Components of Data Communication System

Data Communication is defined as exchange of data between two devices via some form of transmission media such as a cable, wire or it can be air or vacuum also. For occurrence of data communication, communicating devices must be a part of communication system made up of a combination of hardware or software devices and programs.

Data Communication System Components :
There are mainly five components of a data communication system:

1. Message
2. Sender
3. Receiver
4. Transmission Medium
5. Set of rules (Protocol)

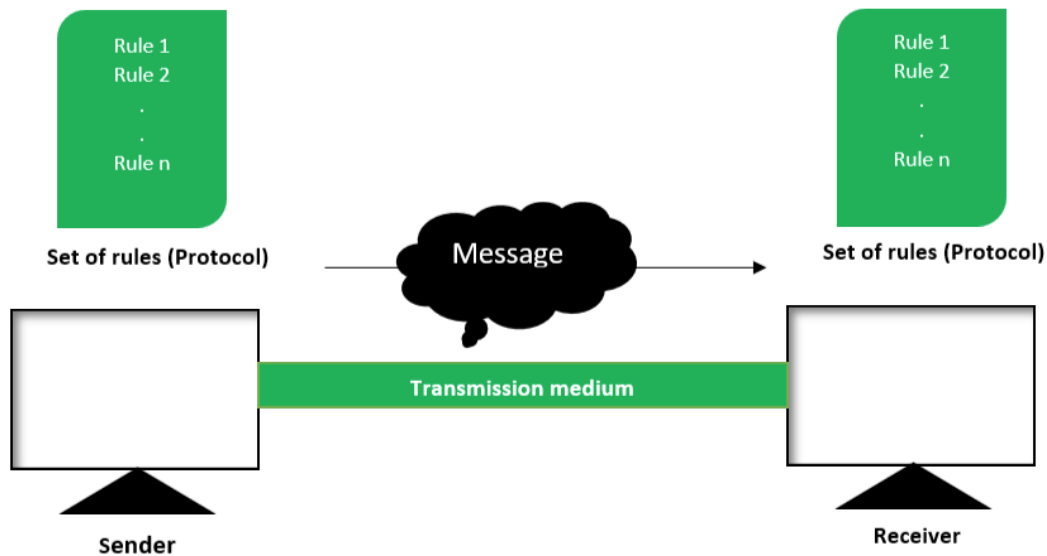All above mentioned elements are described below:

Figure – Components of Data Communication System

1.   **Message :**
This is most useful asset of a data communication system. The message simply refers to data or piece of information which is to be communicated. A message could be in any form, it may be in form of a text file, an audio file, a video file, etc.

2. **Sender :**
To transfer message from source to destination, someone must be there who will play role of a source. Sender plays part of a source in data communication system. It is simple a device that sends data message. The device could be in form of a computer, mobile, telephone, laptop, video camera, or a workstation, etc.

3. **Receiver :**
   It is destination where finally message sent by source has arrived. It is a device that receives message. Same as sender, receiver can also be in form of a computer, telephone mobile, workstation, etc.

4. **Transmission Medium :**
   In entire process of data communication, there must be something which could act as a bridge between sender and receiver, Transmission medium plays that part. It is physical path by which data or message travels from sender to receiver. Transmission medium could be guided (with wires) or unguided (without wires), for example, twisted pair cable, fiber optic cable, radio waves, microwaves, etc.

5. **Set of rules (Protocol) :**
   To govern data communications, various sets of rules had been already designed by the designers of the communication systems, which represent a kind of agreement between communicating devices. These are defined as protocol. In simple terms, the protocol is a set of rules that govern data communication. If two different devices are connected but there is no protocol among them, there would not be any kind of communication between those two devices. Thus the protocol is necessary for data communication to take place.

A typical example of a data communication system is sending an e-mail. The user which send email act as sender, message is data which user wants to send, receiver is one whom user wants to send message, there are many protocols involved in this entire process, one of them is Simple Mail Transfer Protocol (SMTP), both sender and receiver must have an internet connection which uses a wireless medium to send and receive email.

Transmission Modes in Computer Networks (Simplex, Half-Duplex and Full-Duplex)

29-07-2017

Transmission mode means transferring of data between two devices. It is also known as communication mode. Buses and networks are designed to allow communication to occur between individual devices that are interconnected. There are three types of transmission mode:-
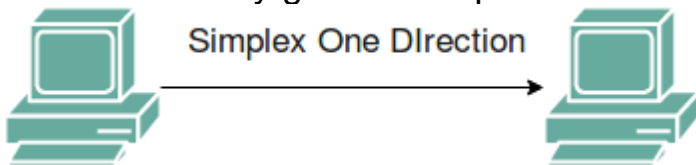
- **Simplex Mode**

- **Half-Duplex Mode**

- **Full-Duplex Mode**
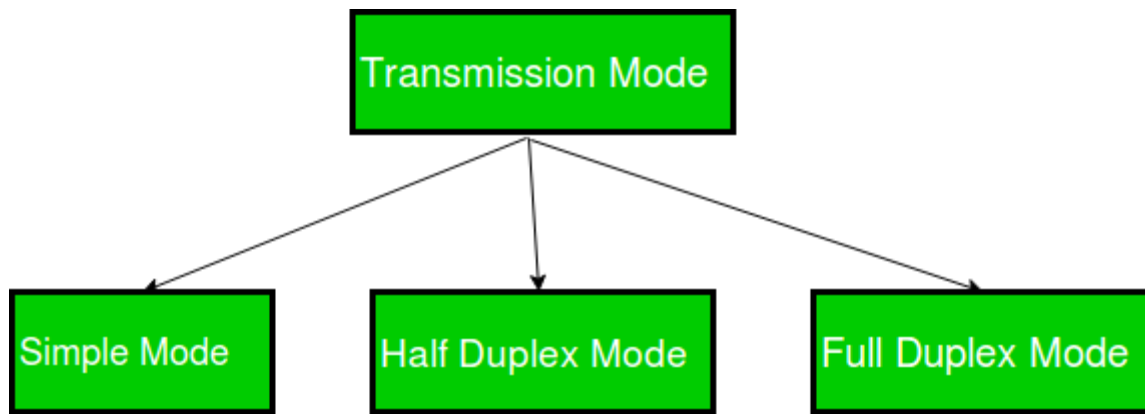
Simplex Mode

In Simplex mode, the communication is unidirectional, as on a one-way street. Only one of the two devices on a link can transmit, the other can only receive. The simplex mode can use the entire capacity of the channel to send data in one direction.

Example: Keyboard and traditional monitors. The keyboard can only introduce input, the monitor can only give the output.

Half-Duplex Mode

In half-duplex mode, each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa. The half-duplex mode is used in cases where there is no need for communication in both direction at the same time. The entire capacity of the channel can be utilized for each direction.

Example: Walkie- talkie in which message is sent one at a time and messages are sent in both the directions.
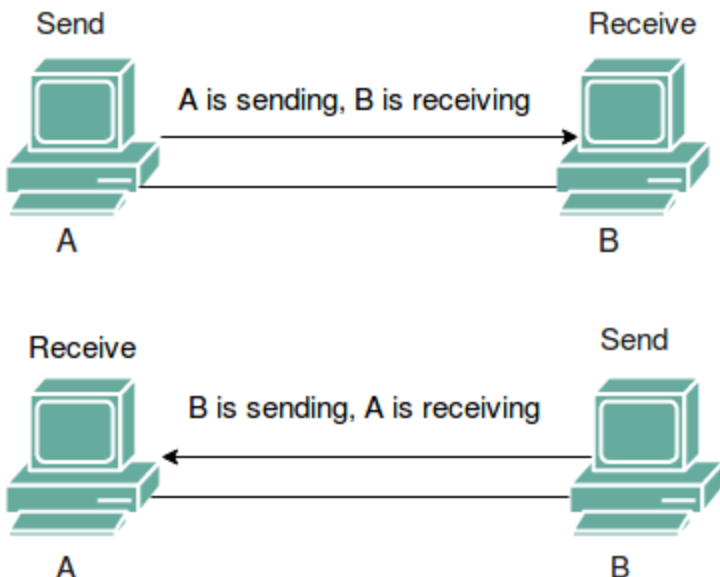
Full-Duplex Mode

In full-duplex mode, both stations can transmit and receive simultaneously. In full_duplex mode, signals going in one direction share the capacity of the link with signals going in other direction, this sharing can occur in two ways:

- Either the link must contain two physically separate transmission paths, one for sending and other for receiving.

- Or the capacity is divided between signals travelling in both directions.

Full-duplex mode is used when communication in both direction is required all the time. The capacity of the channel, however must be divided between the two directions.
Example: Telephone Network in which there is communication between two persons by a telephone line, through which both can talk and listen at the same time.
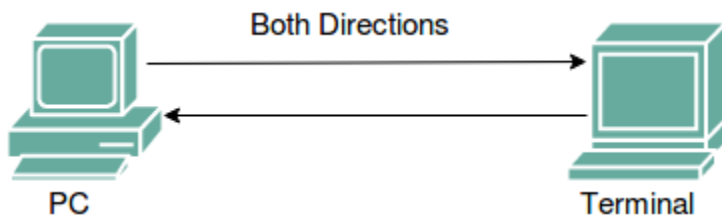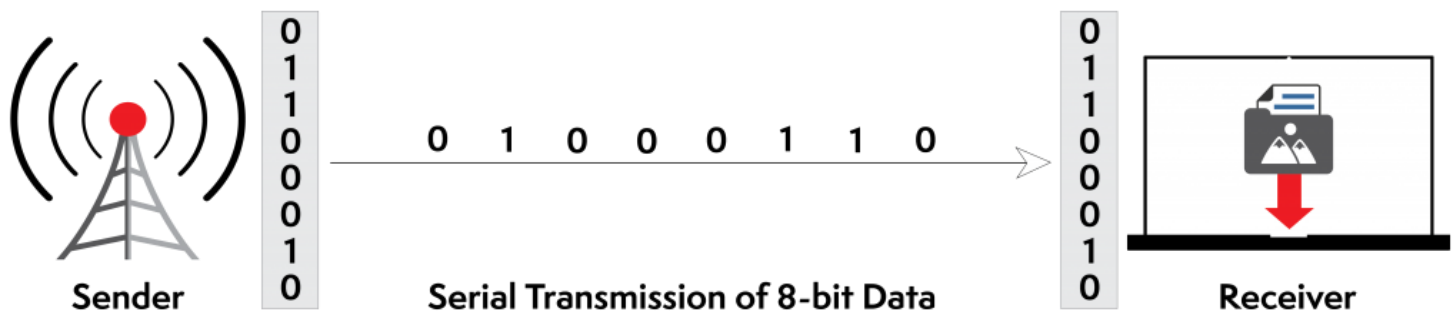

What is data transmission?

Data transmission refers to the process of transferring data between two or more digital devices. Data is transmitted from one device to another in analog or digital format. Basically, data transmission enables devices or components within devices to speak to each other.

How does data transmission work between digital devices?

Data is transferred in the form of bits between two or more digital devices. There are two methods used to transmit data between digital devices: serial transmission and parallel transmission. Serial data transmission sends data bits one after another over a single channel. Parallel data transmission sends multiple data bits at the same time over multiple channels.

What is serial transmission?

When data is sent or received using serial data transmission, the data bits are organized in a specific order, since they can only be sent one after another. The order of the data bits is important as it dictates how the transmission is organized when it is received. It is viewed as a reliable data transmission method because a data bit is only sent if the previous data bit has already been received.

Example of Serial Data Transmission

Serial transmission has two classifications: asynchronous and synchronous.

Asynchronous Serial Transmission
Data bits can be sent at any point in time. Stop bits and start bits are used between data bytes to synchronize the transmitter and receiver and to ensure that the data is transmitted correctly. The time between sending and receiving data bits is not constant, so gaps are used to provide time between transmissions.

The advantage of using the asynchronous method is that no synchronization is required between the transmitter and receiver devices. It is also a more cost effective method. A disadvantage is that data transmission can be slower, but this is not always the case.

Synchronous Serial Transmission
Data bits are transmitted as a continuous stream in time with a master clock. The data transmitter and receiver both operate using a synchronized clock frequency; therefore, start bits, stop bits, and gaps are not used. This means that data moves faster and timing errors are less frequent because the transmitter and receiver time is synced. However, data accuracy is highly dependent on timing being synced correctly between devices. In comparison with asynchronous serial transmission, this method is usually more expensive.

When is serial transmission used to send data?

Serial transmission is normally used for long-distance data transfer. It is also used in cases where the amount of data being sent is relatively small. It ensures that data integrity is maintained as it transmits the data bits in a specific order, one after another. In this way, data bits are received in-sync with one another.
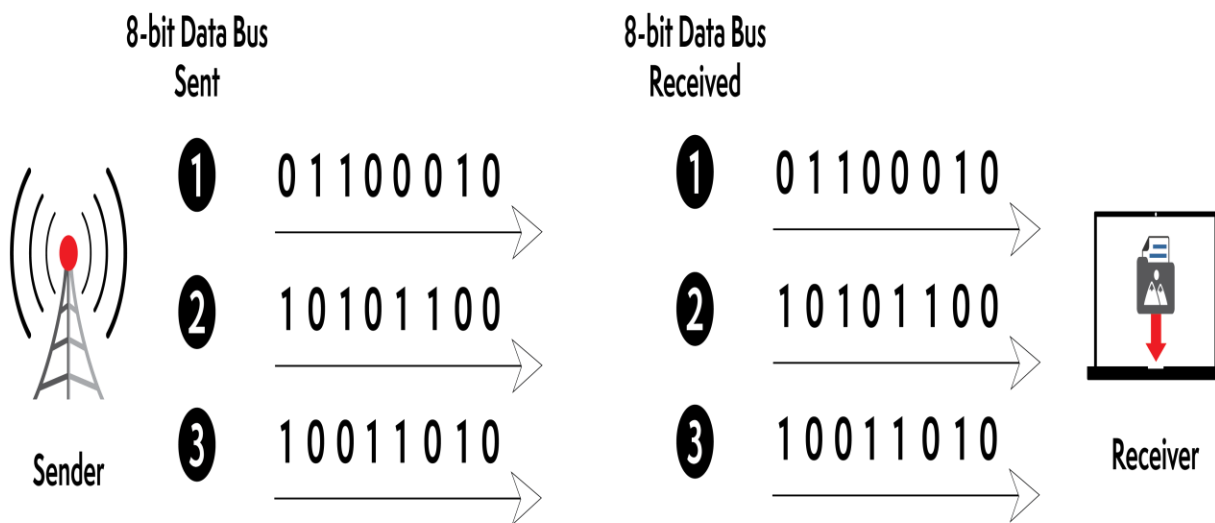
What is parallel transmission?

When data is sent using parallel data transmission, multiple data bits are transmitted over multiple channels at the same time. This means that data can be sent much faster than using serial transmission methods.
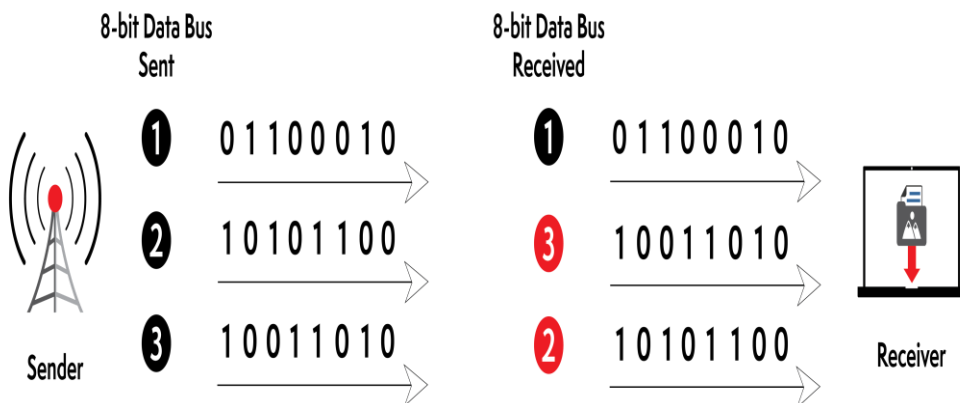
Example of Parallel Data Transmission

Given that multiple bits are sent over multiple channels at the same time, the order in which a bit string is received can depend on various conditions, such as proximity to the data source, user location, and bandwidth availability. Two examples of parallel interfaces can be seen below. In the first parallel interface, the data is sent and received in the correct order. In the second parallel interface, the data is sent in the correct order, but some bits were received faster than others.

Example of Parallel Transmission – Data Received Correctly

Example of Parallel Transmission – Data Received Incorrectly

Advantages and Disadvantages of Using Parallel Data Transmission

The main advantages of parallel transmission over serial transmission are:

- it is easier to program;
- and data is sent faster.

Although parallel transmission can transfer data faster, it requires more transmission channels than serial transmission. This means that data bits can be out of sync, depending on transfer distance and how fast each bit loads. A simple of example of where this can be seen is with a voice over IP (VOIP) call when distortion or interference is noticeable. It can also be seen when there is skipping or interference on a video stream.

When is parallel transmission used to send data?

Parallel transmission is used when:

- a large amount of data is being sent;
- the data being sent is time-sensitive;
- and the data needs to be sent quickly.

A scenario where parallel transmission is used to send data is video streaming. When a video is streamed to a viewer, bits need to be received quickly to prevent a video pausing or buffering. Video streaming also requires the transmission of large volumes of data. The data being sent is also time-sensitive as slow data streams result in poor viewer experience.

Switching techniques

In large networks, there can be multiple paths from sender to receiver. The switching technique will decide the best route for data transmission.

Switching technique is used to connect the systems for making one-to-one communication.

**Classification Of Switching Techniques**
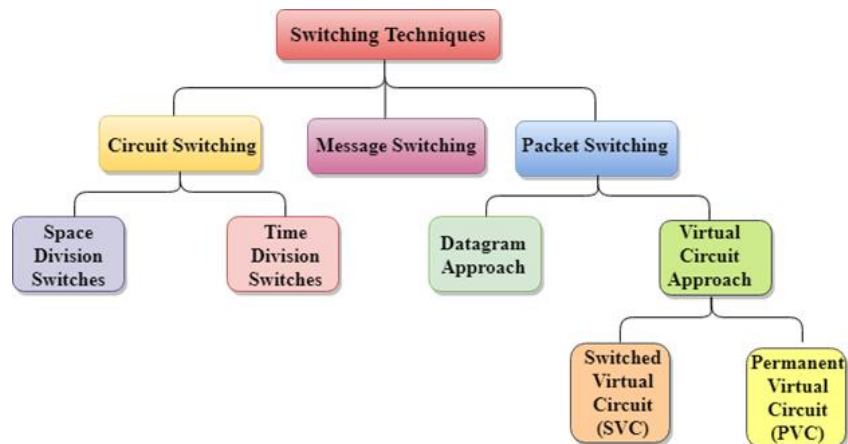
- o Circuit switching is a switching technique that establishes a dedicated path between sender and receiver.
- o In the Circuit Switching Technique, once the connection is established then the dedicated path will remain to exist until the connection is terminated.
- o Circuit switching in a network operates in a similar way as the telephone works.
- o A complete end-to-end path must exist before the communication takes place.
- o In case of circuit switching technique, when any user wants to send the data, voice, video, a request signal is sent to the receiver then the receiver sends back the acknowledgment to ensure the availability of the dedicated path. After receiving the acknowledgment, dedicated path transfers the data.
- o Circuit switching is used in public telephone network. It is used for voice transmission.
- o Fixed data can be transferred at a time in circuit switching technology.

Communication through circuit switching has 3 phases:

- o Circuit establishment
- o Data transfer
- o Circuit Disconnect
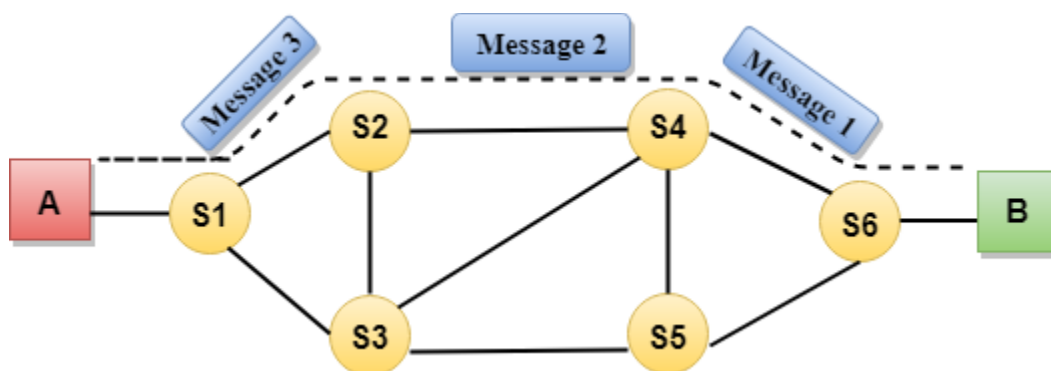
Circuit Switching can use either of the two technologies:

Space Division Switches:

- o Space Division Switching is a circuit switching technology in which a single transmission path is accomplished in a switch by using a physically separate set of crosspoints.

- Space Division Switching can be achieved by using crossbar switch. A crossbar switch is a metallic crosspoint or semiconductor gate that can be enabled or disabled by a control unit.
- The Crossbar switch is made by using the semiconductor. For example, Xilinx crossbar switch using FPGAs.
- Space Division Switching has high speed, high capacity, and nonblocking switches.

Space Division Switches can be categorized in two ways:

- **Crossbar Switch**
- **Multistage Switch**

Crossbar Switch

The Crossbar switch is a switch that has n input lines and n output lines. The crossbar switch has n^2 intersection points known as **crosspoints.**

Disadvantage of Crossbar switch:

The number of crosspoints increases as the number of stations is increased. Therefore, it becomes very expensive for a large switch. The solution to this is to use a multistage switch.

Multistage Switch

- Multistage Switch is made by splitting the crossbar switch into the smaller units and then interconnecting them.
- It reduces the number of crosspoints.
- If one path fails, then there will be an availability of another path.

Advantages Of Circuit Switching:

- In the case of Circuit Switching technique, the communication channel is dedicated.
- It has fixed bandwidth.

Disadvantages Of Circuit Switching:

- Once the dedicated path is established, the only delay occurs in the speed of data transmission.
- It takes a long time to establish a connection approx 10 seconds during which no data can be transmitted.

- It is more expensive than other switching techniques as a dedicated path is required for each connection.
- It is inefficient to use because once the path is established and no data is transferred, then the capacity of the path is wasted.
- In this case, the connection is dedicated therefore no other data can be transferred even if the channel is free.

Message Switching

- Message Switching is a switching technique in which a message is transferred as a complete unit and routed through intermediate nodes at which it is stored and forwarded.
- In Message Switching technique, there is no establishment of a dedicated path between the sender and receiver.
- The destination address is appended to the message. Message Switching provides a dynamic routing as the message is routed through the intermediate nodes based on the information available in the message.
- Message switches are programmed in such a way so that they can provide the most efficient routes.
- Each and every node stores the entire message and then forward it to the next node. This type of network is known as **store and forward network.**
- Message switching treats each message as an independent entity.
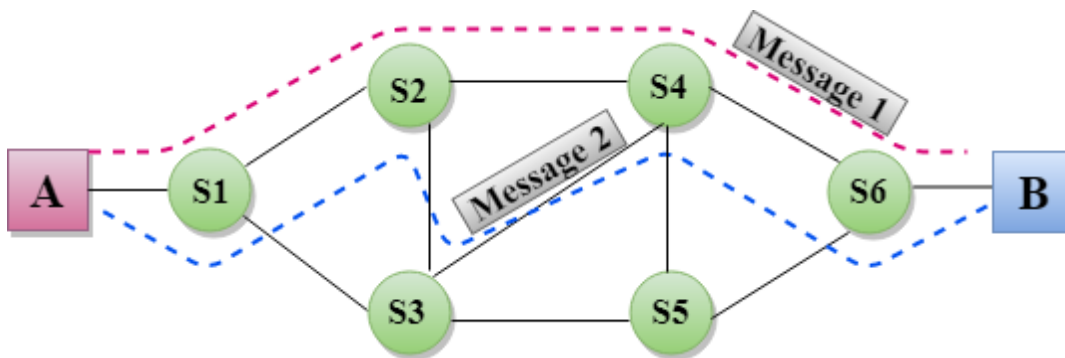
Advantages Of Message Switching

- Data channels are shared among the communicating devices that improve the efficiency of using available bandwidth.
- Traffic congestion can be reduced because the message is temporarily stored in the nodes.
- Message priority can be used to manage the network.

o The size of the message which is sent over the network can be varied. Therefore, it supports the data of unlimited size.

Disadvantages Of Message Switching

o The message switches must be equipped with sufficient storage to enable them to store the messages until the message is forwarded.

o The Long delay can occur due to the storing and forwarding facility provided by the message switching technique.

Packet Switching

o The packet switching is a switching technique in which the message is sent in one go, but it is divided into smaller pieces, and they are sent individually.

o The message splits into smaller pieces known as packets and packets are given a unique number to identify their order at the receiving end.

o Every packet contains some information in its headers such as source address, destination address and sequence number.

o Packets will travel across the network, taking the shortest path as possible.

o All the packets are reassembled at the receiving end in correct order.

o If any packet is missing or corrupted, then the message will be sent to resend the message.

o If the correct order of the packets is reached, then the acknowledgment message will be sent.
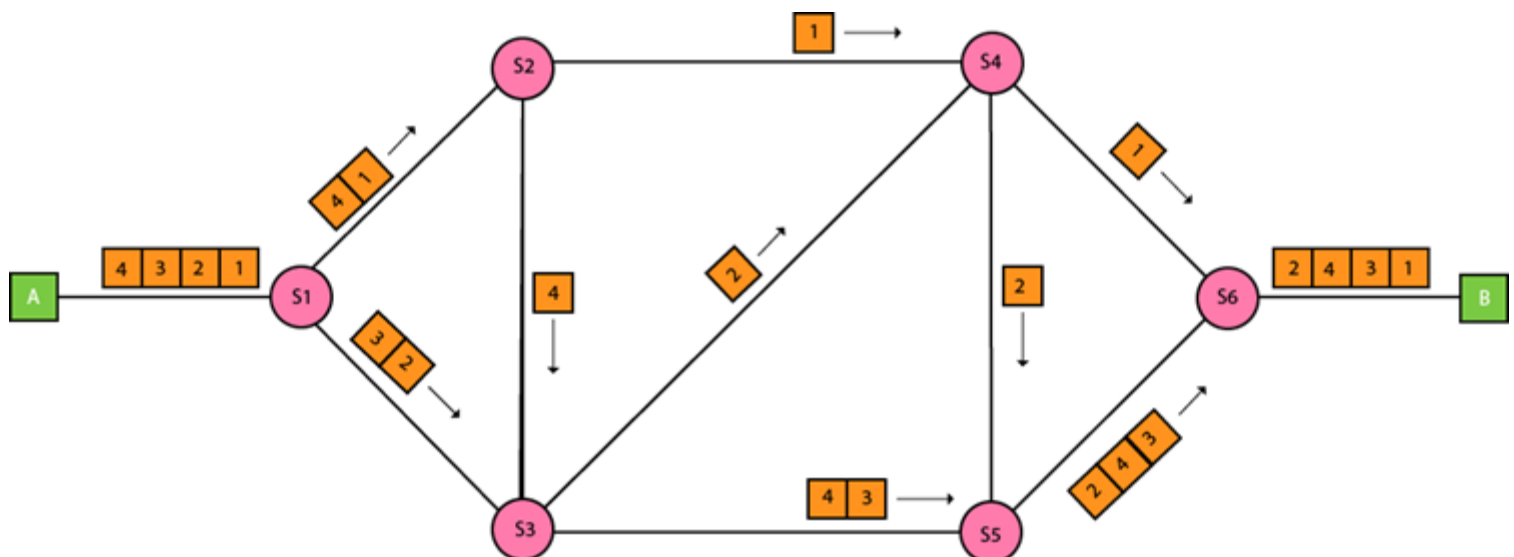
Approaches Of Packet Switching:

There are two approaches to Packet Switching:

Datagram Packet switching:

- o It is a packet switching technology in which packet is known as a datagram, is considered as an independent entity. Each packet contains the information about the destination and switch uses this information to forward the packet to the correct destination.
- o The packets are reassembled at the receiving end in correct order.
- o In Datagram Packet Switching technique, the path is not fixed.
- o Intermediate nodes take the routing decisions to forward the packets.
- o Datagram Packet Switching is also known as connectionless switching.

Virtual Circuit Switching

- o Virtual Circuit Switching is also known as connection-oriented switching.
- o In the case of Virtual circuit switching, a preplanned route is established before the messages are sent.
- o Call request and call accept packets are used to establish the connection between sender and receiver.
- o In this case, the path is fixed for the duration of a logical connection.

Let's understand the concept of virtual circuit switching through a diagram:
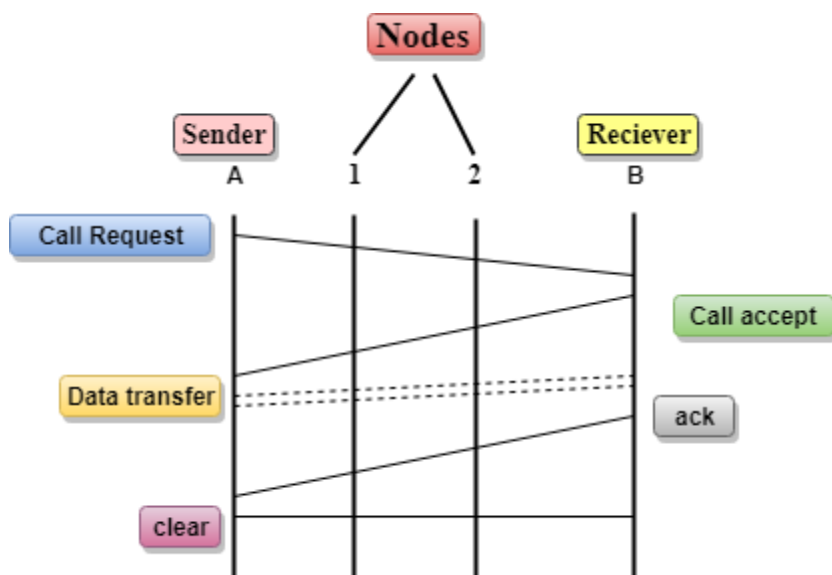
- o In the above diagram, A and B are the sender and receiver respectively. 1 and 2 are the nodes.

- Call request and call accept packets are used to establish a connection between the sender and receiver.
- When a route is established, data will be transferred.
- After transmission of data, an acknowledgment signal is sent by the receiver that the message has been received.
- If the user wants to terminate the connection, a clear signal is sent for the termination.

Differences b/w Datagram approach and Virtual Circuit approach

| Datagram approach	Virtual Circuit approach
Node takes routing decisions to forward the packets.	Node does not take any routing decision.
Congestion cannot occur as all the packets travel in different directions.	Congestion can occur when the node is busy, and it does not allow other packets to pass through.
It is more flexible as all the packets are treated as an independent entity.	It is not very flexible.

Advantages Of Packet Switching:

- **Cost-effective:** In packet switching technique, switching devices do not require massive secondary storage to store the packets, so cost is minimized to some extent. Therefore, we can say that the packet switching technique is a cost-effective technique.
- **Reliable:** If any node is busy, then the packets can be rerouted. This ensures that the Packet Switching technique provides reliable communication.
- **Efficient:** Packet Switching is an efficient technique. It does not require any established path prior to the transmission, and many users can use the same communication channel simultaneously, hence makes use of available bandwidth very efficiently.

Disadvantages Of Packet Switching:

- Packet Switching technique cannot be implemented in those applications that require low delay and high-quality services.
- The protocols used in a packet switching technique are very complex and requires high implementation cost.
- If the network is overloaded or corrupted, then it requires retransmission of lost packets. It can also lead to the loss of critical information if errors are nor recovered.
- **What is OSI Model?**
- The OSI Model is a logical and conceptual model that defines network communication used by systems open to interconnection and communication with other systems. The Open System Interconnection (OSI Model) also defines a logical network and effectively describes computer packet transfer by using various layers of protocols.
- **What is TCP/IP Model?**
- TCP/IP helps you to determine how a specific computer should be connected to the internet and how you can transmit data between them. It helps you to create a virtual network when multiple computer networks are connected together.

TCP/IP stands for Transmission Control Protocol/ Internet Protocol. It is specifically designed as a model to offer highly reliable and end-to-end byte stream over an unreliable internetwork.
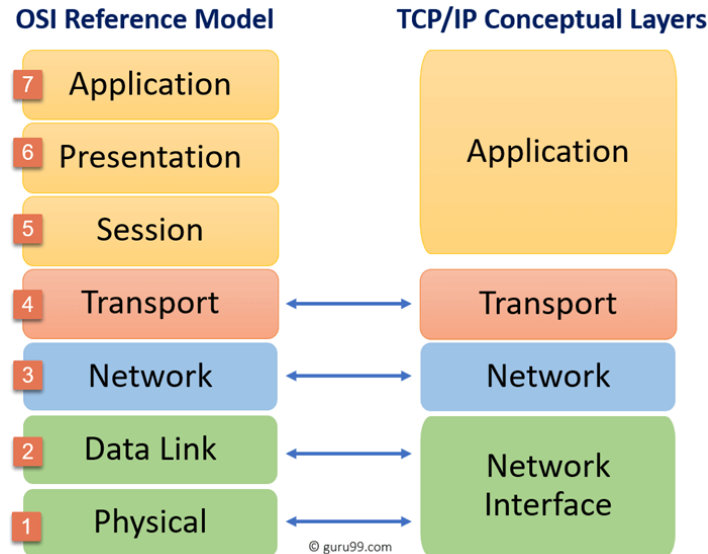
KEY DIFFERENCE

- OSI has 7 layers whereas TCP/IP has 4 layers.
- The OSI Model is a logical and conceptual model that defines network communication used by systems open to interconnection and communication with other systems. On the other hand, TCP/IP helps you to determine how a specific computer should be connected to the internet and how you can be transmitted between them.
- OSI header is 5 bytes whereas TCP/IP header size is 20 bytes.

- OSI refers to Open Systems Interconnection whereas TCP/IP refers to Transmission Control Protocol.
- OSI follows a vertical approach whereas TCP/IP follows a horizontal approach.
- OSI model, the transport layer, is only connection-oriented whereas the TCP/IP model is both connection-oriented and connectionless.
- OSI model is developed by ISO (International Standard Organization), whereas TCP Model is developed by ARPANET (Advanced Research Project Agency Network).
- OSI model helps you to standardize router, switch, motherboard, and other hardware whereas TCP/IP helps you to establish a connection between different types of computers.

History of OSI Model

Here are some important landmarks from the history of the OSI model:

- In the late 1970s, the ISO conducted a program to develop general standards and methods of networking.
- In 1973, an Experimental Packet Switched System in the UK identified the requirement for defining the higher-level protocols.
- In the year 1983, the OSI model was initially intended to be a detailed specification of actual interfaces.
- In 1984, the OSI architecture was formally adopted by ISO as an international standard.

History of TCP/IP

Here are some important landmarks from the history of TCP/IP:

- In 1974, Vint Cerf and Bob Kahn published a paper "A Protocol for Packet Network Interconnection" which describes the TCP/IP Model.
- By 1978, testing and further development of this language led to a new suite of protocols called TCP/IP.
- In 1982, it was decided that TCP/IP should be replaced NCP as the standard language of the ARPAnet.
- On January 1, 1983, ARPAnet switched over to TCP/IP,
- ARPAnet finished its existence in 1990. The Internet has since grown from ARPAnet's roots, and TCP/IP evolved to meet the changing requirements of the Internet.

Characteristics of the OSI Model

Here are some important characteristics of the OSI model:

- A layer should only be created where the definite levels of abstraction are needed.
- The function of each layer should be selected as per the internationally standardized protocols.

- The number of layers should be large so that separate functions should not be put in the same layer. At the same time, it should be small enough so that architecture doesn't become very complicated.
- In the OSI model, each layer relies on the next lower layer to perform primitive functions. Every level should able to provide services to the next higher layer.
- Changes made in one layer should not need changes in other lavers.

Characteristics TCP/IP Model

Here are the essential characteristics of the TCP/IP protocol:

- Support for a flexible architecture
- Adding more systems to a network is easy.
- In TCP/IP, the network remains intact until the source and destination machines were functioning properly.
- TCP is a connection-oriented protocol.
- TCP offers reliability and ensures that data which arrives out of sequence should put back into order.
- TCP allows you to implement flow control, so the sender never overpowers a receiver with data.

Difference between OSI Model and TCP/IP Model

Here are some important differences between the OSI and TCP/IP model:

OSI Model	TCP/IP Model
It is developed by ISO (International Standard Organization)	It is developed by ARPANET (Advanced Research Project Agency Network).

OSI model provides a clear distinction between interfaces, services, and protocols.	TCP/IP doesn't have any clear distinguishing points between services, interfaces, and protocols.
OSI refers to Open Systems Interconnection.	TCP refers to Transmission Control Protocol.
OSI uses the network layer to define routing standards and protocols.	TCP/IP uses only the Internet layer.
OSI follows a vertical approach.	TCP/IP follows a horizontal approach.
OSI layers have seven layers.	TCP/IP has four layers.
In the OSI model, the transport layer is only connection-oriented.	A layer of the TCP/IP model is both connection-oriented and connectionless.
In the OSI model, the data link layer and physical are separate layers.	In TCP, physical and data link are both combined as a single host-to-network layer.

Session and presentation layers are a part of the OSI model.	There is no session and presentation layer in the TCP model.
It is defined after the advent of the Internet.	It is defined before the advent of the internet.
The minimum size of the OSI header is 5 bytes.	The minimum header size is 20 bytes.

Advantages of the OSI Model

Here are the major benefits/pros of using the OSI model:

- It helps you to standardize router, switch, motherboard, and other hardware
- Reduces complexity and standardizes interfaces
- Facilitates modular engineering
- Helps you to ensure interoperable technology
- Helps you to accelerate the evolution
- Protocols can be replaced by new protocols when technology changes.
- Provide support for connection-oriented services as well as connectionless service.
- It is a standard model in computer networking.
- Supports connectionless and connection-oriented services.
- It offers flexibility to adapt to various types of protocols.

Advantages of TCP/IP

Here, are pros/benefits of using the TCP/IP model:

- It helps you to establish/set up a connection between different types of computers.
- It operates independently of the operating system.
- It supports many routing-protocols.
- It enables the internetworking between the organizations.
- TCP/IP model has a highly scalable client-server architecture.
- It can be operated independently.
- Supports several routing protocols.

- It can be used to establish a connection between two computers.

Disadvantages of OSI Model

Here are some cons/ drawbacks of using OSI Model:

- Fitting of protocols is a tedious task.
- You can only use it as a reference model.
- It doesn't define any specific protocol.
- In the OSI network layer model, some services are duplicated in many layers such as the transport and data link layers
- Layers can't work in parallel as each layer need to wait to obtain data from the previous layer.

Disadvantages of TCP/IP

Here, are few drawbacks of using the TCP/IP model:

- TCP/IP is a complicated model to set up and manage.
- The shallow/overhead of TCP/IP is higher-than IPX (Internetwork Packet Exchange).
- In this, model the transport layer does not guarantee delivery of packets.
- Replacing protocol in TCP/IP is not easy.
- It has no clear separation from its services, interfaces, and protocols.