



# Data Communications and Networks

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# Introduction

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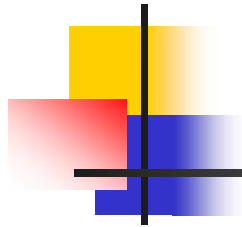
- Computers were originally developed as standalone, single-user systems. Stand-alone computers can receive user's data, manipulate them and provide useful information for making decisions. Here, the user uses his own data for his own decision making purposes. When the use of computers spread across government offices and business organizations, a number of issues were raised.
- What if a user wants to share his computer generated information with other colleagues?
- What if a user wants to explore the possibility of using certain information stored elsewhere?
- These issues were addressed by the subsequent developments in software, hardware and communication technologies which have enabled the computers to communicate between each other and exchange information quickly and accurately and at any time.



# Introduction

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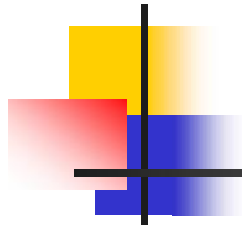
- The process of electronic transfer of information between two locations is known as data communication. The five basic elements of data communication are:
  - Message: It is the information to be communicated. It may be in the form of text, pictures, audio, video, or any combination of these.
  - Sender: It is the device that creates and transmits the information.
  - Receiver: It is the device that receives the information.
  - Medium: It is the communication channel through which the information travels from sender to receiver. It could be a physical wire or radio waves.
  - Protocol: It represents a set of rules that governs the communication process between the sender and the receiver.
- Data communication may occur in a simple point-to-point mode or in a multipoint mode where more than two computers are connected together in the form of a network. A network is a system of interconnected computers that can communicate with one another to share applications and data.



# Computer Network

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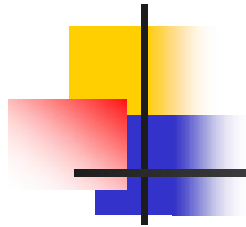
- Computer network is a system of interconnected computers that enable the computers to communicate with each other and share their resources, data and application.
- The physical location of each computer is tailored to personal and organizational needs. A network may include only personal computers or a mix of PCs, minis and mainframes spanning a particular geographical area.
- Computer networks that are commonly used today may be classified as follows:



# Computer Network

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- Based on geographical area:
  - Local Area Networks (LANs)
  - Wide Area Networks (WANs)
  - Metropolitan Area Networks (MANs)
  - International Network (Internet)
  - Intranet



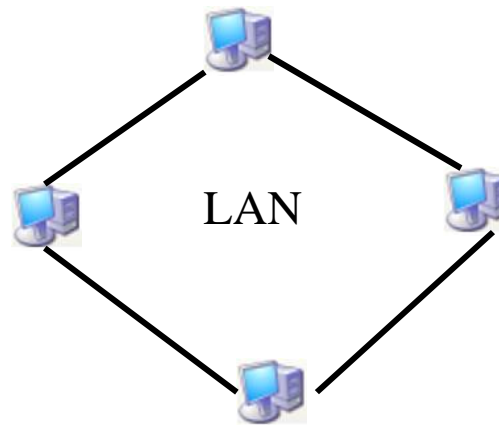
# Computer Network

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- Based on how computer nodes are used:
  - Client Server Networks (CSNs)
  - Peer-to-Peer Networks (PPNs)
  - Valued-added Networks (VANs)

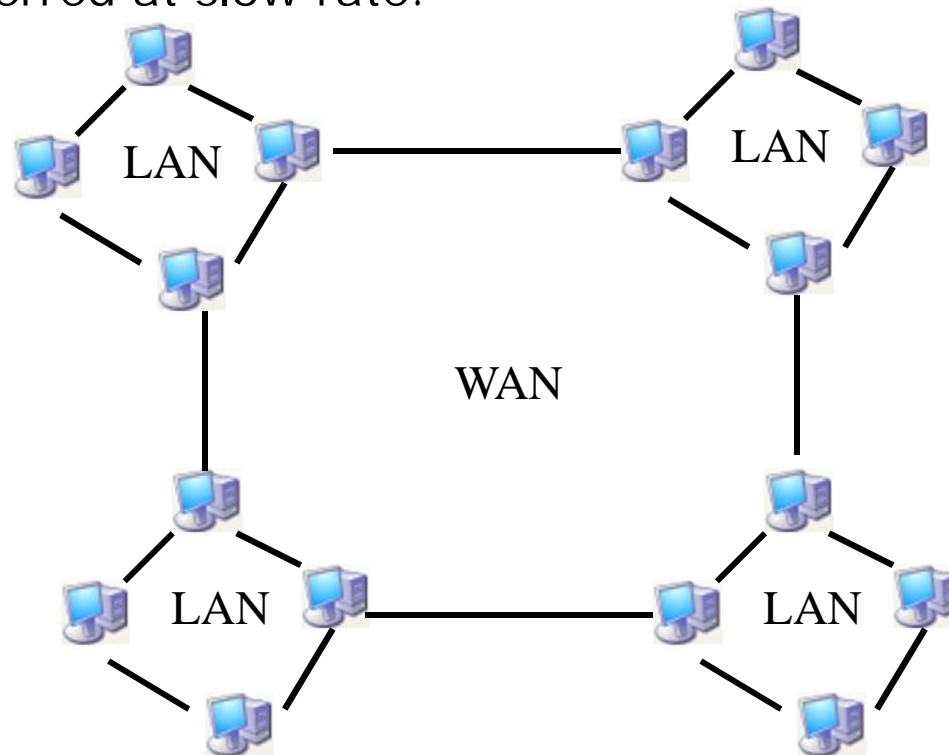
# Local Area Network (LAN)

- LAN is a group of computers that are connected in a small area such as building, home, etc.
- Through this type of network, users can easily communicate with each other by sending and receiving messages.
- Though the number of computers connected in a LAN is limited, the data is transferred at an extremely faster rate.



# Wide Area Network (WAN)

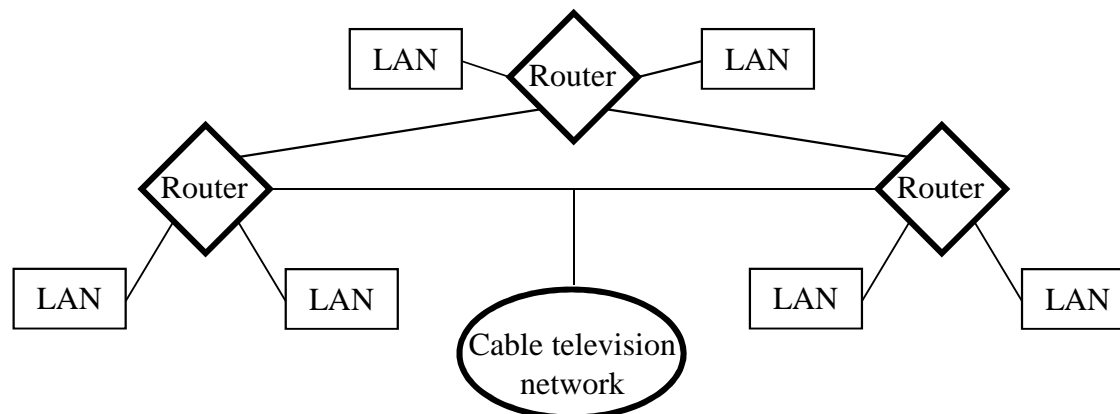
- WAN is a group of computers that are connected in a large area such as continent, country, etc. WAN is generally used for connecting two or more LANs through some medium such as leased telephone lines, microwaves, etc. In WAN, data is transferred at slow rate.





# Metropolitan Area Network (MAN)

- MAN is a network of computers that covers a large area like a city. The size of the MAN generally lies between that of LAN and WAN, typically covering a distance of 5Km to 50 Km.
- The geographical area covered by MAN is comparatively larger than LAN but smaller than WAN. MAN is generally owned by private organizations.
- MAN is generally connected with the help of optical fibres, copper wires etc. One of the most common example of MAN is cable television network within a city. A network device known as router is used to connect the LANs together. The router directs the information packets to the desired destination.





# The Internet

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- The Internet is a global area network that allows computers connected over the network to share resources and information using different protocols. It is basically a network of networks across the globe.
- Users at different locations can very easily communicate with each other via the Internet. The Internet basically uses a set of protocols such as Transmission Control Protocol/Internet Protocol (TCP/IP) for transferring the data over the network. The following are the different types of services provided by the Internet to the users:
  - E-mail
  - Online chat
  - Online shopping
  - ...



# The Internet

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- There are various advantages of using the Internet:
  - Information: The Internet allows users to access large amount of information efficiently.
  - Availability: The Internet is available continuously to the users all the time without any delay. Users can access the information from the Internet at any time.
  - Cost: The Internet provides different facilities to the users at a low cost. Users can access any website over the Internet absolutely free. The cost of sending messages through e-mail is also cheaper as compared to postal messages.



# The Internet

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- The following are some of the disadvantages of using the Internet:
  - Hacking: The process of illegally accessing the personal information stored over the Internet is called hacking.
  - Virus: The software program that itself gets activated in our computer system and destroys the stored information is called virus. Virus usually corrupts the resources that are connected over the Internet.
  - Bulk e-mail: It is the most common problem of the Internet where the unwanted bulk messages such as subscription mails, advertisement mails, job alert mails etc. are received on the users account. These messages are sometimes frustrating and irritating for the users because the user simply does not require these mails.



# The Intranet

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- Intranet is a private network, which is confined at a single organization only. This type of computer network allows only the internal users of the organization to share the resources. However, the users outside the organization can also access the Intranet but they can do so only if they are authorized.
- The concept of Intranet was used for sharing the company's information amongst the employees. Certain protocols such as TCP/IP, HTTP, etc. are used by Intranet for enabling the communication between the computer systems.
- The website of the Intranet is provided with the firewall, which is a layer that helps in ensuring the security of the information and resources.
- The only disadvantage of Intranet is that it is relatively insecure as compared to the other networks.



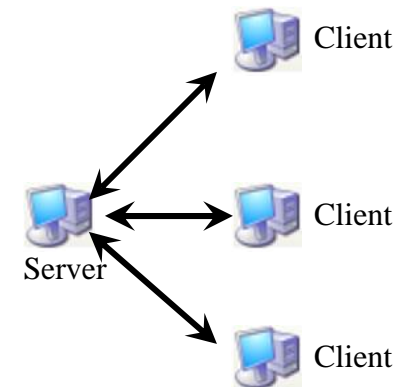
# The Intranet

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- The various advantages of using Intranet are as follows:
  - ▣ It allows the employees of an organization to access the organizations' information easily and quickly
  - ▣ Intranet users can easily communicate with each other within the organization
  - ▣ It is relatively easier to maintain and implement Intranet than the Internet

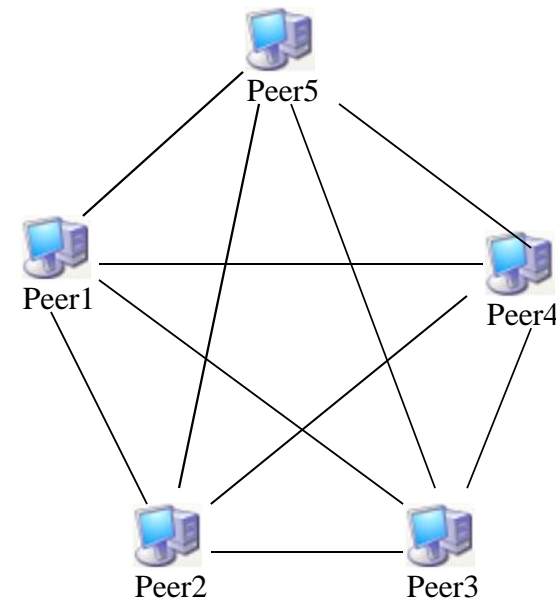
# Client Server Network (CSN)

- CSN basically consists of two computers, client computer and server computer. The client computers are dummy computers, which simply send requests to the server computer, whereas the server computers receive and execute the requests sent by the client computer.
- CSN is also known as the client server architecture. This architecture is a two-tier architecture, which is divided into two layers. The first layer comprises of the user interface that is located on the client's desktop. On the other hand, the second layer is the database management layer, which is located on the server machine so as to provide services to the clients.
- In CSN, a client computer sends a request related to processing of data to the server. The server receives the request from the client computer and processes the data. It then sends the output obtained after the processing of data to the client computer as a response to its request.



# Peer-to-peer Network (PPN)

- In PPN, there is no separate division as clients and servers. Every computer in the PPN is treated equally and can send as well as receive the messages directly.
- PPN architecture cannot work under heavy load. This type of architecture is commonly used for file sharing and chatting in real time.
- Computers connected in this network can easily share their resources with the other computers. PPN is used in a variety of fields such as business, education, telecommunications, military etc.







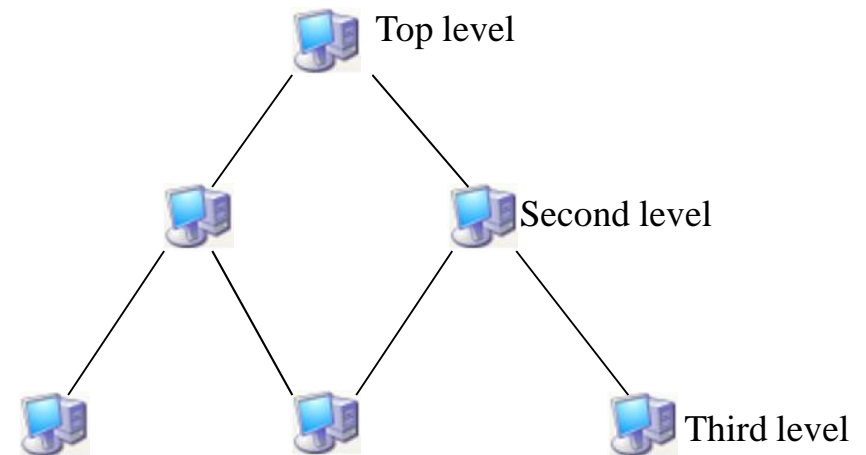
# Network Topologies

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- Network topology refers to the arrangement of computers connected in a network through some physical medium such as cable, optical fibre etc. Topology generally determines the shape of the network and the communication path between the various computers (nodes) of the network. The various types of network topologies are as follows:
  - Hierarchical topology
  - Bus topology
  - Star topology
  - Ring topology
  - Mesh topology
  - Hybrid topology

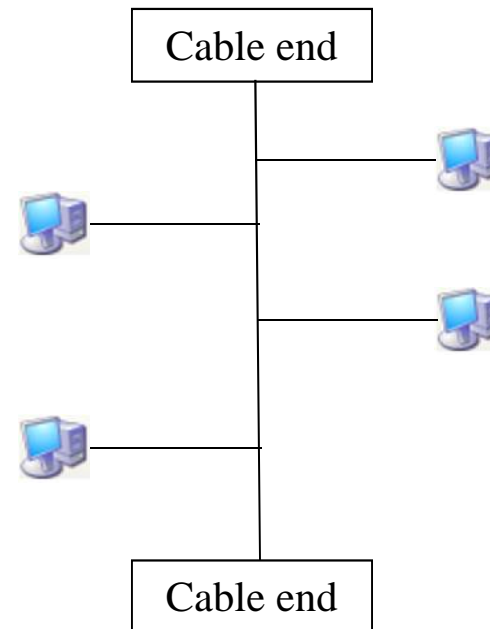
# Hierarchical Topology

- The hierarchical topology is also known as tree topology, which is divided into different levels.
- This type of topology is arranged in the form of a tree structure in which top level contains parent node (root node), which is connected with the child nodes in the second level of hierarchy with the point-to-point link.
- The second level nodes are connected to the third level nodes, which in turn are connected to the fourth level nodes and so on.
- Except the top-level node, each level node has a parent node.



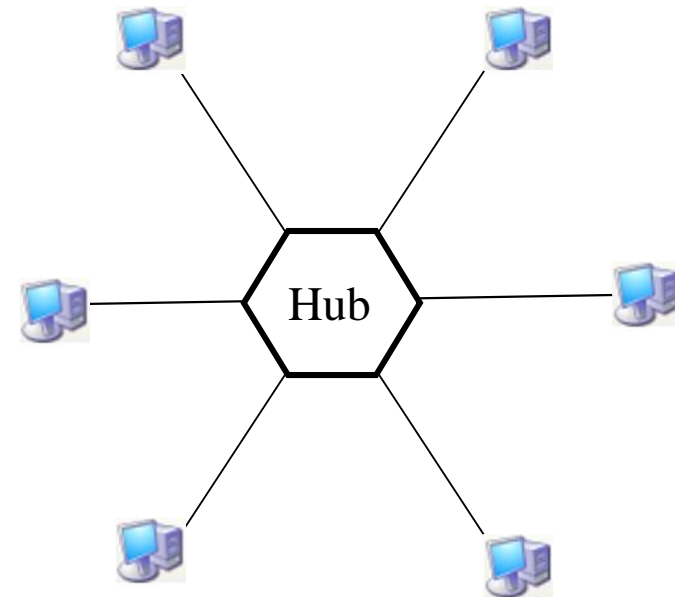
# Linear Bus Topology

- In the linear bus topology, all the nodes are connected to the single backbone or bus with some medium.
- When a node wants to communicate with the other nodes in the network, it simply sends a message to the common bus. All the nodes in the network then receive the message but the nodes for which it was actually sent only processes it. The other nodes discard the message.



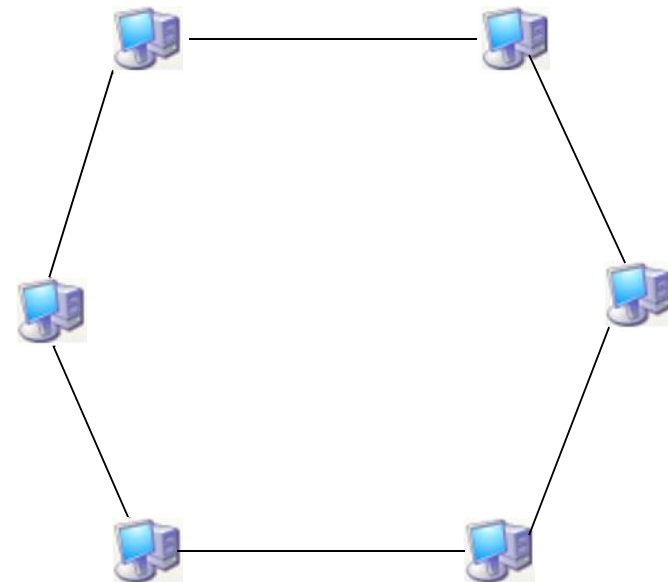
# Star Topology

- In the star topology, all the nodes are connected to a common device known as hub.
- When a node wants to send a message to the other nodes, it first sends the message to the hub, which in turn forwards the message to the intended node.
- Each node in the network is connected with a point-to-point line to the centralized hub. The task of hub is to detect the faulty node present in the network. On the other hand, it also manages the overall data transmission in the network.



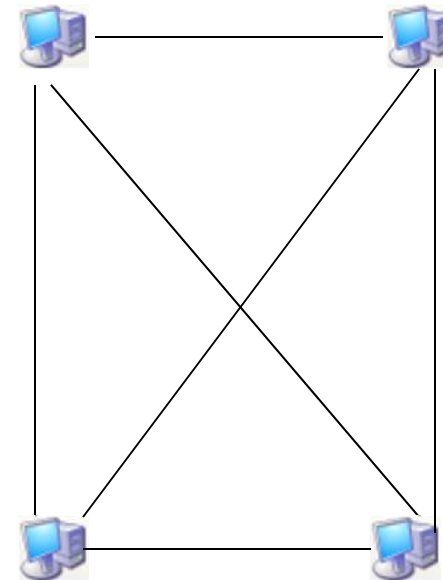
# Ring Topology

- In the ring topology, the nodes are connected in the form of a ring. Each node is connected directly to the other two nodes in the network.
- The node, which wants to send a message, first passes the message to its consecutive node in the network.
- Data is transmitted in the clockwise direction from one node to another.
- Each node incorporates a repeater, which passes the message to next node when the message is intended for another node.



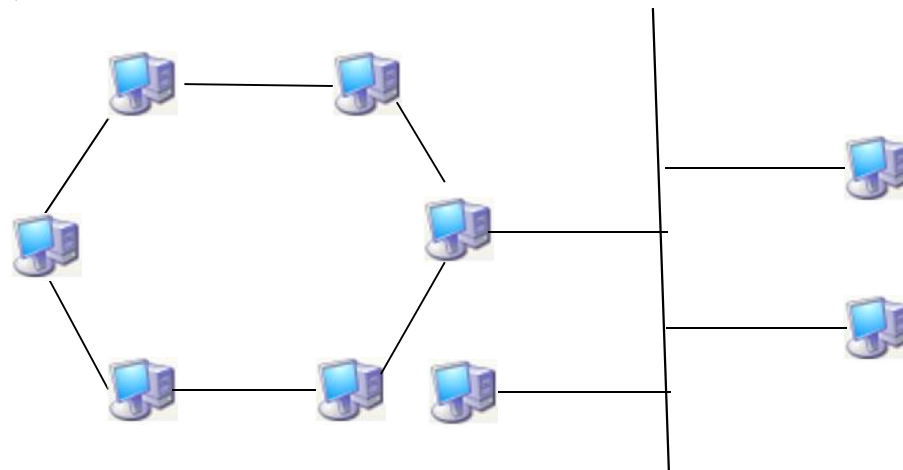
# Mesh Topology

- In mesh topology, each computer is connected to every other computer in point-to-point mode.
- For example, if we have four computers, we must have six links. If we have  $n$  computers, we must have  $n(n-1)/2$  links.
- A message can take several possible paths to reach a destination.



# Hybrid Topology

- The hybrid topology is the combination of multiple topologies, used for constructing a single large topology.
- The hybrid topology is created when two different network topologies are interconnected. If two ring topologies are connected then the resultant topology is not the hybrid topology.
- On the other hand, if the ring topology is connected to the bus topology then the resulting topology is called the hybrid topology. This topology generally combines the features of the two topologies and is therefore more effective and efficient than the individual topologies.





# Network Media

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- Network media refers to the physical media used to connect the computer nodes together. There are many types of transmission media, the most popular ones are:
- Cables: Some of the commonly used cables are telephone lines, twisted-pair cables, coaxial cables. Cable is one of the easiest methods of transferring messages from one place to another.
- Optical fibre: A thin strand of glass that transmits pulsating beams of light rather than electric current. These light pulses carry information. Fibre-optic cables can thus carry information in digital form. They can carry enormous amount of messages at extremely fast speed. These are used for long distance communications. It is a highly secured transmission medium.

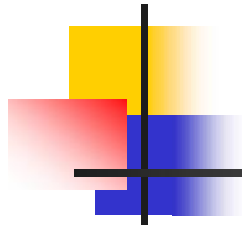




# Network Media

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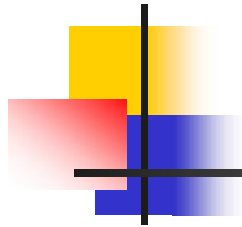
- Microwave: communication through microwave can be used when the transmitting and receiving ends are located at a large distance from one another. Microwaves are used to transmit analog signals. WANs often use microwave links to connect LANs together. This mode of transmission is greatly affected by the weather conditions.
- Satellite: Satellites are used for receiving and transmitting analog signals globally. We can send data from one country to another with the help of satellites. WANs that cover long distances often use satellites for linking LANs.



# Network Protocol

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- In order to share data between computers, it is essential to have appropriate network protocols and software. With the help of network protocol, computers can easily communicate with each other and can share data, resources etc.
- Network protocols are the set of rules and regulations that are generally used for communication between two networks.
- Any two networks communicate with each other by sending and receiving messages in the form of packets. The techniques that is used separating a message into packets is called packet switching.
- Each packet contains the address of the computer from which the message was sent and also of the computer, which will receive the message. In order to send the packet, routers and switches are connected over the network path that forwards, the packet to the intended receiver.



# Network Protocol

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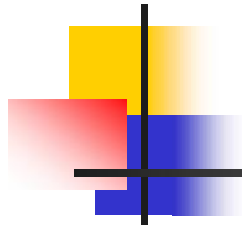
- Using network protocol, the following tasks can be performed:
  - ▣ Identification of the type of the physical connection used
  - ▣ Error detection and correction of the improper message
  - ▣ Initiation and termination of the communication session
  - ▣ Message formatting
- Some of the commonly used network protocols are Hyper Text Transfer protocol (HTTP), Simple Mail Transfer Protocol (SMTP), File Transfer Protocol (FTP), Transmission Control Protocol/Internet Protocol (TCP/IP), Telecommunications Network (Telnet), Domain Name System (DNS) etc.



# Network Software

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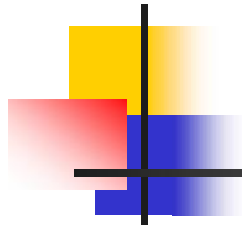
- Network software refers to the set of instructions that are given to the computers connected in a network to perform different tasks. These instructions are given in the form of a program, which is usually written in some programming language such as C++, Java, C etc.
- The network software generally provides support to the computers connected in a network so that they can communicate with each other by exchanging information.
- Network operating system software is the type of network software that basically controls the network traffic, access to the network resources such as printers, files, etc. This type of software generally provides multiuser, multitasking facilities so as to ensure effective communication between the computers over the network. It also establishes the communication between multiple computers that are performing a single task.



# Applications of Network

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- Network is the system of computers generally linked together to enable the flow of data between the interconnected computers. With the help of network, we can access the data remotely. Some of the applications of a network are:
  - ▣ Data sharing: In order to share the data among multiple users, it is generally stored on the servers. Different applications can therefore access the data from these servers easily.
  - ▣ Remote data access: Remote data access is the process of accessing the data from remote location in an efficient way. Different software programs are used to provide an interface to the end users for accessing the data remotely.

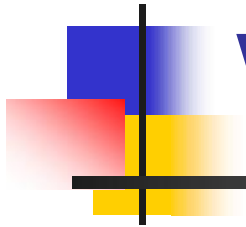


# Applications of Network

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- Resource sharing: It is the process of sharing the resources such as storage devices, input/output devices, etc. over the network. For example, printer can be shared among the computers connected in a network by attaching it to the server computer. When the users want their documents to be printed they can simply give the print command from there computers and get their document printed. The sharing of a printer on a network is relatively cheaper than attaching separate printers to the individual computer connected in the network.
- Personal communication: The far-reaching applications of networks are electronic mail and teleconferencing. These applications allow individuals as well as organizations to use networks for exchanging messages (written, voice and video) extensively. Emails enables a person to send and receive instant messages over a computer network with the help of Internet. On the other hand, teleconferencing enables real-time communication over a distance by allowing people at different locations to communicate with each other by seeing the video picture of people at other sites.

# The Internet and World Wide Web





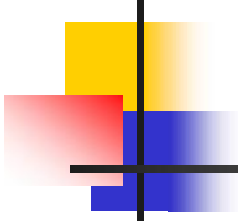
# The Internet and World Wide Web

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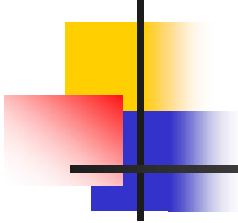
- Internet is a popular buzzword among many people today. Almost everyone working in government offices and business organizations is using the Internet for exchange of information in one form or the other.
- World Wide Web is another popular phrase among the computer users. It is commonly referred to as the Web. Most people consider the Internet and the World Wide Web to be synonymous, but they are not. Although these two terms are used interchangeably, they actually describe two different but related things.



# The Internet and World Wide Web

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- The Internet is a massive network of networks that links together thousands of independent networks thus bringing millions of computers on a single network to provide a global communication system. It acts as a facilitator for exchange of information between computers that are connected to the Internet. It is like a network of roads in a country that facilitates the movement of vehicles around the country.
  - We can create special documents known as hypertext documents containing text, graphics, sounds and video on a computer. The storage location of these documents is known as website. The World Wide Web is the network of all such websites all around the world. It is popularly known as WWW or Web. The websites are spread across the Internet and therefore, the information contained in the websites can be transmitted through the Internet. It is like transporting the goods stored in the warehouses using the road network. So the Web is just a portion on the Internet and not same as the Internet.

# Understanding the World Wide Web

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- WWW is a collection of web servers, which contain several web pages pertaining to different websites. The web pages contain hypertext, simple text, images, videos and graphics. The web pages are designed with the help of HyperText Markup Language (HTML).
  - To view the web pages provided by a web server, the software known as web browser is required. To display the web pages, a web browser runs the HTML code segment written for a particular web page. Each web page on the Internet is provided its own address known as Uniform Resource Identifier (URI or URL).
  - This URL helps the web browser in locating a web page on the Internet. A URL string begins with the name of a protocol such as http or ftp that represents the protocol through which a web page is accessed. The rest of the URL string contains the domain server name of the web page being accessed and the location of the web page on the local web server.



# Web Browsers

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- Web browser is the software, which is used to access the Internet and the WWW. It is basically used to access and view the web pages of the various websites available on the Internet. A web browser provides many advanced features that help achieve easy access to the Internet and WWW.
- When we open a web browser, the first page, which appears in the web browser window, is the home page set of that particular web browser.
- The most commonly used web browsers are Internet Explorer (IE), Netscape Navigator and Mozilla Firefox.

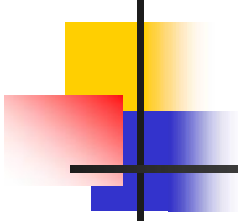


# Protocols Used for the Internet

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- Each computer on a network has a unique address, which is known as the Internet Protocol (IP) address.
- An IP address is a group of four numbers and the numbers are separated from each other by a dot. When any data is sent from one computer to another computer over the network, it is divided into small modules known as packets or datagrams. These packets are transmitted on the network by the Internet Protocol.
- Each packet transmitted on the network contains the addresses of both source and destination computer. A gateway present on the network reads the address of the destination computer and sends the data to the specified address. Gateway is a computer, which contains the software required for the transmission of data over different networks.

# Protocols Used for the Internet

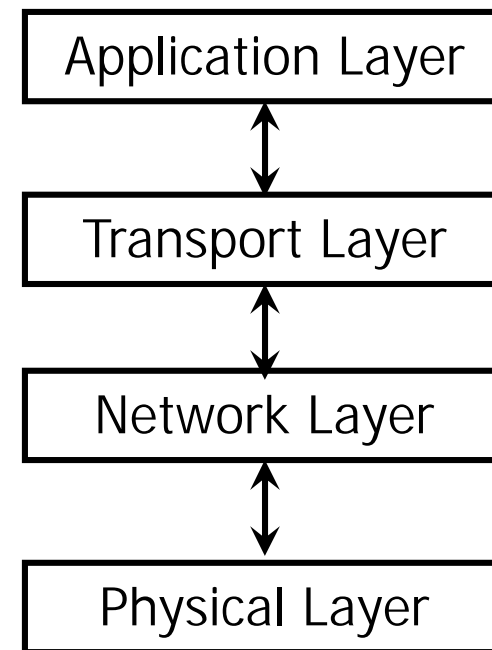
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- Each packet on the network is an independent entity, so they are transferred through different routes to reach the destination computer.
  - The packets received at the destination are not in the same sequence in which they were transmitted. As a result, these packets are arranged in a right sequence by a protocol known as TCP and then are merged at the destination to form the complete data.
  - TCP and IP work in coordination with other protocols such as Telnet and User Datagram Protocol (UDP) but are considered as the most fundamental of all protocols. All these protocols are collectively known as TCP/IP suite.
  - A model known as TCP/IP model determines how the protocols of the TCP/IP suite will work together for the transfer of data between computers in a network.



# TCP/IP Model

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- The TCP/IP model was initially developed by US Defence Advanced Research Projects Agency (DARPA). This model is also known as the Internet Reference model or DoD model. It consists of four layers, namely application layer, transport layer, network layer, and physical layer.
- The physical layer in the TCP/IP model is responsible for interacting with the medium of transmission of data, whereas the application layer helps in interacting with the users. The four layers of TCP/IP and the functions performed by these layers are as follows:





# TCP/IP Model

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- Application layer: It is responsible for managing all the user interface requirements. Many of the protocols, such as telnet, FTP, SMTP, DNS, NFS, LPD, and DHCP work on this layers.
- Transport layer: It is responsible for the delivery of packets or datagrams. It also hides the packet routing details form the upper layer, i.e. the application layer. In addition, the transport layer allows detection and correction of errors and helps to achieve end-to-end communication between devices. The transport layer connects the application layer to the network layer through two protocols , namely TCP and UDP.



# TCP/IP Model

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- Network layer: It contains three protocols that perform different functions:
  - Internet Protocol (IP): IP is a connectionless protocol that is responsible for the delivery of packets. The IP protocol contains all the address and control information for each transmitted packet.
  - Internet Control Message Protocol (ICMP): It is responsible for reporting errors, sending error messages and controlling the flow of packets. It is more reliable than the IP as it is capable of determining errors during data transmission
  - Address Resolution Protocol (ARP): It is responsible for determining the Media Access Control (MAC) address corresponding to an IP address. It sends an ARP request on the network for a particular IP address and the device, which identifies the IP address as its own, returns an ARP reply along with its MAC address.





# TCP/IP Model

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- Physical layer: It is responsible for collecting packets so that the frames, which are transmitted on the network, can be formed. It performs all the functions required to transmit the data on the network and determining the ways for accessing the medium through which data will be transmitted. This layer does not contain any protocols but instead of protocols, it contains some standards such as RS-232C, V.35 and IEEE 802.3.