

Telecommunications and Networks

Learning Objectives

- ◆ To identify major developments and trends in the industries, technologies and business applications relating to telecommunications and Internet technologies;
- ◆ To understand various topologies and architectures that a computer network might use;
- ◆ To identify the basic components, functions, and types of telecommunications networks used in enterprises;
- ◆ To identify the risks involved in using a computer network and the control mechanisms to curb those risks;
- ◆ To explain the functions of major types of telecommunications network, hardware, software, media, and services;
- ◆ To name specific types of wired and wireless transmission media and explain how they transmit data;
- ◆ To understand some of the transmission protocols used in exchanging information over the network; and
- ◆ To have an overview of e-Commerce and m-Commerce.

Task Statements

- ◆ To review and evaluate developments and trends of telecommunication and Internet technologies;
- ◆ To make use Internet, intranet, and extranet applications in businesses;
- ◆ To identify the suitability of components, functions, and types of telecommunications networks;
- ◆ To do the classification and application of various topologies and architectures of a computer network;
- ◆ To secure communication over a network, to some extent;
- ◆ To explain and name specific types of wired and wireless transmission media; and
- ◆ To use e-Commerce and m-Commerce in various functions of an enterprise.

Knowledge Statements

- ◆ To know the basic components, functions, and types of telecommunications networks used in business;
- ◆ To know the risks and related controls of a telecommunications network;
- ◆ To know various network topologies and applications;
- ◆ To know the specific types of wired and wireless transmission media; and
- ◆ To know various transmission protocols used to exchange information over the network.

3.1 Introduction

Organizations are becoming internetworked enterprises that use the Internet, intranets, and other telecommunications networks to support e-business operations and collaboration within the enterprise, and with their customers, suppliers, and other business partners. Telecommunications has entered a deregulated and fiercely competitive environment with many vendors, carriers, and services. Telecommunications technology is moving toward open, internetworked digital networks for voice, data, video, and multimedia. A major trend is the pervasive use of the Internet and its technologies to build interconnected enterprises and global networks, like intranets and extranets, to support enterprise collaboration, electronic commerce, and other e-business applications.

The explosive growth of the Internet and the use of its enabling technologies have revolutionized computing and telecommunications. The Internet has become the key platform for a rapidly expanding list of information and entertainment services and business applications, including enterprise collaboration and electronic commerce systems. Open systems with unrestricted connectivity using Internet technologies are the primary telecommunications technology drivers in e-business systems. Their primary goal is to promote easy and secure access by business professionals and consumers to the resources of the Internet, enterprise intranets, and inter-organizational extranets.

Companies are deriving strategic business value from the Internet, which enables them to disseminate information globally, communicate and trade interactively with customized information and services for individual customers, and foster collaboration of people and integration of business processes within the enterprise and with business partners. These capabilities allow them to generate cost savings from using Internet technologies, revenue increases from electronic commerce, and better customer service and relationships through interactive marketing and customer relationship management.

Businesses are installing and extending intranets throughout their organizations to improve communications and collaboration among individuals and teams within the enterprise; to publish and share valuable business information easily, inexpensively, and effectively via enterprise information portals and intranet websites and other intranet services; and to develop and deploy critical applications to support business operations and decision making.

The primary role of extranets is to link the intranet resources of a company to the intranets of its customers, suppliers, and other business partners. Extranets can also provide access to operational company databases and legacy systems to business partners. Thus, extranets provide significant business value by facilitating and strengthening the business relationships of a company with customers and suppliers, improving collaboration with its business partners, and enabling the development of new kinds of Web-based services for its customers, suppliers, and others.

The major generic components of any telecommunications network are terminals, telecommunications processors, communication channels, computers, and telecommunications software. There are several basic types of telecommunications networks, including wide area networks (WANs) and local area networks (LANs). Most WANs and LANs are interconnected using client/server, network computing, peer-to-peer, and Internet networking technologies.

Telecommunications processors include modems, multiplexers, internetworked processors, and various devices to help interconnect and enhance the capacity and efficiency of telecommunications channels. Telecommunications networks use such media as twisted-pair wiring, coaxial cables, fiber-optic cables, terrestrial microwave, communications satellites, cellular and PCS systems, wireless LANs, and other wireless technologies. Telecommunications software, such as network operating systems and telecommunications monitors, controls and manages the communications activity in a telecommunications network.

3.2 Networking an Enterprise

In today's world, most businesses are expected to be networked enterprises to be able to sustain and grow. The Internet and Internet-like networks inside the enterprise are called Intranets, between an enterprise and its trading partners are called Extranets. These and other types of networks serve as the primary information technology infrastructure for many enterprises. Managers, teams, end users, and workgroups use telecommunications networks to electronically exchange data and information anywhere in the world with other end users, customers, suppliers, and business partners. By using such networks, companies can perform more effectively as they can:

- ◆ Collaborate more creatively;
- ◆ Manage their business operations and organizational resources more effectively; and
- ◆ Compete successfully in today's fast changing global economy.

Now-a-days, survival of many organizations is not feasible without a variety of interconnected computer networks to service their various information processing and communications needs.

3.3 Trends in Telecommunication

Major trends are occurring in the field of telecommunications and these have a significant impact on management decisions. Therefore, it is necessary for managers, end users and

other stakeholders to be aware of major trends in telecommunications industries, technologies, and applications that significantly increase the decision alternatives confronting their organizations. A pictorial representation of major telecommunications trend is shown in the Fig. 3.3.1.

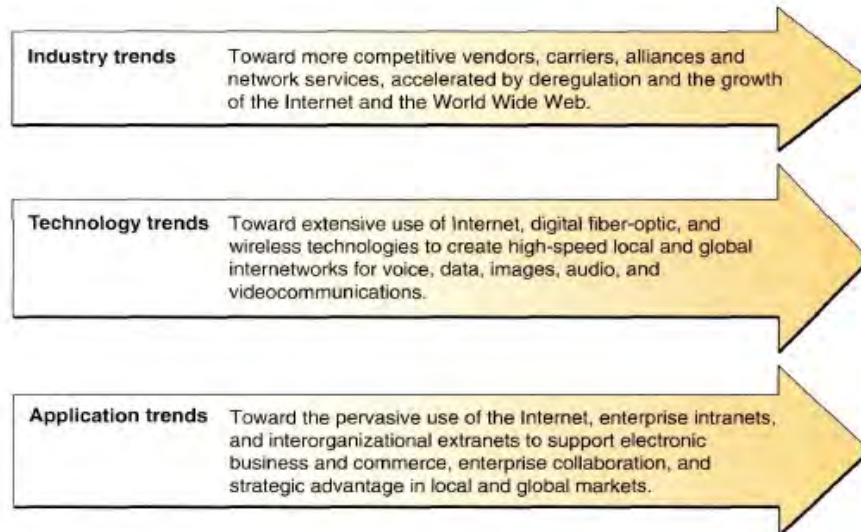


Fig. 3.3.1: Trends in Telecommunication

Let us discuss these aforementioned trends in detail.

3.3.1 Industry Trends

Some of the major industry trends are:

- ◆ Telecommunications networks and services are available from numerous large and small telecommunications companies.
- ◆ Explosive growth of the Internet and the World Wide Web has created a host of new telecommunications products, services and providers.
- ◆ Business firms have dramatically increased their use of the Internet and the Web for electronic commerce and collaboration.

3.3.2 Technology Trends

Now-a-days, technology is moving towards:

- ◆ Open systems with unrestricted connectivity, using Internet networking technologies as their technology platform, are becoming the primary telecommunications technology drivers.

- ◆ Increased industry and technical moves towards building client/server networks based on open system architecture. Open systems are information systems that use common standards for hardware, software, applications, and networking. Any open system provides greater connectivity, that is, the ability of network computers and other devices to easily access and communicate with each other and share information. Open systems architecture also provides a high degree of network interoperability. That is, open systems enable many different applications of end users to be accomplished using the different varieties of computer systems, software packages, and databases provided by a variety of interconnected networks.
- ◆ Change from analog to digital network technologies. Local and global telecommunications networks are rapidly converting to digital transmission technologies that transmit information in the form of discrete pulses, rather than waves. Digital transmission offers higher transmission speeds (transmits with pulses), movement of greater amounts of information, greater economy, much lower error rates than analog systems, and telecommunications networks to carry multiple types of communications (data, voice, and video) on the same circuits. (Integrated Services Digital Network (ISDN) technology)
- ◆ Change in communications media. Many telecommunications networks are changing from copper wire-based media and land-based microwave relay systems to fiber-optic lines and communications satellite transmissions. Fiber-optic transmission, which uses pulses of a laser-generated light, offer significant advantages in terms of:
 - Reduced size and installation effort
 - Greater communication capacity,
 - Faster transmission speeds, and
 - Freedom from electrical interference.

3.3.3 Business Application Trends

Some of the today's application trends are:

- ◆ The trend toward more vendors, services, Internet technologies, and open systems, and the rapid growth of the Internet, the World Wide Web, and corporate intranets and extranets, dramatically increases the number of feasible telecommunications applications.
- ◆ Telecommunications networks are playing a vital and pervasive role in electronic commerce, enterprise collaboration, and internal business applications that support the operations, management, and strategic objectives of both large and small companies.
- ◆ Telecommunications functions have become an integral part of local and global computer networks that are used to dramatically:
 - Lock in customers and suppliers,

- Shorten business lead times and response times,
- Support electronic commerce,
- Improve the collaboration of workgroups,
- Develop new products and services,
- Share resources,
- Cut costs, and
- Develop online operational processes.

3.4 The Business Value of Telecommunications

Information technology, especially in telecommunications-based business applications, helps company overcome barriers to business success. The widely used information systems in enterprises are highly facilitated through telecommunication systems that help in increase in productivity and performance of an organization. The strategic capabilities of telecommunications and other information technologies include:

- ◆ Overcome geographic barriers: capture information about business transactions from remote locations.
- ◆ Overcome time barriers: Provide information to remote locations immediately after it is requested.
- ◆ Overcome cost barriers: Reduce the cost of more traditional means of communication.
- ◆ Overcome structural barriers: Support linkages for competitive advantage.

Organizations, therefore, in a telecommunication network can improve communication, reduce costs, improve efficiency, reduce errors and improve consistency under the light of the aforementioned capabilities of computer network.

3.5 Telecommunication Network

Telecommunications is a highly technical, rapidly changing field of information systems technology. Most end users do not need a detailed knowledge of its technical characteristics. However, they need a basic understanding and appreciation for some of the important characteristics of the basic components of telecommunications networks.

3.5.1 Need and Scope of Networks

As the business grows, good communication between employees is needed. The organizations can improve efficiency by sharing information such as common files, databases and business application software over a telecommunication network. With improvements in network capacity and the ability to work wirelessly or remotely, successful businesses should regularly re-evaluate their needs and their IT infrastructure. Here are some of the advantages of a computer network in an organization:

- (i) **File Sharing** - It provides sharing and grouping of data files over the network.
- (ii) **Resource Sharing** - It provides sharing of computer resources such as hard disk, printers etc. by multiple users simultaneously to reduce the cost of installing and maintaining multiple resources in the organization.
- (iii) **Remote Access** - Network allows users to remotely access the data and information from organization's network via Internet in cost effective manner.
- (iv) **Shared Databases** - Network facilitates simultaneous access to the shared databases to multiple users at the same time by ensuring the integrity of the database.
- (v) **Fault Tolerance** - By using network, fault tolerance can be implemented as a defense against accidental data loss. Usually, primary and secondary line of defense backups the data in case of system failure. Additional measures can also be taken by attaching a server with un-interruptible power supply in case of power failure or blackouts.
- (vi) **Internet Access and Security** - It provides access to the Internet for transferring the document and to access the resources available on World Wide Web by maintaining data security through firewall system in the organization's network.

3.5.2 Telecommunication Network Model

Generally, a communication network is any arrangement where a sender transmits a message to a receiver over a channel consisting of some type of medium.

Fig. 3.5.1 illustrates a simple conceptual model of a telecommunications network, which shows that it consists of five basic categories of components: Terminals, Telecommunications Processors, Telecommunications Media/Channels, Computers and Telecommunications Control Software.

A. Terminals: Terminals are the starting and stopping points in any telecommunication network environment. Any input or output device that is used to transmit or receive data can be classified as a terminal component. These include Video Terminals, Microcomputers, Telephones, Office Equipment and Transaction Terminals.

B. Telecommunications Processors: Telecommunications Processors support data transmission and reception between terminals and computers by providing a variety of control and support functions. They include Network Interface Card, Modem, Multiplexer and Internetworked Processors.

- ◆ **Network Interface Card (NIC):** Network Interface Card (NIC) is a computer hardware component that connects a computer to a computer network. It has additional memory for buffering incoming and outgoing data packets, thus improving the network throughput.
- ◆ **Modems:** A MODEM is a device that converts a digital computer signal into an analog telephone signal (i.e. it modulates the signal) and converts an analog telephone signal into a digital computer signal (i.e. it demodulates the signal) in a data communication system. The word "modem" is a contraction of modulate and demodulate. Modems are

required to send computer data with ordinary telephone lines because computer data is in digital form but telephone lines are analog.

- ◆ **Multiplexers:** A multiplexer is a communications processor that allows a single communications channel to carry simultaneous data transmissions from many terminals. Typically, a multiplexer merges the transmissions of several terminals at one end of a communications channel, while a similar unit separates the individual transmissions at the receiving end.
- ◆ **Internetwork Processors:** Telecommunications networks are interconnected by special-purpose communications processors called internetwork processors such as switches, routers, hubs, bridges, repeaters and gateways.
 - **Switch** - Switch is a communications processor that makes connections between telecommunications circuits in a network so that a telecommunications message can reach its intended destination.
 - **Router** – Router is a communications processor that interconnects networks based on different rules or *protocols*, so that a telecommunications message can be routed to its destination.
 - **Hub** – Hub is a port-switching communications processor. This allows for the sharing of the network resources such as servers, LAN workstations, printers, etc.
 - **Bridge** – Bridge is a communications processor that connects numerous Local Area Networks (LAN). It magnifies the data transmission signal while passing data from one LAN to another.
 - **Repeater** – Repeater is a communications processor that boosts or amplifies the signal before passing it to the next section of cable in a network.
 - **Gateway** – Gateway is a communications processor that connects networks that use different communication architectures.

C. Telecommunications Media/Channels: Telecommunications channels are the part of a telecommunications network that connects the message source with the message receiver. Data are transmitted and received over channels, which use a variety of telecommunications media.

Telecommunications media are grouped into Unguided Media and Guided Media.

- ◆ **Guided Media:** Guided Transmission Media uses a "cabling" system that guides the data signals along a specific path. The data signals are bound by the "cabling" system. Guided Media is also known as Bound Media. Some of the common examples of guided media are Twisted Pair, Coaxial cable and Fiber optics.
 - **Twisted-Pair Wire:** Twisted-pair is ordinary telephone wire, consisting of copper wire twisted into pairs. It is the most widely used media for telecommunications and is used for both voice and data transmissions. It is used extensively in home and

office telephone systems and many LANs and WANs. However, there are few disadvantages of the same. Twisted Pair Wire is susceptible to various types of electrical interference (noise), which limits the practical distances that data can be transmitted without being garbled. Signals must be “refreshed” every one to two miles through the use of repeaters, which are very expensive and does not offer security.

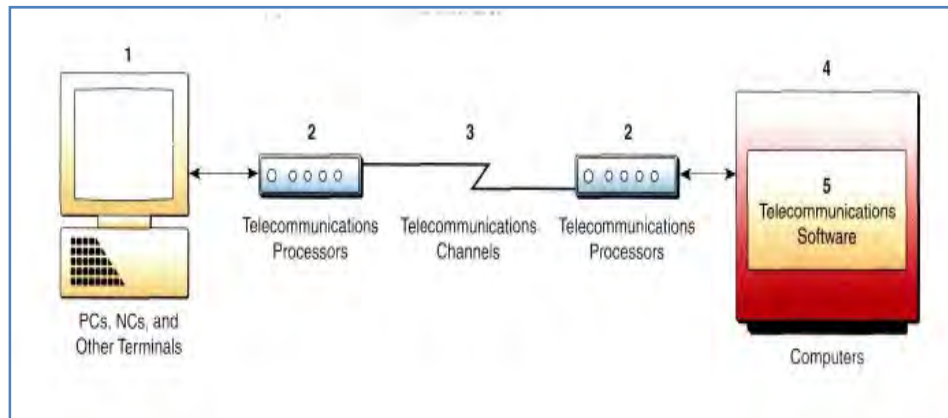


Fig. 3.5.1: Telecommunications Network Model

- **Coaxial Cable:** This telecommunications media consists of copper or aluminum wire wrapped with spacers to insulate and protect it. Insulation minimizes interference and distortion of the signals the cable carries. Coaxial cables can carry a large volume of data and allows high-speed data transmission used in high-service metropolitan areas for cable TV systems, and for short-distance connection of computers and peripheral devices. These cables can be bundled together into a much larger cable for ease of installation and can be placed underground and laid on the floors of lakes and oceans. It is used extensively in office buildings and other work sites for local area networks. The only disadvantage of coaxial cable is that it is more expensive than twisted pair.
- **Fiber Optics:** This media consists of one or more hair-thin filaments of glass fiber wrapped in a protective jacket. Signals are converted to light form and fired by laser in bursts. Optical fibers can carry digital as well as analog signals and provides increased speed and greater carrying capacity than coaxial cable and twisted-pair lines. It is not affected by electromagnetic radiation and not susceptible to electronic noise and so it has much lower error rates than twisted-pair and coaxial cable. Fiber optic cables are easy to install since they are smaller and more flexible and can be used undersea for transatlantic use. Speed of communications is 10,000 times faster than that of microwave and satellite systems.

Biggest disadvantages of using fiber optic cable are that installation can be difficult and costly to purchase.

- ◆ **Unguided Media:** Unguided Transmission Media consists of a means for the data signals to travel but nothing to guide them along a specific path. The data signals are not bound to a cabling media and as such are often called Unbound Media. Some of the common examples of unguided media are Terrestrial Microwave Systems, Radio waves, Micro Waves, Infrared Waves and Communications Satellites.
 - **Terrestrial Microwave:** Terrestrial microwave involves earthbound microwave systems, which transmit high-speed radio signals in a line-of-sight path between relay stations spaced approximately 30 miles apart. Terrestrial microwave media uses the atmosphere as the medium through which to transmit signals, and is used extensively for high-volume as well as long-distance communication of both data and voice in the form of electromagnetic waves. However major disadvantage of terrestrial microwave is that it cannot bend around the curvature of the earth.
 - **Radio Waves:** Wireless networks do not require any physical media or cables for data transmission. Radio waves are an invisible form of electromagnetic radiation that varies in wavelength from around a millimeter to 100,000 km, making it one of the widest ranges in the electromagnetic spectrum. Radio waves are most commonly used transmission media in the wireless Local Area Networks.
 - **Micro Waves:** Microwaves are radio waves with wavelengths ranging from as long as one meter to as short as one millimeter, or equivalently, with frequencies between 300 MHz (0.3 GHz) and 300 GHz. These are used for communication, radar systems, radio astronomy, navigation and spectroscopy.
 - **Infrared Waves:** Infrared light is used in industrial, scientific, and medical applications. Night-vision devices using infrared illumination allow people or animals to be observed without the observer being detected. Infrared tracking, also known as infrared homing, refers to a passive missile guidance system which uses the emission from a target of electromagnetic radiation in the infrared part of the spectrum to track it.
 - **Communication Satellites:** Communication satellites use the atmosphere (microwave radio waves) as the medium through which to transmit signals. A satellite is some solar-powered electronic device that receives, amplifies, and retransmits signals; the satellite acts as a relay station between satellite transmissions stations on the ground (earth stations). They are used extensively for high-volume as well as long-distance communication of both data and voice. It is cost-effective method for moving large quantities of data over long distances. However, satellites are very expensive to develop and place in orbit and have an age limit of 7-10 years. Signals weaken over long distances; weather conditions and solar activity can also cause noise interference. Anyone can listen in on satellite signals, so sensitive data must be sent in a secret, or encrypted, form.
- D. **Computers:** In a telecommunications networks, computers of all sizes and types are connected through media to perform their communication assignments. They include Host

Computers (mainframes), Front-End Processors (minicomputers) and Network Servers (microcomputers).

E. Telecommunications Control Software: This consists of programs that control telecommunications activities and manage the functions of telecommunications networks. They include Telecommunication Monitors (mainframe host computers), Network Operating Systems (microcomputer network servers) for network servers, Network Management Components and Communication Packages (Microcomputer Web browsers). This software can reside on almost any component of the network and can provide such features as performance monitoring, activity monitoring, priority assigning, transmission error correction and network problem mitigation.

- ◆ **Network Management:** Telecommunications software packages provide a variety of communication support services. For example, they work with a communications processor to connect and disconnect communications links and establish communications parameters such as transmission speed, mode, and direction. Examples of major network management functions include:
 - **Traffic management**– manages network resources and traffic to avoid congestion and optimize telecommunications service levels to users.
 - **Security**– provides authentication, encryption, and auditing functions, and enforces security policies.
 - **Network monitoring**– troubleshoot and watch over the network, informing network administrators of potential problems before they occur.
 - **Capacity planning**– surveys network resources and traffic patterns and users' needs to determine how best to accommodate the needs of the network as it grows and changes.

3.6 Types of Telecommunications Networks

There are many different types of telecommunications networks which can be classified on the basis of different factors like: Area Coverage Based, Functional Based, Ownership-based and Media-based etc. as briefed in the Table 3.6.1.

Table 3.6.1: Computer Networks Classification

1	Class I	Area Coverage Based Classification
	LAN	A Local Area Network (LAN) is a group of computers and network devices connected together, usually within the same building, campus or spanned over limited distance. It provides high speed data transfer and is relatively inexpensive.
	MAN	A Metropolitan Area Network (MAN) is a larger network that usually spans in the same city or town. Cable network is an example of a MAN.

	WAN	A Wide Area Network (WAN) is not restricted to a geographical location, although it might be confined within the bounds of a state or country. The technology is high speed and relatively expensive. The Internet is an example of a world-wide public WAN.
2	Class II	Functional Based Classification
	Client-Server	This partitions tasks or workloads between the providers of a resource or service, called servers, and service requesters, called clients.
	Peer-to-Peer	It is a type of decentralized and distributed network architecture in which individual nodes in the network (called "peers") act as both suppliers and consumers of resources
	Multi-Tier	
3	Class III	Ownership-based Classification
	Public Network	Network established for all users across the world is known as public network. Internet is an example of public network.
	Private Network	Private Network is used by particular organization, particular campus or particular enterprise only. This is a network that is not available to the outside world. Intranet is an example of it.
	Virtual Private Network (VPN)	A Virtual Private Network (VPN) is a network that uses a public network, such as the Internet, to provide secure access to organization's private network. A key feature of a VPN is its ability to work over both private networks as well as public networks like the Internet. Using a method called tunneling, a VPN uses the same hardware infrastructure as existing Internet or Intranet links.

A detailed discussion on the aforementioned networks is as follows:

3.6.1 Area Coverage Based Classification

A. Local Area Network (LAN)

Local area networks are telecommunications networks that connect information-processing devices within a limited physical area. These networks cover areas such as Offices, Classrooms, Buildings, Manufacturing plant etc.

Some of the characteristics of LANs include the following:

- LANs use a variety of telecommunications media, such as ordinary telephone wiring, coaxial cable, or wireless radio systems to interconnect microcomputer workstations and computer peripherals.
- To communicate over the network, a PC usually has a circuit board called a network interface card.

- Most LANs use a powerful microcomputer with a large disk capacity as a file server or network server that contains a network operating system (e.g., Novell NetWare) that controls telecommunications and the use of network resources.
- LANs allow end users in a workgroup to communicate electronically; share hardware, software, and data resources; and pool their efforts when working on group projects.

LANs on a distributed environment allow to have our own independent processing stations while sharing expensive computer resources like disk files, printers and plotters. Further LAN provides:

- (i) **Security** - Security for programs and data can be achieved using servers that are locked through both software and by physical means. Diskless nodes also offer security by not allowing users to download important data on floppies/CDs or upload unwanted software or virus.
 - (ii) **Expanded PC usage through inexpensive workstation** - Once a LAN has been set up, it actually costs less to automate additional employees through diskless PCs. Existing PCs can be easily converted into nodes by adding network interface cards.
 - (iii) **Distributed processing** - Many organizations operate as if they had distributed system in place. If numerous PCs are installed around the office, these machines represent the basic platform for a LAN with inter-user communication and information exchange.
 - (iv) **Electronic mail and Message Broadcasting**- Electronic mail allows users to communicate more easily among them. Messages to other users can be dropped into the recipient's mail-box and read by them when they log into the network.
 - (v) **Organizational Benefits** - LANs provide numerous benefits that include reduced costs in computer hardware, software and peripherals, and a drastic reduction in the time and cost of training or re-training manpower to use the systems.
 - (vi) **Data management benefits**-Since data is located centrally on the server, it becomes much easier to manage it, access it, as well as back it up.
 - (vii) **Software cost and up-gradation** - If the organization is concerned about using licensed software purchasing, a network version can save a lot of money since there would be no need to buy multiple copies of the same software for every machine in the organization. Therefore, software upgrades are much easier as any given package is stored centrally on the server.
- B. **Metropolitan Area Network (MAN)**: A Metropolitan Area Network (MAN) is somewhere between a LAN and a WAN. The term MAN is sometimes used to refer to networks which connect systems or local area networks within a metropolitan area (roughly 40 km in length from one point to another). A MAN interconnects computer resources in a

geographic area or region larger than that covered by a large LAN but smaller than the area covered by a WAN.

A MAN can support both data and voice. Cable television networks are examples of MANs that distribute television signals. A MAN just has one or two cables and does not contain switching elements.

- C. **Wide Area Network (WAN):** Wide Area Networks are telecommunications networks that cover large geographic areas with various communication facilities such as long distance telephone service, satellite transmission, and under-sea cables. These networks cover areas such as:

- Large city or metropolitan area
- Whole country
- Many countries and continents

Examples of WANs are interstate banking networks and airline reservation systems.

3.6.2 Functional Based Classification

A. Client-Server Networking

Client/Server (C/S) Networks: Client/server networks have become predominate information architecture of enterprise computing. Computing power has rapidly become distributed and interconnected throughout many organizations by networked computer systems that take the form of client/server networks. The Client/Server computing is an environment that satisfies the business need buy appropriate allocating the application processing between the client and the server processors.

- **Client:** A client is a single-user workstation that provides a presentation services and the appropriate computing, connectivity and the database services relevant t the business need. Client computers can be classified as **Fat Client**, **Thin Client** or **Hybrid Client**.
 - **Fat / Thick Client:** A fat client or thick client is a client that performs the bulk of any data processing operations itself, and does not necessarily rely on the server. Unlike thin clients, thick clients do not rely on a central processing server because the processing is done locally on the user system, and the server is accessed primarily for storage purposes. For that reason, thick clients often are not well-suited for public environments. To maintain a thick client, IT needs to maintain all systems for software deployment and upgrades, rather than just maintaining the applications on the server. For example – Personal Computer.
 - **Thin Client:** Thin clients use the resources of the host computer. A thin client generally only presents processed data provided by an application server, which performs the bulk of any required data processing. A thin client machine is going to communicate with a central processing server, meaning there is

little hardware and software installed on the user's machine. A device using web application (such as Office Web Apps) is a thin client.

- **Hybrid Client:** A hybrid client is a mixture of the above two client models. Similar to a fat client, it processes locally, but relies on the server for storing persistent data. This approach offers features from both the fat client (multimedia support, high performance) and the thin client (high manageability, flexibility). Hybrid clients are well suited for video gaming.
- **Server:** A server is one or more multi-user processors with share memory providing computing, connectivity and the database services and the interfaces relevant to the business need.

Working of a Client/Server Network: A typical Client/Server architecture has been shown in the Fig. 3.6.1.

- Servers are typically powerful computers running advanced network operating systems. Servers can host e-mail; store common data files and serve powerful network applications such as Microsoft's SQL Server. As a centerpiece of the network, the server validates login to the network and can deny access to both networking resources as well as client software.
- End user Personal Computer or Network Computer workstations are the Clients.
- Clients are interconnected by local area networks and share application processing with network servers, which also manage the networks. Client and Server can operate on separate computer platforms.
- Either the client platform or the server platform can be upgraded without having to upgrade the other platform.
- The server is able to service multiple clients concurrently; in some client/server systems, clients can access multiple servers.
- Action is usually initiated at the client end, not the server end.
- The network system implemented within the client/server technology is commonly called by the computer industry as **Middleware**. Middleware is all the distributed software needed to allow clients and servers to interact. General Middleware allows for communication, directory services, queuing, distributed file sharing, and printing.

A typical Client/Server architecture looks like Fig. 3.6.1.

Some of the prominent characteristics of C/S architecture are as follows:

- **Service:** C/S provides as clean separation of function based on the idea of service. The server process is a provider of services and the client is a consumer of services.

- **Shared Resources:** A server can service many clients at the same time and regulate their access to the shared resources.
- **Transparency of Location:** C/S software usually masks the location of the server from the clients by the redirecting the service calls when needed.
- **Mix-and-Match:** The ideal C/S software is independent of hardware or Operating System software platforms.
- **Scalability:** In a C/S environment, client workstations can either be added or removed and also the server load can be distributed across multiple servers.
- **Integrity:** The server code and server data is centrally managed, which results in cheaper maintenance and the guarding of shared data integrity. At the same time, the clients remain personal and independent.

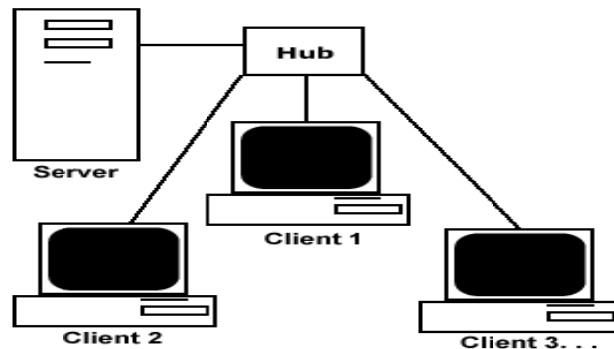


Fig. 3.6.1: Client/Server Components

Issues in Client/Server Network

- When the server goes down or crashes, all the computers connected to it become unavailable to use.
- Simultaneous access to data and services by the user takes little more time for server to process the task.

B. Peer-to-Peer Networking (P2P)

Peer-to-Peer Network: A Peer-to-Peer (P2P) network is created with two or more PCs connected together and share resources without going through a separate server computer. A P2P network can be an ad hoc connection - a couple of computers connected via a universal serial bus to transfer files. A P2P network also can be a permanent infrastructure that links half-dozen computers in a small office over copper wires. Refer to the Fig. 3.6.2.

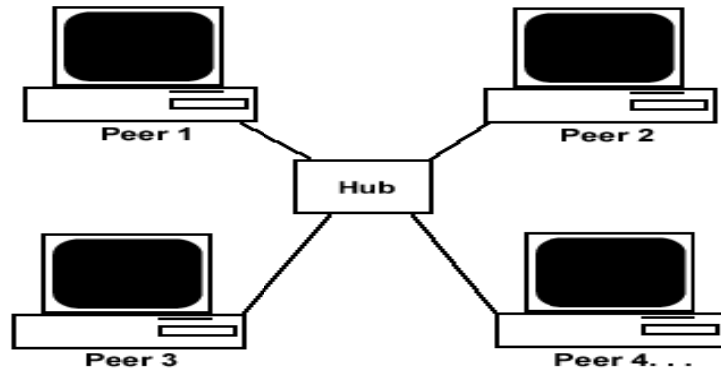


Fig. 3.6.2: Peer-to-Peer Architecture

The prime objective goal of a P2P (Peer-to-Peer) file-sharing network is that many computers come together and pool their resources to form a content distribution system. The computers are often simply home computers. They do not need to be machines in Internet data centers. The computers are called peers because each one can alternately act as a client to another peer, fetching its content, and as a server, providing content to other peers. Though there is no dedicated infrastructure, P2P networks handle a very high volume of file sharing traffic by distributing the load across many computers on the Internet. Everyone participates in the task of distributing content, and there is often no central point of control.

Configured computers in P2P workgroups allow sharing of files, printers and other resources across all of the devices. Peer networks allow data to be shared easily in both directions, whether for downloads to the computer or uploads from the computer. Because they do not rely exclusively on central servers, P2P networks both scale better and are more resilient than client-server networks in case of failures or traffic bottlenecks. A P2P network can be a network on a much grander scale in which special protocols and applications set up direct relationships among users over the Internet.

Advantages

Following are the major advantages of Peer-to-Peer networks:

- (i) Peer-to-Peer Networks are easy and simple to set up and only require a Hub or a Switch to connect all the computers together.
- (ii) It is very simple and cost effective.
- (iii) If one computer fails to work, all other computers connected to it continue to work.

Disadvantages

The major disadvantages of peer-to-peer networks are as below:

- (i) There can be problem in accessing files if computers are not connected properly.
- (ii) It does not support connections with too many computers as the performance gets degraded in case of high network size.
- (iii) The data security is very poor in this architecture.

C. Multi-Tier Architecture

A tier is a distinct part of hardware or software.

a. Single Tier Systems/ One-Tier architecture

A single computer that contains a database and a front-end (GUI) to access the database is known as Single Tier System. Generally, this type of system is used in small businesses.

One-tier architecture involves putting all of the required components for a software application or technology on a single server or platform. This kind of architecture is often contrasted with multi-tiered architecture or the three-tier architecture that's used for some Web applications and other technologies where various presentation, business and data access layers are housed separately. There is one computer which stores all of the company's data on a single database. The interface used to interact with the database may be part of the database or another program which ties into the database itself.

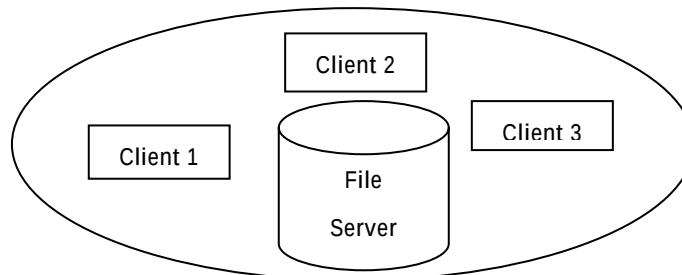


Fig. 3.6.3: Single Tier Architecture

Advantages: A single-tier system requires only one stand-alone computer. It also requires only one installation of proprietary software which makes it the most cost-effective system available.

Disadvantages: It can be used by only one user at a time. A single tier system is impractical for an organization which requires two or more users to interact with the organizational data stores at the same time.

b. Two Tier Systems

A two-tier system consists of a client and a server. A two-tier architecture is a software architecture in which a presentation layer or interface runs on a client, and a data layer or data structure gets stored on a server. In other words, the database is stored on the server, and the interface used to access the database is installed on the client.

Separating these two components into different locations represents two-tier architecture, as opposed to single-tier architecture. Other kinds of multi-tier architectures add additional layers in distributed software design. The user system interface is usually located in the user's desktop environment and the database management services are usually in a server that is more powerful machine that services many clients.

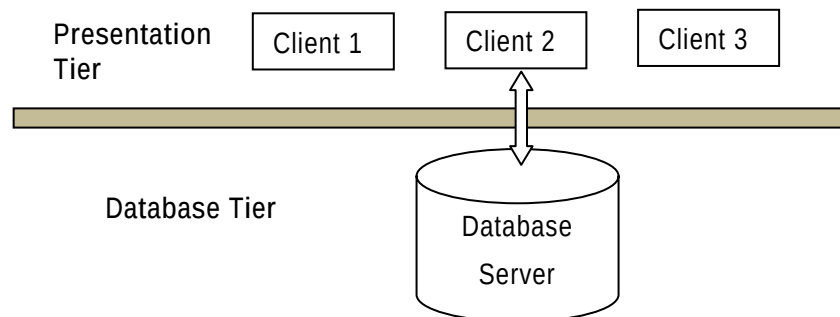


Fig. 3.6.4: 2-Tier Architecture

The advantages of Two-Tier systems are as follows:

- The system performance is higher because business logic and database are physically close.
- Since processing is shared between the client and server, more users could interact with system.
- By having simple structure, it is easy to setup and maintain entire system smoothly.

The disadvantages of Two-Tier systems are as follows:

- Performance deteriorates if number of users is greater than 100.
- There is restricted flexibility and choice of DBMS, since data language used in server is proprietary to each vendor.

c. n-tier Architecture

n-tier architecture is a client-server architecture in which presentation, application processing, and data management functions are logically separated. By segregating an application into tiers, developers acquire the option of modifying or adding a specific layer, instead of reworking the entire application. For example, an application that

uses middleware to service data requests between a user and a database employs multi-tier architecture. The most widespread use of multi-tier architecture is the Three-tier architecture.

Three Tier Architecture

Three-tier architecture is a client-server architecture in which the functional process logic, data access, computer data storage and user interface are developed and maintained as independent modules on separate platforms. Three-tier architecture is a software design pattern and well-established software architecture. Its three tiers are the presentation tier, application tier and data tier. The three tier architecture is used when an effective distributed client/server design is needed that provides (when compared to the two-tier) increased performance, flexibility, maintainability, reusability and scalability, while holding the complexity of distributed processing from the user.

The three tiers in three-tier architecture are:

- i. **Presentation Tier:** Occupies the top level and displays information related to services available on a website. This tier communicates with other tiers by sending results to the browser and other tiers in the network.
- ii. **Application Tier:** Also called the middle tier, logic tier, business logic or logic tier, this tier is pulled from the presentation tier. It controls application functionality by performing detailed processing.
- iii. **Data Tier:** Houses database servers where information is stored and retrieved. Data in this tier is kept independent of application servers or business logic.

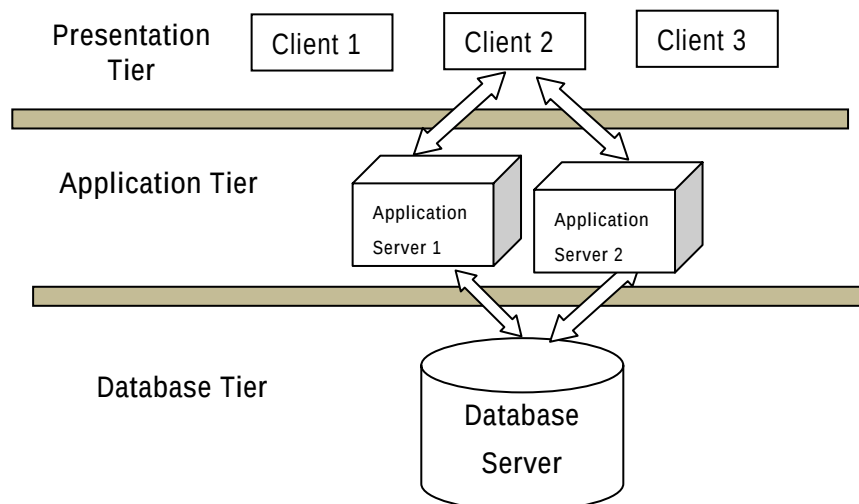


Fig. 3.6.5: Three-Tier Architecture

The following are the advantages of Three-Tier systems:

- **Clear separation of user-interface-control and data presentation from application-logic:** Through this separation more clients are able to have access to a wide variety of server applications. The two main advantages for client-applications are clear: quicker development through the reuse of pre-built business-logic components and a shorter test phase, because the server-components have already been tested.
- **Dynamic load balancing:** If bottlenecks in terms of performance occur, the server process can be moved to other servers at runtime.
- **Change management:** It is easy and faster to exchange a component on the server than to furnish numerous PCs with new program versions.

The disadvantages of Three-Tier systems are as below:

- It creates an increased need for network traffic management, server load balancing, and fault tolerance.
- Current tools are relatively immature and are more complex.
- Maintenance tools are currently inadequate for maintaining server libraries. This is a potential obstacle for simplifying maintenance and promoting code reuse throughout the organization.

3.6.3 Ownership Based Classification

- A. **Public Data Network:** A public data network is defined as a network shared and accessed by users not belonging to a single organization. It is a network established and operated by a telecommunications administration, or a recognized private operating agency, for the specific purpose of providing data transmission services for the public. The Internet is an example of a Public Data Network.
- B. **Private Data Network:** Private data networks provide businesses, government agencies and organizations of all sizes a dedicated network to continuously receive and transmit data critical to both the daily operations and mission critical needs of the organization.

Fig. 3.6.6 displays the difference between Private and Public data Networks.

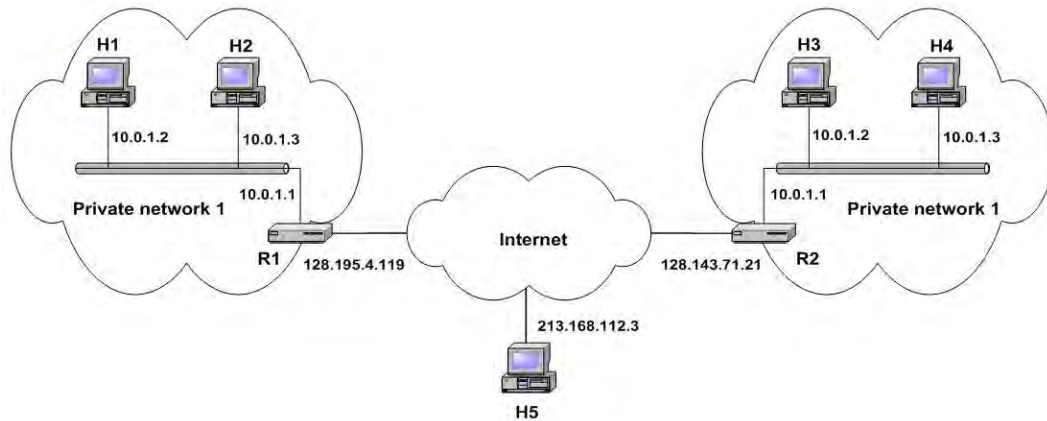


Fig. 3.6.6: Public vs. Private Network

- C. **Virtual Private Networks (VPN):** Many companies have offices and plants scattered over many cities, sometimes over multiple countries. In the olden days, before public data networks, it was common for such companies to lease lines from the telephone company between some or all pairs of locations. Private networks work fine and are very secure. If the only lines available are the leased lines, no traffic can leak out of company locations and intruders have to physically wiretap the lines to break in, which is not easy to do. The problem with private networks is that leasing a dedicated line between two is too expensive.

This demand soon led to the innovation of VPNs (Virtual Private Networks), which are overlay networks on top of public networks but with most of the properties of private networks. They are called “virtual” because they are merely an illusion, just as virtual.

Many organizations use Virtual Private Networks (VPNs) to establish secure intranets and extranets. A VPN is a private network that uses a public network (usually the Internet) to connect remote sites or users together. The VPN uses “virtual” connections routed through the Internet from the business's private network to the remote site or employee. By using a VPN, businesses ensure security -- anyone intercepting the encrypted data can't read it.

VPN is a secure network that uses the Internet as its main backbone network, but relies on the firewalls and other security features of the Internet and Intranet connections and those of participating organizations.

3.7 Network Computing

The growing reliance on the computer hardware, software, and data resources of the Internet, Intranets, extranets, and other networks has emphasized that for many users “the network is the computer”.

Fig. 3.7.1 depicts network computing model.

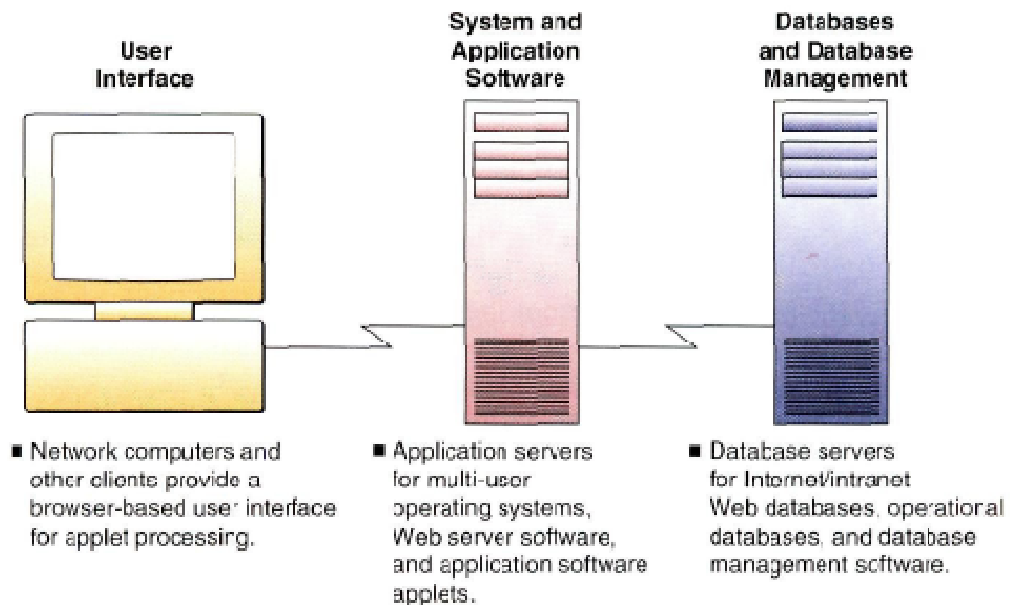


Fig. 3.7.1: Network Computing

This network computing, or network-centric, concept views networks as the central computing resource of any computing environment. Features of network computing include:

- ◆ Network computers provide a browser-based user interface for processing small application programs called applets.
- ◆ Network computers are microcomputers without floppy or hard disk drives that are designed as low-cost networking computing devices.
- ◆ Servers provide the operating system, applets, databases, and database management software needed by the end users in the network.

Centralised Computing: Centralized computing is computing done at a central location, using terminals that are attached to a central computer. The computer itself may control all the peripherals directly (if they are physically connected to the central computer), or they may be attached via a terminal server. It offers greater security over decentralized systems because all of the processing is controlled in a central location. In addition, if one terminal breaks down, the user can simply go to another terminal and log in again, and all of their files will still be accessible. Depending on the system, they may even be able to resume their session from the point they were at before, as if nothing had happened.

This type of arrangement does have some disadvantages. The central computer performs the computing functions and controls the remote terminals. This type of system relies totally on the central computer. Should the central computer crash, the entire system will "go down" (i.e. will be unavailable).

Another disadvantage is that central computing relies heavily on the quality of administration and resources provided to its users. Should the central computer be inadequately supported by any means (e.g. size of home directories, problems regarding administration), then your usage will suffer greatly. The reverse situation, however, (i.e., a system supported better than your needs) is one of the key advantages to centralized computing.

Decentralized Computing: Decentralized computing is the allocation of resources, both hardware and software, to each individual workstation, or office location. In contrast, centralized computing exists when the majority of functions are carried out, or obtained from a remote centralized location. A collection of decentralized computers systems are components of a larger computer network, held together by local stations of equal importance and capability. These systems are capable of running independently of each other. Decentralized systems enable file sharing and all computers can share peripherals such as printers and scanners as well as modems, allowing all the computers in the network to connect to the internet.

However, in case of up-gradation, all computers have to be updated individually with new software, unlike a centralized computer system.

3.7.1 Network Topologies

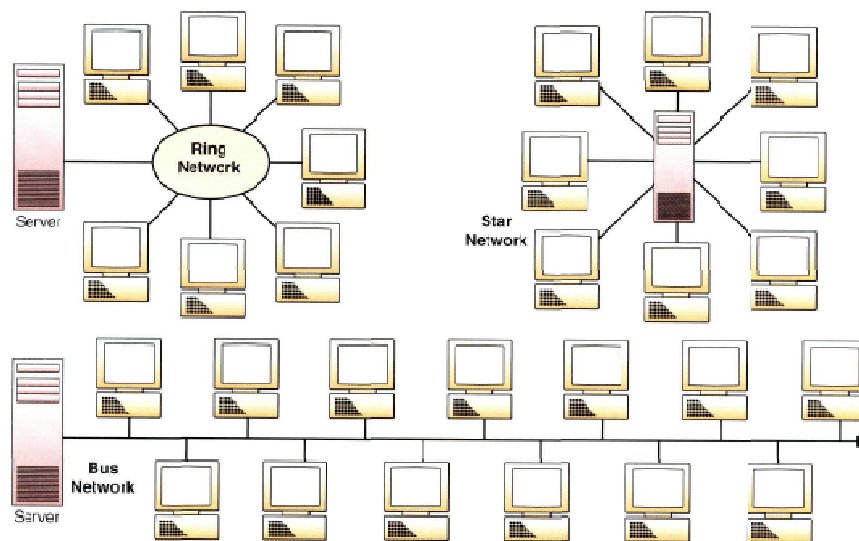


Fig. 3.7.1: Ring, Star and Bus Topologies

There are several basic types of network topologies, or structures, in telecommunications networks as shown in the Fig. 3.7.1. Four basic topologies used in wide area and local area telecommunications networks are the:

- ◆ Star network
- ◆ Ring network

- ◆ Bus network
- ◆ Mesh Network
- A. **Star Network:** The star network, a popular network configuration, involves a central unit that has a number of terminals tied into it. The characteristics of a star network are:
 - It ties end user computers to a central computer.
 - The central unit in the star network acts as the traffic controller among all the other computers tied to it. The central computer is usually a mainframe (host), which acts as the file server.
 - A star network is well suited to companies with one large data processing facility shared by a number of smaller departments. Many star networks take the form of hierarchical networks with a centralized approach.

Advantages of the star network include:

- Several users can use the central unit at the same time.
- It is easy to add new nodes and remove existing nodes.
- A node failure does not bring down the entire network.
- It is easier to diagnose network problems through a central hub.

Disadvantages of the star network are:

- The whole network is affected if the main unit “goes down,” and all communications stop.
- Considered less reliable than a ring network, since the other computers in the star are heavily dependent on the central host computer. If it fails, there is no backup processing and communications capability and the local computers will be cut off from the corporate headquarters and from each other.
- Cost of cabling the central system and the points of the star network together are very high.

- B. **Bus Network:** In a bus network, a single length of wire, cable, or optical fiber connects a number of computers. The features of a bus network are as follows:
 - All communications travel along this cable, which is called a bus.
 - Bus networks have a decentralized approach.

Advantages of bus network include:

- There is no host computer or file server, which makes bus network reliable as well as easy to use and understand.
- If one of the microcomputers fails, it will not affect the entire network.

- Requires the least amount of cable to connect the computers together and therefore is less expensive than other cabling arrangements.
- Is easy to extend. Two cables can be easily joined with a connector, making a longer cable for more computers to join the network.
- A repeater can also be used to extend a bus configuration.

Disadvantages of bus network include:

- Heavy network traffic can slow a bus considerably since any computer can transmit at any time. But networks do not coordinate when information is sent. Computers interrupting each other can use a lot of bandwidth.
- Each connection between two cables weakens the electrical signal.
- The bus configuration can be difficult to troubleshoot. A cable break or malfunctioning computer can be difficult to find and can cause the whole network to stop functioning.

C. Ring Network: A ring network is much like a bus network, except the length of wire, cable, or optical fiber connects to form a loop. The characteristics of a ring network are:

- Local computer processors are tied together sequentially in a ring with each device being connected to two other devices.
- A ring network has a decentralized approach.
- When one computer needs data from another computer, the data is passed along the ring.
- Considered more reliable and less costly than star networks because if one computer fails, the other computers in the ring can continue to process their own work and communicate with each other.

Advantages of ring network include:

- Ring networks do not require a central computer to control activity nor does it need a file server.
- Each computer connected to the network can communicate directly with the other computers in the network by using the common communication channel, and each computer does its own independent applications processing.
- The ring network is not as susceptible to breakdowns as the star network, because when one computer in the ring fails, it does not necessarily affect the processing or communications capabilities of the other computers in the ring.
- Ring networks offer high performance for a small number of workstations or for larger networks where each station has a similar workload.
- Ring networks can span longer distances than other types of networks.

- Ring networks are easily extendable.

Disadvantages of ring network are:

- Relatively expensive and difficult to install.
- Failure of one computer on the network can affect the whole network.
- It is difficult to troubleshoot a ring network.
- Adding or removing computers can disrupt the network.

- D. **Mesh Network:** In this structure, there is random connection of nodes using communication links. A mesh network may be fully connected (as shown in Fig 3.7.2) or connected with only partial links. In fully interconnected topology, each node is connected by a dedicated point to point link to every node. The reliability is very high as there are always alternate paths available if direct link between two nodes is down or dysfunctional. Fully connected networks are not very common because of the high cost. Only military installations, which need high degree of redundancy, may have such networks, that too with a small number of nodes.

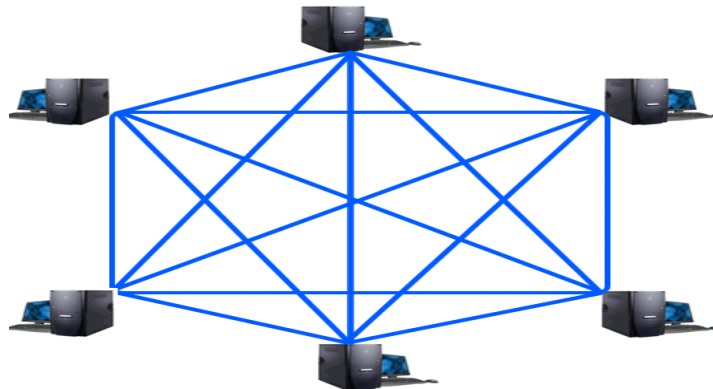


Fig. 3.7.2: Mesh Network

Advantages of mesh network are as under:

- Yields the greatest amount of redundancy in the event that if one of the nodes fails, the network traffic can be redirected to another node.
- Network problems are easier to diagnose.

Disadvantage of mesh network is its high cost of installation and maintenance (more cable is required than any other configuration).

3.7.2 Transmission Technologies

A given transmission on a communication channel between two machines can occur in several different ways. The transmission is characterized by: