Ethernet CSMA/CD algorithm

1. NIC receives datagram from network layer, creates frame
2. If NIC senses channel:

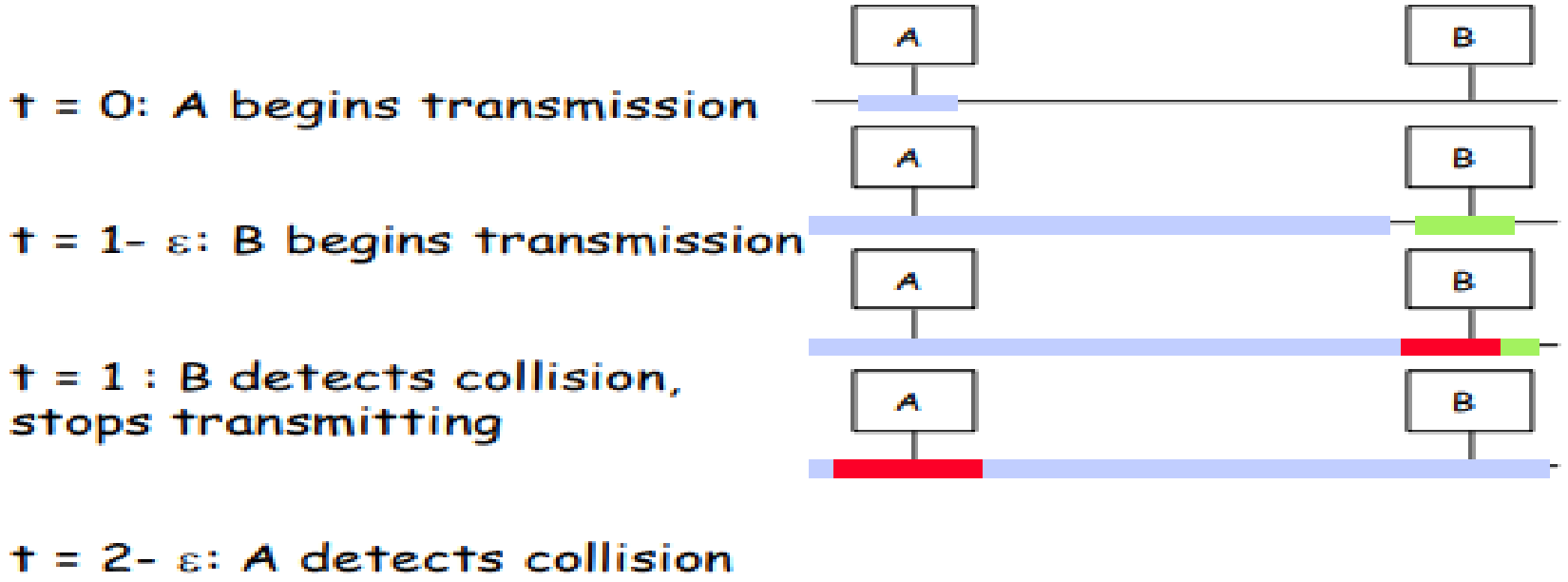
   if idle: start frame transmission.

   if busy: wait until channel idle, then transmit
3. If NIC transmits entire frame without collision, NIC is done with frame !
4. If NIC detects another transmission while sending: abort, send jam signal
5. After aborting, NIC enters *binary (exponential) backoff:*
   - after *m*th collision, NIC chooses *K* at random from $\{0,1,2, \ldots, 2^m-1\}$. NIC waits $K \cdot 512$ bit times, returns to Step 2
   - more collisions: longer backoff interval

Minimum Packet Size

- Why enforce a minimum packet size?
- Give a host enough time to detect collisions
- In Ethernet, minimum packet size = 64 bytes (two 6-byte addresses, 2-byte type, 4-byte CRC, and 46 bytes of data)
- If host has less than 46 bytes to send, the adaptor pads (adds) bytes to make it 46 bytes
- What is the relationship between minimum packet size and the length of the LAN?

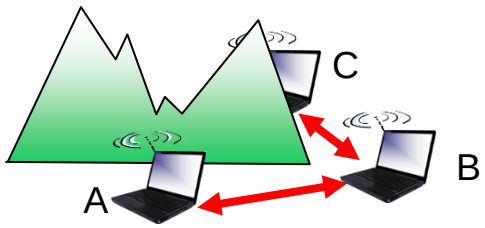
Minimum Frame Size

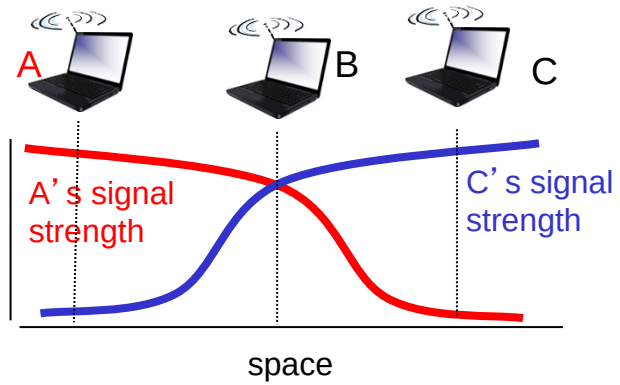


- a minimum frame size equal to number of bits transmitted during one round trip is required to detect all collisions.
- Min ethernet frame size is 512 bits i.e., 64 bytes for 10Mbps/100Mbps (51.2us at 10Mbps)
- 512 bytes for 1000Mbps (Why Increased?)
- LAN Cable length = Speed of light (in twisted/coax/fiber) * time to transmit minimum frame size/2
- LAN length = (min_frame_size)*(light_speed)/(2*bandwidth)

IEEE 802.11 (Wi-Fi): 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

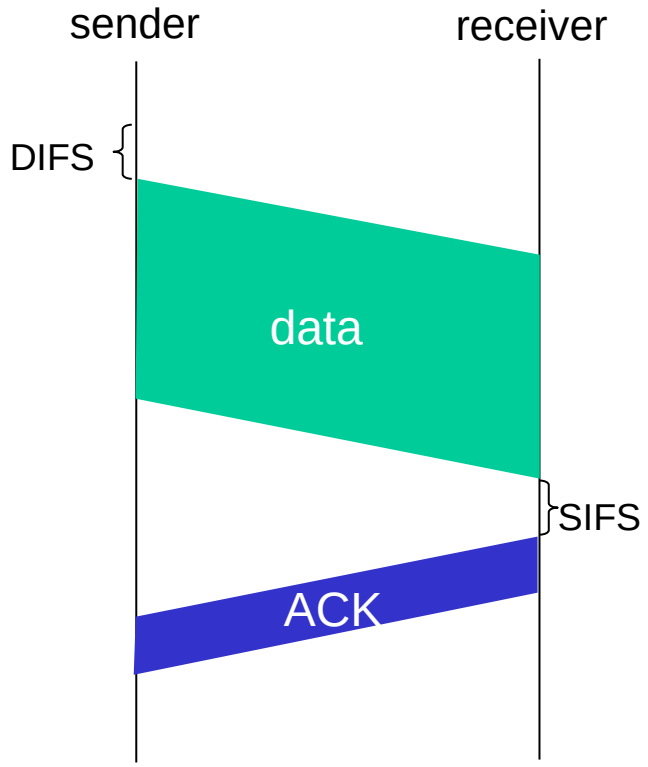
802.11 sender

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)



CSMA/CA timers
Short InterFrame Spacing (SIFS)
Distributed InterFrame Spacing (DIFS) *Larger than SIFS, to give ACK priority over data*

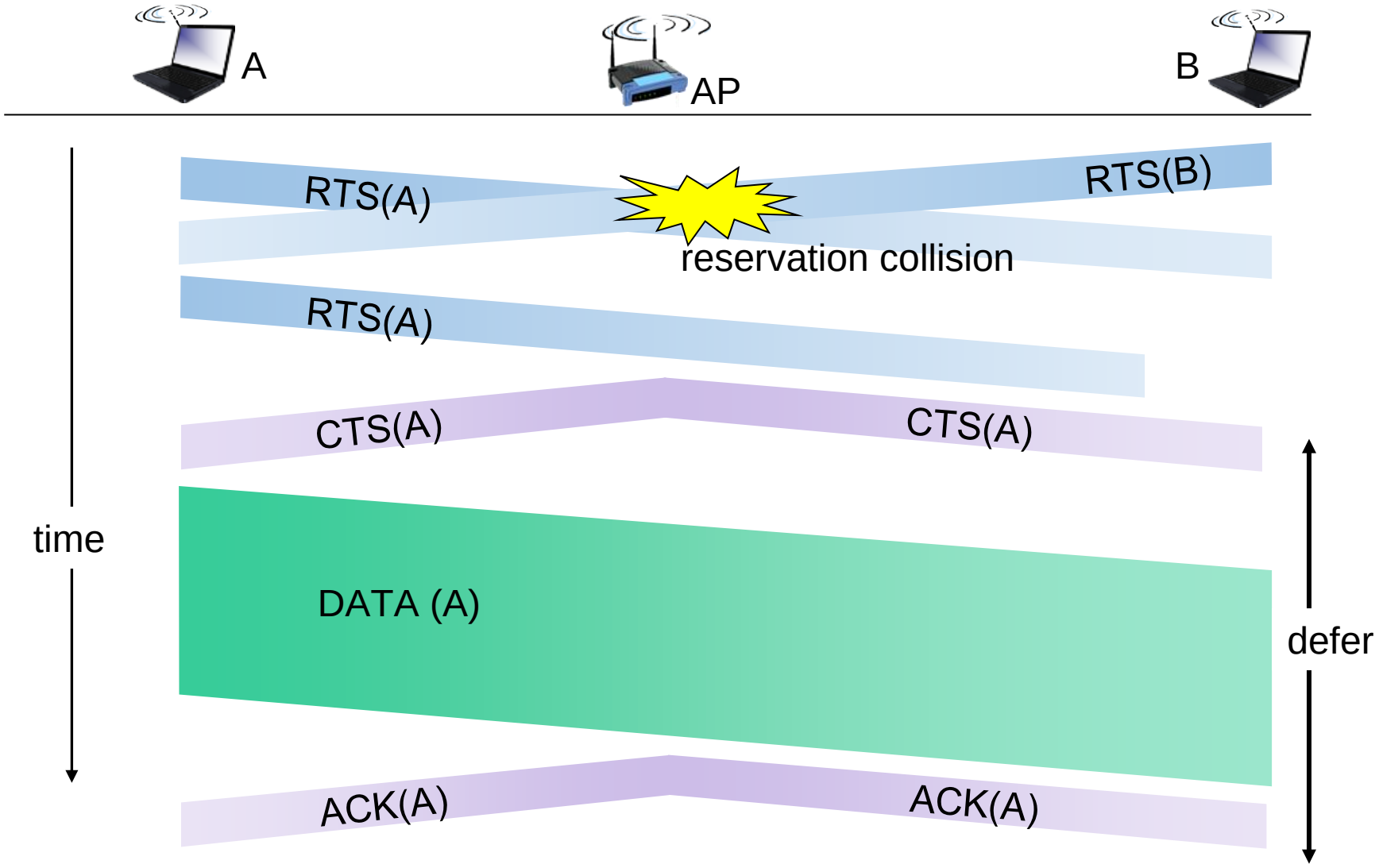
Avoiding collisions (more)

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

- sender first transmits *small* request-to-send (RTS) packet to AP using CSMA
  - RTSs may still collide with each other (but they're short)
- AP 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 using small reservation Frames!

Collision Avoidance: RTS-CTS exchange



Backoff - more complex example