UNIT II

SWITCHING :

Circuit-Switched Networks, Datagram Networks, Virtual-Circuit Networks, Message Switched Networks, Asynchronous Transfer Mode: Evolution, Benefits, Concepts, Exploring Broadband Integrated Services Digital Network, Layer and Adaptation Layer

2.1 SWITCHING

2.1.1 Circuit-switched Networks

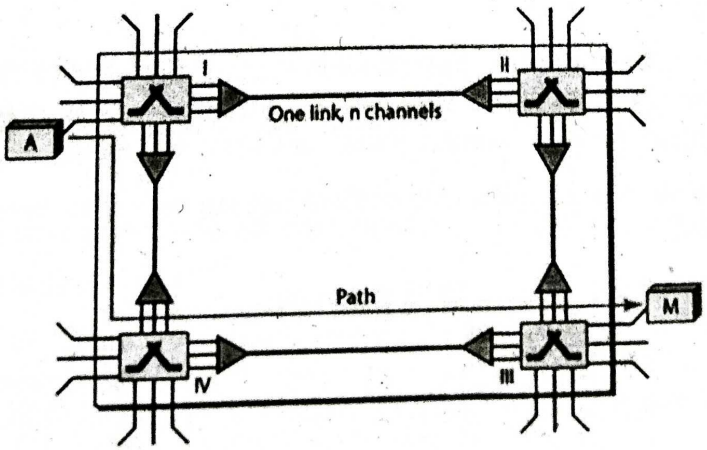
Q1. Explain about circuit switched networks.

Ans : **(Imp.)**

A network consists of a set of switches that are connected by the physical links commonly known as Circuit-Switched Network.

- Whenever one device communicates with another device then a dedicated communi- cation path is established between them over the network.
- There is only a dedicated channel on each link used by each connection. Also, each link can be easily divided into n channels by using the TDM(Time Division Multiplexing) or FDM(Frequency Divison Multiplexing) technique.
- The Circuit Switching technique is mainly used in the public telephone network for voice communication as well as for data communication.
- Data communication is less efficient than voice communication.
- The Circuit switching technique mainly takes place at the physical layer.
- In Circuit-switched networks, the data transfer mode mainly involves a dedicated end-to-end connection. Until the end of the communication, this dedicated path is maintained. After the communication is over the link is released.

The following figure shows a trivial circuit-switched network with four switches and four links. Each link is divided into n (n is 3 in the figure) channels by using FDM or TDM.Phases in



Circuit Switching

In order to transfer data using Circuit switching there is a need to establish a circuit (these circuits can either be permanent or temporary) so that data transfer can take place smoothly. Given below are three phases that are used in Circuit Switching for actual communication:

1. Setup Phase
2. Data Transfer Phase
3. Teardown Phase

1. **Setup Phase**

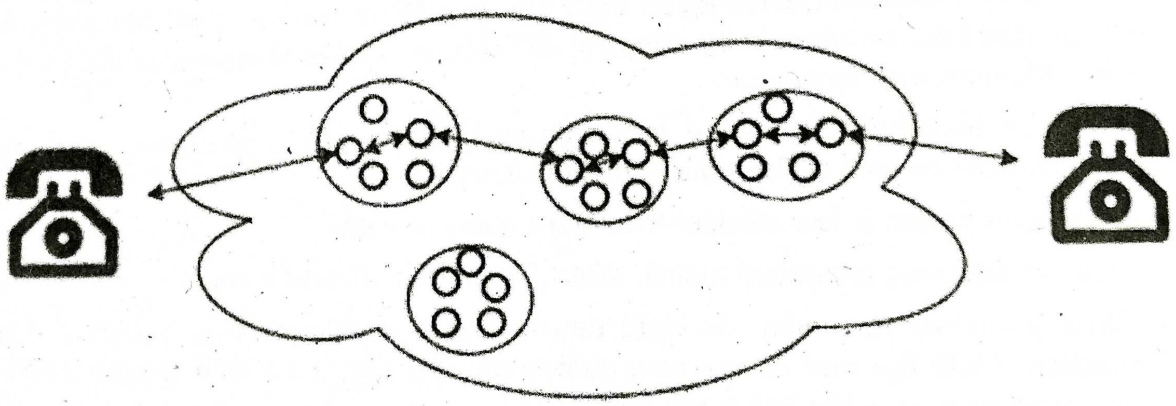
It is the first phase of the Circuit switching technique and in this, there is an establishment of the circuit that simply means a dedicated link is established between the sender and the receiver with the help of several switching centers or nodes.

2. **Data Transfer Phase**

After the establishment of the circuit, the connection is established which means that data transfer can take place between sender and receiver.

3. **Teardown Phase**

On the completion of communication between the sender and receiver the circuit disconnects. In order to disconnect a signal is sent either by the sender or receiver



One of the best examples of Circuit switching is a telephone. Suppose there are two persons Person A and Person B; they both want to communicate with each other and located at a distance far from each other.

Person A makes a call to Person B this phase is the setup phase of circuit switching. After the establishment of the connection and after call pick up by Person B; they both can communicate with each other. This is the data transfer phase of Circuit switching

Once the communication is complete one of them can cut the call or break the connection. This is a teardown phase.

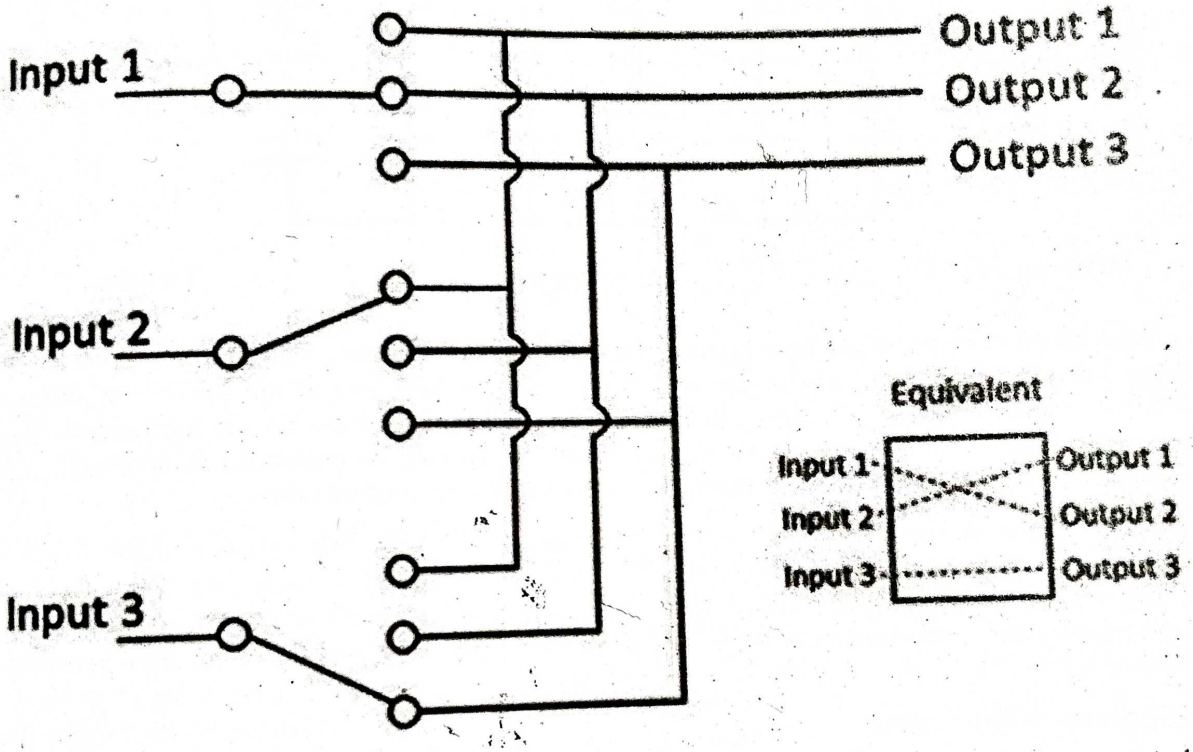
Circuit Switching can be further classified into two:

1. Space-Division Switching
2. Time-Division Switching

1. **Space Division Switching**

The paths in a circuit are separated from each other, spatially in space division switching. Though initially designed for analog networks, it is being used for both analog and digital switching. A Crosspoint switch is mostly referred to as a space division switch because it moves a bit stream from one circuit or bus to another.

The switching system where any channel of one of its incoming PCM highway is connected to any channel of an outgoing PCM highway, where both of them are spatially separated is called the Space Division Switching. The Crosspoint matrix connects the incoming and outgoing PCM highways, where different channels of an incoming PCM frame may need to be switched by different Cross points in order to reach different destinations.



Though the space division switching was developed for the analog environment, it has been carried over to digital communication as well. This requires separate physical path for each signal connection, and uses metallic or semiconductor gates.

Advantages

Following is the advantage of Space Division Switching -

- It is instantaneous.

Disadvantages

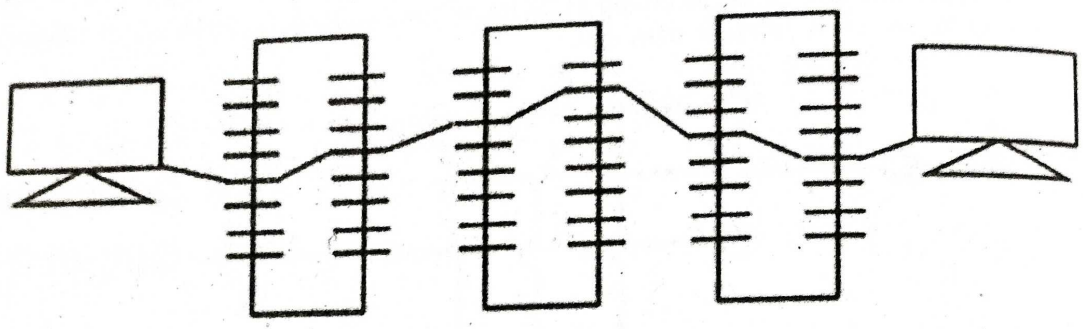
- Number of Cross points required to make space-division switching are acceptable in terms of blocking.

2. **Time Division Switching**

Time division switching comes under digital switching techniques, where the Pulse Code Modulated signals are mostly present at the input and the output ports. A digital Switching system is one, where the inputs of any PCM highway can be connected to the outputs of any PCM highway, to establish a call.1

The incoming and outgoing signals when received and re-transmitted in a different time slot, is called Time Division Switching. The digitized speech information is sliced into a sequence of time intervals or slots. Additional voice circuit slots, corresponding to other users are inserted into this bit stream of data. Hence, the data is sent in time frames.

The main difference between space division multiplexing and time division multiplexing is sharing of Cross points. Crosspoints are not shared in space division switching, whereas they can be shared in time division multiplexing, for shorter periods. This helps in reassigning the Crosspoints and its associated circuitry for other connections as well.



Time division switches use time division multiplexing, in switching. The two popular methods of TDM are TSI (Time and Slot Interchange) and TDM bus. The data sent at the transmitter reaches the receiver in the same order, in an ordinary time division multiplexing whereas, in TSI mechanism, the data sent is changed according to the ordering of slots based on the desired connections. It consists of RAM with several memory locations such as input, output locations and control unit.

Both of the techniques are used in digital transmission. The TDM bus utilizes multiplexing to place all the signals on a common transmission path. The bus must have higher data rate than individual I/O lines. The main advantage of time division multiplexing is that, there is no need of Crosspoints. However, processing each connection creates delay as each time slot must be stored by RAM, then retrieved and then passed on.

Time Division Multiplexing

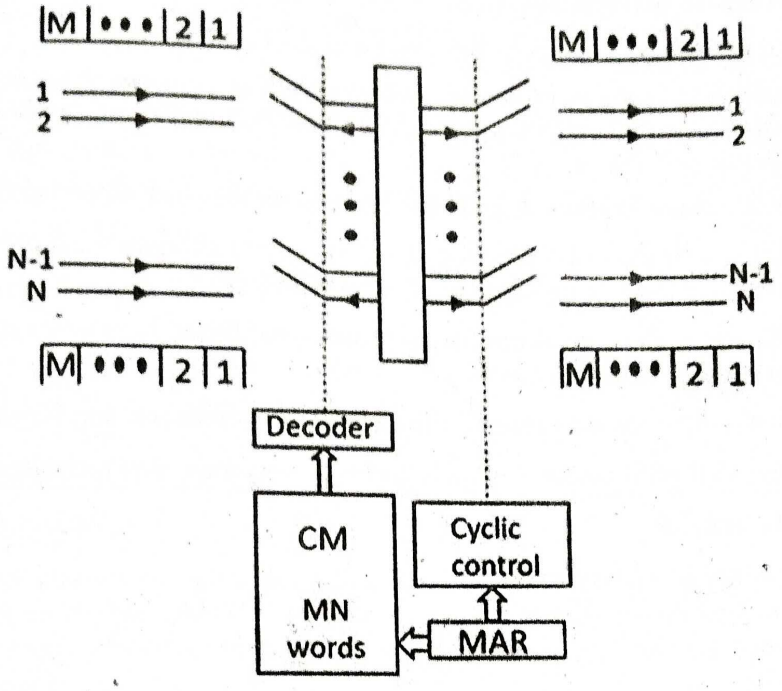
When the transmission of data or signals is done in digital means, using the limited number of resources available, then the Time Division Multiplexing is used for the transmission of such data. Multiplexing is the process in communication, which merges two or more signals at its input into a single output, which when de-multiplexed, offers all those signals separately as they were.

The Multiplexers are broadly classified as Analog and Digital, where the Time Division Multiplexing comes under Digital Multiplexing. There are two types of TDM called as Synchronous and Asynchronous TDM.

Time Division Space Switching

Time division switches may also employ space division switching techniques, whereas an appropriate mixture of both time and space division switching is advantageous in various circumstances.

A Time division space switch takes outputs of several time-division switches (say, TSI switches) which are then given as inputs to space division switches. This means that one of the two similar outputs produced by a TDM switch, can be selected by space switch to deliver to another output path which reduces the number of Crosspoints. The model of time division space switch is as shown in the following figure.



The interchange of time slots is not possible in time division switching, as the incoming time slot transfers the data to its dedicated output time slot only. Hence, time multiplexed switches do not provide full availability.

A time multiplexed Time Division Space Switch can be configured around a space array, which has M input horizontals and N output verticals. If both inputs and outputs are equal, M=N the switch leads to non-blocking. If inputs are greater than outputs; for concentrating switch we have M>N and if the outputs are higher, the switch expands gathering one more connection. In every time slot, one logic gate per vertical if M>N, or one logic per horizontal if M>N is enabled for one-to-one connections.

In every time slot, up to N or M samples are switched simultaneously. Because of the parallel transfer of N or M data samples in each time slot, a large number of channels can be multiplexed per input line. If along with multiplexing for N control memory modules, full availability has to be achieved, one should opt for time division time multiplexing technique.

Q2. Explain the benefits and Limitations of Circuit Switching.

Ans:

Advantages of Circuit Switching

Given below are some of the benefits of Circuit Switching:

1. **Offers Dedicated Transmission**

   As there is a dedicated link between the sender and the receiver. Thus Circuit-Switched network provides a guarantee of dedicated transmission.

2. **No Delay in Transmission**

   There is a dedicated path between sender and receiver thus there are no chances for the delay.

3. The Circuit Switching technique is best for long transmission because it facilitates a dedicated link between sender and receiver.

Disadvantages of Circuit Switching

There are some drawbacks of Circuit Switching and these are as follows:

- One of the main disadvantages of Circuit switching is that as there is a dedicated path between sender and receiver; thus this path is received for these two particular devices and cannot be used by any other device.
- There is a need for more bandwidth as a dedicated path requires more bandwidth.
- Utilization of resources is not done properly as resources are allocated to a connection for the entire duration and thus became unavailable for all other connections.
- It becomes inefficient in the case if the connection is established between sender and receiver but there is no data transfer between them.
- Sometimes it takes a long time to establish the connection between sender and receiver.
- As there is a dedicated path between sender and receiver; thus, this technique is expensive.

2.1.2 Datagram Networks

Q3. Explain about Datagram Networks.

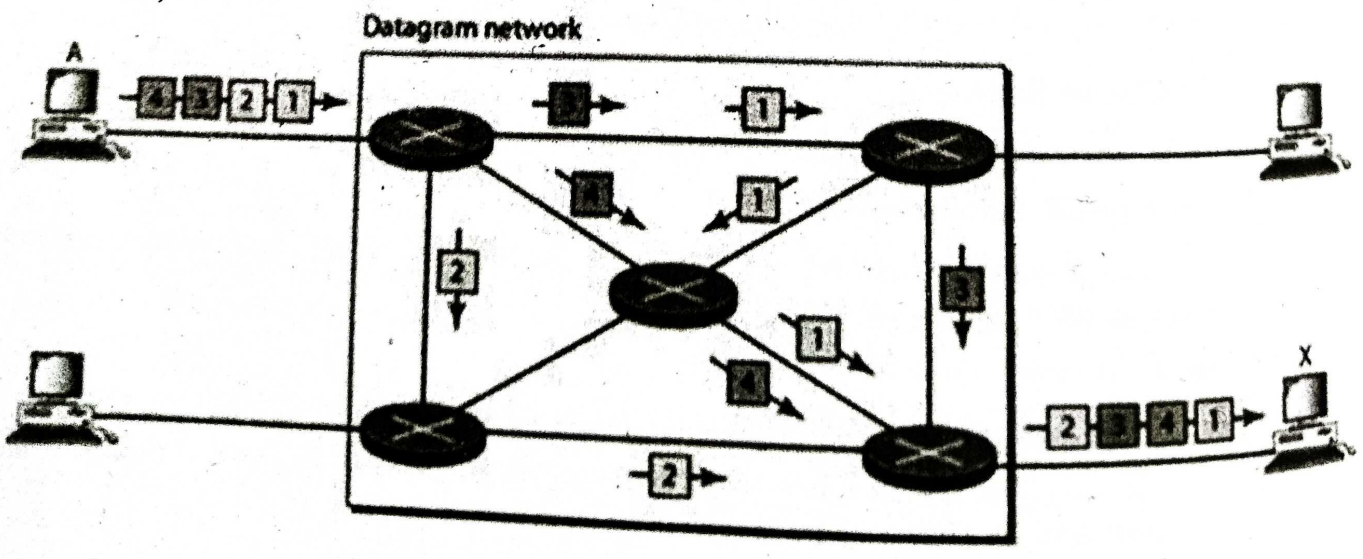
Ans: **(Imp.)**

Introduction

It is a packet-switching technique in which each packet, known as a datagram, is treated as a separate entity. Each packet carries destination information, which the switch uses to route the packet to the correct destination. There is no need to reserve resources because there is no specified channel for a connection session. As a result, packets contain a header including all of the destination's information. The intermediate nodes examine the header of a packet and choose an appropriate link to a different node closer to the destination.

Resources in datagram networks are allocated on a First Come First Serve (FCFS) basis. When a packet arrives at a router, it must wait if other packets are being processed, regardless of its source or destination.

The diagram below displays datagram packets sent from host H1 to host H2. The four datagram packets with the labels A, B, C, and D are all parts of the same message each being routed individually through a different route. The message's packets arrive out of sequence at their destination. In order to recover the original message, it is H2's obligation to reorder the packets.



In this example, all four packets (or datagrams) belong to the same message, but may travel different paths to reach their destination. This is so because the links may be involved in carrying packets from other sources and do not have the necessary bandwidth available to carry all the packets from A to X. This approach can cause the datagrams of a transmission to arrive at their destination out of order with different delays between the packets. Packets may also be lost or dropped because of a lack of resources. In most protocols, it is the responsibility of an upper-layer protocol to reorder the datagrams or ask for lost datagrams before passing them on to the application.

The datagram networks are sometimes referred to as connectionless networks.

- **Routing Table**

In this type of network, each switch (or packet switch) has a routing table which is based on the destination address. The routing tables are dynamic and are updated periodically. The destination addresses and the corresponding forwarding output ports are recorded in the tables. This is different from the table of a circuit switched network in which each entry is created when the setup phase is completed and deleted when the teardown phase is over.

- **Destination Address**

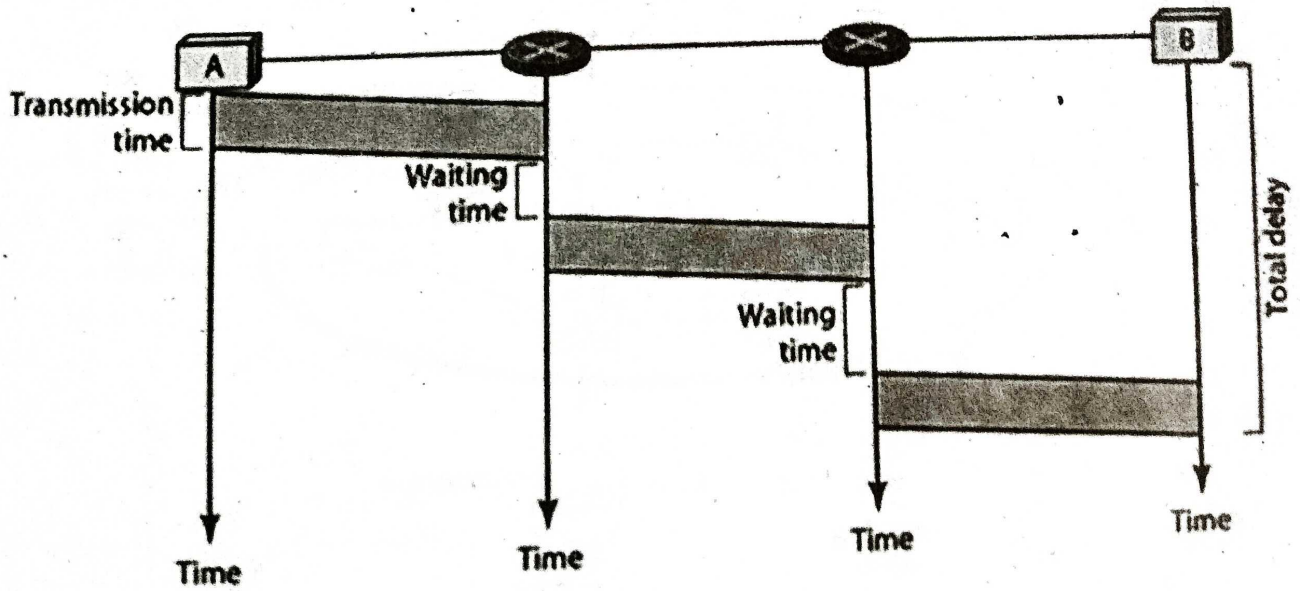
Every packet in a datagram network carries a header that contains, among other information, the destination address of the packet. When the switch receives the packet, this destination address is examined; the routing table is consulted to find the corresponding port through which the packet should be forwarded.

- **Efficiency**

The efficiency of a datagram network is better than that of a circuit-switched network. Resources are allocated only when there are packets to be transferred. If a source sends a packet and there is a delay of a few minutes before another packet can be sent, the resources can be reallocated during these minutes for other packets from other sources.

- **Delay**

There may be greater delay in a datagram network than in a virtual-circuit network. Although there are no setup and teardown phases, each packet may experience a wait at a switch before it is forwarded. In addition, since not all packets in a message necessarily travel through the same switches, the delay is not uniform for the packets of a message. The following figure gives an example of delay in a datagram network for one single packet.



The various important points related to Datagram Networks.

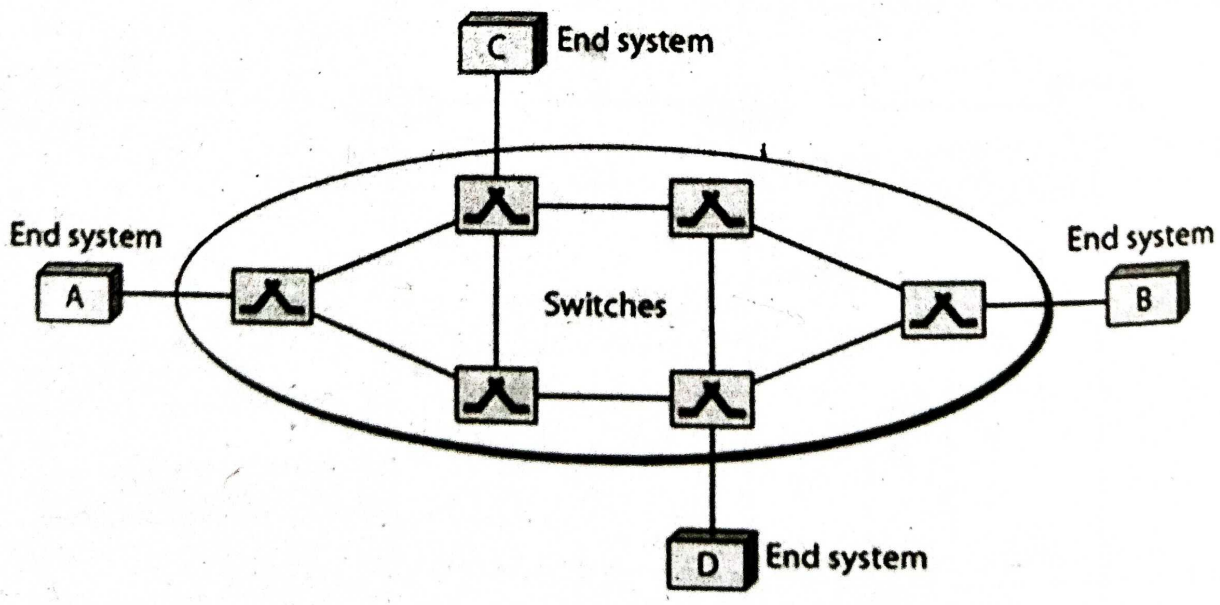
- At the network layer, datagram networks are computer networks that provide a connectionless service.
- Since there is no specific path for a connection session, there is no need to reserve resources.
- Datagram networks are implemented in routers in the network core and end systems.
- The order in which the packets were sent does not necessarily reflect the order in which they arrive at their destination.
- Since routing tables on routers change dynamically, all packets are free to go through any intermediary router chosen at the time.
- Datagram networks are unreliable because their connectionless nature causes data packets to arrive at their destination out of the sequence as they were sent from the source.
- Since there is no need to reserve resources every time an application needs to communicate, datagram networks are always affordable and straightforward to install.
- Every packet must be associated with the complete address of the destination site (header) since every packet in datagram networks is free to choose any path.
- Route changes and packet loss are possible with malfunctioning routers.
- It is typically utilized in IP networks, which support data services like the internet.

Advantages

- Greater line utilization efficiency.
- Priorities are used.
- When traffic becomes heavy some calls are blocked.
- Errors are corrected by retransmission,
- Cost of intermittent data communication is reduced.

Disadvantages

- Delay.
- Overall packet delay can vary substantially.
- More processing required at the node.



Addressing

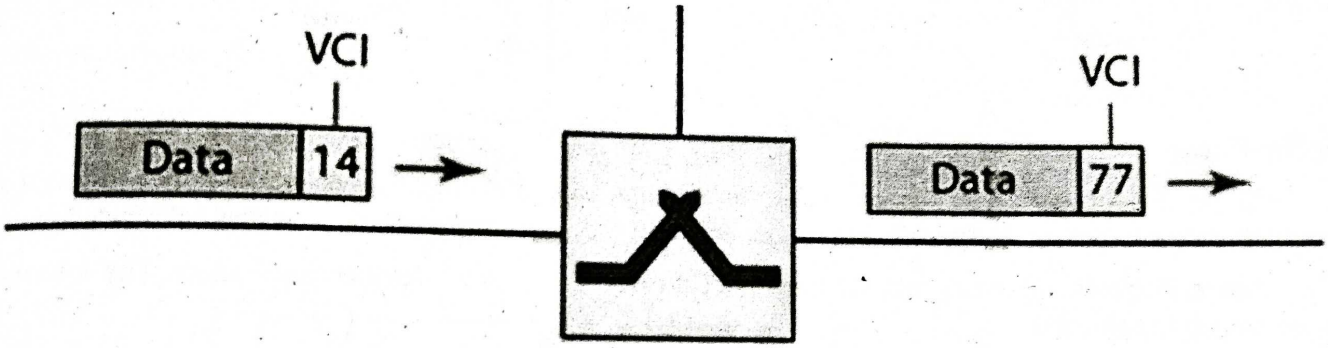
In a virtual-circuit network, two types of addressing are involved: global and local (virtual-circuit identifier).

Global Addressing

A source or a destination needs to have a global address-an address that can be unique in the scope of the network or internationally if the network is part of an international network.

Virtual-Circuit Identifier

The identifier that is actually used for data transfer is called the virtual-circuit identifier (VCI). A VCI, unlike a global address, is a small number that has only switch scope. It is used by a frame between two switches. When a frame arrives at a switch, it has a VCI; when it leaves, it has a different VCI. The following figure show how the VCI in a data frame changes from one switch to another. Note that a VCI does not need to be a large number since each switch can use its own unique set of VCIs.



Three Phases

As in a circuit-switched network, a source and destination need to go through three phases in a virtual-circuit network: setup, data transfer, and teardown.

setup phase, the source and destination use their global addresses to help switches make table entries for the connection.

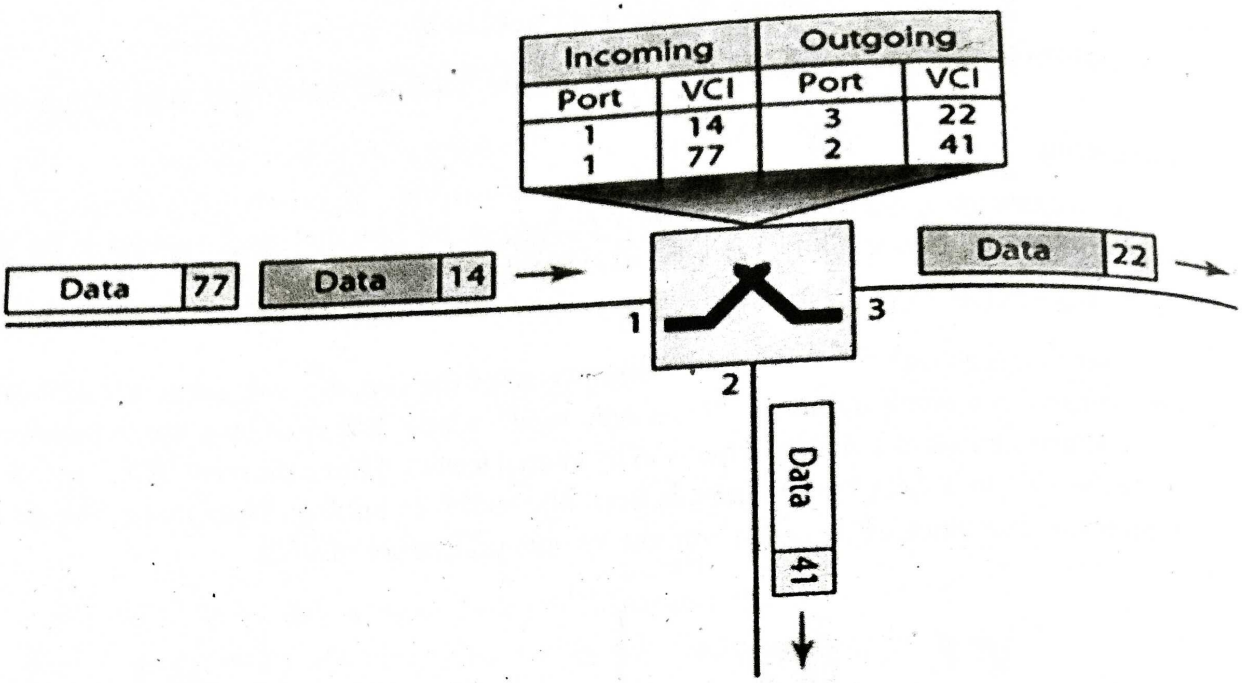
In the teardown phase, the source and destination inform the switches to delete the corresponding entry.

Data transfer occurs between these two phases.

Data Transfer Phase

To transfer a frame from a source to its destination, all switches need to have a table entry for this virtual circuit. The table, in its simplest form, has four columns. This means that the switch holds four pieces of information for each virtual circuit that is already set up. We show later how the switches make their table entries, but for the moment we assume that each switch has a table with entries for all active virtual circuits.

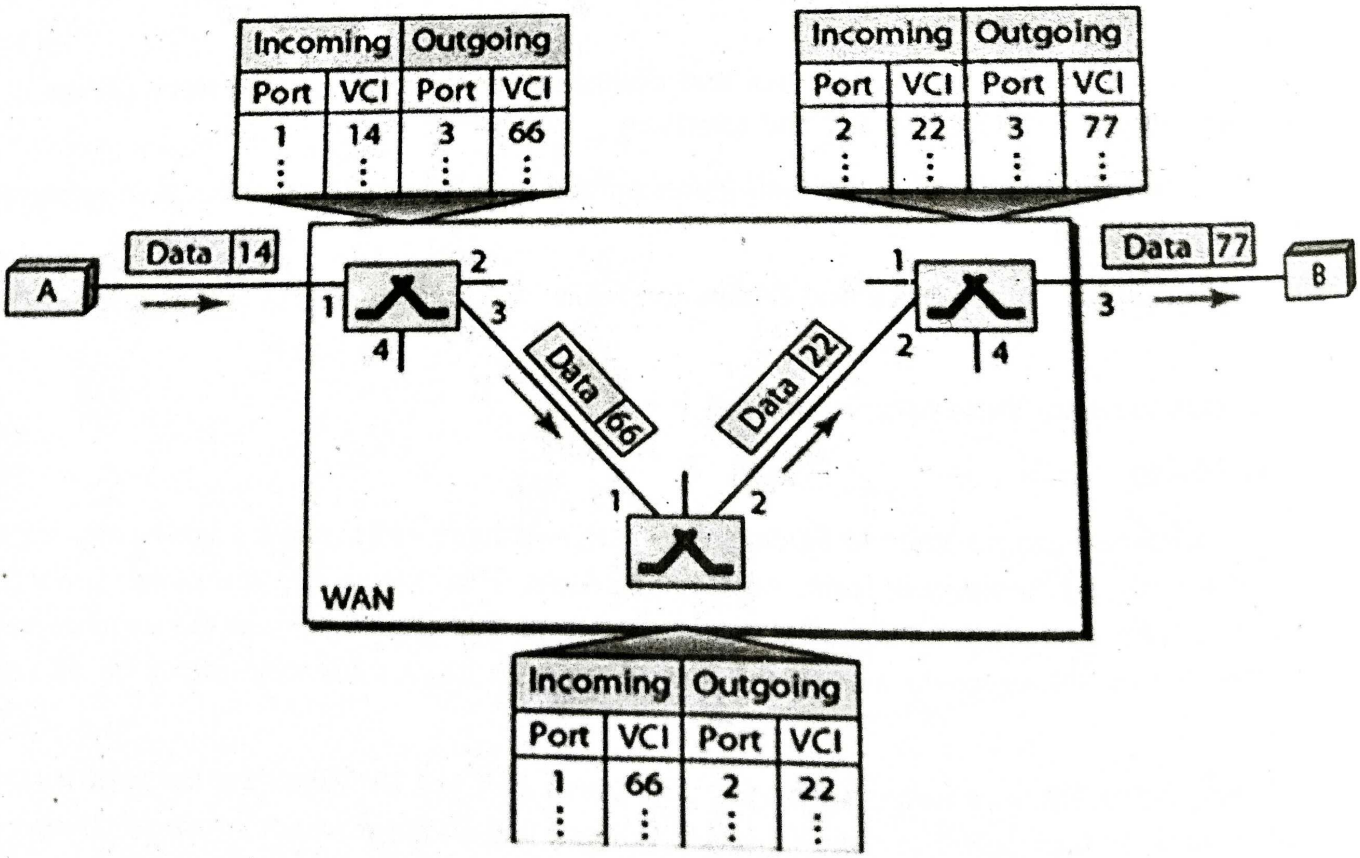
The following figure shows a frame arriving at port 1 with a VCI of 14. When the frame arrives, the switch looks in its table to find port 1 and a VCI of 14. When it is found, the switch knows to change the VCI to 22 and send out the frame from port 3.



Setup Phase

In the setup phase, a switch creates an entry for a virtual circuit. For example, suppose source A needs to create a virtual circuit to B. Two steps are required: the setup request and the acknowledgment.

Setup Request: A setup request frame is sent from the source to the destination. The following figure shows the process.



(a) Source A sends a setup frame to switch 1.

(b) Switch 1 receives the setup request frame. It knows that a frame going from A to B goes out through port 3. The switch, in the setup phase, acts as a packet switch and it has a routing table which is different from the switching table. For the moment, assume that it knows the output port. The switch creates an entry in its table for this virtual circuit, but it is only able to fill three of the four columns. The switch assigns the incoming port (1) and chooses an available incoming VCI (14) and the outgoing port (3). It does not yet know the outgoing VCI, which will be found during the acknowledgment step. The switch then forwards the frame through port 3 to switch 2.

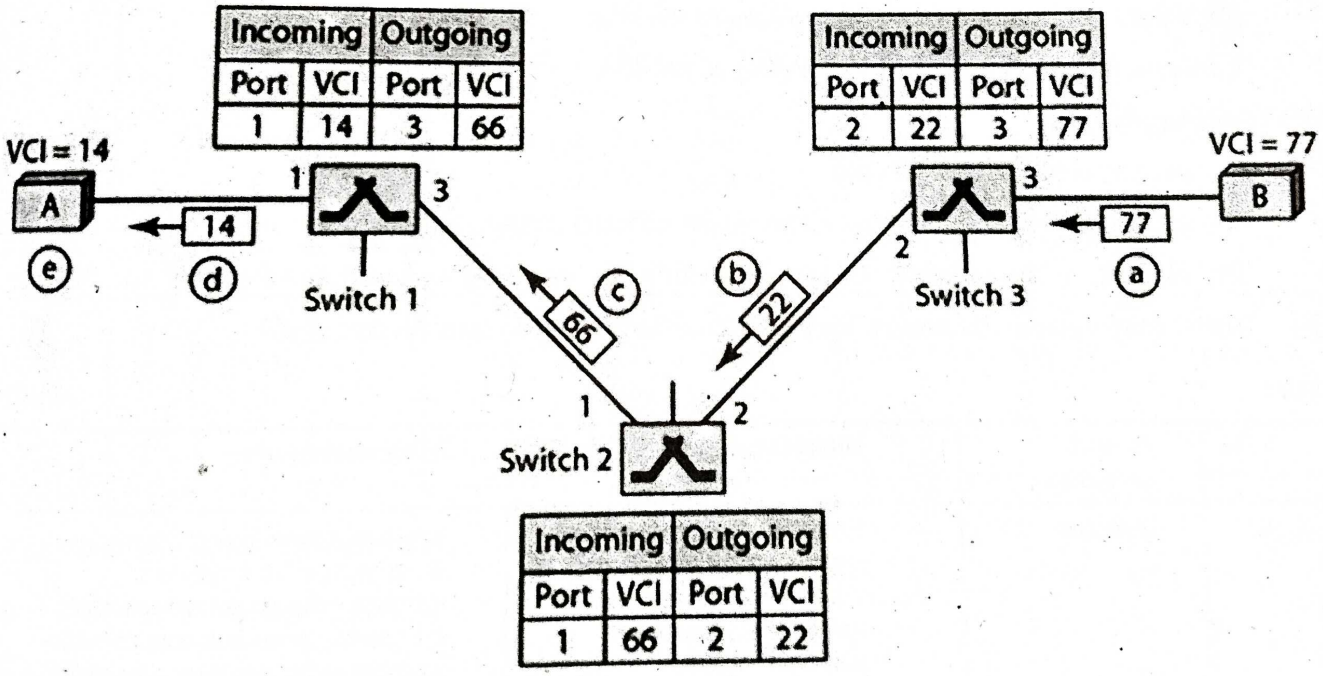
(c) Switch 2 receives the setup request frame. The same events happen here as at switch 1 and three columns of the table are completed: in this case, incoming port (l), incoming VCI (66), and outgoing port (2).

(d) Switch 3 receives the setup request frame. Again, three columns are completed: incoming port (2), incoming VCI (22), and outgoing port (3).

(e) Destination B receives the setup frame, and if it is ready to receive frames from A, it assigns a VCI to the incoming frames that come from A, in this case 77. This VCI lets the destination know that the frames come from A, and no other sources.

Acknowledgment

A special frame, called the acknowledgment frame, completes the entries in the switching tables. The following figure shows the process.



(a) The destination sends an acknowledgment to switch 3. The acknowledgment carries the global source and destination addresses so the switch knows which entry in the table is to be completed. The frame also carries VCI 77, chosen by the destination as the incoming VCI for frames from A. Switch 3 uses this VCI to complete the outgoing VCI column for this entry. Note that 77 is the incoming VCI for destination B, but the outgoing VCI for switch 3.

(b) Switch 3 sends an acknowledgment to switch 2 that contains its incoming VCI in the table, chosen in the previous step. Switch 2 uses this as the outgoing VCI in the table.

(c) Switch 2 sends an acknowledgment to switch 1 that contains its incoming VCI in the table, chosen in the previous step. Switch 1 uses this as the outgoing VCI in the table.

(d) Finally switch 1 sends an acknowledgment to source A that contains its incoming VCI in the table, chosen in the previous step.

(e) The source uses this as the outgoing VCI for the data frames to be sent to destination B.

Teardown Phase

In this phase, source A, after sending all frames to B, sends a special frame called a teardown request. Destination B responds with a teardown confirmation frame. All switches delete the corresponding entry from their tables.

Efficiency

- Resource reservation in a virtual-circuit network can be made during the setup or can be on demand during the data transfer phase. In the first case, the delay for each packet is the same; in the second case, each packet may encounter different delays.
- There is one big advantage in a virtual-circuit network even if resource allocation is on demand. The source can check the availability of the resources, without actually reserving it.

Advantages

- No of bit required in the header is much smaller than no required to provide full destination address.
- Resources can be allocated during connection setup.
- It follows fast processing and forwarding of packets.

Disadvantages

- Connection setup is not possible.
- In the case of fault occurs in the network, all affected connections must be setup again.
- The switches in the network need to maintain information about the flows they are handling.

Q4. Write Differences between Virtual Circuits & Datagram Networks.

(Imp.)

Ans:

S.No.	Basis of comparison	Virtual Circuits	Datagram Networks
1.	Definition	Virtual Circuits are also known as connection-oriented switching. Virtual circuit switching establishes a predetermined path before messages are sent. to the correct destination.	It is a packet-switching technique in which each packet, known as a datagram, is treated as a separate entity. Each packet carries destination information, which the switch uses to route the packet
2.	Connectivity	It is connection-oriented.	It is connectionless.
3.	Path	In these networks, the path taken by the initial data packet between the source and destination nodes is allocated. All subsequent data packets sent between them will take the same path. different paths to their destination.	Since each datagram is treated independently, there is no fixed dedicated path for data transfer. The intermediate routers use dynamically updating routing tables to route each datagram. Therefore, two subsequent packets from the source may travel entirely

4.	**Header**	Since they are all part of the same virtual circuit, all packets that make up a message have the same header information.	Even though they are part of the same communication, the separate datagram packets have different header information.
5.	**Phases**	Transmission is performed in three steps: setup, data transfer, and teardown.	There are no such communication phases.
6.	**Complexity**	In comparison to a datagram network, a virtual circuit is less complex.	However, compared to the virtual circuit, datagram networks are more complex.
7.	**Cost**	Installation and maintenance costs for virtual circuits are higher.	Networks using datagrams are much easier to set up and maintain.
8.	**Resource Utilization**	All resources, including CPUs, band width, and buffers, are reserved before transmission. All data packets use the same resources, which are only released when the transmission is complete.	Before the transmission starts, no initial resource allocation is made for the individual packets. The resources are distributed on demand on a First-Come First-Serve (FCFS) basis when a packet arrives at a router.
9.	**Reliability**	In comparison to the Datagram network, Virtual Circuits are more reliable for data transmission due to the defined path and assurance of fixed resources.	On the other hand, datagram networks are less reliable than virtual circuits since they allocate resources dynamically and follow dynamic paths.
10.	**Addressing**	During setup, the addressing and route are decided. As a result, each packet just includes the VC number.	The complete source and destination addresses are included in each datagram packet.
11.	**Application**	Virtual Circuits are implemented in networks using Asynchronous Transfer Mode (ATM) communi-cations, such as when placing phone calls.	User Datagram Protocol (UDP) typically serves as the framework for datagram communication. In IP networks, they are used.

2.1.3 Message Switched Networks

Q5. What is Message Switching? Explain.

(Imp.)

Ans:

Message Switching is a network switching strategy in which data or message is transmitted entirely from the source to the destination node, one hop at a time. Every intermediary switch in the network stores the entire message during message routing.

If all of the network's resources are used up, or the network becomes blocked, the message-switched network stores and delays the message until sufficient resources are available for effective transmission. Message switching served as an adequate replacement for circuit switching before the development of

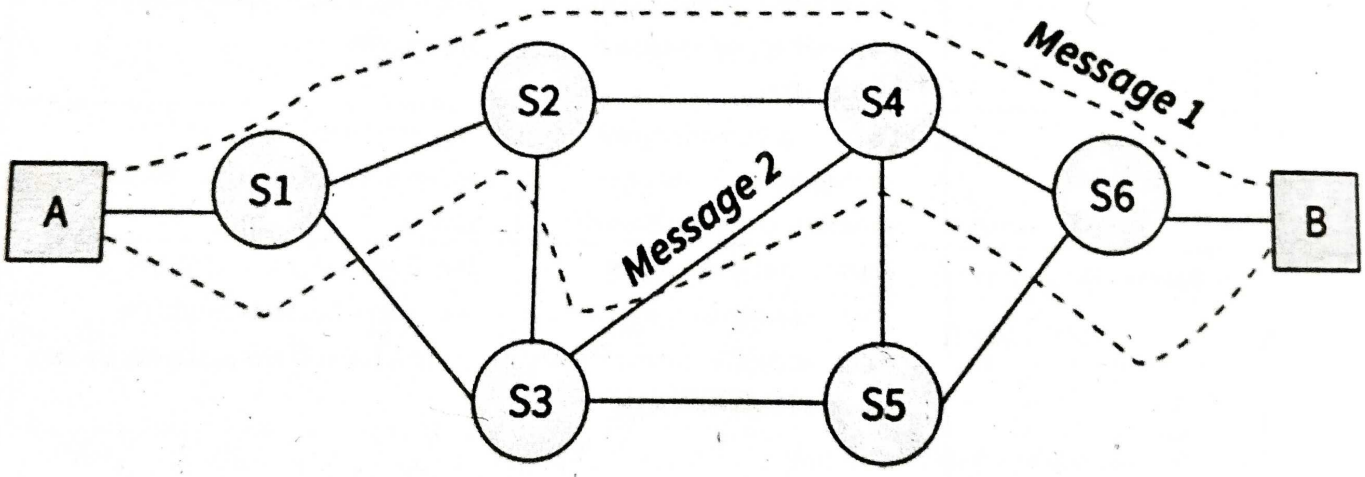
packet switching. The first applications of it were in data transmissions via telex networks and paper tape relay systems. Although packet switching has completely supplanted message switching, ad hoc sensor networks, military networks, and satellite communications networks still use the technique.

The source node and destination nodes are not directly coupled in message switching. Instead, intermediary nodes (mostly switches) are in charge of transmitting messages from one node to the next. As a result, every intermediary node in the network must retain each message before retransmitting them one at a time as appropriate resources become available. Messages are retained indefinitely if the resources are not available. This process is referred to as store and forward. Every message should include a header, which generally contains routing information such as the source and destination, expiry time, priority level, and so on.

Each switching node in a message switching network must have enough storage to buffer messages because message switching treats each message as a single complete entity. So if the message size exceeds the storage capacity of the switch, then the message is strictly discarded. This is one of the significant disadvantages of using these switching methods.

The figure below explains how messages are transferred from sender to receiver in the Message Switching networks.

In the figure Message 1 follows the path A->S1->S2->S4->S6->B, while the Message 2 follows A->S1->S2->S3->S4->S6->B. This is due to the fact Message switching uses dynamic routing.

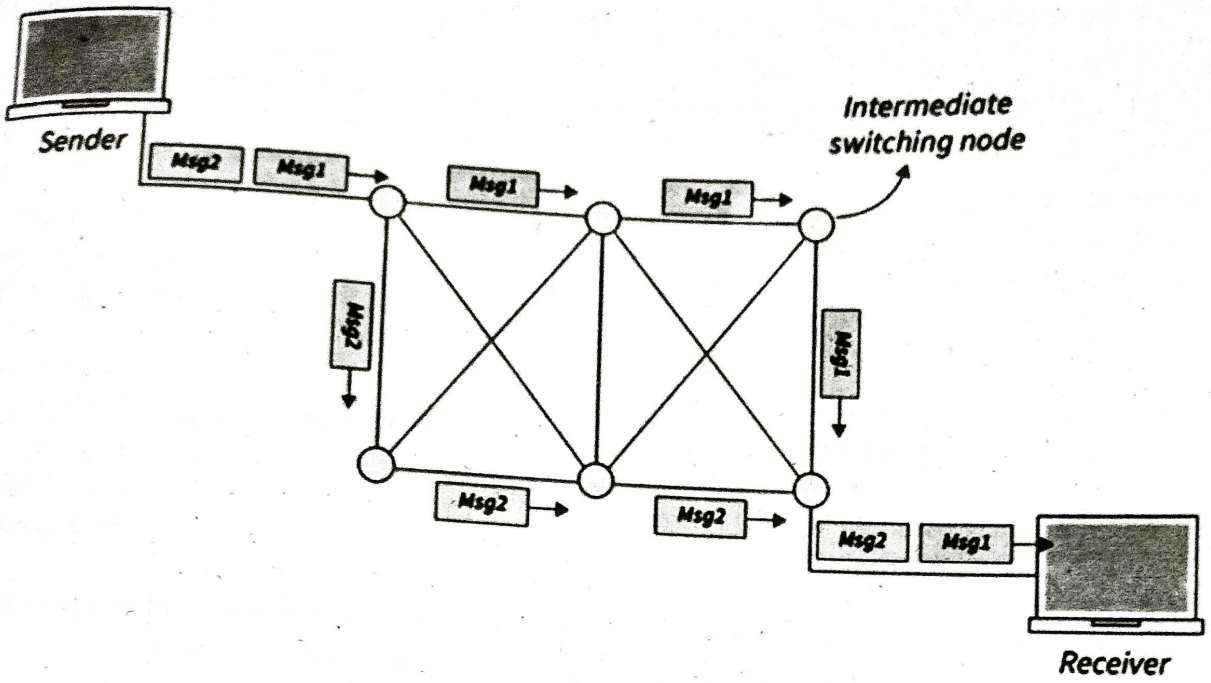


Process of Message Switching

Message switching treats each message as a separate entity. The sender node adds the destination address to the message before sending the message. Then the message is completely delivered to the next intermediate switching node. The intermediate node stores the complete message, checks for transmission errors, validates the destination address and then forwards it to the next node. This process is repeated until the message reaches its destination.

If the needed outgoing circuit is busy, the incoming message is not discarded by the switching node. Instead, it is queued for that route and retransmitted when the required route becomes available. This is referred to as a store and forward network.

The diagram given below illustrates the complete process of Message Switching.



Characteristics

1. **Store and Forward**

In a Message Switching network, the sender and receiver are physically not connected to each other. As a result, intermediate nodes between sender and receiver are primarily in charge of forwarding the message to the next node in the network.

Thus, intermediate nodes must have storage capacity to transfer the message because any message will only be transferred if the next node and the link between them are accessible to connect; otherwise, this message will be retained indefinitely.

A store-and-forward switch will thus forward a message only if adequate resources are available and the following node is ready to accept the data. The procedure is repeated until the data is transferred to the destination node. As a result, it is known as the store-and-forward property. Previously, the store-and-forward property was used in telegraph message switching facilities.

2. **Message Delivery**

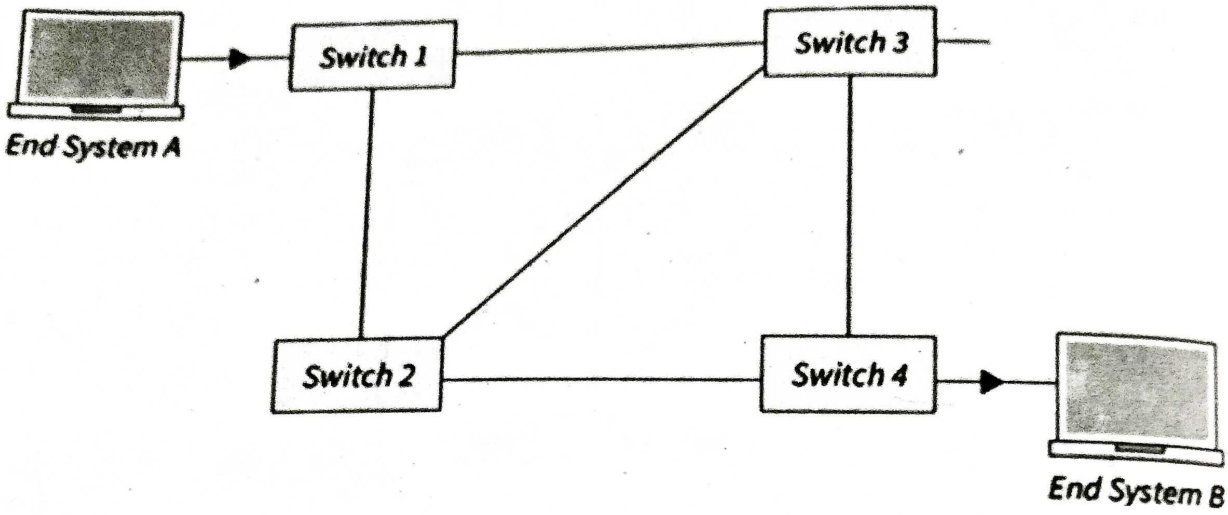
This implies encapsulating the complete information in a single message and sending it from the source to the destination node. Each message must have a header with message routing information, such as the source and destination.

3. **Delay in Message Switching**

A message switched network comprises store-and-forward switches linked together by trunks. A single trunk is usually enough to connect two switches.

We can provide multiple trunks to boost reliability. Every switch has a storage unit where all incoming messages are momentarily held before being transmitted to another switch.

A network trunk is a communications link or link that is designed to transport multiple signals at same time to offer network access between two points.



(iii) The store-and-forward service operates similarly to the telegram service. A message is forwarded from switch to switch with the destination address till it reaches the destination.

(iv) As illustrated in Fig, assume that end system A wishes to transmit a message to end system B. A sends its message to entry switch 1 coupled with the destination's and its own addresses. The addresses are contained in the message's header.

(v) The message is accepted by Switch 1, and the destination address is examined. Each node maintains its routing table. This routing table contains entries representing destination nodes and the switch's corresponding outgoing trunks. Every trunk has its queue.

(vi) As we can reach the destination node via multiple routes, the decision to send the message to a specific next switch is based on the expected delay in its queue. Assume the message from A is queued for node 2.

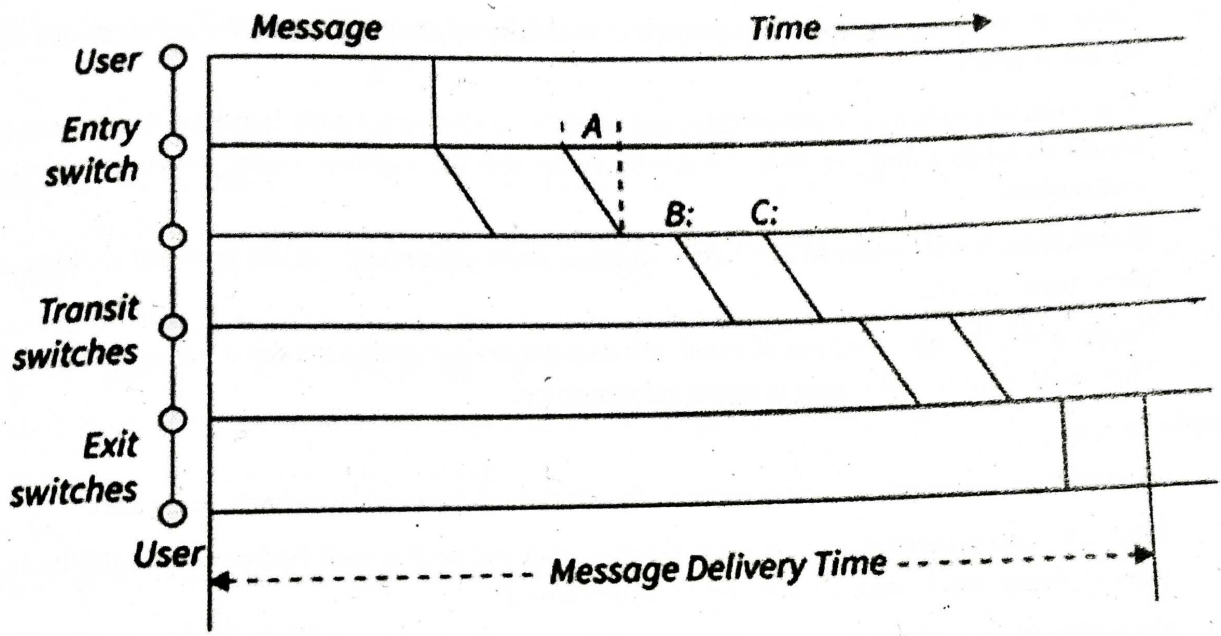
(vii) The message received at switch 2 is added to a queue of messages waiting to be transmitted to switch 4. When its turn comes, the message is routed to switch 4, which forwards it to the intended recipient.

(viii) Some of the fundamental characteristics of store-and-forward message switching, which are the main reasons for delay in message switching networks, are as follows:

- The store-and-forward service is unidirectional. The network does not send confirmation to the source after the message is delivered. Suppose end system B is required to send an acknowledgment to the message received from A. In that case, the network treats the acknowledgment like any other message and includes the destination and source addresses.
- The network may use an error control mechanism for message transfer from switch to switch. The message may be appended with error-checking bits, and if an error is detected, the receiving switch may request the retransmission of the message from the sending switch. As a result, the sending switch must retain a copy of the message until an acknowledgment is received.

- As the message is buffered at the switch at each transmission stage, each switch-to-switch transfer is a separate operation. The trunks can operate at a variety of data rates. The end systems at the source and destination can operate at different data rates.
- The network treats each message as a distinct entity in message switching; therefore, each message's destination and source addresses are repeated.

(ix) Delay in delivery. The time diagram for routing a message through a message switching network is shown in Figure. The message travels through the entry switch, two transit switches, and ultimately the exit switch to reach its destination.



A : switch to switch propagation time

B : switch Delay

C : Message transmission time

So the total time in message delivery is calculated by the sum of the following components:

- The Switch delay.
- Switch To switch propagation delay.
- Message Transmission Time.

Advantages

- Message switching reduces network traffic congestion because it can store messages for which no communication channel is available.
- Message broadcasting takes far less bandwidth than circuit switching.
- Unlike circuit switching, it does not require the physical connection of source and destination devices.
- It is possible to include priority in the messages because they are transmitted using a store and forward approach.

- We can alter the size of the message sent across the network. As a result, it handles any amount of data.
- Data channels are shared across connected devices, improving the available bandwidth's efficiency
- Message switching systems can send a single message to several destinations; however, this capability is not available in circuit switching.

Disadvantages

- Since message length is unbounded, each switching node must have enough storage to buffer messages.
- Message switching cannot be employed for real-time applications since storing messages adds time to the process.
- The message switching method does not establish a dedicated path between the devices. There is no direct relationship between the sender node and the receiver node, hence communication is not reliable.
- Message-switched networks are highly sluggish since processing occurs in every node, resulting in poor performance.
- People are generally unaware of whether messages are correctly sent since the system is so complex. This could lead to difficulties in social relationships.

Applications

- In telegraph message switching centers, the store-and-forward approach was used.
- Although many essential networks and systems today are packet-switched or circuit-switched networks, their delivery mechanisms might be message-based.
- For instance, In most electronic mail systems, the delivery mechanism is based on message switching, whereas the network is circuit-switched or packet-switched.

2.2 Asynchronous Transfer Mode

2.2.1 Evolution

Q6. Write about how ATM evolved.

Ans:

The concept of ATM was developed at first hand itself. In the 1990s, the mobile data carrier speed along with the internet speed saw a boom in the transfer rate. On the other hand, other internet technologies such as voice call and video calls had also started to come into the play. So, in a nutshell, it was not only the internet world but also the telephony world which were converging into each other. Thus networking QoS factors such as latency, jitter, data rate, real-time data delivery, etc., became more important.

It is an International Telecommunication Union - Telecommunications Standards Section (ITU-T) efficient for call relay and it transmits all information including multiple service types such as data, video, or voice which is conveyed in small fixed-size packets called cells. Cells are transmitted asynchronously and the network is connection-oriented.

ATM is a technology that has some event in the development of broadband ISDN in the 1970s and 1980s, which can be considered an evolution of packet switching. Each cell is 53 bytes long – 5 bytes header and 48 bytes payload. Making an ATM call requires first sending a message to set up a connection.

Subsequently, all cells follow the same path to the destination. It can handle both constant rate traffic and variable rate traffic. Thus it can carry multiple types of traffic with end-to-end quality of service. ATM is independent of a transmission medium, they may be sent on a wire or fiber by themselves or they may also be packaged inside the payload of other carrier systems. ATM networks use "Packet" or "cell" Switching with virtual circuits. Its design helps in the implementation of high-performance multimedia networking.

2.2.2 Benefits

Q7. Write the benefits and Drawbacks of ATM network. **(Imp.)**

Ans:

Benefits

Following are the benefits or advantages of Asynchronous Transfer Mode (ATM):

- It is optimized to transport voice, data and video i.e. single network for everything. It is used for mixed traffic, real-time and non real time traffic types.
- It is easy to integrate with LAN, MAN and WAN network types i.e. seamless integration.
- It is QoS oriented and high speed oriented.
- It enables efficient use of network resources using bandwidth on demand concept.
- It uses simplified network infrastructure.

Drawbacks

Following are the disadvantages of Asynchronous Transfer Mode (ATM):

- Overhead of cell header (5 bytes per cell)
- Complex mechanisms are used to achieve QoS.
- Congestion may cause cell losses
- ATM switch is very expensive compared to LAN hardware. Moreover ATM NIC is more expensive compared to ethernet NIC.
- As ATM is connection oriented technology, the time required for connection setup and tear down is larger compare to time required to use it.

2.2.3 Concepts

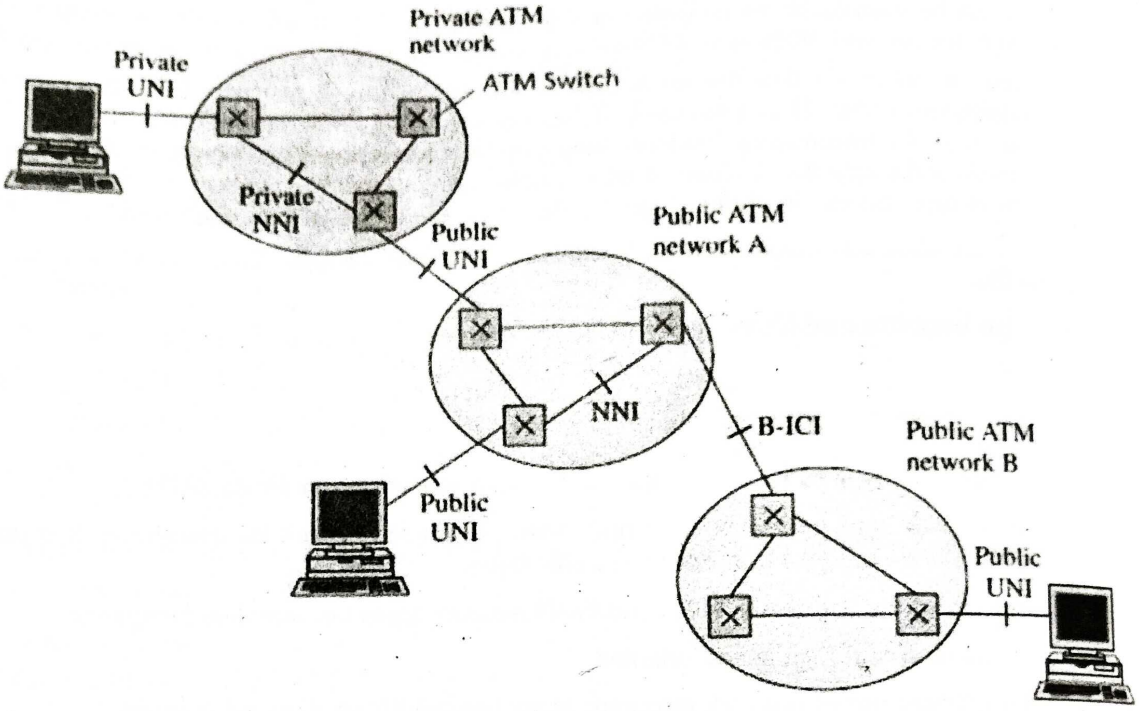
Q8. What is Asynchronous Transfer Mode (ATM)? Expalin. **(Imp.)**

Ans:

Introduction:

ATM stands for Asynchronous Transfer Mode. ATM technology uses ATM cells for data transmission between source and destination. ATM cell uses fixed size of 53 bytes which consists of header (5 bytes) and data (48 bytes). It is behind the success of B-ISDN used for voice/data/video transportation.

ATM transmits cells only when there is data to be transmitted unlike STM (Synchronous Transfer Mode) where bandwidth is assigned periodically like TDM. ATM is connection oriented which uses virtual packet switching. Multiple logical connections are multiplexed over single physical connection.



The full form of the ATM is Asynchronous Transfer Mode. Asynchronous Transfer Mode is a switching technique and time division multiplexing (TDM) is used by ATMs for data communication. Time-division multiplexing (TDM) is a method in which multiple data

Importance

1. Driven by the integration of services and performance requirements of both telephony and data networking: "broadband integrated service vision" (B-ISON).
2. Telephone networks support a single quality of service and are expensive to boot.
3. Internet supports no quality of service but is flexible and cheap.
4. ATM networks were meant to support a range of service qualities at a reasonable cost- intended to subsume both the telephone network and the Internet.

Asynchronous Transfer Mode (ATM):

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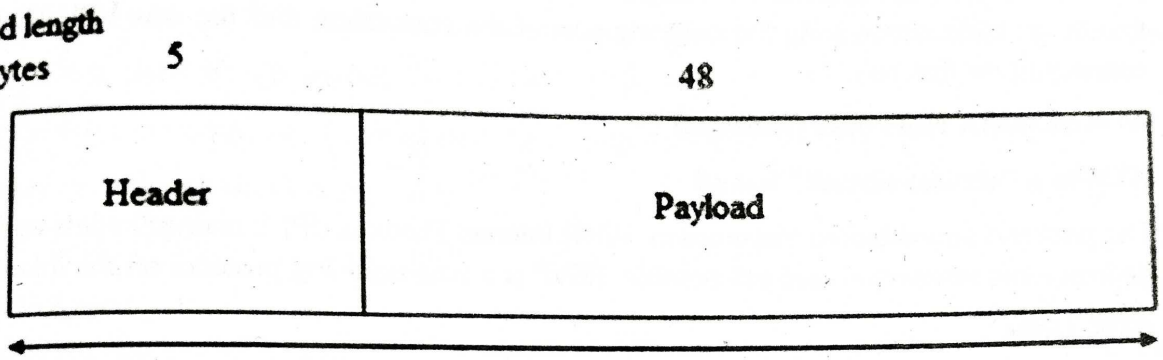
may also be packaged inside the payload of other carrier systems. ATM networks use "Packet" or "cell" Switching with virtual circuits. Its design helps in the implementation of high-performance multimedia networking.

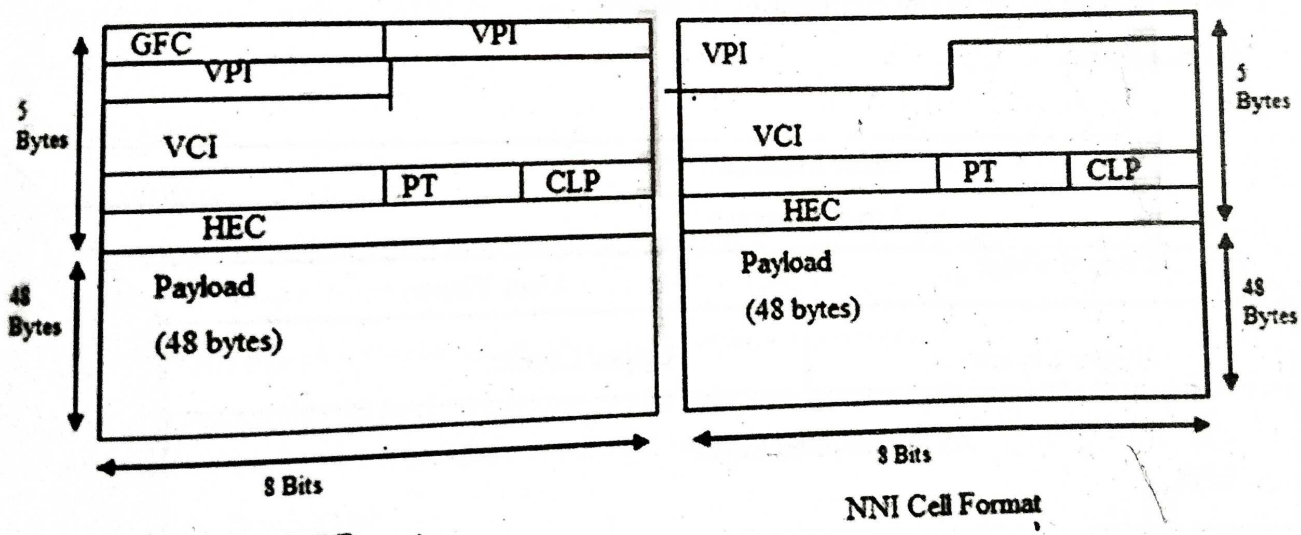
ATM Cell Format

As information is transmitted in ATM in the form of fixed-size units called cells. As known already each cell is 53 bytes long which consists of a 5 bytes header and 48 bytes payload.



ATM Cell Format

Asynchronous Transfer Mode can be of two format types which are as follows:



UNI Header: This is used within private networks of ATMs for communication between ATM endpoints and ATM switches. It includes the Generic Flow Control (GFC) field.

1. **NNI Header**

Is used for communication between ATM switches, and it does not include the Generic Flow Control (GFC) instead it includes a Virtual Path Identifier (VPI) which occupies the first 12 bits.

Working of ATM:

ATM standard uses two types of connections. i.e., Virtual path connections (VPCs) which consist of Virtual channel connections (VCCs) bundled together which is a basic unit carrying a single stream

of cells from user to user. A virtual path can be created end-to-end across an ATM network, as it does not rout the cells to a particular virtual circuit. In case of major failure, all cells belonging to a particular virtual path are routed the same way through the ATM network, thus helping in faster recovery.

Switches connected to subscribers use both VPIs and VCIs to switch the cells which are Virtual Path and Virtual Connection switches that can have different virtual channel connections between them, serving the purpose of creating a *virtual trunk* between the switches which can be handled as a single entity. Its basic operation is straightforward by looking up the connection value in the local translation table determining the outgoing port of the connection and the new VPI/VCI value of connection on that link.

ATM vs DATA Networks (Internet) :

- **ATM is a "virtual circuit" based**

The path is reserved before transmission. While Internet Protocol (IP) is connectionless and end-to-end resource reservations are not possible. RSVP is a new signaling protocol on the internet.

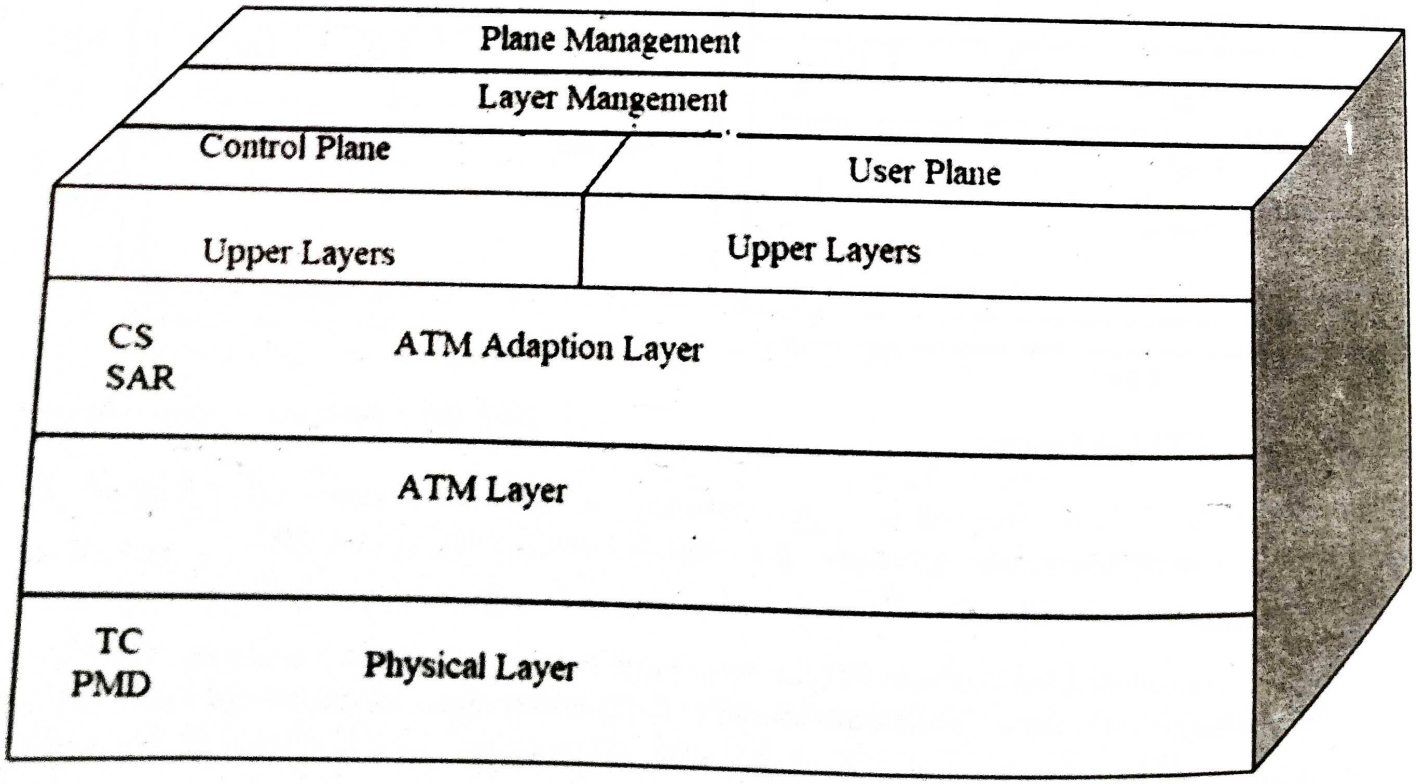
- **ATM Cells**

Fixed or small size and Trade off is between voice or data. While IP packets are of variable size.

- **Addressing**

ATM uses 20-byte global NSAP addresses for signaling and 32-bit locally assigned labels in cells. While IP uses 32-bit global addresses in all packets.

ATM Layers:



1. **ATM Adaption Layer (AAL)**

It is meant for isolating higher-layer protocols from details of ATM processes and prepares for conversion of user data into cells and segments it into 48-byte cell payloads. AAL protocol excepts transmission from upper-layer services and helps them in mapping applications, e.g., voice, data to ATM cells.

2. **Physical Layer**

It manages the medium-dependent transmission and is divided into two parts physical medium-dependent sublayer and transmission convergence sublayer. The main functions are as follows:

- It converts cells into a bitstream.
- It controls the transmission and receipt of bits in the physical medium.
- It can track the ATM cell boundaries.
- Look for the packaging of cells into the appropriate type of frames.

3. **ATM Layer**

It handles transmission, switching, congestion control, cell header processing, sequential delivery, etc., and is responsible for simultaneously sharing the virtual circuits over the physical link known as cell multiplexing and passing cells through an ATM network known as cell relay making use of the VPI and VCI information in the cell header.

Q9. Explain about various ATM Applications.

Ans:

ATM Applications

1. **ATM WANs**

It can be used as a WAN to send cells over long distances, a router serving as an end-point between ATM network and other networks, which has two stacks of the protocol.

2. **Multimedia virtual private networks and managed services**

It helps in managing ATM, LAN, voice, and video services and is capable of full-service virtual private networking, which includes integrated access to multimedia.

3. **Frame relay backbone**

Frame relay services are used as a networking infrastructure for a range of data services and enabling frame-relay ATM service to Internet working services.

4. **Residential broadband networks**

ATM is by choice provides the networking infrastructure for the establishment of residential broadband services in the search of highly scalable solutions.

5. **Carrier infrastructure for telephone and private line networks**

To make more effective use of SONET/SDH fiber infrastructures by building the ATM infrastructure for carrying the telephonic and private-line traffic.

2.2.4 Exploring Broadband Integrated Services

Q10. Write about broadband integrated services.

Ans: (Imp.)

Meaning

The B-ISDN (broadband integrated services digital network) is a virtual circuit-switched network that can use high-speed packet switching services. The B-ISDN will use a flexible multiplexing format called ATM (asynchronous transfer mode).

B-ISDN services are classified into interactive and distribution services. Interactive services contain the bidirectional flow of user information between two subscribers or between a subscriber and a service provider.

Interactive services

The interactive services are further divided into three sub-categories which are as follows-

1. **Conversational**

   Conversational service involves the real-time exchange of information such as sound, video, data or entire documents. Examples include video-telephony, video-conference, and high-speed data transfer. Video-telephony is like the normal video telephony service but also has video capture, transmission and display capabilities. Video-conference supports voice and video communication between two conference rooms or between several individuals.

2. **Messaging**

   Messaging service involves the non-real-time exchange of information between subscribers in a store-and-forward fashion.

3. **Retrieval**

   Retrieval services provide subscribers with retrieval access to centrally-stored public information. Examples include broadband videotext (retrieval of video images/sequences with sound, text and graphics), video retrieval (subscriber create to video libraries of movies) and return of high-resolution pictures and records from multiple archives and data centers.

Distribution Services

Distribution services contain the unidirectional flow of user information from a service provider to a subscriber.

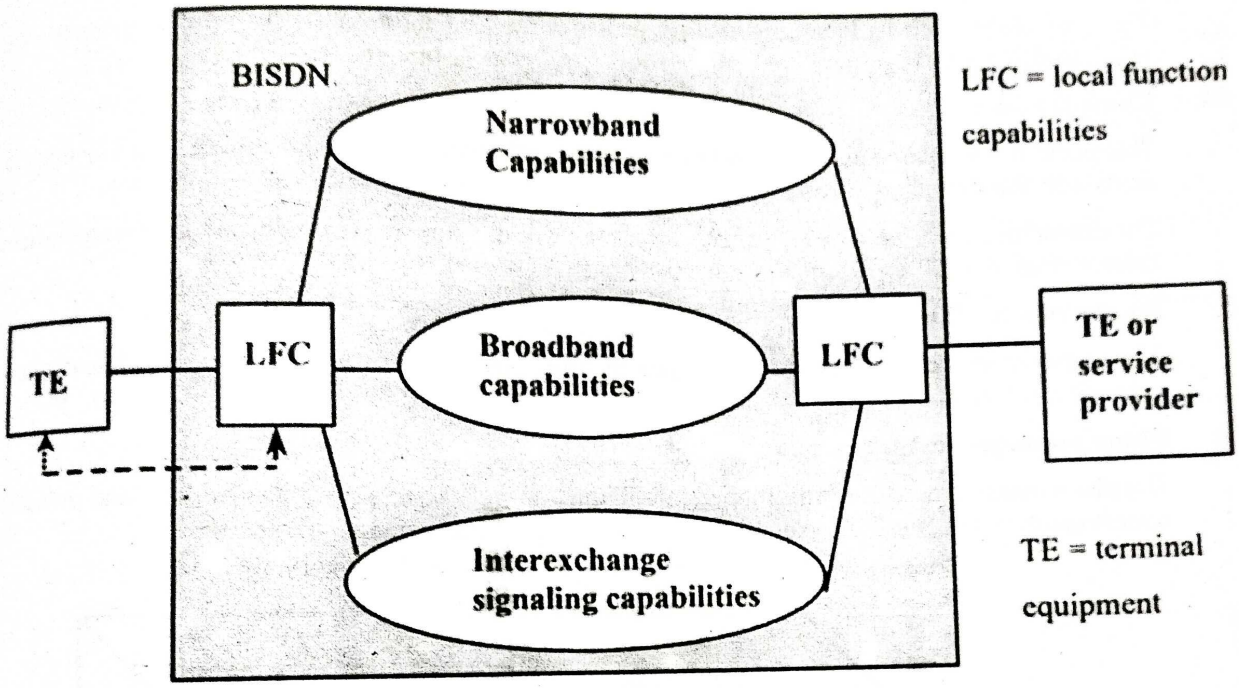
Distribution services are divided into two sub-categories, which are as follows:

1. Distribution services without user presentation control involve the central broadcast of information to many subscribers, where subscribers have no control over data display. Examples include the broadcast of TV programs, electronic newspapers, and electronic publishing.
2. Distribution services with user presentation control are the same as the previous category. The information is offered as cyclically repeated frames, thereby enabling the subscribers to control the start and the order of the frames presentation. Examples include electronic newspaper and tele-advertising.

Q11. Explain about B-ISDN Architecture. **(Imp.)**

Ans:

The B-ISDN architecture is shown in the diagram below -



The architecture of the B-ISDN includes low Layer capabilities and high Layer capabilities. These capabilities support the services within the B-ISDN and other networks by means of interworking B-ISDN with those networks.

Low Layer capabilities

The low layer capabilities of B-ISDN architecture are explained below -

- From the functional capabilities of the B-ISDN, as shown in Figure, the information transfer capabilities require further description.
- Broadband information transfer is provided by an ATM at the B-ISDN user-network interface (UNI) and at switching entities inside the network.

High Layer capabilities

The high layer capabilities of B-ISDN architecture are explained below -

- Normally, the high Layer functional capabilities are involved only in the terminal equipment.
- The support of some services, provision of high layer functions could be made through special nodes in the B-ISDN belonging to the public network or to centres operated by other organizations and accessed via B-ISDN user-network or network node interfaces (NNIs).

2.2.5 Digital Network Layer And Adaptation Layer

Q12. Explain B-ISDN layers for ATM.

Ans: (Imp.)

1) User plane

The user plane, with its layered structure, provides for user information flow transfer, along with associated controls (e.g. flow control, and recovery from errors, etc.).

2) Control plane

This plane has a layered structure and performs the call control and connection control functions; it deals with the signalling necessary to set up, supervise and release calls and connections.

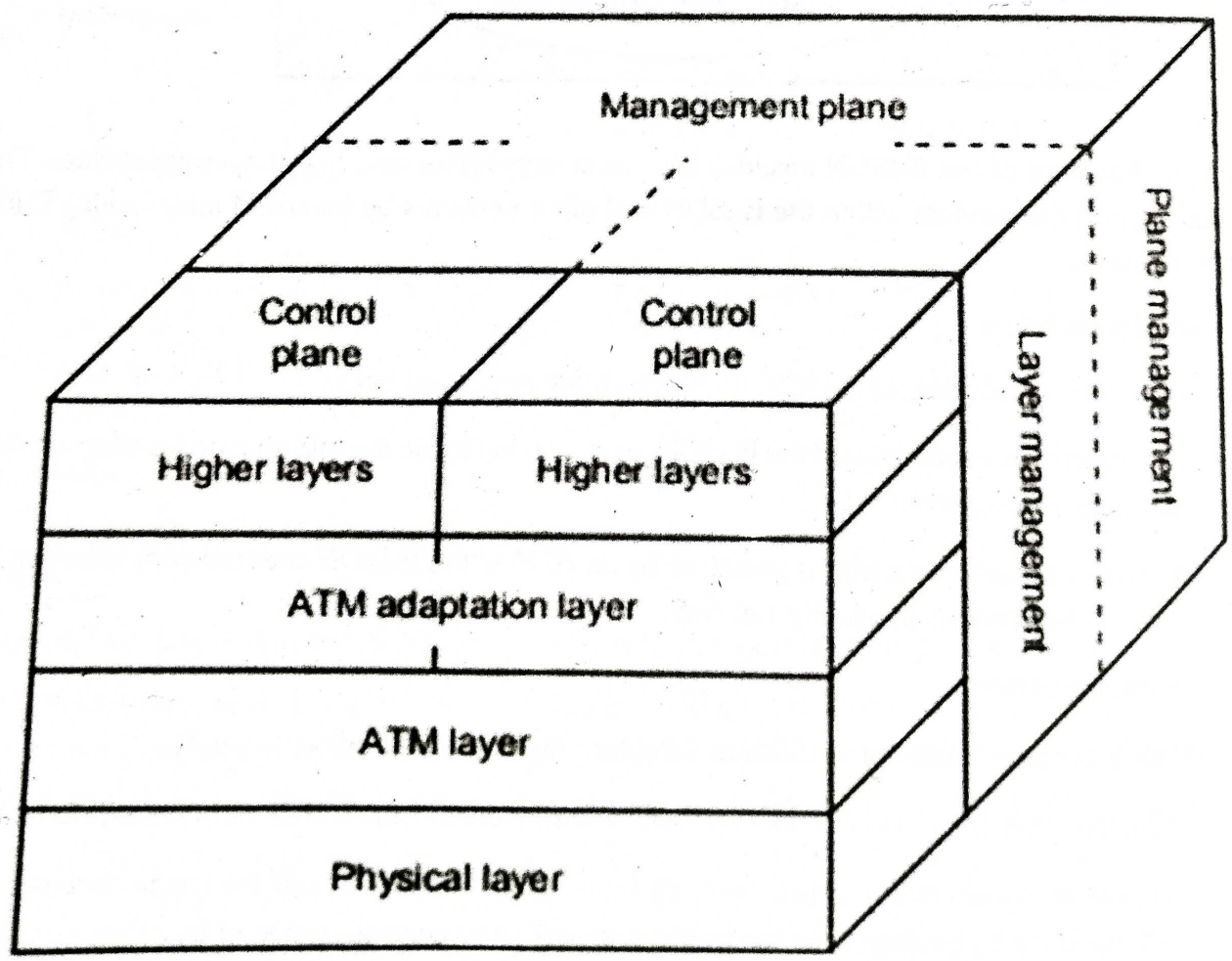
The distinction, if any, between local and global control plane functions in the broadband environment is for further study.

3) Management plane

The management plane provides two types of functions, namely Layer Management and plane management functions.

(i) Plane management functions

The plane management performs management functions related to a system as a whole and provides coordination between all the planes. Plane management has no layered structure.



(ii) Layer Management functions

Layer Management performs management functions (e.g. meta-signalling) relating to resources and parameters residing in its protocol entities. Layer Management handles the operation and maintenance (OAM) information flows specific to the layer concerned.

Functions of the individual layers of the B-ISDN PRM

The functions of each layer, the primitives exchanged between layers, and primitives exchanged between the layers and the management plane are described below. The information flows described do not imply a specific physical realization. Figure illustrates the layers of the PRM, and identifies the functions of the Physical Layer, the ATM Layer, and the AAL.

Higher layer functions	Higher layers	
Convergence	CS	AAL
Segmentation and reassembly	SAR	
Generic flow control Cell header generation/extraction Cell VPI/VCI translation Cell multiplex and demultiplex	ATM	
Cell rate decoupling HEC header sequence generation/verification Cell delineation Transmission frame adaptation Transmission frame generation/recovery	TC	
Bit timing Physical medium	PM	

CS Convergence sublayer
PM Physical medium
SAR Segmentation and reassembly sublayer
TC Transmission convergence

1. Physical layer

The lowest layer in the ATM protocol. It describes the physical transmission media.We can use shielded and shielded twisted pair,Coaxial cable and fibre optic cable.

2. ATM layer

It performs all function relating to the routing and multiplexing of cells over VCs.It generates a header to the segment streams generated bye the AAL, Similarly on the receipt of a cell streams it removes the header from the cell and pass the cell contents to the AAl protocol.To perform all these function, The ATM layer maintains a table which contain a list of VCIs.

3. ATM Adaptation Layer

Top layer in the ATM protocol model. It converts the submitted information into streams of 48-octet segments and transports these in the payload field of multiple ATM cells.Similarly an receipt of the stream of cells relating to the same cell, it converts the 48-octet information field into required form for delivery to the particular higher protocol layer.

Short Question & Answers

1. Explain about circuit switched networks.

Ans :

A network consists of a set of switches that are connected by the physical links commonly known as Circuit-Switched Network.

- Whenever one device communicates with another device then a dedicated communi- cation path is established between them over the network.
- There is only a dedicated channel on each link used by each connection. Also, each link can be easily divided into n channels by using the TDM(Time Division Multiplexing) or FDM(Frequency Divison Multiplexing) technique,
- The Circuit Switching technique is mainly used in the public telephone network for voice communication as well as for data communication.
- Data communication is less efficient than voice communication.

2. Datagram Networks.

Ans:

It is a packet-switching technique in which each packet, known as a datagram, is treated as a separate entity. Each packet carries destination information, which the switch uses to route the packet to the correct destination. There is no need to reserve resources because there is no specified channel for a connection session. As a result, packets contain a header including all of the destination's information. The intermediate nodes examine the header of a packet and choose an appropriate link to a different node closer to the destination.

Resources in datagram networks are allocated on a First Come First Serve (FCFS) basis. When a packet arrives at a router, it must wait if other packets are being processed, regardless of its source or destination.

3. Write Differences between Virtual Circuits & Datagram Networks.

Ans:

S.No.	Basis of comparison	Virtual Circuits	Datagram Networks
1.	Definition	Virtual Circuits are also known as connection-oriented switching. Virtual circuit switching establishes a predetermined path before messages are sent. to the correct destination.	It is a packet-switching technique in which each packet, known as a datagram, is treated as a separate entity. Each packet carries destination information, which the switch uses to route the packet
2.	Connectivity	It is connection-oriented.	It is connectionless.
3.	Path	In these networks, the path taken by the initial data packet between the source and destination nodes is allocated. All subsequent data packets sent between them will take the same path. different paths to their destination.	Since each datagram is treated independently, there is no fixed dedicated path for data transfer. The intermediate routers use dynamically updating routing tables to route each datagram. Therefore, two subsequent packets from the source may travel entirely

4.	Header	Since they are all part of the same virtual circuit, all packets that make up a message have the same header information.	Even though they are part of the same communication, the separate datagram packets have different header information.
5.	Phases	Transmission is performed in three steps: setup, data transfer, and teardown.	There are no such communication phases.
6.	Complexity	In comparison to a datagram network, a virtual circuit is less complex.	However, compared to the virtual circuit, datagram networks are more complex.
7.	Cost	Installation and maintenance costs for virtual circuits are higher.	Networks using datagrams are much easier to set up and maintain.

4. Message Switching.

Ans:

Message Switching is a network switching strategy in which data or message is transmitted entirely from the source to the destination node, one hop at a time. Every intermediary switch in the network stores the entire message during message routing.

If all of the network's resources are used up, or the network becomes blocked, the message-switched network stores and delays the message until sufficient resources are available for effective transmission. Message switching served as an adequate replacement for circuit switching before the development of packet switching. The first applications of it were in data transmissions via telex networks and paper tape relay systems. Although packet switching has completely supplanted message switching, ad hoc sensor networks, military networks, and satellite communications networks still use the technique.

The source node and destination nodes are not directly coupled in message switching. Instead, intermediary nodes (mostly switches) are in charge of transmitting messages from one node to the next. As a result, every intermediary node in the network must retain each message before retransmitting them one at a time as appropriate resources become available. Messages are retained indefinitely if the resources are not available. This process is referred to as store and forward. Every message should include a header, which generally contains routing information such as the source and destination, expiry time, priority level, and so on.

5. ATM.

Ans:

The concept of ATM was developed at first hand itself. In the 1990s, the mobile data carrier speed along with the internet speed saw a boom in the transfer rate. On the other hand, other internet technologies such as voice call and video calls had also started to come into the play. So, in a nutshell, it was not only the internet world but also the telephony world which were converging into each other. Thus networking QoS factors such as latency, jitter, data rate, real-time data delivery, etc., became more important.

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6. Drawbacks of ATM network.

Ans:

Drawbacks

Following are the disadvantages of Asynchronous Transfer Mode (ATM):

- Overhead of cell header (5 bytes per cell)
- Complex mechanisms are used to achieve QoS.
- Congestion may cause cell losses
- ATM switch is very expensive compared to LAN hardware. Moreover ATM NIC is more expensive compared to ethernet NIC.
- As ATM is connection oriented technology, the time required for connection setup and tear down is larger compare to time required to use it.

7. Asynchronous Transfer Mode.

Ans:

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8. ATM Applications.

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9. Broadband integrated services.

Ans:

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10. Functions of the individual layers of the B-ISDN PRM.

Ans:

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Choose the Correct Answers

1. A _____ network is a cross between a circuit-switched network and a datagram network. It has some characteristics of both. [a]
   (a) Virtual-circuit (b) Packet-switched
   (c) Frame-switched (d) None of the above

2. Circuit switching can involve the use of _____. [d]
   (a) Space division switches (b) Time domain switches
   (c) TDM bus (d) All of the above

3. There are two popular approaches to packet switching : [d]
   (a) Datagram (b) Virtual circuit
   (c) TDS (d) Both option A & B

4. Datagram networks mainly refers to _____. [b]
   (a) Connection oriented networks (b) Connection less networks
   (c) Telephone networks (d) Internetwork

5. Packets in datagram switching are referred to as _____ [c]
   (a) Switches (b) Segments
   (c) Datagrams (d) Data-packets

6. Which of the following is not a phase of virtual circuit network? [c]
   (a) Setup phase (b) Data transfer phase
   (c) Termination phase (d) Teardown phase

7. In virtual circuit network, the number of delay times for setup and teardown respectively are _____ [a]
   (a) 1 and 1 (b) 1 and 2
   (c) 2 and 1 (d) 2 and 2

8. Store and forward are terms used to describe _____ switching. [c]
   (a) Circuit (b) Packet
   (c) Message (d) All of the above

9. Each ATM _____ contains a table to identify paths to other switches [b]
   (a) Cell (b) Switch
   (c) Station (d) a and b

10. An ATM cell consists of _____ bytes. [b]
   (a) 48 (b) 53
   (c) 256 (D) a variable number of

Fill in the blanks

1. The required resources for communication between end systems are reserved for the duration of the session between end systems in _____ method.
2. Store and forward are terms used to describe _____
3. In a _____ network , data are transmitted in discrete units of potentially variable length blocks called packets.
4. A _____ network is a cross between a circuit-switched network and a datagram network.
5. In a packet-switching technique in which each packet, known as a _____
6. During teardown phase, the source, after sending all the frames to destination, sends a _____ to notify termination.
7. The simplest ATM switch is the _____ switch.
8. The _____ layer accepts transmissions from upper-layer services.
9. The _____ is a virtual circuit-switched network that can use high-speed packet switching services.
10. B-ISDN services are classified into_____ and _____services

ANSWERS

1. Circuit switching
2. Message Switching
3. Packet switching
4. Virtual-circuit
5. Datagram
6. Teardown request
7. Crossbar
8. AAL
9. B-ISDN (broadband integrated services digital network)
10. Interactive and distribution