Computer Network

Lecture 2
MAC Layer

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Contents

- **Basic Terminologies**
- MAC Overview
- Random Access Protocols
- Controlled Access Protocols
- Channelization Protocols

Attitude

"컴퓨터 네트워크를 이해하기 위한 기본 마음 가짐”

Vocabulary

다양성의 인정

(옳고 그름이 아닌, 장단점을 갖는 복수의 접근 방법)

Five Basic Terminologies

"컴퓨터 네트워크를 이해하기 위한 기본 단어"

(1) Message

- information(data) to be communicated.
- text, numbers, pictures, sound, video or any combination of these

(2) Sender

- the device that sends the data message.
- computer, telephone handset, video camera

(3) Receiver

- is the device that receives the message.
- computer, telephone handset, video camera

(4) Medium

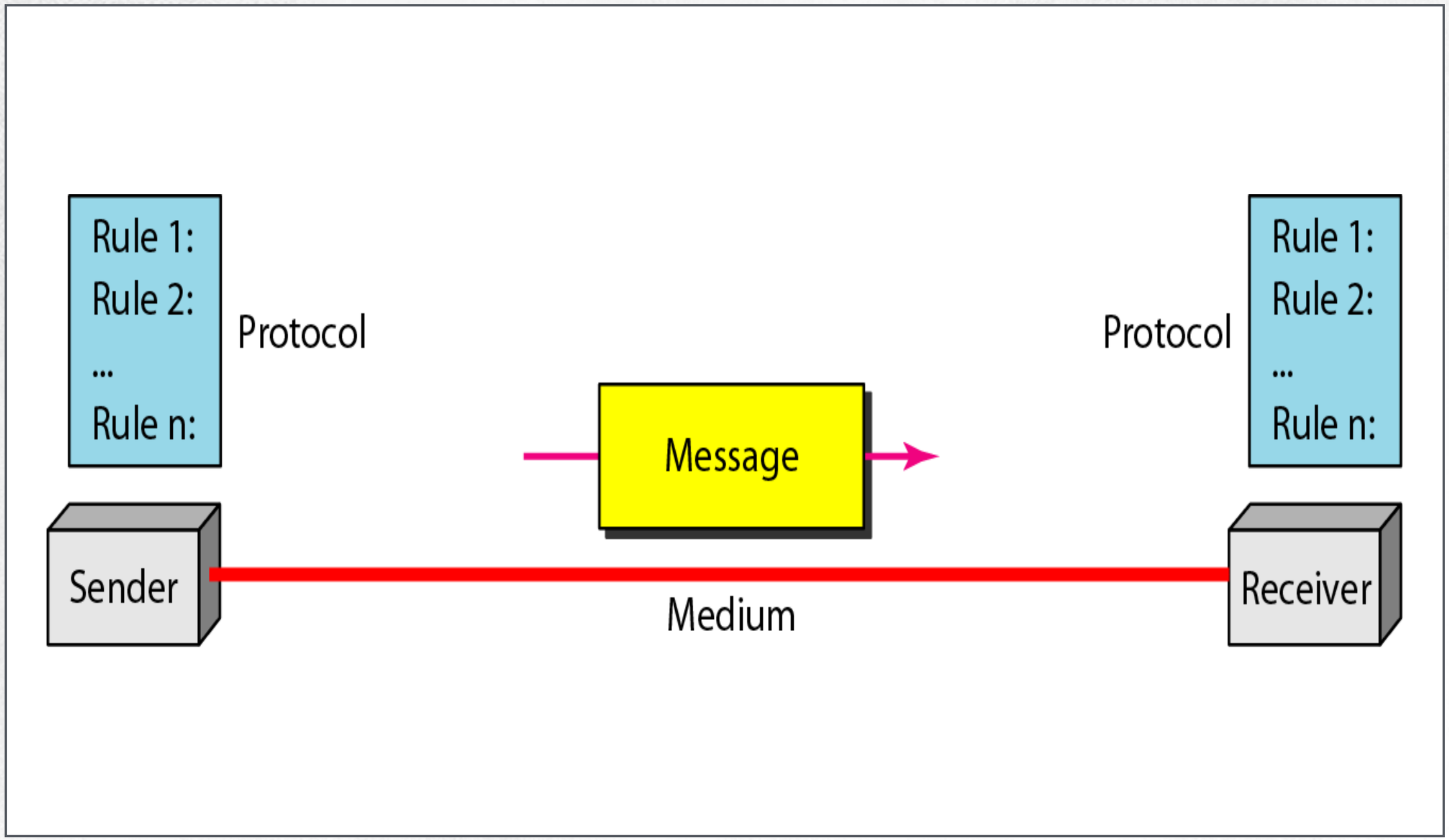
- physical path by which a message travels from sender to receiver.
- twisted pair wire, coaxial cable, fiber- optic cable, laser , or radio waves

(5) Protocol

- set of rules that govern data communication.

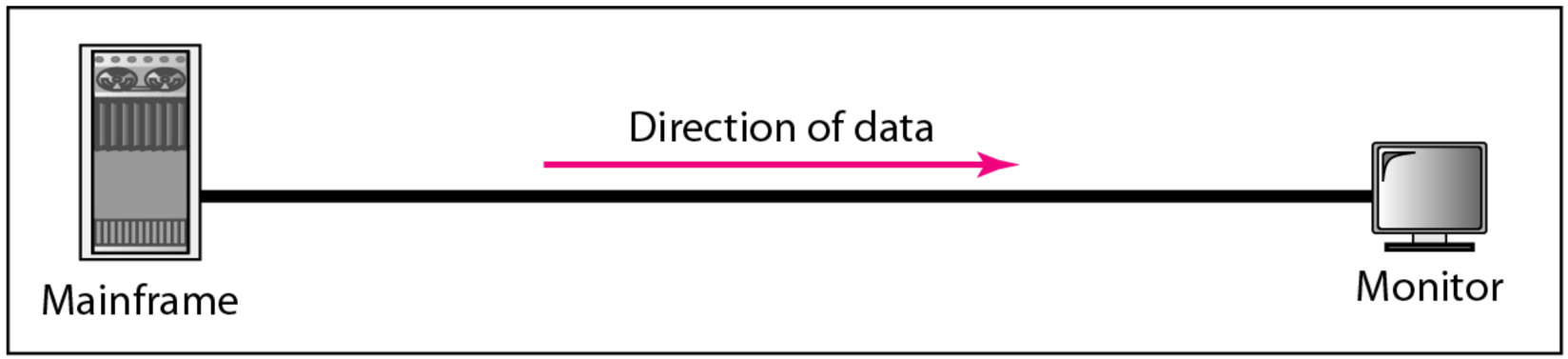
Five Basic Terminologies

"컴퓨터 네트워크를 이해하기 위한 기본 단어”

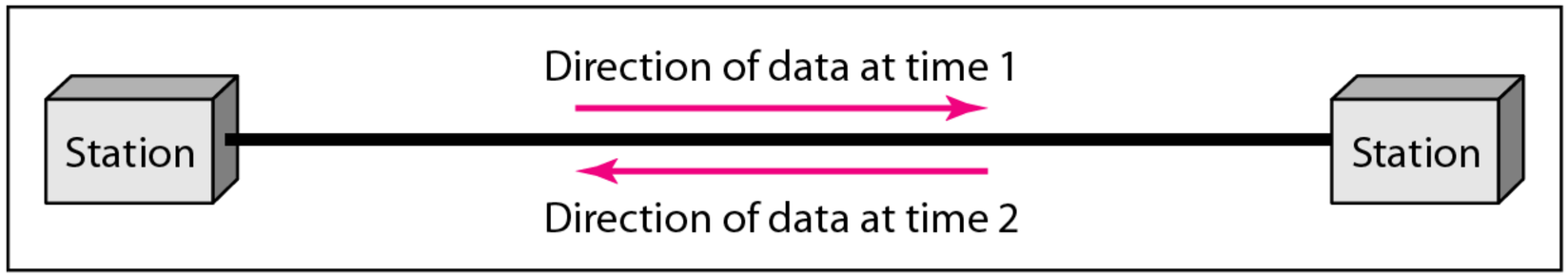


Data Flow Direction

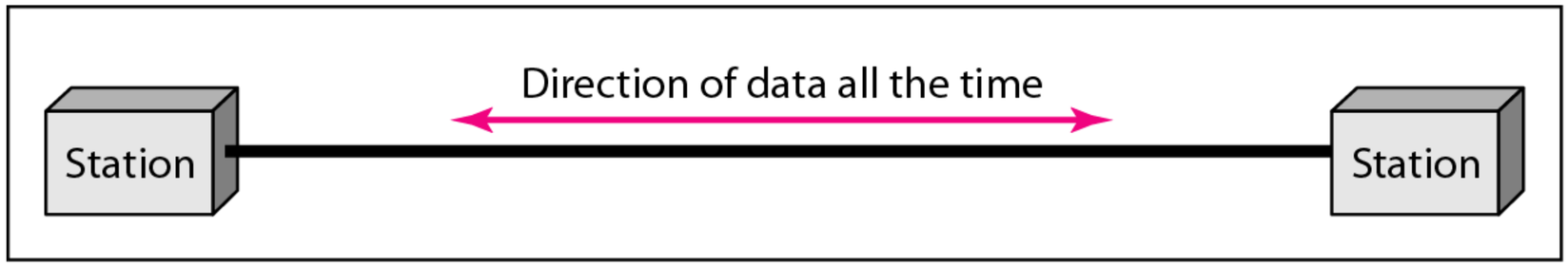
"컴퓨터 네트워크에서 정보를 주고 받는 방향별 명칭"



a. Simplex



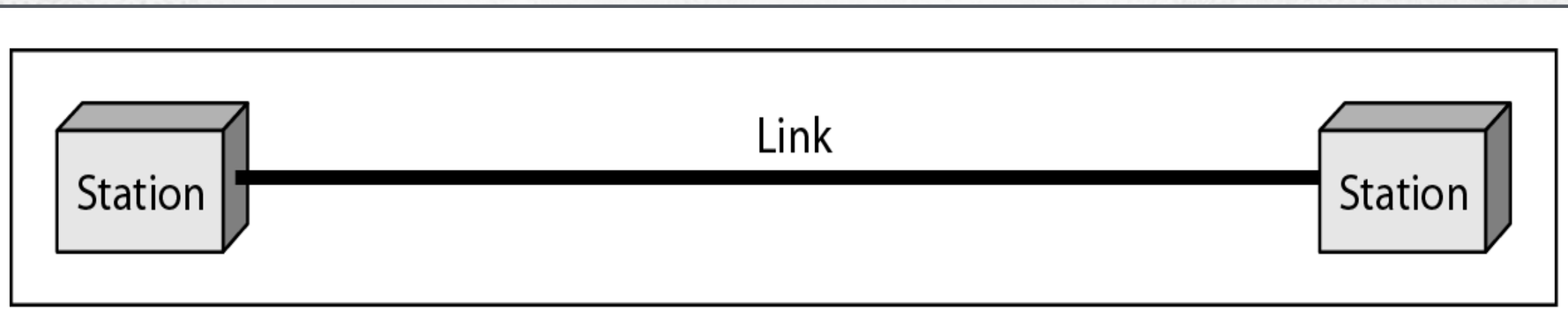
b. Half-duplex



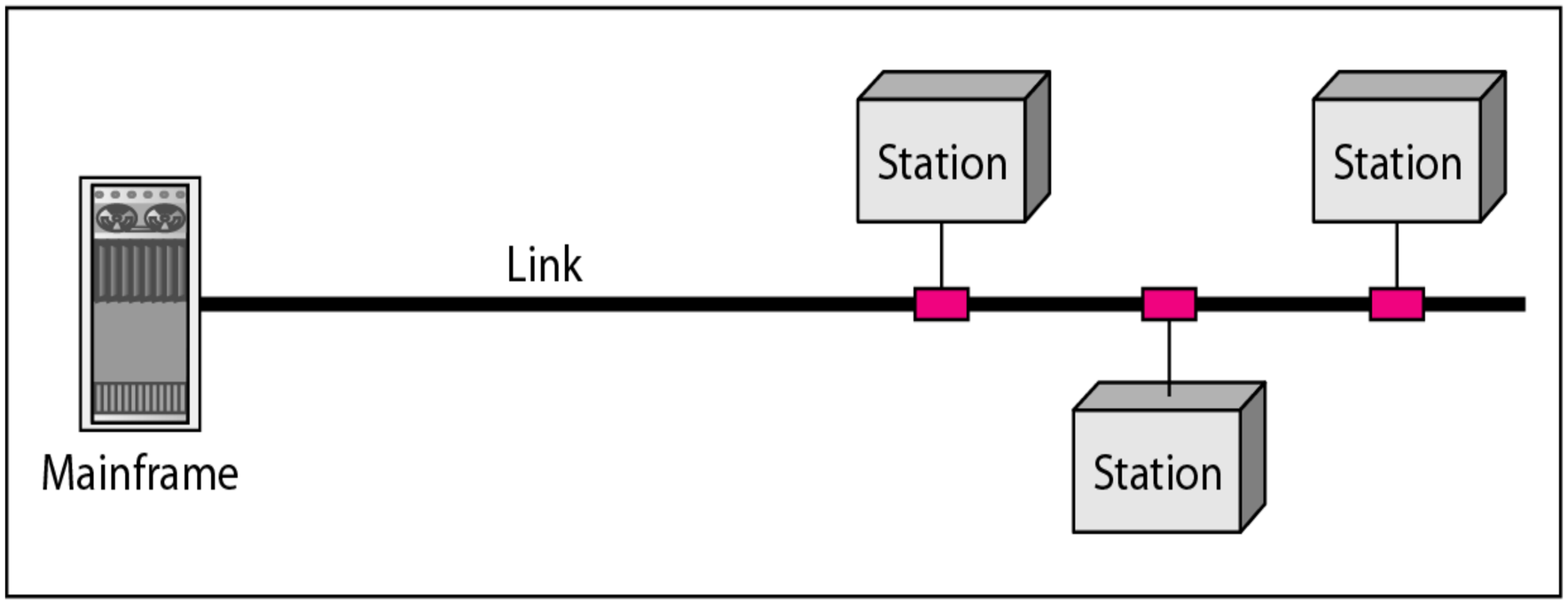
c. Full-duplex

Physical Structure

"컴퓨터 네트워크에서 Medium의 연결 방식에 대한 명칭"



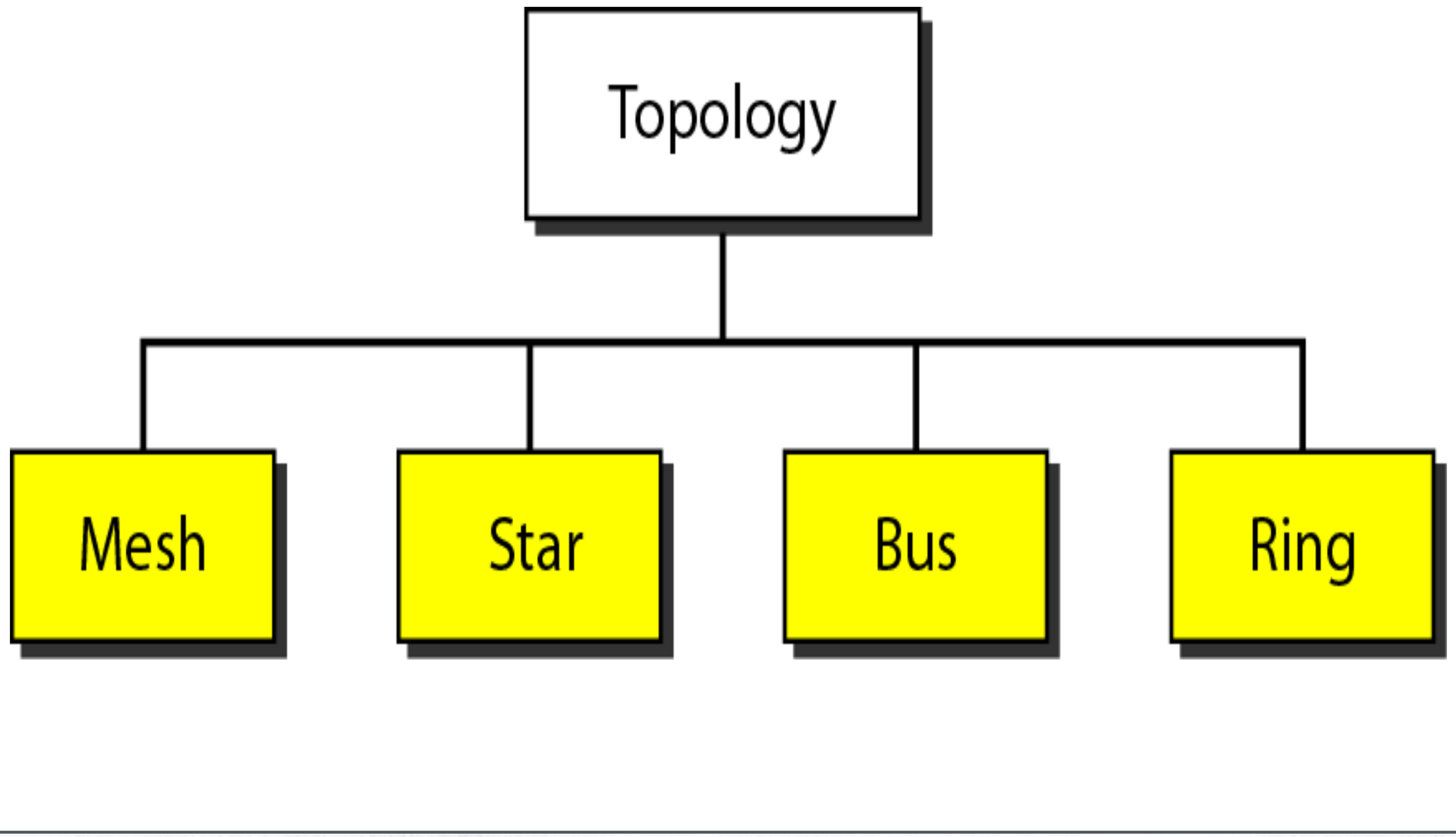
a. Point-to-point



b. Multipoint

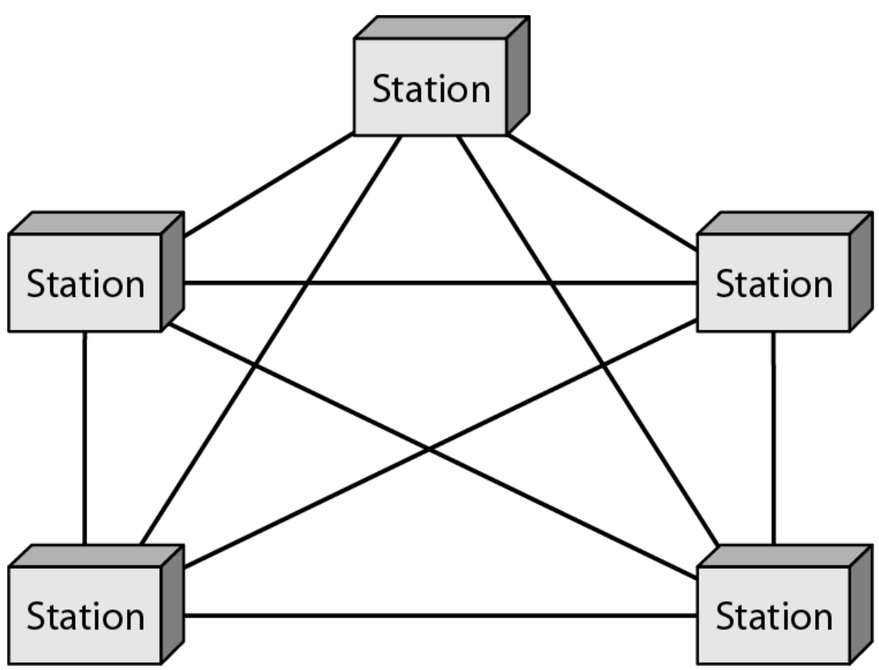
Physical Topology

"컴퓨터 네트워크의 대표적인 연결 형태(들)"



Physical Topology

“Mesh Topology”

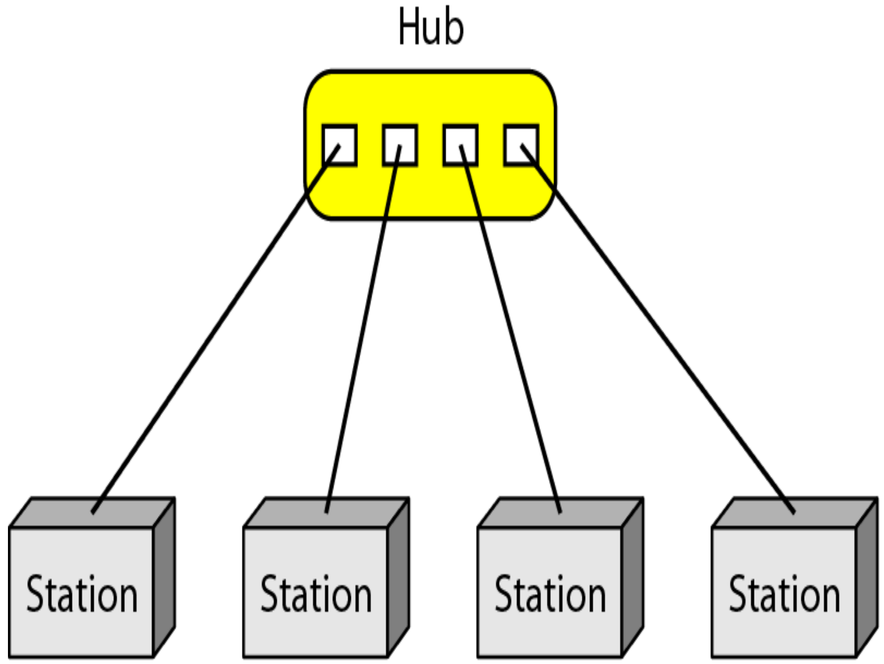


- Advantages
  - The use of dedicated links guarantees that each connection can carry its data load
  - Mesh topology is robust
  - Privacy and security
  - fault identification and fault isolation easy

- Disadvantages
  - amount of cabling and the number of I/O ports

Physical Topology

“Star (or Tree) Topology”



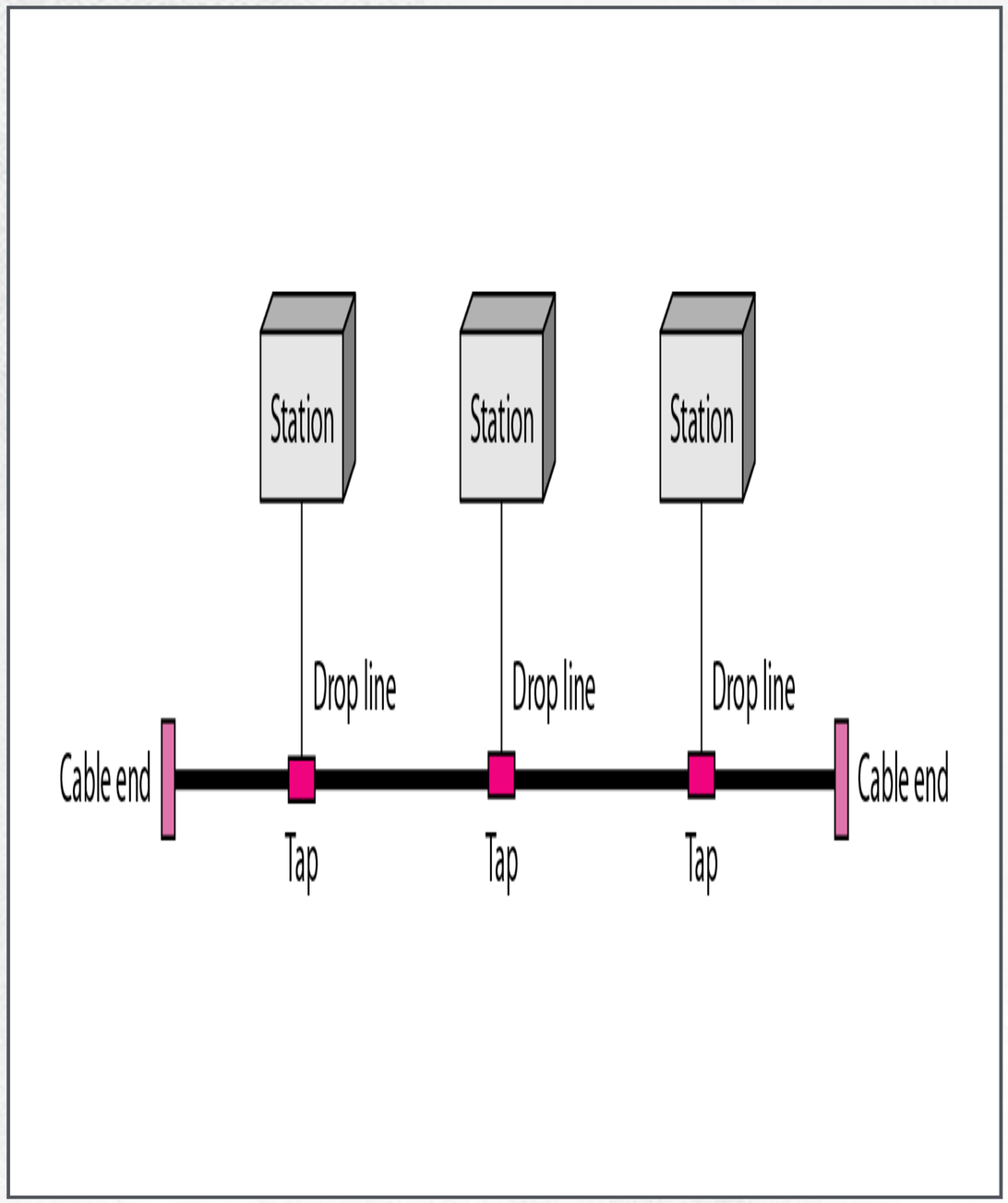
- Advantages
  - Each device needs only one link and one I/O port to connect it to any number of others (easy to install and reconfigure)
  - Robustness: if one link fails, only that link is affected

- Disadvantages
  - **GUESS !! (Important)**

- Tree topology
  - is a variation of a star

Physical Topology

“Bus Topology”

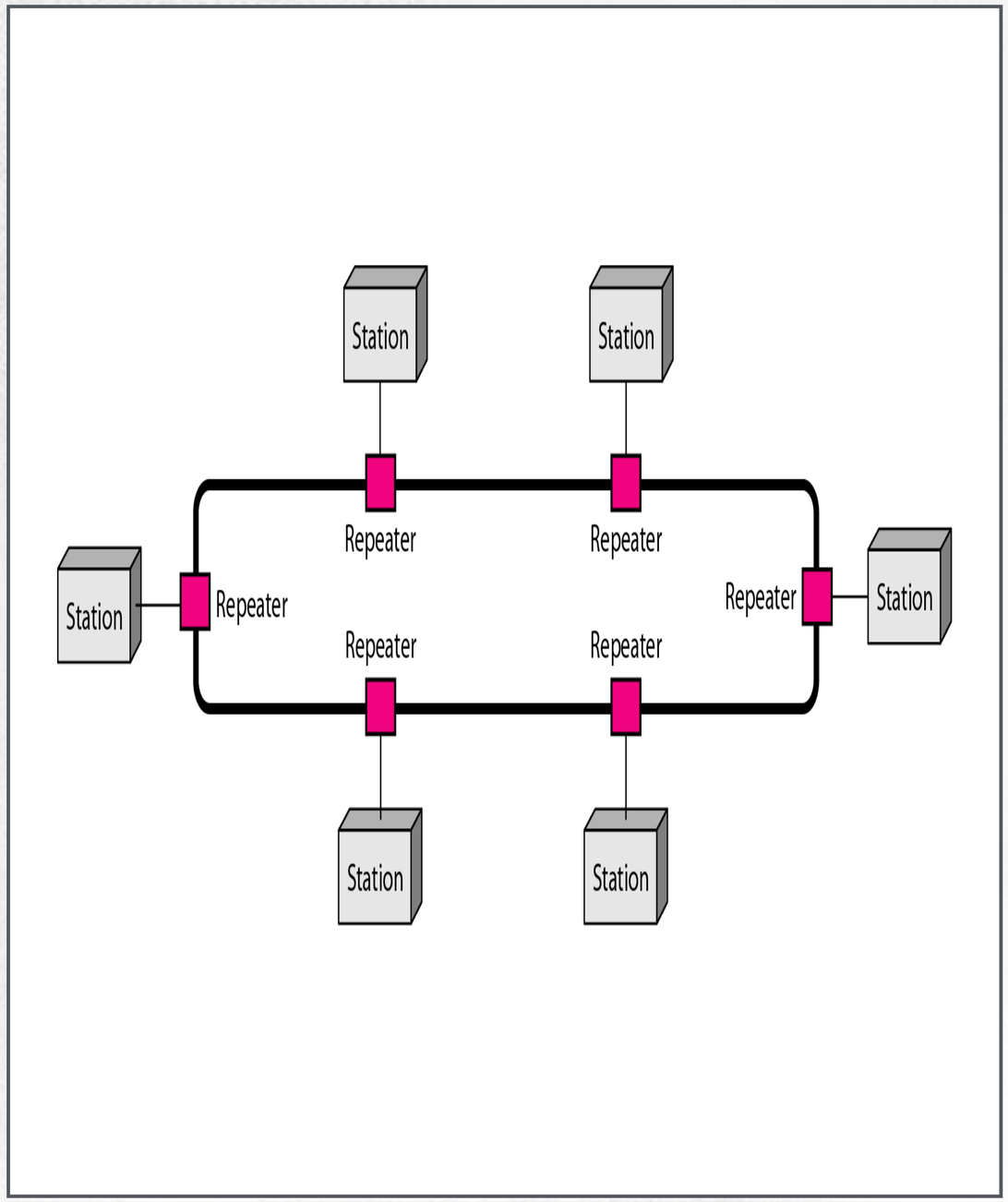


- Advantages
  - include ease of installation

- Disadvantages
  - include difficult reconfiguration and fault isolation

Physical Topology

“Ring Topology”

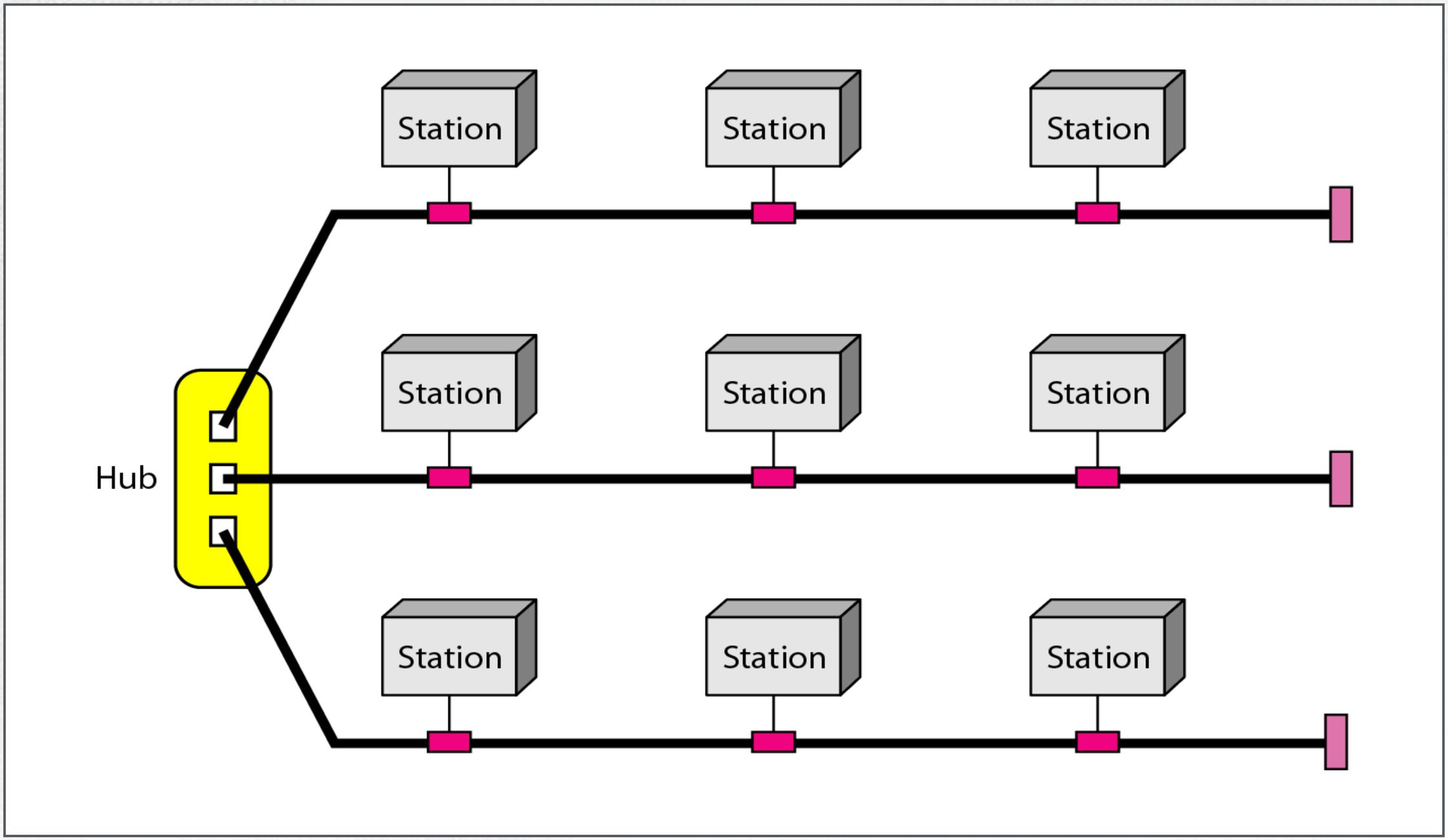


- Advantage
  - is relatively easy to install and reconfigure
  - fault isolation is simplified

- Disadvantage
  - unidirectional traffic
  - break in the ring can disable the entire network (needs dual ring)

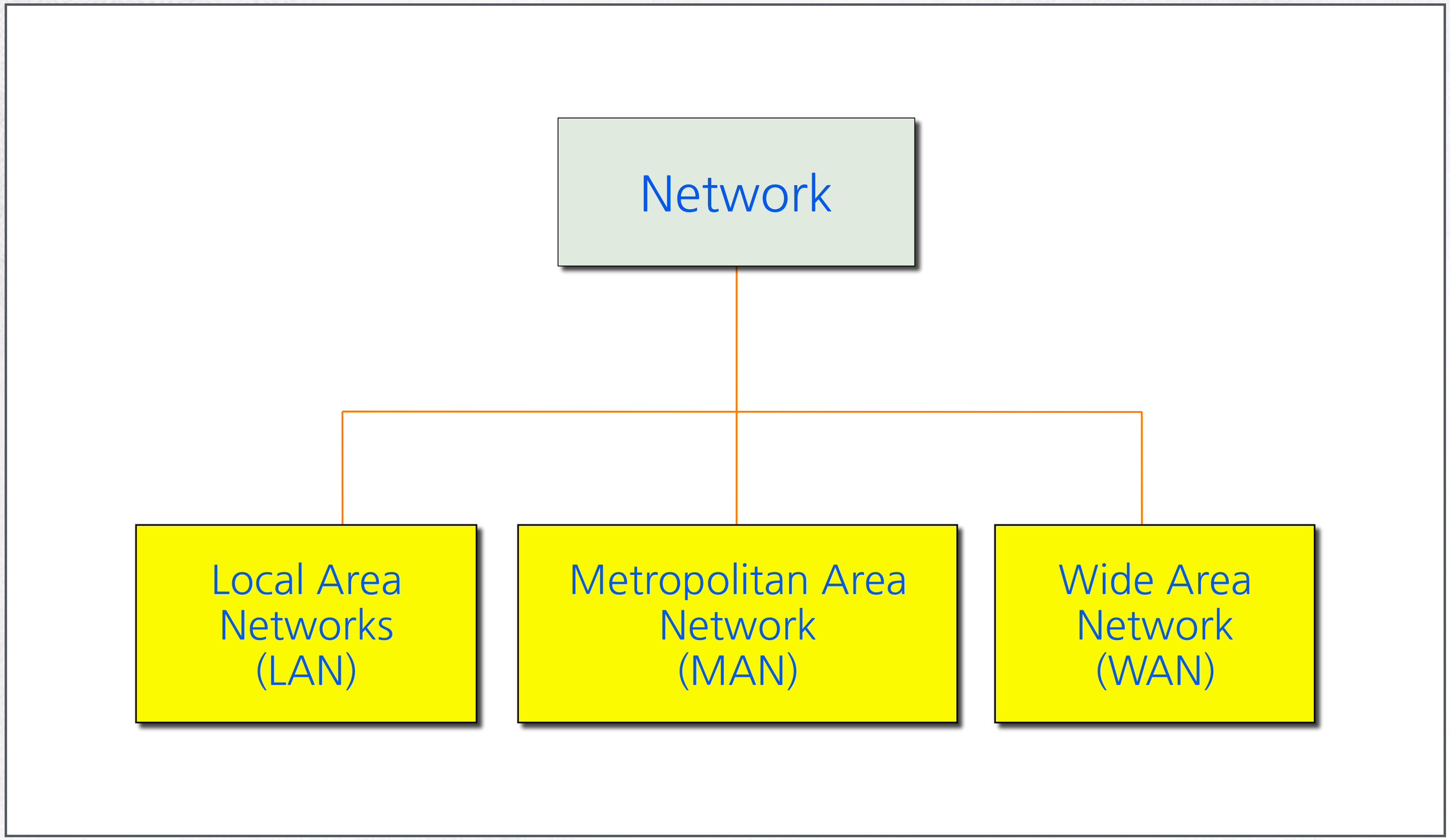
Physical Topology

"Hybrid - Combination of Topologies"



Categories of Networks

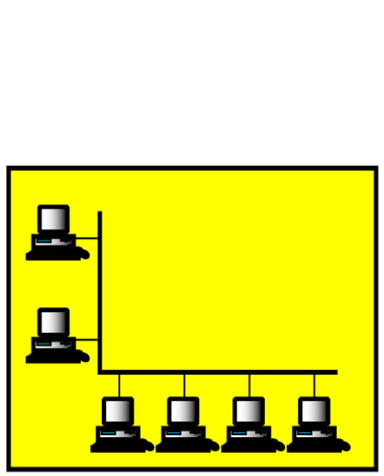
"네트워크 규모에 대한 명칭 - 그외에 PAN/BAN도 있음"



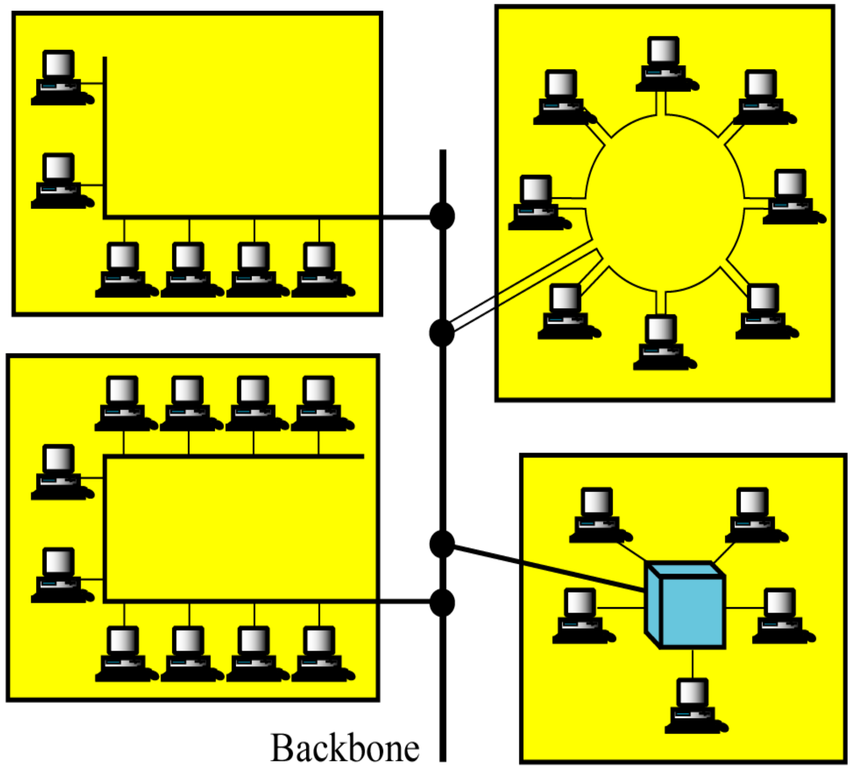
Categories of Networks

“Local Area Network”

LAN is usually privately owned and links the devices in a single office, building or campus



a. Single building LAN

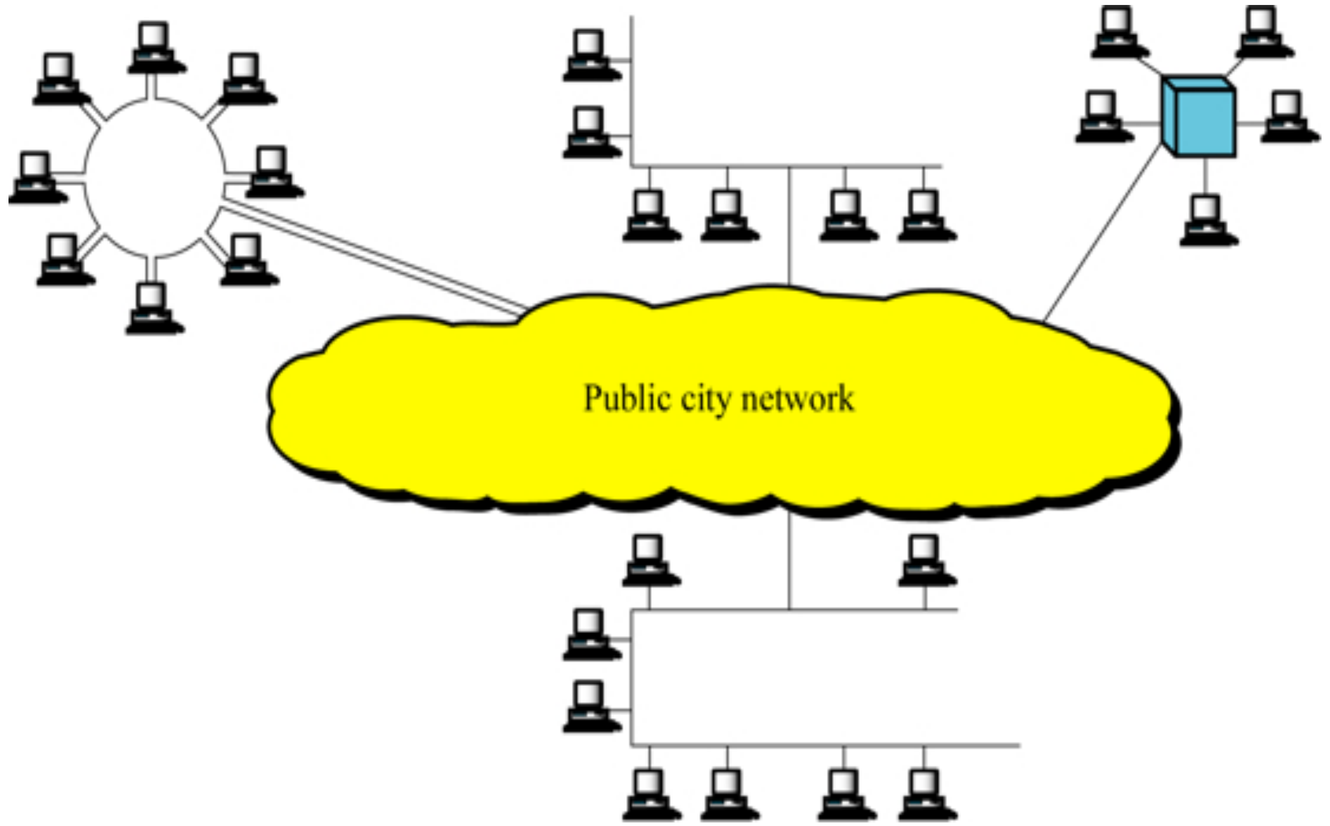


b. Multiple building LAN

Categories of Networks

“Metropolitan Area Network”

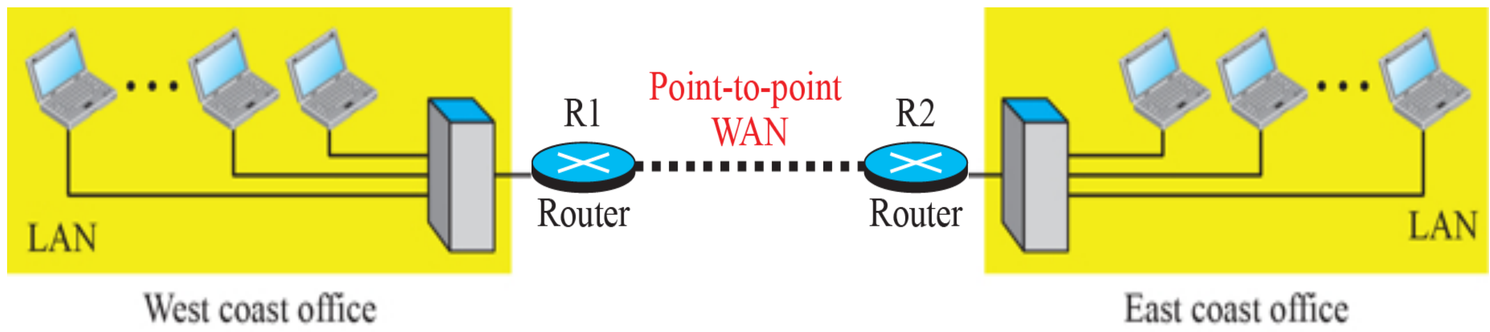
MAN is designed to extend over an entire city



Categories of Networks

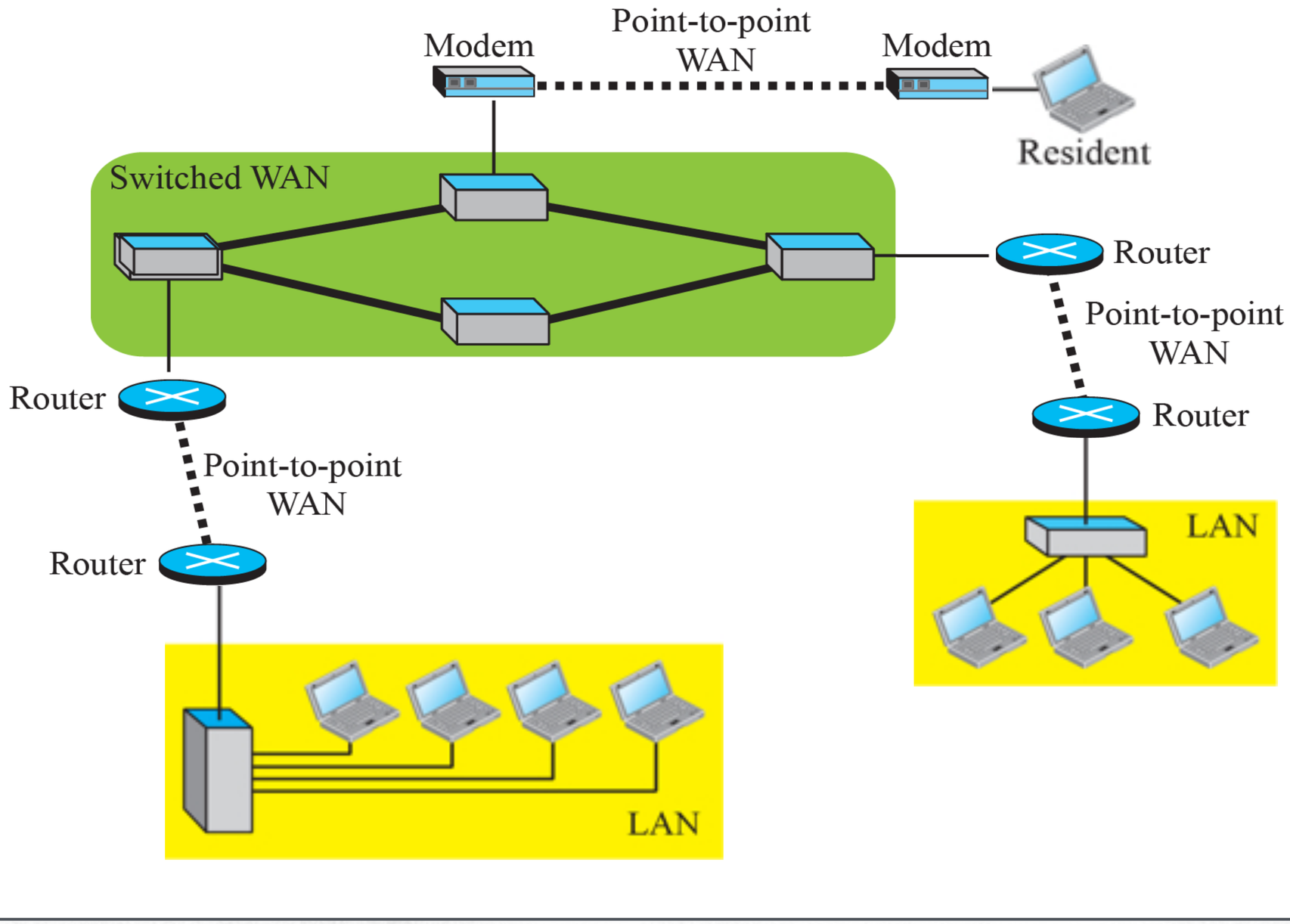
"Wide Area Network"

WAN provides long-distance transmission of data, voice, image, and video information over large geographical areas that may comprise a country, a continent, or even the whole world



Categories of Networks

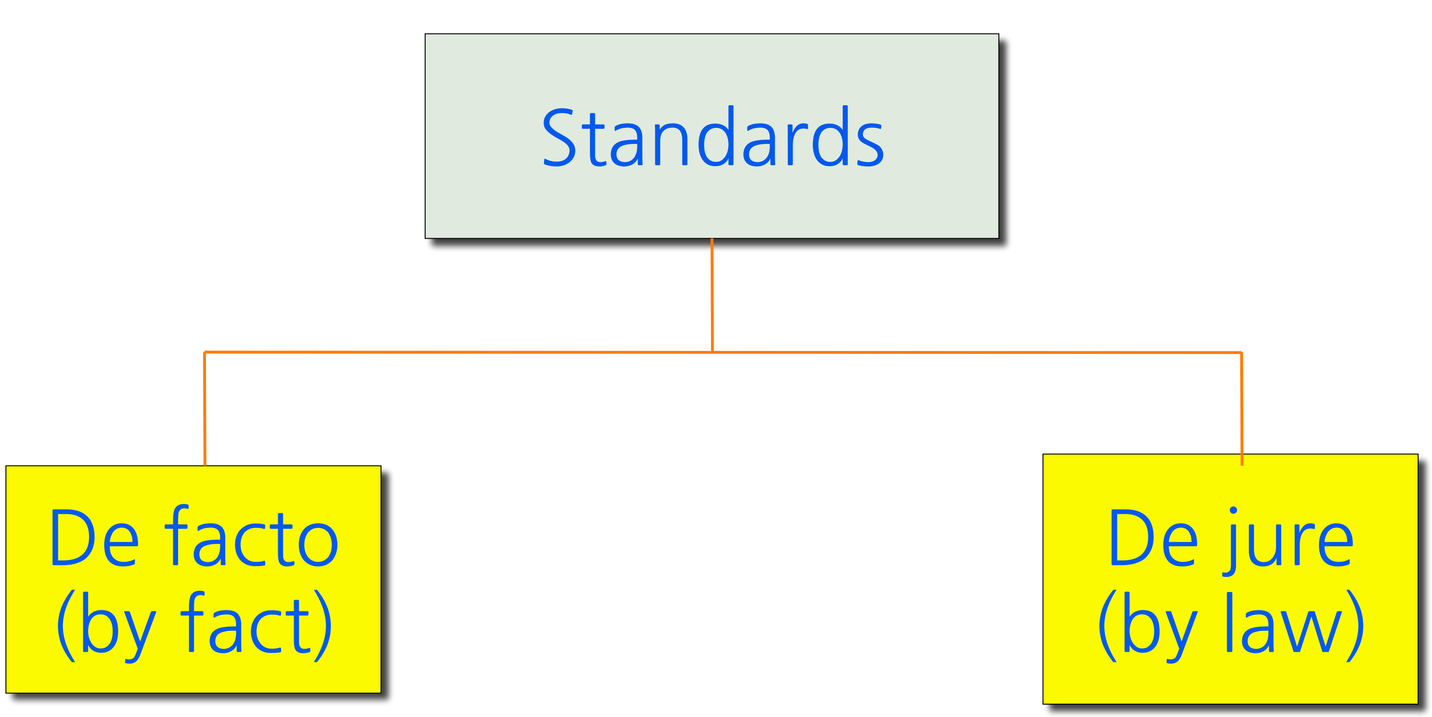
"Combination of LAN/WAN/MAN"



Standard

"상호 연동성의 기준"

Essential in creating and maintaining an open and competitive market for equipment manufactures and in guaranteeing national and international interoperability of data and communications technology and processes.



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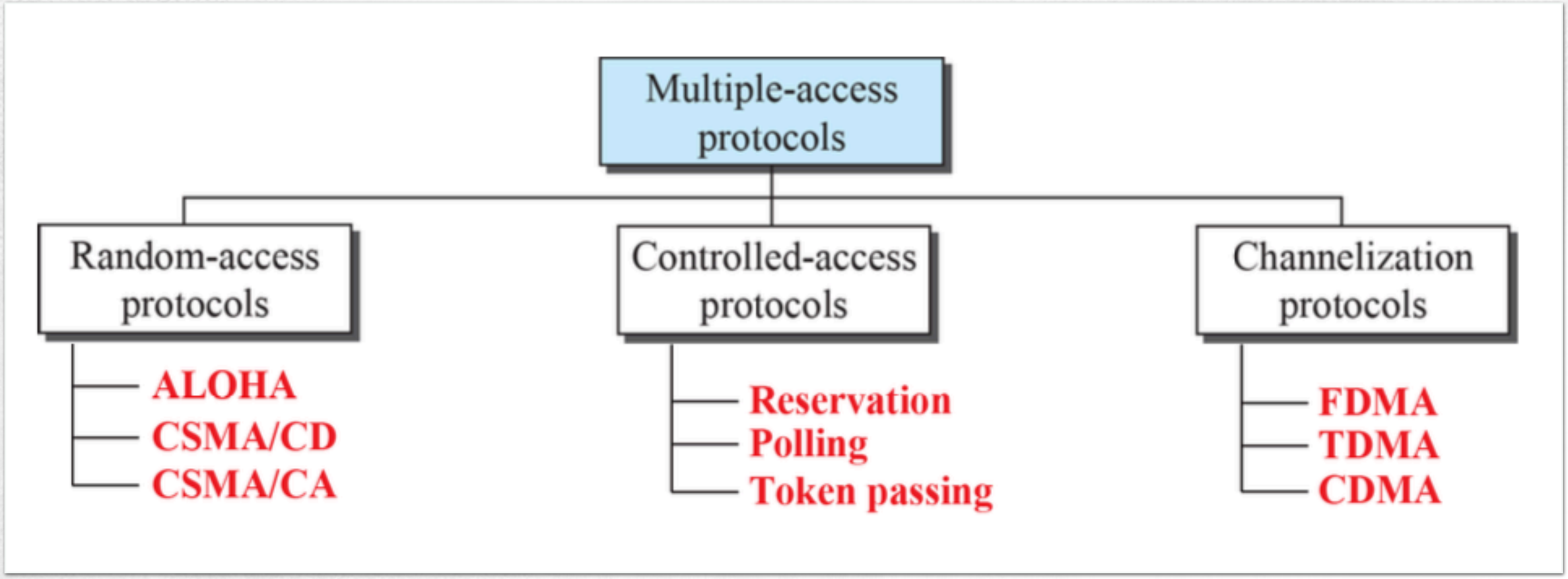
- **MAC Overview**
- Random Access Protocols
- Controlled Access Protocols
- Channelization Protocols

Categories


Multiple-access protocols
Random-access protocols
ALOHA
CSMA/CD
CSMA/CA
Controlled-access protocols
Reservation
Polling
Token passing
Channelization protocols
FDMA
TDMA
CDMA

Contents

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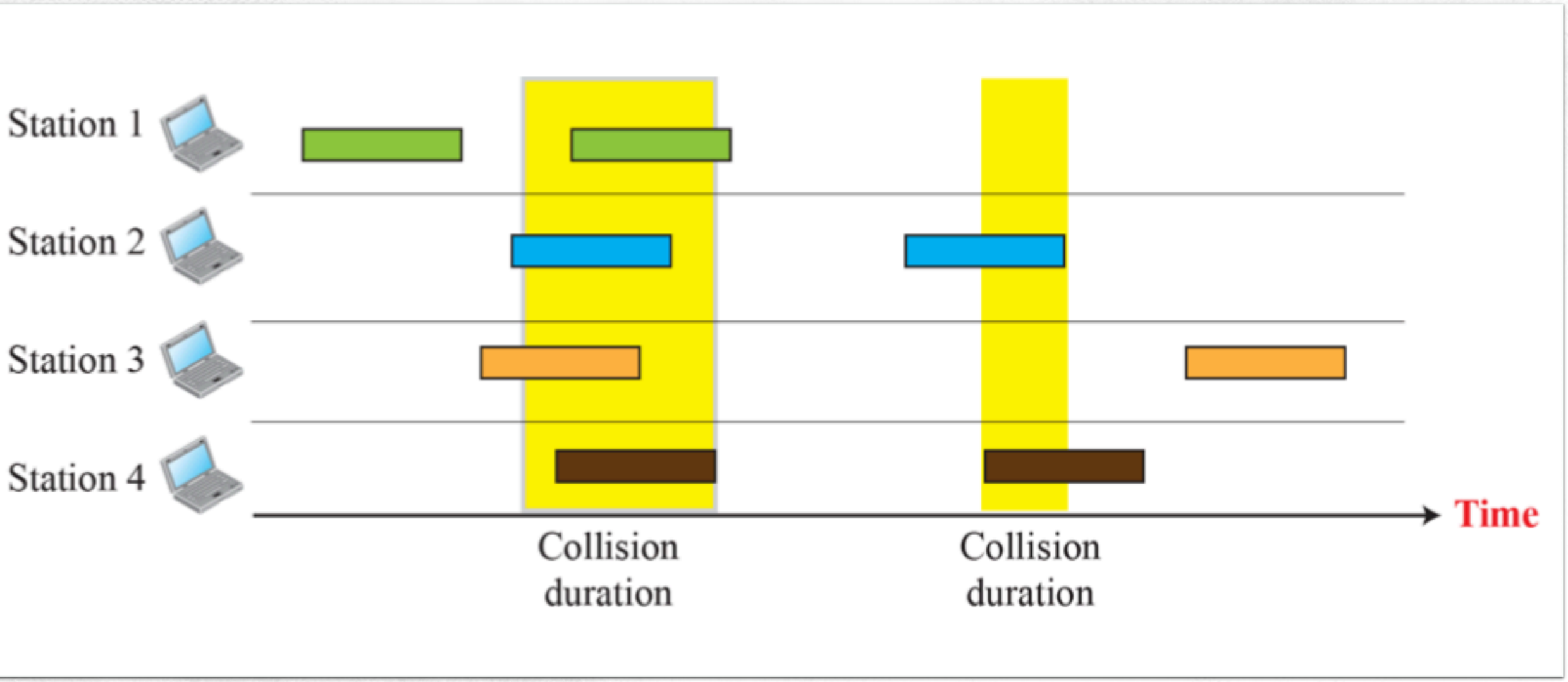
Concept

- In Random-Access or Contention
  - No station is superior to another station
  - None is assigned control over 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)

ALOHA

- ALOHA, the earliest random access method,
  - was developed at the University of Hawaii in early 1970
  - was designed for a radio (wireless) LAN, but it can be used on any shared medium
  - is obvious that there are potential collisions in this arrangement
  - 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.

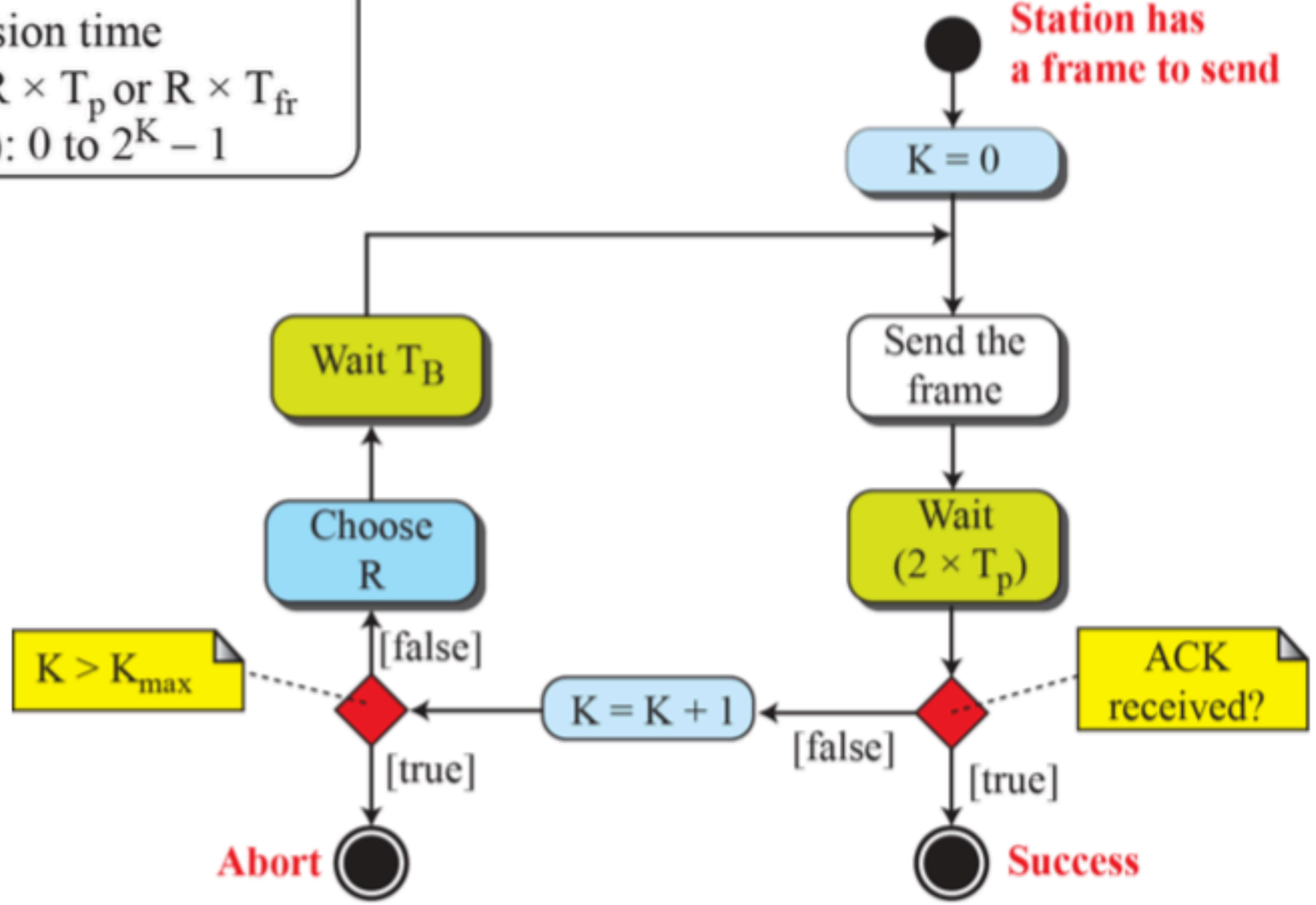
Frames in a pure ALOHA Network



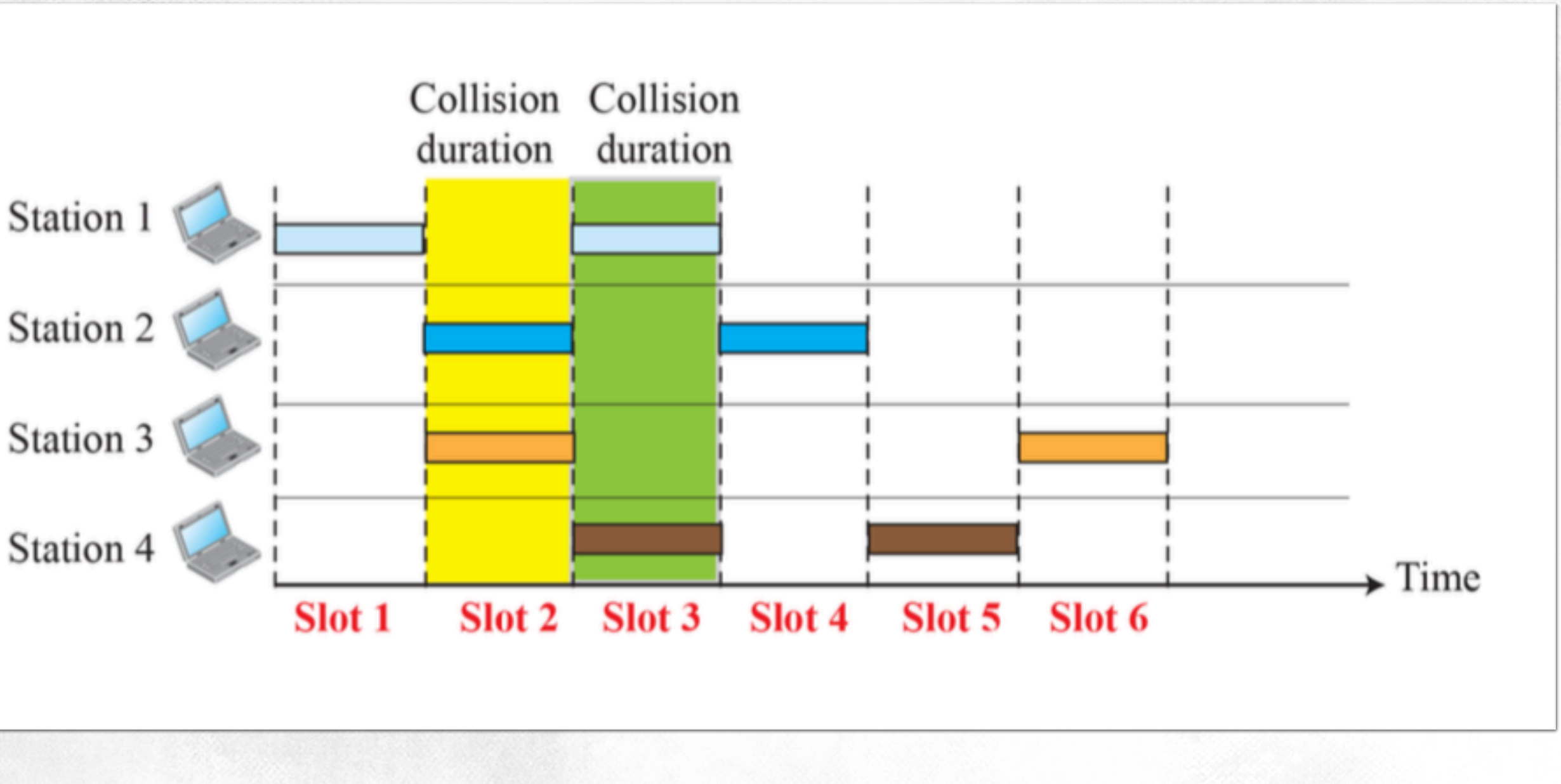
Procedure for pure ALOHA protocol

Legend

K : Number of attempts
T_p : Maximum propagation time
T_{fr} : Average transmission time
T_B : (Back-off time): $R \times T_p$ or $R \times T_{fr}$
R : (Random number): 0 to $2^K - 1$



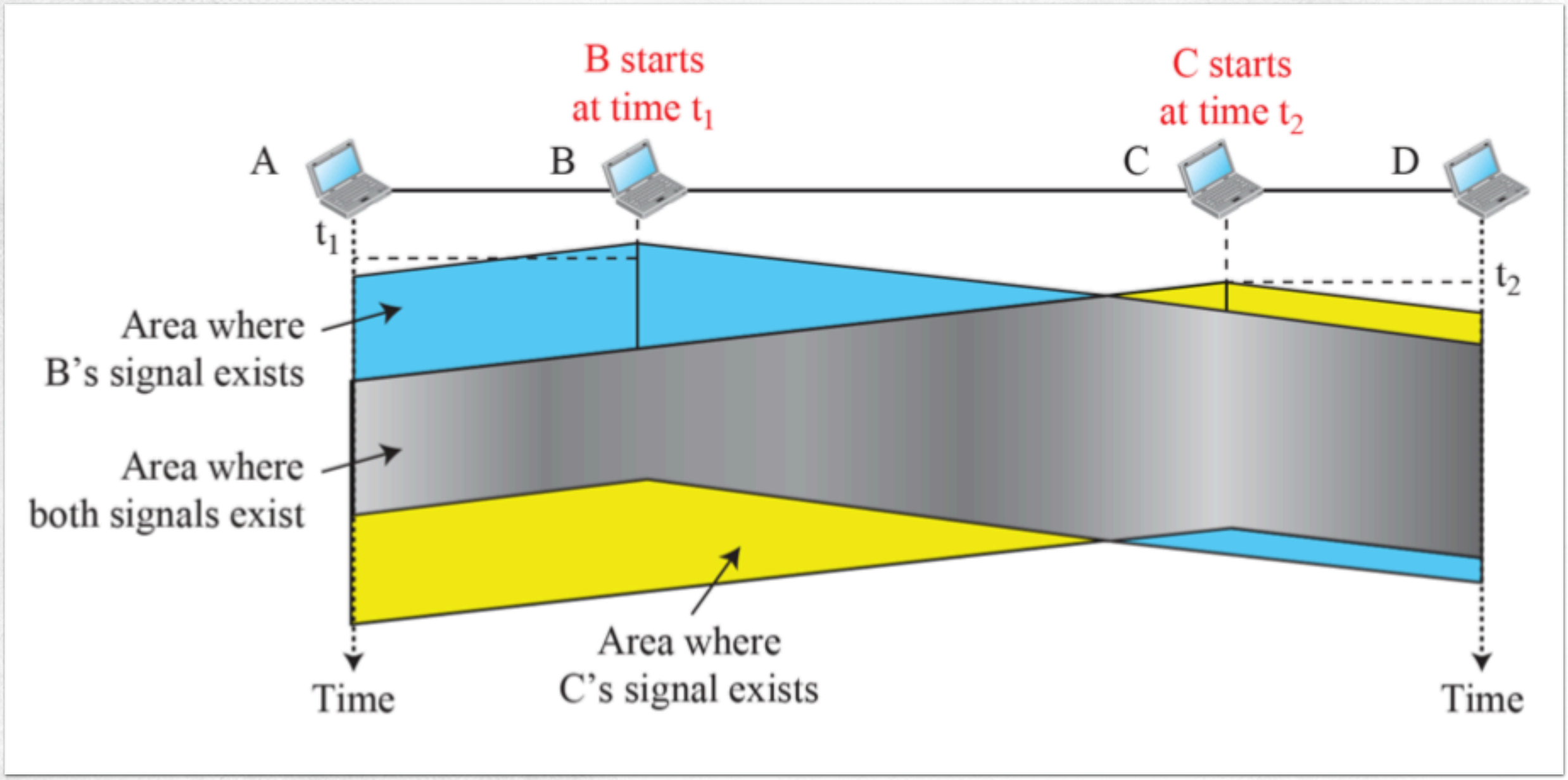
Slotted ALOHA network



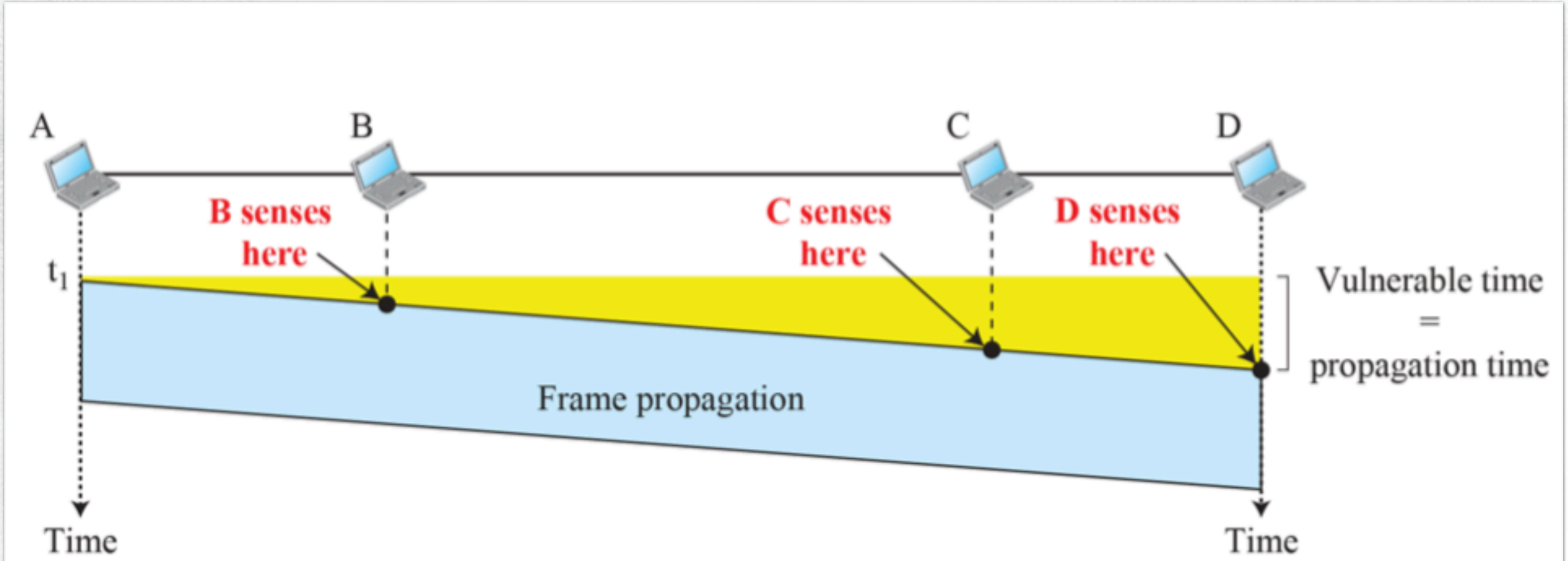
CSMA

- To minimize the chance of collision and, therefore, increase the performance, the CSMA method was developed.
- The chance of collision can be reduced if a station senses the medium before trying to use it.
- Carrier sense multiple access (CSMA) requires that each station first listen to the medium (or check the state of the medium) before sending.
- In other words, CSMA is based on the principle “sense before transmit” or “listen before talk.”

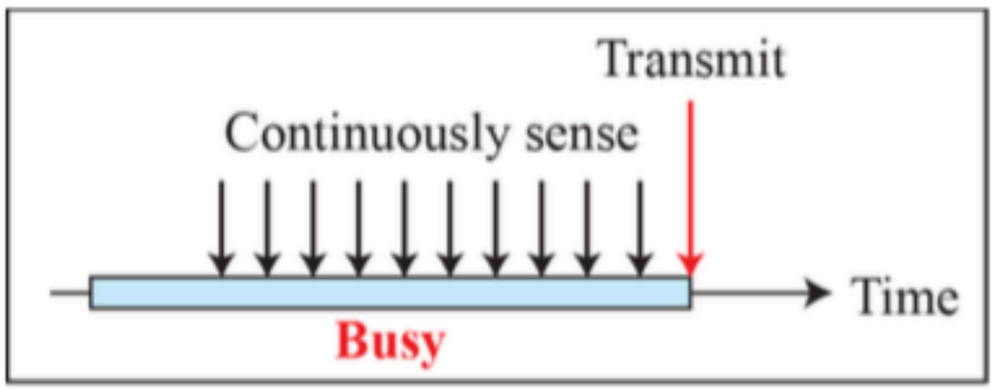
Space/Time model of a collision in CSMA



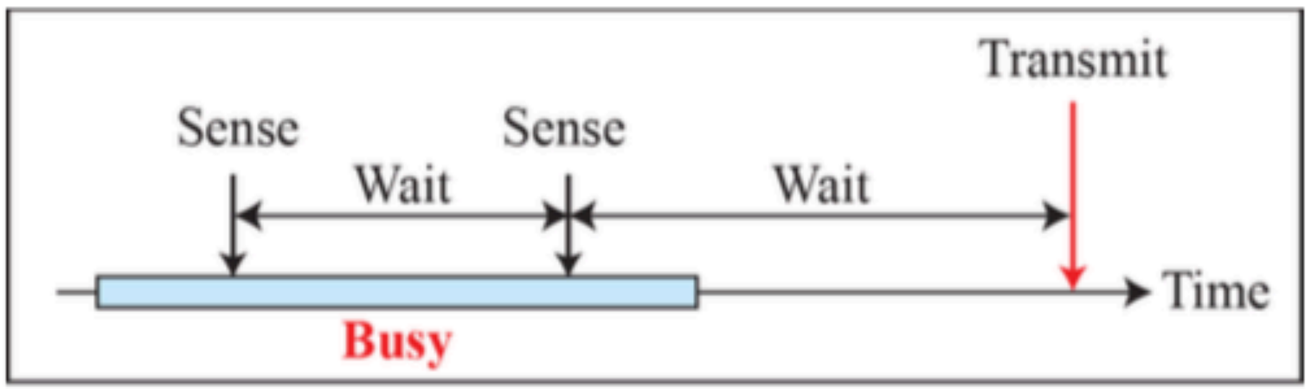
Vulnerable time in CSMA



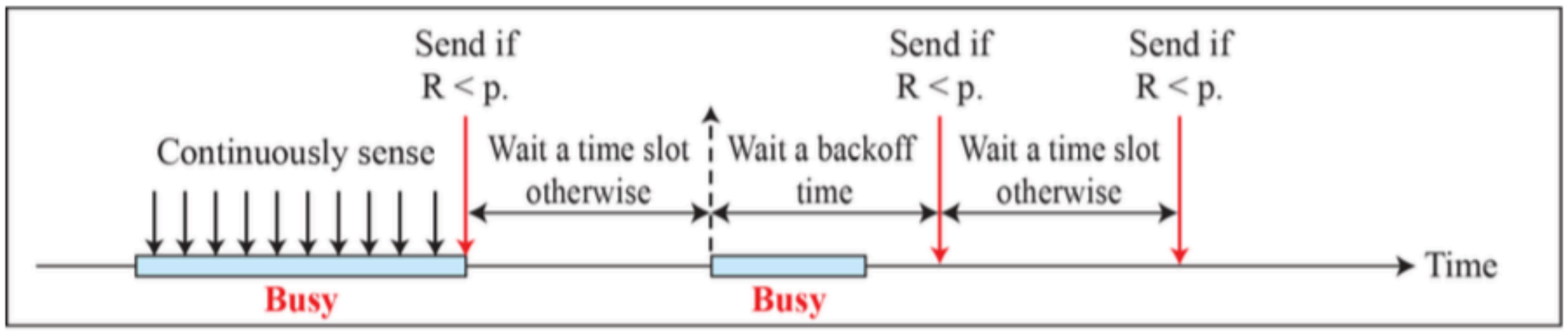
Behavior of three persistence methods



a. 1-persistent

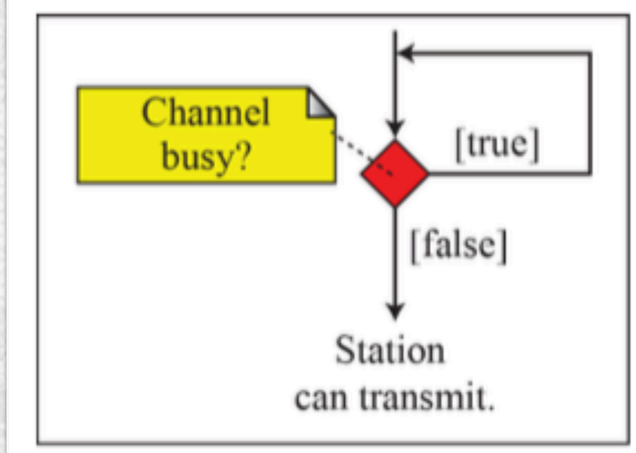


b. Nonpersistent

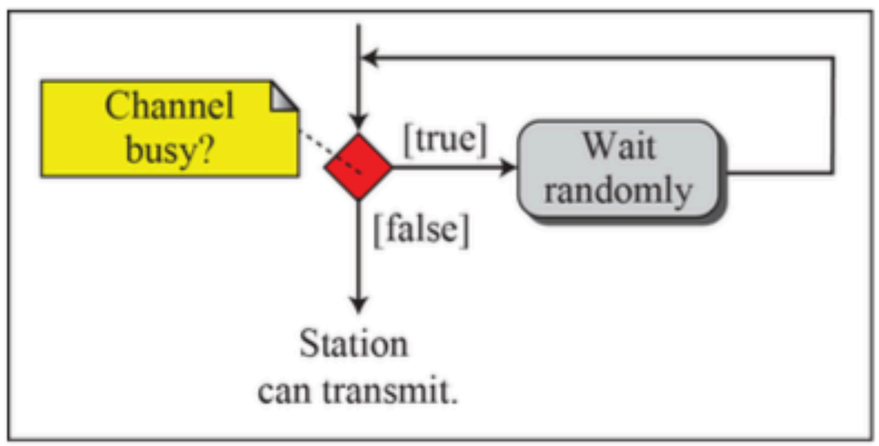


c. *p*-persistent

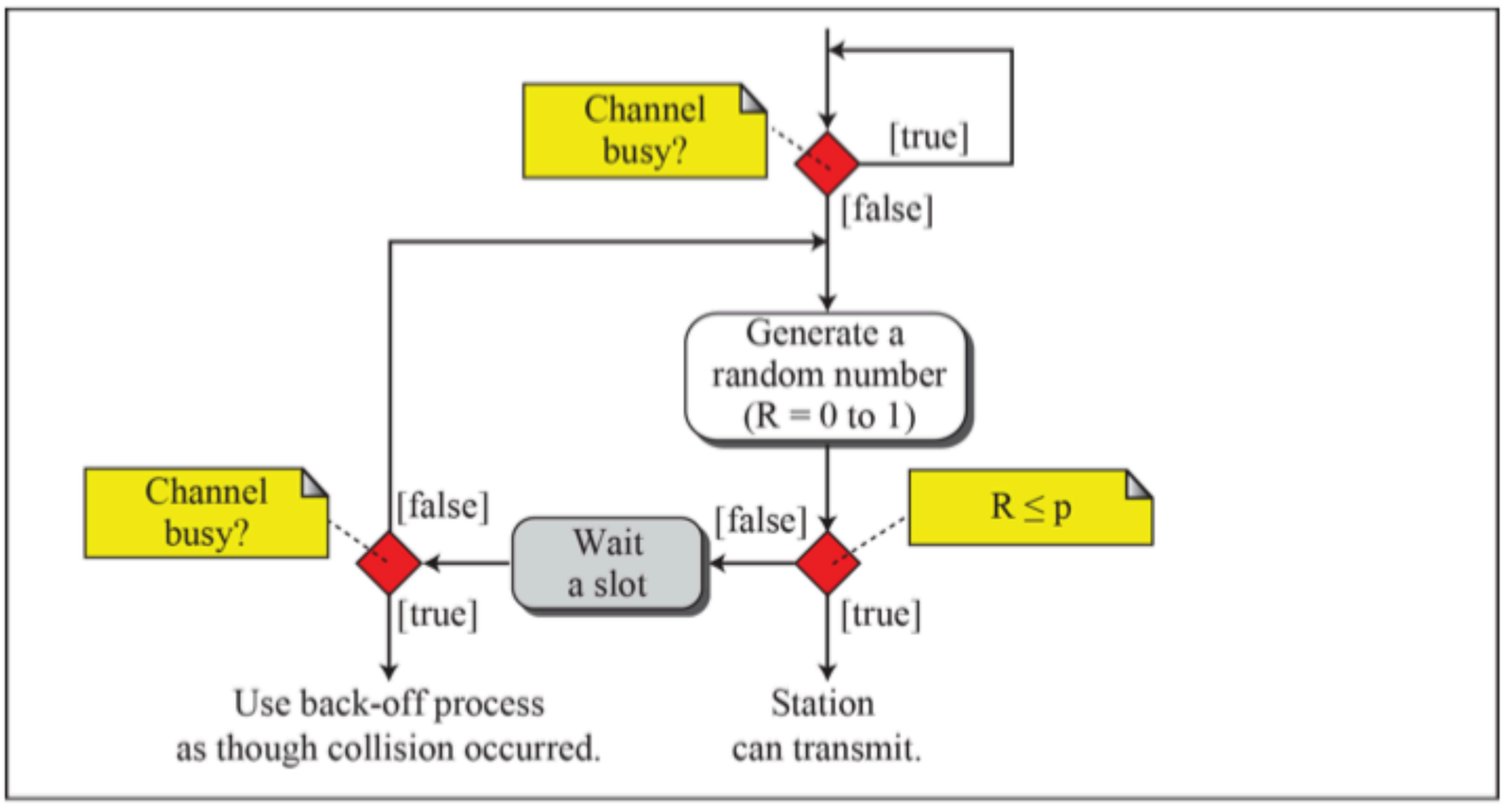
Flow diagram for three persistence methods



a. 1-persistent



b. Nonpersistent

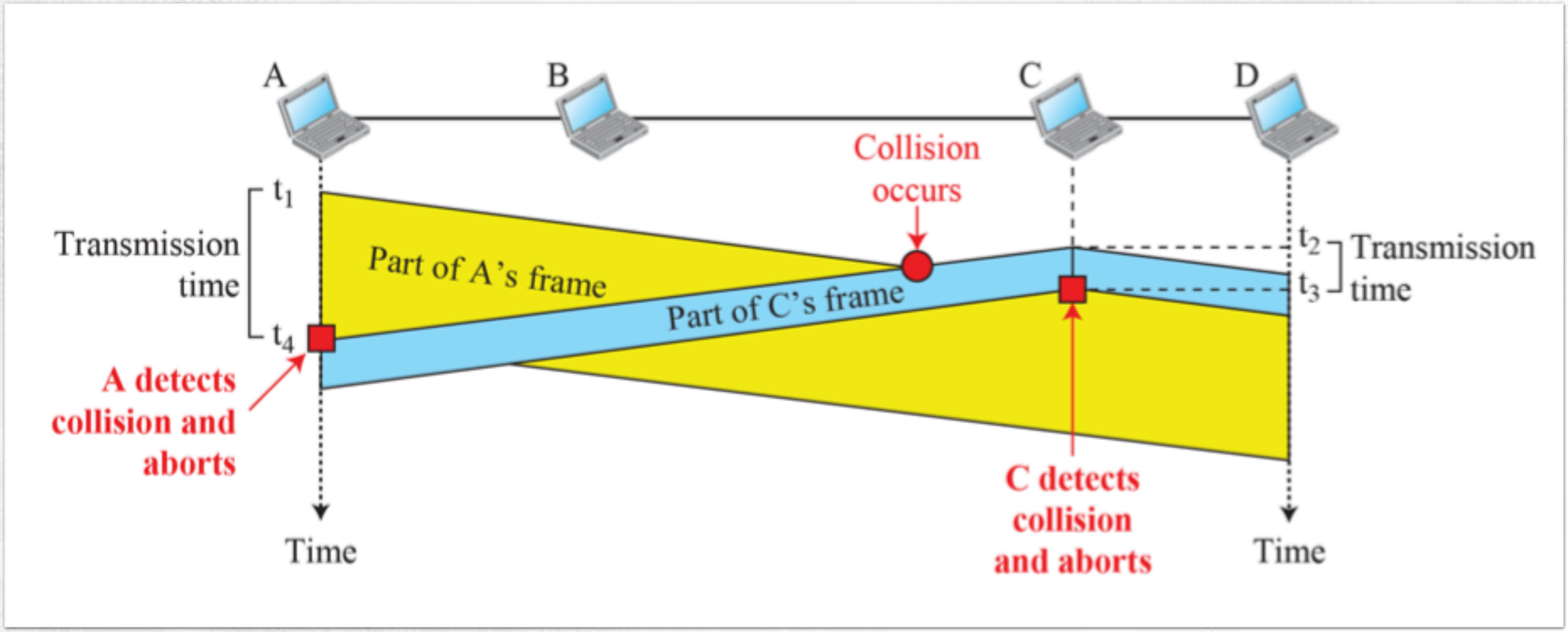


c. *p*-persistent

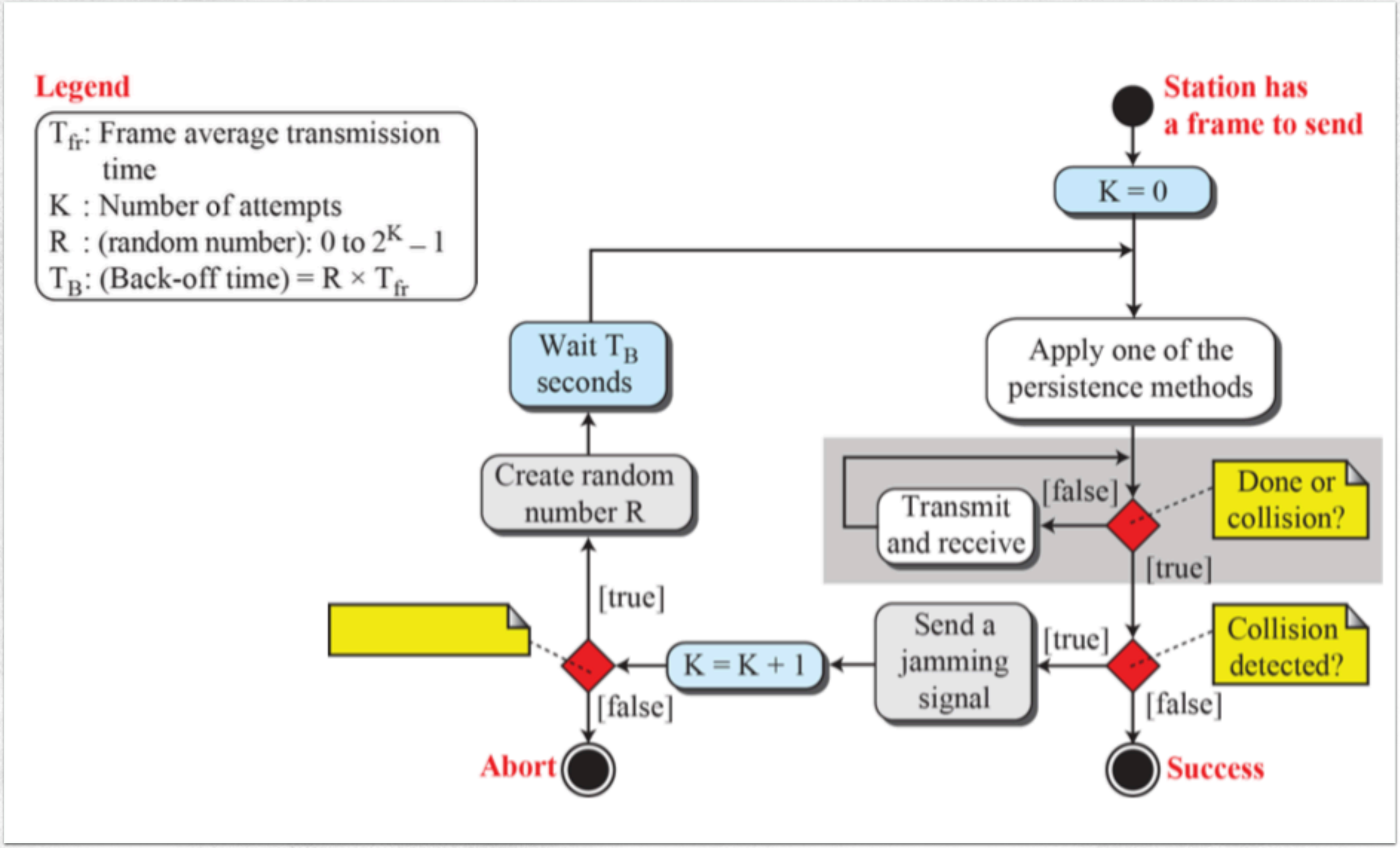
CSMA/CD

- The CSMA method does not specify the procedure following a collision.
- 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.

Collision and abortion in CSMA/CD



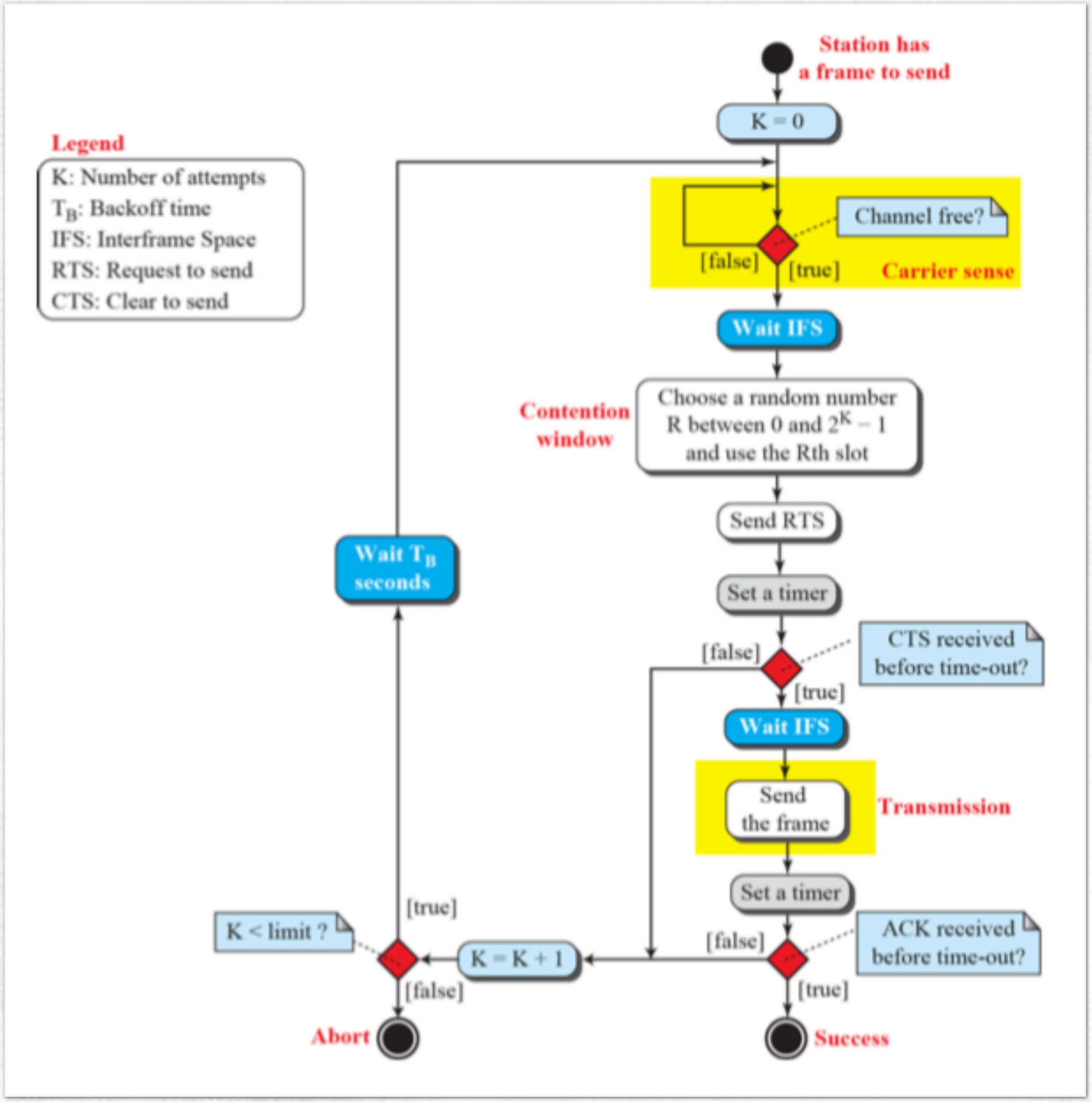
Flow diagram for the CSMA/CD



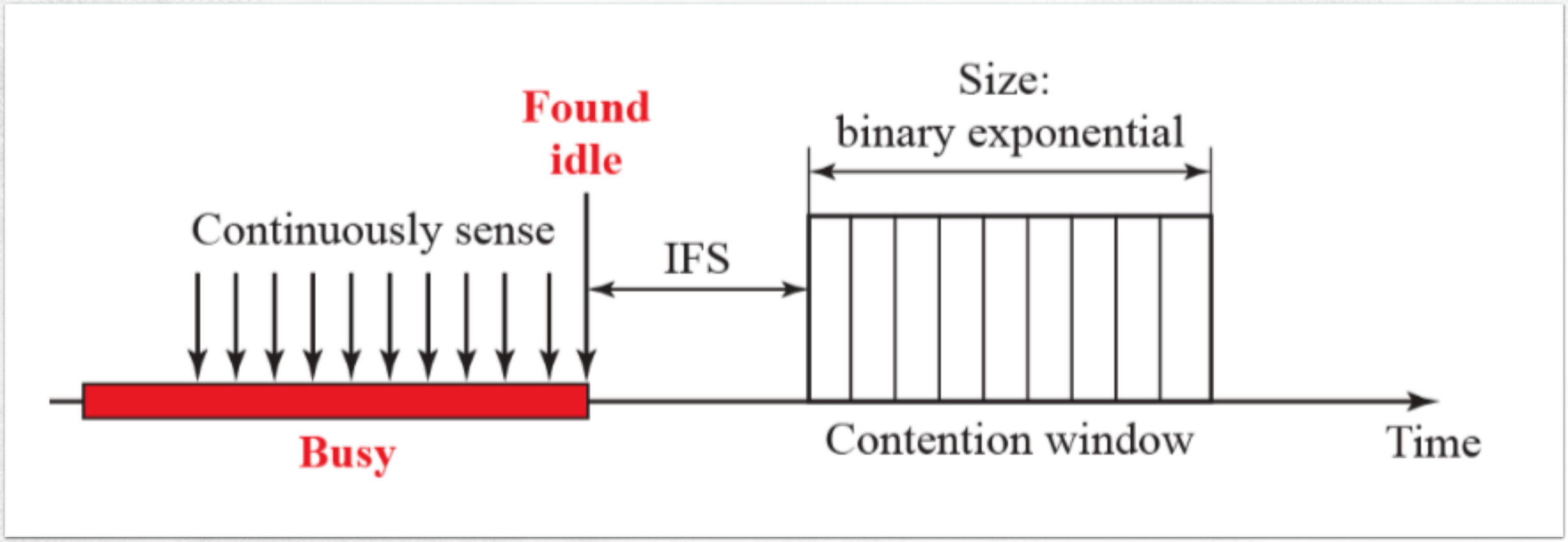
CSMA/CA

- Carrier sense multiple access with collision avoidance (CSMA/CA) was invented for wireless networks.
- Collisions are avoided through the use of CSMA/ CA's three strategies: the inter-frame space, the contention window, and acknowledgments.
- We discuss RTS and CTS frames later.

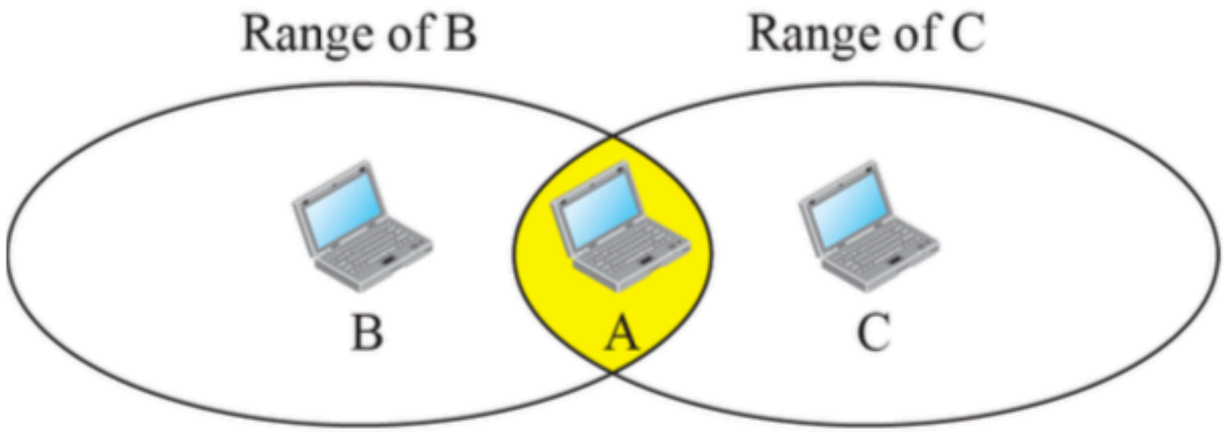
Flow diagram for CSMA/CA



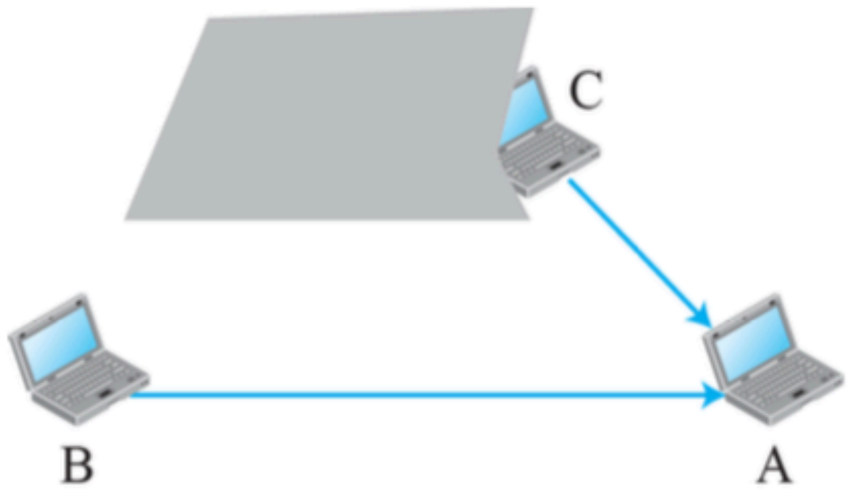
Contention window



Hidden station problem

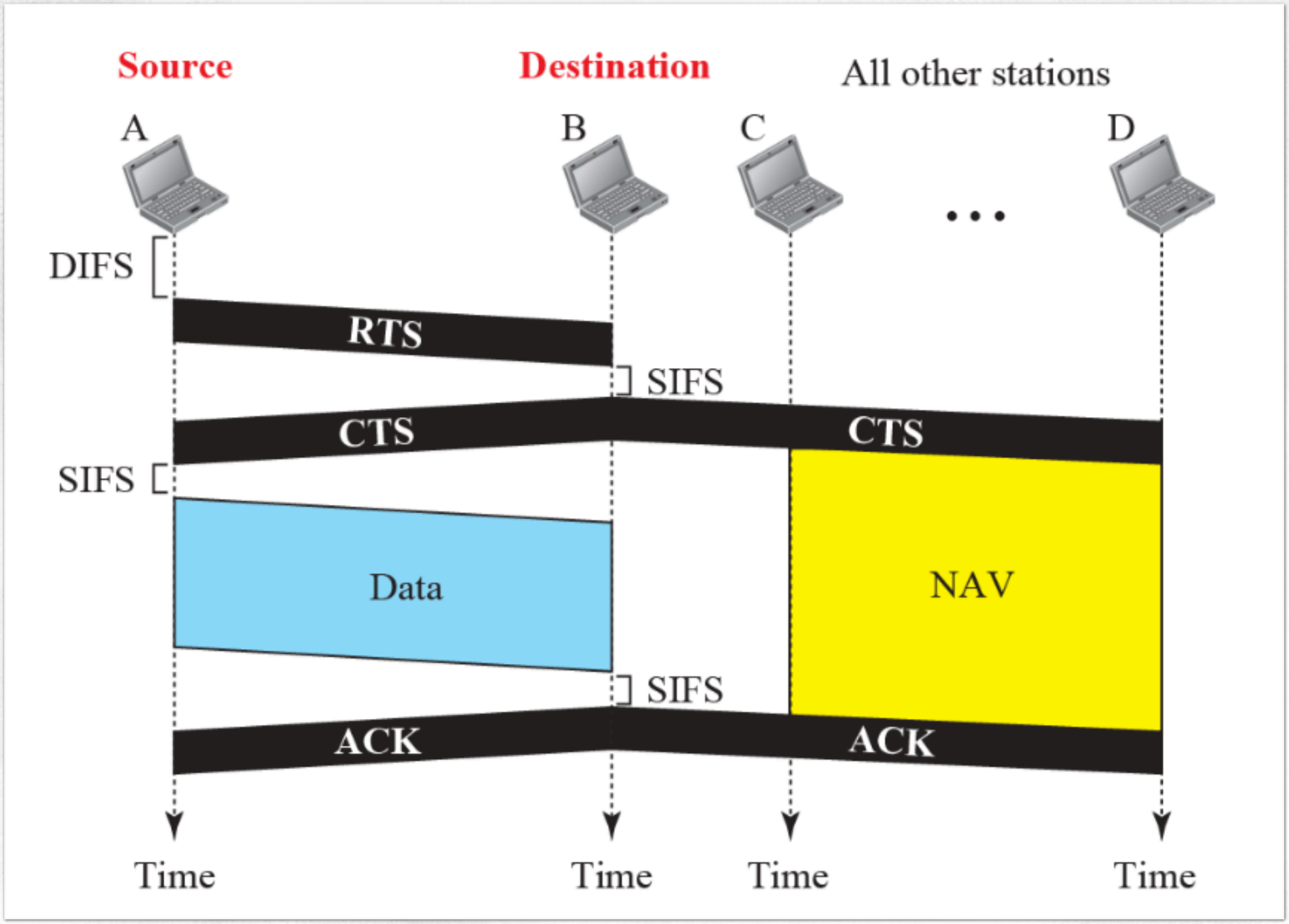


a. Stations B and C are not in each other's range.



b. Stations B and C are hidden from each other.

CSMA/CA and NAV



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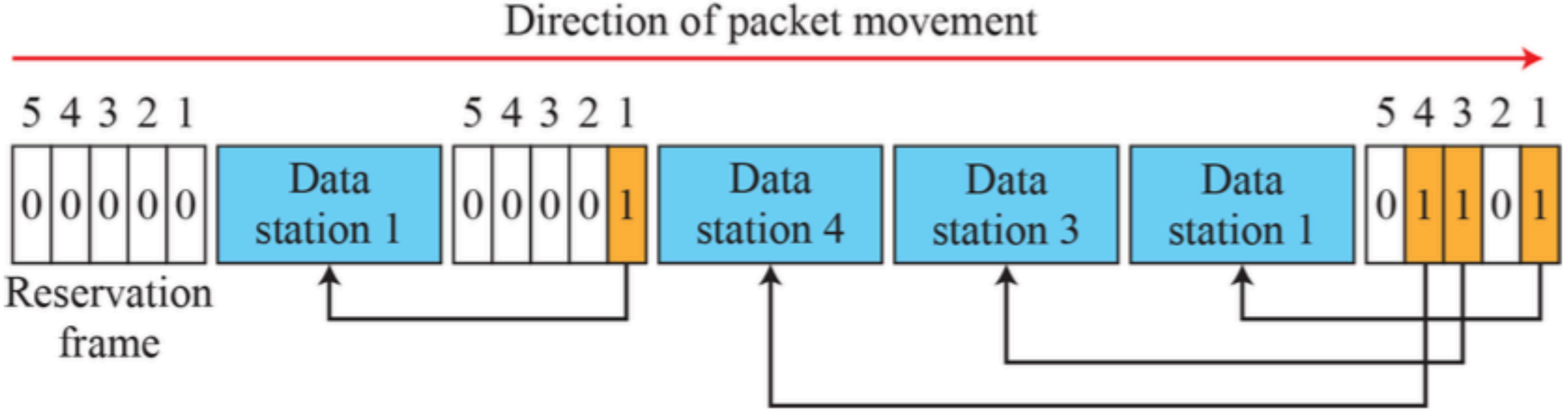
Concept

- 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.
- We discuss three controlled-access methods.

Reservation

- In the reservation method, 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.

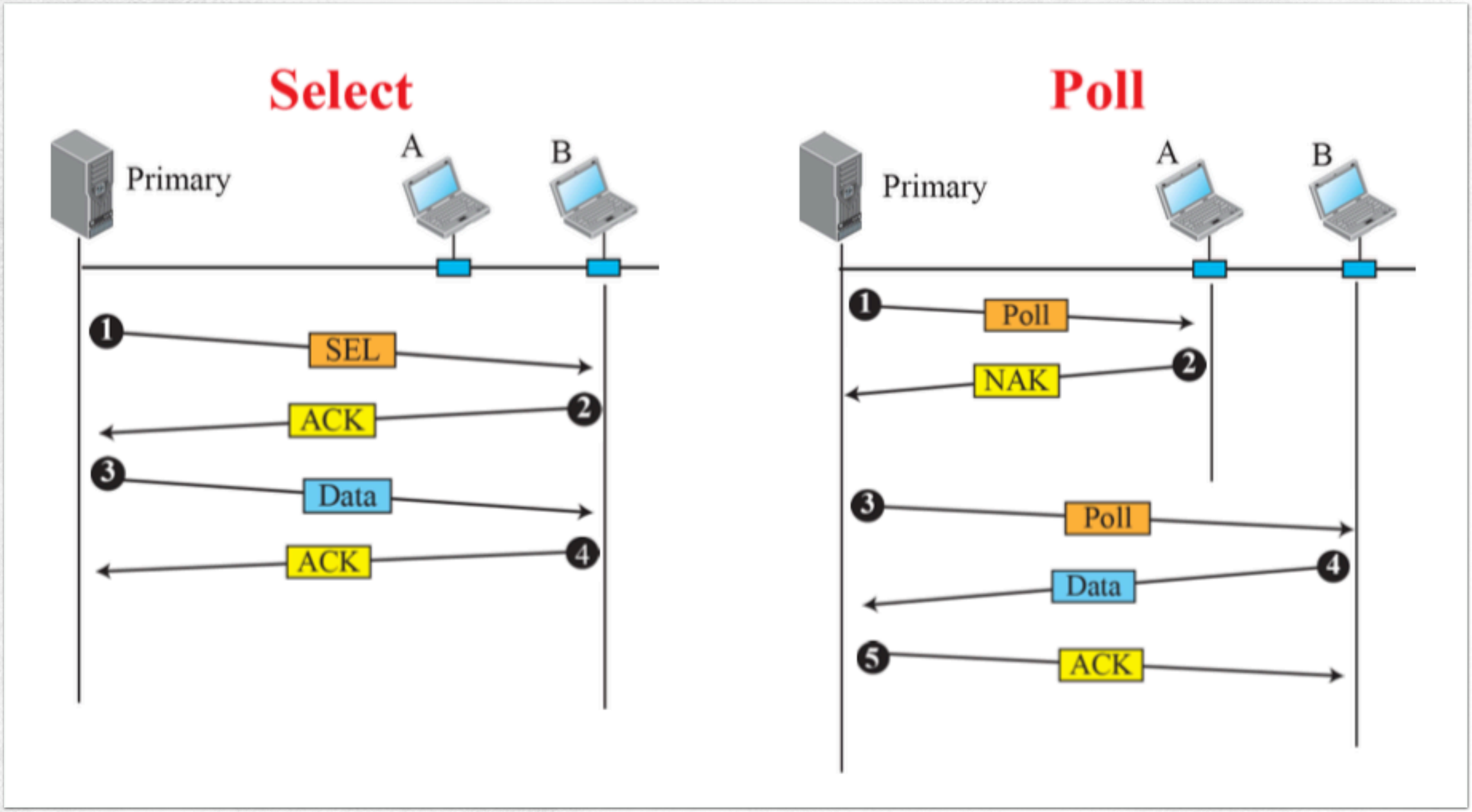
Reservation access method



Polling

- Polling works with topologies in which one device is designated as a primary station and the other devices are secondary stations.
- All data exchanges must be made through the primary device even when the ultimate destination is a secondary device.
- The primary device controls the link; the secondary devices follow its instructions.
- It is up to the primary device to determine which device is allowed to use the channel at a given time.

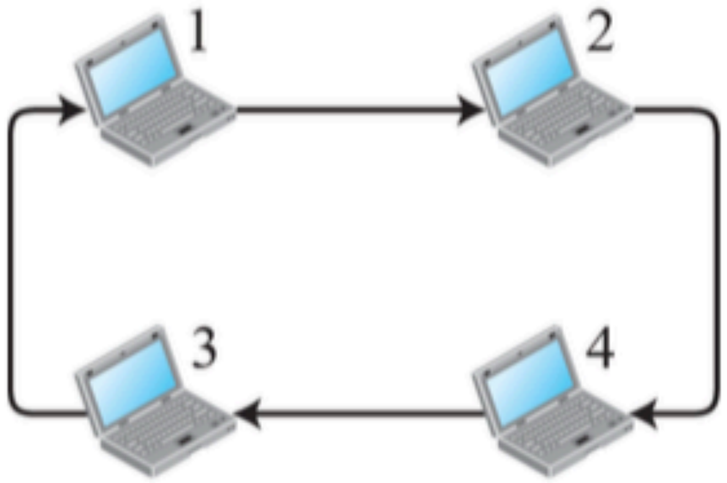
Select and poll functions in polling-access method



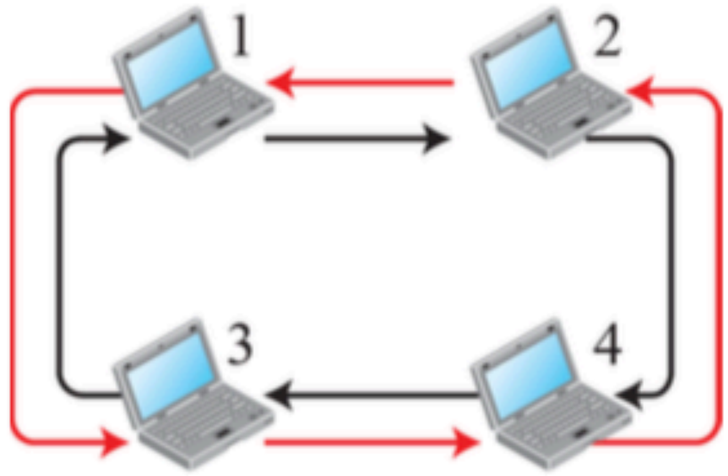
Token Passing

- In the token-passing method, the stations in a network are organized in a logical ring.
- In other words, for each station, there is a predecessor and a successor.
- The predecessor is the station which is logically before the station in the ring; the successor is the station which is after the station in the ring.

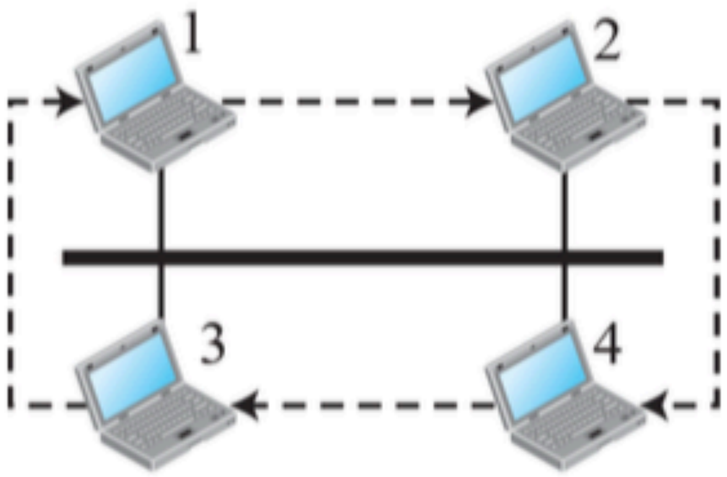
Logical ring and physical topology



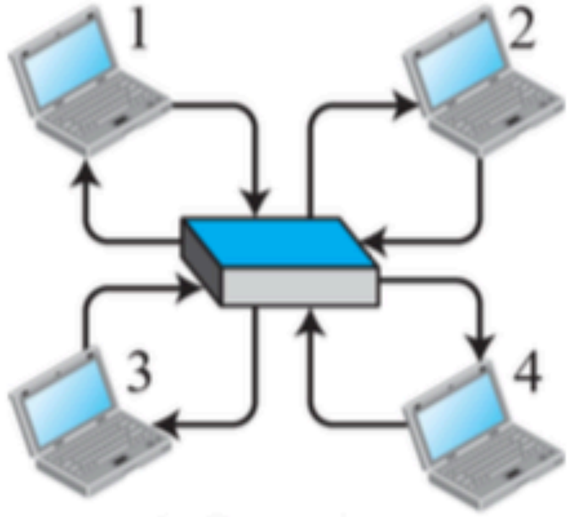
a. Physical ring



b. Dual ring



c. Bus ring



d. Star ring

Contents

- Basic Terminologies
- MAC Overview
- Random Access Protocols
- Controlled Access Protocols
- **Channelization Protocols**

Concept

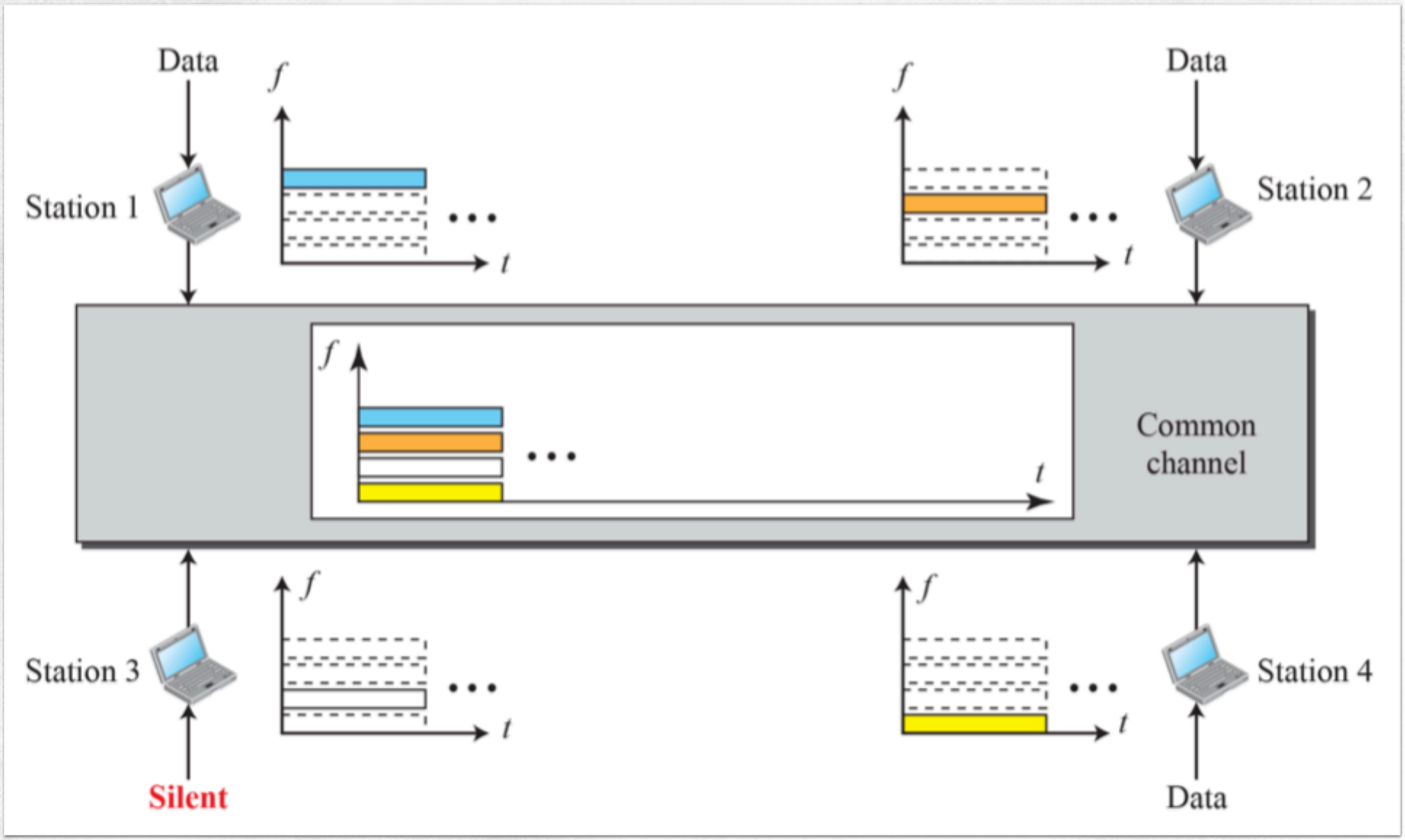
- Channelization (or channel partition, as it is sometimes called) is a multiple-access method in which the available bandwidth of a link is shared in time, frequency, or through code, among different stations.
- In this section, we discuss three protocols: FDMA, TDMA, and CDMA.

FDMA

- In frequency-division multiple access (FDMA), the available bandwidth is divided into frequency bands.
- Each station is allocated a band to send its data.
- In other words, each band is reserved for a specific station, and it belongs to the station all the time.
- Each station also uses a bandpass filter to confine the transmitter frequencies.

Channelization Protocols

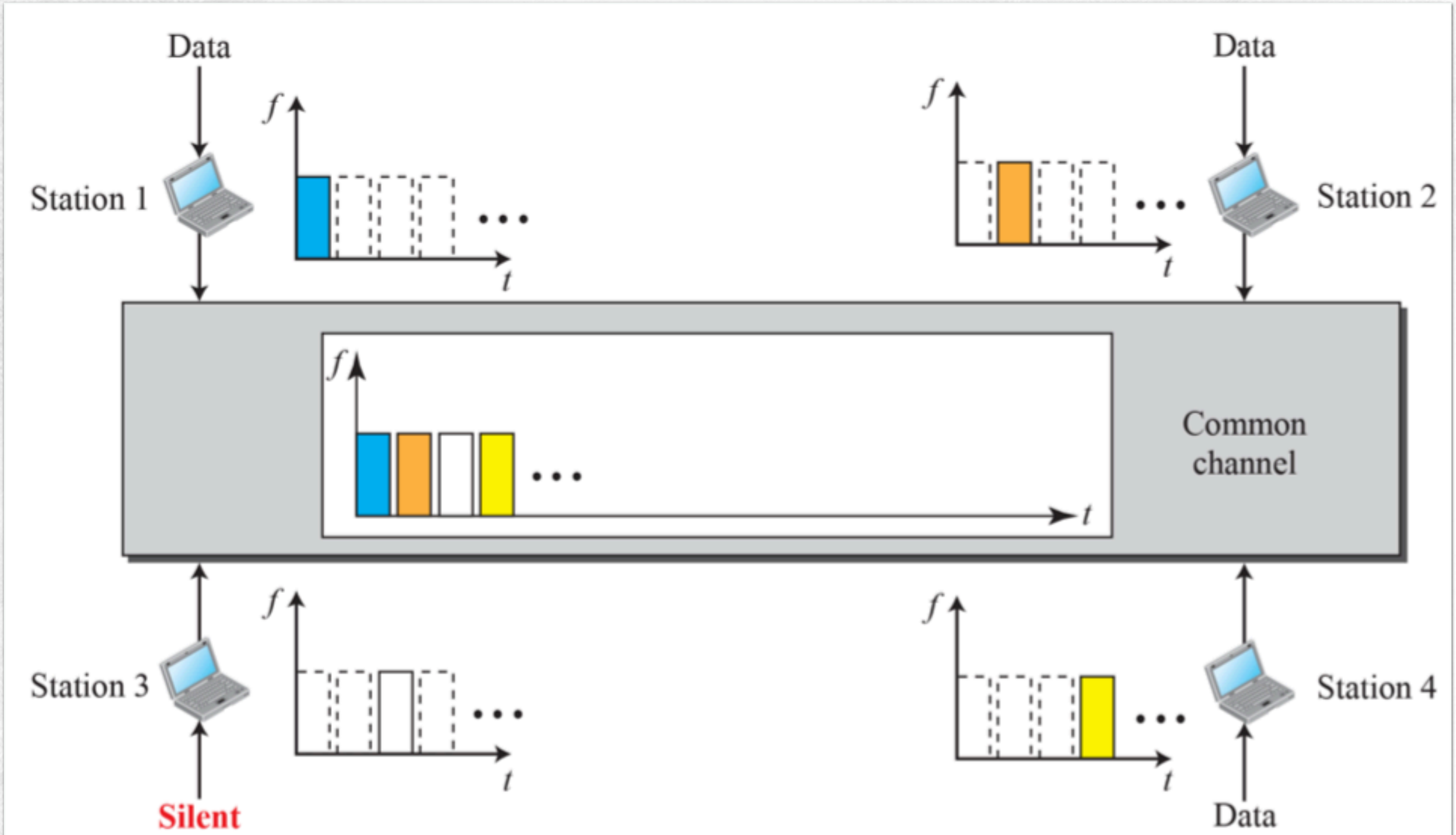
FDMA



TDMA

- In time-division multiple access (TDMA), the stations share the bandwidth of the channel in time.
- Each station is allocated a time slot during which it can send data.
- Each station transmits its data in its assigned time slot.

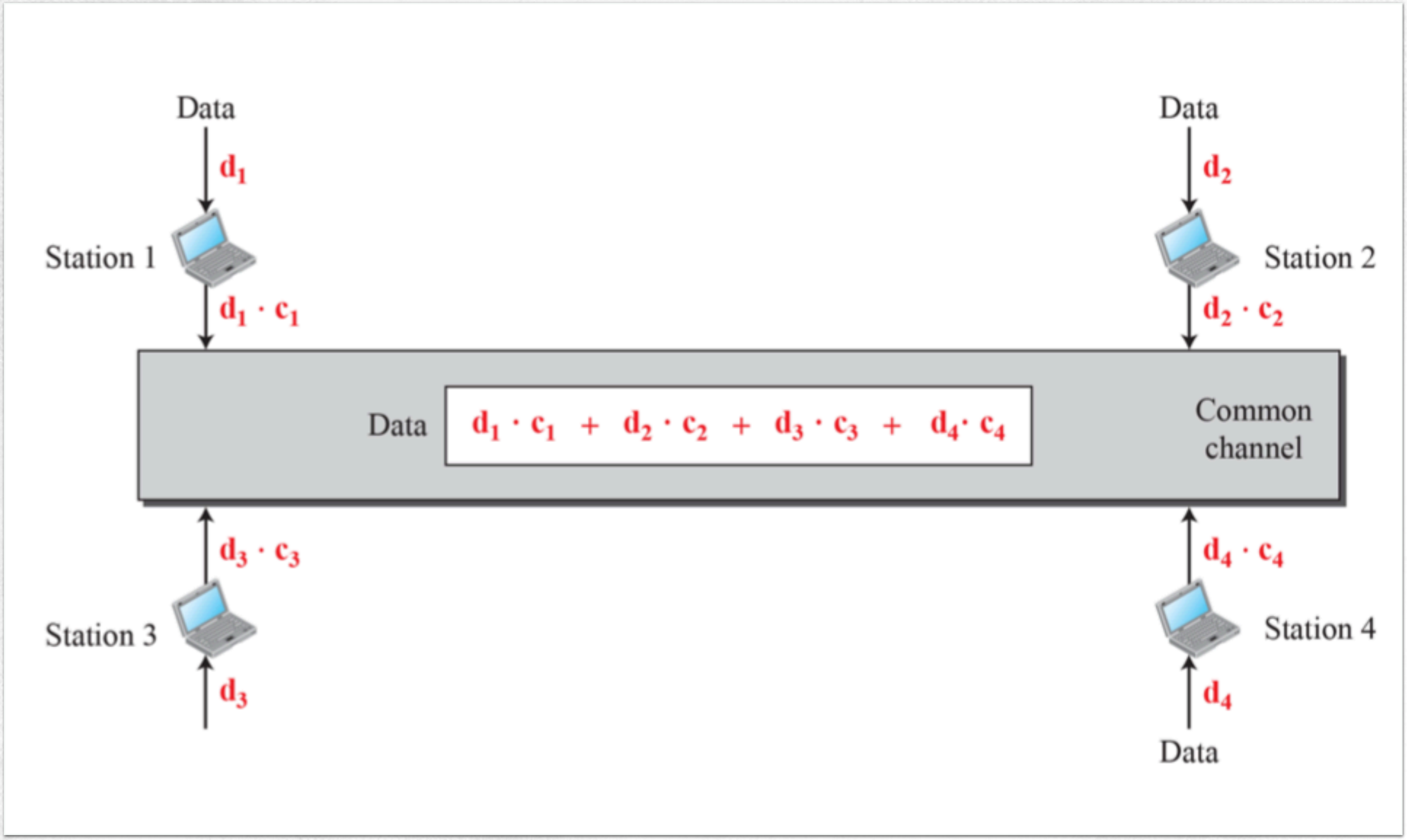
Time-division multiple access (TDMA)



CDMA

- Code-division multiple access (CDMA) was conceived several decades ago.
- Recent advances in electronic technology have finally made its implementation possible.
- CDMA differs from FDMA in that only one channel occupies the entire bandwidth of the link.
- It differs from TDMA in that all stations can send data simultaneously; there is no timesharing.

Simple idea of communication with code



Chip sequences

C_1

[+1 +1 +1 +1]

C_2

[+1 −1 +1 −1]

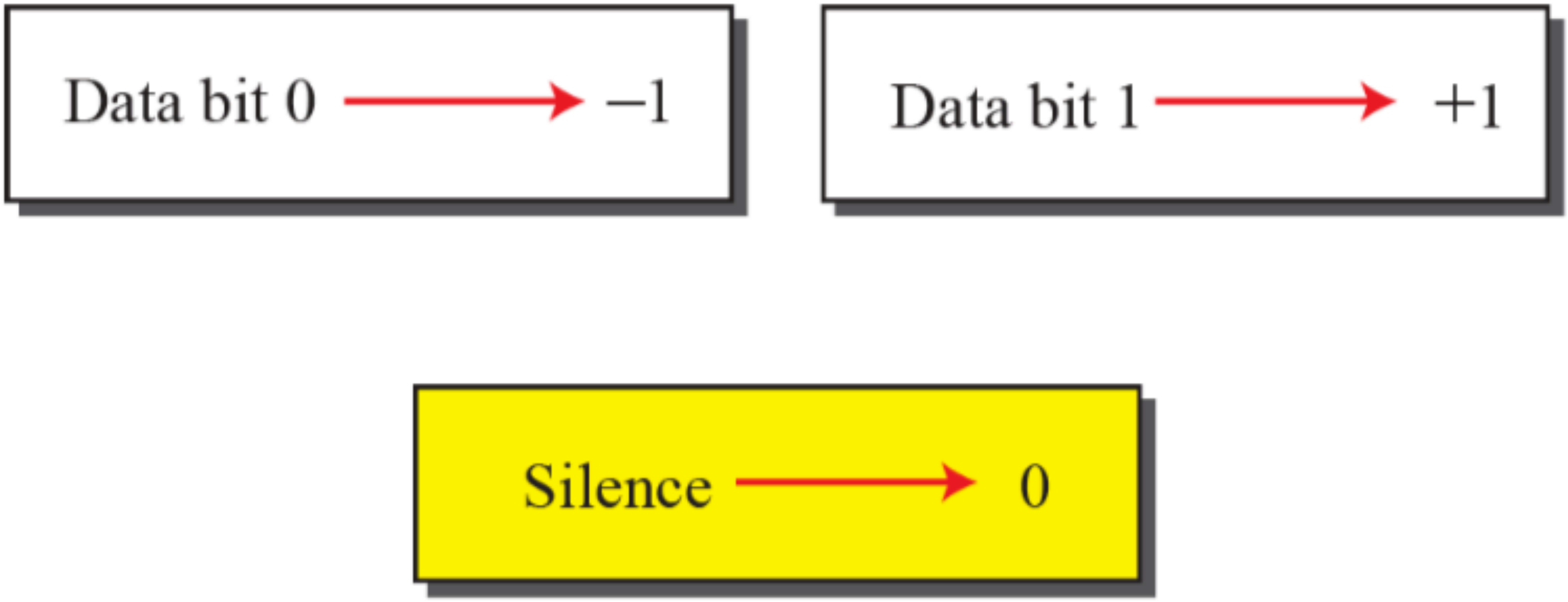
C_3

[+1 +1 −1 −1]

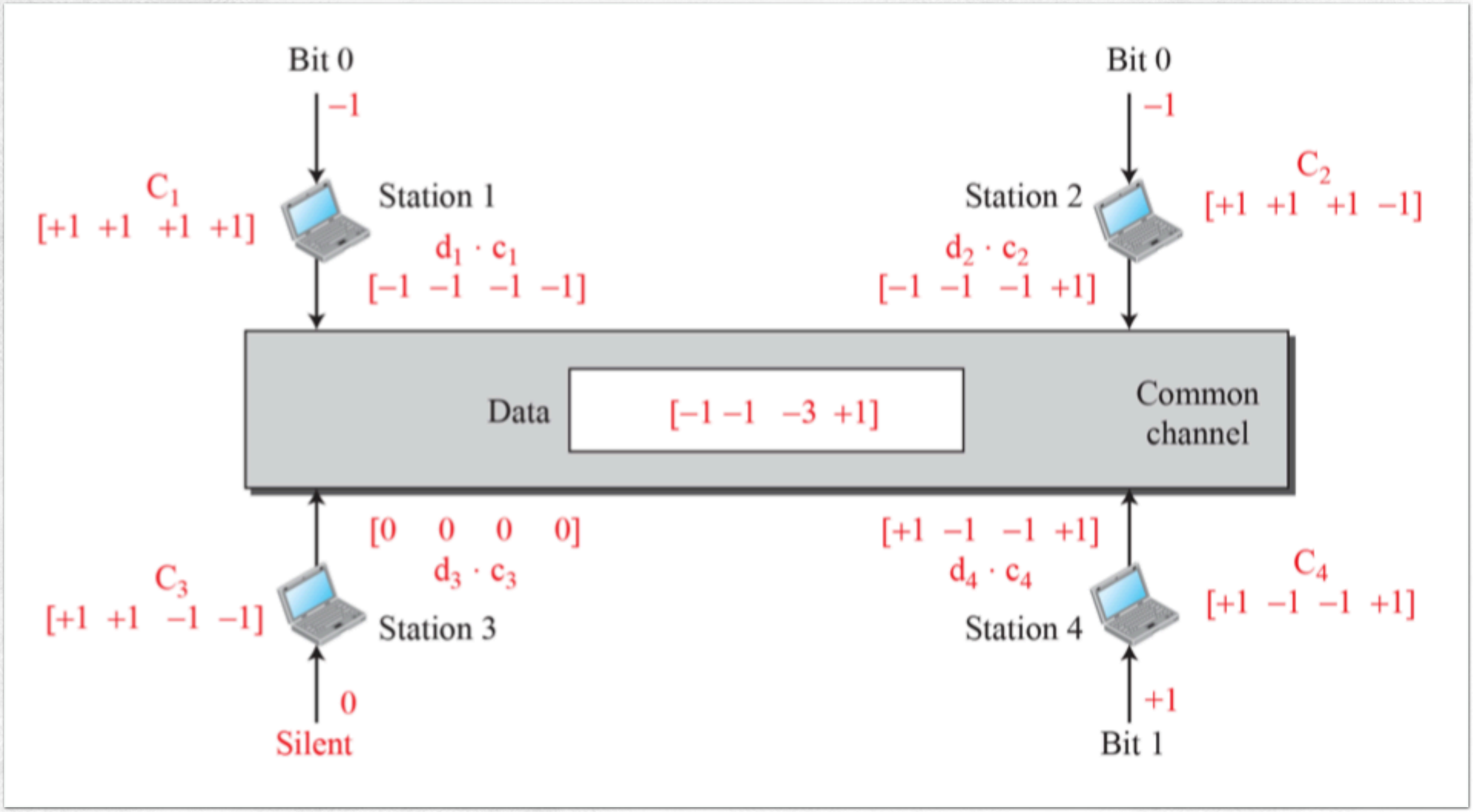
C_4

[+1 −1 −1 +1]

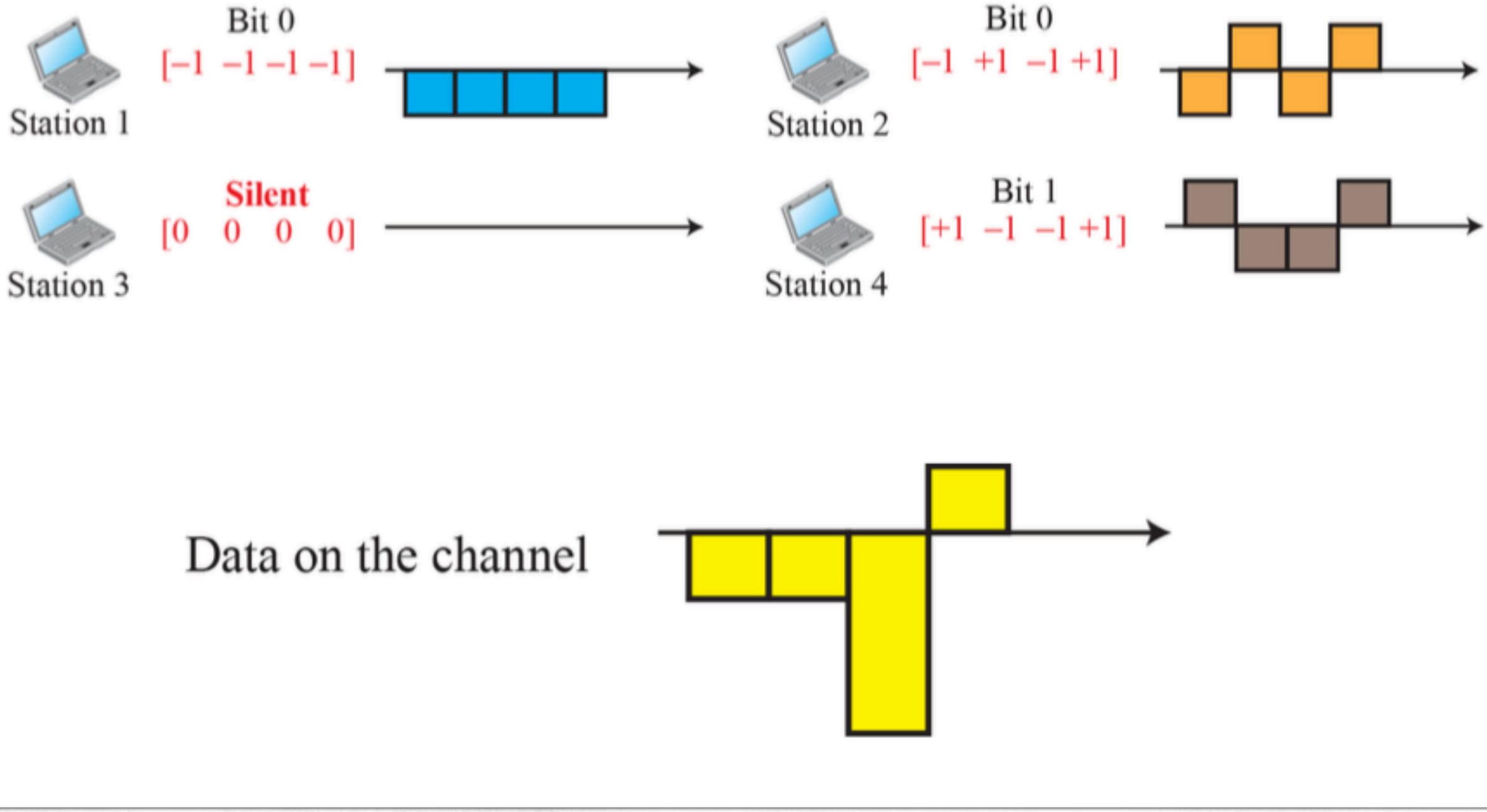
Data representation in CDMA



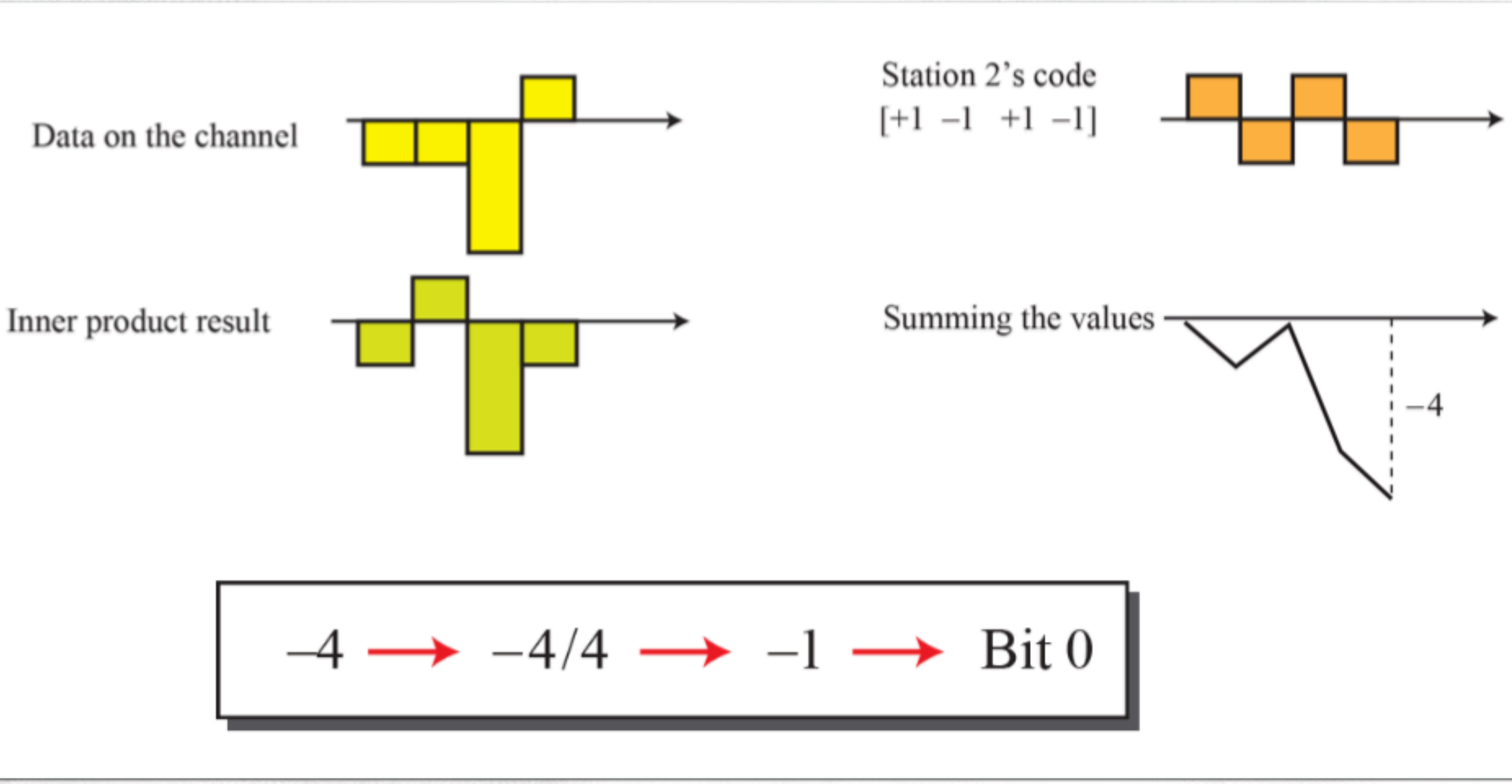
Sharing channel in CDMA



Digital signal created by four stations in CDMA



Decoding of the composite signal for one in CDMA



General rules and examples of creating Walsh tables

$$W_1 = [+1] \qquad W_{2N} = \begin{bmatrix} W_N & W_N \\ W_N & \overline{W_N} \end{bmatrix}$$

a. Two basic rules

$$W_2 = \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix} \qquad W_4 = \begin{bmatrix} +1 & +1 & +1 & +1 \\ +1 & -1 & +1 & -1 \\ +1 & +1 & -1 & -1 \\ +1 & -1 & -1 & +1 \end{bmatrix}$$

b. Generation of W_1, W_2, and W_4

Thank you

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