Chapter 2

Network Models

Behrouz A. Forouzan "Data communication and Networking"
Fourth edition

Layered Tasks

We use the concept of layers in our daily life. As an example, let us consider two friends who communicate through postal mail. The process of sending a letter to a friend would be complex if there were no services available from the post office.

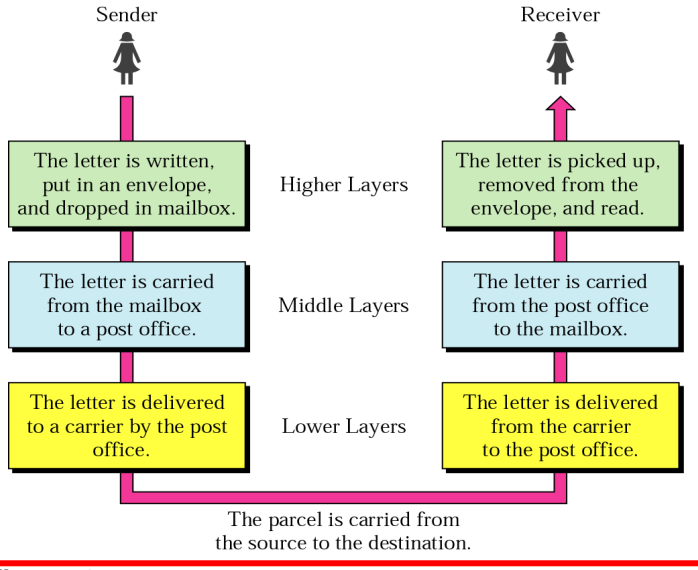
Process of sending a letter

Sender, Receiver, and Carrier

Hierarchy: Tasks must be done in order given in hierarchy

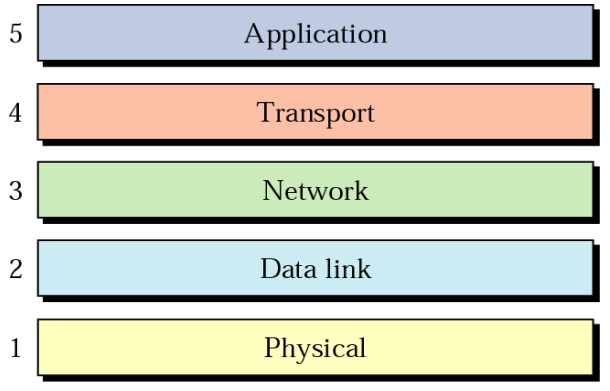
Services : each layer at the sending site uses the services of the layer below it.

Sending a letter



Internet layers

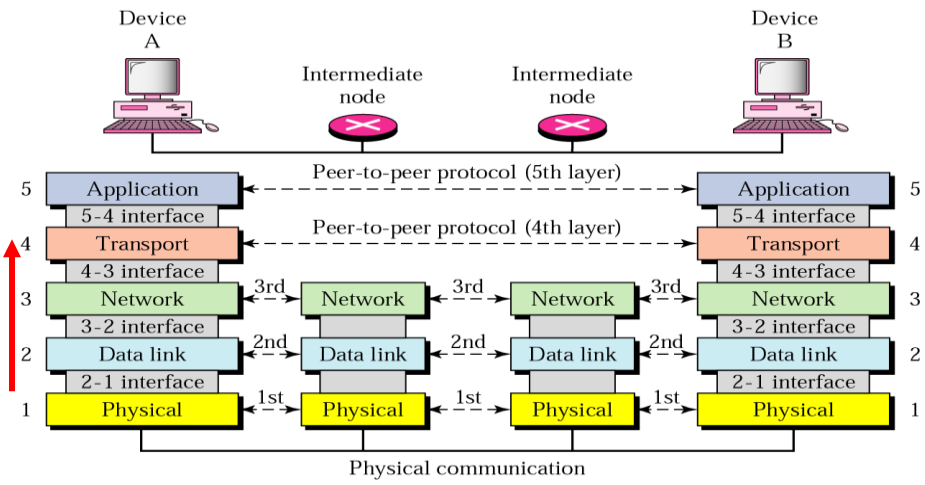
The layers in the TCP/IP protocol suite is made of five layers: physical, data link, network, transport, and application.



Layer: A grouping of related tasks involving the transfer of information .Each layer addresses an essential networking tasks

Ex: device A sends a stream of bits to device B

Peer-to-peer process



Internet Model

- Within a single machine, each layer use services provided by layer below it and provides services for layer above it .
- Ex. Layer 3 provides services to layer 4 and uses services provided by layer 2.
- **Peer-to-peer process** : The processes on each machine that communicate at a given layer are called peer –to-peer processes
- Between machines layer x communicates with layer x on another machine by protocols.
- Communication between machines is peer-to-peer processing using the protocols appropriate to a given layer.

Interfaces : Between each pair of adjacent layers . It defines what information and services a layer must provide for layer above it

Organization of the layers

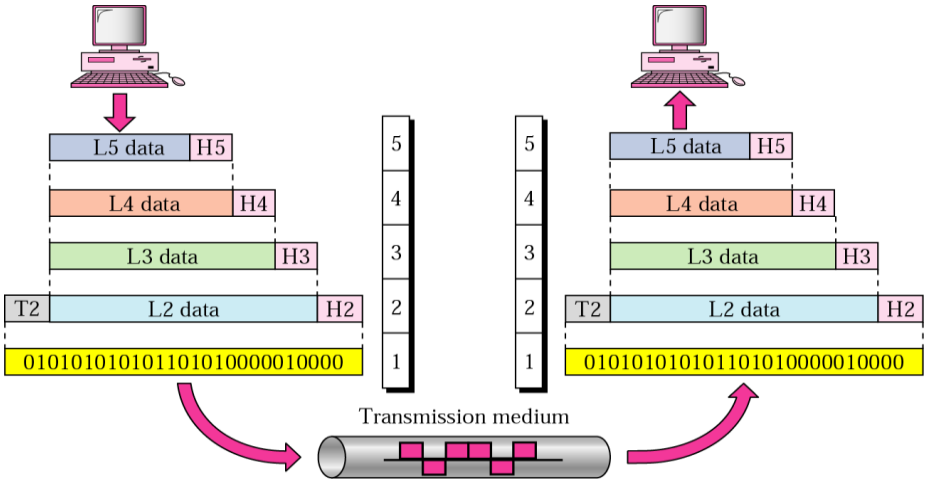
- Network support layer :

Deal with the physical aspects of moving data from one device to another such as :electrical specifications , physical connections, physical addressing, transport timing and reliability. Includes Layers 1, 2 and 3

- User support layer: Application layer

Layer 4(transport layer) links the two subgroups to insure that what the lower layers have transmitted is in form the upper layer can use

An exchange using the Internet model



At sender:

- at each layer, a header can added to the data unit.
- At layer 2 a trailer is added as well .
- When formatted data unit passes through physical layer it is changed into an electromagnetic signal and transported along physical link.

Encapsulation:

A packet (header and data) at level 5 is encapsulated in a packet in level 4, and so on.

The data portion of packet at level N-1 carries the whole packet (data and header/trailer) from level N.

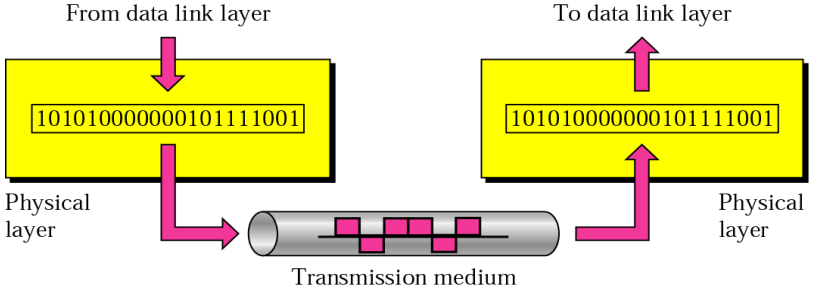
At destination:

- A data then move back up through the layer
- a headers and trailers attached to data at the corresponding layer are removed (decapsulated) and action appropriate to that layer are taken. (unwrapped/decapsulated)
- At layer 5 the message is again in form appropriate to the application and is made available to user.

Function of the layers

1. Physical layer

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



Duties of physical layer

Physical characteristic of interfaces and media:

- It defines the characteristic of the interface between devices and media. It also define the type of transmission media

Representation of bits:

- The bit stream must be encoded into signals. It defines the type of representation (how 0, 1 are changed to signal).

Data rate:

- It defines the number of bits sent per second and also the duration of bits.

Synchronization of bits

- The sender and receiver must be use the same bit rate also the receiver clock must be synchronized

Duties of physical layer

Line configuration

- Physical layer is concerned with the connection of devices to the media **(point-to point or multipoint)**

Physical topology:

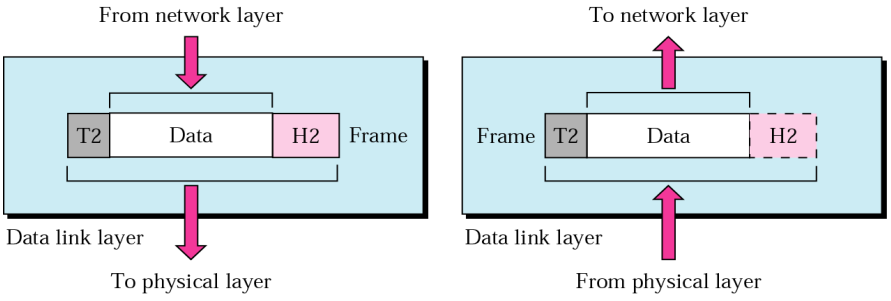
- How devices connected to make a network
- Devices can connected by using **Star, mesh , bus, ring or hybrid topology**

Transmission mode:

- It defines the direction of transmission between two devices (**simplex, half-duplex, or full duplex**)

2. Data link layer hop to- hop delivery

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



Duties of data link layer

Framing:

- **Divide the stream of bits received from network layer into data units called frames**

Physical addressing:

- **It adds a header to the frame to define the sender and receiver of the frame.**
- **If the frame for a system outside the sender's network the receiver address: is the address of the connecting device that connects the network to next one (Router/switch).**

Flow control:

- **It imposes a flow control mechanism , if the data rate at the receiver is less than produced by sender the data link layer imposes a flow control to avoid overwhelming the receiver**

Duties of data link layer

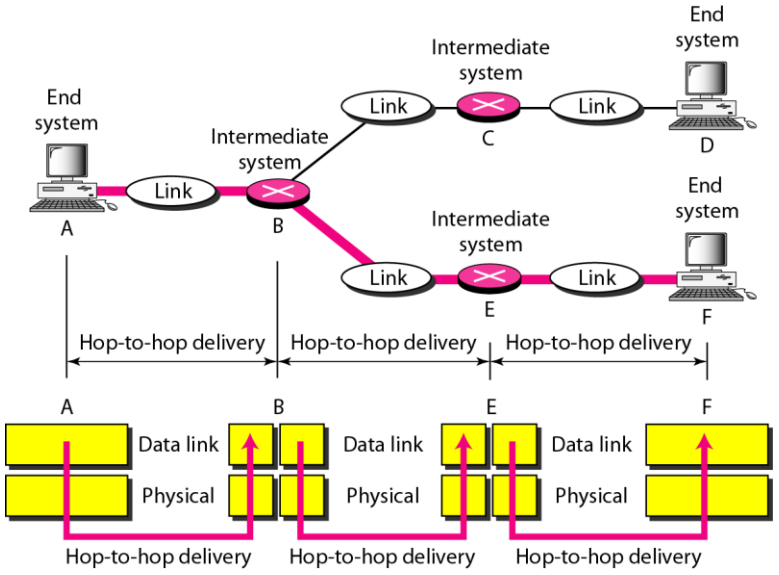
Error control:

- **Add mechanisms to detect and retransmit damaged or lost frames.**
- **Prevent also duplication of frames.**
- **Error control is normally achieved through a trailer added to the end of frame.**

Access control:

- **When two or more devices than one devices are connected to the same link, data link layer protocols are necessary to determine which device has control over the link at given time.**

Hop-to-hop delivery



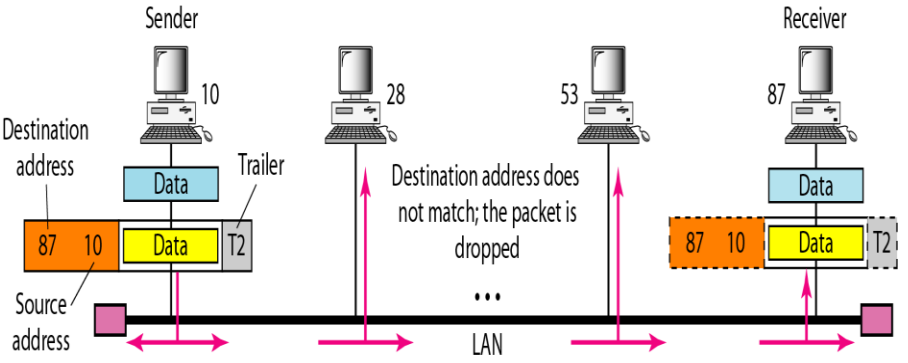
Physical address

- *known also as the MAC or link address*
- *Is the address of a node as defined by its LAN or WAN*
- *It is included in the frame used by data link layer (Header)*
- *Ethernet uses 6-bytes (48-bits) physical address that imprinted on the NIC*

Example 1

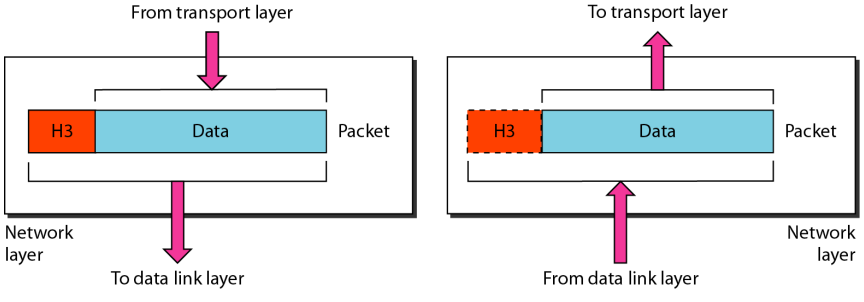
A node with physical address 10 sends a frame to a node with physical address 87. The two nodes are connected by a link. At the data link level this frame contains physical addresses in the header. These are the only addresses needed. The rest of the header contains other information needed at this level. The trailer usually contains extra bits needed for error detection

Example1 :Physical addresses



3. Network layer source to destination delivery

- **The network layer is responsible for the delivery of individual packets from the source host to the destination host across multiple network.**
- **If two system are connected to the same link (network), no need for this layer.**



Duties of network layer (internetwork layer)

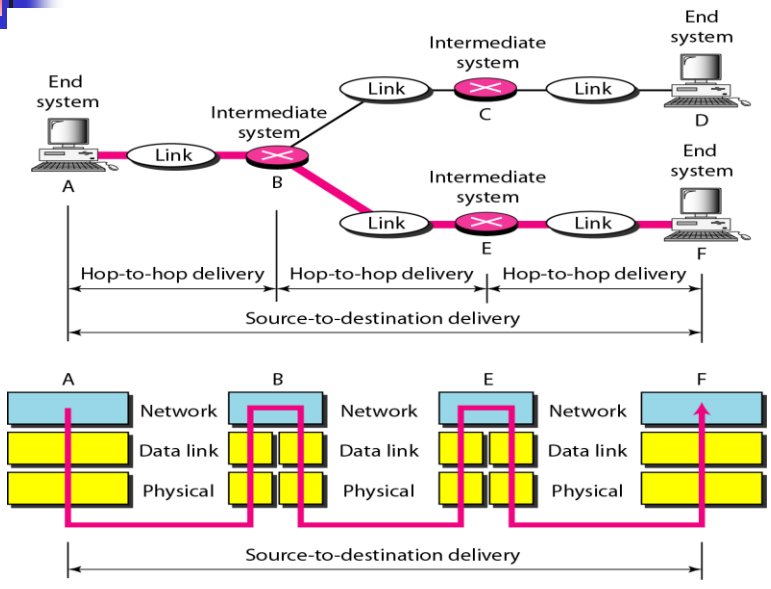
- **Logical addressing**
  - In contrast to physical addressing implemented by data link layer handling the addressing problem locally. Net work layer adds unique identifier (IP or logical address) to the packet.
  - These unique identifier(as tel. no, each tel. has unique number) enable special devices called router to make sure the packet get to correct system.

Routing:

provide the routing mechanism for the **router** which route the packet to their final destination.

Routers : devices used when independent networks are connected to create an internetworking (network of networks)

Source-to-destination delivery



Logical address (IP)

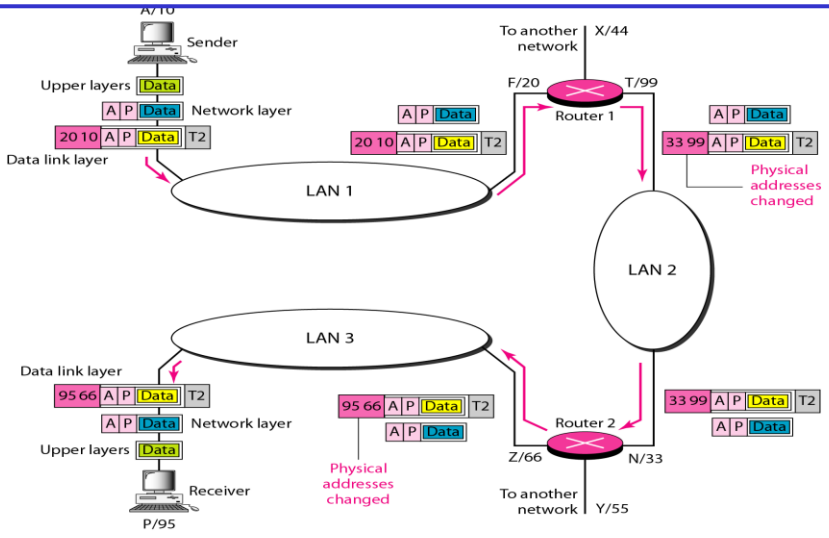
- *IP addresses are necessary for universal communications that are independent of physical network.*
- *No two host address on the internet can have the same IP address*
- ***IP addresses 32-bit address that uniquley define a host connected to the Internet***

The physical addresses will change from hop to hop, but the logical addresses remain the same.

Example 2

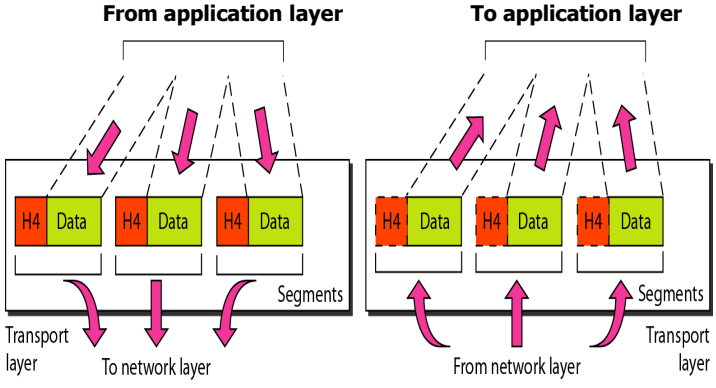
The following figure shows a part of an internet with two routers connecting three LANs. Each device (computer or router) has a pair of addresses (logical and physical) for each connection. In this case, each computer is connected to only one link and therefore has only one pair of addresses. Each router, however, is connected to three networks (only two are shown in the figure). So each router has three pairs of addresses, one for each connection.

Example 2: *IP addresses (logical address)*



Transport layer (process-to-process delivery)

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



Duties of transport layer

1. **Port addressing (Service-point addressing)**
   - Computer often run several process (running programs) at the same time, so the process to process delivery means delivery from a specific process on a computer to specific process to the other.
   - The transport layer header must include Port address
   - Port address: 16-bit addresses represented by decimal number range from 0-65535 to **choose among multiple processes on the destination host**
   - Destination port No is needed for delivery
   - Source port no is needed for replay.

Note:

IP (logical address)and port address play different roles in selecting the final destination

- ***IP: defines the host among the different hosts in the world***
- ***After host is selected , the port address defines one of the processes on this particular host.***

Duties of transport layer

2. Segmentation and reassembly

- A message is divided into small pieces (Segment), each segment containing sequence number. These number enable the transport layer to reassemble the message correctly at destination and to identify and replace segment that were lost in transmission.

3.Flow control:

Like the data link layer, transport layer responsible for flow control. Flow control at this layer is performed end to end rather than across a signal link.

Duties of transport layer

4. Error control

- **Error control at this layer is performed process-to-process rather than across a single link**
- **The sending transport layer makes sure that the entire message arrives at the receiving transport layer without error (damage, loss or duplicated).**
- **Error correction is usually achieved through retransmission**

Duties of transport layer

5.Connection control

The transport layer can be either connection less or connection oriented

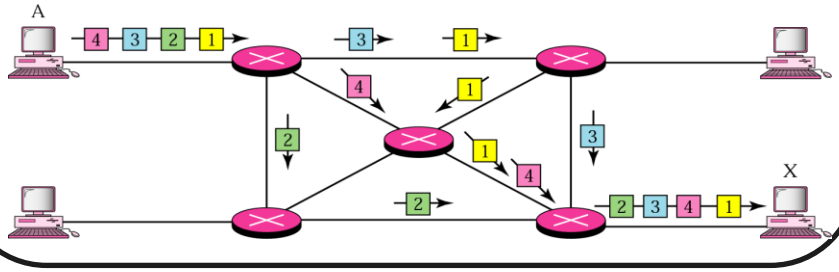
1. Connection oriented

- Makes a connection with the transport layer at the destination machine first before delivering the packers.
- When the connection established a sequence of packets from source to the destination can be sent one after another on the same path and in sequential order.
- When all packets of message have been delivered, the connection is terminated
- This makes the sending transport **layer ensure that the message arrives at the receiving transport layer without error (damage, loss or duplication**

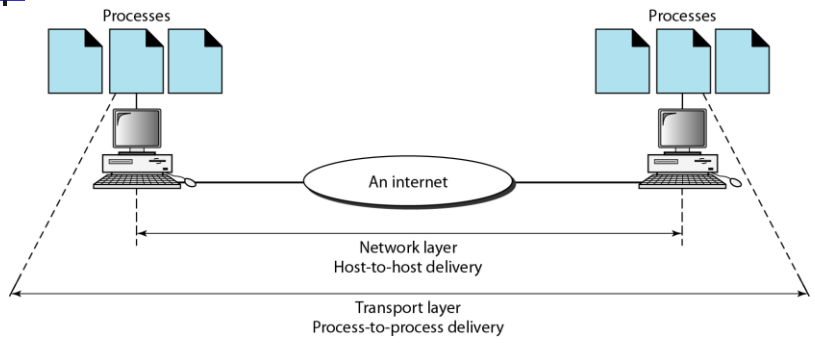
Duties of transport layer

Connection Less (as Internet)

- **It sends the data, but does not establish and verify a connection between hosts before sending data.**
- **Treats each packet independently, the packets in a message may or may not travel the same path to their destination.**



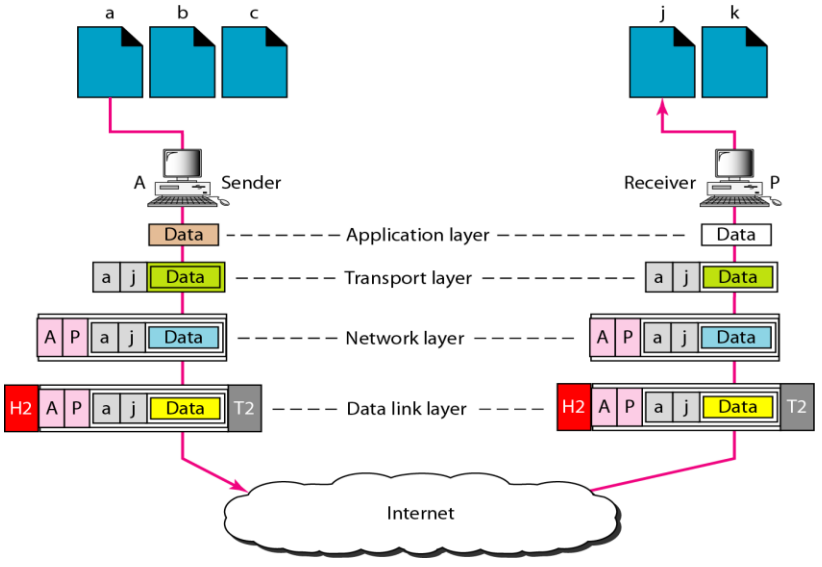
Reliable process-to-process delivery of a message



The network layer gets each packet to the correct computer; the transport layer gets the message to the correct processes on that computer

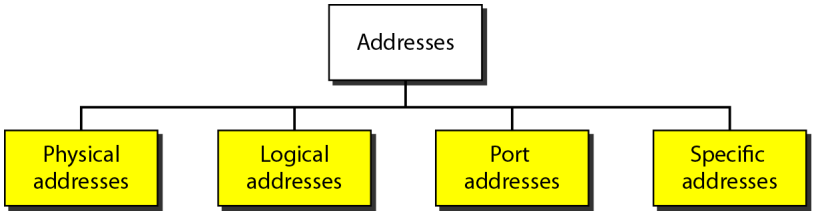
Example

The following figure shows two computers communicating via the Internet. The sending computer is running three processes at this time with port addresses a, b, and c. The receiving computer is running two processes at this time with port addresses j and k. Process a in the sending computer needs to communicate with process j in the receiving computer. Note that although physical addresses change from hop to hop, logical and port addresses remain the same from the source to destination.



ADDRESSING

Four levels of addresses are used in an internet employing the TCP/IP protocols: physical, logical , port and Specific addresses



Specific adresses:

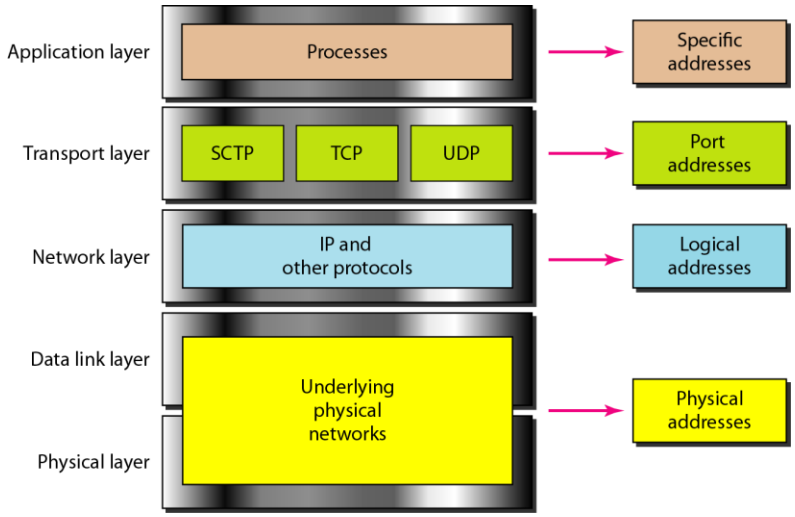
examples:

e-mail addresses (gihanagib @yahoo.com) to define the recipient of an e-mail

URL addresses (www. Mhhe.com) to find a document on the world wide web

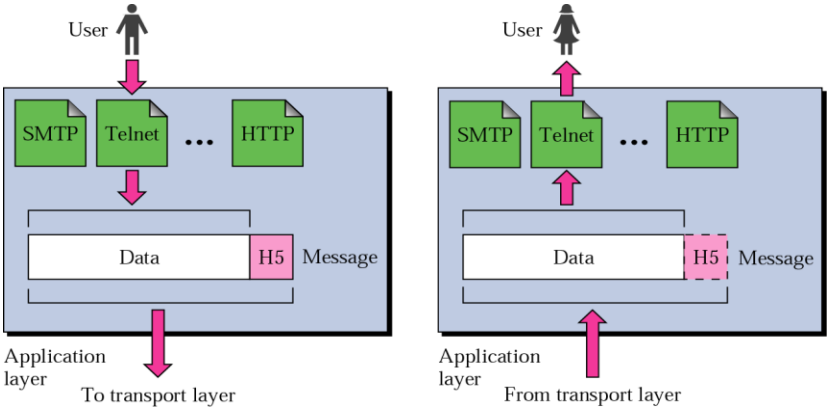
The addresses get changed to the corresponding port and logical addresses by the sending computer

Relationship of layers and addresses in TCP/IP



Application layer

The application layer enables the user to access the network



Note:

The application layer is responsible for providing services to the user such as

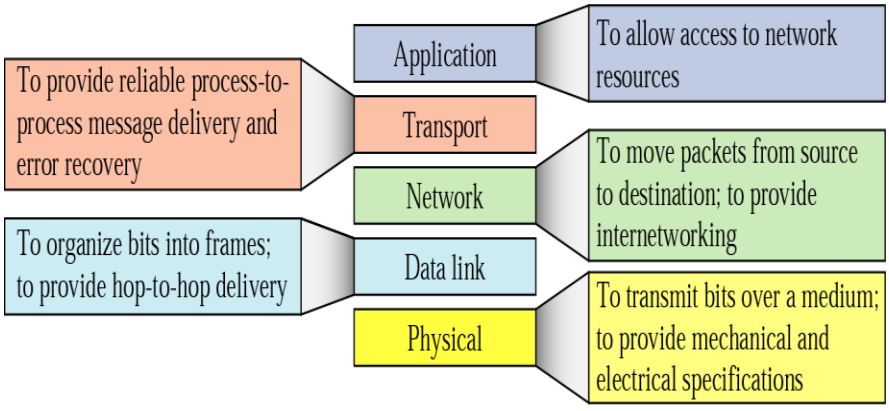
Mail services
File transfer and access
Remote log-in
Accessing the web (WWW)

•Telnet: A service that enables users on the internet to log onto remote systems from their own host system.

•HTTP: Hyper text transfer protocol used for network file transfers in WWW environment

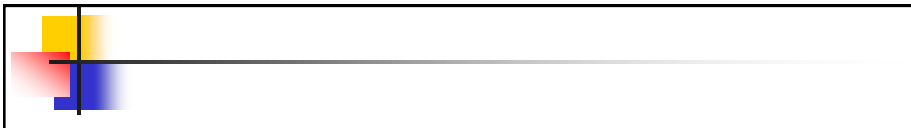
•SMTP: Simple mail transfer protocol used to send electronic mail on the internet.

Summary of duties



THE OSI MODEL

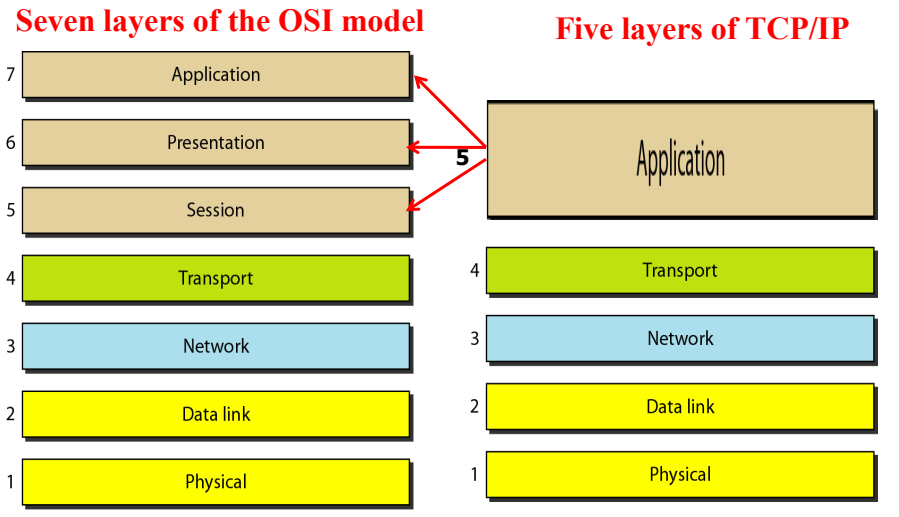
Established in 1947, the International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards. An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model. It was first introduced in the late 1970s.



Note

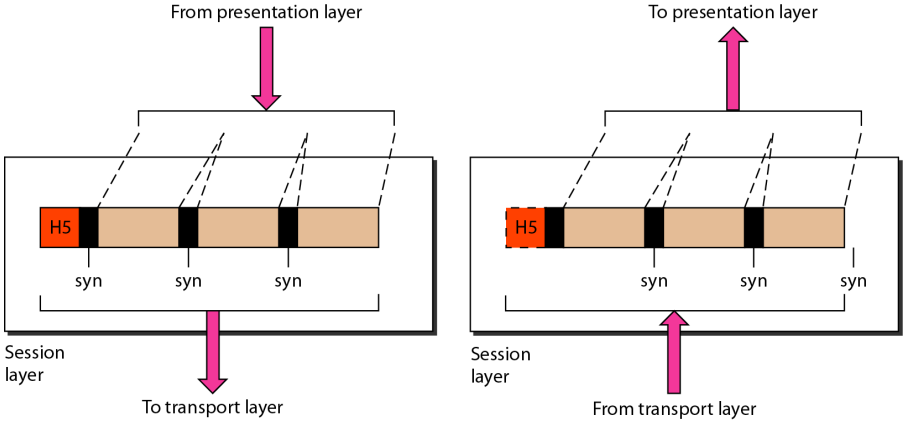
ISO is the organization.
OSI is the model.

OSI and TCP/IP network models



The session layer

The session layer is responsible for dialog control and synchronization



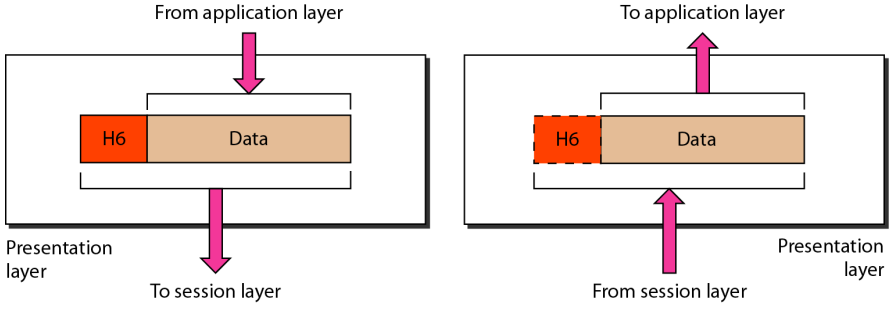
Duties of Session layer

1. **Dialog control:**
   Allows two systems to enter into dialog. It allows communication between two processes in either half or full duplex.

2. **Synchronization (Recovery)**
   Allow a process to add **check points (Synchronization point)** into a stream of data . So that if a failure of some sort occurs between checkpoints, the layer can retransmit all data since the last checkpoint.

Presentation layer

The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems



Note

The presentation layer is responsible for translation, compression, and encryption.

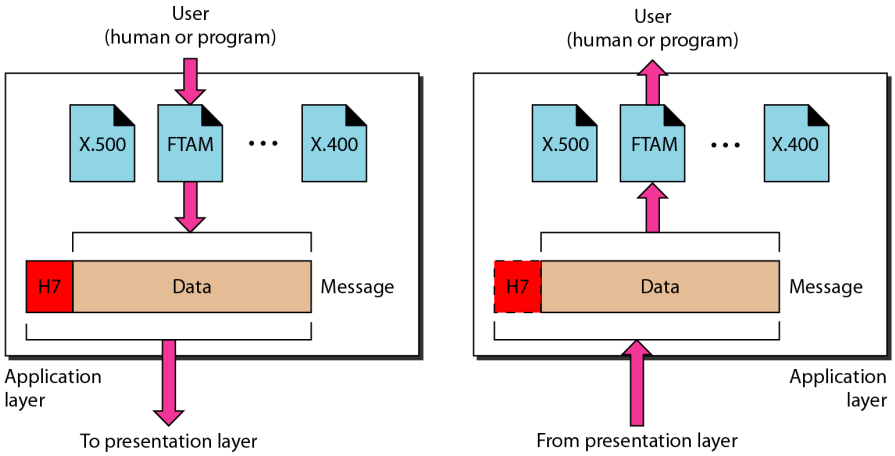
Duties of presentation layer

1. **Translation**
   At the sender it changes the information from its sender – dependent format into common format. At receiving, changes the common format into its receiver-dependent format

2. **Encryption-Decryption**
   To ensure privacy and security

3. **Compression**
   Data compression reduces the number of bits contained in the information. It is important in the transmission of multimedia such as audio or video

Application layer



Note

The application layer is responsible for providing services to the user.

OSI Model

	Layer	Data Unit	Function
User support layer	Application	DATA	Access to Network Resources
	Presentation		Data representation: translate compress and encryption
	Session		Controls the dialogues , Establishes, manages and terminates the connections between the local and remote application
Link	Transport	Segment	End-to-end connections and reliability
Network support layer	Network	Datagram/Packet	Path determination (Routing) and logical Addressing
	Data link	Frame	Hop to Hop delivery and Physical addressing
	Physical	Bit	Media, signal and binary transmission,…

Summary of layers