Controlled Access

Overview

- 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.
- The three popular controlled-access methods are as follows:
    1. Reservation
    2. Polling
    3. Token Passing

Reservation

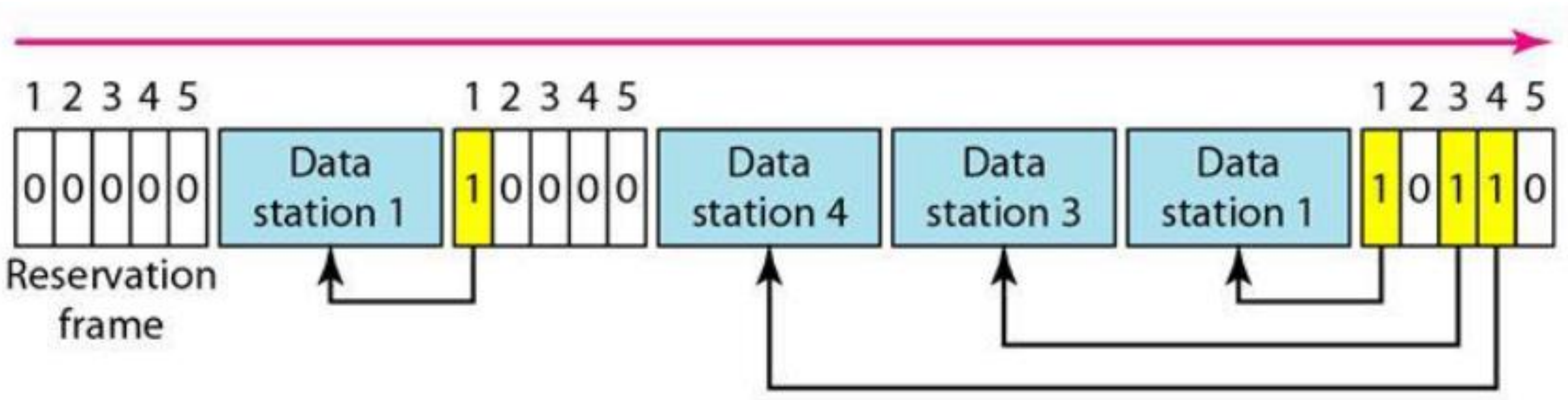
- In this method, a station needs to make a reservation before sending data.
- The time is divided into intervals. In each interval, a reservation frame precedes the data frames sent in that interval.
- If there are N stations, then there are exactly N reservation slots in the reservation frame.
- Each slot belongs to a station.

Reservation

- When a station needs to send a frame, it makes a reservation in its own slot.
- The stations that have made reservations can send their frames after the reservation frame.

Reservation

The following figure shows a situation with five stations and a five-minislot reservation frame. In the first interval, only stations 1, 3, and 4 have made reservations. In the second interval, only station 1 has made a reservation.



Polling

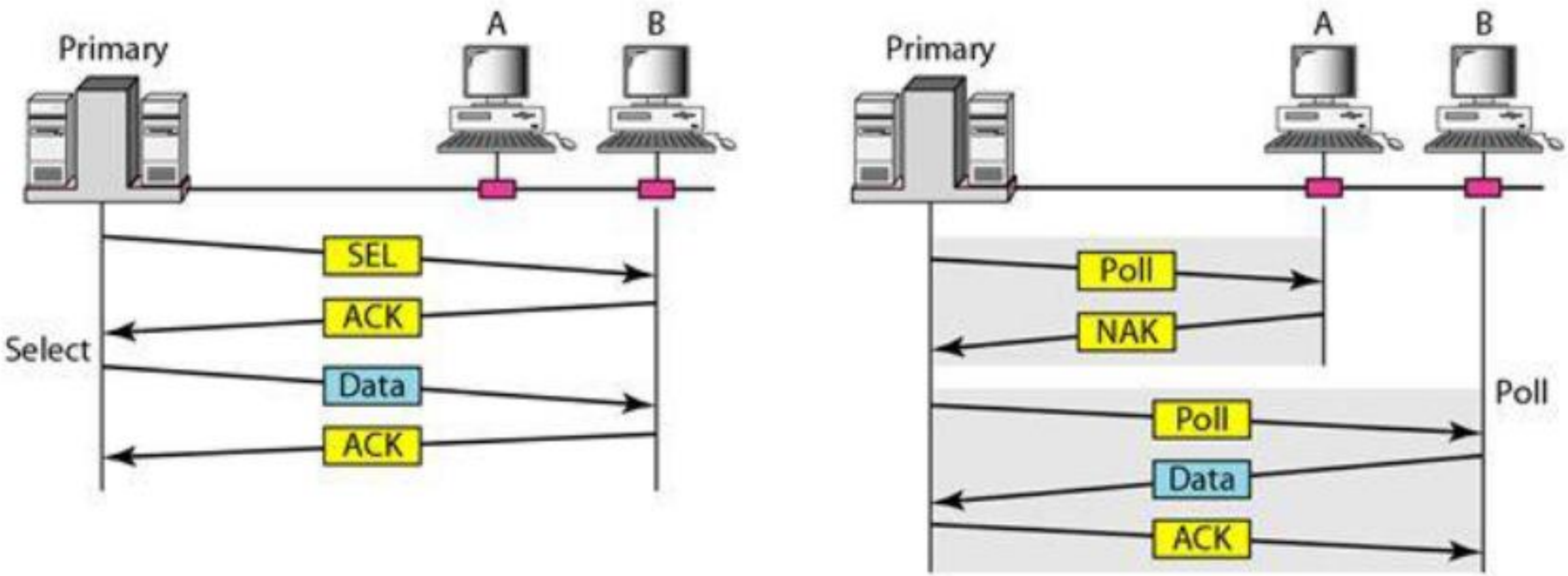
- Polling works with topologies in which one device is designated as a primary station and the other devices are secondary stations.

- All data exchanges must be made through the primary device even when the ultimate destination is a secondary device.

Polling

- 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.
- The primary device, therefore, is always the initiator of a session.

Polling



If the primary wants to receive data, it asks the secondaries if they have anything to send, this is called **poll** function. If the primary wants to send data, it tells the secondary to get ready to receive; this is called **select** function.

Efficiency

- Let T_{poll} be the time for polling and T_t be the time required for transmission of data. Then,

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

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 in case of Token bus, each station uses the bus to send the token to the next station in some predefined order.

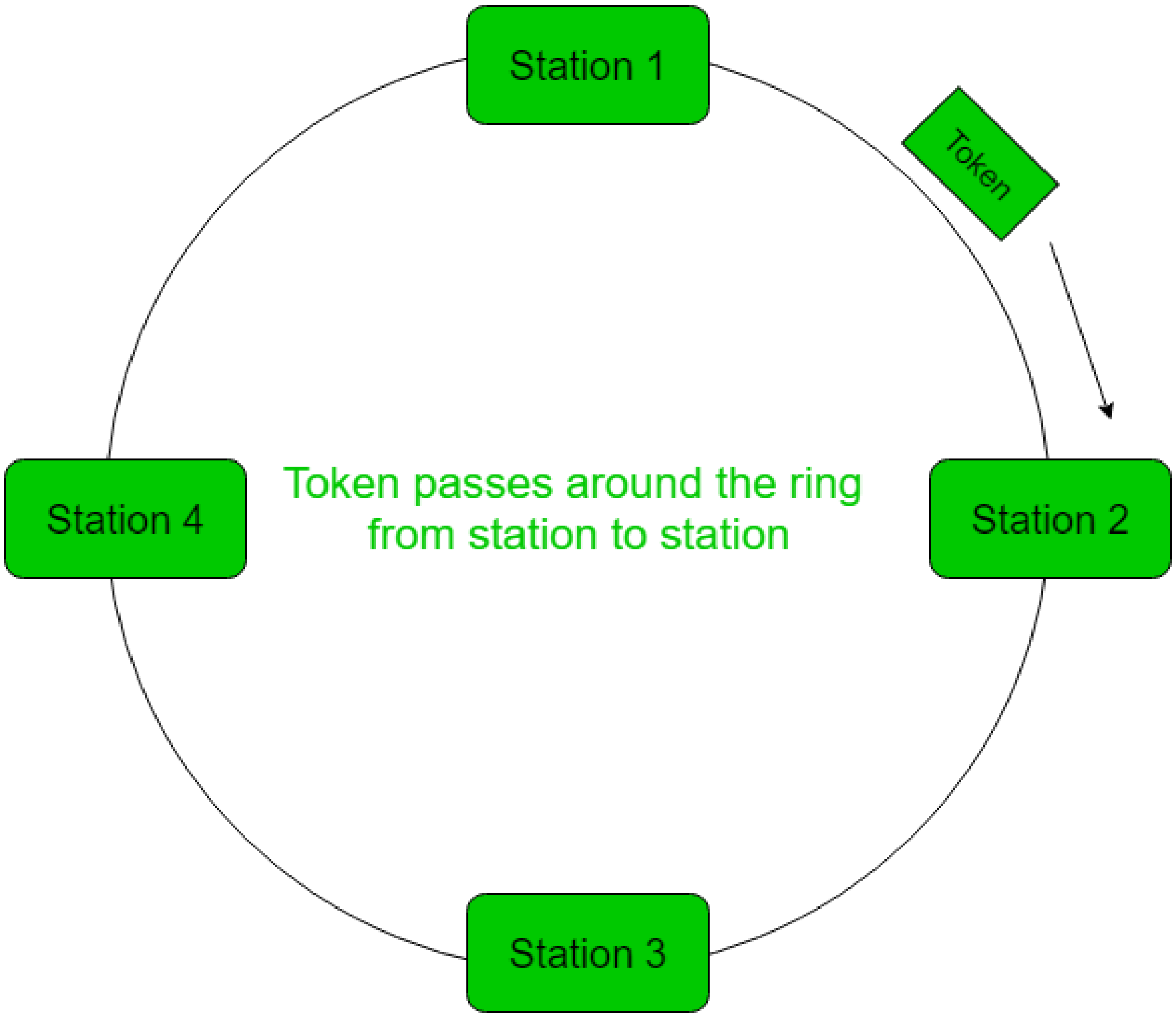
Token Passing

- In both cases, token represents permission to send.
- If a station has a frame queued for transmission when it receives the token, it can send that frame before it passes the token to the next station.
- If it has no queued frame, it passes the token simply.

Token Passing

- After sending a frame, each station must wait for all N stations (including itself) to send the token to their neighbors and the other N – 1 stations to send a frame, if they have one.
- There exist problems like duplication of token or token is lost or insertion of new station, removal of a station, which need be tackled for correct and reliable operation of this scheme.

Token Passing



Performance

- Performance of token ring can be concluded by 2 parameters: -

1. **Delay**, which is a measure of time between when a packet is ready and when it is delivered. So, the average time (delay) required to send a token to the next station = a/N.

2. **Throughput**, which is a measure of the successful traffic.

Performance

- Throughput, $S = 1/\,(1 + a/N)$ for $a<1$

  and

- $S = 1/\,\{a\,(1 + 1/N)\}$ for $a>1$.

where N = number of stations

$a = T_p/T_t$

(T_p = propagation delay and T_t =transmission delay)

Channelization Protocol

- Channelization is a multiple access method in which the available bandwidth of a link is shared in time, frequency or code between different stations.
- There are three basic channelization protocols:
  - Frequency Division Multiple Access (FDMA)
  - Time Division Multiple Access (TDMA)
  - Code Division Multiple Access (CDMA)

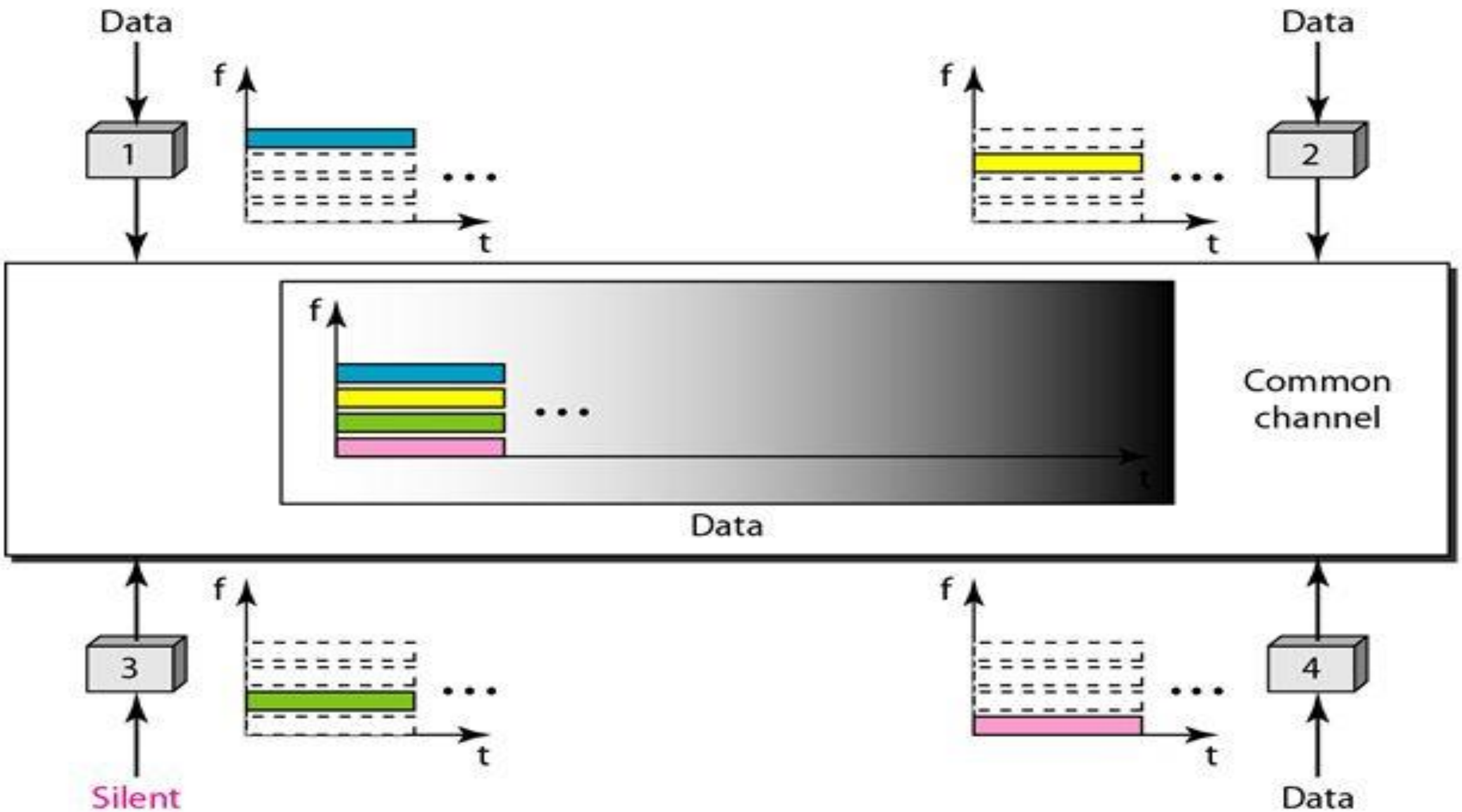
FDMA

- In FDMA, the available bandwidth is divided into frequency bands.
- Each station is allocated a band to send its data.
- This band is reserved for that station for all the time.
- The frequency bands of different stations are separated by small bands of unused frequency.

FDMA

- These unused bands are called guard bands that prevent station interferences.
- FDMA is different from FDM (Frequency Division Multiplexing).
- FDM is a physical layer technique, whereas, FDMA is an access method in the data link layer.

FDMA



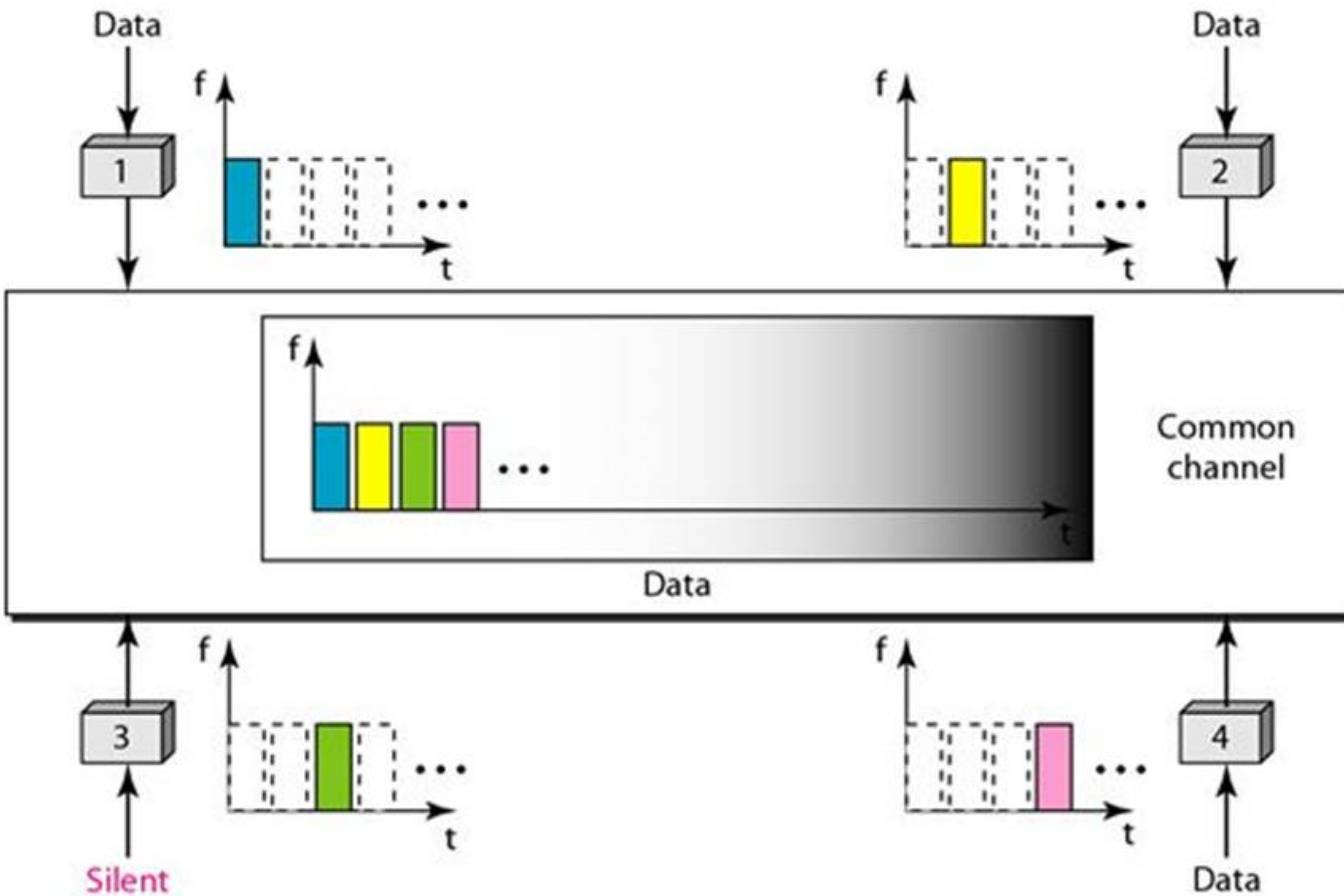
TDMA

- In TDMA, the bandwidth of channel is divided among various stations on the basis of time.
- Each station is allocated a time slot during which it can send its data.
- Each station must know the beginning of its time slot.
- TDMA requires synchronization between different stations.

TDMA

- Synchronization is achieved by using some synchronization bits at the beginning of each slot.
- TDMA is also different from TDM. TDM is a physical layer technique, whereas, TDMA is an access method in data link layer.

TDMA



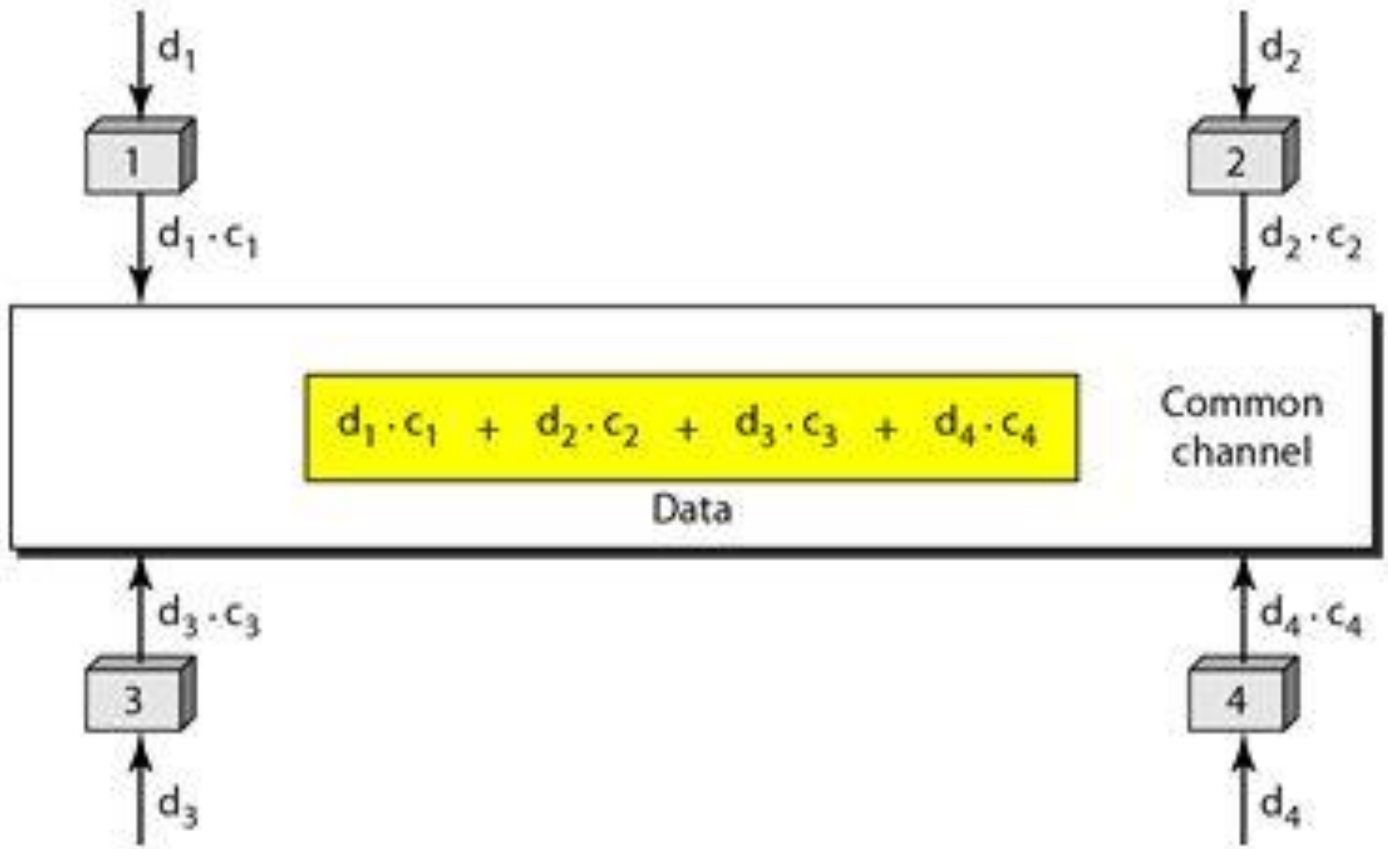
CDMA

- Unlike TDMA, in CDMA all stations can transmit data simultaneously.
- CDMA allows each station to transmit over the entire frequency spectrum all the time.
- Multiple simultaneous transmissions are separated using coding theory.
- In CDMA, each user is given a unique code sequence.

Working of CDMA

- Let us assume that we have four stations: 1, 2, 3 and 4 that are connected to the same channel.
- The data from station 1 is d_1, from station 2 is d_2 and so on.
- The code assigned to station 1 is c_1, station 2 is c_2 and so on.
- These assigned codes have two properties:
  - If we multiply each code by another, we get 0.
  - If we multiply each code by itself, we get 4, (no. of stations).

Working of CDMA



Working of CDMA

- When these four stations send data on the same channel, then station 1 multiplies its data by its code i.e. $d_1.c_1$, station 2 multiplies its data by its code i.e. $d_2.c_2$ and so on.
- The data that goes on the channel is the sum of all these terms:

$$d_1.c_1 + d_2.c_2 + d_3.c_3 + d_4.c_4$$

Working of CDMA

- Any station that wants to receive data from the channel multiplies the data on the channel by the code of the sender.
- For e.g.: suppose station 2 wants to receive data from station1.
- It multiplies the data on the channel by c_1, (code of station 1).
- Because $(c_1.c_1)$ is 4, but $(c_2.c_1)$, $(c_3.c_1)$ and $(c_4.c_1)$ are all 0s, station 2 divides the result by 4 to get the data from station 1.

Working of CDMA

$$\text{data} = (d_1.c_1 + d_2.c_2 + d_3.c_3 + d_4.c_4).c_1$$

$$= d_1.\ c_1.\ c_1 + d_2.\ c_2.\ c_1 + d_3.\ c_3.\ c_1 + d_4.\ c_4.\ c_1$$

$$= d_1.4 + 0 + 0 + 0$$

$$= (d_1.4)\ /\ 4 = d_1$$

- The code assigned to each station is a sequence of numbers called **chips**.
- These chips are called orthogonal sequences.
- Each sequence is made of N elements, where N is the number of stations.

Working of CDMA

c_1	c_2	c_3	c_4
[+1 +1 +1 +1]	[+1 -1 +1 -1]	[+1 +1 -1 -1]	[+1 -1 -1 +1]

This sequence has following properties:

1. If we multiply two equal sequences, element by element, and add the result, we get N, where N is the number of elements in the sequence.
2. This is called inner product of two equal sequence.
   [+1 +1 -1 -1] . [+1 +1 -1 -1] = 1 + 1 + 1 + 1 = 4

3. If we multiply two different sequences, element by element, and add the result, we get 0.
4. This is called inner product of two different sequence.
   [+1 +1 -1 -1] . [+1 +1 +1 +1] = 1 + 1 - 1 - 1 = 0

Difference between FDMA, CDMA and TDMA :

FDMA	TDMA	CDMA
FDMA stands for Frequency Division Multiple Access.	TDMA stands for Time Division Multiple Access.	CDMA stands for Code Division Multiple Access.
In this, sharing of bandwidth among different stations takes place.	In this, only the sharing of time of satellite transponder takes place.	In this, there is sharing of both i.e. bandwidth and time among different stations takes place.
There is no need of any codeword.	There is no need of any codeword.	Codeword is necessary.
In this, there is only need of guard bands between the adjacent channels are necessary.	In this, guard time of the adjacent slots are necessary.	In this, both guard bands and guard time are necessary.
Synchronization is not required.	Synchronization is required.	Synchronization is not required.
The rate of data is low.	The rate of data is medium.	The rate of data is high.
Mode of data transfer is continuous signal.	Mode of data transfer is signal in burts.	Mode of data transfer is digital signal.
It is little flexible.	It is moderate flexible.	It is highly flexible.