Cyclic Redundancy Check-

•Cyclic Redundancy Check (CRC) is an error detection method.
•It is based on binary division.

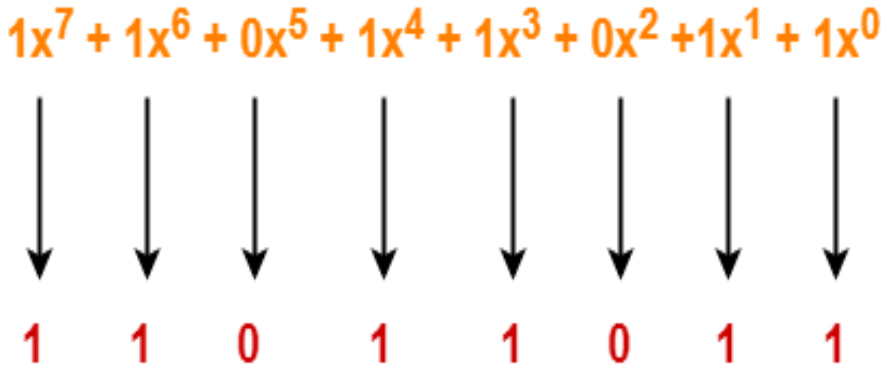
CRC Generator-

•CRC generator is an algebraic polynomial represented as a bit pattern.
•Bit pattern is obtained from the CRC generator using the following rule-

The power of each term gives the position of the bit and the coefficient gives the value of the bit.

Example-

Consider the CRC generator is $x^7 + x^6 + x^4 + x^3 + x + 1$.
The corresponding binary pattern is obtained as-



Thus, for the given CRC generator, the corresponding binary pattern is 11011011.

Sender Side (Generation of Encoded Data from Data and Generator Polynomial (or Key)):

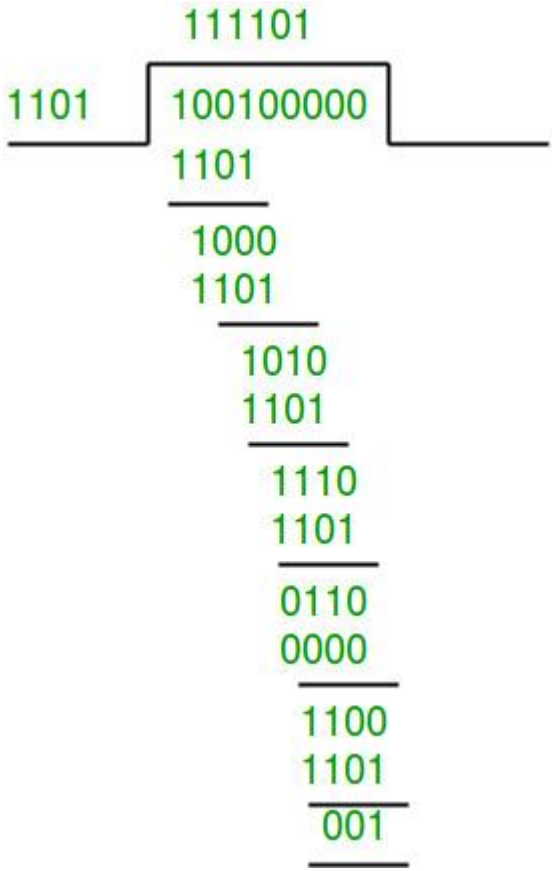
1.The binary data is first augmented by adding k-1 zeros in the end of the data
2.Use ***modulo-2 binary division*** to divide binary data by the key and store remainder of division.
3.Append the remainder at the end of the data to form the encoded data and send the same

Receiver Side (Check if there are errors introduced in transmission)

Perform modulo-2 division again and if the remainder is 0, then there are no errors.
In this article we will focus only on finding the remainder i.e. check word and the code word.

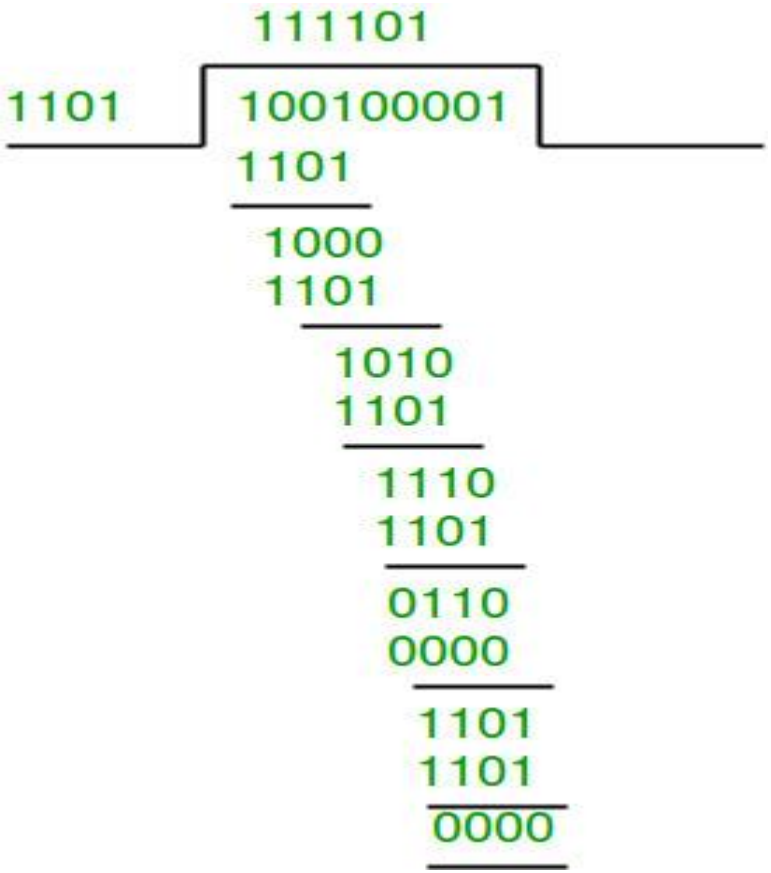
Example (No error in transmission):

Sender Side:



Therefore, the remainder is 001.

Receiver Side: Code word received at the receiver side 100100001



Therefore, the remainder is all zeros. Hence, the data received has no error.

BIT ORIENTED APPROACH

★ It simply views the frame as a collection of bits.

Bit Oriented Protocol

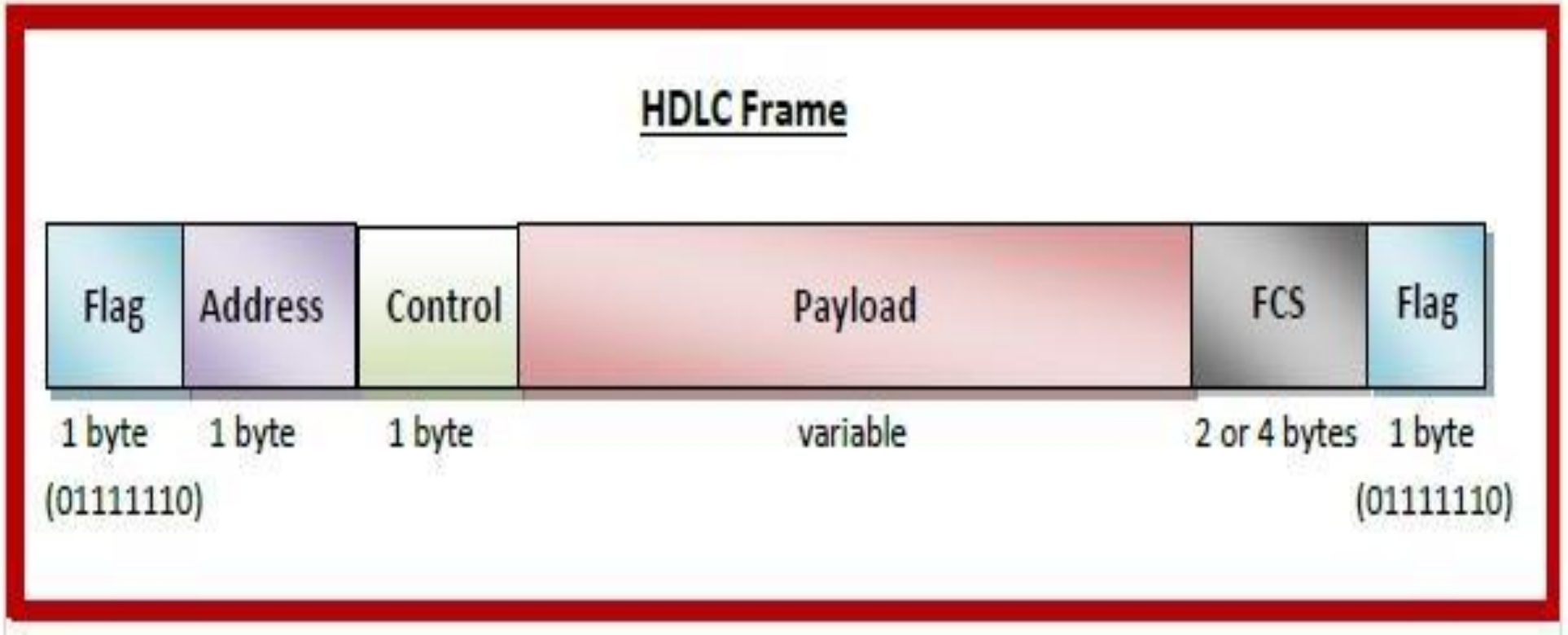
HDLC <-> High-Level Data Link Control

HDLC

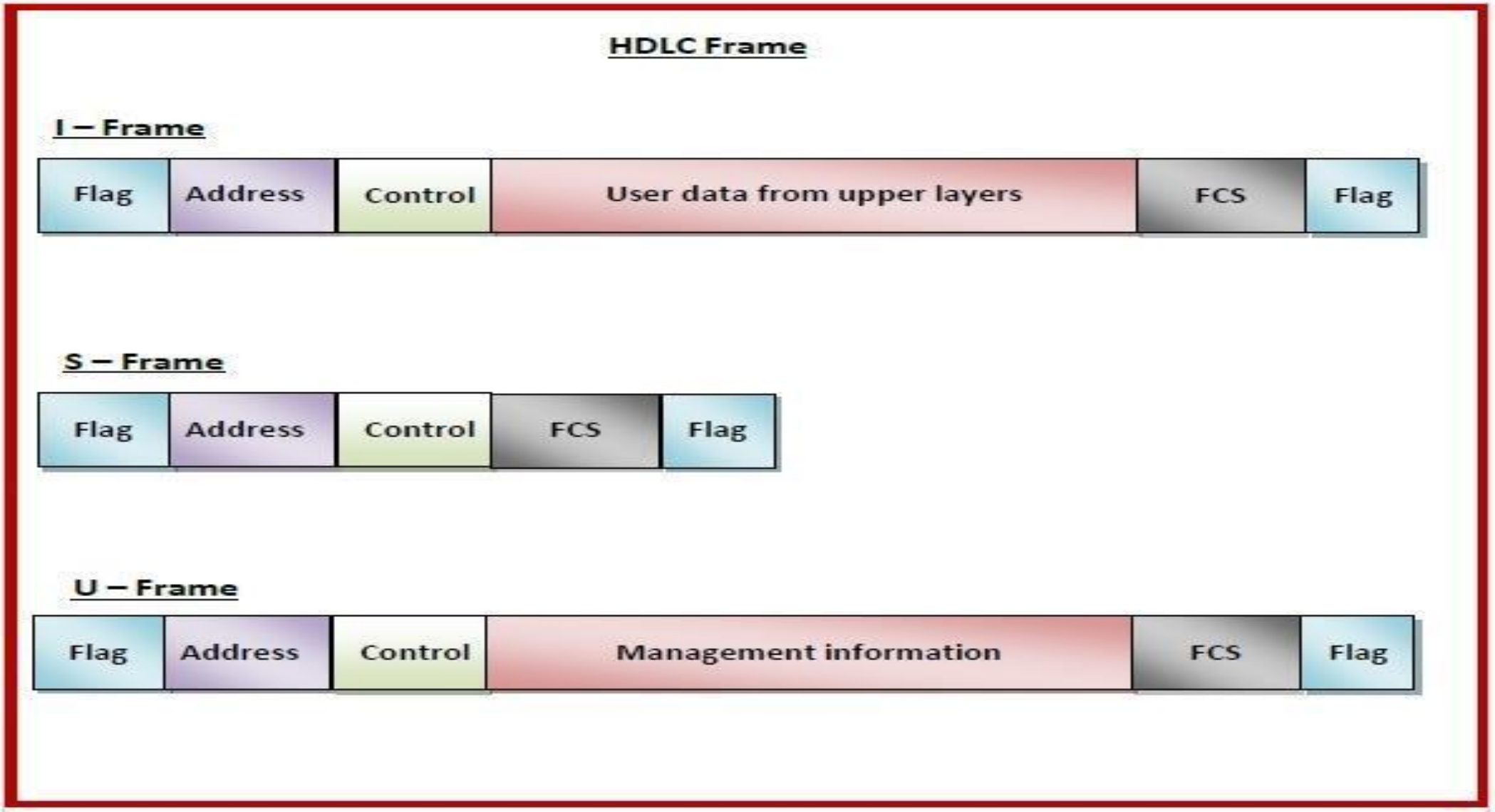
- ★ The Synchronous Data Link Control (SDLC) protocol developed by IBM is an example of a bit-oriented protocol.
- ★ SDLC was later standardized by the ISO as the High-Level Data Link Control (HDLC) protocol.
- ★ Bit Oriented Protocol.

High Level Data Link Control (HDLC):

High-level Data Link Control (HDLC) is a group of communication protocols of the data link layer for transmitting data between network points or nodes. Since it is a data link protocol, data is organized into frames.



Types of HDLC Frames

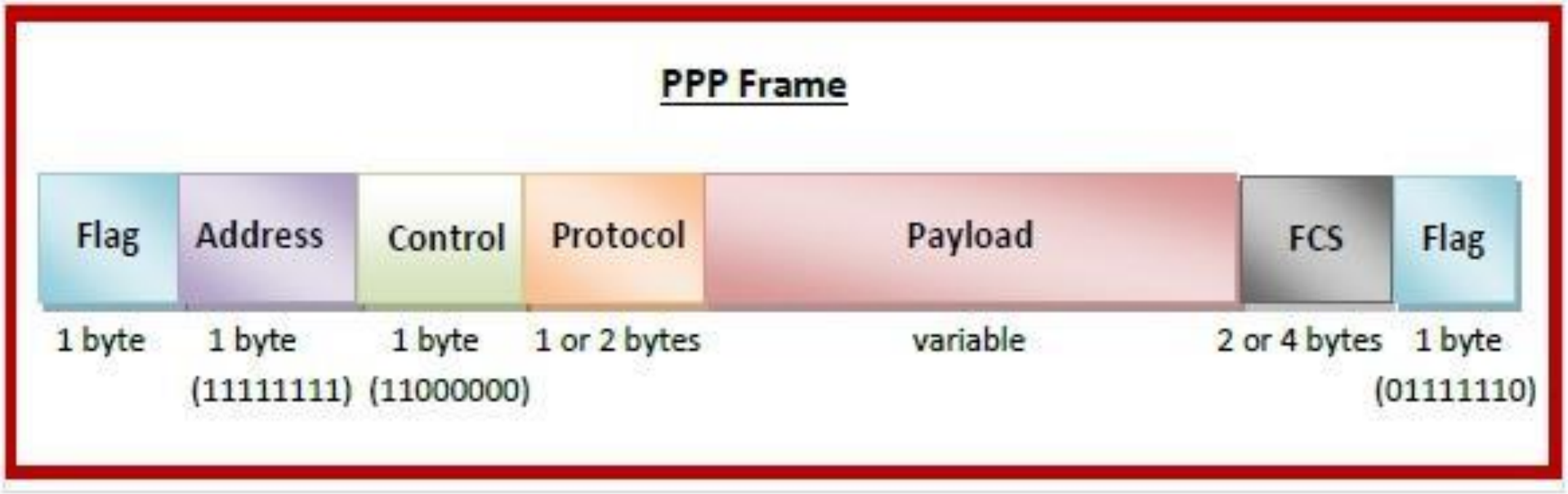


- **I-frame** − I-frames or Information frames carry user data from the network layer. They also include flow and error control information that is piggybacked on user data. The first bit of control field of I-frame is 0.

- **S-frame** − S-frames or Supervisory frames do not contain information field. They are used for flow and error control when piggybacking is not required. The first two bits of control field of S-frame is 10.
-
- **U-frame** − U-frames or Un-numbered frames are used for myriad miscellaneous functions, like link management. It may contain an information field, if required. The first two bits of control field of U-frame is 11

Point-to-Point Protocol (PPP):

- Although HDLC is a general protocol that can be used for both point-to-point and multipoint configurations, one of the most common protocols for point-to-point access is the Point-to-Point Protocol (PPP).
- Today, millions of Internet users who need to connect their home computers to the server of an Internet service provider use PPP.



Channel Allocation Problem:

- When there are more than one user who desire to access a shared network channel, an algorithm is deployed for channel allocation among the competing users.
- The network channel may be a single cable or optical fiber connecting multiple nodes, or a portion of the wireless spectrum.
- Channel allocation algorithms allocate the wired channels and bandwidths to the users, who may be base stations, access points or terminal equipment.

Channel Allocation may be done using two schemes:

- Static Channel Allocation
- Dynamic Channel Allocation

Static Channel Allocation

- In static channel allocation scheme, a fixed portion of the frequency channel is allotted to each user.
- For N competing users, the bandwidth is divided into N channels using frequency division multiplexing (FDM), and each portion is assigned to one user.
- This scheme is also referred as fixed channel allocation or fixed channel assignment.

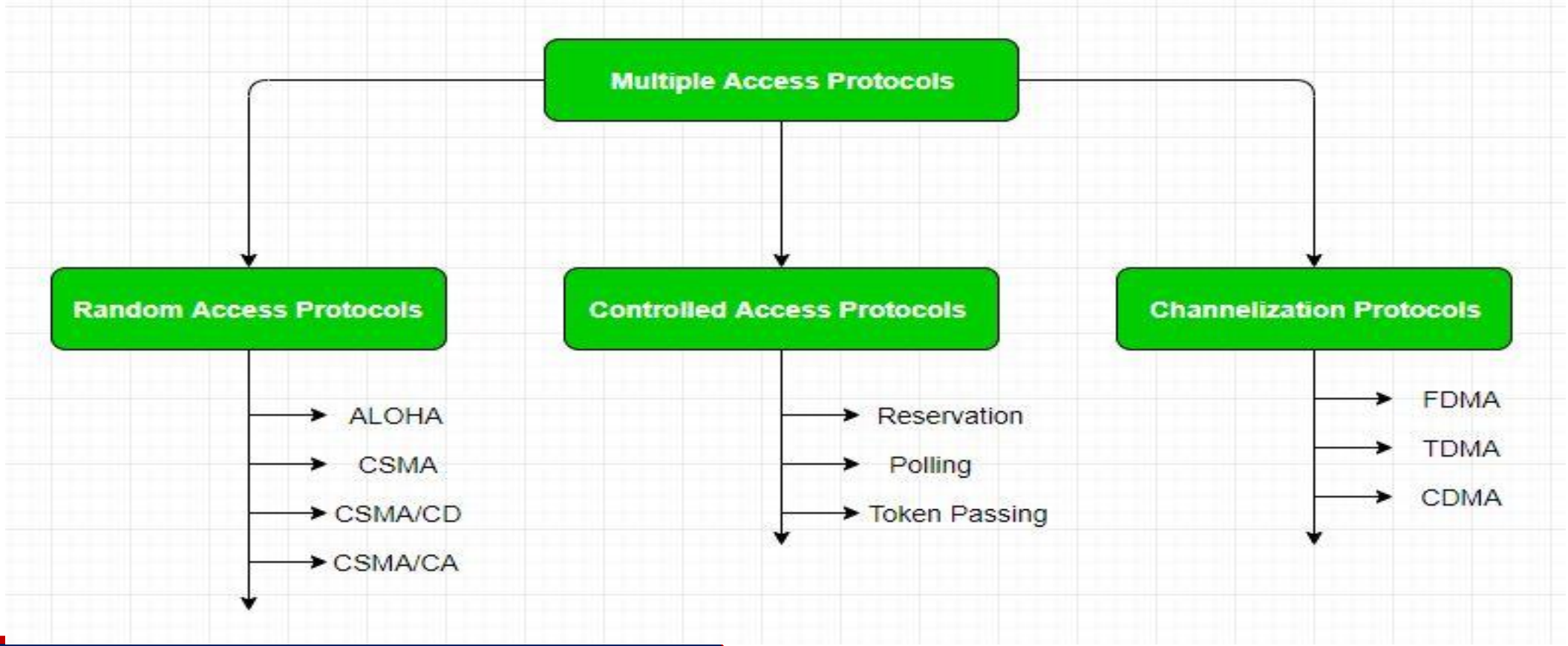
Dynamic Channel Allocation

- In dynamic channel allocation scheme, frequency bands are not permanently assigned to the users.
- Instead, channels are allotted to users dynamically as needed, from a central pool.

The allocation is done considering a number of parameters so that transmission interference is minimized

Multiple Access Protocols:

- When nodes or stations are connected and use a common link, called a multipoint or broadcast link, we need a multiple access protocol to coordinate access to the link.
- Many formal protocols have been devised to handle access to a shared link. We categorize them into three groups.



Random access:

- In random access or contention methods, no station is superior to another station and none is assigned the control
- over another.
- There is no fixed time for sending data
- There is no fixed sequence of stations sending data

ALOHA:

The **multiple access protocol** ALOHA (Advocates of Linux Open-source Hawaii Association) is used to transmit data over a public network channel.

- ALOHA is the earliest random-access method developed for wireless LAN but can be used on any shared medium.

Aloha Rules

Any station can transmit data to a channel at any time.

It does not require any carrier sensing.

Collision and data frames may be lost during the transmission of data through multiple stations.

It requires retransmission of data after some random amount of time.

Carrier Sense Multiple Access (CSMA):

- The chance of collision can be reduced if a station senses the medium before trying to use it.
- Carrier Sense Multiple Access ensures fewer collisions as the station is required to first sense the medium (for idle or busy) before transmitting data.
- If it is idle then it sends data, otherwise it waits till the channel becomes idle. (Listen before talk)
- However, there is still chance of collision in CSMA due to propagation delay.

carrier sense multiple access/collision avoidance (CSMA/CA)

Carrier sense multiple access/collision avoidance (CSMA/CA) is a protocol for carrier transmission in 802.11 networks. It was developed to minimize the potential of a collision occurring when two or more stations send their signals over a data link layer.

In this scenario, CSMA requires each station to first check the state of the medium before initiating a transmission. This helps to avert potential collisions by listening to the broadcasting nodes and then informing devices to transmit when the channel is free.

For example, as soon as a node receives a packet to transmit across the network, it will check to ensure the channel is clear and no other node is transmitting at the same time. If the network channel is idle, the packet is sent.

Carrier sense multiple access with collision detection (CSMA/CD):

- In Carrier sense multiple access with collision detection method, a station monitors the medium after it sends a frame to see if the transmission was successful. If so, the transmission is completed. However, if there is a collision, the frame is sent again.

The basic idea behind CSMA/CD is that a station needs to be able to receive while transmitting, to detect a collision.

When there is no collision, the station receives one signal; its own signal.

When there is a collision, the station receives two signals: its own signal and the signal transmitted by a second station.

To distinguish between these two cases, the received signals in these two cases must be significantly different. In other words, the signal from the second station needs to add a significant amount of energy to the one created by the first station.

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.
- We discuss three popular controlled-access methods: Reservation, Polling & Token Passing

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.
- If there are N stations in the system, there are exactly N reservation minislots in the reservation frame. Each minislot belongs to a station.
- When a station needs to send a data frame, it makes a reservation in its own minislot.

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.

Token Passing

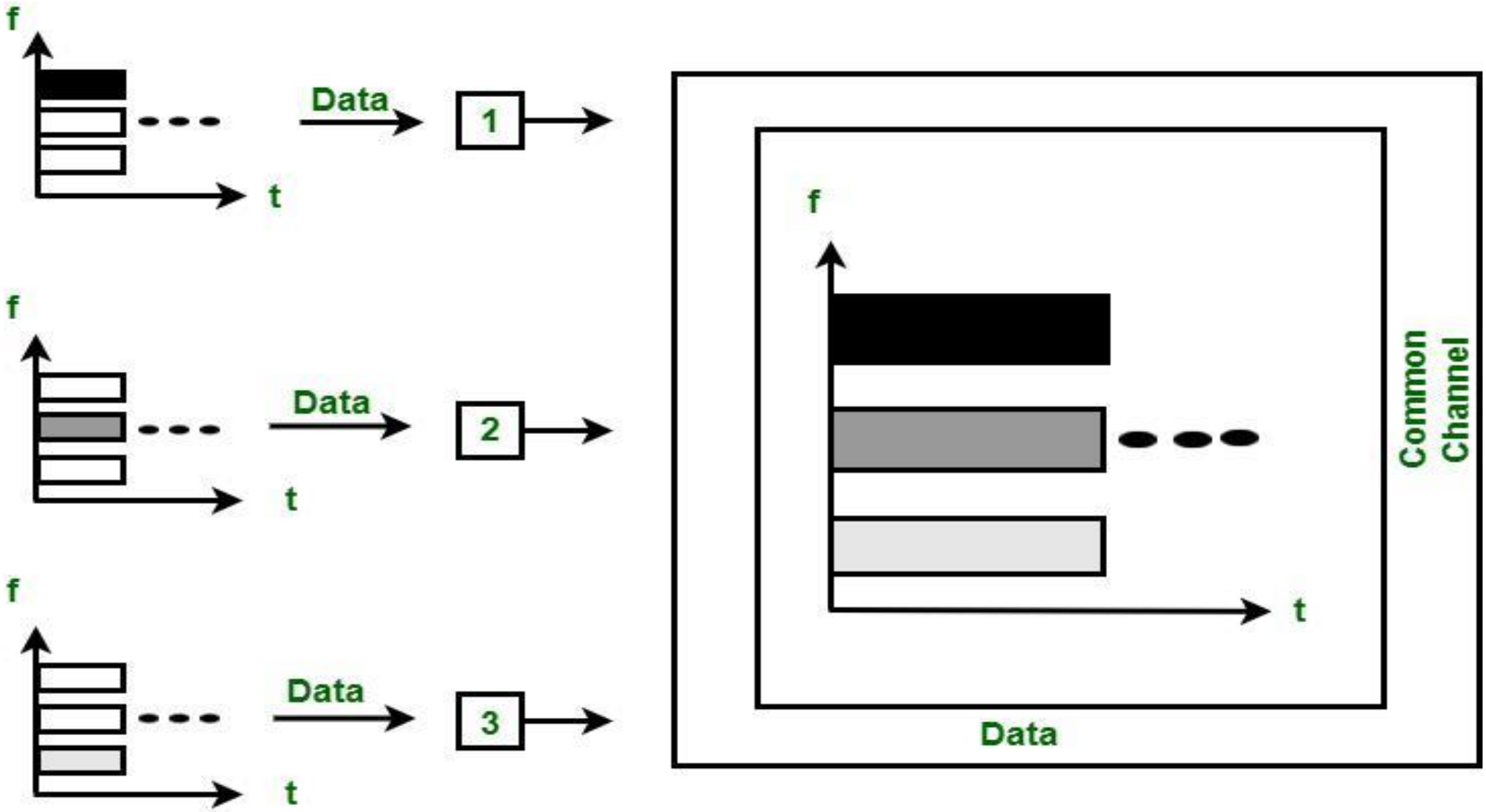
- In the token-passing method, the stations in a network are organized in a logical ring. In other words, for each station, there is a predecessor and a successor.
- The current station is the one that is accessing the channel now. The right to this access has been passed from the predecessor to the current station.
- The right will be passed to the successor when the current station has no more data to send.
- But how is the right to access the channel passed from one station to another? In this method, a special packet called a token circulates through the ring.

Channelization:

- Channelization is a multiple-access method in which the available bandwidth of a link is shared in time, frequency, or through code, between different stations.
- There are three channelization protocols: FDMA, TDMA, and CDMA.

Frequency-Division Multiple Access (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.
- FDMA specifies a predetermined frequency band for the entire period of communication. This means that stream data (a continuous flow of data that may not be packetized) can easily be used with FDMA.


f
t
Data
1
f
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Data
2
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t
Data
3
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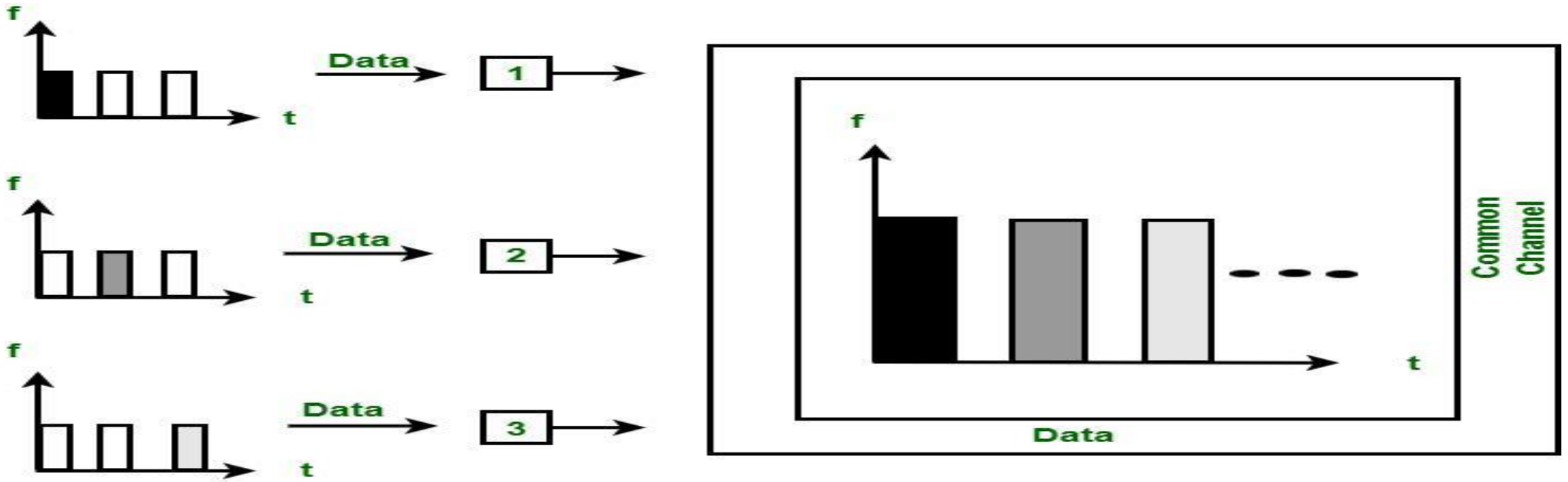
t
Common Channel
Data

Time-Division Multiple Access (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 is assigned time slot.
- The main problem with TDMA lies in achieving synchronization between the different stations. Each station needs to know the beginning of its slot and the location of its slot.
- This may be difficult because of propagation delays introduced in the system if the stations are spread over a large area. To compensate for the delays, we can insert guard times.
- Synchronization is normally accomplished by having some synchronization bits (normally referred to as preamble bits) at the beginning of each slot.



Code Division Multiple Access (CDMA):

- Code-division multiple access (CDMA) was conceived several decades ago. Recent advances in electronic technology have finally made its implementation possible.

- CDMA simply means communication with different codes.

For example, in a large room with many people, two people can talk in English if nobody else understands English. Another two people can talk in Chinese if they are the only ones who understand Chinese, and so on. In other words, the common channel, the space of the room in this case, can easily allow communication between several couples, but in different languages (codes).

Wired LAN: IEEE Standards

In 1985, the Computer Society of the IEEE (Institute of Electrical and Electronics Engineers) started a project, called Project 802, to set standards to enable intercommunication among equipment from a variety of manufacturers. Project 802 does not seek to replace any part of the OSI or the Internet model. Instead, it is a way of specifying functions of the physical layer and the data link layer of major LAN protocols.

IEEE 802 is comprised of standards with separate working groups that regulate different communication networks, including IEEE 802.1 for bridging , 802.2 for Logical link

802.3 for Ethernet, 802.5 for token ring, 802.11 for Wi-Fi, 802.15 for Wireless Personal area networks,

802.15.1 for Bluetooth, 802.16 for Wireless Metropolitan Area Networks etc.

Ethernet:

The original Ethernet was created in 1976 and since then, it has gone through four generations. Ethernet is most widely used LAN Technology, which is defined under IEEE standards 802.3. The reason behind its wide usability is Ethernet is easy to understand, implement, maintain and allows low-cost network implementation. Also, Ethernet offers flexibility in terms of topologies which are allowed. Ethernet generally uses Bus Topology. Ethernet operates in two layers of the OSI model, Physical Layer, and Data Link Layer.

Fiber Distributed Data Interface (FDDI):

Fiber Distributed Data Interface (FDDI) is a standard for transmission of data in local area network (LAN) over fiber optic cables. It is applicable in large LANs that can extend up to 200 kilometers in diameter.

Features

- FDDI uses optical fiber as its physical medium.
- It operates in the physical and medium access
- It provides high data rate of 100 Mbps and can support thousands of users.
- It is used in LANs up to 200 kilometers for long distance voice and multimedia communication.

Wireless LANs: IEEE 802.11x

IEEE has defined the specifications for a wireless LAN, called IEEE 802.11, which covers the physical and data link layers. IEEE 802.11, commonly known as **Wi-Fi**, specifies an over-the-air interface between a wireless client and a base station or between two wireless clients.

Bluetooth:

Bluetooth is a short-range wireless communication technology that allows devices such as mobile phones, computers, and peripherals to transmit data over a short distance.

The purpose of Bluetooth is to replace the cables that normally connect devices, while still keeping the communications between them secure.

It creates a 10-meter radius wireless network, called a personal area network (PAN).

Bluetooth uses less power and costs less to implement than Wi-Fi. Its lower power also makes it far less prone to suffering from or causing interference with other wireless devices in the same 2.4GHz radio band.

Token Ring:

Token ring is the IEEE 802.5 standard for a token-passing ring in Communication networks.

A ring consists of a collection of ring interfaces connected by point-to-point lines i.e. ring interface of one station is connected to the ring interfaces of its left station as well as right station.

Token Bus:

Token Bus (IEEE 802.4) is a standard for implementing token ring over virtual ring in LANs.

The physical media has a bus or a tree topology and uses coaxial cables.

The working principle of token bus is similar to Token Ring

Virtual LANs:

- A station is considered part of a LAN if it physically belongs to that LAN. The criterion of membership is geographic.
- What happens if we need a virtual connection between two stations belonging to two different physical LANs?
- We can roughly define a virtual local area network (VLAN) as a local area network configured by software, not by physical wiring.