Chapter -4

OSI Reference Model

Objectives

- Concept of Reference Model.
- OSI Reference Model Concept.
- Layers of OSI Reference Model.

4.1 Introduction– Layered Architecture , Peer-to- Peer Processes, Interfaces between Layer, Protocols, Organization of the Layers, Encapsulation.
4.2 Layers of the OSI Reference Model (Functions of each Layer & Protocols used) –Physical Layer, Data-Link Layer, Network Layer, Transport Layer, Session Layer, Presentation Layer, Application Layer.

4.1 Introduction– Layered Architecture

Communication Architecture

- Strategy for connecting host computers and other communicating equipment.
- Defines necessary elements for data communication between devices.
- A communication architecture, therefore, defines a standard for the communicating hosts.
- A programmer formats data in a manner defined by the communication architecture and passes it on to the communication software.
- Separating communication functions adds flexibility, for example, we do not need to modify the entire host software to include more communication devices.

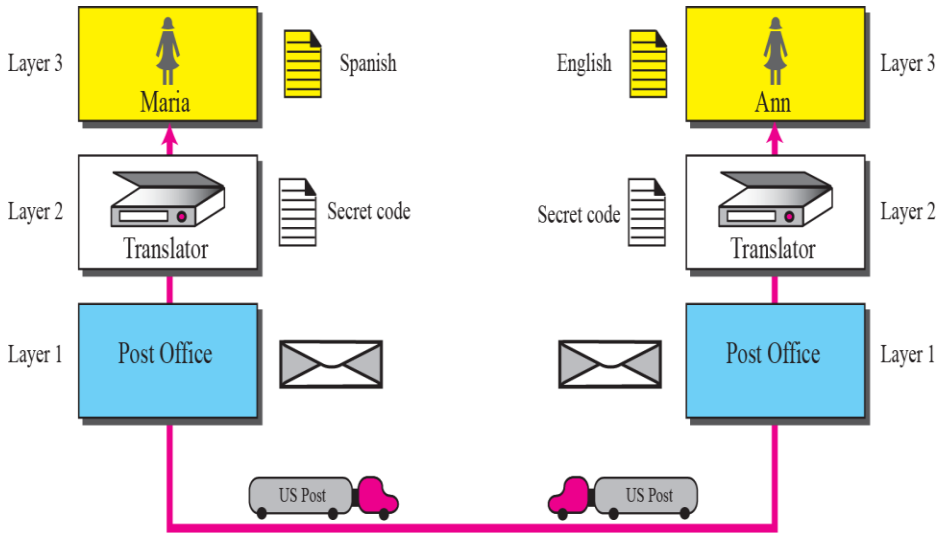
Why Layered Architecture?

- Layer architecture simplifies the network design.
- It is easy to debug network applications in a layered architecture network.
- The network management is easier due to the layered architecture.
- Network layers follow a set of rules, called protocol.
- The protocol defines the format of the data being exchanged, and the control and timing for the handshake between layers.

Following Example shows need to have layered Architecture

- Assume **Maria** and **Ann** are neighbors with a lot of common ideas.
- However, **Maria speaks only Spanish**, and **Ann speaks only English.**
- Since both have learned the **sign language** in their childhood, they enjoy meeting in a cafe a couple of days per week and exchange their ideas using signs.
- Occasionally, they also use a bilingual dictionary.
- **Communication is face to face** and Happens in one layer as shown in Figure.

- Now assume that Ann has to move to another town because of her job.
- Although both are sad, Maria opens a packet that contains two small machines.
- The first machine can scan and **transform a letter in English** to a secret code or vice versa.
- The other machine can scan and translate a letter in **Spanish** to the same secret code or vice versa.
- Ann takes the first machine; Maria keeps the second one.
- The two friends can still communicate using the secret code, as shown in Figure.



ISO –OSI Open Systems Interconnection Model

- International standard organization (ISO) established a committee in 1977 to develop an architecture for computer communication.
- Open Systems Interconnection (OSI) reference model is the result of this effort.
- In 1984, the Open Systems Interconnection (OSI) reference model was approved as an international standard for communications architecture.
- Term "open" denotes the ability to connect any two systems which conform to the reference model and associated standards.
- The OSI model is now considered the primary Architectural model for inter - computer communications.
- The OSI model describes how information or data makes its way from application programmes (such as spreadsheets) through a network medium (such as wire) to another application programme located on another network.
- The OSI reference model divides the problem of moving information between computers over a network medium into SEVEN smaller and more manageable problems is known as layering.
- The OSI model is a **theoretical blueprint** that helps us understand **how data gets from one user's computer to another**.
- It is also a model that **helps develop standards** so that all of our hardware and software talks nicely to each other.
- It aids standardization of networking technologies.
- It provides an organized structure for hardware and software developers to follow, to insure their products are **compatible with current and future technologies.**

- ***ISO is the organization; OSI is the model.***

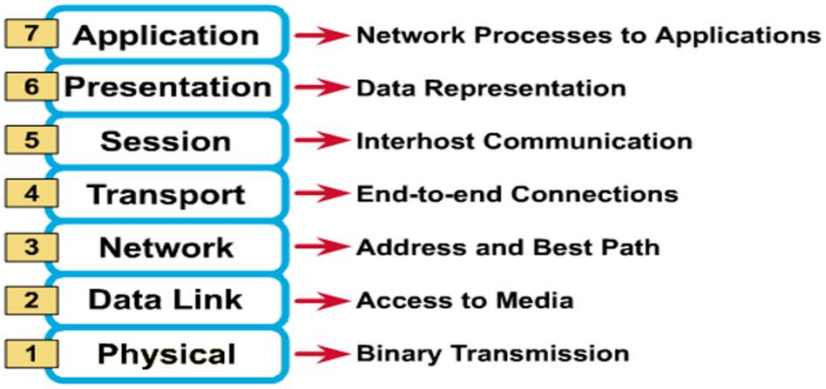
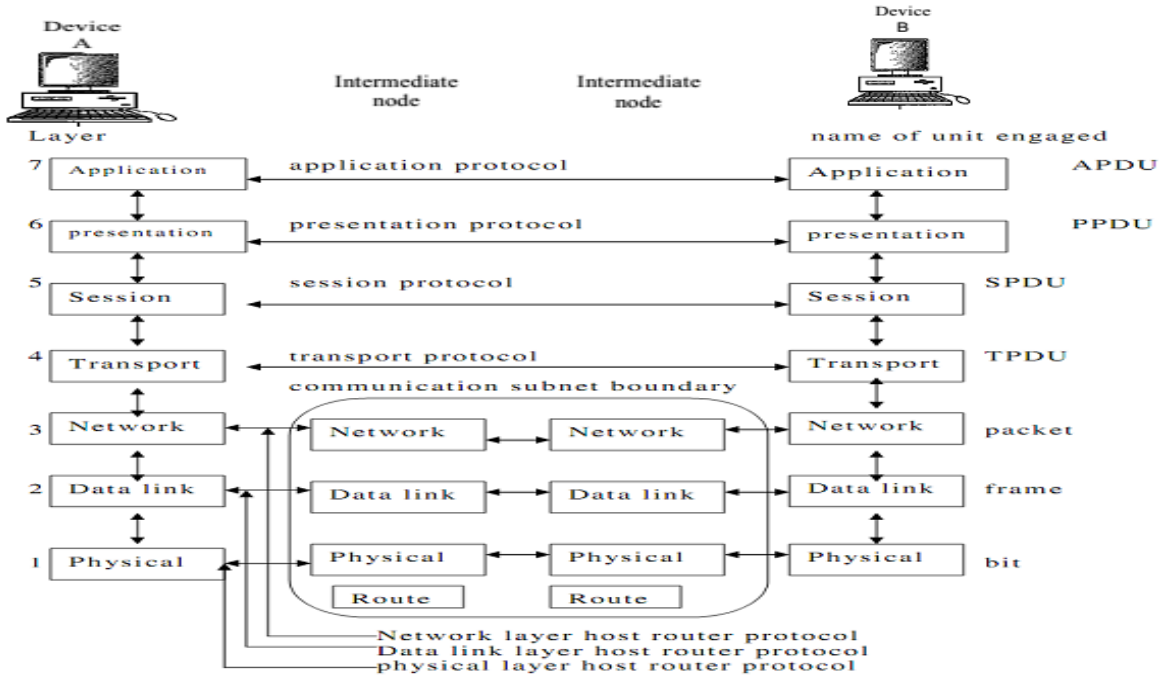


Fig: 7 Layers of ISO-OSI Reference Model

OSI: A Layered Network Model

- The process of breaking up the functions or tasks of networking into layers reduces complexity.
- The **lower 4 layers** (transport, network, data link and physical - Layers 4, 3, 2, and 1) are concerned with the flow of data from end to end through the network.
- The **upper three layers** of the OSI model (application, presentation and session- Layers 7, 6 and 5) are orientated more toward services to the applications.
- The layers involved when a message is sent from **device A to device B**.
- As the message travels from A to B, it may pass through many **intermediate nodes**.
- These intermediate nodes involve only the **first three layers** of the OSI model.
- Each layer performs **unique and specific task** and it **offers services to the layer above it**.
- For example, **Layer 3 uses the services provided by layer 2** and **provides services for layer 4**.



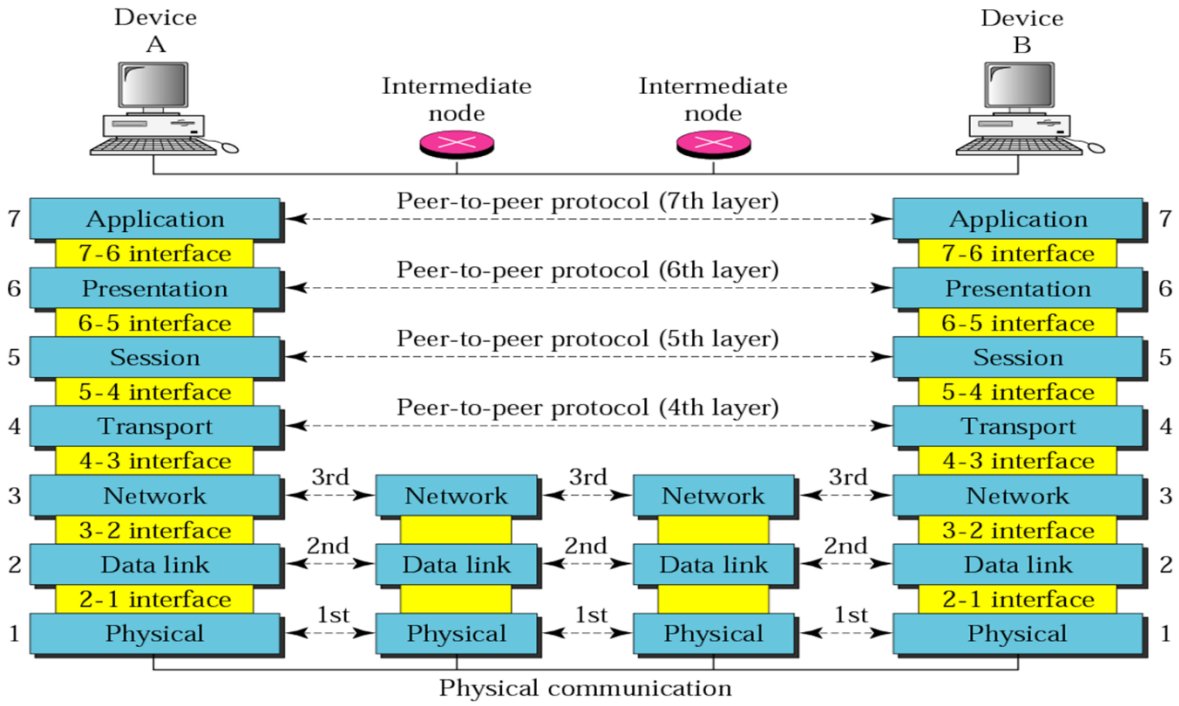
- Between machines, layer *x* on one machine communicates with layer *x* on another machine.
- This communication is governed by an agreed-upon series of rules and conventions called **protocols**.

Peer-to-Peer processes

- The processes on each machine that communicate at a given layer are called **peer-to-peer processes**.
- At the physical layer, communication is direct: Device A sends a stream of bits to device B (through intermediate nodes).
- At higher layers each layer in the sending machines adds its own information to the message it receives from the layer just above it and passes the whole package to the layer just below it.

Interfaces between Layers

- An interface defines the operations and services offered by lower layer to the upper layer. This is an interface between each pair of adjacent layers.
- The passing of the data and network information down through the layers of the sending device and receiving device is made possible by an interface between each pair of adjacent layers.



Data Encapsulation

- The outgoing information will travel down through the layers to the lowest layer.
- While moving down on the source machine, it acquires all the control information which is required to reach the destination machine.

- The control information is in the form of Headers and Trailer which surrounds the data received from the layer above.
- This process of adding headers and trailers to the data is called as **data encapsulation.**
- The information added by each layer is in the form of **headers or trailers**.
- At layer 1 the entire package is converted to a form that can be transferred to the receiving machine.
- At the **receiving machine**, **the message is unwrapped layer by layer**, with each process receiving and removing the data meant for it.
- For example, layer 2 removes the data meant for it, then passes the rest to layer 3.
- Layer 3 then removes the data meant for it and passes the rest to layer 4, and so on.
- The headers and trailers contain control information. The headers and trailers form **the envelope** which carries the message to the desired destination.

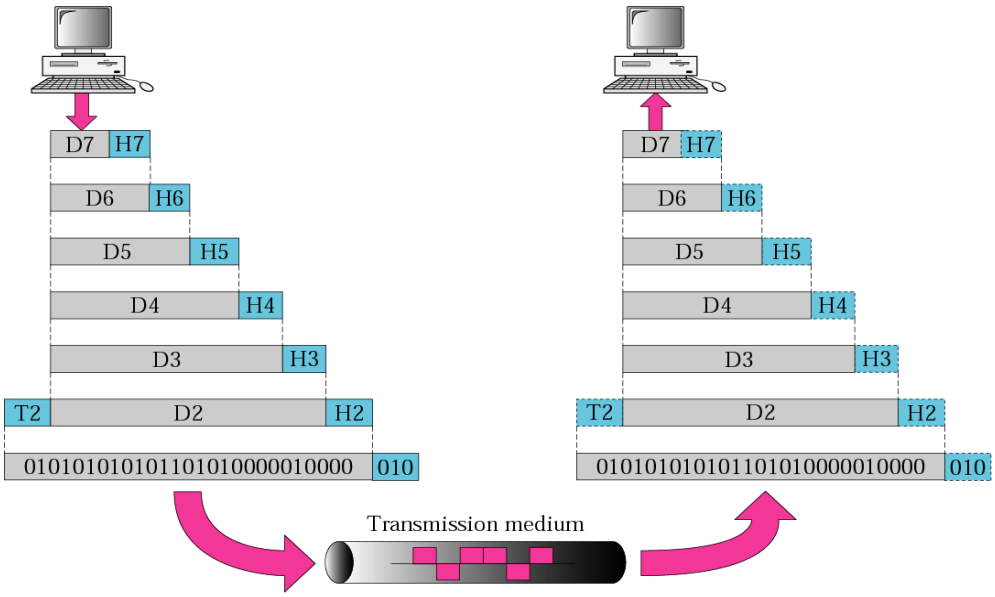
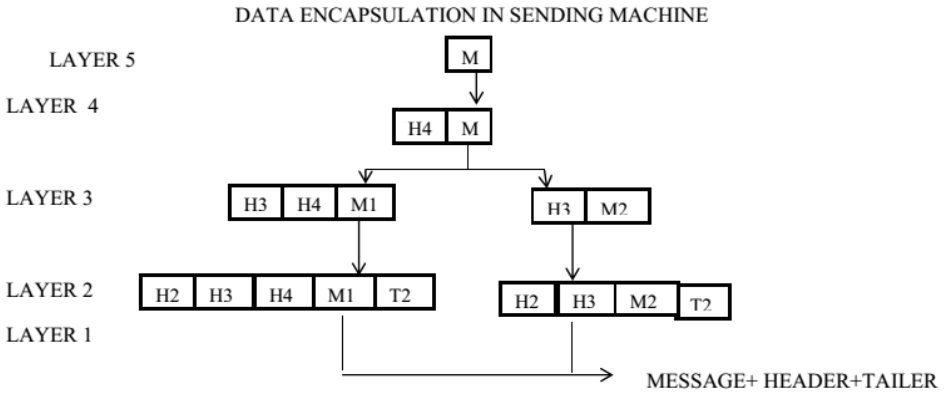


Figure: Data Encapsulation

- D7 means the data unit at layer 7, D6 means the data unit at layer 6, and so on.
- The process starts at layer 7 (the application layer), then moves from layer to layer in descending, sequential order.
- 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 passes through the physical layer (layer 1), it is changed into an electromagnetic signal and transported along a physical link.

Example of Data Encapsulation



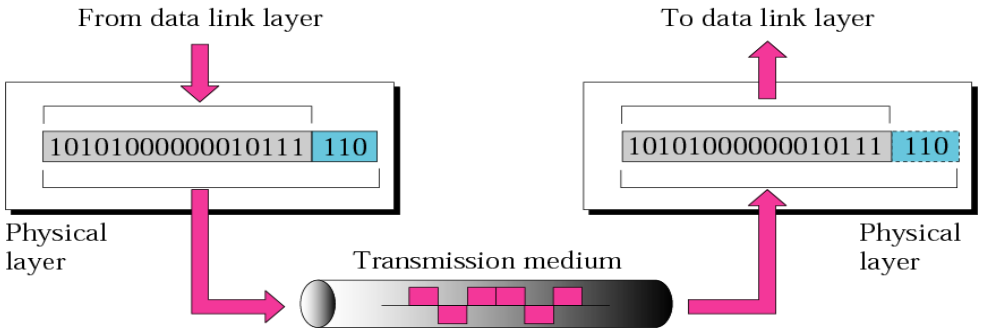
The figure shows the example of five layer stack for data encapsulation.

- The fifth layer of sending machine wants to send a message M to the fifth layer of destination machine.
- The message M is produced by layer 5 of machine 1 and given to layer 4 for transmission. Layer 4 adds header H4 in front of the message and pass it to layer 3.
- Layer 3 breaks up the incoming message into small units as M1 and M2 and pass these packets to layer 2.
- Layer 2 adds the header as well as footer to each packet obtained from layer 3 and pass it to layer 1 for physical transmission.

4.2 Layers of the OSI Reference Model

1. Physical Layer

- It co-ordinates the functions required to transmit bit stream over physical medium.
- Provides physical interface for transmission of information.
- Defines rules by which bits are passed from one system to another on a physical communication medium.
- Covers all - **mechanical, electrical, functional** and **procedural** - aspects for physical communication.



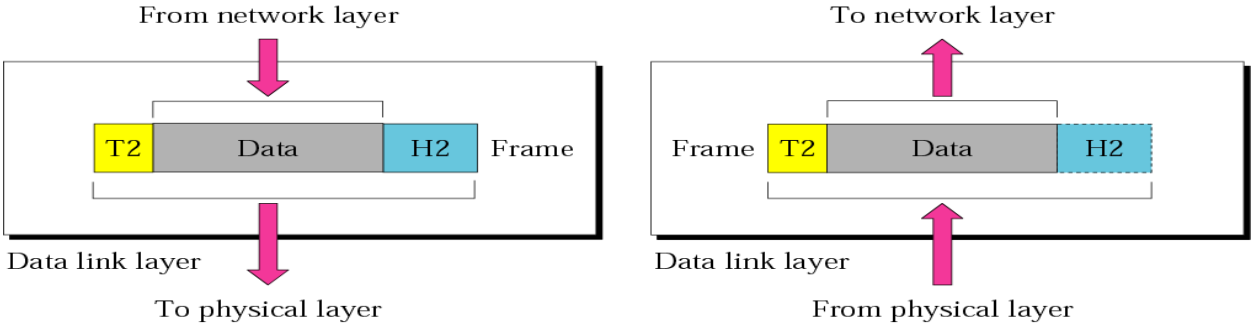
The physical layer is responsible for the movement of individual bits from one hop (node) to the next.

Functions of Physical Layer

- **Physical characteristics** of interfaces and medium.
  - It also defines the type of transmission medium.
  - How many pins the network connector has and what each pin is used for.
- **Representation of bits.** What electrical signals should be used to represent a 1 and a 0.
- **Data rate:** How many nanoseconds a bit lasts and bits per second.
- **Synchronization of bits**.
  - Sender and Receiver must be synchronized
- **Physical topology**
  - Mesh, Ring, Star, etc.
- **Transmission mode.** Whether transmission may proceed simultaneously in both directions.
  - Simplex, Half duplex, Duplex

2. Data Link Layer

- Data link layer attempts to provide reliable communication over the physical layer interface.
- **Breaks the outgoing data into frames** and **re-assemble the received frames**.
- Create and detect frame boundaries.
- **Handle errors** by implementing an acknowledgement and retransmission scheme.
- **Implement flow control**.



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

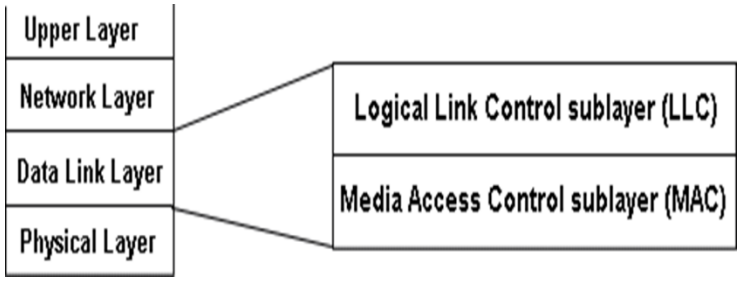
Functions of Data Link Layer

- **Framing-**
  - Divides the stream of bits into manageable data units called frames.
- **Physical addressing-**
  - Adds a header to the frame to define the sender and/or receiver of the frame.
- **Flow control-**
  - Imposes a flow control mechanism to avoid overwhelming the receiver. Synchronization between fast sender and slow receiver.
- **Error control-**
  - Adds mechanisms to detect and retransmit damaged or lost frames (CRC).

- **Access control-**
  - Determine which device has control over the link at any given time.
- **Link establishment and termination**:
  - Establishes and terminates the logical link between two nodes.
- **Frame sequencing**:
  - Transmits/receives frames sequentially.
- **Frame acknowledgment**:
  - Provides/expects frame acknowledgments.

DLL is divided into two Sub-Layers

- **LLC Sub Layer**
- **MAC Sub Layer**



Logical Link Control Sub Layer

- It is upper portion of the Data Link layer.
- Performs **Flow control** and **management of connection errors**.
- LLC supports three types of connections:

1. **Unacknowledged connectionless service**:
   - does not perform reliability checks or maintain a connection, very fast, most commonly used
2. **Connection oriented service**:
   - once the connection is established, blocks of data can be transferred between nodes until one of the node terminates the connection.
3. **Acknowledged connectionless service**:
   - provides a mechanism through which individual frames can be acknowledged.

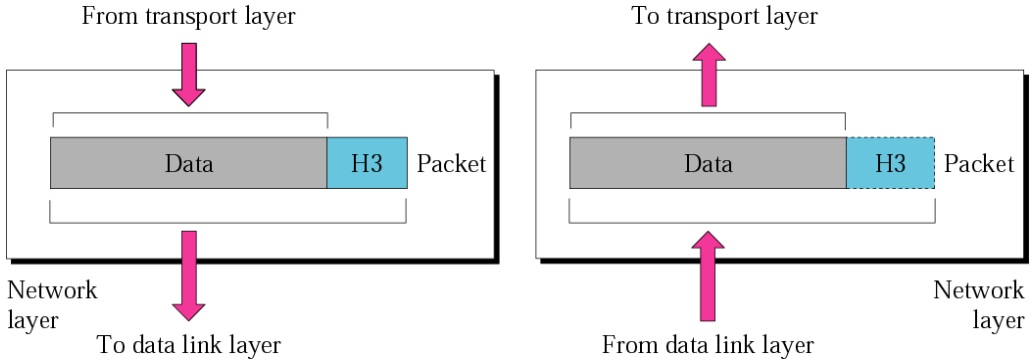
Media Access Control Sub Layer

- This sub layer contains methods to **regulate the timing** of data signals and **eliminate collisions**.

- The MAC sub layer determines where one frame of data ends and the next one starts - **frame synchronization.**
- There are four means of frame synchronization:
    - Time based,
    - Character counting,
    - Byte stuffing and
    - Bit stuffing.

3. Network Layer

- It is responsible for source to destination delivery of individual packets across multiple networks.
- Defines the **most optimum path** the packet should take from the source to the destination
- Defines **logical addressing** so that any endpoint can be identified.
- **Handles congestion** in the network.
- Facilitates interconnection between heterogeneous networks (Internetworking).
- The network layer also defines how to fragment a packet into smaller packets to accommodate different media.



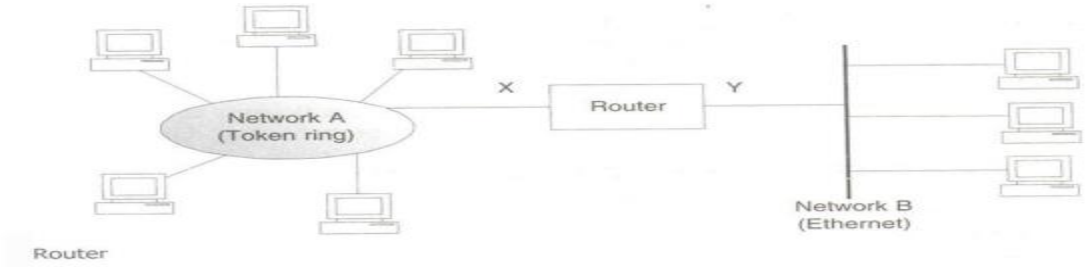
The network layer is responsible for the delivery of individual packets from the source host to the destination host.

Functions of Network Layer

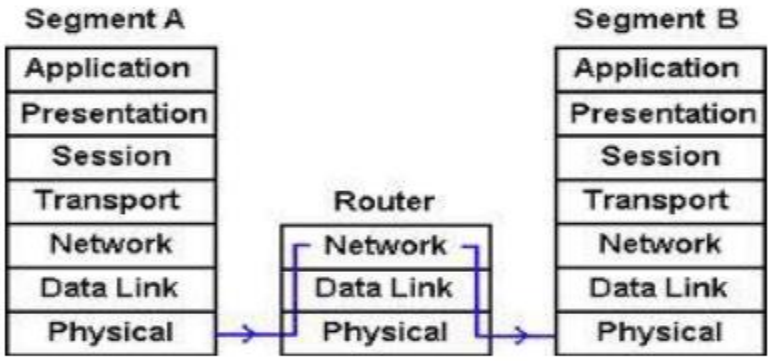
1. Logical addressing
2. Routing.
3. Congestion control
4. Accounting and billing
5. Address transformation
6. Source host to destination host error free delivery of packet.

Que: With the help of neat sketch describe the working of router. Describe in detail the operation of router considering OSI model.

Answer: Router is a device that connects two or more computer network together this allows two or more disparate computer network to send data to each other.



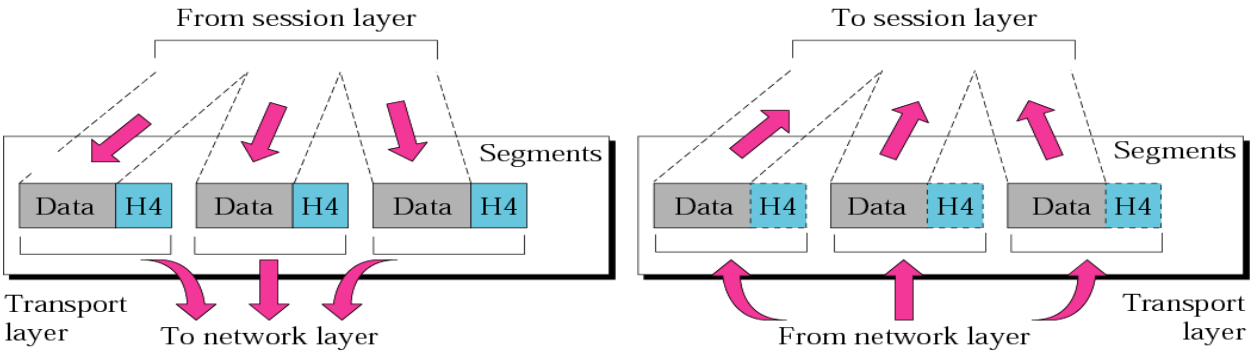
The figure shows a router connecting to two networks viz: A (Token Ring) and B (Ethernet) at points X and Y respectively. This means that the router must have two interfaces and also two Network interface cards (NICs) one to interact with network A at point X, and the other to interact with network B at point Y. this enable it to send data between the two networks A and B. A router connect more than two networks.



A router operates at a the physical, data link and network layer of the OSI model, as shown in fig a router is termed as an intelligent device. A router is useful for interconnecting two or more networks. These networks can be heterogeneous, which means that they can differ in their physical characteristics such as frame size, transmission rates, topologies, addressing etc. thus, if a router has to connect such different networks, it has to consider all these issues. A router has to determine the best possible transmission path among several available.

4. Transport Layer

- Purpose of this layer is to provide a **reliable mechanism** for the **exchange of data between two processes** in different computers.
- Ensures that the data units are **delivered error free**.
- Ensures that data units are **delivered in sequence**.
- Ensures that there is **no loss or duplication** of data units.
- Provides **connectionless or connection oriented** service.



The transport layer is responsible for the delivery of a message from one process to another.

Functions of Transport Layer

1. Service point addressing
2. Segmentation and reassembly
3. Connection control
4. Flow control: Flow control is performed end to end
5. Error control

5. Session Layer

- Session layer provides mechanism for **controlling the dialogue** between the two end systems.
- It defines how to **start, control and end** conversations (called sessions) between applications.
- This layer requests for a logical connection to be established on an end-user's request.
- Any necessary **log-on or password validation** is also handled by this layer.

Functions of Session Layer

- Dialog control
- Synchronization, session and sub session
- Session closure

6. Presentation Layer

- Presentation layer defines the format in which the data is to be exchanged between the two communicating entities.
- Also handles data compression and data encryption (cryptography**).**

Functions of Presentation layer:

- **Translation:** presentation layer is responsible for converting various formats into required format of the recipient.
- **Encryption:** Data encryption and decryption is done by presentation layer for security.
- **Compression and Decompression:** data to be transform compressed while sending and decompress while receiving for reducing time of transmission.

7. Application Layer

- Application layer interacts with application programs and is the highest level of OSI model.
- Application layer contains management functions to support distributed applications.
- Examples of application layer are applications such as
    - File Transfer,
    - Electronic Mail,
    - Remote Login Etc.

Functions of Application layer:

1. Network virtual terminal
2. File transfer access and management
3. Mail services and directory services

Horizontal communication

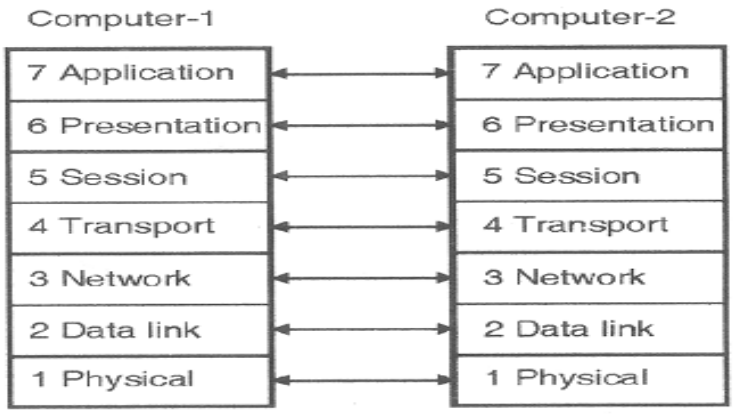


Fig: Horizontal Communication in OSI Model.

1. The horizontal communication is the logical connection between the layers, there is no direct communication between them.
2. Information included in each protocol header by the transmitting system is a message that will be carried to the same protocol in the destination system.
3. For two computers to communicate over a n/w, the protocol used at each layer of the OSI model in the transmitting system must be duplicated at the receiving system.
4. The packet travels up through the protocol stack and each successive header is stripped of by the appropriate protocol & processed.
5. When the packet arrived at its destination, the process by which the headers are applied at the source is repeated in server.

Vertical communication:

1. In addition to communicating horizontally with the same protocol in the other system, the header information also enables each layer to communicate with the layer above & below it.
   Eg. The n/w layer will communicate with the data link layer & transport layer.
2. This interlayer communication is called communication vertical.
3. When a system receives a packet & passes it up through various layers the data link layer protocol header includes a field which specifies the name of n/w layer protocol to be used to process the packet.
4. The n/w layer protocol header will specify the name of transport layer protocol to be used to process the packet.
5. Due to vertical communication, it becomes protocol at each layer simultaneously.

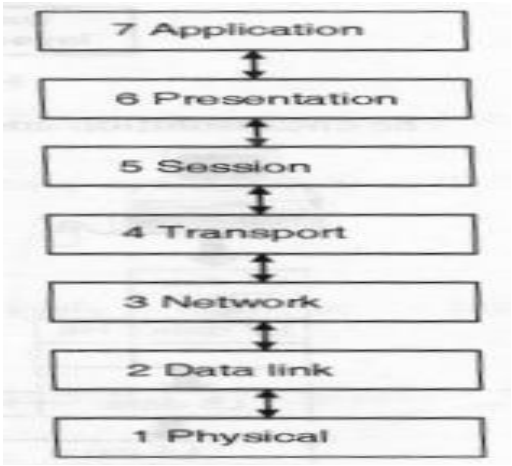
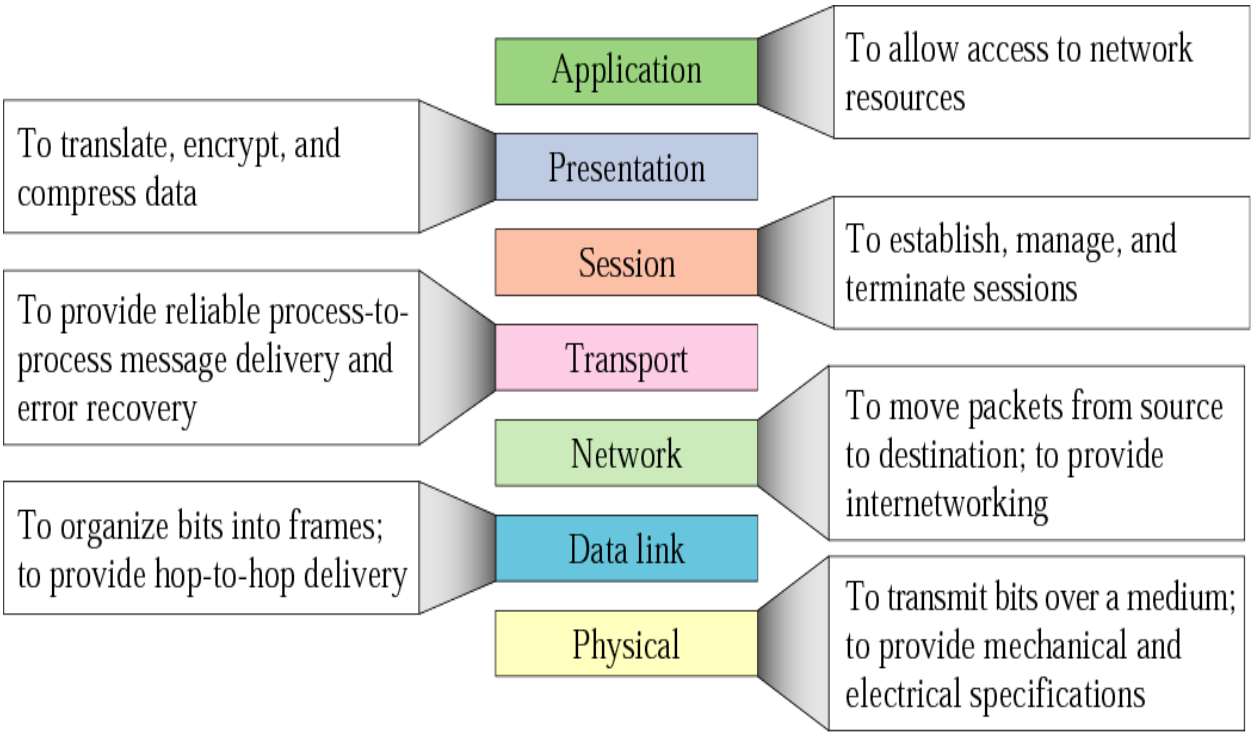


Fig: Vertical communication

Summery



Protocols in Each Layer

Protocols - Layer 7	HTTP FTP SMTP POP DNS Telnet
Protocols - Layer 6	Graphics: TIFF, JPEG, GIF Text: ASCII, EBCDIC, Unicode, Encrypted Audio: Midi, MPEG, WAV, MP3 Video: Quicktime, AVI
Protocols - Layer 5	NFS - Network File System RPC - Remote Procedure Call ASP - Appletalk Session Protocol
Protocols - Layer 4	Connection Oriented (TCP) Connectionless (UDP)
Protocols - Layer 3	Routed Routing (IP)
Protocols - Layer 2	MAC - Media Access Control LLC - Logical Link Control
Protocols - Layer 1	Organizations: IEE, TIA/ETA, ANSI, etc. Cable (ie. RJ45)

Devices

Devices - Layer 7	Hosts PC Servers Mobile Phones, gateways
Devices - Layer 3	Routers
Devices - Layer 2	Bridges, Switches, NIC (Layers 1 & 2)
Devices - Layer 1	Hubs, repeaters NIC (Layers 1 & 2) Media: Coax, Fiber, Twisted Pair, Wireless