CS311: Data Communication

Medium Access Control - II

by

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Outline of the lecture

- Random Access MAC
  - CSMA [Kleinrock and Tobagi, 1975]
  - CSMA/CA [Colvin 1983]
  - MACA [Karn 1990]
  - MACAW [Bharghavan et al. 1994]
- Controlled MAC
- Channelization MAC
  - CDMA

Collision Avoidance (CA)

- Collision Detection is not useful in wireless networks
- Why??
  - In wireless, send power (generally around 100mW) and receive sensitivity (commonly around 0.01 to 0.0001mW)
  - The sending would cover up any possible chance of receiving a foreign signal, no chance of "Collision Detection“
  - So, wireless transceivers can't send and receive on the same channel at the same time

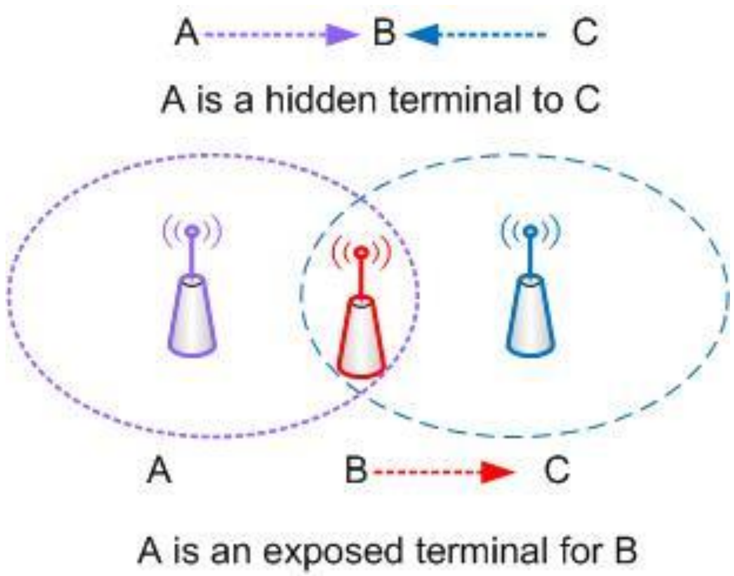
  - But, in wired networks (like Ethernet) the voltage is around 1 to 2.5v; sending and receiving are roughly same voltage
  - Let, sending a 2.5v signal, and someone else collides with a 2.5v signal; so receive signal would be around 5v.

  - Further, the adapter not able to detect all collision due to signal obstruction and fading

- So, Collision Avoidance was proposed

MACA

- CSMA protocol frequently suffers from hidden terminal and exposed terminal problems
- In case of HT: lack of carrier doesn’t always mean it’s OK to transmit
- In case of ET: presence of carrier doesn’t always mean that it’s bad to transmit

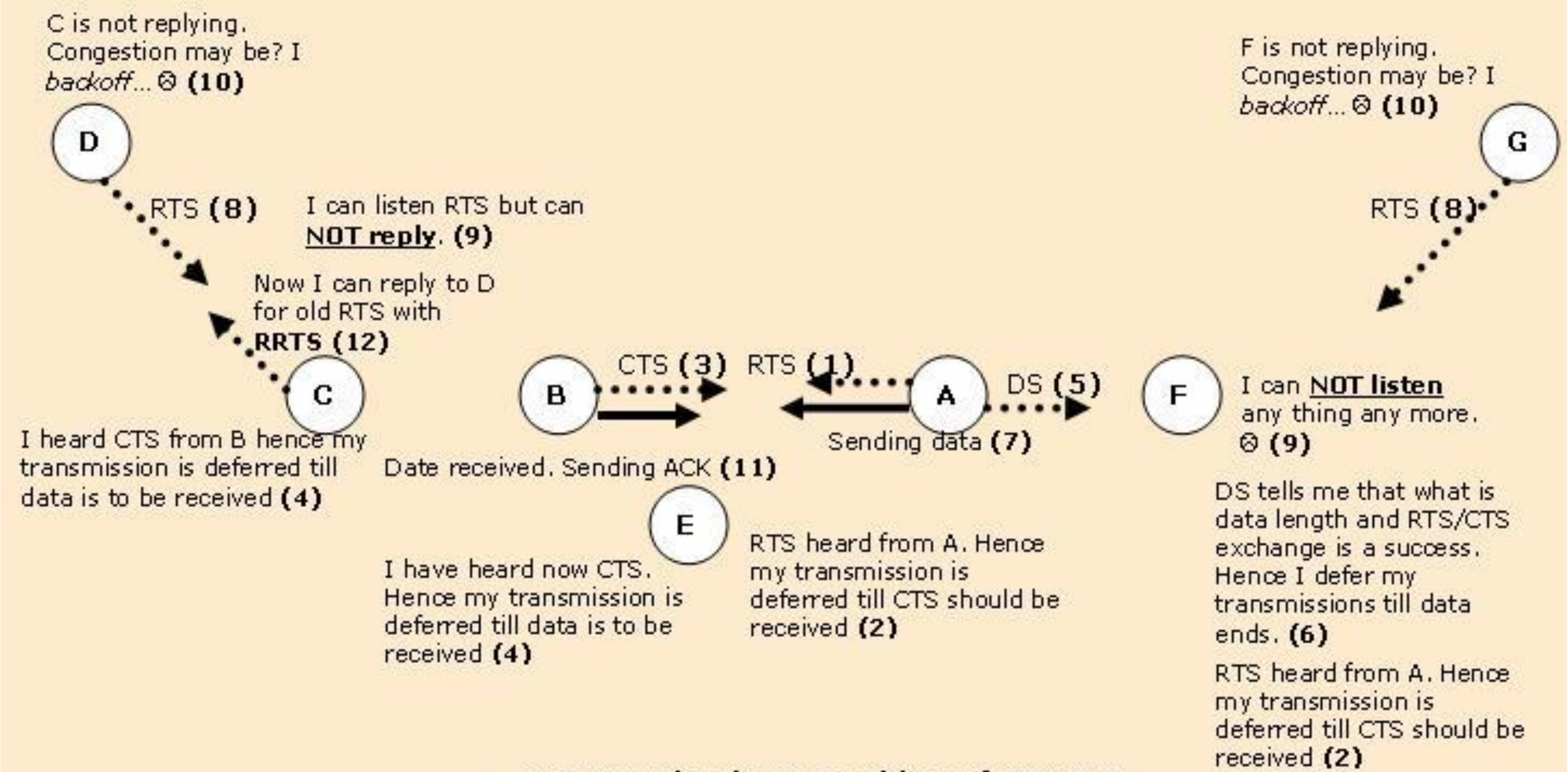


- Solution:
  - Multiple Access with Collision Avoidance (MACA)
    - makes an announcement before sends the data frame
    - slotted media access control protocol
    - suitable for wireless networks
    - a node that hears RTS should remain silent to avoid conflict with CTS
    - a node that hears CTS should keep silent until the data transmission is complete

Limitation: MACA can’t avoid collision completely.

MACAW

- MACA for Wireless (MACAW) extends the function of MACA
  - nodes send ACK after each successful transmission
  - It uses *RTS-CTS-DS-DATA-ACK* frame sequence for transferring data,
  - sometimes preceded by an *RTS-RRTS* frame sequence



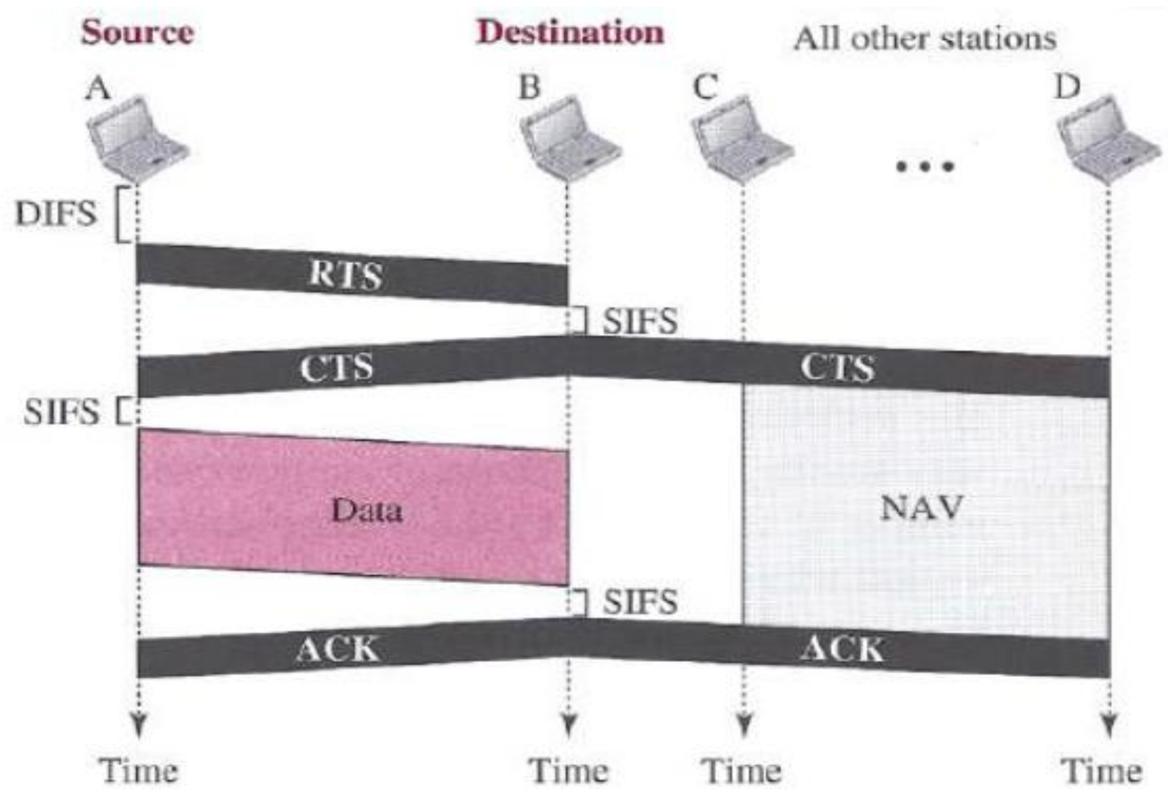
An Example about working of MACAW

CSMA/CA

- Common features:
  - Channel sensing; Retransmission; Backoff

- Important modifications:
  - Inter-Frame Space (IFS): used instead of persistent method
  - Contention window (CW) and Binary exponential backoff (BEB) : time is treated in slots
  - Acknowledgement / Timeout : no collision detection
  - Basic / RTS-CTS mode of transmission
  - Use of Network Allocation Vector (NAV)

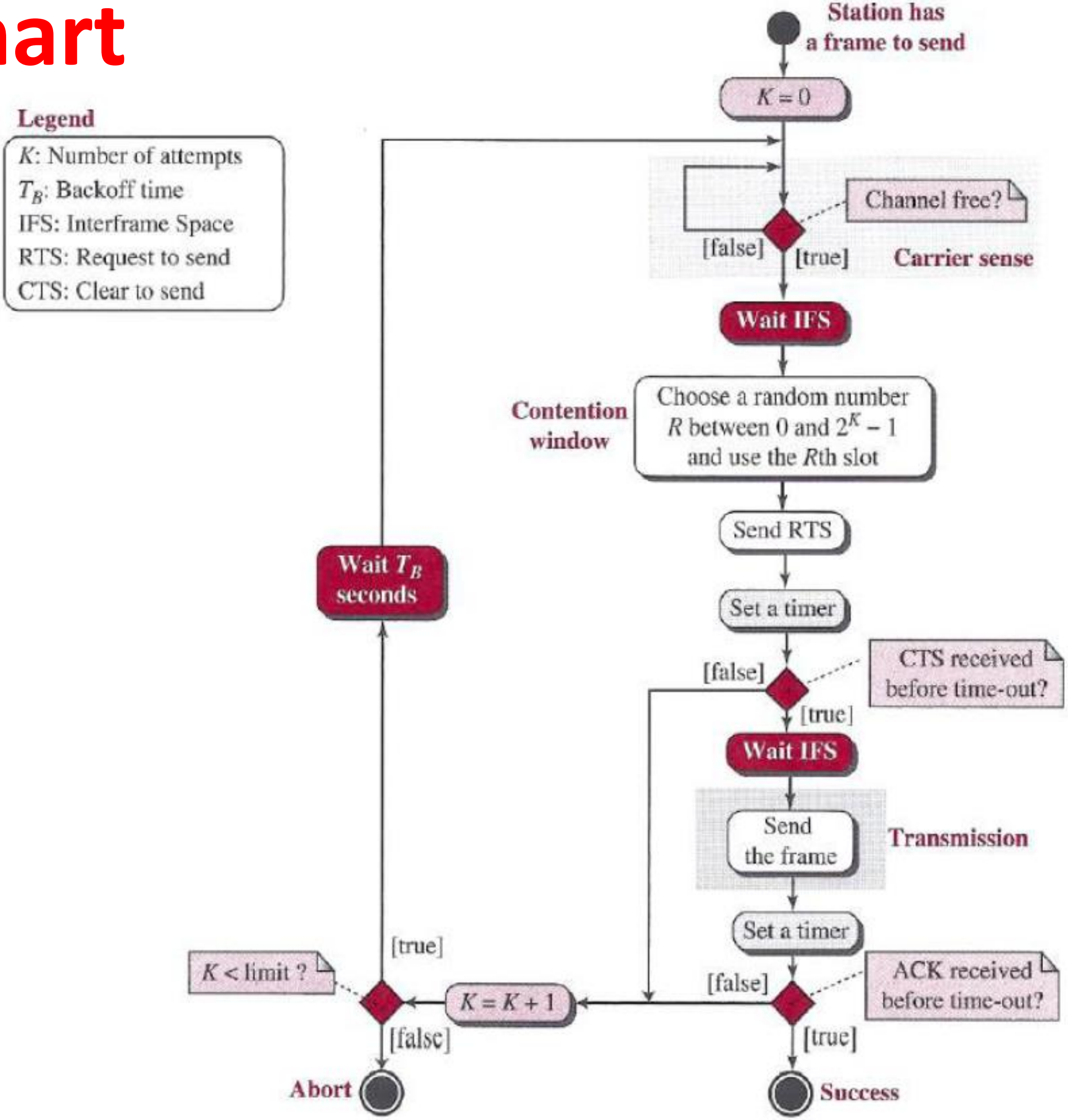
CSMA/CA with RTS/CTS



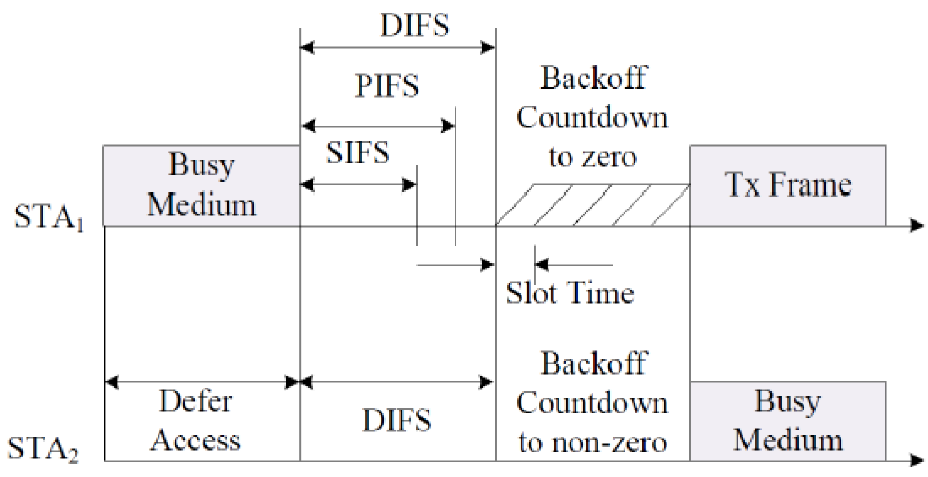
RTS: Request-to-send
CTS: Clear-to-send
ACK: Acknowledgement

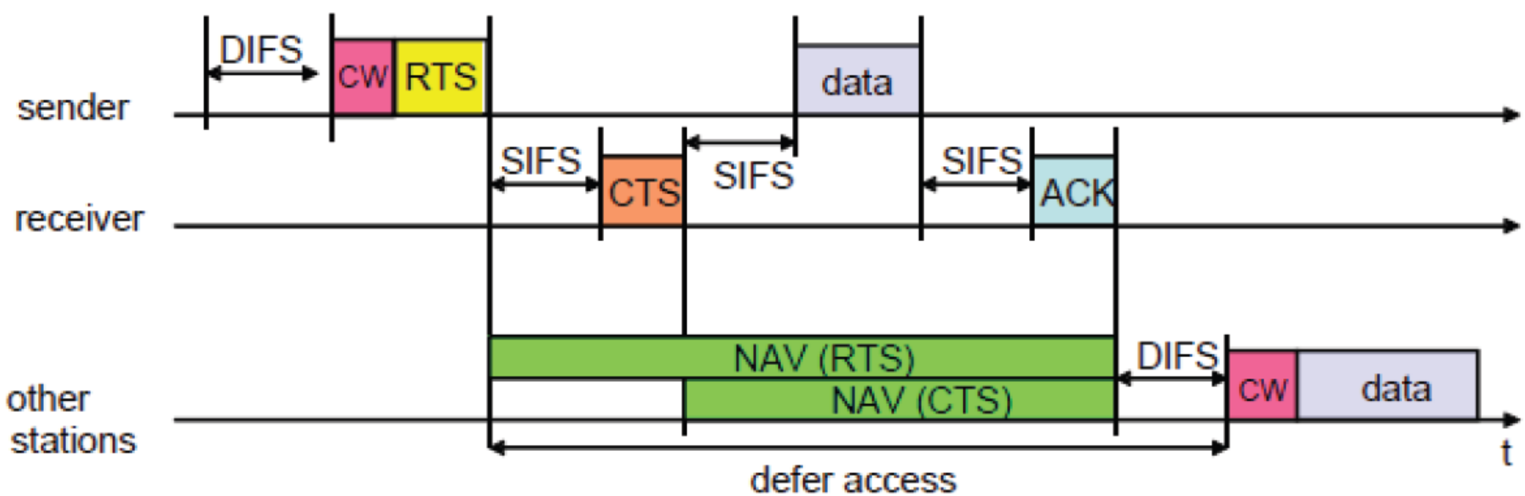
NAV: how much time must pass before these stations are allowed to check the channel for idleness.
DIFS: DCF Inter-frame Space = SIFS + 2*slot time
SIFS: Short Inter-frame Space

Flowchart


Legend
K: Number of attempts
T_B: Backoff time
IFS: Interframe Space
RTS: Request to send
CTS: Clear to send
Station has a frame to send
K = 0
Channel free?
[false]
[true]
Carrier sense
Wait IFS
Contention window
Choose a random number R between 0 and $2^K - 1$ and use the Rth slot
Send RTS
Set a timer
Wait T_B seconds
CTS received before time-out?
[false]
[true]
Wait IFS
Send the frame
Transmission
Set a timer
ACK received before time-out?
[false]
[true]
K = K + 1
K < limit ?
[true]
[false]
Abort
Success

Timing Diagram of DCF MAC

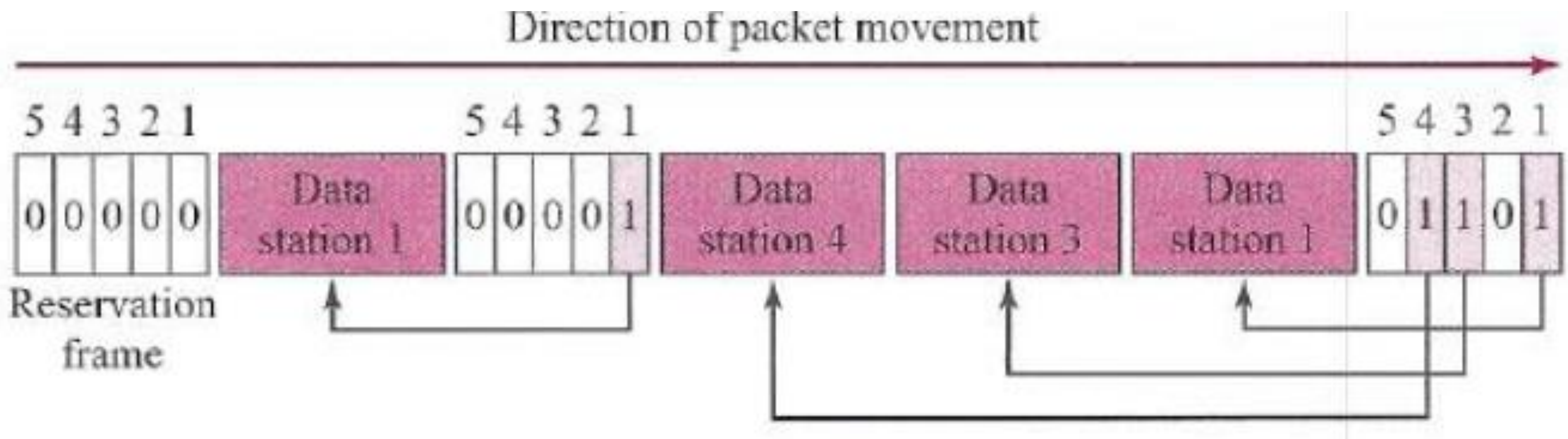




Controlled Access

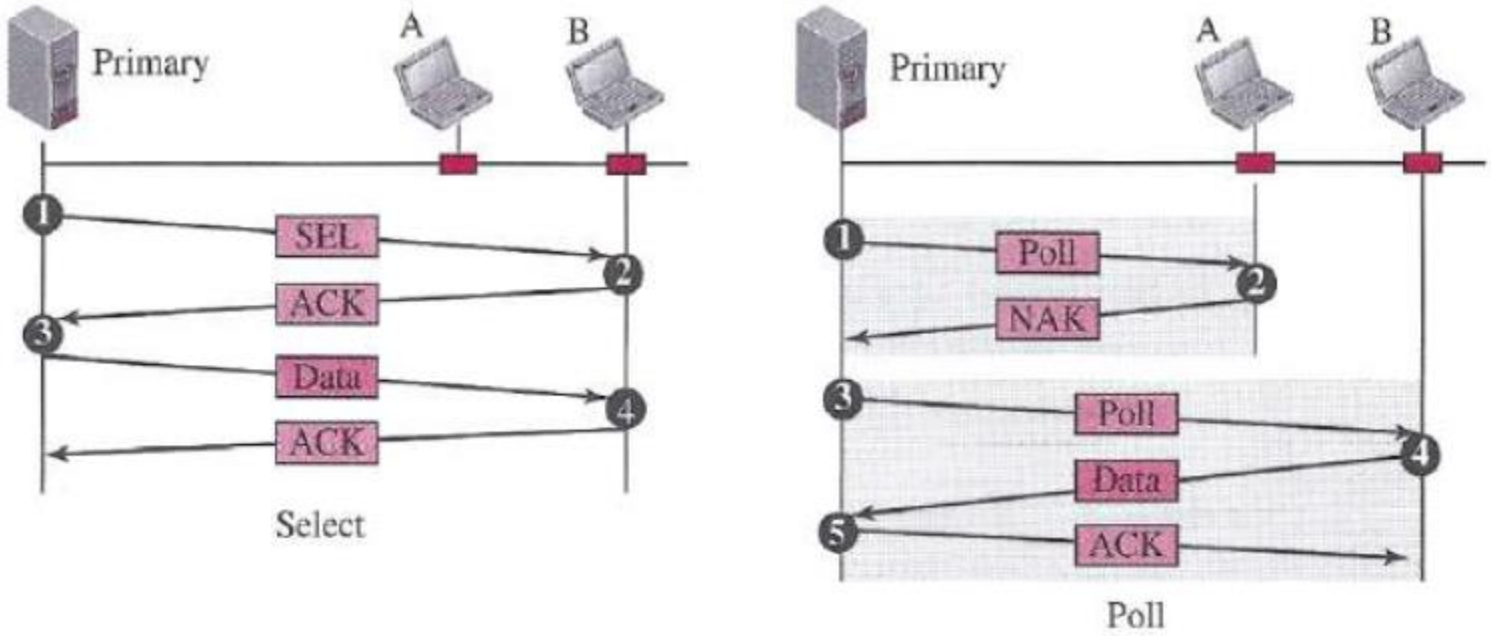
- Basic Idea: the stations consult one another before transmission

- Approaches:
  - Reservation (e.g., R-ALOHA)



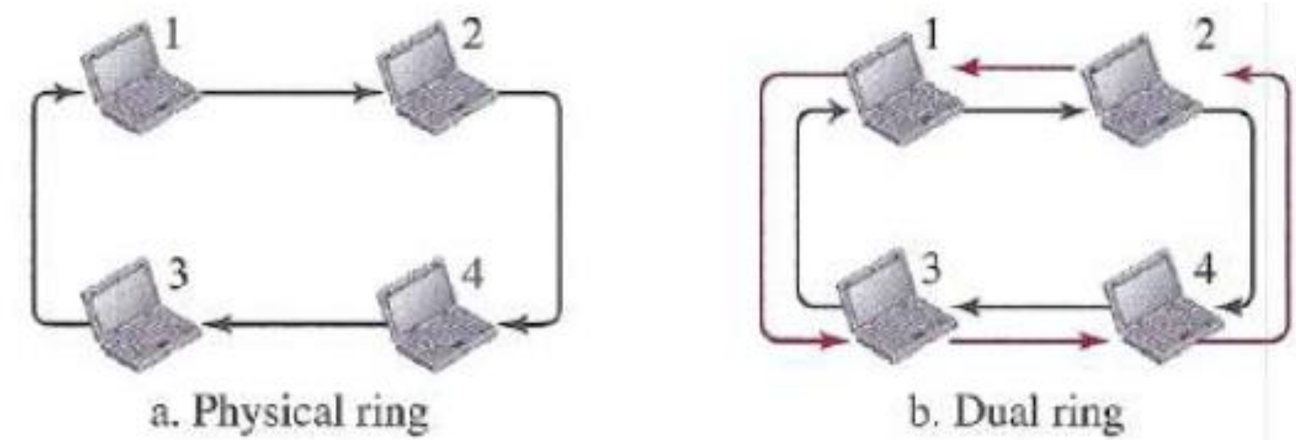
  - Polling
  - Token Passing

Polling



- Stations take turns in accessing the medium
- One station is designated as primary and others are secondary stations
- Select mode when primary sends data
- Polling when the primary wants to receive data

Token Passing



- All stations are logically connected in the form of ring
- Control of the access to the medium is performed using a token; a special bit pattern
- Token is circulated in round robin manner. Holder of token has the right to transmit

Channelization Approach

- Basic idea: the available bandwidth of a link is shared in time, frequency, or through code, among different stations.
- Protocols:
  - FDMA (frequency-division multiple access)
  - TDMA (time-division multiple access)
  - CDMA (code-division multiple access)

Basic Idea of CDMA

- Let 4 stations: 1,2,3,4
- Their data frames: d_1, d_2, d_3, d_4
- Assigned codes: c_1, c_2, c_3, c_4
  - Property-1: $c_i \,.\, c_k$ => 0
  - Property-2: $c_i \,.\, c_i$ => 4 (number of station)

- Channel carrying:
  - $(d_1.c_1)+(d_2.c_2)+(d_3.c_3)+(d_4.c_4)$

- Let station 1 & 3 are talking,
- station1 wants data from station3

- Station1 do:
  $(d1.c1)+(d2.c2)+(d3.c3)+(d4.c4).c_3 = 4.d_3$

Chip Sequences & Operations

C_1	C_2	C_3	C_4
[+1 +1 +1 +1]	[+1 −1 +1 −1]	[+1 +1 −1 −1]	[+1 −1 −1 +1]

- Multiply by number: $2 \bullet [+1\ +1\ -1\ -1] = [+2\ +2\ -2\ -2]$
- Inner product: $[+1\ +1\ -1\ -1] \bullet [+1\ +1\ -1\ -1] = 1 + 1 + 1 + 1 = 4$

  $[+1\ +1\ -1\ -1] \bullet [+1\ +1\ +1\ +1] = 1 + 1 - 1 - 1 = 0$
- Addition: $[+1\ +1\ -1\ -1] + [+1\ +1\ +1\ +1] = [+2\ +2\ 0\ 0]$
- Encoding Rules:

  0 => -1; 1=> 1; silence => 0

Example

- wants to send:
  - Station1: 0; Station2: 0; Station3: silent; Station4: 1
- Encoded to: [-1, -1, 0, 1]
- Transmitted:

  [-1.(+1 +1 +1 +1)] + [-1.(+1 -1 +1 -1)] + [0.(+1 +1 -1 -1)] +[+1 .(+1 -1 -1 +1)]

  =[-1 -1 -1 -1] + [-1 +1 -1 +1] + [0 0 0 0] + [+1 -1 -1 +1]

  =[-1 -1 -3 1]
- Let station4 wants to listen station2
  - Station4 do: [-1 -1 -3 +1].[+1 -1 +1 -1] = -4
  - Receive: -4/4 = -1 → bit 0

Walsh Table

$$W_1 = \begin{bmatrix} +1 \end{bmatrix} \quad W_{2N} = \begin{bmatrix} W_N & W_N \\ W_N & \overline{W_N} \end{bmatrix}$$

a. Two basic rules

$$W_2 = \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix} \quad W_4 = \begin{bmatrix} +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 \end{bmatrix}$$

b. Generation of W_2 and W_4

Thanks!

Figure and slide materials are taken from the following sources:

1. W. Stallings, (2010), Data and Computer Communications
2. NPTL lecture on Data Communication, by Prof. A. K. Pal, IIT Kharagpur
3. B. A. Forouzan, (2013), Data Communication and Networking