**Competency Level: 6.10**

## Investigates the role of reference models to describe the network architecture

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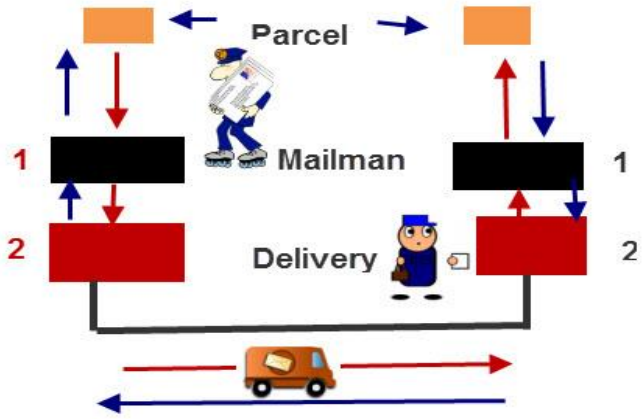
## Models to describe the network architecture

- Basic network architecture and construction is a starting how communication systems function.
- Networking engineering is a complicated task, which involves software, firmware, chip level engineering, hardware, and electric pulses.
- Architectures are typically based on a model showing how protocols and functions fit together.
- A model is a way to organize a system's functions and features to define its structural design.
- A design can help us understand how a communication system accomplishes tasks to form a protocol suite.
- To ease network engineering, the whole networking concept is divided into multiple layers.
- Layers share data between them and they depend on each other only to take input and send output.

## Layered Tasks

- In layered architecture of Network Model, one whole network process is divided into small tasks.
- Each small task is then assigned to a particular layer which works dedicatedly to process the task only. Every layer does only specific work.
- In layered communication system, one layer of a host deals with the task done by or to be done by its peer layer at the same level on the remote host.
- If the task is initiated by the-top most layer, it is passed on to the layer below it for further processing.

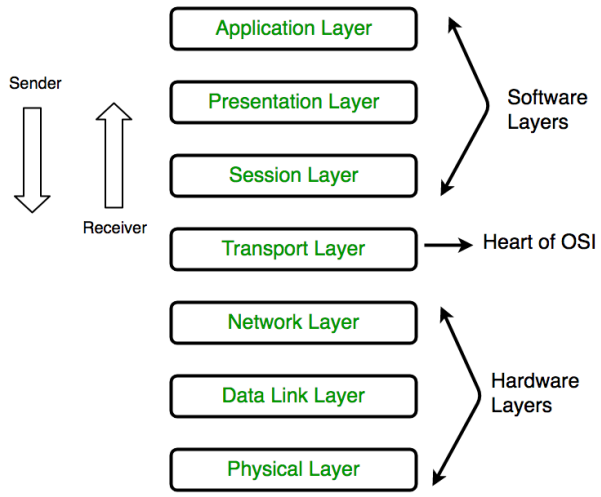


Layered System Example

- The lower layer does the same thing, it processes the task and passes on to lower layer.
- If the task is initiated by lower most layer, then the reverse path is taken.

## Protocol of seven layers

- The OSI Model (Open Systems Interconnection Model) is a conceptual framework used to describe the functions of a networking system.
- The OSI model characterizes computing functions into a universal set of rules and requirements in order to support interoperability between different products and software.
- In the OSI reference model, the communications between a computing systems are split into seven different abstraction layers:




- The OSI was published in 1974 by the International Organization for Standardization (ISO).

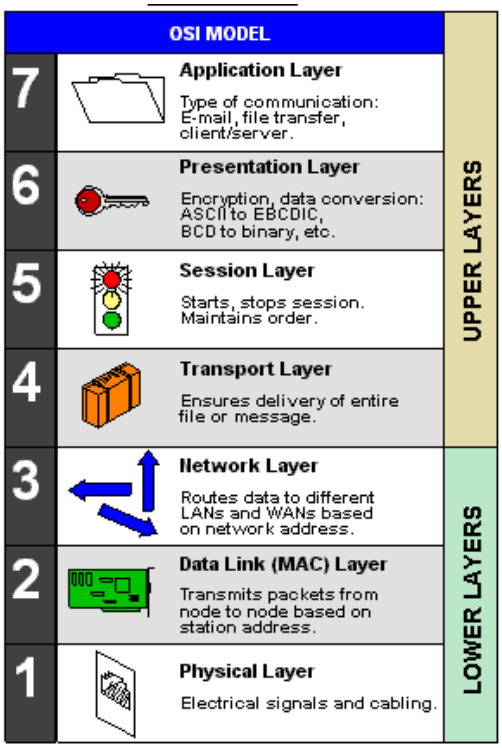
## Advantages of the OSI Model

- It helps you to standardize router, switch, motherboard, and other hardware
- Reduces complexity and standardizes interfaces
- Facilitates modular engineering
- 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.
- Offers flexibility to adapt to various types of protocols

## Disadvantages of the OSI Model

- Fitting of protocols is a difficult t task.
- This can only use it as a reference model.
- 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.

## Application Layer 7




- This top layer defines the language and syntax that programs use to communicate with other programs.
- It represents the purpose of communicating in the first place.
- This layer is responsible for providing interface to the application user. This layer use protocols which directly interact with the user.

- **Example**, a program in a client workstation uses commands to request data from a program in the server. Common functions at this layer are opening, closing, reading and writing files, transferring files and email messages, executing remote jobs and obtaining directory information about network resources.

**The function of the Application Layers are:**

- Application-layer helps you to identify communication partners, determining resource availability, and synchronizing communication.
- It allows users to log on to a remote host
- This layer provides various e-mail services
- This application offers distributed database sources and access for global information about various objects and services.

## Presentation Layer 6

- When data are transmitted between different types of computer systems, the presentation layer negotiates and manages the way data are represented and encoded.
- It also formats and encrypts data which should be sent across all the networks
- This layer defines how data in the native format of remote host should be presented in the native format of host.
- This layer transforms data into the form which is accepted by the application.
- This layer is also known as a **syntax layer**.

- **Example,** it provides a common denominator between ASCII and EBCDIC machines as well as between different floating point and binary formats. Sun's XDR and OSI's ASN.1 are two protocols used for this purpose. This layer is also used for encryption and decryption.

**The function of Presentation Layers:**

- Character code translation from ASCII to EBCDIC.
- Data compression: Allows to reduce the number of bits that needs to be transmitted on the network.
- Data encryption: Helps you to encrypt data for security purposes — for example, password encryption.
- It provides a user interface and support for services like email and file transfer.

## Session Layer 5

- Provides coordination of the communications in an orderly manner.
- It determines one-way or two-way communications and manages the dialog between both parties
- It helps you to establish starting and terminating the connections between the local and remote application.
- This layer request for a logical connection which should be established on end user's requirement.
- This layer handles all the important log-on or password validation.
- Session layer offers services like dialog discipline, which can be duplex or half-duplex.
- It is mostly implemented in application environments that use remote procedure calls.

**Important function of Session Layer:**

- It establishes, maintains, and ends a session.
- Session layer enables two systems to enter into a dialog
- It also allows a process to add a checkpoint to steam of data.

**Example,**

Making sure that the previous request has been fulfilled before the next one is sent. It also marks significant parts of the transmitted data with checkpoints to allow for fast recovery in the event of a connection failure. In practice, this layer is often incorporated into the transport layer.

## Transport Layer 4

- Responsible for overall end-to-end validity and integrity of the transmission.
- The transport layer builds on the network layer to provide data transport from a process on a source machine to a process on a destination machine.
- It is hosted using single or multiple networks, and also maintains the quality of service functions.
- It determines how much data should be sent where and at what rate. This layer builds on the message which are received from the application layer.
- It helps ensure that data units are delivered error-free and in sequence.
- The transport layer also offers an acknowledgment of the successful data transmission and sends the next data in case no errors occurred.
- The lower layers may drop packets, but the transport layer performs a sequence check on the data and ensures that if a 12MB file is sent, the full 12MB is received.

Important functions of Transport Layers:

- It divides the message received from the session layer into segments and numbers them to make a sequence.
- Transport layer makes sure that the message is delivered to the correct process on the destination machine.
- It also makes sure that the entire message arrives without any error else it should be retransmitted.

- **"OSI transport services" include layers 1 through 4, collectively responsible for delivering a complete message or file from sending to receiving station without error.**

- **Layers 3 through 1 move packets from the sending station to the receiving station.**

## Network Layer 3

- Establishes the route between sender and receiver across switching points, which are typically routers.
- The network layer provides the functional and procedural means of transferring variable length data sequences from one node to another connected in "different networks".
- Message delivery at the network layer does not give any guaranteed to be reliable network layer protocol.

**Example**

The IP protocol in TCP/IP. IPX, SNA and AppleTalk are examples of earlier routable protocols, they included a network and station address in their addressing system. If all stations are contained within a single network segment, then the routing capability in this layer is not required. This layer is also the switching function of the dial-up telephone system.

**Layer-management protocols that belong to the network layer are:**

1. routing protocols
2. multicast group management
3. Network-layer address assignment.

## Data Link Layer 2

- Responsible for node-to-node validity and integrity of the transmission.
- Data link layer corrects errors which can occur at the physical layer.
- The layer allows you to define the protocol to establish and terminates a connection between two connected network devices.
- It is IP address understandable layer, which helps you to define logical addressing so that any endpoint should be identified.
- The layer also helps you implement routing of packets through a network. It helps you to define the best path, which allows you to take data from the source to the destination.

## The data link layer is subdivided into two types of sub layers:

1. Media Access Control (MAC) layer- It is responsible for controlling how device in a network gain access to medium and permits to transmit data.
2. Logical link control layer- This layer is responsible for identity and encapsulating network-layer protocols and allows you to find the error.

## Important Functions of Data link Layer:

- Framing which divides the data from Network layer into frames.
- Allows to add header to the frame to define the physical address of the source and the destination machine
- Adds Logical addresses of the sender and receivers
- It is also responsible for delivery of the entire message.
- It also offers a system for error control in which it detects retransmits damage or lost frames.

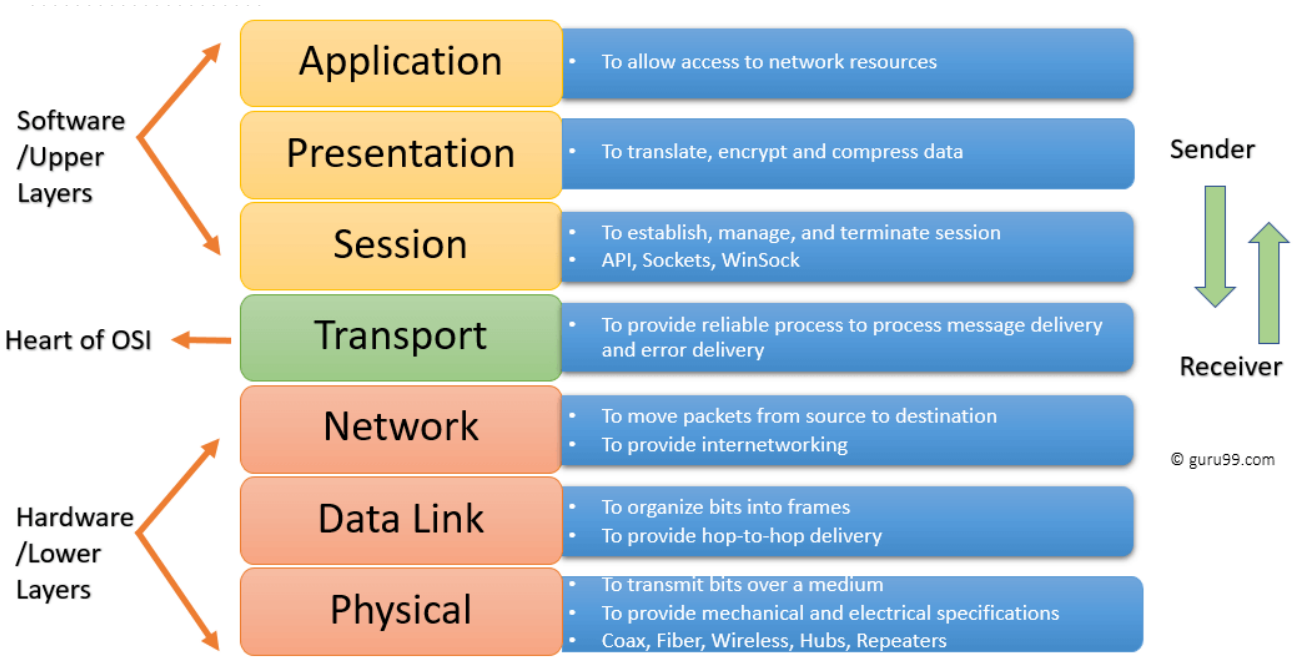
## Physical Layer 1

- Passes bits onto and receives bits from the connecting medium (wire, fiber).
- This layer has no understanding of the meaning of the bits, but deals with the electrical characteristics of the signals and signaling methods.
- The physical layer helps you to define the electrical and physical specifications of the data connection.
- This level establishes the relationship between a device and a physical transmission medium.
- The physical layer is not concerned with protocols or other such higher-layer items.

Examples of hardware in the physical layer are network adapters, Ethernet, repeaters, networking hubs, etc.

Protocols supported at various levels

| Layer | Name | Function | Protocols |
|---|---|---|---|
| Layer 7 | Application | To allow access to network resources. | SMTP, HTTP, FTP, POP3, SNMP |
| Layer 6 | Presentation | To translate, encrypt and compress data. | MPEG, ASCH, SSL, TLS |
| Layer 5 | Session | To establish, manage, and terminate the session | NetBIOS, SAP |
| Layer 4 | Transport | The transport layer builds on the network layer to provide data transport from a process on a source machine to a process on a destination machine. | TCP, UDP |
| Layer 3 | Network | To provide internetworking To move packets from source to destination | IPV5, IPV6, ICMP, IPSEC, ARP, MPLS. |
| Layer 2 | Data Link | To organize bits into frames To provide hop-to-hop delivery | RAPA, PPP, Frame Relay, ATM, Fiber Cable, etc. |
| Layer 1 | Physical | To transmit bits over a medium To provide mechanical and electrical specifications | RS232, 100BaseTX, ISDN, 11. |


Application
To allow access to network resources
Presentation
To translate, encrypt and compress data
Session
To establish, manage, and terminate session
API, Sockets, WinSock
Transport
To provide reliable process to process message delivery and error delivery
Network
To move packets from source to destination
To provide internetworking
Data Link
To organize bits into frames
To provide hop-to-hop delivery
Physical
To transmit bits over a medium
To provide mechanical and electrical specifications
Coax, Fiber, Wireless, Hubs, Repeaters
Software /Upper Layers
Heart of OSI
Hardware /Lower Layers
Sender
Receiver
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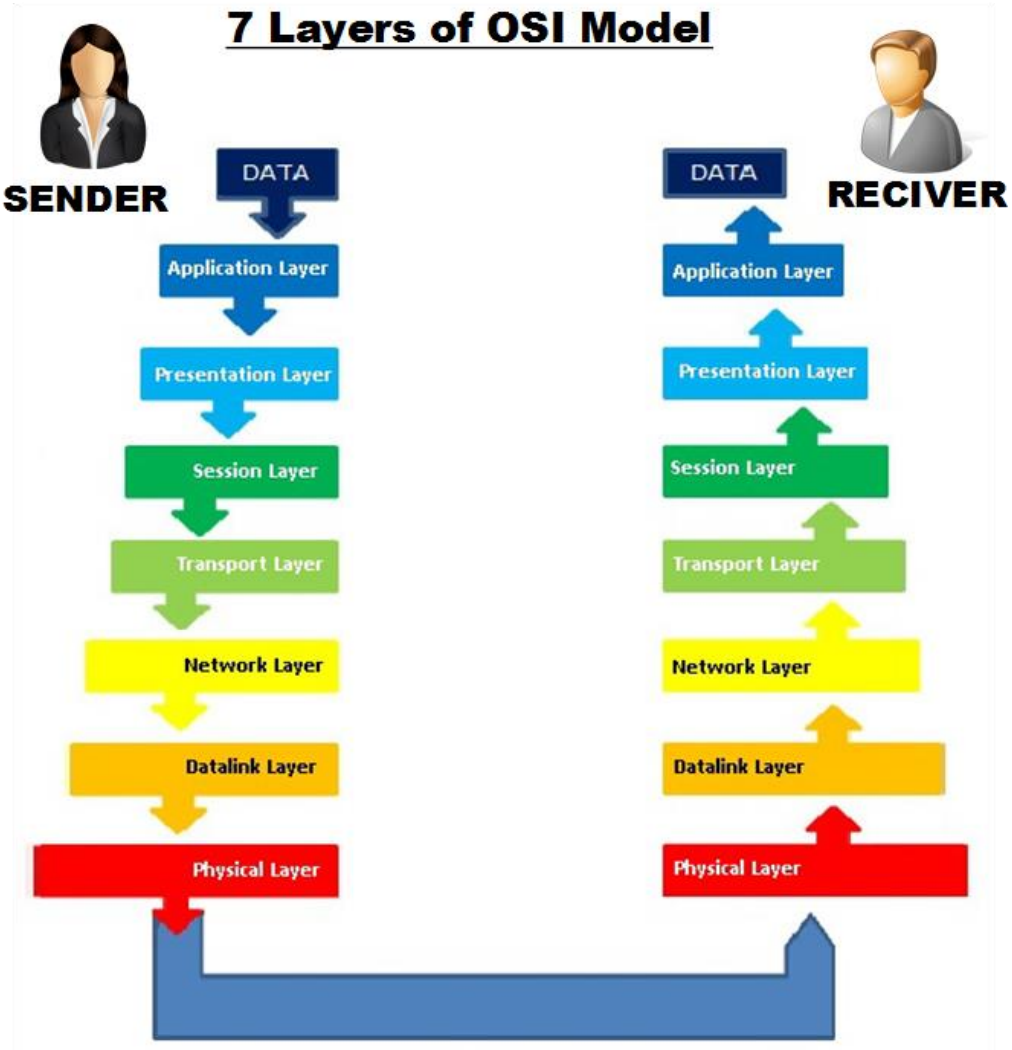

7 Layers of OSI Model
SENDER
RECIVER
DATA
DATA
Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Datalink Layer
Physical Layer
Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Datalink Layer
Physical Layer

## TCP/IP Protocol Architecture

### TCP/IP Model

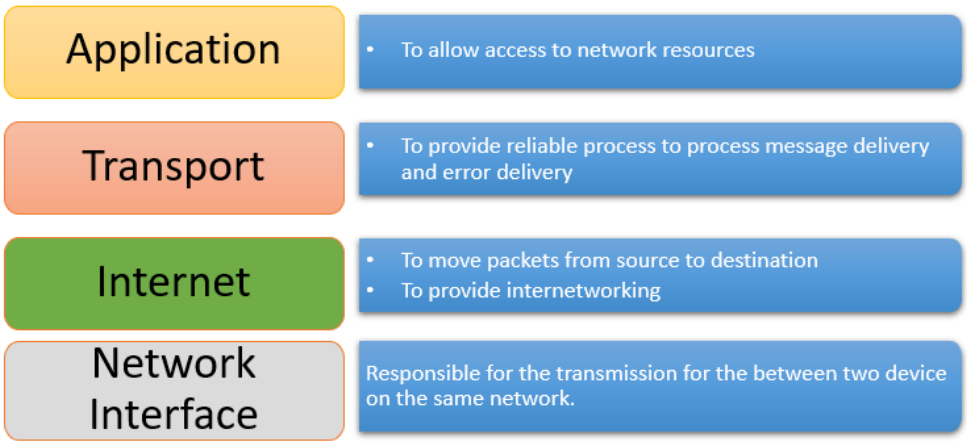
- TCP/IP Model determine how a specific computer should be connected to the internet and how data should be transmitted between them.
- It helps to create a virtual network when multiple computer networks are connected together.
- The purpose of TCP/IP model is to allow communication over large distances.
- TCP/IP stands for Transmission Control Protocol/ Internet Protocol.
- TCP/IP Protocol is specifically designed as a model to offer highly reliable and end-to-end byte stream over an unreliable internetwork.
- Protocols are set of rules which govern every possible communication over the internet.
- These protocols describe the movement of data between the host computers or internet and offers simple naming and addressing schemes.
- TCP/IP that is Transmission Control Protocol and Internet Protocol was developed by Department of **Defense's Project Research Agency** (ARPA, later DARPA) as a part of a research project of network interconnection to connect remote machines

### TCP Characteristics

- Support for a flexible TCP/IP architecture
- Adding more system 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 sender never overpowers a receiver with data.

### Different Layers of TCP/IP

- The functionality of the TCP IP model is divided into four layers, and each includes specific protocols.
- TCP/IP is a layered server architecture system in which each layer is defined according to a specific function to perform.
- All these four TCP/IP layers work collaboratively to transmit the data from one layer to another.



## Layer 1: The Network Interface Layer

- Lowest layer of the all.
- Protocol is used to connect to the host, so that the packets can be sent over it.
- Varies from host to host and network to network.
- Network Interface Layer is this layer of the four-layer TCP/IP model.
- This layer is also called a network access layer.
- It helps you to define details of how data should be sent using the network.
- It also includes how bits should optically be signaled by hardware devices. Which directly interfaces with a network medium, like coaxial, optical, coaxial, fiber, or twisted-pair cables.
- A network layer is a combination of the data line and defined in the article of OSI reference model.
- This layer defines how the data should be sent physically through the network.
- This layer is responsible for the transmission of the data between two devices on the same network.

## Layer 2: Internet layer

- An internet layer is a second layer of TCP/IP layers of the TCP/IP model.
- It is also known as a network layer.
- Selection of a packet switching network which is based on a connectionless internetwork layer is called a internet layer.
- It is the layer which holds the whole architecture together.
- It helps the packet to travel independently to the destination.
- The main work of this layer is to send the packets from any network, and any computer still they reach the destination irrespective of the route they take.
- Order in which packets are received is different from the way they are sent.
- IP (Internet Protocol) is used in this layer.
- The various functions performed by the Internet Layer are:
- Delivering IP packets
- Performing routing
- Avoiding congestion
- \The Internet layer offers the functional and procedural method for transferring variable length data sequences from one node to another with the help of various networks.
- Message delivery at the network layer does not give any guaranteed to be reliable network layer protocol.

**Layer-management protocols that belong to the network layer are:**

1. Routing protocols
2. Multicast group management
3. Network-layer address assignment.

## Layer 3: Transport Layer

- It decides if data transmission should be on parallel path or single path.
- Functions such as multiplexing, segmenting or splitting on the data is done by transport layer.
- The applications can read and write to the transport layer.
- Transport layer adds header information to the data.
- Transport layer breaks the message (data) into small units so that they are handled more efficiently by the network layer.
- Transport layer also arrange the packets to be sent, in sequence.
- Transport layer builds on the network layer in order to provide data transport from a process on a source system machine to a process on a destination system.
- It is hosted using single or multiple networks, and also maintains the quality of service functions.
- It determines how much data should be sent where and at what rate.
- This layer builds on the message which are received from the application layer. It helps ensure that data units are delivered error-free and in sequence.
- Transport layer helps you to control the reliability of a link through flow control, error control, and segmentation or de-segmentation.
- The transport layer also offers an acknowledgment of the successful data transmission and sends the next data in case no errors occurred.
- TCP is the best-known example of the transport layer.

## Important functions of Transport Layers:

- It divides the message received from the session layer into segments and numbers them to make a sequence.
- Transport layer makes sure that the message is delivered to the correct process on the destination machine.
- It also makes sure that the entire message arrives without any error else it should be retransmitted.

## Layer 4: Application Layer

- Application layer interacts with an application program, which is the highest level of OSI model.
- It means the OSI application layer allows users to interact with other software application.
- The TCP/IP specifications described a lot of applications that were at the top of the protocol stack. Some of them were TELNET, FTP, SMTP, DNS etc.
- TELNET is a two-way communication protocol which allows connecting to a remote machine and run applications on it.
- FTP (File Transfer Protocol) is a protocol that allows File transfer amongst computer users connected over a network. It is reliable, simple and efficient.
- SMTP (Simple Mail Transport Protocol) is a protocol, which is used to transport electronic mail between a source and destination, directed via a route.

- DNS (Domain Name Server) resolves an IP address into a textual address for Hosts connected over a network.
- It defines two end-to-end protocols: TCP and UDP
- TCP (Transmission Control Protocol): It is a reliable connection-oriented protocol which handles byte-stream from source to destination without error and flow control.

- UDP (User-Datagram Protocol): It is an unreliable connection-less protocol that do not want TCPs, sequencing and flow control. Eg: One-shot request-reply kind of service.
- Application layer interacts with software applications to implement a communicating component. The interpretation of data by the application program is always outside the scope of the OSI model.
- Example of the application layer is an application such as file transfer, email, remote login, etc.

**The function of the Application Layers are:**

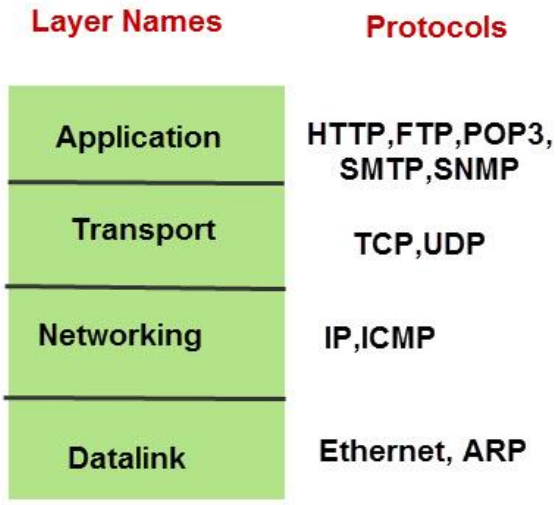
- Application-layer helps you to identify communication partners, determining resource availability, and synchronizing communication.
- It allows users to log on to a remote host
- This layer provides various e-mail services
- This application offers distributed database sources and access for global information about various objects and services.
- It allows peer entities to carry conversation.

## Advantages of TCP/IP model

- It operated independently.
- Client/server architecture.
- Supports a number of routing protocols.
- Can be used to establish a connection between two computers.

## Disadvantages of TCP/IP

- In this, the transport layer does not guarantee delivery of packets.
- The model cannot be used in any other application.
- Replacing protocol is not easy.
- It has not clearly separated its services, interfaces and protocols.



TCP/IP Networking Model

## Differences between OSI & TCP/IP

| OSI Model | TCP/IP model |
|---|---|
| OSI model provides a clear distinction between interfaces, services, and protocols. | TCP/IP doesn't offer any clear distinguishing points between services, interfaces, and protocols. |
| OSI uses the network layer to define routing standards and protocols. | TCP/IP uses only the Internet layer. |
| OSI model use two separate layers physical and data link to define the functionality of the bottom layers | TCP/IP uses only one layer (link). |
| OSI model, the transport layer is only connection-oriented. | A layer of the TCP/IP model is both connection-oriented and connectionless. |
| In OSI model, data link layer and physical are separate layers. | In TCP data link layer and physical layer are combined as a single host-to-network layer. |
| The minimum size of the OSI header is 5 bytes. | Minimum header size is 20 bytes. |