MEDIA ACCESS CONTROL

Outline

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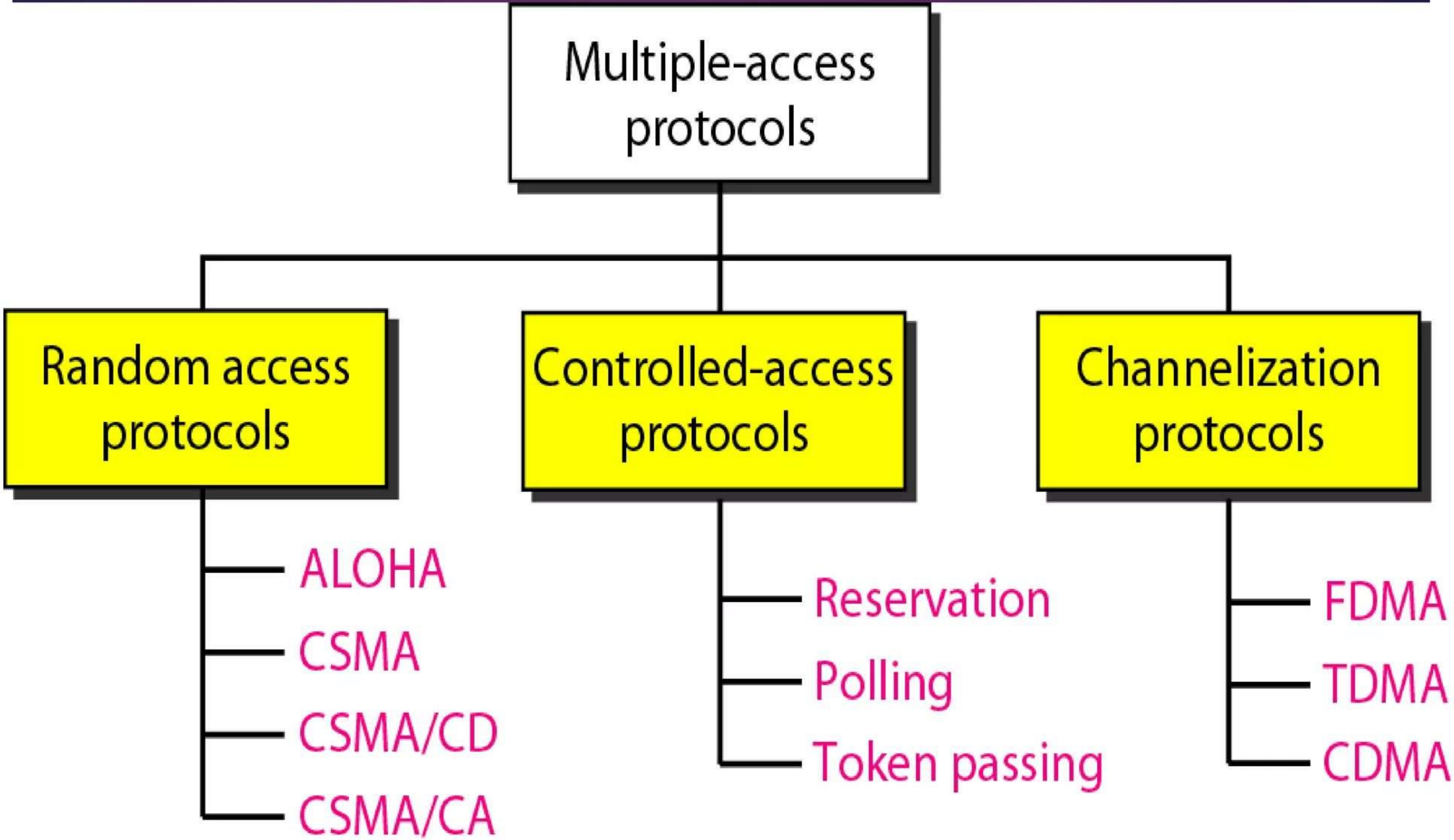
Introduction

- The medium access control (MAC) is a **sublayer** of the data link layer.
- The MAC sublayer emulates a **full-duplex** logical communication channel in a multipoint network.
- This channel may provide unicast, multicast, or broadcast communication service.
- The **MAC** sublayer uses **MAC** protocols to ensure that signals sent from different stations across the same channel don't collide. Eg: two people speak
- A multiple-access protocol to coordinate access to the link (*multipoint* or *broadcast link)*.
- Many protocols have been devised to handle access to a shared link.

Taxonomy of Multiple-access protocols



Random Access

12.1Random Access

- Also called **contention-based** access
- No station is **superior** to another station and No station is assigned to control another.
- A station that has data to send uses a procedure defined by the protocol to make a **decision on whether or not to send**.
- Decision depends on the state of the medium (**idle or busy**).
- Two features of RA:
  - **No scheduled time for a station to transmit**
  - **No rules specify which station should send next**
- Stations compete with one another to access the medium

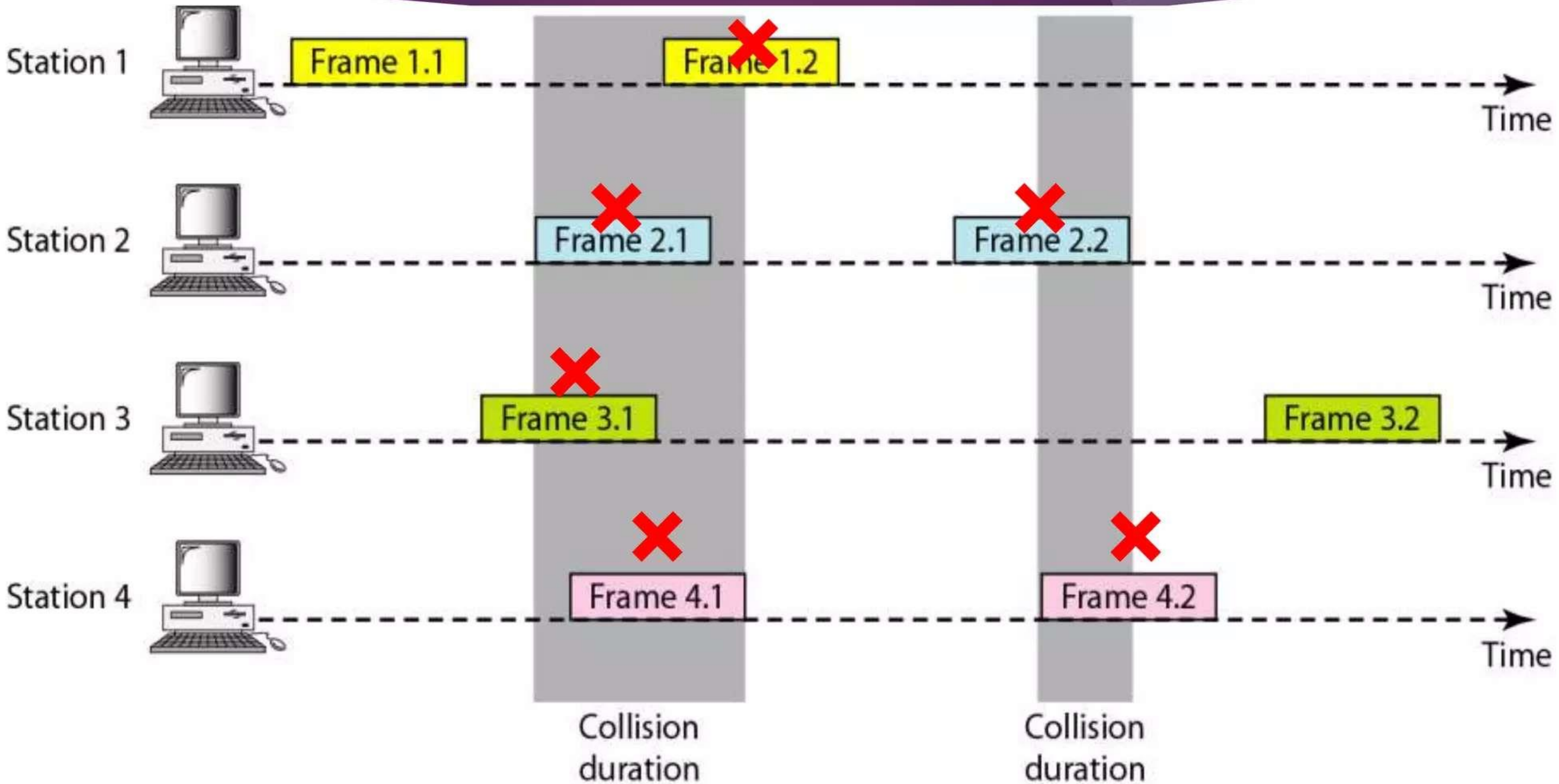
12.1.1 ALOHA

- Aloha is the type of Random access protocol
- **ALOHA,** was developed at the University of Hawaii in early 1970.
- It was designed for a radio (wireless) LAN, but it can be used on any shared medium.
- It have two types one is **Pure Aloha** and another is **Slotted Aloha**.
- There is a potential of **collisions**
- The **medium is shared** between the stations.
- When a station **sends data**, another station may attempt to do so at the **same time**.
- The data from the two stations **collide** and become garbled.

12.1.1Pure ALOHA

- The original ALOHA protocol is called ***pure ALOHA.***
- This is a **simple** but elegant protocol.
- The idea is that each station sends a frame whenever it has a **frame to send** (multiple access).
- However, since there is only **one channel to share**, there is the **possibility of collision** between frames from different stations.

Frames in Pure ALOHA



12.1.1Pure ALOHA Contd…

- If collision occurs then **retransmission** frames.
- The pure ALOHA protocol relies on **acknowledgments** from the receiver.
- If the acknowledgment does not arrive after a **time-out** period, then retransmission take place.
- If all these stations try to resend their frames after the time-out, the frames will collide again.
- After time-out, each station waits a random amount of time **(backoff time T_B)** before resending its frame.
- This help avoid more collisions.

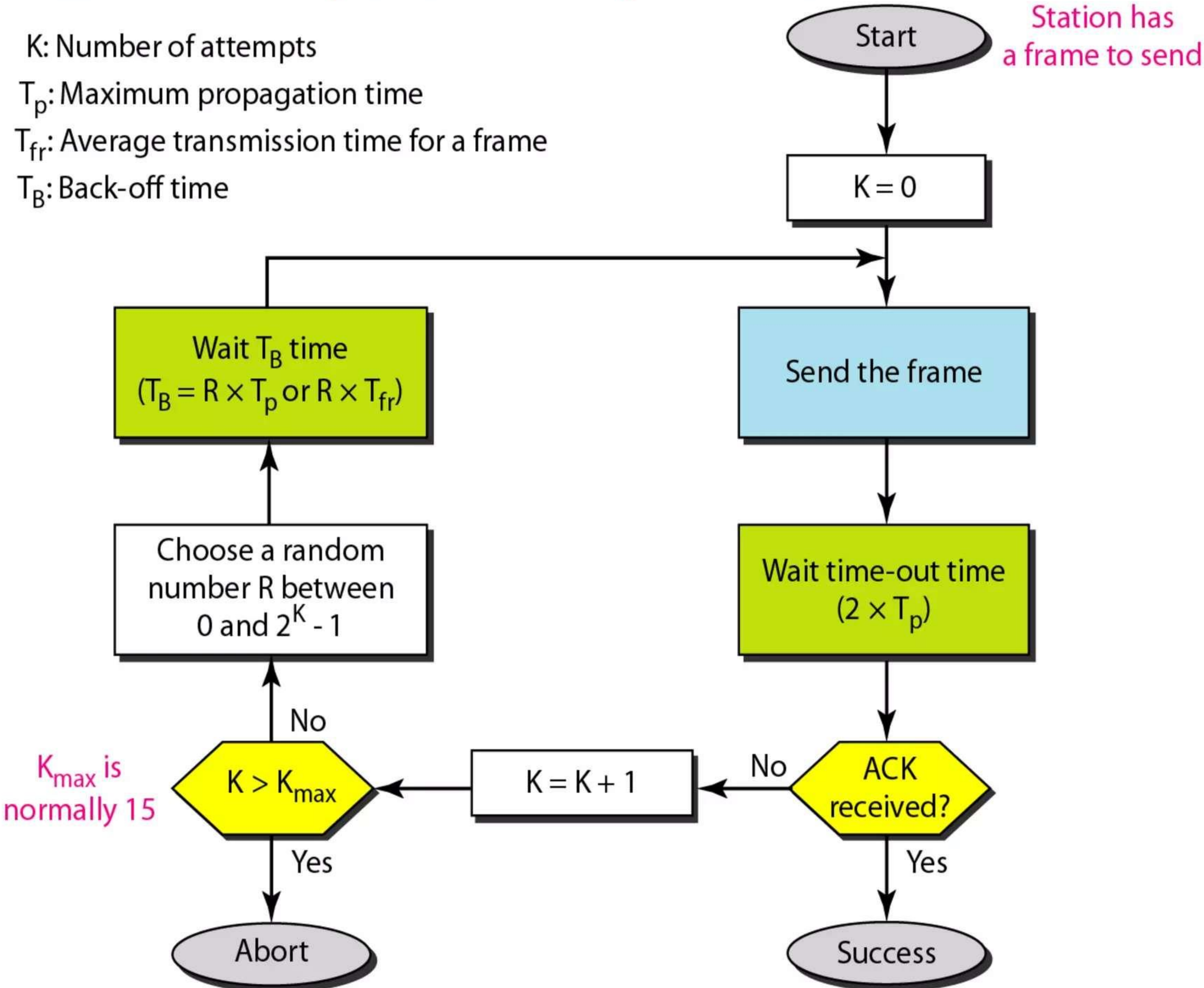
Procedure for pure ALOHA protocol

K: Number of attempts

T_p: Maximum propagation time

T_{fr}: Average transmission time for a frame

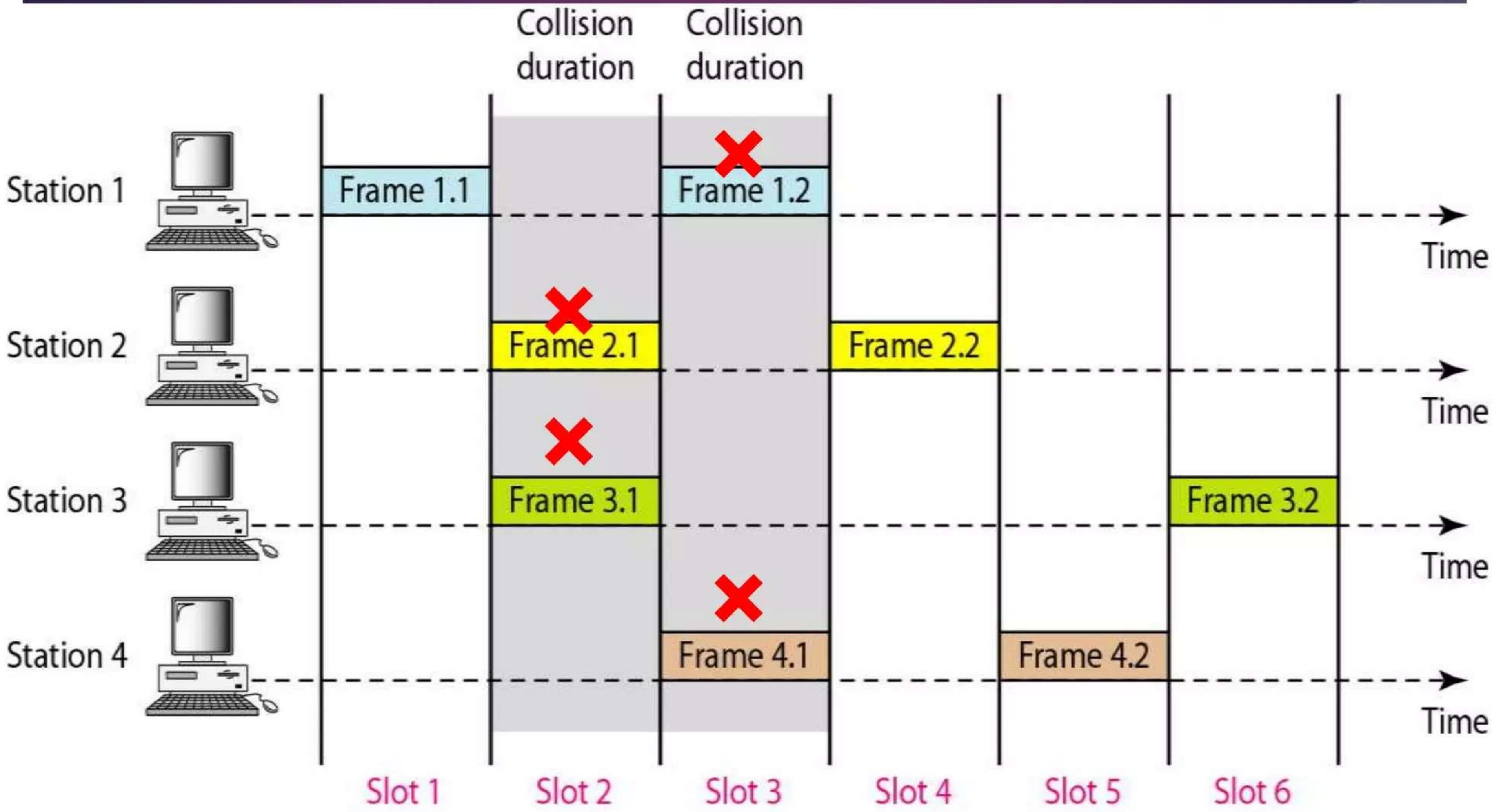
T_B: Back-off time



12.1.1.2 Slotted ALOHA

- Slotted Aloha divides the time of shared channel into discrete intervals called as **time slots**.
- Any station can transmit its data in any time slot.
- The only condition is that station must start its transmission from the beginning of the time slot.
- If the beginning of the slot is missed, then station has to wait until the beginning of the next time slot.
- A **collision** may occur if two or more stations try to transmit data at the beginning of the same time slot.
- Slotted ALOHA was invented to **improve** the efficiency of pure ALOHA.

12.1.1.2 Slotted ALOHA



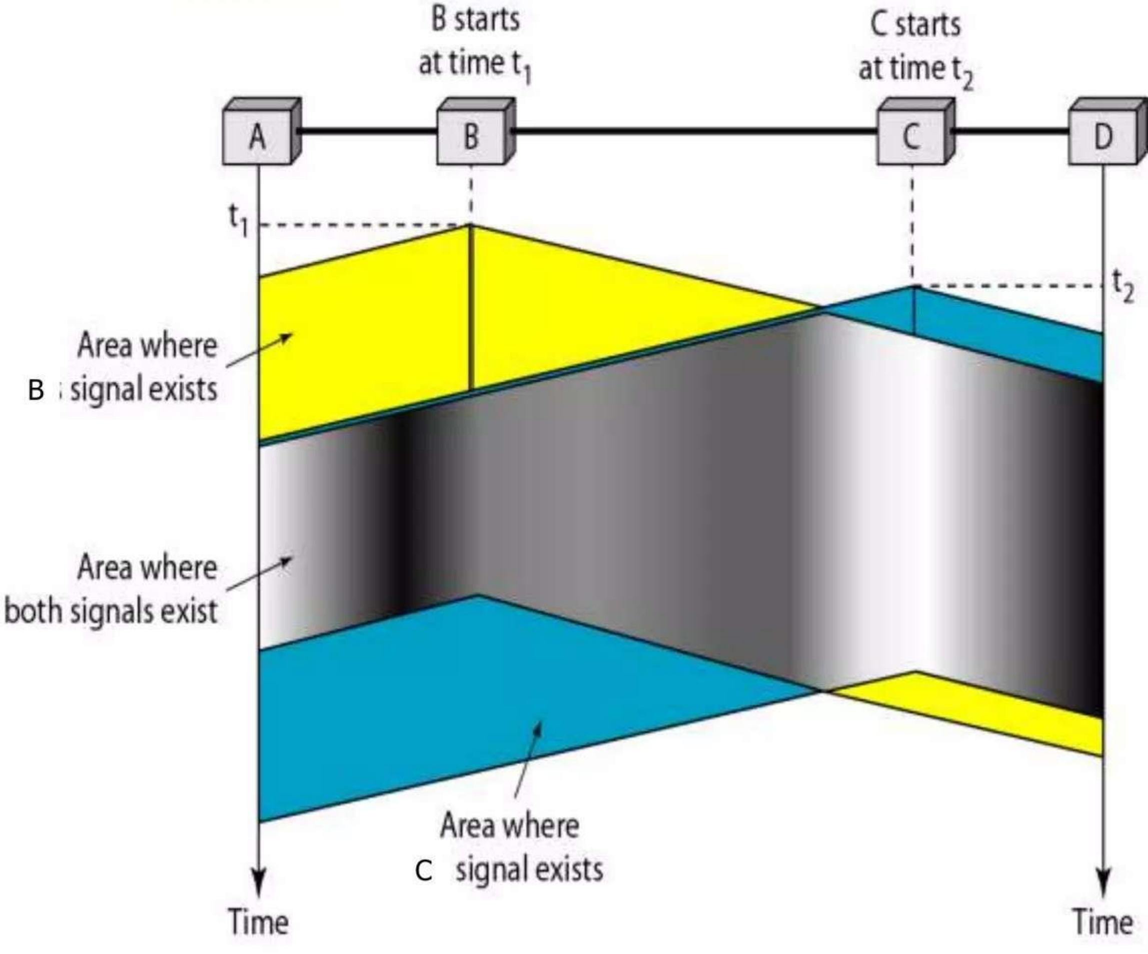
CSMA

12.1.2 CSMA

- To minimize the chance of collision and to increase the performance
- Principle of CSMA: “sense before transmit” or “listen before talk”
- Carrier busy= Transmission is taking place
- Carrier idle= No transmission currently taking place
- CSMA can reduce the possibility of collision, but it cannot eliminate it.

12.1.2 Collision in CSMA

- At time ***t*1**, station B senses the medium and finds it idle, so it sends a frame.
- At time ***t*2 (*t*2 > *t*1),** station C senses the medium and finds it idle because, at this time, the first bits from station B have not reached station C.
- Station C also sends a frame.
- The two signals collide and both frames are destroyed.

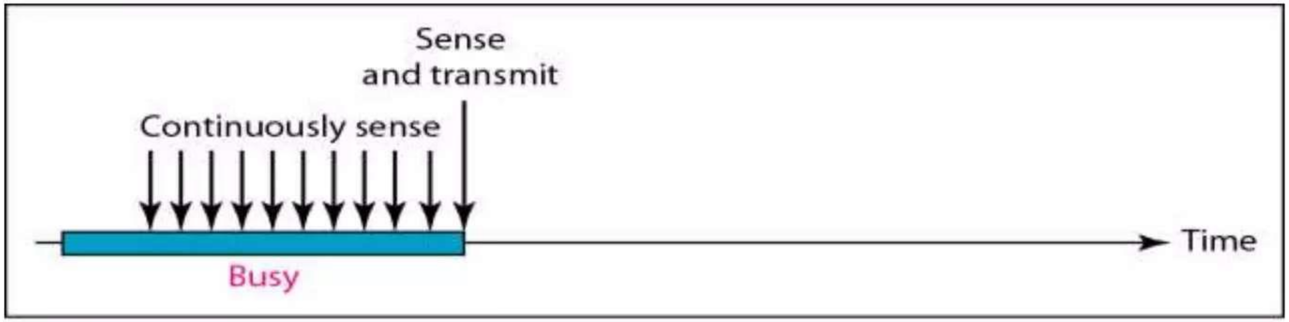


Persistence Methods

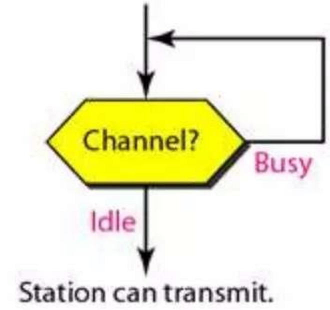
- What should a station do if the channel is busy?
- What should a station do if the channel is idle?
- Three methods have been devised to answer these questions:
  - **1-persistent method**
  - **nonpersistent method**
  - ***p*-persistent method**

1-Persistent

- The ***1-persistent method*** is simple and straightforward.
- In this method, after the **station finds the line idle**, it sends its frame immediately (**with probability 1**).
- This method has the **highest chance of collision** because **two or more stations may find the line idle** and send their frames immediately.

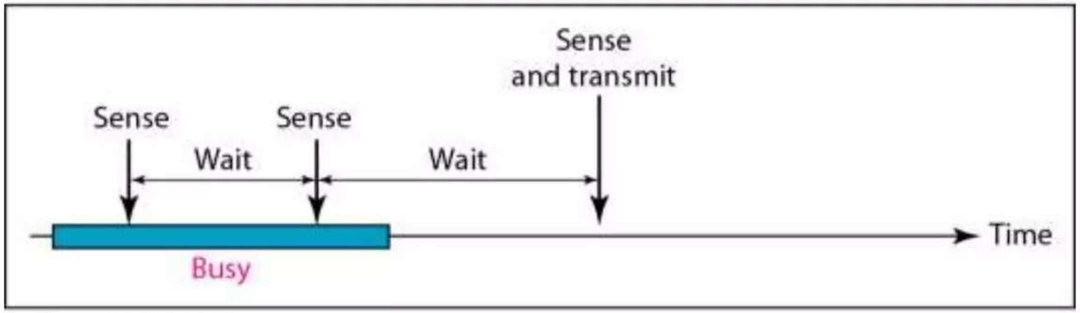


a. 1-persistent

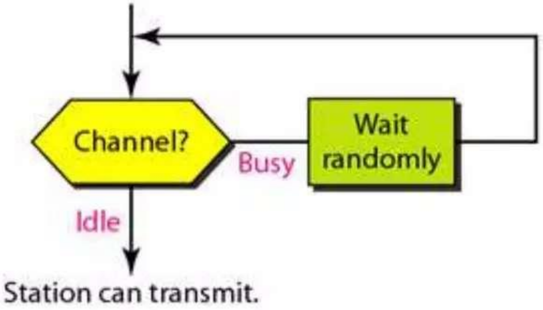


Non-persistent

- In the *non-persistent method,* a station that has a frame to send senses the line
- 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 nonpersistent approach reduces the chance of collision

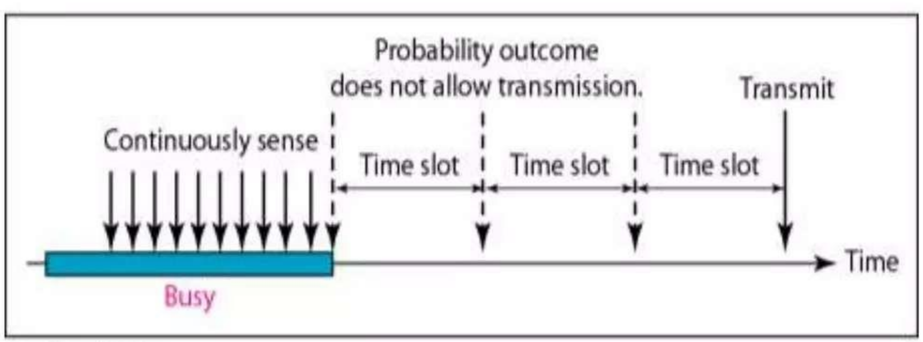


b. Nonpersistent

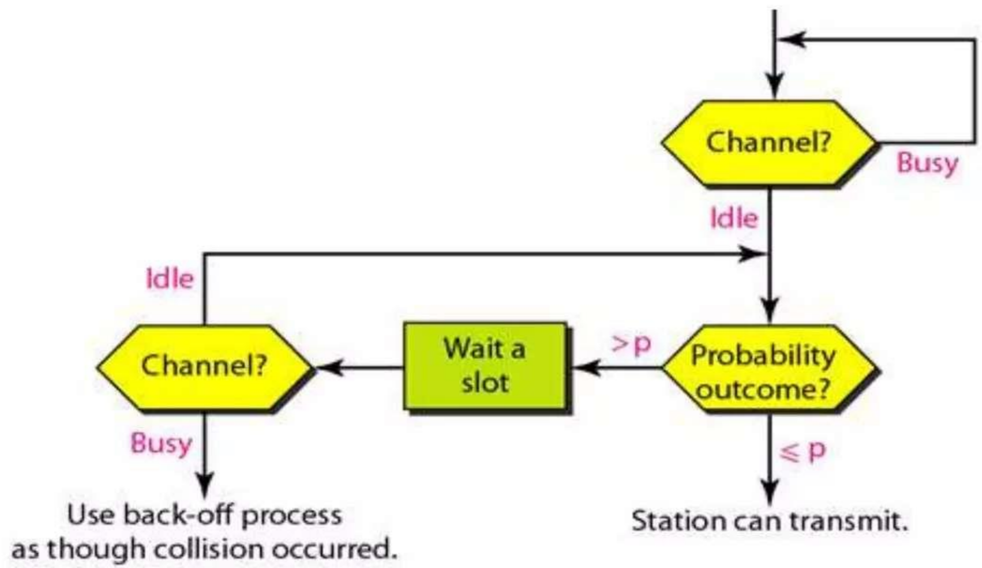


p-*Persistent*

- If the channel has time slots with a slot duration equal to or greater than the maximum propagation time.
- The *p*-persistent approach combines the advantages of the other two strategies.
- It reduces the chance of collision and improves efficiency.



c. p-persistent

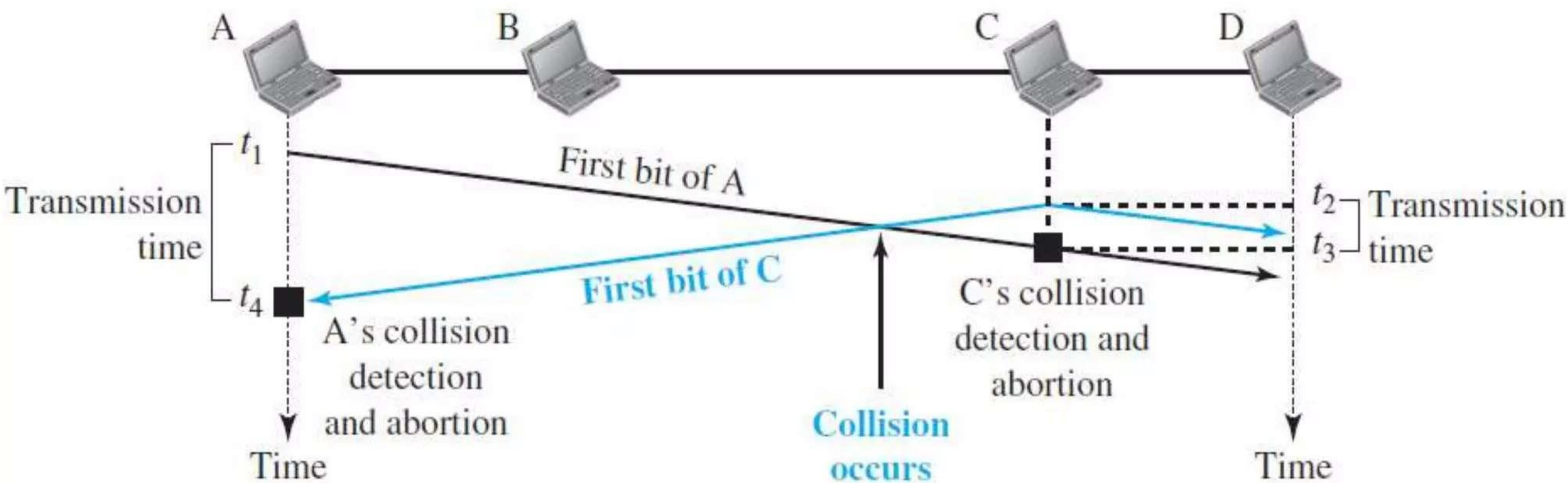


CSMA/CD

12.1.3 CSMA/CD

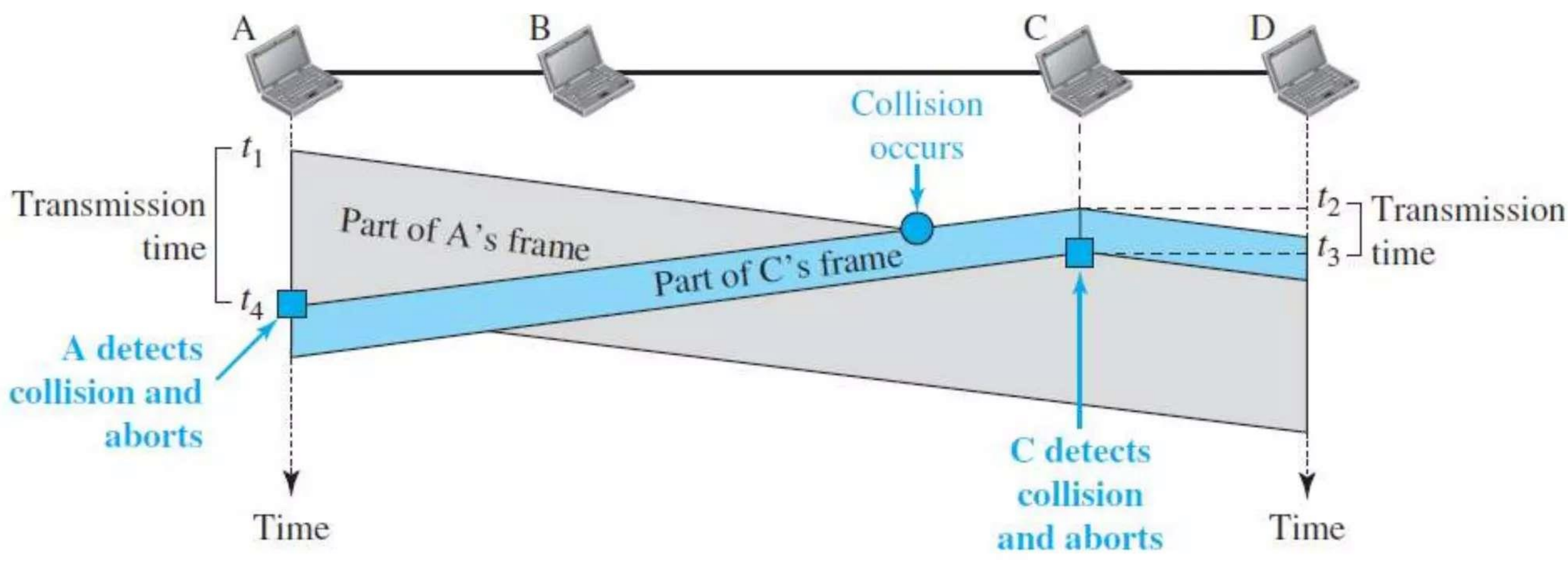
- <u>**C**</u>arrier <u>**S**</u>ense <u>**M**</u>ultiple <u>**A**</u>ccess with <u>**C**</u>ollision <u>**D**</u>etection
- Station monitors channel while sending a frame
- If, however, there is a collision, the frame is sent again.
- Eg. Collision of the first bit in CSMA/CD,stations A and C are involved in the collision.

- At time ***t*1**, **station A** has executed its persistence procedure and starts sending the bits of its frame.
- At time ***t*2**, **station C** has **not yet sensed the first bit sent by A.**
- **Station C** executes its persistence procedure and starts sending the bits in its frame, which propagate both to the left and to the right.
- The **collision occurs** sometime after time *t*2.
- Station **C detects a collision at time *t*3** when it receives the first bit of A's frame.
- **Station C** immediately aborts transmission.
- **Station A detects collision at time *t*4** when it receives the first bit of C's frame; it also immediately aborts transmission.
- Looking at the figure, we see that A transmits for the duration ***t*4 − *t*1**; C transmits for the duration ***t*3 − *t*2.**

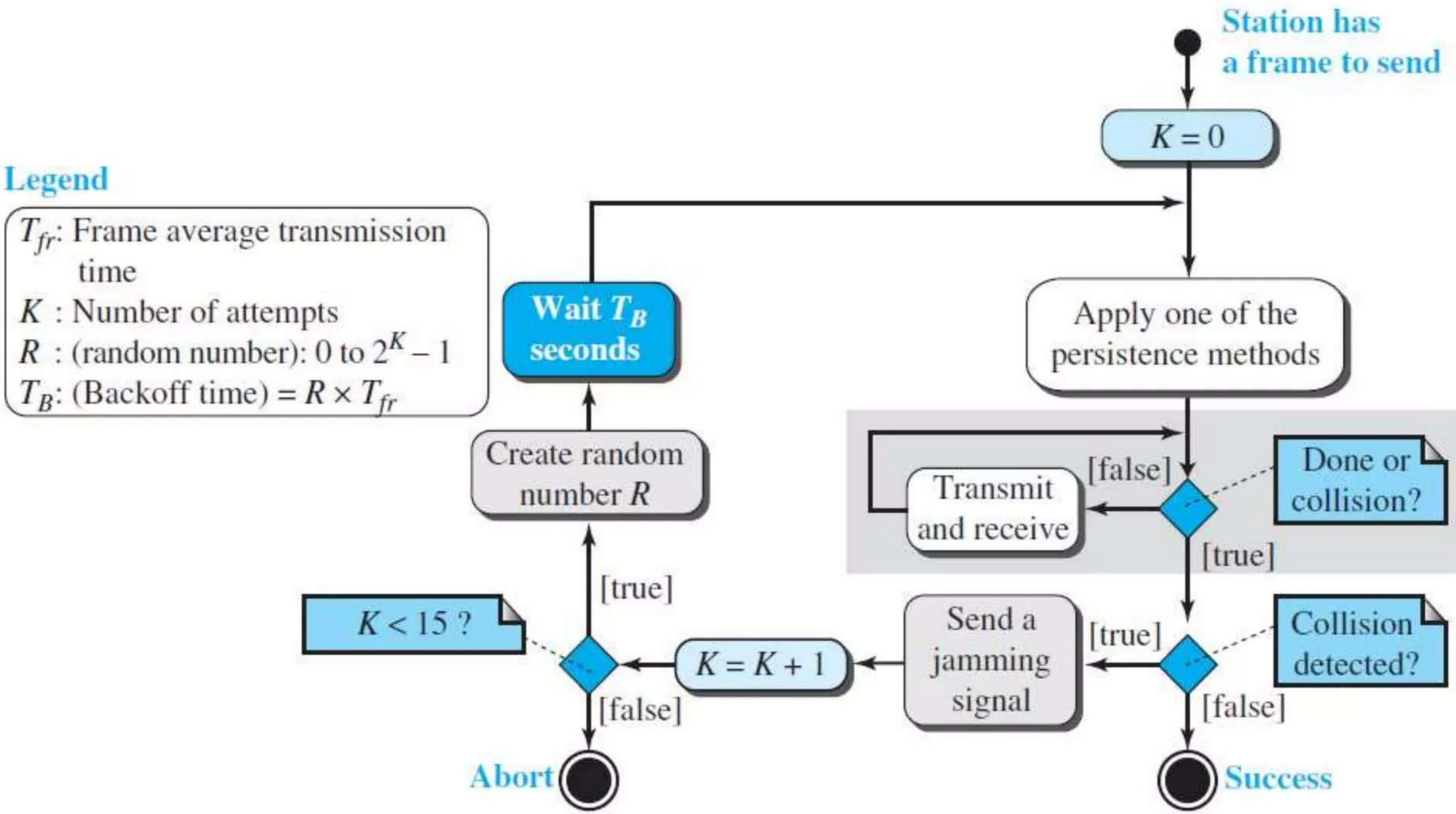


Collision and abortion in CSMA/CD

Figure 12.12 *Collision and abortion in CSMA/CD*



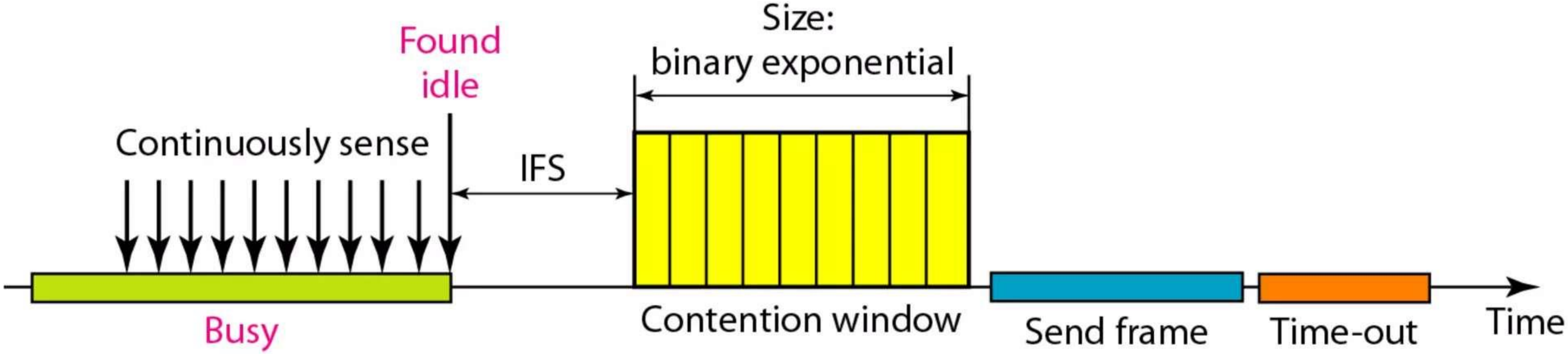
CSMA/CD: Flow Diagram



CSMA/CA

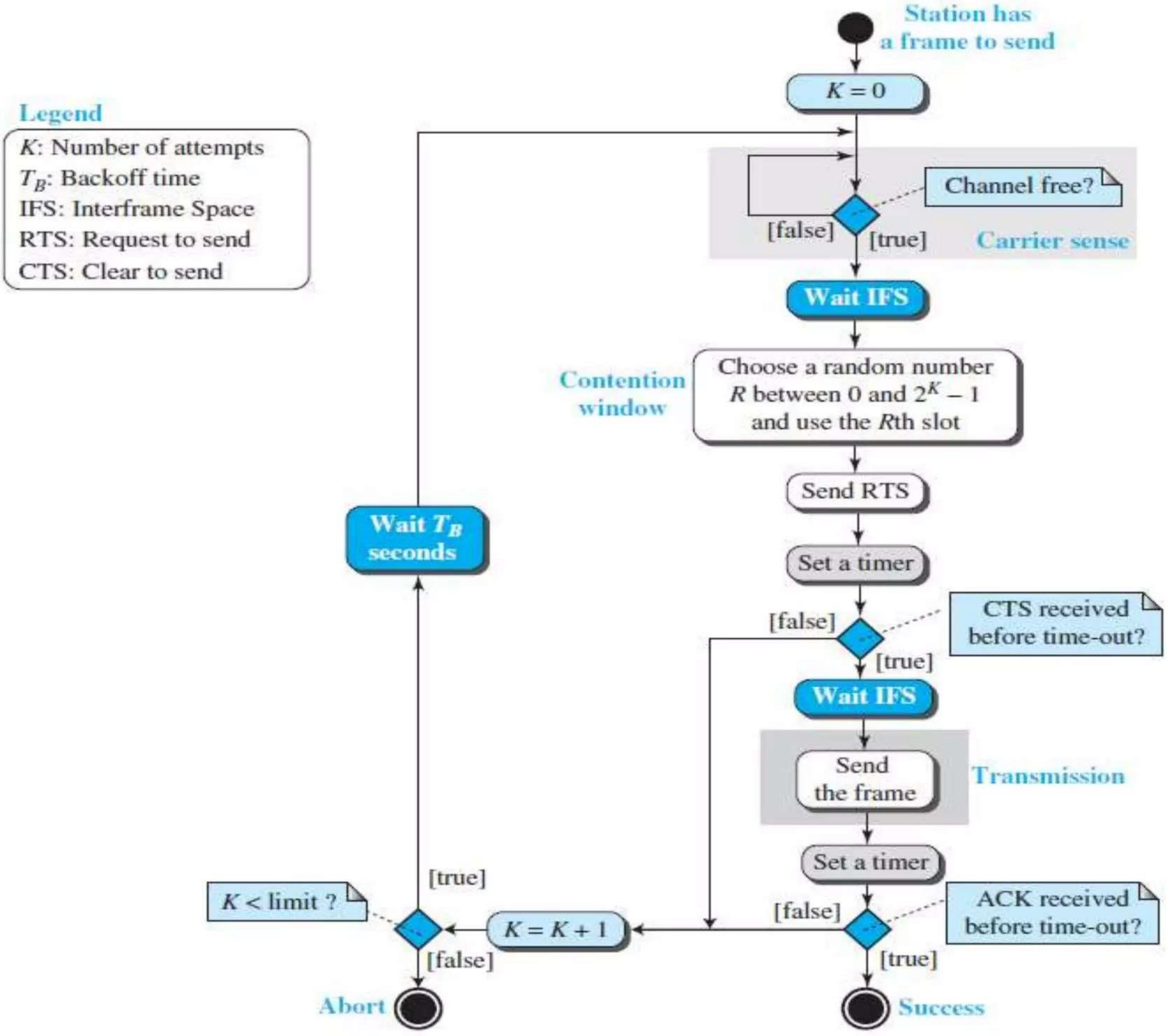
12.1.3 CSMA/CA

- Carrier Sense Multiple Access with Collision Avoidance was invented for **wireless networks**
- Used in a network where collision cannot be detected
- Collisions are avoided through the use of CSMA/CA's three strategies:
  - **Interframe space (IFS)**
  - **Contention window**
  - **Acknowledgments**



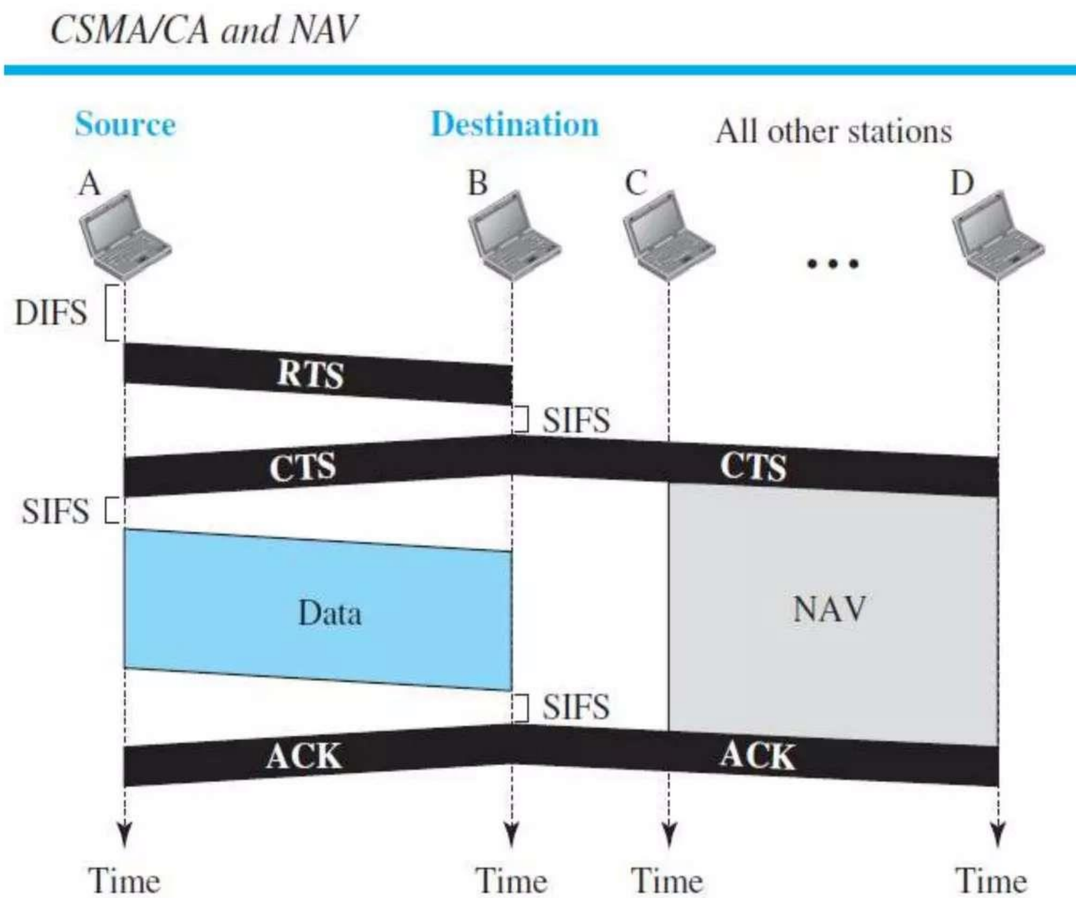
12.1.3 CSMA/CA Contd…

- **Interframe space (IFS)**
  - 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*.**
- ***Contention Window***
  - The **contention window** is an amount of time divided into slots.
  - if station determine that the channel is free, they wait a random amount of time before they start sending.
  - This time window doubles with each collision and corresponds to the binary exponential backoff (BEB) that is familiar from CSMA/CD.
- ***Acknowledgment:***
  - The positive acknowledgment and the time-out timer can help guarantee that the receiver has received the frame.


Station has a frame to send
K = 0
Legend
K: Number of attempts
T_B: Backoff time
IFS: Interframe Space
RTS: Request to send
CTS: Clear to send
Channel free?
[false]
[true]
Carrier sense
Wait IFS
Contention window
Choose a random number R between 0 and 2^K – 1 and use the Rth slot
Send RTS
Wait T_B seconds
Set a timer
CTS received before time-out?
[false]
[true]
Wait IFS
Send the frame
Transmission
Set a timer
[true]
K < limit ?
ACK received before time-out?
[false]
K = K + 1
[false]
[true]
Abort
Success

CSMA/ CA and NAV

- *DIFS: DCF interframe space*
- RTS: Request to Send
- *SIFS: Short interframe space (SIFS)*
- *NAV: Network Allocation Vector*



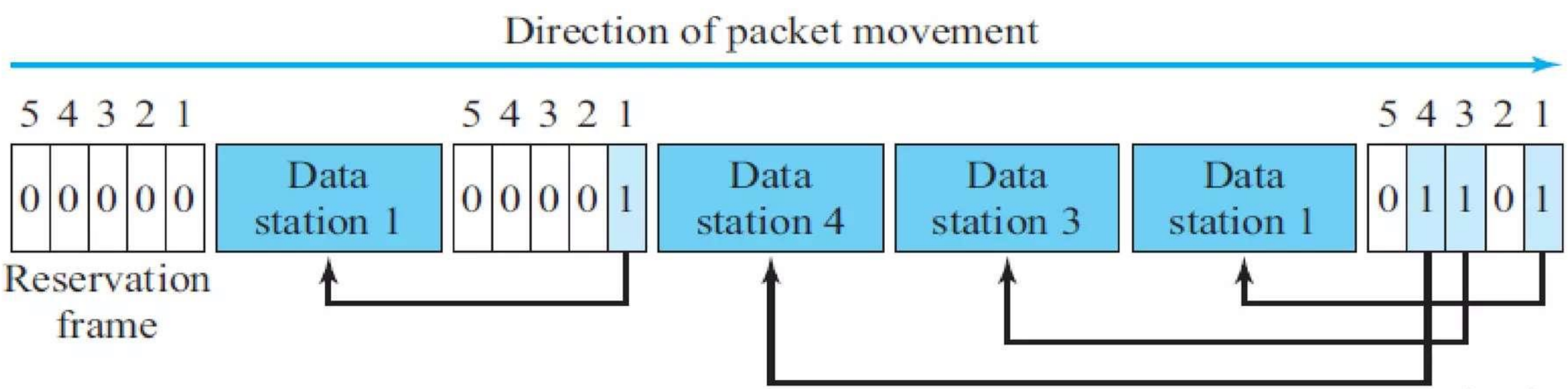
Controlled Access

12.2 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.
- Three common methods:
  - **Reservation**
  - **Polling**
  - **Token passing**

12.2.1 Reservation

- A station needs to make a **reservation** before sending data.
- **Time is divided into intervals.**
- In each interval, a reservation frame precedes the **data frames** sent in that interval.
- If there are **N stations** in the system, there are exactly **N reservation minislots** in the reservation frame.

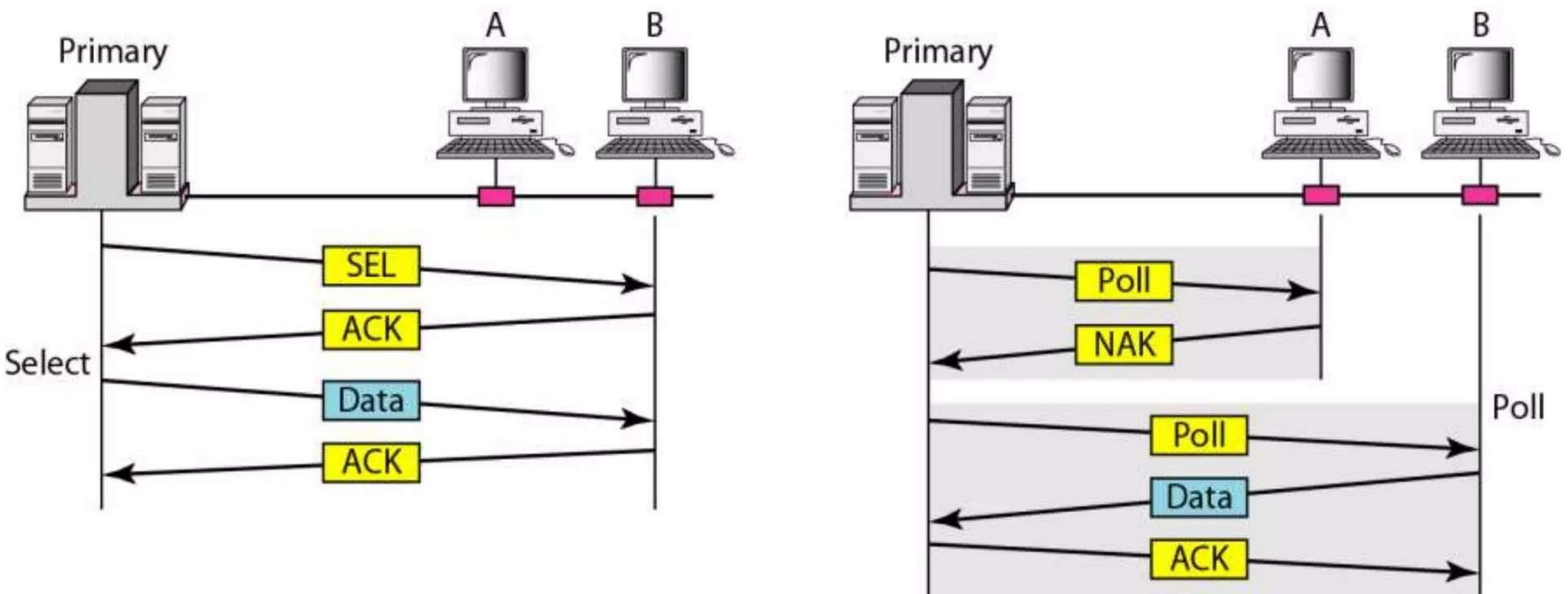


12.2.2 Polling

- **Polling** works with topologies in which one device is designated as a ***primary station*** and the other devices are ***secondary stations*****.**
- **Primary device** is the **initiator** of a session.
- **All data exchanges must be made through the primary device**.
- **Primary device controls the link;** the secondary devices follow its **instructions**.

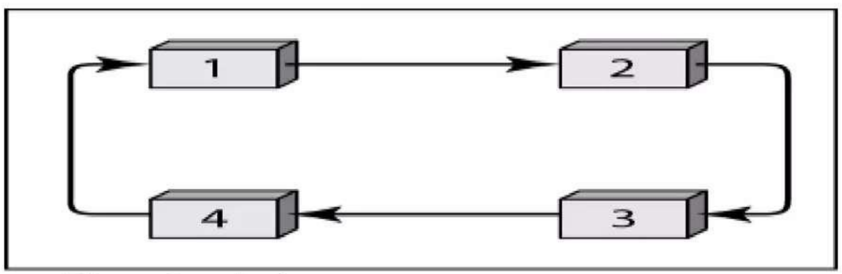
Select and poll functions in polling-access method

- ***Select***
  - The *select* function is used whenever the **primary device has something to send**.
- ***Poll***
  - The *poll* function is used by the **primary device to solicit transmissions** from the **secondary devices**.

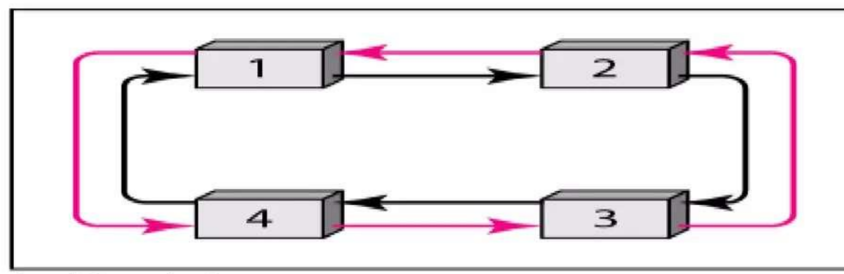


12.2.3 Token Passing

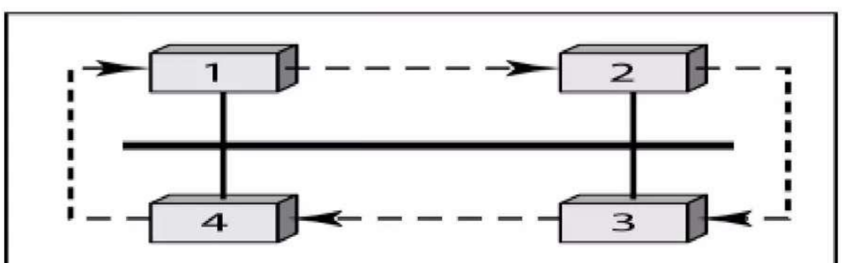
- The stations in a network are organized in **a logical ring.**
- For each station, there is **a predecessor and a successor.**
- The **right to this access** has been passed from the **predecessor to the current** station.
- The right will be passed to the **successor when the current station has no more data to send.**
- The RIGHT passed from by means of special packet called **"TOKEN".**



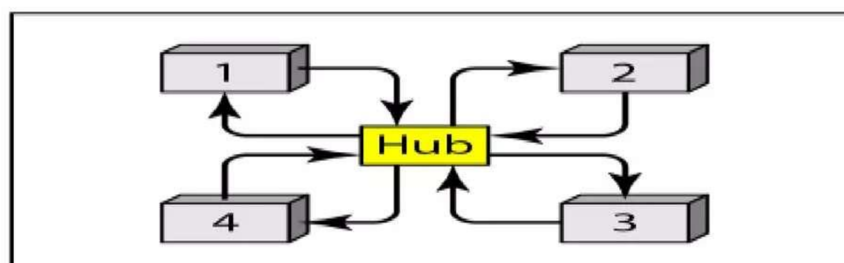
a. Physical ring



b. Dual ring



c. Bus ring



d. Star ring

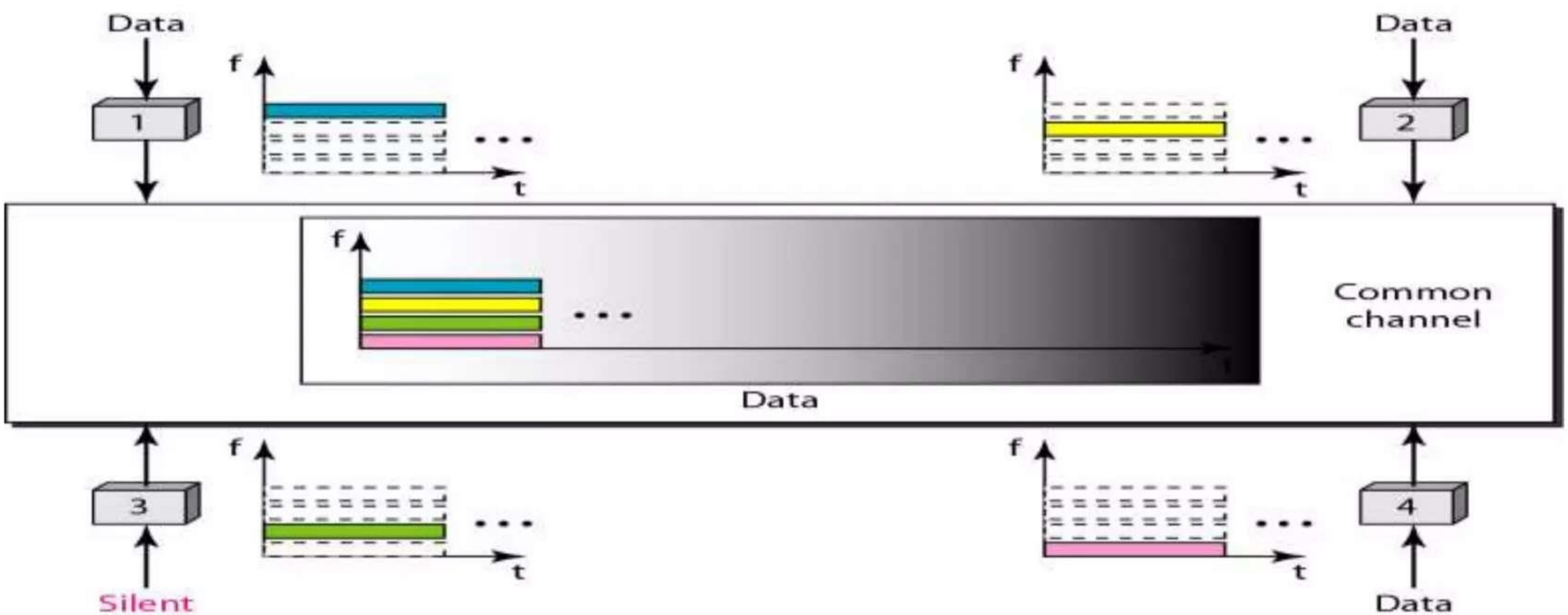
Channelization

12.3 Channelization

- **Channelization** is a multiple-access method in which the available bandwidth of a link is shared in **time**, **frequency,** or through **code**, among different stations.
- Similar to multiplexing
- Three schemes
  - **Frequency-Division Multiple Access (FDMA)**
  - **Time-Division Multiple Access (TDMA)**
  - **Code-Division Multiple Access (CDMA)**

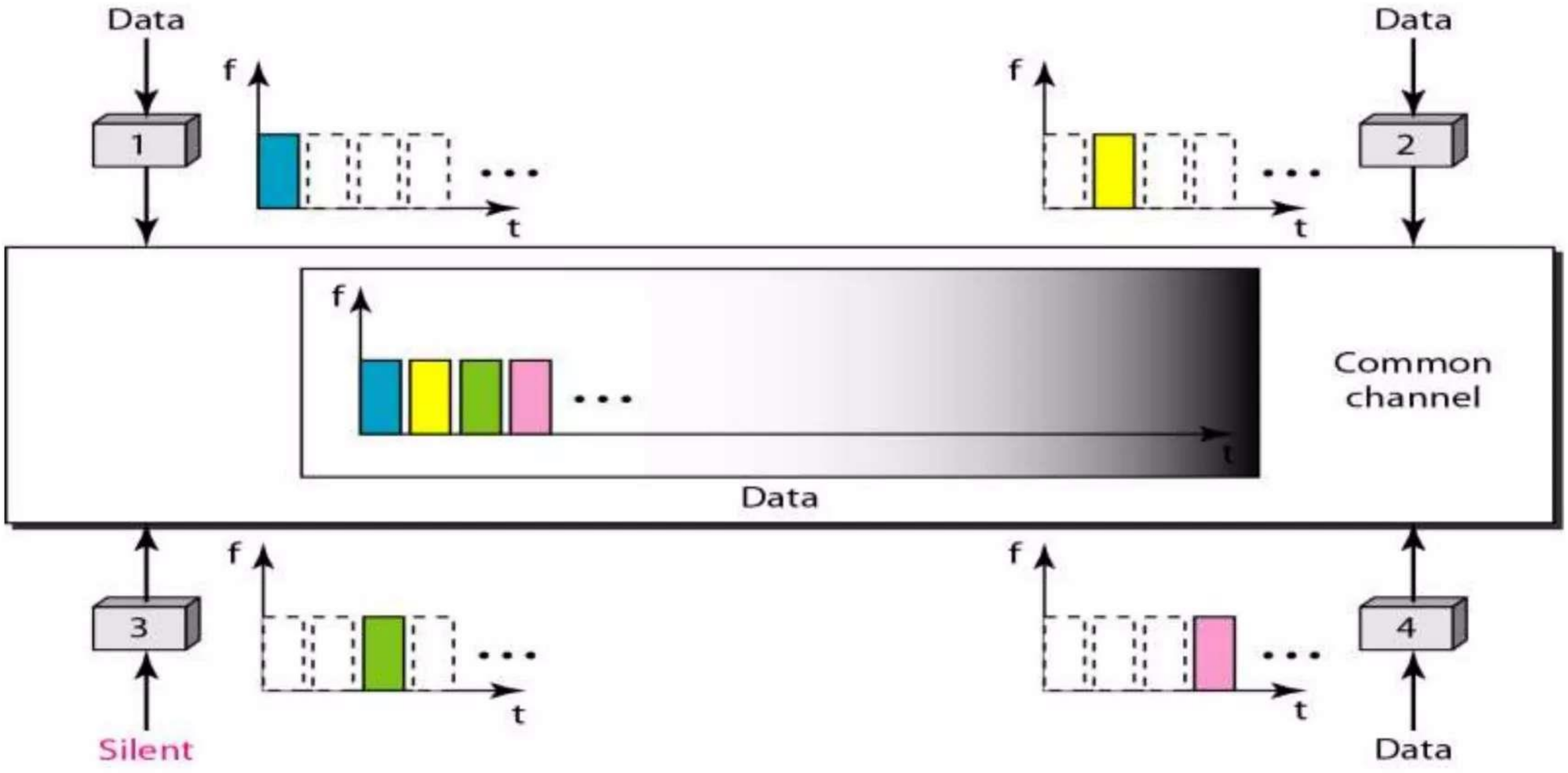
12.3.1 Frequency-Division Multiple Access (FDMA)

- **Available bandwidth is divided into frequency bands.**
- **Each band is reserved for a specific station.**
- Each station also uses a bandpass filter to confine the transmitter frequencies.



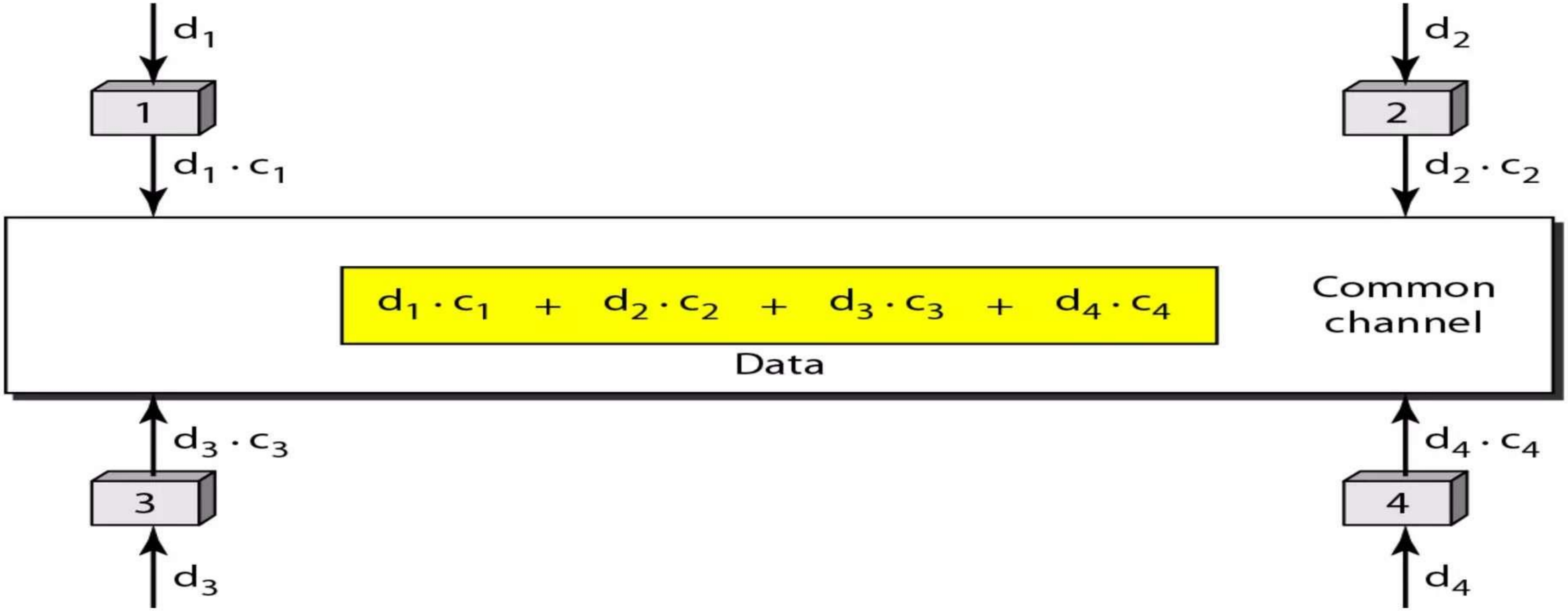
12.3.2 TDMA

- Stations **share the bandwidth** of the channel in time.
- Each station is allocated a **time slot** during which it can send data.



12.3.3 CDMA

- One channel carries all transmissions at the same time
- https://www.youtube.com/watch?v=5plZGFd-cWc
- Each channel is separated by code



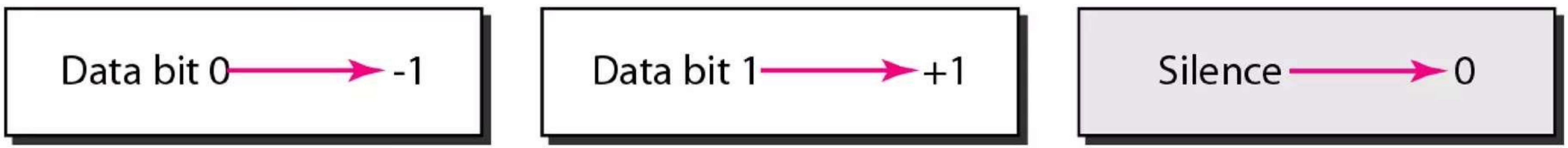
CDMA: Chip Sequences

- Each station is assigned a unique chip sequence

C_1	C_2	C_3	C_4
[+1 +1 +1 +1]	[+1 -1 +1 -1]	[+1 +1 -1 - 1]	[+1 -1 -1 +1]

- Chip sequences are orthogonal vectors
  - Inner product of any pair must be zero
- With N stations, sequences must have the following properties:
  - They are of length N
  - Their self inner product is always N

CDMA: Bit Representation



Transmission in CDMA