Topic 1 Notes

1.1 Definitions

Network - A group of computers connected together in a way that allows information to be exchanged between the computers.

Node - Anything that is connected to the network. While a node is typically a computer, it can also be devices such as:

- Mainframes, minicomputers, supercomputers
- Workstations
- Printers, disk servers, robots
- X-terminals
- Gateways, switches, routers, bridges
- Cellular phone, Pager.
- Refrigerator, Television, Video Tape Recorder

Segment - Any portion of a network that is separated, by a switch, bridge or router, from other parts of the network.

Backbone - The main cabling of a network that all of the segments connect to. Typically, the backbone is capable of carrying more information than the individual segments. For example, each segment may have a transfer rate of 10 Mbps (megabits per second: 1 million bits a second), while the backbone may operate at 100 Mbps.

Topology - The way that each node is physically connected to the network.

1.2 Network Types (classification based on Network size)

LAN - Local Area Network - A LAN connects network devices over a relatively short distance. A networked office building, school, or home usually contains a single LAN, though sometimes one building will contain a few small LANs (perhaps one per room), and occasionally a LAN will span a group of nearby buildings.

Metropolitan Area Network - a network spanning a physical area larger than a LAN but smaller than a WAN, such as a city. A MAN is typically owned an operated by a single entity such as a government body or large corporation.

WAN - Wide Area Network - As the term implies, a WAN spans a large physical distance. The Internet is the largest WAN, spanning the Earth. A WAN is a geographically-dispersed collection of LANs. A network device called a router connects LANs to a WAN.

1.3 Basic Components of Network

The most common components of a network are:

Terminal

Over the years, the data terminal market has increased substantially and there are now literally hundreds of manufactures and many different kinds if terminal. However, the fact is that all of these terminals have been designed primarily to input and display information in some form or another. Therefore, even though specific characteristics such as screen size and keyboard layout may differ, they can generally be categorized into three simple groups.

i. **Dumb Terminals**

   Dumb terminals are those which have limited functions and are driven with information from a host computer. Normally, they consist of a Cathode Ray Tube (CRT) display screen with a full alphanumeric keyboard and can be connected directly to a computer system (host computer) through some sort of communications interface. In most cases, data is transmitted directly through the communication interface as it is typed on the keyboard.

ii. Intelligent Terminals

The category of intelligent or programmable terminals is probably the largest and widest ranging group. Unlike dumb terminals, intelligent terminals are equipped with a processor that can support an instruction set to direct the basic functions of the terminal. Like any other type of computer that has a processor, these terminals normally have additional memory and storage devices such as disc drives.

Intelligent terminal are, therefore, capable of stand-alone processing and can support a variety of software applications which, in turn, enable them to support a variety of communications interfaces through the use of emulation program. This is also means that, unlike dumb terminals, intelligent terminals are able to use addresses and sophisticated access method to transmit and receive messages.

iii. Graphic Terminals

Graphic terminals are display devices that provide a means not only for displaying data in graphical form, but also for manipulating and modifying the data presented. Generally, graphic terminal keyboards have a number of specific or programmable function keys in addition to the full alphanumeric keys of a normal keyboard and the resolution of the display screen is normally a lot higher to enable more detailed displays

Workstation

A workstation is a client. More specifically, it is a standalone computer equipped with it‘s own processor, system and application software. It can perform its functions independent of the network. To expand its resources and knowledge, it may get connected to a network.

Server

Network plays one of two basic roles at any given moment, the computer is either acting s a client or as a server. A server is a computer that shares its resources across the network, and a client are one that accesses shared resources. Depending on the size and requirements of the network, servers can be classified as below:

i. **File Server**

A file server allows user to share files. It several LAN users need access to an application such as word processing, only one copy of the application software needs to reside on a file server. This copy can be shared among all the users. When a user requests to start an application, that application is downloaded into the user’s workstation.

Consider the saving in disk space in a company having 100 users for application package that requires 10 MB of disk storage. Storage on the file server requires only 10 MB of disk space for all users. Storing the same application on 100 users local disk drives will require 1,000 MB of disk space.

This is only an example of one application. Same logic can be applied when hundreds of different application programs needed.

ii. **Database Server**

The database server was developed to solve the problem of passing an entire file over the medium. The most common example of a database server is the SQL server. Structured Query Language (SQL) is standard database definition, access, and update language for relational database. An SQL server accepts a database request, accesses all necessary records locally, and then sends only the result back to the requester (not the whole database).

iii. **Print Server**

Print server allows anyone on the network to have access to a printing service.

iv. **Disk Server**

It is server with large storage. A portion of storage is given to each user to store their files/data. It is very useful in university where each student is given a user account with password and some storage space in disk server. Once the student completes the education the same space can be assigned to new student.

v. **Dedicated Vs Non-Dedicated Server**

Many networks will let their user run standard programs while their computer is simultaneously functioning as a server to others. A computer that both runs standard programs and lets other user see its data at the same time is said to be ―non-dedicated server‖. Nondedicated servers can be clever way of setting up a small LAN without having to buy any extra system. Dedicated server are specially assigned for network management and provided no general-purpose services.

Network Interface Card

Attaching a computer to a network requires a physical interface between computer and the networking medium. For PCs, this interface resides in a special network interface card (NIC), also known as network adapter or a network card that plugs into an adapter slot inside the computer‘s case. Laptops and other computers may include built-in interface or use special modular interface such as PC card interface, to accommodate a network adapter of some kind.

For any computer, a NIC performs following crucial tasks:

- It establishes and manages the computer‘s network connection.
- It translates digital data(of source computer) into signals (appropriate for the networking medium) for outgoing messages, and translates from signals into digital computer data for incoming messages.
- Converts serial incoming data via cable into parallel data to for CPU, and vice versa.
- It has some memory, which acts as a holding tank or buffer. It buffers the data to control the data flow.

Table 1.1: Other Network Devices

Network Component	**Functions**	**OSI Model**
Modem	Puts a message (baseband signal) on a carrier for efficient transmission; takes the baseband signal from the carrier.	Physical (Layer 1)
Repeater	Receives signal, amplifies it, and then	Physical (Layer 1)
(Regenerator)	retransmits it.	

Bridge	Connects networks with different Layer 2 protocols; divides a network into several segments to filter traffic.	Data Link (Layer 2)
Hub	Connects computers in a network; receives a packet from a sending computer and transmits it to all other computers.	Physical (Layer 1)
Switch	Connects computers in a network; receives a packet from a sending computer and transmits it only to its destination.	Data Link (Layer 2)
Access Point	Connects computers in a wireless network; connects the wireless network to wired networks; connects it to the Internet.	Data Link (Layer 2)
Router	Forwards a packet to its destination by examining the packet destination network address.	Network (Layer 3)
Residential Gateway	Connects a home network to the Internet; hides all computers in the home network from the Internet.	Network (Layer 3)
Gateway	Connects two totally different networks; translates one signaling/protocol into another.	All layers

1.4 Network Topologies

A network topology can be physical or logical.

Physical Topology is the actual layout of a network and its connections. Logical Topology is the way in which data accesses the medium and transmits packets. There are several network topologies:

Physical Bus Topology

Each node is daisy-chained (connected one right after the other) along the same backbone. Information sent from a node travels along the backbone until it reaches its destination node. Each end of a bus network must be terminated with a resistor to keep the packets from getting lost.

Physical Ring Topology
Similar to a bus network, rings have nodes daisy chained, but the end of the network in a ring topology comes back around to the first node, creating a complete circuit. Each node takes a turn sending and receiving information through the use of a token. The token along with any data is sent from the first node to the second node which extracts the data addressed to it and adds any data it wishes to send. Then second node passes the token and data to the third node, etc. until it comes back around to the first node again. Only the node with the token is allowed to send data. All other nodes must wait for the token to come to them.

Physical Star Topology
In a star network, each node is connected to a central device called a hub. The hub takes a signal that comes from any node and passes it along to all the other nodes in the network. A hub does not perform any type of filtering or routing of the data. A hub is a junction that joins all the different nodes together.

Logical Topologies
There are three logical topologies (bus, ring, and switching) which are usually implemented as a physical star.

Logical Bus Topology
Modern Ethernet networks are Star Topologies (physically) but logically they are bus topologies. The Hub is at the centre, and defines a Star Topology. In any network, computers communicate by sending information across the media as a series of signals. In a logical bus topology, the signals travel along the length of the cable in all directions until they weaken enough so as not to be detectable or until they encounter a device that absorbs them. This traveling across the medium is called **signal propagation**

When a computer has data to send, it addresses that data, breaks it into manageable chunks, and sends it across the network as electronic signals

- All computers on a logical bus receive them
- Only the destination computer accepts the data
- All users must share the available amount of transmission time, implying network performance is reduced
- Collisions are bound to occur since all nodes are sharing same bus.

Logical Ring Topology
Data in a logical ring topology travels from one computer to the next computer until the data reaches its destination. Token passing is one method for sending data around a ring Token is a small packet which passes around the ring to each computer in turn.

If a computer (sender) has packets to send, it modifies the token, adds address and data, and sends it around the ring. The receiver returns an acknowledgement packet to the sender. Upon receiving the acknowledgement packet, the sender releases the tokens and sends it around the ring for another sender to use.

Logical ring can be implemented on a physical star. Modern logical ring topologies use “smart hubs” that recognize a computer‘s failure and remove the computer from the ring automatically. One advantage of the ring topology lies in its capability to share network resources fairly.

1.5 Network Operating Systems
Any modern Operating System contains built-in software designed to simplify networking of a computer. Typical O/S software includes an implementation of TCP/IP protocol stack and related

utility programs like ping and traceroute (is a computer network diagnostic tool for displaying the route (path) and measuring transit delays of packets across an Internet Protocol (IP) network.). This includes the necessary device drivers and other software to automatically enable a device's Ethernet interface. Mobile devices also normally provide the programs needed to enable Wi-Fi, Bluetooth, or other wireless connectivity.

The early versions of Microsoft Windows did not provide any computer networking support. Microsoft added basic networking capability into its operating system starting with Windows 95 and Windows for Workgroups. Microsoft also introduced its Internet Connection Sharing (ICS) feature in Windows 98 Second Edition (Win98 SE). Contrast that with Unix, which was designed from the beginning with networking capability. Nearly any consumer O/S today qualifies as a network operating system due to the popularity of the Internet.

Network operating systems (NOSs) distribute their functions over a number of networked computers they add functions that allow access to shared resources by a number of users concurrently. Client systems contain specialized software that allows them to request shared resources that are controlled by server systems responding to a client request. The NOS enhances the reach of the client PC by making remote services available as extensions of the local native operating system. NOSs also support multiple user accounts at the same time and enables concurrent access to shared resources by multiple clients. A NOS server is a multitasking system.

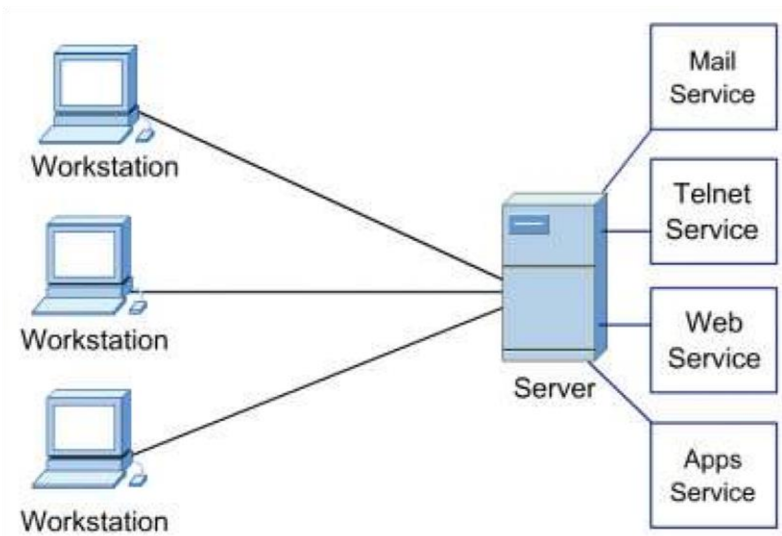

Fig 1.1: Several clients in a network

1.5.1 Choosing a NOS

The main features to consider when selecting a NOS include:

i. Performance
ii. Management and monitoring tools
iii. Security
iv. Scalability
v. Robustness/fault tolerance

1.5.2 Types of NOS

There are two popular competing NOS families. Windows based and Unix based. The former is proprietary whereas the latter is open source.

Windows NOS

Windows server-based networks that run Windows NT Server or Windows 2000 Server are based on the concept of the domain. A domain is a group of computers and users that serves a boundary of administrative authority. Windows NT domains and Windows 2000 domains, although similar in function, interact with one another differently. In Windows NT 4.0, the Domain Structure of Windows NT was entirely different from the Domain Structure in Windows 2000.

Instead of Active Directory, Windows NT provides an administrative tool called the User Manager for Domains. It is accessed from the domain controller and is used to create, manage, and remove domain user accounts. Each NT domain requires one Primary Domain Controller (PDC). A domain can also have one or more Backup Domain Controllers (BDCs).

Windows 2000 and 2003 Family of Operating Systems includes:

- Windows 2000 Professional
- Windows 2000 Server
- Windows 2000 Advanced Server

Unix/Linux

Linux is an operating system similar to UNIX. It runs on many different computers and was first released in 1991. Linux is portable, which means versions can be found running on name brand or clone PCs. It offers many features adopted from other versions of UNIX. The UNIX NOS was developed in 1969, and it has evolved into many varieties.

The source code is opened, that is, available at no cost to anyone who wants to modify it. It is written in C programming language so businesses, academic institutions, and even individuals can develop their own versions. There are hundreds of different versions of UNIX. Linux is sometimes referred to as "UNIX Lite", and it is designed to run on Intel-compatible PCs. Linux brings the advantages of UNIX to home and small business computers.

The following are a few of the most popular types:

- Red Hat Linux
- Linux Mandrake
- Caldera eDesktop and eServer
- Debian GNU/Linux
- Corel Linux
- Turbo Linux
- Ubuntu

1.5.3 Other Software and Programs

A popular use of a Linux system is a web server. Web server software uses Hypertext Transfer Protocol (HTTP) to deliver files to users that request them, using a web browser from their workstation. A Mail Server is a system that is configured with the proper programs and services that enable handling the exchange of e-mail sent from one client to another.

1.6 Switching Techniques

The main objective of networking is to connect all the devices so that resources and information can be shared efficiently. Whenever we have multiple devices, we have problem of connecting them to make one-to-one connection possible. One solution is to install a point to point link between each pair of devices such as in mesh topology or between a central device and every other device as in star topology. These methods, however, are impractical and wasteful when applied to very large network. The number and length of the links require too many infrastructures to be cost efficient; and majority of those links would be idle most of the time.

A better solution is to uses switching. A switch network consists of a series of inter-linked nodes, called switches. Switched are hardware and/or software capable of creating temporary connection between two or more devices linked to switch but not to each other.

Traditionally, three methods of switching have been important:

- Circuit switching
- Packet switching and
- Message switching

1.6.1 Circuit Switching

Communication via circuit switching implies that there is a dedicated communication path between two stations. The path is a connected sequence of links between network nodes. On each physical link, a channel is dedicated to the connection. A common example of circuit switching is the telephone network..

Communication via circuit switching involves three phases:

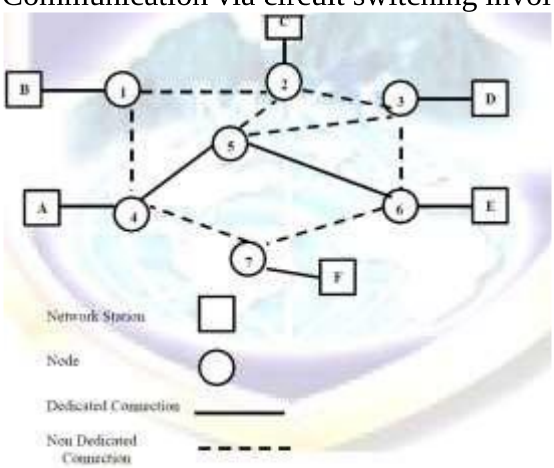

Fig 1.2: Circuit Switching Network

1. **Circuit Establishment**

Before any signals can be transmitted, an end-to-end (station to station) circuit must be established. For example, station A wants to communicate with station E. station A sends a request to node 4 requesting a connection to station E. typically, the link from A to 4 is a dedicated line, so that part of connection already exists. On the basis of routing information and measures availability and perhaps cost, lets assume that node 4,5, and 6 are used to complete the connection. In completing the connection, a test is made to determine if station E is busy or is prepared to accept the connection.

2. **Information Transfer**

Information now can transmit from A through the network to E the transmission may be analog voice, or binary data. Generally, the connection is full duplex, and signals may be transmitted in both direction simultaneously.

3. **Circuit Disconnection**

One the transmission is completed, the connection is terminated, usually by the action of one of the two station. Signals must be propagated to the nodes 4,5, and 6 to deallocate the dedicated resources.

Circuit switching can be rather inefficient. Channel capacity is dedicated for the duration of a connection, even if no data are being transferred. The connection provides for transmission at a constant data rate. Thus, each of the devices that are connected must transmit and receive at the same data rate as the other.

1.6.2 Packet Switching

In a packet switching data are transmitted in short packets. A typical packet length is 1000 byte. If a source has longer message to send, the message is broken up into a series of packets. Each packet contains a portion (or the entire short message) of the user's data plus some control information. These packets

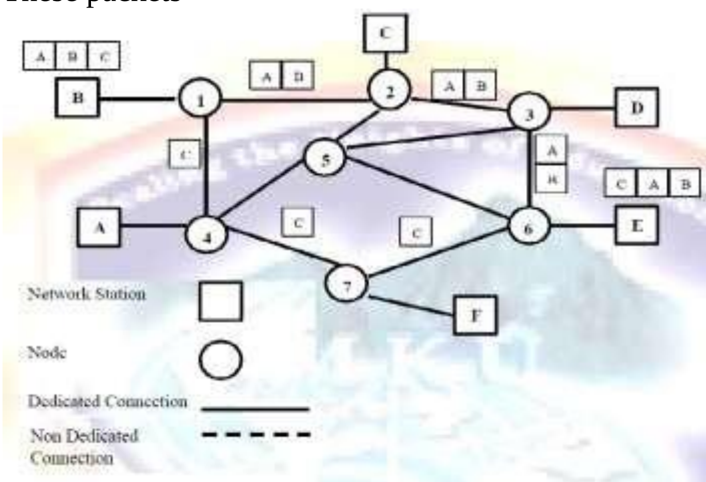

Fig 1.3: Packet Switching Networks

Above figure illustrate the basic operation. A transmitting computer or other device sends a message as a sequence of packets. Each packet includes control information including the destination station. The packets are initially sent to the node to which the sending station attaches. As each packet arrives at these nodes, the node stores the packet briefly, and determines the next available link. When the link is available, the packet is transmitted to the next node. The entire packet eventually delivered to the intended node. There are two popular approaches to packet switching: datagram and virtual circuit.

a) Datagram Approach

In the datagram approach to packet switching, each packet is treated independently from all others and each packet can be sent via any available path, with no reference to packet that have gone before. In the datagram approach packets, with the same destination address, do not all follow the same route, and they may arrive out of sequence at the exit point.

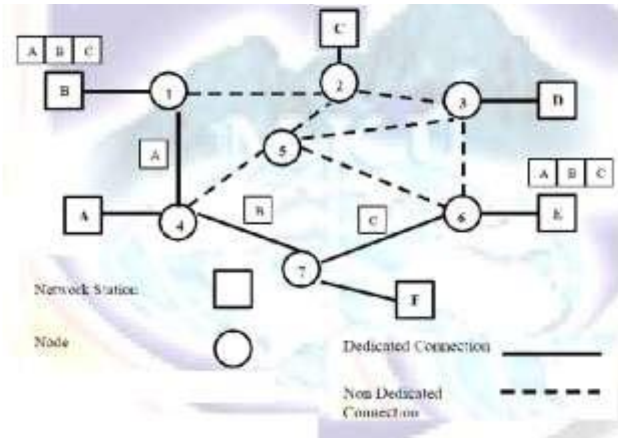

Fig 1.4: Virtual Switching Network

b) Virtual Circuit

In this approach, a preplanned route is established before any packets are sent. Once the route is established, all the packets between a pair of communicating parties follow this same route through the network. Each packet now contains a virtual circuit identifier as well as the data. Each node on the pre-established route knows where to direct such packet. No routing decisions are required. At any time, each station can have more than one virtual circuit to any other station and can have virtual circuits to more than one station.

1.6.3 Message Switching

The descriptive term store and forward best known message switching. In this mechanism, a anode (usually a special computer with number of disks) receives a message, stores it until the appropriate route is free, then send it along. Note that in message switching the messages are stored and relayed from the secondary storage (disk), while in packet switching the packets are stored and forward from primary storage (RAM).

The primary uses of message switching have been to provide high-level network service (e.g. delayed delivery, broadcast) for unintelligent devices. Since such devices have been replaced, message switching has virtually disappeared. Also delays inherent in the process, as well as the requirement for large capacity storage media at each node, make it unpopular for direct communication.

1.7 Multiplexing

Multiplexing is the process of combining separate signal channels into one composite stream. It is carried out to increase the utilization of transmission channel. In a multiplexed system, n devices share the capacity of one link. In the following figure, four devices on the left direct their transmission stream to a multiplexer (MUX) which combines them into a single stream (many to one). At the receiving end, the stream is fed into a demultiplexer (DEMX), which separates the stream back into its component transmissions (one to many) and directs them to their receiving devices.

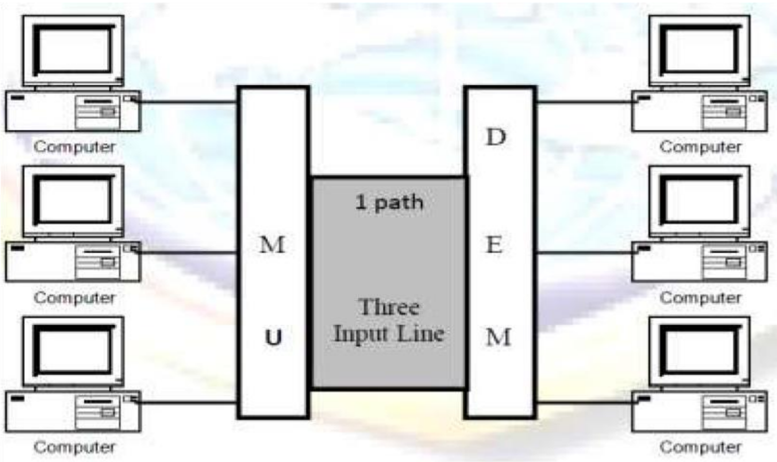

Fig 1.5: Multiplexing

1.7.1 Frequency Division Multiplexing

FDM is an analogue technique that works by dividing slicing the total bandwidth of a media into a number of narrow bandwidth units known as channels.

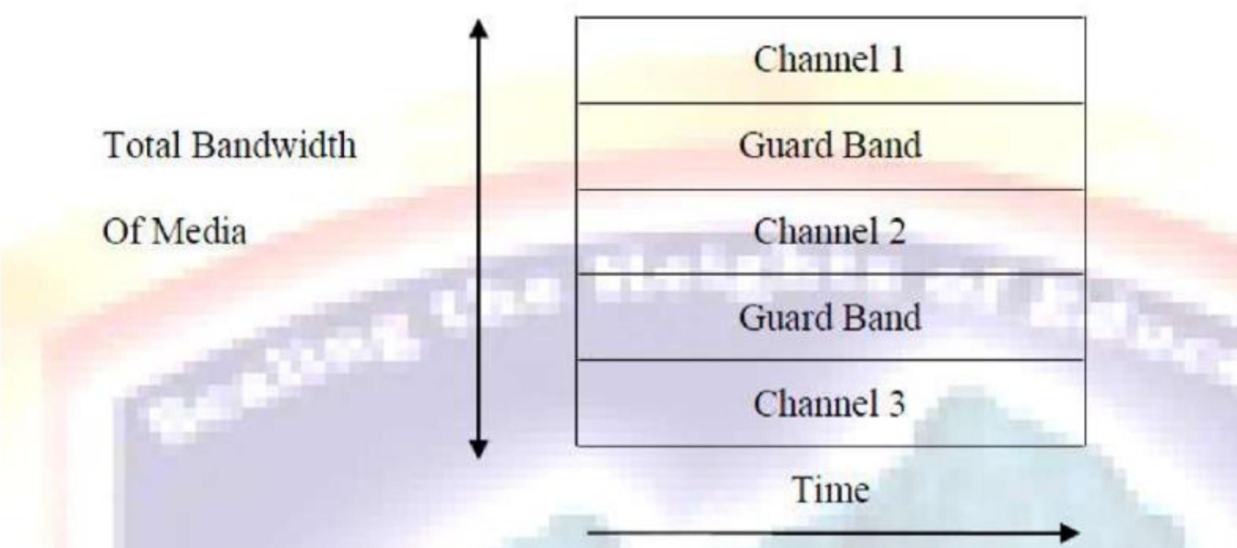

Fig 1.6: FDM

These channels are separated by further narrower slices, known as guard bands, to prevent inter-channel interface. This actual waste of bandwidth is offset by the lower costs of the filter (frequency selection device). The closer the channels are together (the narrower the guard bands (the more critical and expensive the channel filter become.

Figure above gives a conceptual view of FDM. In this illustration, the transmission path is divided into three parts (based on different frequencies), each representing a channel to carry one transmission.

Example: Cable Television

A familiar application of FDM is cable television. The coaxial cable used in a cable television system has a bandwidth of approximately 500 MHz. An individual television channel requires about 6 MHz of bandwidth for transmission. The coaxial cable, therefore, can carry many multiplexed channels (theoretically 83 channels, but actually fewer to allow for guard band). A demultiplexer at your television allows you to select which of those channels you wish to receive.

1.7.2 Time Division Multiplexing

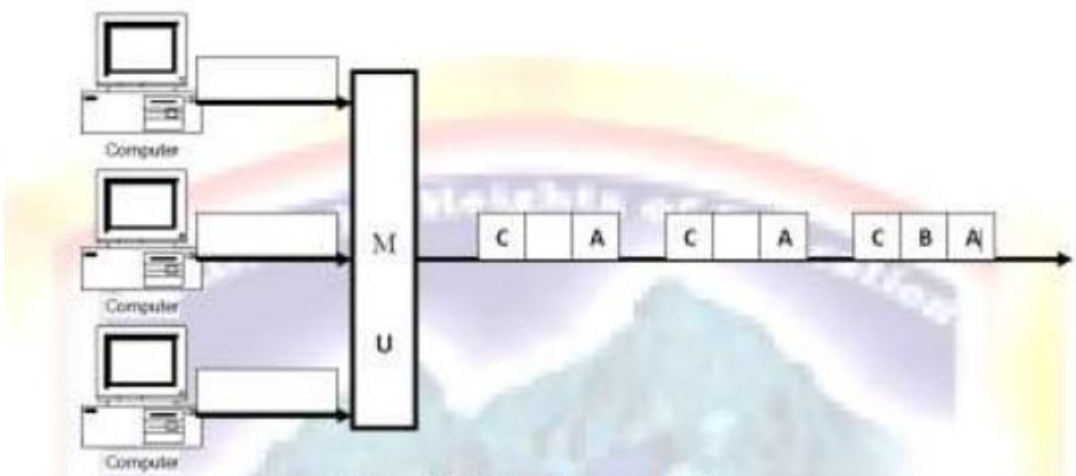

Fig 1.7: TDM

In this method, multiplexer allocates the same time slot to each device at all time, whether or not a device has anything to transmit. IF there are n input line than there must be n time slots in the frame (time slots are grouped into frames). Time slot (lets say T), for example, is assigned to device (lets say D) alone and can not be used by any other device. Each time its allocated time slot comes in (in a round robin fashion), Device D has the opportunity to send a portion of its data for time slot T. If the device D is unable to transmit or does not have data to send, its time slot remains empty and no other device can use it, another words it is wasted.

Asynchronous TDM (Statistical TDM)

Asynchronous TDM provide better utilization of media. Like synchronous TDM, asynchronous TDM allows a number of lower speed input lines to be multiplexed to a single higher speed line. Unlike synchronous TDM, however, in asynchronous TDM the total speed of input line can be greater than the capacity of the media. In asynchronous TDM the number of slots in the frame are less than numbers of input lines. Slots are not preassigned; each slot is available to any of the attached input lines that has data to send. The multiplexer scans the input line, accepts the portion of data until a frame is filed, and then sends the frame across the link. Since the slots are not pre-assigned for each input line, line address must be added along with the data to send.

1.8 Analog and Digital Data transmission

1.8.1Analog Signals

A continuously varying electromagnetic wave that may be propagated over a variety of media, depending on frequency. Examples of media:

- Copper wire media (twisted pair and coaxial cable)
- Fiber optic cable
- Atmosphere or space propagation

Analog signals can propagate analog and digital data.

1.8.2 Digital Signals

A sequence of voltage pulses that may be transmitted over a copper wire medium, generally cheaper than analog signaling, less susceptible to noise interference, Suffer more from attenuation. Digital signals can propagate analog and digital data

1.8.3 Analog Transmission

Transmit analog signals without regard to content, Attenuation limits length of transmission link, Cascaded amplifiers boost signal's energy for longer distances but cause distortion and Analog data can tolerate distortion, Introduces errors in digital data

1.8.4 Digital Transmission

Concerned with the content of the signal, Attenuation endangers integrity of data, Digital Signal, Repeaters achieve greater distance, Repeaters recover the signal and retransmit, Analog signal carrying digital data, Retransmission device recovers the digital data from analog signal and Generates new, clean analog signal

Revision questions

1. Define the term network
2. What is a network topology?
3. Which components can be integrated in a network?
4. How is switching achieved in a network
5. Differentiate analog and digital data transmission