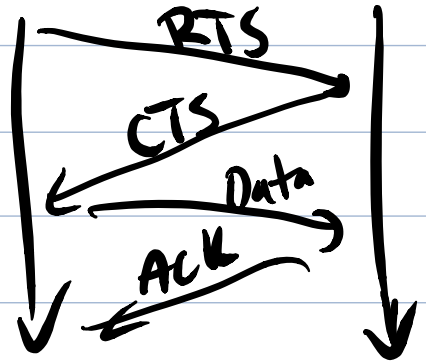
Wi-Fi (IEEE 802.11)

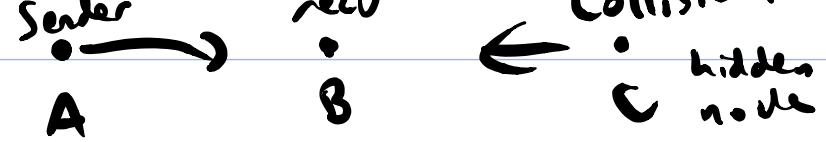
- **PCF**
  - AP → controller
- **DCF → CSMA/CA**
  - AP → normal node
    - w/ handshaking
      - decision: frame size
    - w/o handshaking
      - vs. RTS handshaking



WiFi problems:

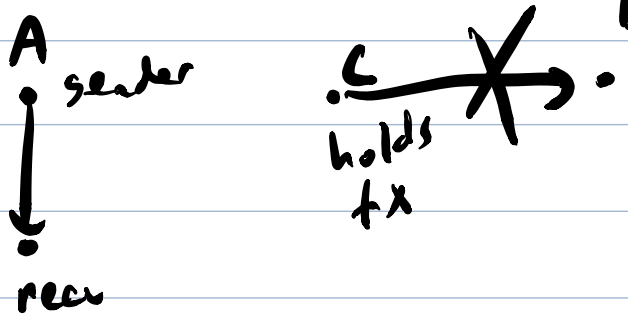
① Hidden terminal

sol^n: CSMA/CA



② Exposed terminal

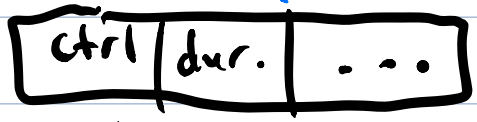
sol^n: None



CSMA/CA

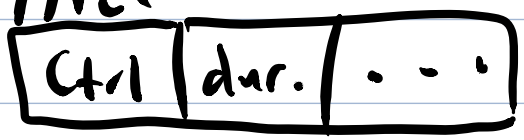
frame types ↗ Values in μseconds

RTS



20 bytes

CTS/Ack



14 bytes

Data

34 bytes overhead + data size

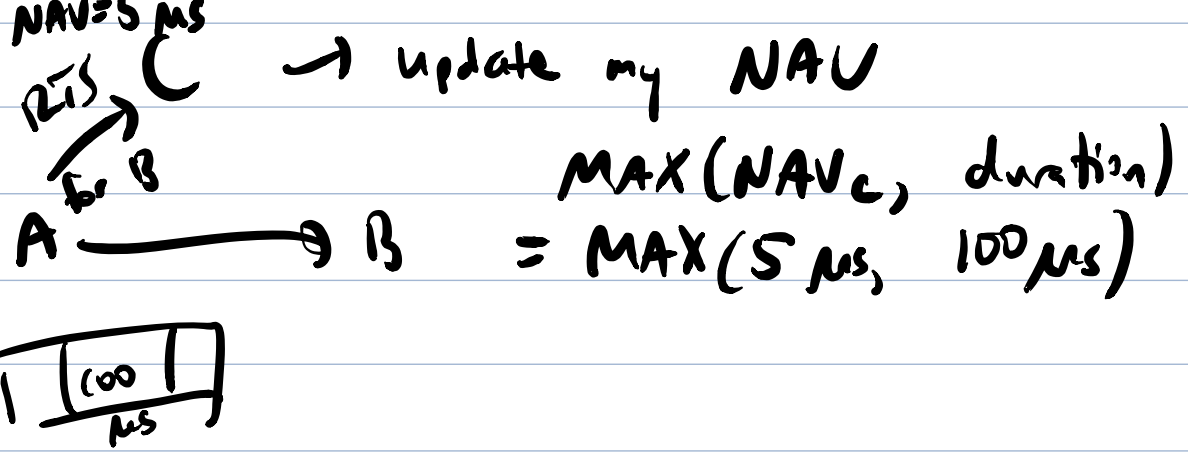
CSMA/CA collision avoidance:

- PHY-level carrier sensing in recv hardware
- Virtual carrier sensing (a MAC protocol concept)
  - int var in each node called NAV (Net. Allocation Vector) indicates hidden node likely to be txing now
    - NAV > 0 ⇒ most likely node txing
    - NAV = 0 ⇒ no one txing
    - NAV < 0 ⇒ does not occur

Tx cond: Medium idle @ recv

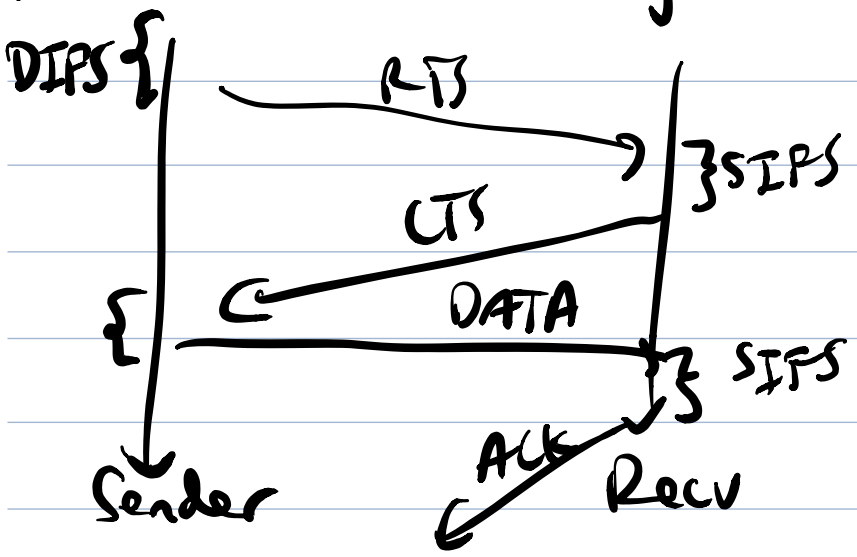
(Carrier absent) AND (NAV=0)

duration = reservation time for medium
all nodes that receive RTS & CTS (& DATA)
update their NAV as follows:
initially NAV = 0
With each passing μs:
  if (NAV > 0) NAV -= 1
  else stop decrementing NAV (ch. free)
If frame w/ duration received
  NAV = max(NAV, Duration)



802.11 MAC defines 4 timing intervals:
2 at PHY level:
- SIFS: Short Inter-Frame Space
  10 μs b/w successive frames (RTS, DATA, ACK...)
- a Slot 20 μs - max prop. thru delay
2 at MAC level
- PIFS: priority (in PCF) IFS = SIFS + aSlot
- DIFS: distributed IFS (= PIFS + aSlot)

DCF with handshaking:



PCF:

PIFS = SIFS + aSlot = 10 + 20 = 30 μs

time AP waits before polling any users

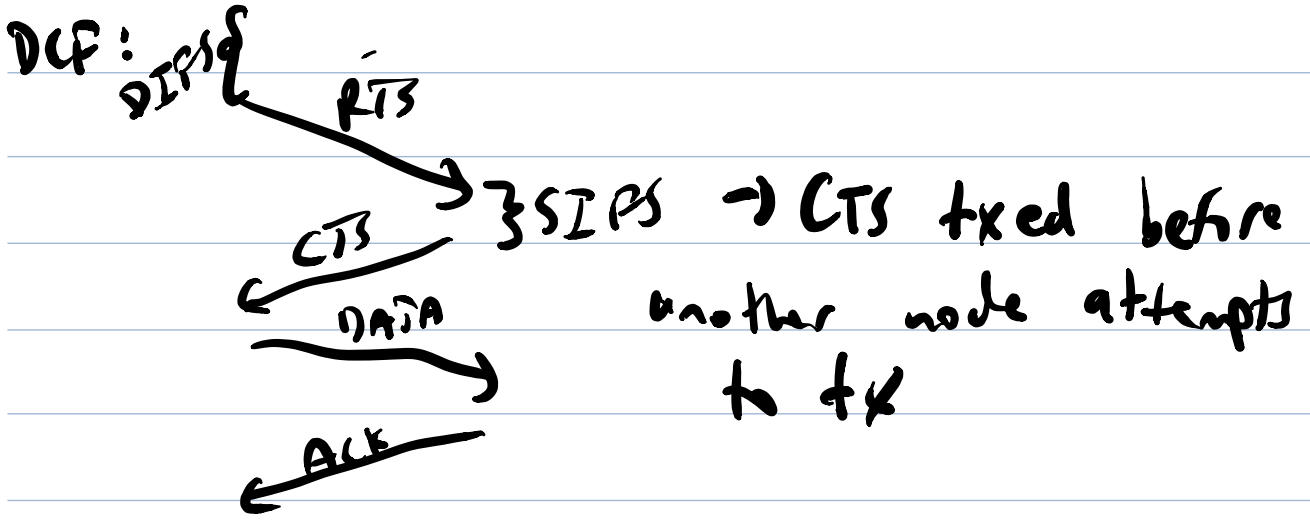
DIFS = PIFS + aSlot

= SIFS + 2aSlot = 10 + 2·20 = 50 μs

period any node has to wait before starting any tx (after tx conditions met)

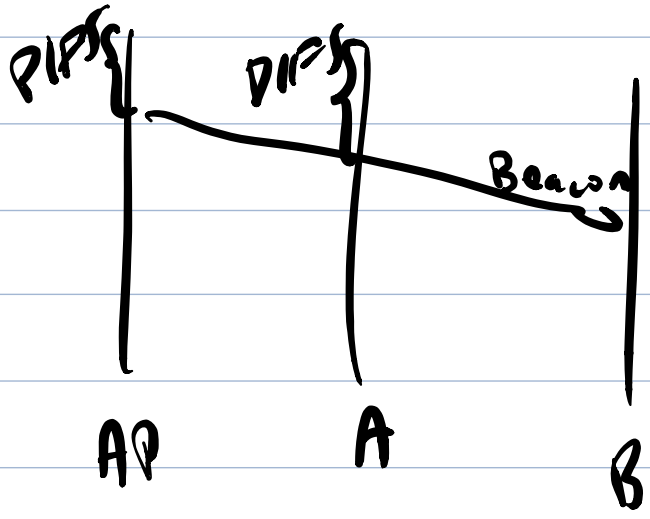
SIFS < PIFS < DIFS

DCF:



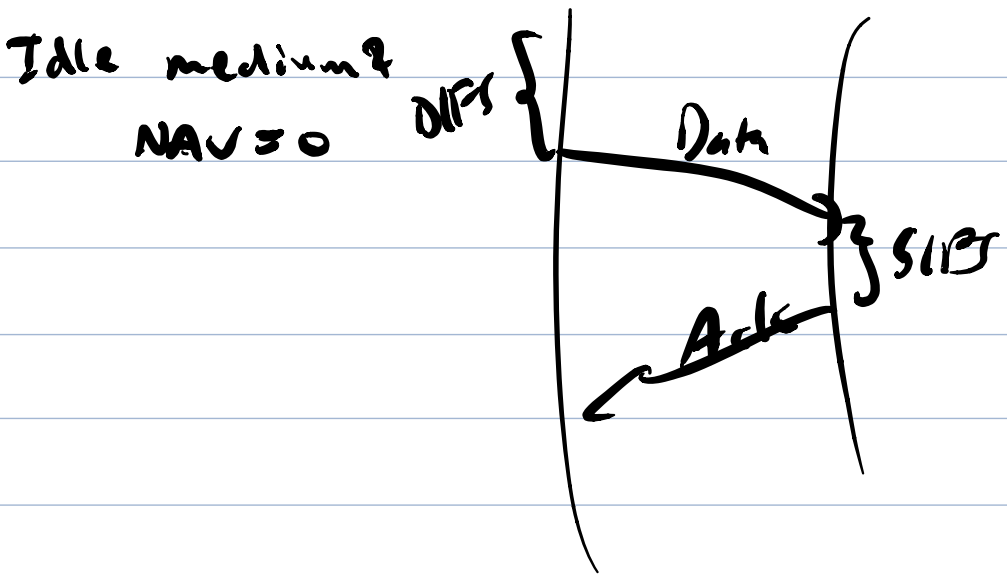
Why PIFS < DIFS?

- advantage when switching to PCF



DCF w/o Handshake

- still use NAV, special case of w/ handshake

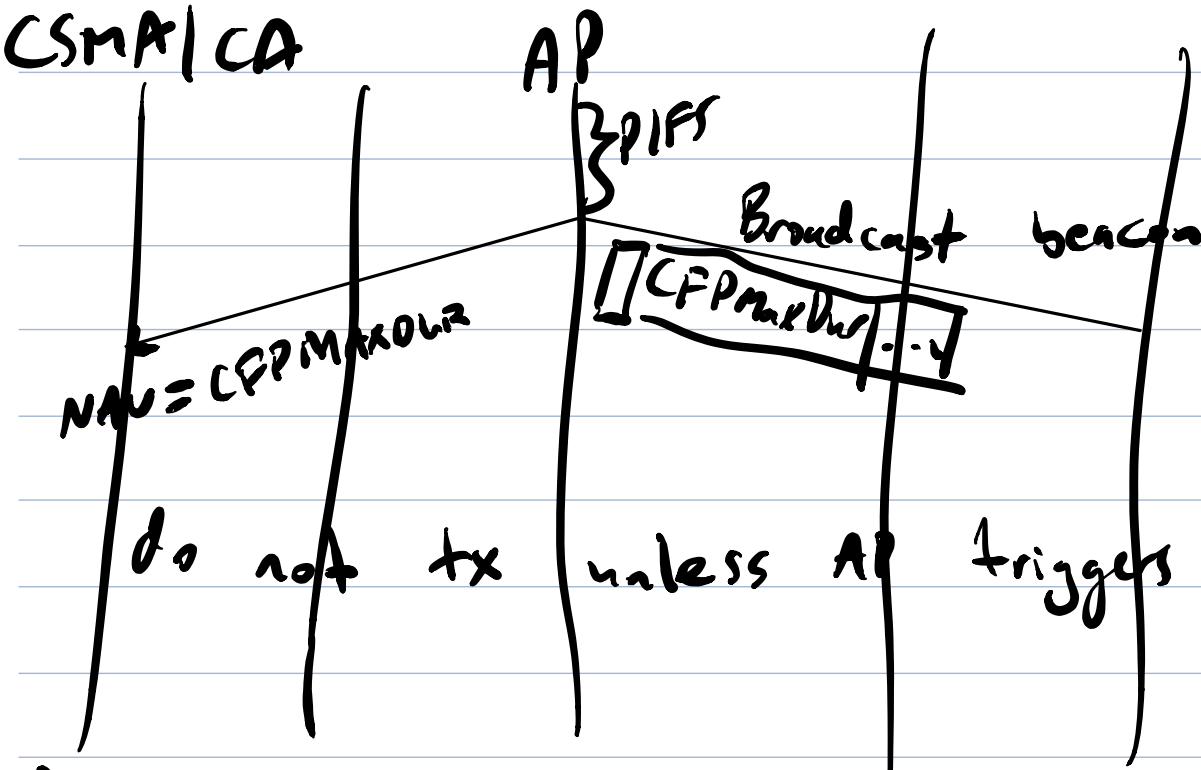


PCF Details

PIFS < DIFS ⇒ AP has priority

if medium idle & NAV=0 for PIFS, AP transmits beacon frame containing CFPMaxDuration field (contention-free period)

Nodes rcv beacon update their NAV to CFPMaxDur. ⇒ perceive medium busy for that time, do not tx until AP asks



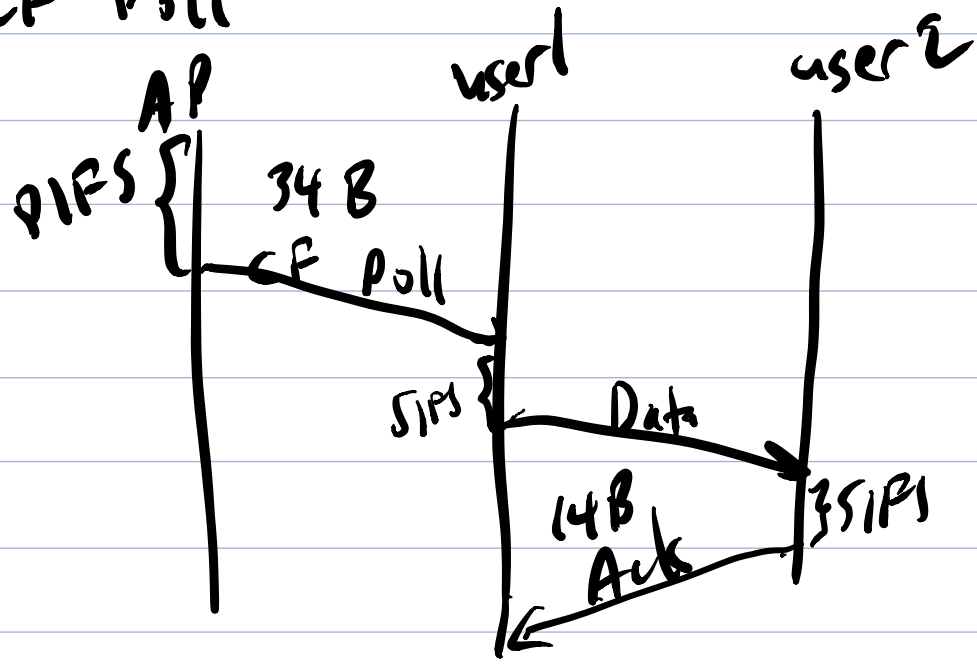
AP waits for PIFS before tx'ing one of the following:

- DATA
- CF Poll
- DATA + CF Poll
- Ack
- CF End (end of PCF Mode)
- ↳ DCF

-user has no data ⇒ send null DATA frame
-Ack not recvd ⇒ wait to be polled again

- No ACK for AP → nodes broadcast, only for unicast

CF Poll



tx delay for cycle = $PIFS + d_{tx}(CF\,Poll) + SIFS + d_{tx}(Data) + SIFS + d_{tx}(Ack)$

Upon CF End frame, recv nodes set NAV = 0, PCF mode → DCF Mode

Wi-Fi → 2.4 GHz → 85 MHz ↔ Europe: 13 ch. NA: only 11 ch.

- In Wi-Fi, there are 14 channels → each channel has a 22 MHz b/w
- The central frequency of 2 consecutive channels are 5 MHz
- Two channels are considered non-overlapping if they are separated by 4 or more channels

- The only set of 3 non-overlapping channels are {1, 6, 11}