Open System Interconnection (OSI) Model

- OSI model is an ISO (International Standards Organization) standard framework for defining standards for linking heterogeneous computers in a packet switched network.

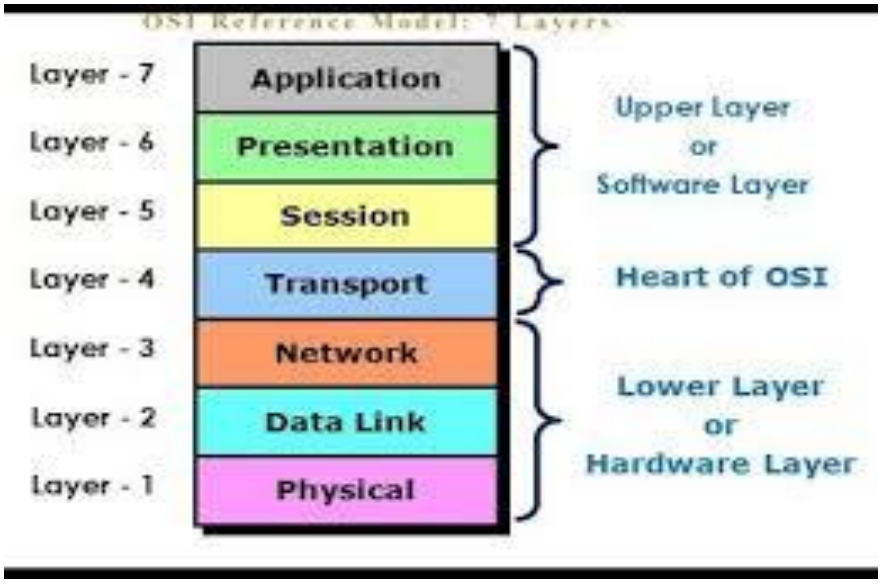
  (Packet-switched describes the type of network in which relatively small units of data called packets are routed through a network based on the destination address contained within each packet)
- It is reference model that deals in connecting a system to all other systems in the world.
- Although OSI model is not actual model used to support internet but its understanding is necessary as many networks & products often refer to the OSI model for definition.
- In OSI architecture, firstly layers are developed and then the functions & the protocols to be followed are developed.
- This model is standard interface which consist of 7 layers. They are:
  - Physical, Data link, Network, Transport, Session, Presentation, Application Layer.
  - Each layer run individually but the output of one layer might be the input of another layer.

Why Layering?

- To reduce Complexity.
- To support modular engineering approach.
- Standard interface.

7 Layers of OSI Model

The **O**pen **S**ystem **I**nterconnection (OSI) model defines a networking framework to implement protocols in seven layers. It divides network communication into seven layers. Layers 1-4 are considered the lower layers, and mostly concern themselves with moving data around. Layers 5-7, the upper layers, contain application-level data. Each layer takes care of a very specific job, and then passes the data onto the next layer. The seven layers of OSI are:



Layer 1: Physical layer

- Primarily concerned with transferring raw bits over a communication channel & other physical aspects of media.

- (The other physical aspects) Modulation & encoding of data bits on carrier signal & ensures bit synchronization.
- Provides services to data link layer. The stream of 0s & 1s are converted into signals which represent stream of bits (data link convert it into frame).
- Takes care of Physical network & transmission media.
- It deals with the **mechanical & electrical** specification of the interface & transmission media.
- It focus on three aspects:
  Mechanical: cable plugs, pins etc. talks how devices are developed & placed in network
  Electrical: Modulation, signal strength, voltage level, bit times etc. defines how data transfer takes place electrically.
  Procedural check: defines the procedure & functions that physical devices & interface have to perform for the transmission to occur.
- **Device Working:** Hubs, Repeaters, Cables, Modems etc.
- **Major responsibilities**
  - **i. Physical characteristics of interface & media:**
    - Defines the characteristics of the interface between the device and transmission media
    - Also defines the type of transmission media
  - **ii. Data Rate Control**
    - Maintain data transfer speed
    - The number of bits send per second (bps) is defined
  - **iii. Bits signal Representation**
    - Since the transmission media can't carry the bits we need to represent the bits by the signal i.e. electrical or ectromagnetic wave that can propagate through the medium.
  - **iv. Bit synchronization**
    - Determines the synchronization of bits by providing the clocking mechanism that controls the sender & receiver.
    - Sender & receiver mostly are synchronized at bit level.
  - **v. Multiplexing**
    - Number of independent signal is combined into a composite signal suitable for transmission over a common communication channel.
  - **vi. Switching**
    - For circuit switching only
      (A type of communications in which a dedicated channel (or circuit) is established for the duration of a transmission. Example of circuit-switching network is the telephone system, which links together wire segments to create a single unbroken line for each telephone call.)

Layer 2: Data Link Layer

- It provides reliable transmission of data between two end systems. The primary function of this layer is to combine all bit signals in terms of single unit namely **frame**.
- It manages transmission circuit established in Layer 1 & send error free data to the above layer (Network layer).
- The data link layer takes a raw transmission facility and transforms it into a line that appears free of transmission error in the network layer.

- The data link layer is responsible for carrying the frame from one hop to another hop (computer or router).
- This layer also performs error checking using Frame Check Sequence (FCS).
- This layer is further divided into '2' sub layers

i. **Media Access Control (MAC)**
   - MAC concerns itself with the access control method & determines how physical transmission is controlled.
   - It is concerned with physical address which is a 48-bit address.(12 digits hexadecimal number)

ii. **Logical Link Control (LLC)**
   - Establish links between physical and network layer.
   - Multiplex information by splitting it into frames of data, sending the frames across the line and arranging the frames back in order.
   - It shields (protect) the higher level layers from concerns with the specific LAN implementation

Working Device

i. **Switch:** Connects two similar LAN segment

ii. **Bridge:** Connects two similar or dissimilar LAN segments

Major Responsibilities

i. Framing
   - Combining of single data bits into a frame which is coming from the layer 1.
   - Splitting the data packets into the frames if it is coming from layer 3.

ii. Flow Control
   - Enforce the flow control mechanism to avoid the overflow & underflow condition
   - Provides the data rate at which receiver can absorb the data.

iii. Error Control
   - Reliability is added into physical layer by data link layer to detect & re-transmit lost or damaged frames to prevent the duplication of frame.
   - This is achieved through trailer added to the end of the frame.

iv. Access Control
   - If the multiple nodes are connected to a common network & share common communication medium then there is a high possibility of data collision. To prevent the collision there is a need of Media Access Control.
   - This method defines the procedure a computer follows when it needs to send frames.

v. Physical Addressing
   - Data link Layer addresses are called Physical address or MAC Address.
   - These are used to find out the address of next hop in hop to hop delivery.
   - 48 bits address is used. i.e. 12 digit Hexadecimal number. E.g. 0F-.2D - 3B - 4A - CD - E8

Layer 3: Network Layer (Internet Protocol (IP), Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Reverse Address Resolution Protocol (RARP))

- Responsible for Source to destination delivery of packet across multiple Networks.
- Provides the best path to reach the packet to the destination.

- Logical addressing works on this layer.
- Routing & packet forwarding are the basic functions.

Device Working: Router

Major Responsibilities:

i. Inter-networking

- The main duty of N/w layer is providing internetworking, the logical networking of heterogeneous physical networks together to look like a single N/w to the upper transport layer.

ii. Logical Addressing

- At the network layer we need to uniquely identify each device on the internet (IP address). Different addressing problems are solved in this layer.

iii. Routing

- Choosing the best path from the multiple alternatives using different techniques. It can be static or dynamic.

iv. Congestion Control

- If too many packets temporarily available in the subnet then the problem of congestion arise. It is often called the bottleneck problem. This issue is solved by the network layer.

Layer 4: Transport Layer

- Responsible for process to process delivery, this is source to destination delivery of the entire message.
- Ordering & reassembly of packets that may have been broken up to travel across certain media.
- The basic function is to accept the data from session layer, split it into the smaller units and pass these pieces to the network layer.
- The transport layer also decides which type of service to provide to the session layer as well as establishing and deleting connection across the network layer.
- Also called host to host or end to end layer.
- **DLL** is responsible for reliable transmission of data over single link/
- **TL** is responsible for reliable transmission of data from source to destination.
- The protocol in this layer is **TCP (**Connection Oriented protocol**) UDP (**connection less protocol**)**

Major Responsibilities

i. Segmentation & Re-assembling

- A message is divided into segments and each segment contains a sequence number.
- These numbers enable the transport layer to reassemble the message correctly upon arriving at the destination
- The packets lost in the transmission is identified and replaced.

ii. Service Point (Port) Addressing

- Computers run several programs at the same time. Source to destination delivery means delivery from a specific process on one computer to a specific process on the other.
- Transport layer header thus includes a type of address called a service point address i.e. socket addressing of 16 bits.

iii. Connection Control

- Transport layer can be either connectionless or connection oriented.

- In connection oriented all data gets transferred through a single path. simply best route is determined firstly and then packets are forwarded, TCP is used as protocol. Entire packets get transmitted through a single best route.
- Connectionless service use UDP as a protocol here data ca flow from different paths.
- Connectionless transport layer treats segment as independent packets and deliver it to the transport layer. It does not guarantee reliability.

iv. **Flow Control**
- End-to-end flow control is performed.

v. Error Control
- At the sending side, the transport layer makes sure that the entire message arrives at the receiving transport layer without error.
- Error correction is achieved through re-transmission.
- End to end error Correction.

Layer 5: Session Layer
- Allows user on separate machine to establish session.
- Defines how the data conversations are established, controlled and terminated.
- The session layer manages the conversations and creates notification if anything fails.
- Only after a complete conversation the data is passed to the presentation layer.
- IT is the network dialog controller. It establishes, maintains and synchronizes the interaction between communicating systems.

Major Responsibilities

i. **Dialog Control**
- Allows'2' systems to enter into a dialog. Communication between 2 processes takes place either in half duplex or full duplex.
- E.g. the dialog between the terminals connected to a mainframe can be half duplex.

ii. Synchronization
- Session layer allows a process to add checkpoints into a stream of data.
- E.g. if a system is sending 2000 pages, checkpoints can be inserted after every 100 pages to ensure that each 100 pages unit is advised and acknowledged independently. So if a crash arises during the transmission of page 523, retransmission begins from 501. Pages 1 to 500 need not to be retransmitted.

Layer 6: Presentation Layer
- Concerned with the syntax and semantics of information transmitted.
- This layer is also concerned with other aspect of information representation such as data compression (to reduce the size of information to be transmitted), cryptography (for privacy and authenticity).

Major Responsibilities

i. Translation

The processes (running program) in two systems are usually exchanging information in the form of character, string, and numbers and so on. The information must be changed to bit streams before being transmitted.

ii. Encryption

To carry sensitive information, a system must be able to ensure privacy. Encryption means that the sender transforms the original information into different forms and sends through the network. Decryption reverses the transformed message back to its original form.

iii. **Compression**

Compression is the process of reducing number of bits without reducing the content of original data. It is widely used during the transmission of multimedia information.

Layer 7: Application Layer

- It contains a variety of protocols that are commonly needed & is employed in software packages which implement client server software.
- Used when an application on one machine starts communicating with other machine. The header contains parameters that are agreed between applications which are often only sent at the beginning of an application operation.
- Enables the user (human or software) to access the network or not.
- Provides user interface & support for services like electronic mail, remote file access & transfer, shared database management.

Major Responsibilities

i. **Network virtual Terminal**

A network virtual terminal is an s/w version of a physical terminal & allows a user to log on to remote host.

ii. **File transfer, access, and management**

This application allows a user to access files in a remote host to retrieve the files from a remote computer for use in local computer and to manage or control files in a remote computer locally.

iii. **Mail services**

This application provides the basis for email forwarding and storage

iv. **Directory Services**

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

The OSI Model Vs the Real World

- The major difficulty of OSI Model is that it does not map well to the real world.
- The OSI model was created by academicians for academic purposes only.