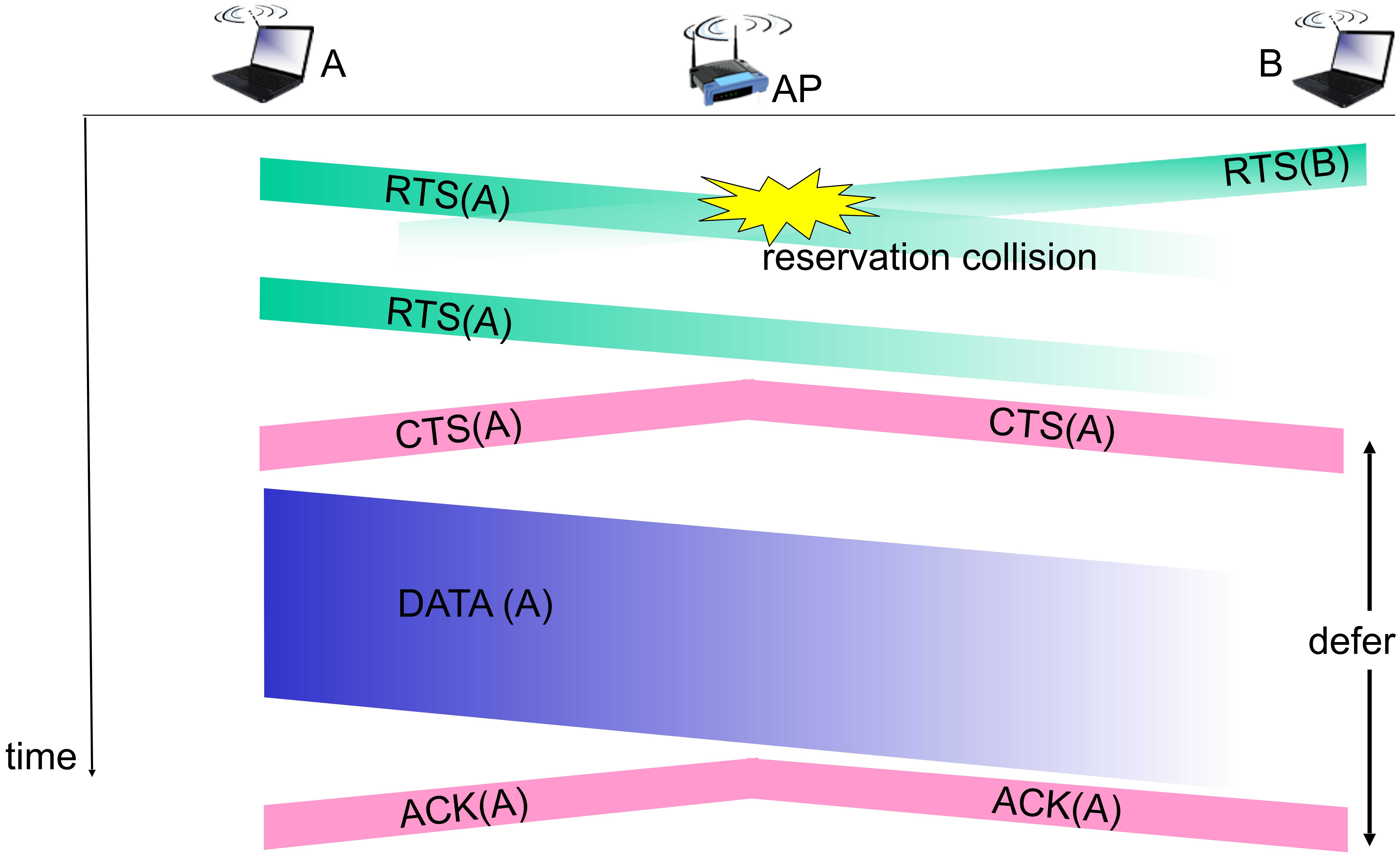
Avoiding collisions (more)

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

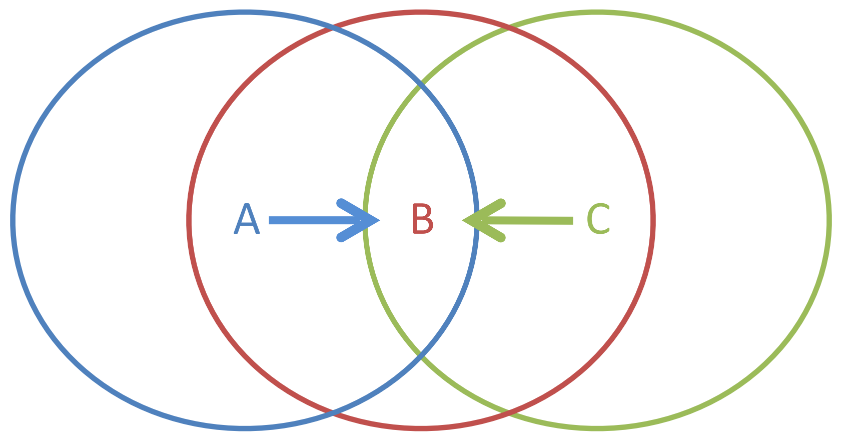
avoid data frame collisions completely using small reservation packets!

Collision Avoidance: RTS-CTS exchange



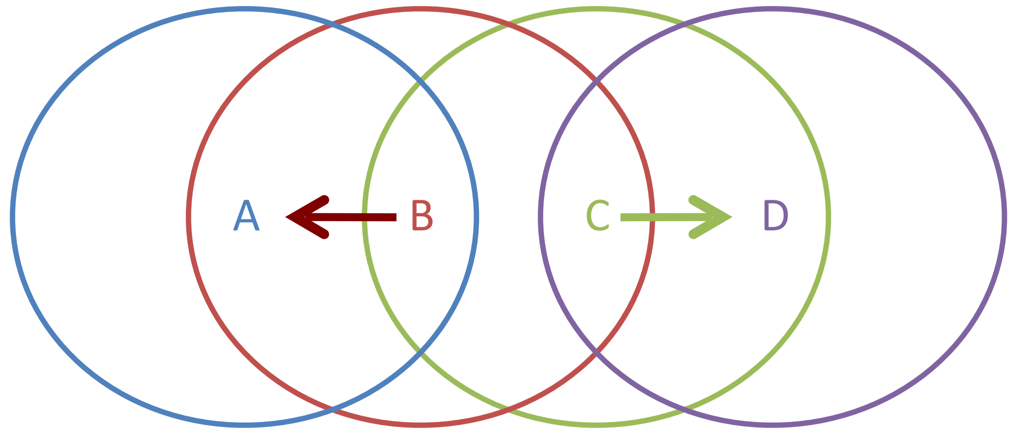
Solving Hidden Terminal Problem

- A and C cant see each other, both send to B



- RTS/CTS can help
  - Both A and C would send RTS that B would see first
  - B only responds with one CTS (say, echoing A's RTS)
  - C detects that CTS doesn't match and wont send

Exposed Terminal Problem



- B sending to A, C wants to send to D
- As C receives packets, carrier sense would prevent it from sending to D, even though wouldn't interfere
- RTS/CTS can help
  - C hears RTS from B, but not CTS from A
  - C knows its transmission will not interfere at B's receiver
  - C is safe to transmit to D