**COMPUTER NETWORK & DATA COMMUNICATIONS**

Unit I:

Introduction: Data Communications and Networking for Today's Enterprise - A Communications Model - Data Communications - Networks - The Internet. The Need for a Protocol Architecture - The TCP/IP Protocol Architecture - The OSI Model - Standardization within a Protocol Architecture - Traditional Internet-Based Applications ~ Multimedia

DATA COMMUNICATIONS

definition

- ❖ Data Communication is defined as exchange of data between two devices via some form of transmission media such as a cable, wire or it can be air or vacuum also.

- ❖ For occurrence of data communication, communicating devices must be a part of communication system made up of a combination of hardware or software devices and programs.

- ❖ Data can be any text, image, audio, video, and multimedia files. Communication is an act of sending or receiving data.

- ❖ Thus, data communication refers to the exchange of data between two or more networked or connected devices.

- ❖ communication is a process or act in which we can send or receive data.

- ❖ A network of computers is defined as an interconnected collection of autonomous computers. Autonomous means no computer can start, stop or control another computer.
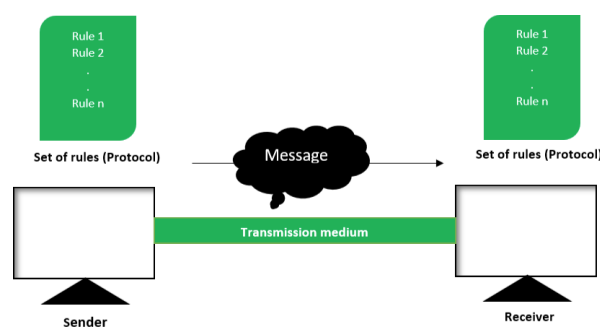
**Data Communication System Components :**

There are mainly five components of a data communication system:

1. Message

2. Sender

3. Receiver

4. Transmission Medium

5. Set of rules (Protocol)

1. **Message:** A message is a piece of information that is to be transmitted from one person to another. It could be a text file, an audio file, a video file, etc.
2. **Sender:** It is simply a device that sends data messages. It can be a computer, mobile, telephone, laptop, video camera, or workstation, etc.
3. **Receiver:** It is a device that receives messages. It can be a computer, telephone mobile, workstation, etc.
4. **Transmission Medium / Communication Channels:** Communication channels are the medium that connect two or more workstations. Workstations can be connected by either wired media or wireless media.
5. **Set of rules (Protocol):** When someone sends the data (The sender), it should be understandable to the receiver also otherwise it is meaningless.

DATA COMMUNICATION MODEL IN NETWORKING

The basic communication model in computer networking is where the Sender (encodes the message) channel sends a message over a channel or medium and receiver (decodes the message) .
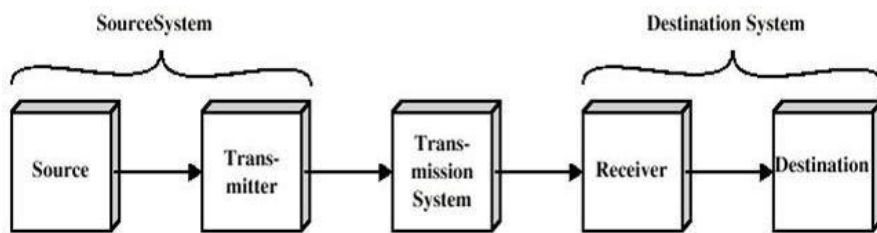
The components involved in the successful implementation of the basic communication model are as follows –

- **Sender** – Who sends the message.
- **Encodes** – Translates messages into symbols like words, pictures, sound, etc.
- **Channel or medium** – It used to transmit messages. Some channels are face-to-face communication, over telephone, letters, television, newspapers, radio, etc.
- **Decode** – Receiver decodes these symbols to understand what the sender wants to say.
- **Receiver** – A person who receives the message.
- **Feedback** – After receiving a message, the receiver sends feedback to the sender, answer and what he understands from the message.
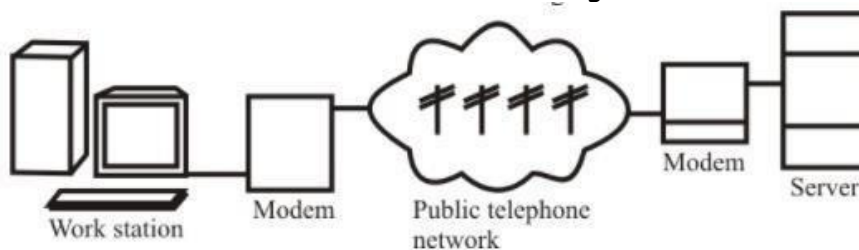
INTRODUCTION TO NETWORK
Definition
A computer network is a system in which multiple computers are connected to each other to share information and resources.

- o Computer Network is a group of computers connected with each other through wires, optical fibres or optical links so that various devices can interact with each other through a network.
- o The aim of the computer network is the sharing of resources among various devices.
- o In the case of computer network technology, there are several types of networks that vary from simple to complex level.


The features of a computer network are –

- Sharing – Computer networks enable sharing of files, software, hardware resources and computing capabilities.
- Speed: The communication speed among the components is fast enough to be comparable with a centralized system.
- Scalability – Sizes of computer networks dynamically increase with time. The networks have to be scalable so that they can evolve adequately for future deployments.
- Integration – All the components of the network work in a coordinated manner for a seamless user experience.
- Security – Networks allow security and access rights to the users for restricted sharing of resources and information.
- Cost Effectiveness – Networking reduces the deployment cost of hardware and software of a centralized system.

Computer Network Types
A computer network is a group of computers linked to each other that enables the computer to communicate with another computer and share their resources, data, and applications.
A computer network can be categorized by their size.

A **computer network** is mainly of **four types**:
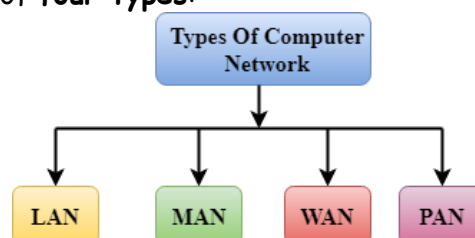
- o LAN(Local Area Network)
- o MAN(Metropolitan Area Network)
- o WAN(Wide Area Network)

LAN(Local Area Network)
- o Local Area Network is a group of computers connected to each other in a small area such as building, offices, schools, colleges or universities
- o LAN is used for connecting two or more personal computers through a communication medium such as twisted pair, coaxial cable, etc.
- o It is less costly as it is built with inexpensive hardware such as hubs, network adapters, and ethernet cables.
- o The data is transferred at an extremely faster rate in Local Area Network.
- o Local Area Network provides higher security.
- o LAN provides a useful way of sharing the resources between end users.The resources such as printers, file servers, scanners, and internet are easily sharable among computers.
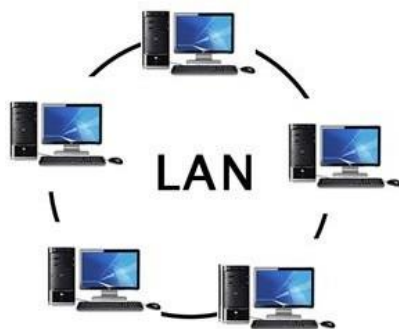
MAN(Metropolitan Area Network)
- o A metropolitan area network is a network that covers a larger geographic area by interconnecting a different LAN to form a larger network.
- o Government agencies use MAN to connect to the citizens and private industries.
- o In MAN, various LANs are connected to each other through a telephone exchange line.
- o The most widely used protocols in MAN are RS-232, Frame Relay, ATM, ISDN, OC-3, ADSL, etc.
- o It has a higher range than Local Area Network(LAN).
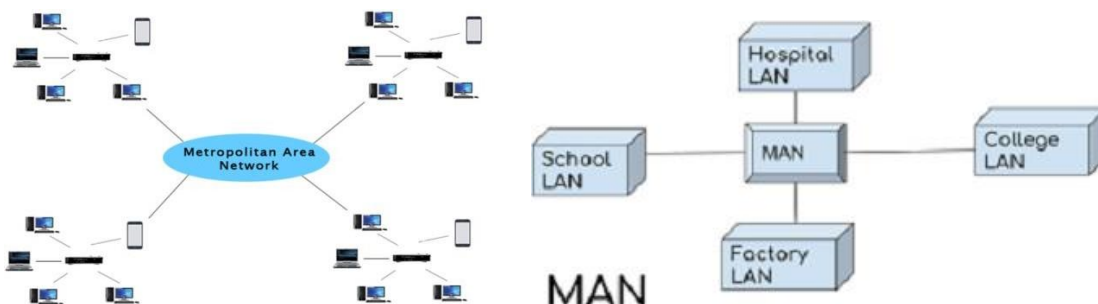
Uses Of Metropolitan Area Network:

- o MAN is used in communication between the banks in a city.
- o It can be used in an Airline Reservation.
- o It can be used in a college within a city.
- o It can also be used for communication in the military.
- o etropolitan Area Network (MAN)
- o This kind of network covers a metropolitan area like a town or city. A MAN is setup by connecting local area networks of a town or city. It is the best network for the people of a specific region to share any information or data.
- o

WAN(Wide Area Network)

- o A Wide Area Network is a network that extends over a large geographical area such as states or countries.
- o A Wide Area Network is quite bigger network than the LAN.
- o A Wide Area Network is not limited to a single location, but it spans over a large geographical area through a telephone line, fibre optic cable or satellite links.
- o The internet is one of the biggest WAN in the world.
- o A Wide Area Network is widely used in the field of Business, government, and education.
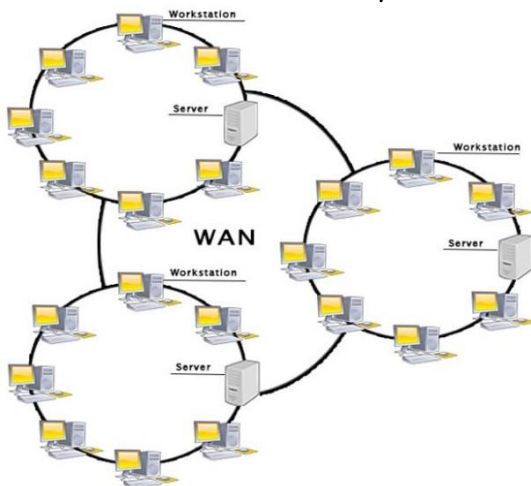
Examples Of Wide Area Network:

- o Mobile Broadband: A 4G network is widely used across a region or country.
- o Last mile: A telecom company is used to provide the internet services to the customers in hundreds of cities by connecting their home with fiber.
- o Private network: A bank provides a private network that connects the 44 offices. This network is made by using the telephone leased line provided by the telecom company.

INTERNET

Internet is defined as an Information super Highway, to access information over the web. However, It can be defined in many ways as follows:

- Internet is a world-wide global system of interconnected computer networks.
- Internet uses the standard Internet Protocol (TCP/IP).

- Every computer in internet is identified by a unique IP address.
- IP Address is a unique set of numbers (such as 110.22.33.114) which identifies a computer location.
- A special computer DNS (Domain Name Server) is used to give name to the IP Address so that user can locate a computer by a name

Evolution

The concept of Internet was originated in 1969 and has undergone several technological & Infrastructural changes as discussed below:

- The origin of Internet devised from the concept of **Advanced Research Project Agency Network (ARPANET).**
- **ARPANET** was developed by United States Department of Defense.
- Basic purpose of ARPANET was to provide communication among the various bodies of government.
- Initially, there were only four nodes, formally called **Hosts.**
- In 1972, the **ARPANET** spread over the globe with 23 nodes located at different countries and thus became known as **Internet.**
- By the time, with invention of new technologies such as TCP/IP protocols, DNS, WWW, browsers, scripting languages etc.,Internet provided a medium to publish and access information over the web.

Advantages

Internet covers almost every aspect of life, one can think of. Here, we will discuss some of the advantages of Internet:
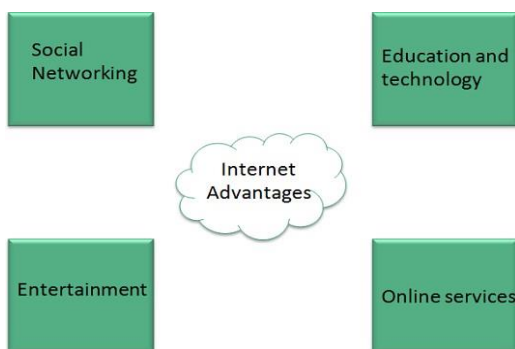

- Internet allows us to communicate with the people sitting at remote locations. There are various apps available on the wed that uses Internet as a medium for communication. One can find various social networking sites such as:
    - Facebook
    - Twitter
    - Yahoo
    - Google+
    - Flickr
    - Orkut

- One can surf for any kind of information over the internet. Information regarding various topics such as Technology, Health & Science, Social Studies, Geographical Information, Information Technology, Products etc can be surfed with help of a search engine.
-
- Apart from communication and source of information, internet also serves a medium for entertainment. Following are the various modes for entertainment over internet.
    - Online Television
    - Online Games
    - Songs
    - Videos
    - Social Networking Apps

- Internet allows us to use many services like:
    - Internet Banking
    - Matrimonial Services
    - Online Shopping
    - Online Ticket Booking
    - Online Bill Payment
    - Data Sharing
    - E-mail

Disadvantages

However, Internet has prooved to be a powerful source of information in almost every field, yet there exists many disadvanatges discussed below:
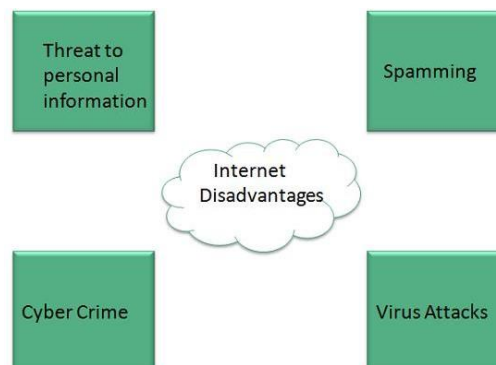
- There are always chances to loose personal information such as name, address, credit card number. Therefore, one should be very careful while sharing such information. One should use credit cards only through authenticated sites.
- Another disadvantage is the **Spamming**.Spamming corresponds to the unwanted e-mails in bulk. These e-mails serve no purpose and lead to obstruction of entire system.
- **Virus** can easily be spread to the computers connected to internet. Such virus attacks may cause your system to crash or your important data may get deleted.
- There are various websites that do not provide the authenticated information. This leads to misconception among many people.

THE NEED FOR A PROTOCOL ARCHITECTURE

A protocol is simply defined as a set of rules and regulations for data communication.

Rules are basically defined for each and every step and process at time of communication among two or more computers.

Networks are needed to follow these protocols to transmit data successfully. All protocols might be implemented using hardware, software, or combination of both of them.

There are three aspects of protocols given below :

- **Syntax**–
  It is used to explain data format that is needed to be sent or received.
- **Semantics**–
  It is used to explain exact meaning of each of sections of bits that are usually transferred.
- **Timings**–
  It is used to explain exact time at which data is generally transferred along with speed at which it is transferred

TCP/IP REFERENCE MODEL

TCP/IP Reference Model is a four-layered suite of communication protocols. It was developed by the DoD (Department of Defence) in the 1960s. It is named after the two main protocols that are used in the model, namely, TCP and IP. TCP stands for Transmission Control Protocol and IP stands for Internet Protocol.

The four layers in the TCP/IP protocol suite are –

- **Host-to- Network Layer** –It is the lowest layer that is concerned with the physical transmission of data. TCP/IP does not specifically define any protocol here but supports all the standard protocols.
- **Internet Layer** –It defines the protocols for logical transmission of data over the network. The main protocol in this layer is Internet Protocol (IP) and it is supported by the protocols ICMP, IGMP, RARP, and ARP.
- **Transport Layer** – It is responsible for error-free end-to-end delivery of data. The protocols defined here are Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).
- **Application Layer** – This is the topmost layer and defines the interface of host programs with the transport layer services. This layer includes all high-level protocols like Telnet, DNS, HTTP, FTP, SMTP, etc.

The following diagram shows the layers and the protocols in each of the layers –
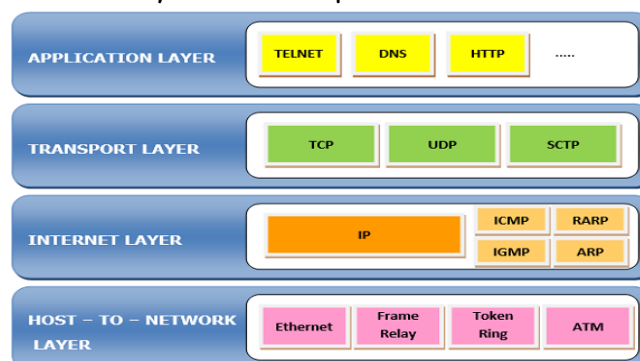
Key features

TCP/IP model represents the Transmission Control Protocol / Internet Protocol.
TCP/IP model depends on standard protocols about which the computer network has created. It is a connection protocol that assigns the network of hosts over the internet.
The protocols were created first and then built the TCP/IP model.
It does not provide quality services.
It does not mention the services, interfaces, and protocols.
The TCP/IP model protocols are not hidden, and we cannot fit a new protocol stack in it.
It is simpler than OSI.
It provides connectionless transmission in the network layer and supports connecting and connectionless-oriented transmission in the transport layer.
It uses a vertical approach.
The smallest size of the TCP/IP header is 20 bytes.
In TCP/IP, returning protocol is not difficult.

OSI Reference Model

 OSI or Open System Interconnection model was developed by International Standards Organization (ISO). It gives a layered networking framework that conceptualizes how communications should be done between heterogeneous systems.

It has seven interconnected layers.

The seven layers of the OSI Model are a physical layer, data link layer, network layer, transport layer, session layer, presentation layer, and application layer, as shown in the following diagram –
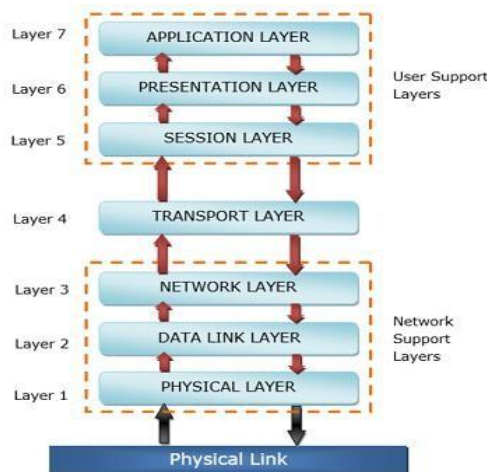
The physical layer, data link layer and the network layer are the network support layers. The layers manage a physical transfer of data from one device to another. Session layer, presentation layer, and application layer are the user support layers. These layers allow communication among unrelated software in dissimilar environments. Transport layer links the two groups.

The main functions of each of the layers are as follows –

- **Physical Layer** – Its function is to transmit individual bits from one node to another over a physical medium.
- **Data Link Layer** – It is responsible for the reliable transfer of data frames from one node to another connected by the physical layer.
- **Network Layer** – It manages the delivery of individual data packets from source to destination through appropriate addressing and routing.
- **Transport Layer** –It is responsible for delivery of the entire message from the source host to destination host.
- **Session Layer** – It establishes sessions between users and offers services like dialog control and synchronization.
- **Presentation Layer** – It monitors syntax and semantics of transmitted information through translation, compression, and encryption.
- **Application Layer** – It provides high-level APIs (application program interface) to the users.

Key features

OSI represents Open System Interconnection.
OSI is a generic, protocol independent standard. It is acting as an interaction gateway between the network and the final-user.
The OSI model was developed first, and then protocols were created to fit the network architecture's needs.
It provides quality services.
The OSI model represents defines administration, interfaces and conventions. It describes clearly which layer provides services.
The protocols of the OSI model are better unseen and can be returned with another appropriate protocol quickly.
It is difficult as distinguished to TCP/IP.
It provides both connection and connectionless oriented transmission in the network layer; however, only connection-oriented transmission in the transport layer.
It uses a horizontal approach.
The smallest size of the OSI header is 5 bytes.

Protocols are unknown in the OSI model and are returned while the technology modifies.

STANDARDIZATION WITHIN A PROTOCOL ARCHITECTURE
Traditional Internet-Based Applications

WebProtocols

Three key standards associated with the world wide web:

- o HyperText Markup Language (HTML) - spec for content and layout of web pages
- o Uniform Resource Locator (URL) - specs format and meaning of web page identifiers
- o HyperText Transfer Protocol (HTTP) - specs how data is transferred between browser (client) and server.

Document Representation with HTML

An HTML document is a plain text file

- However HTML can specify web pages that contain multimedia
- HTML documents tell WHAT must be done, not HOW it will be done.
- HTML gives guidelines for display, not specifics.
- This gives the browser flexibility to vary the display according to the capabilities of the underlying hardware.
- The general form of an HTML document is illustrated by this example:

Uniform Resource Locators and Hyperlinks
The user of a browser specifies the resource s/he wants with a *Uniform Resource Locator (URL)*. The syntax is:

> *protocol://computer_name:port/document_name?parameters*

- Some popular protocols used in browsers are:

  - o *HyperText Transfer Protocol (HTTP),*
  - o *Hypertext Transfer Protocol over Secure Socket Layer (HTTPS),* and
  - o *File Transfer Protocol (FTP)*

Web Document Transfer with HTTP

Web browsers and servers communicate according to the HyperText Transfer Protocol (HTTP)

- The four basic operations available to HTTP clients are
  - o GET (to get status information and an item (e.g. an HTML document),
  - o HEAD (to get only status information about an item),
  - o POST (to add to an item stored on the server -- e.g. a list of messages), and

o   PUT (to replace an item stored on the server).

Browser Architecture

Web browsers are more complicated than web servers. Parts of a web browser include

- A controller to manage a GUI and call other modules (clients and interpreters)
- HTML interpreter to render HTML documents
- other interpreters (e.g. for various image formats)
- drivers to be used by interpreters to create output
- HTTP client to make requests from servers - using HTTP protocol
- other clients (e.g. e-mail, FTP, HTTPS) for using other client protocols,
- network interface for clients to use for communication

File Transfer Protocol (FTP)

In the early days of networking it quickly became apparent that there was a need for general file transfer software - to transfer various types of files between various types of computers.

- FTP:
    o   deals well with differences between computing systems,
    o   transfers files in both directions
    o   permits transfer of arbitrary data, and
    o   deals well with file permissions and ownership.
    o   allows browsing through file systems
    o   utilizes plain text control messages
- FTP has been around longer than IP or TCP.
- Users are often not aware of it but FTP is used for almost all the downloading done with web browsers and other network applications.

Electronic Mail

The typical old style e-mail transmission goes like this:

    o   User employs an email interface program to compose a message and place it in an outgoing queue
    o   The e-mail transfer program (mail transfer agent, MTA) running on the user's computer finds the message in the queue, opens a connection to the mail server on the destination machine and sends the message.
    o   The mail server on the destination machine places the message into the intended recipient's mail box
    o   The recipient uses an email interface program to view the contents of her mailbox
    o   The categories of protocol standards used for Internet email

The Simple Mail Transfer Protocol (SMTP)

"Simple" is in the name because there was a complex predecessor that SMTP replaced.

- SMTP is the (TCP/IP) protocol used in client-server mode by e-mail transfer software.

- SMTP handles reliable delivery details.
- SMTP allows sender to ask the receiving host if the intended recipient mailbox exists.
- SMTP follows a stream paradigm
- SMTP control messages are plain text
- SMTP is <u>only for transfer of plain text messages</u>
- If a user on host X sends a message to three users on host Y then the e-mail transfer process only transmits one copy of the message from X to Y. On Y the e-mail transmission software puts a copy of the message in each of the three recipients mailboxes.
- It would be a waste of network bandwidth to send three copies of the message from X to Y.

ISPs, Mail Servers, and Mail Access

The typical ISP runs email server and email transfer software on its computers, and provides email transfer service for subscribers

- ISP computers provide email mailboxes for ISP subscribers
- Subscribers access their email using a web interface provided by the ISP or a special-purpose email interface application.
- The advantage of the web interface is that one can read mail using a browser on any computer connected to the Internet
- The advantage of the special-purpose application is that users with laptops can download all their email and interact with it while offline.

Mail Access Protocols (POP3, IMAP)

POP3 and IMAP are protocols for providing an interface to email

- Typically an ISP runs POP3 and/or IMAP server software, and subscribers run clients
- The software is designed to allow a single user to access a single mailbox
- The access allows viewing mail headers, downloading messages, deleting email, and sending email.

mail Representation Standards (RFC2822, MIME)

- RFC 2822 specifies the mail message format. A message is a plain text file consisting of:
  - o header
  - o blank line
  - o body
- Header lines have the form: keyword: information
- Keywords include: From, To, Subject, CC
- Arbitrary keywords starting with X can be used - never considered bad syntax
- MIME is the Multi-purpose Internet Mail Extension.

- Internet e-mail was designed only to transmit printable ASCII characters (plain text).
- Nowadays e-mail software encodes *arbitrary* kinds of data as sequences of printable ASCII characters and transmits it.

Domain Name System (DNS)

Domain name service (DNS) is provided over the Internet

- There are several forms of service but mainly DNS translates hostnames like cs.csustan.edu into an IP addresses like 130.17.70.80.
- Most applications that use Internet services utilize DNS.
- DNS is a distributed database service - there is a hierarchical network of servers in locations all over the Internet, each of which is responsible for answering questions about a portion of the database.
- DNS can work in a recursive mode: if a client asks a server for information that it doesn't have, then the server may ask another server, obtain the answer, and pass it along to the client.
- A DNS server has to know the address of at least one root server
- Top level domains names like .edu and .com are controlled by the Internet Corporation for Assigned Names and Numbers (ICANN)
- ICANN authorizes domain registrars, to which organizations must apply for approval of the domain names that they request.
- Once an organization has been approved to use a domain name like csustan.edu, it can create a naming hierarchy for the hosts in its network -- with names like dijkstra.cs.csustan.edu and muon.physics.csustan.edu.
  - Except for the rightmost two, the segments of a domain name need not correspond to domains, sub-domains, or networks.

Domain Name	Assigned To
aero	Air transport industry
arpa	Infrastructure domain
asia	For or about Asia
biz	Businesses
com	Commercial organizations
coop	Cooperative associations
edu	Educational institutions
gov	United States Government
info	Information
int	International treaty organizations
jobs	Human resource managers
mil	United States military
mobi	Mobile content providers
museum	Museums
name	Individuals
net	Major network support centers
org	Non-commercial organizations
pro	Credentialed professionals
travel	Travel and tourism
country code	A sovereign nation

Extensible Representations (XML)

An extensible protocol or standard like XML allows users to specify new formats for data.

## MULTIMEDIA NETWORKING

Definition of Multimedia

By definition Multimedia is a representation of information in an attractive and interactive manner with the use of a combination of text, audio, video, graphics and animation. '

In other words we can say that Multimedia is a computerized method of presenting information combining textual data, audio, visuals (video), graphics and animations. For examples: E-Mail, Yahoo Messenger, Video Conferencing, and Multimedia Message Service (MMS).

Multimedia as name suggests is the combination of Multi and Media that is many types of media (hardware/software) used for communication of information.
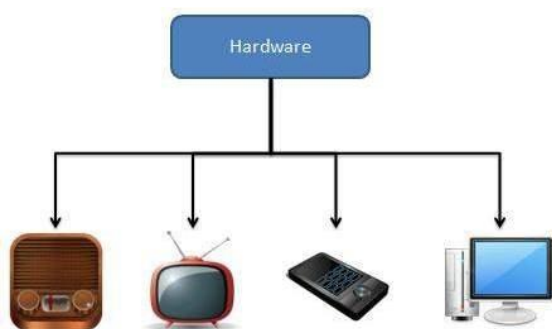
Components of Multimedia
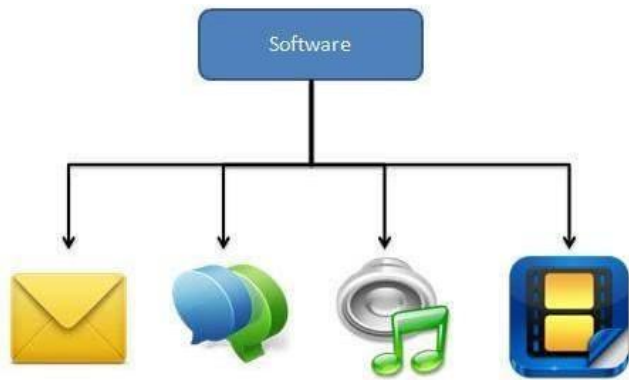
Following are the common components of multimedia:

- **Text**- All multimedia productions contain some amount of text. The text can have various types of fonts and sizes to suit the profession presentation of the multimedia software.
- **Graphics**- Graphics make the multimedia application attractive. In many cases people do not like reading large amount of textual matter on the screen. Therefore, graphics are used more often than text to explain a concept, present background information etc. There are two types of Graphics:
    - **Bitmap images**- Bitmap images are real images that can be captured from devices such as digital cameras or scanners. Generally bitmap images are not editable. Bitmap images require a large amount of memory.
    - **Vector Graphics**- Vector graphics are drawn on the computer and only require a small amount of memory. These graphics are editable.
- **Audio**- A multimedia application may require the use of speech, music and sound effects. These are called audio or sound element of multimedia.Speech is also a perfect way for teaching. Audio are of analog and digital types. Analog audio or sound refers to the original sound signal. Computer stores the sound in digital form. Therefore, the sound used in multimedia application is digital audio.
- **Video**- The term video refers to the moving picture, accompanied by sound such as a picture in television. Video element of multimedia application gives a lot of information in small duration of time.
- **Animation**- Animation is a process of making a static image look like it is moving. An animation is just a continuous series of still images that are displayed in a sequence. The animation can be used effectively for attracting attention. Animation also makes a presentation light and attractive. Animation is very popular in multimedia application.