# Unit 1 : Fundamentals of  Data communications and Computer Network

Components of a Data Communication Network

Data Communication Network:

Data communications are the exchange of data between two devices using one or multiple forms of transmission medium. That is, data communication is movement of data from one device or end-point to another device or end point through electrical or optical medium. Systems that facilitates this movement of data between devices or end-points are called data communication network. The devices which are in need to be a part of a data communication network made up of computer hardware and software. Data communication networks collect data from devices such as microphone and let the data to be carried to the receiver or destination such as a micro-computer or minicomputer. However, it could be the opposite, that is data communication networks can also carry data from a micro-computer or minicomputer to a device such as printer. Data communications networks facilitate more efficient use of computers and improve the day-to-day control of a business by providing faster information flow. They also provide message transfer services to allow computer users to talk to one another via electronic mail, chat, and video streaming.

Following are the five components of a data communication network.

1. Data

2. Sender

3. Receiver

4. Transmission Medium

5. Protocol

**5 Components of a Data Communication Network**

1. Data:

Communication of data means a message or data will be transmitted from one device and will be received in the destination or target device. Thus the first component in a data communication network is data or message to that needs to be delivered and received. Data or message can be of various forms such as text, audio, video, image or combinations of these forms etc.

2. Sender:

A data must has to be sent to a destination from a source. This source is called the sender. The device that sends the data to the destination or target is the Sender. It can be a computer, cell phone, video camera and so on.

3. Receiver:

The destination of a transmitted data is the receiver which will receive the data. The device that receives the data that was sent by the Sender is the Receiver. A receiver can again be a computer, cell phone, video camera and so on.

4. Transmission medium:

In data communication network, the transmission medium is the physical path for the data to travel to its destination after being sent by the Sender. Receiver receives the data at one end of this path and the sender sent from another end of the path. Transmission medium could be like twisted-pair cable, coaxial cable, fiber-optic cable etc.

5. Protocol:

A protocol is nothing but a set of rules that applies on the full data communication procedure. This is like an agreement between the two devices to successfully communicate with each other. For example, how the data will be sent, how the data will be traveling, how to ensure that full data has received, how to handle errors in transmission etc. Both devices follow the same set of rules or protocol so that they understand each other.

**Protocols**

In information technology, a protocol (from the Greek protocollon, which was a leaf of paper glued to a manuscript volume, describing its contents) is the special set of rules that end points in a telecommunication connection use when they communicate. Protocols exist at several levels in a telecommunication connection. For example, there are protocols for the data interchange at the hardware device level and protocols for data interchange at the application program level. In the standard model known as Open Systems Interconnection (OSI), there are one or more protocols attach layer in the telecommunication exchange that both ends of the exchange must recognize and observe. Protocols are often described in an industry or international standard.

**Standards**

A common set of rules.

**Standards Organization**

Standards creation Communities IEEE (Institute of Electrical and Electronics Engineers) IEEE's Constitution defines the purposes of the organization as "scientific and educational, directed toward the advancement of the theory and practice of Electrical, Electronics, Communications and Computer Engineering, as well as Computer Science, the allied branches of engineering and the related arts and sciences." The IEEE is incorporated under the Not-for-Profit Corporation Law of the state of New York, United States. It was formed in 1963 by the merger of the Institute of Radio Engineers (IRE, founded 1912) and the American Institute of Electrical Engineers (AIEE, founded 1884). It has more than 400,000 members in more than 160 countries, 45% outside the United States.In pursuing these goals, the IEEE serves as a major publisher of scientific journals and a conference organizer. It is also a leading developer of industrial standards (having developed over 900 active industry standards) in a broad range of disciplines, including electric power and energy, biomedical technology and health care, information technology, information assurance, telecommunications, consumer electronics, transportation,

aerospace, and nanotechnology. IEEE develops and participates in educational activities such as accreditation of electrical engineering programs in institutes of higher learning. IEEE is one of the leading standards-making organizations in the world. IEEE performs its standards making and maintaining functions through the IEEE Standards Association (IEEE-SA). IEEE standards affect a wide range of industries including: power and energy, biomedical and health care, Information Technology (IT), telecommunications, transportation, nanotechnology, information assurance, and many more. In 2005, IEEE had close to 900 active standards, with 500 standards under development. One of the more notable IEEE standards is the IEEE 802 LAN/MAN group of standards which includes the IEEE 802.3 Ethernet standard and the IEEE 802.11 Wireless Networking standard. ANSI (American National Standards Institute) Though ANSI itself does not develop standards, the Institute oversees the development and use of standards by accrediting the procedures of standards developing organizations. ANSI accreditation signifies that the procedures used by standards developing organizations meet the Institute's requirements for openness, balance, consensus, and due process. ANSI was originally formed in 1918, when five engineering societies and three government agencies founded the American Engineering Standards Committee (AESC). In 1928, the AESC became the American Standards Association (ASA). In 1966, the ASA was reorganized and became the United States of America Standards Institute (USASI). The present name was adopted in 1969.Prior to 1918, these five engineering societies:

· American Institute of Electrical Engineers (AIEE, now IEEE)

· American Society of Mechanical Engineers (ASME)

· American Society of Civil Engineers (ASCE)

· American Institute of Mining Engineers (AIME, now American Institute of Mining, Metallurgical, and Petroleum Engineers)

· American Society for Testing and Materials (now ASTM International)

ANSI also designates specific standards as American National Standards, or ANS, when the Institute determines that the standards were developed in an environment that is equitable, accessible and responsive to the requirements of various stakeholders. The American National Standards process involves:

· consensus by a group that is open to representatives from all interested parties

· broad-based public review and comment on draft standards

· consideration of and response to comments

· incorporation of submitted changes that meet the same consensus requirements into a draft standard

· availability of an appeal by any participant alleging that these principles were not respected during the standards-development process.

ITU (International Telecommunications Union - formerly CCITT) The International Telecommunication Union is the specialized agency of the United Nations which is responsible for information and communication technologies. ITU coordinates the shared global use of the

radio spectrum, promotes international cooperation in assigning satellite orbits, works to improve telecommunication infrastructure in the developing world and establishes worldwide standards. ITU coordinates the shared global use of the radio spectrum, promotes international cooperation in assigning satellite orbits, works to improve telecommunication infrastructure in the developing world and establishes worldwide standards.ITU also organizes worldwide and regional exhibitions and forums, such as ITU TELECOM WORLD, bringing together representatives of government and the telecommunications and ICT industry to exchange ideas, knowledge and technology.The ITU is active in areas including broadband Internet, latest-generation wireless technologies, aeronautical and maritime navigation, radio astronomy, satellite-based meteorology, convergence in fixed-mobile phone, Internet access, data, voice, TV broadcasting, and next-generation networks. ISO (International Organization for Standards) The International Organization for Standardization widely known as ISO, is an international standard-setting body composed of representatives from various national standards organizations. Founded on February 23, 1947, the organization promulgates worldwide proprietary industrial and commercial standards. It has its headquarters in Geneva, Switzerland. While ISO defines itself as a non-governmental organization, its ability to set standards that often become law, either through treaties or national standards, makes it more powerful than most non-governmental organizations. In practice, ISO acts as a consortium with strong links to governments ISO, is an international standard-setting body composed of representatives from various national standards organizations the organization promulgates worldwide proprietary industrial and commercial standards.ISO's main products are the International Standards. ISO also publishes Technical Reports, Technical Specifications, Publicly Available Specifications, Technical Corrigenda, and Guides . EIA (Electronic Industries Association) The Electronic Industries Alliance (EIA, until 1997 Electronic Industries Association) was a standards and trade organization composed as an alliance of trade associations for electronics manufacturers in the United States. They developed standards to ensure the equipment of different manufacturers was compatible and interchangable.In 1924 the Associated Radio Manufacturers alliance was formed, which was renamed to Radio Manufacturers Association (RMA) the same year. Upcoming new electronic technologies brought new members and further name changes: Radio Television Manufacturers Association (RTMA) (1950), Radio Electronics Television Manufacturers (RETMA) (1953) and Electronics Industries Association (EIA) (1957). The last renaming took place in 1997, when EIA became Electronics Industries Alliance (EIA), reflecting the change away from a pure manufacturers association A standard defining serial communication between computers

and modems e. g. was originally drafted by the radio sector as RS-232. Later it was taken over by the EIA as EIA-232. Later this standard was managed by the TIA and the name was changed to the current TIA-232. Because the EIA was accredited by ANSI to help develop standards in its areas, the standards are often described as e. g. ANSI TIA-232 (or formerly as ANSI EIA/TIA-232'). ETSI (European Telecommunications Standards Institute) The European Telecommunications Standards Institute (ETSI) is an independent, non-profit, standardization organization in the telecommunications industry (equipment makers and network operators) in Europe, with worldwide projection. ETSI has been successful in standardizing the Low Power Radio, Short Range Device, GSM cell phone system and the TETRA professional mobile radio system. Significant ETSI standardisation bodies include TISPAN (for fixed networks and Internetmachine-to-machine communications). ETSI inspired the creation of, and is a partner in 3GPP. ETSI was created by CEPT in 1988 and is officially recognized by the European Commission and the EFTA secretariat. Based in Sophia Antipolis (France), ETSI is officially responsible for standardization of Information and Communication Technologies (ICT) within Europe. These technologies include telecommunications, broadcasting and related areas such as intelligent transportation and medical electronics. ETSI has 740 members from 62 countries/provinces inside and outside Europe, including manufacturers, network operators,

administrations, service providers, research bodies and users — in fact, all the key players in the ICT arena. convergence) and M2M (for ETSI has been successful in standardizing the Low Power Radio, Short Range Device, GSMTETRA professional mobile radio system.ETSI was created by CEPT in 1988 and is officially recognized by the European Commission and the EFTASophia Antipolis (France), ETSI is officially responsible for standardization of Information and Communication Technologies (ICT) within Europe. These technologies include telecommunications, broadcasting and related areas such as intelligent transportation and medical electronics. W3C - World Wide Web Consortium The World Wide Web Consortium (W3C) is the main international standards organizationWorld Wide Web (abbreviated WWW or W3). Founded and headed by Tim Berners-Lee,the consortium is made up of member organizations which maintain full-time staff for the purpose of working together in the development of standards for the World Wide Web. As of 18 February 2011, the World Wide Web Consortium (W3C) has 322 members. W3C also engages in education and outreach, develops software and serves as an open for discussion about the Web. W3C also engages in education and outreach, develops software and serves as an open forum for discussion about the Web.W3C was created to ensure compatibility and agreement among industry members in the adoption of new standards. Prior to its creation, incompatible versions of HTML were offered by different vendors, increasing the potential for inconsistency between web pages. The consortium was created to get all those vendors to agree on a set of core principles and components which would be supported by everyone.

**Definition of Bit Rate**

Bit rate can be defined as the number of bit intervals per second. And bit interval is referred to as the time needed to transfer one single bit. In simpler words, the bit rate is the number of bits sent in one second, usually expressed in bits per second (bps). For example, kilobits per second (Kbps), Megabits per second (Mbps), Gigabits per second (Gbps), etc.

**Definition of Baud Rate**

Baud rate is expressed in the number of times a signal can change on transmission line per second. Usually, the transmission line uses only two signal states, and make the baud rate equal to the number of bits per second that can be transferred.

An example can illustrate it. For example, 1500 baud rate illustrates that the channel state can alter up to 1500 times per second. The meaning of changing state means that channel can change its state from 0 to 1 or from 1 to 0 up to 1500 times per second (in the given case).

**Bandwidth:**

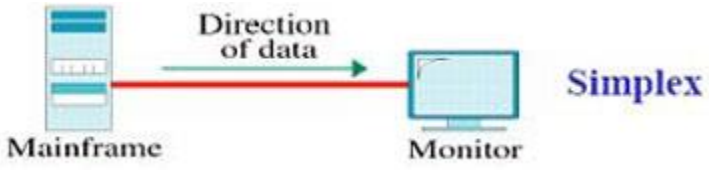
If we assume a signal to be composed of a various number of frequencies, then Bandwidth is defined as the difference between the highest frequency and the lowest frequency of the signal.

| Basis for comparison | Bit rate | Baud rate |
|---|---|---|
| Basic | Bit rate is the count of bits per second. | Baud rate is the count of signal units per second. |
| Meaning | It determines the number of bits traveled per second. | It determines how many times the state of a signal is changing. |
| Term usually used | While the emphasis is on computer efficiency. | While data transmission over the channel is more concerned. |
| Bandwidth determination | Can not determine the bandwidth. | It can determine how much bandwidth is required to send the signal. |
| Equation | Bit rate = baud rate x the count of bits per signal unit | Baud rate = bit rate / the number of bits per signal unit |

## Modes of Communications

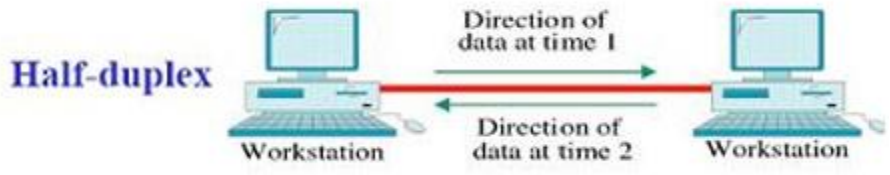
### Simplex

- In simplex transmission mode, the communication between sender and receiver occurs in only one direction.
- The sender can only send the data, and the receiver can only receive the data. The receiver cannot reply to the sender.
- For example, broadcasting of messages




### Half Duplex

- The communication between sender and receiver occurs in both directions in half duplex transmission, but only one at a time.
- The sender and receiver can both send and receive the information, but only one is allowed to send at any given time.
- For example, in walkie-talkies, the speakers at both ends can speak, but they have to speak one by one. They cannot speak simultaneously.




## Full Duplex

- In full duplex transmission mode, the communication between sender and receiver can occur simultaneously.
- The sender and receiver can both transmit and receive at the same time.
- For example, in a telephone conversation, two people communicate, and both are free to speak and listen at the same time.


## Comparison Chart

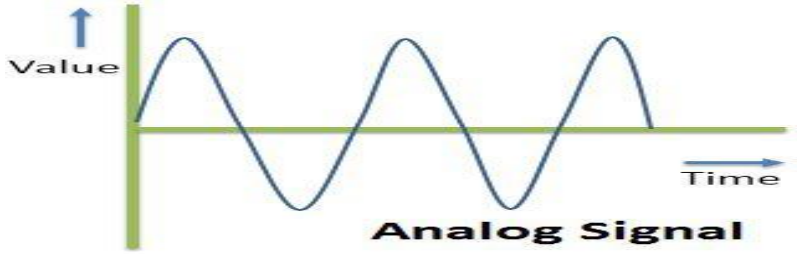
| **Basis for Comparison** | **Simplex** | **Half Duplex** | **Full Duplex** |
|---|---|---|---|
| Direction of Communication | Unidirectional | Two-directional, one at a time | Two-directional, simultaneously |
| Send / Receive | Sender can only send data | Sender can send and receive data, but one a time | Sender can send and receive data simultaneously |
| Performance | Worst performing mode of transmission | Better than Simplex | Best performing mode of transmission |
| Example | Keyboard and monitor | Walkie-talkie | Telephone |

## Analog Signals and Digital Signals

**Analog Signal**

- An analog signal is a continuous wave that changes over a time period.
- An analog signal is represented by a sine wave.
- An analog signal is described by the amplitude, period or frequency, and phase.

- Analog signal has no fixed range
- An analog signal is more prone to distortion.
- An analog signal transmit data in the form of a wave.
- The human voice is the best example of an analog signal.




**Digital Signal**

- A digital signal is a discrete wave that carries information in binary form.
- A digital signal is represented by square waves.
- A digital signal is described by bit rate and bit intervals.
- Digital signal has a finite numbers i.e. 0 and 1.
- A digital signal is less prone to distortion.
- A digital signal carries data in the binary form i.e. 0 and 1.
- Signals used for transmission in a computer are the digital signal.


## Comparison Chart

| Basis for Comparison | Analog Signal | Digital Signal |
|---|---|---|
| Basic | An analog signal is a continuous wave that changes over a time period. | A digital signal is a discrete wave that carries information in binary form. |
| Representation | An analog signal is represented by a sine wave. | A digital signal is represented by square waves. |
| Description | An analog signal is described by the amplitude, period or frequency, and phase. | A digital signal is described by bit rate and bit intervals. |
| Range | Analog signal has no fixed range. | Digital signal has a finite numbers i.e. 0 and 1. |
| Distortion | An analog signal is more prone to | A digital signal is less prone to |

| Basis for Comparison | Analog Signal | Digital Signal |
|---|---|---|
| | distortion. | distortion. |
| Transmit | An analog signal transmit data in the form of a wave. | A digital signal carries data in the binary form i.e. 0 and 1. |
| Example | The human voice is the best example of an analog signal. | Signals used for transmission in a computer are the digital signal. |

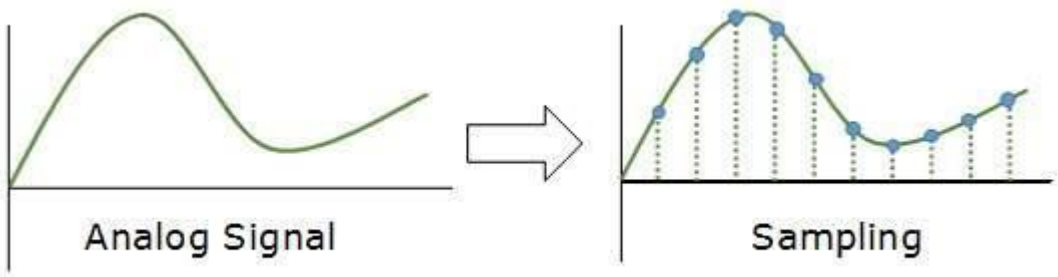
## Analog to Digital Data Transmission

## Analog-to-Digital converter

Microphones create analog voice and camera creates analog videos, which are treated is analog data. To transmit this analog data over digital signals, we need analog to digital conversion. Analog data is a continuous stream of data in the wave form whereas digital data is discrete. To convert analog wave into digital data, we use Pulse Code Modulation (PCM).
PCM is one of the most commonly used method to convert analog data into digital form. It involves three steps:

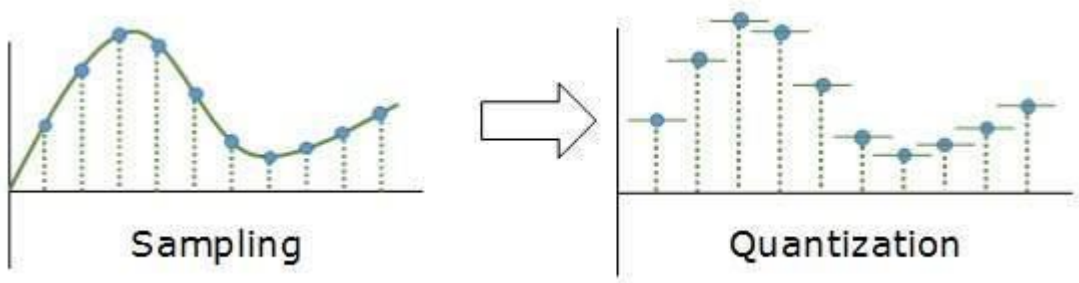
- Sampling
- Quantization
- Encoding.

### Sampling



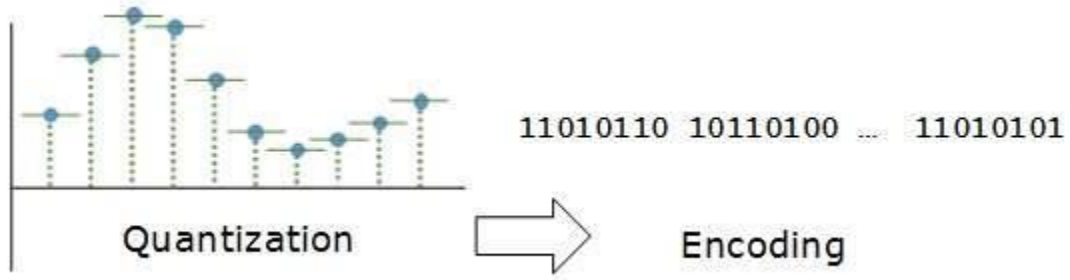

The analog signal is sampled every T interval. Most important factor in sampling is the rate at which analog signal is sampled. According to Nyquist Theorem, the sampling rate must be at least two times of the highest frequency of the signal.

### Quantization




Sampling yields discrete form of continuous analog signal. Every discrete pattern shows the amplitude of the analog signal at that instance. The quantization is done between the maximum amplitude value and the minimum amplitude value. Quantization is approximation of the instantaneous analog value.

## Encoding




In encoding, each approximated value is then converted into binary format.

## Digital-to-Analog Conversion

To send the digital data over an analog media, it needs to be converted into analog signal. There can be two cases according to data formatting.

**Bandpass:** The filters are used to filter and pass frequencies of interest. A bandpass is a band of frequencies which can pass the filter.

**Low-pass:** Low-pass is a filter that passes low frequencies signals.

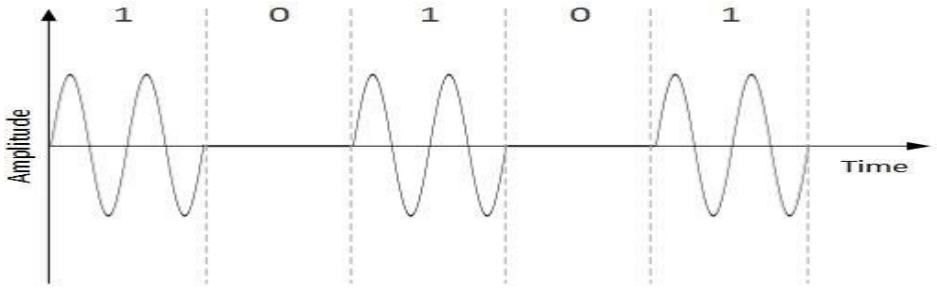
When digital data is converted into a bandpass analog signal, it is called digital-to-analog conversion. When low-pass analog signal is converted into bandpass analog signal, it is called analog-to-analog conversion.

When data from one computer is sent to another via some analog carrier, it is first converted into analog signals. Analog signals are modified to reflect digital data.

An analog signal is characterized by its amplitude, frequency, and phase. There are three kinds of digital-to-analog conversions:

- **Amplitude Shift Keying**

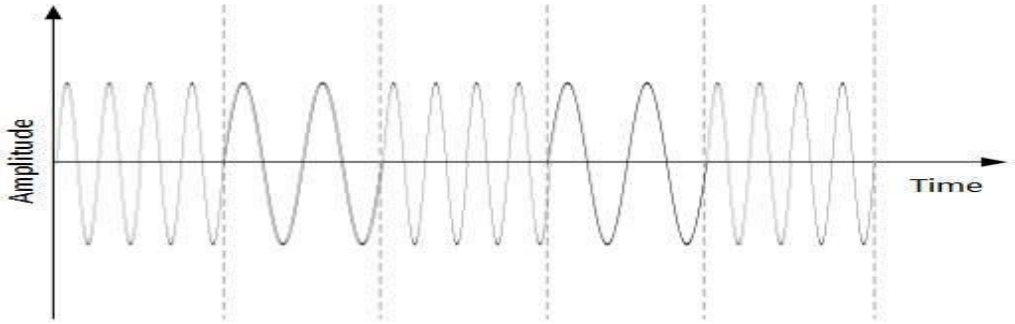
  In this conversion technique, the amplitude of analog carrier signal is modified to reflect binary data.




  When binary data represents digit 1, the amplitude is held; otherwise it is set to 0. Both frequency and phase remain same as in the original carrier signal.

- **Frequency Shift Keying**

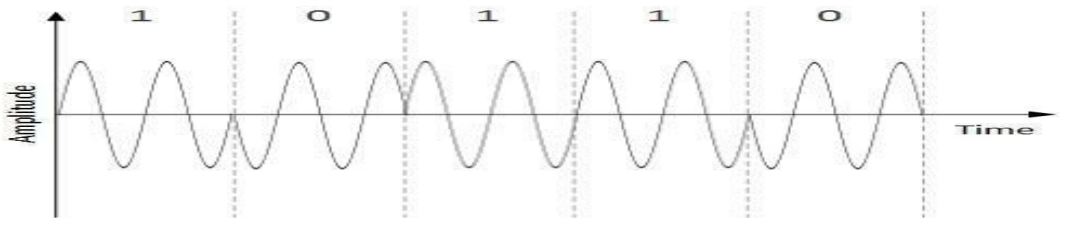
  In this conversion technique, the frequency of the analog carrier signal is modified to reflect binary data.




  This technique uses two frequencies, f1 and f2. One of them, for example f1, is chosen to represent binary digit 1 and the other one is used to represent binary digit 0. Both amplitude and phase of the carrier wave are kept intact.

- **Phase Shift Keying**

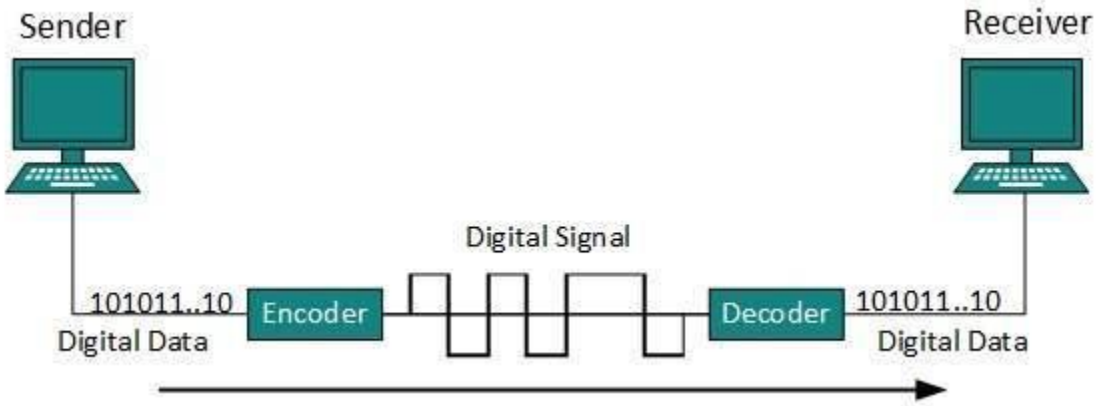
  In this conversion scheme, the phase of the original carrier signal is altered to reflect the binary data.



When a new binary symbol is encountered, the phase of the signal is altered. Amplitude and frequency of the original carrier signal is kept intact.

- **Quadrature Phase Shift Keying**

  QPSK alters the phase to reflect two binary digits at once. This is done in two different phases. The main stream of binary data is divided equally into two sub-streams. The serial data is converted in to parallel in both sub-streams and then each stream is converted to digital signal using NRZ technique. Later, both the digital signals are merged together.




## Fundamentals of Computer Network:

**Definition: A Computer Network** is a set of computers connected together for the purpose of sharing resources. Connected computers can share resources, like access to the Internet, printers, file servers, and others.
The connection between computers can be done via cabling, most commonly the Ethernet cable, or wirelessly through radio waves.

## Need of Computer Network

The following are the potential needs for computer networks.

- **File sharing:** Networking of computers helps the network users to share data files.
- **Hardware sharing:** Users can share devices such as printers, scanners, CD-ROM drives, hard drives etc. Without computer networks, device sharing is not possible.
- **Application sharing:** Applications can be shared over the network, and this allows to implement client/server applications
- **User communication:** Networks allow users to communicate using e-mail, newsgroups, and video conferencing etc.
- **Network gaming:** A lot of network games are available, which allow multi-users to play from different locations.
- **Voice over IP (VoIP)**: Voice over Internet Protocol (IP) is a revolutionary change in telecommunication which allows to send telephone calls (voice data) using standard Internet Protocol (IP) rather than by traditional PSTN.

## Applications of Computer Network

- **E-Commerce:** Computer networks have paved way for a variety of business and commercial transactions online, popularly called e-commerce. Users and organizations can pool funds, buy or sell items, pay bills, manage bank accounts, pay taxes, transfer funds and handle investments electronically.
- **Retrieving Remote Information:** Through computer networks, users can retrieve remote information on a variety of topics. The information is stored in remote databases to which the user gains access through information systems like the **World Wide Web**.
- **Speedy Interpersonal Communication:** Computer networks have increased the speed and volume of communication like never before. **Electronic Mail (email)** is extensively used for sending texts, documents, images, and videos across the globe. Online communications have increased by manifold times through social networking services.
- **VoIP:** VoIP or Voice over Internet protocol has revolutionized telecommunication systems. Through this, telephone calls are made digitally using Internet Protocols instead of the regular analog phone lines.

## Benefits or advantages of Computer Network

- It enhances communication and availability of information.
- It allows for more convenient resource sharing.
- It makes file sharing easier.
- It is highly flexible.
- It boosts storage capacity.

## Classification of Computer Network:

Depending upon the geographical area covered by a network, it is classified as:

- Local Area Network (LAN)
- Metropolitan Area Network (MAN)
- Wide Area Network (WAN)

### Local Area Network (LAN)

A LAN is a network that is used for communicating among computer devices, usually within an office building or home.

•LAN's enable the sharing of resources such as files or hardware devices that may be needed by multiple users•

•Is limited in size, typically spanning a few hundred meters, and no more than a mile

•Is fast, with speeds from 10 Mbps to 10 Gbps. LANs are capable of very high transmission rates (100s Mb/s to G b/s)

•Requires little wiring, typically a single cable connecting to each device

•Has lower cost compared to MAN's or WAN's


**Advantages of LAN**

•Speed

•Cost

•Security

•E-mail

•Resource Sharing

**Disadvantages of LAN**

•Expensive To Install

•Requires Administrative Time

•File Server May Fail

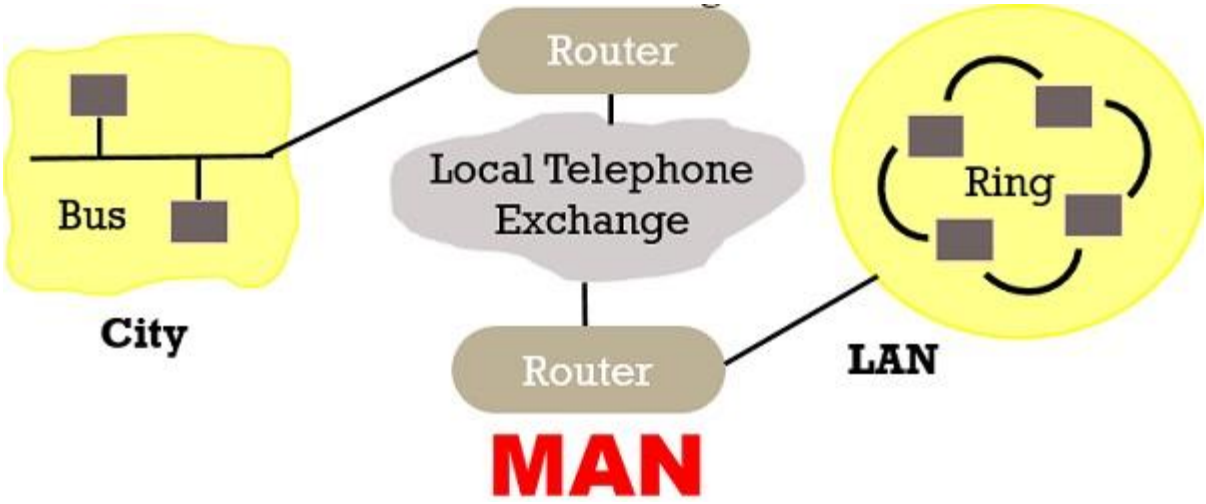
•Cables May Break

**Metropolitan Area Network (MAN)**

•A metropolitan area network(MAN) is a large computer network that usually spans a city or a large campus.
•A MAN is optimized for a larger geographical area than a LAN, ranging from several blocks of buildings to entire cities.
•A MAN might be owned and operated by a single organization, but it usually will be used by many individuals and organizations.
•A MAN often acts as a high speed network to allow sharing of regional resources.

•A MAN typically covers an area of between 5 and 50 km diameter.

•Examples of MAN: Telephone company network that provides a high speed DSL to customers and cable TV network.




## Wide Area Network (WAN)

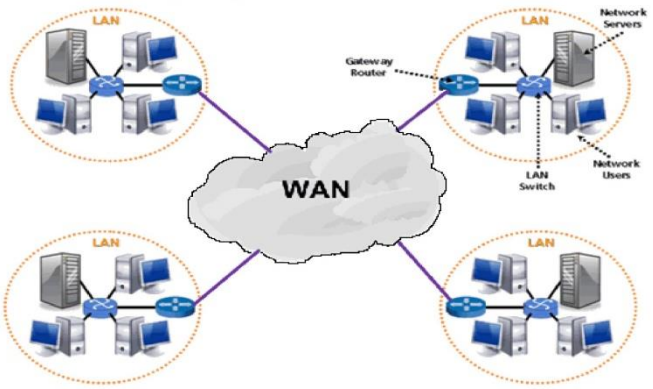
•WAN covers a large geographic area such as country, continent or even whole of the world.

•A WAN is two or more LANs connected together. The LANs can be many miles apart.

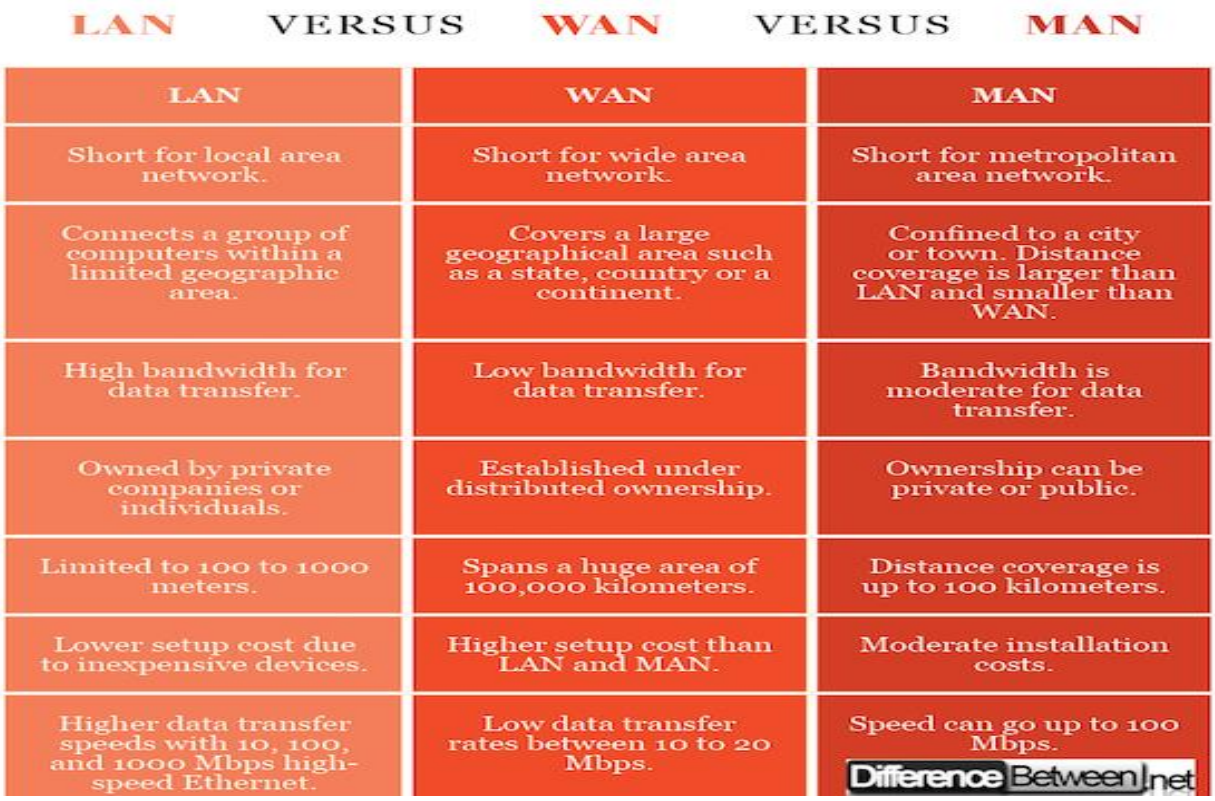
•To cover great distances, WANs may transmit data over leased high-speed phone lines or wireless links such as satellites.

•Multiple LANs can be connected together using devices such as bridges, routers, or gateways, which enable them to share data.

•The world's most popular WAN is the Internet.

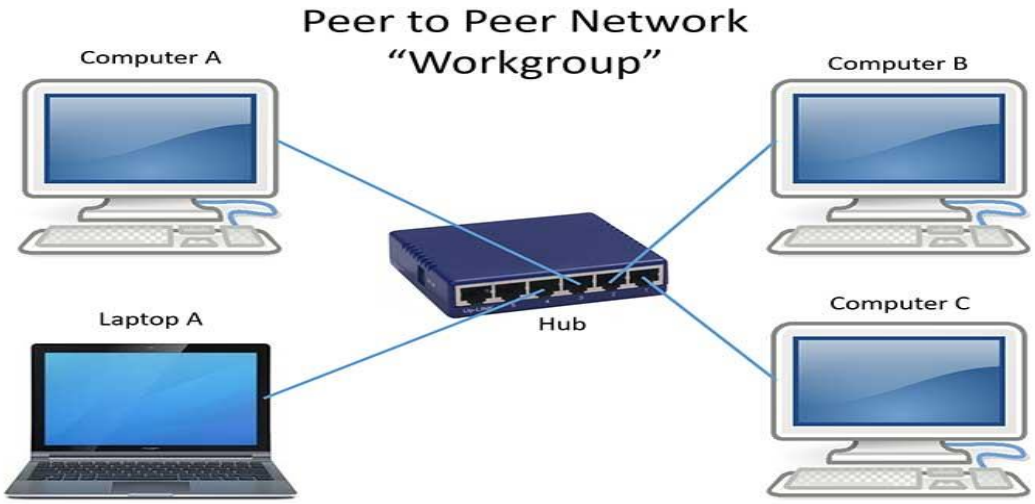


Comparison Chart



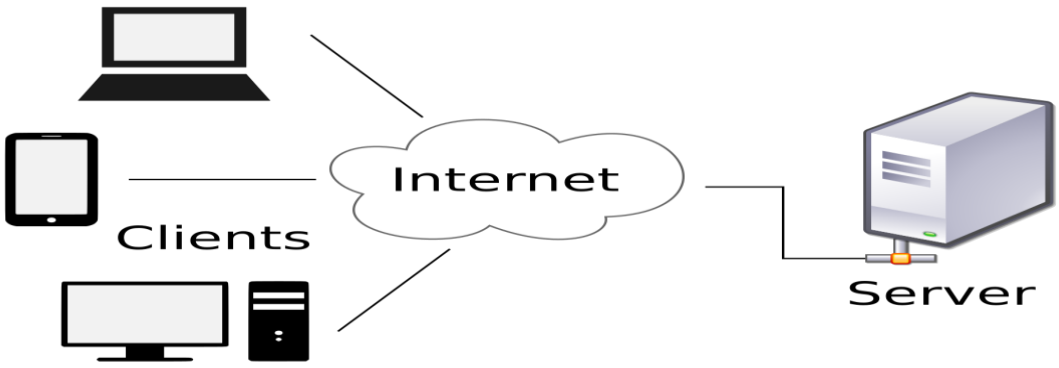

**P2P Network**

- A peer-to-peer network is one in which two or more PCs share files and access to devices such as printers without requiring a separate server computer or server software.
- A peer-to-peer network allows computer hardware and software to communicate without the need for a server.
- Unlike client-server architecture, there is no central server for processing requests in a P2P architecture. The peers directly interact with one another without the requirement of a central server.




**Client Server Network**

- A client-server network is designed for end-users, called clients, to access resources such as files, songs, video collections, or some other service from a central computer called a server.
- The client uses the network as a way to connect with and speak to the server.
- The server can make a request from the client as well. It may want to check up on the status of the client, or ask if it has received any security patches, or if it still needs resources from the server. If not, the server will close the connection in order to free up network traffic.




Comparison Chart

| Client/Server | Peer-To-Peer |
| --- | --- |
| Server has the control ability while clients don't | All computers have equal ability |
| Higher cabling cost | Cheaper cabling cost |
| It is used in small and large networks | Normally used in small networks with less than 10 computers |
| Easy to manage | Hard to manage |
| Install software only in the server while the clients share the software | Install software to every computer |
| One powerful computer acting as server | No server is needed |