Media Access Sublayer and LANs

ICT 2156

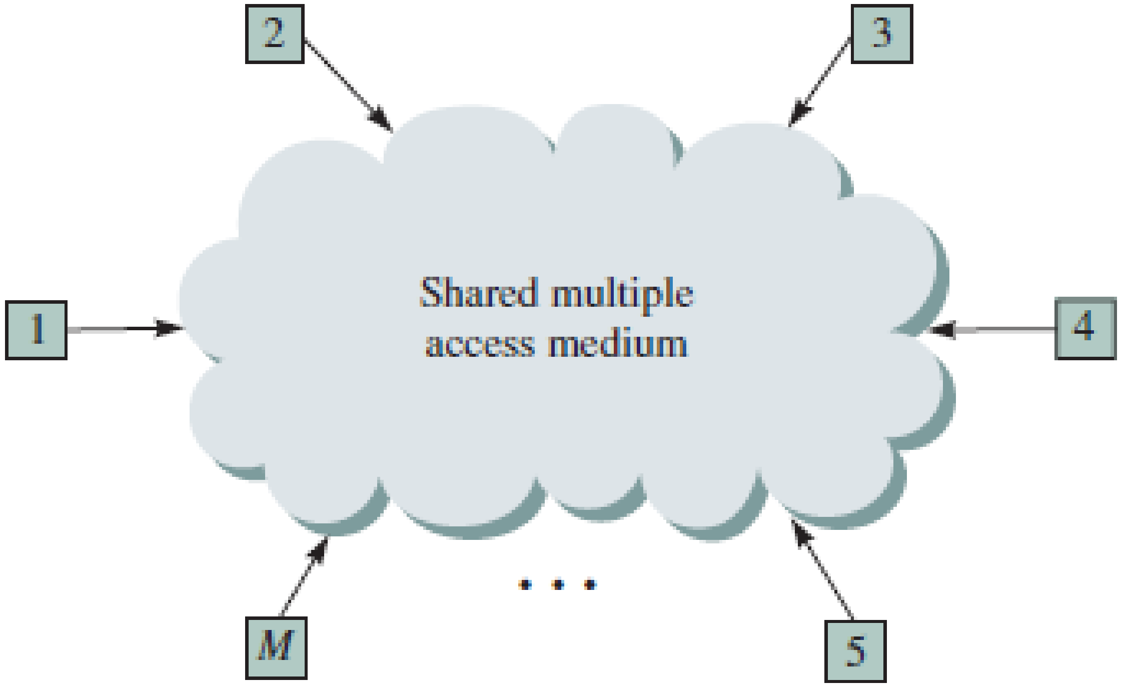
OUTLINE

- Approaches to sharing transmission medium
- Random Access Protocols-
  - Aloha
  - Slotted Aloha
  - CSMA
  - CSMA/CD
- Token Ring protocols
- IEEE LAN standards
- Bridges
- FDDI

Multiple Access Communications

- Broadcast Network:

  Routing not necessary

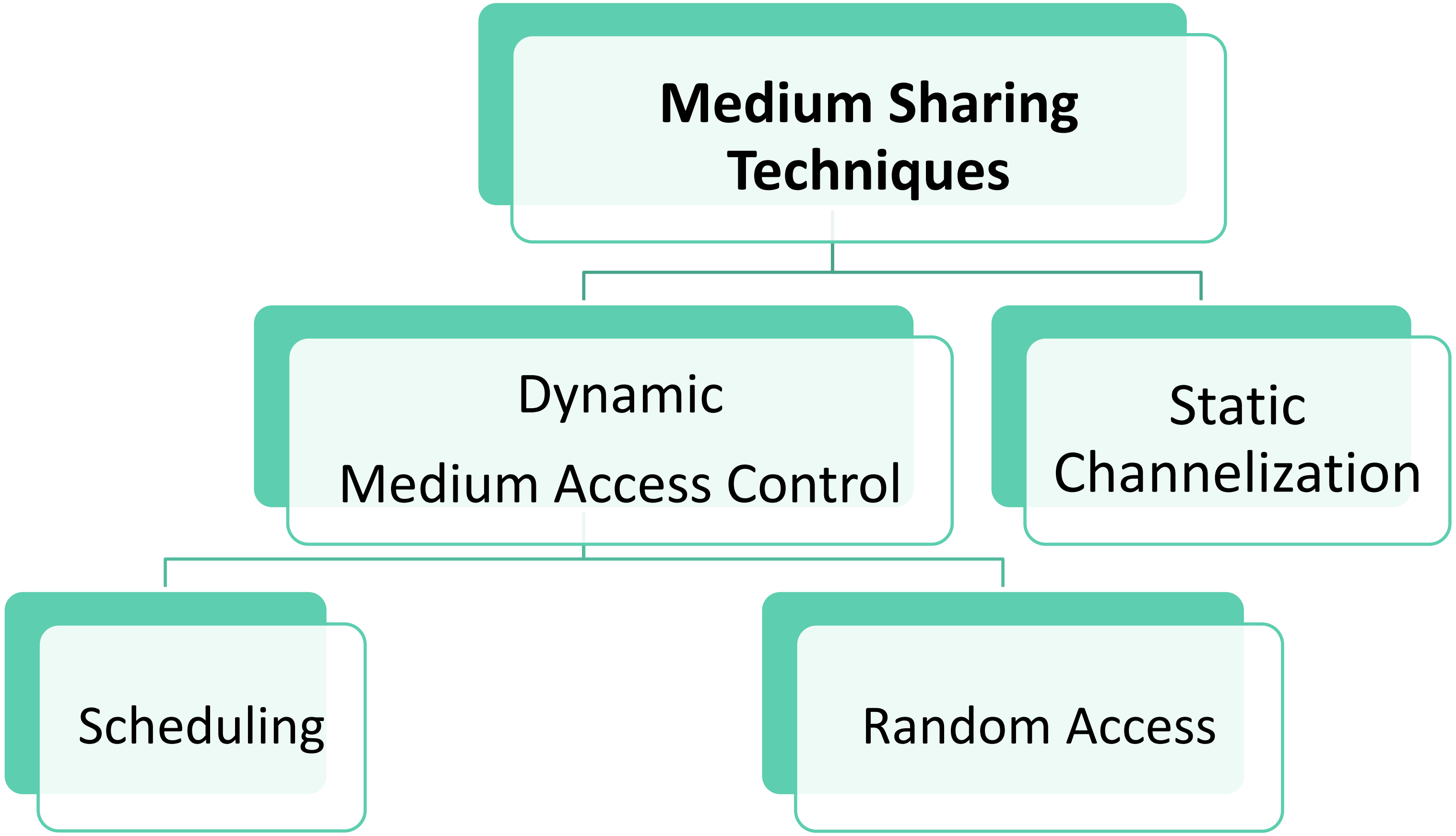


Data Link Layer

Logical Link Control

Media Access Control

Sharing Transmission Medium: Approaches



Sharing Transmission Medium: Approaches

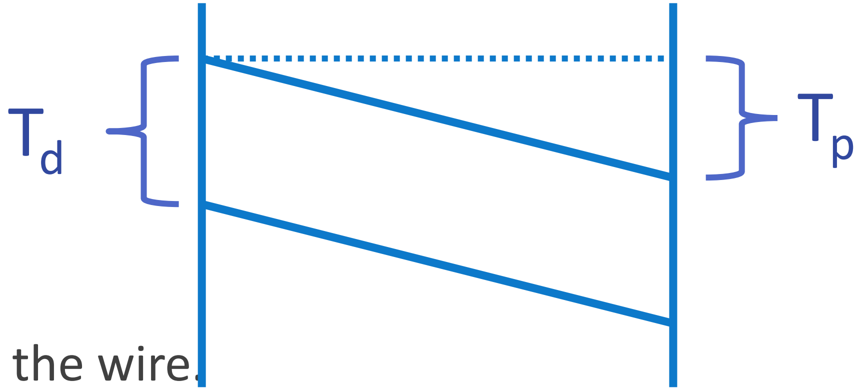
- **Static Channelization :**
  - Partitioning the medium into separate channels and dedicating to particular users.
  - Suitable when there is steady stream of information that makes efficient use of dedicated channel.

- **Dynamic Medium Access Control :**
  - On per packet basis; where the user traffic is not continuous.
  - **Aim**: Eliminate the incidence of collisions.

    To achieve reasonable utilization of the medium.

Delays

- **Propagation Delay**
  - The amount of time it takes for the first bit of signal to travel from the sender to the receiver.
    - $T_P = d/c$



- **Transmission Delay**
  - The amount of time required to push all of the packet's bits into the wire.
  - The delay caused by the data-rate of the link.
  - Transmission delay is a **function of the packet's length** and has **NOTHING to do with the distance between the two nodes**. This delay is proportional to the packet's length in bits.
    - $T_d = N/R$

Question : 1

The stations on a wireless network are a maximum of **300 km** apart. If the network transmits **400-bit frames** on a shared channel of **200 kbps**. Find the propagation and Transmission Delay.

Given:

d= 300 km = 300 x 1000 m

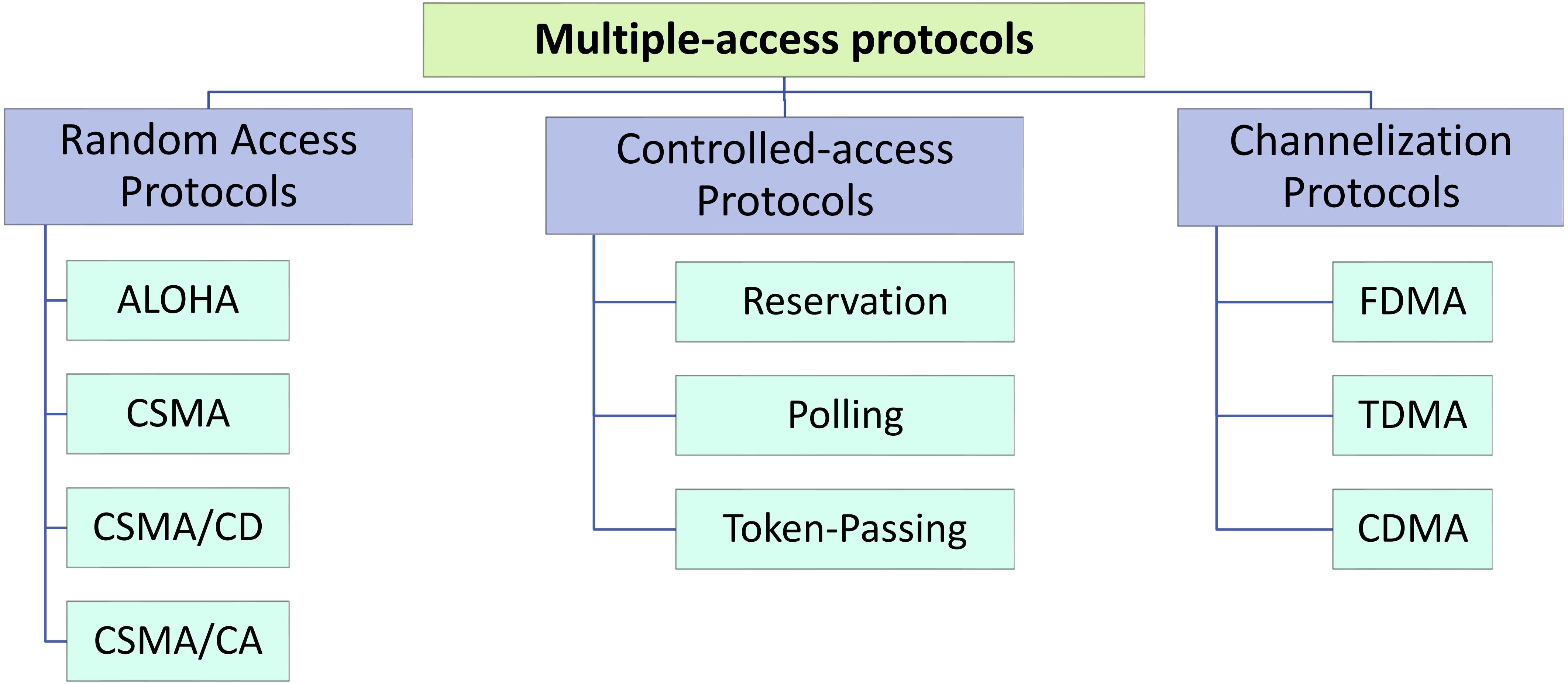
c= 3 x 10^8 m/s

N= 400 bit

R= 200 Kbps = 200 x 10^3 bps

Solution:

Taxonomy of Multiple-access protocols



Random Access or Contention Methods

- **Decentralized** Channel Allocation Method.
- Decision to send or not depends on the state of the medium.
- Random Access
  - No scheduled time for a station to transmit.
  - Transmission is random among stations.
- Contention Methods
  - Stations compete with one another to access the medium

Random Access or Contention Methods

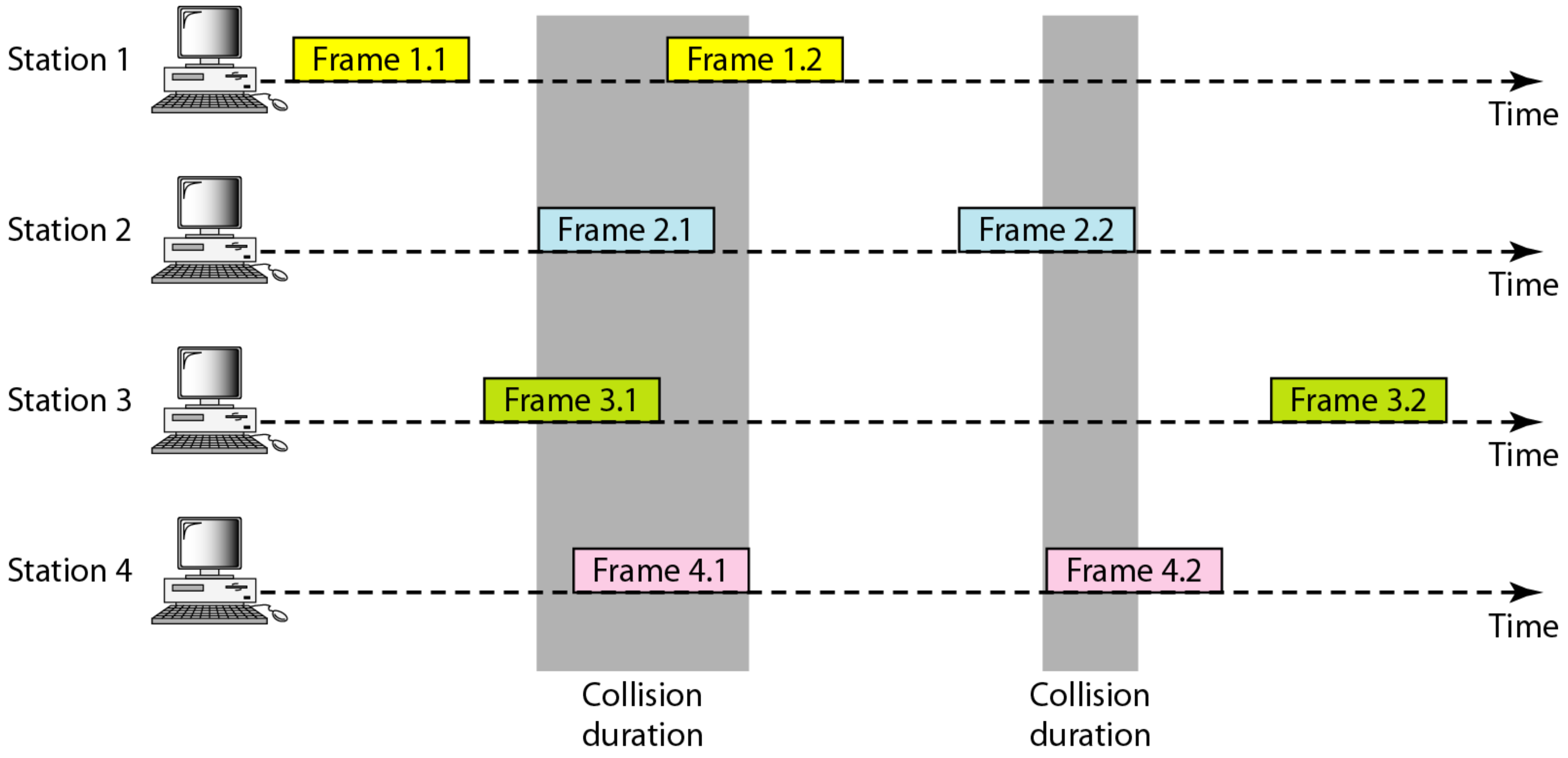
- Contention may lead to access conflict- collision-and destruction or modification of frames.
- Few questions to consider to resolve such conflict:
  - When can the station access the medium?
  - What can the station do if the medium is busy?
  - How can the station determine the success or failure of the transmission?
  - What can the station do if there is an access conflict?

Pure ALOHA

- The original ALOHA protocol is called pure ALOHA.
- Idea:
  - Each station sends a frame whenever it has a frame to send.
- Limitation:
  - The possibility of collision between frames from different stations as there is only one channel to share.

Pure ALOHA

Even if **one bit** of a frame **coexists** on the channel with one bit from another frame, there is a collision, and both will be destroyed.



Frames in a pure ALOHA network

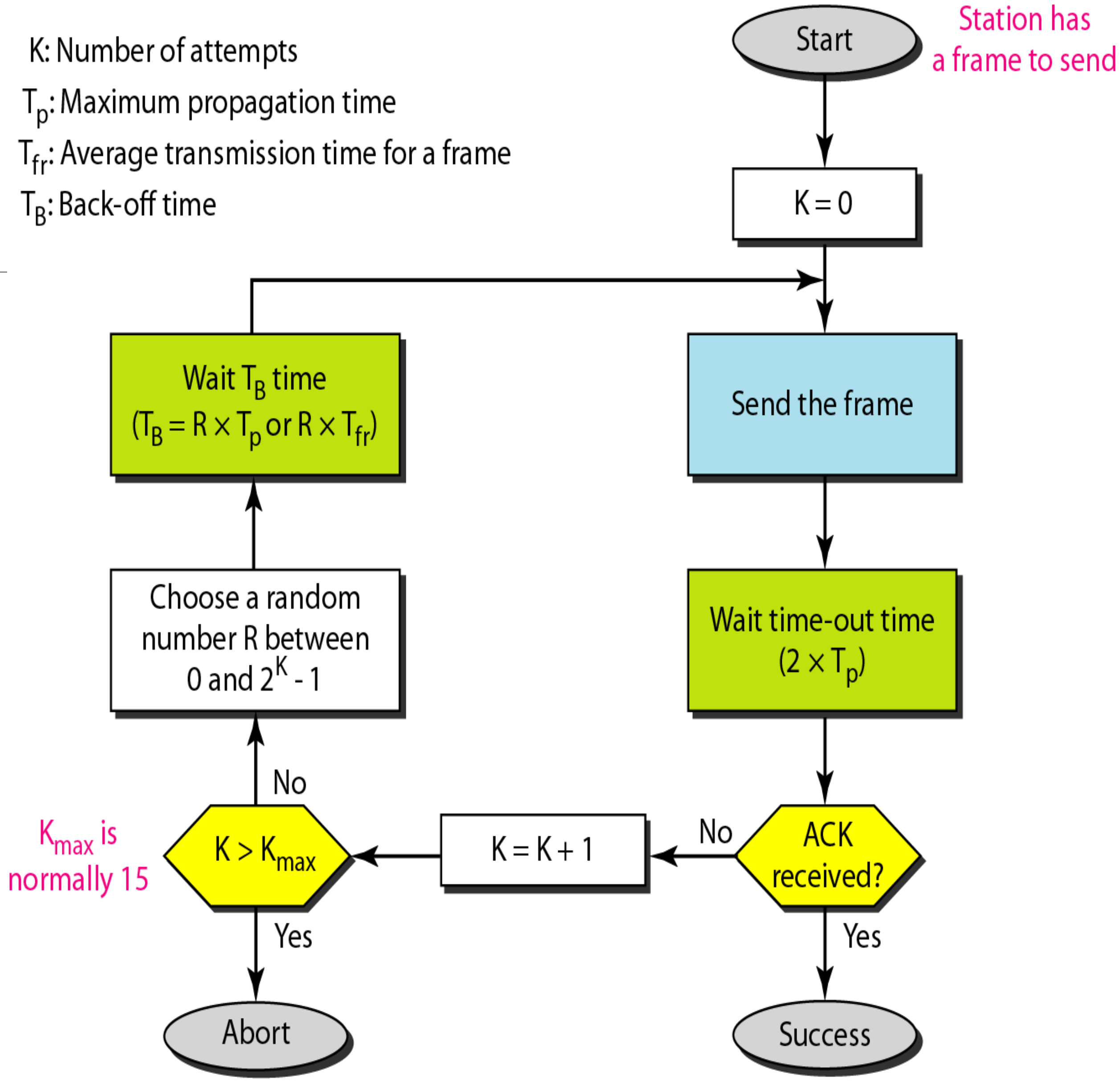
Pure ALOHA

- A collision involves two or more stations.
- ACK from receiver.
- No ACK==>Frame Destroyed===> Resend.
- What happens if all these stations try to resend their frames after the time-out?

- **Back-off time, T_B** : random.

Pure ALOHA

- Second method to prevent congesting the channel with retransmitted frames:
  - After a maximum number of retransmission attempts, K_{max}', a station must give up and try later.



Pure ALOHA

- Time-out period = the maximum possible round-trip T_p.

  = twice the amount of time required to send a frame between the two most widely separated stations ($2 \times T_p$)'

- The back-off time $\mathbf{T_B}$: random value that normally depends on *K*.
- The value of $\mathbf{K_{max}}$ is usually chosen as 15.

Example

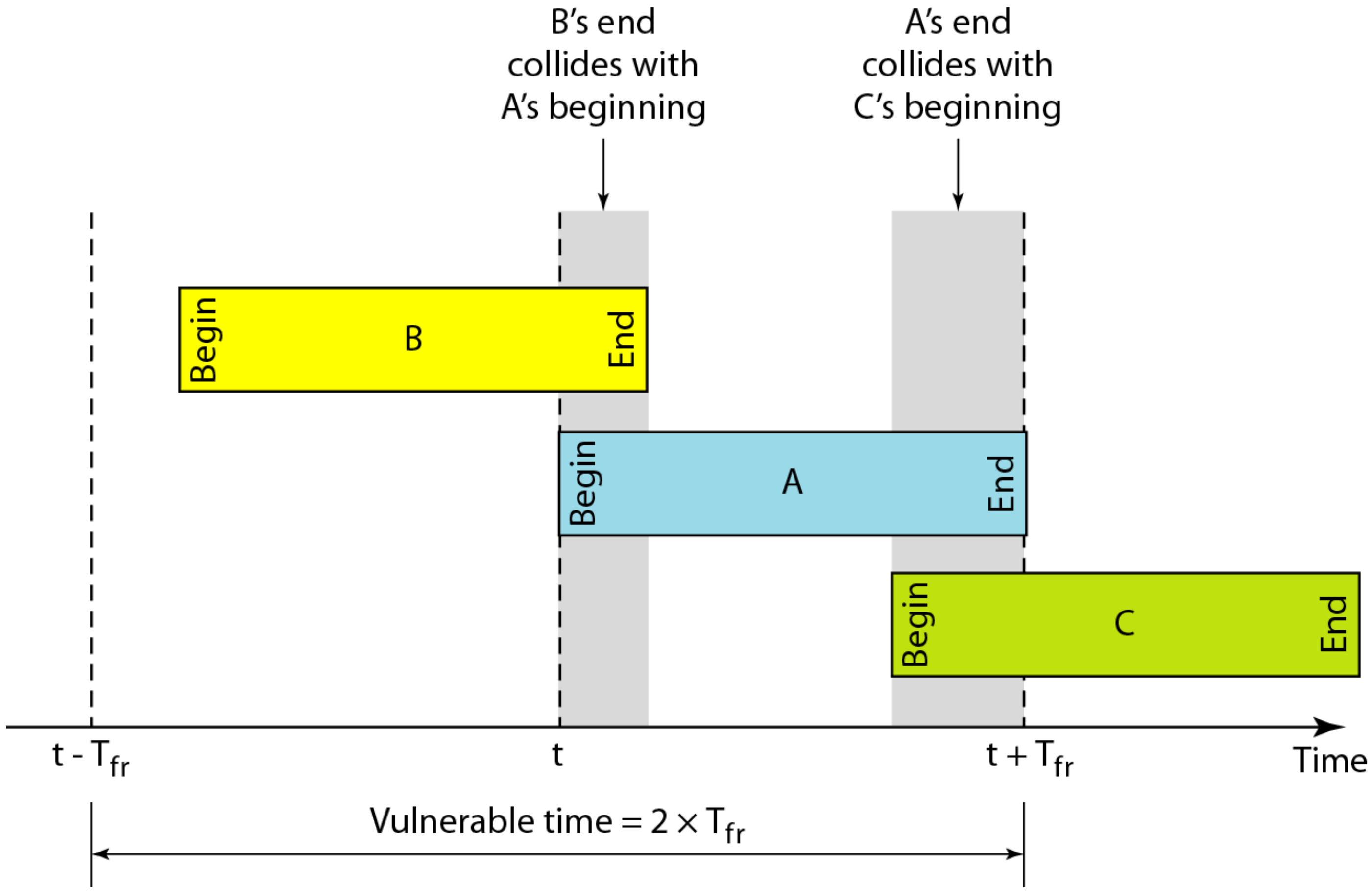
Q: The stations on a wireless ALOHA network are a maximum of **600 km** apart. If we assume that signals propagate at **3×10^8 m/s**, we find the propagation delay as

$$Tp = (6 \times 10^5) / (3 \times 10^8) = 2 \text{ ms.}$$

- Now we can find the value of T_B for different values of K .
- For K = 1, the range is {0, 1}. The station needs to generate a random number with a value of 0 or 1. This means that T_B is either 0 ms (0×2) or 2 ms (1×2), based on the outcome of the random variable.
- For K = 2, the range is {0, 1, 2, 3}. This means that T_B can be 0, 2, 4, or 6 ms, based on the outcome of the random variable.

Pure ALOHA: Vulnerable time

- Vulnerable time: The time in which there is a possibility of collision.
- Assumptions:
  - The stations send fixed-length frames
  - Each frame takes T_{fr} sec to send.



Pure ALOHA: Vulnerable time

Q:

A pure ALOHA network transmits **200-bit frames** on a shared channel of **200 kbps**. What is the requirement to make this frame collision-free?

Solution:

Pure ALOHA: Throughput

If the average number of frames generated by **the system** during one frame transmission time = **G,**

the average number of successful transmissions for pure ALOHA :

$$S = G \times e^{-2G}$$

- If G = 0.5, **S = 0.184** ← S_{max}
- Interpretation?
- Computation of G?
  - $G = n_s \times n_{fs} \times T_{fr}$
  - n_s :the number of stations
  - n_{fs} :the number of frames a station can send per second.

Pure ALOHA: Throughput

Q: What is the throughput if the system (all stations together) produces: a. 1000 frames per second, b. 500 frames per second, c. 250 frames per second? (Assume previous data).

Q: We have a pure ALOHA network with 100 stations. If T_{fr} = 1 microseconds, what is the number of frames/second each station can send to achieve the maximum efficiency?

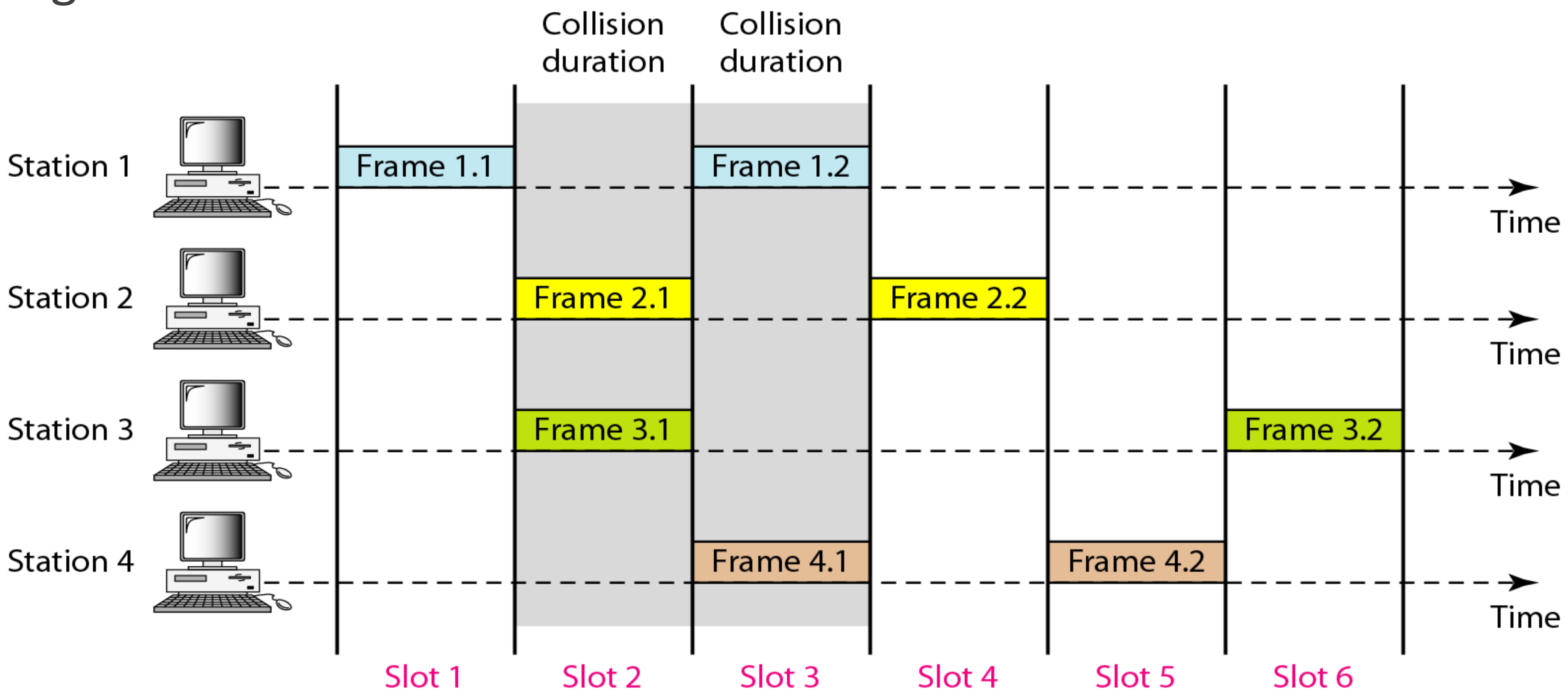
Solution:

To achieve the maximum efficiency in pure ALOHA, G = 1/2.

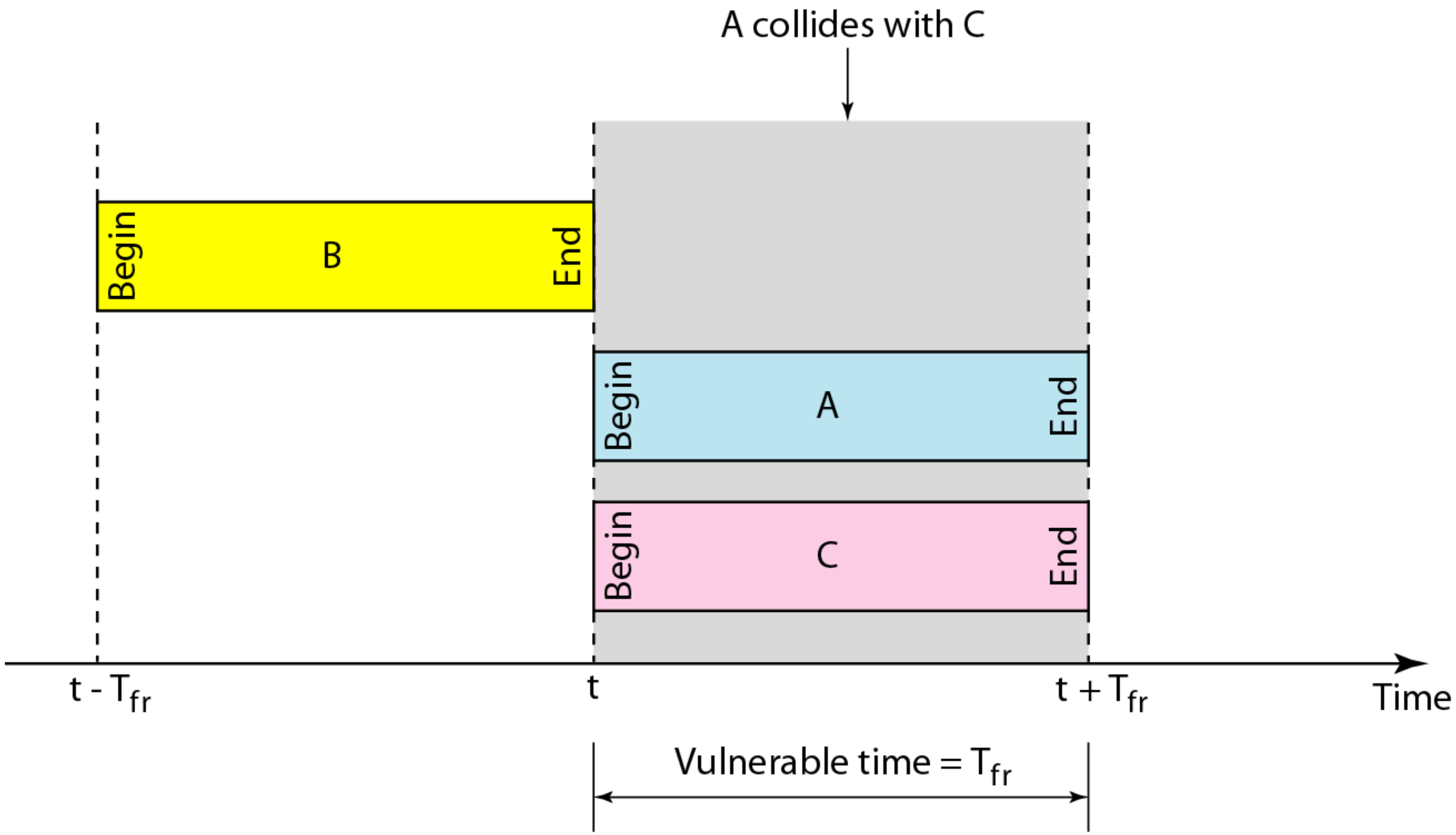
$G = n_s \times n_{fs} \times T_{fr} = 100 \times n_{fs} \times 1\ \mu s = 1/2 \rightarrow n_{fs} = 5000$ frames/second

Slotted ALOHA

- The time is divided into slots of T_{fr} seconds, and the station is forced to send only at the beginning of the time slot.



Slotted ALOHA: Vulnerable Time



Slotted ALOHA: Throughput

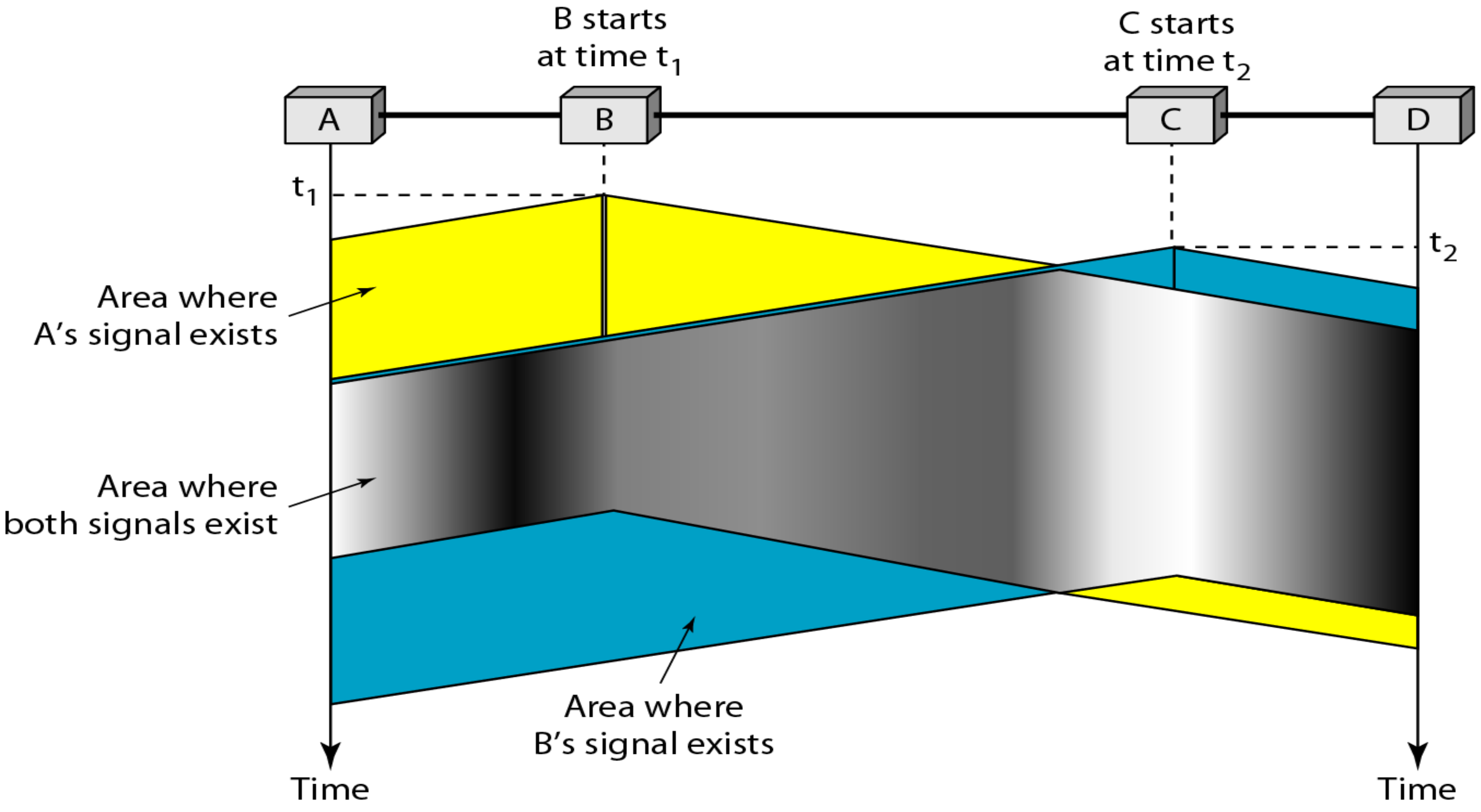
- The throughput for slotted ALOHA is $\mathbf{S = G \times e^{-G}}$ **.**
- The maximum throughput $\mathbf{S_{max} = 0.368}$ when $\mathbf{G = 1}$.
- If a station generates only one frame in this vulnerable time (and no other station generates a frame during this time), the frame will reach its destination successfully.

Q: N= 200 bits, R= 200 Kbps. What is the throughput if the system (all stations together) produces: a. 1000 frames per second, b. 500 frames per second, c. 250 frames per second?

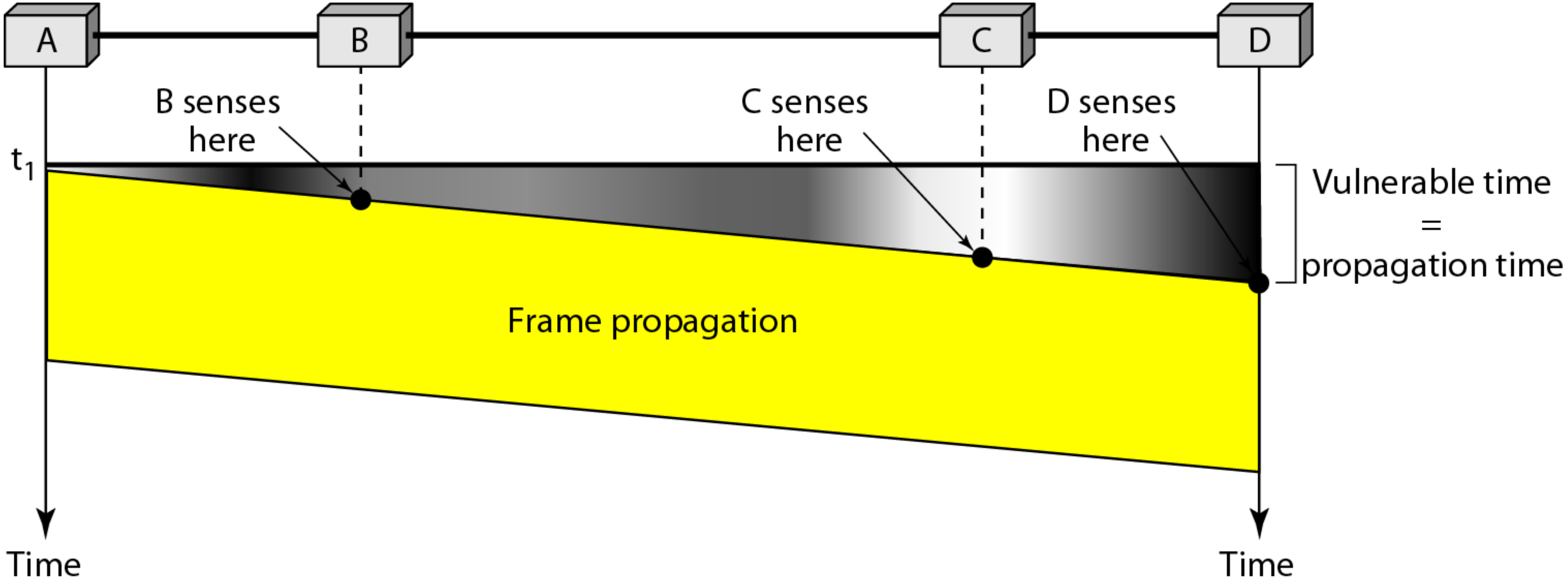
Carrier Sense Multiple Access (CSMA)

- Based on the principle “sense before transmit” or “listen before talk.”
- CSMA requires that each station first listen to the medium (or check the state of the medium) before sending.
- CSMA can reduce the possibility of collision, but it cannot eliminate it.
- The possibility of collision still exists because of propagation delay; a station may sense the medium and find it idle, only because the first bit sent by another station has not yet been received.

CSMA

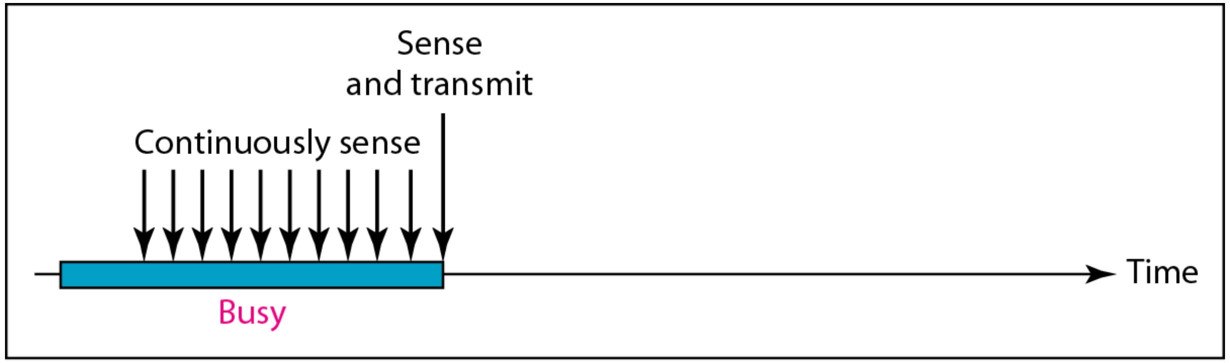

B starts
at time t_1
C starts
at time t_2
A
B
C
D
t_1
t_2
Area where
A's signal exists
Area where
both signals exist
Area where
B's signal exists
Time
Time

CSMA: Vulnerable Time

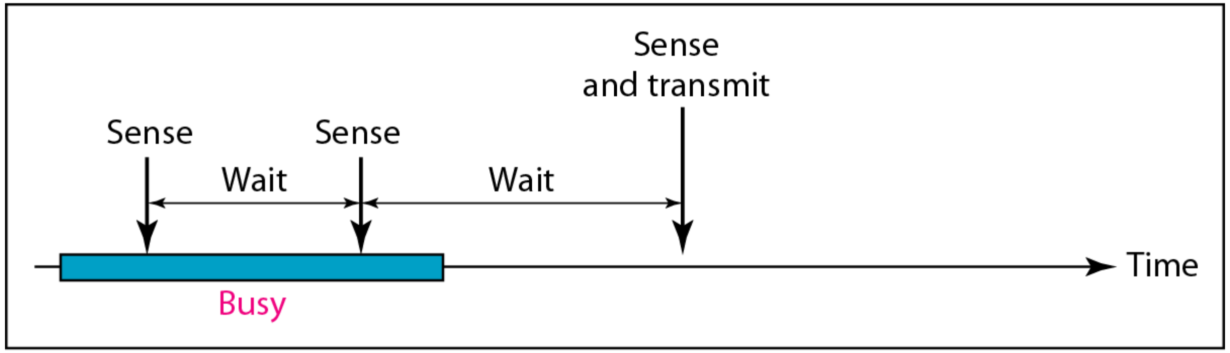


CSMA: Persistent Methods

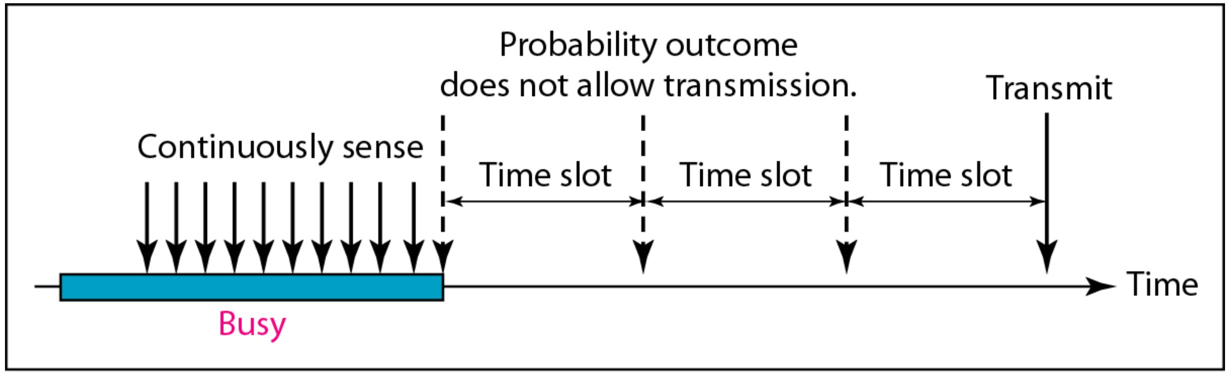
Defines what the system does when the channel is busy/idle.



a. 1-persistent



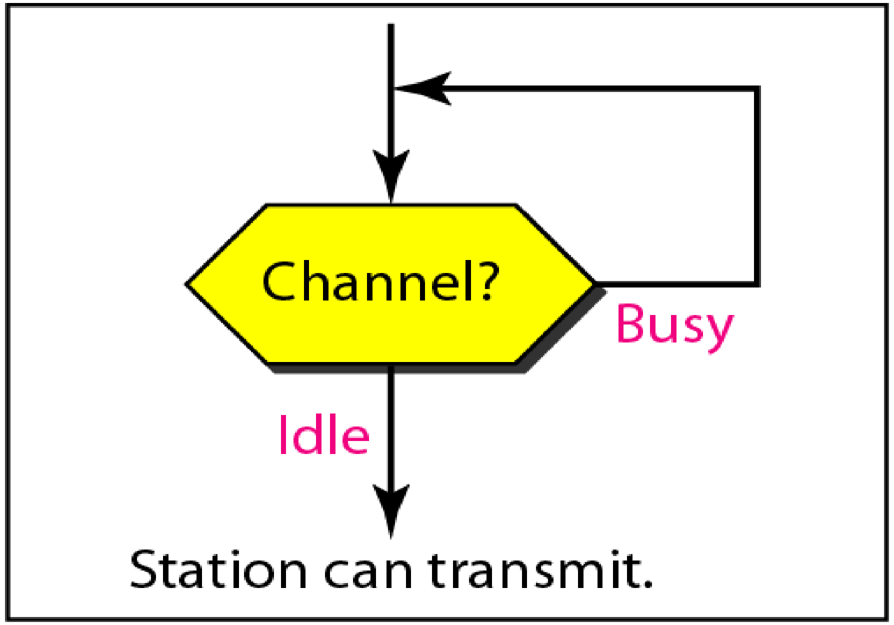
b. Nonpersistent



c. p-persistent

1-Persistent CSMA

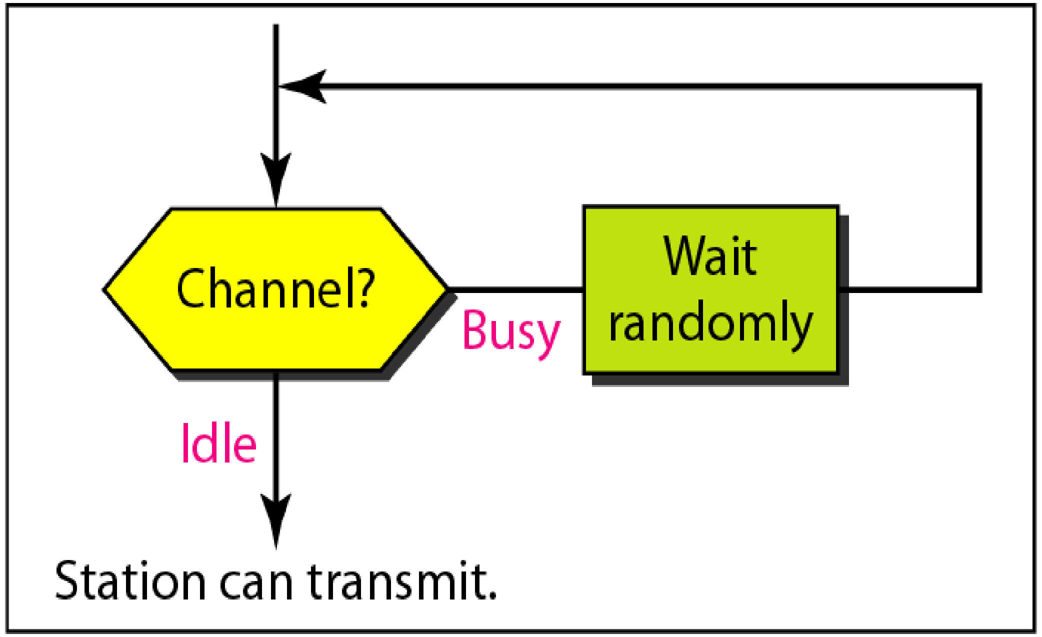
- Keeps sensing the medium continuously.
- If channel is idle, sends a frame immediately, with probability 1.
- Highest chance of collision. Why?



a. 1-persistent

Non-persistent CSMA

- Reduces the chance of collision.
- Reduces the efficiency of the network because the medium remains idle when there may be stations with frames to send.



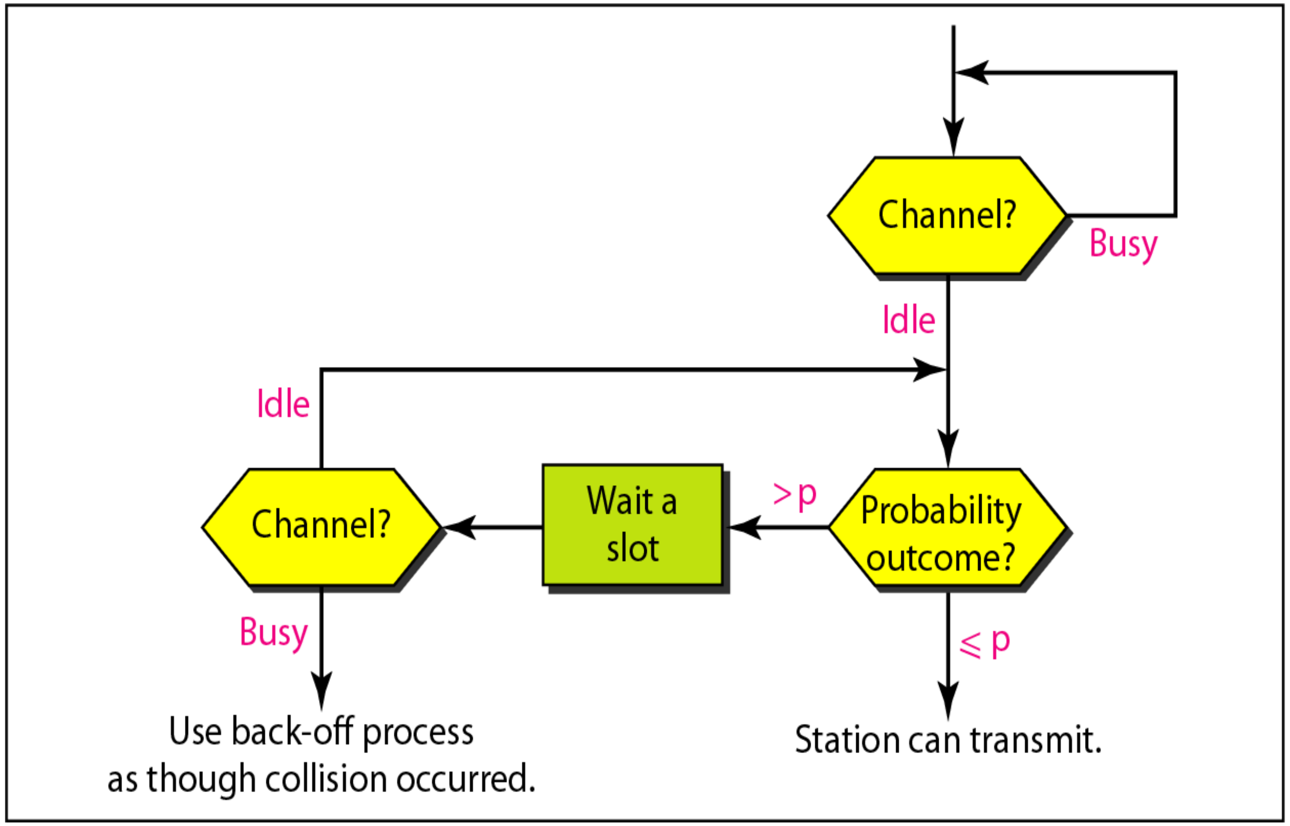
b. Nonpersistent

p-Persistent CSMA

- Used if the channel has time slots with a slot duration ≥ $Tp_{max.}$
- It reduces the chance of collision and improves efficiency.
- In this method, after the station finds the line idle it follows these steps:

   1. With probability *p,* the station sends its frame.
   2. With probability *q* = 1 - *p,* the station waits for the beginning of the next time slot and checks the line again.
      a. If the line is idle, it goes to step 1.
      b. If the line is busy, it acts as though a collision has occurred and uses the back-off procedure.

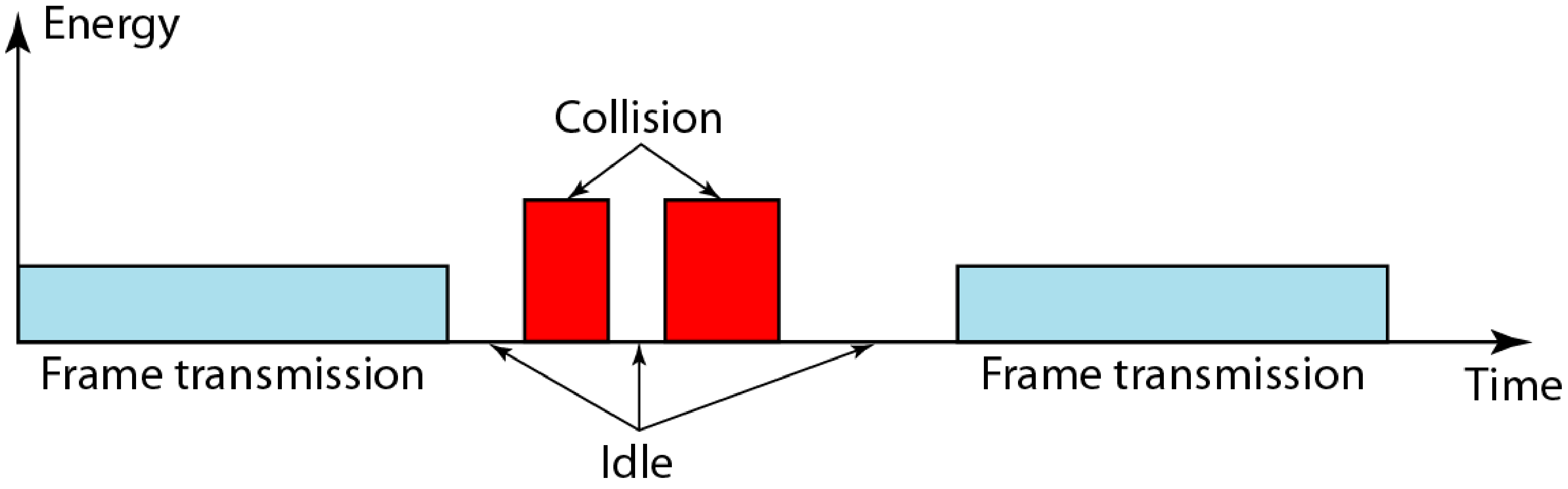
p-Persistent CSMA



c. p-persistent

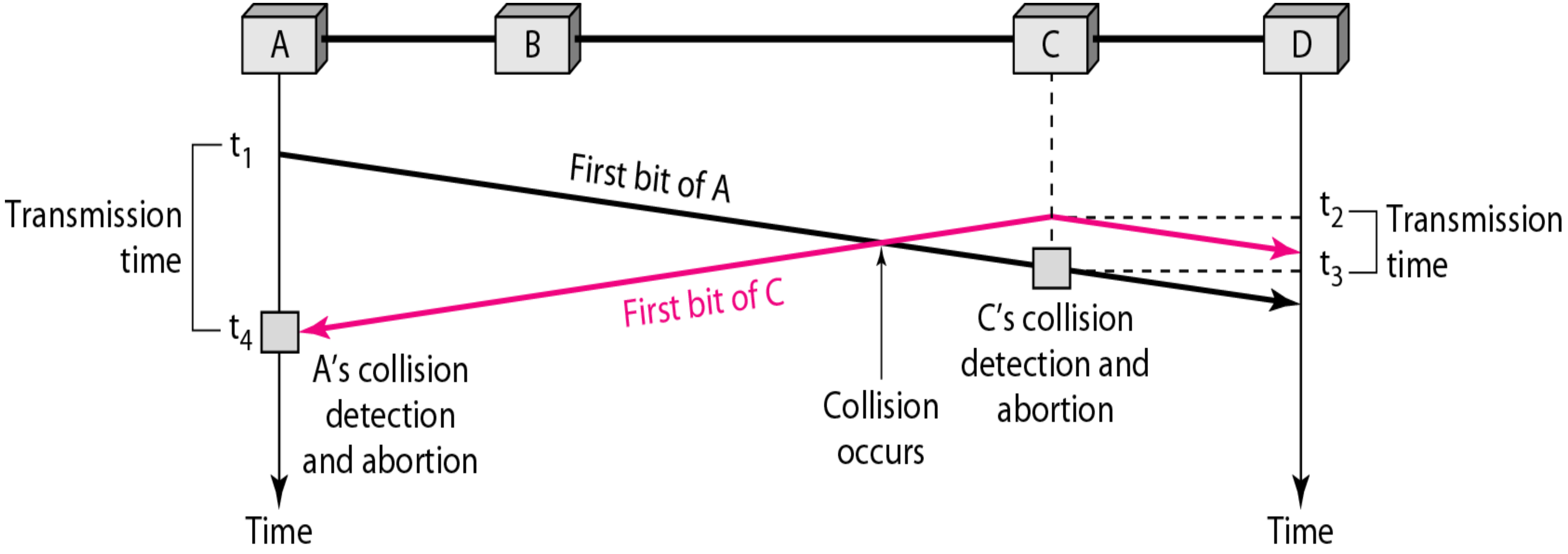
Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

- Limitation of CSMA: Does not specify the procedure following a collision.
- CSMA/CD augments the algorithm to handle the collision.
- Here, a station monitors the medium after it sends a frame to see if the transmission was successful.

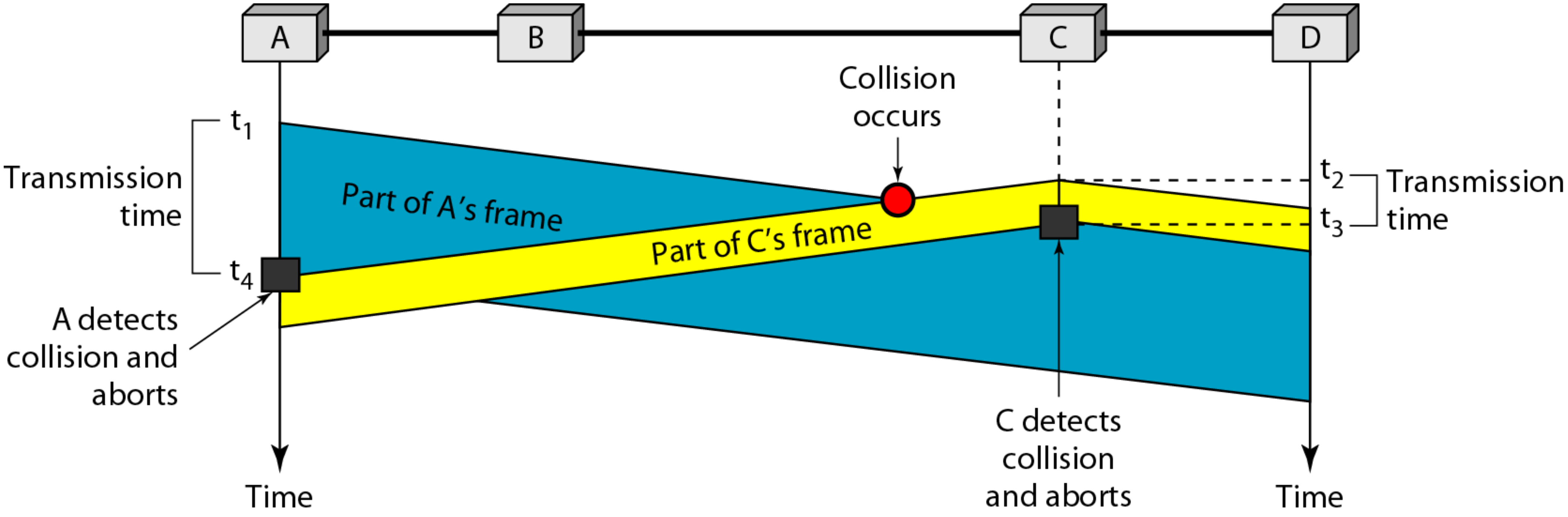


CSMA/CD

- If a collision is detected, transmission is aborted.



CSMA/CD



A
B
C
D
Collision occurs
t_1
Transmission time
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

CSMA/CD: Minimum Frame Size

- Before sending the last bit of the frame, the sending station must detect a collision, if any, and abort the transmission.
- Reason: Once the entire frame is sent, the station does not keep a copy of the frame and does not monitor the line for collision detection.
- $\mathbf{T_{fr} \geq 2 \times T_p}$. Why?
- In the worst-case scenario, if the two stations involved in a collision are the maximum distance apart, the signal from the first takes time $\mathbf{T_p}$ to reach the second, and the effect of the collision takes another time $\mathbf{T_p}$ to reach the first.

CSMA/CD

Q: A network using CSMA/CD has a **bandwidth of 10 Mbps**. If the maximum propagation time (including the delays in the devices and ignoring the time needed to send a jamming signal, as we see later) is **25.6 μs**, what is the minimum size of the frame?

Solution:

The frame transmission time is $T_{fr} = 2 \times T_p = 51.2\ \mu s$.

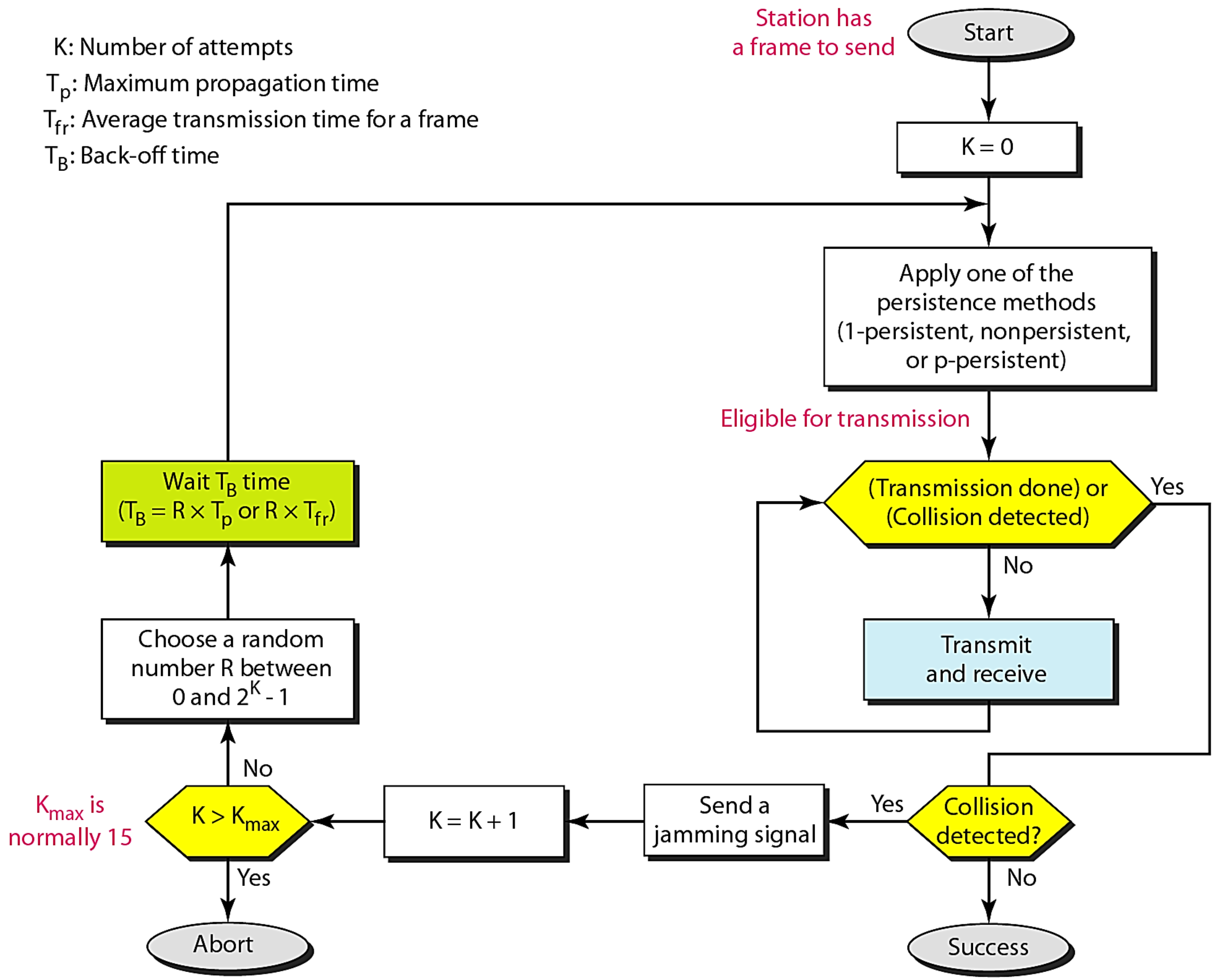
This means, in the worst case, a station needs to transmit for a period of 51.2 μs to detect the collision.

The minimum size of the frame is 10 Mbps × 51.2 μs = 512 bits or 64 bytes.

This is actually the minimum size of the frame for Standard Ethernet.

CSMA/CD

Differences?



CSMA/CD: Throughput

- The throughput of *CSMAICD* is greater than that of pure or slotted ALOHA.
- The maximum throughput occurs at a different value of G and is based on the **persistence method** and the value of '***p***' in the p-persistent approach.
- For 1-persistent method, the maximum throughput is around 50 percent when G =1.
- For non-persistent method, the maximum throughput can go up to 90 percent when G is between 3 and 8.

CSMA/CD

Q: In CSMA/CD, the minimum frame size is 512 bits, if BW=10Mbps. What should be the minimum frame size, if a) BW=100Mbps b) 1Gbps c) 10Gbps?

Hint: Find the relationship between the minimum frame size and the data rate/BW.

Controlled Access

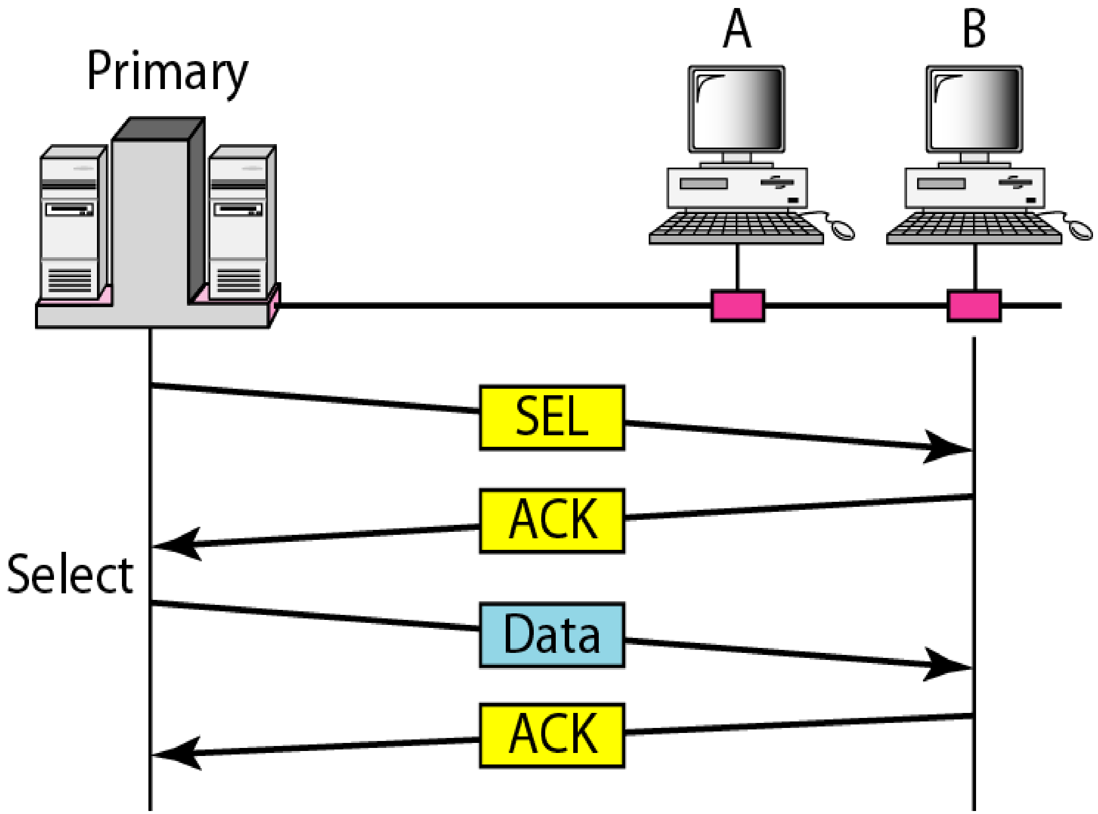
- The stations consult one another to find which station has the right to send.
- A station cannot send unless it has been authorized by other stations.
- Methods:
  - Reservation
  - Polling
  - Token Passing

Polling

- Works with topologies in which one device is designated as a **primary station** and the other devices are **secondary stations**.
- All data exchanges must be made through the primary device even when the ultimate destination is a secondary device.
- The primary device controls the link; the secondary devices follow it instructions.
- The primary device is always the **initiator** of a session.
- They are two functions in polling access method:
  - Select
  - Poll

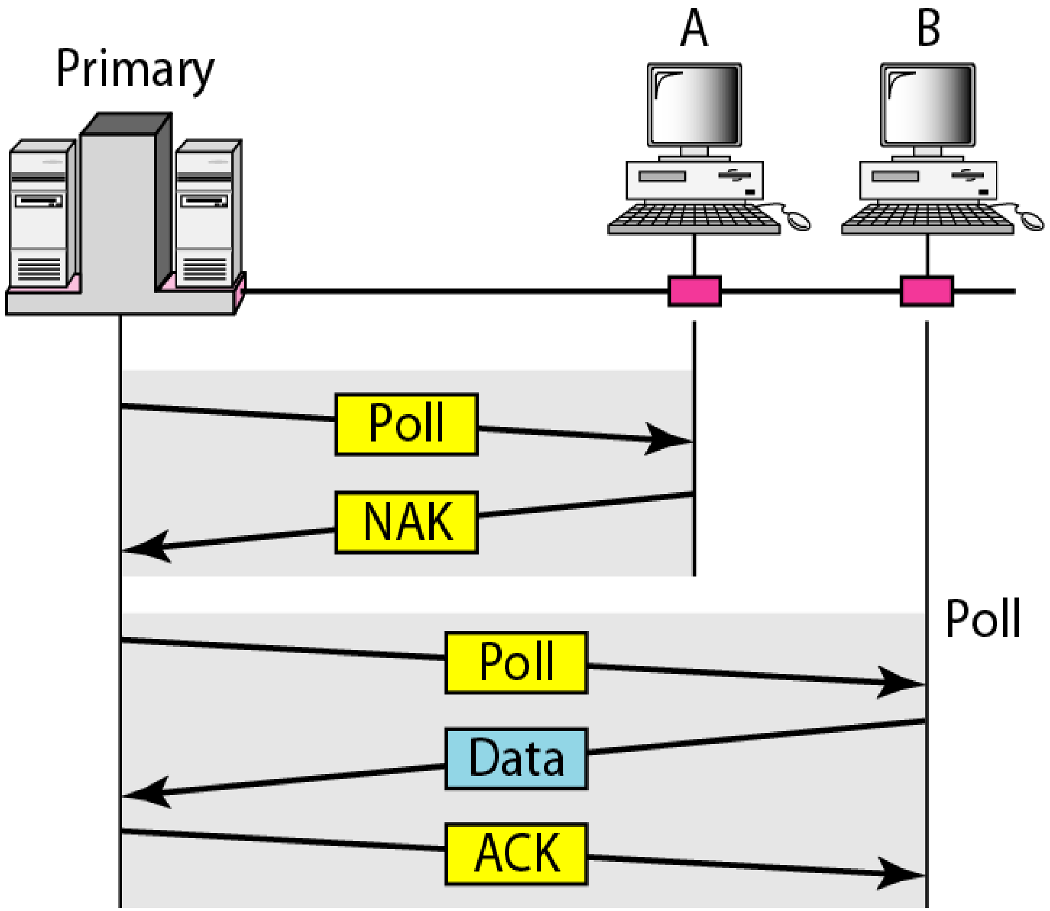
Polling: SELECT

- If the primary is neither sending nor receiving data, it knows the link is available. How?
- The ***select*** function is used whenever the primary device has something to send.
- The primary device must alert the secondary device before sending the transmission.



Polling : POLL

- The ***poll*** function is used by the primary device to solicit transmissions from the secondary devices.
- When the primary is ready to receive data, it must ask (poll) each device in turn if it has anything to send.
- The secondary may respond either with a NAK frame if it has nothing to send or with data if it does.



Polling

Q: A network with **one primary** and **four secondary** stations uses polling.

The size of a data frame is **1000 bytes**.

The size of the poll, ACK, and NAK frames are **32 bytes each**.

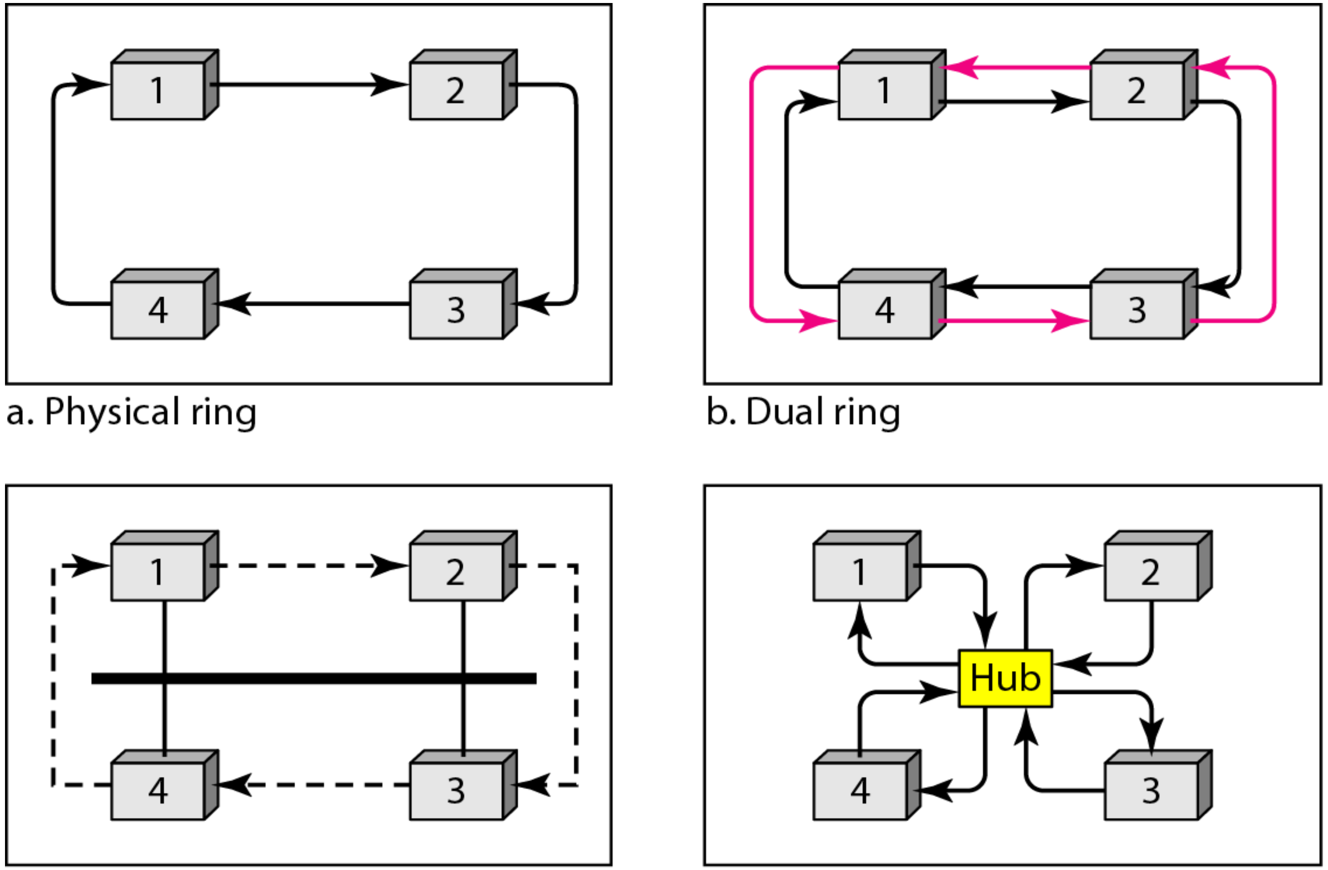
Each station has **5 frames** to send.

How many **total bytes** are exchanged if a station can send **only one frame in response to a poll**?

Token Passing

- The stations in a network are organized in a logical ring, with each station having a ***predecessor*** and a ***successor***.
- The right to channel access has been passed from the predecessor to the current station and will be passed from current station to the successor.
- Right to access is managed through a **token**.
- If a station has some data to send, it must wait for the token from its predecessor.
- **Token management** is needed for this access method: time for holding token, preventing token from getting lost or destroyed, assigning priorities, and so on.

Token Passing : Logical Ring



a. Physical ring
b. Dual ring
c. Bus ring
d. Star ring

Stations **DO NOT** have to be physically connected in a ring. The ring can be a logical one.

Token Passing

Topology	Description	Address?	Example
Physical Ring	• When a station sends the token to its successor, the token cannot be seen by other stations. • Problems?	No need for successor's address.	-
Dual Ring	• Auxiliary ring in reverse direction. • 2 transmitter ports, 2 receiver ports.	No need for successor's address.	FDDI, CDDI
Bus Ring (Token Bus)	• The stations are connected to a single cable called a bus.	Address of successor, and predecessor(?)	Token Bus Lan standardized by IEEE
Star Ring	• Hub acts as the connector. The wiring inside the hub makes the ring; the stations are connected to this ring through the two wire connections. • Advantages?	??	Token Ring LAN by IBM

Books

1. Alberto Leon Garcia – " Communication Networks" – 6.1
2. Behrouz Forouzan, "Data Communications and Networking", 4th ed. , Chapter:12.