- These cables are not affected by the drastic environmental conditions. Because of all these advantages the optical fiber cable is replacing the conventional metallic conductor cable rapidly in many areas.

6.6.2 Disadvantages of Optical Fibers :

Some of the disadvantages of optical communication system are :

1. Sophisticated plants are required for manufacturing optical fibers.
2. The initial cost incurred is high.
3. Joining the optical fibers is a difficult job.

6.6.3 Applications :

1. Optical fiber transmission systems are widely used in the backbone of networks.
2. Optical fibers are now used in the telephone systems.
3. In the Local Area Networks (LANs).

Review Questions

Q. 1 Name the layer which is associated with the transmission media.

Q. 2 Explain the classification of transmission media.

Q. 3 What is the difference between guided and unguided transmission media ?

Q. 4 State the types of guided media.

Q. 5 Explain the difference between UTP and STP.

Q. 6 What is the effect of twisting the wires in UTP cables ?

Q. 7 Give applications of co-axial cable.

Q. 8 What is the advantage of using shielding ?

Q. 9 Compare the guided transmission media.

Q. 10 State advantages of optical fiber cable.

Q. 11 State the three ways of wireless transmission.

Q. 12 Write a note on microwave communication.

Q. 13 State the applications of microwave communication.

Q. 14 Write a note on : Infrared transmission.

Q. 15 State applications of infrared transmission.

Q. 16 Compare twisted pair (UTP and STP).

Q. 17 Compare twisted pair, co-axial and fiber optic cable.

❑❑❑

CHAPTER 7

Unit II

Switching

Syllabus :

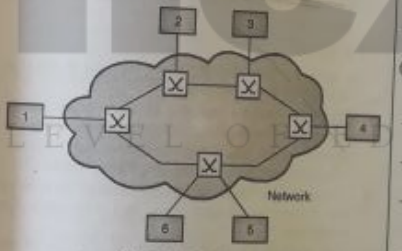
Three methods of switchings, Circuit switched networks, Packet switching.

7.1 Introduction :

A network consists of many switching devices. In order to connect multiple devices, one solution could be to have a point to point connection between each pair of devices. But this increases the number of connections.

The other solution could be to have a central device and connect every device to each other via the central device (Star topology).

Both these methods are wasteful and impractical for very large networks. The other topologies also cannot be used.



(L-616) **Fig. 7.1.1 : Switched network**

Hence a better solution is **switching**. A switched network is made of a series of interconnected nodes called switches.

Switch is a device that creates temporary connections between two or more devices. Fig. 7.1.1 shows a switched network.

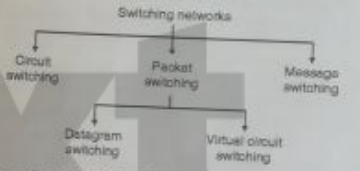
7.2 Switching Methods :

The three basic methods of switching are :

1. Circuit switching
2. Packet switching
3. Message switching

Out of these, the circuit and packet switching are commonly used today but the message switching has been phased out in general communication but is still used in the networking applications.

Fig. 7.2.1 shows the classification of switching methods.



(L-617) **Fig. 7.2.1 : Classification of switching methods**

7.3 Circuit Switching Networks :

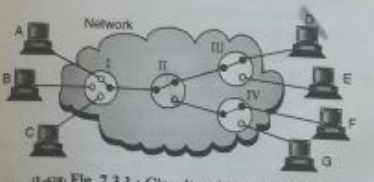
Circuit switching is used in public telephone networks. It was developed to handle voice traffic but it can also handle digital data.

However circuit switching cannot handle digital data efficiently.

Using the circuit switching, a dedicated path is established between two stations for communication.

The telephone network provide telephone service which involves the two way, real-time transmission of voice signals across a network.

The network connection allows electrical current and the associated voice signal to flow between the two users. The end to end connection is maintained for the duration of the call.



(L-618) **Fig. 7.3.1 : Circuit-switched network**

The telephone networks are connection oriented because they require the setting up of a connection before the actual transfer of information can take place.

- The transfer mode of a network that involves setting up a dedicated end to end connection is called circuit switching.
- In circuit switching the routing decision is made when the path is set up across the network. After the link has been set between the sender and receiver, the information is forwarded continuously over the link. After the link has been set up no additional address information about the receiver or destination machine is required.
- In circuit switching a dedicated path is established between the sender and the receiver which is maintained for the entire duration of conversation, as shown in Fig. 7.3.1.
- In telephone systems circuit switching is used. If circuit switching is used in computer networks the sending machine has to first establishes a link with the receiving machine.
- After the link is established the data is transmitted from the sender to the receiver. After the data flow stops, the link is released.
- In Fig. 7.3.1, I, II, III and IV are called as the switching nodes. They are used to connect one user to the other.
- The circuit switched networks operate in three phases :
  1. Set up phase
  2. Data transfer phase
  3. Tear down phase
- The circuit switching corresponds to the physical layer.
- Before starting communication in the setup phase the resources are reserved during communication. Some of these resources are channels, switch buffers, input/output ports etc.
- Data transferred between two stations is not in the packet form instead the data gets transferred continuously.
- No addressing is involved during the data transfer as the dedicated connection is established between the sender and receiver.
- The switches route the data on the basis of the allotted frequency band (FDM) or allotted time slot (TDM).

7.3.1 Three Phases :

- Communication via circuit switching takes place over three phases of operation as follows :
  1. Circuit establishment.
  2. Data transfer.
  3. Circuit disconnect. (tear down).

1. Circuit establishment :

- In a circuit switching network, before any signal is transmitted, it is necessary to establish an end-to-end (station to station) link.
- For example, in Fig. 7.3.1, if the communication is to be between A and D, then the path from A to node I to node II to node III and D has to be established first.
- The node to node links are usually multiplexed. They either use FDM or TDM.

2. Data transfer :

- The information can now be transferred from A to D through the network.
- The data can be analog or digital depending on the nature of network.
- Generally all the internal connections are duplex.

3. Circuit disconnect (tear down phase) :

- After some time the connection between two users is terminated usually by the action of one or two stations.
- Circuit switching is inefficient in most of the applications.
- The entire channel capacity is dedicated for the duration of connection, even if the data is not being transferred.
- Once the circuit is established, the network is effectively transparent to the users with no delays involved.

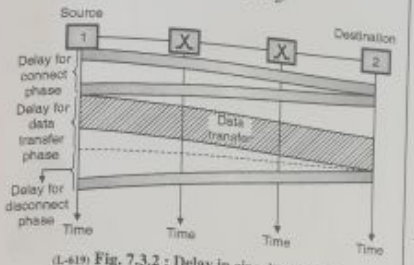
7.3.2 Efficiency :

- In circuit switching the resources remain dedicated as long as a connection is alive.
- Due to the allocation of resources during the entire duration of the connection, the efficiency of circuit switched networks is lower than the other two types of switching.

7.3.3 Delay :

- Eventhough the efficiency is low, the delay in this type of networks is very small.
- Fig. 7.3.2 explains the idea of delay in the circuit switched networks, when only two switches are used.
- During the data transfer the data is not delayed at any switch because there is no waiting time involved.
- The total delay is due to the time required for creating the connection, transfer data, and disconnect the connection.
- The delay at the time of set up is the sum of the following four parts :
  1. The propagation time related to the request message of the source computer (slope of the first gray box in Fig. 7.3.2).
  2. The time required for the transfer of request signal (height of the first gray box in Fig. 7.3.2).
  3. The time taken by the acknowledgement from the destination computer to propagate back to source (slope of the second gray box in Fig. 7.3.2).
  4. The propagation time required to transfer the acknowledgement from destination computer (height of second gray box.).
- The delay corresponding to the data transfer phase is equal to the sum of the following two components :
  1. The propagation delay (slope of hatched portion) for data transfer.

  2. Time required to transfer data (height of hatched portion) which can be very long.



(L-619) **Fig. 7.3.2 : Delay in circuit switching**

- The third component of delay is the delay corresponding to the disconnect or tear down phase. In Fig. 7.3.2 we have considered the situation in which the destination computer requests disconnection because this creates the maximum delay.,

Application :

The circuit switching is used in the telephone networks.

7.3.4 Advantages :

1. The major advantage of circuit switching is that the dedicated transmission channel the computers establish provides a guaranteed data rate.
2. In circuit switching because of the dedicated path there is no delay in data flow.

7.3.5 Disadvantages :

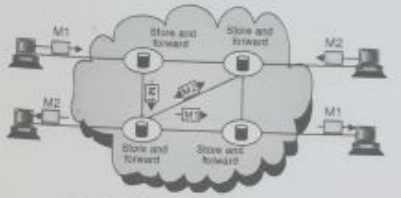
1. The disadvantage of circuit switching is that, since the connection is dedicated it cannot be used to transmit any other data even if the channel is free.
2. Dedicated channels require more bandwidth.
3. It takes long time to establish connection.

7.3.6 Circuit Switched Technology in Telephone Networks :

- The telephone companies previously used the circuit switching technology for switching and routing a call. This was a physical layer technology.
- However, today the tendency is to use other switching techniques. For example the telephone number is used as the global address and a signalling system (called SS7) is used for creating and disconnecting the connections.

7.4 Telegraph Networks and Message Switching :

- In telegraphy the text message is encoded using the Morse code into sequences of dots and dashes. Each dot or dash is communicated by transmitting short and long pulses of electrical current over a copper wire.



(L-620) **Fig. 7.4.1 : Message switching**

- In telegraph networks the text message is transmitted from the source telegraph office to the telegraph switching station. At this switching station an operator takes the decision of routing the message based on the destination address information. The operator will either forward the message if a communication line to the destination is free or store the message still the communication line becomes free.
- Message switching does not establish a dedicated path between two communicating devices. In message switching, each message is treated as an independent unit and includes its own destination and source address.
- Each complete message is then transmitted from device to device through the internetwork as shown in Fig. 7.4.1.
- Each intermediate device receives the message, stores it, until the next device is ready to receive it and then forwards it to the next device. For this reason, a message switching network is sometimes called as a store and forward network.
- Messages switches can be programmed with information about the most efficient routes as well as information regarding neighbouring switches that can be used to forward messages to their ultimate destination.

7.4.1 Advantages :

1. It provides efficient traffic management by assigning priorities to the messages to be switched.
2. It reduces network traffic congestion because it is able to store message until a communication channel becomes available.
3. With message switching, the network devices share the data channels.
4. It provides asynchronous communication across time zones.

7.4.2 Disadvantages :

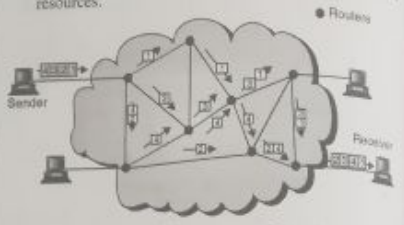
1. The storing and forwarding introduces delay hence cannot be used for real time applications like voice and video.
2. The intermediate devices require a large storing capacity since it has to store the message unless a free path is available.

7.5 Packet Switching :

- In packet switching, messages are broken up into packets. Each packets has a header with source, destination and intermediate node address information. The other part of the packet includes data load.
- Individual packets can take different routes to reach the destination. Independent routing of packets gives two advantages :
  1. Bandwidth is reduced due to splitting data onto different routes in a busy circuit.
  2. If a certain link in the network goes down during the transmission, the remaining packets can be sent through another route.
- The packets can arrive out of order at the receiver and have to be reassembled in proper sequence.
- In packet switchung, the packet length is restricted to a certain maximum length. This length is short enough to allow the switching devices to store the packet data in memory.
- There are two methods of packet switching :
  1. Datagram packet switching
  2. Virtual circuit packet switching.

7.5.1 Datagram Packet Switching :

- In this method a message is divided into a stream of packets. Each packet has its individually included address and treated as an independent unit with its own control instructors.
- The switching devices would route each packet independently through the network. Each intermediate node will determine the packet's next route segment.
- Before transmission starts, the sequence of packets and their destinations are communicated by exchanging control information between the sending terminal, the network and the receiving terminal.
- In packet switching, the resources are not allocated for any packet so there is no reserved bandwidth and no scheduled processing time allotted for each packet.
- No dedicated connection is established between the sender and receiver. The resource allocation is on demand and on the first come first serve basis.
- When a switch receives a packet, it has to wait if there are any other packets being processed. This will increase the delay.
- The datagram packet switching generally corresponds to the network layer. The packet are called as **datagrams.**
- Datagram packet switching is shown in Fig. 7.5.1.
- In this circuit, four packets are to be delivered from the sender to receiver. The switches in the datagram network are called as **routers.**
- All the four packets (datagrams) belong to the same message in this circuit however actually they can get originated from any computer.
- The four datagrams, as shown in Fig. 7.5.1 may travel different paths to reach the destination. Due to this the packets may arrive out of order at the destination.
- The delay associated with each packet will be different as a result of the different paths followed by them. The datagrams may get lost of dropped out due to lack of resources.



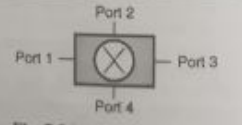
(L-623) **Fig. 7.5.1 : Datagram packet switching**

- The upper layer protocols are supposed to reorder the received datagrams or ask for the lost ones before passing them on the application.
- The datagram networks, are called as the **connectionless** networks. This is because the switch (packet switch) does not keep any information about the connection state. There are no connection set up or tear down processes in the packet switching networks.

7.5.2 Routing Table :

- In packet switched networks, each packet switch has a routing table. This table contains the destination address.
- The routing tables are dynamic and their information is updated on periodic basis. The routing table consists of destination address and the corresponding output port over which the packet is to be forwarded as shown in Fig. 7.5.2.

Destination address	Output port
1323	1
4360	2
9140	3
6436	4



(L-624) **Fig. 7.5.2 : Router and Routing table**

Destination Address :

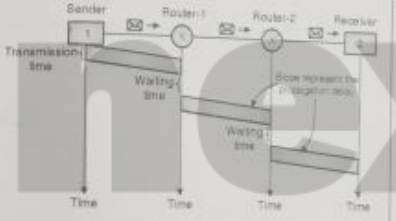
- Every packet in the datagram network consists of a header that contains the destination address where the packet is to be delivered and some additional information.
- When the router receives a packet, it examines the destination address of the packet and refers to its routing table to decide the port through which the packet is to be forwarded.
- For example in the routing table of Fig. 7.5.2, if the destination address on the received packet is 4360 then it will be forwarded through port 2.

7.5.3 Efficiency :

- As the resources are allocated only when the packets are to be transferred, the efficiency of datagram network is **higher** than that of the circuit switched network.

7.5.4 Delay :

- There are no set up or tear down phases in datagram circuit switching but each packet may have to wait at a switch before getting forwarded.
- All the packets in a message take different paths. Hence the delay associated with each packet is different.
- Fig. 7.5.3 illustrates the delays in a datagram network for one single packet.



(L-625) **Fig. 7.5.3 : Delay in datagram network**

- In Fig. 7.5.3, the packet travels through two switches while travelling from sender to receiver. The packet needs some transmission time (T) to travel from source to router-1. Then it has to wait for some time (w_1) before being forwarded.
- The total delay is made up of three transmission times (3T) and three propagation delays (3τ). The propagation delays correspond to the slopes of the lines as shown in Fig. 7.5.3 and the two waiting times w_1 and w_2.

$$\therefore \text{ Total delay} = 3T + 3\tau + w_1 + w_2 \quad \ldots(7.5.1)$$

- The datagram switching is used in Internet.

7.5.5 Advantages of Packet Switching :

1. Greater line utilization efficiency, as a single node-to-node link can be dynamically shared by many packets over time.
2. A packet switching network can perform data-rate conversion.
3. When traffic become heavy on circuit switching network, some calls are blocked. On a packet switching network, packets are still accepted, but delivery delay increases.
4. Priorities can be used.

5. Each terminal in group sharing the same physical circuit may be connected to a totally different destination. This versatility is one of the major strengths of packet switching.
6. No single user or large data block can tie up circuit or node resources indefinitely, making it well suited for interactive traffic.
7. Data protection against corruption or loss, errors are corrected by retransmission.
8. Users can select different destinations for each virtual call, overcoming the inflexibility of point to point dedicated networks.
9. Simultaneous calls allow PC users to access multiple windows to different remote applications.
10. Since many users can share transmission resources efficiently, the cost of intermittent data communication is reduced.
11. New calls can be added and old ones disconnected without affecting other users.

7.5.6 Disadvantages of Packet Switching :

1. Increased delay due to following reasons
   (a) Transmission delay = Length of packet divided by incoming channel rate.
   (b) Variable delay due to processing and queuing.
2. The amount of overall packet delay can vary substantially (jitter) due to the following reasons
   (a) Packets may vary in length.
   (b) Packets may take different routes.
   (c) Packets are subject to varying delays in switches.
   (d) This is not good for real time applications.
3. Header overhead reduces capacity to carry user data.
4. More processing required at node.

7.5.7 Datagram Networks in Internet :

The internet uses the datagram approach to switching at the Network layer. The routing of packets in Internet takes place on the basis of the universal addresses defined in the network layer.

7.6 Comparison of Message, Circuit and Packet Switching :

Parameter	Message switching	Circuit switching	Packet switching
Application	Telegraph network for transmission of telegrams.	Telephone network for bi-directional, real time transfer of voice signals.	Internet for datagram and reliable stream service between computers.
End terminal	Telegraph, teletype.	Telephone, modem.	Computer

Parameter	Message switching	Circuit switching	Packet switching
Information type	Data in the form of Morse, Baudot, ASCII codes.	Analog voice or PCM digital voice	Binary information
Transmission system	Digital data over different transmission media	Analog and digital data over different transmission media	Digital data over different transmission media.
Addressing scheme	Geographical addresses	Hierarchical numbering plan	Hierarchical address space
Routing scheme	Manual	Route selected during call setup.	Each packet is routed independently.
Multiplexing scheme	Character or message multiplexing	Circuit multiplexing.	Packet multiplexing shared media access networks.

Review Questions

- Q. 1 Explain the term circuit switching. How is it different from the packet switching ?
- Q. 2 Explain the three phases related to the communication via circuit switching.
- Q. 3 Write a short note on Space-Division switches.
- Q. 4 Explain the time-division switches.
- Q. 5 Write a short note on Time-space-Time switches.
- Q. 6 Explain the routing system in circuit switching networks.
- Q. 7 State the three switching methods.
- Q. 8 Name different types of switches used in circuit switching.
- Q. 9 How is space division switching better than time division switching ?
- Q. 10 Explain the concept of datagram packet switching.
- Q. 11 State the advantages and drawbacks of datagram packet switching.
- Q. 12 Explain the delays in datagram switching.

□□□

CHAPTER 8

Unit II

Data Link Layer

Syllabus :

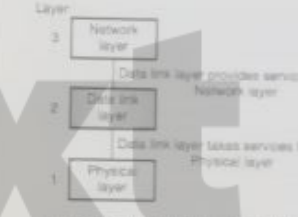
Introduction to data link layer, Nodes and links, Services, Two sub layers, Three types of addresses, Address Resolution Protocol (ARP), Error detection and correction, Introduction, Types of errors, Redundancy, Detection versus correction.

8.1 Introduction :

- The physical layer deals with the transmission of signals over different transmission medias.
- A reliable and efficient communication between two adjacent machines can be achieved via the data link layer.
- This layer basically deals with frame formation, flow control, error control, addressing and link management.
- While sending data from source to destination errors may get introduced. The data communication circuits have only a finite data rate and there is non-zero propagation delay between the instant a bit is sent and the instant at which it is received.
- These limitations affect the efficiency of data transfer. The data link layer protocols used for communication take care of all these problems.
- Data link layer is the second layer in OSI reference model. It is above the physical layer.
- It is interesting to know that the TCP/IP suite does not define any protocol corresponding to data link layer and physical layer. These two layers are known as territories of network.
- These territorial networks can provide services to all the upper layers of TCP/IP suite. They can be either wired or wireless networks.
- We know that various types of networks are connected to each other for the Internet. For interconnecting different networks, the connecting devices such as routers or switches are used.
- The packet sent by a sender host has to travel through all these networks to reach the destination host.

8.1.1 Position of Data Link Layer :

- Fig. 8.1.1 shows the position of data link layer in the five layer Internet model. It is the second layer.

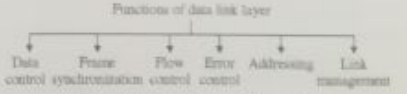


(1.4411) **Fig. 8.1.1 : Position of data link layer**

- It receives services from the physical layer and provides services to the network layer.

8.2 Data Link Layer Design Issues (Functions of Data Link Layer) :

- The data link layer is supposed to carry out many specified functions.
- For effective data communication between two directly (physically) connected transmitting and receiving stations the data link layer has to carry out a number of specific functions as follows :



(1.4412) **Fig. 8.2.1 : Functions of data link layer**

1. **Services provided to the network layer :**
The data link layer provides a well defined service interface to the network layer. The principle service is transferring data from the network layer on sending machine to the network layer on destination machine. This transfer always takes place via the DLL.