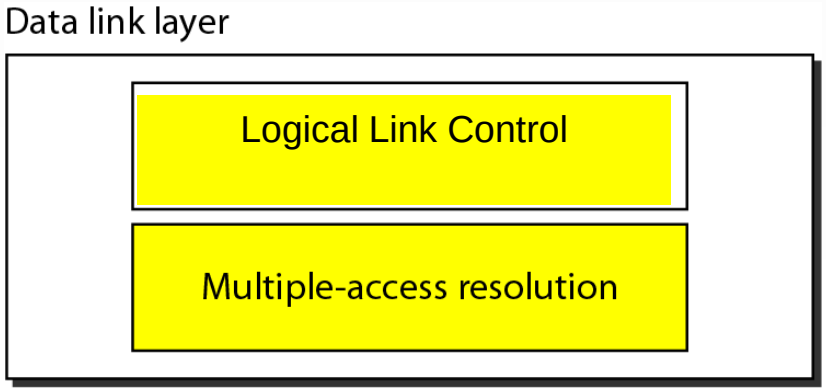
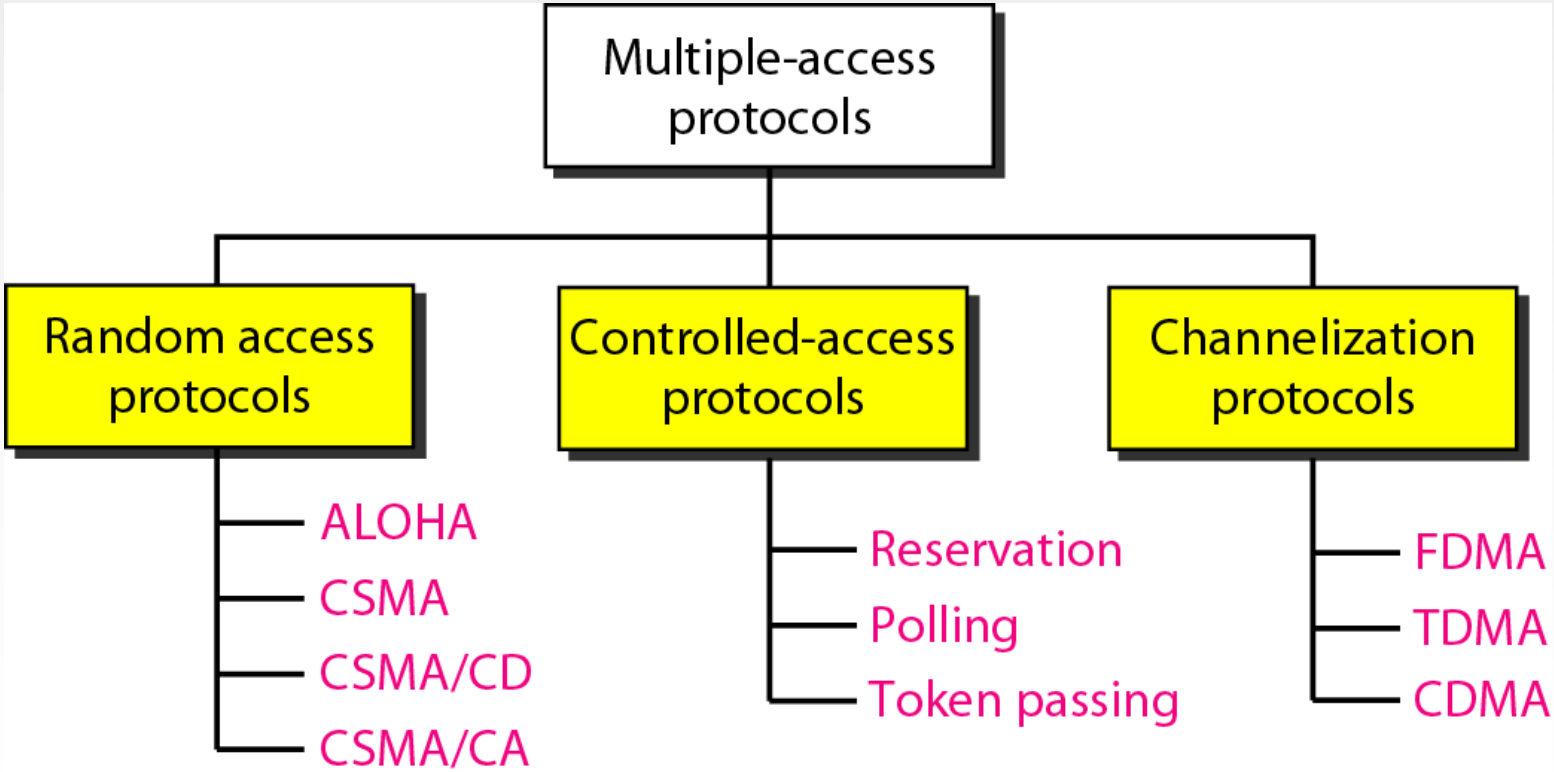
Multiple Access

Data Link Layer: Two sublayers

- Dedicated point to point link may not be available in all cases
- Many users have to use same link
- Data link layer divided into two functionality-oriented sublayers:
  - LLC
  - MAC
- IEEE made this division for LANs

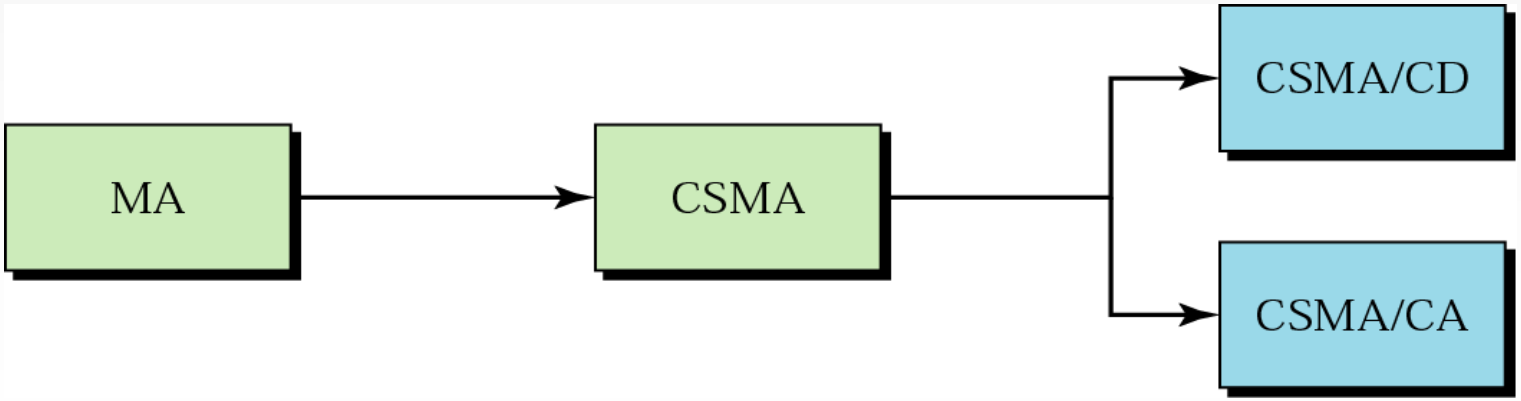


Medium Access Protocols



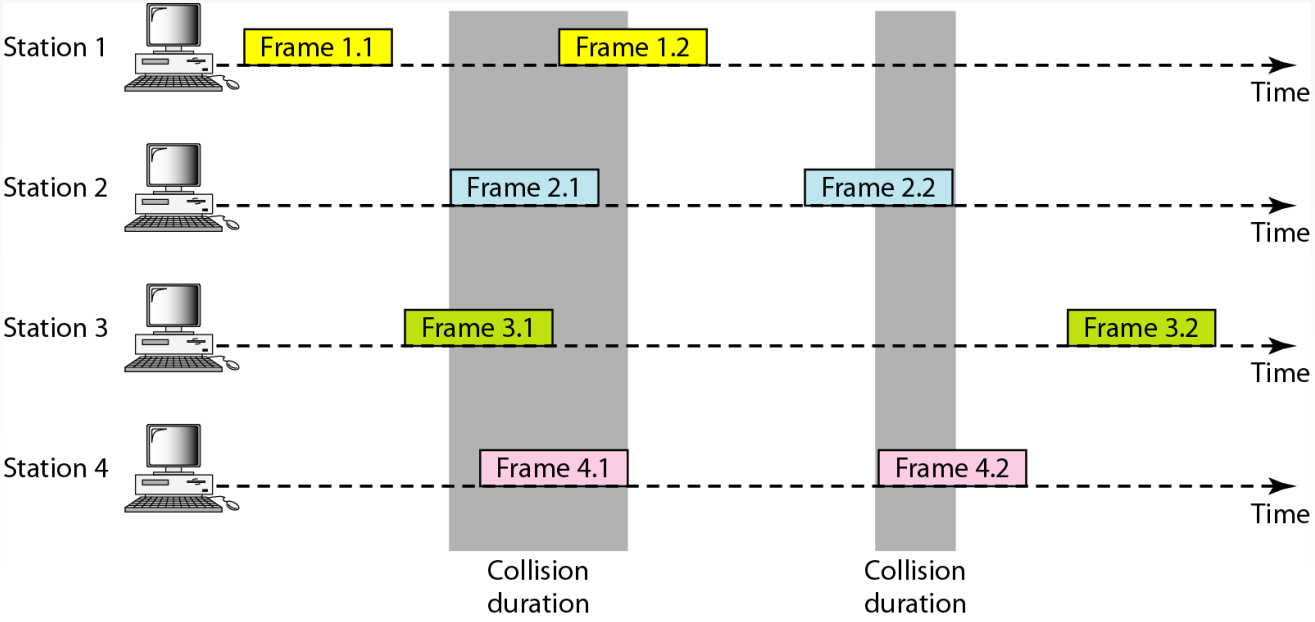
Random Access (Contention)

- Each station has the right to use the medium without being controlled by any other station
- Collision, a access conflict, if more than one station tries to send



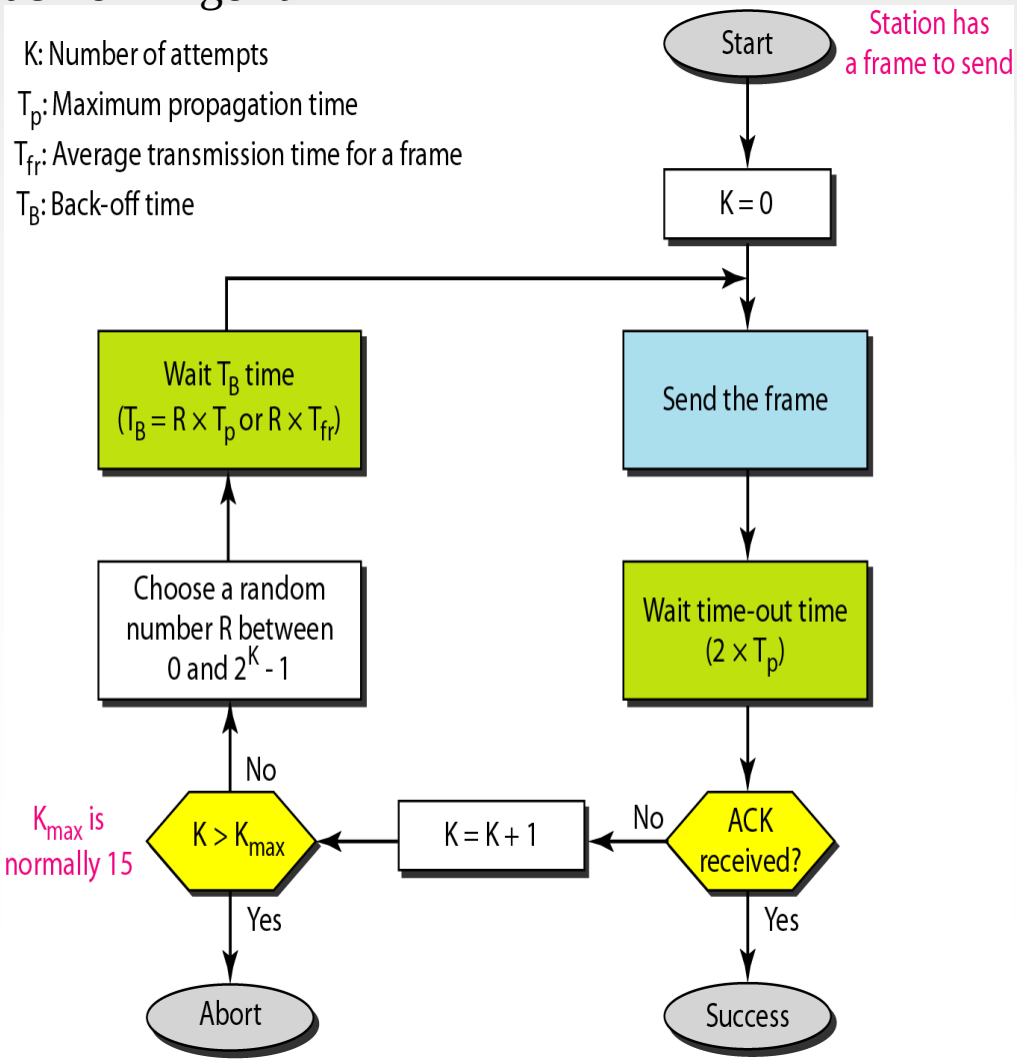
ALOHA

- The earliest random access method developed at the University of Hawaii in the early 1970s
- Designed for a radio (wireless) LAN
- Pure ALOHA and Slotted ALOHA
- Frames in a pure ALOHA network



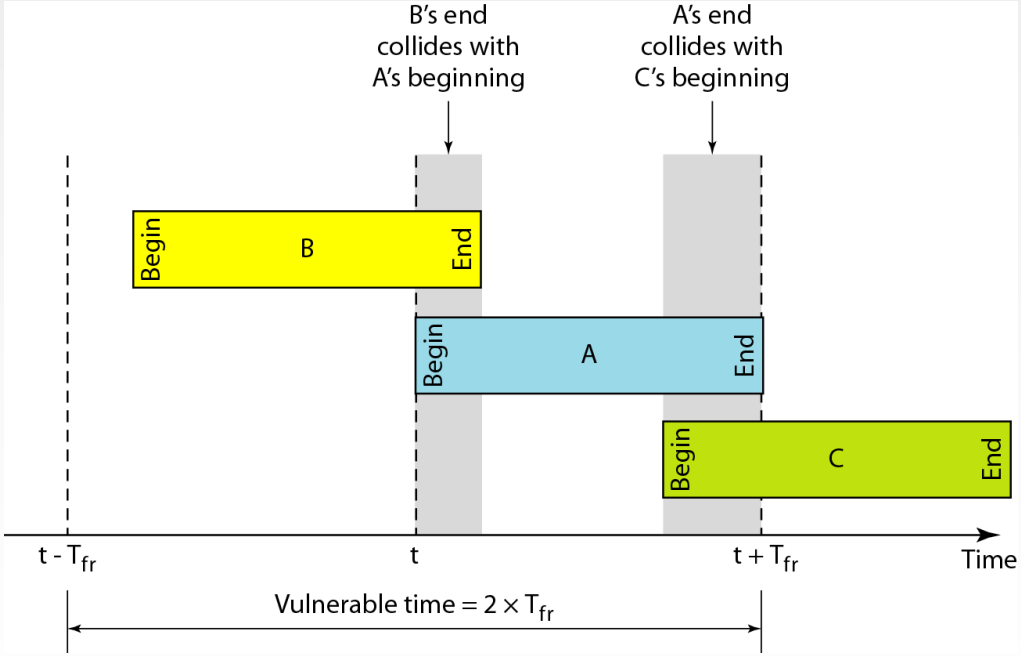
Pure ALOHA Protocol: Procedure

- Binary Exponential Back-off Algorithm



Pure ALOHA Protocol

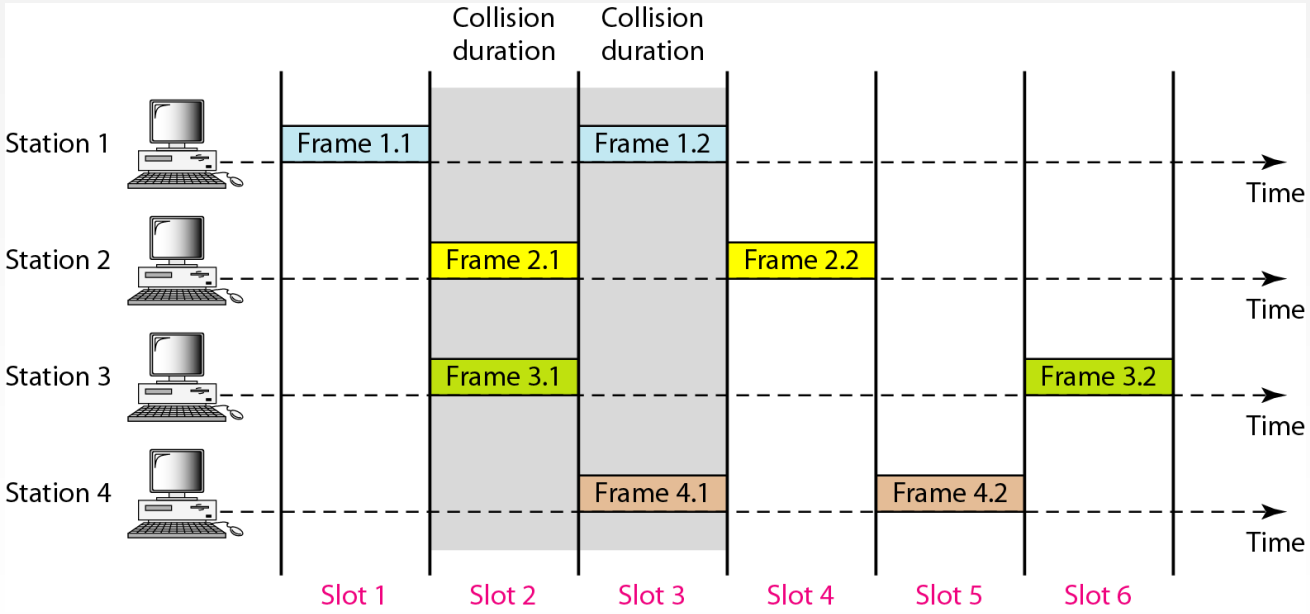
- Pure ALOHA vulnerable time = 2 x T_{fr}



- The throughput for pure ALOHA is $S = G \times e^{-2G}$ where G is average number of frames generated by the system during one transmission time.
- The maximum throughput S_{max} = 0.184 when G= (1/2).

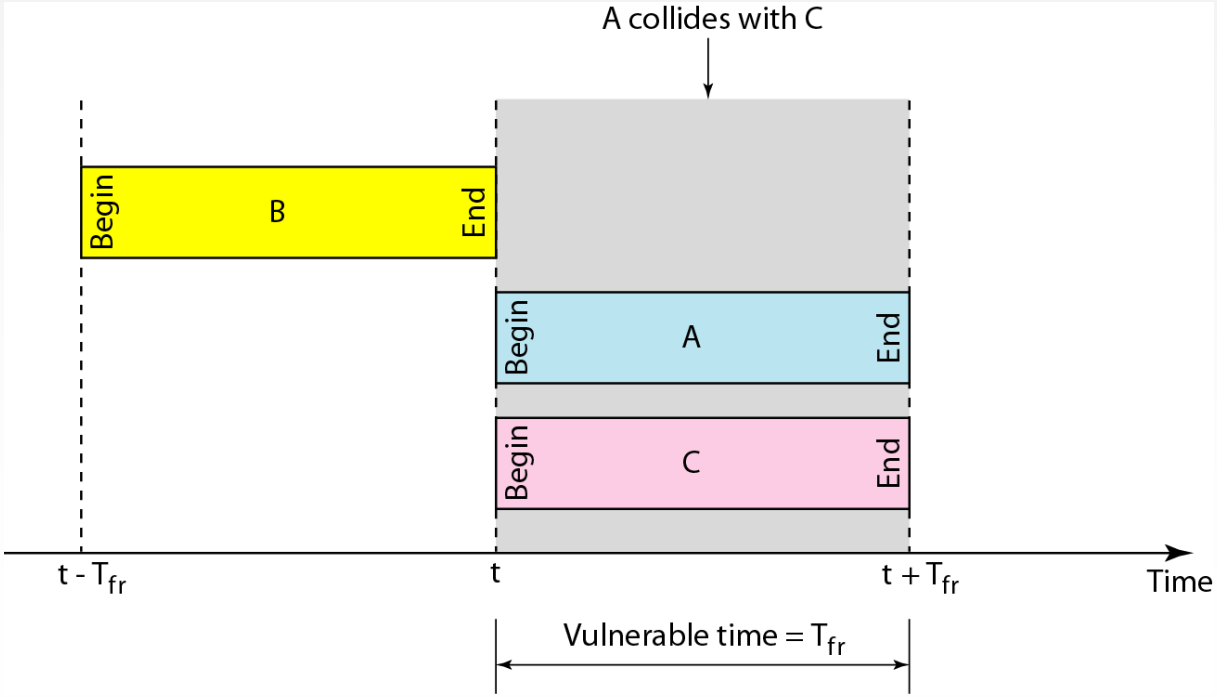
Slotted ALOHA

- Pure ALOHA vulnerable time = 2 x T_{fr} because there is no rule that defines when the station can send
- Slotted ALOHA was invented to improve the efficiency of pure ALOHA



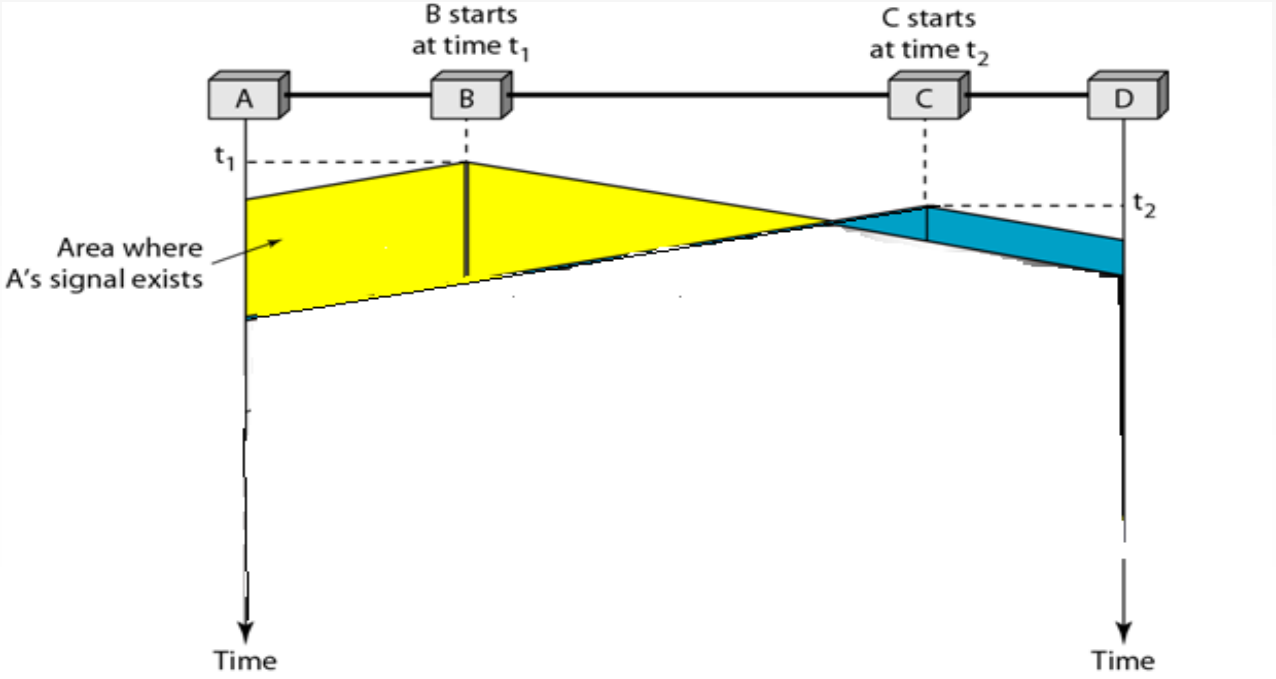
Slotted ALOHA

- Throughput for slotted ALOHA is $S = G \times e^{-G}$.
- The maximum throughput $S_{max} = 0.368$ when $G = 1$
- Slotted ALOHA vulnerable time = T_{fr}

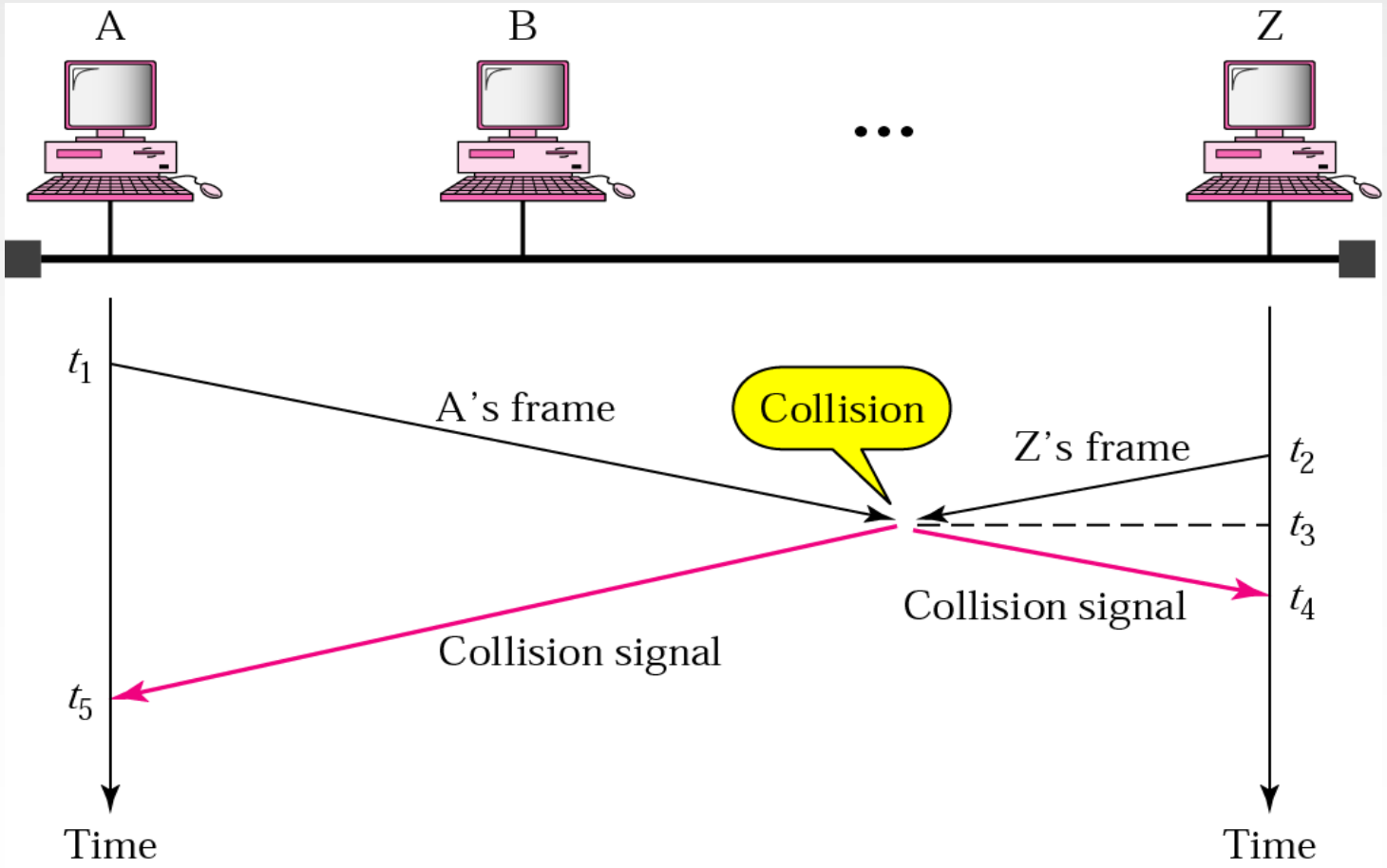


Carrier Sense Multiple Access (CSMA)

- CSMA
- Sense before Transmit
- Listen before Talk
- CSMA can reduce the possibility of collision, but it can not eliminate it

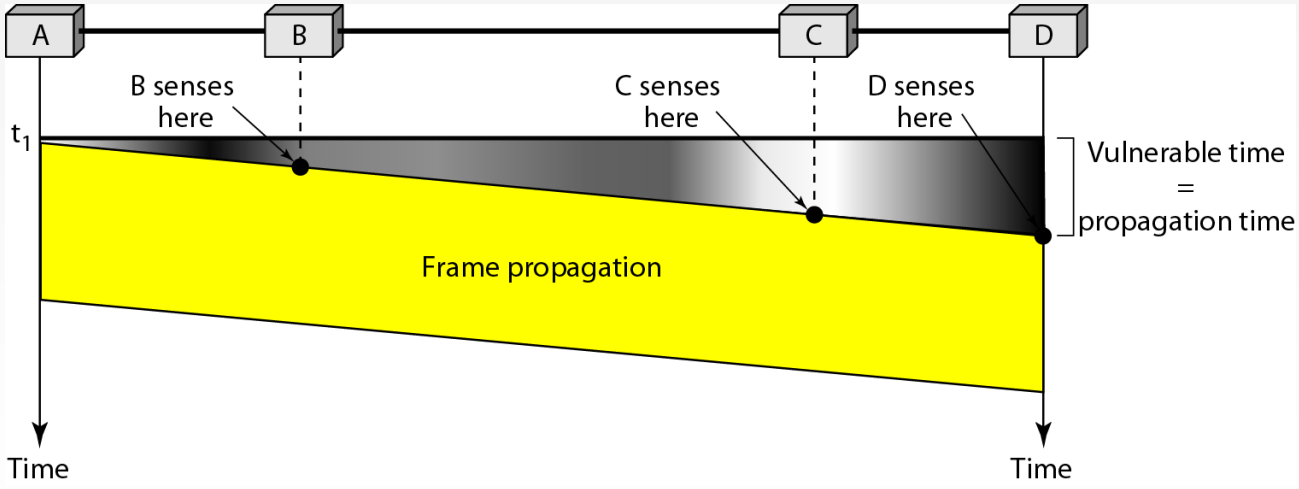


Collision in CSMA



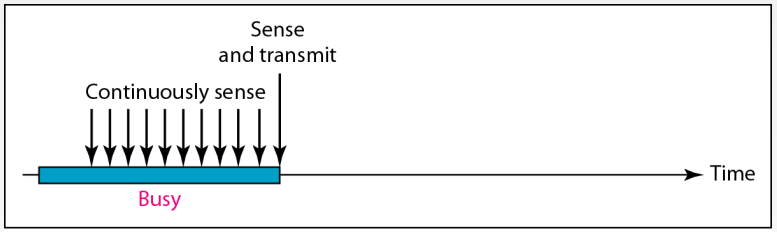
CSMA: Vulnerable Time

- Vulnerable time for CSMA is the propagation time Tp needed for a signal to propagate from one end of the medium to the other

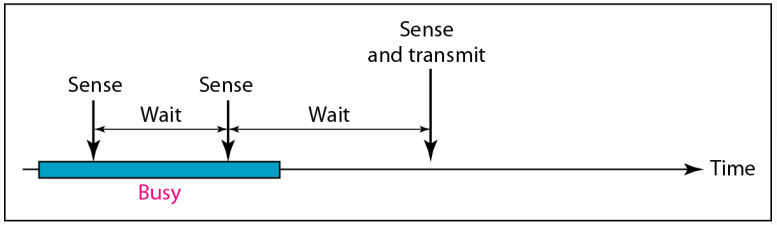


CSMA: Persistence Methods

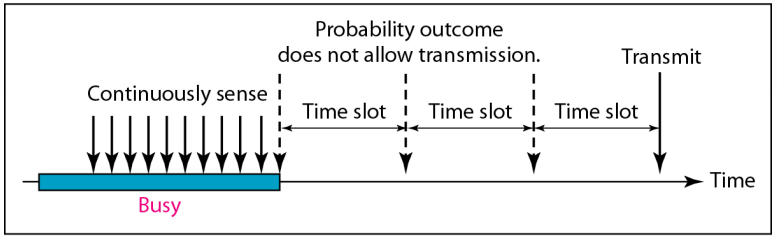
- Behavior of 1-persistent, Nonpersistent, *p*-persistent method



a. 1-persistent



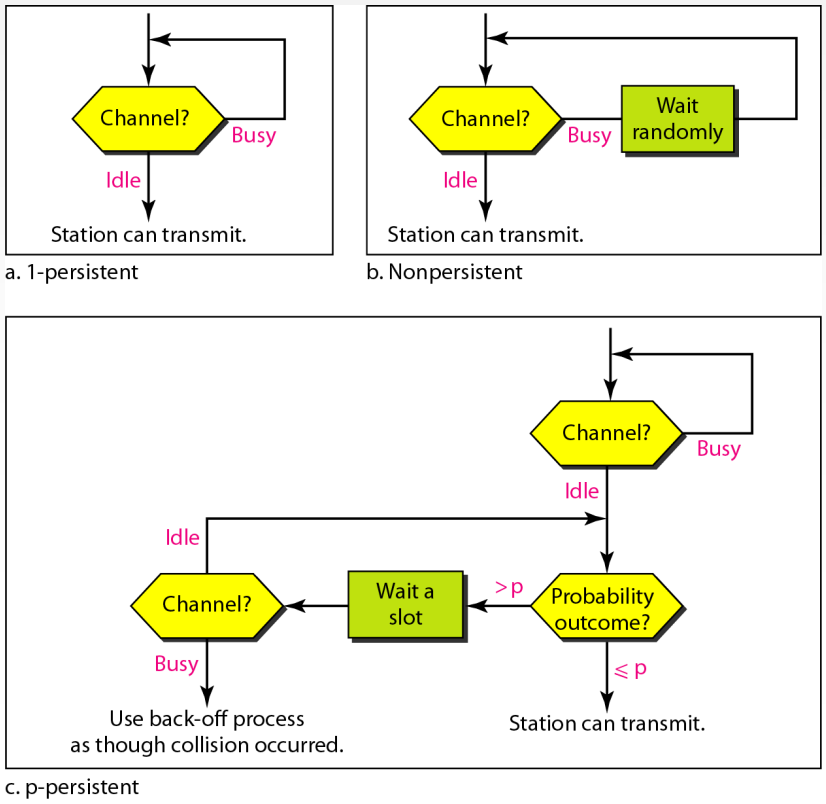
b. Nonpersistent



c. p-persistent

CSMA: Persistence Methods

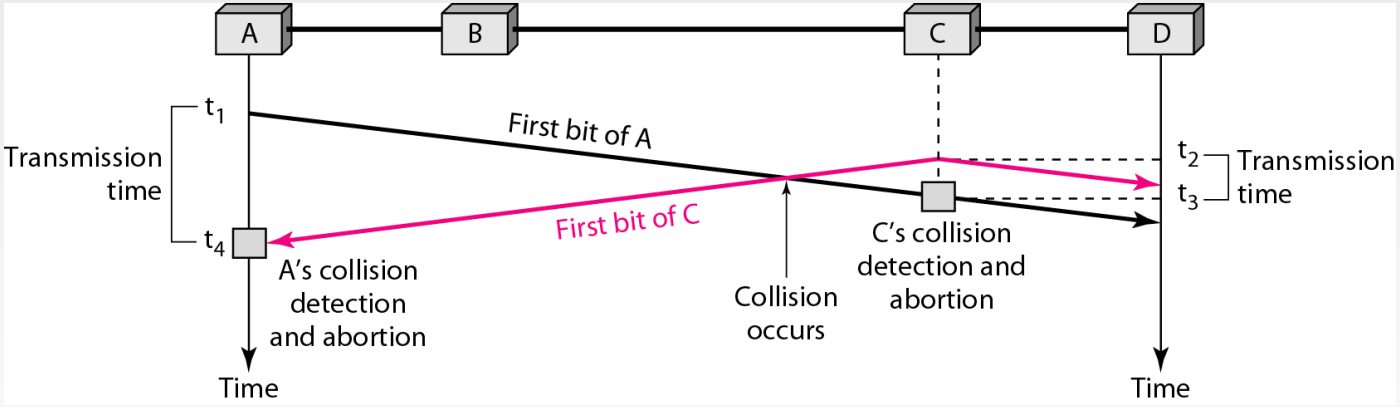
- Flow diagram for 1-persistent, Nonpersistent, p-persistent method

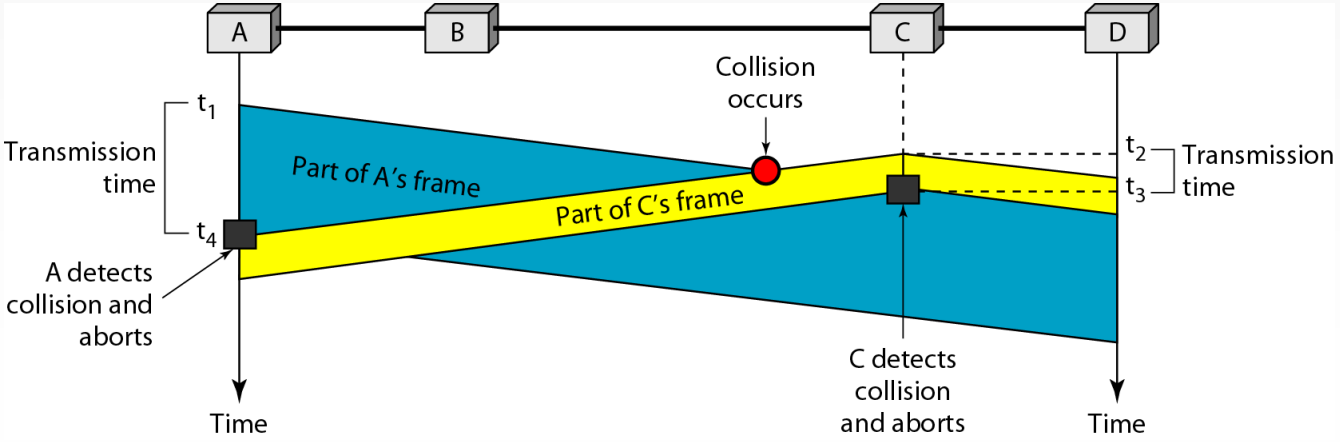


Persistence Strategy

- *1-persistent*
  - Increases the chance of collision
- *Non-persistent* strategy
  - Reduces the chance of collision
  - Reduces the efficiency of the network
- *p-persistent*
  - Reduces the chance of collision and improves the efficiency by combining the other two strategies.

CSMA/CD (Collision Detection)





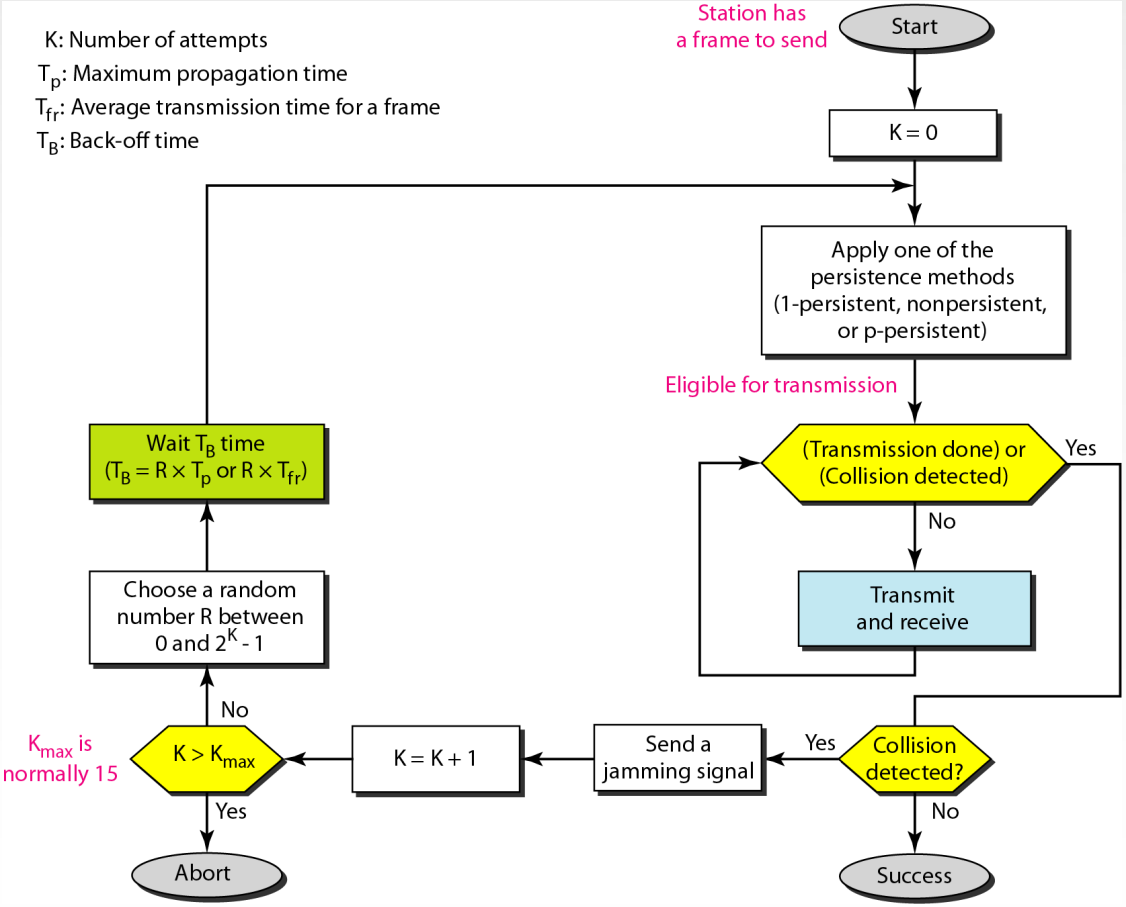
CSMA/CD: Min. Frame Size

• *Example: 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

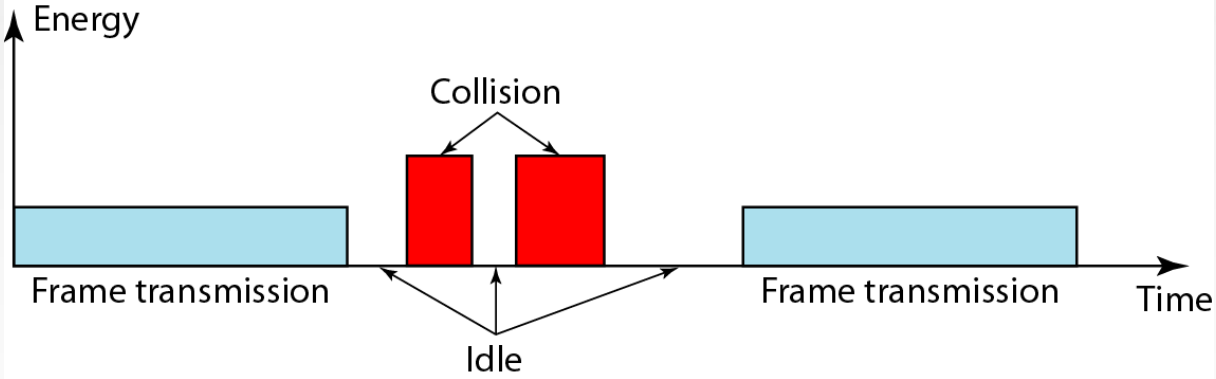
The frame transmission time is $T_{fr} = 2 \times T_p = 51.2$ μs. This means, in the worst case, a station needs to transmit for a period of 51.2 μs to detect the collision. The minimum size of the frame is 10 Mbps × 51.2 μs = 512 bits or 64 bytes. This is actually the minimum size of the frame for Standard Ethernet.

CSMA/CD: Flow Diagram



CSMA/CD: Energy Level & Throughput

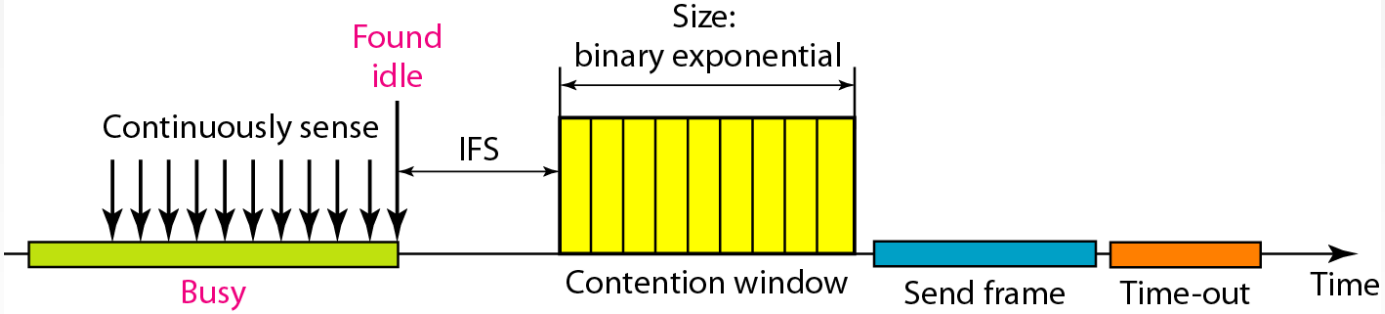
- Energy level during transmission, idleness, or collision



- Throughput of CSMA/CD is greater than that of ALOHA
- The max. throughput occurs at a different value of G and is based on the persistent method and the value of *p* in the *p*-persistent approach
- The max throughput is around 50% when G = 1 for 1-persistent, up to 90% when G is between 3 and 8 for non-persistent

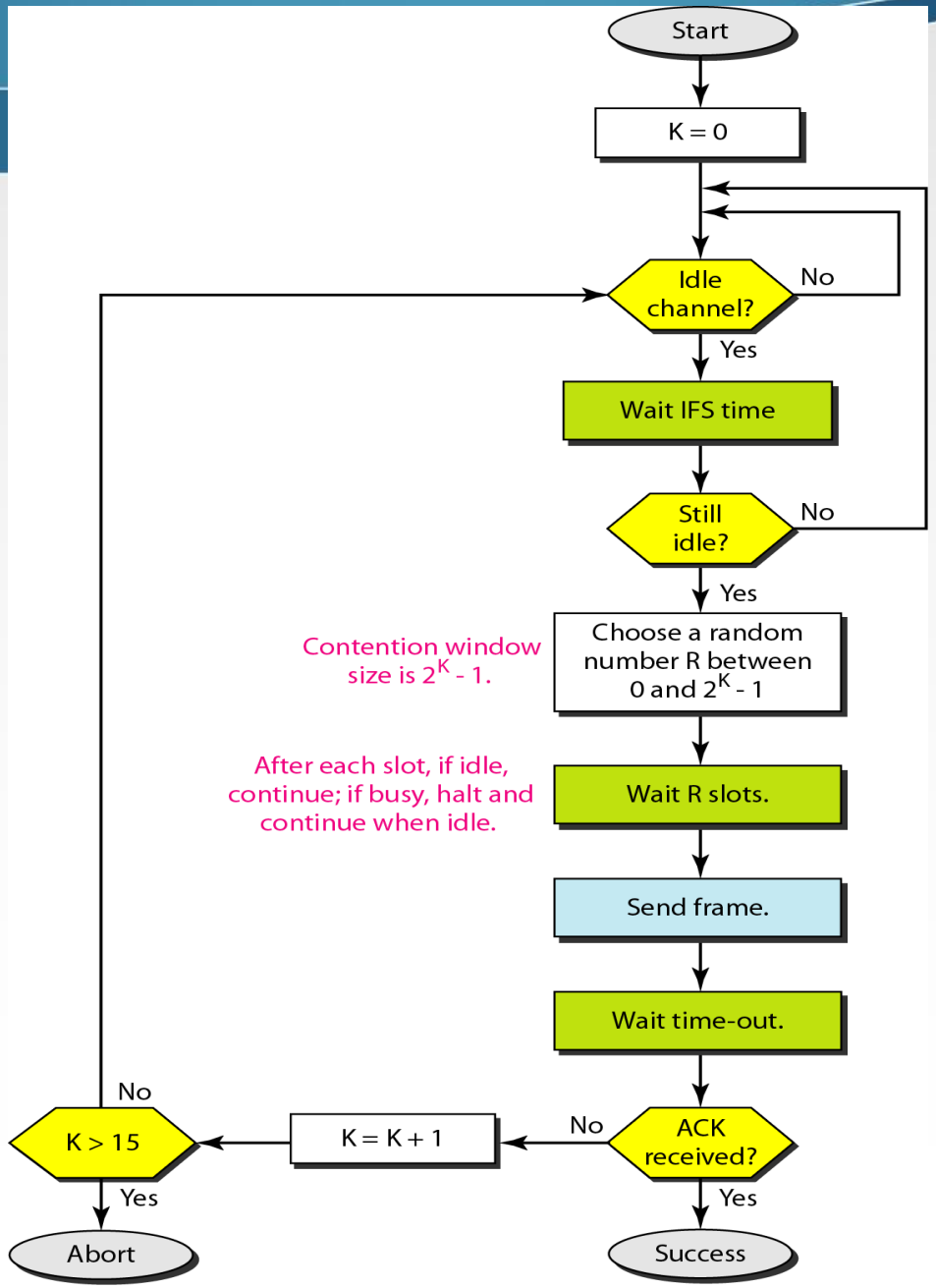
CSMA/CA (Collision Avoidance)

- Invented for wireless network where we cannot detect collisions
- Collision are avoided through the use of CSMA/CA's three strategies: the interframe space, the contention window, and acknowledgement



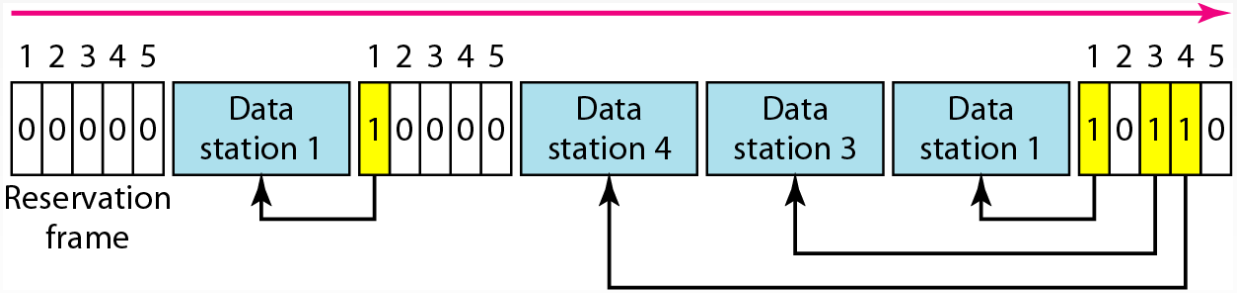
- IFS can also be used to define the priority of a station or a frame
- During the contention window, if the station finds the channel busy, it does not restart the timer of the contention window; it stops the timer and restarts it when the channel becomes idle

CSMA/CA: Flow Diagram

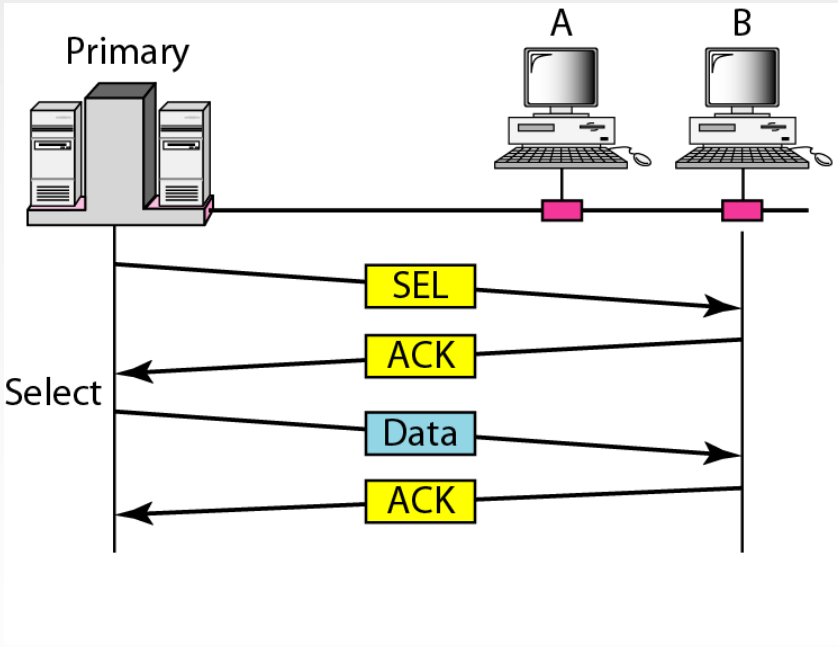


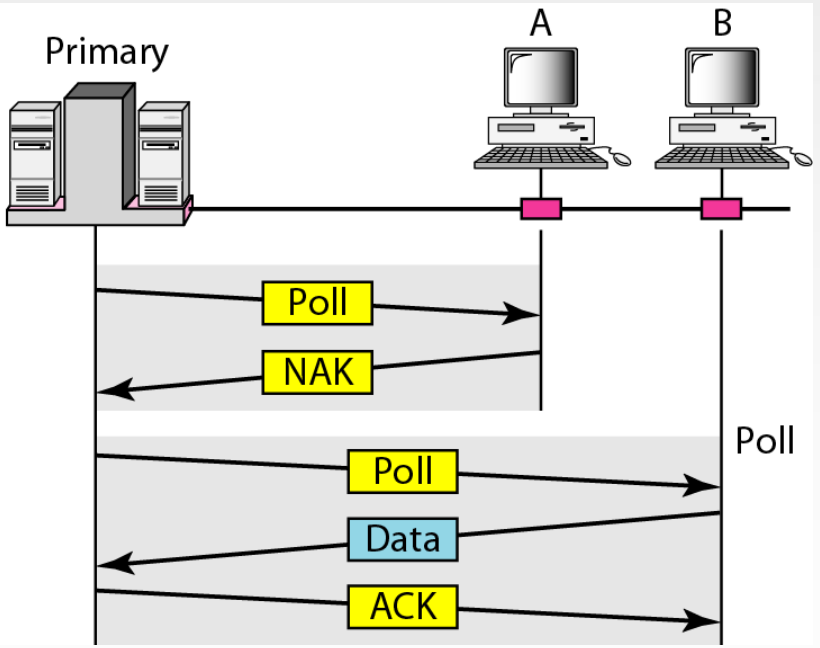
Controlled Access

- The stations consult one another to find which station has the right to send
- Reservation/Polling/ Token passing
- Reservation access method



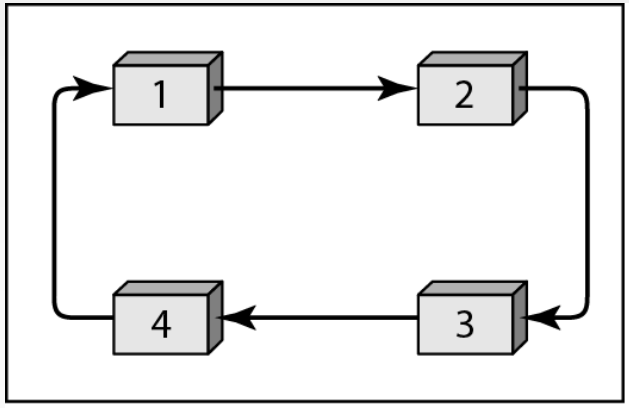
Polling: Select and Poll Functions



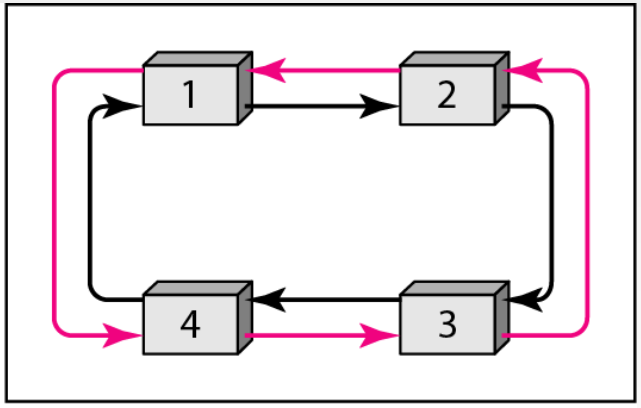


Token Passing

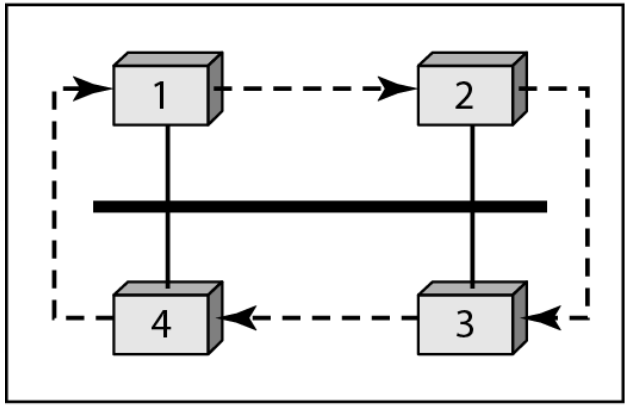
- Logical Ring and Physical Topology



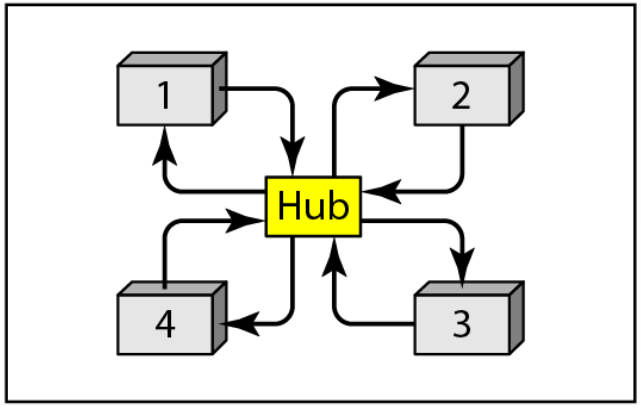
a. Physical ring



b. Dual ring



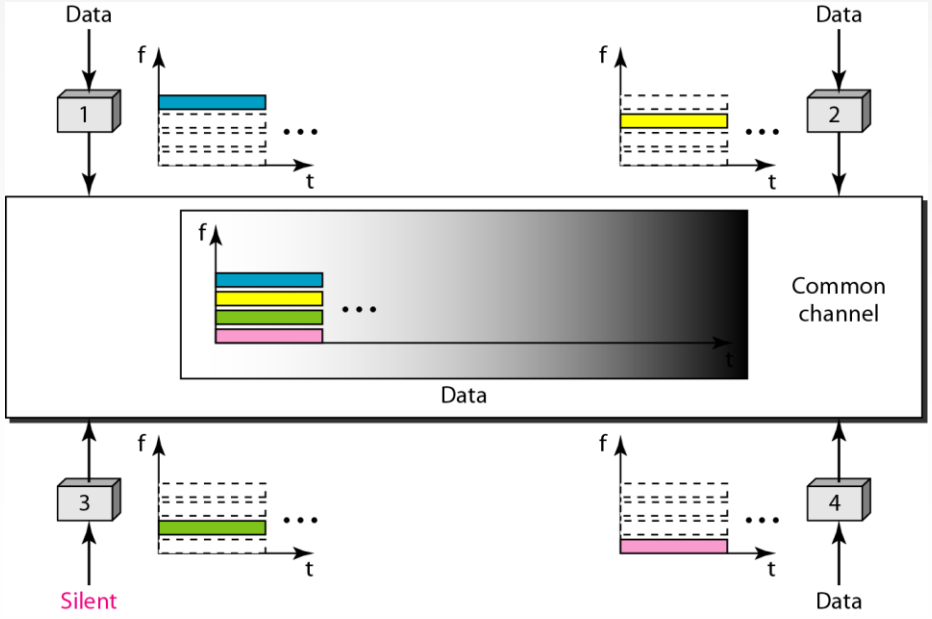
c. Bus ring



d. Star ring

Channelization: FDMA

- FDMA
  - Available bandwidth of the common channel is divided into bands that are separated by guard bands
  - FDMA is an access method in data link layer protocol. But, FDM is a physical layer technique



Channelization: TDMA

- TDMA
  - The bandwidth is just one channel that is timeshared between different stations
  - TDMA is an access method. But, TDM is a physical layer technique