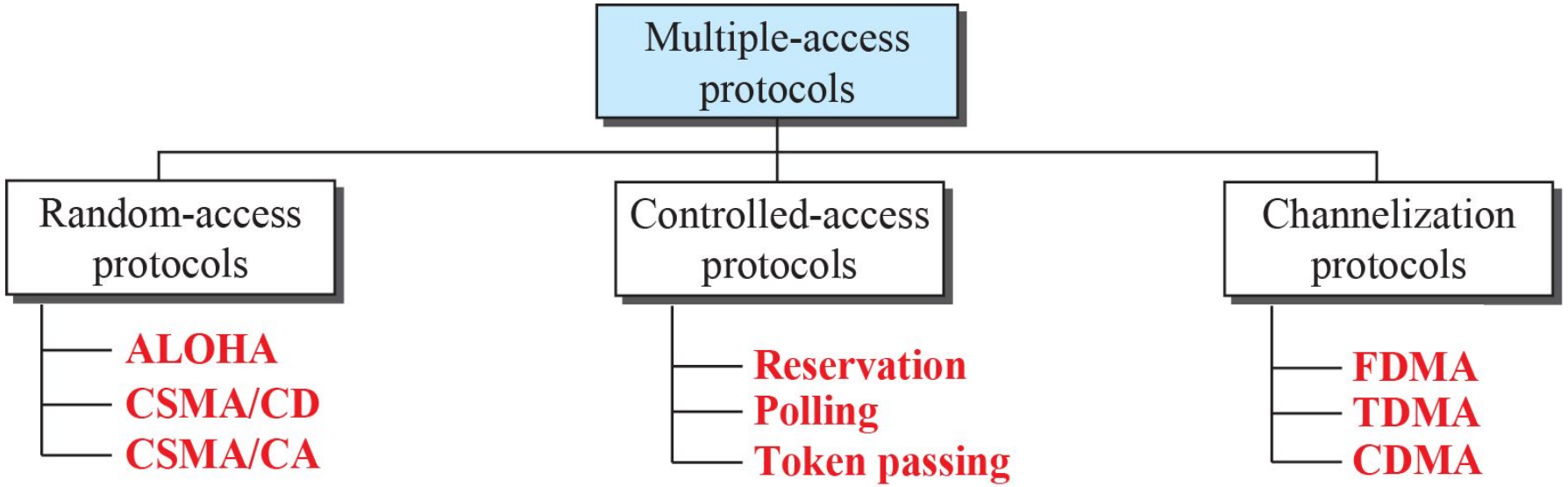
Data Link MAC Layer

Session Objectives

- Multiple Access Protocols
- Random Access Protocols
    - Pure ALOHA and Slotted ALOHA
    - CSMA/CD
    - CSMA/CA
- Controlled Access Protocols
    - Reservation
    - Polling
    - Token Passing
- Channelization Protocols
    - FDMA
    - TDMA
    - CDMA

Multiple Access Protocols

- Many protocols have been devised to handle access to a shared link. These are called MAC protocols.
- Categories: Random-access, controlled-access and channelization protocols



RANDOM ACCESS

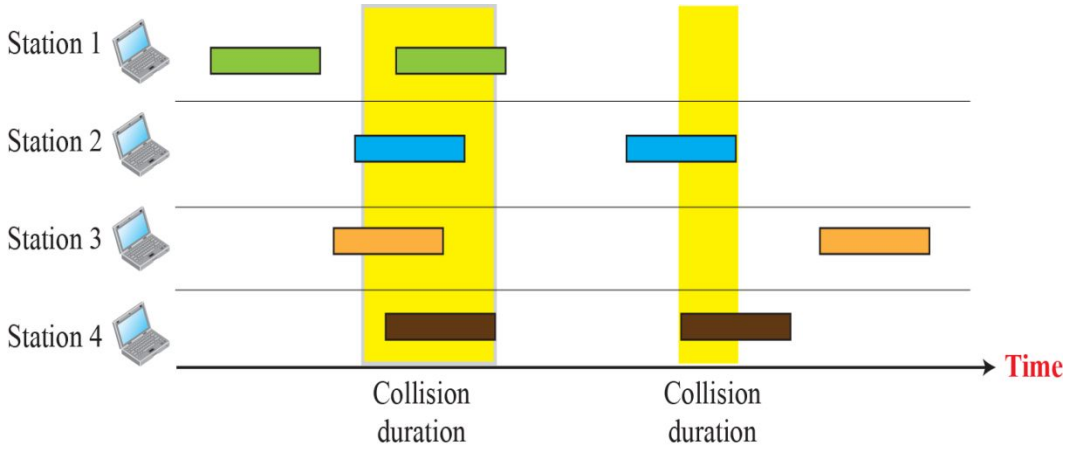
- In random-access or contention **no station is superior** to another station and none is assigned control over another.
- At each instance, a station that has data to send uses a procedure defined by the protocol to make a decision on whether or not to send.
- This decision depends on the state of the medium (idle or busy).

Examples: PURE ALOHA , SLOTTED ALOHA, CSMA/CD and CSMA/CA

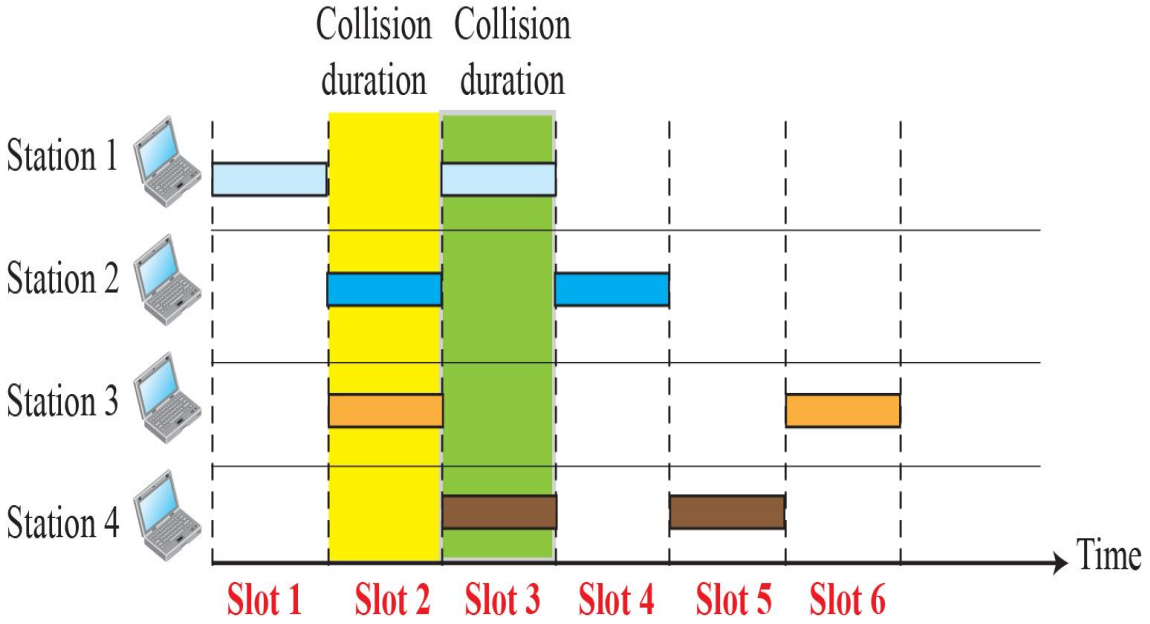
ALOHA Protocol

- ALOHA, the earliest random access method, 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 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.

Pure ALOHA and Slotted ALOHA Protocol



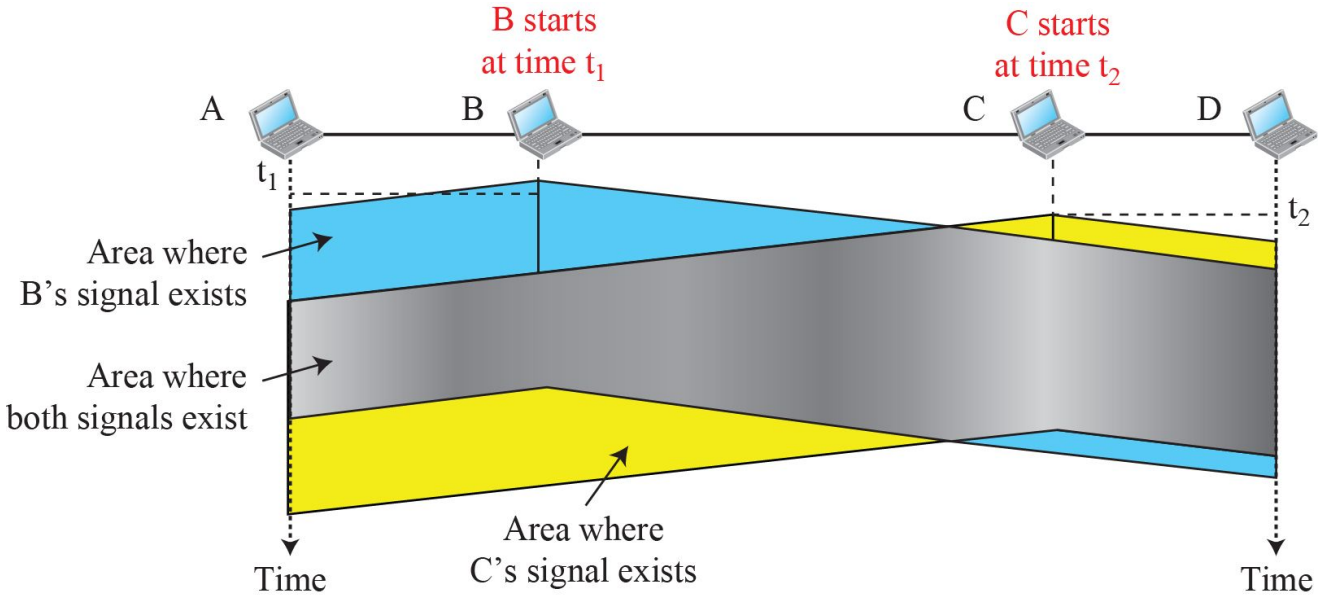
Pure ALOHA network



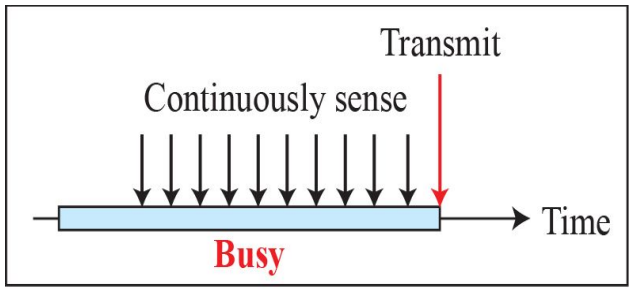
Slotted ALOHA network

Carrier Sense Multiple Access (CSMA) Protocol

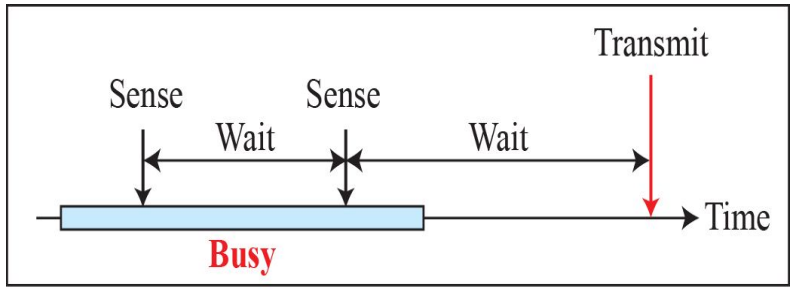
- To **minimize** the chance of **collision** and, therefore, increase the performance, the CSMA method was developed.
- Carrier sense multiple access (CSMA) requires that each station **first listen (sense) to the medium** before sending.
- In other words, CSMA is based on the principle "sense before transmit" or "listen before talk."



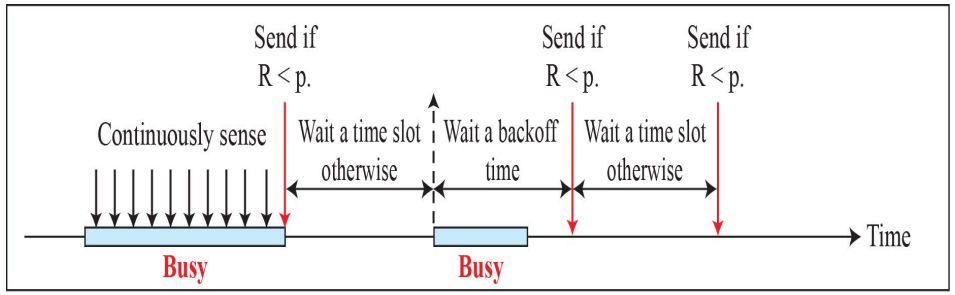
CSMA persistence methods



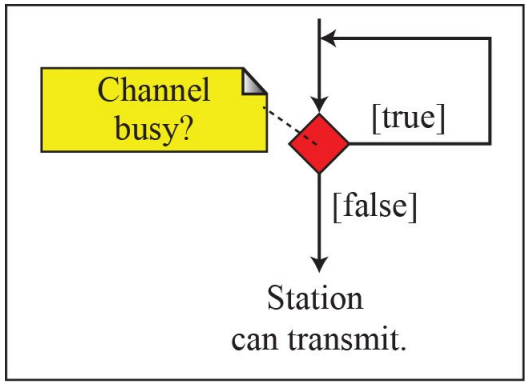
a. 1-persistent



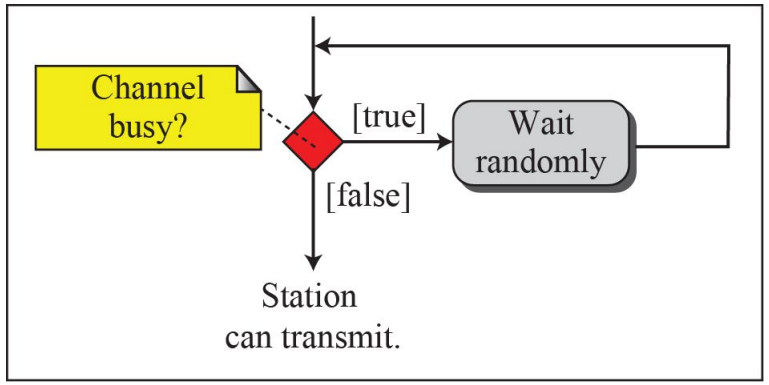
b. Nonpersistent



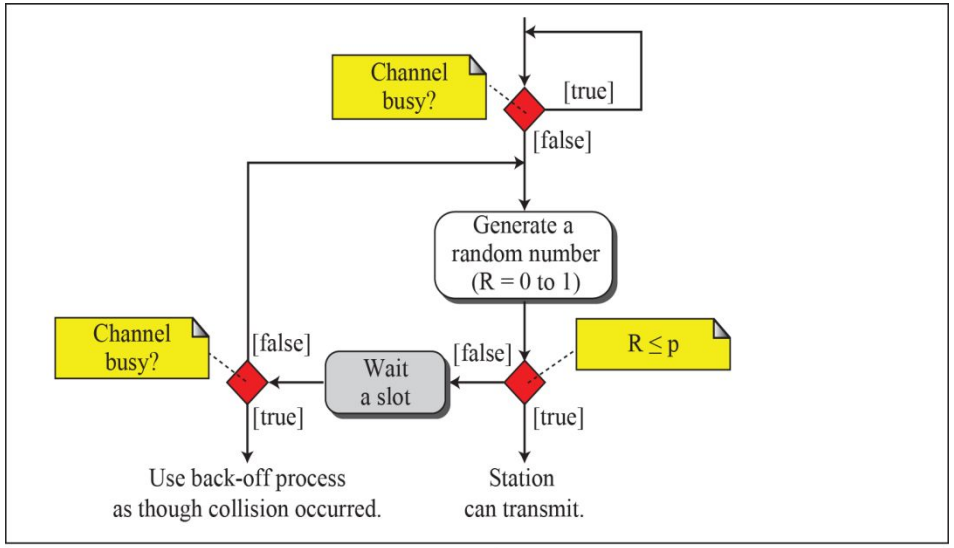
c. *p*-persistent



a. 1-persistent



b. Nonpersistent

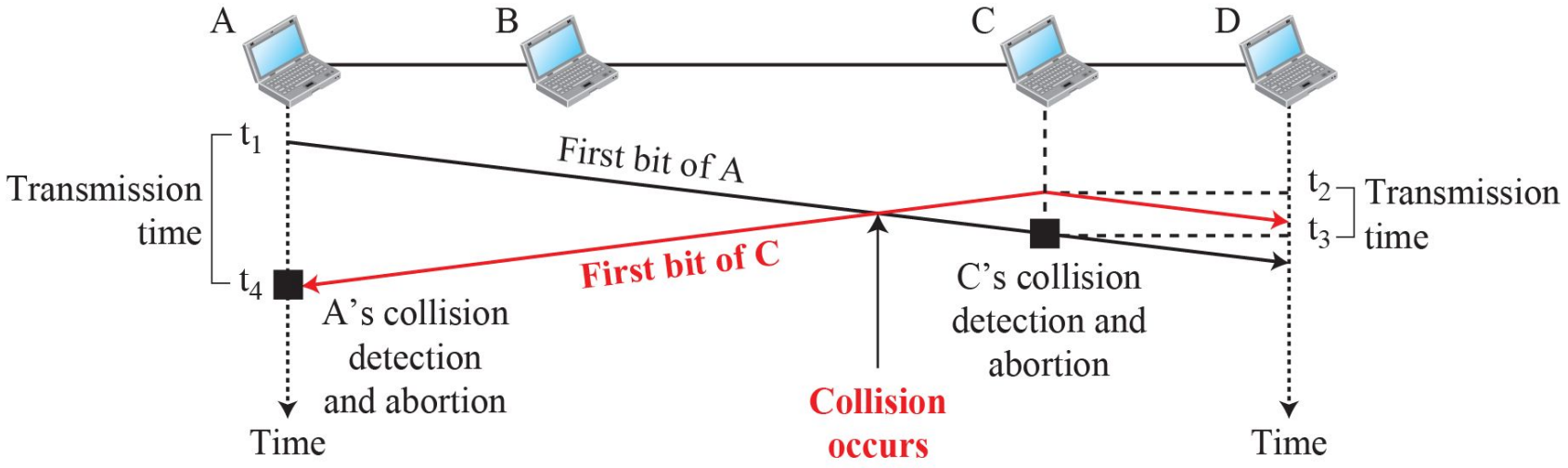


c. *p*-persistent

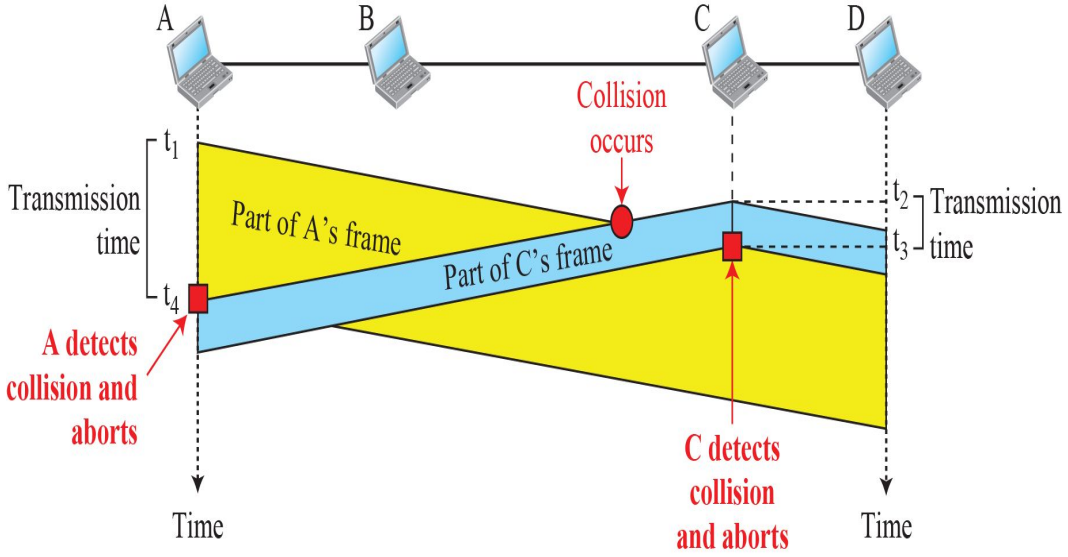
CSMA/CD Protocol

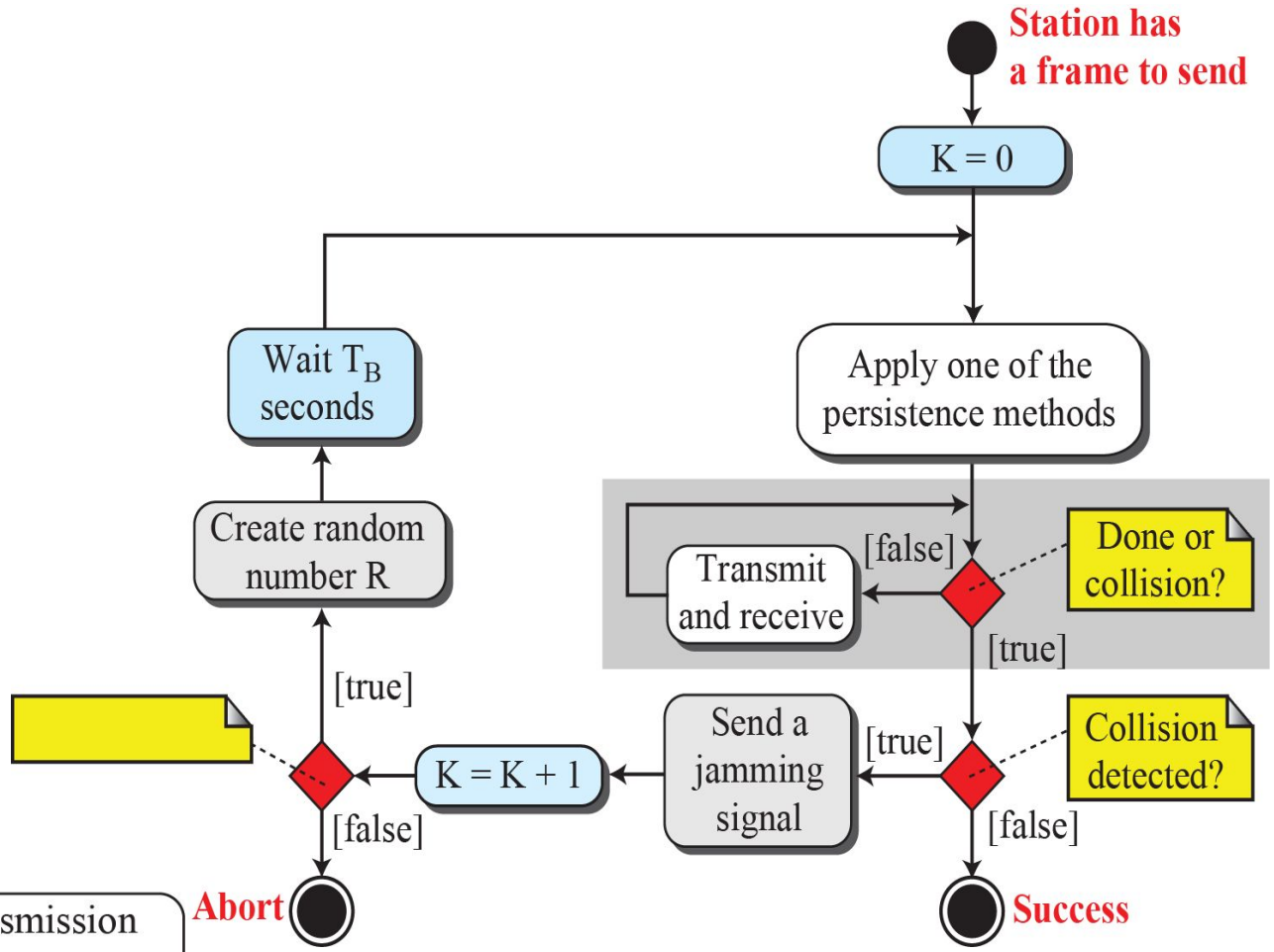
- The CSMA method does not specify the procedure following a collision. Carrier sense multiple access with collision detection (CSMA/CD) augments the algorithm to handle the collision.

- 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.



CSMA/CD Collision Abortion



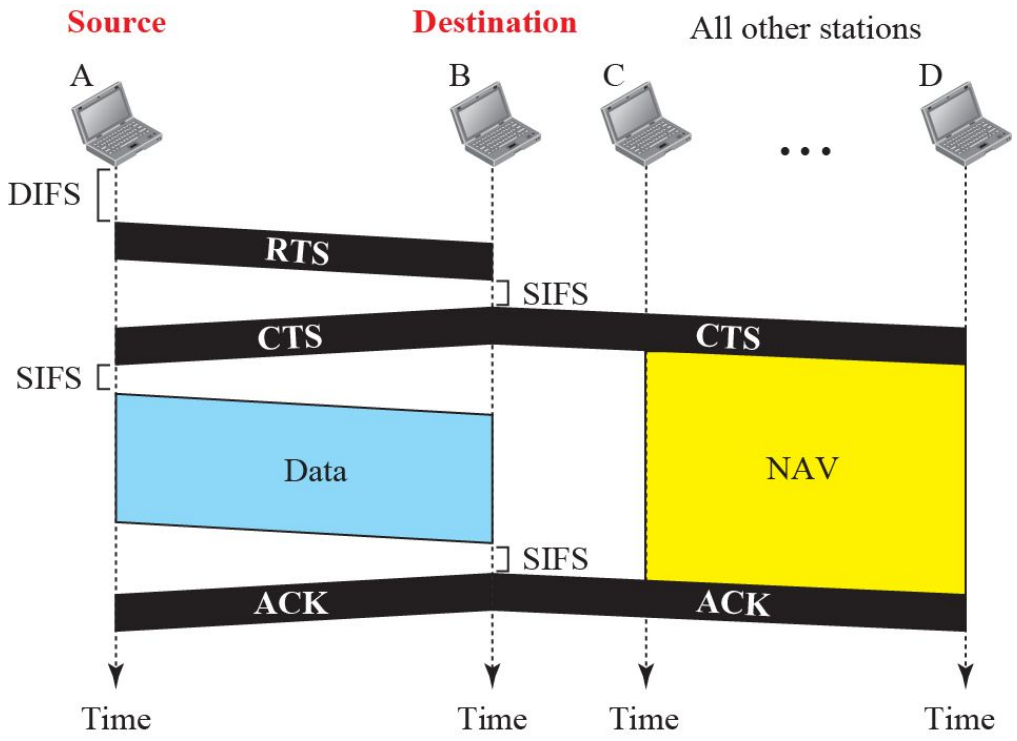


Legend

T_{fr}: Frame average transmission time
K : Number of attempts
R : (random number): 0 to $2^K - 1$
T_B: (Back-off time) = $R \times T_{fr}$

CSMA/CA Protocol

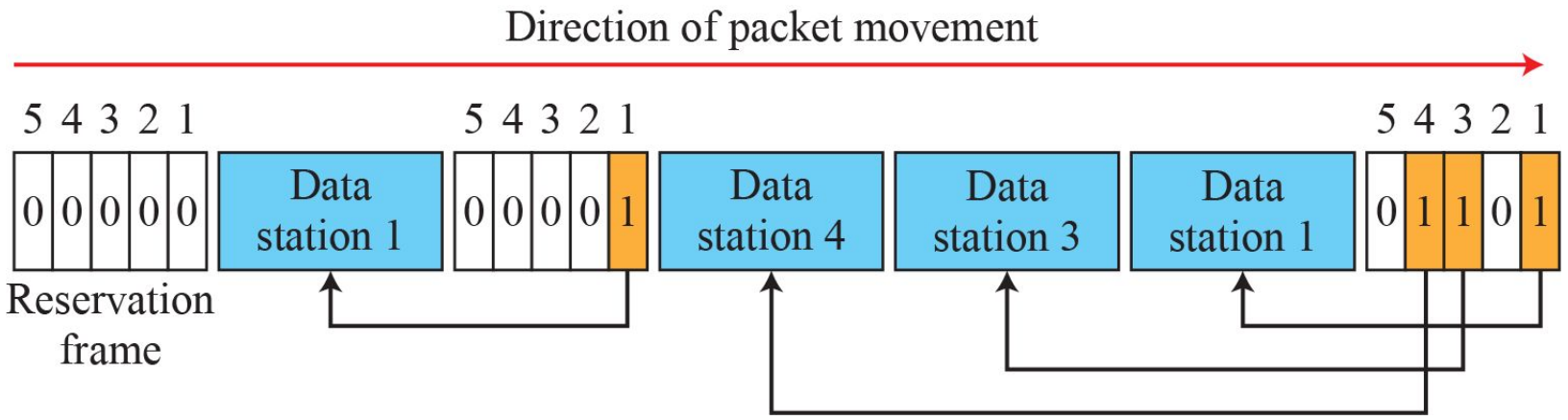
- Carrier sense multiple access with collision avoidance (CSMA/CA) was invented for wireless networks.
- Collisions are avoided through the use of CSMA/CA's **three strategies**: the inter frame space, the contention window, and acknowledgments.



Controlled Access Protocol

Reservation

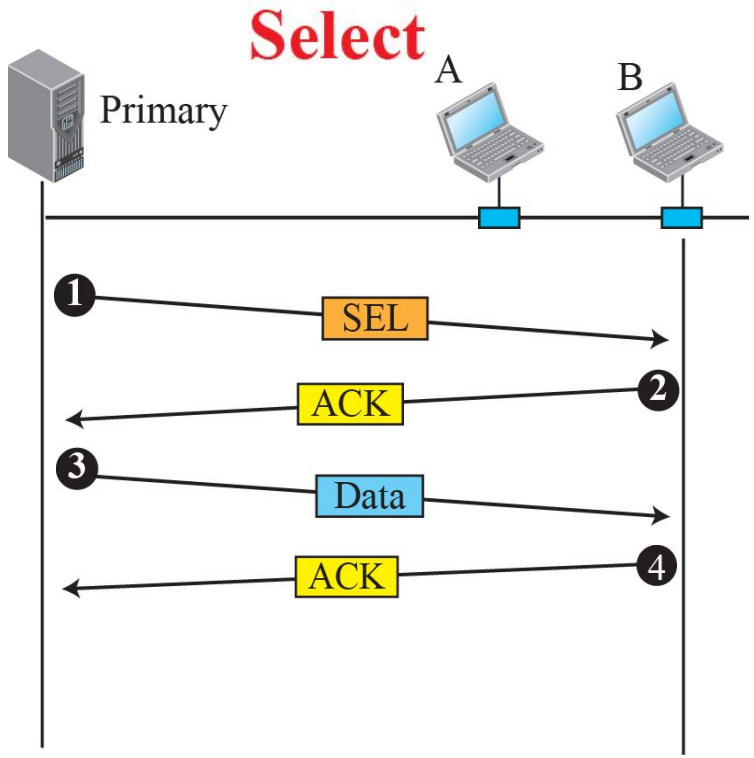
- In the reservation method, a station needs to make a reservation before sending data.
- Time is divided into intervals.
- In each interval, a reservation frame precedes the data frames sent in that interval.

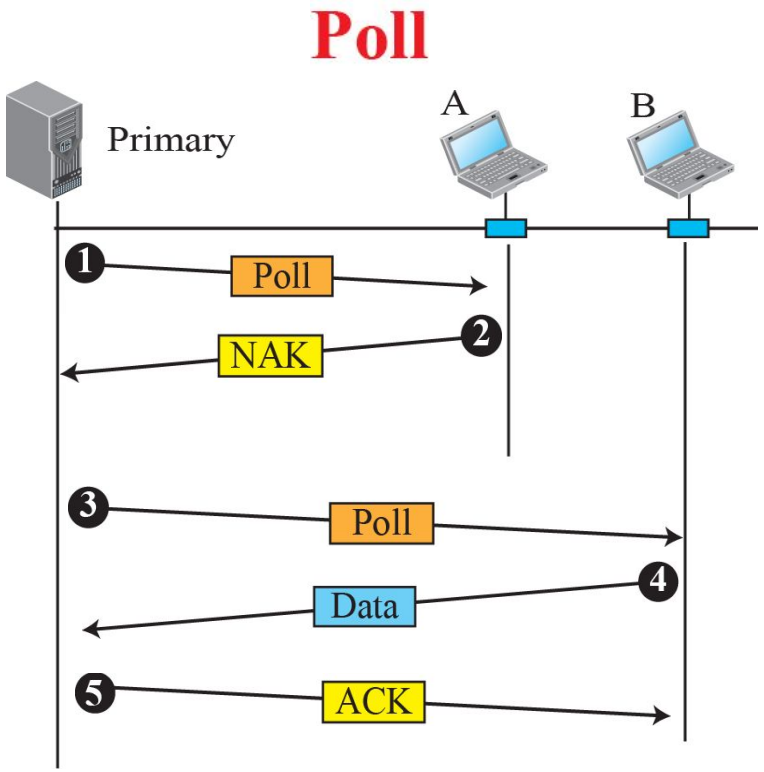


Controlled Access Protocol

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.

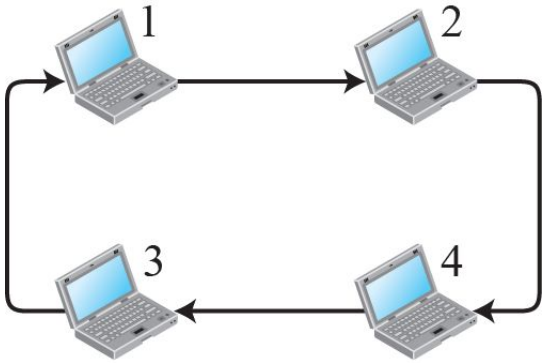




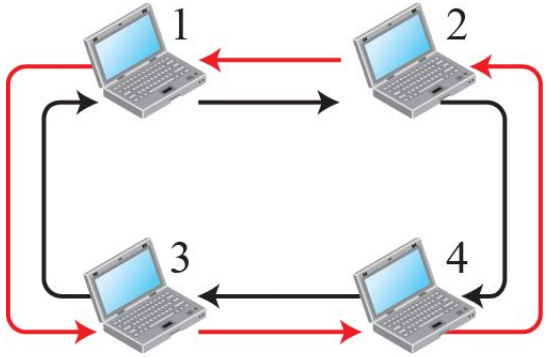
Controlled Access Protocol

Token Passing

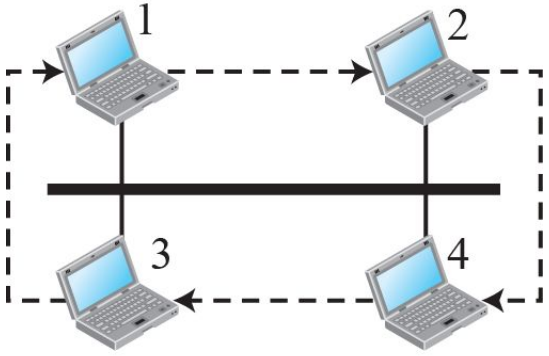
- In the token-passing method, the stations in a network are organized in a logical ring. In other words, for each station, there is a predecessor and a successor.
- The predecessor is the station which is logically before the station in the ring; the successor is the station which is after the station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



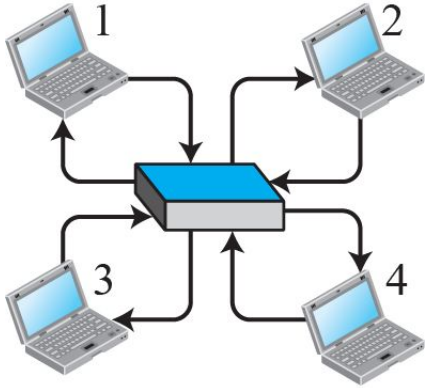
a. Physical ring



b. Dual ring



c. Bus ring



d. Star ring

Channelization Protocol

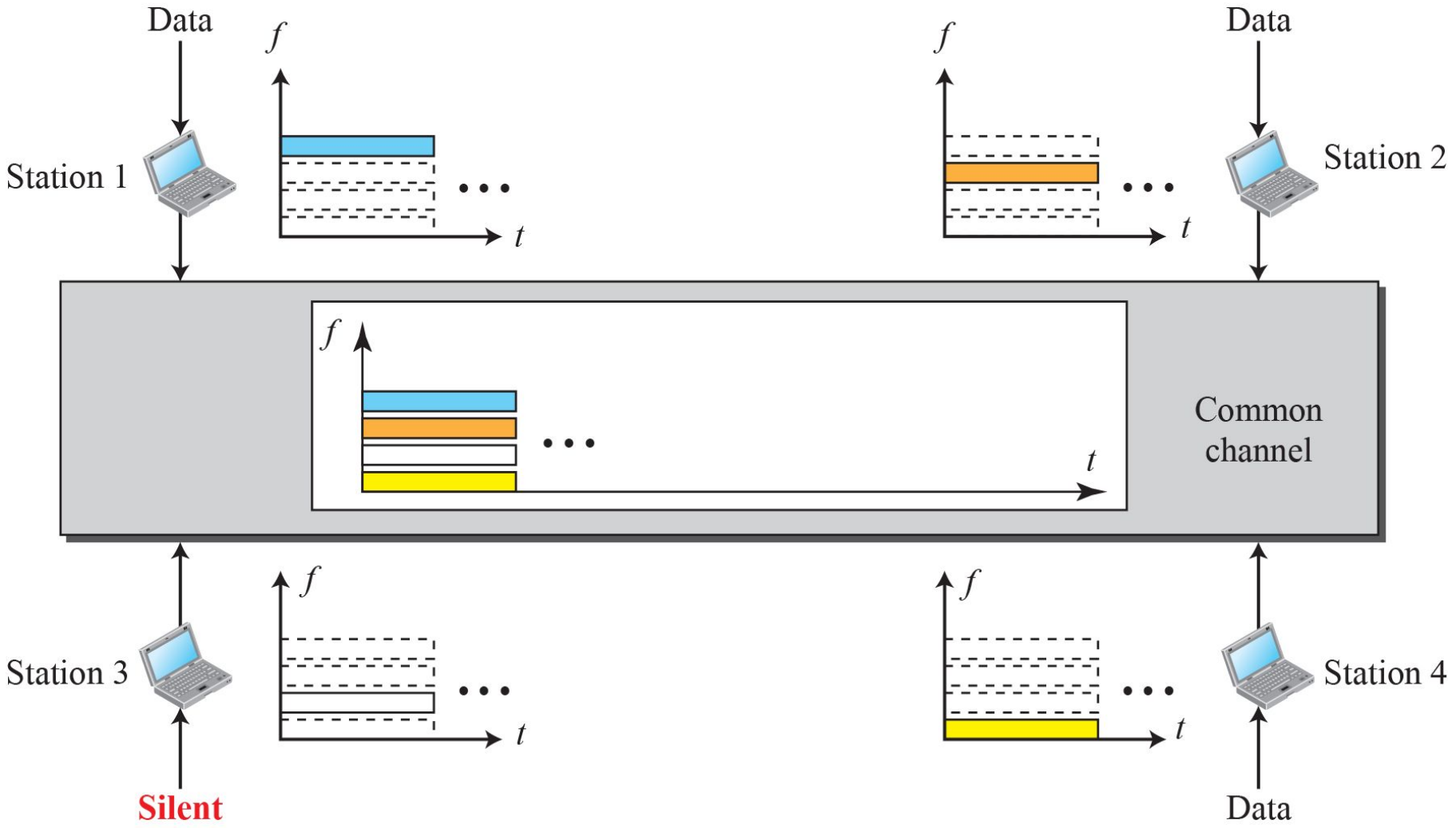
Channelization (or channel partition, as it is sometimes called) is a multiple-access method in which the available bandwidth of a link is shared in time, frequency, or through code, among different stations.

Example: 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.
- Each band is reserved for a specific station, and it belongs to the station all the time.
- Each station also uses a band pass filter to confine the transmitter frequencies.

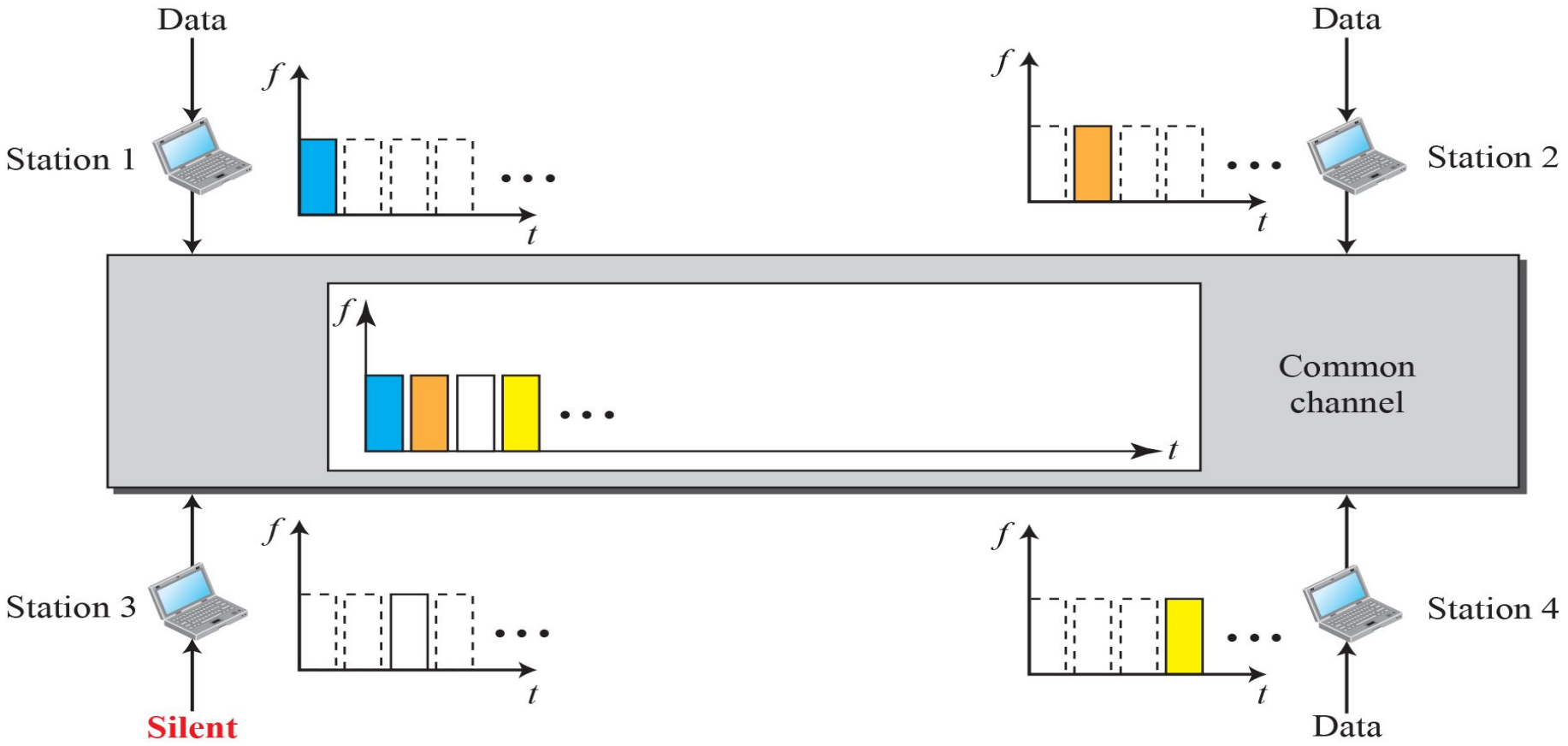
FDMA Protocol



TDMA Protocol

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.

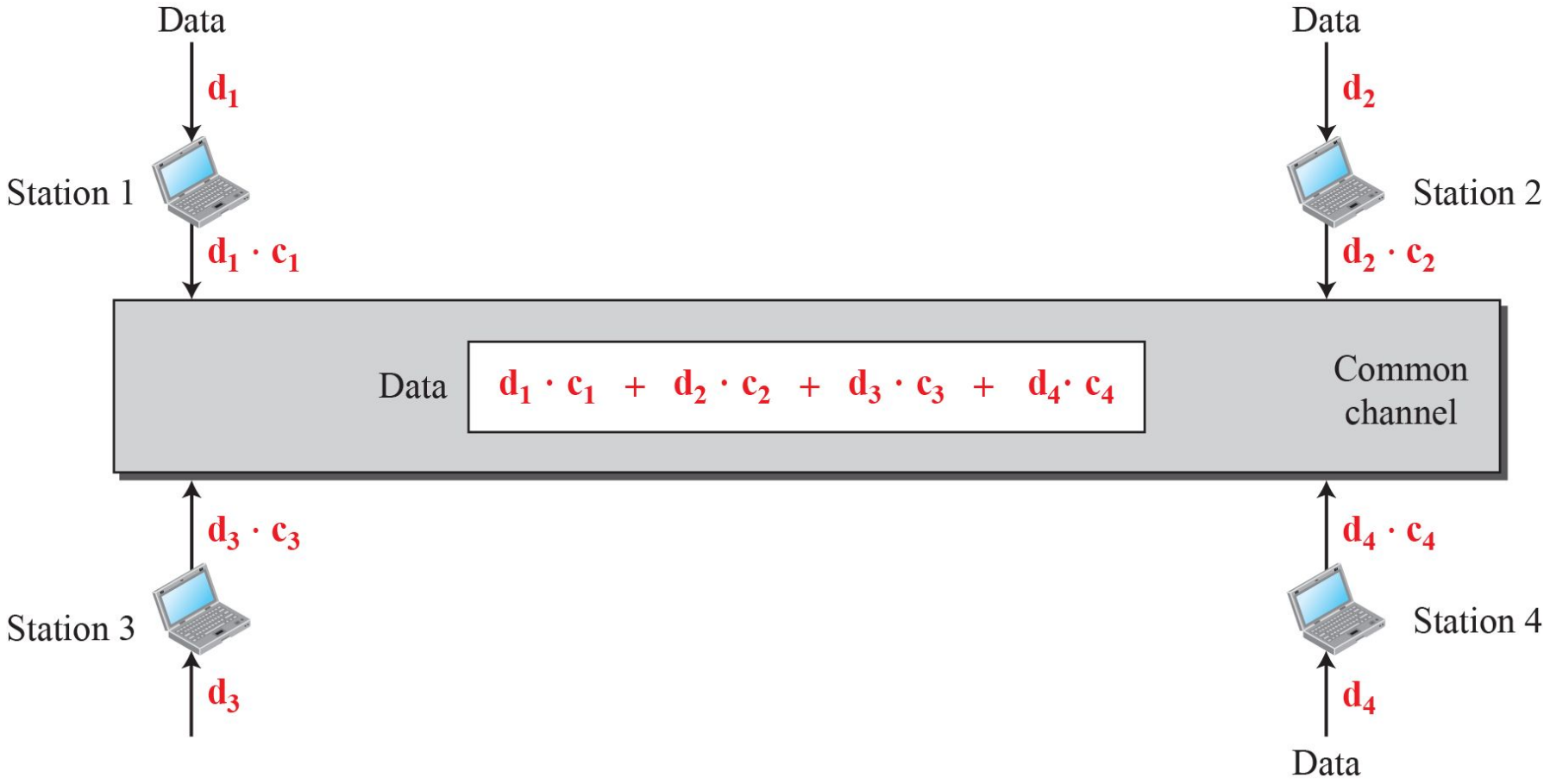


CDMA Protocol

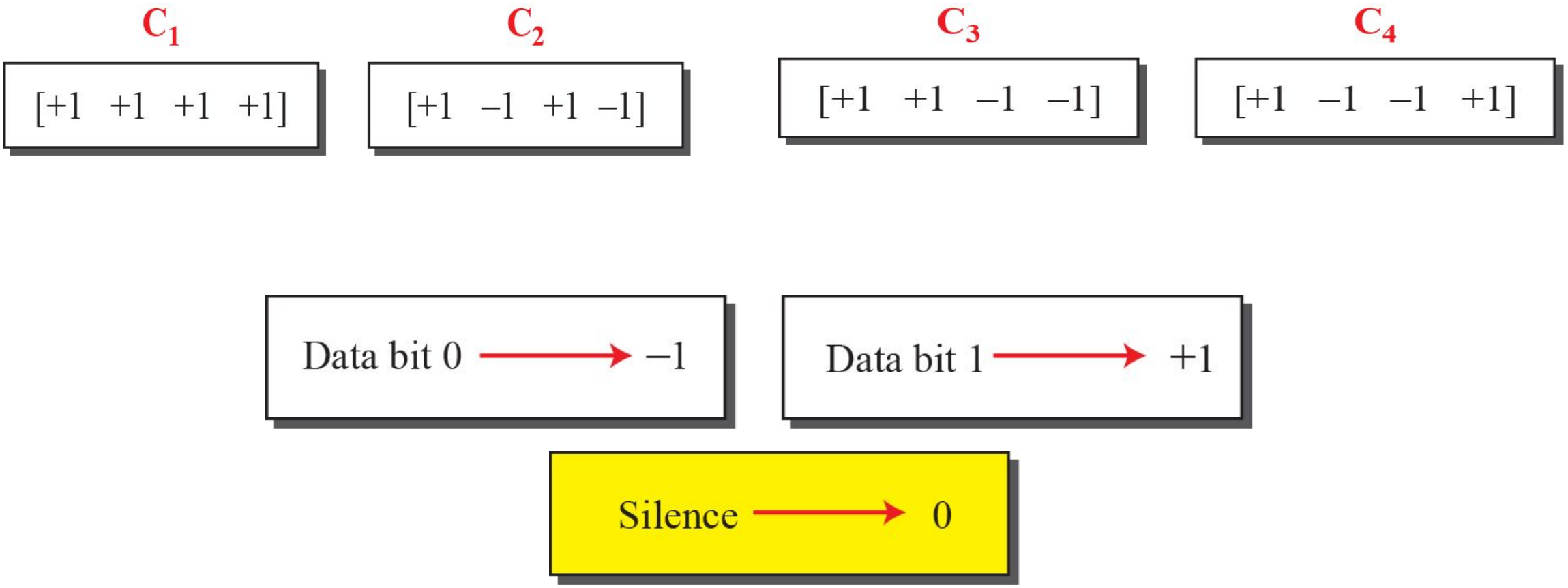
CDMA:

•CDMA differs from FDMA in that only one channel occupies the entire bandwidth of the link.

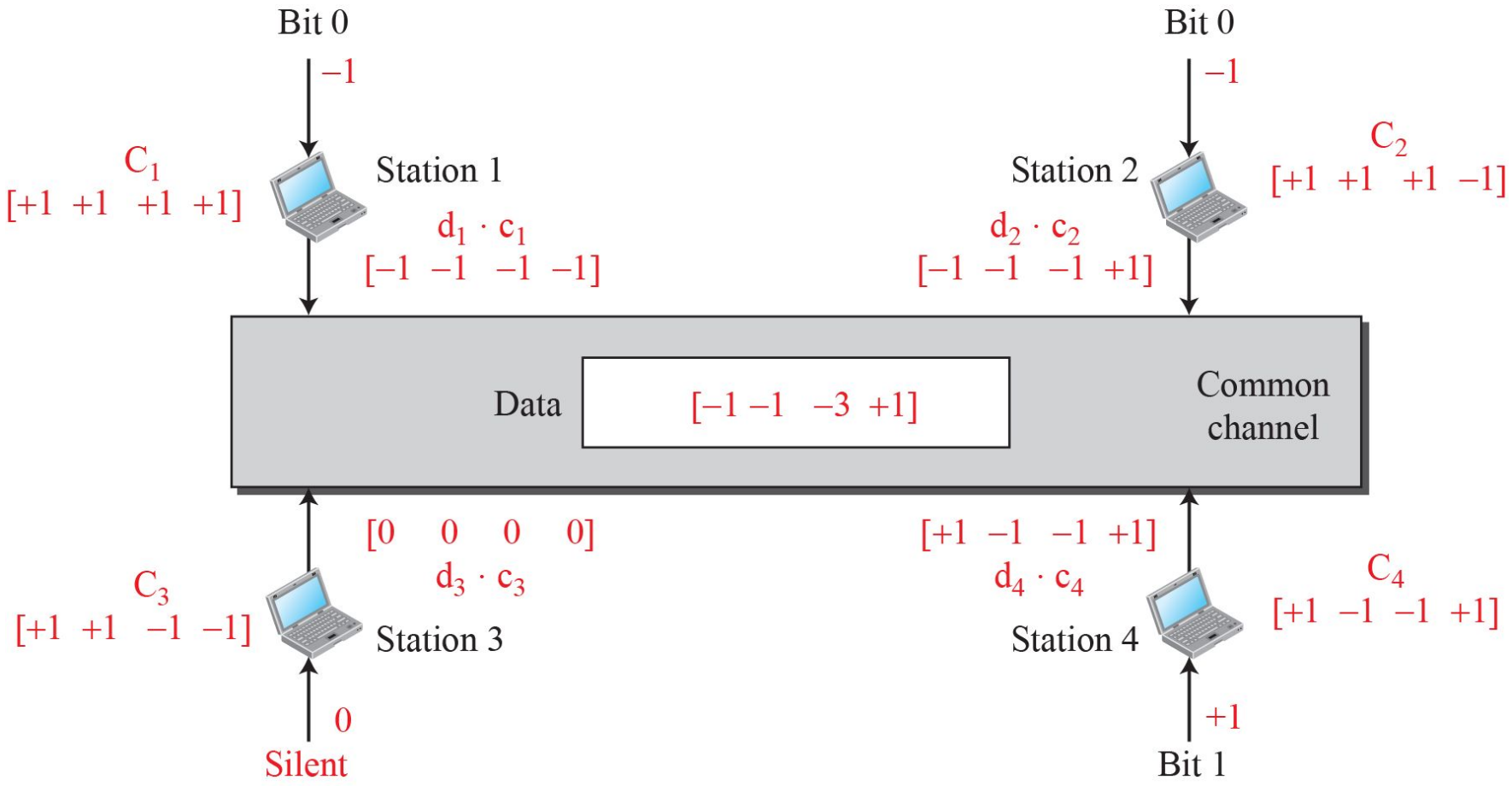
•It differs from TDMA in that all stations can send data simultaneously; there is no timesharing.



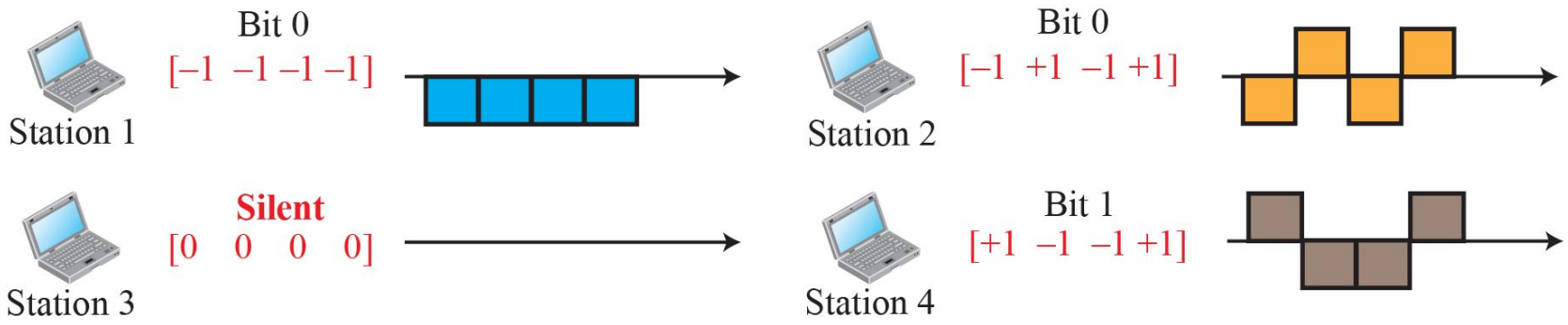
Chipping Sequence and Data Representation in CDMA

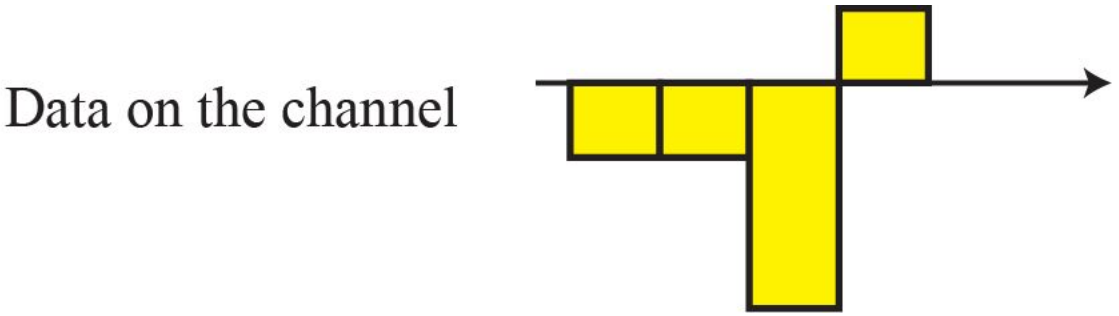


Channel Sharing in CDMA



Signal Representation in CDMA





Summary

In this section we have discussed the following:

- ✔ Multiple Access Protocols
- ✔ Access control Protocols like TDMA, FDMA, CDMA and CSMA etc.


Thank
you!