Computer Networks(CS30006)

Spring Semester (2021-2022)

Multiple Access Protocols

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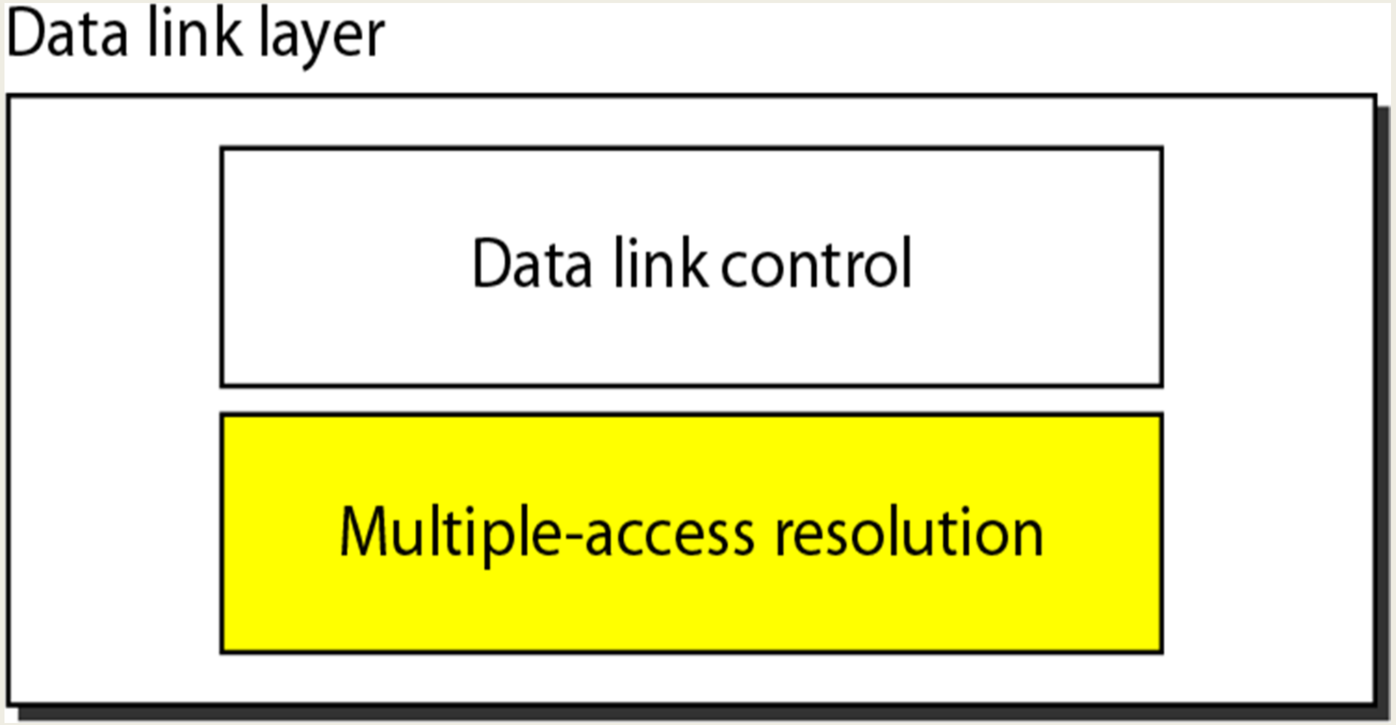
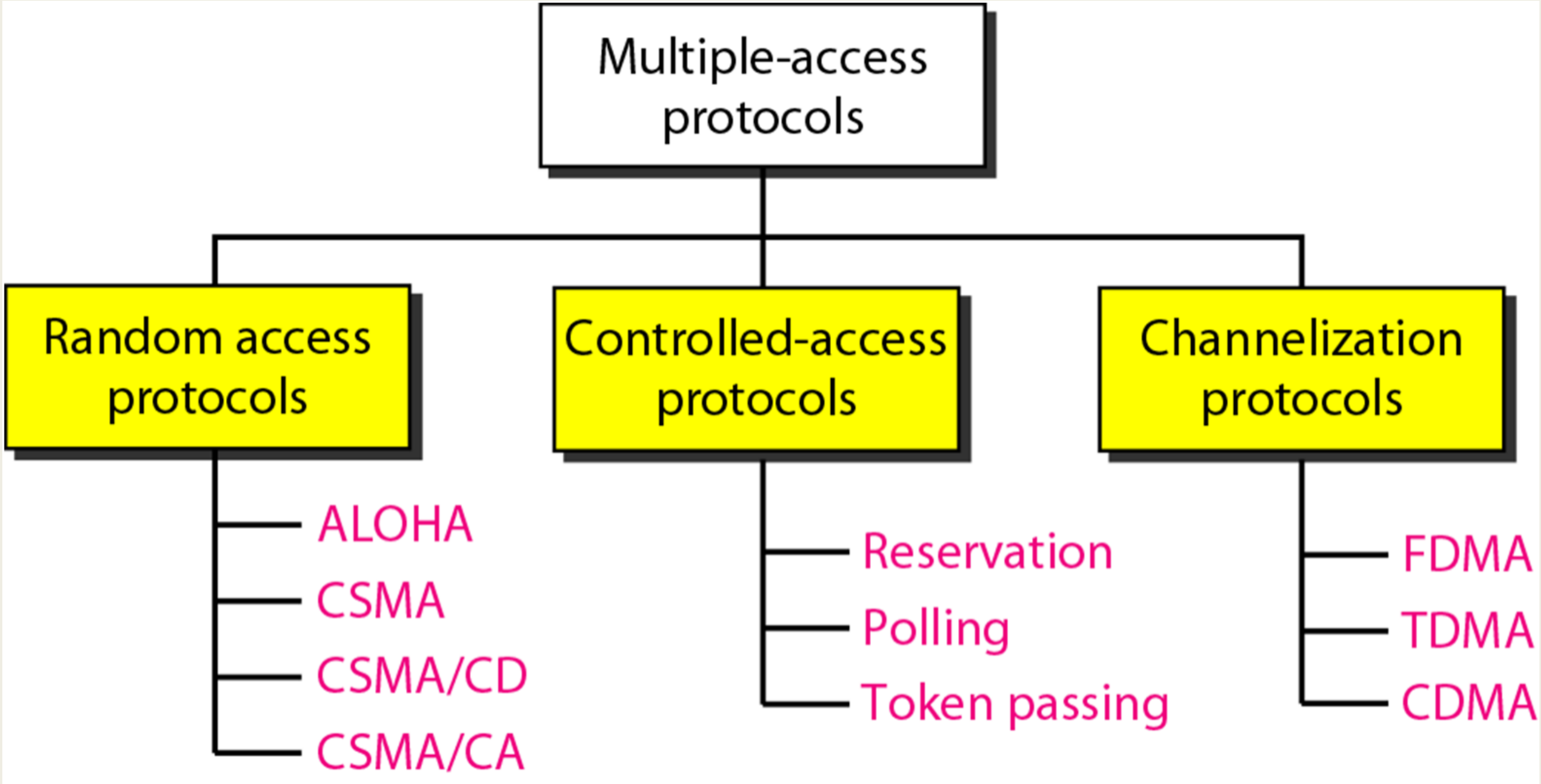
Multiple Access Resolution

Data link layer divided into two functionality-oriented sublayers.



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Taxonomy



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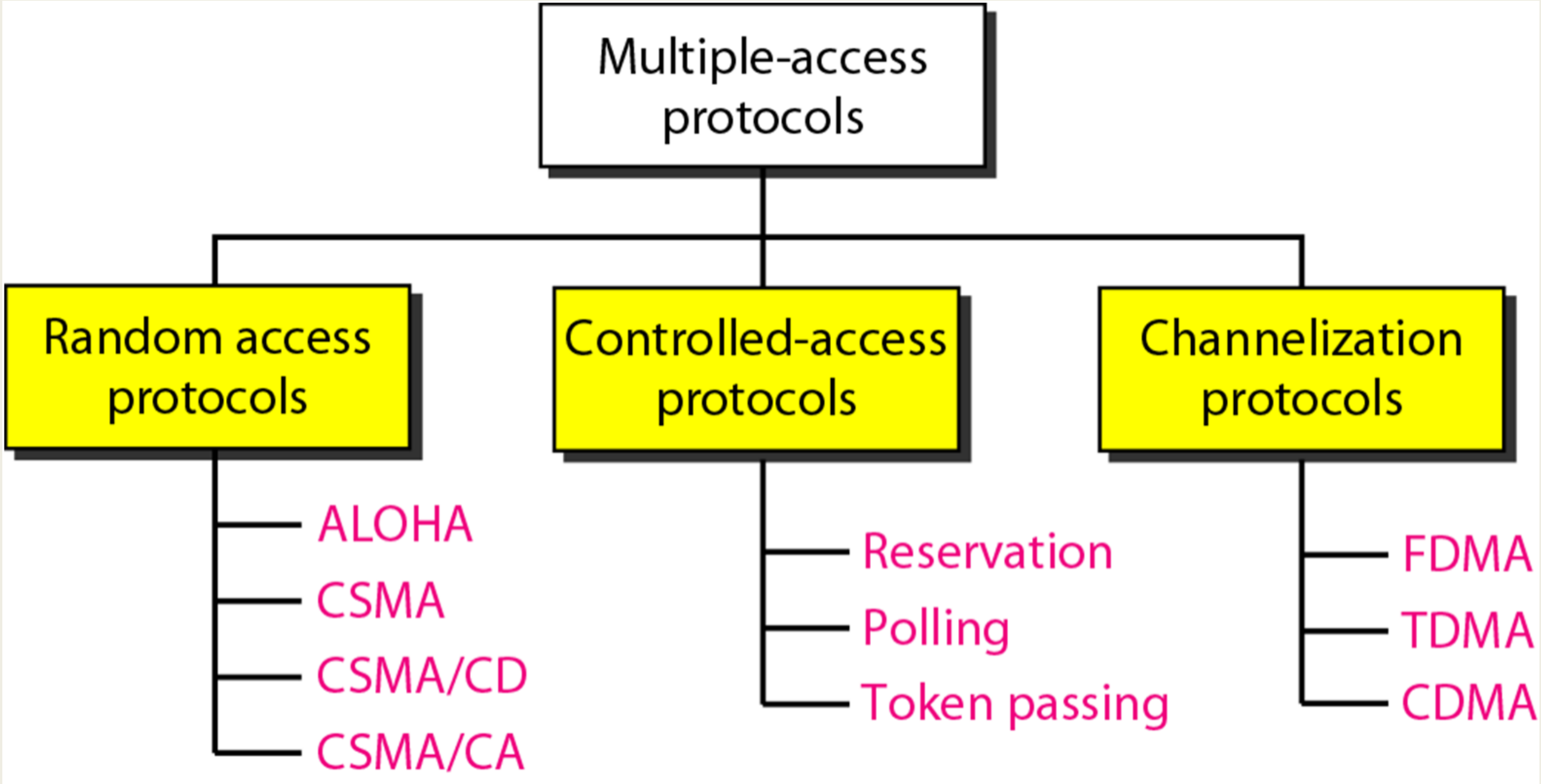
Taxonomy



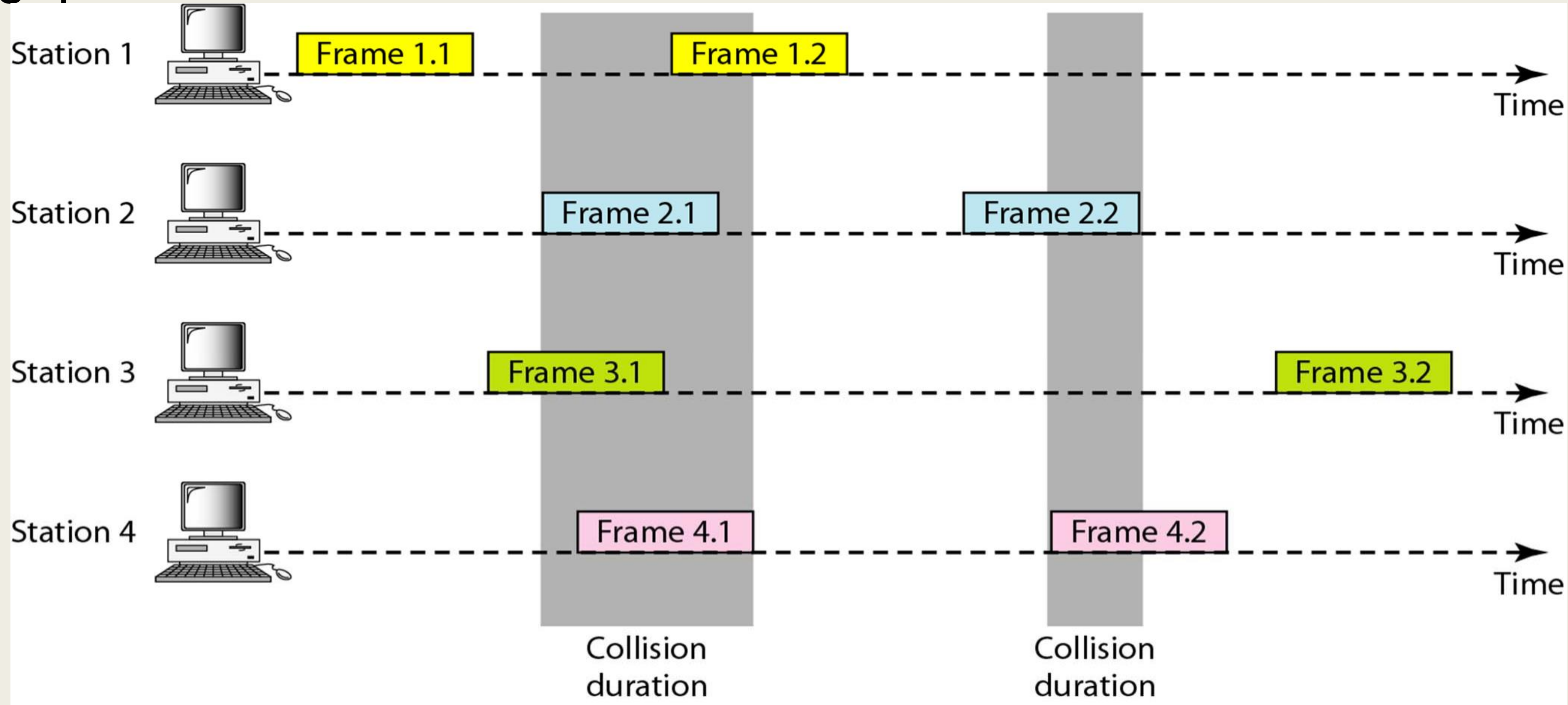
Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Random Access Protocols

- In random access or contention methods, no station is superior to another station and none is assigned the control over another.
- No station permits, or does not permit, another station to send.
- At each instance, a station that has data to send uses a procedure defined by the protocol to make a decision on whether or not to send.

Pure Aloha

- Each station sends a frame whenever it has a frame to send.
- There is only one channel to share, there is the possibility of collision between frames from different stations.
- Throughput $S = G \times e^{-2G}$



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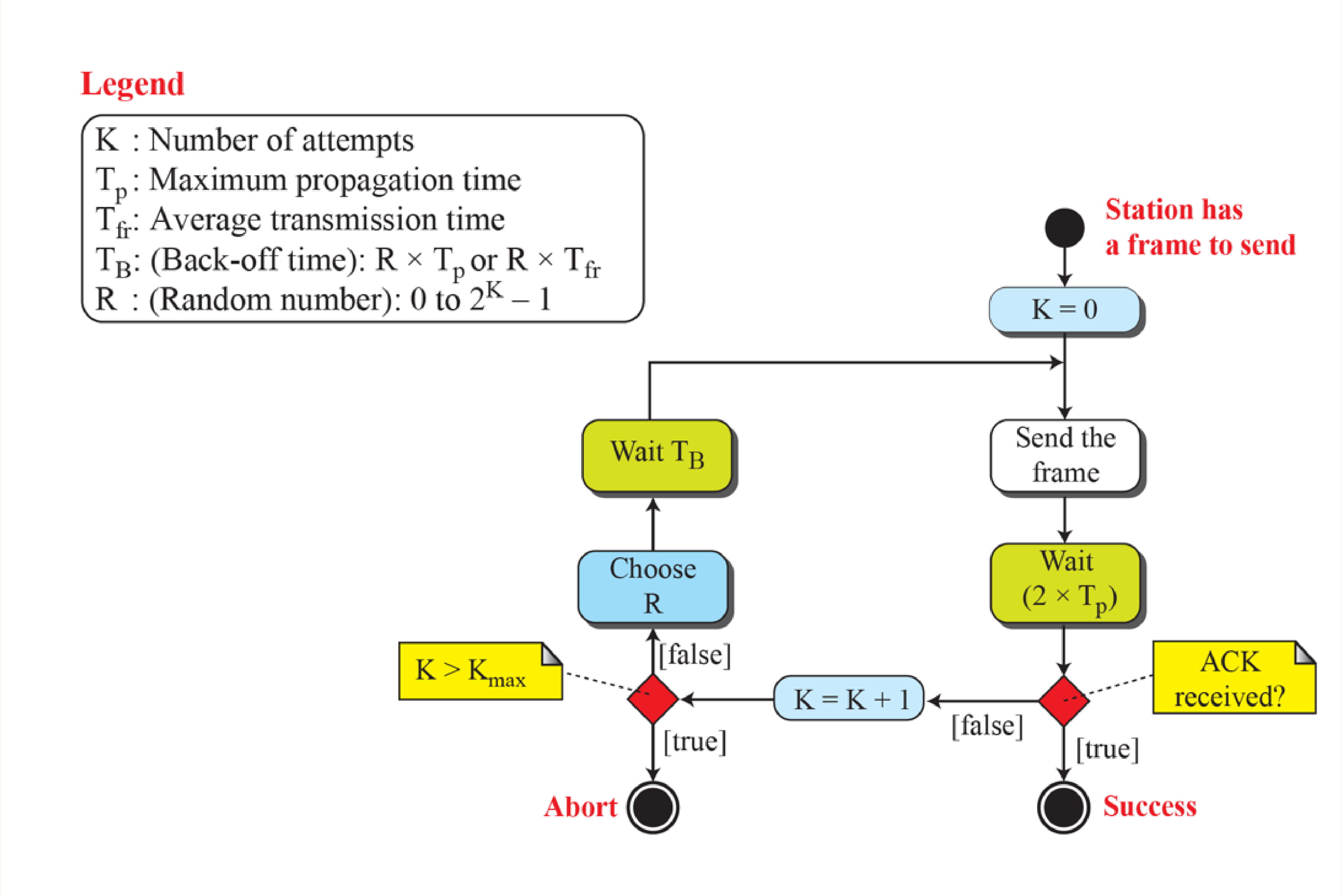
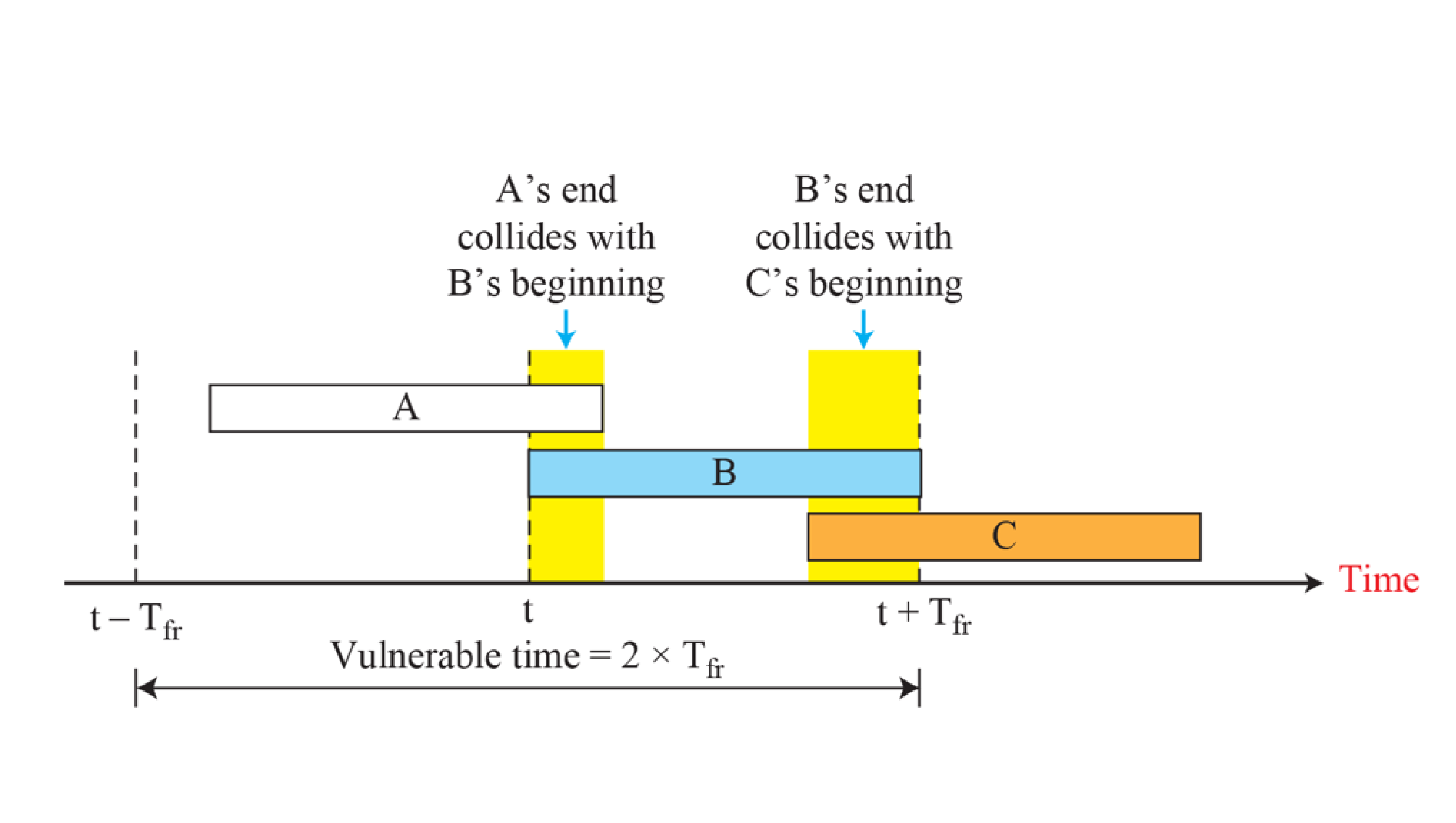
Pure Aloha



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Vulnerable Time for Pure Aloha

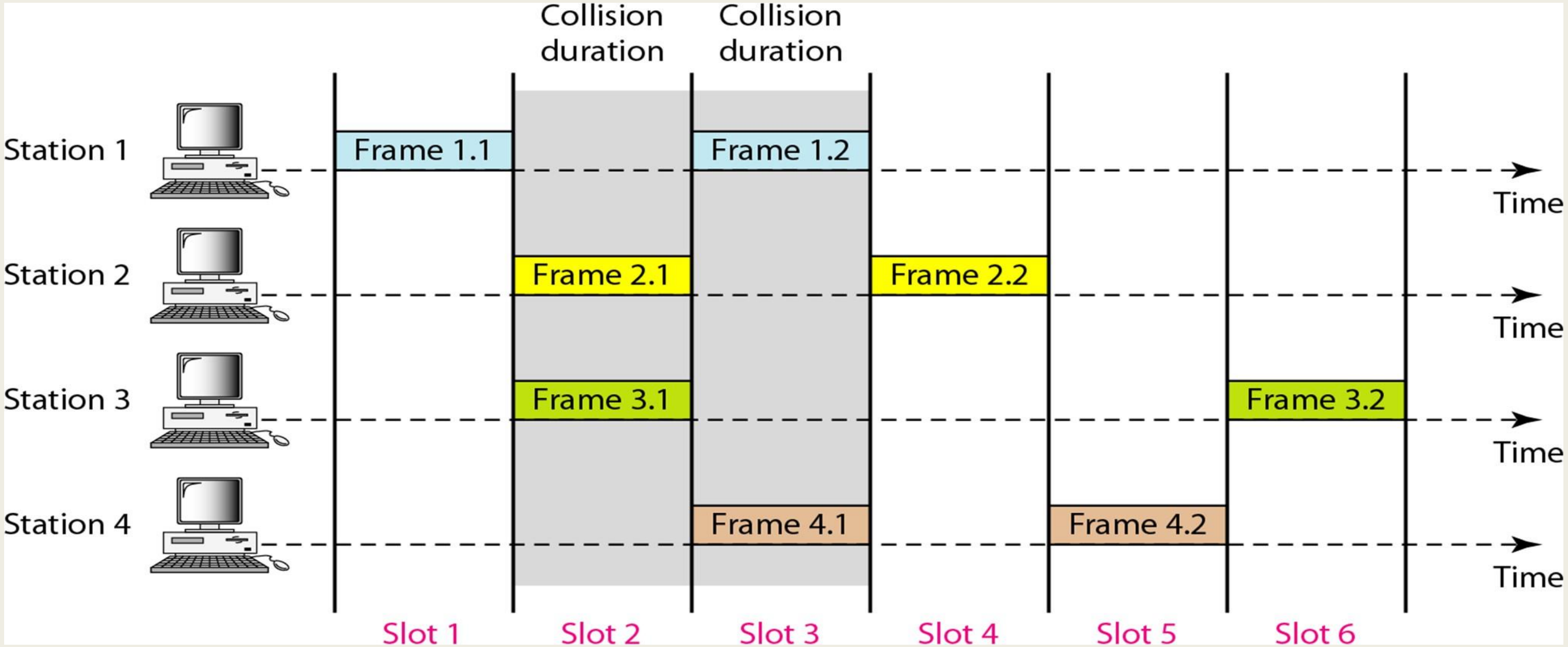
Pure ALOHA has a vulnerable time of 2 x Tfr .



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Slotted Aloha

- The time is divided into slots of T_{fr} s and force the station to send only at the beginning of the time slot.
- Slotted ALOHA vulnerable time = T_{fr}
- The throughput for slotted ALOHA is S =: G x e^{-G}. The maximum throughput $Smax$ == 0.368 when G =1.



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Example

- 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

Average frame transmission time T_{fr} is 200 bits/200 kbps or 1 ms. The vulnerable time is 2×1 ms = 2 ms. This means no station should send later than 1 ms before this station starts transmission and no station should start sending during the period (1 ms) that this station is sending.

Example

A pure ALOHA network transmits 200-bit frames on a shared channel of 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?

Solution

The frame transmission time is 200/200 kbps or 1 ms.

Therefore, in 1s we can send 1000 frames.

Max capacity of the channel = 1000 frames/sec

a) If the system creates 1000 frames per second, or 1 frame per millisecond, then G = 1. In this case $S = G \times e^{-2G} = 0.135$ (13.5 percent). This means that the throughput is1000 × 0.135 = 135 frames. Only 135 frames out of 1000 will probably survive.

G = (No of frames the system is producing) / (Max capacity of the channel).

Cont...

b) If the system creates 500 frames per second, or 1/2 frames per millisecond, then $G = 1/2$. In this case $S = G \times e^{-2G} = 0.184$ (18.4 percent). This means that the throughput is $500 \times 0.184 = 92$ and that only 92 frames out of 500 will probably survive.

c) If the system creates 250 frames per second, or 1/4 frames per millisecond, then $G = 1/4$. In this case $S = G \times e^{-2G} = 0.152$ (15.2 percent). This means that the throughput is $250 \times 0.152 = 38$. Only 38 frames out of 250 will probably survive

Example

A slotted ALOHA network transmits 200-bit frames using a shared channel with a 200-kbps bandwidth. Find the throughput if the system (all stations together) produces

a. 1000 frames per second.
b. 500 frames per second.
c. 250 frames per second.

Solution

This situation is similar to the previous exercise except that the network is using slotted ALOHA instead of pure ALOHA. The frame transmission time is 200/200 kbps or 1 ms.

Max capacity of the channel = 1000 frames/sec

G = (no of frames being input per sec) / (capacity of the channel)

a) In this case G is 1. So $S = G \times e^{-G} = 0.368$ (36.8 percent). This means that the throughput is $1000 \times 0.0368 = 368$ frames. Only 368 out of 1000 frames will probably survive.

Cont...

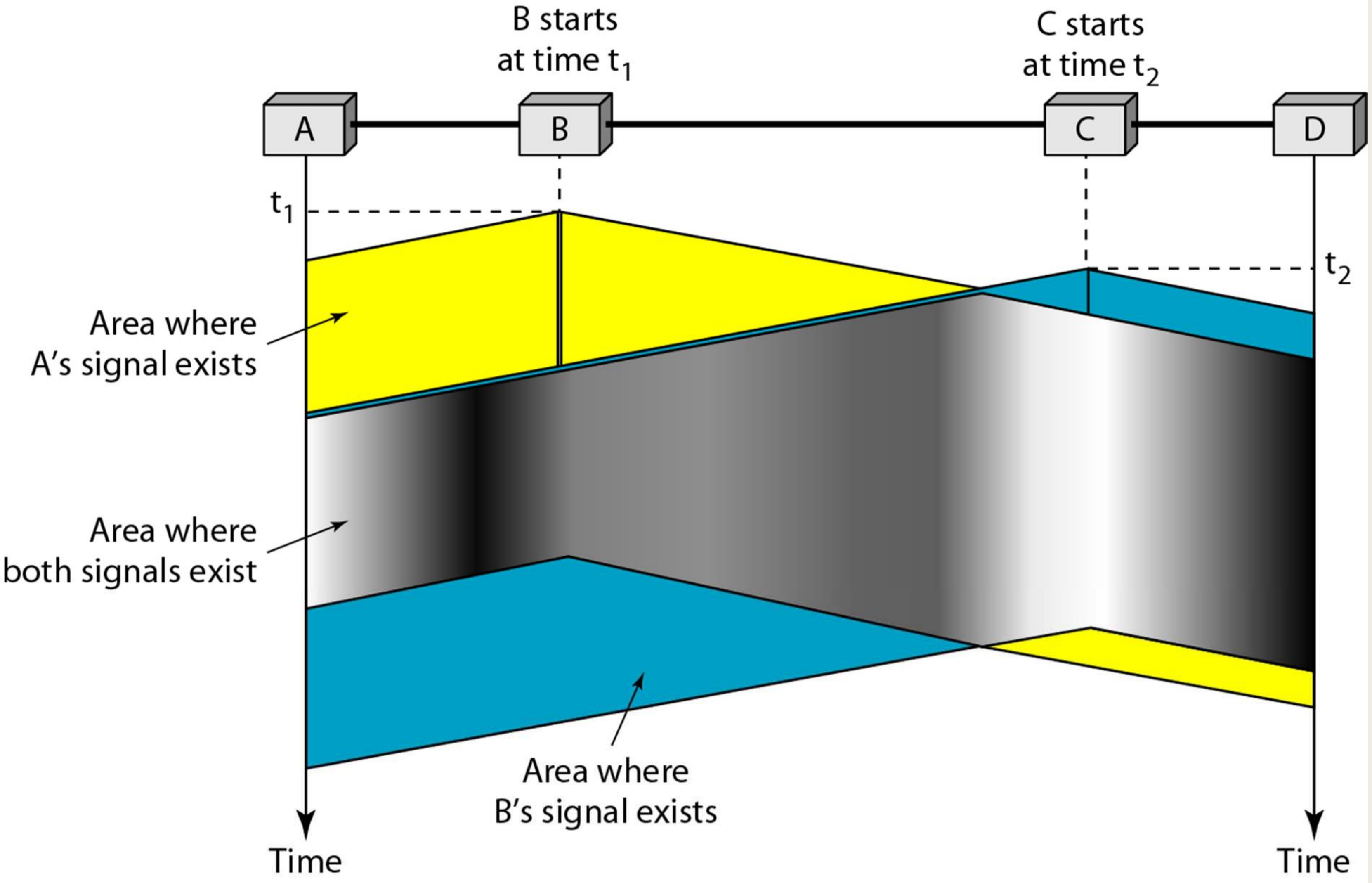
b) Here G is 1/2. In this case $S = G \times e^{-G} = 0.303$ (30.3 percent). This means that the throughput is $500 \times 0.0303 = 1512$. Only 151 frames out of 500 will probably survive.

c) Now G is 1/4. In this case $S = G \times e^{-G} = 0.195$ (19.5 percent). This means that the throughput is $250 \times 0.195 = 49$. Only 49 frames out of 250 will probably survive.

Carrier Sense Multiple Access (CSMA)

- Carrier sense multiple access (CSMA) requires that each station first listen to the medium (or check the state of the medium) before sending.
- CSMA is based on the principle "sense before transmit" or "listen before talk."
- CSMA can reduce the possibility of collision, but it cannot eliminate it.
- The possibility of collision still exists because of propagation delay; when a station sends a frame, it still takes time (although very short) for the first bit to reach every station and for every station to sense it.
- The vulnerable time for CSMA is the propagation time T_p .
- This is the time needed for a signal to propagate from one end of the medium to the other.

Carrier Sense Multiple Access (CSMA)



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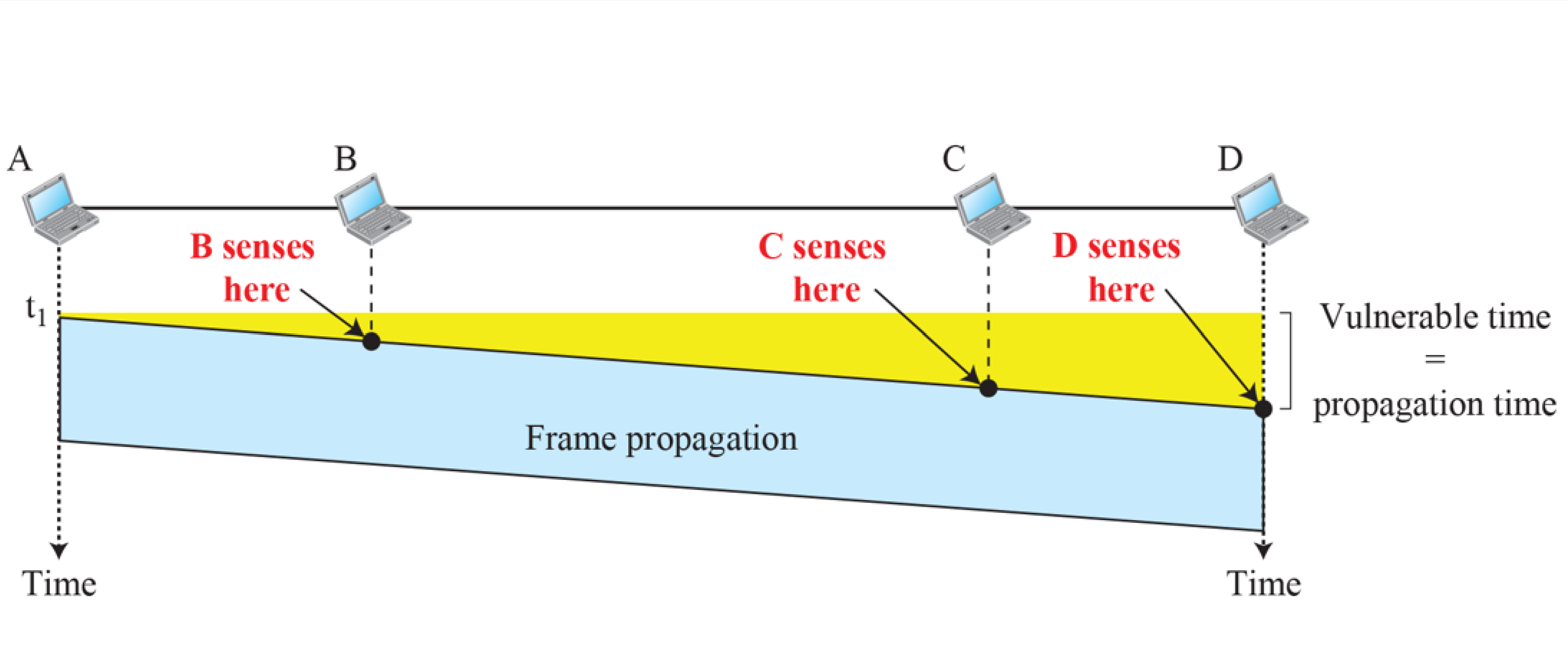
Vulnerable Time for Carrier Sense Multiple Access (CSMA)



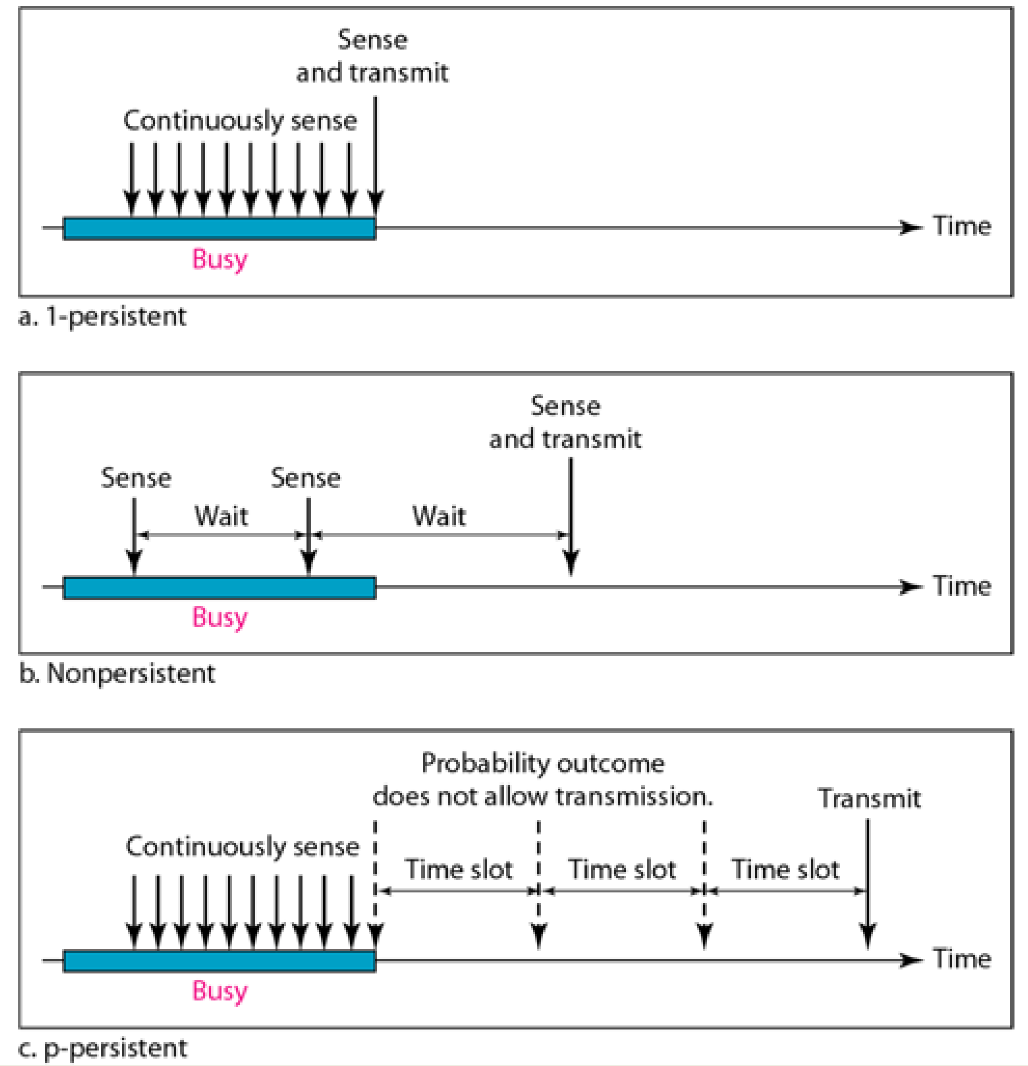
Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Persistent Methods

What does a station do when channel busy/idle?

Three persistent methods are:

- **The I-persistent method:** In this method, after the station finds the line idle, it sends its frame immediately (with probability I).
- **The non-persistent method:** If the line is idle, it sends immediately. If the line is not idle, it waits a
random amount of time and then senses the line again.
- **The p-persistent method:** The p-persistent method is used if the channel has time slots with a slot
duration equal to or greater than the maximum propagation time.



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The p-persistent method:

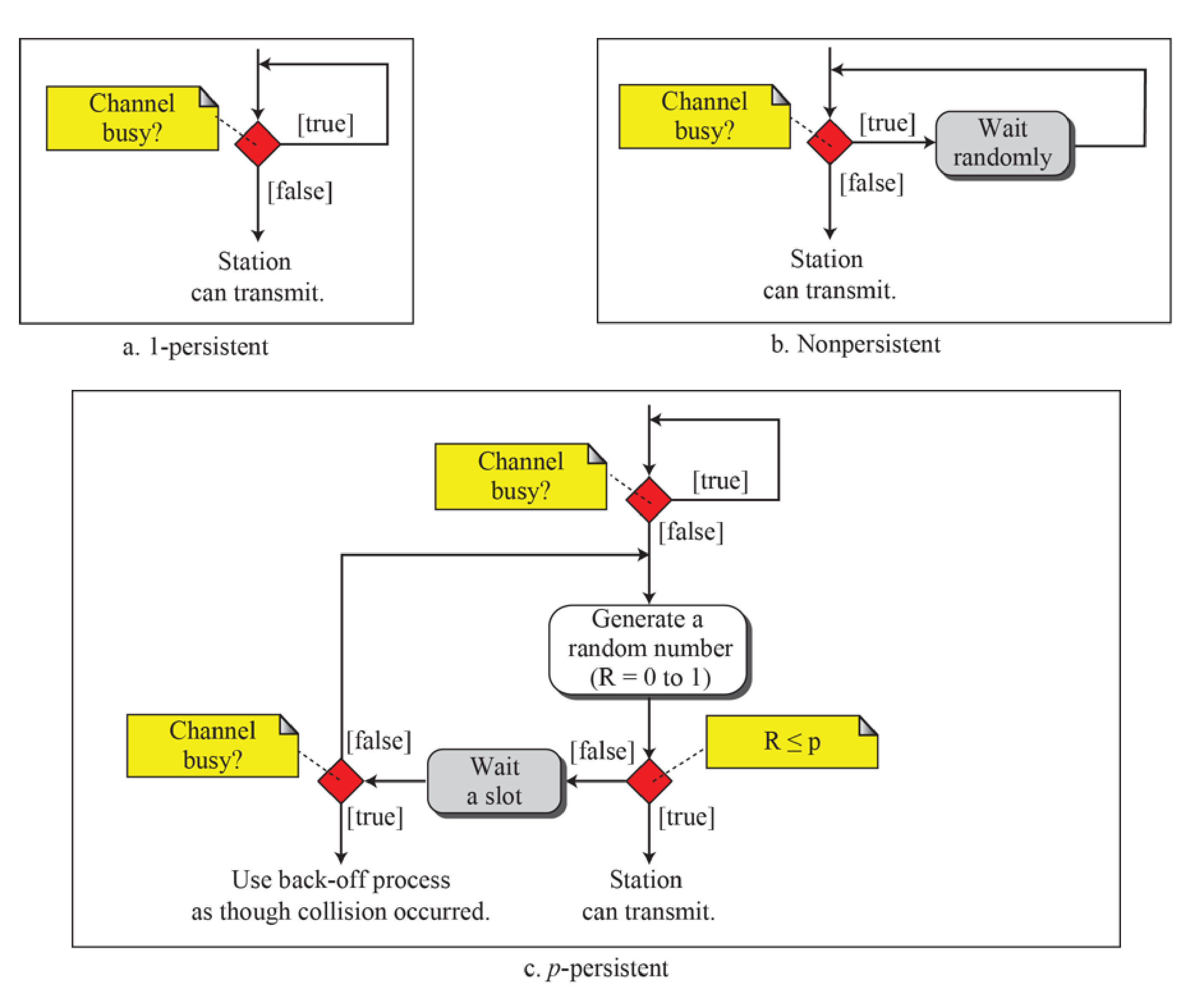
1.With probability p, the station sends its frame.

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 backoff procedure.

Flow Diagram of Persistent Methods



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

- Carrier sense multiple access with collision detection (CSMA/CD) augments the algorithm to handle the collision.
- In this method, a station monitors the medium after it sends a frame to see if the transmission was successful.
- If so, the station is finished. If, however, there is a collision, the frame is sent again.

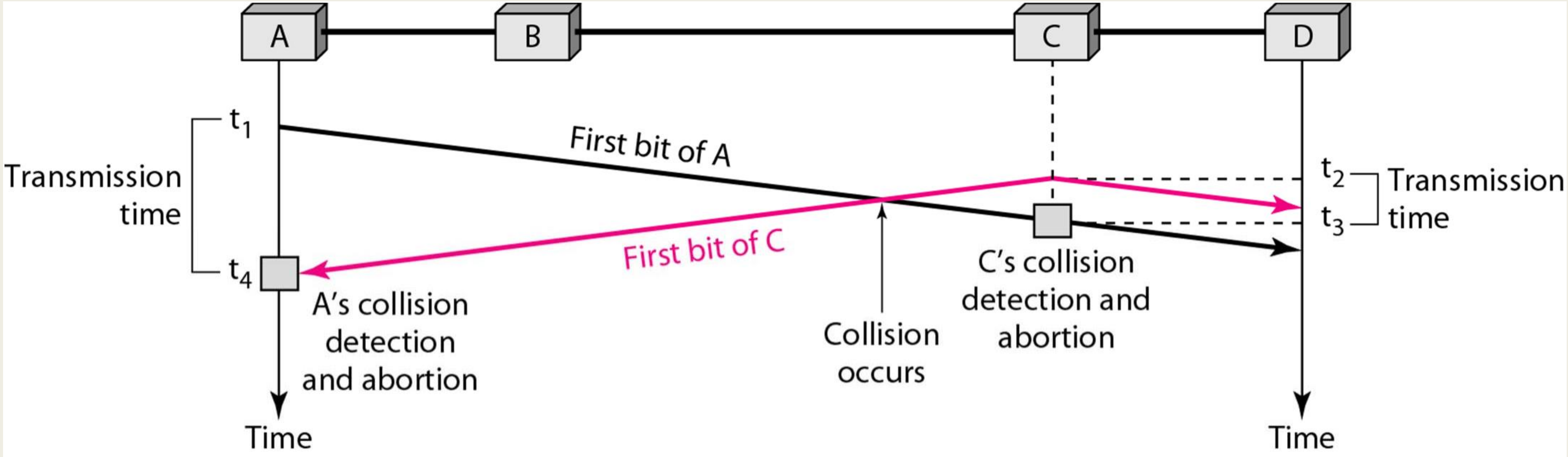


Fig.: Collision of the first bit in CSMA/CD

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Collision and Abortion in CSMA/CD

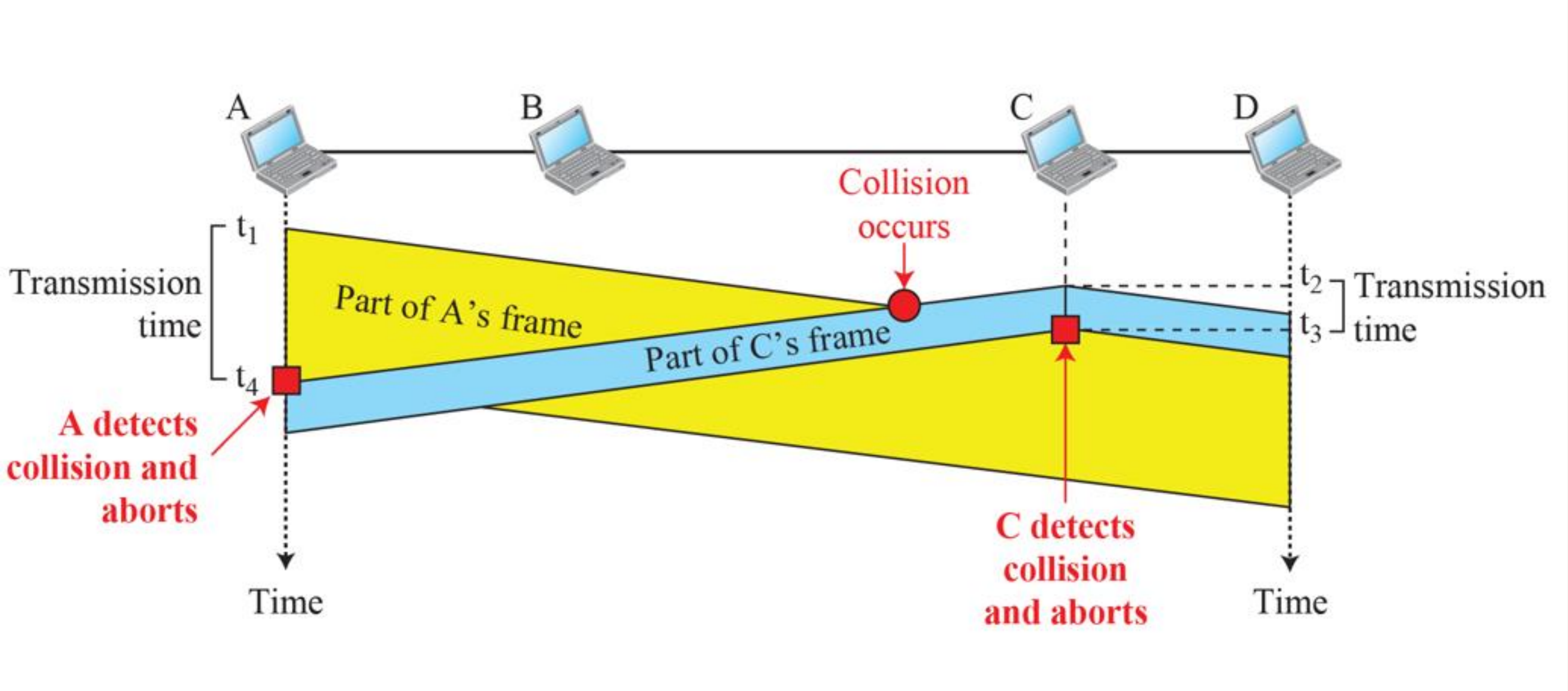
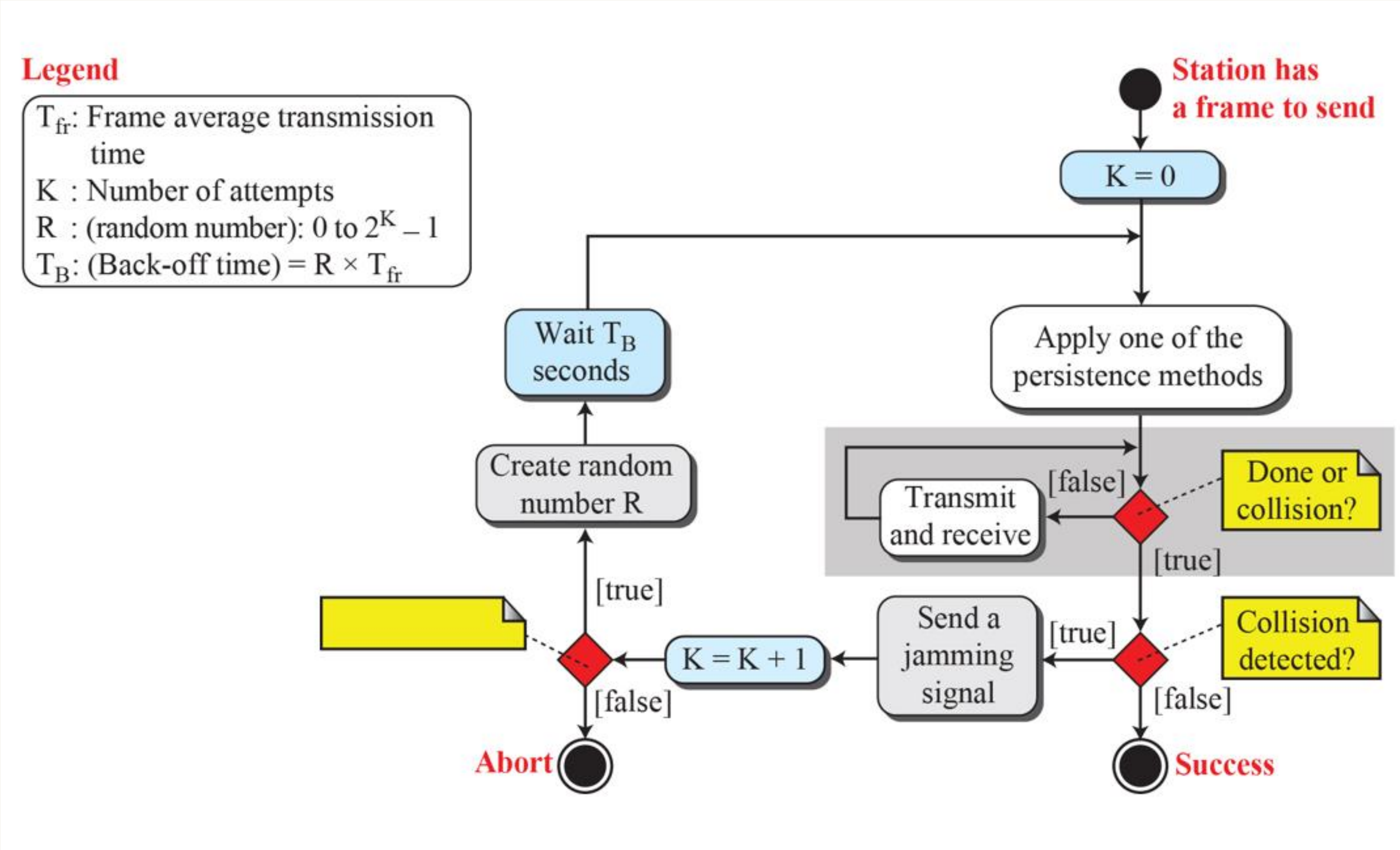


Fig.: Collision and abortion in CSMA/CD

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Flow Diagram of CSMA/CD



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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 minimum frame transmission time is $T_{fr} = 2 \times T_p = 512.2$ μs. This means, in the worst case, a station needs to transmit for a period of 512.2 μs to detect the collision. The minimum size of the frame is 10 Mbps × 512.2 μs = 512 bits or 64 bytes.

Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)

- In CSMA/CA, 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.

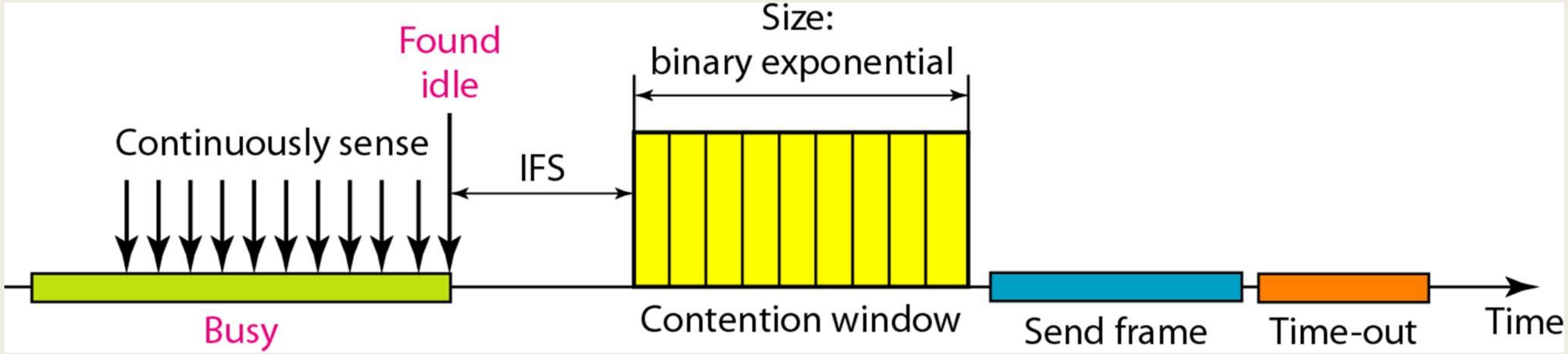


Fig.: Timing in CSMA/CA

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Interframe Space (IFS)

- First, collisions are avoided by deferring transmission even if the channel is found idle. When an idle channel is found, the station does not send immediately. It waits for a period of time called the interframe space or IFS.
- The IFS time allows the front of the transmitted signal by the distant station to reach this station.
- If after the IFS time the channel is still idle, the station can send, but it still needs to wait a time equal to the contention time.
- The contention window is an amount of time divided into slots.
- In CSMA/CA, the IFS can also be used to define the priority of a station or a frame.

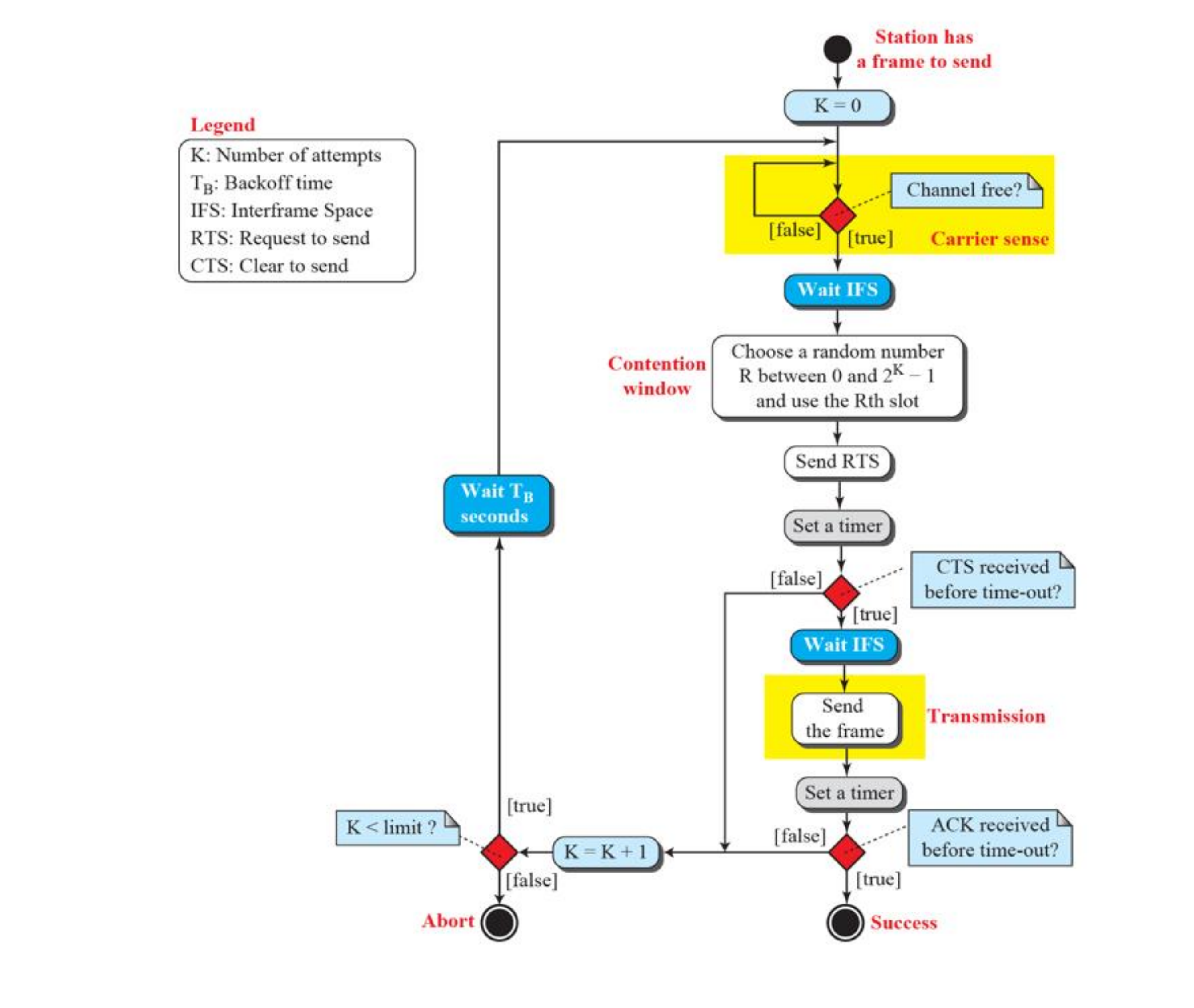
Contention Window

- The contention window is an amount of time divided into slots.
- A station that is ready to send chooses a random number of slots as its wait time.
- The number of slots in the window changes according to the binary exponential back-off strategy.
- It is set to one slot the first time and then doubles each time the station cannot detect an idle channel after the IFS time.
- The station needs to sense the channel after each time slot.
- If the station finds the channel busy, it does not restart the process; it just stops the timer and restarts it when the channel is sensed as idle.

Acknowledgement

- The positive acknowledgment informs the sender that the receiver has successfully received the frame.

Flow Diagram of CSMA/CA



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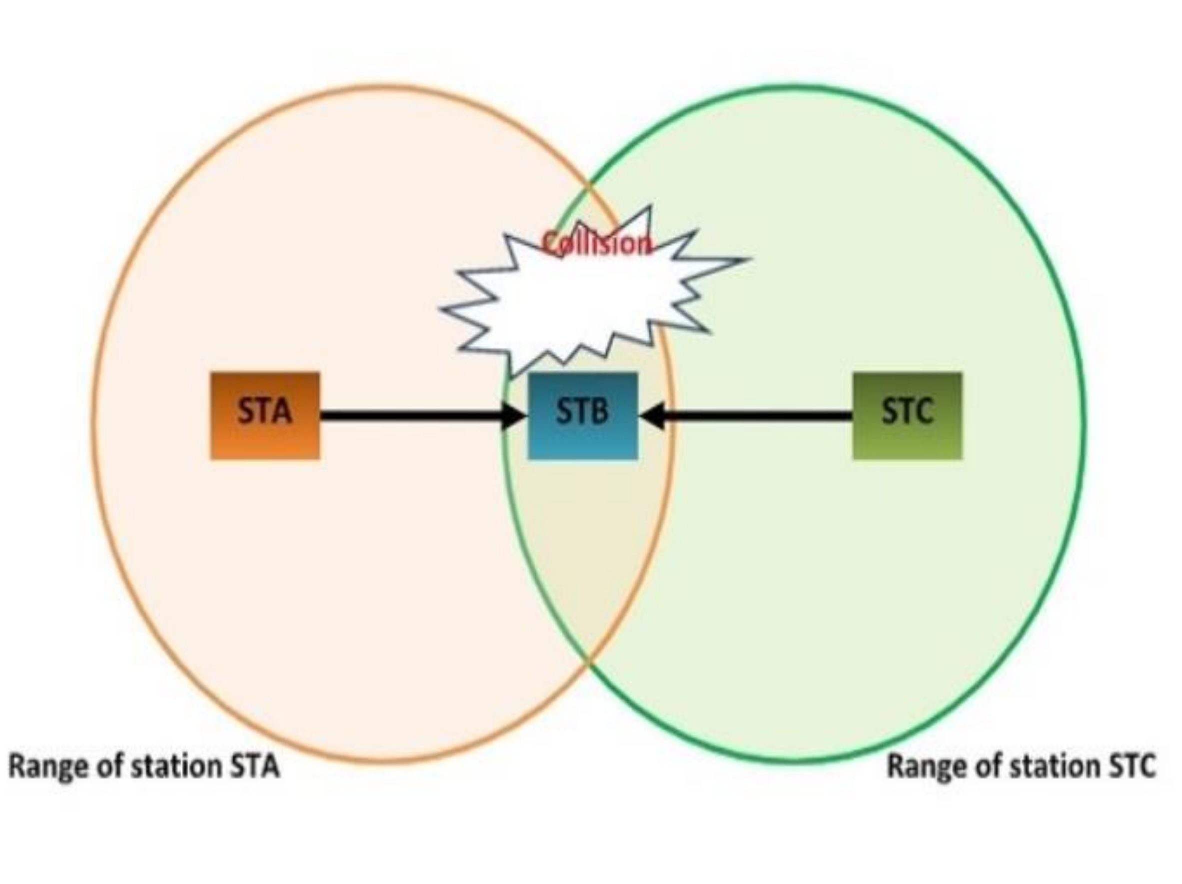
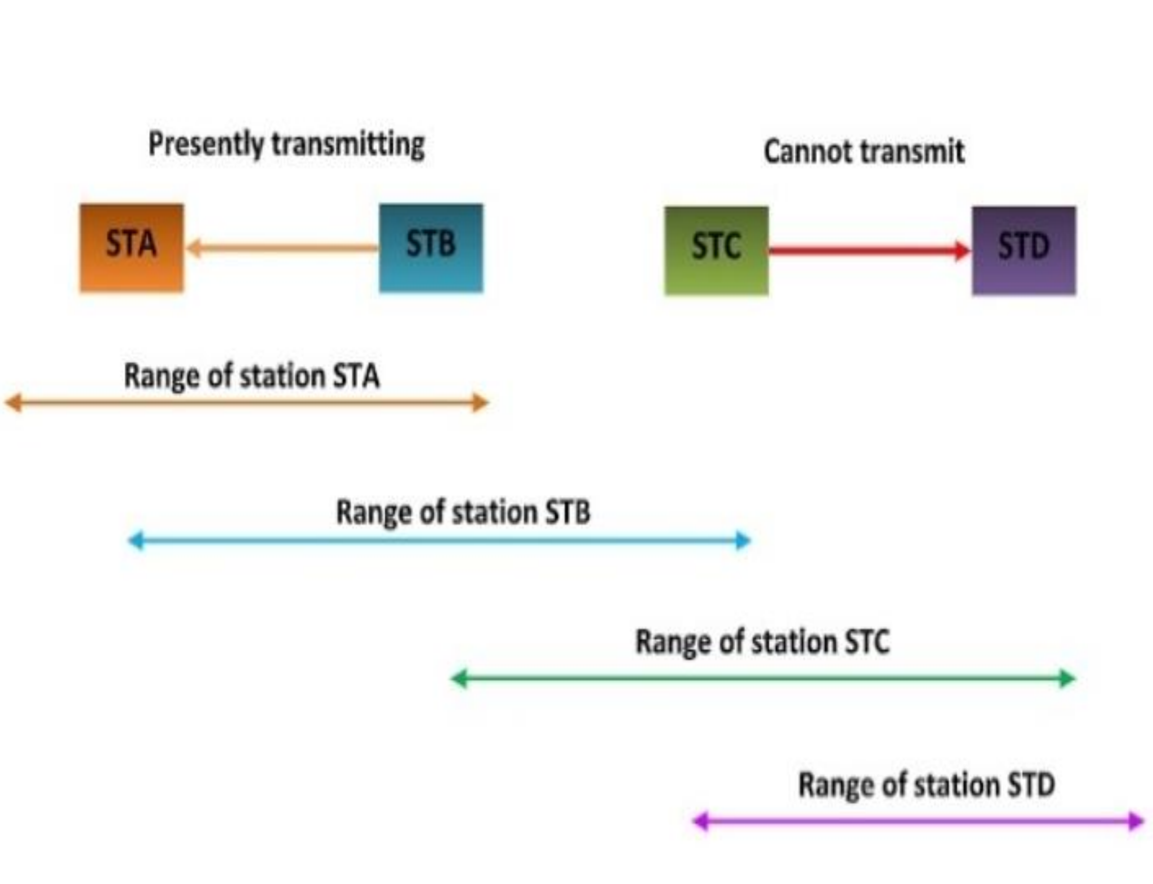
Hidden and Exposed Terminal problem

Hidden Terminal Problem



Exposed Terminal Problem



Source:[Online], Available: https://www.tutorialspoint.com/the-hidden-terminal-problem

Cont…

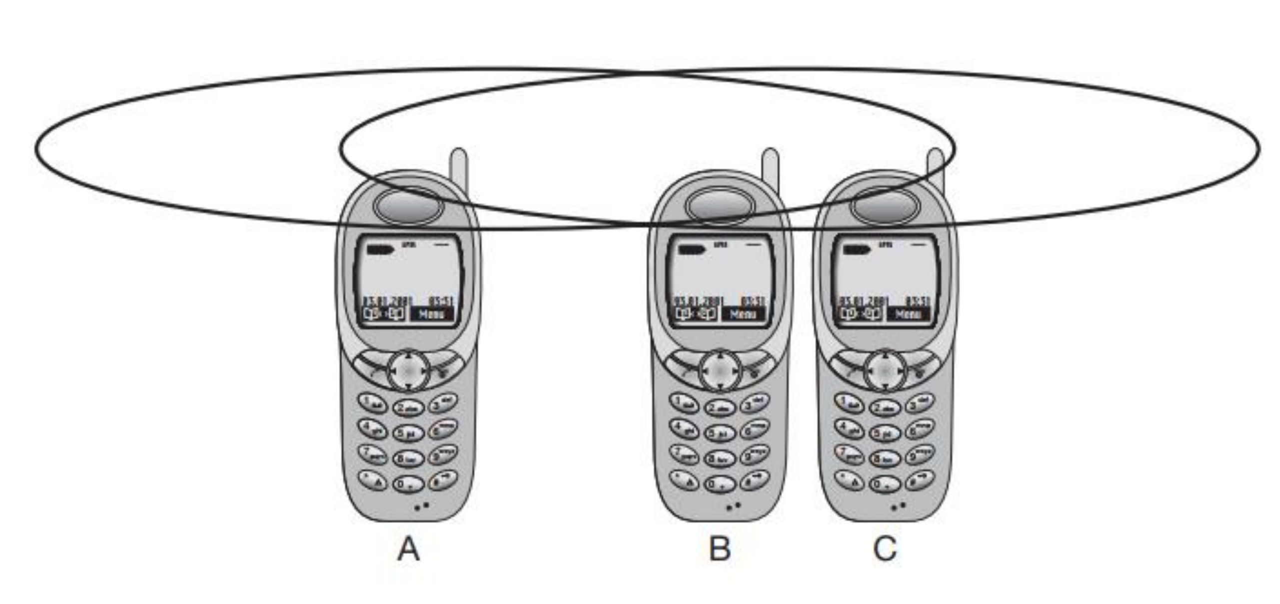
- **Solution:**

A transmitting station sends a RTS frame to the receiving station. The receiving station replies by sending a CTS frame. On receipt of CTS frame, the transmitting station begins transmission.

Any station hearing the RTS is close to the transmitting station and remains silent long enough for the CTS. Any station hearing the CTS is close to the receiving station and remains silent during the data transmission.

Near and Far Terminal

- A and B are both sending with the same transmission power.
- As the signal strength decreases proportionally to the square of the distance, B’s signal drowns out A’s signal.
- As a result, C cannot receive A’s transmission.



Source:[Online], Available: https://www.pvpsiddhartha.ac.in/dep_it/lecture%20notes/MC/unit1.pdf

Controlled Access

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.

Types:

- Reservation
- Polling
- Token passing

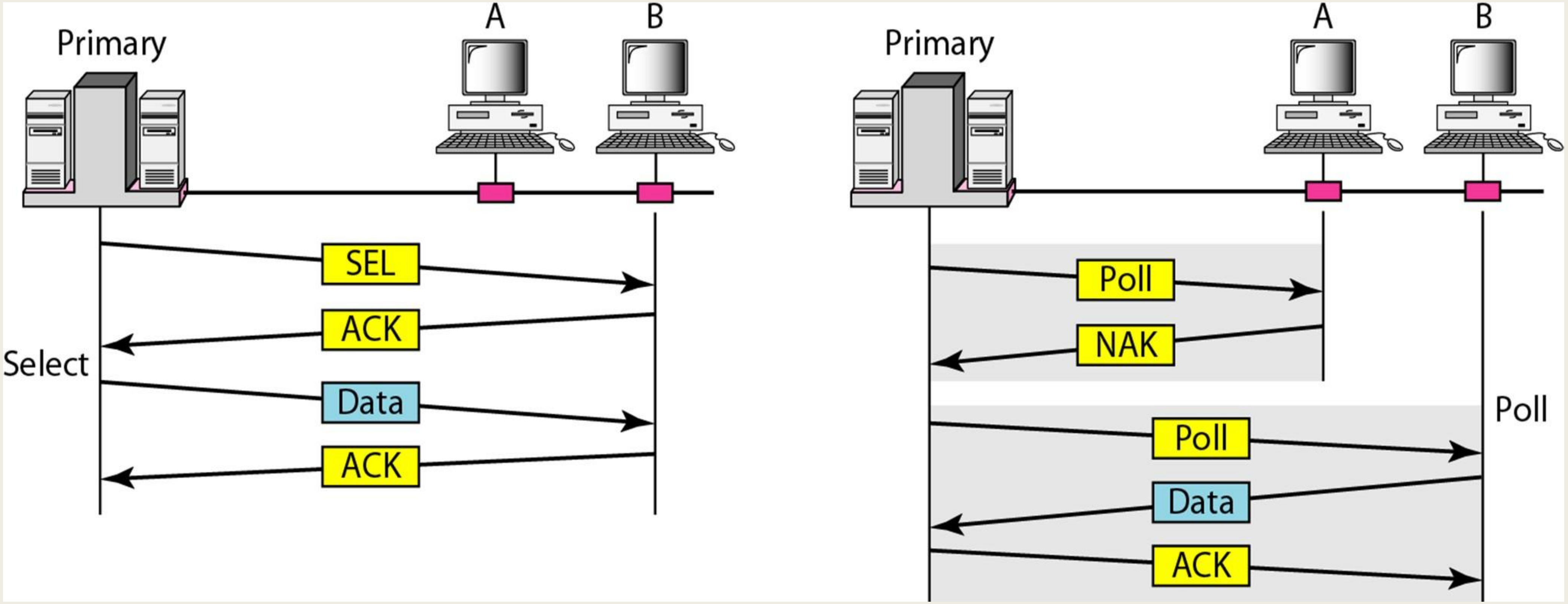
Reservation

- In the reservation method, a station needs to make a reservation before sending data.
- The time line has two kinds of periods:
  - Reservation interval of fixed time length
  - Data transmission period of variable frames.
- If there are M stations, the reservation interval is divided into M slots, and each station has one slot.
- Suppose if station 1 has a frame to send, it transmits 1 bit during the slot 1. No other station is allowed to transmit during this slot.
- In general, i^{th} station may announce that it has a frame to send by inserting a 1 bit into i^{th} slot. After all N slots have been checked, each station knows which stations wish to transmit.
- The stations which have reserved their slots transfer their frames in that order.
- After data transmission period, next reservation interval begins.

Polling

- Polling process is similar to the roll-call performed in class. Just like the teacher, a controller sends a message to each node in turn.
- In this, one acts as a primary station(controller) and the others are secondary stations. All data exchanges must be made through the controller.
- The message sent by the controller contains the address of the node being selected for granting access.
- Although all nodes receive the message but the addressed one responds to it and sends data, if any. If there is no data, usually a “poll reject”(NAK) message is sent back.
- Problems include high overhead of the polling messages and high dependence on the reliability of the controller.

Cont...



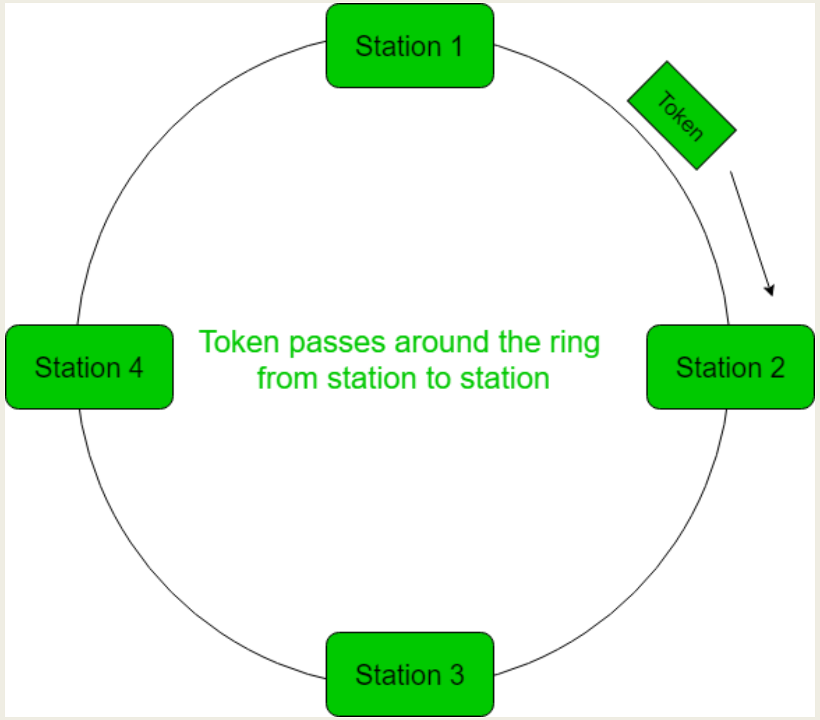
Efficiency = $T_t/(T_t + T_{poll})$

T_t = Time to transmit data, T_{poll} = Time to poll

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Token passing

- In token passing scheme, the stations are connected logically to each other in form of ring and access of stations is governed by tokens.
- A token is a special bit pattern or a small message, which circulate from one station to the next in some predefined order.
- In Token ring, token is passed from one station to another adjacent station in the ring whereas incase of Token bus, each station uses the bus to send the token to the next station in some predefined order.
- Throughput=1/(1+a/N), a<1 and Throughput=1/{a(1+1/N)}, a>1
- where a= propagation time/transmission time



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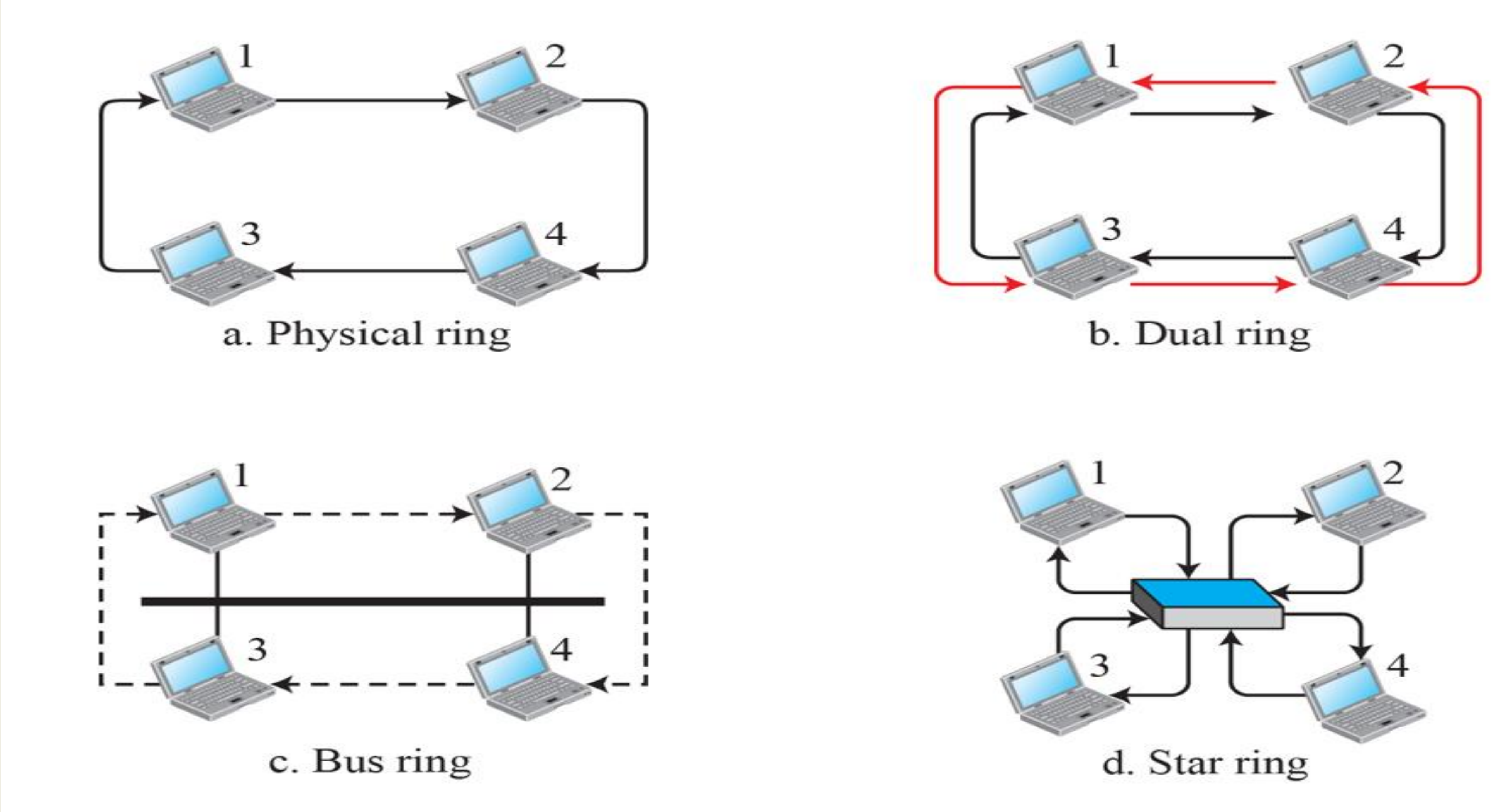
Logical Ring and Physical Topology in Token-Passing



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Channelization

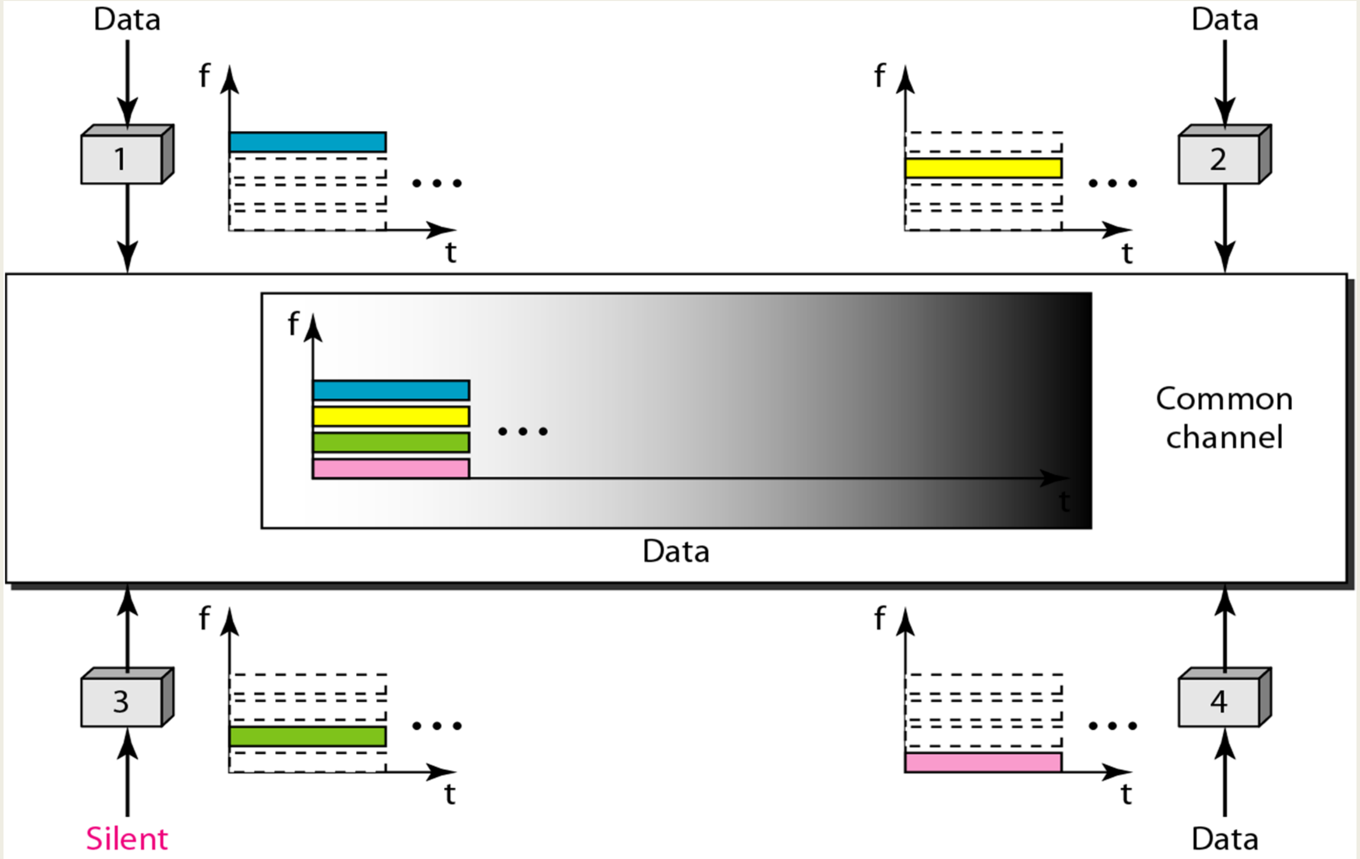
Channelization is a multiple-access method in which the available bandwidth of a link is shared in time, frequency, or through code, between different stations.

Types:

- Frequency-Division Multiple Access (FDMA)
- Time-Division Multiple Access (TDMA)
- Code-Division Multiple Access (CDMA)

FDMA

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



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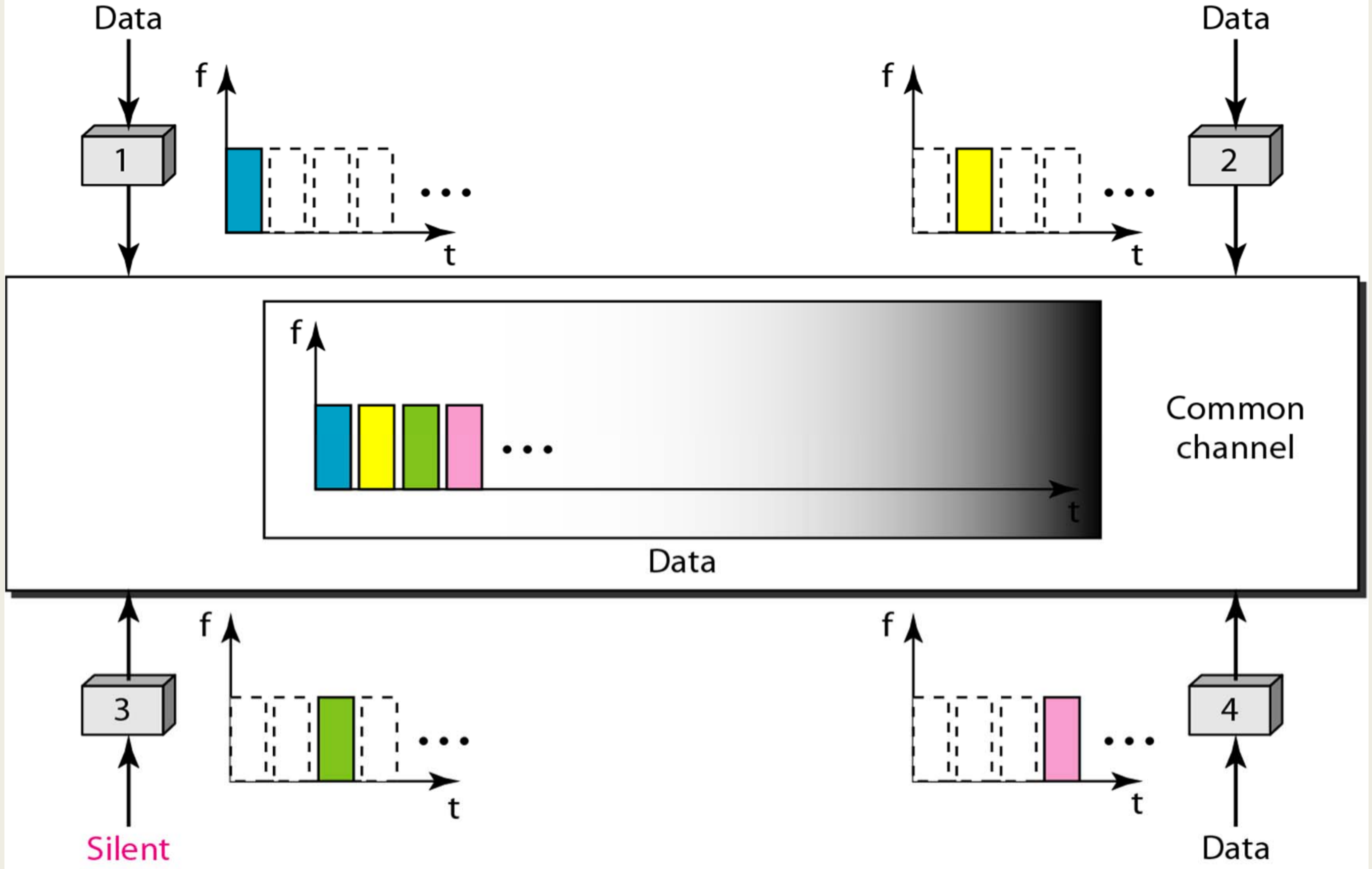
TDMA

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



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CDMA

- Code Division Multiple Access (CDMA) is a sort of multiplexing that facilitates various signals to occupy a single transmission channel.

- It optimizes the use of available bandwidth.

Thank You!!!