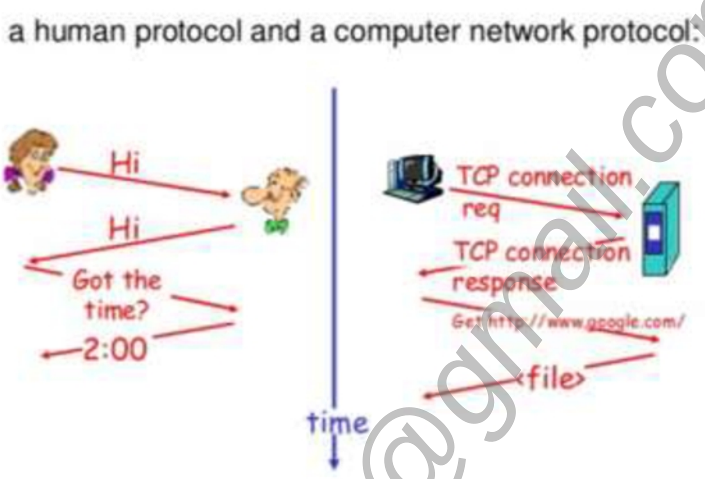
Chapter-2
Protocol Layers

Protocols And Standards

- Protocols are the set of rules that govern all activity in the network that involves two or more communicating remote entities.
- Protocols are running everywhere in the network.
- Example: protocol in router determine a packet path from source to destination, error detection protocol could detect the transmission error etc.



Protocol Stack , Interfaces and Services

- Protocols are the set of rules that govern all the activity in the network that involves two or more communication entities.
- **To reduce the design complexities, network designers organize the protocols, network hardware and software that implement the protocol in layers.**
- A protocol in one layer perform a certain set of operations on data, the data is then passed to the next layer where another protocol perform different set of operations. I.e. each layer provides certain services to upper layer.

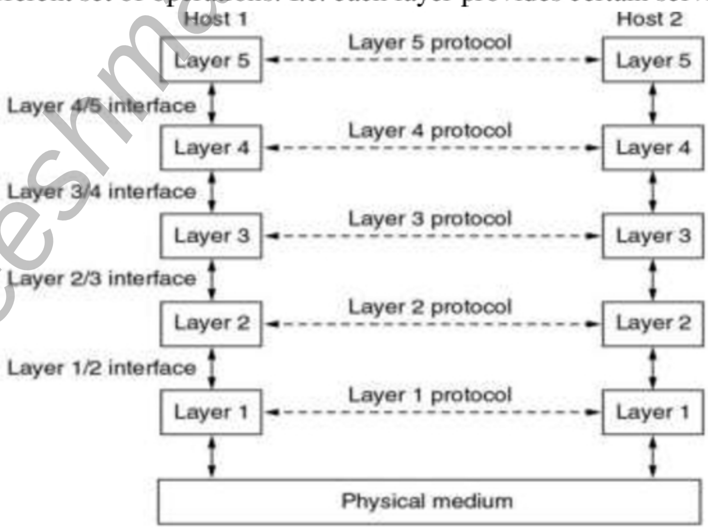


Fig 1: layer, services and interfaces

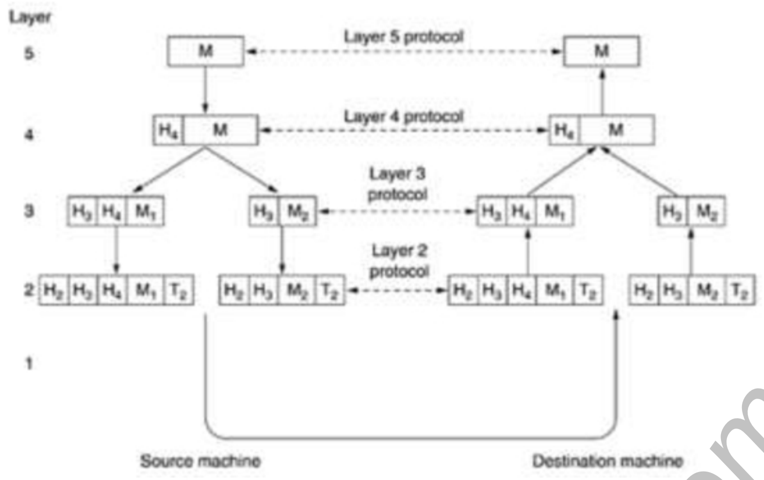


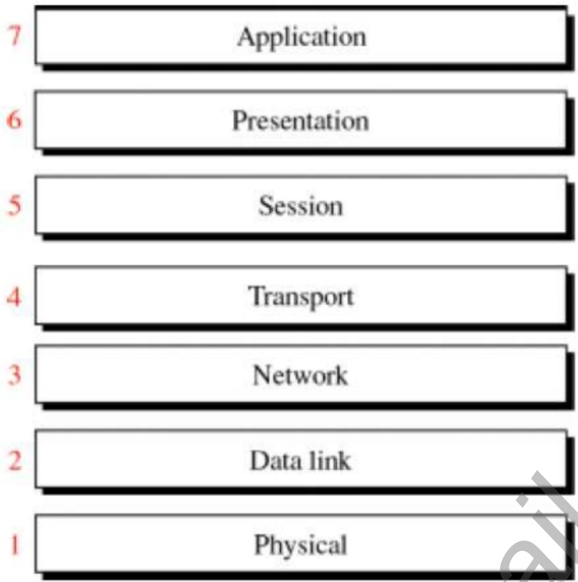
Fig 2: Example information flow supporting virtual connection in layer 5

- The protocols at various layer are called protocol stack.
- The key concept of protocol stack is each n-1 layer provides service to upper layer n.
- These layers communicate with each other by exchanging n-message. These message are called layered-n protocol data unit or n-PDU.
- Between each pair of layer is an **interface** that define the **services** the lower layer provides to upper one.
- Example: The application-to-transport interface defines how application programs make use of the transport layers. For example, this interface level would define how a web browser program would talk to TCP/IP transport software
- In above figure 2, the source generates message in layer 5 and passed down to layer 4. This layer 4 put some header in front of message to obtain 4-PDU. Then this message is passed down to layer3. In layer 3, 4-PDU is divided into two parts M1 and M2 and additional header is appended in front of message. The header may include control information such as sequence number to allow **peer layer 3 on destination** to deliver message on right order. Simply header contains additional information needed by the sending and receiver side.
- The procedure continues in the source, adding more header at each layer until 1-PDU are sent to the destination over a physical link.
- At the other end, the destination host receive 1-PDU and direct them up the protocol stack. At each layer, the corresponding header is removed.
- Finally Message M is obtained from M1 and M2 and then passed to destinaiton applicaton.

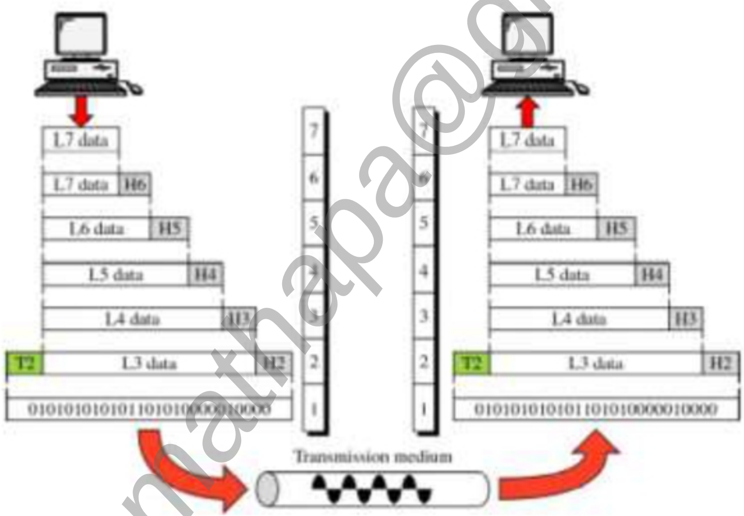
Drawback of Layer approach

1. Possibility of redundancy of functionality
2. Dependency of one layer to another violate the goal of separation of layers.

The OSI Reference Model



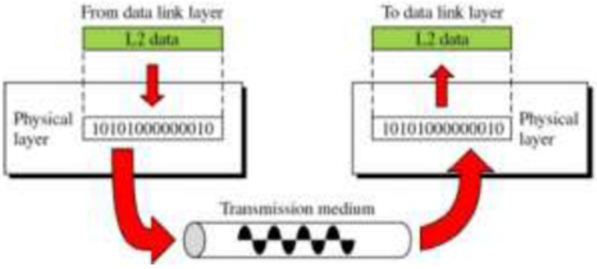
OSI protocols stack



- Appeared after TCP/IP model.
- The international organization for standardization (ISO) has developed OSI (open system interconnection) model in 1977.
- An open system is a set of protocols that allows any two different systems to communicate regardless of their underlying architecture.
- In order for computer communicate, there must be some rules, followed by the computer for transferring information from one computer to another.
- OSI model, simple define which task need to be done and which protocol will handle those tasks at each of the seven layers of the model. These all layers are present in each computer logically; all the information before transferring has to be processed under the seven layers.
- At each layer (except layer 7 and 1) in the sender side, a header is added to the data unit received from the upper layer. At the layer 2, a trailer is added as well.
- As each block of data reaches the next higher layer in receiving end, the header and trailer attached to it at the corresponding layer at the sending device are removed, and actions appropriate to that layer are taken.

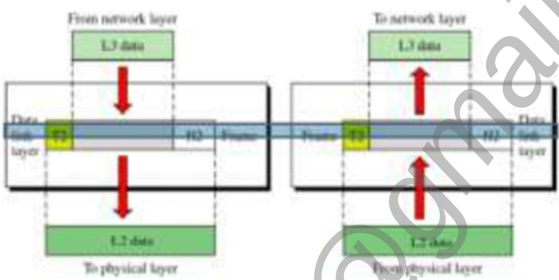
Layers in OSI model

1. **Physical Layer**



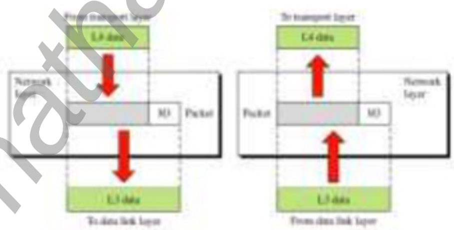
This layer is used for sending bits 1's or 0's from one computer to another computer. It also deals with the physical connection between the computers. It mainly transmits and receives the signal.

2. **Data Link Layer**



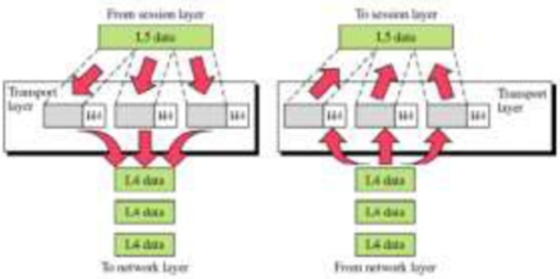
The data link layer provides for the delivery of data over a single link from one device to another in the route and device decided by the network layer. The data link layer is responsible for correcting transmission errors induced during transmission. This is achieved by the data link layer by performing the tasks like framing(encapsulation), flow control, error control, access control, and physical addressing.

3. **Network Layer**



The network layer is responsible for the source-to-destination delivery of a packet possibly across multiple networks. So the network layer is responsible for deciding route and forwarding the packets to a particular device. For this it uses two protocol i.e. IP and routing protocol. IP for translating logical network address to physical machine address. Routing protocols are used to determine the path for the packet if there are several ways a packet can get to its destination.

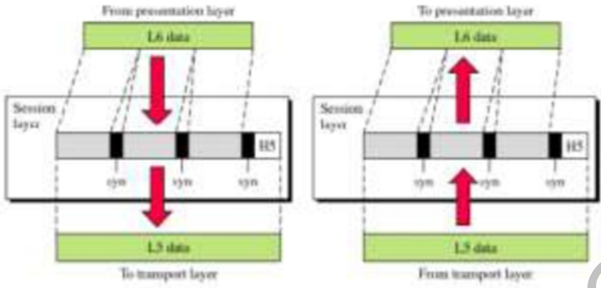
4. **Transport Layer**



This layer is responsible for delivering error free data to destination computer. This layer breaks the large message into small packets and then sends these packets to the destination computer. The transport layer also sends acknowledgement to the sender that message has been sent successfully i.e. the transport layer ensures data is successfully sent and received between two end systems. If data is sent incorrectly, this layer has the responsibility to

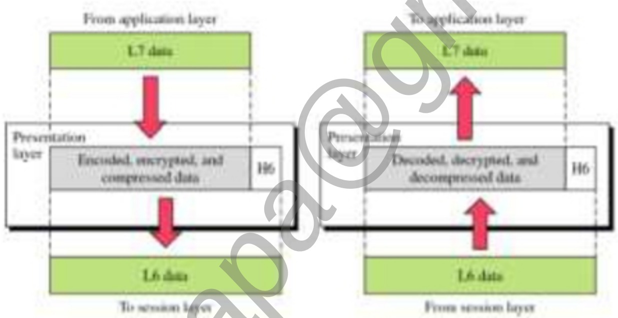
ask for retransmission of the data. Also it ensures data are passed onto the upper layers in the same order in which they were sent. It also provides multiplexing/DE multiplexing for combining data from several source for transmission over a single data path. Congestion control is also provided by this layer.
The Transmission Control Protocol (TCP) of the TCP/IP protocol suite resides at the transport layer.

5. Session Layer



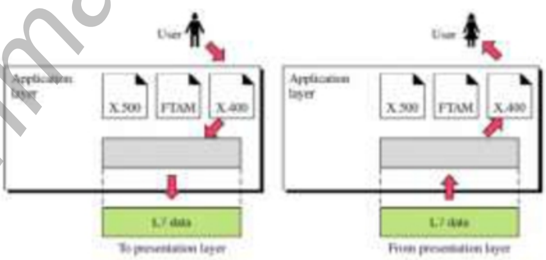
It is responsible for the session between computers to be established and terminated. It provides two systems into a dialog to find each other and provide a common link. Also, the session layer organizes and synchronizes the exchange of data between application processes. It works with the application layer to provide simple data sets called synchronization points that let an application know how the transmission and reception of data are progressing. In simplified terms, the session layer can be thought of as a timing and flow control layer.

6. Presentation Layer



This layers translates the information between the format the network requires and the format the computer expects. The presentation layer is responsible for task like data translation (e.g. converting to ASCII coded file or XML file), compressions, encryption etc.

7. Application Layer



The application layer is the topmost layer of OSI model. It provides services that directly user application such as webpage, email, file transfer etc. it uses many protocols including HTTP to support web, SMTP to support email, FTP to support file transfer, DNS etc.

Summary

Summary:
Physical Layer: How to transmit bits.
Data Link Layer: How to transmits frames
Network: How to route packets to the node.
Transport: How to send packets to the applications.
Session: Manage connections.
Presentation: Encode/Decode messages, security.
Application: Everything else.

Benefits of OSI model

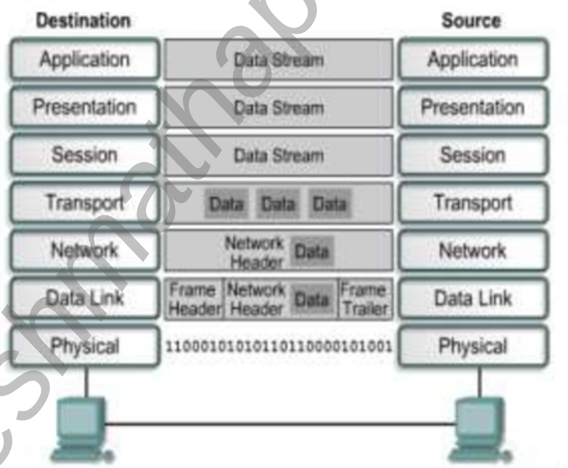
- It breaks network communication into smaller, more manageable parts.
- It standardizes network components to allow multiple vendor development and support.
- It allows different types of network hardware and software to communicate with each other.
- It prevents changes in one layer from affecting other layers.
- It divides network communication into smaller parts to make learning it easier to understand.

Protocols in TCP/IP and OSE

TCP/IP	OSI Model	Protocols
Application Layer	Application Layer	DNS, DHCP, FTP, HTTPS, IMAP, LDAP, NTP, POP3, RTP, RTSP, SSH, SIP, SMTP, SNMP, Telnet, TFTP
	Presentation Layer	JPEG, MIDI, MPEG, PICT, TIFF
	Session Layer	NetBIOS, NFS, PAP, SCP, SQL, ZIP
Transport Layer	Transport Layer	TCP, UDP
Internet Layer	Network Layer	ICMP, IGMP, IPsec, IPv4, IPv6, IPX, RIP
Link Layer	Data Link Layer	ARP, ATM, CDP, FDDI, Frame Relay, HDLC, MPLS, PPP, STP, Token Ring
	Physical Layer	Bluetooth, Ethernet, DSL, ISDN, 802.11 Wi-Fi

Data Encapsulation

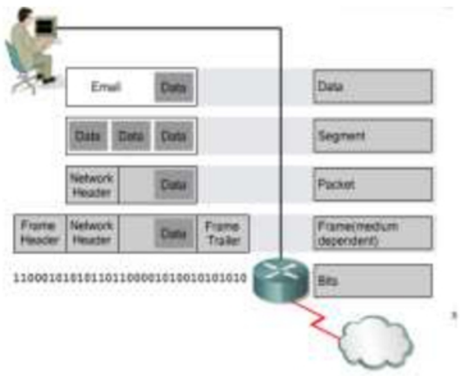
All communications on a network originate at a source, and are sent to a destination. The information sent on a network is referred to as data or data packets. If one computer (host A) wants to send data to another computer (host B), the data must first be packaged through a process called encapsulation. Encapsulation wraps data with the necessary protocol information before network transit. Therefore, as the data packet moves down through the layers of the OSI model, it receives headers, trailers, and other information.



Example:

Perform the following five conversion steps in order to encapsulate the data.

1. Build the data.
2. Package the data for end-to-end transport.
3. Add the network IP address to the header.
4. Add the data link layer header and trailer.
5. Convert to bits for transmission.



TCP/IP Reference Model

The ARPANET was a research network sponsored by the DOD (U.S Department Of Defense). It had connected hundreds of universities and government installations using leased telephone lines. When satellite and radio networks were added later, the existing protocols had trouble inter working with them, so new reference architecture was needed. Thus, the ability to connect multiple networks together without facing any problem was one of the major design goals from the very beginning. This architecture later became known as TCP/IP Reference Model, after its two primary protocols.

This model basically consists of four main layers as describe in figure.

	OSI	TCP/IP	
7	Application	Application	
6	Presentation		Not present in the model
5	Session		
4	Transport	Transport	
3	Network	Internet	
2	Data link	Network Access	
1	Physical		

1. Application layer:

On top the transport layer is the application layer. TCP/IP combines the OSI application, presentation, and session layers into its application layer. The application layer handles high-level protocols, representation, encoding, and dialog control. The TCP/IP protocol suite combines all application related issues into one layer. It ensures that the data is properly packaged before it is passed on to the next layer. TCP/IP has protocols to support file transfer i.e. FTP, e-mail i.e. SMTP, DNS, and remote login etc.

2. Transport Layer:

The transport layer ensures that packets are delivered error free, in sequence and with no losses or duplication. The transport layer break large message from the upper layer application into packet to be sent to the destination computer and again on receiving site resembles packet into the message to be presented to the applicaton layer. The transport layer typically sent an acknowledgement to the originator for message received. Two end to end protocols have been defined here. The first one, TCP (Transmission Control Protocol) is a reliable connection oriented protocol that allows a byte stream originated on one machine to be delivered without error on any other machine in the internet. The second protocol in this layer, UDP (User Datagram Protocol), is unreliable, connectionless protocols for applications that do not want TCP's sequencing or flow control and wish to provide their own. It is also widely used for one-shot, client-server type request reply queries and applications in which prompt delivery is more important than accurate delivery, such as transmitting speech or video.

3.Internet Layer

The main job of this layer is to inject packet into any network and have them travel independently to the destination. The main protocol that function at this layer is IP. Best path determination and packet switching occurs at this layer. Other protocols that operate at this layer are ARP, RARP etc.

4. Network Access:

The network access layer allows an IP packet to make a physical link to the network media. It includes all the detail include in OSI data link and physical layer. Drivers for software applications, modem cards, and other devices operate at the network access layer. The network access layer defines the procedures used to interface with the network hardware and access the transmission medium.

Comparison of OSI Model and TCP/IP Model:

The OSI and TCP/IP models have many similarities:

- Both are based on layers' concept.
- Both have application layers, though they include different services.
- Both have comparable transport and network layers.
- Both use packet-switched instead of circuit-switched technology.
- Networking professionals need to know both models.

Here are some differences of the OSI and TCP/IP models:

- TCP/IP combines the OSI application, presentation, and session layers into its application layer.
- TCP/IP combines the OSI data link and physical layers into its network access layer.
- TCP/IP appears simpler because it has fewer layers.
- When the TCP/IP transport layer uses UDP it does not provide reliable delivery of packets. The transport layer in the OSI model always does.

OSI MODEL	TCP/IP MODEL
Contains 7 Layers	Contains 4 Layers
Uses Strict Layering resulting in vertical layers.	Uses Loose Layering resulting in horizontal layers.
Supports both connectionless & connection-oriented communication in the Network layer, but only connection-oriented communication in Transport Layer	Supports only connectionless communication in the Network layer, but both connectionless & connection-oriented communication in Transport Layer
It distinguishes between Service, Interface and Protocol.	Does not clearly distinguish between Service, Interface and Protocol.
Protocols are better hidden and can be replaced relatively easily as technology changes (No transparency)	Protocols are not hidden and thus cannot be replaced easily. (Transparency) Replacing IP by a substantially different protocol would be virtually impossible
OSI reference model was devised before the corresponding protocols were designed.	The protocols came first and the model was a description of the existing protocols

The Internet was developed based on the standards of the TCP/IP protocols. The TCP/IP model gains credibility because of its protocols. The OSI model is not generally used to build networks. The OSI model is used as a guide to help students understand the communication process.