



CHAPTER 4: DATA COMMUNICATIONS AND COMPUTER NETWORKS

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I. Data Communication

Data communication refers to the exchange of data between a source and a receiver. Data communication is said to be local if communicating devices are in the same building or a similarly restricted geographical area.

The device that transmits the data is known as source and the device that receives the transmitted data is known as receiver.

Datum mean the facts information statistics or the like derived by calculation or experimentation. The facts and information so gathered are processed in accordance with defined systems of procedure. Data can exist in a variety of forms such as numbers, text, bits and bytes. The Figure is an illustration of a simple data communication system.



A **data communication system** may collect data from remote locations through data transmission circuits, and then outputs processed results to remote locations. The different data communication techniques which are presently in widespread use evolved gradually either to improve the data communication techniques already existing or to replace the same with better options and features.

For a data communication to be effective, the following **three** fundamental characteristics should be considered:

- **Delivery:** The system must deliver data to the correct or the intended destination.
- **Accuracy:** The system must deliver data accurately
- **Timeliness:** The system must deliver data in a timely manner without enough time lags.

Components of data communication system

A Communication system has following components:

1. **Message:** It is the information or data to be communicated. It can consist of text, numbers, pictures, sound or video or any combination of these.
2. **Sender:** It is the device/computer that generates and sends that message.
3. **Receiver:** It is the device or computer that receives the message. The location of receiver computer is generally different from the sender computer. The distance between sender and receiver depends upon the types of network used in between.
4. **Medium:** It is the channel or physical path through which the message is carried from sender to the receiver. The medium can be wired like twisted pair wire, coaxial cable, fiber-optic cable or wireless like laser, radio waves, and microwaves.
5. **Protocol:** It is a set of rules that govern the communication between the devices. Both sender and receiver follow same protocols to communicate with each other.

Transmission Modes - What are the different Transmission Modes?

The term **Transmission Mode** defines the direction of the flow of information between two communication devices *i.e.* it tells the direction of signal flow between the two devices.

There are three ways or **modes of data transmission:** Simplex, Half duplex (HDX), Full duplex (FDX)

Simplex: In Communication Networks, Communication can take place in one direction connected to such a circuit are either a send only or receive only device. There is no mechanism for information to be transmitted back to the sender. Communication is unidirectional. TV broadcasting is an example. Simplex transmission generally involves dedicated circuits. Simplex circuits are analogous to escalators, doorbells, fire alarms and security systems:

Examples of Simplex mode:

- A Communication between a computer and a keyboard involves simplex duplex transmission. A television broadcast is an example of simplex duplex transmission.
- Another example of simplex transmission is loudspeaker system. An announcer speaks into a microphone and his/her voice is sent through an amplifier and then to all the speakers.
- Many fire alarm systems work the same way.

Half Duplex: A half duplex system can transmit data in both directions, but only in one direction at a time that mean half duplex modes support two-way traffic but in only one direction at a time. The interactive transmission of data within a time sharing system may be best suited to half-duplex lines. Both the connected devices can transmit and receive but not simultaneously. When one device is sending the other can only receive and vice-versa. Data is transmitted in one direction at a time, for example. a walkie-talkie.

This is generally used for relatively low-speed transmission, usually involving two-wire, analog circuits. Due to switching of communication direction, data transmission in this mode requires more time and processes than under full duplex mode. Examples of half duplex application include line printers, polling of buffers, and modem communications (many modems can support full duplex also).

Example of half duplex mode:

A walkie-talkie operates in half duplex mode. It can only send or receive a transmission at any given time. It cannot do both at the same time.

Full Duplex: A full duplex system can transmit data simultaneously in both directions on transmission path. Full-duplex method is used to transmit the data over a serial communication link. Two wires needed to send data over a serial communication link layer. Full-duplex transmission, the channel capacity is shared by both communicating devices at all times.

Both the connected devices can transmit and receive at the same time. Therefore it represents truly bi-directional system. The link may contain two separate transmission paths one for sending and another for receiving.

Example of Full duplex mode:

- Telephone networks operate in full duplex mode when two persons talk on telephone line, both can listen and speak simultaneously.

Transmission media

Transmission media is a pathway that carries the information from sender to receiver. We use different types of cables or waves to transmit data. Data is transmitted normally through electrical or electromagnetic signals.

An electrical signal is in the form of current. An electromagnetic signal is series of electromagnetic energy pulses at various frequencies. These signals can be transmitted through copper wires, optical fibers, atmosphere, water and vacuum. Different Medias have different properties like bandwidth, delay, cost and ease of installation and maintenance. Transmission media is also called **Communication channel**.

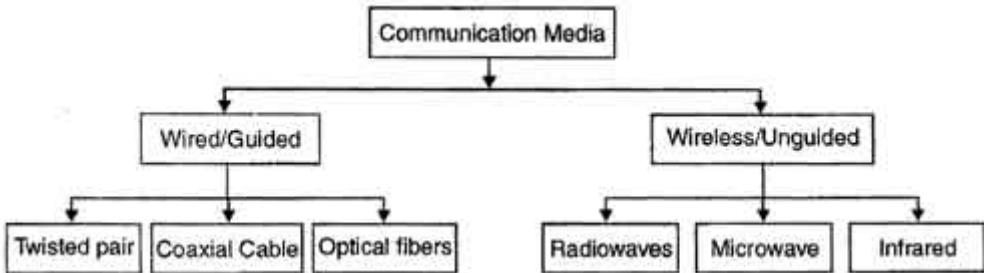
Types of Transmission Media

Transmission media is broadly classified into two groups.

1. Wired or Guided Media or Bound Transmission Media
2. Wireless or Unguided Media or Unbound Transmission Media

Wired or Guided Media or Bound Transmission Media: Bound transmission media are the cables that are tangible or have physical existence and are limited by the physical geography. Popular bound transmission media in use are twisted pair cable, co-axial cable and fiber optical cable. Each of them has its own characteristics like transmission speed, effect of noise, physical appearance, cost etc.

Wireless or Unguided Media or Unbound Transmission Media: Unbound transmission media are the ways of transmitting data without using any cables. These media are not bounded by physical geography. This type of transmission is called **Wireless communication**. Nowadays wireless communication is becoming popular. Wireless LANs are being installed in office and college campuses. This transmission uses Microwave, Radio wave, Infra red are some of popular unbound transmission media.



The data transmission capabilities of various Medias vary differently depending upon the various factors. These factors are:

1. **Bandwidth.** It refers to the data carrying capacity of a channel or medium. Higher bandwidth communication channels support higher data rates.
2. **Radiation.** It refers to the leakage of signal from the medium due to undesirable electrical characteristics of the medium.
3. **Noise Absorption.** It refers to the susceptibility of the media to external electrical noise that can cause distortion of data signal.
4. **Attenuation.** It refers to loss of energy as signal propagates outwards. The amount of energy lost depends on frequency. Radiations and physical characteristics of media contribute to attenuation.

A) WIRED MEDIUM

As the name indicates, in guided media

- Electrical/Optical signals are passed through a solid medium (different types of cables/wires)
- As the path traversed by the signals is guided by the size, shape and length of the wire, this type of media is called guided media. Also, in guided media, the signals are confined within the wire and do not propagate outside of the wire/media.
- E.g., Copper Unshielded Twisted Pair (UTP), Copper Shielded Twisted Pair (STP), Copper Co-axial cables, Fiber Optic Cables.

Twisted Pair Copper:

- It is the most widely deployed media type across the world, as the last mile telephone link connecting every home with the local telephone exchange is made of twisted pair copper. These telephone lines are reused as last mile DSL access links to access the internet from home.
- They are also used in Ethernet LAN cables within homes and offices.
- They support low to High Data Rates (in order of Giga bits)
- However, they are effective only up to a maximum distance of a few kilometers/miles, as the signal strength is lost significantly beyond this distance.
- They come in two variants, namely UTP (unshielded twisted pair) and STP (shielded twisted pair). Within each variant, there are multiple sub-variants, based on the thickness of the material (like UTP-3, UTP-5, UTP-7 etc.)

- E.g. DSL, 10/100/1000Mbps Ethernet cables

Copper Co-axial Cables

- Co-axial copper cables have an inner copper conductor and an outer copper shield, separated by a dielectric insulating material, to prevent signal losses.
- It is primarily used in cable TV networks and as trunk lines between telecommunication equipments.
- It serves as an internet access line from the home.
- It supports medium to High Data Rates
- It has much better immunity to noise and hence signal strength is retained for longer distances than in copper twisted pair media.

Fiber Optic Cables

- Here, information is transmitted by propagation of optical signals (light) through fiber optic cables and not through electrical/electromagnetic signals. Due to this, fiber optics communication supports longer distances as there is no electrical interference.
- As the name indicates, fiber optic cables are made of very thin strands of glass (silica).
- As they support very high data rates, fiber optic lines are used as WAN backbone and trunk lines between data exchange equipments.
- They are also used for accessing internet from home through FTTH (Fiber-To-The-Home) lines.
- Additionally, they are used even for LAN environment with different LAN technologies like Fast Ethernet, Gigabit Ethernet etc. using optical links at the physical layer.
- OC-48, OC-192, FTTC, HFC are examples of Fiber Optical links.

B. UNGUIDED WIRELESS MEDIA

Here information is transmitted by sending electromagnetic signals through free space and hence the name unguided media, as the signals are not guided in any specific direction or inside any specific medium. All unguided media transmission are classified as wireless transmission.

Different forms of wireless communication used in the internet vary mainly based on the following attributes:

- Distance separating the end stations
- Frequency spectrum used by the electromagnetic signals
- Line Encoding technique used

Based on these attributes, a wide variety of wireless PHYs and different types of antennas are used in wireless communication. Wi-Fi, Wi-Max, 3G are example wireless networks used for internet communication

II. COMPUTER NETWORKS

A **Computer Network** is a group of computer systems and other computing hardware devices that are linked together through communication channels to facilitate communication and resource-

sharing among a wide range of users. Networks are commonly categorized based on their characteristics.

Networking refers to the total process of creating and using computer networks, with respect to hardware, protocols and software, including wired and wireless technology. It involves the application of theories from different technological fields, like IT, computer science and computer/electrical engineering.

The need for enhanced telecommunications has led to the advancement of multiple networking hardware technologies, like hubs, switches and routers. It has also spurred the invention of more creative networking mechanisms that use technologies and protocols, primarily in the mobile space.

Networks are used for the following key reasons:

- To facilitate communication via email, video conferencing, instant messaging, etc.
- To enable multiple users to share a single hardware device like a printer or scanner
- To enable file sharing across the network
- To allow for the sharing of software or operating programs on remote systems
- To make information easier to access and maintain among network users

Types of Computer Networks

There are three basic types of Computer Networks

a) LAN - Local Area Network

A LAN connects network devices over a relatively short distance. A networked office building, school, or home usually contains a single LAN, though sometimes one building will contain a few small LANs (perhaps one per room), and occasionally a LAN will span a group of nearby buildings. In TCP/IP networking, a LAN is often but not always implemented as a single IP subnet.

In addition to operating in a limited space, LANs are also typically owned, controlled, and managed by a single person or organization. They also tend to use certain connectivity technologies, primarily Ethernet and Token Ring.

b) MAN - Metropolitan Area Network

A MAN is a network spanning a physical area larger than a LAN but smaller than a WAN, such as a city. A MAN is typically owned and operated by a single entity such as a government body or large corporation.

c) WAN - Wide Area Network

A WAN spans a large physical distance. The Internet is the largest WAN, spanning the Earth. A WAN is a geographically-dispersed collection of LANs. A network device called a router connects LANs to a WAN.

A WAN differs from a LAN in several important ways. Most WANs (like the Internet) are not owned by any one organization but rather exist under collective or distributed ownership and management.

Other Types of Area Networks

While LAN and WAN are by far the most popular network types mentioned, you may also commonly see references to these others: Wireless Local Area Network - a LAN based on WiFi wireless network technology, Campus Area Network - a network spanning multiple LANs but smaller than a MAN, such as on a university or local business campus, Storage Area Network - connects servers to data storage devices through a technology like Fibre Channel, System Area Network - links high-performance computers with high-speed connections in a cluster configuration. Also known as Cluster Area Network.

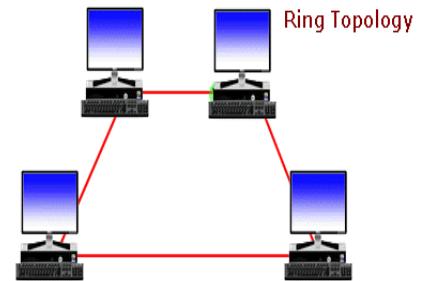
Network Topologies

Network topology is the name given to the way in which the devices (*called nodes*) are physically connected in a network.

Three of the common network topologies, called ring, line (bus) and star are:

a) Ring topology:

In a ring topology, the nodes are connected in a ring and data travels in one direction using a control signal called a 'token'.



Advantages:

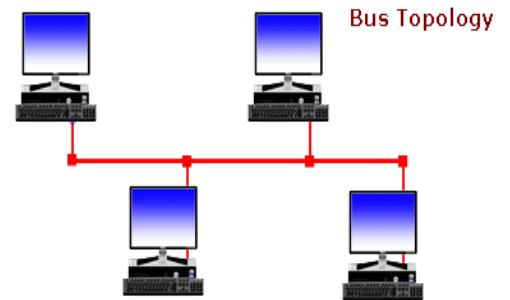
- Not greatly affected by adding further nodes or heavy network traffic as only the node with the 'token' can transmit data so there are no data collisions.
- Relatively cheap to install and expand.

Disadvantages:

- Slower than a star topology under normal load.
- If the cable fails anywhere in the ring then the whole network will fail.
- If any node fails then the token cannot be passed around the ring any longer so the whole network fails..
- The hardest topology to troubleshoot because it can be hard to track down where in the ring the failure has occurred.
- Harder to modify or expand because to add or remove a node you must shut down the network temporarily.
- In order for the nodes to communicate with each other they must all be switched on.

b) Bus (line) topology:

Nodes are connected to a main (bus) cable. If data is being sent between nodes then other nodes cannot transmit. If too many nodes are connected then the transfer of data slows dramatically as the nodes have to wait longer for the bus to be clear.



Advantages:

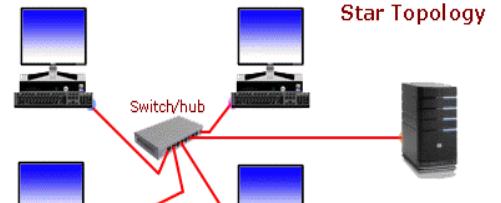
- The simplest and cheapest to install and extend.
- Well suited for temporary networks with not many nodes.
- Very flexible as nodes can be attached or detached without disturbing the rest of the network.
- Failure of one node does not affect the rest of the bus network.
- Simpler than a ring topology to troubleshoot if there is a cable failure because sections can be isolated and tested independently.

Disadvantages:

- If the bus cable fails then the whole network will fail.
- Performance of the network slows down rapidly with more nodes or heavy network traffic.
- The bus cable has a limited length and must be terminated properly at both ends to prevent reflected signals.
- Slower than a ring network as data cannot be transmitted while the bus is in use by other nodes.

c) Star topology:

In this type of network, a central computer (server) usually forms the main node and the subsidiary nodes are connected to it and to each other through a switch or hub.



Advantages:

- The most reliable because the failure of a node or a node cable does not affect other nodes.
- Simple to troubleshoot because only one node is affected by a cable break between the switch and the node.
- Adding further nodes does not greatly affect performance because the data does not pass through unnecessary nodes.
- Easily upgraded from a hub to a switch or with a higher performance switch.
- Easy to install and to expand with extra nodes.

Disadvantages:

- Uses the most cable which makes it more expensive to install than the other two topologies.
- The extra hardware required such as hubs or switches further increases the cost.

- As the central computer controls the whole system, the whole system will be affected if it breaks down or if the cable link between it and the switch fails.
- If the switch, the link to the server or the server itself fails then the whole network fails.

Reading Assignment: Mesh Topology and Tree topology

I. THE INTERNET AND THE WORLD WIDE WEB

The Internet

The **Internet** is a worldwide collection of **networks** that links millions of businesses, government offices, educational institutions, and individuals. Data is transferred over the Internet using **servers**, which are computers that manage network resources and provide centralized storage areas, and **clients**, which are computers that can access the contents of the storage areas. The data travels over communications lines. Each computer or device on a communications line has a numeric address called an **IP** (Internet protocol) **address**, the text version of which is called a **domain name**. Every time you specify a domain name, a **DNS (domain name system) server** translates the domain name into its associated IP address, so data can route to the correct computer.

The Internet is a globally connected network system that uses TCP/IP to transmit data via various types of media. The Internet is a network of global exchanges - including private, public, business, academic and government networks - connected by guided, wireless and fiber-optic technologies. The Internet is the most cost-effective communications method in a world that is now a global village.

The Internet is believed to have originated with the U.S. government, which began building a computer network in the 1960s known as ARPANET. In 1985, the U.S. National Science Foundation (NSF) commissioned the development of a university network backbone called NSFNET. The system was replaced by new networks operated by commercial Internet service providers in 1995. The Internet was brought to the public on a larger scale at around this time.

Ways to access the Internet

You can access the Internet through an Internet service provider, an online service provider, or a wireless service provider. An **Internet service provider (ISP)** provides temporary Internet connections to individuals and companies. An **online service provider (OSP)** also supplies Internet access, in addition to a variety of special content and services. A **wireless service provider (WSP)** provides wireless Internet access to users with wireless modems or Web-enabled handheld computers or devices.

Employees and students often connect to the Internet through a business or school network that connects to a service provider. For home or small business users, dial-up access provides an easy and inexpensive way to connect to the Internet. With **dial-up access**, you use a computer, a modem, and a regular telephone line to dial into an ISP or OSP. Some home and small business users opt for newer, high-speed technologies. **DSL (digital subscriber line)** provides high-speed connections over a regular copper telephone line. A **cable modem** provides high-speed Internet connections through a cable television network.

The World Wide Web (WWW)

The most widely used service on the Internet is the World Wide Web. The **World Wide Web (WWW or Web)** consists of a worldwide collection of electronic documents called **Web pages**. A **browser** is a software program used to access and view Web pages. Each Web page has a unique address, called a **URL (Uniform Resource Locator)**, that tells a browser where to locate the Web page. A URL consists of a protocol, domain name, and sometimes the path to a specific Web page or location on a Web page. Most URLs begin with **http://**, which stands for **hypertext transfer protocol**, the communications standard that enables pages to transfer on the Web.

On a Web page, a **link** is a built-in connection to another related Web page or part of a Web page. A link can be a word, phrase, or image. URLs make it possible to navigate using links, because each link is connected to a URL. When you click a link, the Web site or document associated with the URL is displayed. Some people refer to this activity of jumping from one Web page to another as **surfing the Web**.

Note: The terms Internet and World Wide Web are often used interchangeably, but they are not exactly the same thing; the Internet refers to the global communication system, including hardware and infrastructure, while the Web is one of the services communicated over the Internet. The WWW is one set of software services running on the Internet. The Internet itself is a global, interconnected network of computing devices. This network supports a wide variety of interactions and communications between its devices.

Types of Web pages

There are six basic types of Web pages.

- 1) An **advocacy Web page** contains content that describes a cause, opinion, or idea.
- 2) A **business/marketing Web page** contains content that promotes or sells products or services.
- 3) An **informational Web page** contains factual information.
- 4) A **news Web page** contains newsworthy material including stories and articles relating to current events, life, money, sports, and the weather.
- 5) A **portal Web page** offers a variety of Internet services from a single, convenient location.
- 6) A **personal Web page** is maintained by a private individual who normally is not associated with any organization.

Many Web pages use multimedia. **Multimedia** refers to any application that integrates text with one of the following elements: graphics, sound, video, virtual reality, or other media elements.

A **graphic** is a digital representation of information such as a drawing, chart, or photograph. Two common file formats for graphical images on the Web are **JPEG (Joint Photographic Experts Group)** and **GIF (Graphics Interchange Format)**, which use compression techniques to reduce the size of graphics files and thus speed downloading.

Animation is the appearance of motion created by displaying a series of still images in rapid sequence. One popular type of animation, called an **animated GIF**, uses computer animation and graphics software to combine several images into a single GIF file.

Audio is music, speech, or any other sound. A common format for audio files on the Web is **MP3**, a popular technology that compresses audio. More advanced Web audio applications use **streamingaudio**, which transfers audio data in a continuous and even flow, allowing users to listen to the sound as it downloads. **Video** consists of full-motion images that are played back at various speeds. Video files often are quite large in size. **Streaming video** allows you to view longer or live video images as they are downloaded.

Virtual reality (VR) is the use of computers to simulate a real or imagined environment that appears as a three-dimensional (3-D) space. A **VR world** is an entire 3-D site that contains infinite space and depth.

Webcasting

Pull technology is a method of obtaining information that relies on a client such as your computer to request a Web page from a server. On the other hand, **Webcasting**, also called **push technology**, is a method of obtaining information in which a server automatically downloads content to your computer at regular intervals or whenever updates are made to the site. Webcasting saves time by delivering information at regular intervals and allows users to view Web content when they are **offline**, that is, when they are not connected to the Internet.

Services provided by the Internet

A variety of services are used widely on the Internet, including e-mail, FTP, newsgroups and message boards, mailing lists, chat rooms, and instant messaging.

- a. **E-mail (electronic mail)** is the transmission of messages and files via a computer network. You use an **e-mail program** to create, send, receive, forward, store, print, and delete messages. To receive messages, you need an **e-mail address**, which is a combination of a username and a domain name that identifies a user.
- b. **FTP (File Transfer Protocol)** is an Internet standard that allows you to upload (push) and download (pull) files with other computers on the Internet. An **FTP server** is a computer that allows you to use FTP to upload files to, and download files from, an **FTP site**.
- c. A **newsgroup** is an online area in which users conduct written discussions about a particular subject. The computer that stores and distributes newsgroup messages is called a **news server**. You use a program called a **newsreader** to access a newsgroup, read previously entered messages (called **articles**), and add (**post**) messages of your own.
- d. A **thread** consists of the original article and all subsequent related replies. In a **moderated newsgroup**, a **moderator** reviews articles and posts them, if appropriate.
- e. A **message board** is a popular Web-based type of discussion group that does not require a newsreader and typically is easier to use than a newsgroup. A **mailing list** is a group of e-mail names and addresses given a single name. To add your e-mail name and address to a mailing list you **subscribe** to it; to remove your name, you **unsubscribe**.
- f. A **chat** is **real-time** (meaning everyone involved in the chat is online at the same time) typed conversation that takes place on a computer. A location on an Internet server that permits users to chat is called a **chat room**. Some chat rooms support **voice chats** and **video chats**, where you can hear or see others and they can hear or see you as you chat. A **chat client** is a program on your computer that allows you to connect to a chat server and start a chat session. **Instant messaging (IM)**

is a real-time Internet communications service that notifies you when one or more people are online and then allows you to exchange messages or join a private chat room.

Email services

Also known as webmail, online email service providers enable users to send, receive and review e-mail from their Web browsers. Email services offer easy access and storage of e-mail messages for users who are not connected to the Internet from their usual location.

When logging into an email service, users simply enter the Webmail Web siteURL in their browser's address or location field, and use their Webmail account by typing in a username and password. Instead of the e-mail being downloaded to the computer used for checking the e-mail account from, the messages will stay on the provider's server, allowing the user to access all their e-mail messages regardless of what system or ISP is being used.

Email services offer many of the same features and functionality for managing e-mail as desktop email software counterparts like Microsoft Outlook and Mozilla Thunderbird. Some of the more popular online email services are Yahoo! Mail, Gmail, Hotmail and AOL Mail.

Below is an example and breakdown of an Internet e-mail address.

yourname@yahoo.com

The first portion all e-mail addresses is the alias, user, group, or department of a company. Next, the @ (at sign) is used as a divider in the e-mail address and is always required for all e-mail addresses. Finally, yahoo.com is the computer that provides e-mail service.

To send and receive e-mail messages you can use an **e-mail program**, also known as an **e-mail client** such as Microsoft Outlook or Mozilla Thunderbird or an online e-mail service or webmail such as Mac, Hotmail, Gmail, and Yahoo Mail. Many of the online e-mail services including the above examples are free or have a free account option.