THE OSI MODEL

- The OSI model is not a protocol; it is a model for understanding and designing a network architecture that is flexible, robust, and interoperable.
- The OSI model is a layered framework for the design of network systems that allows communication between all types of computer systems. It consists of seven separate but related layers.

Layered Architecture:

- The OSI model is composed of seven ordered layers: physical (layer 1), data link (layer 2),network (layer 3), transport (layer 4), session (layer 5), presentation (layer 6), and application (layer 7).

Peer-to-Peer Processes:

- At the physical layer, communication is direct: In Figure, device A sends a stream of bits to device B (through intermediate nodes). At the higher layers, however, communication must move down through the layers on device A, over to device B, and then back up through the layers.
- Each layer in the sending device adds its own informationto the message it receives from the layer just above it and passes the whole package tothe layer just below it.

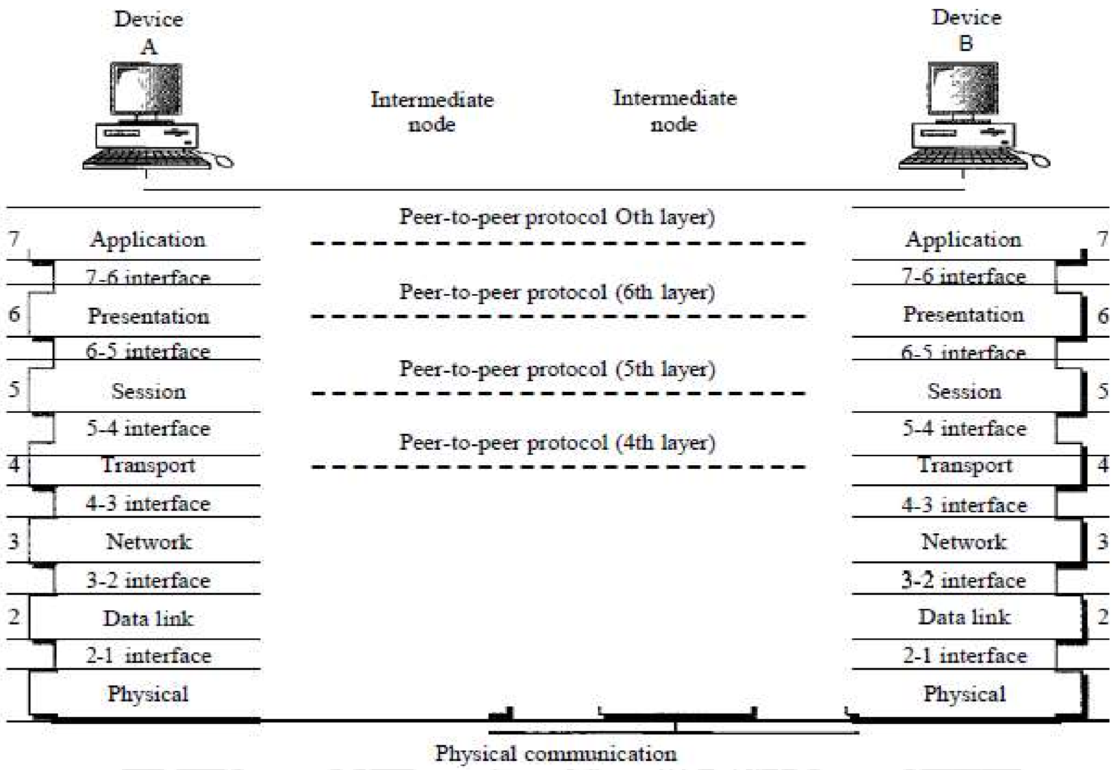

Fig: The interaction between layers in the OSI model.

- At layer I the entire package is converted to a form that can be transmitted to the receiving device. At the receiving machine, the message is unwrapped layer by layer, with each process receiving and removing the data meant for it.

Interfaces Between Layers

- The passing of the data and network information down through the layers of the sendingdevice and back up through the layers of the receiving device is made possible byan interface between each pair of adjacent layers.

Organization ofthe Layers:

- The seven layers can be thought of as belonging to three subgroups. Layers I, 2, and3-physical, data link, and network-are the network support layers; they deal with the physical aspects of moving data from one device to another Layers 5, 6, and 7-session, presentation, and application-can bethought of as the user support layers; they allow interoperability among unrelatedsoftware systems.
- Layer 4, the transport layer, links the two subgroups and ensuresthat what the lower layers have transmitted is in a form that the upper layers can use.

- The upper OSI layers are almost always implemented in software; lower layers are acombination of hardware and software, except for the physical layer, which is mostlyhardware.
- At each layer, a **header,** or possibly a **trailer,** can be added to the data unit.Commonly, the trailer is added only at layer 2. When the formatted data unit passesthrough the physical layer (layer 1), it is changed into an electromagnetic signal andtransported along a physical link.
- Upon reaching its destination, the signal passes into layer 1 and is transformedback into digital form. The data units then move back up through the OSI layers.
- Aseach block of data reaches the next higher layer, the headers and trailers attached to it atthe corresponding sending layer are removed, and actions appropriate to that layer aretaken.
- By the time it reaches layer 7, the message is again in a form appropriate to theapplication and is made available to the recipient.

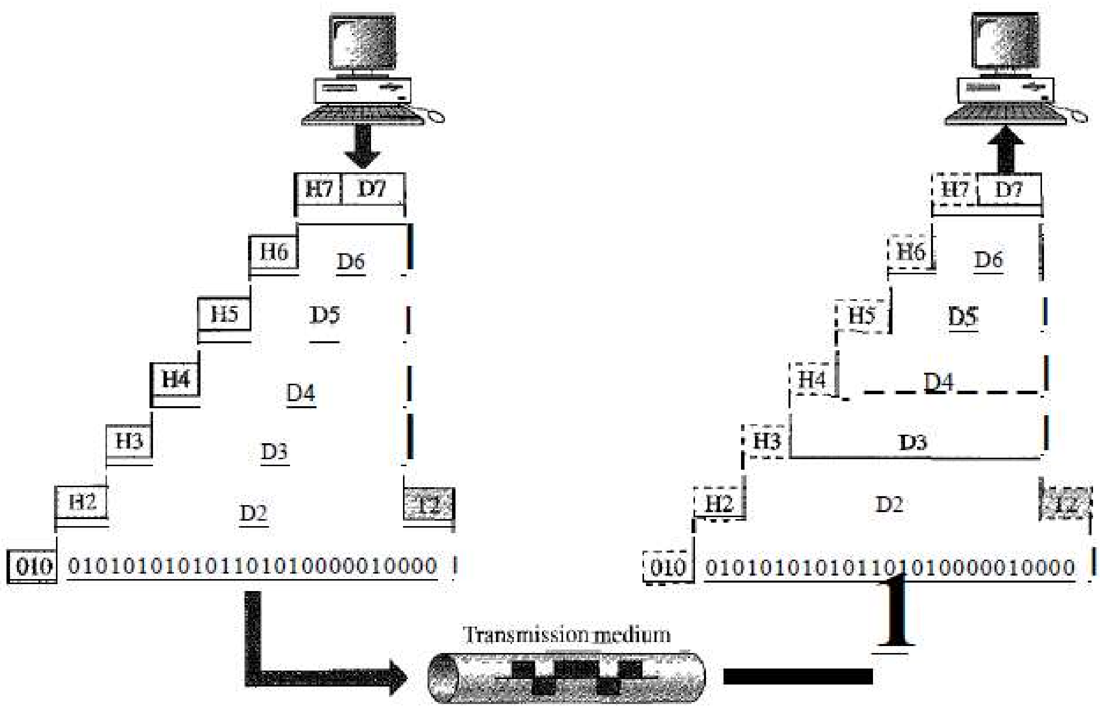

Fig: An exchange using the OSI model.

LAYERS IN THE OSI MODEL:

Physical Layer

- The physical layer coordinates the functions required to carry a bit stream over a physical medium. It deals with the mechanical and electrical specifications of the interface and transmission medium.

- The physical layer is responsible for movements of individual bits from one hop (node) to the next.
- The physical layer is also concerned with the following:

✓ **Physical characteristics of interfaces and medium**.

The physical layer defines the characteristics of the interface between the devices and the transmission medium. It also defines the type of transmission medium.

✓ **Representation of bits**.

The physical layer data consists of a stream of bits(sequence of 0s or 1s) with no interpretation. To be transmitted, bits must be encoded into signals--electrical or optical. The physical layer defines the type of encoding (how 0s and 1s are changed to signals).

✓ **Data rate**.

The transmission rate-the number of bits sent each second-is also defined by the physical layer.

✓ **Synchronization of bits.**

The sender and receiver not only must use the same bit rate but also must be synchronized at the bit level.

✓ **Line configuration**.

The physical layer is concerned with the connection of devices to the media. In a point-to-point configuration, two devices are connected through a dedicated link. In a multipoint configuration, a link is shared among several devices.

✓ **Physical topology**.

The physical topology defines how devices are connected to make a network. Devices can be connected by using a mesh topology (every device is connected to every other device), a star topology (devices are connected through a central device), a ring topology (each device is connected to the next, forming a ring), a bus topology (every device is on a common link), or a hybrid topology (this is a combination of two or more topologies).

✓ **Transmission mode**.

The physical layer also defines the direction of transmission between two devices: simplex, half-duplex, or full-duplex. In simplex mode, only one device can send; the other can only receive. The simplex mode is a one-way communication. In the half-duplex mode, two devices can send and receive, but not at the same time. In a full-duplex (or simply duplex) mode, two devices can send and receive at the same time.

Data Link Layer:

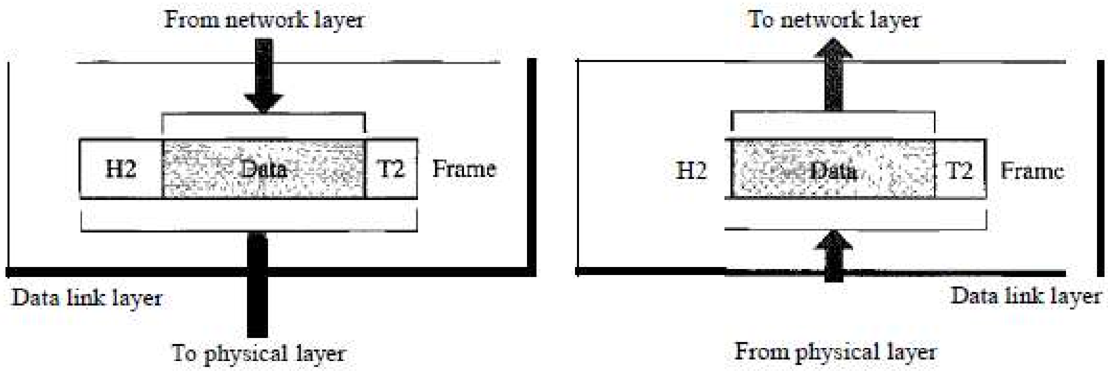

Fig: Data link layer.

The data link layer is responsible for moving frames from one hop (node) to the next.

Other responsibilities of the data link layer.

Framing.

- The data link layer divides the stream of bits received from the network layer into manageable data units called **frames**.

Physical addressing.

- If frames are to be distributed to different systems on the network, the data link layer adds a header to the frame to define the sender and/or receiver of the frame.

Flow control.

- The data link layer imposes a flow control mechanism to avoid overwhelming the receiver.

Error control.

- The data link layer adds reliability to the physical layer by adding mechanisms to detect and retransmit damaged or lost frames.

Access control.

- When two or more devices are connected to the same link, datalink layer protocols are necessary to determine which device has control over thelink at any given time.

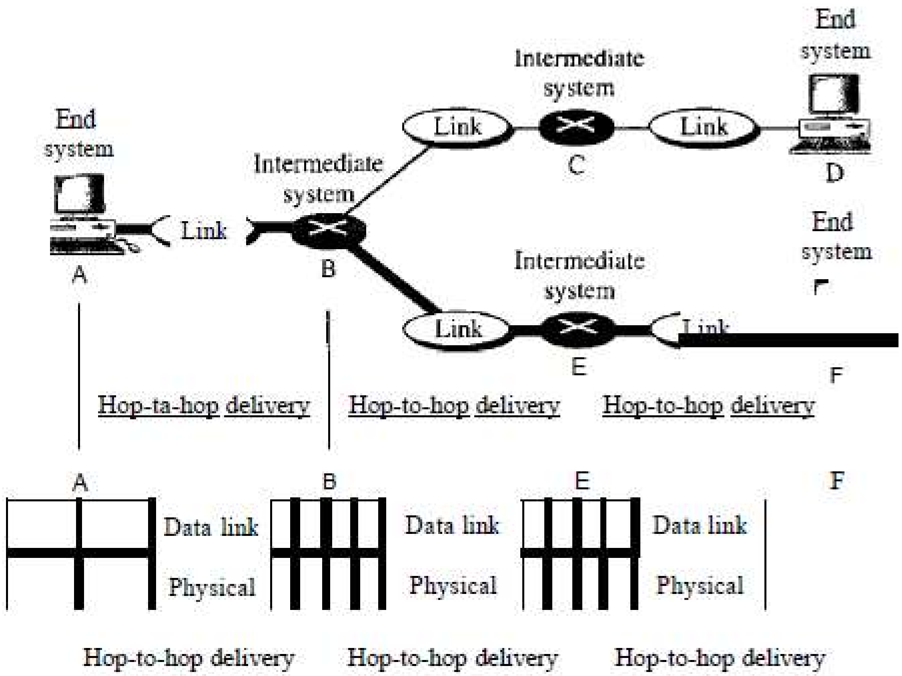

Fig: Hop-to-hop delivery.

Network Layer:

- The network layer is responsible for the source-to-destination delivery of a packet, possibly across multiple networks (links).
- If two systems are connected to the same link, there is usually no need for a network layer. However, if the two systems are attached to different networks (links) with connecting devices between the networks (links), there is often a need for the network layer to accomplish source-to-destination delivery.
- The network layer is responsible for the delivery of individual packets from the source host to the destination host.

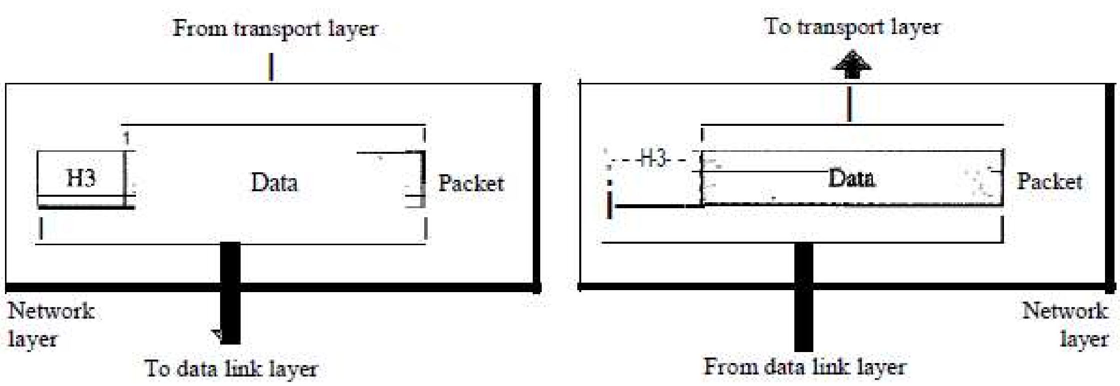

Fig: Network Layer.

Logical addressing.

- The physical addressing implemented by the data link layer handles the addressing problem locally. If a packet passes the network boundary, we need another addressing system to help distinguish the source and destination systems.

Routing.

- When independent networks or links are connected to create *internetworks*(network of networks) or a large network, the connecting devices (called *routers* or *switches)* route or switch the packets to their final destination.

Transport Layer:

- The transport layer is responsible for process-to-process delivery of the entire message.A process is an application program running on a host.The transport layer is responsible for the delivery of a message from one process to another.

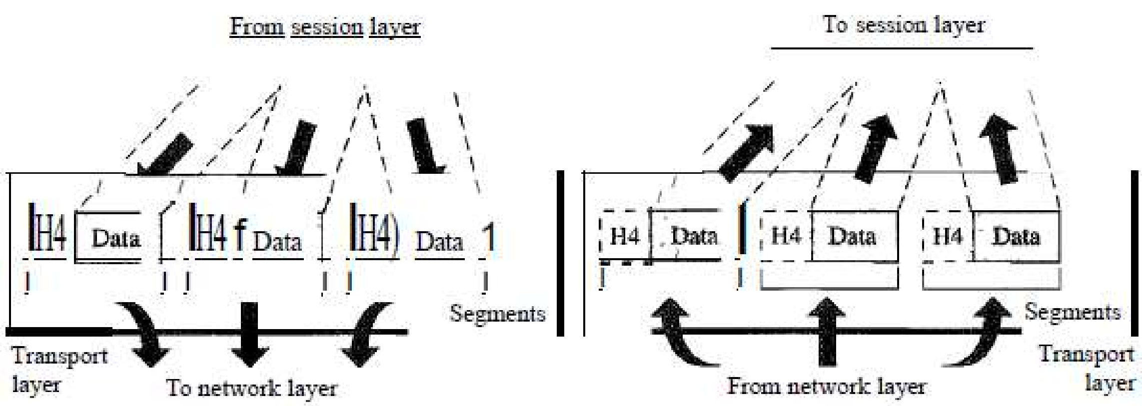

Fig: Transport layer

Service-point addressing.

- The transportlayer header must therefore include a type of address called a *service-pointaddress* (or port address).

Segmentation and reassembly.

- A message is divided into transmittable segments,with each segment containing a sequence number.

Connection control.

- The transport layer can be either connectionless or connection oriented. A connectionless transport layer treats each segment as an independent packet and delivers it to the transport layer at the destination machine. A connection oriented transport layer makes a connection with the transport layer at the destination machine first before delivering the packets.

Flow control.

- Like the data link layer, the transport layer is responsible for flow control.

Error control.

- The transport layer is responsible for error control. However, error control at this layer is performed process-to –process rather than across a single link.

Session Layer:

- The services provided by the first three layers (physical, data link, and network) arenot sufficient for some processes.
- The session layer is the network *dialog controller.* It establishes, maintains, and synchronizes the interaction among communicating systems.
- The session layer is responsible for dialog control and synchronization.

Specific responsibilities

Dialog control.

- The session layer allows two systems to enter into a dialog. It allows the communication between two processes to take place in either half duplex(one way at a time) or full-duplex (two ways at a time) mode.

Synchronization.

- The session layer allows a process to add checkpoints, or synchronization

points, to a stream of data.

Presentation Layer

- The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems.
- The presentation layer is responsible for translation, compression, and encryption.

Specific responsibilities of the presentation layer:

Translation.

- The processes (running programs) in two systems are usually exchanging information in the form of character strings, numbers, and so on. The information must be changed to bit streams before being transmitted. Because different computers use different encoding systems, the presentation layer is responsible for interoperability between these different encoding methods.

- The presentation layer at the sender changes the information from its sender-dependent format into a common format.
- The presentation layer at the receiving machine changes the common format into its receiver-dependent format.

Encryption.

- To carry sensitive information, a system must be able to ensure privacy.
- Encryption means that the sender transforms the original information to another form and sends the resulting message out over the network.
- Decryption reverses the original process to transform the message back to its original form.

Compression.

- Data compression reduces the number of bits contained in the information. Data compression becomes particularly important in the transmission of multimedia such as text, audio, and video.

Application Layer:

- The application layer enables the user, whether human or software, to access the network.
- It provides user interfaces and support for services such as electronic mail, remote file access and transfer, shared database management, and other types of distributed information services.

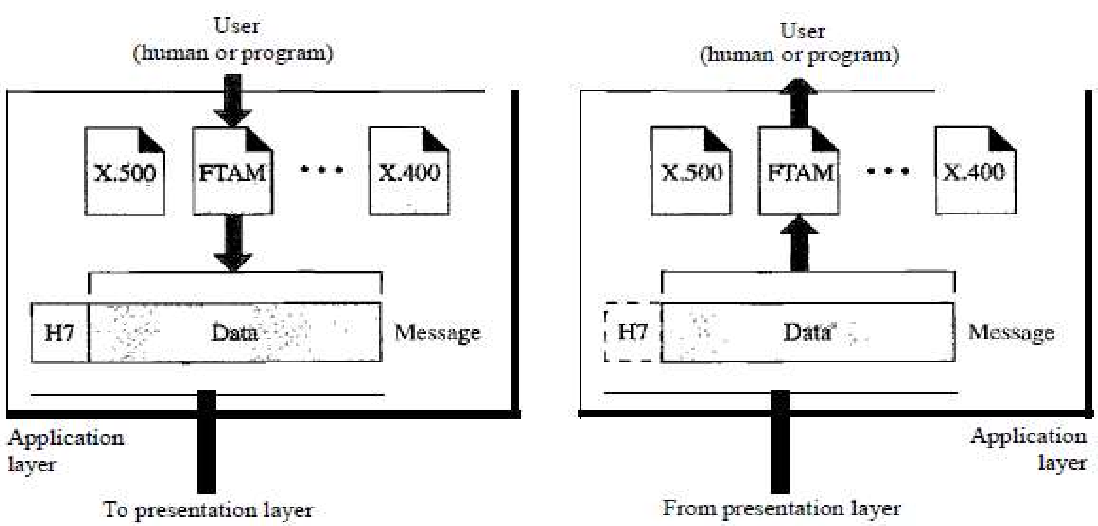

Fig: Application layer

The application layer is responsible for providing services to the user.

Network virtual terminal.

- A network virtual terminal is a software version of a physical terminal, and it allows a user to log on to a remote host.

File transfer, access, and management.

- This application allows a user to access files in a remote host (to make changes or read data), to retrieve files from a remote computer for use in the local computer, and to manage or control files in a remote computer locally.

Mail services.

- This application provides the basis for e-mail forwarding and storage.

Directory services.

- This application provides distributed database sources and access for global information about various objects and services.

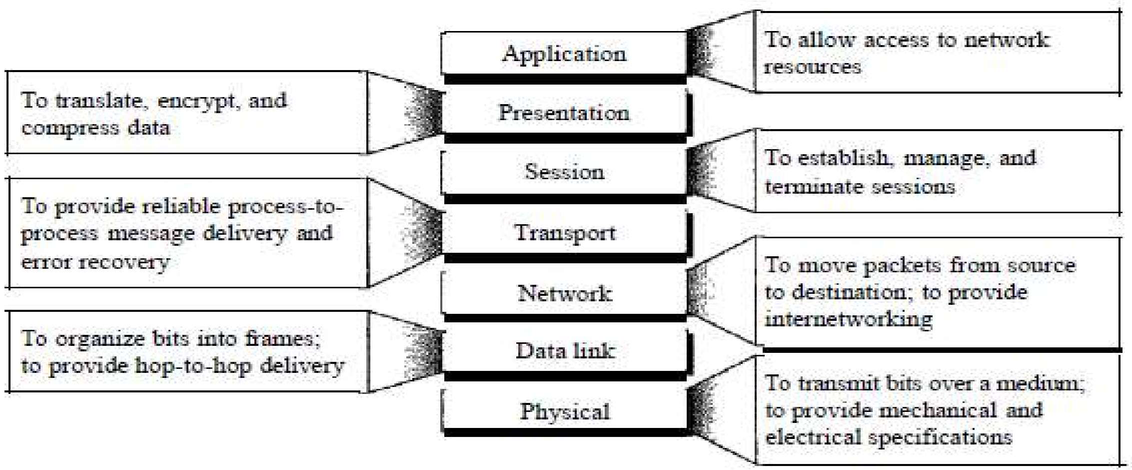

Fig: Summary of layers.

Physical Layer Performance

- One characteristic that measures network performance is bandwidth. It has two different measuring values: bandwidth inhertz and bandwidth in bits per second.
- In networking, we use the term *bandwidth* in two contexts.
  - The first, *bandwidth in hertz,* refers to the range of frequencies in a composite signalor the range of frequencies that a channel can pass.
  - The second, *bandwidth in bits per second,* refers to the speed of bit transmission in achannel or link.

Throughput:

- The **throughput** is a measure of how fast we can actually send data through a network.

We can calculate the throughput as

Throughput =**(12,000** x**10,000) / 60** =**2 Mbps**

Latency (Delay):

- The **latency** or delay defines how long it takes for an entire message to completely arrive at the destination from the time the first bit is sent out from the source.
- We can say that latency is made of four components: propagation time, transmission time, queuing time and processing delay.

Latency =**propagation time +transmission time +queuing time +processing delay**

Propagation Time

- **Propagation time** measures the time required for a bit to travel from the source to the destination. The propagation time is calculated by dividing the distance by the propagation speed.

Propagation time =**Distance / (Propagation Speed)**

Transmission Time:

- The **transmission time** of a message depends on the size of the message and the bandwidth of the channel.

Transmission time =(Message size) / Bandwidth

Queuing Time:

- The third component in latency is the **queuing time**, the time needed for each intermediate or end device to hold the message before it can be processed. The queuing time is not a fixed factor; it changes with the load imposed on the network.
- When there is heavy traffic on the network, the queuing time increases.