

# Study Unit 4

# Introduction to Computer Networks

## Study Session Outline

- Introduction to Computer  
Introduction to  
Computers
- History of the Internet
- Computer Networks
- Layer Architecture

## Study Session

### Duration

This Study Session requires 2 hours of formal study time.

You may spend an additional 2-3 hours for revision.

## Introduction

The internet is here to stay, no doubt about that. Therefore, computer networking skills will remain relevant as you embark on the journey in the world of computing. This study unit will show the learners the building blocks of a computer network. We will explore the various types of computer network and layer architectures that are recognized in computer networking.

## Learning Outcomes of Study Unit 4

Upon completion of this study unit, you should be able to:

- 4.1 Explain the evolution of the internet and the World Wide Web
- 4.2 Identify and describe different types of computer networks.
- 4.3 State the different layer architectures and explain their application.
- 4.4 Compare and contrast between OSI Model and TCP/IP Model

## Terminologies

WWW	Internet, intranet, extranet
Website	Data packets
LAN	OSI Model

## **4.1 Introduction to Computer Networks**

A basic understanding of the interconnectivity of Computers to share information, resources and facilities form a Network. Having taken some courses on the basics of Computer, Computer Networks means the interconnectivity of the computers to form groups with the ability to communicate through a shared medium, Network. Networks are therefore formed to share information. It is therefore dependent on the areas of coverage and reachability. A Computer Network is defined as the composition of Computer systems either closely situated or far distance apart for communication between them.

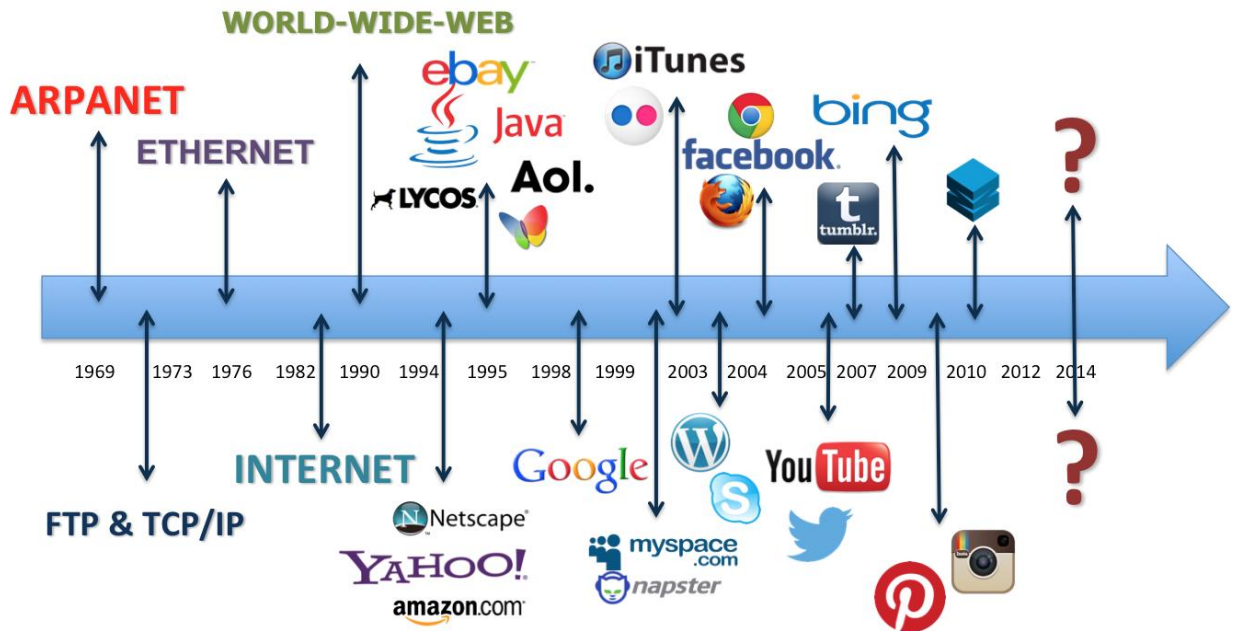
As the course progresses, you will be more exposed to the various and forms of Computer Networks. Which include, Local Area Network (LAN), Metropolitan Area Network (MAN) or Terrestrial Area Network (TAN) and the Wide Area Network (WAN).

### **4.1.1 What is the Internet?**

#### *What is the Internet?*

The Internet is the Inter-Connection of the computer networks to share information. The Computer Network earlier defined in the introduction section forms the Internet. Additionally, the Internet provides wider reachability, time-saving, and more reliable information. This is due to its wide coverage and linkage with other sparsely distributed Networks. It is more than the WAN, TAN and has global connectivity with networks across countries and beyond.

The Internet started as a special LAN-WAN in the US when the Military got the need to share information. The process had Robert Taylor, a head of the Military Information Unit that created the packet switching at the Advanced Research Project Agency (ARPA). The agency later created the network that was able to share resources in the year 1965-68 known as the ARPANET. The implementation of the earliest Network was carried out in the University of California, Los Angeles (UCLA).



*Figure 1: Image Credit - lifeboat.com*

Several other advancements and evolution of the Internet took shape to what we have today as the World Wide Web (WWW) Internet as depicted on Figure 1.

Like electricity, the Internet has been with us for many years. Though electricity was discovered by the British Scientist, Michael Faraday during an experiment in 1831, the Internet started as a research project in the USA at the Department of the Defense (DoD) through the Advance Research Project Agency (ARPA) in collaboration with the University of California, Los Angeles (UCLA).

*Read more on the history of the internet*

Further reading: <https://www.livescience.com/20727-internet-history.html>

## 4.2 Description of Computer Network

### 4.2.1 Definition of Computer Network

Generally, the best form of having to share resource (time, memory, printers, scanners etc.) and other computer peripherals is through a computer network. The interconnection of various computers to share resources over a shared medium forms a Network (See Figure 2).



*Figure 2: Image Credit - [www.ophtek.com](http://www.ophtek.com)*

### DIFFERENT DEFINITIONS OF COMPUTER NETWORKS

1	A computer network is the interconnection of two or more computers, devices to share data resources and applications.
2	A group of computers connected to each other that uses communication protocols to share information and resources.
3	Two or more computers that related to one another for the purpose of communicating data electronically. (Britannica.com)

At the advent of the Internet, only computers (Mainframes and Supercomputers) were connected to the Internet. Today mobile phones, digital cameras, refrigerators, and numerous physical objects are connected to the Internet. Making the Internet easily accessible and ubiquitous.

### **4.2.2 Characteristics of a Computer Network**

- Ability to share data/information from one computer to another. Computer networks can carry different data formats like - text, images, audio, videos, and services.
- Enables the sharing of resources by users on the same network. For example, Users in the same network can use the same resources (such as printers, scanners, cameras etc.) that are connected to their network.
- Computer networks allow people to use the same application and create a forum of general interactivity. For instance, the social media channels and services such as Facebook, Instagram, twitter and a host of others that are hosted on the Internet. Therefore, giving access and interactivity to the billions of people connected to the social network platform.

### **4.2.3 Types of Computer Network**

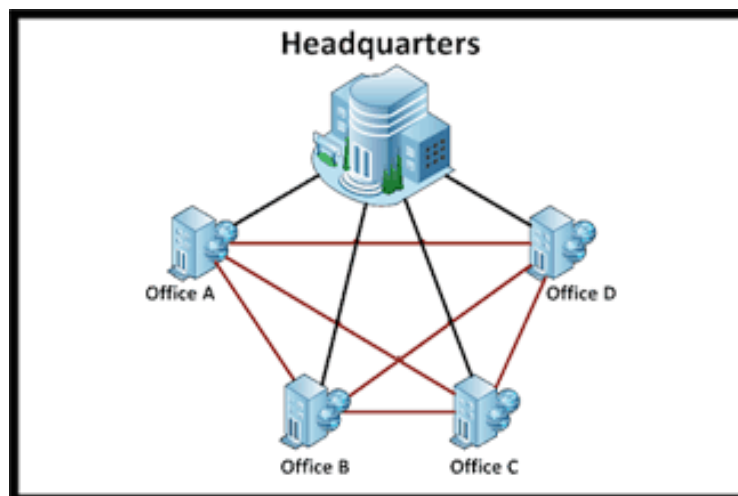
Computer networks are further divided and categorized into the following:

- **Local Area Network (LAN)** - A LAN is a collection of connected devices in one physical location, such as a home, office, or a closed building. A LAN can be small or large, ranging from a home network with one user to a large enterprise network with thousands of users and devices. A LAN may include both wired and wireless devices (presented in Figure 3).



*Figure 3: Local Area Network. Image Credit - [www.itrelease.com](http://www.itrelease.com)*

- **Metropolitan Area Network (MAN)** – Just as the name implies, MAN connects different LANs in a city or metropolis. This helps to form a larger network as compared to the LAN explained earlier.
- **Wide Area Network (WAN)** – Spans over a wide geographical area and accommodates larger different interconnectivity across wide distances. It can span over different regions, states, and countries. Large private and public organizations use WAN to connect their organizations together. The internet is the biggest WAN in the world.



*Figure 4: Wide Area Network [source: [studyencyclopedia.com](http://studyencyclopedia.com)]*



- When a network (LAN, MAN, WAN) is accessed **ONLY** by users within an organization, it is called an **INTRANET**.
- When an INTRANET is accessible by some people outside the organization, it is called an **EXTRANET**. For example, when suppliers of a company can access their internal network.

#### 4.2.4 Setting up a Computer Network

To setup a simple computer network in an office or inside your house. You will need the following.

- a) **The Network devices** - Routers, switch, hub, radios and wireless access point.
- b) **A network medium** – A network medium can be wired (network cables) or wireless (no cables).
- c) **An Internet Protocol (IP) address** – These are a set of special network identifier per user on the Internet. Without an IP address, no computer can communicate or send messages to another computer/system. IP addresses are assigned by the router (for wired connections), wireless router/wireless access point assigns IP addresses for wireless communications. An IP address can be manually or automatically assigned by a network administrator when a host connects to a wireless network. Examples of IP address are 10.9.100.81, 192.168.0.100 etc.
- d) **A host** – A network host or simply host is any device that is connected to a computer network and can send and receive messages with other hosts inside a network. A host can be a workstation, smartphone, server, laptop, printer and tablet



#### 4.2.5 Definition of Terminologies

- Local Area Network (LAN) – see section 4.2.3
- Wide Area Network (WAN) – see section 4.2.3
- Metropolitan Area Network (MAN) – see section 4.2.3
- World Wide Web (WWW) – It is popularly called the Web. A system of information on the Internet that allows web documents (or webpages) to connect to each other using hyperlinks. The users search for information using the Uniform Resource Locator (URL) of the webpage or website.
- **Website** – A set of webpages that are interconnected together that share the same web address or domain name. For e.g., University of Somalia’s website <https://www.uniso.edu.so/> has several webpages.  
These two webpages <https://www.uniso.edu.so/#about> and <https://www.uniso.edu.so/#contact> shares the same domain name which is <https://www.uniso.edu.so/>
- **Search Engine** – A computer program used to search for information on the WWW. When users type in specific keywords like “Where is the source of River Nile”, the search engine crawls around the WWW looking for websites that has information about the “source of River Nile” and displays it for the user.
- **Servers** – These are computers/devices that provide services to other hosts in a network. The services include file services, printer services, email services, and other services that are accessible by hosts in a network
- **Printers** – A computer output device that is used to print text and images from the computer on paper or a User visible format.
- **Download** – The transfer of files from the Internet to storage of a local computer.
- **Upload** – The transfer of files from your local computer to the Internet. For instance, the attachment of documents when sending a mail is called upload.
- **Domain Name** – Also known as website address host. It is a unique name that is used to recognize a website. [www.uniso.edu.so](http://www.uniso.edu.so) is the domain name for the University of Somalia.



- **Internet Service Providers (ISPs)** – These are companies and organizations that provide Internet service. They sell Internet services to businesses, schools, organizations and country as a whole.



*List 5 domain name of any website you have seen or visited.*

#### 4.2.6 Tutor Marked Assignment



- Use any device of your choice (laptop, desktop, smartphone, tablet), outline the steps you took to connect to a computer network.

Explain in detail all your experience.

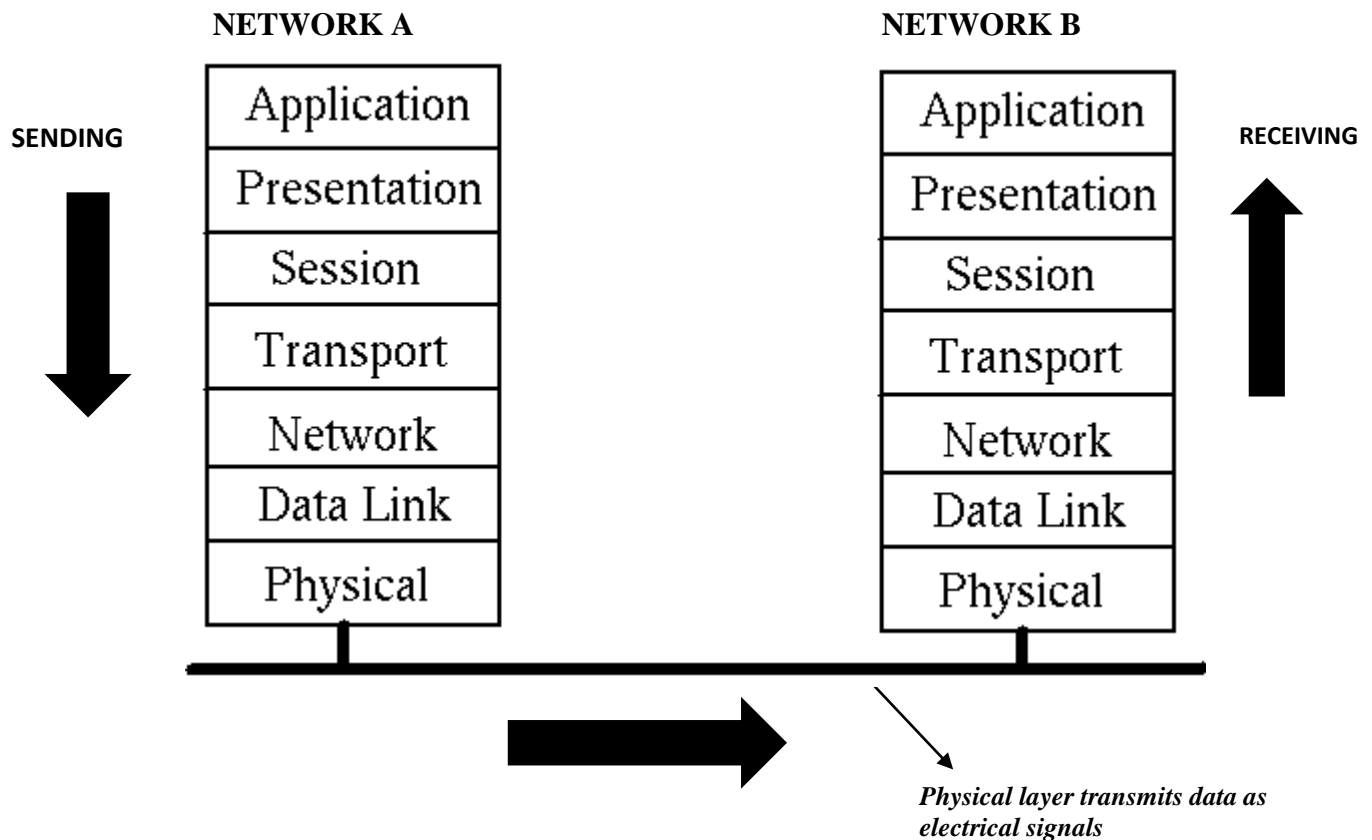
### 4.3 Computer Network Layer Architecture

In the early day of the Internet, there was a need to develop a standard that will allow network hardware from different manufacturers to communicate with each other. The need thus, presented the adequate formation of a Network Layer Architecture.

#### 4.3.1 OSI Model

In 1984, the International Standard Organization (ISO) published the Basic Reference Model for Open Systems Interconnection, usually referred to as the Open Systems Interconnection (OSI) reference model, or simply OSI model.

The OSI model uses a 7-layer abstraction model to describe network architecture – Application, Presentation, Session, Transport, Network, Data Link and Physical.



The model describes how data is transferred or transmitted from one network to another. Each layer contributes and adds to the function of the layer above (see Figure 5).

- When a User wants to send message or transmit data from “**Network A**” to “**Network B**”, the user interacts with the Application layer which makes sure the application programs (like Gmail, Chrome browser) responsible for sending the messages are working properly.
- The Presentation layer encodes the message in a computer readable format.
- The Session layer establishes a connection between the two computers/networks that wants to communicate with each other.
- The Transport layer determines how the data will be transmitted using segment numbering.

- v. The Network layer assigns IP addresses of the sending computer and the destination computer to the data and decides the route the data packets should follow to its destination.
- vi. The Data link layer put the data packets into frames and add the MAC address (i.e., physical address) of the sending computer.
- vii. The Physical layer sends the data in raw form as electrical, optical, and digital signals.

When the data gets to the destination network, the layers at the destination network starts rearranging the original message so the receiving user can view it the way it was sent.

### Application Layer

This layer sits at the topmost layer of the OSI reference model. It displays the information to the User. It ensures an application program can communicate with another application program. The Application layer depends on other lower layers to complete its processes. Examples of services are file transfer, User access and management, and mail services. Application layer protocols are HTTPS, FTP, SMTP, DNS, SMTP, SMTP, POP, TELNET and others. ***NOTE: Network protocols will be explained in study session 3***

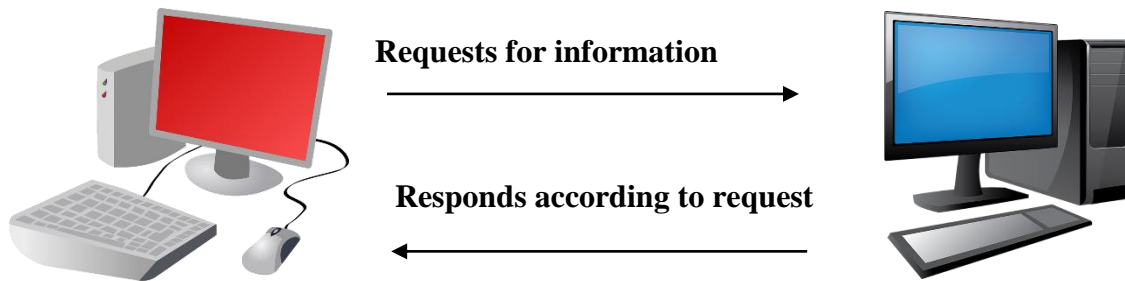
### Presentation Layer

This Presentation layer handles data representation. It formats and delivers information to the Application layer for display. The Presentation layer provides services like data conversion, character code translation, encryption and decryption. An example of Presentation layer protocols is Lightweight Presentation Protocols (LPP),

### Session Layer

For two computers to communicate with each other, a session must be created. When a communication session is not used for a while, the session layer terminates it. It ensures the

information flow during these sessions is properly synchronized. It also provides authentication and authorization services. In the diagram below, Session layer ensures the two computers communicates with each other.



*Figure 6: Communication*

## Transport Layer

The Transport layer assembles message segments from applications and hands them over to the Network Layer. If the data packets are not received in the same order, they were sent due to network congestion, the Transport Layer uses segment numbering to make sure are arranged in order. It also ensures the sending nodes does not transmit more data that can be handled by the receiving node. This layer handles flow control.

The two protocols used in the transport layer are User Datagram Protocol (UDP) and Transmission Control Protocol (TCP).

## Network Layer

The network uses logical addresses (IP addresses) to send data packet through a router. This is called packet forwarding. The packets contain source and destination IP addresses. The packets are also encapsulated within a frame. The router uses IP packet header to send packets through the network from source to destination.

For example, an enormous file is broken into many packets and then transmitted across the network one at a time. The network hardware conveys the packet to the certain destination, where a software regathers them into a single file again.

## **Data Link Layer**

The Data link layer is on top of the physical layer. It handles node-to-node transfer between two connected nodes in a network and manages the movement of data in and out of a network. These data are packaged into frames before sending. The frame header contains the source and destination MAC addresses - the device where the frame originated (source) and the device that receives the frame (destination).

For two networks to communicate, there must be two nodes. One node is sending, the other node is receiving. The sending node encodes the data into frames before sending while the receiving node decodes the data.

## **Data Link Sub Layers**

The Data link has two sub layers - Media Access Control (MAC) and Logical Link Control.

- **Logical Link Control (LLC)** - at the top of the data link layer is the LLC.

It takes care of flow control, acknowledgement, and error notification.



*Flow control allows for proper data transmission rate between two network nodes. The receiver controls the transmission speed, so the receiving node is not overloaded with data from the sending node.*

- **Medium Access Control (MAC)** - this layer determines who can access the media per time. This is done using Carrier-sense multiple access with collision detection (CSMA/CD). CSMA/CD allows a device to check if the network is free when it wants to gain access to a network.

The MAC sub layer controls the start and end of each frame of data in the transmission bitstream.

### **Functions of the Data Link Layer**

- It corrects any problem with transmission errors
- It encapsulates data packets in frames
- Provides physical addressing (MAC Addressing)
- The data link layer fixes errors that might have occurred at the physical layer.

### **Physical Layer**

At the bottom of the OSI layer architecture is the Physical layer. It describes the physical transmission medium. This includes the transmission of raw data in bits (binary digits) between devices and a network transmission medium. This layer changes these bits into electrical, radio and optical signals.

Transmission of bits can be on simplex mode, half duplex mode and full duplex mode.

The general summary of the entire OSI reference model is presented in Table 1.

*Table 1: Summary Table*

<b>A BRIEF SUMMARY OF OSI REFERNECE MODEL</b>	
<b>Application Layer</b>	Closest to the end user
<b>Presentation Layer</b>	Presents the data for the application layer
<b>Session Layer</b>	Creates a session so two computers can communicate
<b>Transport Layer</b>	Transfers data between computer networks. It determines the transfer size, transfer rate,
<b>Network Layer</b>	Forwards packets through different routers to get to destination
<b>Data Link Layer</b>	Provides node-to-node transfer in a local network
<b>Physical Layer</b>	This the physical representation of the network.

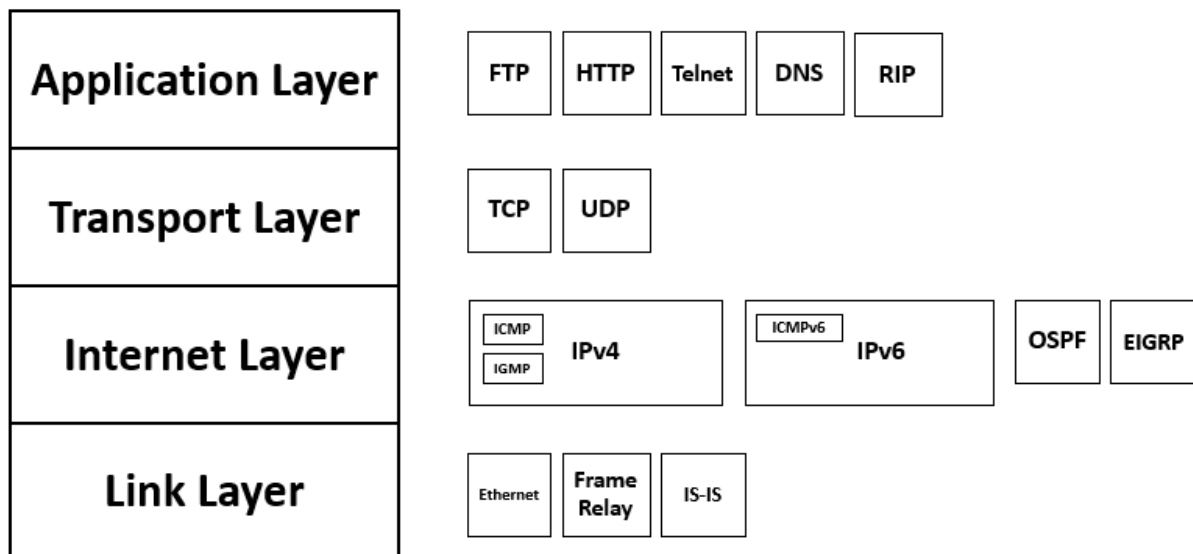
### 4.3.2 TCP/IP Model

The TCP/IP Model existed before the OSI Reference Model, which is a more comprehensive reference framework for general networking systems. It was initiated by the USA Department of Defence (DoD) to guarantee data integrity and secure communication in case of any crisis.

Unlike the OSI Model that has 7 layers, the TCP/IP model consists of 4 layers.

- The 1st layer = Application Layer
- The 2nd layer = Transport Layer
- The 3rd layer = Internet Layer
- The 4th layer = Link Layer





*Figure 7: OSI Model*

## Application Layer

The topmost layer on the TCP/IP architecture is the Application Layer. This layer uses the services provided by the lower layers to generate user data and transfer this data to other applications on another host or the same host.

When one application layer protocol wants to communicate with another application layer, it forwards its data to the transport layer. Examples of Application layer protocols are Hyper Text Transfer Protocol (HTTP), Domain Name System, Simple Mail Transfer Protocol (SMTP), Simple Network Management Protocol (SNMP), TELNET, File Transfer Protocol (FTP).

## **Transport Layer**

The transport layer provides a path for the communication needs of applications. The two protocols used in the transport layer are User Datagram protocol (UDP) and Transmission control protocol (TCP).

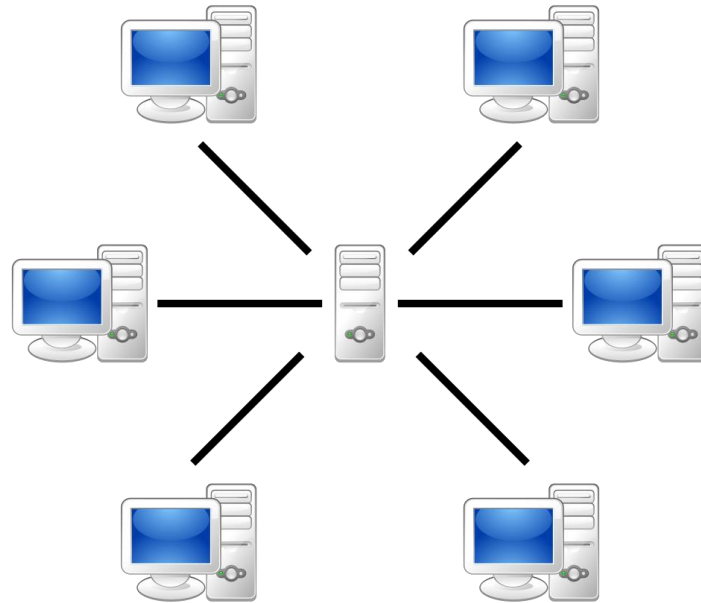
## **Internet Layer**

The main responsibility of the internet layer is to send the packets from any network, and they arrive at the destination irrespective of the route they take. The routing tables and IP addressing are managed on the internet layer. The Internet Protocol (IP) is the protocol that defines IP addresses.

## **Link Layers**

The transmission of data between two devices in the same network is coordinated by the Link Layer. This layer is the combination of the data link layer and the physical layer of the OSI Model.

### 4.3.3 Client-Server Architecture



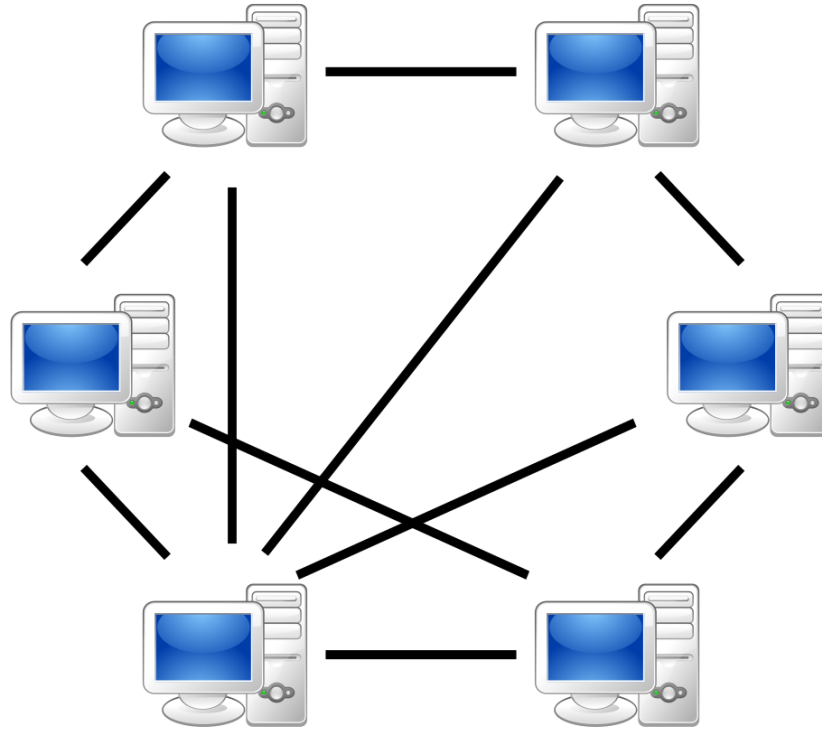
*Figure 8: Client-Server Architecture*

Client-Server network involves a central computer called SERVER that provides services to other computer/hosts called CLIENTS (as shown in Figure 8). A client can be a laptop, desktop, smartphone or any device that needs services from a server. In some cases, the server could be a powerful supercomputer that has great processing abilities to handle millions of requests from clients. In a small networking environment, a computer or workstation can be dedicated as a server. All files are stored in these servers which allow users to access shared data. The servers provide security.



*From the diagram in Figure 8, kindly identify the number of clients and server.*

#### 4.3.4 Peer-to-Peer Architecture



*Figure 9: Peer-to-Peer*

A peer-to-peer (P2P) network uses a distributed architecture whereby clients or hosts could share workloads or tasks among themselves. There is no need for a server because all the clients distribute the workloads among themselves, this is called a decentralized network. This contrasts with client-server architecture whereby a single computer or software is dedicated to serving others. A P2P can also be a software designed to act as a client and server at the same time.

#### Applications of P2P Architecture

1. Cryptocurrencies like Bitcoin, Ether and Peercoin – They have no centralized authority.
2. Torrent Network – In Torrent, any computer in the network can upload a file for other computers to download.

## Group Work



### ***Group Assignment***

*List the advantages and disadvantages of client server network and peer to peer network:*

*Students are to group in four (4) and submit as instructed on the site*