Chapter 1

Introduction to Computer Networks

1.1 Definition

A Computer Network can be defined as a collection of *two or more*, *independent*, *interconnected*, *intelligent nodes*, allowing them to *communicate with each other*.

1.2 Primary Objectives

Some of the objectives of building a Computer Network are:

- Data transfer from machine 'A' to machine 'B'
- Access remote information
- Sharing of data & resources
- Person-to-Person communication
- Interactive entertainment
- E-commerce

1.3 Key Components

Following are the key components required to build a Computer Network:

(i) Nodes or Network Devices

(ii) Media or Links

(iii) Communication Protocols

1.3.1 Nodes or Network Devices

It refers to the active hardware components which takes part in the communication, or which facilitates the communication. Examples include: PCs, Smart Phones, Servers, Modems, Hubs, Switches, Routers etc.

1.3.2 Media or Links

Media interconnects the nodes of a computer network. Media can be broadly subdivided into two types:

(i) *Guided Media*: It refers to the physical wires/cables, which we can see and touch. Examples include: Co-axial & Twisted-pair cables (copper), and Optical Fiber cables (silicon/glass).

(ii) *Unguided Media*: It refers to the wireless types. Examples include: Infrared, Bluetooth, Wi-Fi, WiMAX, Microwave, Satellite communication etc.

1.3.3 Communication Protocols

Communication protocols are a set of formal rules describing how to interconnect and/or transmit data in a network. Low level protocols defines the electrical and physical standards to be observed, while higher level protocols defines data formatting, syntax of messages etc.

Some of the popular protocols include: TCP/IP, IPX/SPX, AppleTalk, Ethernet, and ATM.

1.4 Types of Network Architecture or Network Models

From an architecture point of view, a computer network can be subdivided into two types:

(i) *Peer-to-Peer Model*: In this model, there is no 'master-slave' type of relationships. Any given node can request for service from other nodes (so resembling a *client*), as well as provide service to other nodes (resembling a *server*) at different point of time. Examples includes file sharing services like BitTorrent, Gnutella, and Napster.

(ii) *Client/Server Model*: In this model, a dedicated node (or a set of nodes) known as the *Server* provides the service or replies to requests, while the other nodes in the network, known as the *Clients* requests and obtains the service. Examples include: Web Server, File Server, Mail Server etc.

This model may be implemented in different levels, also known as *tiers*. Some common types are:

(a) *Two-tier Architecture*: In this model, as the name suggests, there are only two tiers. One tier consists of the Server(s), while the other tier consists of the Clients.

(b) *Three-tier Architecture*: In this model, the first tier may consist of the user interface (i.e. the client, eg. a PC with a Web Browser), the second tier may consist of the functional process logic or the "business rules" (eg. a Web Server running PHP), and the third tier may consist of data storage and access facility (eg. a Database Server such a MySQL or Mariadb).

(c) *n-tier Architecture*: More tiers may be introduced into the model. For example, an enterprise application may be broken down into multiple modules. This allows for easy upgrade of a particular module, without affecting the others.

In this scenario, one tier may be for the user interface (eg. Web Browser), the next tier for the Web Server (eg. Apache Web Server), the next tier for the Application Server (eg. RedHat JBoss, Apache Tomcat), and the last tier for the Database Server (eg. Mariadb).

Yet more tiers may be added to this architecture — for example, a Load Balancer to distribute the requests to different Web Servers.

1.5 Classification of Computer Networks

A computer network may be classified based on the *size* or *scale* of the network, it's *organizational scope*, and *transmission technology*.

1.5.1 Based on Scale

- *Personal Area Network (PAN)*: These includes network created within few devices of a person. For example, a Bluetooth network between a smart phone and a PC.
- *Local Area Network (LAN)*: This kind of network is mostly built within a building or even a room, consisting of a few dozens of nodes.
- *Campus Area Network (CAN)*: A network spanning an entire institute campus may be classified in this category.
- *Metropolitan Area Network (MAN)*: A network spanning an entire city or metro may be called a MAN.
- *Wide Area Network (WAN)*: A wide area network may span a country or even continents.

- *Internetwork*: An interconnection of multiple types of individual networks spanning the entire globe can be called a Internetwork.

Note 1: Smaller networks tends to be generally faster than bigger ones.
Note 2: There are also other special types of networks, which may have varying sizes. Examples include *Storage Area Network (SAN)*, and *Controller Area Network (CAN)*.

1.5.2 Based on Organizational Scope

In this category, the networks are differentiated based on if the network(s) have an owner or if the network is controlled by a single or multiple entity or organization(s). There are primarily three types:

(i) *Intranet*: An intranet is a privately owned network. It is created, maintained, and controlled by a single organization for its private use. Outside people are not given access to an intranet.

(ii) *Internet*: The Internet consists of interconnected individual networks. These networks generally hosts information or services or resources for public viewing or use. On most part, anyone connected to the Internet can access these information.

(iii) *Extranet*: The scope of this type of network lies between intranet and Internet. In this case, using the facilities of the Internet, a company's private intranet information may be made accessible to selected customers or persons. A organization may even interconnect it's different branch offices, which may be geographically far apart, using the Internet, and yet may not make them publicly available to all.

1.5.3 Based on Transmission Technology

In this category, the networks are differentiated based on whether the transmission type is:

(i) *Point-to-Point*, or

(ii) *Broadcast*

In a point-to-point network (also called *unicast*), a source node can directly talk to the destination node. However, in a broadcast network, all the nodes of a network share a common media. As such, a message sent by any node is broadcast to all the other nodes in the network. Each node checks the message to ascertain if it is addressed to itself. In case the message is not meant for it, it simply ignores the communication.

1.6 Basic Hardware Components

A computer network is composed of many hardware components. Some of them are:

- Modem
- Network Interface Card (NIC)
- Hub
- Bridge
- Switch (layer 2, and layer 3)
- Router

Some of the components can also be implemented both in hardware as well as in software. Examples include:

- Proxy
- Firewall
- Network Address Translator (NAT)

1.7 Data Transmission

1.7.1 Modes of Communication

Transmission of bits can be done in either of the following two methods:

(i) *Serial Communication*

(ii) *Parallel Communication*

In case of serial communication, data bits are transmitted sequentially one after the other. Serial communication is used for long distance communication and most computer networks.

In case of parallel communication however, a group of data bits are transmitted at a time. As a result, the sender and the receiver must have multiple data lines or multiple communication channels to support parallel transmission of bits.

1.7.2 Types of Signaling

When data bits are transmitted, the receiver must distinguish between noise and data in the channel. Moreover, it must know when to start reading the bits, when to stop, duration of each bit etc. For this purpose, any of the following two methods may be used:

(i) *Synchronous Transmission*

(ii) *Asynchronous Transmission*

In synchronous communication, the transmission of bits rely upon a clock signal. For this, a separate data line may be used to transmit the clock signal. In some cases, the clock signal may be embedded into the data bits itself. Parallel communication generally uses synchronous communication (eg. data & control bus inside a computer system).

Asynchronous communication does not rely upon an external clock. Instead, arrangements like *start & stop bits* are used to synchronize the communication. This type of communication is preferred when data bits are produced at irregular intervals (eg. a keyboard).

Synchronous transmission provides better throughput than asynchronous transmission.

1.7.3 Types of Communication Channels

The sender and the receiver may use different types of communication links to send/receive data. Some of them are:

(i) *Simplex*: In this case, the communication link is only one-way. i.e. one party can only send, while the other party can only receive the data. Examples includes radio broadcasting and television transmission. This type of communication is not suitable for computer networks.

(ii) *Half-Duplex*: In this case, while both the parties can send & receive data, they can't do it at the same time, i.e. while one party transmits, the other party can only listen, and vice-versa. Example include Walkie-Talkies.

(iii) *Full-Duplex*: In this case, both the parties can send and receive data at the same time. To facilitate this type of transmission, multiple wires or multiple channels must be present in the media. Examples include telephone and mobile phones. Full-duplex communication enjoys the following benefits:

- No collision
- Full data capacity in both the directions
- No waiting time

1.8 Network Topology

The topology of a network refers to the layout or shape of the network.

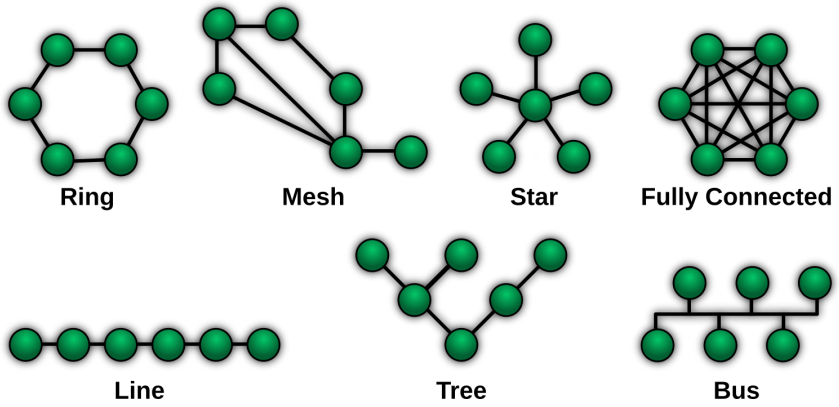

Figure 1.1: Common Network Topologies (Courtesy: Wikipedia)

1.8.1 Types

It can be divided into two types:

(i) *Physical Topology:* Tells us how the different networking components are laid out in the network.

(ii) *Logical Topology:* Tells us how the data actually flows in the network.

1.8.2 Classification

Some of the common topologies are (Refer to figure 1.1):

- Point-to-Point
- Bus
- Star
- Ring
- Mesh[1]
- Tree
- Hybrid

Note: The physical and the logical topology of a given network may not be the same. For example, when using a *hub*, the data flow in a *Star* network actually happens like a *Bus*. So, though the physical topology in this case is a star, the logical topology is actually a bus.

1.9 Types of Service

In a computer network, services may be provided in two ways:

(i) *Connection-oriented Service*

(ii) *Connectionless Service*

In connection-oriented service, the parties involved in the communication first checks for the presence and availability of the other party (called *handshaking*). Phone calls are example of this type of service.

In case of connectionless service, the intended communication is blindly sent, in the hope that it reaches the other party. The mail service is an example of this type of service.

[1] Maybe fully connected, or partially connected.