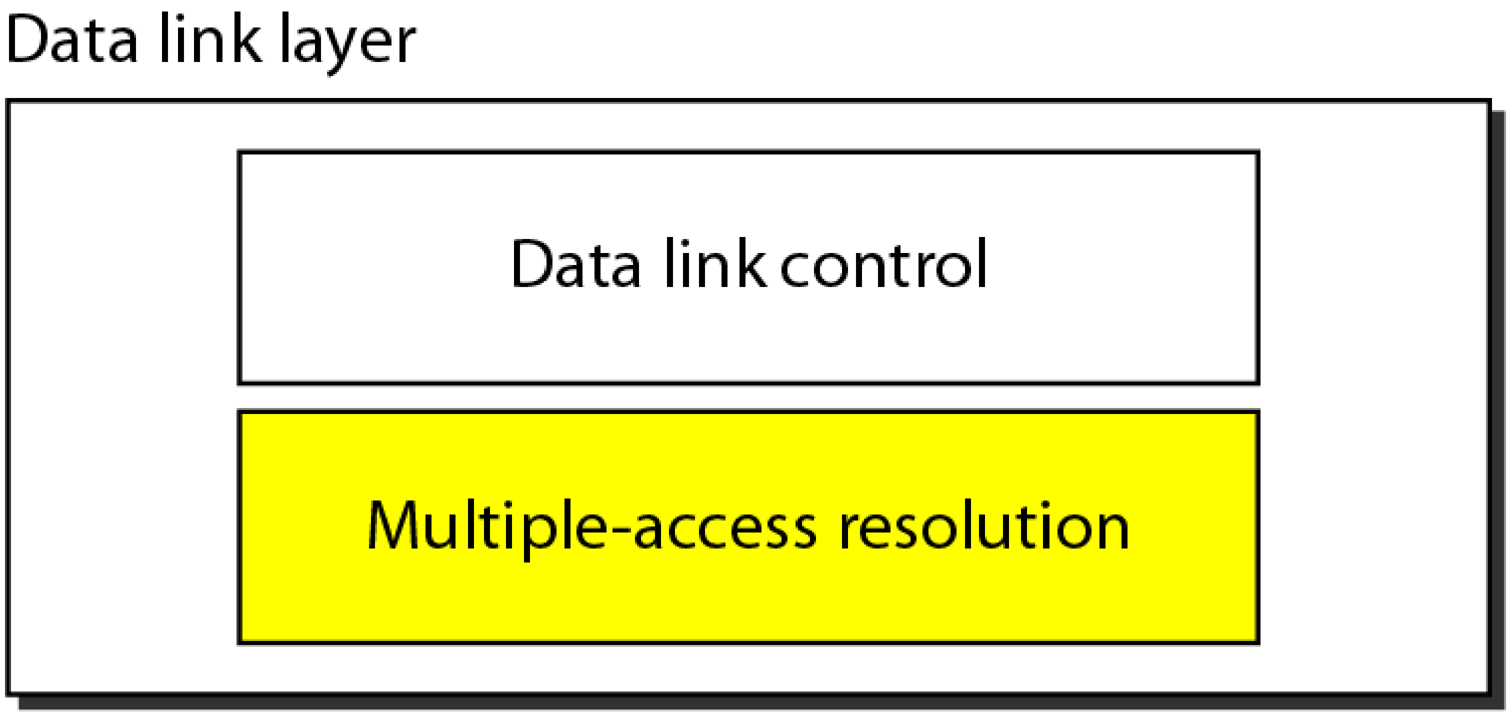
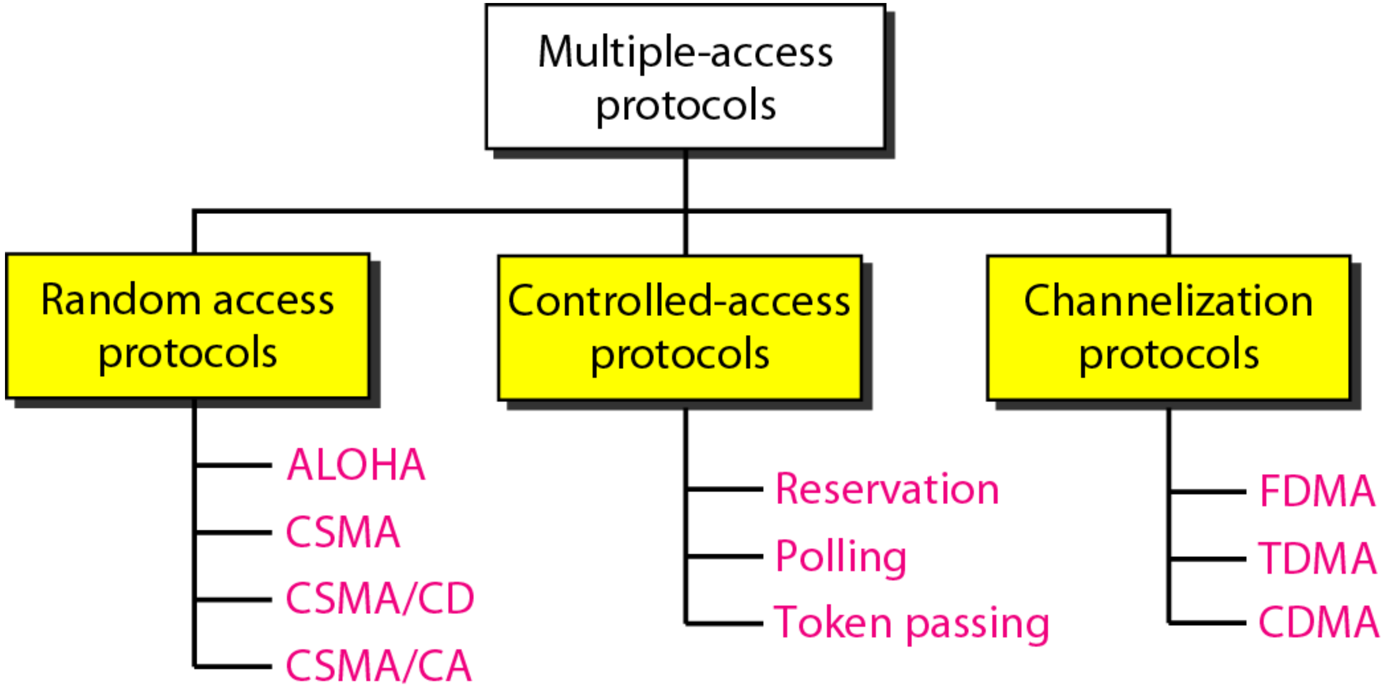
Media Access Control

Sublayers of Data Link Layer



Multiple Access Mechanisms

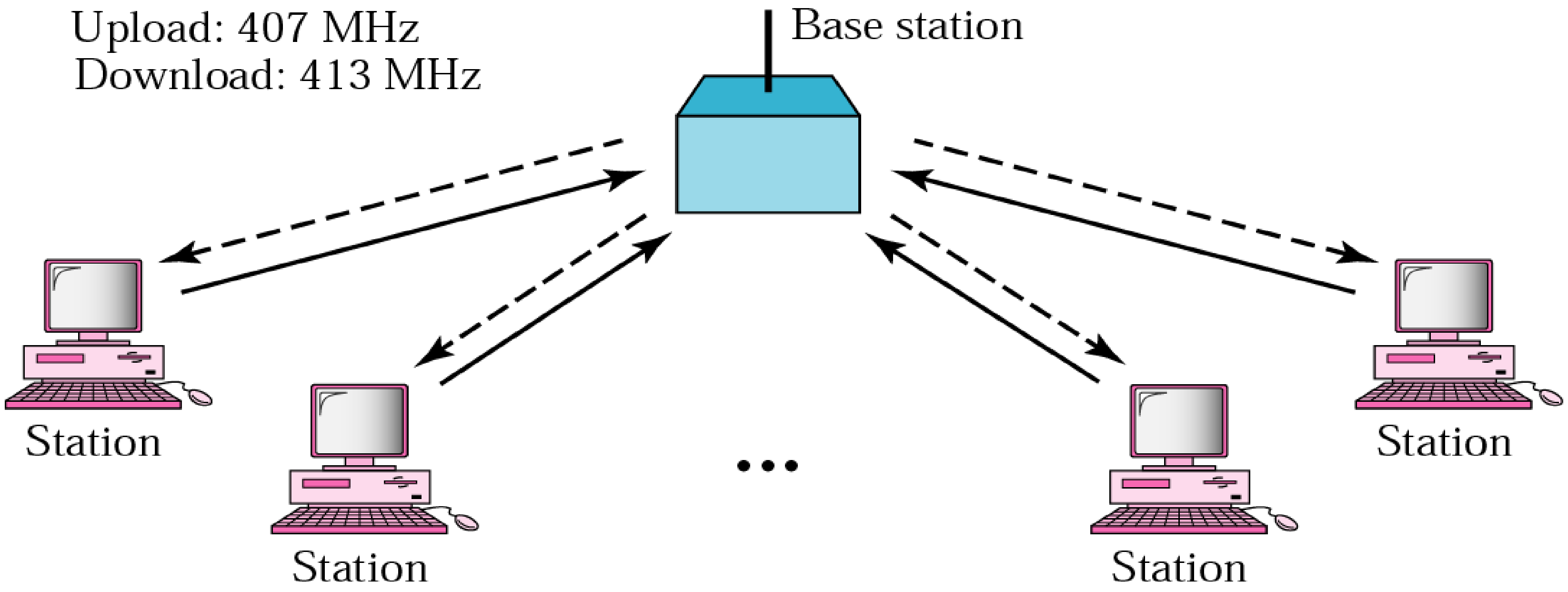


Random Access

- Also called contention-based access
- No station is assigned to control another
- Station having data to send uses a procedure defined by the protocol to make a decision on whether or not to send.
- There is no scheduled time for a station to transmit and transmission is random.
- Protocols answer the following questions:
  - 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?

ALOHA

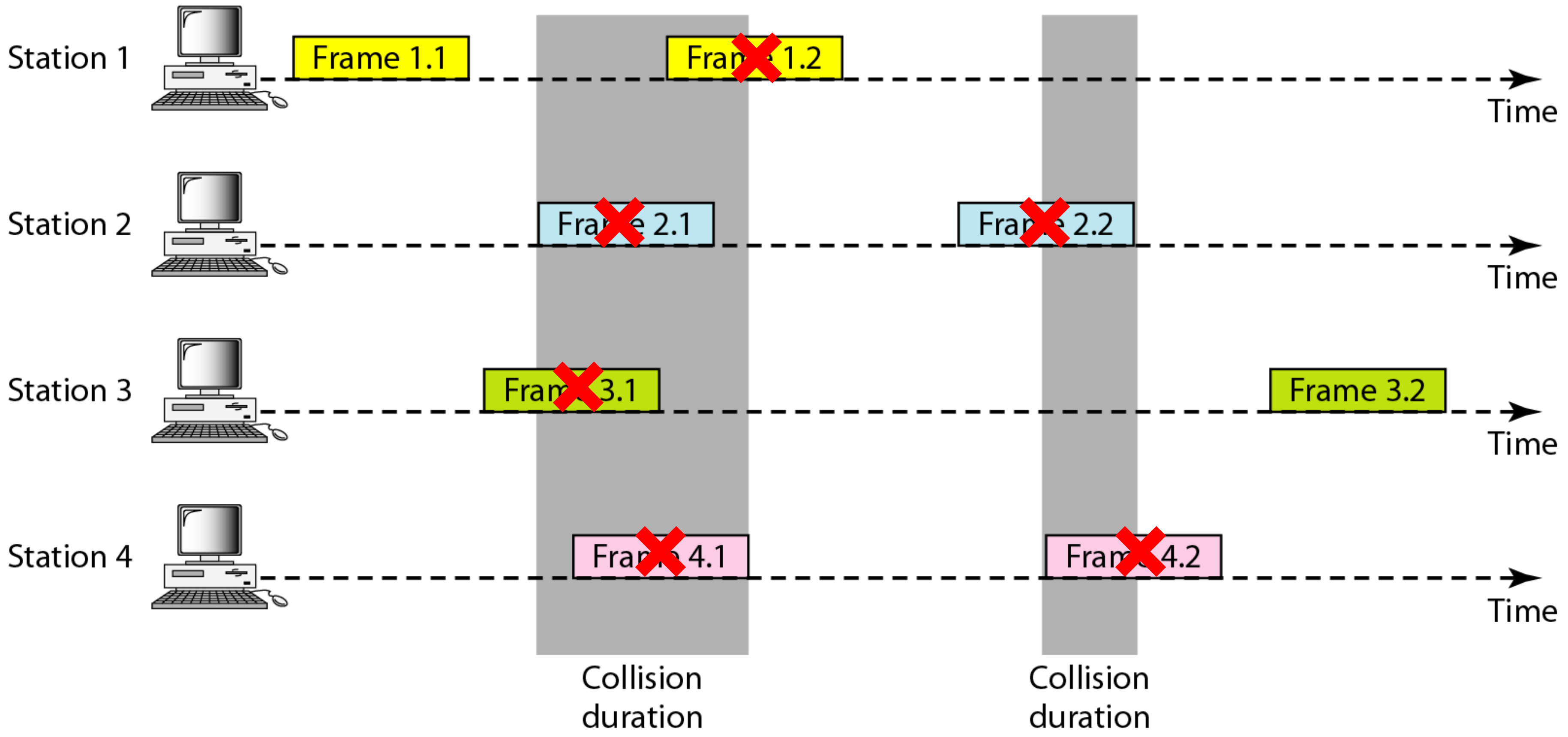
- Earliest random access method.
- Has two variants:
  - Pure ALOHA
  - Slotted ALOHA



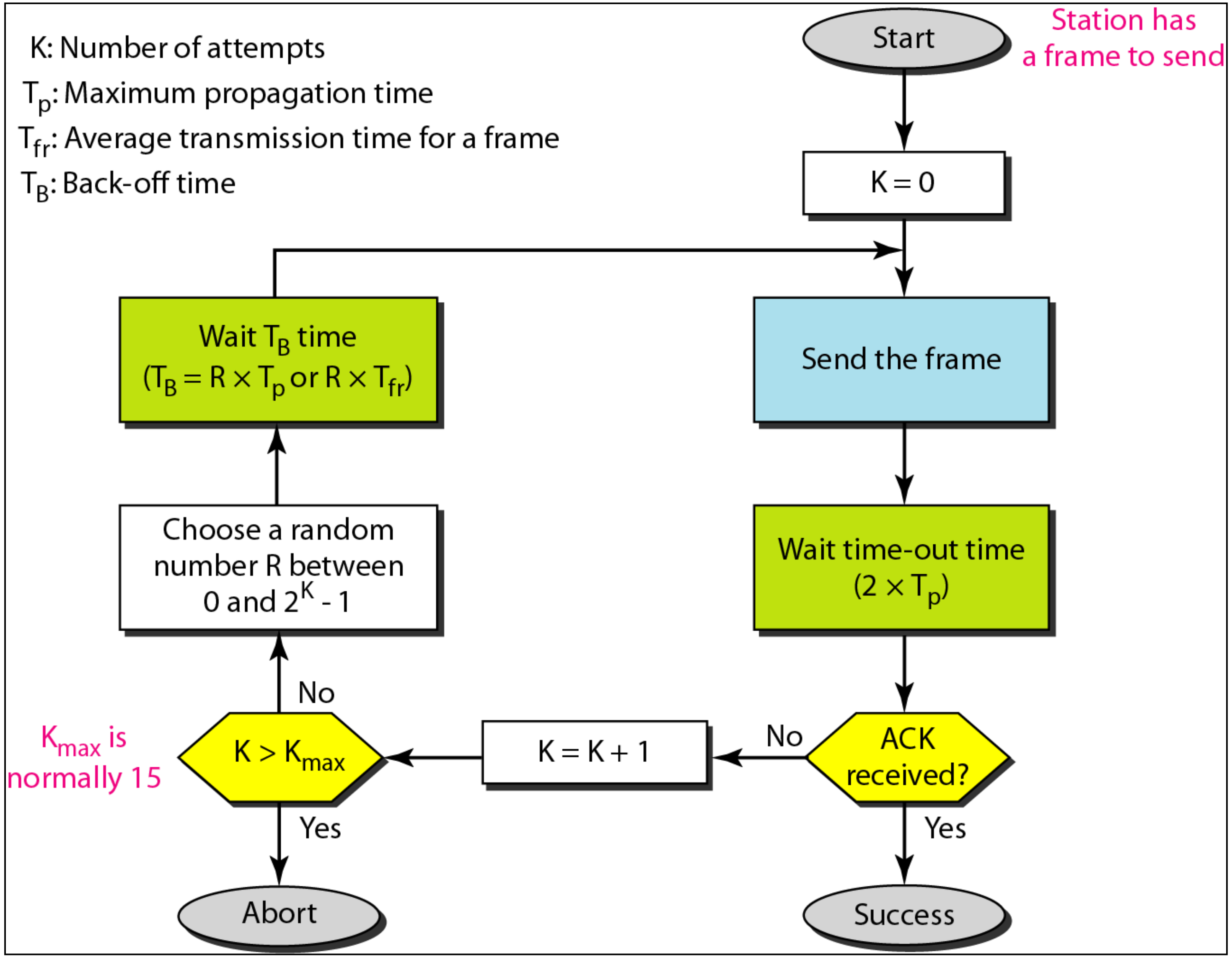
Pure ALOHA

- Pure ALOHA:
  – Each station sends a frame whenever it has a frame to send
  – If some other station is sending at the same time, collision will occur.
  – Post collision stations need to resend frames.
  – Station expects a acknowledgement.
  – Waits for a time-out period and starts retransmission.
  – To avoid collision again, every stations waits for a random amount of time [Back-Off Time] computed using one common formula i.e. Binary Exponential Backoff
  – A station has to give up and try again after n no. of transmissions.

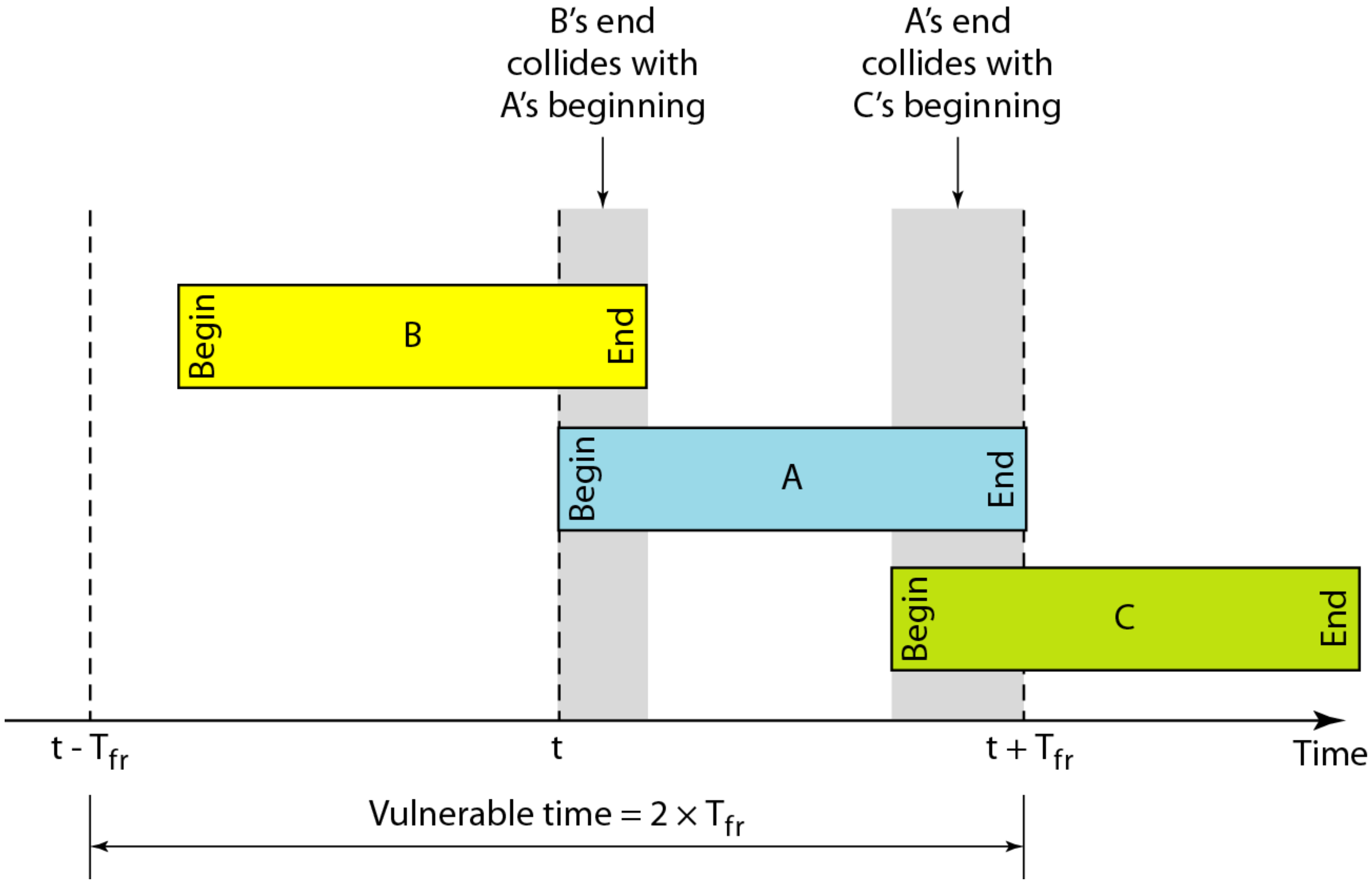
Frames in Pure ALOHA



ALOHA Protocol



ALOHA: Vulnerable Time



ALOHA: Throughput

- Assume number of stations trying to transmit follow Poisson Distribution
- The throughput for pure ALOHA is

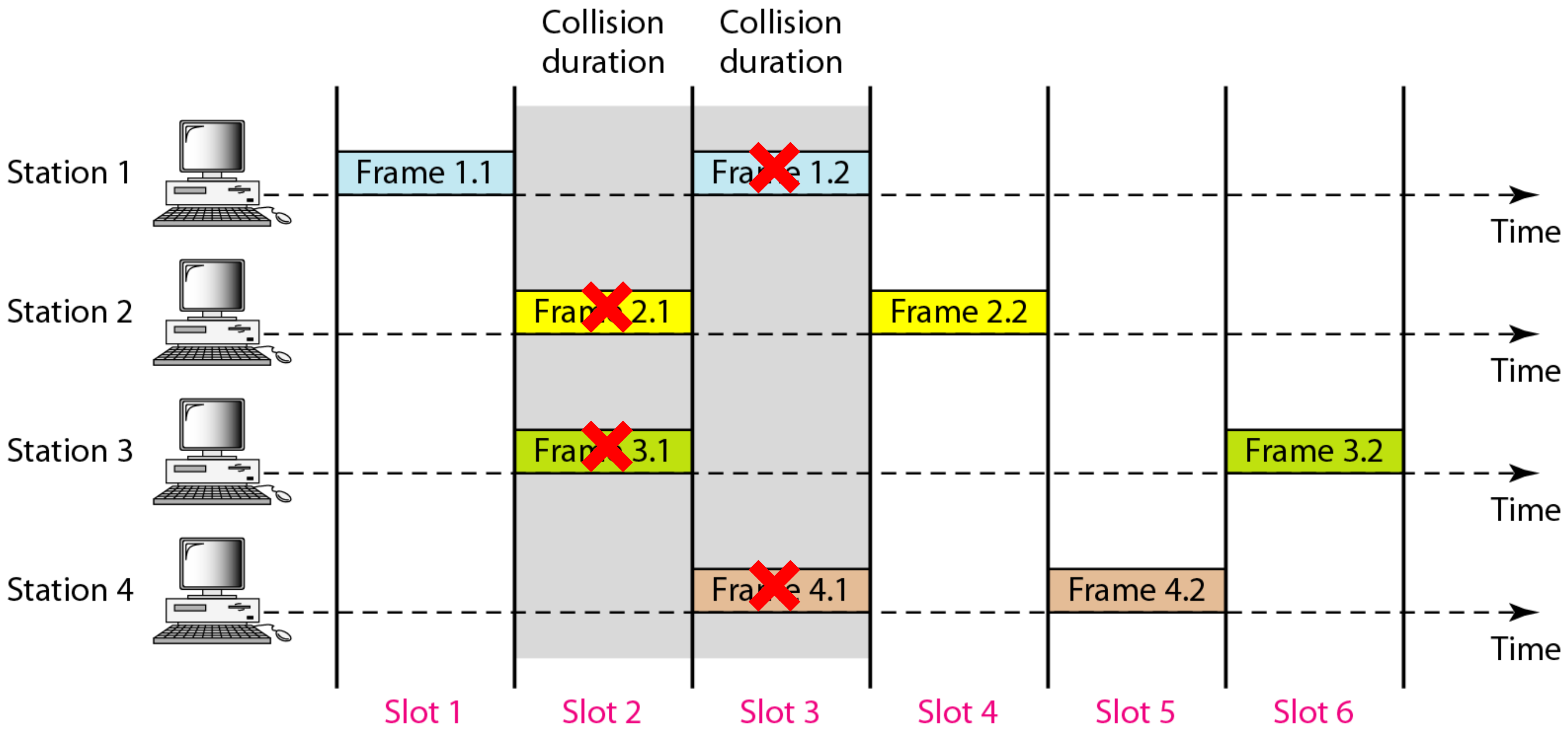
$$S = G \times e^{-2G}$$

  where G is the average number of frames requested per frame-time
- The maximum throughput
  - $S_{max} = 0.184$ when $G = 1/2$

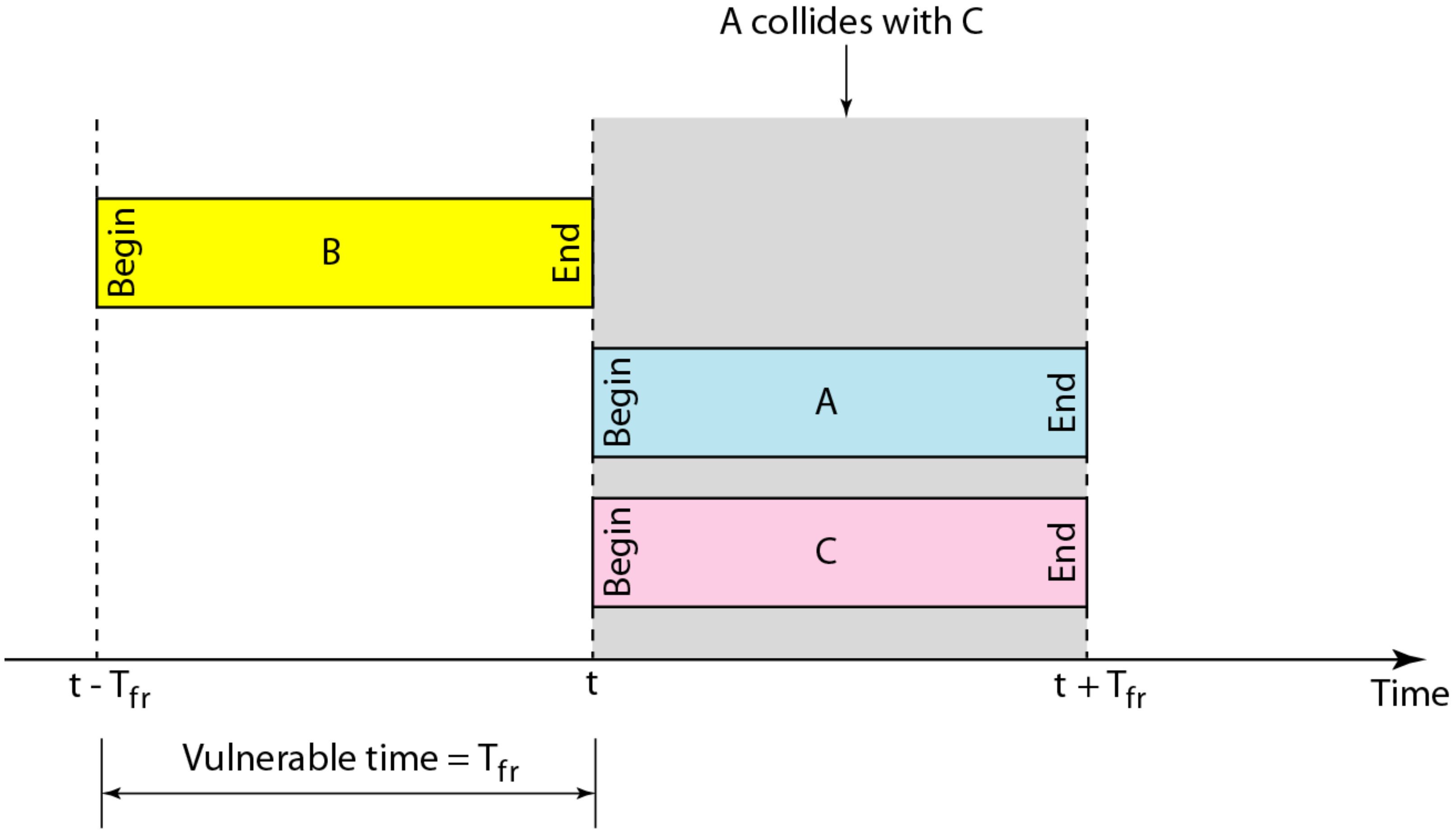
Slotted ALOHA

- Divide the time into slots of T_{fr}
- Force the station to send only at the beginning of the time slot.
- If a station misses this moment, it must wait until the beginning of the next time slot.
- Possibility of collision, if two stations try to send at the beginning of the same time slot.

Slotted ALOHA



Slotted ALOHA: Vulnerable Time



Slotted ALOHA: Throughput

- The throughput for Slotted ALOHA is

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

  where G is the average number of frames requested per frame-time
- The maximum throughput
  - $S_{max} = 0.368$ when G= 1

CSMA

- **<u>C</u>**arrier **<u>S</u>**ense **<u>M</u>**ultiple **<u>A</u>**ccess
  - "Listen before talk"
- Reduce the possibility of collision
  - But cannot completely eliminate it
- Carrier sense multiple access (CSMA) requires that each station first listen to the medium (or check the state of the medium) before sending

CSMA

- CSMA can reduce the possibility of collision, but it cannot eliminate it.
- Possibility of collision still exists because of propagation delay.
- Consider a case when a station sends a frame, but it will take some time for the frame to reach the medium.
- And meanwhile if some other station senses medium, finding it free it starts the transmission.
- The vulnerable time for CSMA is the propagation time *Tp*

CSMA

- What to do when a channel is busy and when a channel is idle?
- Three solutions are devised as a possible answer to the above question.
  - 1-Persistent Method
    - In this method, after the station finds the line idle, it sends its frame immediately.
    - This method has the highest chance of collision because two or more stations may find the line idle and send their frames immediately.
    - Method continuously monitors the channel and sensing it free, immediately transmits.

CSMA

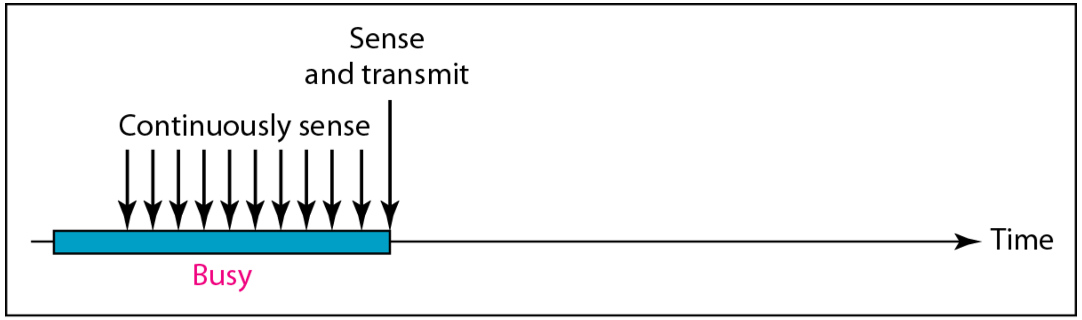
- Non Persistent Method
  - If a station that has a frame to send senses the line.
  - If the line is idle, it sends immediately.
  - If not idle than waits for a random amount of time and then senses again.
  - Non-persistent approach reduces the chance of collision because it is unlikely that two or more stations will wait the same amount of time.
  - reduces the efficiency of the network because the medium remains idle when there may be stations with frames to send.

CSMA

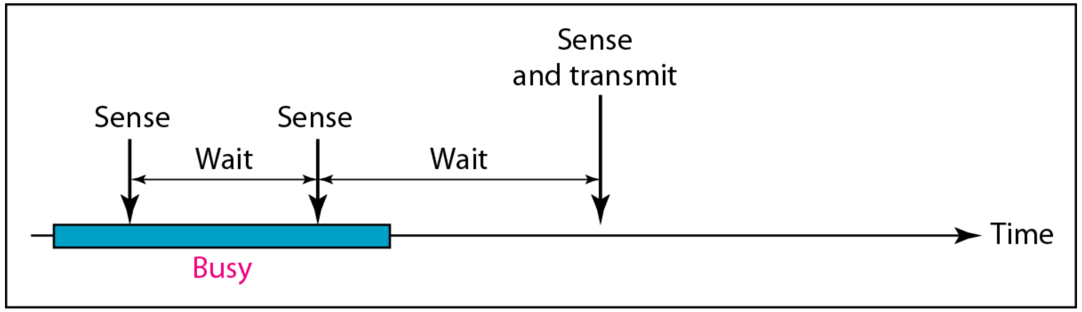
- P-Persistent Method
  - This methods is based on both 1- persistent and non-persistent method.
  - Method is used if the channel has time slots.
  - With a probability p it station transmits its packets
  - If the channel is sensed busy than it waits with probability q = 1-p for the start of next time slot and senses the channel again

Persistence Methods

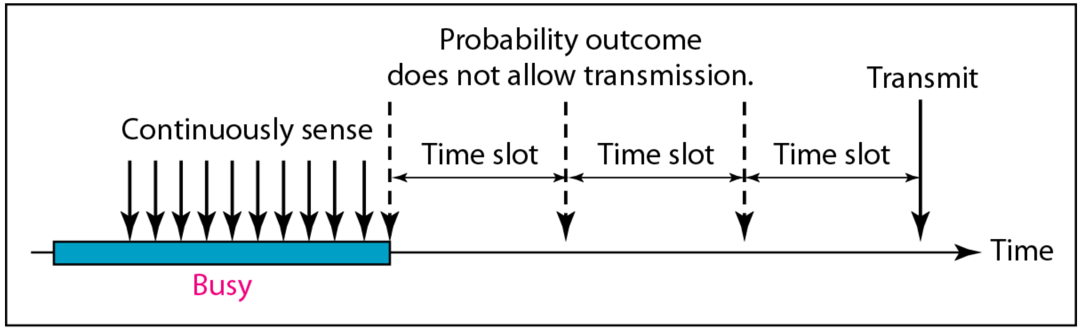
- What a station does when channel is idle or busy



a. 1-persistent



b. Nonpersistent

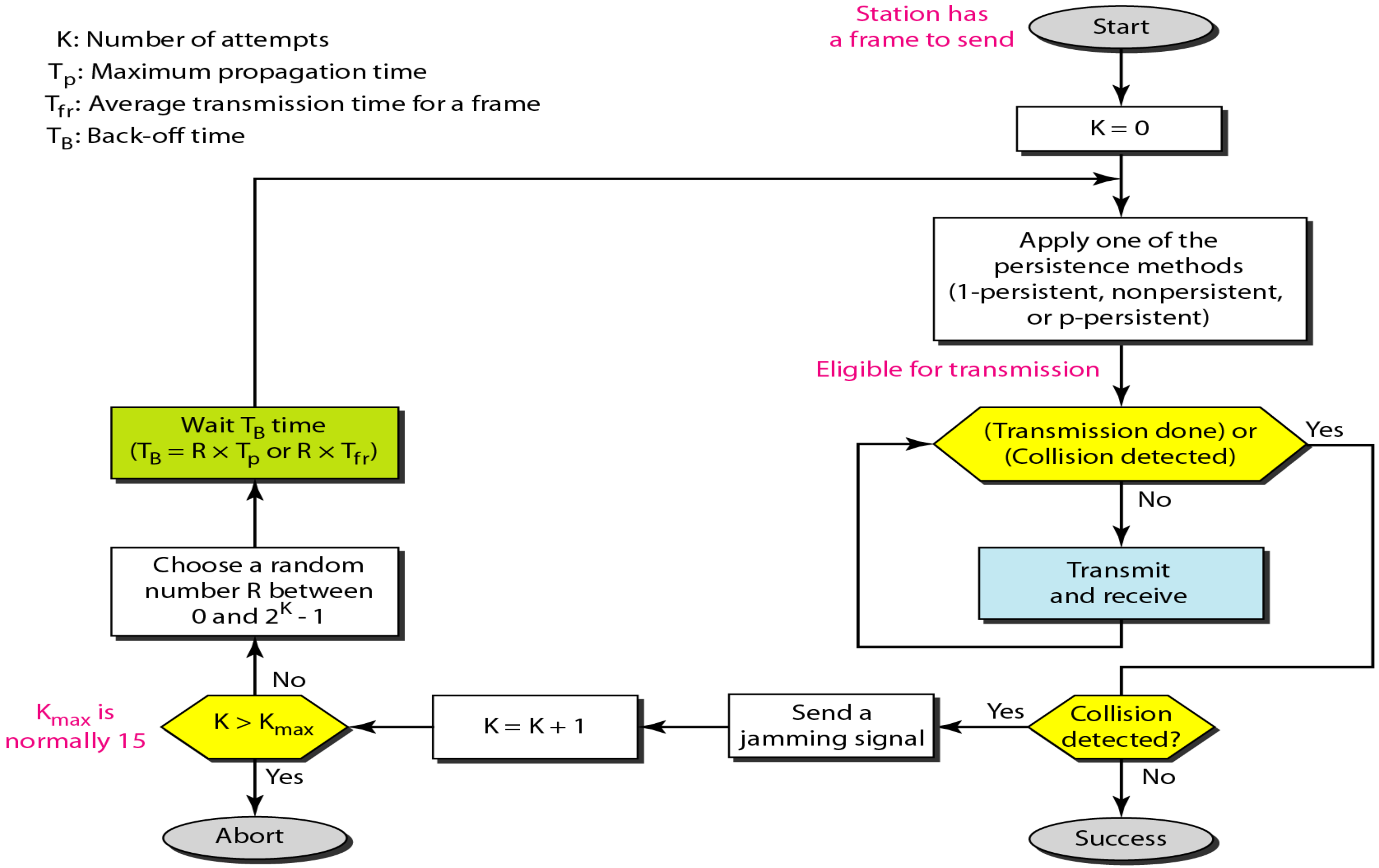


c. p-persistent

CSMA/CD

- CSMA method does not specify the procedure following a collision
- **C**arrier **S**ense **M**ultiple **A**ccess with **C**ollision **D**etection
- Station monitors channel while sending a frame
- As soon as a station detects a collision, it aborts the transmission.
- The station waits for a random amount of time and senses channel again for sending data.

CSMA/CD: Flow Diagram

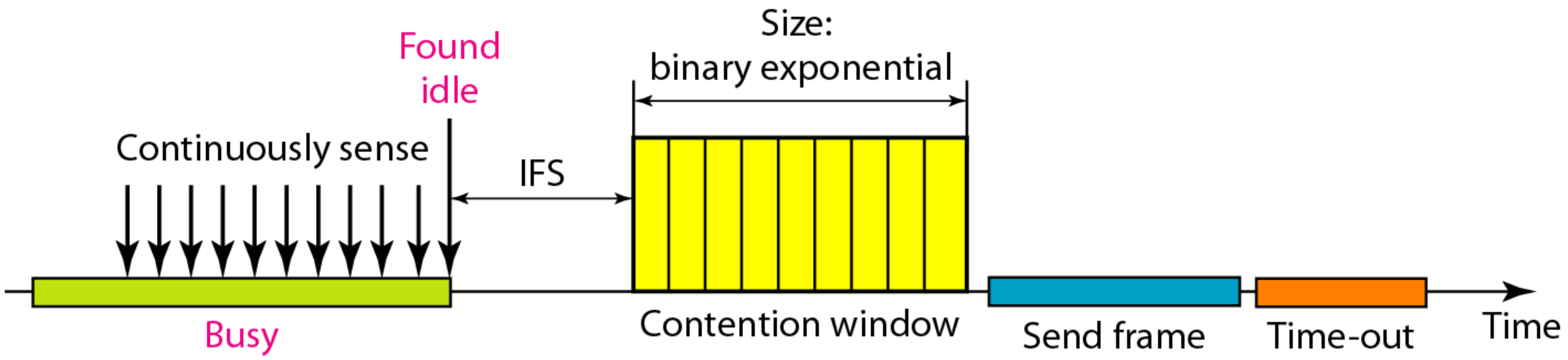


CSMA/CA

- Algorithm of CSMA/CA is:
  - When a frame is ready, the transmitting station checks whether the channel is idle or busy.
  - If the channel is busy, the station waits until the channel becomes idle.
  - If the channel is idle, the station waits for an Inter-frame gap (IFG) amount of time and then sends the frame.
  - After sending the frame, it sets a timer.
  - The station then waits for acknowledgement from the receiver. If it receives the acknowledgement before expiry of timer, it marks a successful transmission.
  - Otherwise, it waits for a back-off time period and restarts the algorithm.

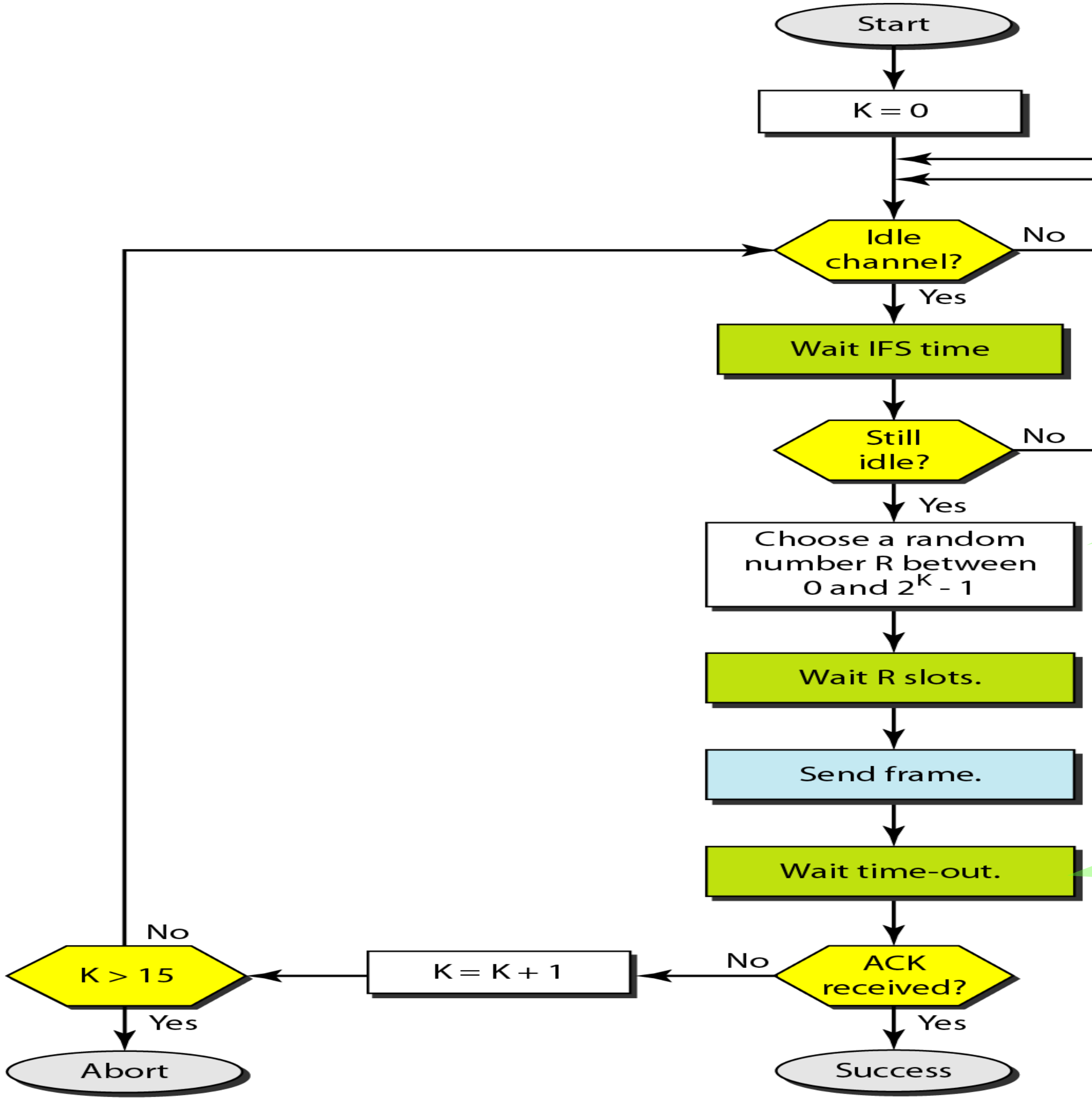
CSMA/CA

- **Carrier Sense Multiple Access with Collision Avoidance**
- Used in a network where collision cannot be detected
  - E.g., wireless LAN



IFS – Interframe Space

CSMA/CA: Flow Diagram

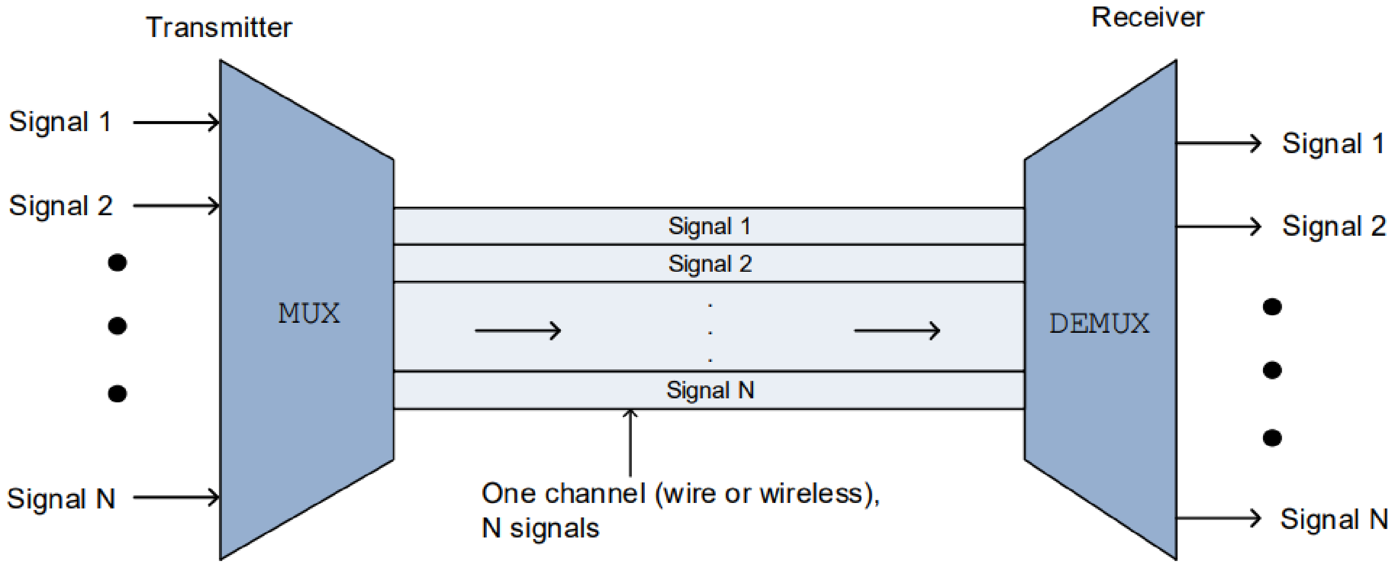


contention window size is 2^K-1

After each slot:
- If idle, continue counting
- If busy, stop counting

Multiplexing

- To efficiently utilize the bandwidth of the channel very often multiple signals are transmitted over one channel.
- Multiplexing is the process of sharing a single communication channel (or medium) for transmission of multiple signals.

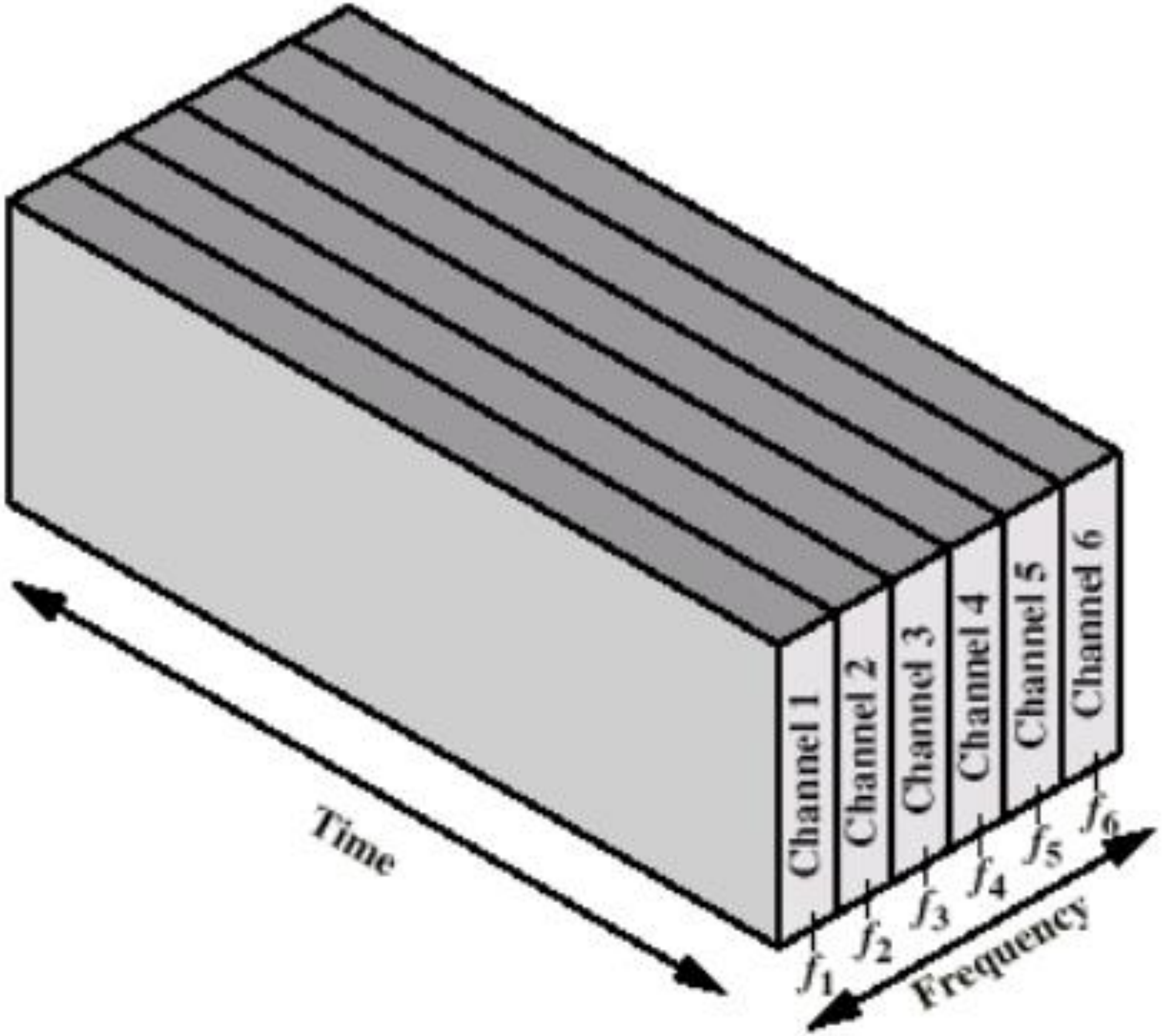


Frequency Division Multiplexing (FDM)

- Multiples signals share the same channel by transmitting at different carrier frequency within the channel’s bandwidth.
- They share the bandwidth of a common communication channel.
- FDM is usually used for analog data.
- Some of the commutation systems that use FDM include cable TV (each signal gets a 6MHz channel), FM stereo broadcasting.

Frequency Division Multiplexing (FDM)

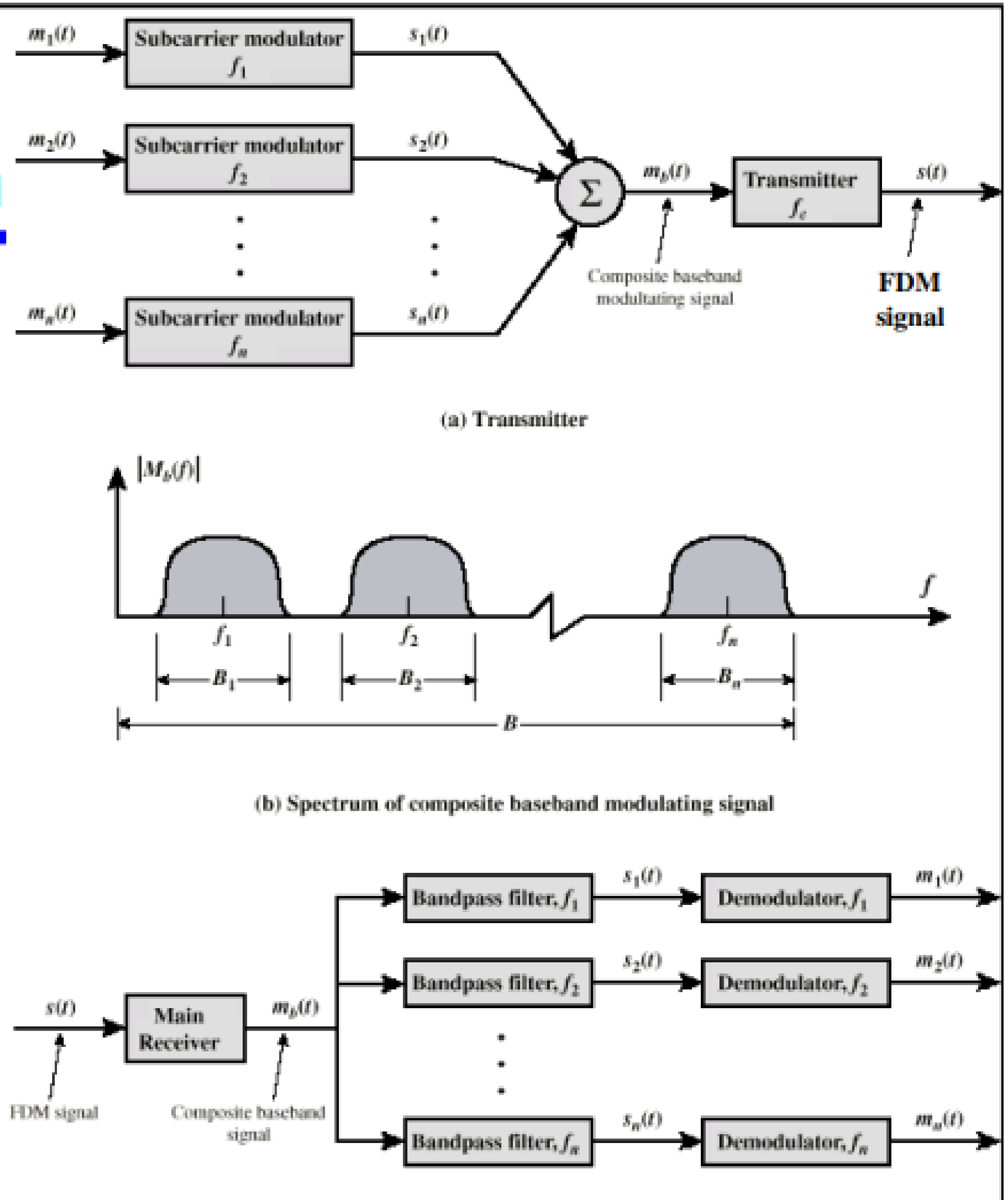
- A number of signals can be carried simultaneously if each signal is modulated onto a different carrier frequency .
- Carrier frequencies must be sufficiently separated so that signals do not overlap
- Each modulated signal requires a certain bandwidth cantered on its carrier frequency, referred to as Channel.
- To prevent interference, the channels must be separated by guard bands, which are unused portions of the spectrum.
- Channel is allocated even if no data is to be sent


Channel 1
Channel 2
Channel 3
Channel 4
Channel 5
Channel 6
f_1
f_2
f_3
f_4
f_5
f_6
Time
Frequency

FDM System

Block Diagram

- The composite signal transmitted across the medium is analog
- Input signals may be digital or analog, which are MUXed onto the same tx medium
- Each signal $m_i(t)$ is modulated onto a carrier frequency f_i
- Multiple carriers are used, each one is referred to as a subcarrier
- The resulting analog modulated signals are summed to produce composite baseband signal $m_b(t)$



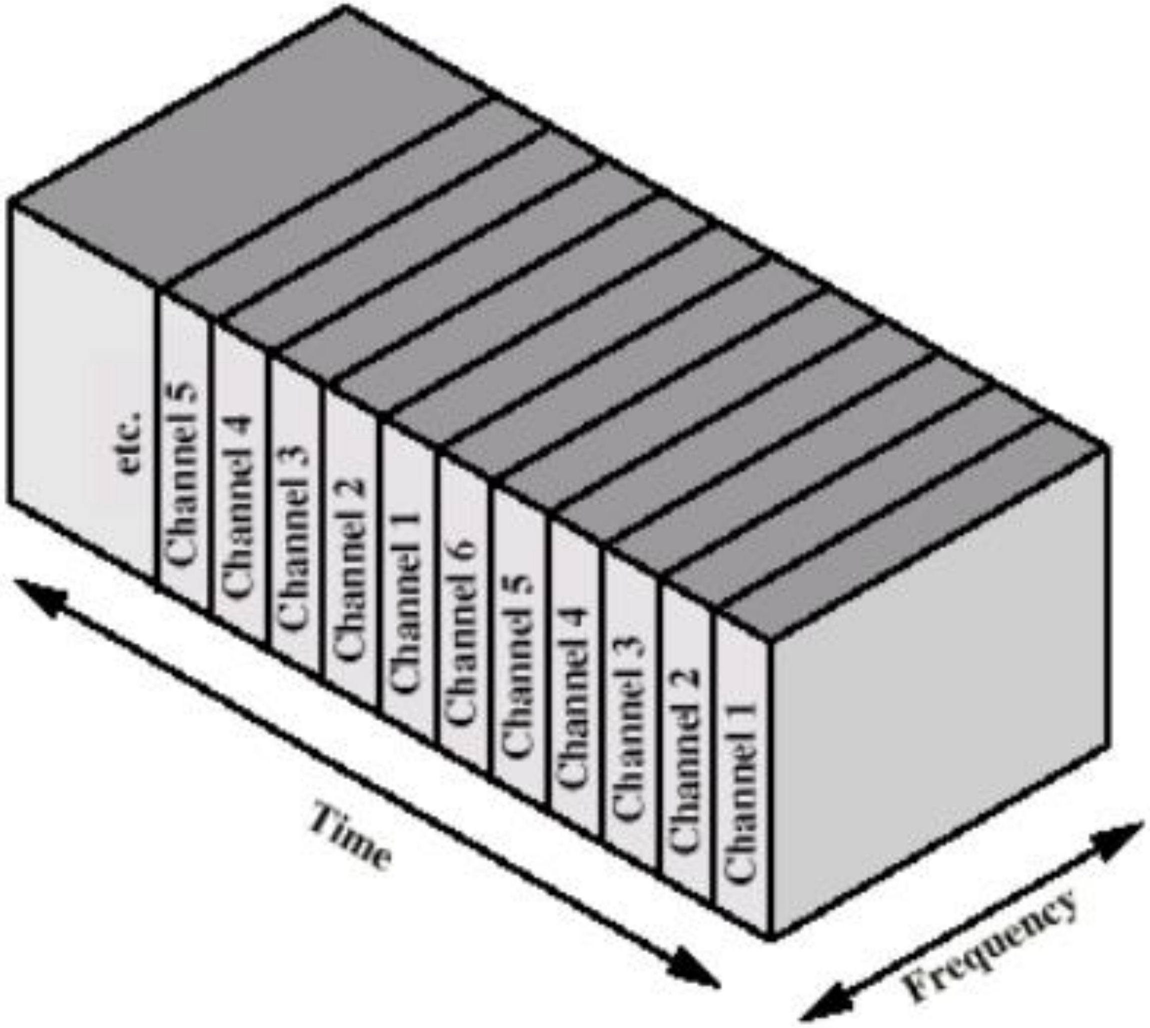
(a) Transmitter

(b) Spectrum of composite baseband modulating signal

(c) Receiver

Time Division Multiplexing

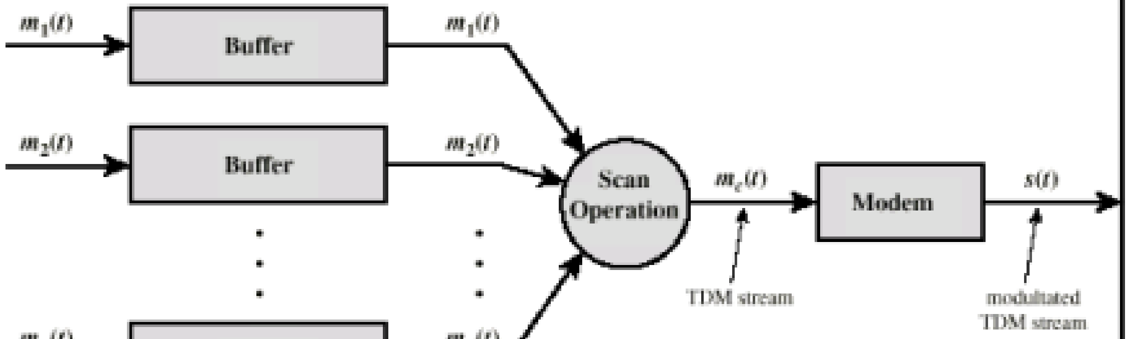
- TDM is possible when the data rate of medium exceeds the data rate of digital signals to be transmitted.
- Multiple digital signals are interleaved in time
- Interleaving may be at bit level or in blocks of bytes or larger quantities
- Time slots pre-assigned to sources and fixed
- Time slots allocated even if no data
- Time slots do not have to be evenly distributed amongst sources


etc.
Channel 5
Channel 4
Channel 3
Channel 2
Channel 1
Channel 6
Channel 5
Channel 4
Channel 3
Channel 2
Channel 1
Time
Frequency

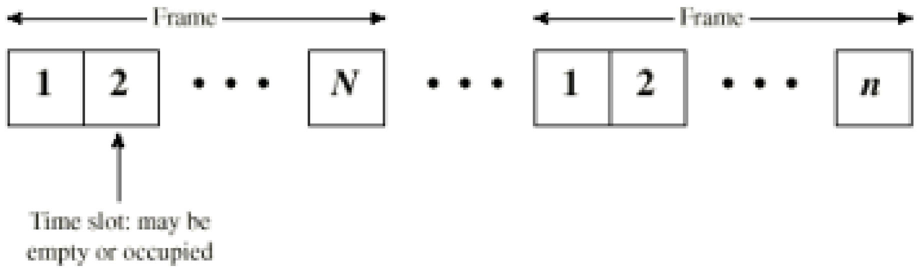
TDM System

Block Diagram

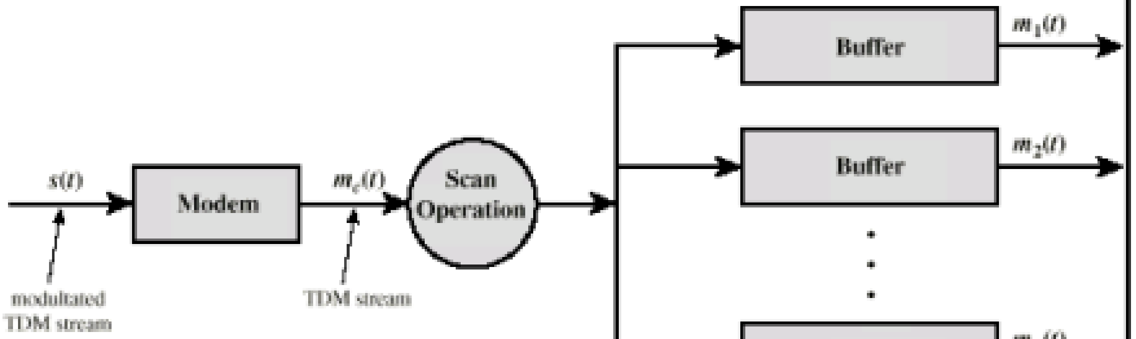
- A number of signals $m_i(t)$, i=1..n are to be MUXed onto the same tx medium
- The signals carry digital data and are generally digital signals
- The incoming data from each source are buffered
- Each buffer is typically 1 bit or 1 character in length
- The buffers are scanned sequentially to form a composite digital data stream $m_c(t)$
- Scan operation is sufficiently rapid so that each buffer is emptied before more data can arrive
- Data rate of $m_c(t) = \Sigma$ data rates of $m_i(t)$
- Digital signal $m_c(t)$ is passed through a modem so that an analog signal is transmitted



(a) Transmitter



(b) TDM Frames



(c) Receiver

Time Division Multiplexing

- Data are organized into frames
- Each frame contains a cycle of timeslots
- In each frame, one or more slots are dedicated to each data source
- The sequence of slots dedicated to one source, from frame to frame is called a channel
- The slot length = tx buffer length

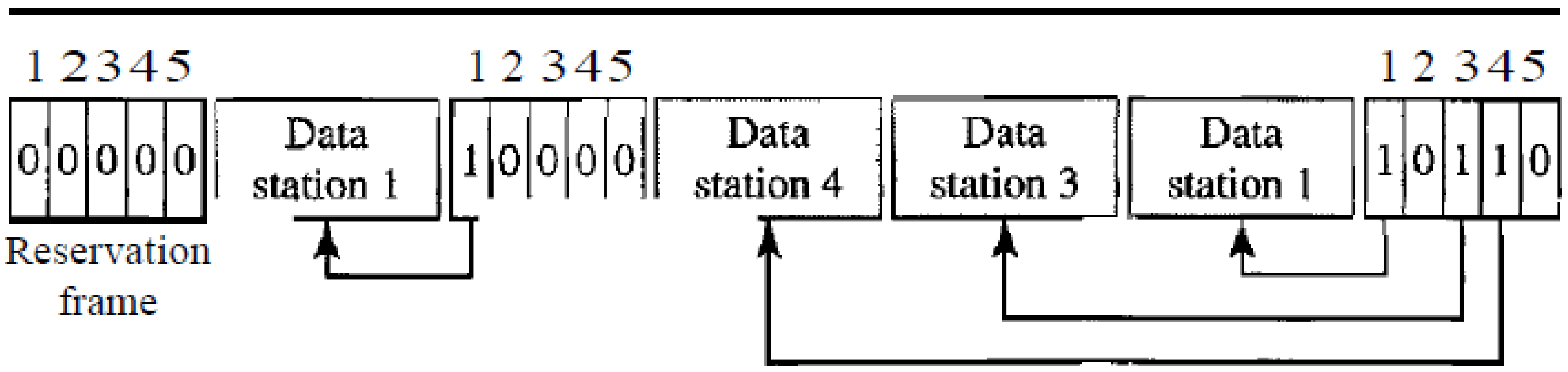
Code Division Multiple Access

- Code Division Multiplexing or (CDM) allots a unique code to every channel.
- Allows the channels of the same spectrum to be used simultaneously at the same time.
- Each channel transmits its bits as a coded channel-specific sequence of pulses called chips.
- Number of chips per bit, or chips per symbol, is the spreading factor.

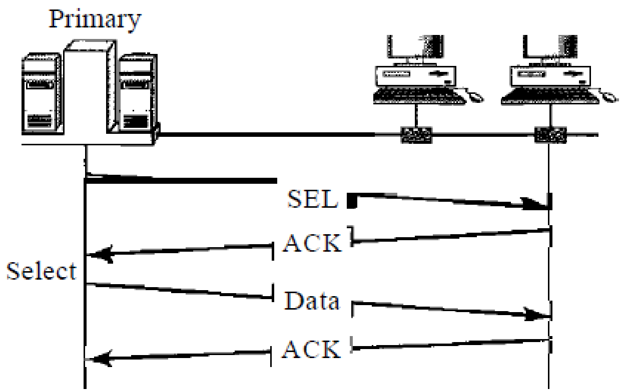
Controlled Access

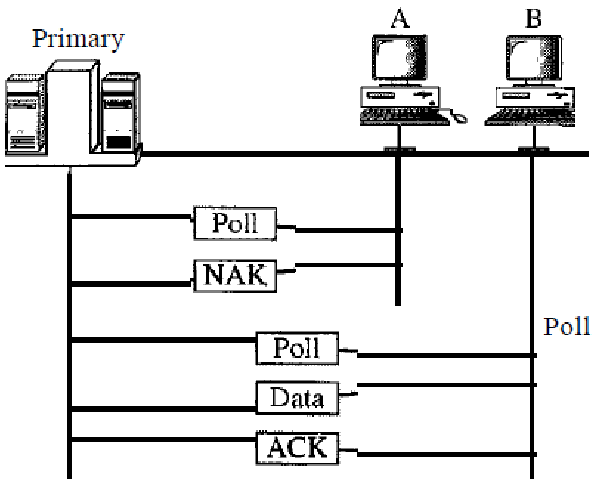
- Stations consult one another to find which station has the right to send.
- Station cannot send unless it has been authorized by other stations
- Common Controlled Based Methods:
  - Reservation
  - Polling
  - Token Passing

Reservation

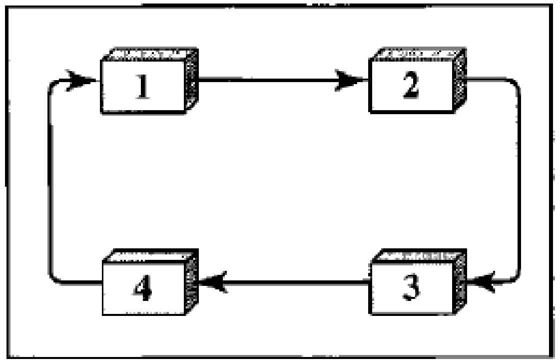


Polling

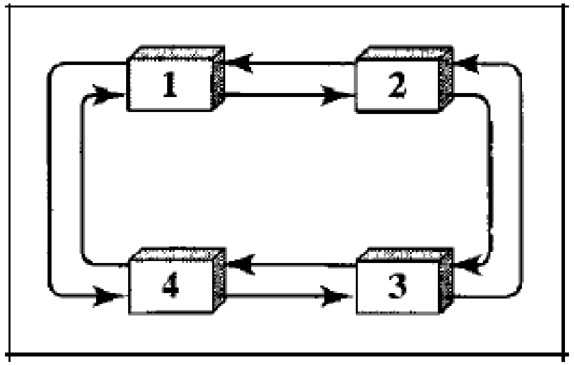




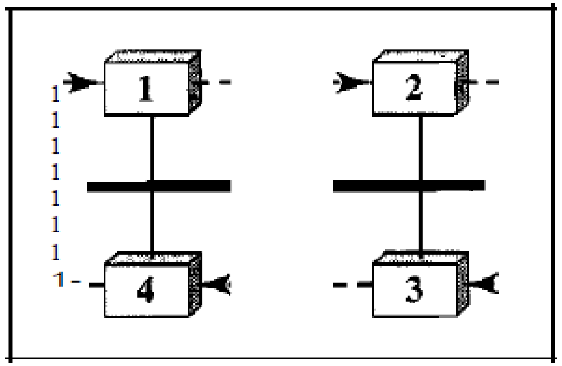
Token Passing



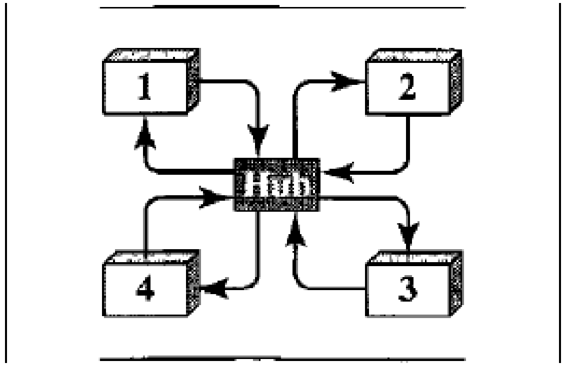
a. Physical ring



b. Dual ring



c. Bus ring



d. Star ring