5.1 COMPUTER NETWORK FUNDAMENTALS

5.1.1 Concept

- **Computer networks** is an important component of Computer based Information Systems. It has also become a vital tool for modern business organizations. The reason for the same being that :
  - Networks facilitate companies to share important information across different inter and intra organizational systems efficiently.
  - Networks form a significant linkage between business organizations, their business partners, their suppliers and their customers.
  - Geographically dispersed employees can easily communicate, interact and share their ideas with the help of networking facility.
- **Computer Networks** is an interconnection of various devices such as computers, routers, printers etc., with the help of some form of communication medium in order to transmit information. Different types of communication media can have different transmission rates measured in bits per second and more commonly called as **bandwidth**. Bandwidth can vary from around 750 MHz for coaxial cables to few THz for optic fibres. Voice as well as data communications can happen over different bandwidths.

5.1.2 Types of Networks

There are different **types of computer networks** from small range to wide range.

- The shortest range networks are the **Personal area networks (PANs)** which have their scope only over a few meters. The devices need to be placed very close to each other in order to transmit and receive information.
- **Local Area Networks (LANS)** that can span over a comparatively larger area as of PANs, say within the same building. Every device in the LAN has a *network interface card* (NIC) that facilitates the connection of the device on the network to the communication medium.
- **Wide Area Networks (WANs)** that cover very large geographic areas like countries or continents. WANs usually connect two or more LANs. Internet is a common example of WAN. Different telephone companies and communications service providers provide this networking capability.
- Another type of network which is just a combination of the above mentioned networks is the **Enterprise Network**. Large enterprises can combine multiple LANs and WANs for communication purposes between different departments within same organization or outside the organizations with business partners and customers who are remotely located.

5.1.3 The Internet and the World Wide Web(WWW)

- The **Internet** is a universal WAN that connects millions of computer networks all over the world. Commonly referred to as "NET", it is a network of networks.

- Today, the Internet has become a very fundamental communication, collaboration and information sharing need for all business organizations connected worldwide. It can be accessed easily and inexpensively using devices such as computers, laptops, mainframes, palmtops, smart phones etc.
- The Internet facility can be made available on various devices by subscribing for a connection with the **Internet Service Provider (ISP)** such as Microsoft, America Online and many more. Also, many **telephone companies** and **cable service providers** offer Internet connectivity. Fees are charged for the setup and periodic subscription.
- Each device on the Internet is identified by a unique address, called the **Internet Protocol (IP) address**. The IP address consists of sets of numbers, in four or six parts, separated by dots depending upon which addressing scheme is being used either **IPV4 or IPV6**.
- For example, the IPV4 address of your computer might look like this 135.62.128.91 which is 32 bit address.
- Whereas an IPV6 address takes a form 2001:0db8:85a3:0000:0000:8a2e:0370:7334 which follows a 128 bit addressing scheme. The increasing number of devices being connected to the Internet such as smart phones, smart watches, Alexa etc and each requiring a unique IP address has led to the need of IPV6 addressing scheme with 2^{128} addresses possible.
- **The Internet Corporation for Assigned Names (ICANN)** takes the responsibility of assigning these addresses throughout the world.
- The **World Wide Web (WWW)** is a system of universally accepted standards for storing, retrieving, formatting, and displaying information via client/server architecture.
- The Internet and **WWW** are different. The Internet functions as a transport mechanism, whereas the World Wide Web is an application that uses those transport functions.
- The Web comprises of all types of data like text, images, audio, video, graphics, animation, and hypermedia.
- Organizations that wish to offer information through the Web must create their **Website**, which is nothing but a collection of pages or rather, **webpages** that are linked to one another. They provide basic information about the organization and its products and services. Certain websites facilitate ecommerce transactions as well.
- The user must specify a **uniform resource locator (URL)** to access the website. The URL points to the address of the computer/server from where the specified resource can be accessed on the Web.
- Suppose, a user wants to access a website of Amazon. It can be accessed using an IP address. But as numeric IP addresses are difficult to remember, most of the computers can be remembered by their human readable names as well.
- These names are called **domain names** which are registered through companies such as GoDaddy who are also called as *registrars*.
- They have been authorized by ICANN for this purpose. DNS is like Internet phone directory and stands for **"Domain Name System"**.

- It is a system that lets you connect to websites by mapping the domain names with the unique IP address of the server where a website is stored.
- For example, consider the **uniform resource locator (url)** of Amazon **http://www.*amazon.com***. There are three important parts: rightmost one is the top-level domain or TLD (sometimes called an extension or domain suffix)(i.e. com), a domain name (or IP address) (i.e. amazon), and an optional subdomain (i.e.www).
- The domain name and top-level domain taken together form the "root domain." The "http://" is part of a page's URL and is known as the "hypertext transfer protocol."
- Few popular TLDs include **com** for commercial sites, **edu** for educational sites, **mil** for military government sites, **gov** for civilian government sites, **org** for organizations.
- Users access the Web primarily through software applications called **browsers**.

5.1.4 Network Protocols

Network Protocols are the rules and procedures that the various devices connected to the network should follow to be able to communicate with one another. The two major protocols are the **Ethernet and Transmission Control Protocol/Internet Protocol.**

- **Ethernet :** It is a common LAN protocol .Most large corporations use10 gigabit Ethernet, where the network provides data transmission speeds of 10 gigabits (10 billion bits per second).
- **Transmission Control Protocol/Internet Protocol :** It is the protocol for the Internet. It is a set of many protocols, the core ones being the Transmission Control Protocol (TCP) and the Internet Protocol (IP).
- The basic functions of **Transmission Control Protocol (TCP)** is to establish a connection between the computers on the network for transmission of data packets, proper sequencing , assembly and reassembly of packets, and acknowledgement of packets that have been transmitted.
- **Internet Protocol (IP)** is responsible for routing of packets from the source to the destination. Each packet carries information such as source and destination IP address. The packets travel independently across the network
- The **Application layer** enables client application programs to access the other layers, and it defines the protocols that applications use to exchange data. One such application layer protocol is the **Hypertext Transfer Protocol (HTTP)** used by the **World Wide Web**, which defines how messages are formulated and how they are interpreted by the web browsers and web servers. It is an important part of the url of a website as already seen above.
- **Network Applications :** Business organizations use networks to improve their business processes. There are various network applications that satisfy the different business functions such as communication through emails, e-chats and internet telephony, collaborative work platforms by virtual meets through video conferencing, e-learning via Massive Online Open Courses or MOOCs, virtual universities, and telecommuting etc.

5.1.5 N/W architectures

Usually, the network processing happens in a distributed manner .The organization's computer systems are not located at one place and are distributed over the entire firm. The common types of distributed processing are: **(a) Client/Server and (b)Peer-to- Peer.**

(a) Client / Server Architecture

- In this type of architecture, some computer systems act as clients where as some act as servers. The systems that request for a service are clients and the ones that satisfy the request are servers.
- All the computing services and major processing happens at the servers which are very powerful machines.
- Less powerful machines like the clients request these services from the servers. 'Thin' and 'Fat' clients are examples of such architecture where *fat clients* have large storage and processing power and therefore can run local programs even if the network goes down.
- In contrast, *thin clients* may have no local storage and only limited processing power. Thus, they must depend on the network to run applications. A simple representation of client/server model is shown in Fig. 5.1.5(a).

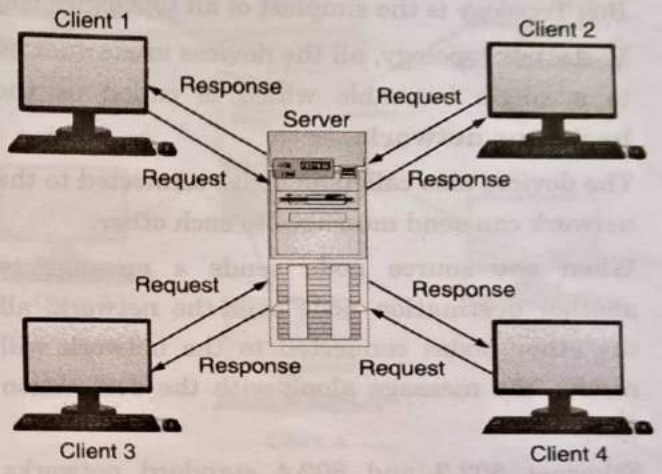

Fig. 5.1.5(a) : Client/server network processing

(b) Peer-to-Peer

- Peer-to-peer (P2P) processing is a type of client/server distributed processing where each computer system can behave as both a client and a server.
- Each computer can access all files on all other computers. BitTorrent is an open-source, free, peer-to-peer file-sharing application that simplifies the problem of sharing large files over the network by dividing them into tiny pieces, or "torrents. Peer-to-peer model looks like as depicted in Fig. 5.1.5(b).

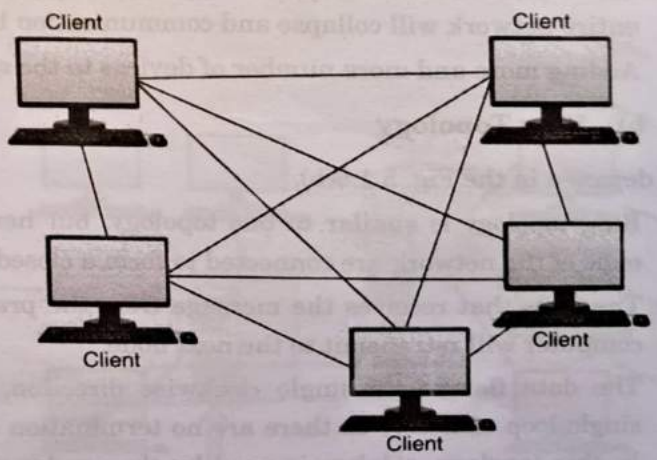

Fig. 5.1.5(b) : Peer-to-Peer processing

5.1.6 Network Topologies

The physical network topology defines the structure of how the various devices are connected to one another in a network. The common topologies are discussed below.

(a) Bus Topology	(b) Ring Topology	(c) Star Topology
(d) Tree topology	(e) Mesh topology	

(a) Bus Topology

As shown in the Fig. 5.1.6(a),

- Bus Topology is the simplest of all topologies with a single bus that carries all the messages.
- In the bus topology, all the devices are connected to a single bus/cable which is called as the **backbone network**.
- The devices also called as nodes connected to the network can send messages to each other.
- When one source node sends a message to another destination node over the network, all the other nodes connected to the network will receive the message along with the destination node.
- Ethernet 802.3 and 802.4 standard networks make use of this topology.

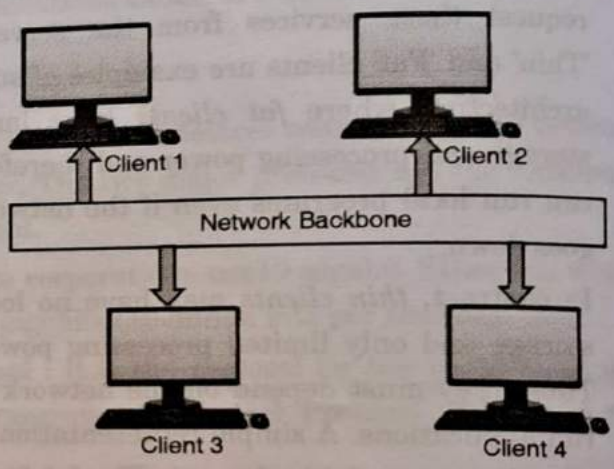

Fig. 5.1.6(a) : Bus Topology

- A bus topology is the simplest, but still it requires a lot of cabling and as a result determining the cable faults becomes tedious. If any fault occurs in the cable which is the network backbone, then entire network will collapse and communication between nodes will be hampered.
- Adding more and more number of devices to the same network would slow down the network.

b) Ring Topology

As depicted in the Fig. 5.1.6(b),

- Ring topology is similar to bus topology, but here the ends of the network are connected to form a closed loop.
- The node that receives the message from the previous computer will retransmit to the next node.
- The data flows in a single clockwise direction, in a single loop endlessly as there are no termination ends. In this topology, a token is used by the sender which contains the destination address along with the data.

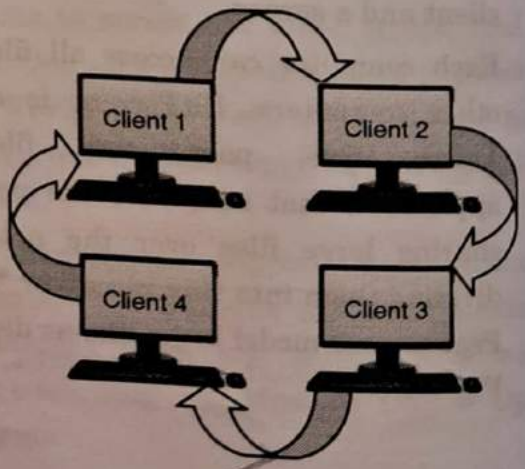

Fig. 5.1.6(b) : Ring Topology

- The data is passed from one node to another node until it reaches the destination. Once the token is received by the destination device, then it sends the acknowledgment to the sender.
- Same issue as in bus topology persists with ring topology, that if fault occurs in the cable then entire communication between nodes will be hampered.
- Also, adding more number of devices would slow down the network.
- Here in addition, the breakdown of any one node leads to the failure of the overall network.

(c) Star Topology

- As shown in Fig. 5.1.6(c), In Star topology every node in the network is connected to a central controlling node.
- The central node or hub is often known as the server, and the peripheral nodes connected to the server are known as clients.
- Hubs or switches can also be used as connection devices in a physical star topology.
- Troubleshooting is easier as all the devices are connected to a central node.
- Failure at one node will not affect the rest of the network.

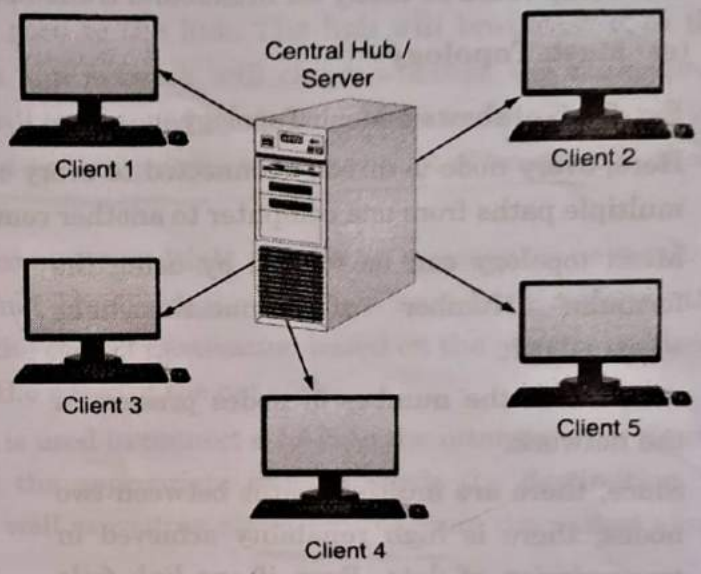

Fig. 5.1.6(c) : Star Topology

- Adding new devices is easy as it needs just making a connection with the central node.
- If the central hub fails, then the entire network crashes and none of the devices will be able to communicate.

(d) Tree Topology

As shown in Fig. 5.1.6(d),

- Tree Topology combines the characteristics of both bus topology and star topology.
- All the nodes are connected with each other in hierarchical fashion.
- The top-most node in tree topology is known as a root node, and all other nodes are the descendants of the root node. Normally, it forms a parent-child like hierarchical structure.

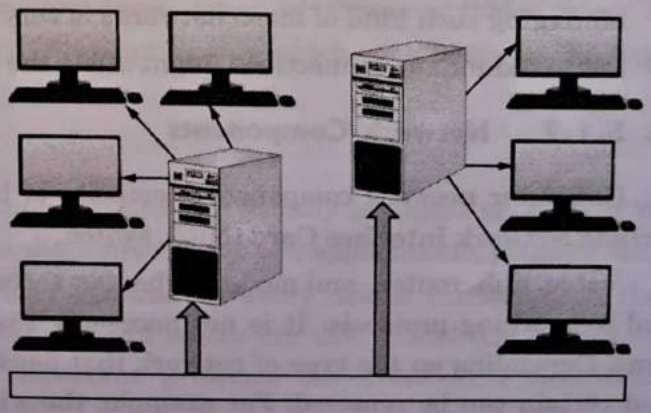

Fig. 5.1.6(d) : Tree Topology

- The whole network can be divided into separate segments each being managed as a star network.
- This topology is frequently used for broadband transmission where signals are to be sent over long distances without being attenuated.
- Tree topology is easily expandable.
- Breakdown of a single link does not affect the rest of the network but as the root nodes are sharing a common bus and if that fails, the entire network would fail.
- Since, the hierarchy can be long; troubleshooting could be a tedious task.
- The setup could be costly for broadband transmission.

(e) Mesh Topology

Fig. 5.1.6(e) shows a Mesh Topology.

- Here, every node is directly connected to every other node in the network and therefore there are multiple paths from one computer to another computer.
- Mesh topology can be formed by using the formula: Number of connections/links = (n*(n-1))/2;
  where n is the number of nodes present in the network.
- Since, there are multiple paths between two nodes, there is high reliability achieved in transmission of data. Even if one link fails (may be the direct link), data can take another path to reach the destination although it might take a little longer time.

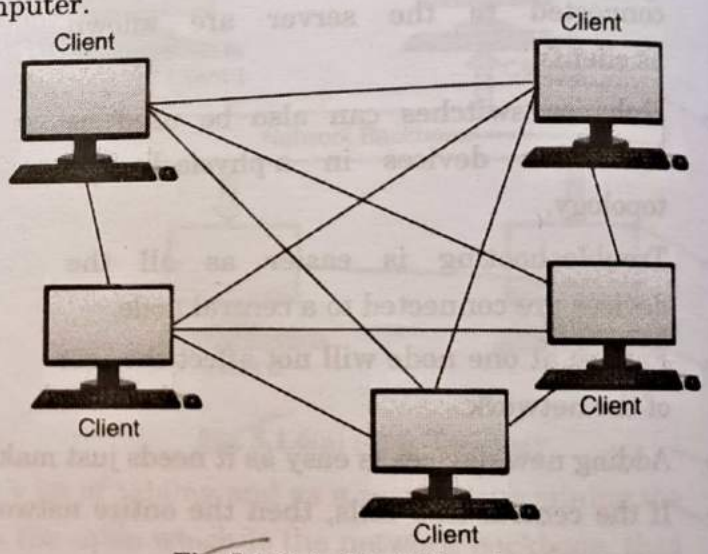

Fig. 5.1.6(e) : Mesh Topology

- But when there is point-to-point direct transmission, it is comparatively faster.
- Adding a new connection or a new device does not affect the working of the rest of the network.
- Managing such kind of mesh networks is very cumbersome.
- Lot of redundant connections might affect the efficiency of the network.

5.1.7 Network Components

Computer network components comprise of both hardware and software. Hardware components include Network Interface Card (NIC), switch,

cable, hub, router, and modem whereas software components include network operating system and networking protocols. It is not necessary that all the components will be required at the same time. Depending on the type of network that needs to be configured certain components can be added and certain can be removed. For example, the wireless network will not require an explicit cable so that can be removed. Let us discuss each of them.

(a) Hardware Components

i) **Network Interface Card (NIC) :** NIC is a hardware component used to connect a computer with another computer onto a network. To identify the network card or rather the device uniquely a physical address or MAC address is encoded on the card. NIC comes in two flavors wired and wireless. Wired NIC is present inside the motherboard and requires cables to transfer data. Whereas Wireless NIC has an antenna to obtain connection over wireless network as found in laptops.

ii) **Hub :** A hub is a hardware device that divides the network connection among multiple devices. When computer sends some message, first it goes to the hub. The hub will broadcast it to the entire network. All the devices connected on the network will check whether the message is destined for them or not. If not, the message will be dropped by those devices and will be accepted only by the node to which it is addressed to. But as this process consumes a lot of bandwidth, these days hubs are replaced by switches and routers.

iii) **Switch :** A switch is a hardware device that connects multiple devices on a computer network. A switch is smarter than a hub. Switch does not broadcast the message sent by a node on the network instead delivers the message only to the correct destination based on the physical address present in the message. It therefore increases the speed of the network.

iv) **Router :** A router is a hardware device which is used to connect a LAN to the internet. It is checks the incoming packets and forwards them to the appropriate route towards the destination. It makes use of routing and forwarding table as well as routing algorithms to route the packet along the shortest path available.

v) **Modem :** A modem is a hardware device that allows the computer to connect to the internet over the existing telephone line. It stands for Modulator/Demodulator. It converts the digital data into an analog signal over the telephone lines. Based on the differences in speed and transmission rate, there are different types of modems like Standard PC modem or Dial-up modem, Cellular Modem and Cable modem.

vi) **Cables and Connectors**: Cables and connectors are used to connect two or more devices over the network so that they can transmit data. There are three types of common cables used in transmission: Twisted pair cable, Coaxial cable and Fibre-optic cable which we will see in the next section.

(b) Software Components

- **Network Operating System :** Network Operating Systems are usually installed on the server and facilitate computers connected in a network to share files, database, applications, printers etc.
- **Protocol Suite :** A protocol suite is a set of rules followed by every device connected on the network for data communication. The two popular protocol suites are OSI Model (Open System Interconnections) and TCP / IP Model. The important protocols for networking and data transmission have been already discussed in Section 5.1.4.

5.2 TYPES OF TRANSMISSION MEDIA- WIRED AND WIRELESS TECHNOLOGIES

- The data that needs to be transmitted from source to destination requires some kind of communication media to carry the data. Communication channels such as wired or wireless can be used as a medium for the same.
- Twisted-pair cable, coaxial cable, or fiber-optic cable are examples of wired/cabled or guided media whereas microwave, satellite, radio, or infrared are examples of wireless/broadcast or unguided media.
- Wired media use physical wires or cables to transmit data. Twisted-pair and coaxial cables are made of copper, and fiber-optic cable is made of glass.
- Data transmissions over wireless media are through electromagnetic waves. The classification of transmission media can be summarized as in Fig. 5.2.1.

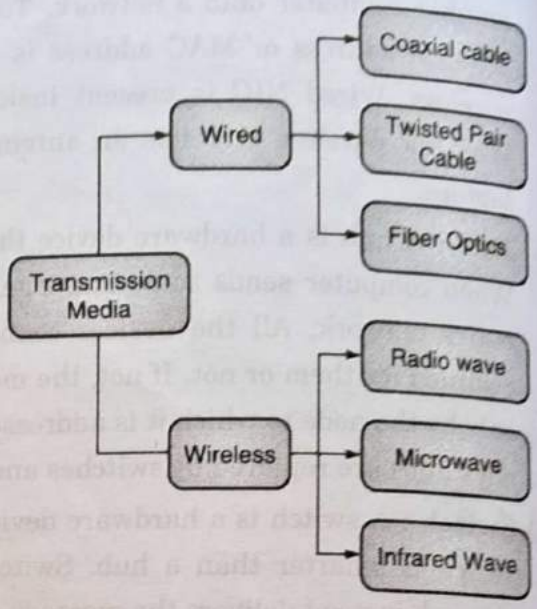

Fig. 5.2.1 : Transmission Media

5.2.1 Wired Networks

- Wired network consists of physical connection between two or more devices using physical cables. They are also called as Ethernet networks and mostly used in local area networks (LAN).
- Ethernet is the fastest wired network protocol, with connection speeds of 10 megabits per second (Mbps) to 100 Mbps or higher (now upto 10000Mbps/10 Gbps).
- The most commonly used wired network topologies are bus, ring, star, mesh which have been already discussed in Section 5.1.6.
- The benefit of a wired network is that bandwidth is very high and that interference is very limited due to direct connections and hence is safer.
- But the only disadvantage is that they need a lot of rewiring every time they are moved.
- Normally the range of wired networks is somewhere within a 2,000-foot-radius.Beyond these distances the data transmission may become slow or even nonexistent.

Types of wired media are:

(a) Twisted-Pair Wire (b) Coaxial Cable (c) Fiber Optics

(a) Twisted-Pair Wire

- It consists of strands of copper wires twisted in pairs.
- The twisting of wires reduces noise on the wires by cancelling the electromagnetic interference from the environment during transmission.

- It is a very common form of wiring and used in almost all business telephone wiring.
- These types of wires are widely available and quiet inexpensive but relatively slow in transmission.
- The twisted pair wires look like as shown in Fig. 5.2.1(a).

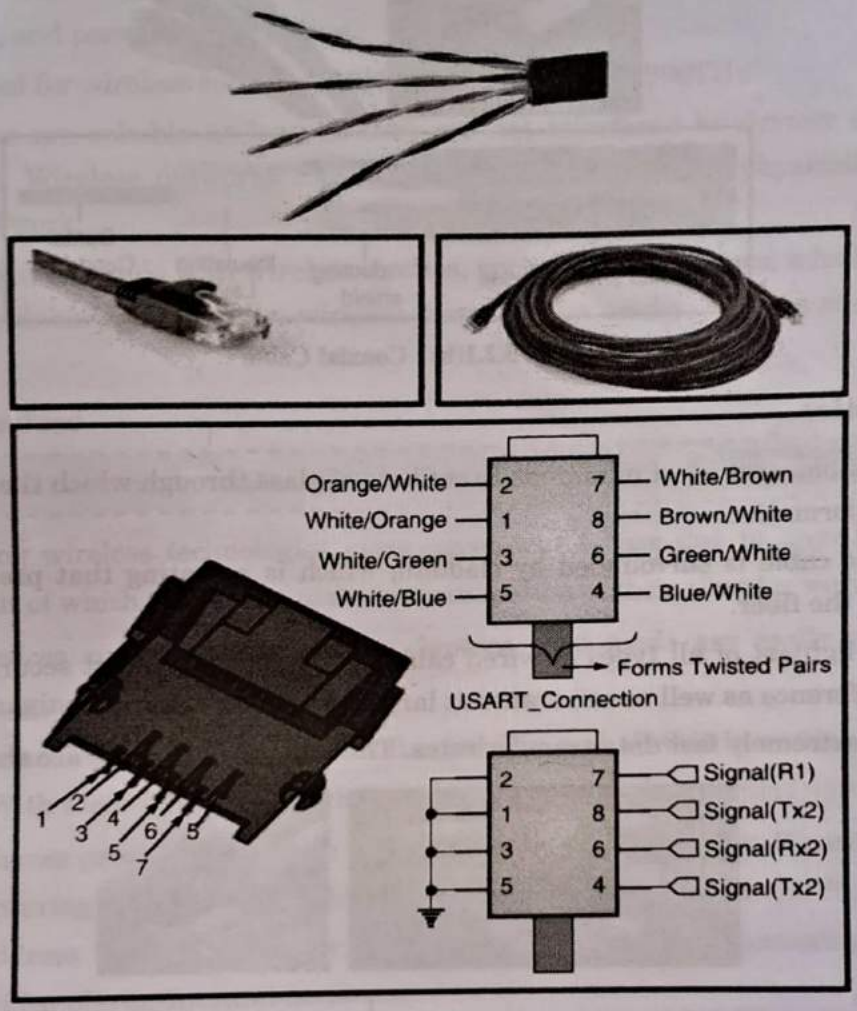

Fig. 5.2.1(a) : Twisted Pair Cable

(b) Coaxial Cable

- Coaxial Cables consist of insulated copper wires.
- There is a cylindrical wire between an insulating sheath. Surrounding the insulating sheath is a conductive sheath, acting simultaneously as a shield and a return path for the signal.
- Due to this shielding most of the electromagnetic energy remains inside the surrounding conductive sheath and as a result avoids interference of noise.
- These cables are even more noise resistant than twisted pair cables.
- Coaxial cables can carry large amounts of data and therefore used for high speed transmission as in Cable TV network.

- However, coaxial cables are very expensive as well as inflexible as compared to twisted pair cables. The coaxial cables are shown in Fig. 5.2.1(b).

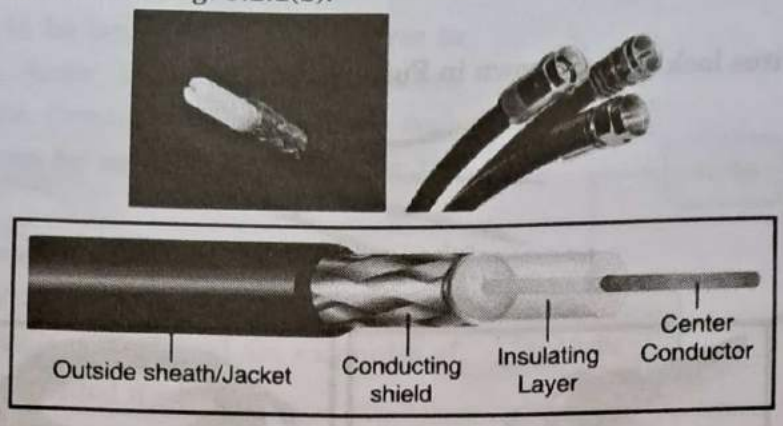

Fig. 5.2.1(b) : Coaxial Cable

(c) Fiber Optics

- Fiber Optics cables consist of numerous thin fibres of glass through which the light pulses are sent to transmit information.
- The fiber-optic cable is surrounded by cladding which is a coating that prevents the light from leaking out of the fiber.
- They are the lightest of all types of wired cables, provide the greatest security from any kind of external interference as well as can transmit large amounts of data.
- They provide extremely fast data transfer rates. The Fiber Optic Cables are shown in Fig. 5.2.1(c)

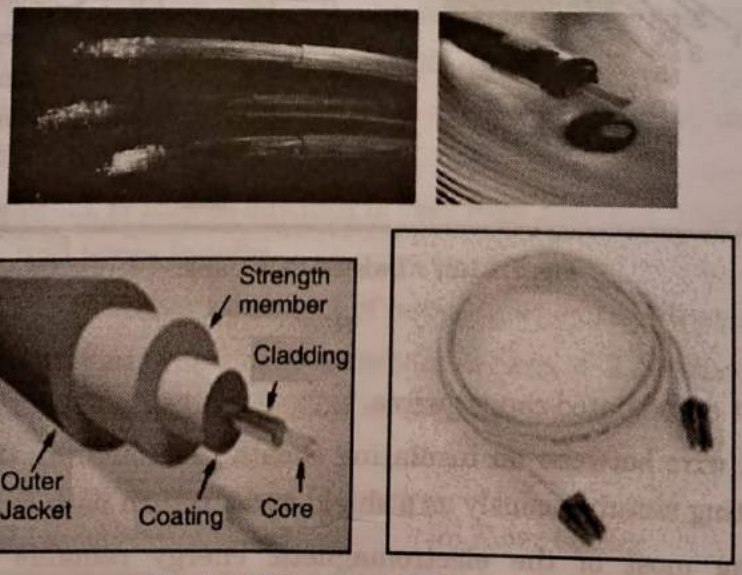

Fig. 5.2.1(c) : Fibre Optic Cable

5.2.2 Wireless Networks

- In wireless networks, there are no physical wires instead electromagnetic waves are used for transmission of information.
- This increases mobility but surely affects the range of transmission.

- These networks provide anytime, anywhere access to information by devices such as personal computers, smart phones, laptops, iPads etc.
- Wireless networks can be stationary as in microwave towers or they can be mobile as in MiFi devices. Wireless technologies enable individuals and organizations to conduct mobile computing, mobile commerce, and pervasive computing.
- The frequency used for wireless communication is from 3 KHz to 900THz.
- Wireless networks are reliable as long as they are not interfered by devices operating at same radio frequencies. Wireless networks can easily be installed without physically destructing the existing wired network.
- Wireless technologies include both wireless devices, such as smart phones, which are small, easily portable and affordable and secondly, wireless transmission media, such as microwave, satellite, and radio.

(A) Wireless Devices

UQ. Describe the most common types of wireless devices. **MU - Q.3(c), Jan. 21, 5 Marks**

- People are finding wireless technologies more convenient to use due to anywhere and anytime access. As a result of which people can make best utilization of their time for work while travelling.
- The wireless devices such as smart phones, laptops, and ipads are easily portable and give flexibility in managing the working hours.
- The devices have achieved high computational capability and all this is available at a reasonably affordable cost. With the help of these devices we can connect to the Internet wirelessly.
- Modern smart phones provide capabilities that include cellular telephony, Bluetooth, Wi-Fi, digital cameras for capturing images and video, global positioning system (GPS), an organizer, a scheduler, an address book, a calculator, access to e-mail, instant messaging, text messaging, music player, a video player, Internet access etc.
- Also there are small portable wireless devices such as MiFi, that provide Wi-Fi hotspot to upto 5 devices to connect at the same time anywhere you go. The range is upto 30 feet or around 10 meters. Thus wireless technologies and devices are making the work easy, convenient and faster.

(B) Wireless Transmission Media

(a) Microwave

- Microwave transmission systems transmit data via electromagnetic waves. The signals which have transmitting frequency ranging from 1GHz to 300GHz are called microwaves.
- These types of transmissions are used when very large amounts of data need to be transmitted and need to cover finitely long distances. The transmitters and receivers need to be in **line-of-sight** to each other for efficient communication without interference.

- But as the Earth's surface is curved and not flat, the microwave towers should be spaced after every 30 miles to satisfy the line-of-sight constraint.
- For very long distances microwave systems provide very limited support. Also, disturbances in climatic conditions like heavy storms or rains can affect the transmission.

(b) Satellite

- Satellite transmission systems make use of communication satellites.
- The three satellites orbiting around the Earth are :

  (i) Geostationary-earth-orbit(GEO), (ii) Medium-earth-orbit(MEO), and

  (iii) Low-earth-orbit(LEO).
- GEO is the farthest from earth and LEO is the closest. The three communication satellites along with their features and distance from earth's surface are summarized in the below given Table 5.2.2. Like in microwave there is constraint of line of sight, similarly in satellite communication there is something called **footprint.**
- The footprint is dependent on distance. The farther the satellite from the Earth's surface, highest is its footprint and the nearer the satellite, shorter is the footprint. The same has been depicted in Fig. 5.2.2.

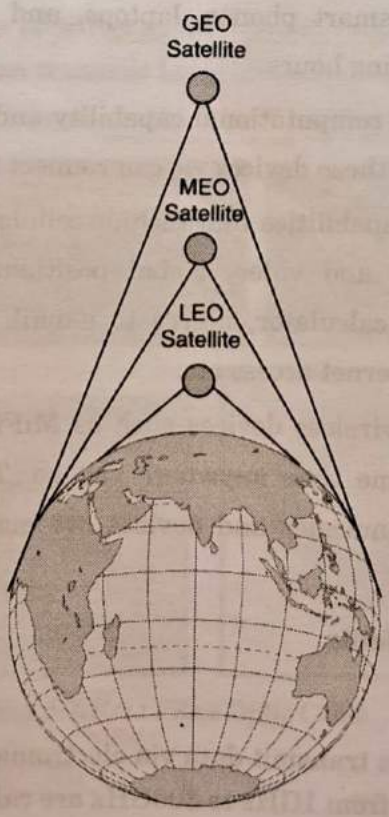

Fig. 5.2.2 : Satellite Orbits and Footprints

Table 5.2.2 : Details of communication satellites

Name of satellite	Key features	Number of satellites orbiting around the earth	Distance above earth's surface
Geostationary Earth Orbit(GEO)	1. Since they are farthest from the earth's surface, their footprint / coverage is the maximum. 2. Therefore number of satellites required is less. 3. Satellites appear stationary relative to point on earth. 4. Transmission delay is high as it is farthest from earth's surface.	8	22,300 miles (from equator)
Medium Earth Orbit(MEO)	1. Since, they are closer from the earth's surface as compared to GEO satellites, their footprint / coverage is comparatively lesser than GEO. 2. Therefore, number of satellites required is more. 3. Satellites are moving relative to point on earth 4. Transmission delay is less as it is a little nearer to earth's surface.	10-12	6434 miles
Low Earth Orbit(LEO)	1. Since they are closest to the earth's surface, their footprint is the least. 2. Therefore number of satellites required is more. 3. Satellites are moving relative to point on earth. 4. Transmission delay is minimum as they are closest to earth's surface.	Too many	400-700 miles

☞ Internet over Satellite(IoS)

- There are many remote areas or hilly areas in the world where installing physical cables is impossible or too expensive to provide Internet access. Internet over Satellite (IoS) is the best option for such regions.
- IoS enables users to access the Internet via GEO satellites from a dish mounted on the side of their homes.
- As these satellites are too far from the surface of the earth, some amounts of transmission delays may occur. Also, they are susceptible to environmental disturbances like heavy storms and rains.

☞ Radio

- **Radio transmissions** use radio frequencies to transmit data at high speeds and can easily cross organizational walls.
- The signals which have transmitting frequency ranging from 3 KHz to 1 GHz are called radio waves.
- The problem with this type of transmission is that two devices operating at same radiofrequency can create interference problems for each other.
- Radio signals can travel only 30 to 40 miles from their source and if the distance increases the signal diminishes. However, satellite radio can be used to overcome this problem.

☞ Infrared

- Infrared waves are another type of wireless media having transmitting frequency ranging from 300GHz to 400THz.
- **Infrared** light is red light that is not commonly visible to human eyes.
- Use of infrared waves is done in remote control units for televisions, CD and DVD players.
- Infrared transceivers are used for short distance communication between connecting devices.

5.2.3 Wireless Computer Networks Based on Distance Coverage

In the previous sections we saw the various transmission media and the devices that make use of them to form wireless computer networks. We will now discuss few wireless networks based on the distance that they can cover. They are categorized as short range, medium range and wide range wireless networks.

☞ (A) Short Range Wireless Networks

(i) Bluetooth

- Bluetooth technology makes use of omnidirectional, low power radio waves to create a connection between two Bluetooth enabled devices.
- In Bluetooth 1.0 around 8 devices can be linked and they should be spaced not more than 10 meters to achieve transmission rates of 700 kbps.

- In Bluetooth 2.0 around 8 devices can be linked and they should be spaced not more than 100 meters to achieve transmission rates of 2.1 Mbps.
- Different devices such as Bluetooth enabled Laptops or mobile phones, Bluetooth speakers, Bluetooth headphones make use of this technology.

(ii) Near Field Communications (NFC)

- This technology is found embedded in mobile phones, credit cards or many other smart cards for sharing pictures, contacts or making payments.
- Its range is the smallest upto few cms-4cm or 1 1/2 inch and base frequency of 13.56 MHz

☞ (B) Medium Range Wireless Networks

(i) Wireless Fidelity (WiFi)

- A type of medium range wireless LAN technology.
- It requires wireless access point to connect to Wireless LAN or satellite dishes that provide internet connection.
- The distance it can cover is upto 300 feet and you can get connected to such WiFi networks anywhere, also in many public places like airports, railway stations, many hotels and restaurants provide this WiFi connectivity. The only thing is, you need to have the network security key to access that wireless network.
- WiFi frequency ranges somewhere between 2.4GHz to 5 GHz.
- WiFi speed ranges fom 54Kbps for 802.11a standard to upto 7 Gbps for 802.11ad standard
- Mobile devices such as laptops, PCs, smartphones have built in wireless network interface capability to connect wirelessly to the internet.

(ii) Wi-Fi Direct

- It is a type of WiFi technology where the devices can connect and communicate directly without the need of wireless antenna. It is peer-to-peer wireless connection.
- **Wi-Fi Direct** enables devices such as mobile phones, PCs, and gaming devices to create their own **Wi-Fi** networks without an internet connection.
- It's frequency ranges from 2.4 GHz upto 5 GHz and it can cover a distance of around 200 meters(600-800 feet)
- The technology is similar to bluetooth with wider scope and speeds of upto 250 Mbps.

(iii) Mi-Fi

- This technology makes use of small, portable wireless device with the help of which maximum 5 devices can be connected and communicate at the same time.
- The device provides Wi-Fi connectivity anywhere you travel but the devices should be in the range of 10 meters from the wireless device.

(C) Wide Area Wireless Networks

- These types of networks provide internet connectivity over geographically dispersed areas.
- They operate over licensed wireless spectrums regulated by Government as against bluetooth, Wi-Fi which operate over unlicensed spectrum.
- The two types of wide area wireless networks are cellular radio and wireless broadband.

(i) Cellular Radio

- It is a type of communication network with very high transmission speed.
- In this technology, two way radio communications happens over a cellular network of base stations.The cell phones communicate with radio antennas or towers placed within adjacent geographic areas called cells.
- This technology has evolved in several stages such as:
  - First generation (1G) cellular networks that used analog signals and had low bandwidth.
  - 2G technology was primarily developed for voice communication, and it provides data communication up to 10 kbps.
  - 2.5G provides voice and data communication upto 144 kbps.
  - 3G supports voice and data upto 384 kbps when device is moving and 2 Mbps at fixed locations. It supports video, web browsing, instant messaging etc.
  - 4G maintains 100 Mbps for high mobility and 1 Gbps for low mobility. It is a more intelligent and faster technology.

(ii) Wireless Broadband or WiMax

- Wireless Broadband provides long distance broadband wireless internet connections to homes and businesses located miles away and also in rural areas.
- It has an access range of upto 31 miles.
- The transfer rate is upto 75 Mbps and it supports voice and video communication.
- Mobile WiMAX is implemented in three spectrum bands 2.3-2.4 GHz, 2.5-2.7 GHz, and 3.4-3.6 GHz.

UQ. Differentiate between computer network wired and wireless technology.

(MU - Q.1(E), Dec. 19, 5Marks)

Sr.No.	Wired Technology	Wireless Technology
1	Makes use of cables/wires as transmission media.	Makes use of electromagnetic waves as transmission media.
2	More secured and faster as there is direct physical connectivity and also the transmission is guided.	Less secured and transmission can suffer from external interference and tapping as transmission is through air which is unguided

Sr.No.	Wired Technology	Wireless Technology
3	Superior networking performance even for longer distances.	Networking performance is distance sensitive.
4	Expensive technology	Cost-effective technology
5	No mobility can be achieved.	Greater mobility is achieved through wireless networks.

5.2.4 Pervasive Computing

UQ. Describe technologies that underline pervasive computing, providing examples of how businesses can utilize them? **(MU - Q.3(D), Jan. 21, 5 Marks)**

- **Pervasive Computing** also called as **Ubiquitous Computing** is anywhere, anytime computing.
- According to this technology, every object around us such as mobile phones, clothes, washing machines, books etc. can be made to have computational capabilty.
- The processing power is embedded into these objects with the help of microprocessor chips.
- Ubiquitous computing has evolved after mobile computing and includes various technologies such as wireless communication and networking, mobile devices, embedded systems, wearable devices, radio frequency ID (RFID) tags, software agents, Internet capabilities, voice recognition and artificial intelligence (AI).
- The two key technologies behind Pervasive Computing are : **Radio frequency identification (RFID) technology** and **Wireless sensor networks (WSNs).**

(a) Radio frequency identification(RFID) technology

- **Radio-frequency identification (RFID)** uses electromagnetic waves to automatically detect tags attached to objects.
- An RFID system basically consists of a transponder (transmitter and responder) .When it receives an electromagnetic signal from a nearby RFID reader device, the tag transmits digital data back to the reader.
- Manufacturers attach tags with radio transponders and RFID chips on goods and then track their movement through radio signals.
- RFID technology facilitates large organizations to manage and track their stock and inventory.An RFID tag can be attached to all the objects in the inventory and used to track and manage the stock details without manual data entry.
- Manufactured products such as automobiles or garments can be tracked from the factory until shipped to the customer.
- Many organisations require that their vendors place RFID tags on all shipments to improve supply chain management.

(b) Wireless sensor Networks (WSNs)

- WSNs are formed by interconnection of several battery powered wireless sensors called motes that are placed anywhere in the physical environment. These motes are capable of collecting, processing and storing the data.
- Embedding processor chips and sensors in any kind of object and using Web Technology is making these objects smart.egs: Smart watches, Digital thermostats, Sensors in vegetable cartons, Jet engines, etc.
- This technology can be broadly called as Internet of Things (IOT).
- Having their roots in military applications for battlefield surveillance; today WSNs are widely used in industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, etc.
- WSNs are used in agriculture field to monitor environmental conditions and manage irrigation facilities.
- Sensors in jet engines produce data in real time on the operating performance of the engines.
- Sensors in fruit and vegetable cartons can track location and even sense the freshness of the product thereby warning about spoilage.
- IBM has initiated a long-term project with the local government to use sensors, software, and the Internet to improve the city's use of water, electricity, and transportation.

5.2.5 Cloud Computing Model

- Cloud computing is a type of computing that lets customers easily access resources such as servers, storage, applications etc. over the Internet.
- These resources are shared by multiple computing devices over the network and can be acquired as and when needed and released when the work is done.
- Cloud computing refers to offering computing services from servers in a network.
- **Typical features of cloud services are :**
  - o available on demand
  - o can be accessed over a network
  - o share resources between multiple applications and tenants
  - o scale elastically based on dynamic computing needs
  - o provide measured service
  - o pay-per-use(utility computing)
- As shown in the Fig. 5.2.5, there are multiple cloud services right from infrastructure, applications to storage that can be accessed from thousands of different locations globally.

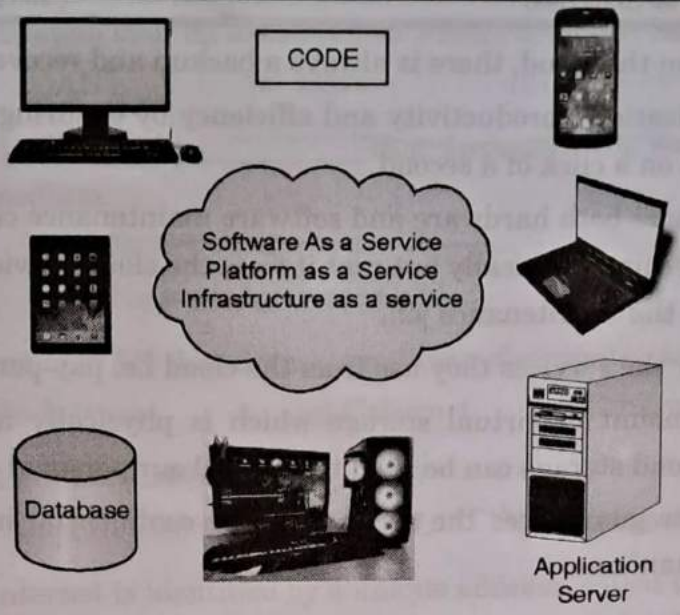

Fig. 5.2.5 : Cloud Computing Model

Cloud Computing Deployment Models based on Infrastructure Ownership

- **Private :** Private cloud is cloud infrastructure deployed for a single organization, whether managed internally or by a third party, and hosted either internally or externally.
- **Public :** When the cloud services are deployed over the public Internet it is called Public cloud. Many services are free for general public over public cloud but certain premium services may be charged.
- **Hybrid :** Hybrid cloud is a combination of a public cloud and a private cloud. This type of infrastructure might be advisable when certain temporary resource needs cannot be satisfied by private clouds.
- **Community :** Community cloud shares infrastructure between several organizations from a specific community with common concerns (security, compliance, jurisdiction, etc.), whether managed internally or by a third-party, and either hosted internally or externally.

Cloud Computing Models based on Services provided

- **Infrastructure-as-a-Service (IaaS) :** These are cloud based services that provide infrastructure services as and when required over the internet such as storage, networking, virtualization etc.
- **Platform-as-a-Service (PaaS) :** These are cloud services that provide services such as hardware and software environment required for development over the internet
- **Software-as-a-Service (SaaS) :** This cloud service makes available different application softwares for use over the internet.

Advantages of Cloud Computing

1. Users can easily access or store information from anywhere, anytime, from any device connected to the internet.

2. As the data is stored on the cloud, there is always a backup and recovery for your data.
3. It enhances an organization's productivity and efficiency by ensuring that the data is all the time available and that too on a click of a second.
4. Cloud computing reduces both hardware and software maintenance costs for organizations as they do not hold or buy anything physically but rent it from the cloud service provider. The cloud service provider takes care of the maintenance job.
5. The users pay only for the services they use from the cloud i.e. pay-per-usage.
6. Cloud offers huge amount of virtual storage which is physically not possible on our personal computer systems. Cloud storage can be used to store all our personal data, photos, documents etc.
7. Cloud service provider guarantees the security of our confidential information by implementing various security mechanisms.

☞ Disadvantages of Cloud Computing

1. You need to be always connected to the internet to access cloud services.
2. Organizations may face problems when transferring their services from one vendor to another, if the platforms provided by the vendors are different.
3. The cloud users have limited control over the services within a cloud infrastructure as everything is controlled by the cloud service provider.
4. Although cloud service providers take full responsibility of security of your confidential data on the cloud but still there could be chances that as we are sending our sensitive information to a third party, it could be hacked.

⏭ 5.3 MULTIPLE CHOICE QUESTIONS

Q.1 Traveling sales people and those at regional sales offices can use the Internet, extranets, and other networks to transmit customer orders from their laptop or desktop PCs, thus breaking barriers. **(Jan. 21, 2 Marks)**

(a) Physical (b) Competition (c) Structural (d) Geographic ✓ **Ans. : (d)**

Q.2 All of the following would typically be supported by an organization's intranet information portal except: **(Jan. 21, 2 Marks)**

(a) Communication and collaboration (b) Business operations and management
(c) Web publishing (d) Recruitment ✓ **Ans. : (d)**

Q.3 _____ is a method of delivering software in which a vendor hosts the applications and customers access these applications over the Internet. **(Jan. 21, 2 Marks)**

(a) Software-as-a-Service (b) Prototyping Option
(c) Leasing the application (d) Service-oriented architecture ✓ **Ans. : (a)**

Q.4 Transmission rates of communication media measured in bits per second is also called as

(a) Bandwidth (b) Velocity (c) Speed (d) Frequency ✓ **Ans. : (a)**

Q.5 _____ networks span over an area such as within the same building.

(a) WAN (b) MAN (c) CAN (d) LAN ✓ **Ans. : (d)**

Q.6 Every device in the LAN has a _____that facilitates the connection of every device to the communication medium.

(a) SIM card (b) Smart Card

(c) ID Card (d) Network Interface Card ✓ **Ans. : (d)**

Q.7 The _____is a universal WAN that connects millions of computer networks all over the world.

(a) Internet (b) Intranet (c) Cybernet (d) Ethernet ✓ **Ans. : (a)**

Q.8 Which of these is not an Internet Service Provider?

(a) Microsoft (b) America Online (c) MTNL (d) Facebook ✓ **Ans. : (d)**

Q.9 Each device on the Internet is identified by a unique address, called the _____

(a) IP address (b) LAN address

(c) PAN address (d) WAN addresss ✓ **Ans. : (a)**

Q.10 _____takes the responsibility of assigning IP addresses to systems throughout the world globally.

(a) The Indian Institute of Technical Education

(b) The Certification Authority

(c) The Internet Corporation for Assigned Names

(d) None of above ✓ **Ans. : (c)**

Q.11 Human readable names for IP addresses are called _____

(a) Aliases (b) MAC addresses

(c) domain classes (d) domain names ✓ **Ans. : (d)**

Q.12 Users access the Web primarily through software applications called _____

(a) Operating system (b) Browsers (c) Portals (d) Compilers ✓ **Ans. : (b)**

Q.13 In the URL www.amazon.com , com is called

(a) Top level domain (b) Sub domain (c) domain (d) None of above ✓ **Ans. : (a)**

Q.14 Which of these is not an Internet protocol?

(a) TCP (b) IP (c) Ethernet (d) None of above ✓ **Ans. : (c)**

Q.15 _____is a protocol used by the World Wide Web, which defines how messages are formulated and how they are interpreted by the web browsers and web servers.

(a) http (b) TCP (c) IP (d) ftp ✓ **Ans. : (a)**

Q.16 Which of these is not a network application?

(a) e-learning (b) telecommuting

(c) videoconferencing (d) talking ✓ **Ans. : (d)**

Q.17 In client-server architecture, the system with all the computing capability is called
(a) client (b) server (c) peer (d) master ✓ **Ans. : (b)**

Q.18 Which of these is a peer-to-peer application?
(a) Thin client (b) Fat client (c) Flat client (d) BitTorrent ✓ **Ans. : (d)**

Q.19 In this topology, a token is used by the sender which contains the destination address along with the data.
(a) Ring topology (b) Bus topology (c) Star topology (d) Tree topology ✓ **Ans. : (a)**

Q.20 If the central hub fails, then the entire network crashes and none of the devices will be able to communicate. This is a drawback of which network topology?
(a) Ring topology (b) Bus topology (c) Star topology (d) Tree topology ✓ **Ans. : (c)**

Q.21 Mesh topology can be formed by using which formula for number of connections?
(a) (n+1)/2 (b) (n*(n+1))/2 (c) (n-1)/2 (d) (n*(n-1))/2 ✓ **Ans. : (d)**

Q.22 A hub is a hardware device
(a) that divides the network connection among multiple devices.
(b) that routes data packets on the network.
(c) that connects a LAN to the internet.
(d) that allows the computer to connect to the internet. ✓ **Ans. : (a)**

Q.23 A switch is a hardware device
(a) that takes care of sequencing of data packets.
(b) that connects multiple devices on a computer network smartly.
(c) that connects a LAN to the internet
(d) that allows the computer to connect .to the internet over existing telephone line. ✓ **Ans. : (b)**

Q.24 A _____ is a hardware device that connects a LAN to the internet.
(a) Switch (b) Hub (c) Router (d) Modem ✓ **Ans. : (c)**

Q.25 A modem is a hardware device
(a) that divides the network connection among multiple devices.
(b) that takes care of sequencing of data packets.
(c) that routes data packets on the network.
(d) that allows the computer to connect to the internet over existing telephone line. ✓ **Ans. : (d)**

Q.26 Which is the fastest wired network protocol?
(a) Ethernet (b) HTTP (c) Bluetooth (d) Zigbee ✓ **Ans. : (a)**

Q.27 The twisting of wires in twisted pair cables
(a) makes the transmission faster as physical wires are twisted.
(b) reduces noise on the wires by cancelling the electromagnetic interference.
(c) increases bandwidth due to twisting more than one wire.
(d) doesn't cause any significant change. ✓ **Ans. : (b)**

Q.28 The microwave signals have transmitting frequency ranging from
(a) 1GHz to 300GHz (b) 1MHz to 50 MHz
(c) 1MHz to 300MHz (d) 1GHz to 50 GHz
✓ **Ans. : (a)**

Q.29 Distance of GEO satellite from the equator is
(a) 6434 miles (b) 22,300 miles (c) 400-700 miles (d) 10,000 miles
✓ **Ans. : (b)**

Q.30 Distance of MEO satellite from the earth's surface is
(a) 6434 miles (b) 22,300 miles (c) 400-700 miles (d) 10,000 miles
✓ **Ans. : (a)**

Q.31 Distance of LEO satellite from the earth's surface is
(a) 6434 miles (b) 22,300 miles (c) 400-700 miles (d) 10,000 miles
✓ **Ans. : (c)**

Q.32 No. of GEO satellites orbiting around the earth are
(a) 8 (b) 12 (c) 10 (d) 4
✓ **Ans. : (a)**

Q.33 No. of MEO satellites orbiting around the earth are
(a) 8 (b) 10-12 (c) 15 (d) 4
✓ **Ans. : (b)**

Q.34 Which type of satellite transmission has the highest transmission delay?
(a) Geostationary Earth Orbit (b) Low Earth Orbit
(c) Medium Earth Orbit (d) None of above
✓ **Ans. : (a)**

Q.35 Which electromagnetic signals are used in remote control units for televisions, CD and DVD players?
(a) Microwave (b) Radiowave (c) Bluetooth (d) Infrared
✓ **Ans. : (d)**

Q.36 Which of these wireless technologies is omnidirectional?
(a) *Bluetooth* (b) NFC (c) Infrared (d) None of above
✓ **Ans. : (a)**

Q.37 *Bluetooth* 2.0 has a range of
(a) 10 meters (b) 100 meters (c) 10 feet (d) 100 feet
✓ **Ans. : (b)**

Q.38 The technology which is similar to Bluetooth but has a wider scope and speeds of upto 250 Mbps.
(a) WiFi (b) NFC (c) WiFi Direct (d) Infrared
✓ **Ans. : (c)**

Q.39 3G cellular networks support
(a) data communication (b) voice and data communication
(c) voice communication (d) none of above
✓ **Ans. : (b)**

Q.40 In _____computing, the processing power is embedded into any object with the help of microprocessor chips.
(a) Parallel Computing (b) Data Computing
(c) Soft Computing (d) Pervasive Computing
✓ **Ans. : (d)**

Q.41 Which of these is not a feature of Cloud Computing?
(a) pay-per-use (b) single-tenancy
(c) on demand computing (d) elasticity
✓ **Ans. : (b)**

Q.42 Cloud service model that provides services such as network virtualization is

(a) Software as a service (b) Platform as a service

(c) Infrastructure as a service (d) Virtualization as a service ✓ **Ans. : (c)**

Q.43 Gmail is an example of which cloud service model.

(a) Software as a service (b) Platform as a service

(c) Infrastructure as a service (d) Virtualization as a service ✓ **Ans. : (a)**

Q.44 This cloud service model provides the necessary environment required for development over the internet

(a) Software as a service (b) Platform as a service

(c) Infrastructure as a service (d) Virtualization as a service ✓ **Ans. : (b)**

Q.45 Which cloud service makes available different application softwares over the internet?

(a) Software as a service (b) Platform as a service

(c) Infrastructure as a service (d) Virtualization as a service ✓ **Ans. : (a)**

Q.46 Private cloud is cloud infrastructure that is

(a) deployed over the public Internet

(b) deployed for a single organization, whether managed internally or by a third party

(c) deployed when temporary resource needs cannot be satisfied by private clouds

(d) shared between several organizations from a specific community ✓ **Ans. : (b)**

Q.47 In _____ deployment model, services are deployed over the public Internet mostly free of cost.

(a) Public Cloud (b) Private Cloud

(c) Hybrid Cloud (d) Community Cloud ✓ **Ans. : (a)**

Q.48 Hybrid cloud is a cloud infrastructure that is

(a) deployed over the public Internet

(b) deployed for a single organization, whether managed internally or by a third party

(c) deployed when temporary resource needs cannot be satisfied by private clouds.

(d) shared between several organizations from a specific community ✓ **Ans. : (c)**

Q.49 _____refers to offering computing services from servers in a network.

(a) Soft Computing (b) Cloud Computing

(c) Data Computing (d) Hard Computing ✓ **Ans. : (b)**

Q.50 _____maps the domain name with the unique IP address of the server.

(a) Sever (b) DNS (c) ICANN (d) ISP ✓ **Ans. : (b)**

Chapter Ends...

□□□