Medium Access Control

We can consider the data link layer as two sublayers.

The upper sublayer is responsible for data link control, and the lower sublayer is responsible for resolving access to the shared media.

Medium Access Control

Multiple Access Protocols

Random Access Protocols

Channelization Protocols

Controlled Access Protocols

Questions:

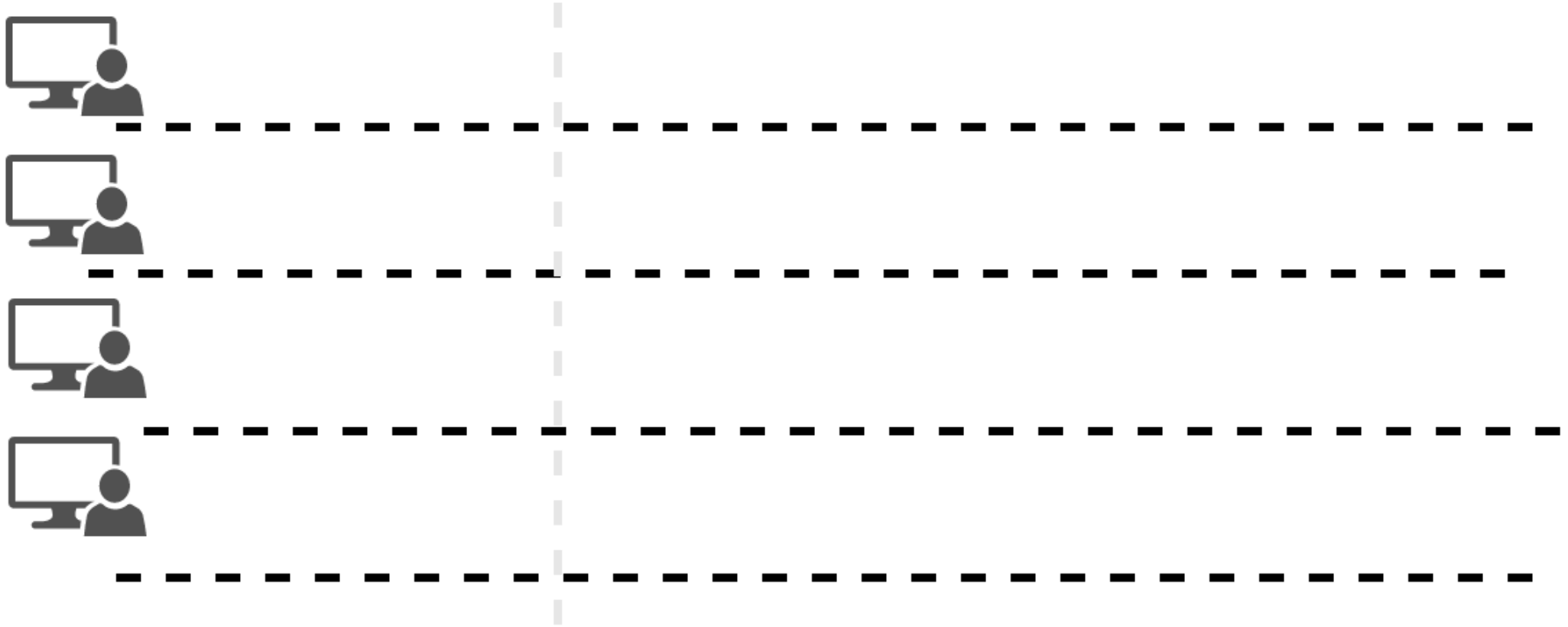
1. When can the station access the medium?
2. What can the station do if the medium is busy?
3. How can the station determine the success or failure of the transmission?
4. What can the station do if there is an access conflict?

ALOHA

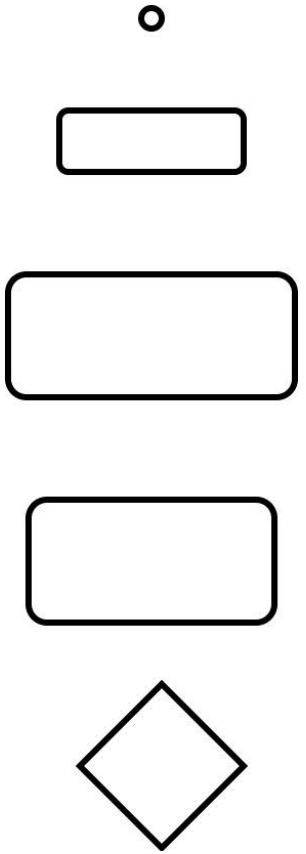
1.

2.

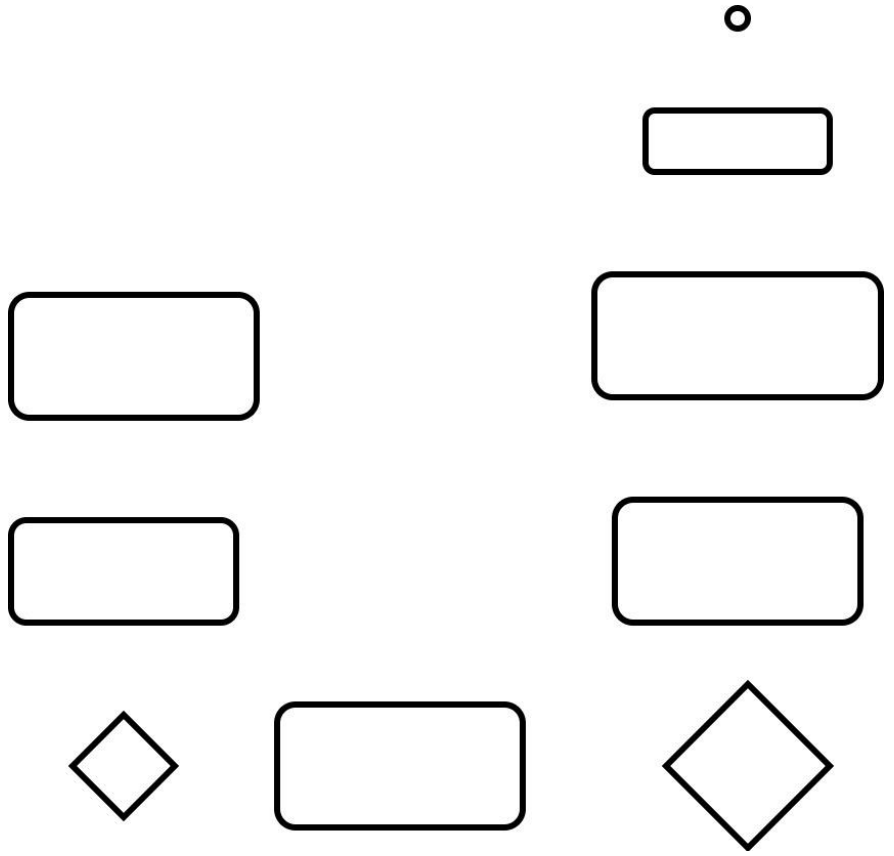
ALOHA



Pure ALOHA



Pure ALOHA



Pure ALOHA

Binary Exponential Backoff time

Pure ALOHA

600KM

3*10^8 m/s

K=

Vulnerable Time

Throughput

G is the average number f frames generated by the system in one frame transmission time.

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G is the average number f frames generated by the system in one frame transmission time.

Fame size= 200bits

Channel= 200kbps

Throughput if, 1000 frames per second

Throughput

G is the average number f frames generated by the system in one frame transmission time.

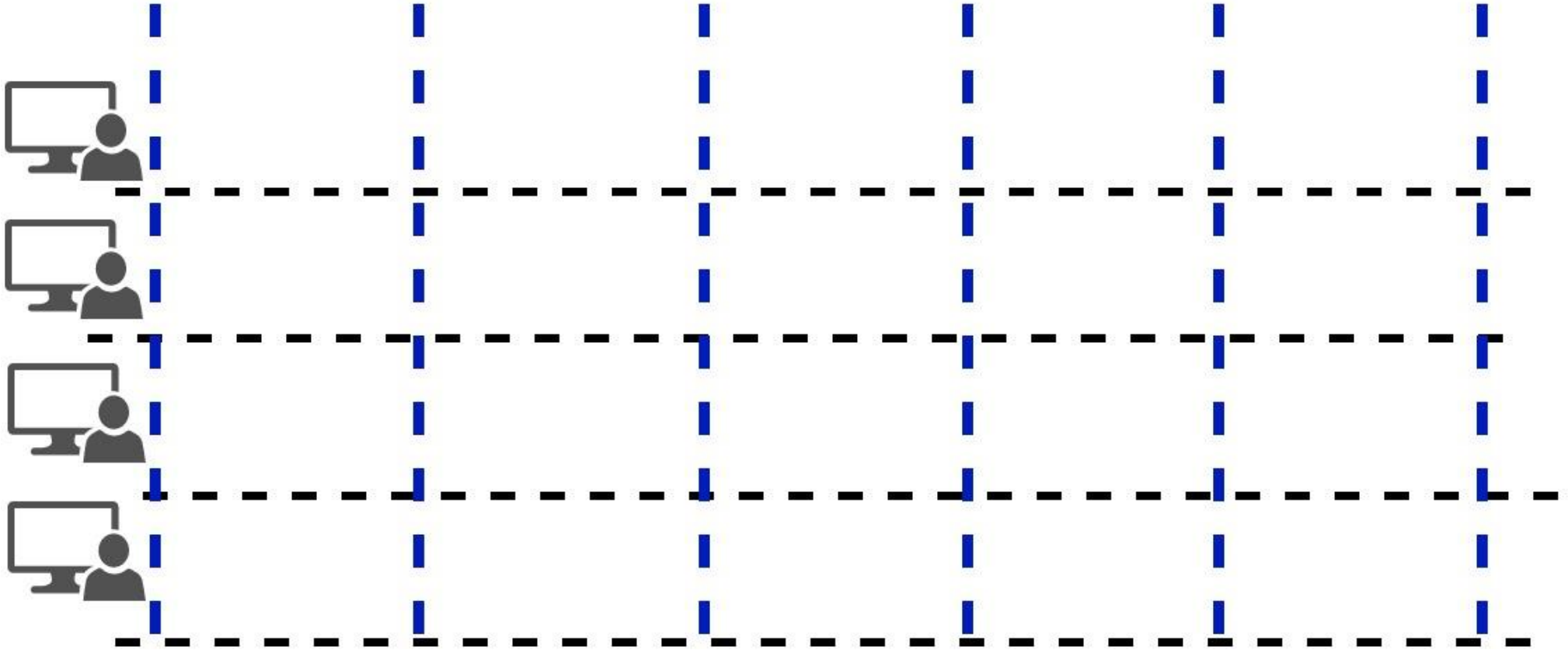
Fame size= 200bits

Channel= 200kbps

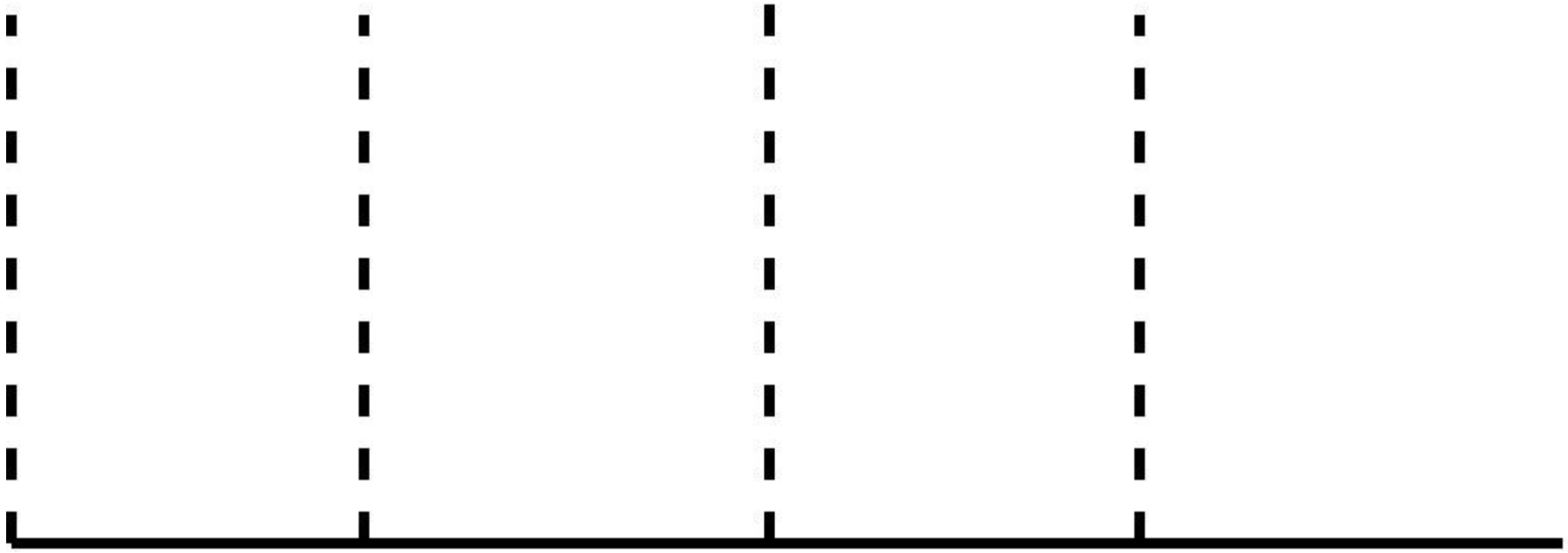
Throughput if, 500 frames per second

Reduce Vulnerable time

Slotted ALOHA



Vulnerable Time



Throughput(Slotted ALOHA)

G is the average number f frames generated by the system in one frame transmission time.

Fame size= 200bits

Channel= 200kbps

Throughput if, 200 frames per second

CSMA – Carrier Sense Multiple Access

To minimize the collision CSMA was developed, chance of collision was reduced

Station **senses the channel before accessing medium**.

The possibility of collision still exists because of propagation delay

CSMA – Carrier Sense Multiple Access

Types of CSMA

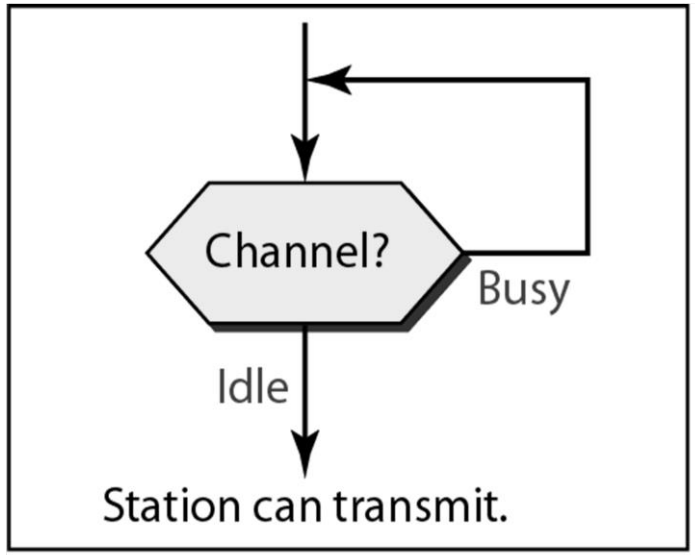
1-Persistent Method

Non- Persistent Method

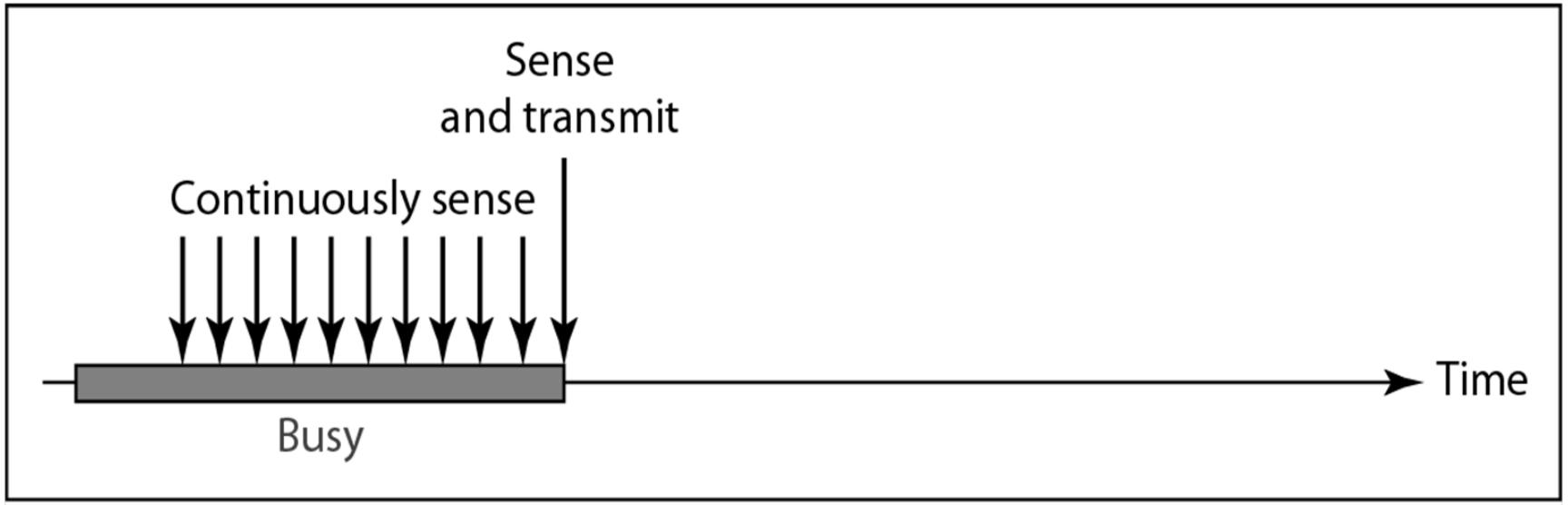
P-Persistent Method

1- Persistent Method

- If the channel is idle it sends its frame immediately with probability 1
- When two or more stations find the line idle and send their frames immediately to create collisions



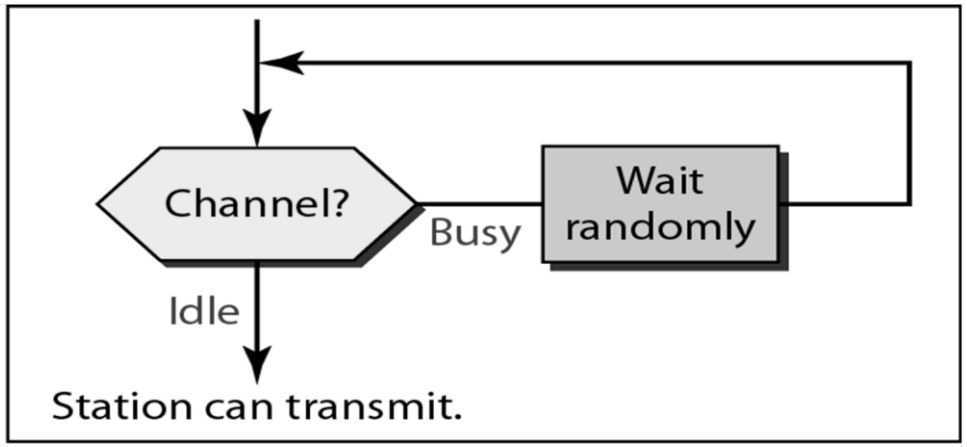
a. 1-persistent



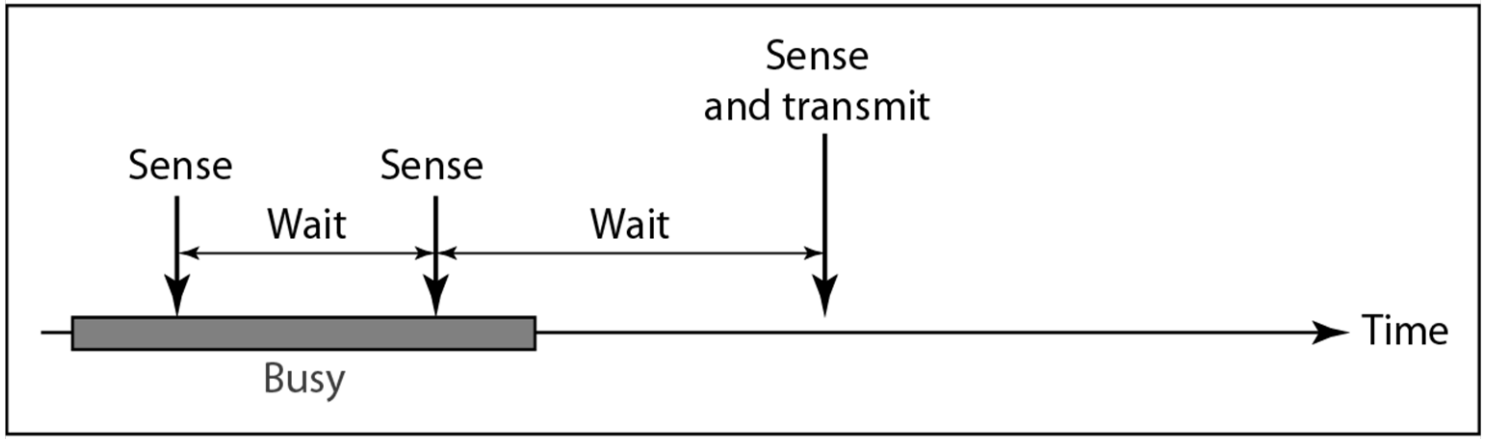
a. 1-persistent

Non-Persistent Method

- If the line is idle it sends its frame immediately.
- If the line is busy it waits random amount of time and then senses the line again.
- Reduces the collision because it is unlikely that two or more stations will wait the same amount of time and retry

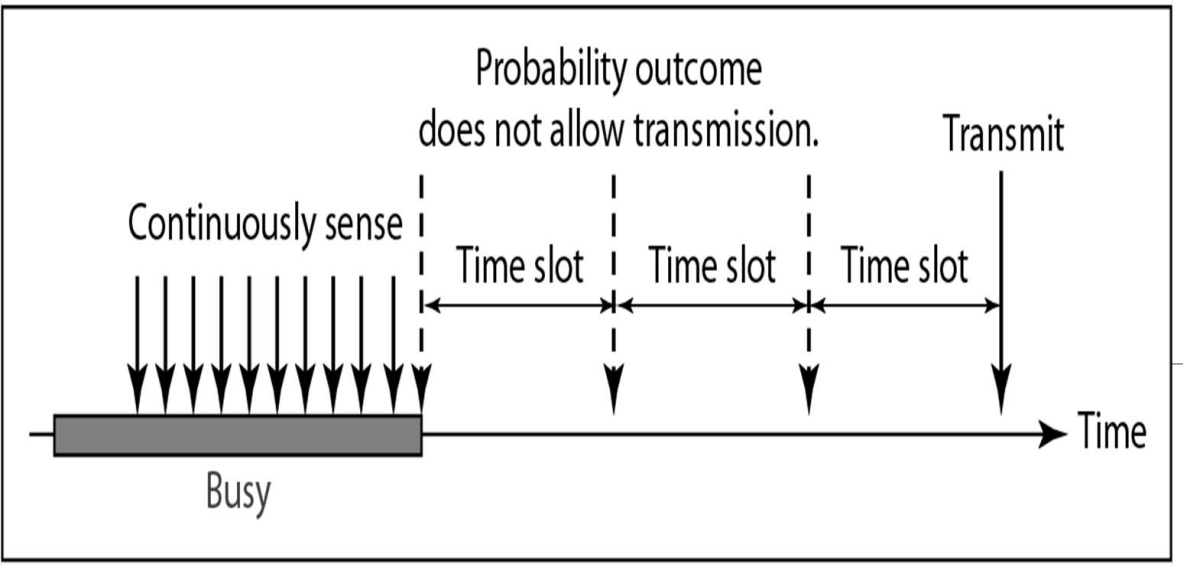


b. Nonpersistent

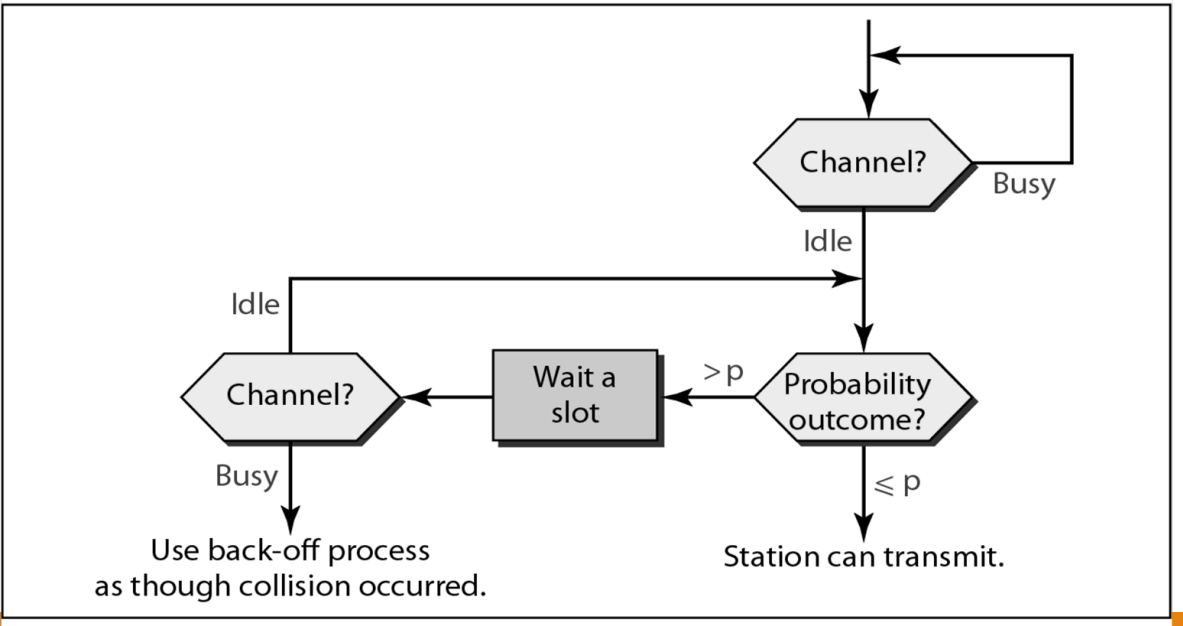


b. Nonpersistent

P-Persistent Method



c. p-persistent

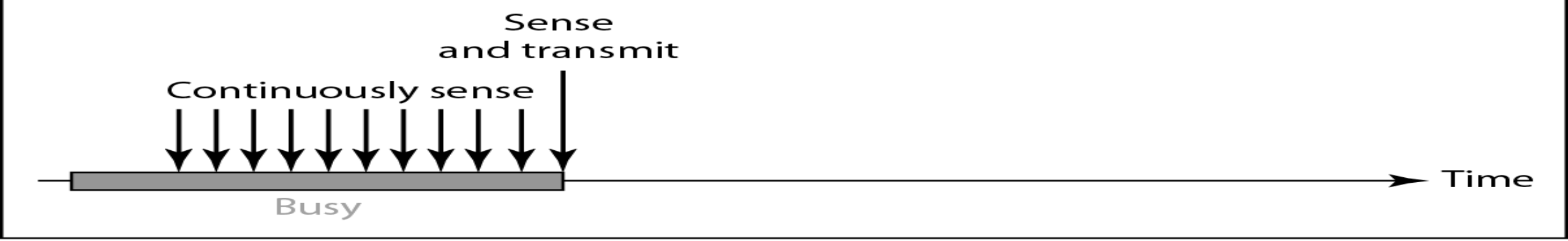


c. p-persistent

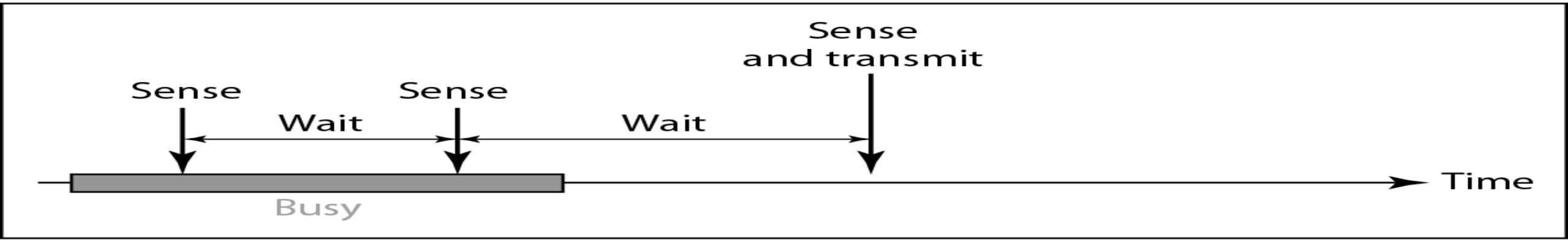
It applies to slotted channels.

1. It senses the channel, if it is idle, it transmits with a probability p.

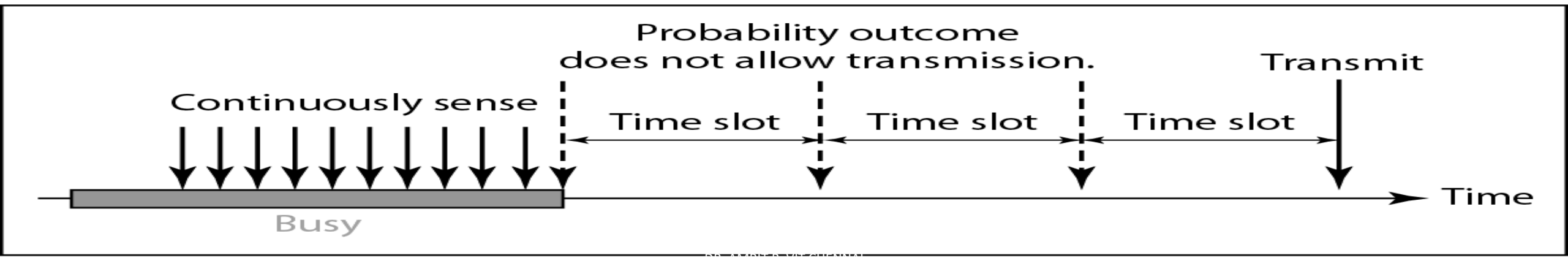
2. With a probability q = 1 - p, it waits for the next slot.
   - If that slot is idle, it goes to step 1
   - If the line is busy it act as though collision has occurred and uses the back off procedure .



a. 1-persistent



b. Nonpersistent



c. p-persistent

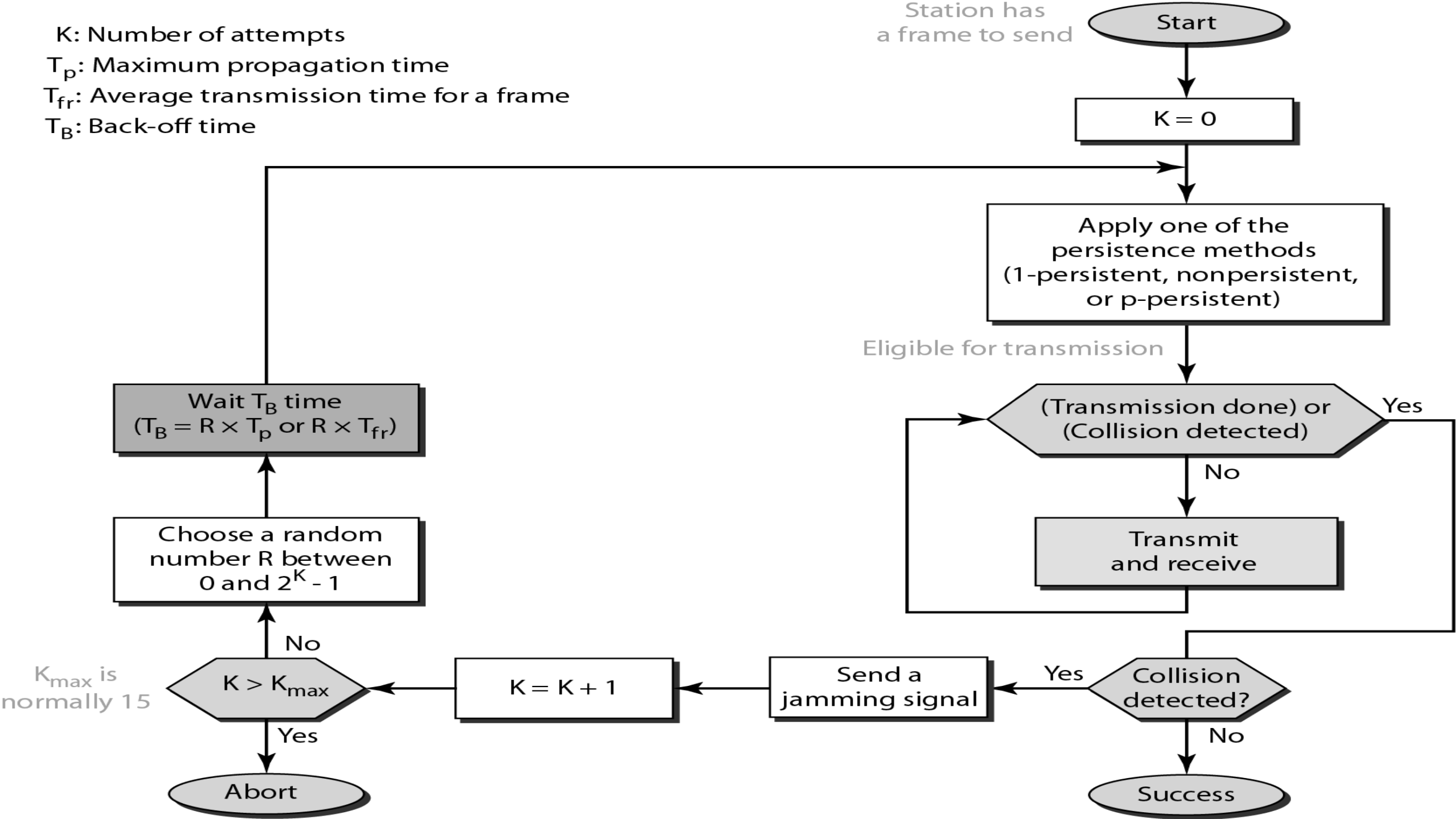
Carrier Sense Multiple Access with Collision Detection (CSMA-CD)

Abort their transmissions as soon as they detect a collision

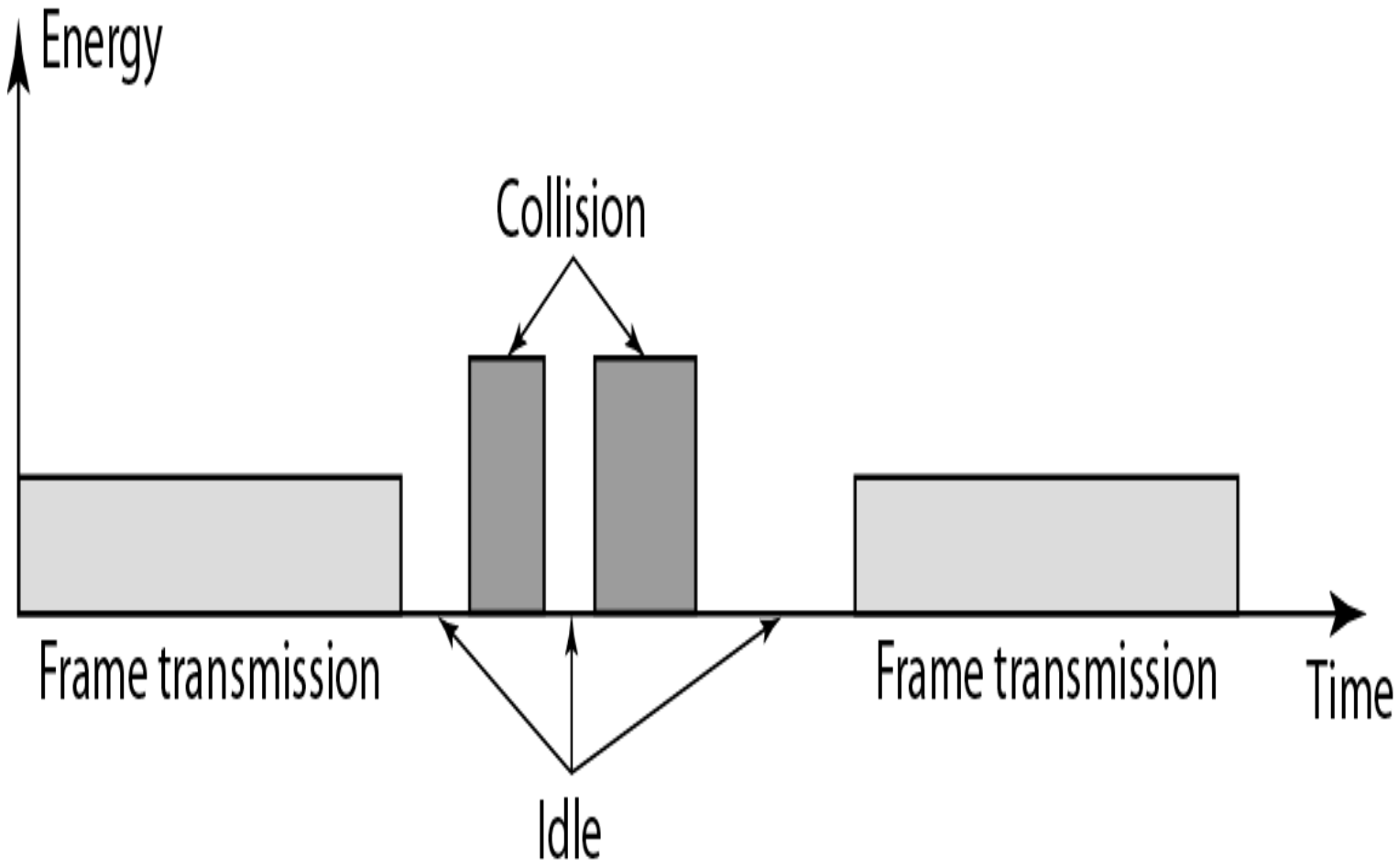
Waits a random period of time, and then tries again, assuming that no other station has started transmitting in the meantime.

Frame transmission time must be two times the maximum propagation time: $Tfr = 2 \times Tp$

Energy levels: zero, Normal Abnormal.


K: Number of attempts
T_p: Maximum propagation time
T_{fr}: Average transmission time for a frame
T_B: Back-off time
Station has a frame to send
Start
K = 0
Apply one of the persistence methods (1-persistent, nonpersistent, or p-persistent)
Eligible for transmission
(Transmission done) or (Collision detected)
Yes
No
Transmit and receive
Collision detected?
Yes
No
Success
Send a jamming signal
K = K + 1
$K > K_{max}$
K_{max} is normally 15
No
Yes
Abort
Choose a random number R between 0 and $2^K - 1$
Wait T_B time ($T_B = R \times T_p$ or $R \times T_{fr}$)

Energy Level during transmission, idleness, or collision



Carrier Sense Multiple Access with Collisio Avoidance (CSMA-CA)

- When there is collision the station receives two signals: its own and the signal transmitted by a second station.
- In wired network received signal is the same as the sent signal (Losses are less).
- In wireless network much of the sent energy is lost in transmission (Transmission Losses).
- Avoid collision on wireless network because they cannot be detected.

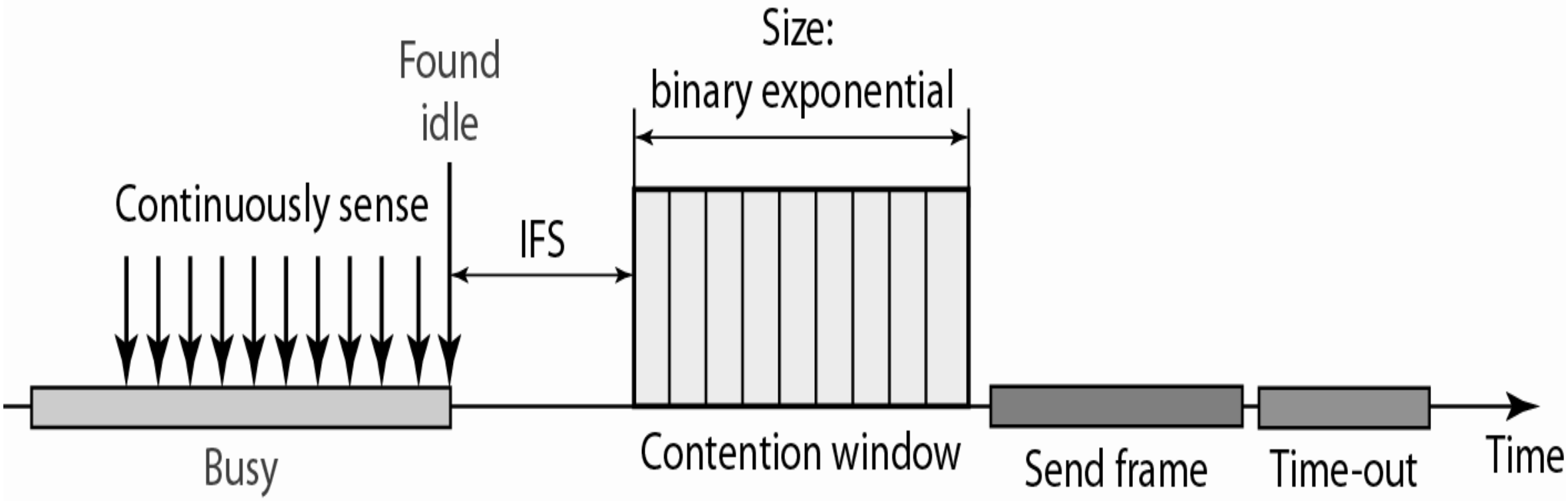
CSMA-CA …

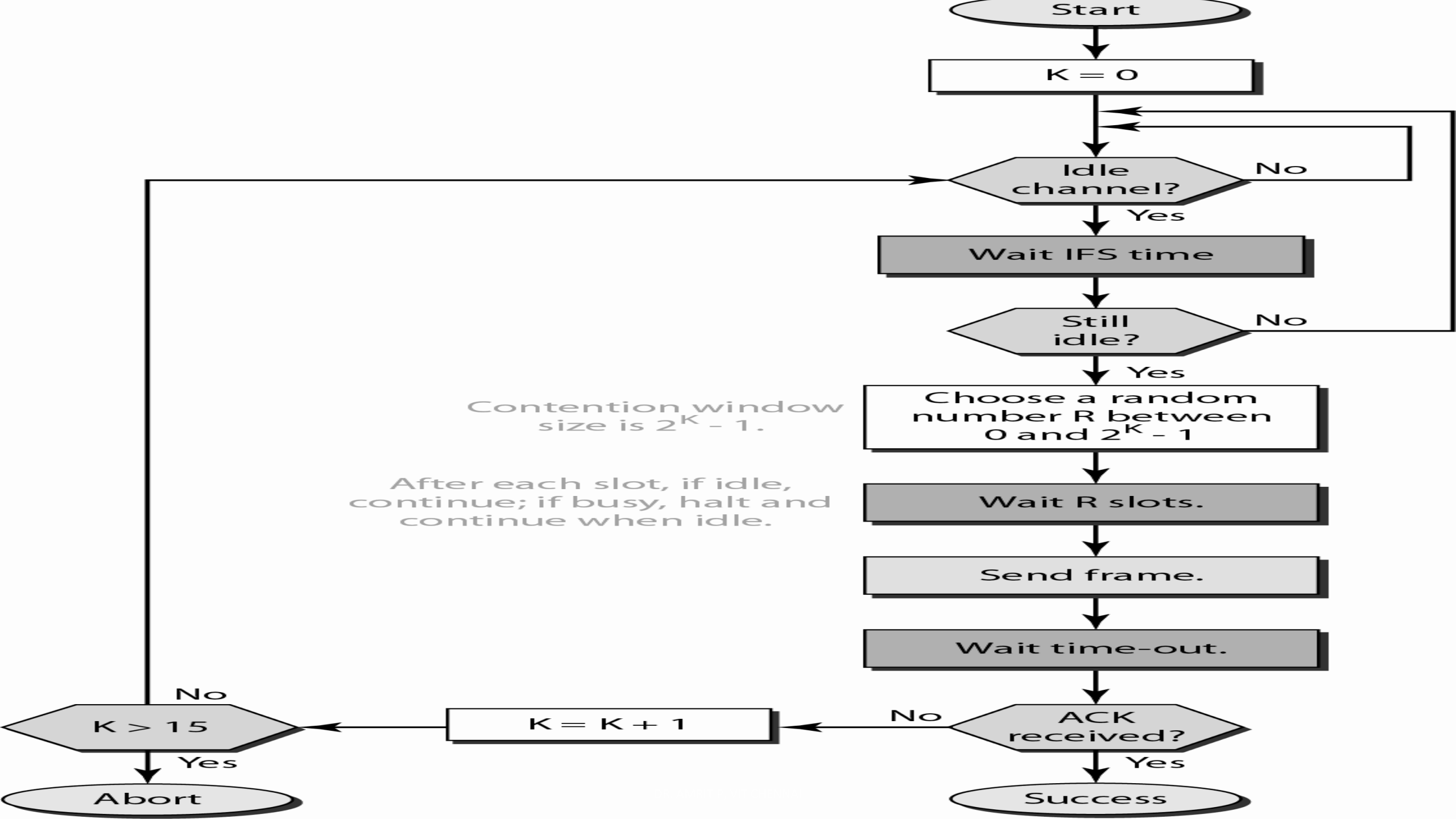
When channel is free waits for period of time called the interframe space or IFS.

After IFS time the station still waits to a time equal to the contention time

Contention window is an amount of time divided into slots.

Timing in CSMA-CA




Start
K = 0
Idle channel?
No
Yes
Wait IFS time
Still idle?
No
Yes
Choose a random number R between 0 and 2^K - 1
Wait R slots.
Send frame.
Wait time-out.
ACK received?
No
Yes
Success
K = K + 1
K > 15
No
Yes
Abort
Contention window size is 2^K - 1.
After each slot, if idle, continue; if busy, halt and continue when idle.

Controlled Access Protocols

In 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.

The three types of Controlled Access Protocols are

- Reservation
- Polling
- Token Passing

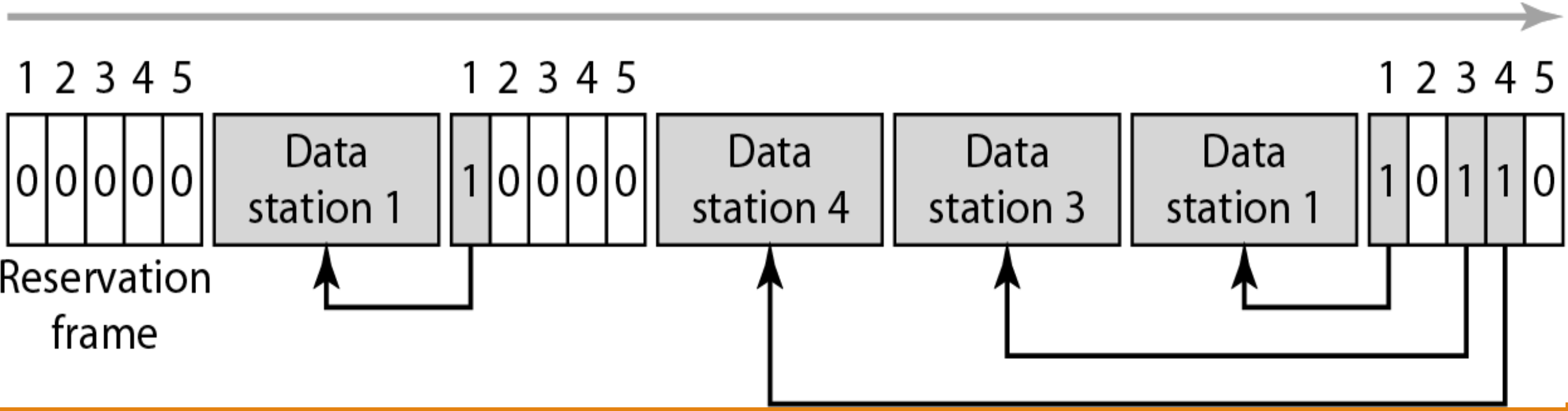
Reservation Access Method

A station must make a reservation before sending data

Time is divided into intervals

- A reservation frame proceeds each time interval
- Number of stations and number of time slots in the reservation frame are equal
- Each time slot belongs to a particular station

Reservation Access Method…

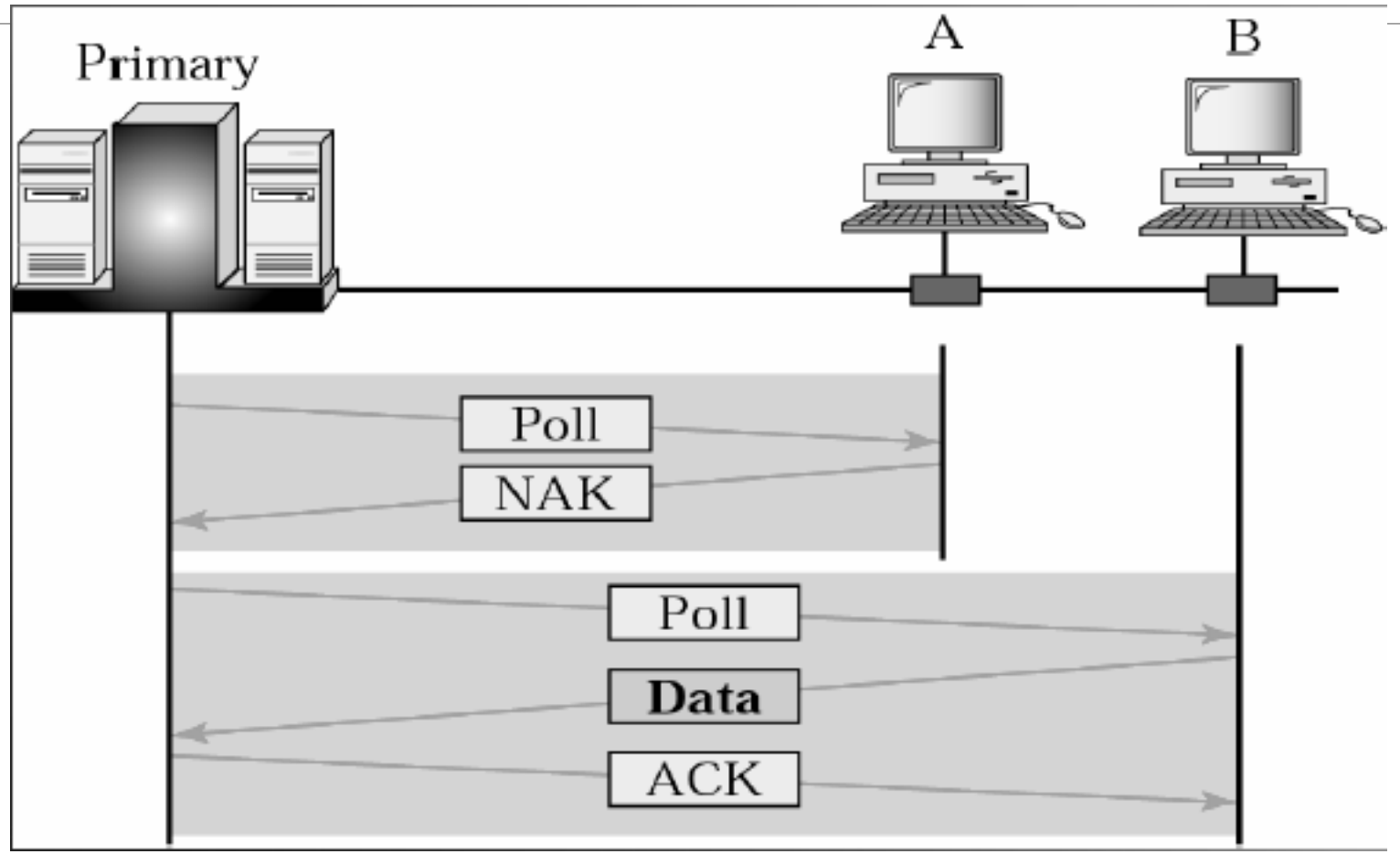


Polling Method

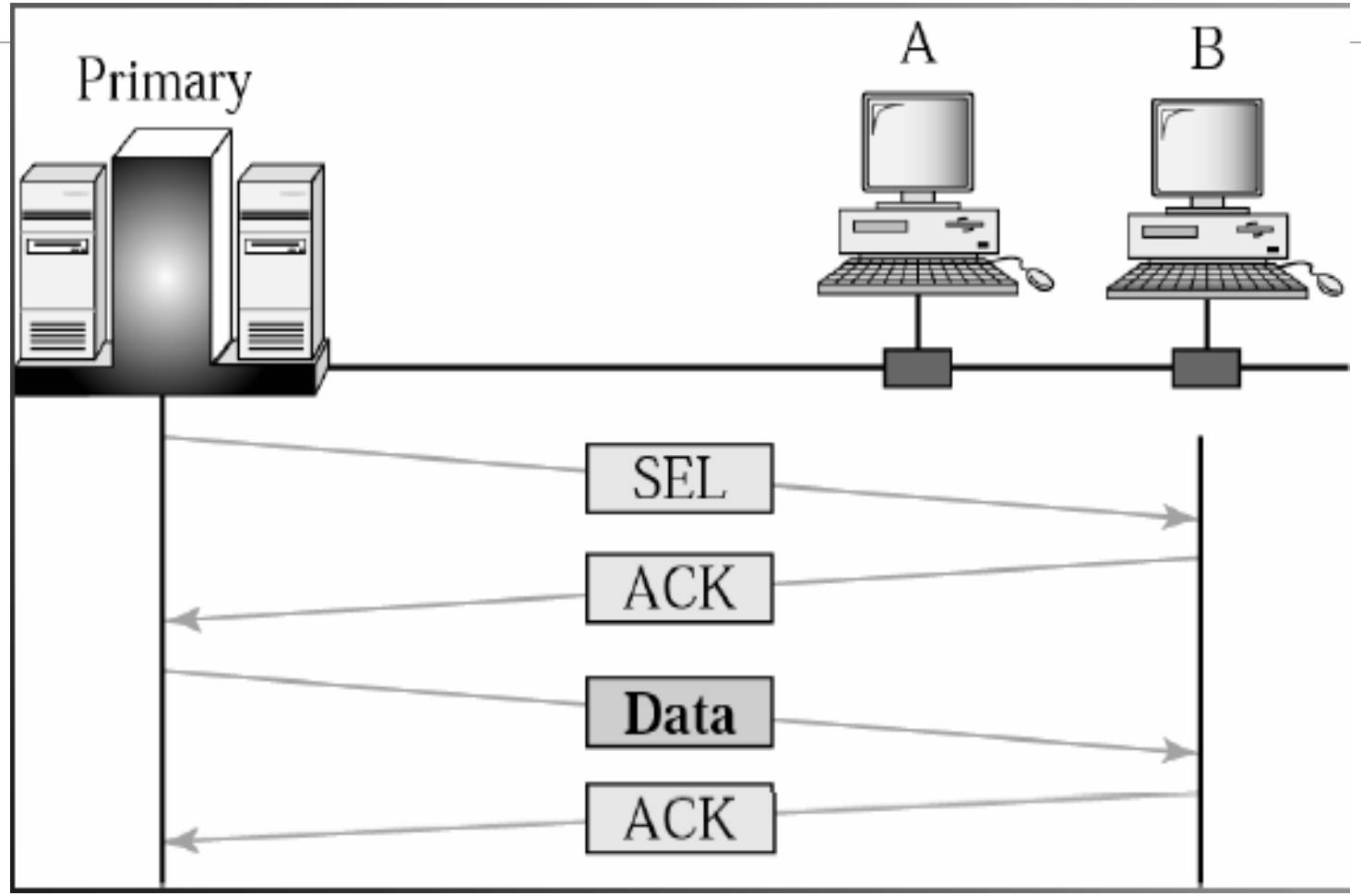
- Devices are categorized as
  - Primary Station (PS)
  - Secondary Station (SS)
- All data exchange must go through the primary station
- Primary station controls the link and initiates the session
- Secondary station obey the instructions of PS.

1. PS polls stations
   - Asking SS if they have something to send
2. PS select a SS
   - Telling it to get ready to receive data

Primary Station (PS) polls stations



Primary Station select a Secondary Station



Token Passing Method

Stations in a network are organized in a **logical ring,** for each station, there is a **predecessor and a successor**

For a station to access the channel**, it must posses a token (special packet)** that gives the station the right to access the channel and send its data

Once the station has finished its task, the token will then be passed to the successor (next station)

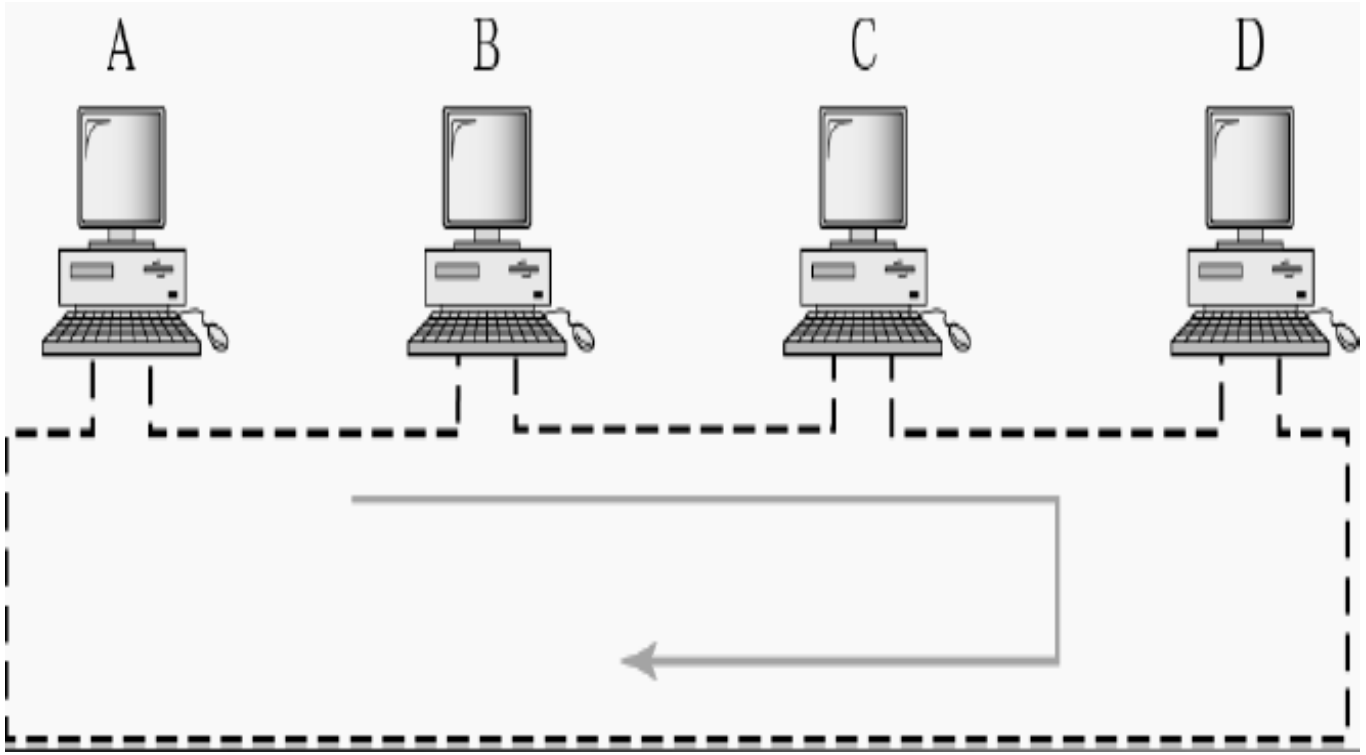
Token Passing Method

The station **cannot send data** **until it** **receives the token again** in the next round

Token management is necessary

- Every station is limited in the time of token possession
- Token must be monitored to ensure no lose or destroyed
- Assign priorities to the stations and to the types of data transmitted
- To make low-priority stations release the token to high priority stations

Token Passing Procedure



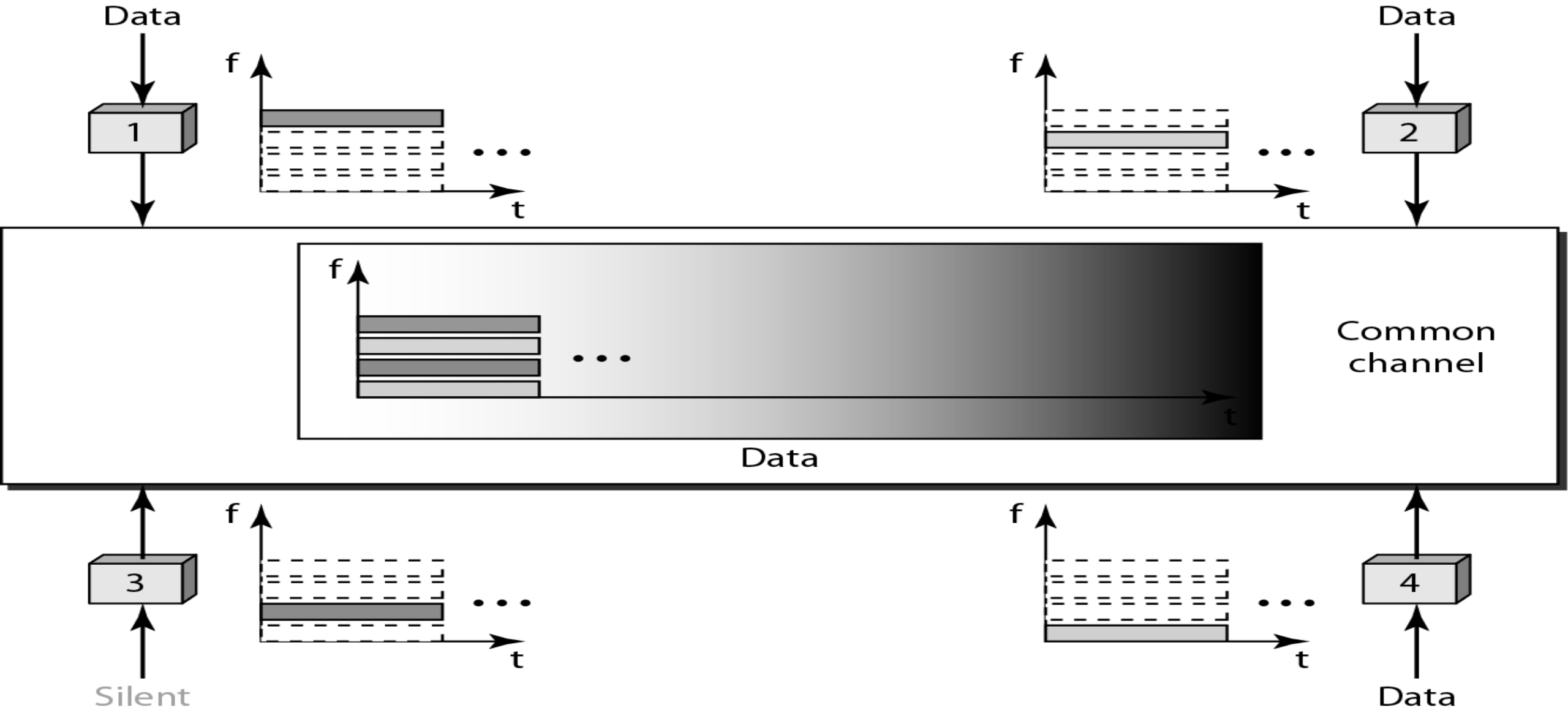
Channelization Method

- Channelization is a multiple-access method. Here, available bandwidth of a link is shared in time, frequency, or through code, between different stations.
- There are three types
  - **Frequency-Division Multiple Access (FDMA)**
  - **Time-Division Multiple Access (TDMA)**
  - **Code-Division Multiple Access (CDMA)**

Frequency Division Multiple Access (FDMA)

In FDMA, the available bandwidth of the common channel is divided into bands that are separated by guard bands.

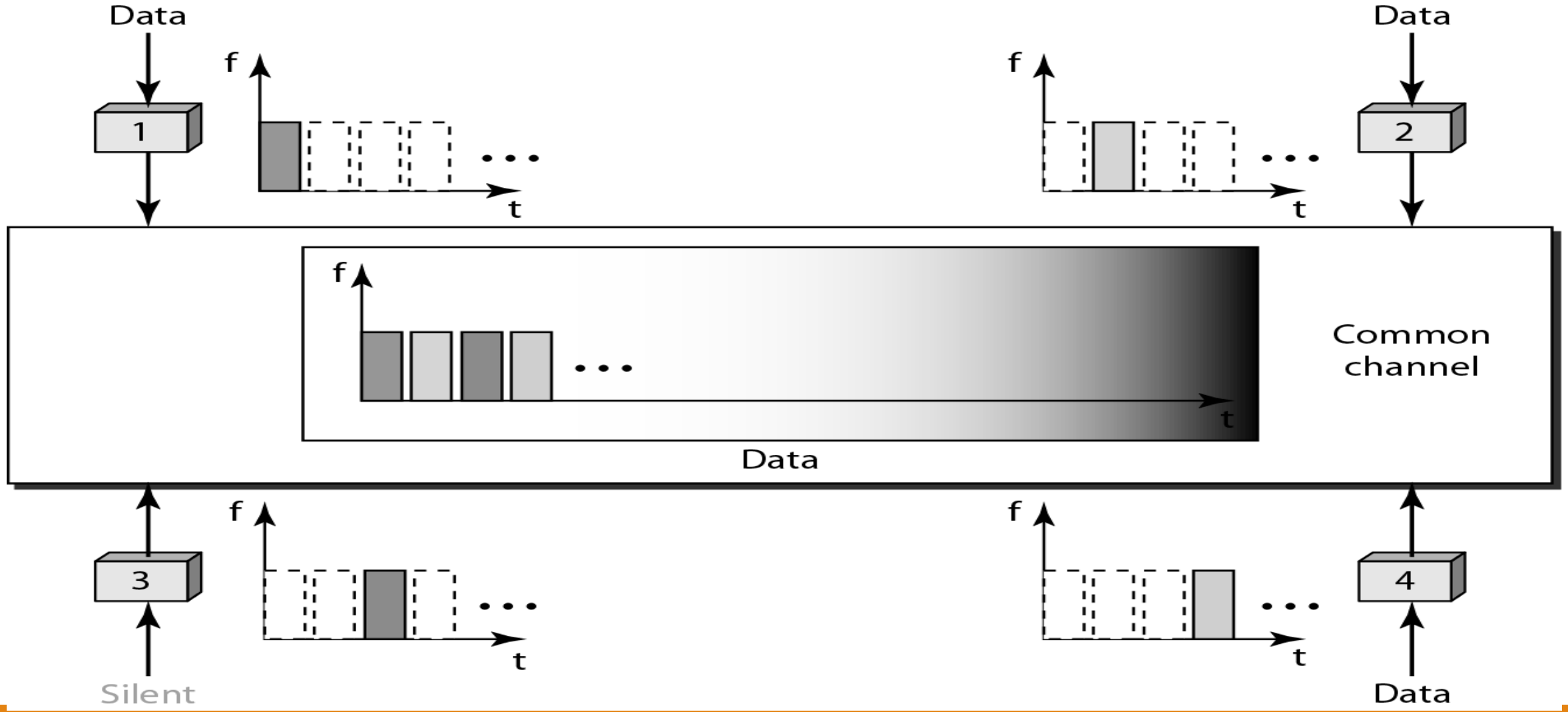
Frequency-division multiple access (FDMA)



Time-Division Multiple Access (TDMA

In TDMA, the bandwidth is just one channel that is timeshared between different stations.

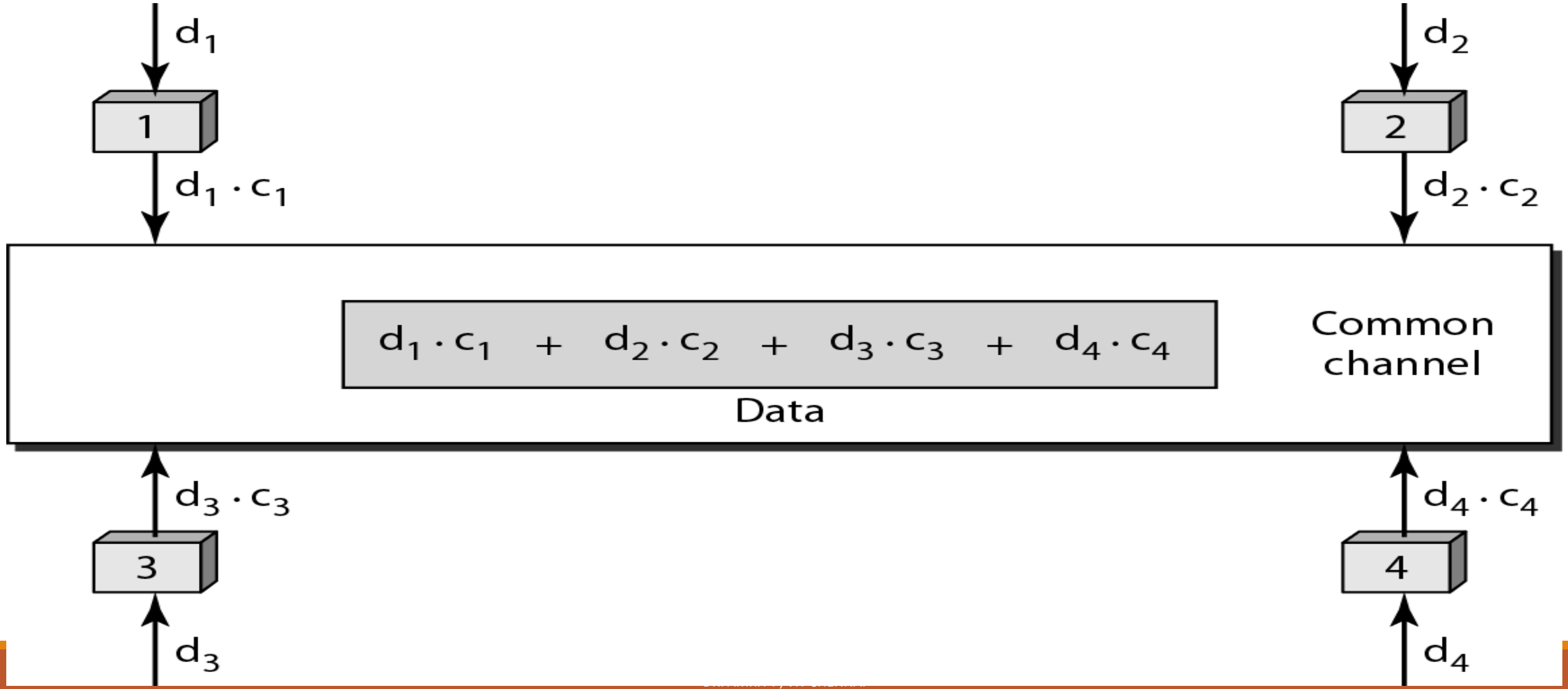
Time-Division Multiple Access (TDMA)



Code-Division Multiple Access (CDMA)

In CDMA, one channel carries all transmissions simultaneously.

Code-Division Multiple Access (CDMA)



Frame Formation in Datalink Layer

Bit Stuffing Method

Byte Stuffing Method

Bit Stuffing Method

Allows frame to contain arbitrary number of bits and arbitrary character size. The frames are separated by separating flag.

Each frame begins and ends with a special bit pattern, 01111110 called a flag byte. When five consecutive l's are encountered in the data, it automatically stuffs a '0' bit into outgoing bit stream.

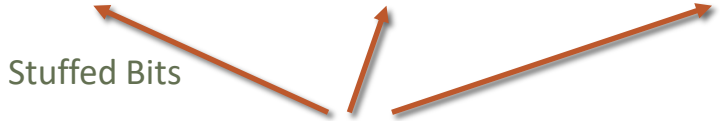
In this method, frames contain an arbitrary number of bits and allow character codes with an arbitrary number of bits per character. In this case, each frame starts and ends with a special bit pattern, 01111110.

In the data a 0 bit is automatically stuffed into the outgoing bit stream whenever the sender's data link layer finds five consecutive 1s.

Bit Stuffing Method…

(a) 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0

(b) 0 1 1 0 1 1 1 1 1 0 1 1 1 1 1 0 1 1 1 1 1 0 1 0 0 1 0



(c) 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0

Byte Stuffing Method

Start and end of frame are recognized with the help of flag bytes.

Each frames starts with and ends with a "Flag Byte".

Two consecutive flag bytes indicate the end of one frame and start of the next one.

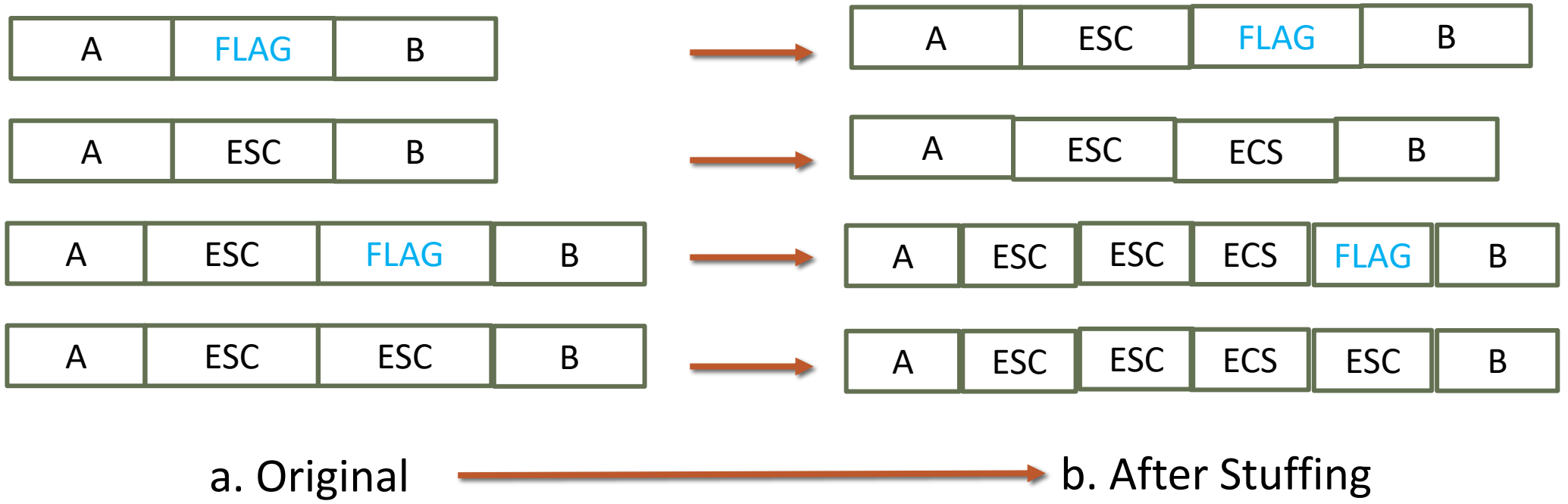
The flag bytes used is named as "ESC" flag byte.

A frame delimited by flag bytes.

Disadvantage:

- It is applicable for 8-bit character codes

Byte Stuffing Method…



References

Computer Networks: A Systems Approach, Larry Peterson and Bruce Davie, 5th Ed, The Morgan Kaufmann Series, Elsevier, 2011.

Computer Networking: A Top-Down Approach Featuring the Internet, J. F. Kurose and K. W. Ross, 6th Ed., Pearson Education, 2012.

Data Communications and Networking, Behrouz A. Forouzan, McGraw Hill Education, 5th Ed., 2012

TCP/IP Protocol Suite, Behrouz A. Forouzan, McGraw-Hill Education, 4 Ed., 2009

Data and Computer Communications, William Stallings, Pearson Education, 10th Ed, 2013.