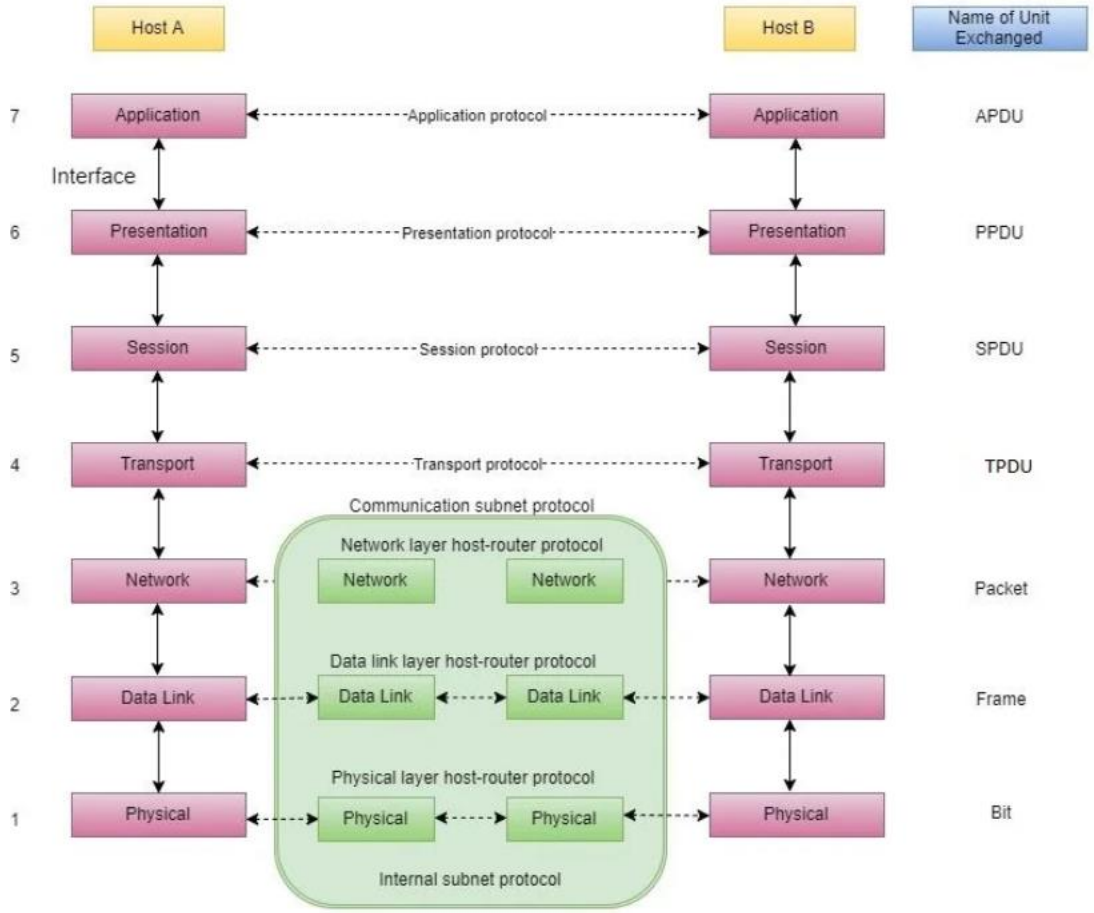
ISO OSI MODEL

There are n numbers of users who use computer network and are located over the world. So to ensure, national and worldwide data communication, systems must be developed which are compatible to communicate with each other ISO has developed a standard. ISO stands for **International organization of Standardization**. This is called a model for **Open System Interconnection** (OSI) and is commonly known as OSI model.

The ISO-OSI model is a seven layer architecture. It defines seven layers or levels in a complete communication system. They are:

1. Application Layer
2. Presentation Layer
3. Session Layer
4. Transport Layer
5. Network Layer
6. Datalink Layer
7. Physical Layer

Below we have the complete representation of the OSI model, showcasing all the layers and how they communicate with each other.



In the table below, we have specified the **protocols** used and the **data unit** exchanged by each layer of the OSI Model.

Layer	Name of Protocol	Name of Unit exchanged
Application	Application Protocol	APDU - Application Protocol Data Unit
Presentation	Presentation Protocol	PPDU - Presentation Protocol Data Unit
Session	Session Protocol	SPDU - Session Protocol Data Unit
Transport	Transport Protocol	TPDU - Transport Protocol Data Unit
Network	Network layer host-router Protocol	Packet
Data LInk	Data link layer host-router Protocol	Frame
Physical	Physical layer host-router Protocol	Bit

Feature of OSI Model

1. Big picture of communication over network is understandable through this OSI model.
2. We see how hardware and software work together.
3. We can understand new technologies as they are developed.
4. Troubleshooting is easier by separate networks.
5. Can be used to compare basic functional relationships on different networks.

Principles of OSI Reference Model

The OSI reference model has 7 layers. The principles that were applied to arrive at the seven layers can be briefly summarized as follows:

1. A layer should be created where a different abstraction is needed.
2. Each layer should perform a well-defined function.
3. The function of each layer should be chosen with an eye toward defining internationally standardized protocols.
4. The layer boundaries should be chosen to minimize the information flow across the interfaces.
5. The number of layers should be large enough that distinct functions need not be thrown together in the same layer out of necessity and small enough that architecture does not become unwieldly.

OSI Model Layer 1: The Physical Layer

1. Physical Layer is the lowest layer of the OSI Model.
2. It activates, maintains and deactivates the physical connection.
3. It is responsible for transmission and reception of the unstructured raw data over network.
4. Voltages and data rates needed for transmission is defined in the physical layer.
5. It converts the digital/analog bits into electrical signal or optical signals.
6. Data encoding is also done in this layer.

Functions of Physical Layer

Following are the various functions performed by the Physical layer of the OSI model.

1. **Representation of Bits:** Data in this layer consists of stream of bits. The bits must be encoded into signals for transmission. It defines the type of encoding i.e. how 0's and 1's are changed to signal.
2. **Data Rate:** This layer defines the rate of transmission which is the number of bits per second.
3. **Synchronization:** It deals with the synchronization of the transmitter and receiver. The sender and receiver are synchronized at bit level.
4. **Interface:** The physical layer defines the transmission interface between devices and transmission medium.
5. **Line Configuration:** This layer connects devices with the medium: Point to Point configuration and Multipoint configuration.
6. **Topologies:** Devices must be connected using the following topologies: Mesh, Star, Ring and Bus.
7. **Transmission Modes:** Physical Layer defines the direction of transmission between two devices: Simplex, Half Duplex, Full Duplex.
8. Deals with baseband and broadband transmission.

Design Issues with Physical Layer

- The Physical Layer is concerned with transmitting raw bits over a communication channel.
- The design issue has to do with making sure that when one side sends a `1` bit, it is received by the other side as a `1` bit and not as a `0` bit.
- **Typical questions here are:**
  - How many volts should be used to represent a `1` bit and how many for a `0`?
  - How many nanoseconds a bit lasts?
  - Whether transmission may proceed simultaneously in both directions?
  - Whether transmission may proceed simultaneously in both directions?
  - How many pins the network connector has and what each pin is used for?
- The design issues here largely deal with mechanical, electrical and timing interfaces, and the physical transmission medium, which lies below the physical layer.

OSI Model Layer 2: Data Link Layer

1. Data link layer synchronizes the information which is to be transmitted over the physical layer.
2. The main function of this layer is to make sure data transfer is error free from one node to another, over the physical layer.
3. Transmitting and receiving data frames sequentially is managed by this layer.
4. This layer sends and expects acknowledgements for frames received and sent respectively. Resending of non-acknowledgement received frames is also handled by this layer.
5. This layer establishes a logical layer between two nodes and also manages the Frame traffic control over the network. It signals the transmitting node to stop, when the frame buffers are full.

Data link layer performs the most reliable node to node delivery of data. It forms frames from the packets that are received from network layer and gives it to physical layer. It also synchronizes the information which is to be transmitted over the data. Error controlling is easily done. The encoded data are then passed to physical.

Error detection bits are used by the data link layer. It also corrects the errors. Outgoing messages are assembled into frames. Then the system waits for the acknowledgements to be received after the transmission. It is reliable to send message.

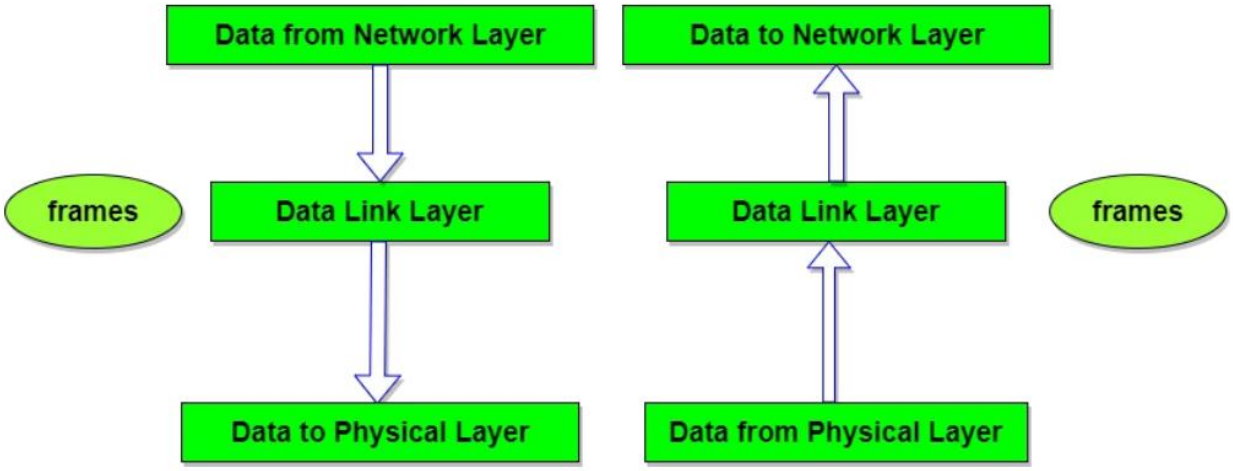
The main task of the **data link layer** is to transform a raw transmission facility into a line that appears free of undetected transmission errors to the network layer. It accomplishes this task by having the sender break up the input data into **data frames**(typically a few hundred or few thousand bytes) and transmit the frames sequentially. If the service is reliable, the receiver confirms correct receipt of each frame by send back an **acknowledgement frame**.

Functions of Data Link Layer

1. **Framing:** Frames are the streams of bits received from the network layer into manageable data units. This division of stream of bits is done by Data Link Layer.
2. **Physical Addressing:** The Data Link layer adds a header to the frame in order to define physical address of the sender or receiver of the frame, if the frames are to be distributed to different systems on the network.
3. **Flow Control:** A flow control mechanism to avoid a fast transmitter from running a slow receiver by buffering the extra bit is provided by flow control. This prevents traffic jam at the receiver side.
4. **Error Control:** Error control is achieved by adding a trailer at the end of the frame. Duplication of frames are also prevented by using this mechanism. Data Link Layers adds mechanism to prevent duplication of frames.
5. **Access Control:** Protocols of this layer determine which of the devices has control over the link at any given time, when two or more devices are connected to the same link.

Design Issues with Data Link Layer

- The issue that arises in the data link layer(and most of the higher layers as well) is how to keep a fast transmitter from drowning a slow receiver in data. Some traffic regulation mechanism is often needed to let the transmitter know how much buffer space the receiver has at the moment. Frequently, the flow regulation and the error handling are integrated.
- Broadcast networks have an additional issue in the data link layer: How to control access to the shared channel. A special sublayer of the data link layer, the Medium Access Control(MAC) sublayer, deals with this problem.



Network Layer - OSI Model

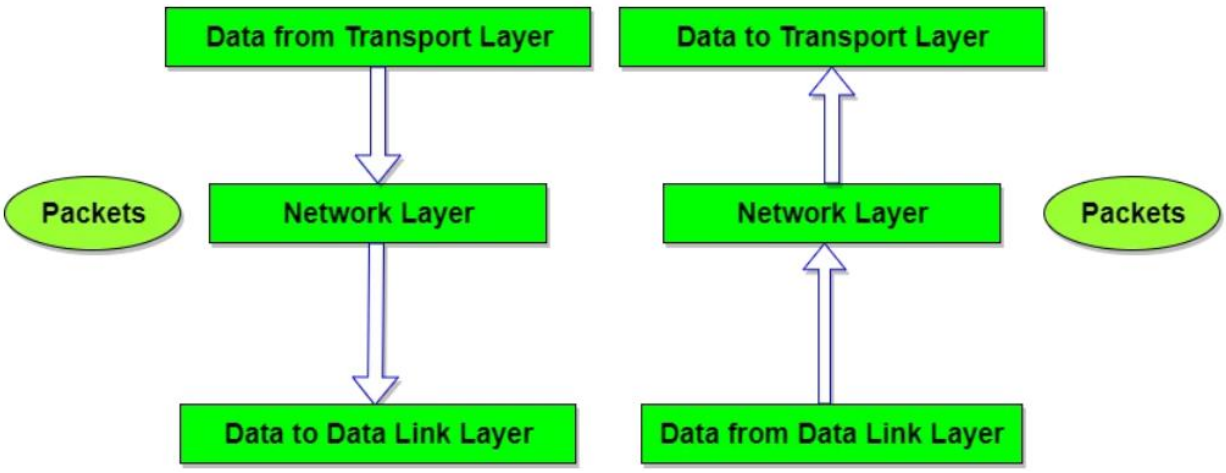
The network Layer controls the operation of the subnet. The main aim of this layer is to deliver packets from source to destination across multiple links (networks). If two computers (system) are connected on the same link, then there is no need for a network layer. It routes the signal through different channels to the other end and acts as a network controller.

It also divides the outgoing messages into packets and to assemble incoming packets into messages for higher levels.

In broadcast networks, the routing problem is simple, so the network layer is often thin or even non-existent.

Functions of Network Layer

1. It translates logical network address into physical address. Concerned with circuit, message or packet switching.
2. Routers and gateways operate in the network layer. Mechanism is provided by Network Layer for routing the packets to final destination.
3. Connection services are provided including network layer flow control, network layer error control and packet sequence control.
4. Breaks larger packets into small packets.



Design Issues with Network Layer

- A key design issue is **determining how packets are routed from source to destination**. Routes can be based on static tables that are wired into the network and rarely changed. They can also be highly dynamic, being determined anew for each packet, to reflect the current network load.
- If **too many packets** are present in the subnet at the same time, they will get into one another's way, forming **bottlenecks**. The **control of such congestion** also belongs to the network layer.
- Moreover, the **quality of service** provided(delay, transmit time, jitter, etc) is also a network layer issue.
- When a packet has to **travel from one network to another to get to its destination**, many problems can arise such as:
  - The addressing used by the second network may be different from the first one.
  - The second one may not accept the packet at all because it is too large.
  - The protocols may differ, and so on.
- It is up to the network layer to overcome all these problems to allow heterogeneous networks to be interconnected.

Transport Layer - OSI Model

The basic function of the Transport layer is to accept data from the layer above, split it up into smaller units, pass these data units to the Network layer, and ensure that all the pieces arrive correctly at the other end.

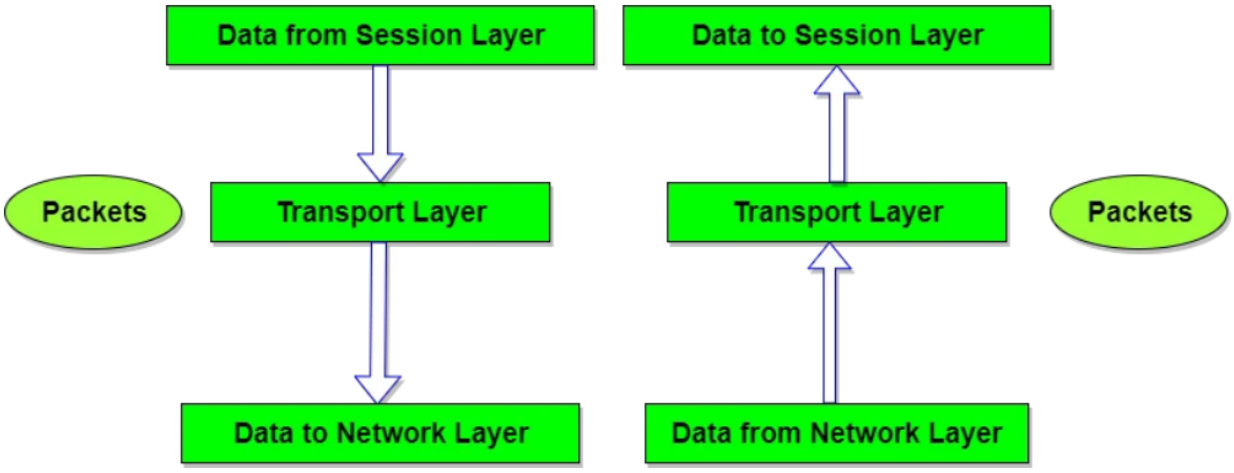
Furthermore, all this must be done efficiently and in a way that isolates the upper layers from the inevitable changes in the hardware technology.

The Transport layer also determines what type of service to provide to the Session layer, and, ultimately, to the users of the network. The most popular type of transport connection is an **error-free point-to-point channel** that delivers messages or bytes in the order in which they were sent.

The Transport layer is a true end-to-end layer, all the way from the source to the destination. In other words, a program on the source machine carries on a conversation with a similar program on the destination machine, using the message headers and control messages.

Functions of Transport Layer

1. **Service Point Addressing:** Transport Layer header includes service point address which is port address. This layer gets the message to the correct process on the computer unlike Network Layer, which gets each packet to the correct computer.
2. **Segmentation and Reassembling:** A message is divided into segments; each segment contains sequence number, which enables this layer in reassembling the message. Message is reassembled correctly upon arrival at the destination and replaces packets which were lost in transmission.
3. **Connection Control:** It includes 2 types:
   - Connectionless Transport Layer : Each segment is considered as an independent packet and delivered to the transport layer at the destination machine.
   - Connection Oriented Transport Layer : Before delivering packets, connection is made with transport layer at the destination machine.
4. **Flow Control:** In this layer, flow control is performed end to end.
5. **Error Control:** Error Control is performed end to end in this layer to ensure that the complete message arrives at the receiving transport layer without any error. Error Correction is done through retransmission.



Design Issues with Transport Layer

- Accepting data from Session layer, split it into segments and send to the network layer.
- Ensure correct delivery of data with efficiency.
- Isolate upper layers from the technological changes.
- Error control and flow control.

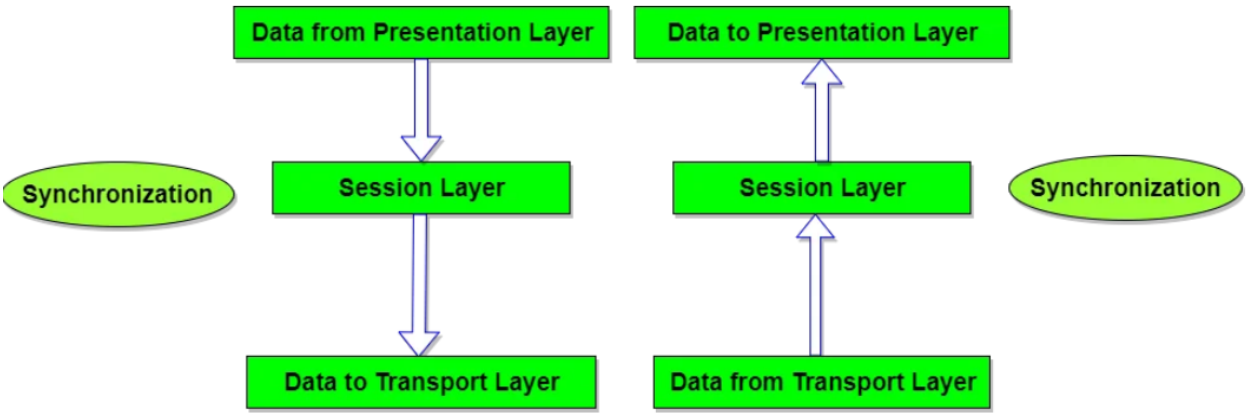
Session Layer - OSI Model

The Session Layer allows users on different machines to establish active communication sessions between them.

It's main aim is to establish, maintain and synchronize the interaction between communicating systems. Session layer manages and synchronize the conversation between two different applications. In Session layer, streams of data are marked and are resynchronized properly, so that the ends of the messages are not cut prematurely and data loss is avoided.

Functions of Session Layer

1. **Dialog Control :** This layer allows two systems to start communication with each other in half-duplex or full-duplex.
2. **Token Management:** This layer prevents two parties from attempting the same critical operation at the same time.
3. **Synchronization :** This layer allows a process to add checkpoints which are considered as synchronization points into stream of data. Example: If a system is sending a file of 800 pages, adding checkpoints after every 50 pages is recommended. This ensures that 50 page unit is successfully received and acknowledged. This is beneficial at the time of crash as if a crash happens at page number 110; there is no need to retransmit 1 to100 pages.



Design Issues with Session Layer

- To allow machines to establish sessions between them in a seamless fashion.
- Provide enhanced services to the user.
- To manage dialog control.
- To provide services such as **Token management** and **Synchronization**.

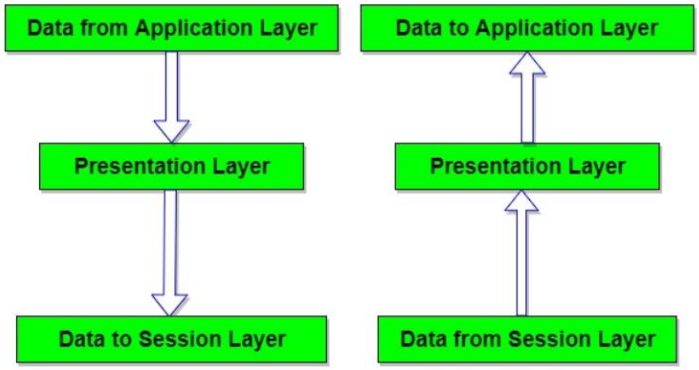
Presentation Layer - OSI Model

The primary goal of this layer is to take care of the **syntax** and **semantics** of the information exchanged between two communicating systems. Presentation layer takes care that the data is sent in such a way that the receiver will understand the information(data) and will be able to use the data. Languages(syntax) can be different of the two communicating systems. Under this condition presentation layer plays a role translator.

In order to make it possible for computers with different data representations to communicate, the data structures to be exchanged can be defined in an **abstract** way. The presentation layer manages these **abstract data structures** and allows higher-level data structures(eg: banking records), to be defined and exchanged.

Functions of Presentation Layer

1. **Translation:** Before being transmitted, information in the form of characters and numbers should be changed to bit streams. The presentation layer is responsible for interoperability between encoding methods as different computers use different encoding methods. It translates data between the formats the network requires and the format the computer.
2. **Encryption:** It carries out encryption at the transmitter and decryption at the receiver.
3. **Compression:** It carries out data compression to reduce the bandwidth of the data to be transmitted. The primary role of Data compression is to reduce the number of bits to be 0transmitted. It is important in transmitting multimedia such as audio, video, text etc.



Design Issues with Presentation Layer

- To manage and maintain the **Syntax** and **Semantics** of the information transmitted.
- **Encoding data** in a standard agreed upon way. Eg: String, double, date, etc.
- Perform **Standard Encoding** on wire.

Application Layer - OSI Model

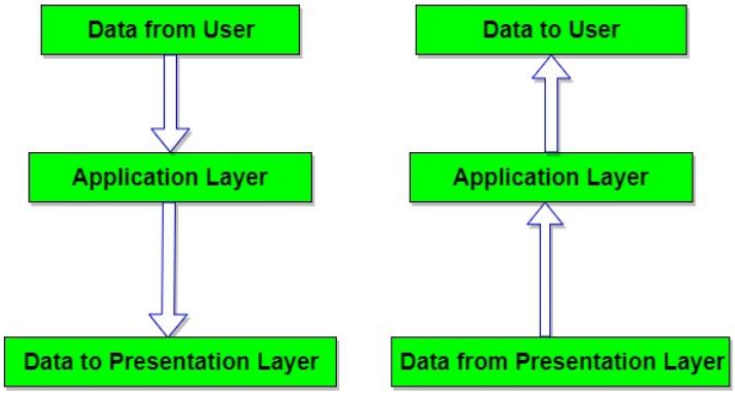
It is the top most layer of OSI Model. Manipulation of data(information) in various ways is done in this layer which enables user or software to get access to the network. Some services provided by this layer includes: E-Mail, transferring files, distributing the results to user, directory services, network resources, etc.

The Application Layer contains a variety of protocols that are commonly needed by users. One widely-used application protocol is **HTTP(HyperText Transfer Protocol)**, which is the basis for the World Wide Web. When a browser wants a web page, it sends the name of the page it wants to the server using HTTP. The server then sends the page back.

Other Application protocols that are used are: **File Transfer Protocol(FTP)**, **Trivial File Transfer Protocol(TFTP)**, **Simple Mail Transfer Protocol(SMTP)**, **TELNET**, **Domain Name System(DNS)** etc.

Functions of Application Layer

1. **Mail Services:** This layer provides the basis for E-mail forwarding and storage.
2. **Network Virtual Terminal:** It allows a user to log on to a remote host. The application creates software emulation of a terminal at the remote host. User's computer talks to the software terminal which in turn talks to the host and vice versa. Then the remote host believes it is communicating with one of its own terminals and allows user to log on.
3. **Directory Services:** This layer provides access for global information about various services.
4. **File Transfer, Access and Management (FTAM):** It is a standard mechanism to access files and manages it. Users can access files in a remote computer and manage it. They can also retrieve files from a remote computer.



Design Issues with Application Layer

There are commonly reoccurring problems that occur in the design and implementation of Application Layer protocols and can be addressed by patterns from several different pattern languages:

- Pattern Language for Application-level Communication Protocols
- Service Design Patterns
- Patterns of Enterprise Application Architecture
- Pattern-Oriented Software Architecture