ADITYA ENGINEERING COLLEGE (A)

Computer Networks

By

Dr. M. Vamsi Krishna
Professor
Dept of Computer Science and Engineering
Aditya Engineering College(A)
Surampalem.

Unit – III

- **Media Access Control**:
- Random Access: ALOHA, Carrier sense multiple access (CSMA), CSMA with Collision Detection, CSMA with Collision Avoidance
- Controlled Access: Reservation, Polling, Token Passing,
- Channelization: frequency division multiple Access(FDMA), time division multiple access(TDMA), code division multiple access(CDMA).
- Wired LANs: Ethernet, Ethernet Protocol, Standard Ethernet, Fast Ethernet(100 Mbps), Gigabit Ethernet, 10 Gigabit Ethernet.

Media Access Control

- Random Access
  - ALOHA
  - Carrier sense multiple access (CSMA)
  - CSMA with Collision Detection
  - CSMA with Collision Avoidance

Introduction

- *The protocols used to determine who goes next on a multiaccess channel belong to a sublayer of the data link layer called the MAC (Medium Access Control) sublayer.*
- *The MAC sublayer is especially important in LANs, particularly wireless ones because wireless is naturally a broadcast channel.*
- *WANs, in contrast, use point-to-point links, except for satellite networks.*
- *Technically, the MAC sublayer is the bottom part of the data link layer.*

Channel Allocation Problem

- The protocols used to determine who goes next on a multi access channel belong to a sub layer of the data link layer called the **MAC (Medium Access Control)** sublayer.
- **Static Channel Allocation:**
- *The traditional way of allocating a single channel, such as a telephone trunk, among multiple competing users is to chop up its capacity by using one of the multiplexing schemes***.**

- *If there are N users, the bandwidth is divided into N equal-sized portions, with each user being assigned one portion.*
- *Since each user has a private frequency band, there is now no interference among users.*
- *When there is only a small and constant number of users, each of which has a steady stream or a heavy load of traffic, this division is a simple and efficient allocation mechanism.*
- *A wireless example is FM radio stations. Each station gets a portion of the FM band and uses it most of the time to broadcast its signal.*

- *However, when the number of senders is large and varying or the traffic is bursty, FDM presents some problems.*
- *If the spectrum is cut up into N regions and fewer than N users are currently interested in communicating, a large piece of valuable spectrum will be wasted.*
- *And if more than N users want to communicate, some of them will be denied permission for lack of bandwidth, even if some of the users who have been assigned a frequency band hardly ever transmit or receive anything.*

- *Precisely the same arguments that apply to FDM also apply to other ways of statically dividing the channel.*
- *If we were to use time division multiplexing (TDM) and allocate each user every Nth time slot, if a user does not use the allocated slot, it would just lie fallow.*
- *The same would hold if we split up the networks physically.*
- *Since none of the traditional static channel allocation methods work well at all with bursty traffic, we will now explore dynamic methods.*

Assumptions for Dynamic Channel Allocation:

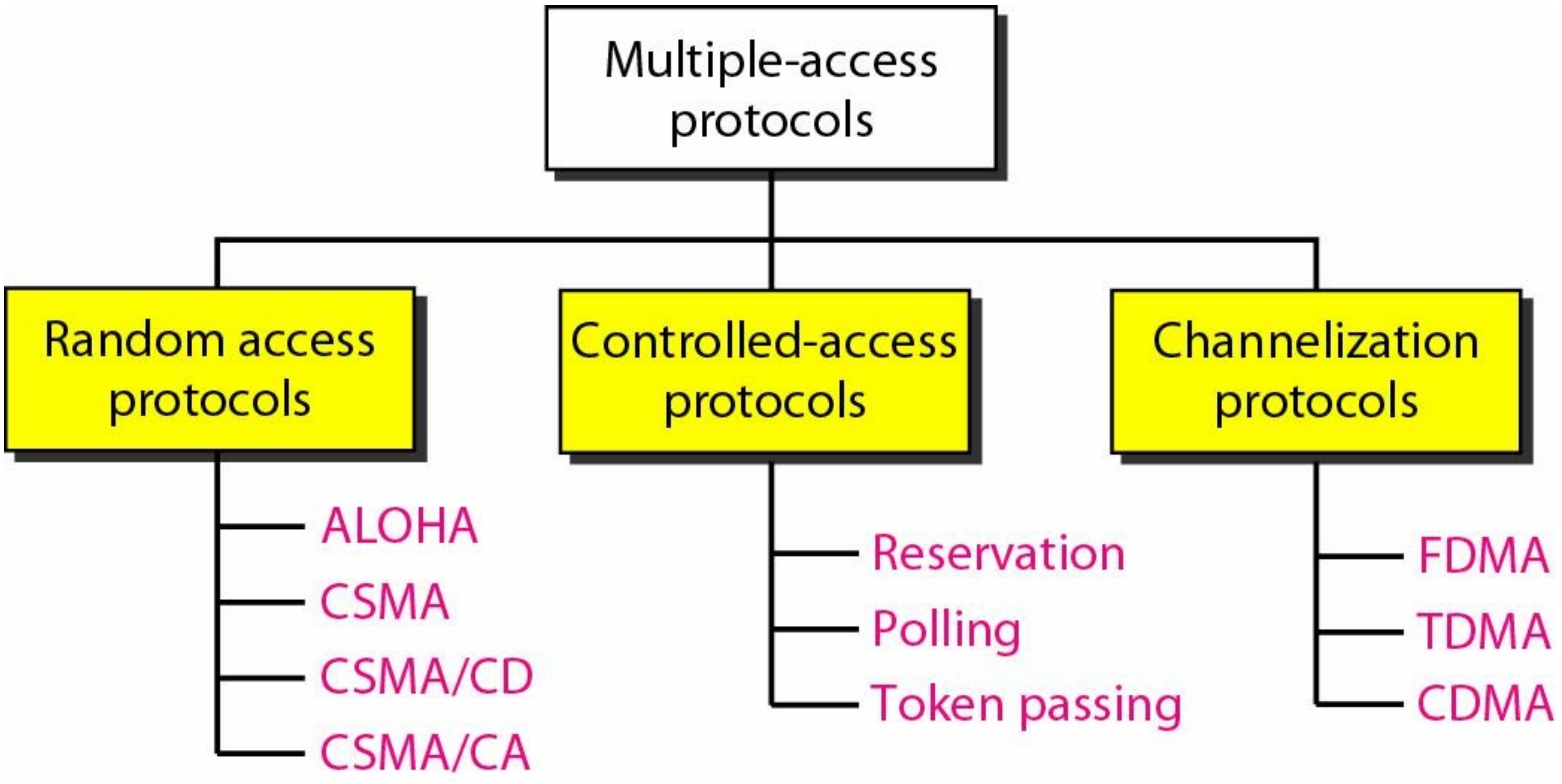
- Independent Traffic.
- Single Channel.
- Observable Collisions
- Continuous or Slotted Time.
- Carrier Sense or No Carrier Sense.

Independent Traffic

- *The model consists of N independent stations (e.g., computers, telephones), each with a program or user that generates frames for transmission.*
- *The expected number of frames generated in an interval of length Δt is $\lambda \Delta t$, where λ is a constant (the arrival rate of new frames).*
- *Once a frame has been generated, the station is blocked and does nothing until the frame has been successfully transmitted.*

- ***Single Channel***. *A single channel is available for all communication. All stations can transmit on it and all can receive from it. The stations are assumed to be equally capable, though protocols may assign them different roles (e.g., priorities).*
- ***Observable Collisions***. *If two frames are transmitted simultaneously, they overlap in time and the resulting signal is garbled. This event is called a* ***collision***. *All stations can detect that a collision has occurred. A collided frame must be transmitted again later. No errors other than those generated by collisions occur.*

- ***Continuous or Slotted Time****. Time may be assumed continuous, in which case frame transmission can begin at any instant. Alternatively, time may be slotted or divided into discrete intervals (called slots). Frame transmissions must then begin at the start of a slot. A slot may contain 0, 1, or more frames, corresponding to an idle slot, a successful transmission, or a collision, respectively.*
- ***Carrier Sense or No Carrier Sense****. With the carrier sense assumption, stations can tell if the channel is in use before trying to use it. No station will attempt to use the channel while it is sensed as busy. If there is no carrier sense, stations cannot sense the channel before trying to use it. They just go ahead and transmit. Only later can they determine whether the transmission was successful.*


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

- **Random Access Protocols:**
- In this, all stations have same superiority that is no station has more priority than another station. Any station can send data depending on medium's state(idle or busy).
- **Controlled Access Protocols:**
- In this, the data is sent by that station which is approved by all other stations.
- **Channelization Protocols:**
- In this, the available bandwidth of the link is shared in time, frequency and code to multiple stations to access channel simultaneously.

ALOHA:

- It was designed for wireless LAN but is also applicable for shared medium.
- In this, multiple stations can transmit data at the same time and can hence lead to collision and data being garbled.
- We will discuss two versions of ALOHA here: **pure** and **slotted**.

Pure ALOHA:

- When a station sends data it waits for an acknowledgement. If the acknowledgement doesn't come within the allotted time then the station waits for a random amount of time called back-off time (Tb) and re-sends the data.

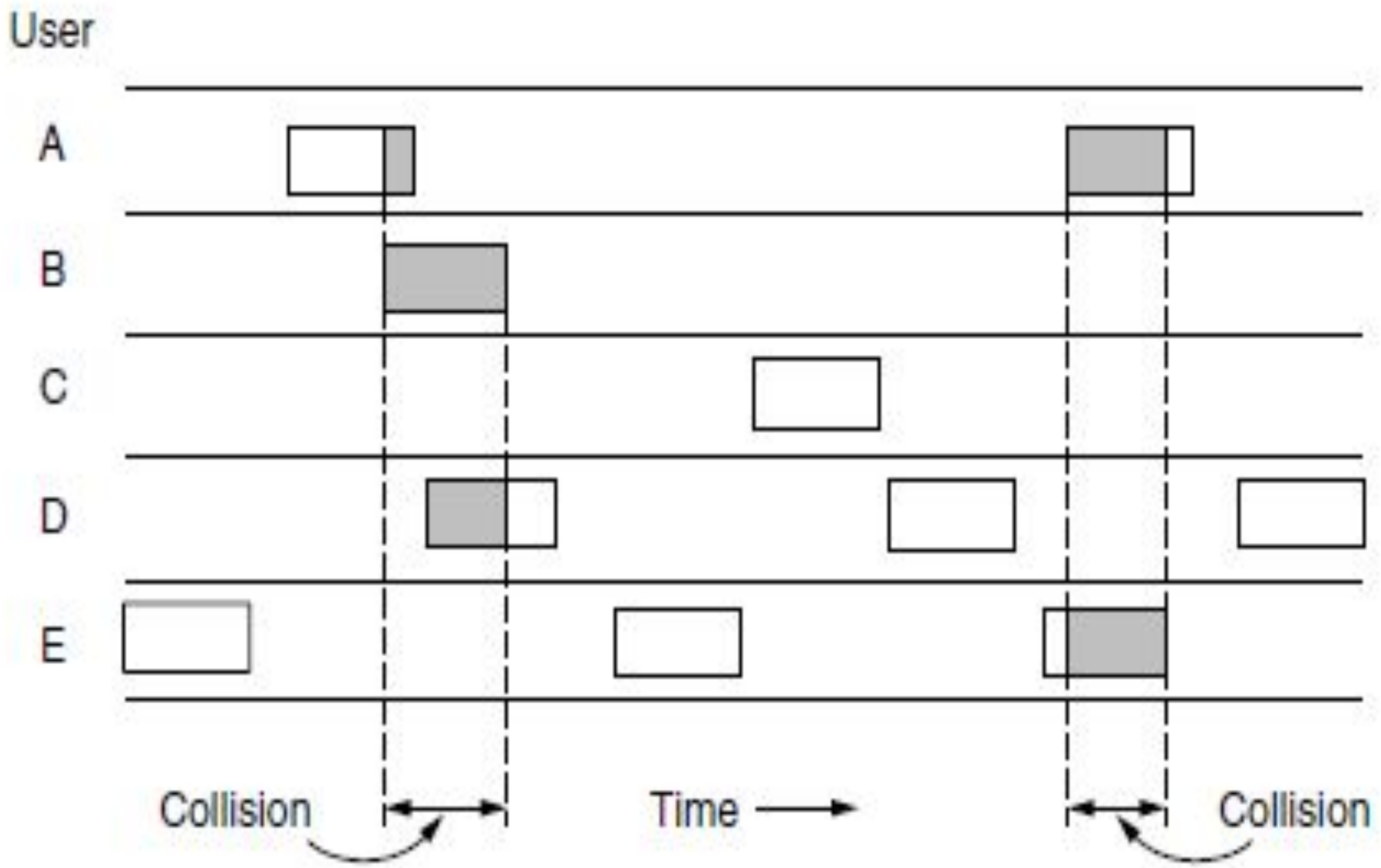


Figure 4-1. In pure ALOHA, frames are transmitted at completely arbitrary times.

- In this aloha, any station can transmit the data at any time.
- In this, the time is continuous and not globally synchronized.
- Pure aloha doesn’t reduces the number of collisions.
- In Pure Aloha, Probability of successful transmission of

data packet= G x e^{-2G}

Slotted ALOHA:

- We divide time into slots and sending of data is allowed only at the beginning of these slots.
- If a station misses out the allowed time, it must wait for the next slot

- In this, The time is discrete and globally synchronized.
- In Slotted Aloha, Probability of successful transmission of data packet= $G \times e^{-G}$
- Slotted aloha reduces the number of collisions to half and doubles the efficiency of pure aloha

Pure Aloha

- *Whenever data is available for sending over a channel at stations, we use Pure Aloha.*
- *In pure Aloha, when each station transmits data to a channel without checking whether the channel is idle or not, the chances of collision may occur, and the data frame can be lost.*
- *When any station transmits the data frame to a channel, the pure Aloha waits for the receiver's acknowledgment.*
- *If it does not acknowledge the receiver end within the specified time, the station waits for a random amount of time, called the backoff time (Tb). And the station may assume the frame has been lost or destroyed.*
- *Therefore, it retransmits the frame until all the data are successfully transmitted to the receiver.*

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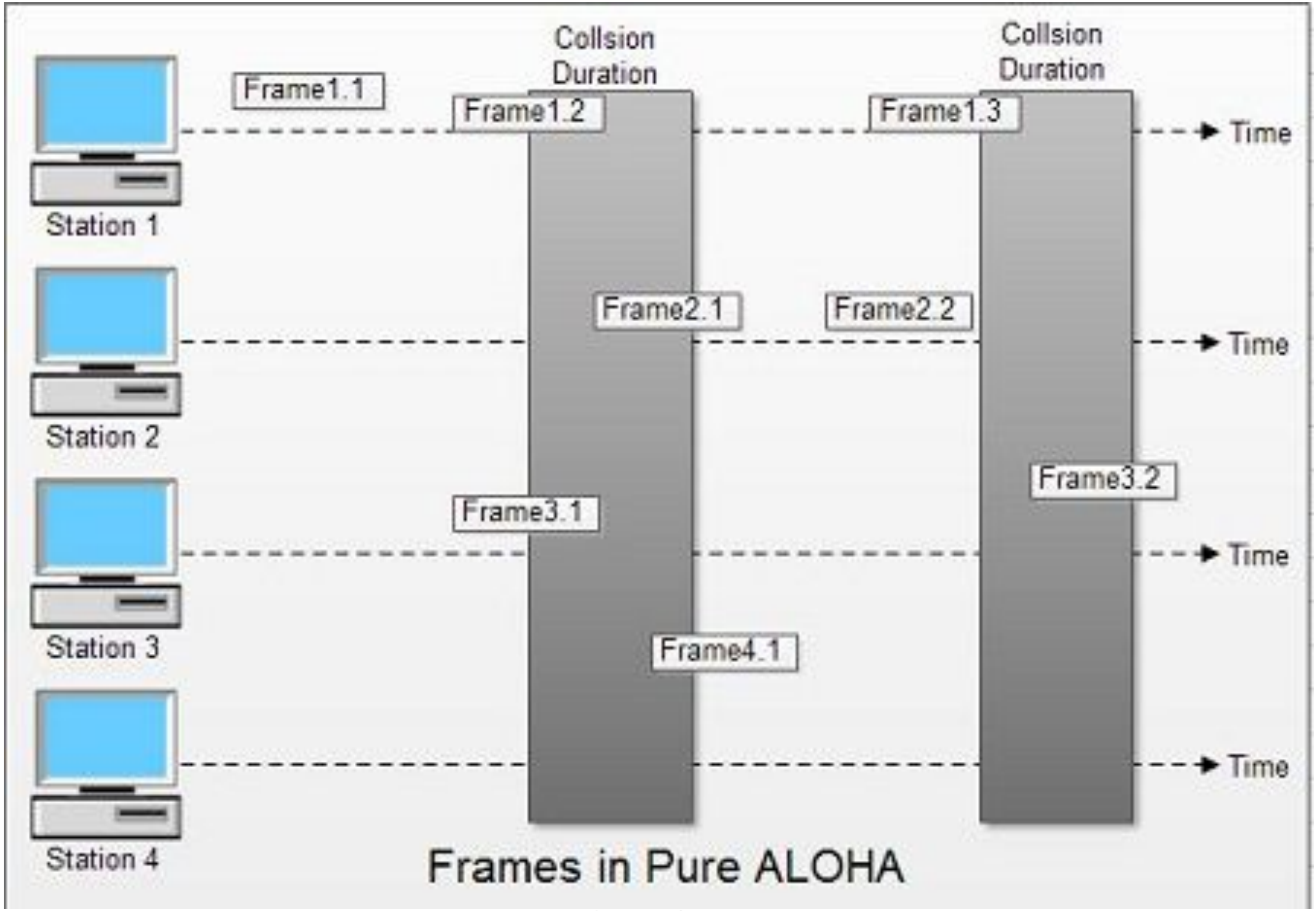
1. The total vulnerable time of pure Aloha is 2 * Tfr.
2. Maximum throughput occurs when G = 1/ 2 that is 18.4%.
3. Successful transmission of data frame is S = G * e ^ - 2 G.


Collsion
Duration
Collsion
Duration
Frame1.1
Frame1.2
Frame1.3
Time
Station 1
Frame2.1
Frame2.2
Time
Station 2
Frame3.1
Frame3.2
Time
Station 3
Frame4.1
Time
Station 4
Frames in Pure ALOHA

- *As we can see in the figure above, there are four stations for accessing a shared channel and transmitting data frames.*
- *Some frames collide because most stations send their frames at the same time.*
- *Only two frames, frame 1.1 and frame 2.2, are successfully transmitted to the receiver end.*
- *At the same time, other frames are lost or destroyed.*
- *Whenever two frames fall on a shared channel simultaneously, collisions can occur, and both will suffer damage.*
- *If the new frame's first bit enters the channel before finishing the last bit of the second frame.*
- *Both frames are completely finished, and both stations must retransmit the data frame.*

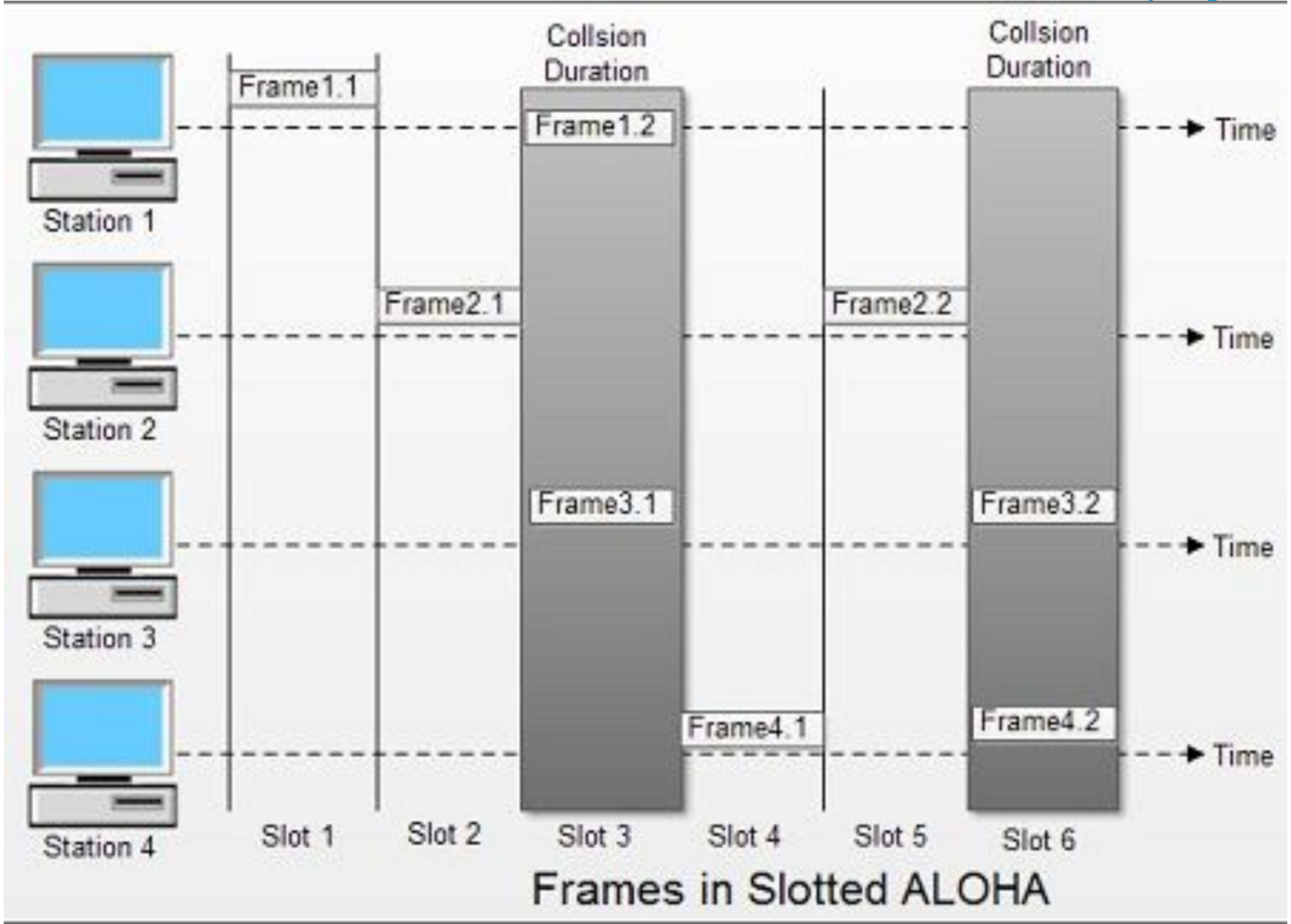
Slotted Aloha

- *The slotted Aloha is designed to overcome the pure Aloha's efficiency because pure Aloha has a very high possibility of frame hitting.*
- *In slotted Aloha, the shared channel is divided into a fixed time interval called* **slots**. *So that, if a station wants to send a frame to a shared channel, the frame can only be sent at the beginning of the slot, and only one frame is allowed to be sent to each slot.*
- *And if the stations are unable to send data to the beginning of the slot, the station will have to wait until the beginning of the slot for the next time.*
- *However, the possibility of a collision remains when trying to send a frame at the beginning of two or more station time slot.*

1. Maximum throughput occurs in the slotted Aloha when G = 1 that is 37%.

2. The probability of successfully transmitting the data frame in the slotted Aloha is S = G * e ^ - 2 G.

3. The total vulnerable time required in slotted Aloha is Tfr.


Station 1
Station 2
Station 3
Station 4
Frame1.1
Collsion Duration
Frame1.2
Collsion Duration
Time
Frame2.1
Frame2.2
Time
Frame3.1
Frame3.2
Time
Frame4.1
Frame4.2
Time
Slot 1
Slot 2
Slot 3
Slot 4
Slot 5
Slot 6
Frames in Slotted ALOHA

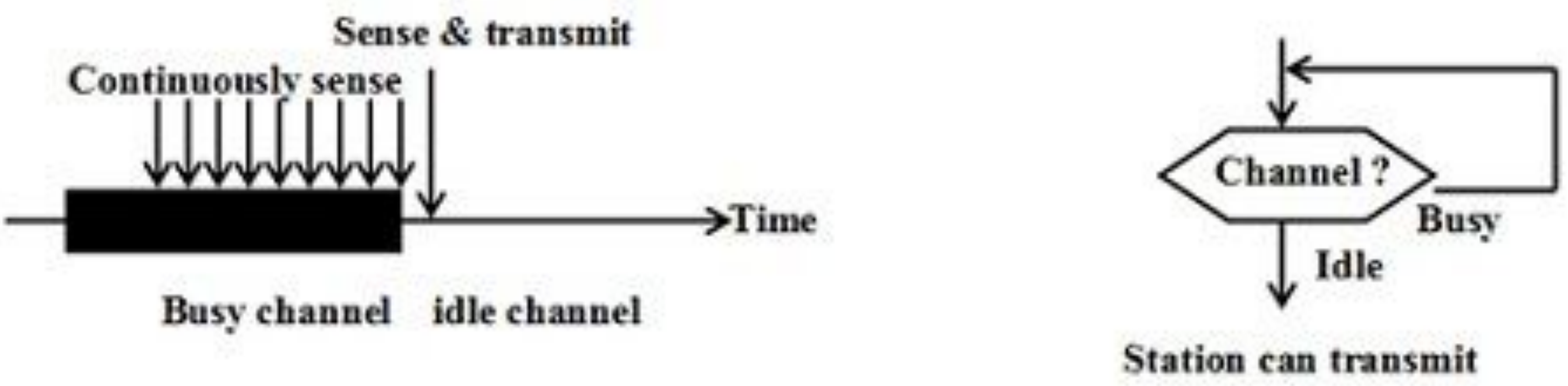
CSMA (Carrier Sense Multiple Access)

- *It is a* ***carrier sense multiple access*** *based on media access protocol to sense the traffic on a channel (idle or busy) before transmitting the data.*
- *It means that if the channel is idle, the station can send data to the channel.*
- *Otherwise, it must wait until the channel becomes idle.*
- *Hence, it reduces the chances of a collision on a transmission medium.*

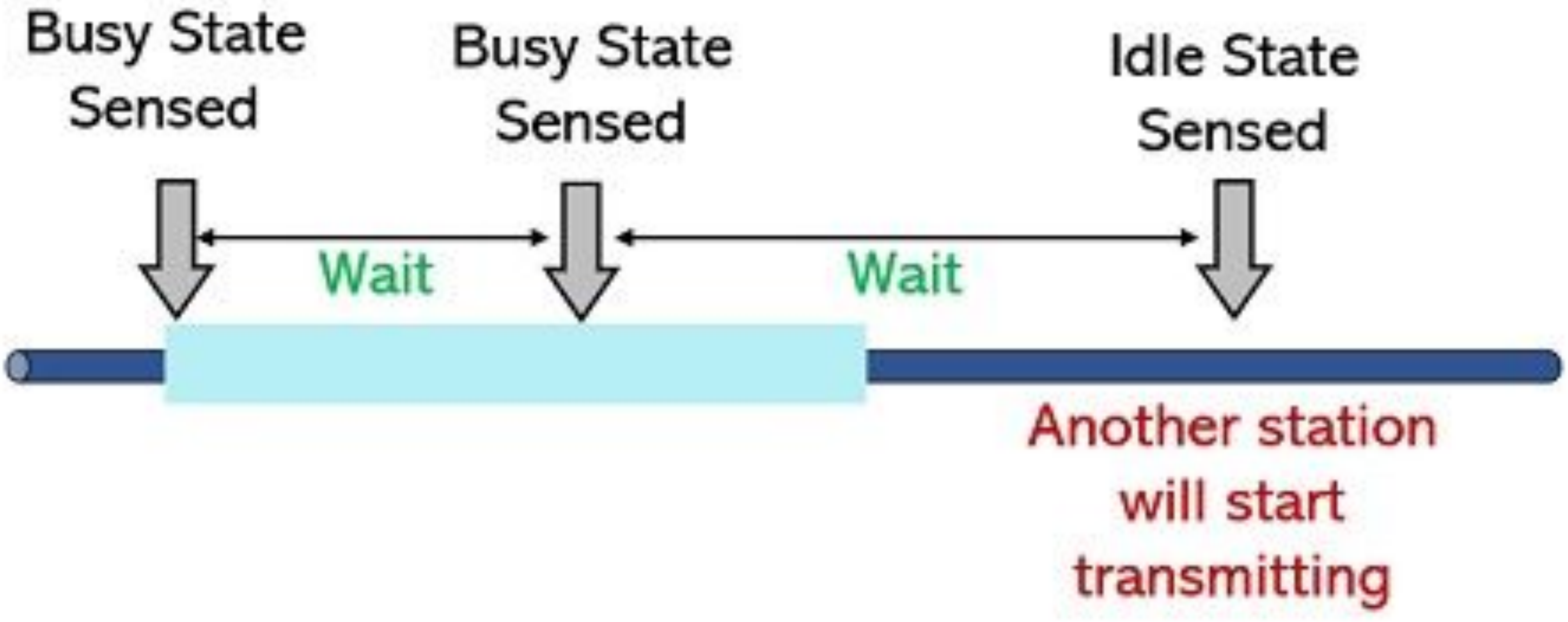
CSMA Access Modes

- **1-Persistent:** In the 1-Persistent mode of CSMA that defines each node, first sense the shared channel and if the channel is idle, it immediately sends the data. Else it must wait and keep track of the status of the channel to be idle and broadcast the frame unconditionally as soon as the channel is idle.
- **Non-Persistent:** It is the access mode of CSMA that defines before transmitting the data, each node must sense the channel, and if the channel is inactive, it immediately sends the data. Otherwise, the station must wait for a random time (not continuously), and when the channel is found to be idle, it transmits the frames.

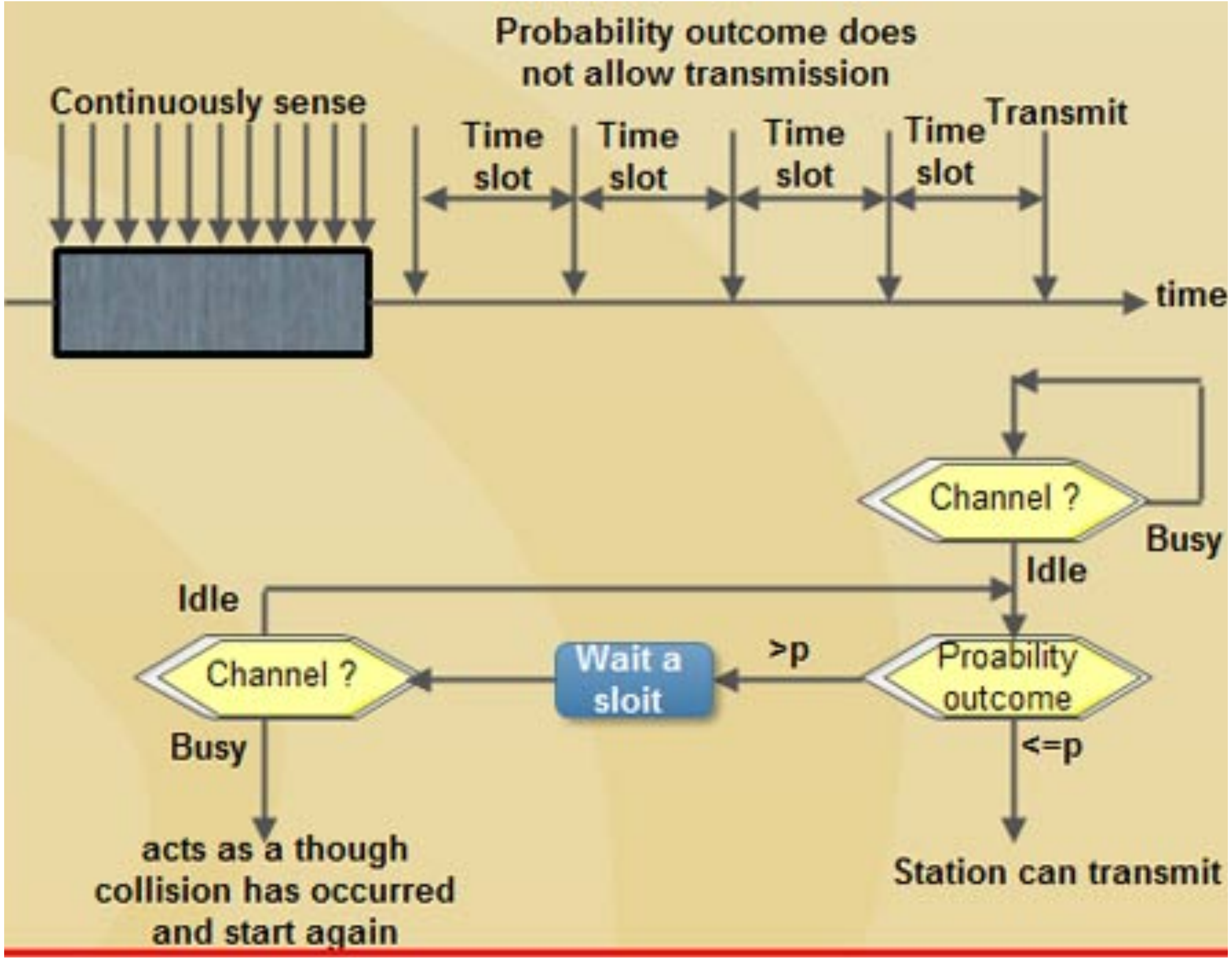
- **P-Persistent:** It is the combination of 1-Persistent and Non-persistent modes. The P-Persistent mode defines that each node senses the channel, and if the channel is inactive, it sends a frame with a **P** probability. If the data is not transmitted, it waits for a (**q = 1-p probability**) random time and resumes the frame with the next time slot.
- **O- Persistent:** It is an O-persistent method that defines the superiority of the station before the transmission of the frame on the shared channel. If it is found that the channel is inactive, each station waits for its turn to retransmit the data.



1-persistent CSMA



Non-Persistent Mode of CSMA



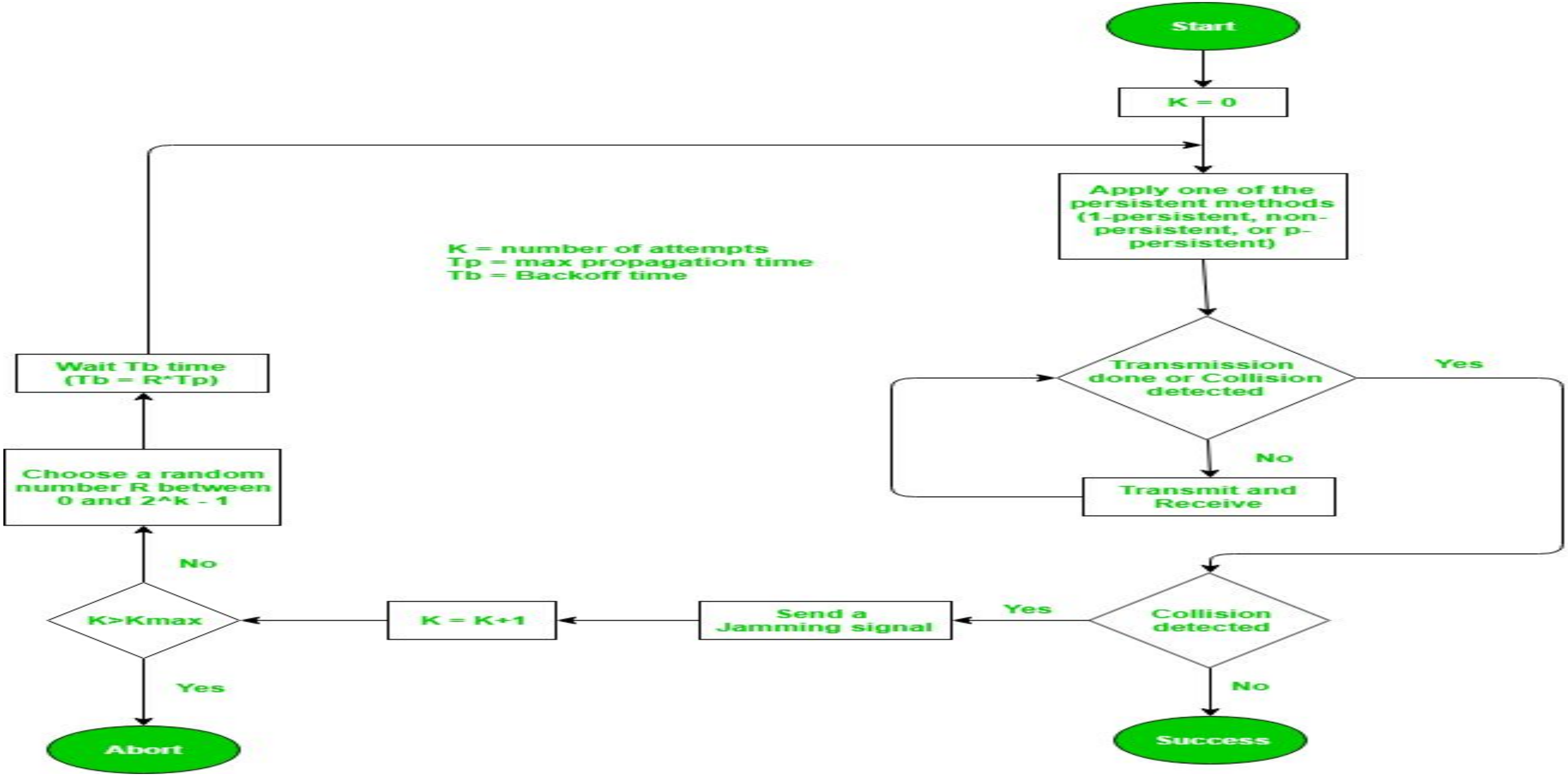
Probability outcome does not allow transmission
Continuously sense
Time slot
Time slot
Time slot
Time slot
Transmit
time
Channel ?
Busy
Idle
Idle
Channel ?
Wait a sloit
>p
Proability outcome
<=p
Busy
acts as a though collision has occurred and start again
Station can transmit

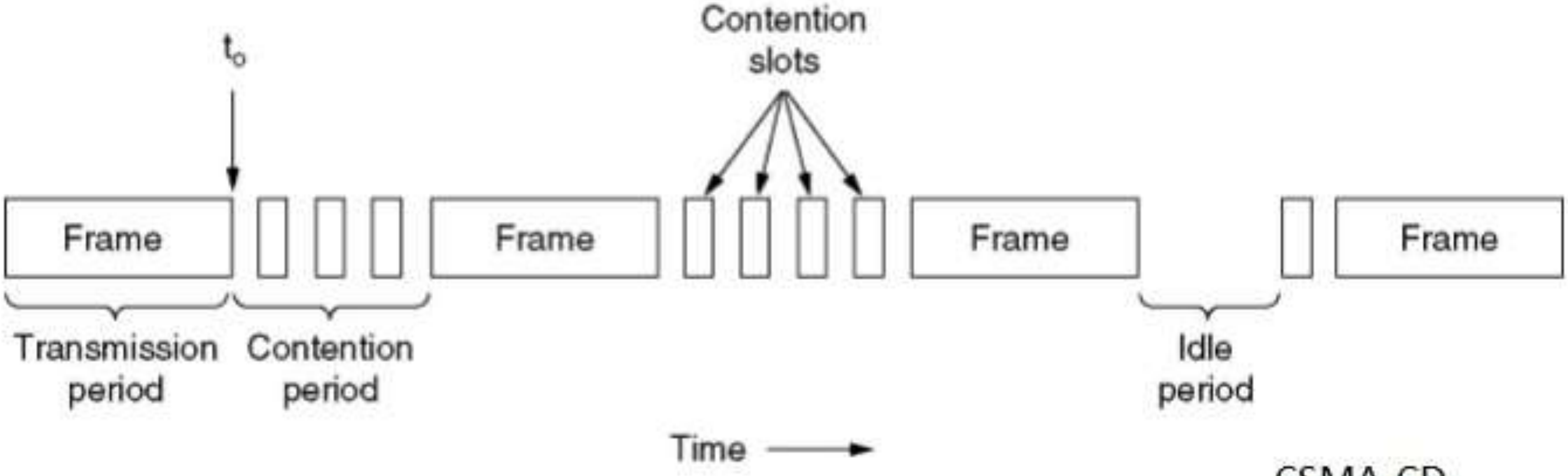
CSMA/ CD

- *It is a **carrier sense multiple access/ collision detection** network protocol to transmit data frames.*
- *The CSMA/CD protocol works with a medium access control layer.*
- *Therefore, it first senses the shared channel before broadcasting the frames, and if the channel is idle, it transmits a frame to check whether the transmission was successful.*
- *If the frame is successfully received, the station sends another frame.*
- *If any collision is detected in the CSMA/CD, the station sends a jam/ stop signal to the shared channel to terminate data transmission. After that, it waits for a random time before sending a frame to a channel.*

Rules for CSMA / CD

- If medium is idle, transmit, otherwise go to 2
- If the medium is busy, continue to listen until the channel is idle, then transmit immediately
- If collision is detected during transmission then transmit a brief jamming signal to assure that all station knows that there has been a collision so that stations can cease the transmission
- After transmitting the jamming signal wait for a random amount of time reffered as back off then attemps transmit again.


Start
K = 0
Apply one of the persistent methods (1-persistent, non-persistent, or p-persistent)
K = number of attempts
Tp = max propagation time
Tb = Backoff time
Transmission done or Collision detected
Yes
No
Transmit and Receive
Wait Tb time (Tb = R*Tp)
Choose a random number R between 0 and 2^k - 1
No
K>Kmax
Yes
Abort
K = K+1
Send a Jamming signal
Yes
Collision detected
No
Success


Contention
slots
t_0
Frame
Frame
Frame
Frame
Transmission
period
Contention
period
Idle
period
Time

CSMA-CD

- *At the point marked t 0, a station has finished transmitting its frame.*
- *Any other station having a frame to send may now attempt to do so. If two or more stations decide to transmit simultaneously, there will be a collision.*
- *If a station detects a collision, it aborts its transmission, waits a random period of time, and then tries again.*
- *Therefore, our model for CSMA/CD will consist of alternating contention and transmission periods, with idle periods occurring when all stations are quiet.*

The algorithm of Collision Resolution

- The station continues transmission of the current frame for a specified time along with a jam signal, to ensure that all the other stations detect collision.
- The station increments the retransmission counter.
- If the maximum number of retransmission attempts is reached, then the station aborts transmission.
- Otherwise, the station waits for a backoff period which is generally a function of the number of collisions and restart main algorithm.

Carrier Sense Multiple Access / Collision Avoidance

- In contrast to CSMA/CD (Carrier Sense Multiple Access/Collision Detection) that deals with collisions after their occurrence, CSMA/CA prevents collisions prior to their occurrence.

The algorithm of CSMA/CA is:

- When a frame is ready, the transmitting station checks whether the channel is idle or busy.
- If the channel is busy, the station waits until the channel becomes idle.
- If the channel is idle, the station waits for an Inter-frame gap (IFG) amount of time and then sends the frame.
- After sending the frame, it sets a timer.
- The station then waits for acknowledgement from the receiver. If it receives the acknowledgement before expiry of timer, it marks a successful transmission.
- Otherwise, it waits for a back-off time period and restarts the algorithm.

Advantages of CMSA/CA

- CMSA/CA prevents collision.
- Due to acknowledgements, data is not lost unnecessarily.
- It avoids wasteful transmission.
- It is very much suited for wireless transmissions.

Disadvantages of CSMA/CA

- The algorithm calls for long waiting times.
- It has high power consumption

Controlled Access Protocols

- In controlled access, the stations seek information from one another to find which station has the right to send.
- It allows only one node to send at a time, to avoid collision of messages on shared medium.

The three controlled-access methods are:

- Reservation
- Polling
- Token Passing

Reservation

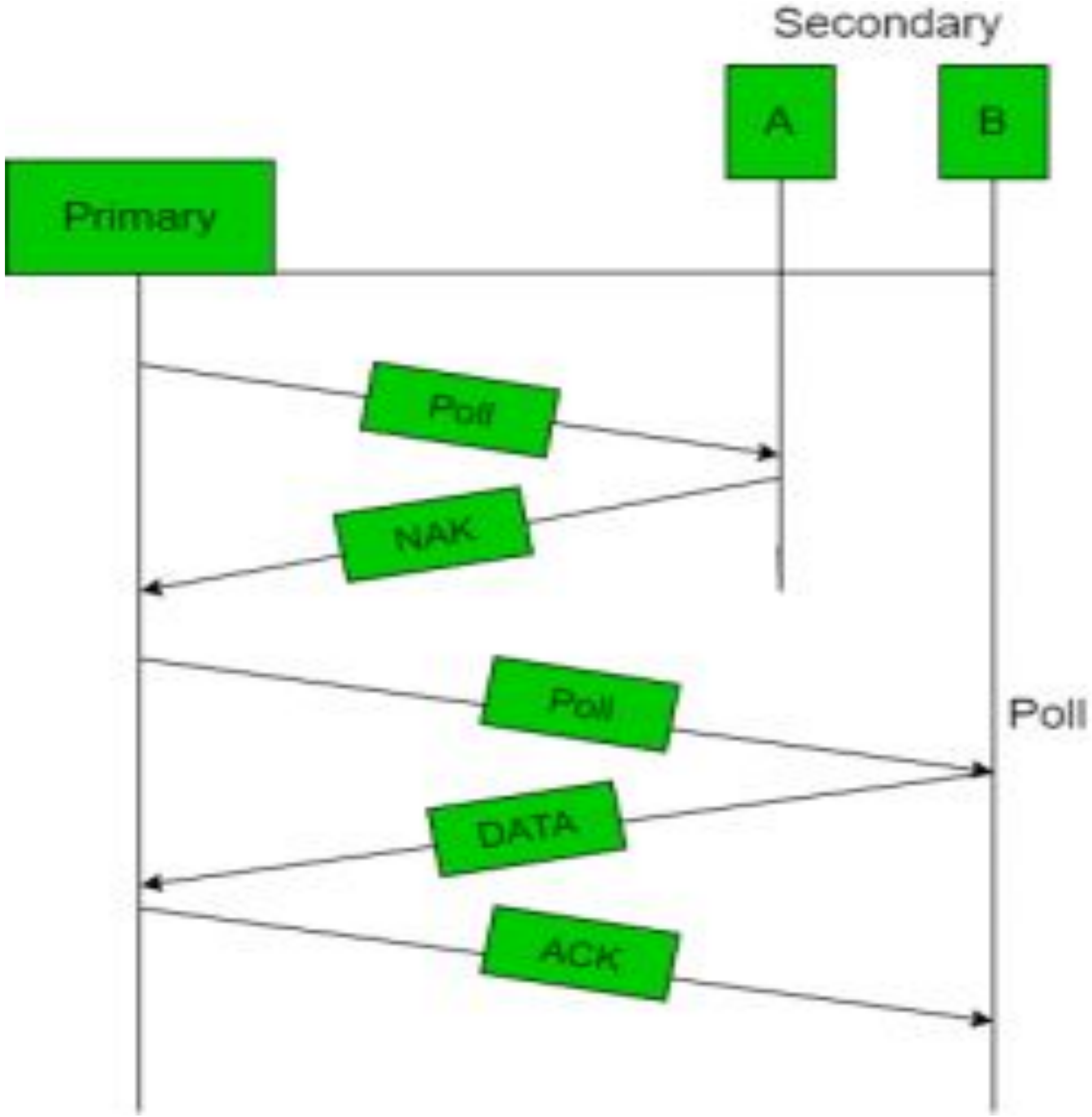
- In the reservation method, a station needs to make a reservation before sending data.
- The time line has two kinds of periods:
  - Reservation interval of fixed time length
  - Data transmission period of variable frames.
- If there are M stations, the reservation interval is divided into M slots, 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.

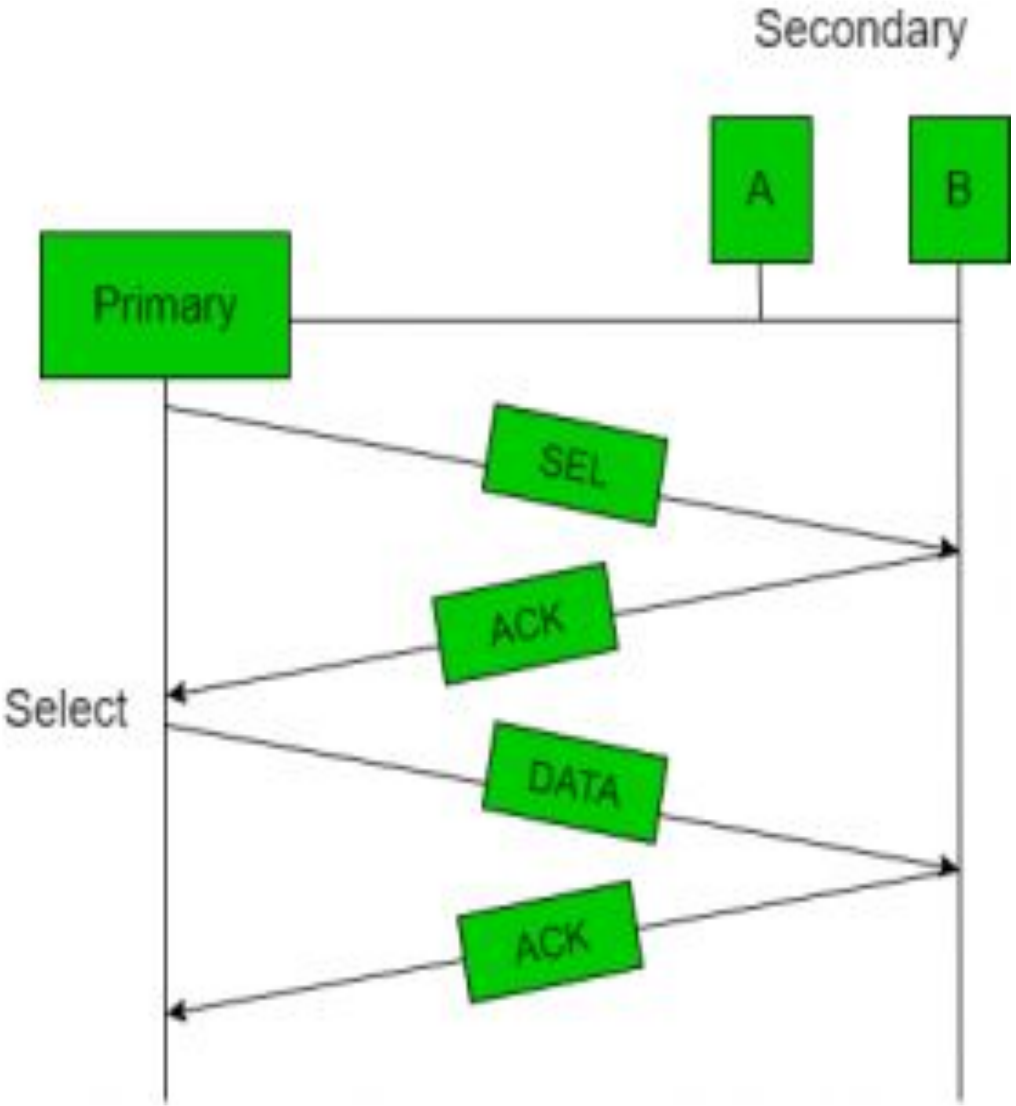
- In general, i th station may announce that it has a frame to send by inserting a 1 bit into i th slot. After all N slots have been checked, each station knows which stations wish to transmit.
- The stations which have reserved their slots transfer their frames in that order.
- After data transmission period, next reservation interval begins.
- Since everyone agrees on who goes next, there will never be any collisions.

- The following figure shows a situation with five stations and a five slot 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 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.


Secondary
A
B
Primary
Poll
NAK
Poll
Poll
DATA
ACK


Secondary
A
B
Primary
SEL
ACK
Select
DATA
ACK

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 the 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.
- 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

- 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 exists 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

Channelization Protocols

- FDMA
- TDMA
- CDMA

Channelization

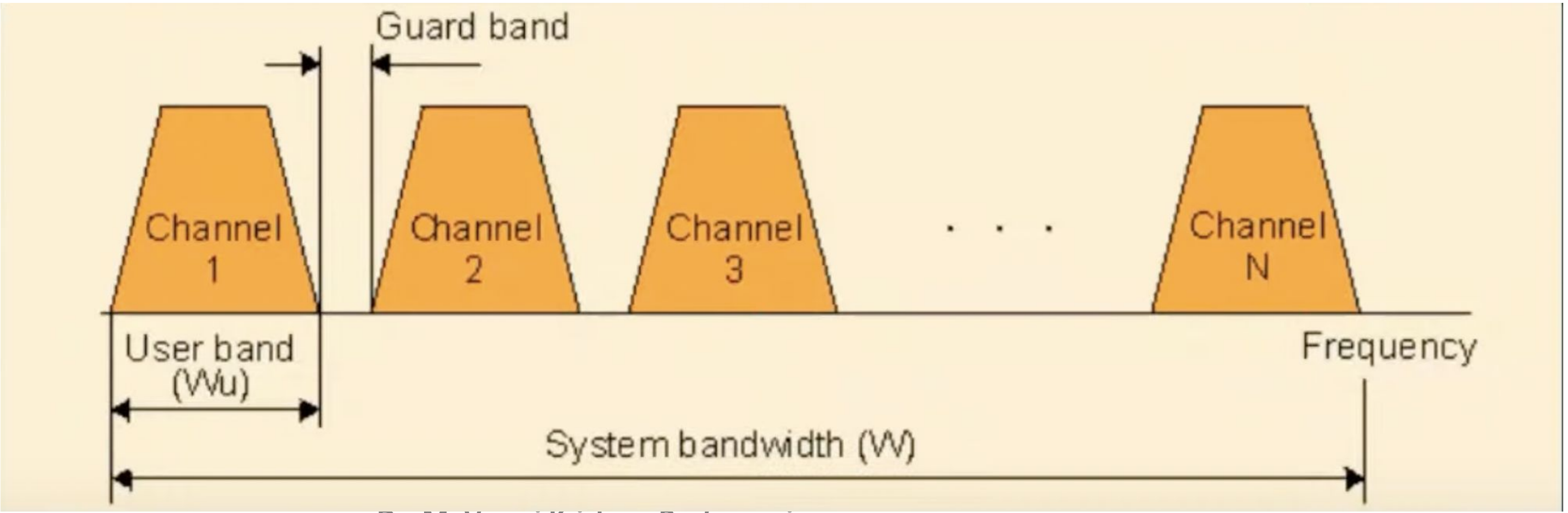
- It is multiple access method in which the available bandwidth of a link is shared in time, frequency, or through code between different stations.

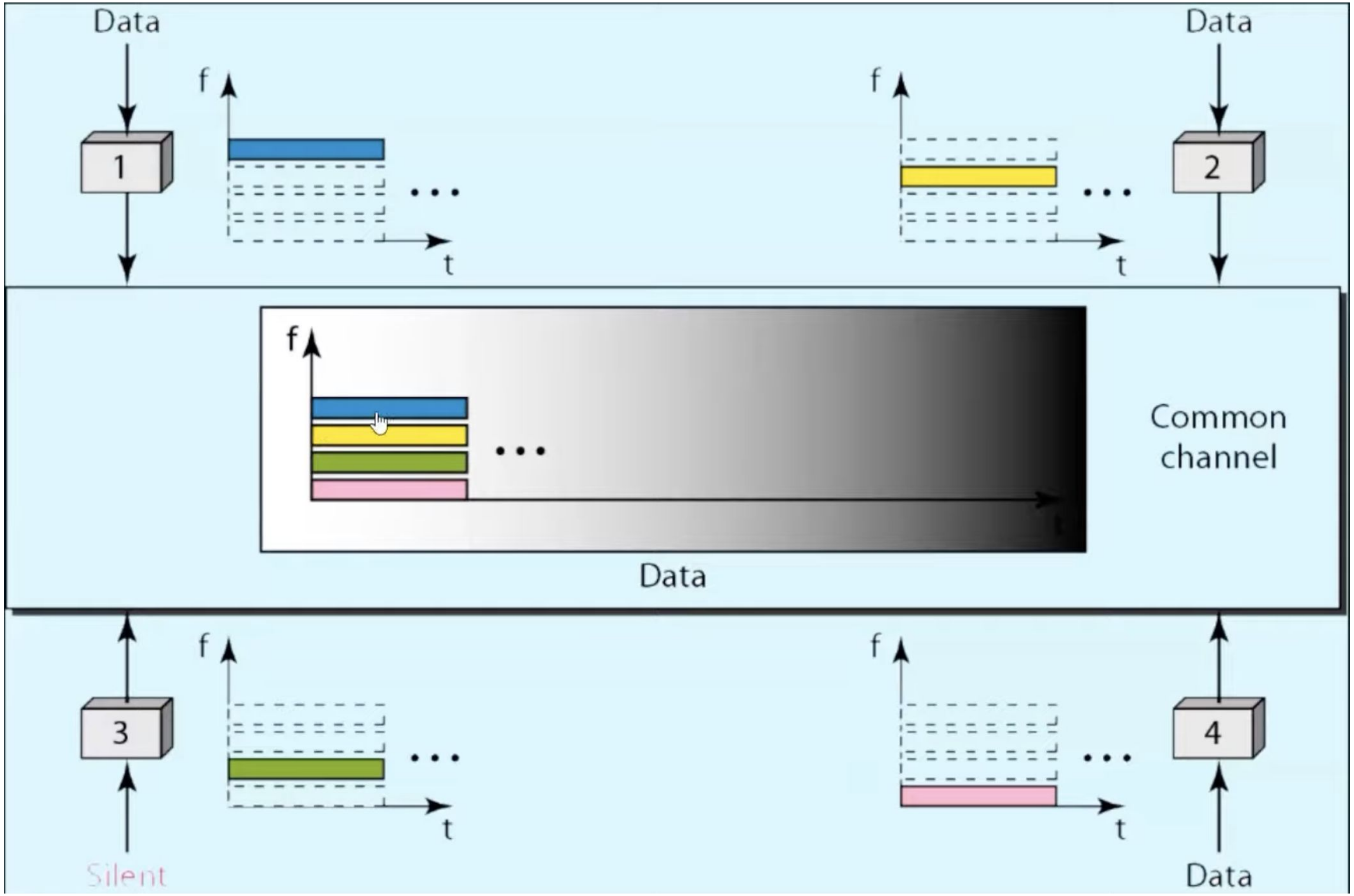
Multiplexing

- Multiplexing in computer networking means multiple signals are combined together thus travel simultaneously in a shared medium.
- Multiplexing is sharing the bandwidth.

FDMA

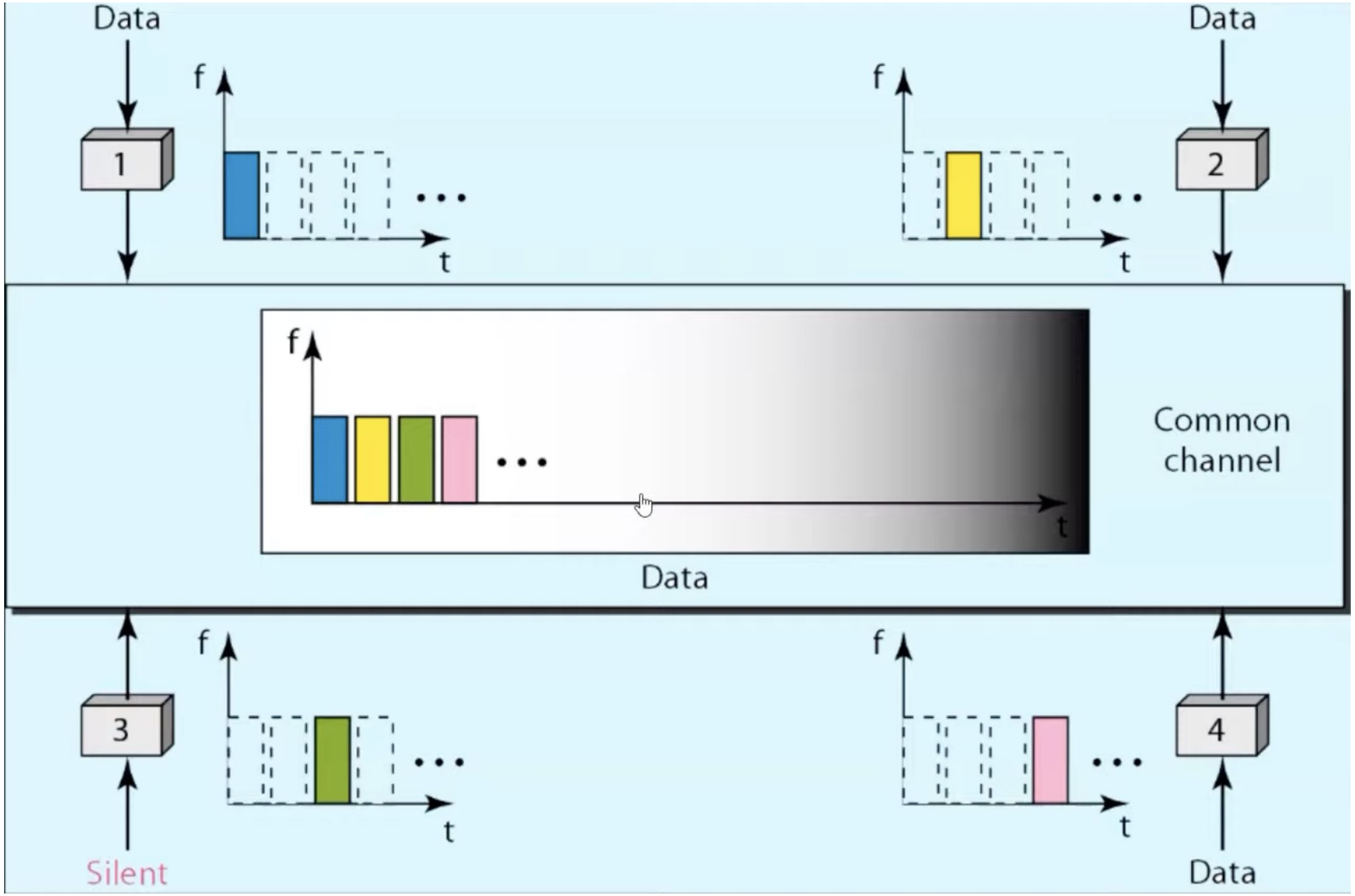
- The available bandwidth of the common channel is divided into bands that are separated by guard bands.
- Available bandwidth is shared by all stations.
- FDMA is a datalink layer protocol that uses FDM at physical layer.




Data
1
f
t
Data
2
f
t
f
Common
channel
Data
3
f
t
Silent
4
f
t
Data

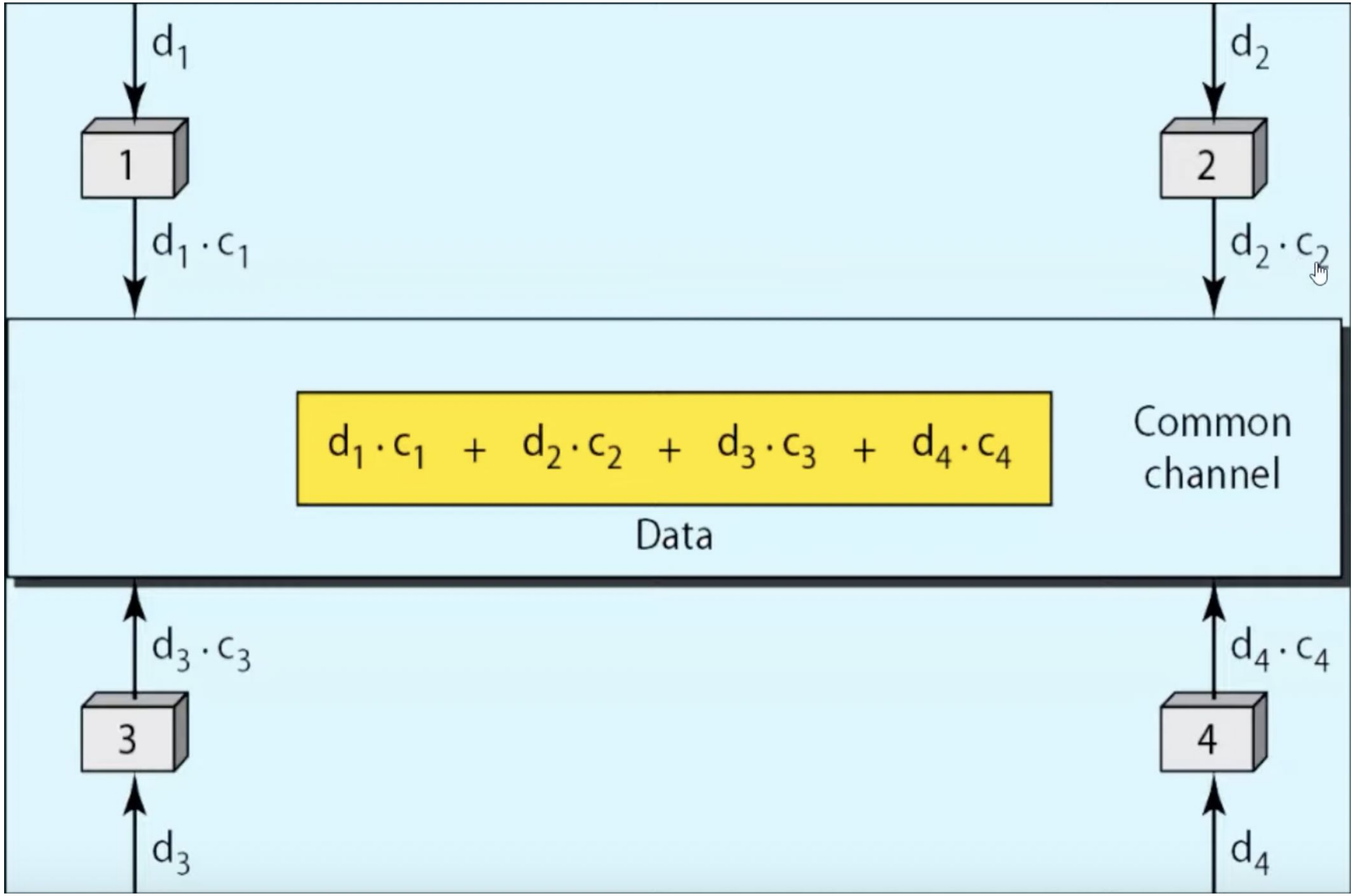
TDMA

- In TDMA, the bandwidth is just one channel that is time shared between different stations.
- The entire bandwidth is just one channel.
- Stations share the capacity of a channel in time.


Data
f
1
t
Data
f
2
t
f
t
Data
Common
channel
f
3
t
Silent
f
4
t
Data

CDMA

- In CDMA, one channel carries all transmissions simultaneously.
- CDMA differs from FDMA because only one channel occupies the entire bandwidth of the link.
- It differs from TDMA because all stations can send data simultaneously; i.e. these is no time sharing.
- Multiple simultaneous transmissions are separated using **coding theory**.
- the key to CDMA is to be able to extract the desired signal while rejecting everything else as random noise


d_1
d_2
1
2
$d_1 \cdot c_1$
$d_2 \cdot c_2$
$d_1 \cdot c_1 + d_2 \cdot c_2 + d_3 \cdot c_3 + d_4 \cdot c_4$
Common channel
Data
$d_3 \cdot c_3$
$d_4 \cdot c_4$
3
4
d_3
d_4

- The 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(the number of stations).

Example:

$$\text{Data} = (d_1 c_1 + d_2 c_2 + d_3 c_3 + d_4 c_4) \times c_1 = 4 \times d_1$$