(iii) Flow Control: If the rate at which the data are absorbed by the receiver is less than the rate produced in the sender, the data link layer imposes a flow control mechanism to prevent overwhelming the receiver.

(iv) Error Control: The data link layer adds reliability to the physical layer by adding mechanism to detect and retransmit damaged or lost frames. It also uses a mechanism to prevent duplication of frames. Error control is normally achieved through a trailer added to the end of the frame.

(v) Access Control: When two or more devices are connected to the same link, data link layer protocols are necessary to determine which device has control over the link at any given time.

(3) Network Layer: The network layer is responsible for the source-to-destination delivery of a packet possibly across multiple networks (links). Whereas the data link layer oversees the delivery of the packet between two systems on the same network (links), the network layer ensure that each packet gets from its point of origin to its final destination.

Functions of Network Layer:

(i) Logical addressing :- The network layer adds a header to the packet coming from the upper layer that, among other things, includes the logical addresses of the sender and receiver.

(ii) Routing :- When independent networks or links are connected together to create an internetworks (a network of networks) or a large network, the connecting devices (called routers or gateways) route the packets to their final destination. One of the functions of the network layer is to provide this mechanism.

④ Transport Layer :- The transport layer is responsible for source-to destination (end to end) delivery of the entire message. Where as the network layer oversees end-to-end delivery of individual packets, it does not recognize any relationship between those packets.

functions of Transport Layer :-

(i) Service-point addressing :- The transport layer header therefore must include a type of address called a service-point address (or Port address). The network layer gets each packets to

Port address

the correct computer; the transport layer gets the entire message to the correct process on that computer.

(ii) Segmentation and Reassembly: A message is divided into transmittable segments, each segment containing a sequence number. These numbers enable the transport layer to reassemble the message correctly upon arriving at the destination and to identify the replace packets that were lost in the transmission.

(iii) Connection Control: The transport layer can be either connectionless or connection-oriented.

Connectionless / connection-oriented

A connectionless transport layer treats each segment as an independent packet and delivers it to the transport layer at the destination machine.

A connection oriented transport layer makes a connection with the transport layer at the destination machine first before delivering the packets. After all the data are transferred, the connection is terminated.

(iv) Flow Control: Like the DLL, the transport layer is responsible for flow control. However, flow control at this layer is performed end-to-end rather than across a single link.

(v) Error Control: Like the data link layer, the transport layer is responsible

for error control. However, error control at this layer is performed end-to-end rather than across a single link. The sending transport layer makes sure that the entire message arrives at the receiving transport layer without error (damage, loss or duplication).

(5) Session Layer: The services provided by the first three layers (physical, data link, and network) are not sufficient for some processes. The session layer is the network dialog controller. It establishes, maintains and synchronizes the interaction between communicating systems.

Functions of Session layer:

(i) Dialog Control: The session layer allows two systems to enter into a dialog. It allows the communication between two processes to take place either in half-duplex or full duplex.

(ii) Synchronization: The session layer allows a process to add checkpoints (synchronization points) into a stream of data.

For example, if a system is sending a file of 2000 pages, it is advisable to insert checkpoints after every 100 pages to ensure that each 100 page unit is received and acknowledged independently. In this case, if a crash happens during the transmission

of page 523, retransmission begins at 501:, Pages 1 to 500 need not be retransmitted.

⑥ Presentation Layer:- The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems.)

functions of Presentation Layer:

(i) Translation:- The processes (running programs) in two systems are usually exchanging information in the form of character strings, numbers, and so on. The information should be changed to bit streams before being transmitted. because different computers use different encoding systems, the presentation layer is responsible for interoperability between these different encoding method.

(ii) Encryption:- To carry, sensitive information, a system must be able to assure privacy. Encryption means that the sender transforms the original information to another form and sends the resulting message out over the network. Decryption reverses the original process to transform the message back to its original form.

(iii) Compression: Data compression reduces the number of bits to be transmitted. Data compression becomes particularly important in the transmission of multimedia such as text, audio and video.

7) Application layer: The application layer enables the user, whether human or software, to access the network. It provides user interfaces and support for services such as electronic mail, remote file access and transfer, shared data base management, and other types of distributed information services.

Functions of Application layer:

(i) Network virtual terminal: A network virtual terminal is a software version of a physical terminal and allows a user to log on to a remote host.

(ii) file transfer Access, and Management: The application allows a user to access files in a remote computer (to make change or read data), to retrieve files from a remote computer, and to manage or control files in a remote computer.

(iii) Mail Services: This application provides the basis for e-mail forwarding and storage.

(iv) Directory Services: This application provides distributed data base sources and access for global information about various objects and services.

TCP/IP Reference model: The TCP/IP protocol, used in the internet, was developed prior to the OSI model. Therefore, the layers in the Transmission Control protocol/Internetworking Protocol (TCP/IP) protocol do not match exactly with those in the OSI model. The TCP/IP protocol is made of five layers:

(i) Physical layer
(ii) Data link layer
(iii) Network layer
(iv) Transport layer
(v) Application layer.

The first four layer provide physical standards, network interface, internetworking and transport functions that correspond to the first four layers of the OSI model.

The three topmost layers in the OSI model, however, are represented in TCP/IP by a single layer called the application layer.

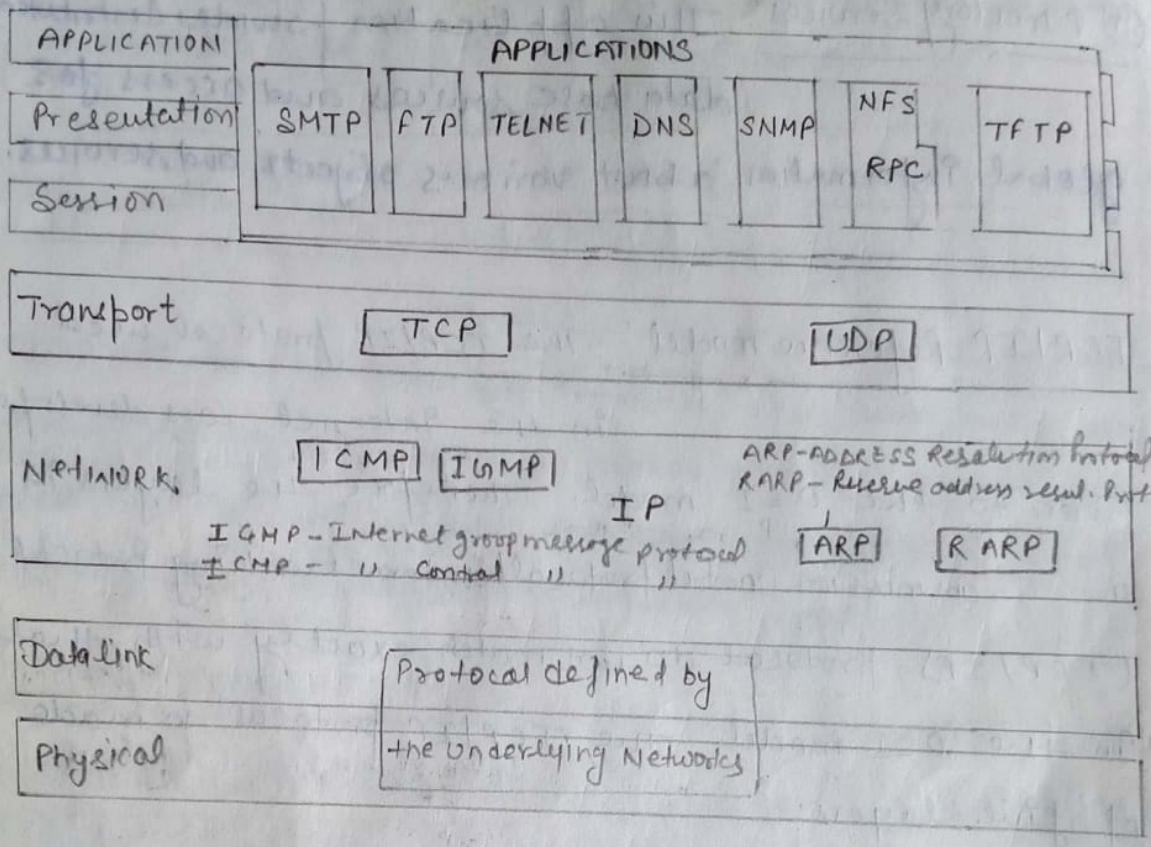


fig TCP/IP and OSI model

TELNET : Terminal N/W
SMTP : Simple mail transfer protocol
FTP : file transfer Protocol
DNS : Domain Name System
SNMP : Simple Network Mang Protocol
RPC : Remote Procedure call
TFTP : Trivial file transfer Prot
UDP : user datagram Protocol

At the transport layer, TCP/IP defines two protocols TCP and UDP. At the Network layer the main protocol defined by TCP/IP is internetworking protocol (IP);

The layered protocal stack that dominates data communications and networking today is the five layer Internet model, some times called the TCP/IP protocal suite. The model is composed of five or seven layers.

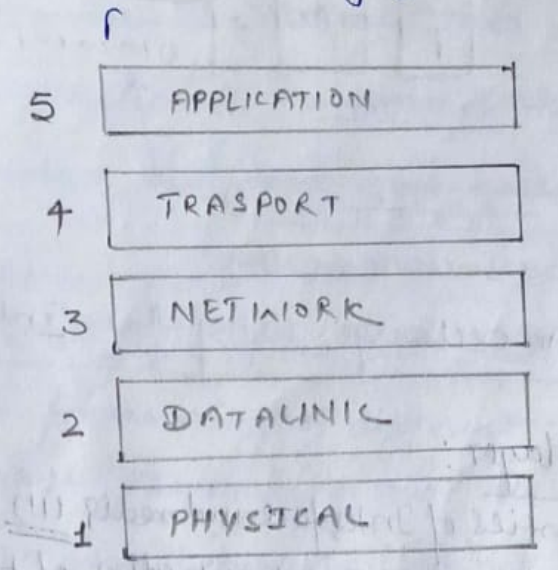
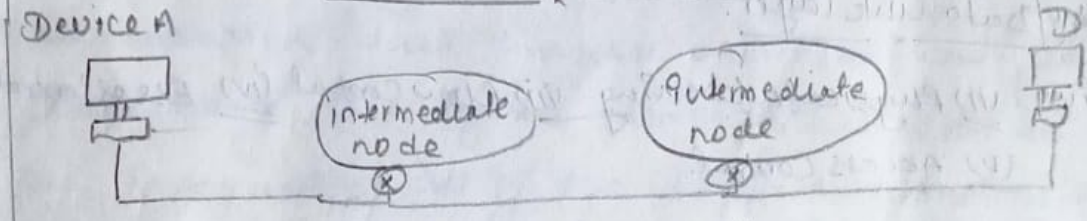


fig Internet model (layer) or TCP/IP model



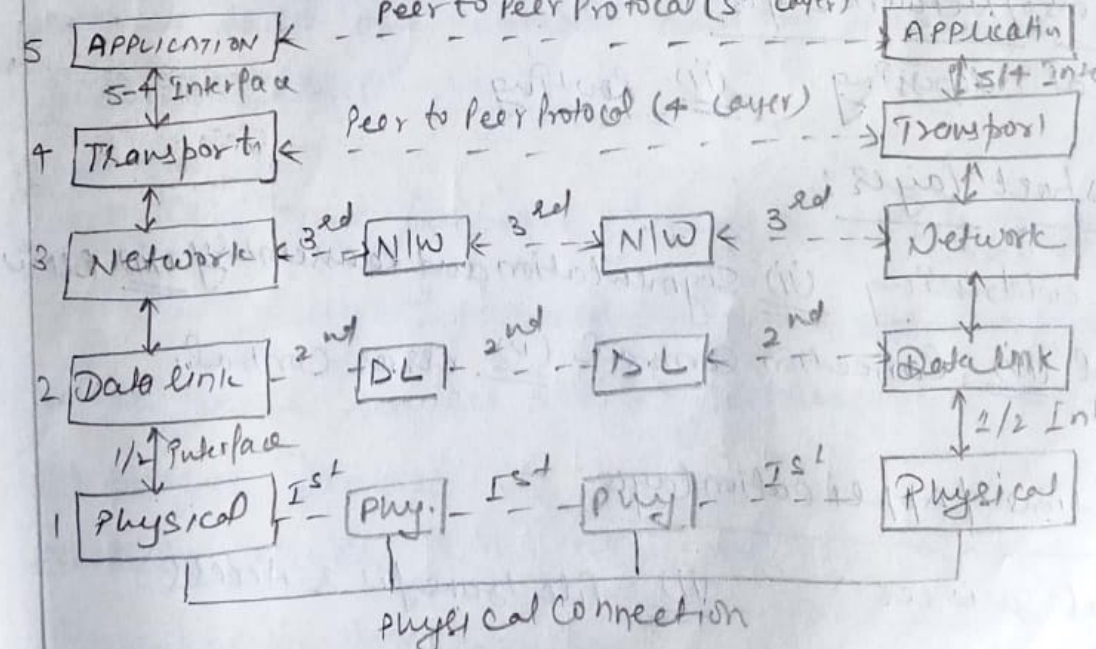


fig: Peer to peer processes

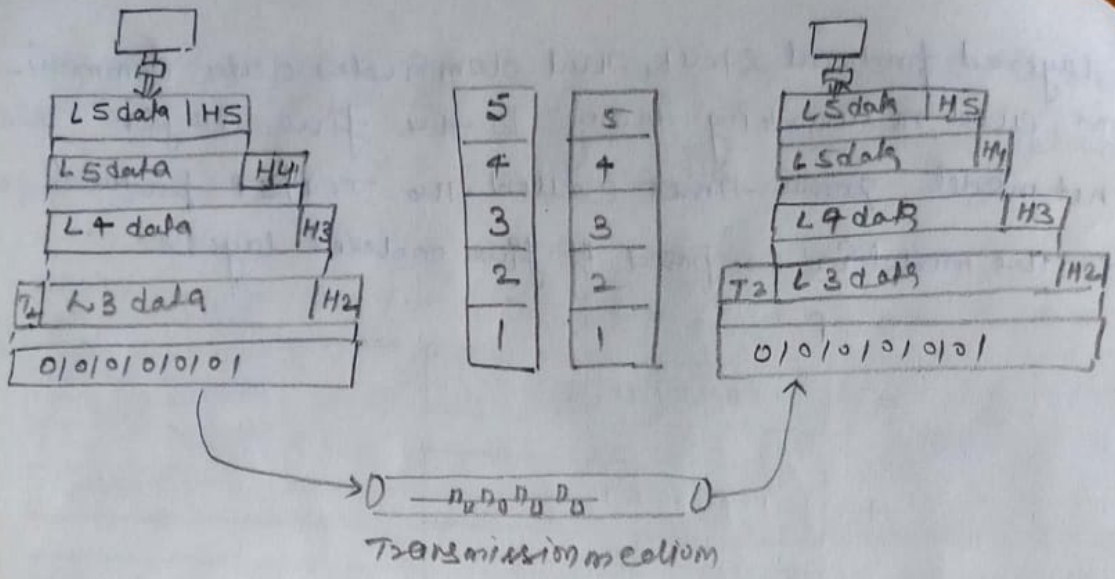


fig An exchange using the Internet model or TCP/IP

① functions of Physical layer:

(i) Physical characteristics of Interface and media (ii) Representation of bits (iii) Data rate (iv) Synchronization of bits.

② functions of Data link layer:

(i) framing (ii) Physical addressing (iii) Flow control (iv) Error control (v) Access control

③ functions of Network layer:

(i) Logical addressing (ii) Routing

④ Transport layer:

(i) Port addressing (ii) Segmentation and reassembly (iii) Flow control (iv) Connection control (v) error control.

⑤ functions of Application layer:

(i) Mail services (ii) file transfer & Access

(iii) Remote log in (iv) Accessing the world wide web.

Integrated Services digital Networks:

[ISDN was developed in 1976. It is a set of protocals that combines digital telephony and data transport services. The whole idea is to digitize the telephone network to permit the transmission of audio, video, and text over existing telephone lines.]

(ISDN is a state of the art public switched digital (PSDN) Network for provisioning of different services - voice, data and image transmission over the telephone line through the telephone network.)

The Goal of ISDN is to form a wide area network that provides universal end-to-end connectivity over digital media. This can be done by integrating all of the separate transmission services into one without adding new links or subscriber lines.

(Services: The purpose of the ISDN is to provide fully integrated digital services to users. These services are as follows:

(i) Bearer Services

(ii) Teleservices

(iii) Supplementary services)

(1) Bearer Services: (Bearer services) provide the ~~means~~ to transfer information (voice, data and video between users without the network manipulating the content of that information. The network does not need to process the information and ~~therefore~~ therefore does not change the content. (Bearer services belong to the first three layers of the OSI model.)
Example of Bearer Services: Circuit switching, Packet switching & Frame switching, Cell switching.

(2) Teleservices: (In teleservicing, the network may change or process the contents of the data. These services correspond to layers 4-7 of the OSI model.) Teleservices rely on the facilities of the bearer services and are designed to accommodate complex user needs without the user having to be aware of the details of the process.
(Example of Teleservices: Telephony, Telefax, & Tele conferencing.)

(3) Supplementary Services: (Supplementary services are those services that provide additional functionality to the bearer services and teleservices. Examples of these services are Call waiting and message handling.) ~~all fa~~

Uses of ISDN:-

(1) Voice call (2) Fax transmission (3) Linking to the internet
(4) Data transmission & voice at same time
(5) video conferencing
(6) Play online games to relax.
(7) Connecting to the office n/w from home (small n/w)

Integrated digital Network (IDN): Customers began to require access to a variety of networks, such as packet switch networks and circuit switched networks. To meet these needs, the telephone companies created Integrated digital Networks (IDN). An IDN is a combination of Networks available for different purpose. Access to these networks is by digital pipes, which are time-multiplexed channels sharing very-high speed paths.

Customers can use their local loops to transmit both voice and data to their telephone company's central office. The office then directs these calls to the appropriate digital networks via the digital pipes.

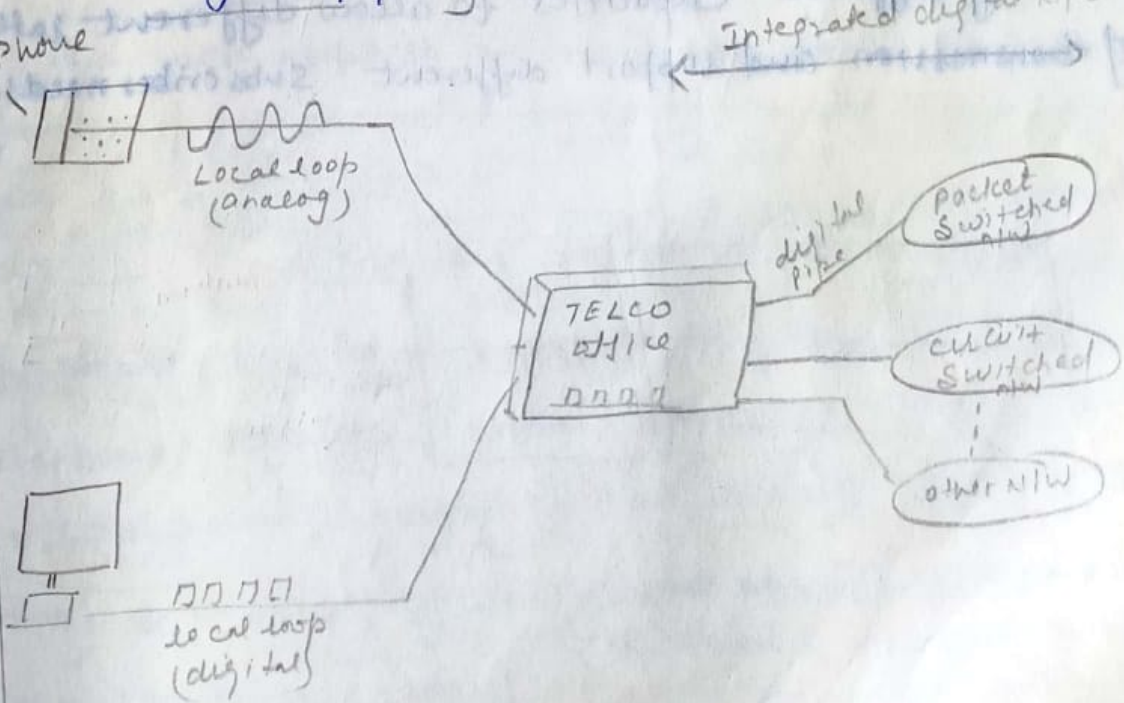


fig IDN

The ISDN integrates customers services with the ISDN. Fully digital services are much more efficient and flexible than analog services. To receive the maximum benefit from the integrated digital network, the next step is to replace the analog local loops with digital subscriber loops. voice transmissions can be digitized at the source, thereby removing the final need for analog carriers.

It then becomes possible to send data, voice & image and so on over any digital network. with ISDN all customer services will become digital rather than alalog. ISDN will allow all communication connections in a home or building to occur via a single interface.

A conceptual view of the connections between users and an ISDN central office. Each user is linked to the central office through a digital pipe. These pipe can be of different capacities to allow different rates of transmission and support different subscriber needs.

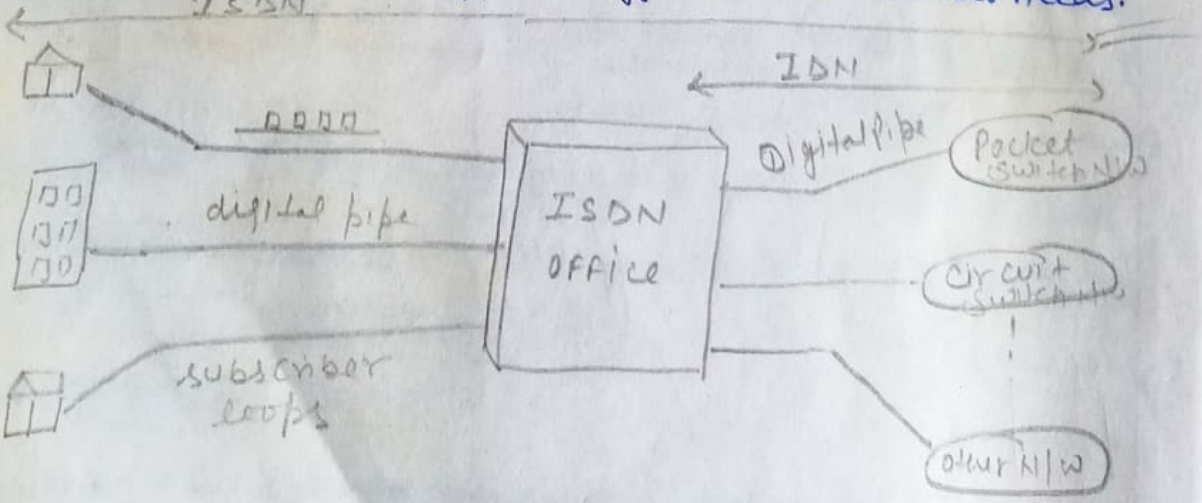


fig ISDN

Subscriber Access to the ISDN:- To allow flexibility, digital pipes between customers and the ISDN office are organized into multiple channels of different sizes. The ISDN standard defines three channel types, each with a different transmission rate:)

(i) B channels:- (A bearer channel (B-channel) is define at a rate 64 kbps. It is the basic user channel and can carry any type of digital information in full duplex mode as long as the required transmission rate does not exceed 64 kbps.) forexample:, a B channel can be used to carry digital data, and digitized voice.

(ii) D channels:- (A data channel (D channel) can be either 16 or 64 kbps, depending on the needs of the user) Although the name says data, (the primary function of a D channel is to carry control signaling for the B channels.)

Up to this point, the transmission protocols we have examined all use in channel (in-band) signaling. (Control information (such as call establishment, ringing, call interrupt or synchronization) is carried by the same channel that carries the message data.)

(iii) H channels: Hybrid channels (H channels) are available with data rates of 384 Kbps, 1536 Kbps or 1920 Kbps. These rates suit H channels for high data-rate applications, ~~such as~~ for example video, teleconferencing etc.)

Benefits of ISDN ✓

(i) Single connection can support both voice and data.
(ii) Eight terminals can be connected on a single line.
(iii) Two call can be established simultaniously on a single pair of wires.
(iv) The call set time is very short (1-2 seconds).

How is ISDN ~~the~~ superior to the phone line:

(i) The signal on the ISDN line. voice or data, is sent in digital mode.
(ii) The ISDN subscriber can establish two simultaneous independent calls which could be voice, data, image as combination of any two whereas only one call is possible on ordinary telephone lines.)
(iii) The call set-up time between two ISDN subscribers is extremely short.

Access to Internet:- ISDN subscribers can have access to internet with a higher bandwidth of 64/128 kbps.

Switching :- A switched network consists of a series of interlinked nodes, called switches. Switches are Hardware and/or software devices capable of creating temporary connections between two or more devices linked to the switch but not to each other. In a switched network, some of these nodes are connected to the communication devices. others are used only for routing.

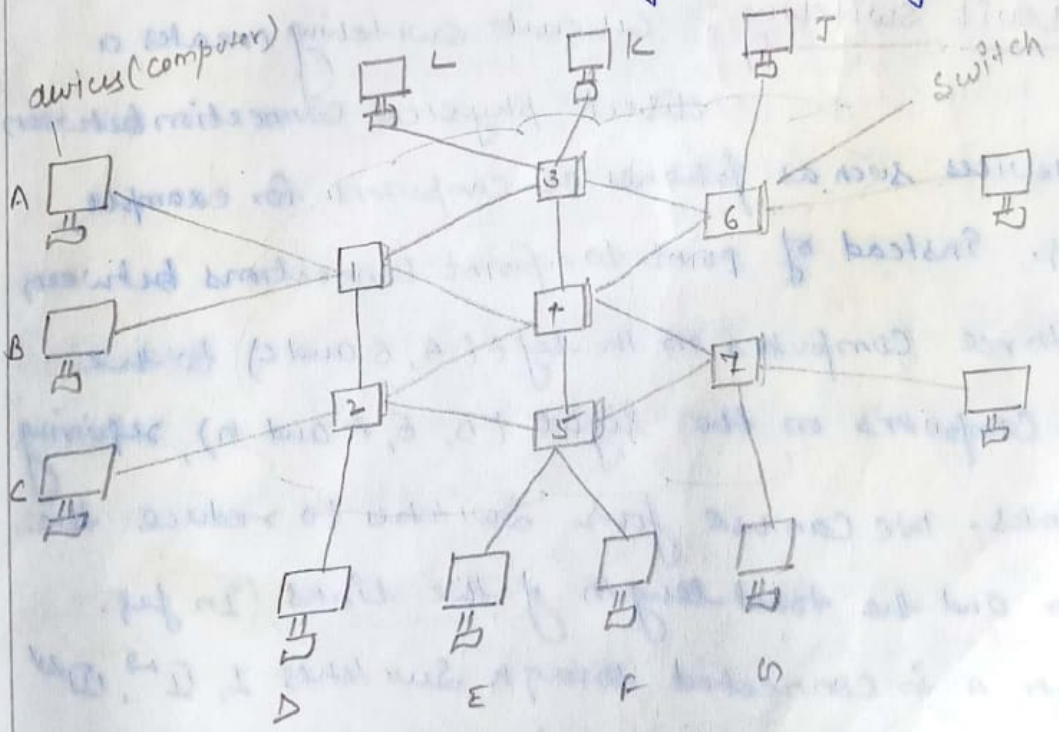


fig Switched N/W

Switching methods :- Traditionally, three methods of switching have been important: circuit switching, packet switching and message switching. The first two are commonly used today. The third has been phased out in general communications but still has network applications.

large figure ?

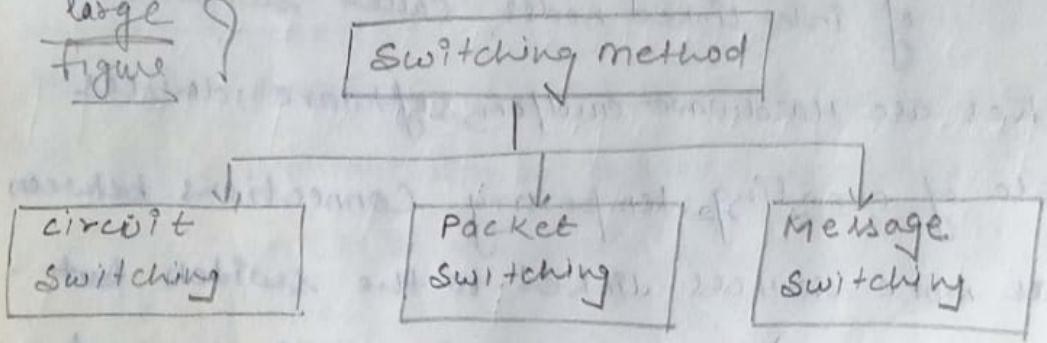


fig: Switching methods

① circuit switching :- Circuit switching creates a direct physical connection between two devices such as phones or computers. for example, in fig., instead of point-to-point connections between the three computers on the left (A, B and C) to the four computers on the right (D, E, F and G), requiring 12 links. We can use four switches to reduce the number and the total length of the links. In fig. Computer A is connected through switches I, II, III & IV to computer D.

An ex- of circuit switching is the telephone n/w (Public Switched Telep. N/W)(PSTN).

A circuit switch is a device with n inputs and m outputs that creates a temporary connection between an input link and an output link. (circuit switching today can use either of two technology)

(i) space-division switches
(ii) Time-division switches.)

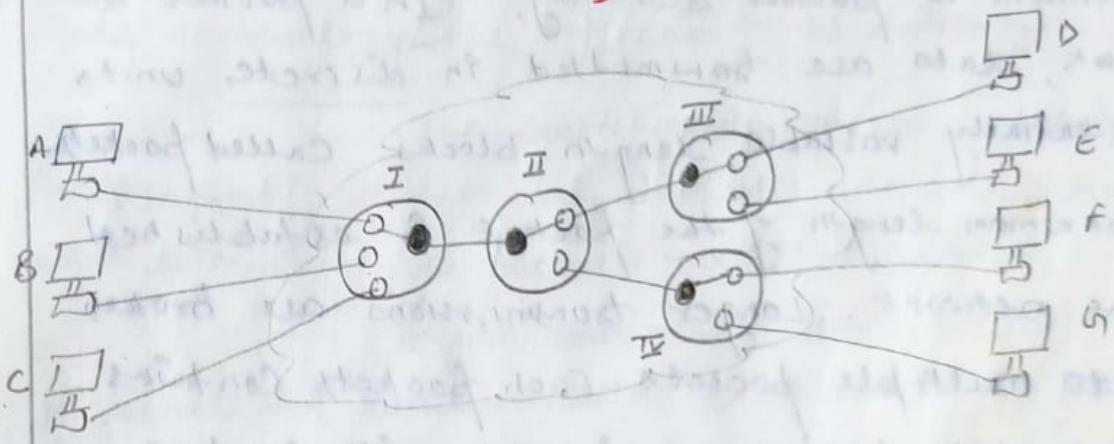


fig: circuit switched network

(i) Space-division switches: In space-division switching, the path in the circuit are separated from each other spatially. This technology was originally designed for use in analog networks but it is used currently in both analog and digital networks.

(ii) Time-division switches: T.D.S. uses time-division multiplexing to achieve switching. There are two popular methods used in time-division multiplexing: the time slot interchange and the TDM BUS.

Packet Switching :- Circuit switching was designed for voice communication. The disadvantage of circuit switching is that, since the connection is (established) dedicated, it cannot be used to transmit any other data even if the channel is free.

A better solution for data transmission is packet switching. In a packet-switched network, data are transmitted in discrete units of potentially variable length blocks called packets. The maximum length of the packet is established by the network. Longer transmissions are broken up into multiple packets. Each packet contains not only data but also a header with control information (such as priority codes and source & destination addresses). The packets are sent over the network node to node. At each node, the packet is stored briefly then routed according to the information in its header.

There are two popular approaches to packet switching

i) Datagram

ii) virtual circuit

(a) SVC (Switched virtual circuit)

(b) PVC (Permanent virtual circuit)

(1) Datagram Approach :- (In the datagram approach to packet switching, each packet is treated independently from all others.) Even when one packet represent just a piece of a multipacket transmission, the network (& N/w layer functions) treats it as though it existed ~~along~~ alone. Packet in this technology are reffered to as datagrams.

The switching devices route each packet independently through the network, with each intermediate node determining the packet's next route segment.

(Before transmissim starts, the sequence of packets and their destinations are established by the exchange of control information between the sending terminal, the Network and the receiving terminal.)

(Fig show how the datagram approach can be used to deliver four packets from station A to station X. In this example, all four packets (or datagrams) belong to the same message but may go by different ~~paths~~ paths to reach their destination.

This approach can cause the datagrams of a transmission to arrive at their destination out of order. It is the responsibility of the transport layer in most protocals to reOrder the datagrams before passing them on to the destination port.)

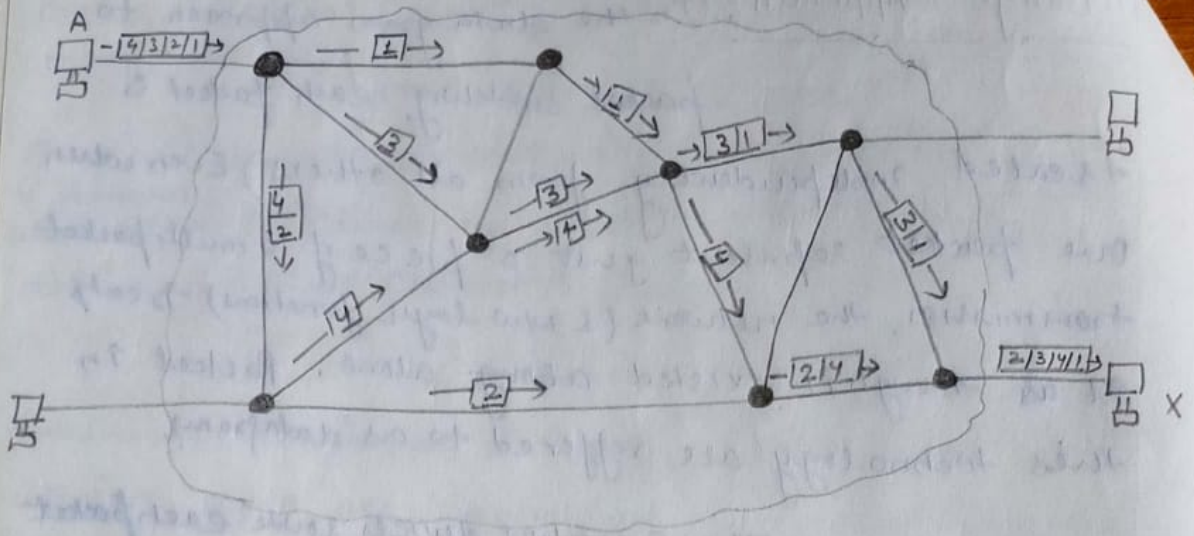


fig Datagram approach

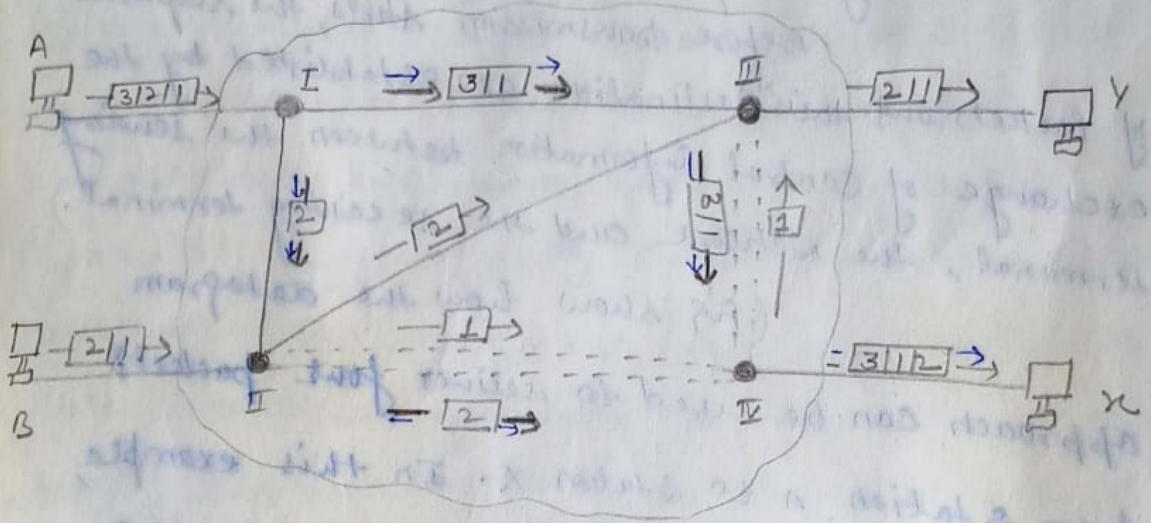


fig: Multiple channels in datagram approach

Channel 1 = Computer A to Computer x

" 2 = Computer B to Computer y

(ii) virtual circuit approach: In the virtual circuit approach to packet switching, the relationship between all packets belonging to a message or session is preserved. A single route is chosen between sender and receiver at the beginning of the session. When the data are sent, all packets of the transmission travel one after another along that route.

= [= It establishes a logical connection between the sending and receiving devices called virtual circuit.]

(virtual circuit transmission is implemented in two formats:

(a) Switched virtual circuit (SVC).
(b) Permanent virtual circuit (PVC).)

(a) Switched virtual circuit: The switched virtual circuit (SVC) format is comparable conceptually to dial-up lines in circuit switching. In this method, (A virtual circuit is created whenever it is needed and exists only for the duration of the specific exchange).

(For example, Station A wants to send for ~~four~~ packets to station X. first, A

(station) requests the establishment of a Connection to x. Once the Connection is in place (establishment), the packets are sent one after another and in sequential order. When the ~~last~~ all (last) packet has been received and, if necessary, acknowledgement is received, the connection is released and that virtual circuit ceases to exist.

Only one single route exists for the duration of transmission, although the network could pick an alternate route in response to failure or congestion. (Each time that A wishes to communicate with x, a new route is established. The route may be the same each time, or it may differ in response to varying network conditions.)

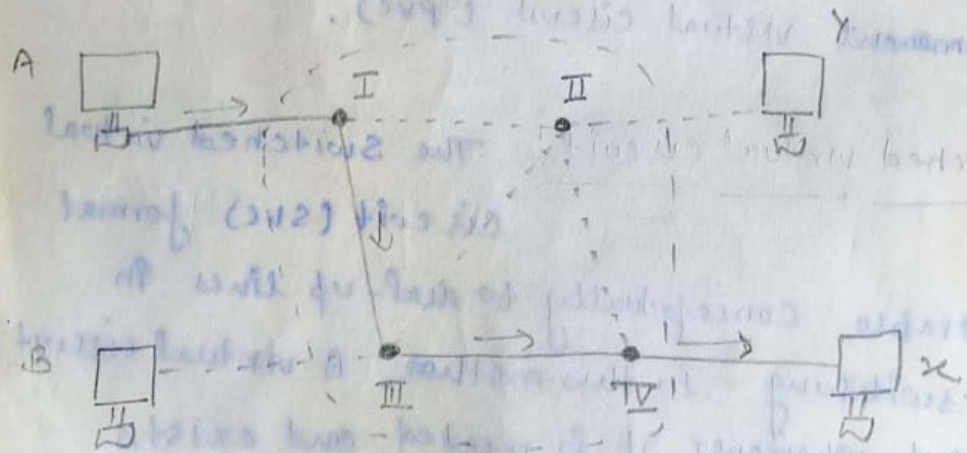
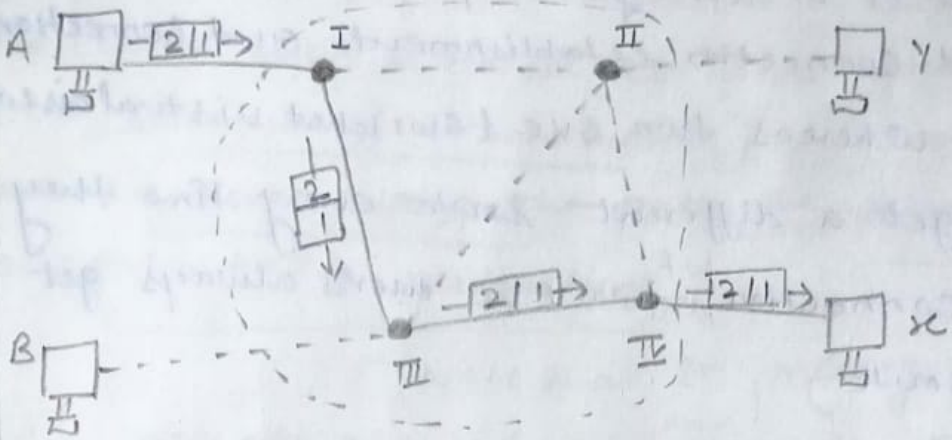
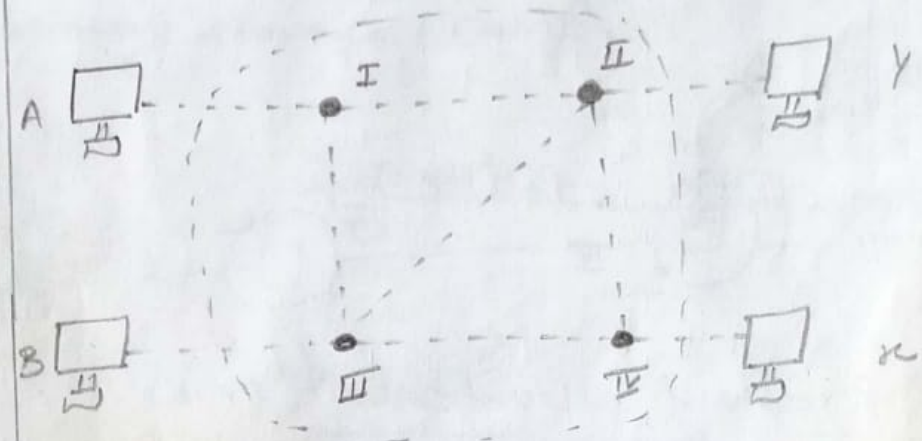


fig: Connection establishment



(b) data transfer



(c) Connection Release

fig: Switched virtual circuit

(b) Permanent virtual circuits (PVC): PVC are comparable to leased lines in circuit switching. [In this method, the same virtual circuit is provided between two users on a continuous basis. The circuit is dedicated to the specific users. No one else can use it

and because it is always in place, it can be used without connection establishment and connection termination. whereas two SVC (switched virtual circuit) users may get a different route every time they request a connection, but two PVC users always get the same route.)

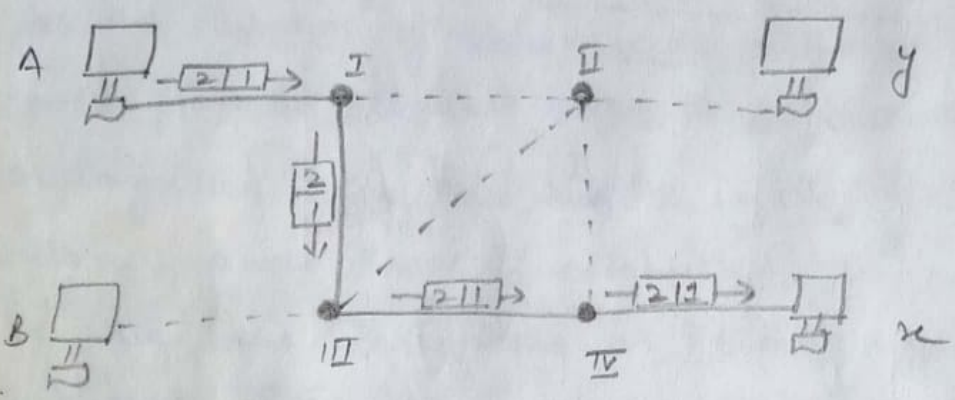


fig: Permanent virtual circuit (PVC)
(Permanent connection for the duration of the lease)

(2) Message Switching: (Message switching is best known by the descriptive term store and forward. In this mechanism, a node (computer) receives a message, store it until the appropriate route is free, then sends it along.)

(Store and forward is considered a switching technique because their is no direct link between the sender and receiver of a transmission.) A message is delivered to the node along one path then routed along another to its destination.

(Note that in message switching, the message are stored and any relayed from secondary storage (disk), while in packet switching the packet are stored and forwarded from primary storage (RAM).)

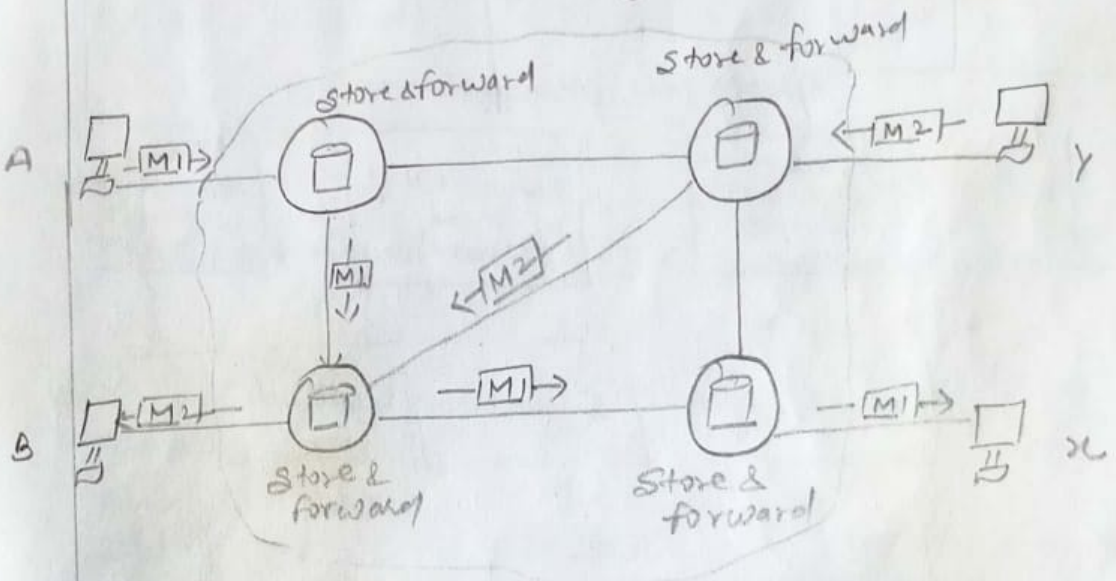
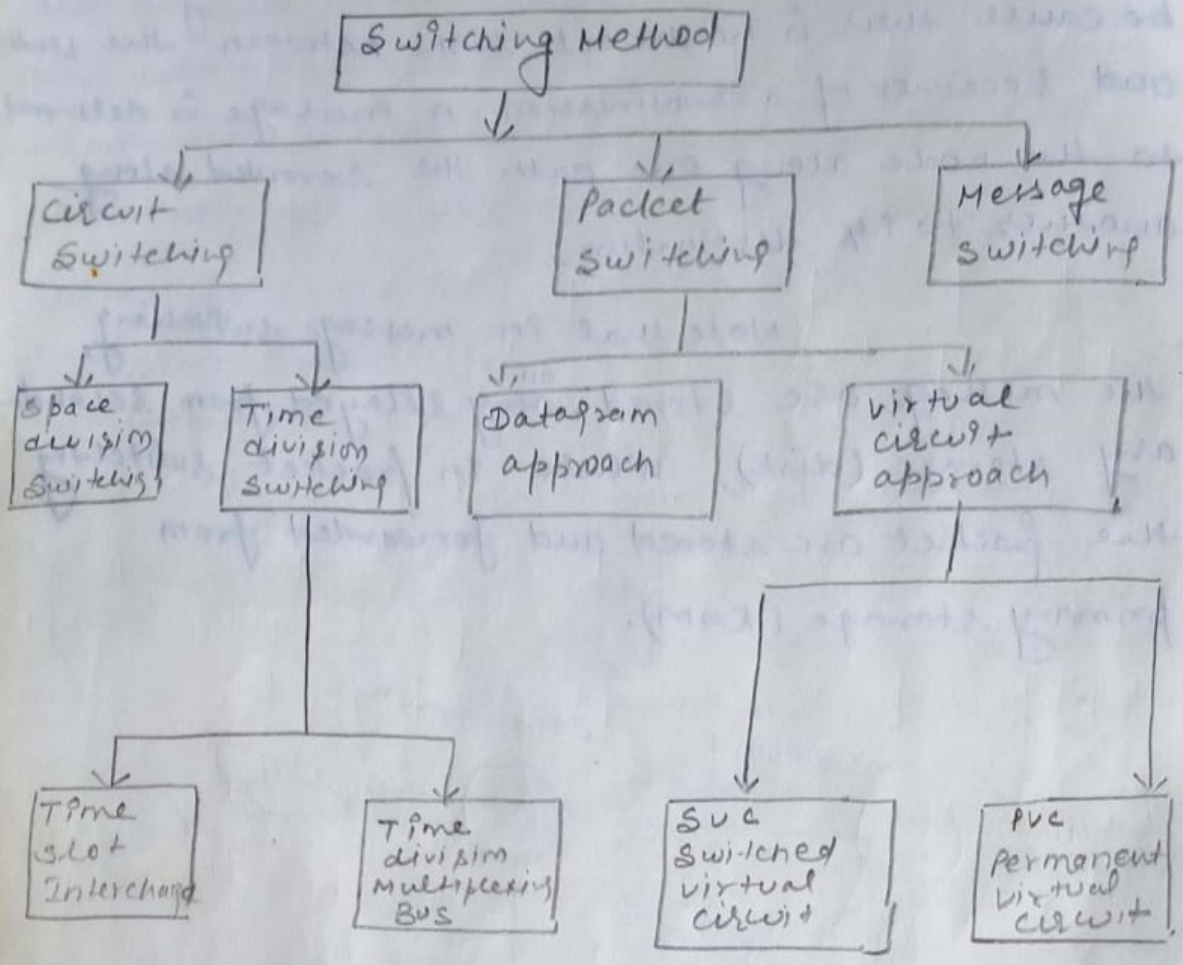


fig: Message switching



Classification of Switching Method

Scanned by CamScanner

Transmission media: Media are what the message is transmitted over. In other words a communication channel is also called as a medium. Different media have different properties and used in different environments for different purposes. The purpose of the physical layer is to transport a raw bit stream from one computer to another.

Classification of Transmission Media: We can classify transmission media into two categories.

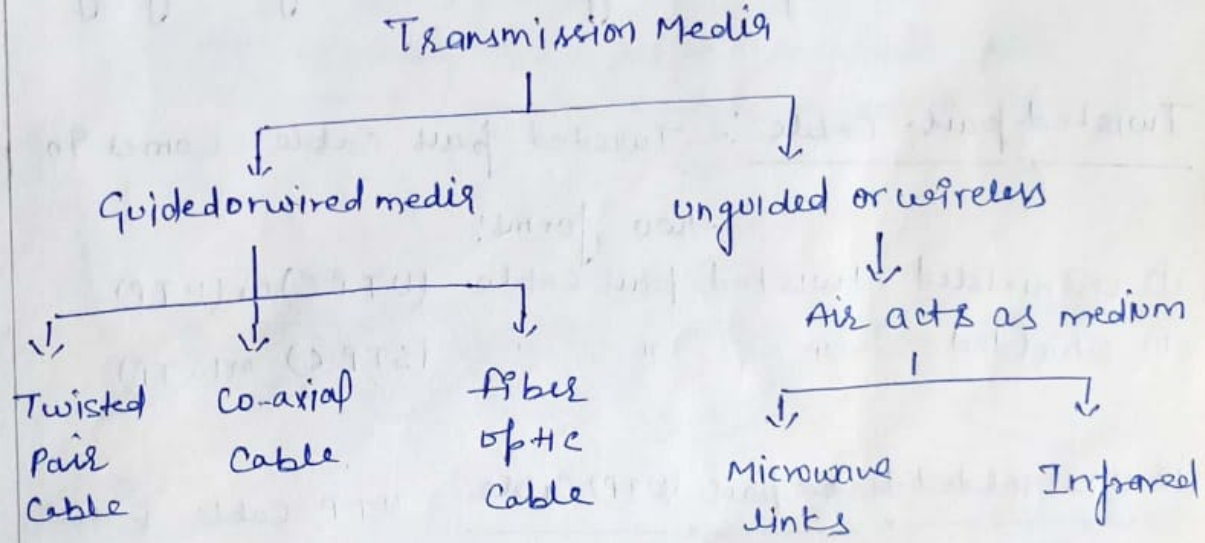


fig: classification of transmission media

(1) **Guided media**: Guided media is a communication medium which allows the data to get guided along it. For this the media need to have a point to point physical connection.

Guided media, which are those that provide a conduit (a channel, a pipe, electric wires covering pipe) from one device to another, include twisted pair cable, coaxial cable and fiber-optic cable.

A signal traveling along any of these media is directed and contained by the physical limits of the medium. Twisted pair and coaxial cable use metallic (copper) conductors that accept and transport signals in the form of electrical current. Optical fiber is a glass or plastic cable that accepts and transports signals in the form of light.

Twisted-pair cable :- Twisted pair cable comes in two forms:

(i) unshielded twisted pair cable (UTPC) or (UTP)
(ii) shielded " " " (STPC) or (STP)

(i) unshielded twisted pair (UTP) cable: UTP cable is the most common type of telecommunication medium in use today. Although most familiar from its use in telephone system, its frequency range is suitable for transmitting both data and voice. A twisted pair consists of two conductors (usually copper), each with its own colored plastic insulation. The plastic insulation is color-banded

for identification. Colors are used both to identify the specific conductors in a cable and to indicate which wires belong in pairs and how they relate to other pairs in a larger bundle.

" A twisted pair consists of two conductors each surrounded by an insulating meterial".

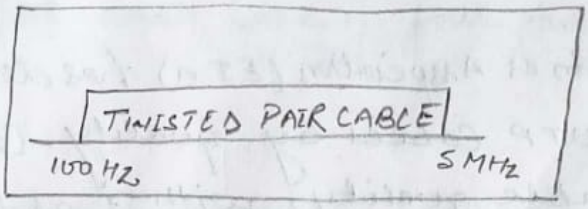


fig: Frequency Range for twisted pair cable

fig: Twisted-pair Cable

Advantages of UTP are its cost and ease of use. UTP is cheap, flexible, and easy to install. Higher grades of UTP are used in many LAN technologies including Ethernet and Token Ring.

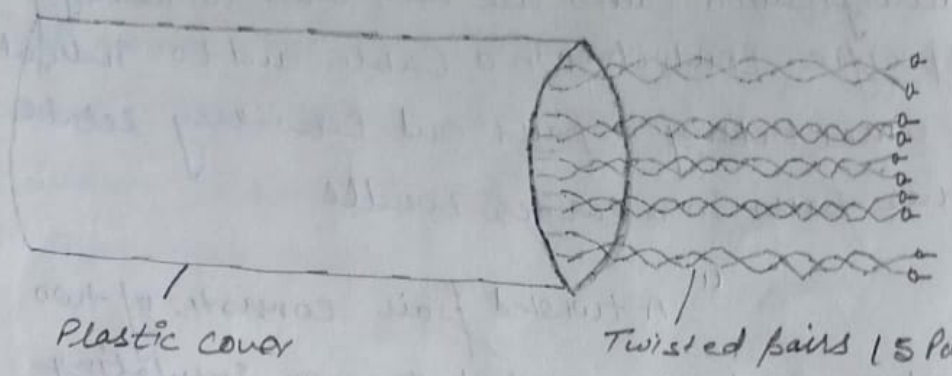


Fig Cable with five unshielded twisted pairs of wires

The Electronic Industries Association (EIA) has developed standards to grade UTP cables by quality. Categories are determined by cable quality, with 1 as the lowest and 5 as the highest.

* Category 1: The basic twisted-pair cabling used in telephone systems. This level of quality is fine for voice but inadequate for all but low-speed data communication.

* Category 2: The next higher grade, suitable for voice and for data transmission of up to 4 Mbps.

* Category 3: Required to have at least three twists per foot and can be used for data transmission of up to 10 Mbps. It is now the standard cable for most telephone systems.

* Category 4: Must also have at least three twists per foot as well as other conditions to bring the possible transmission rate to 16 Mbps.

* Category 5: used for data transmission up to 100 Mbps.

"The most frequently used of these plugs is an RJ45 connector with eight conductors, one for each wire of four twisted pairs".

(ii) shielded twisted pair (STP) cable: STP cable has a metal foil or braided-mesh covering that encases each pair of insulated conductors. The metal casing prevents the penetration of electromagnetic noise.

It also can eliminate a phenomenon called crosstalk, which is the undesired effect of one circuit (or channel) on another circuit (or channel). It occurs when one line (acting as a kind of receiving antenna) picks up some of the signals traveling down another line (acting as a kind of sending antenna). This effect can be experienced during telephone conversations when one can hear other conversations in the background. shielding each pair of a twisted-pair cable can eliminate

most crosstalk.

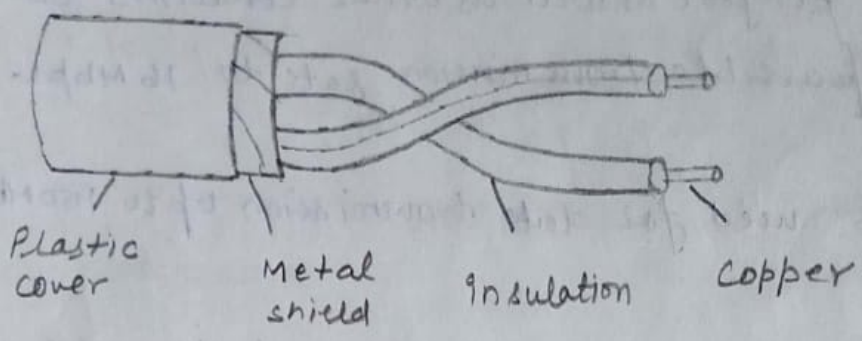


Fig: Shielded twisted pair cable

STP has the same quality considerations and uses the same connectors as UTP; but the shield must be connected to a ground. Materials and manufacturing requirements make STP more expensive than UTP but less susceptible to noise.

② Coaxial Cable: Coaxial Cable (or coax) carries signals of higher frequency ranges than twisted-pair cable, in part because the two media are constructed quite differently. Instead of having two wires, Coax has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid or a combination of the two (also usually copper).

The outer metallic wrapping serves both as a shield against noise and as the second conductor, which completes the circuit. This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.

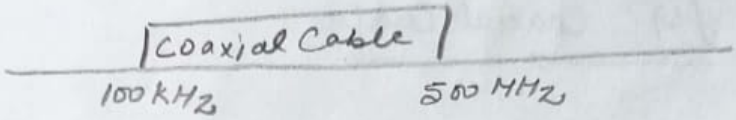


fig: Frequency range of coaxial cable

Coaxial Cable Standards: Different coaxial cable designs are categorized by their radio government (RG) ratings.

Each cable defined by RG ratings is adapted for a specialized function. The following are a few of the common ones:

* RG-8, used in thick Ethernet
* RG-9, used " " "
* RG-11, " " " "
* RG-58, " " thin "
* RG-59, used for T.V.

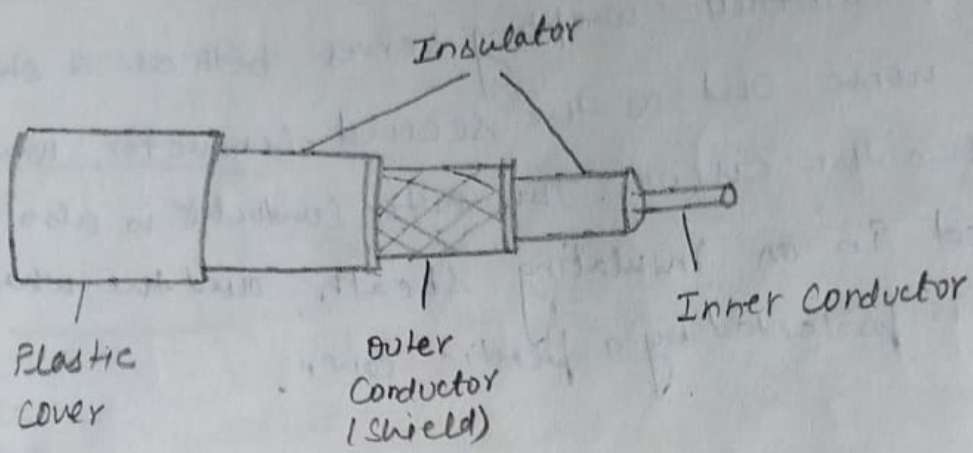


fig: Coaxial Cable

Coaxial Cable connectors: The most common type of Connector used for coaxial cables is the Bayone-Neill-Concelman or BNC connectors or (bayonet network connector. The various types of BNC Connectors

(i) BNC Connector
(ii) BNC-T Connector
(iii) BNC terminator

The BNC connector is used to connect the end to end of the cable to a device such as a T.V. set.

The BNC-T connector is used in Ethernet networks for branching out a cable for connection to a computer or other devices.

The BNC Terminator is used at the end of the Cable to prevent the reflection of the signal.