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Class: B.Sc. Computer Science (Entire)- III **Semester : 5**

Course Title: Data Communication

UNIT 3

Protocols and Standards

I. Protocols:

- In computer networks, communication occurs between entities in different systems.
- An entity is anything capable of sending or receiving information.
- A *protocol* is a set of rules that govern data communications.
- A protocol defines what is communicated, how it is communicated, and when it is communicated.

The key elements of a protocol are

1) Syntax

2) Semantics

3) Timing.

1.Syntax:

The term syntax refers to the structure or format of the data, meaning the order in which they are presented. For example, a simple protocol might expect the first 8 bits of data to be the address of the sender, the second 8 bits to be the address of the receiver, and the rest of the stream to be the message

itself.

2.Semantics:

The word semantics refers to the meaning of each section of bits. How is a particular pattern to be interpreted, and what action is to be taken based on that interpretation? For example, does an address identify the route to be taken or the final destination of the message?

3.Timing:

The term timing refers to two characteristics: when data should be sent and how fast they can be sent. For example, if a sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps, the transmission will overload the receiver and some data will be lost.

II. Standards:

Standards are essential in creating and maintaining an open and competitive market for equipment manufacturers and in guaranteeing national and international interoperability of data and telecommunications technology and processes. Standards provide guidelines to manufacturers, vendors, government agencies, and other service providers to ensure the kind of interconnectivity necessary in today's marketplace and in international communications. Data communication standards fall into two categories: de facto (meaning "by fact" or "by convention") and de jure (meaning "by law" or "by regulation").

a. De facto:

Standards that have not been approved by an organized body but have been adopted as standards through widespread use are de facto standards. De facto standards are often established originally by manufacturers who seek to define the functionality of a new product or technology.

Examples: 1) Hewlett-Packard Printer Control Language (PCL) for laser printers

2) The QWERTY system for typewriters and keyboards

3) **MP3**

b. De jure:

Those standards that have been legislated by an officially recognized body are de jure standards

Examples: IEEE, ISO, ASCII.

Some de jure hardware standards include USB, FireWire and HDMI.

What is Multiplexing?

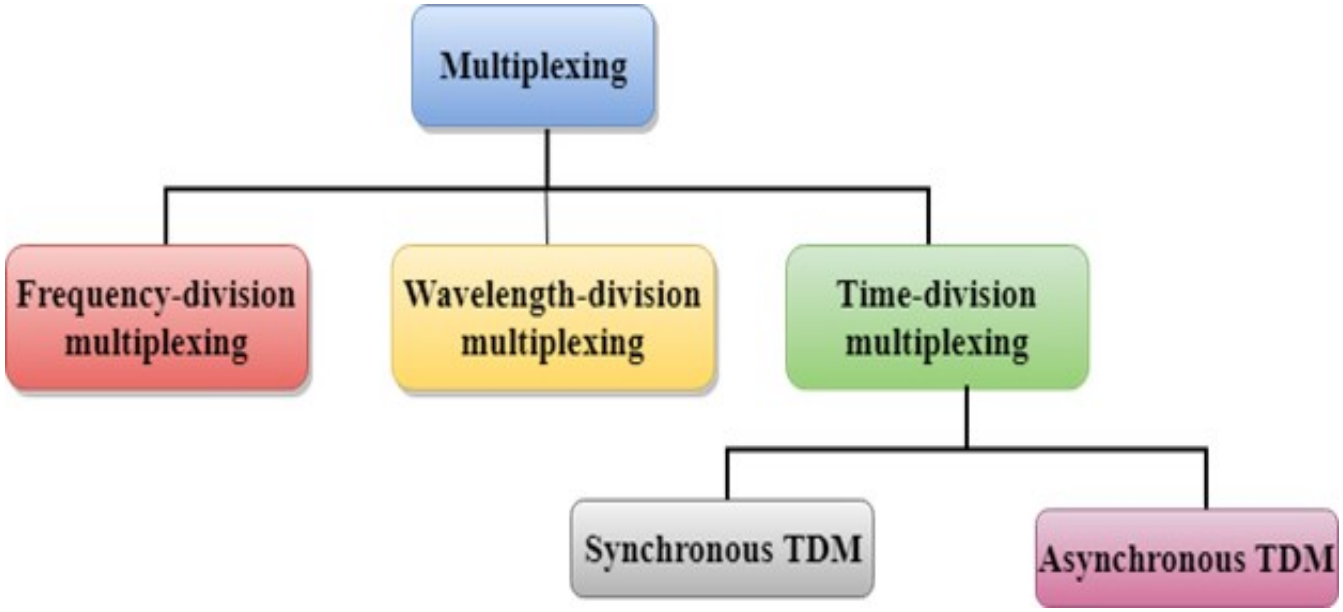
- Multiplexing is a technique used to combine and send the multiple data streams over a single medium.
- The process of combining the data streams is known as multiplexing and hardware used for multiplexing is known as a multiplexer.
- Multiplexing is achieved by using a device called Multiplexer (MUX) that combines n input lines to generate a single output line.
- Multiplexing follows many-to-one, i.e., n input lines and one output line.
- Demultiplexing is achieved by using a device called Demultiplexer (DEMUX) available at the receiving end.
- DEMUX separates a signal into its component signals (one input and n outputs). Therefore, we can say that demultiplexing follows the one-to-many approach.

Why Multiplexing?

- The transmission medium is used to send the signal from sender to receiver.
- The medium can only have one signal at a time.
- If there are multiple signals to share one medium, then the medium must be divided in such a way that each signal is given some portion of the available bandwidth.
- For example: If there are 10 signals and bandwidth of medium is100 units, then the 10 unit is shared by each signal.
- When multiple signals share the common medium, there is a possibility of collision.
- Multiplexing concept is used to avoid such collision.
- Transmission services are very expensive.

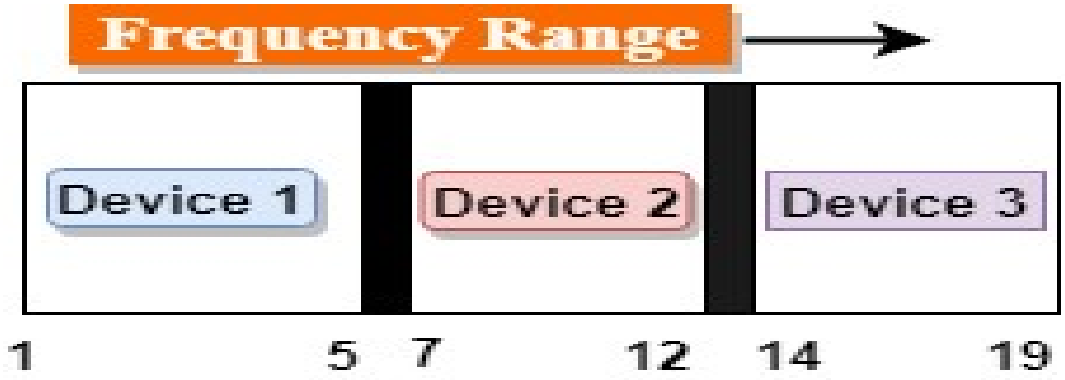
Multiplexing Techniques:

Multiplexing techniques can be classified as:



1. Frequency-division Multiplexing (FDM)

- It is an analog technique.
- **Frequency Division Multiplexing** is a technique in which the available bandwidth of a single transmission medium is subdivided into several channels.



- In the above diagram, a single transmission medium is subdivided into several frequency channels, and each frequency channel is given to different devices. Device 1 has a frequency channel of range from 1 to 5.
- The input signals are translated into frequency bands by using modulation techniques, and they are combined by a multiplexer to form a composite signal.
- The main aim of the FDM is to subdivide the available bandwidth into different frequency channels and allocate them to different devices.
- Using the modulation technique, the input signals are transmitted into frequency bands and then combined to form a composite signal.
- The carriers which are used for modulating the signals are known as **sub-carriers**. They are represented as f1,f2..fn.
- **FDM** is mainly used in radio broadcasts and TV networks.

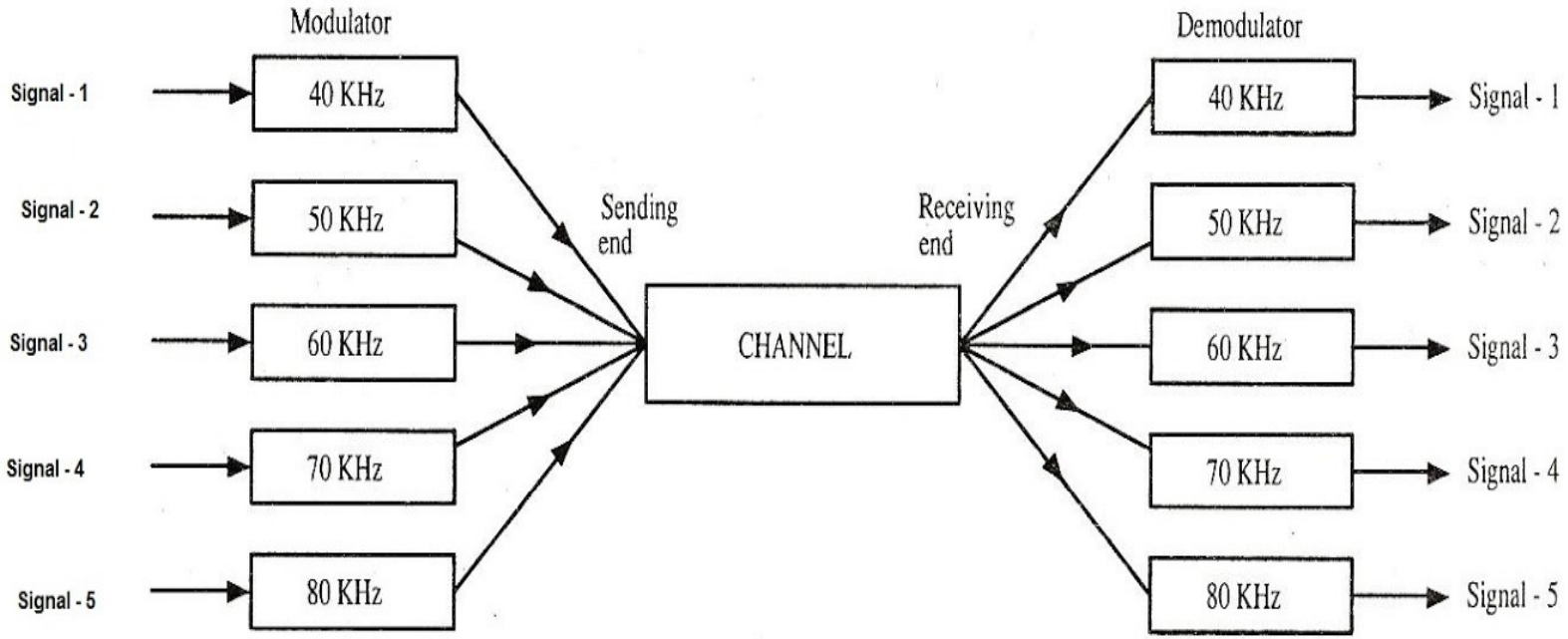


Figure 1. Frequency division multiplexing

Advantages Of FDM:

1. FDM is used for analog signals.
2. FDM process is very simple and easy modulation.
3. A Large number of signals can be sent through an FDM simultaneously.
4. It does not require any synchronization between sender and receiver.

Disadvantages Of FDM:

1. FDM technique is used only when low-speed channels are required.
2. It suffers the problem of crosstalk.
3. A Large number of modulators are required.
4. It requires a high bandwidth channel.

Applications Of FDM:

1. FDM is commonly used in TV networks.
2. It is used in FM and AM broadcasting. Each FM radio station has different frequencies, and they are multiplexed to form a composite signal. The multiplexed signal is transmitted in the air.

2. Wavelength Division Multiplexing (WDM)

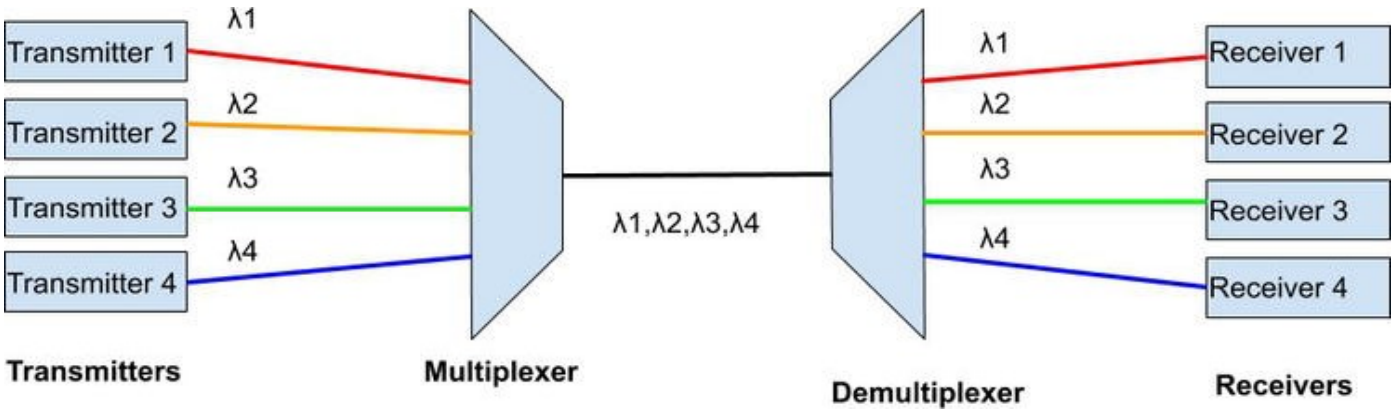


Fig. Wavelength Division Multiplexing (WDM)

- Wavelength Division Multiplexing is same as FDM except that the optical signals are transmitted through the fiber optic cable.
- WDM is used on fiber optics to increase the capacity of a single fiber.
- It is used to utilize the high data rate capability of fiber optic cable.
- It is an analog multiplexing technique.
- Optical signals from different source are combined to form a wider band of light with the help of multiplexer.
- At the receiving end, demultiplexer separates the signals to transmit them to their respective destinations.
- Multiplexing and Demultiplexing can be achieved by using a prism.
- Prism can perform a role of multiplexer by combining the various optical signals to form a composite signal, and the composite signal is transmitted through a fiber optic cable.
- Prism also performs a reverse operation, i.e., demultiplexing the signal.

- **Categories of WDM**

1.CWDM (Coarse Wavelength Division Multiplexing)

- CWDM is short-range communications.
- It uses wide-range frequencies and spreads wavelengths
- CWDM generally operates with 8 channels where the spacing between the channels is 20 nm (nanometres) apart. It consumes less energy than DWDM and is less expensive.

2. DWDM (Dense Wavelength Division Multiplexing)

- DWDM is defined in terms of frequencies.
- DWDM is designed for long transmissions where wavelengths are packed tightly.
- In DWDM, the number of multiplexed channels much larger than CWDM. It is either 40 at 100GHz spacing or 80 with 50GHz spacing.
- Dense Wavelength Division Multiplexing (DWDM) is a technique or technology for transmission of huge information or data over long distances.

3. Time Division Multiplexing

- It is a digital technique.
- In Frequency Division Multiplexing Technique, all signals operate at the same time with different frequency, but in case of Time Division Multiplexing technique, all signals operate at the same frequency with different time.
- In **Time Division Multiplexing technique**, the total time available in the channel is distributed among different users. Therefore, each user is allocated with different time interval known as a Time slot at which data is to be transmitted by the sender.
- A user takes control of the channel for a fixed amount of time.
- In Time Division Multiplexing technique, data is not transmitted simultaneously rather the data is transmitted one-by-one.
- In TDM, the signal is transmitted in the form of frames. Frames contain a cycle of time slots in which each frame contains one or more slots dedicated to each user.
- It can be used to multiplex both digital and analog signals but mainly used to multiplex digital signals.

Types of TDM:

1. Synchronous TDM
2. Asynchronous TDM

1. Synchronous TDM

- A Synchronous TDM is a technique in which time slot is preassigned to every device.
- In Synchronous TDM, each device is given some time slot irrespective of the fact that the device contains the data or not.
- If the device does not have any data, then the slot will remain empty.
- In Synchronous TDM, signals are sent in the form of frames. Time slots are organized in the form of frames. If a device does not have data for a particular time slot, then the empty slot will be transmitted.
- The most popular Synchronous TDM are T-1 multiplexing, ISDN multiplexing, and SONET multiplexing.
- If there are n devices, then there are n slots.

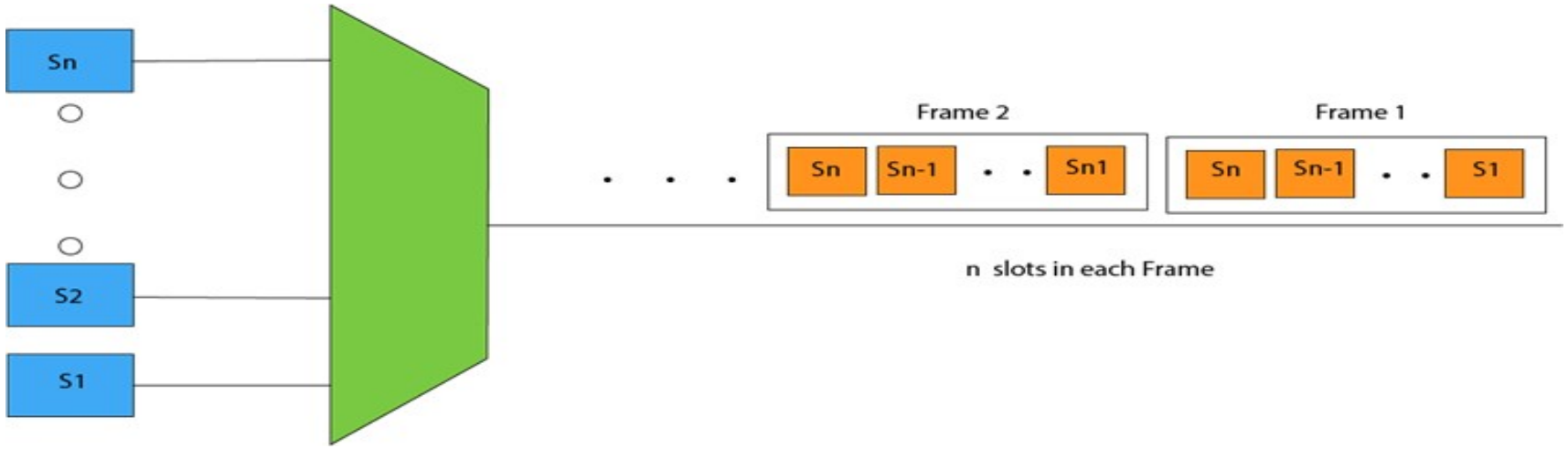


Fig. Synchronous TDM

Disadvantages Of Synchronous TDM:

1. The capacity of the channel is not fully utilized as the empty slots are also transmitted which is having no data. In the above figure, the first frame is completely filled, but in the last two frames, some slots are empty. Therefore, we can say that the capacity of the channel is not utilized efficiently.
2. The speed of the transmission medium should be greater than the total speed of the input lines. An alternative approach to the Synchronous TDM is Asynchronous Time Division Multiplexing.

2. Asynchronous TDM

- An asynchronous TDM is also known as Statistical TDM.
- An asynchronous TDM is a technique in which time slots are not fixed as in the case of Synchronous TDM. Time slots are allocated to only those devices which have the data to send. Therefore, we can say that Asynchronous Time Division multiplexor transmits only the data from active workstations.
- An asynchronous TDM technique dynamically allocates the time slots to the devices.
- In Asynchronous TDM, total speed of the input lines can be greater than the capacity of the channel.
- Asynchronous Time Division multiplexor accepts the incoming data streams and creates a frame that contains only data with no empty slots.
- In Asynchronous TDM, each slot contains an address part that identifies the source of the data.

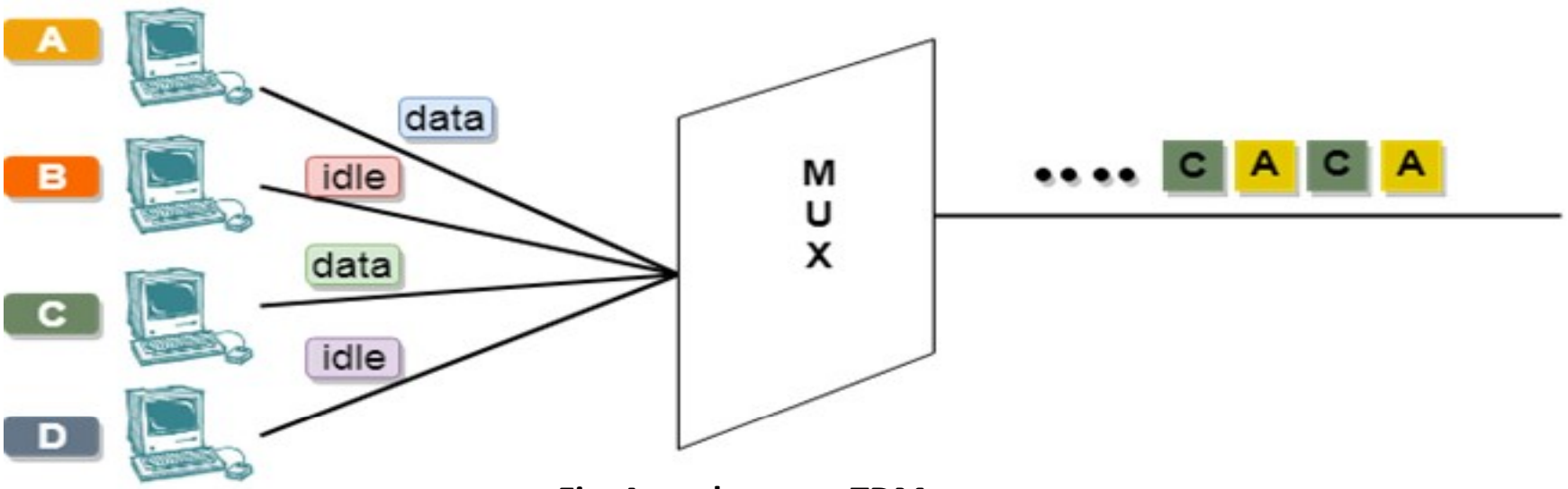


Fig. Asynchronous TDM

In the above diagram, there are 4 devices, but only two devices are sending the data, i.e., A and C. Therefore, the data of A and C are only transmitted through the transmission line.

- **The difference between Asynchronous TDM and Synchronous TDM**

1. Many slots in Synchronous TDM are unutilized, but in Asynchronous TDM, slots are fully utilized. This leads to the smaller transmission time and efficient utilization of the capacity of the channel.
2. In Synchronous TDM, if there are n sending devices, then there are n time slots. In Asynchronous TDM, if there are n sending devices, then there are m time slots where m is less than n (**m<n**).

Advantages of TDM

1. Simple circuit design.
2. It uses entire channel bandwidth for the transmission of the signal.
3. The problem of Intermodulation distortion is not present in TDM.
4. Pulse overlapping can sometimes cause crosstalk but it can be reduced by utilizing guard time. Thus, is not much serious.

Disadvantages of TDM

1. The transmitting and receiving section must be properly synchronized in order to have proper signal transmission and reception.
2. Slow narrowband fading can wipe out all the TDM channels.

Applications of Time division multiplexing

TDM finds its application mainly in a digital communication system, in cellular radio and in satellite communication system.

Switching

When a user accesses the internet or another computer network outside their immediate location, messages are sent through the network of transmission media. This technique of transferring the information from one computer network to another network is known as **switching**.

- Switching in a computer network is achieved by using switches. A switch is a small hardware device which is used to join multiple computers together with one local area network (LAN).
- Network switches operate at layer 2 (Data link layer) in the OSI model.
- Switching is transparent to the user and does not require any configuration in the home network.
- Switches are used to forward the packets based on MAC addresses.
- A Switch is used to transfer the data only to the device that has been addressed. It verifies the destination address to route the packet appropriately.
- It is operated in full duplex mode.
- Packet collision is minimum as it directly communicates between source and destination.
- It does not broadcast the message as it works with limited bandwidth.

Why is Switching Concept required?

Switching concept is developed because of the following reasons:

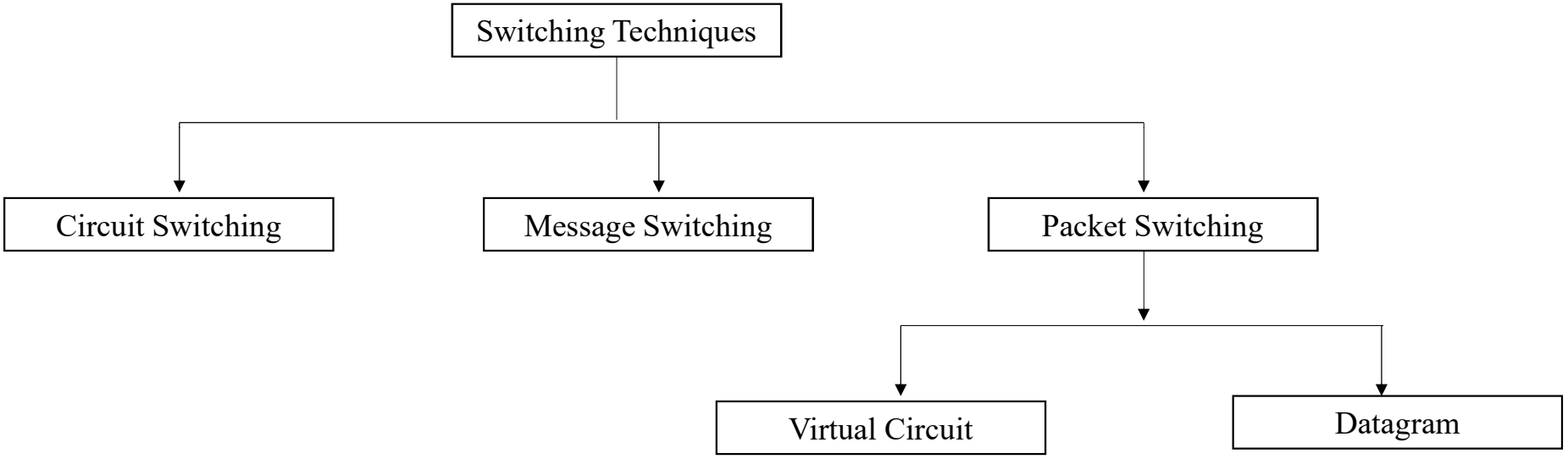
Bandwidth: It is defined as the maximum transfer rate of a cable. It is a very critical and expensive resource. Therefore, switching techniques are used for the effective utilization of the bandwidth of a network.

Collision: Collision is the effect that occurs when more than one device transmits the message over the same physical media, and they collide with each other. To overcome this problem, switching technology is implemented so that packets do not collide with each other.

Switching techniques

In large networks, there can be multiple paths from sender to receiver. The switching technique will decide the best route for data transmission. Switching technique is used to connect the systems for making one-to-one communication.

Classification Of Switching Techniques:



1. Circuit Switching

- Circuit switching is a switching technique that establishes a dedicated path between sender and receiver.
- In the Circuit Switching Technique, **once the connection is established** then the **dedicated path will remain to exist until the connection is terminated**.
- Circuit switching in a network operates in a similar way as the **telephone** works.
- A complete end-to-end path must exist before the communication takes place.
- In case of circuit switching technique, when any user wants to send the data, voice, video, a request signal is sent to the receiver then the receiver sends back the acknowledgment to ensure the availability of the dedicated path. After receiving the acknowledgment, dedicated path transfers the data.
- Circuit switching is used in public telephone network.
- It is used for voice transmission.
- Fixed data can be transferred at a time in circuit switching technology.

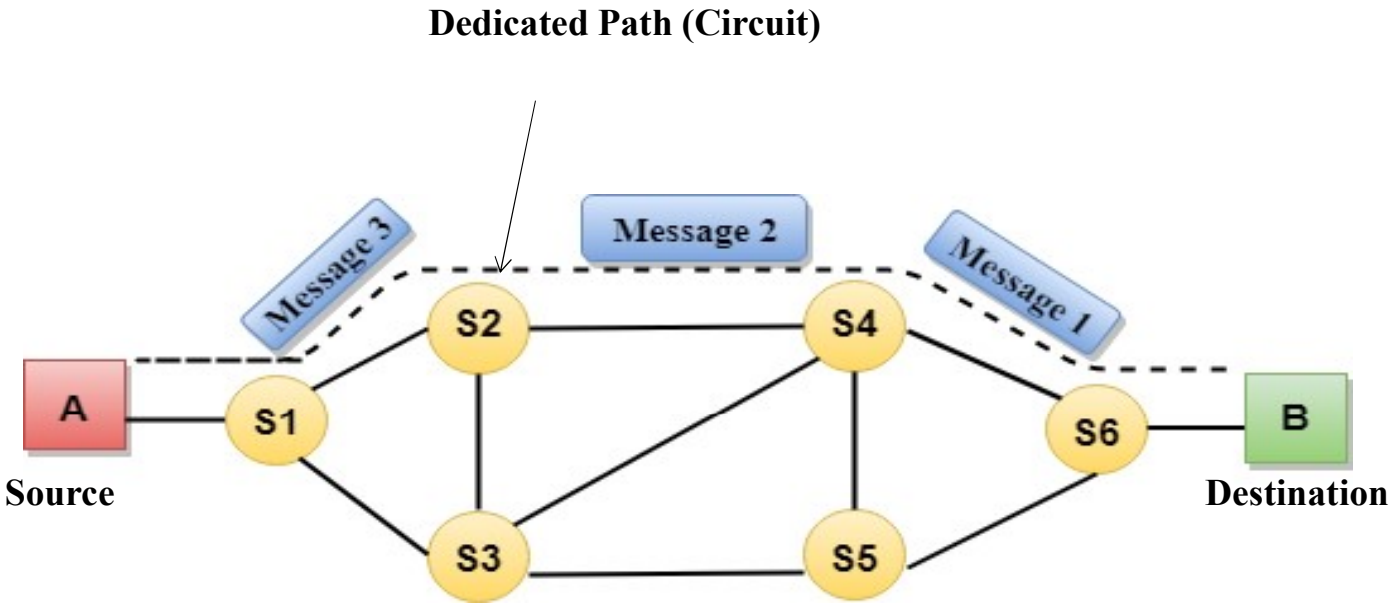


Fig. Circuit Switching

Advantages Of Circuit Switching:

1. In the case of Circuit Switching technique, the communication channel is dedicated.
2. It has fixed bandwidth.

Disadvantages Of Circuit Switching:

1. Once the dedicated path is established, the only delay occurs in the speed of data transmission.
2. It takes a long time to establish a connection approx 10 seconds during which no data can be transmitted.
3. It is more expensive than other switching techniques as a dedicated path is required for each connection.
4. It is inefficient to use because once the path is established and no data is transferred, then the capacity of the path is wasted.
5. In this case, the connection is dedicated therefore no other data can be transferred even if the channel is free.

2. Message Switching

- Message Switching is a switching technique in which a message is transferred as a complete unit and routed through intermediate nodes at which it is stored and forwarded.
- In Message Switching technique, there is no establishment of a dedicated path between the sender and receiver.
- The destination address is appended to the message. Message Switching provides a dynamic routing as the message is routed through the intermediate nodes based on the information available in the message.
- Message switches are programmed in such a way so that they can provide the most efficient routes.
- Each and every node stores the entire message and then forward it to the next node. This type of network is known as **store and forward network.**
- Message switching treats each message as an independent entity.

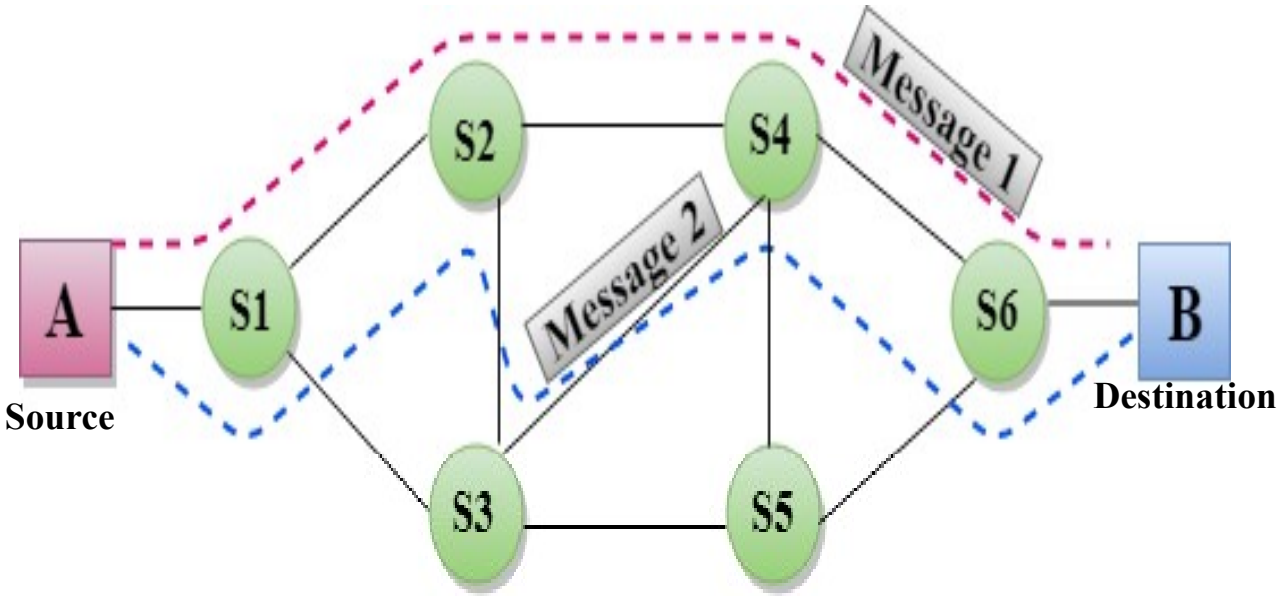


Fig. Message Switching

Advantages Of Message Switching

1. Data channels are shared among the communicating devices that improve the efficiency of using available bandwidth.
2. Traffic congestion can be reduced because the message is temporarily stored in the nodes.
3. Message priority can be used to manage the network.
4. The size of the message which is sent over the network can be varied. Therefore, it supports the data of unlimited size.

Disadvantages Of Message Switching

1. The message switches must be equipped with sufficient storage to enable them to store the messages until the message is forwarded.
2. The Long delay can occur due to the storing and forwarding facility provided by the message switching technique.

3. Packet Switching

- The packet switching is a switching technique in which the message is sent in one go, but it is divided into smaller pieces, and they are sent individually.
- The message splits into smaller pieces known as packets and packets are given a unique number to identify their order at the receiving end.
- Every packet contains some information in its headers such as source address, destination address and sequence number.
- Packets will travel across the network, taking the shortest path as possible.
- All the packets are reassembled at the receiving end in correct order.
- If any packet is missing or corrupted, then the message will be sent to resend the message.
- If the correct order of the packets is reached, then the acknowledgment message will be sent.

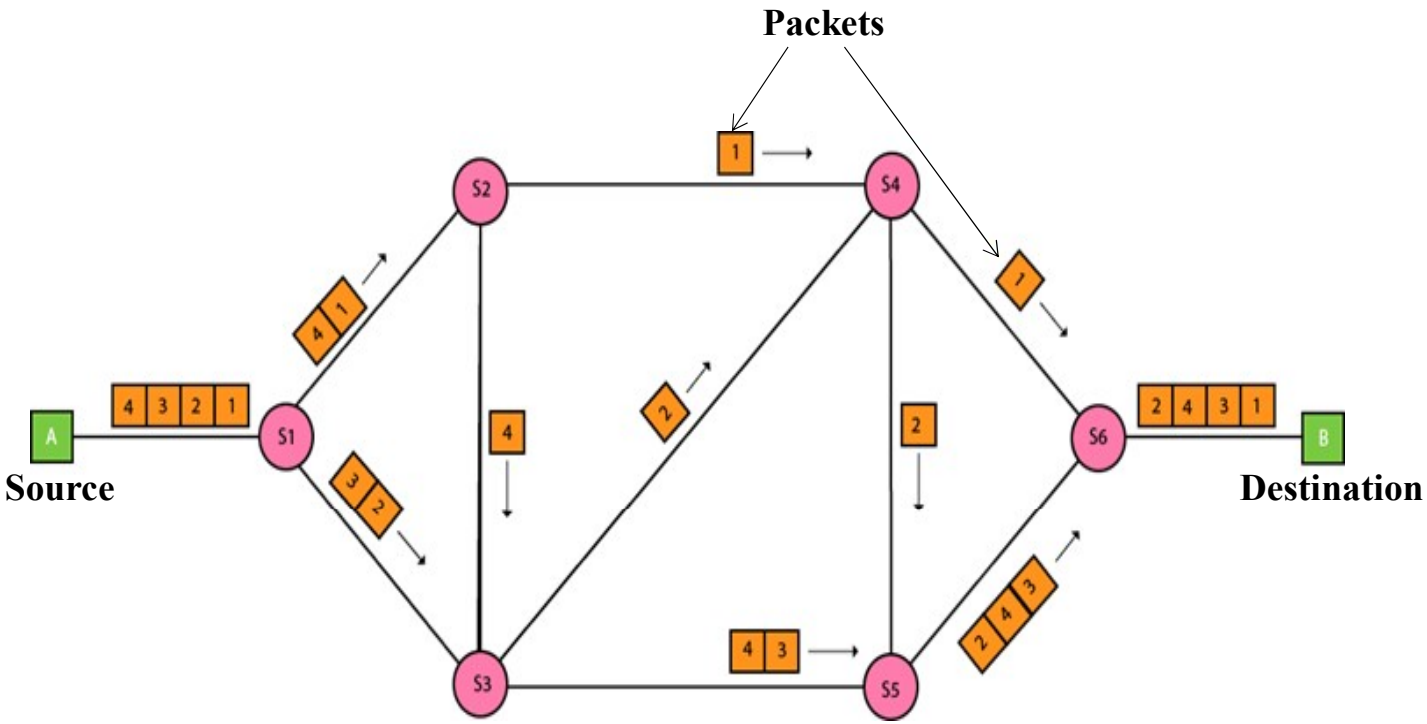


Fig. Packet Switching

- **Types of Packet Switching**

1. Datagram Packet Switching
2. Virtual Circuit Switching

1. Datagram Packet switching:

- It is a packet switching technology in which packet is known as a datagram, is considered as an independent entity. Each packet contains the information about the destination and switch uses this information to forward the packet to the correct destination.
- The packets are reassembled at the receiving end in correct order.
- In Datagram Packet Switching technique, the path is not fixed.
- Intermediate nodes take the routing decisions to forward the packets.
- Datagram Packet Switching is also known as connectionless switching.

2. Virtual Circuit Switching

- Virtual Circuit Switching is also known as connection-oriented switching.
- In the case of Virtual circuit switching, a preplanned route is established before the messages are sent.
- Call request and call accept packets are used to establish the connection between sender and receiver.
- In this case, the path is fixed for the duration of a logical connection.

Let's understand the concept of virtual circuit switching through a diagram:

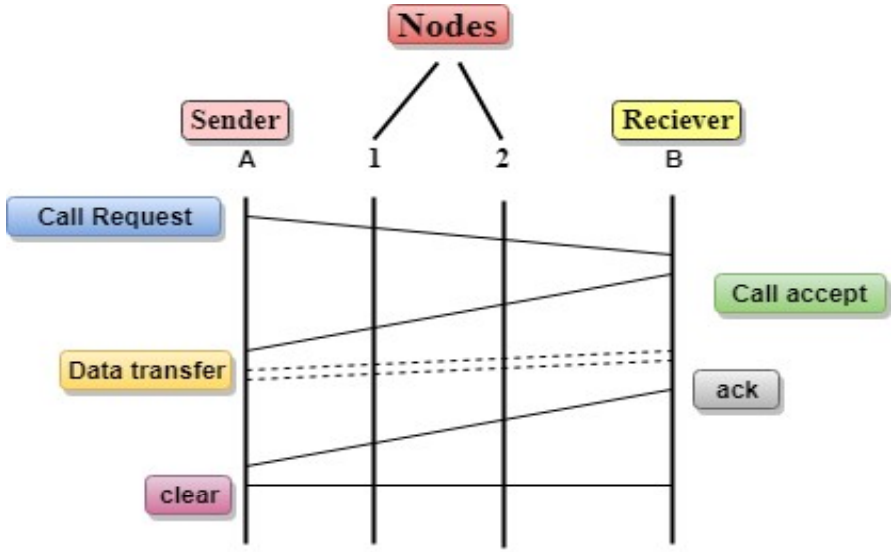


Fig. Virtual Circuit Switching

- In the above diagram, A and B are the sender and receiver respectively. 1 and 2 are the nodes.
- Call request and call accept packets are used to establish a connection between the sender and receiver.
- When a route is established, data will be transferred.
- After transmission of data, an acknowledgment signal is sent by the receiver that the message has been received.
- If the user wants to terminate the connection, a clear signal is sent for the termination.

Advantages Of Packet Switching:

1. **Cost-effective:** In packet switching technique, switching devices do not require massive secondary storage to store the packets, so cost is minimized to some extent. Therefore, we can say that the packet switching technique is a cost-effective technique.
2. **Reliable:** If any node is busy, then the packets can be rerouted. This ensures that the Packet Switching technique provides reliable communication.
3. **Efficient:** Packet Switching is an efficient technique. It does not require any established path prior to the transmission, and many users can use the same communication channel simultaneously, hence makes use of available bandwidth very efficiently.

Disadvantages Of Packet Switching:

1. Packet Switching technique cannot be implemented in those applications that require low delay and high-quality services.
2. The protocols used in a packet switching technique are very complex and requires high implementation cost.
3. If the network is overloaded or corrupted, then it requires retransmission of lost packets. It can also lead to the loss of critical information if errors are nor recovered.

- **Differences between Datagram approach and Virtual Circuit approach**

Datagram approach	Virtual Circuit approach
1. Node takes routing decisions to forward the packets.	1. Node does not take any routing decision.
2. Congestion cannot occur as all the packets travel in different directions.	2. Congestion can occur when the node is busy, and it does not allow other packets to pass through.
3. It is more flexible as all the packets are treated as an independent entity.	3. It is not very flexible.

THANK YOU…