CS311: Data Communication

Medium Access Control - I

by

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Outline of the lecture

- Introduction
- Broadcast networks
- Issues in MAC
- Goals in MAC
- MAC techniques
- Random Access MAC techniques
  - ALOHA, Slotted ALOHA, CSMA, CSMA/CD

Introduction to MAC

- Types of network
  - Switched communication networks
    - Users are interconnected by means of transmission lines, multiplexers and switches
  - Broadcast networks
    - A single transmission media is shared by all the users and information is broadcast by an user into the medium

- Two types of network links:
  - point-to-point links
    - protocol => PPP, HDLC
  - broadcast links
    - protocol => multiple access protocols

Issues in MAC

- The question is “who goes next?”
- The protocols used for this purpose are known as medium access control (MAC) techniques
- The key issues involved – where and how the control is exercised

Where ?

- Centralized : a designated station has an authority to grant access to the network.
  - Simple logic at each station
  - Greater control to provide features like priority, overrides and guaranteed bandwidth
  - Easy coordination
  - Lower reliability

- Distributed: stations can dynamically determine transmission order.
  - Complex, reliable and scalable

How?

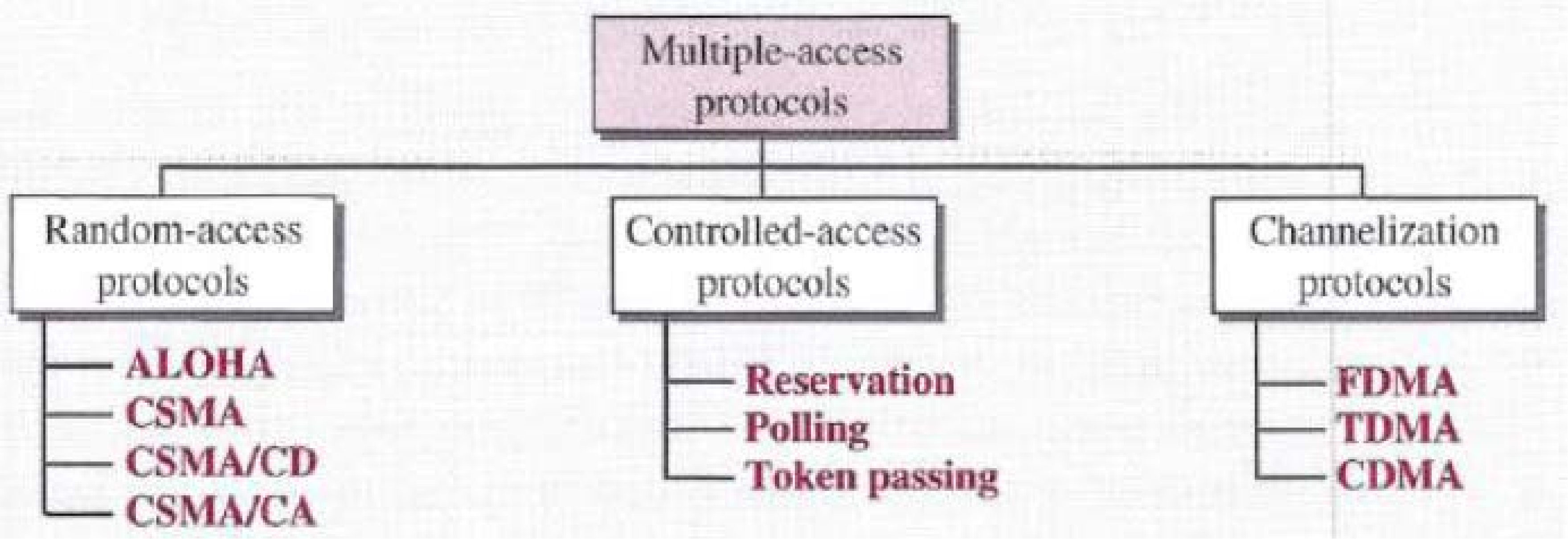
- Synchronous: dedicated specific capacity to a connection.

- Asynchronous: allocates capacity dynamically

Goals of MAC

- Initialization
- Fairness
- Priority
- Limitation to one station
- Receipt
- Error limitation
- Recovery
- Re-configurability
- Compatibility
- Reliability

Multiple Access Protocols



- Random Access
  - No station is superior to another station
  - None is assigned control over another
  - No scheduled time for transmission
  - Station compete with one another to access the medium

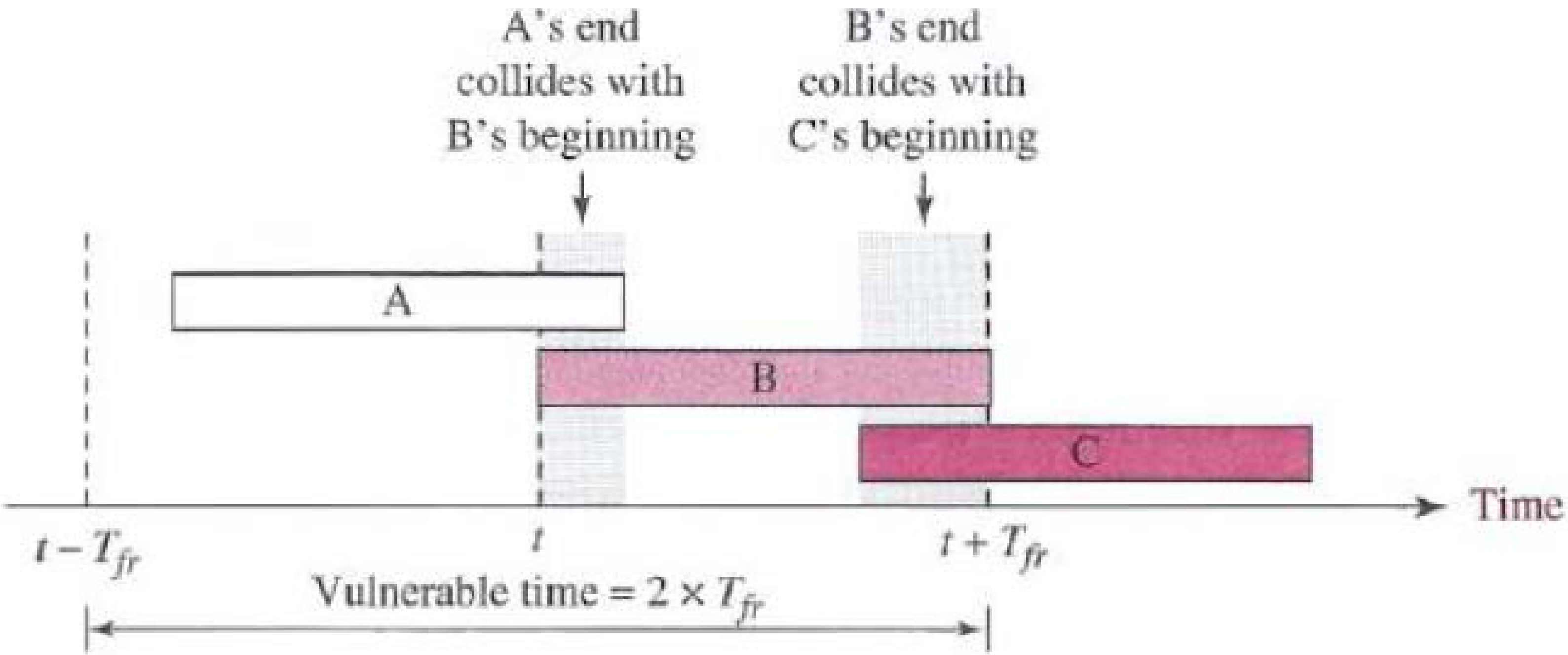
Pure ALOHA

- Developed in early 1970 at University of Hawaii
- Principle:
  - each station sends a frame whenever it has a frame to send
  - relies on acknowledgments from the receiver
  - if time-out occurs, then wait for random backoff time before retransmission
  - after a maximum number of retransmission, a station must give up and try later

  - Time-out := maximum round-trip time
  - Backoff time := random value generated by backoff algorithm (e.g. binary exponential backoff)

Problem in Pure ALOHA

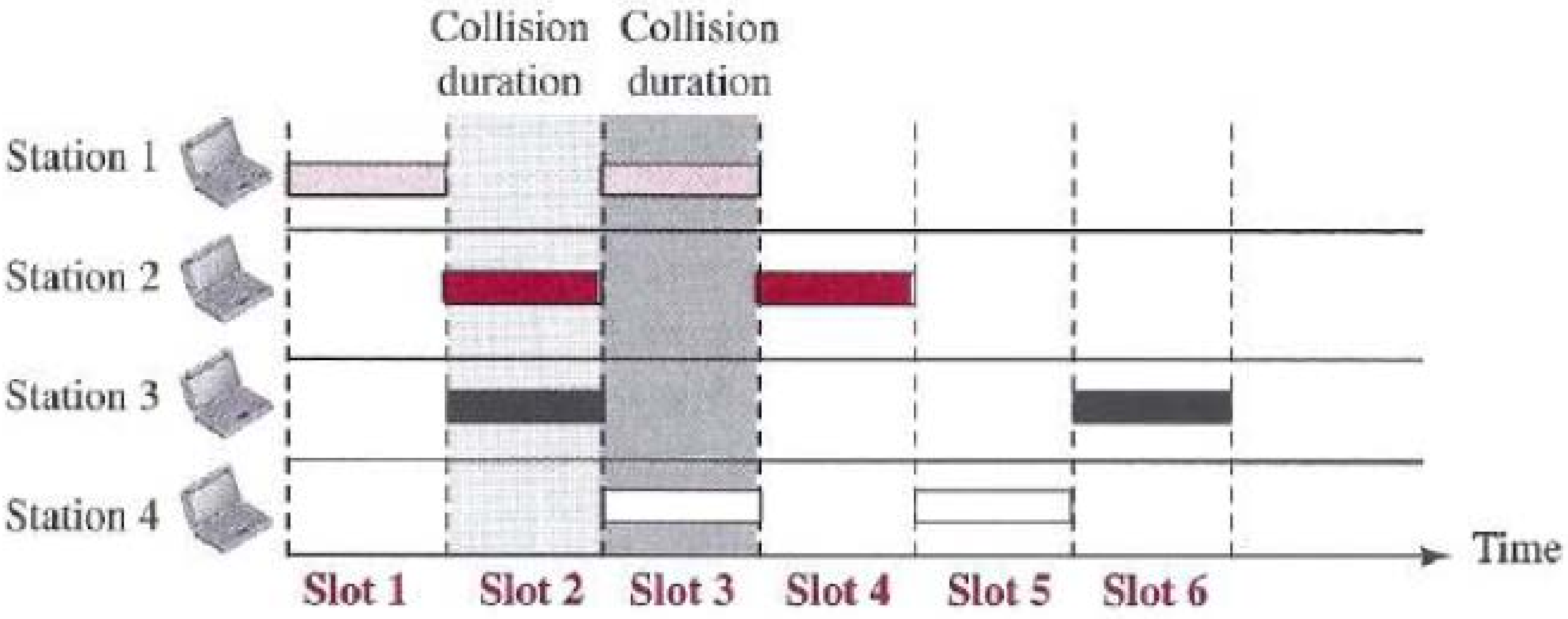
- Frame Collision


A's end collides with B's beginning
B's end collides with C's beginning
A
B
C
Time
$t - T_{fr}$
t
$t + T_{fr}$
Vulnerable time = $2 \times T_{fr}$

- vulnerable time: the length of time in which there is a possibility of collision.

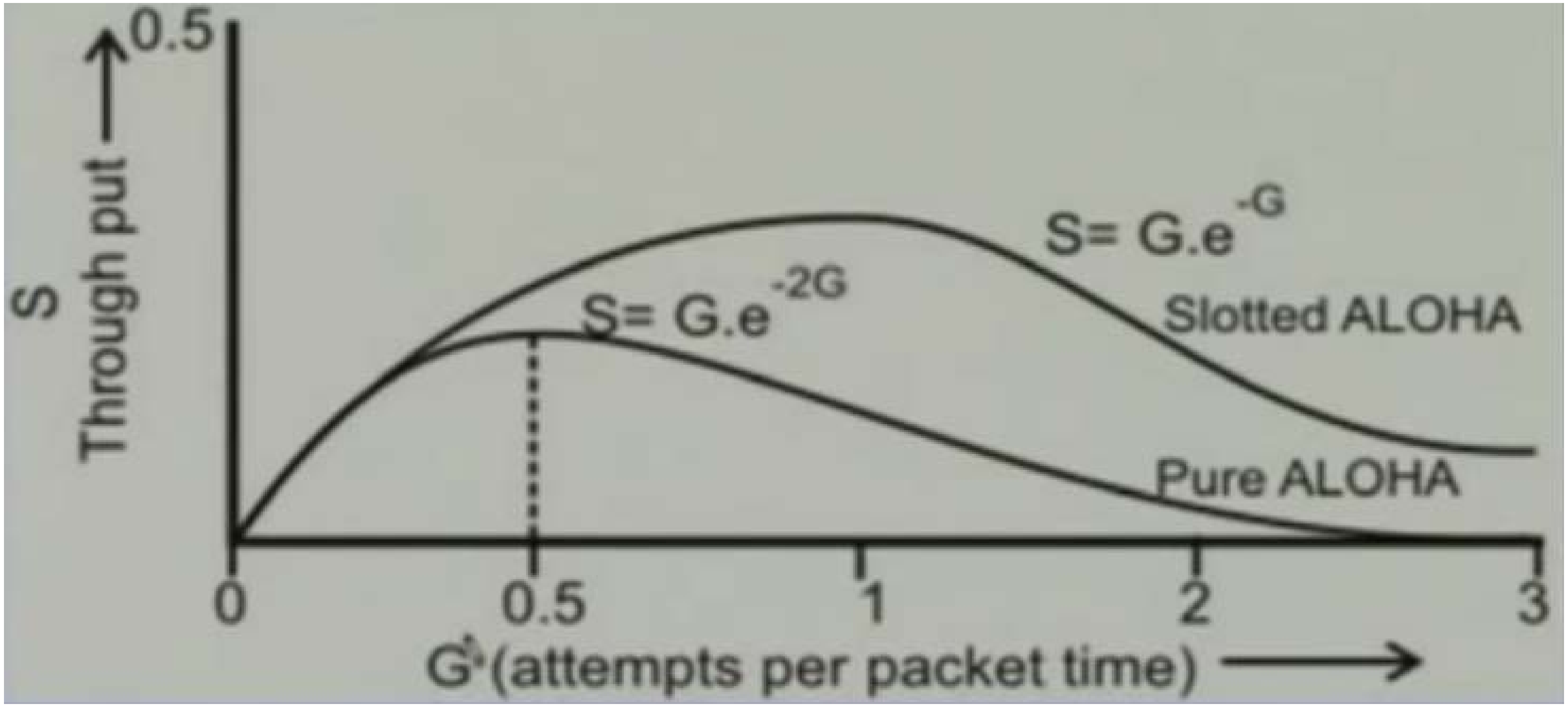
Slotted ALOHA

- we divide the time into slots of T_{fr} seconds and force the station to send only at the beginning of the time slot



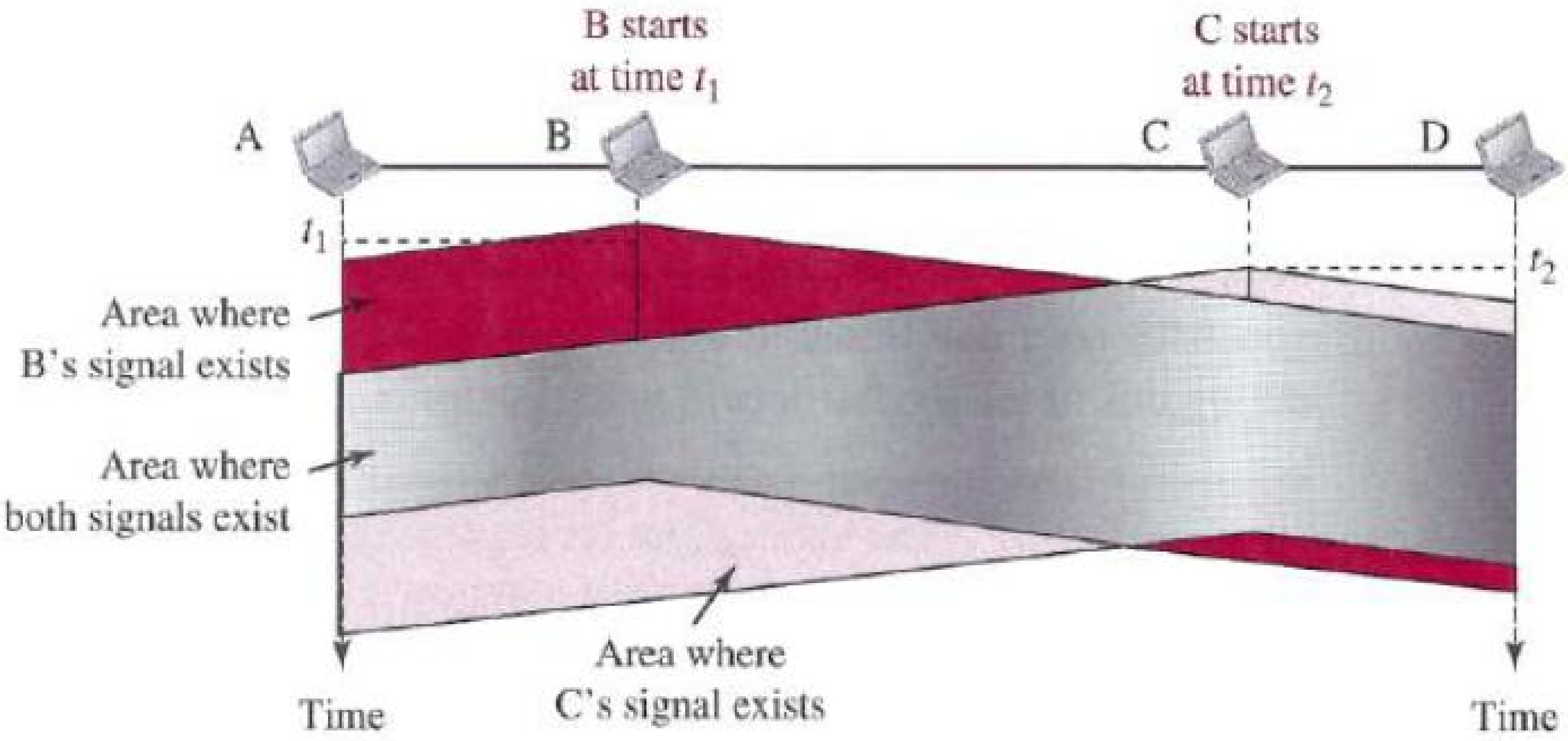
- Vulnerable time= T_{fr}

Performance

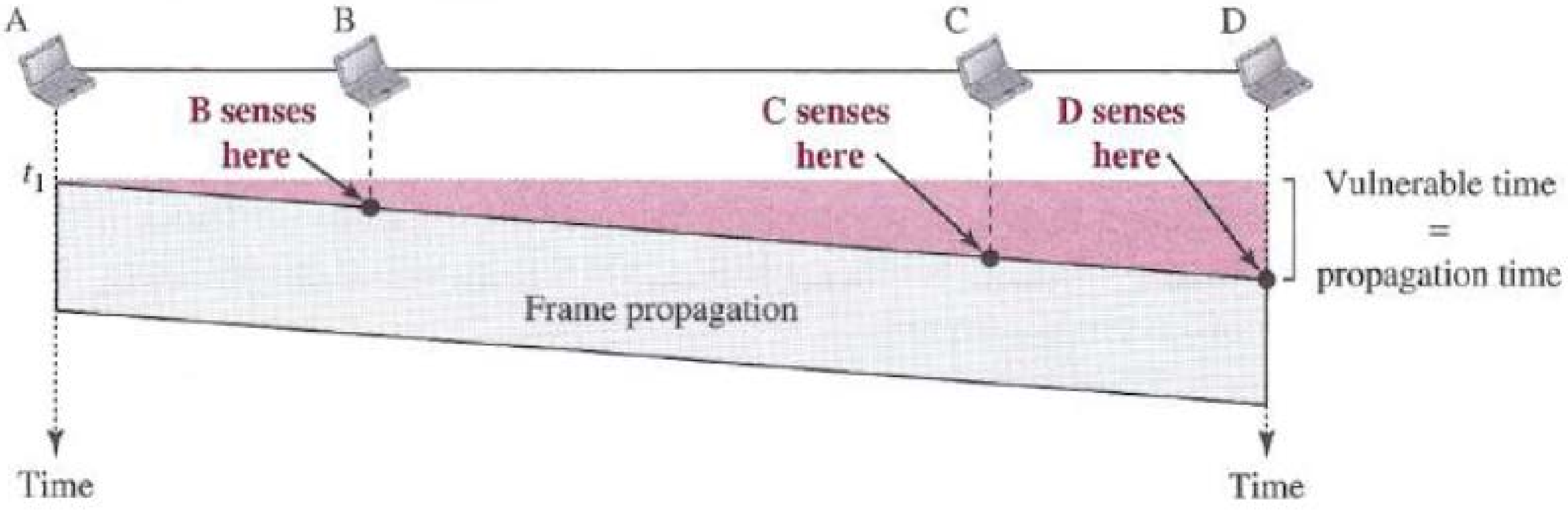


Carrier Sense Multiple Access

- Sense the medium before trying to use it
- “sense before transmit” or “listen before talk”



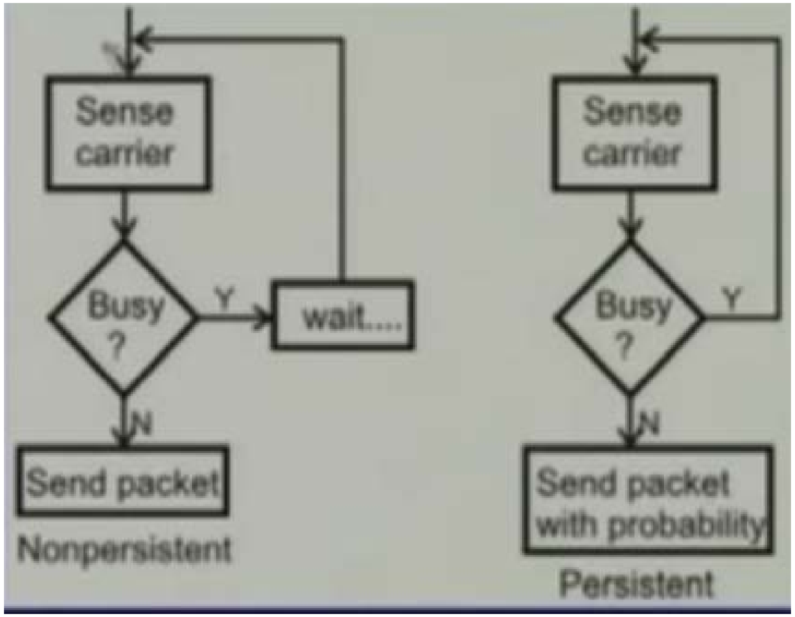
CSMA vulnerable time



- Vulnerable period = t(prop) (one propagation time)

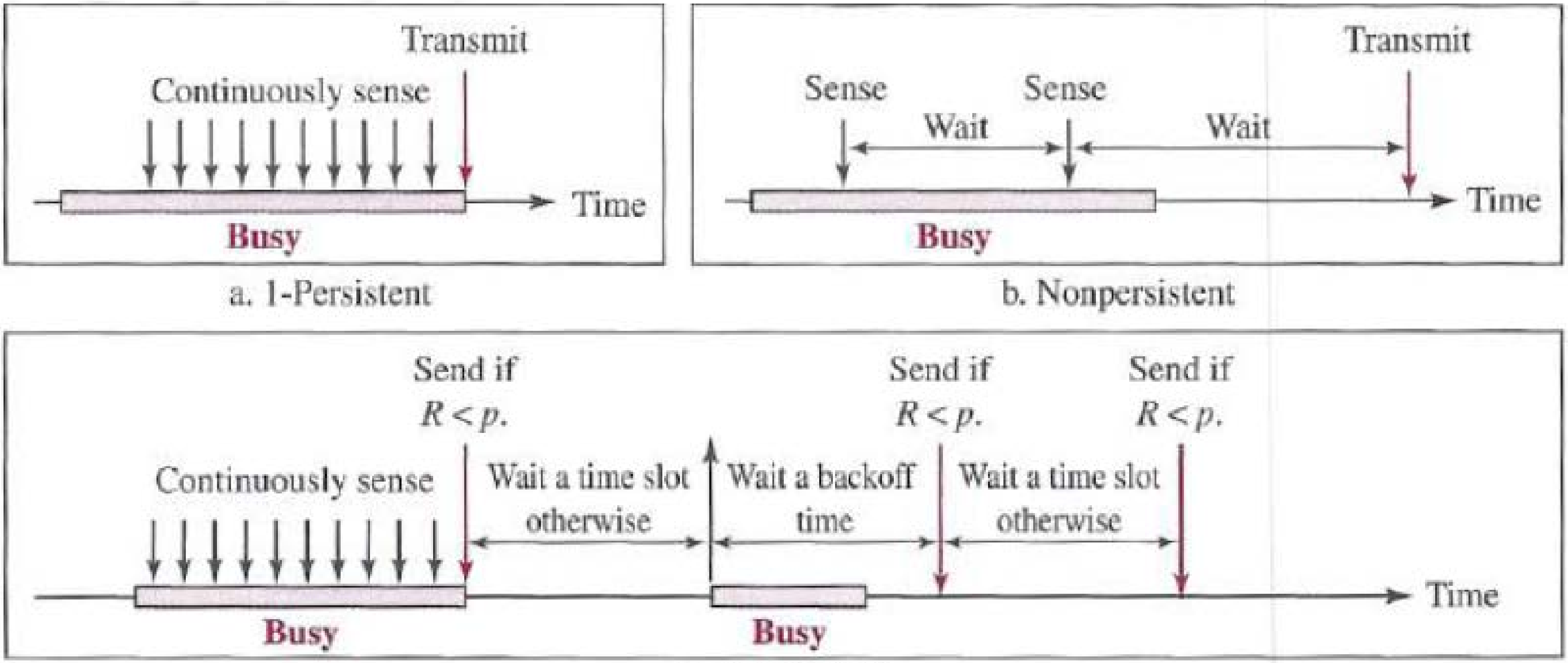
- What should a station do if channel is busy/idle?
  - 1-persistent
  - Non-persistent
  - p-persistent

Persistent Methods



- 1-persistent
  - Continuously sense the channel
  - if idle, transmit frame (with probability 1)
- Non-persistent
  - Sense the channel
  - If idle, transmit frame (with probability 1)
  - If busy, wait a random amount of time and then sense the channel again
- *p*-persistent
  - Non-persistent , but transmit frame (with probability *p)*

Cont…



a. 1-Persistent

b. Nonpersistent

c. *p*-Persistent

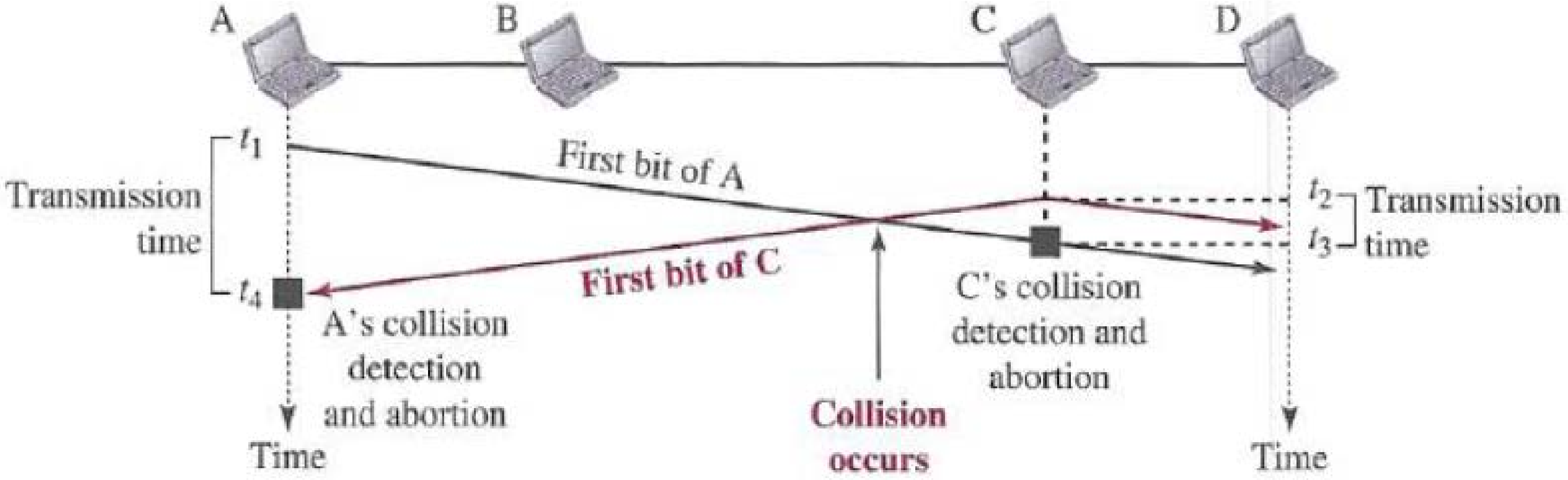
CSMA/CD (Collision Detection)

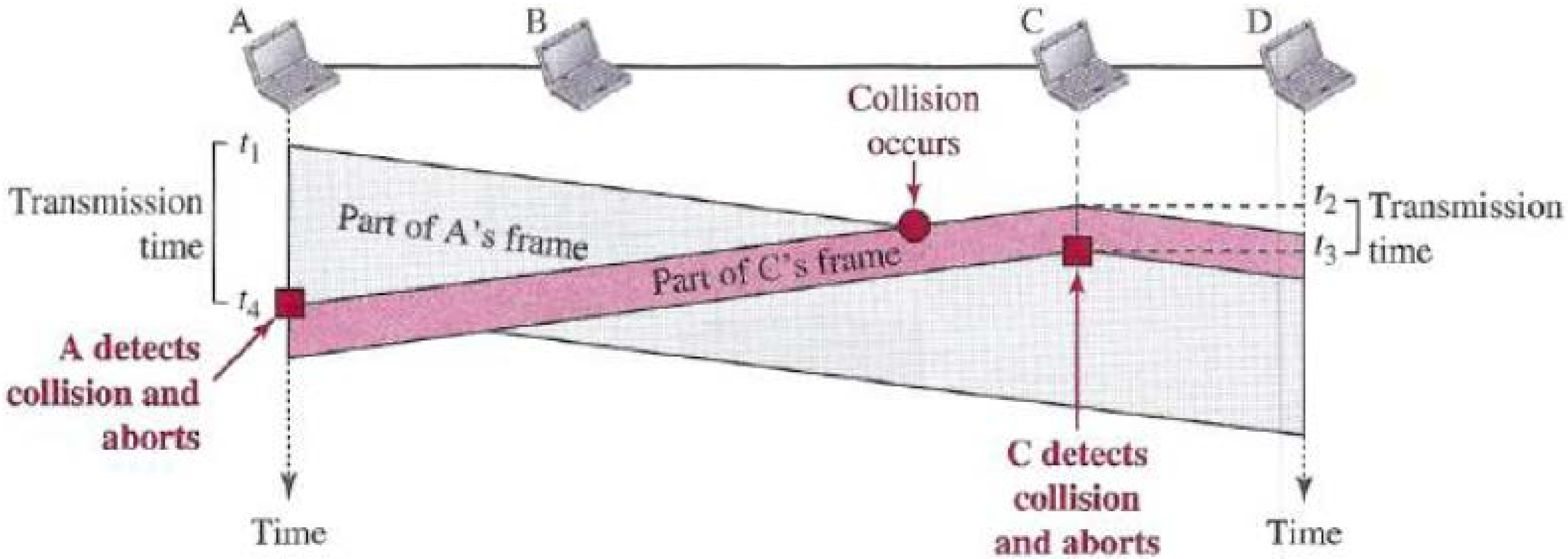
- CSMA with Collision Detection (CSMA/CD)
- Stations listens to the medium while transmitting; Listen while talking (LWT).
- Three cases:
  - If channel idle:
    - Packet is transmitted if non-persistent or 1-persistent
    - For p-persistent, the packet is sent with probability p or delayed by the end-to-end propagation delay with probability (1-p).

CSMA/CD

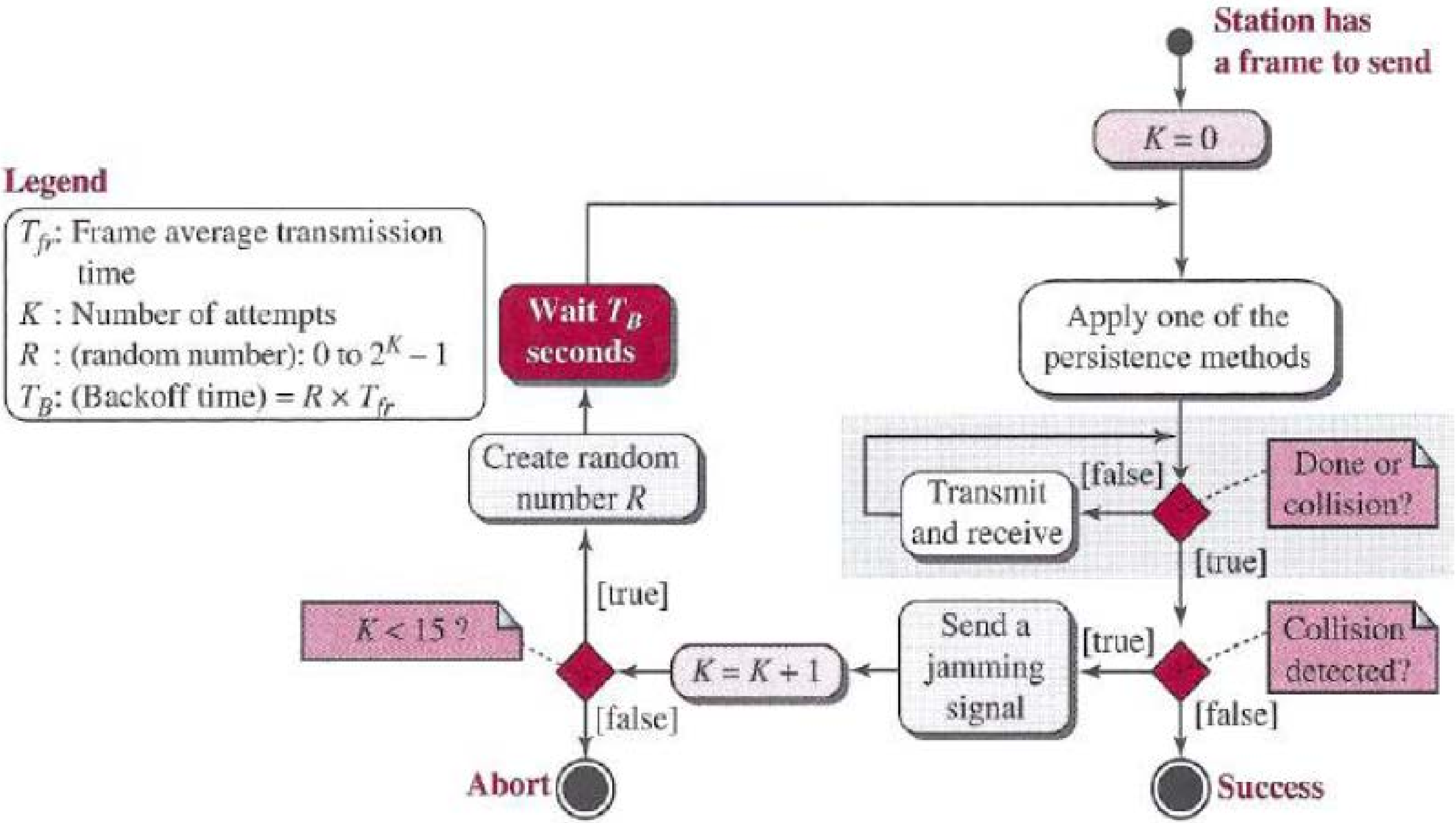
- If channel is busy:
  - The packet is backed off and the algorithm is repeated for non-persistent case
  - The station defers transmission until the channel is sensed idle and then immediately transmits in 1-persistent case
  - For p-persistent CSMA/CD the stations defers until the channel is idle, then follow the channel idle procedure.

CSMA/CD


A
B
C
D
Transmission time
t_1
t_4
First bit of A
First bit of C
t_2
t_3
Transmission time
A's collision detection and abortion
Collision occurs
C's collision detection and abortion
Time
Time


A
B
C
D
Collision occurs
Transmission time
t_1
t_4
Part of A's frame
Part of C's frame
t_2
t_3
Transmission time
A detects collision and aborts
C detects collision and aborts
Time
Time

Cont…


Station has a frame to send
$K = 0$
Legend
T_{fr}: Frame average transmission time
K : Number of attempts
R : (random number): 0 to $2^K - 1$
T_B: (Backoff time) = $R \times T_{fr}$
Wait T_B seconds
Apply one of the persistence methods
Create random number R
Transmit and receive
[false]
Done or collision?
[true]
$K < 15$?
[true]
Send a jamming signal
[true]
Collision detected?
$K = K + 1$
[false]
[false]
Abort
Success

Cont…

- Points to remember:
  - Use of the persistence process
  - The station transmits and receives continuously and simultaneously (using two different ports or a bidirectional port)
  - We constantly monitor in order to detect one of two conditions: either transmission is finished or a collision is detected
  - sending of a short jamming signal to make sure that all other stations become aware of the collision
  - Use of random backoff mechanism
  - Use of retransmission limit

Jamming Signal in CSMA/CD

- Did a collision occur? If so, go to collision detected procedure.
  - In that procedure, continue transmission (**with a jam signal** instead of frame header/data/CRC) until minimum packet time is reached to ensure that all receivers detect the collision.
  - The **jam signal** is a signal that carries a 32-bit binary pattern
  - The maximum jam-time:
    - The maximum allowed diameter of an Ethernet is limited to 232 bits. This makes a round-trip-time of 464 bits. As the slot time in Ethernet is 512 bits, the difference between slot time and round-trip-time is 48 bits (6 bytes), which is the maximum "jam-time".

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