IEEE 802.11 MAC

$\longrightarrow$ CSMA/CA with exponential backoff

$\longrightarrow$ almost like CSMA/CD

$\longrightarrow$ drop CD

$\longrightarrow$ CSMA with explicit ACK frame

$\longrightarrow$ added optional feature: CA (collision avoidance)

Two modes for MAC operation:

- Distributed coordination function (DCF)

  $\rightarrow$ multiple access

- Point coordination function (PCF)

  $\rightarrow$ polling-based priority

... neither PCF nor CA used in practice

CSMA: (i) explicit ACK and (ii) exponential backoff

Sender:

- MAC (firmware in NIC) receives frame from upper layer (i.e., device driver)

- Goto `Backoff` procedure

- Transmit frame

- Wait for ACK

- If timeout, goto `Backoff` procedure

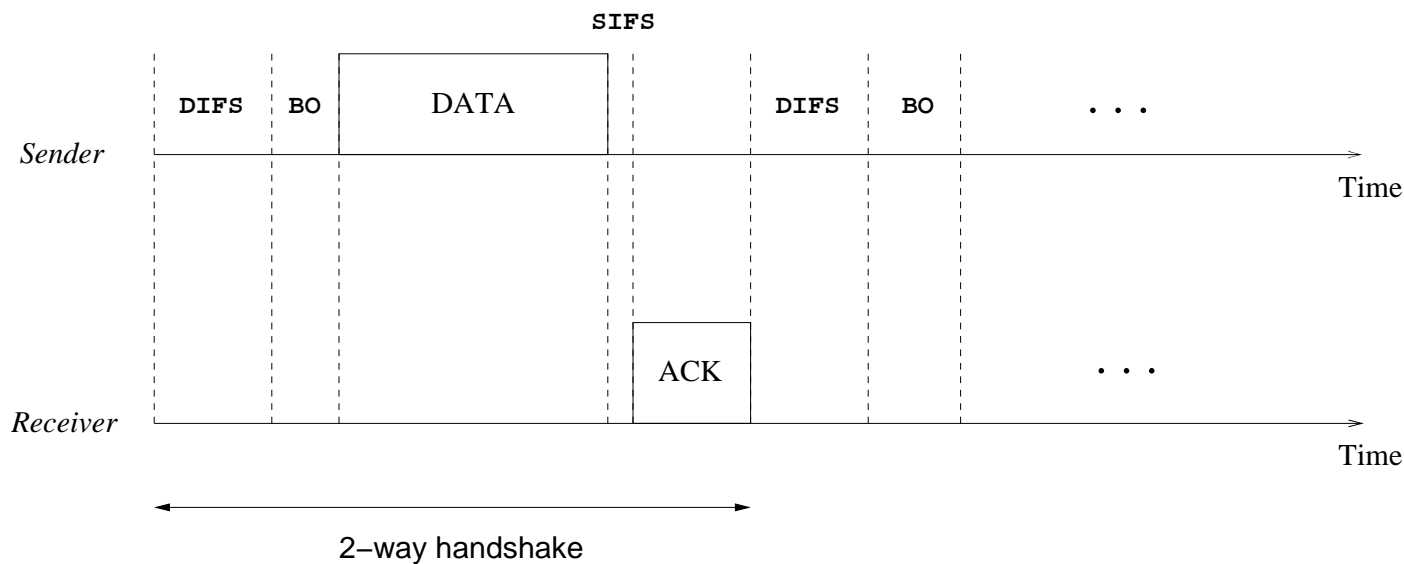Receiver:

- Check if received frame is ok

- Wait for SIFS

- Transmit ACK

`Backoff`:

- If due to timeout, double contention window (`CW`)

- Else wait until channel is idle plus an additional DIFS

- Choose random waiting time between $[1, \texttt{CW}]$

  $\rightarrow$ `CW` is in units of slot time

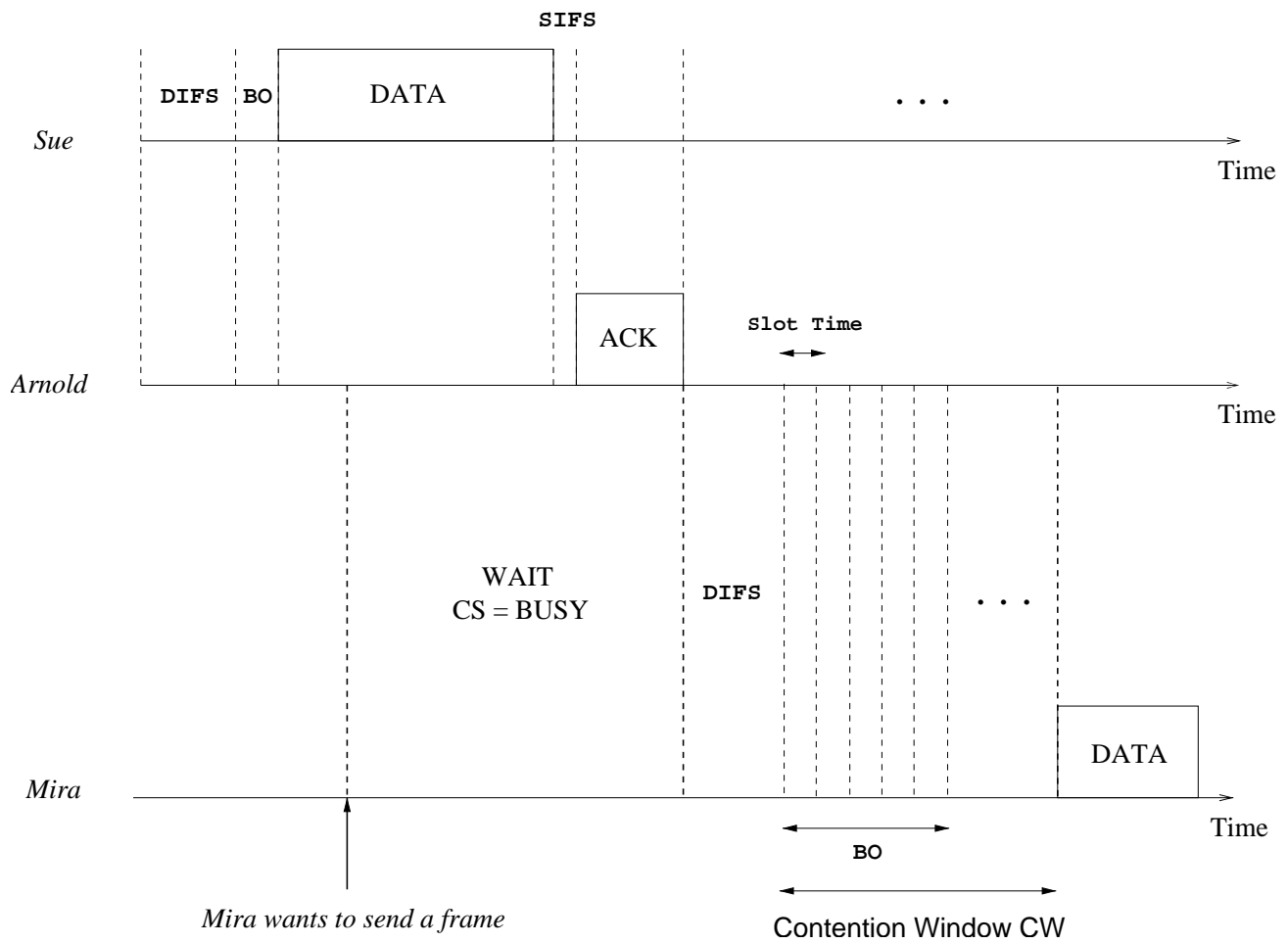- Decrement `CW` when channel is idle
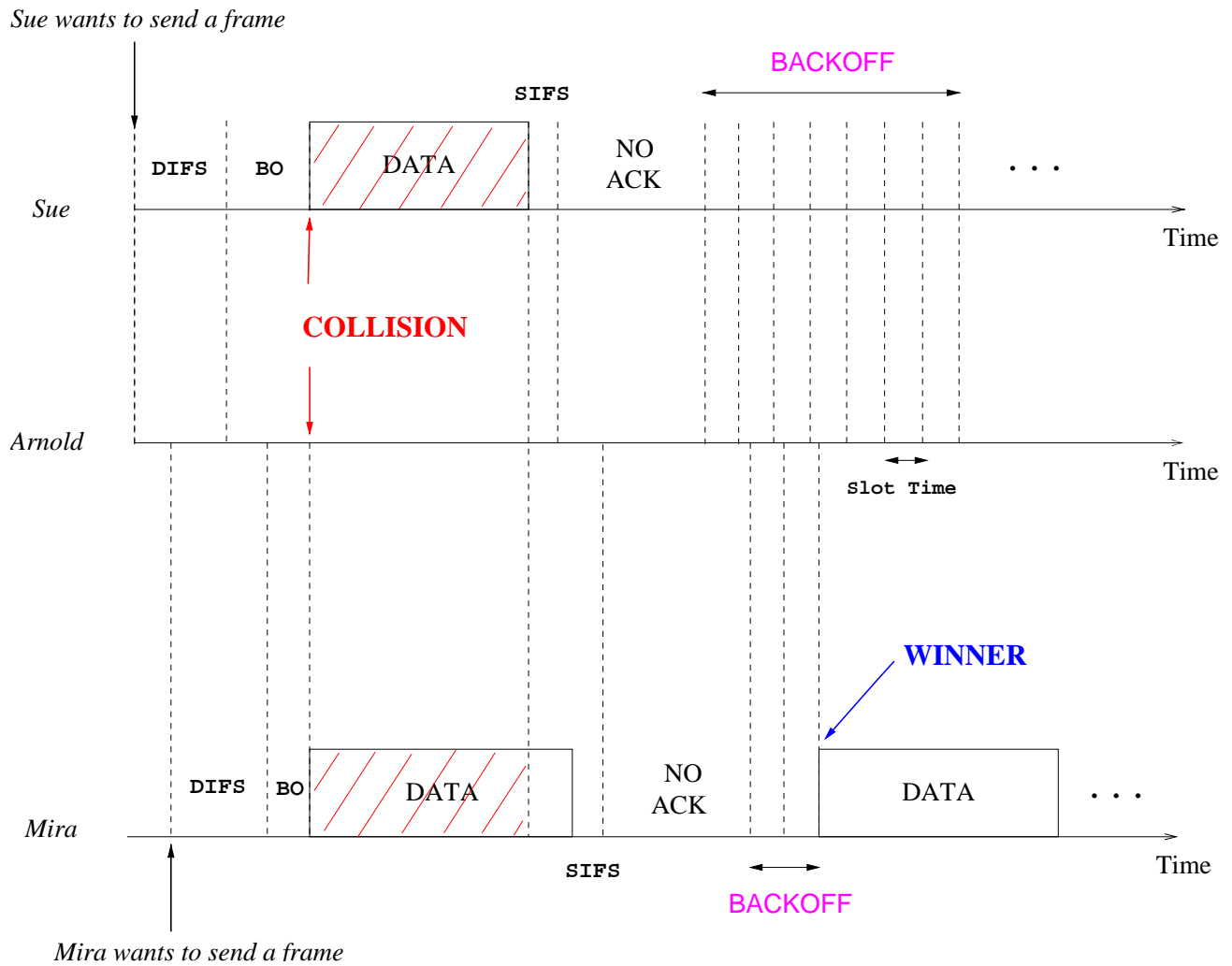
- Return when $\texttt{CW} = 0$

Timeline without collision:

- SIFS (short interframe space): 10 μs

- Slot Time: 20 μs

- DIFS (distributed interframe space): 50 μs

  $\rightarrow$ DIFS = SIFS + 2 $\times$ slot time

- BO: variable back-off (within one `CW`)

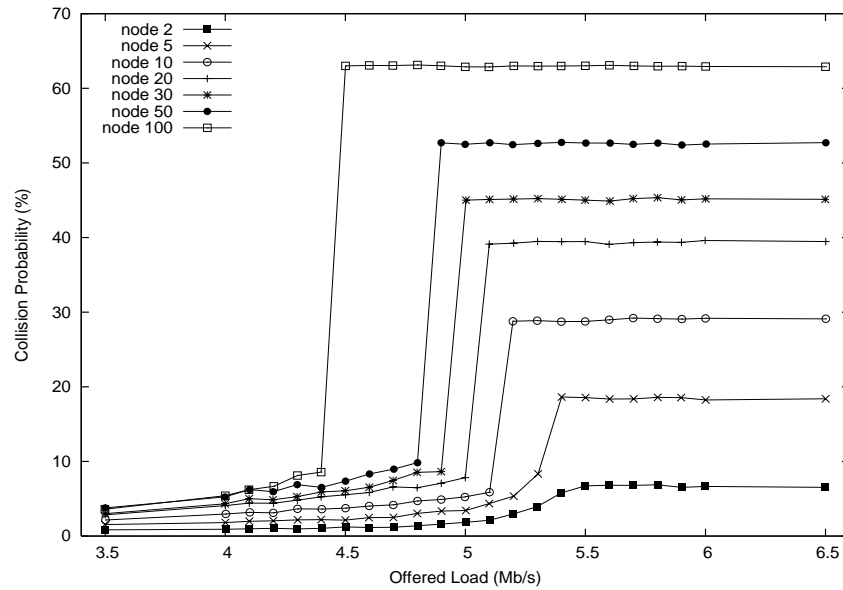 $\rightarrow$ `CWmin`: 31; `CWmax`: 1023

Time snapshot with Mira-come-lately:

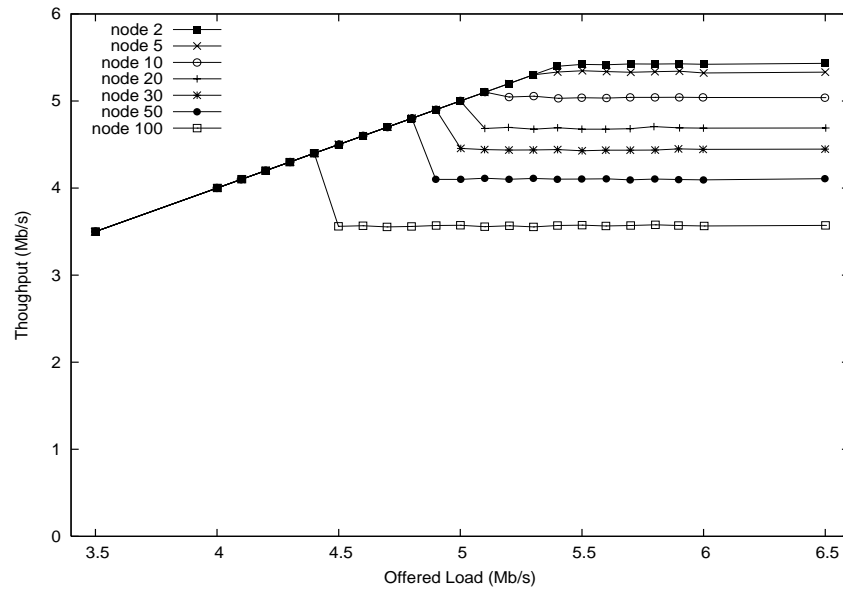$\longrightarrow$ Sue sends to Arnold

SIFS

| DIFS | BO | DATA |

Sue   . . .   Time

ACK

Slot Time

Arnold   Time

WAIT
CS = BUSY

DIFS

. . .

DATA

Mira   Time

Mira wants to send a frame

BO

Contention Window CW

Time snapshot with collision (Sue & Mira):

Sue wants to send a frame

BACKOFF

SIFS

DIFS | **BO** | DATA | NO ACK | . . .

Sue

Time

COLLISION

Arnold

Time

Slot Time

WINNER

DIFS | **BO** | DATA | NO ACK | DATA | . . .

Mira

Time

SIFS
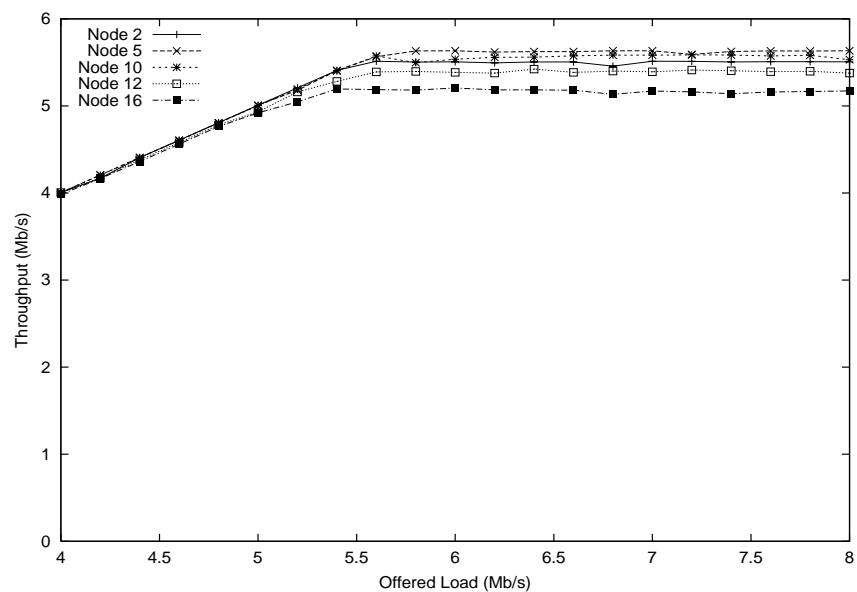
BACKOFF

Mira wants to send a frame

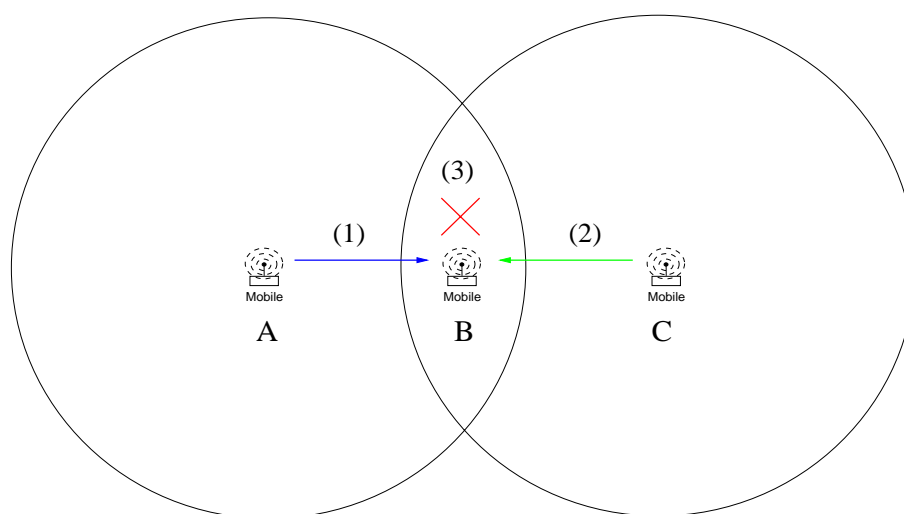# MAC throughput and collision (ns simulation):

MAC throughput:

⟶ experiment: iPAQ running Linux
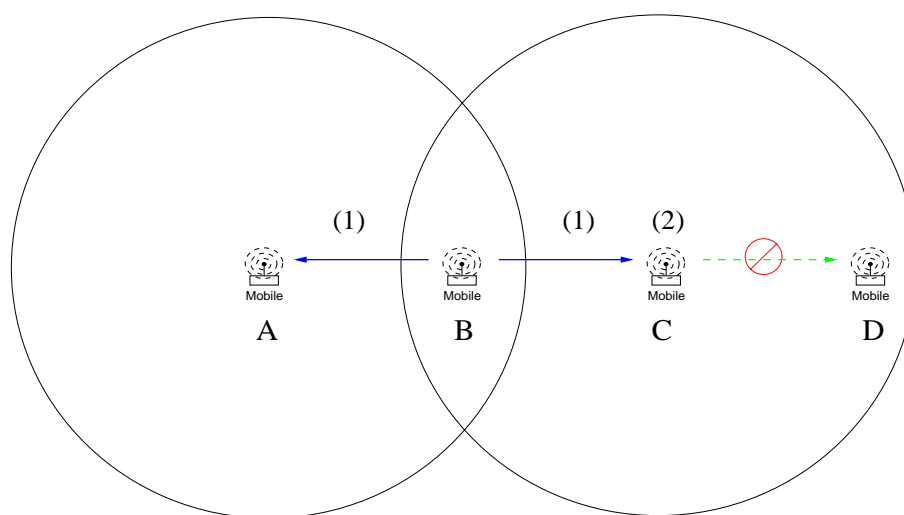
Additional issues with CSMA in wireless media:

Hidden station problem:

Hidden Station Problem

(1) A transmits to B

(2) C does not sense A; transmits to B

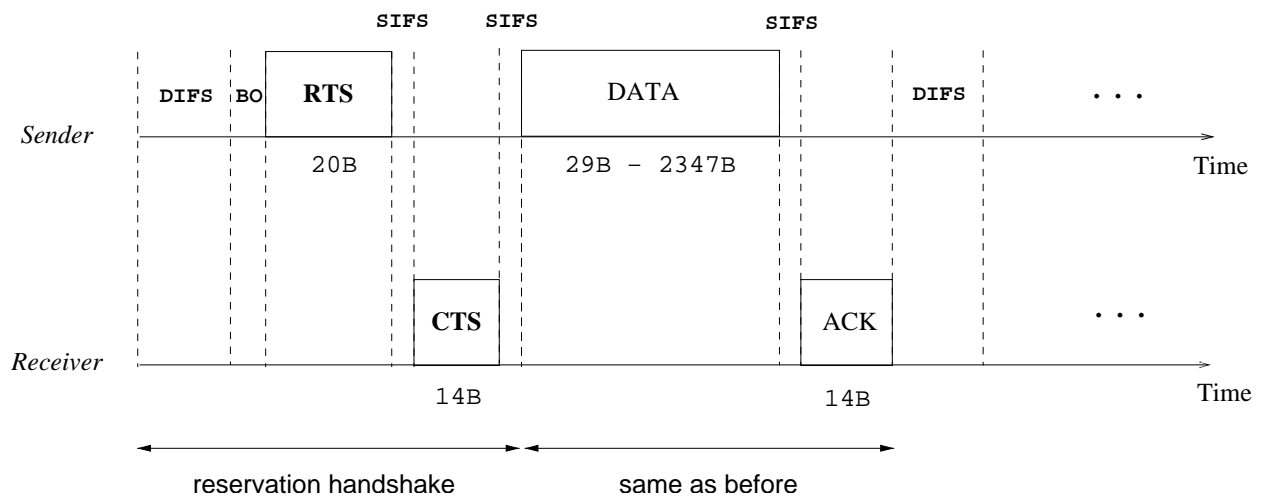(3) interference occurs at B: i.e., collision

Exposed station problem:

Exposed Station Problem

(1) B transmits to A

(2) C wants to transmits to D but senses B

$\rightarrow C$ refrains from transmitting to D

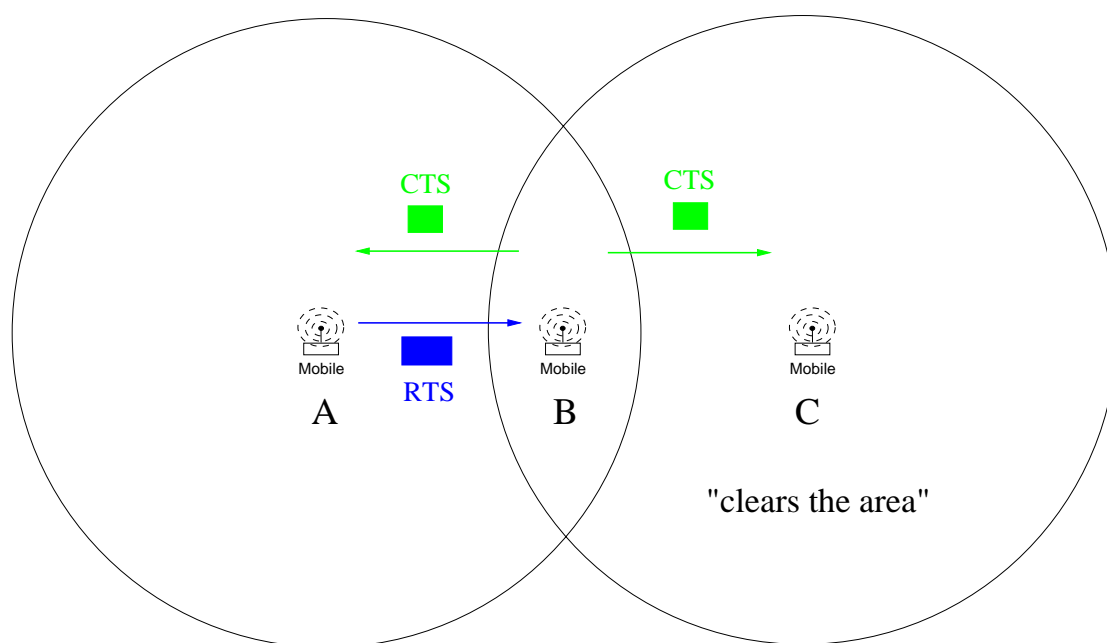$\rightarrow$ omni-directional antenna

Solution: CA (congestion avoidance)

$\longrightarrow$ RTS/CTS reservation handshake

• Before data transmit, perform RTS/CTS handshake

• RTS: request to send

• CTS: clear to send

Hidden station problem: RTS/CTS handshake "clears" hidden area

CTS   CTS

Mobile   Mobile   Mobile

A   RTS   B   C

"clears the area"

RTS/CTS Handshake

RTS/CTS perform only if data > RTS threshold

    ⟶   why not for small data?

... feature available but not actively used