CSE 401

# Computer Networks

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**Books**

Computer Networks (5th Edition)
Andrew S. Tanenbaum

Data Communications and Networking (5th Edition)
Behrouz A. Forouzan

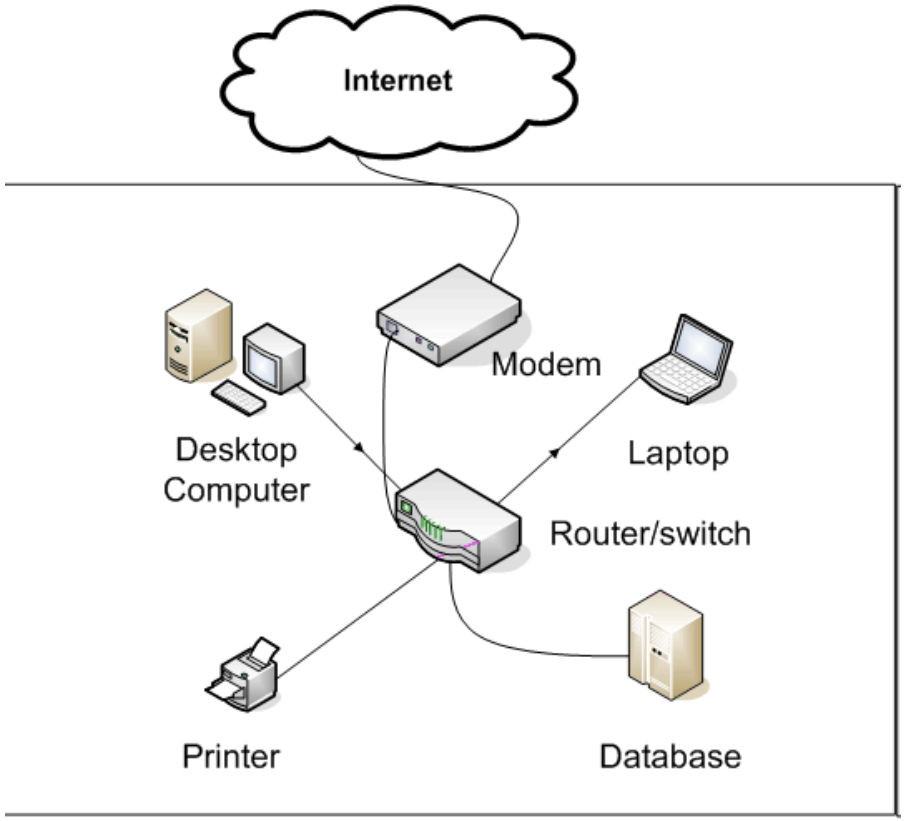
Data And Computer Communications
William Stallings

# Computer Networks

- ✓ The old model of a single computer serving all of the organization's computational needs has been replaced by one in which a large number of separate but interconnected computers do the job.

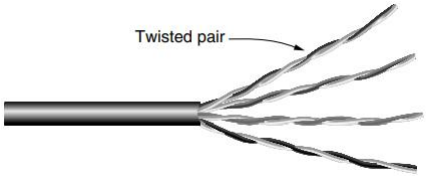
- ✓ A **computer network** is a set of connected computers (called node) for the purpose of communicating data electronically or to share resources.

# Components of Computer Network

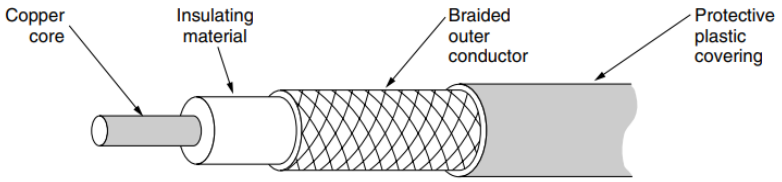



PC (Basically is a personal computer), NIC (Network Interface Card), Hub , Switch , Router, Connectors, Modems, OLTE, and physical transmission medium (wired or wireless).

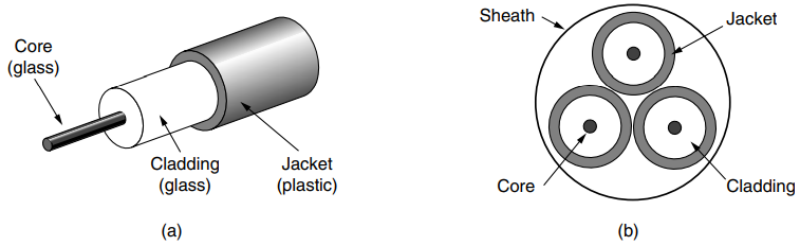
# Physical Transmission Medium



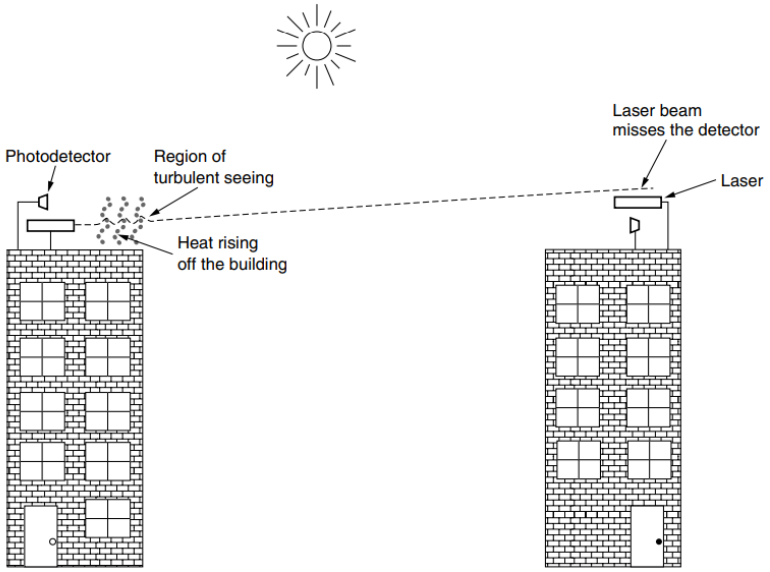

Unshielded Twisted Pair



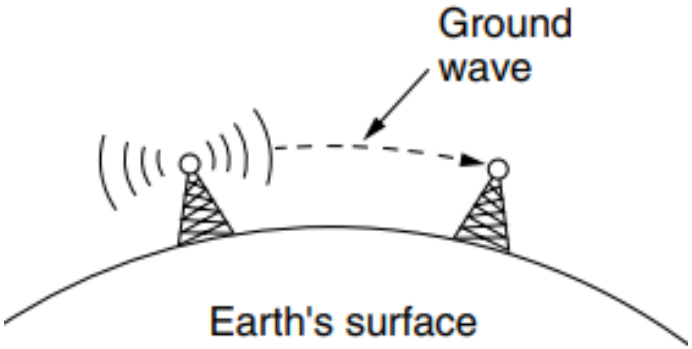

**Coaxial Cable**




Optical fibre

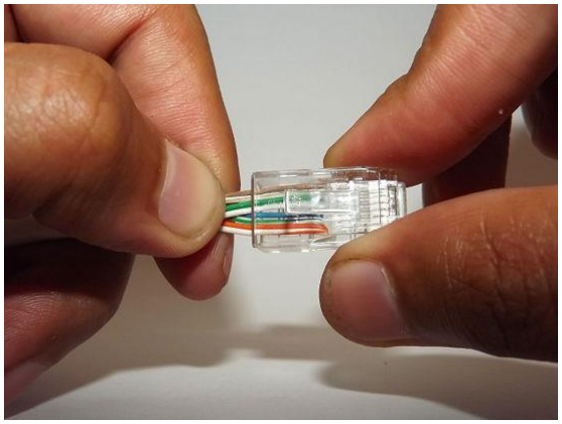



**laser communication systems**




Wireless Communication

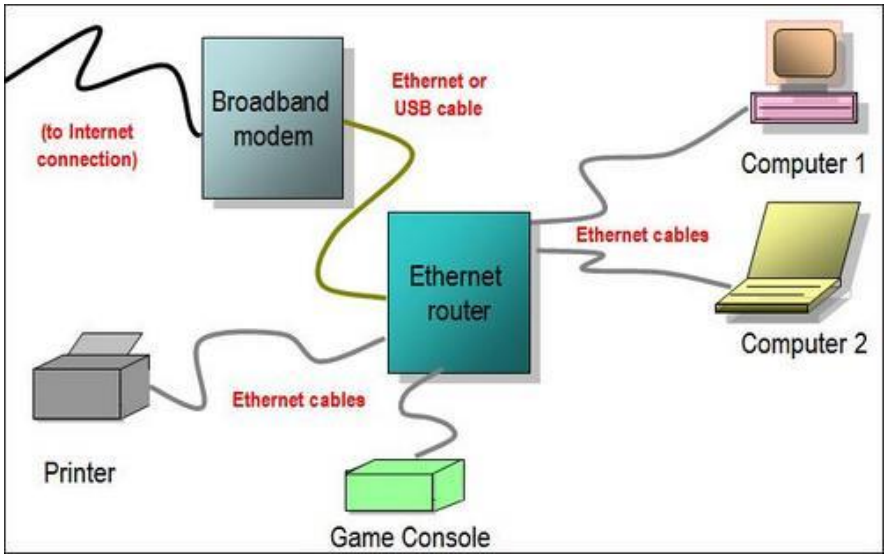
BNC
Connector



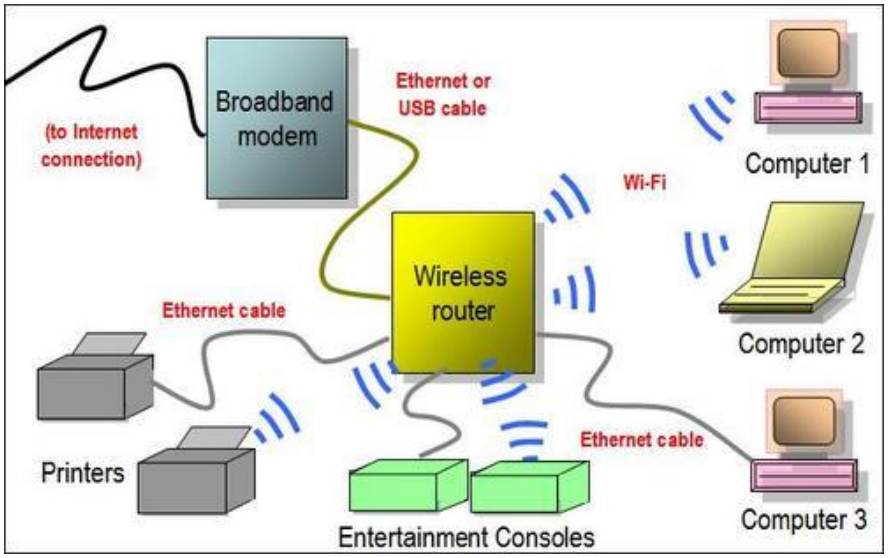
RJ45
Connector

Modem

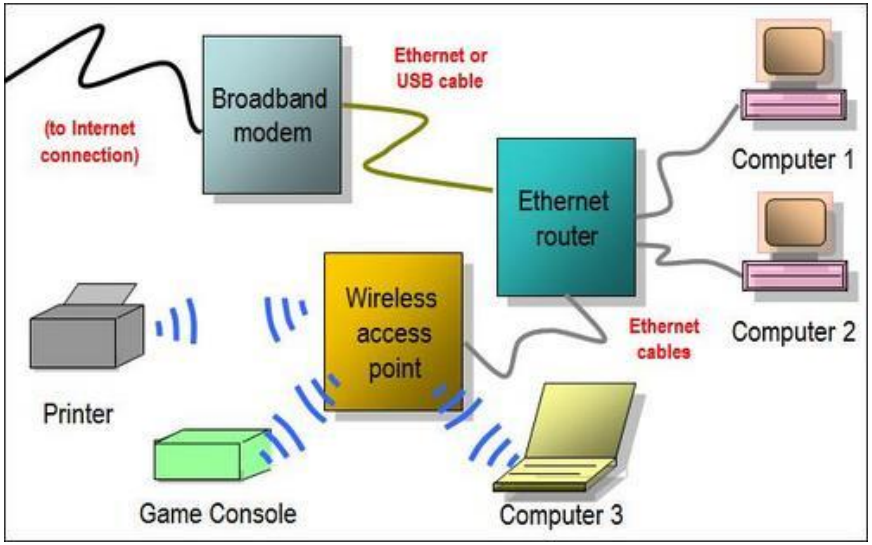
OLTE




Wired Network

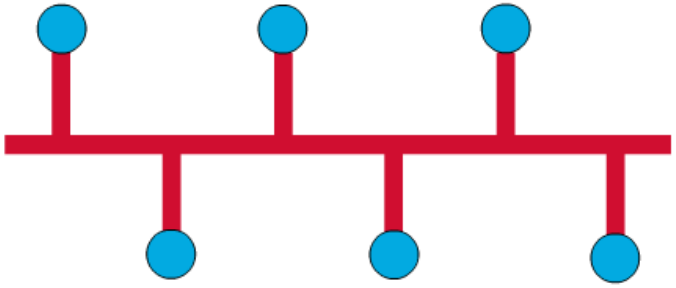



Wireless Network

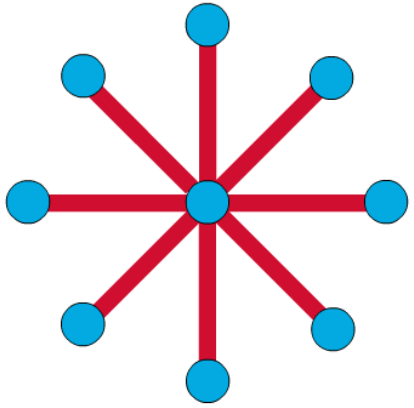



Hybrid Network

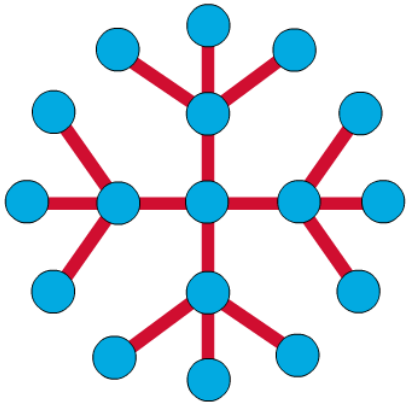
The **network topology** defines the way in which computers, printers, and other devices are connected.



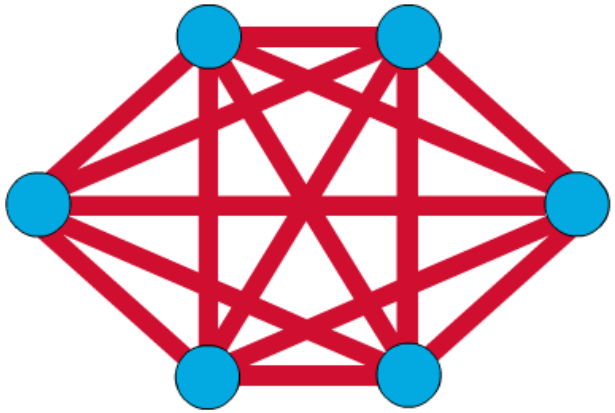
Commonly referred to as a linear bus, all the devices on a bus topology are connected by one single cable.



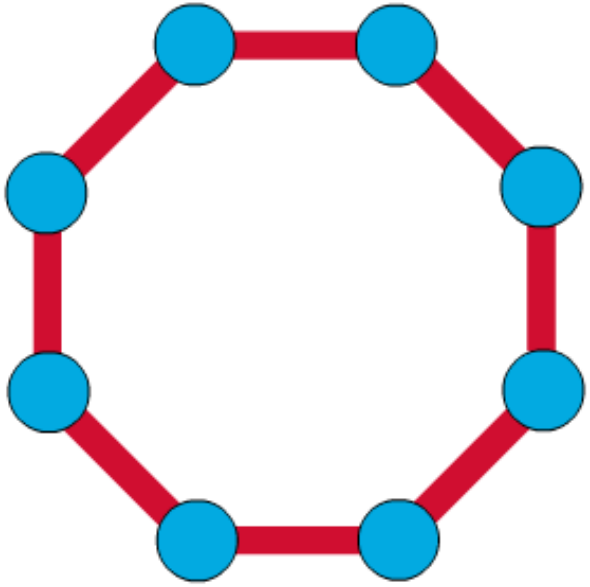
The star topology resembles spokes in a bicycle wheel



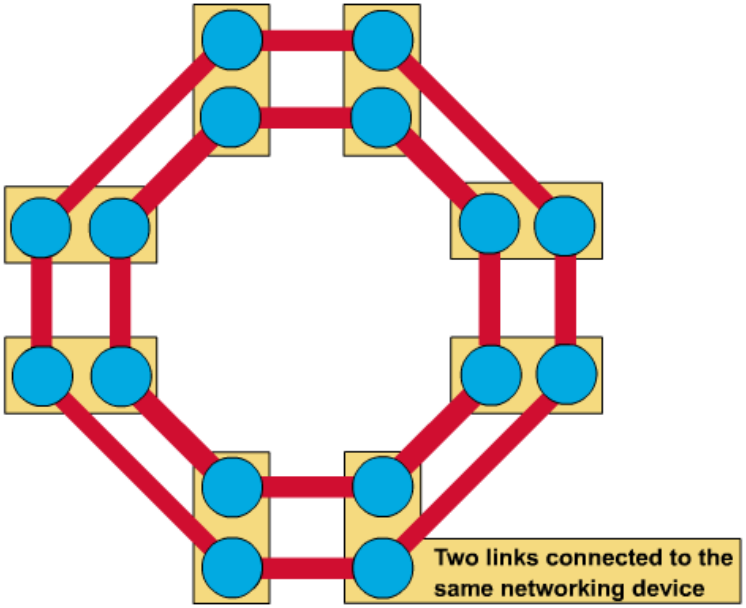
Larger networks use the extended star topology also called tree topology.



The mesh topology connects all devices (nodes) to each other



A frame travels around the ring, stopping at each node (ring topology).



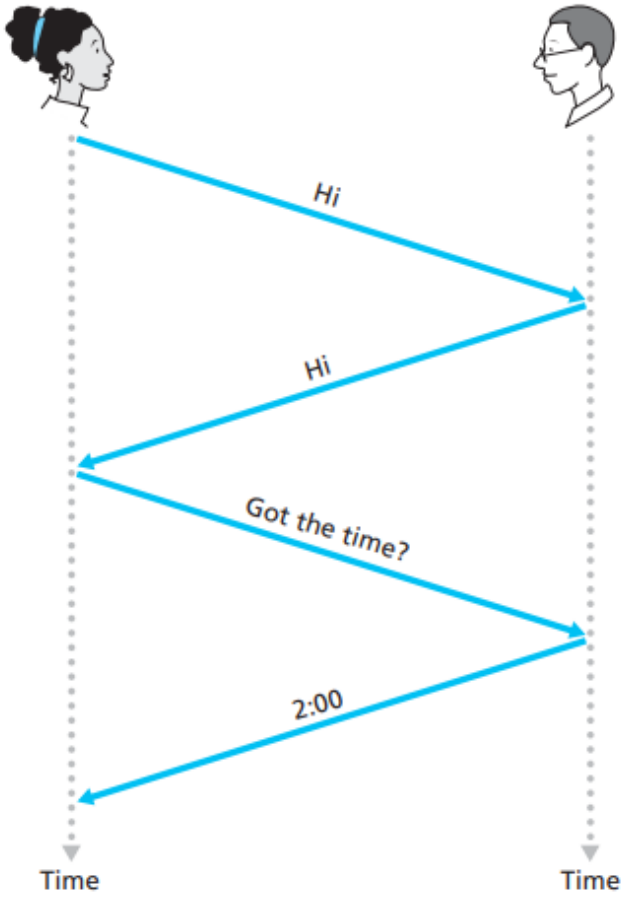

The dual ring topology allows data to be sent in both directions.

# Protocol Hierarchies

✓In computer communication **protocol** defines the rules that both the sender and receiver and all inter connected devices need to follow to be able to communicate effectively.

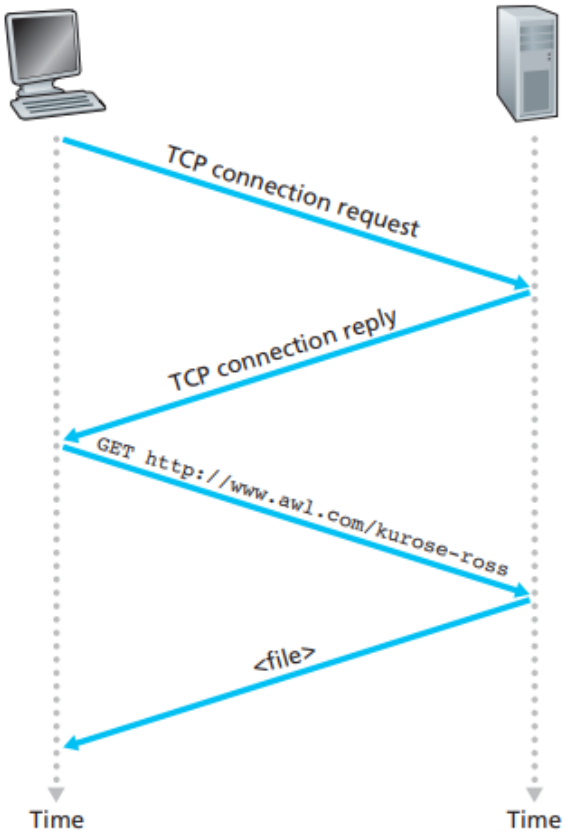
✓A protocol is an agreement between the communicating parties on how communication is to proceed.

✓It is probably easiest to understand the notion of a computer network protocol by first considering some human analogies, since we humans execute protocols all of the time like Figure below.




A human protocol

- ✓ When you make a request to a Web server, then you type the URL of a Web page into your Web browser.
- ✓ First, your computer will send a connection request message to the Web server and wait for a reply. The Web server will eventually receive your connection request message and return a connection reply message.
- ✓ Knowing that it is now OK to request the Web document, your computer then sends the name of the Web page it wants to fetch from that Web server in a GET message.
- ✓ Finally, the Web server returns the Web page (file) to your computer.




A computer network protocol

✓When communication is simple we need only one simple protocol but when communication is complex we need to divide the entire tasks among different layers, where we need a protocol at each layer or protocol layering or protocol stack.

✓To reduce design complexity, most networks are organized as a stack of layers or levels. For example, each of the seven layers of the OSI model hides the implementation details of the lower layers from the upper layers.

✓In a sense each layer is a kind of virtual machine offering certain services to layer above or below it.

# Example-1

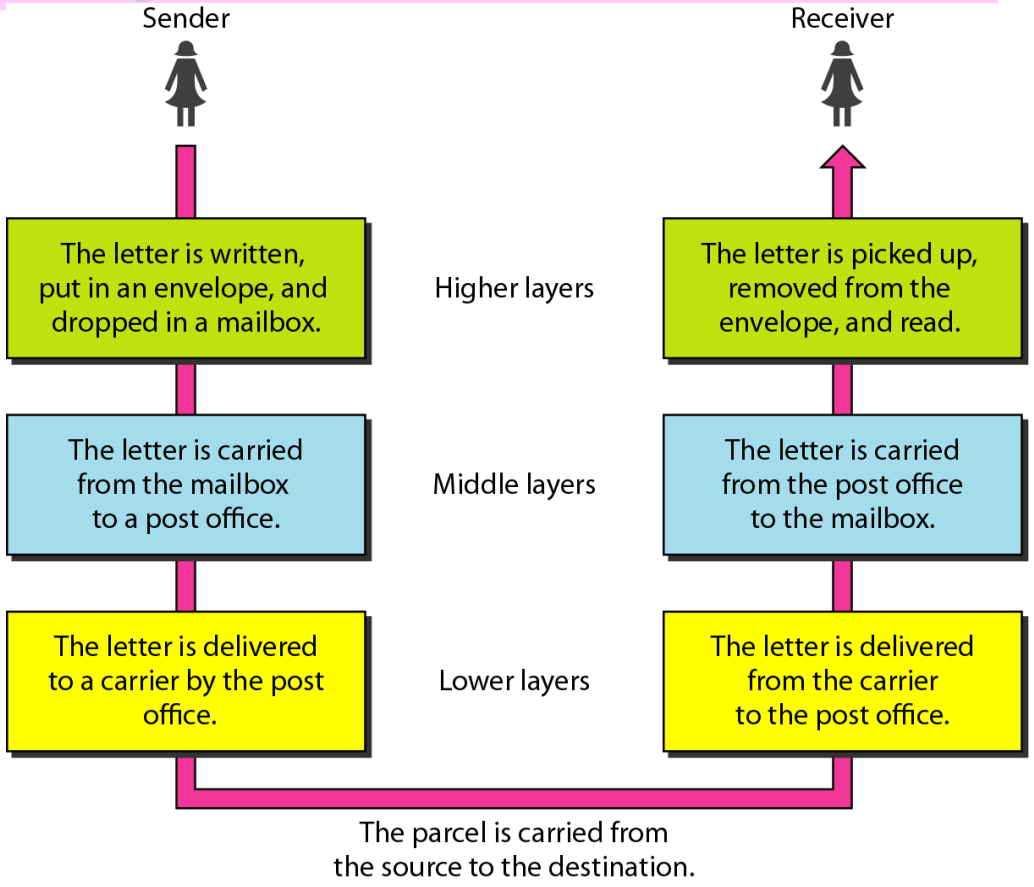
We use the concept of layers in our daily life. As an example, let us consider two friends who communicate through postal mail. The process of sending a letter to a friend would be complex if there were no services available from the post office.

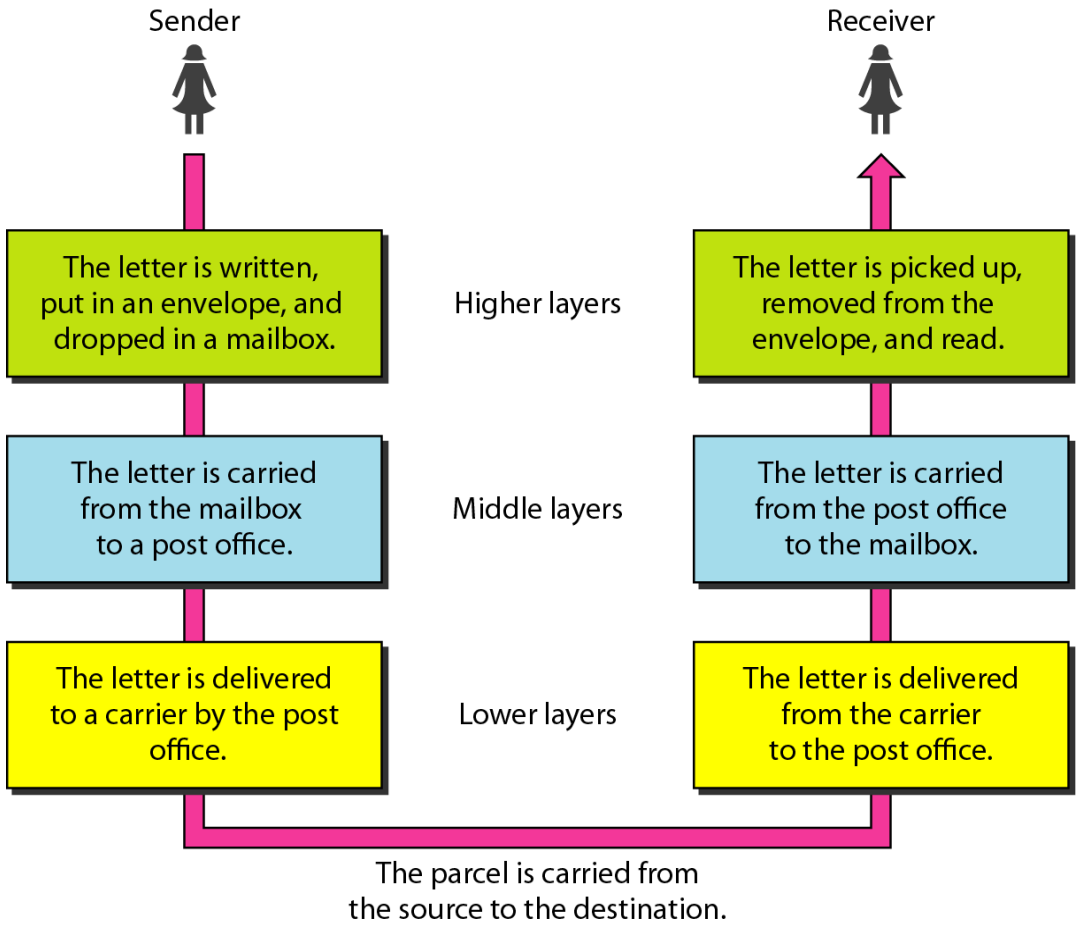
**Sender Side**

**Higher layer:** The sender writes the letter, inserts in an envelope, writes the sender and receiver addresses, and drops in a mailbox.

**Middle layer:** The letter is picked up by a letter carrier and delivered to the post office.

**Lower layer:** The letter is sorted at the post office and deliver to the carrier transports.






## Receiving Side

**Lower layer:** The carrier transports the letter to the post office.

**Middle layer:** The letter is sorted and delivered to the recipient's mailbox.

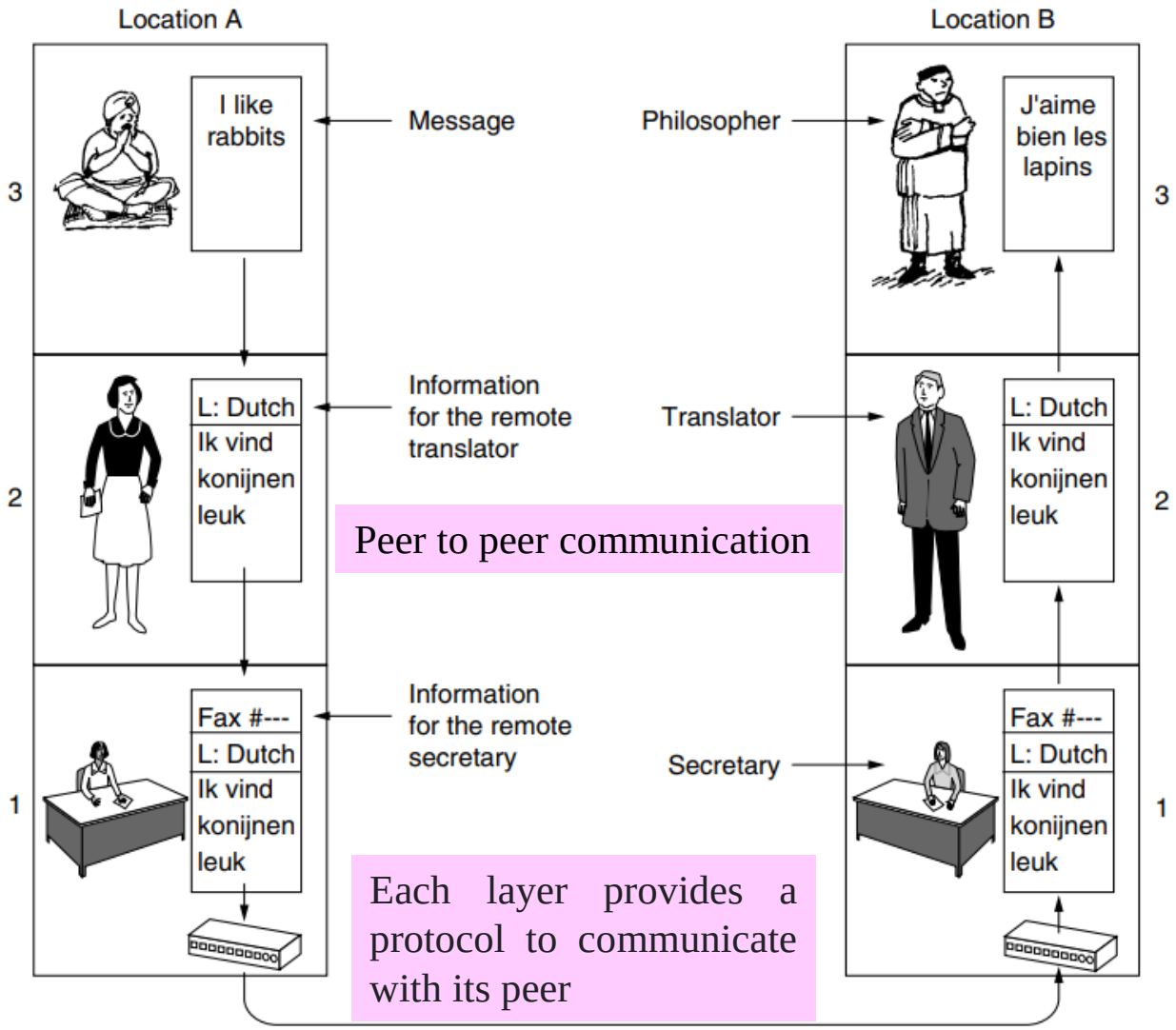
**Higher layer:** The receiver picks up the letter, opens the envelope, and reads it

**Fig.1 Tasks involved in sending a letter**

# Example-2

An analogy may help explain the idea of multilayer communication.

**Urdu** and **English**




**Chinese** and **French**

Fig.2 The philosopher-translator-secretary architecture

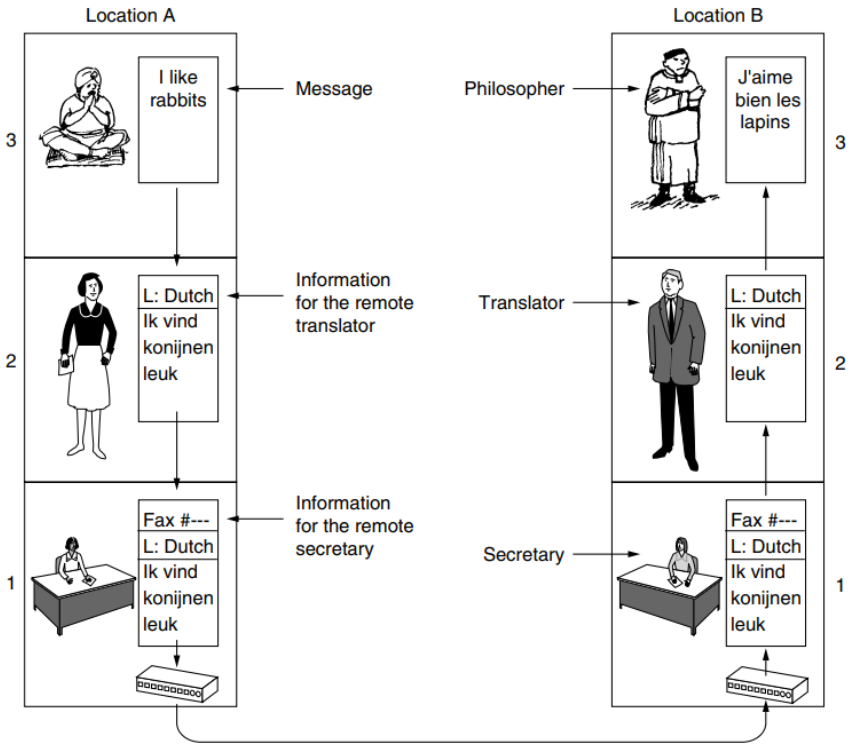
✓Imagine two philosophers (peer processes in layer 3), one of whom speaks Urdu and English and one of whom speaks Chinese and French.

✓Since they have no common language, they each engage a translator (peer processes at layer 2), each of whom in turn contacts a secretary (peer processes in layer 1).

✓Philosopher -1 passes a message (in English) across the 2/3 interface to his translator, saying "I like rabbits," as illustrated in the Fig.

**Urdu** and **English**

**Chinese** and **French**



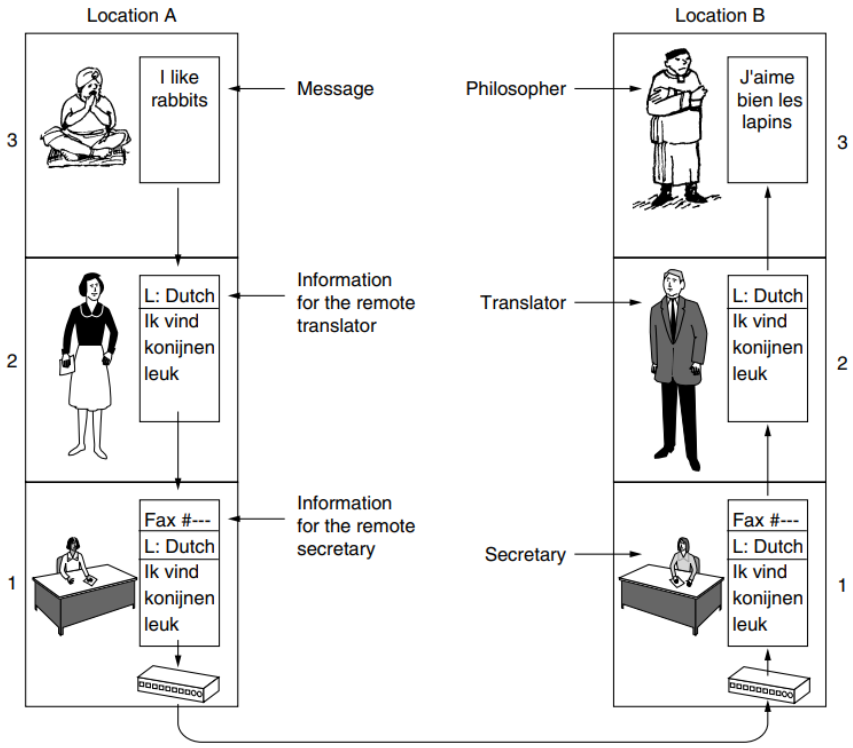
✓The translators have agreed on a neutral language known to both of them, Dutch, so the message is converted to "Ik vind konijnen leuk". The choice of language is the layer 2 protocol and is up to the layer 2 peer processes.

✓The translator then gives the message to a secretary for transmission, by, for example, fax (the layer 1 protocol).

✓When the message arrives, it is delivered to the translator at layer 2. The translator then translate it into French and passed across the 2/3 interface to philosopher 2.

**Urdu** and **English**

**Chinese** and **French**

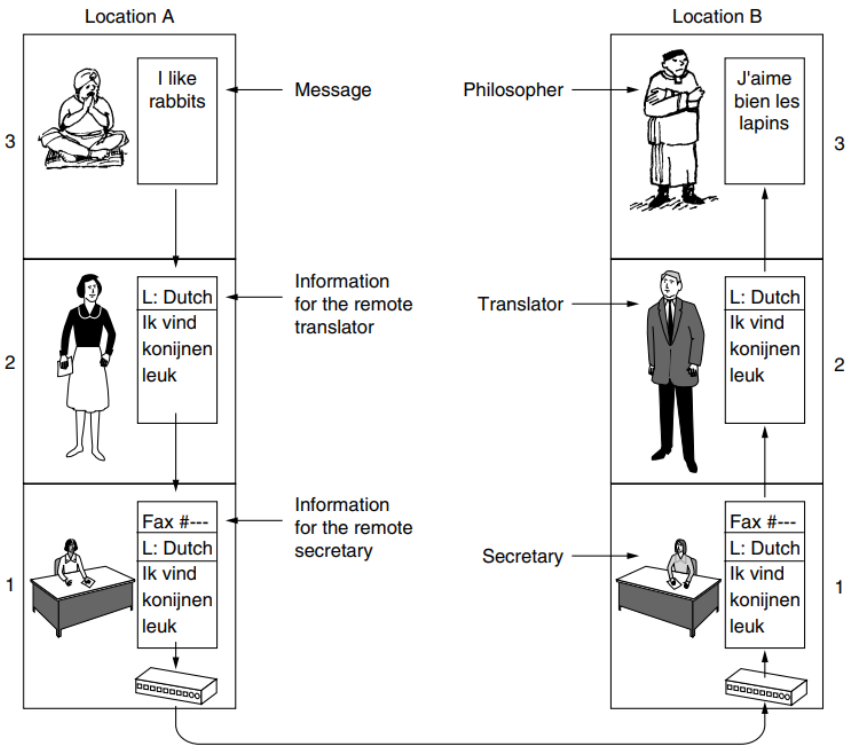


✓Note that each protocol is completely independent of the other ones as long as the interfaces are not changed. The translators can switch from Dutch to say, Finnish, at will, provided that they both agree, and neither changes his interface with either layer 1 or layer 3.

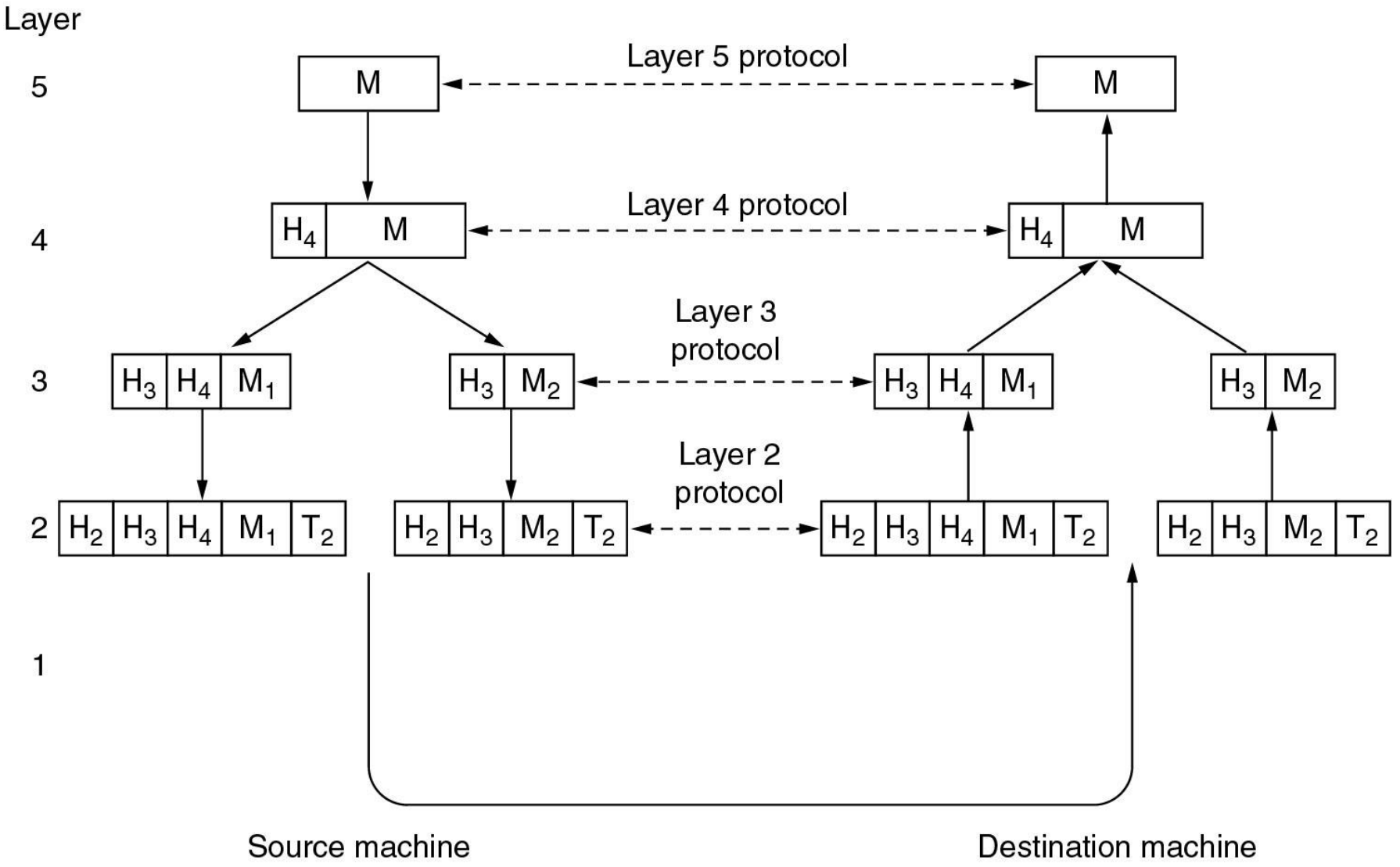
✓Similarly, the secretaries can switch from fax to e-mail or telephone without disturbing (or even informing) the other layers. Each process may add some information intended only for its peer. This information is not passed upward to the layer above.

**Urdu** and **English**

**Chinese** and **French**



# Example information flow supporting virtual communication in layer 5



# Layers of networks deals with:

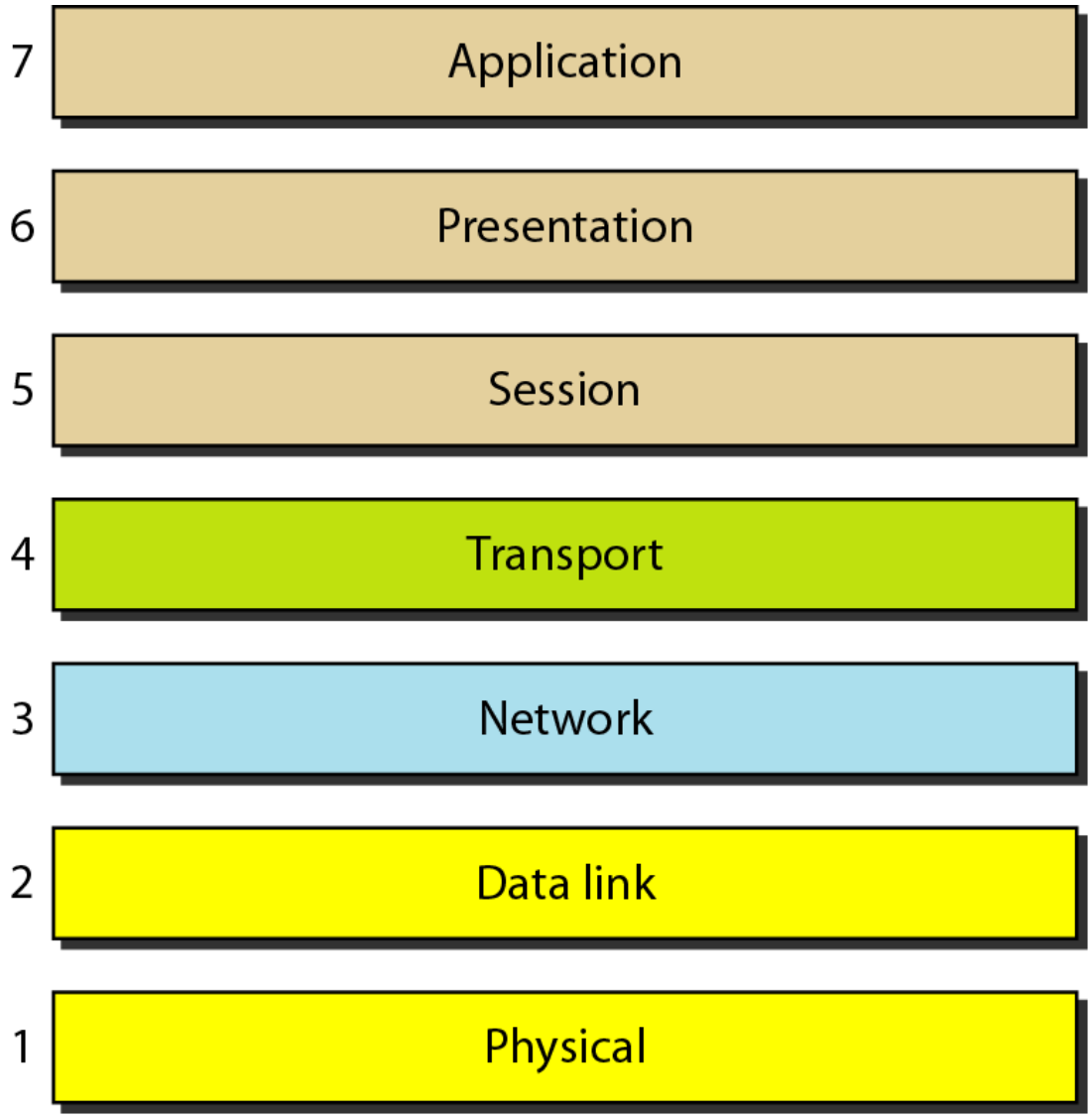
- Formation of pulse of raw data and modulation
- Multiplexing/De-multiplexing
- Addressing
- Error control
- Flow control
- Routing
- Data encoding for compression
- Data encryption etc.

# The OSI Reference Model

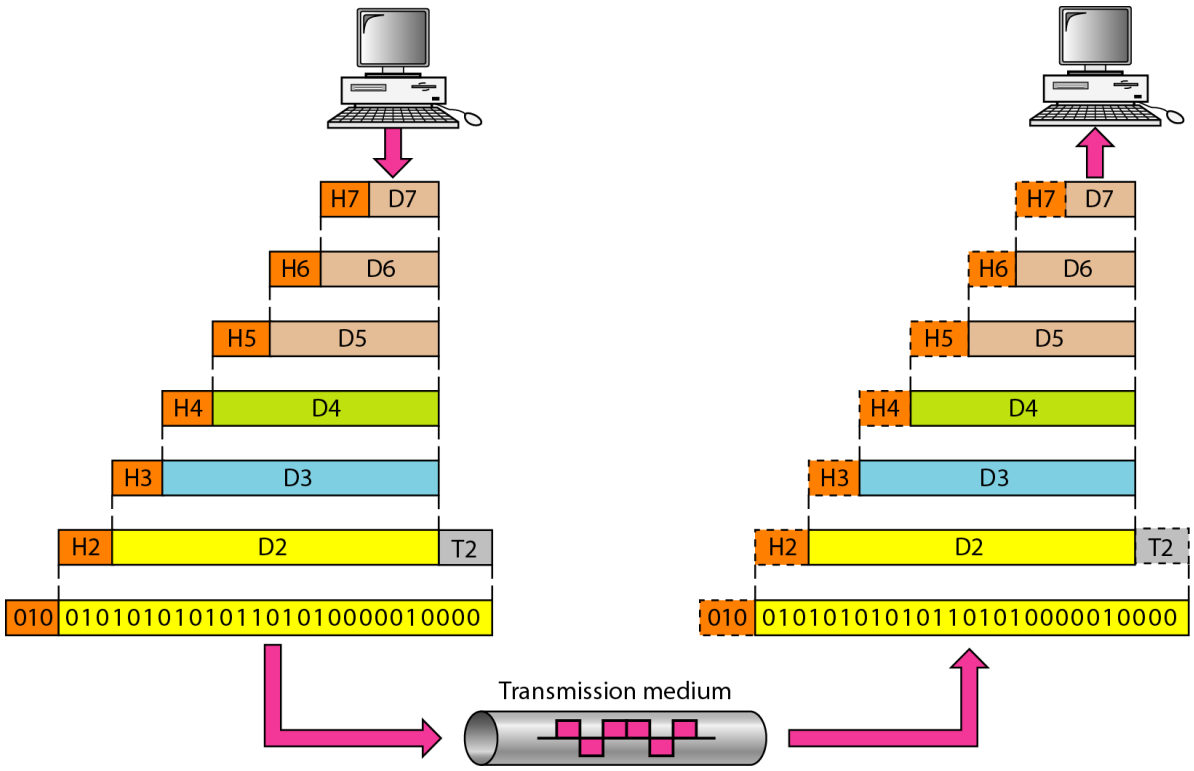
This model is based on a proposal developed by the international standard organization (ISO) as a first step toward international standardization of the protocols used in the various layers (1983).

It was revised in 1995 and the model become OSI (Open System interconnection) **Reference Model** because it deals with connecting open systems-that, systems that are open for communication with other systems.

# Seven layers of the OSI model

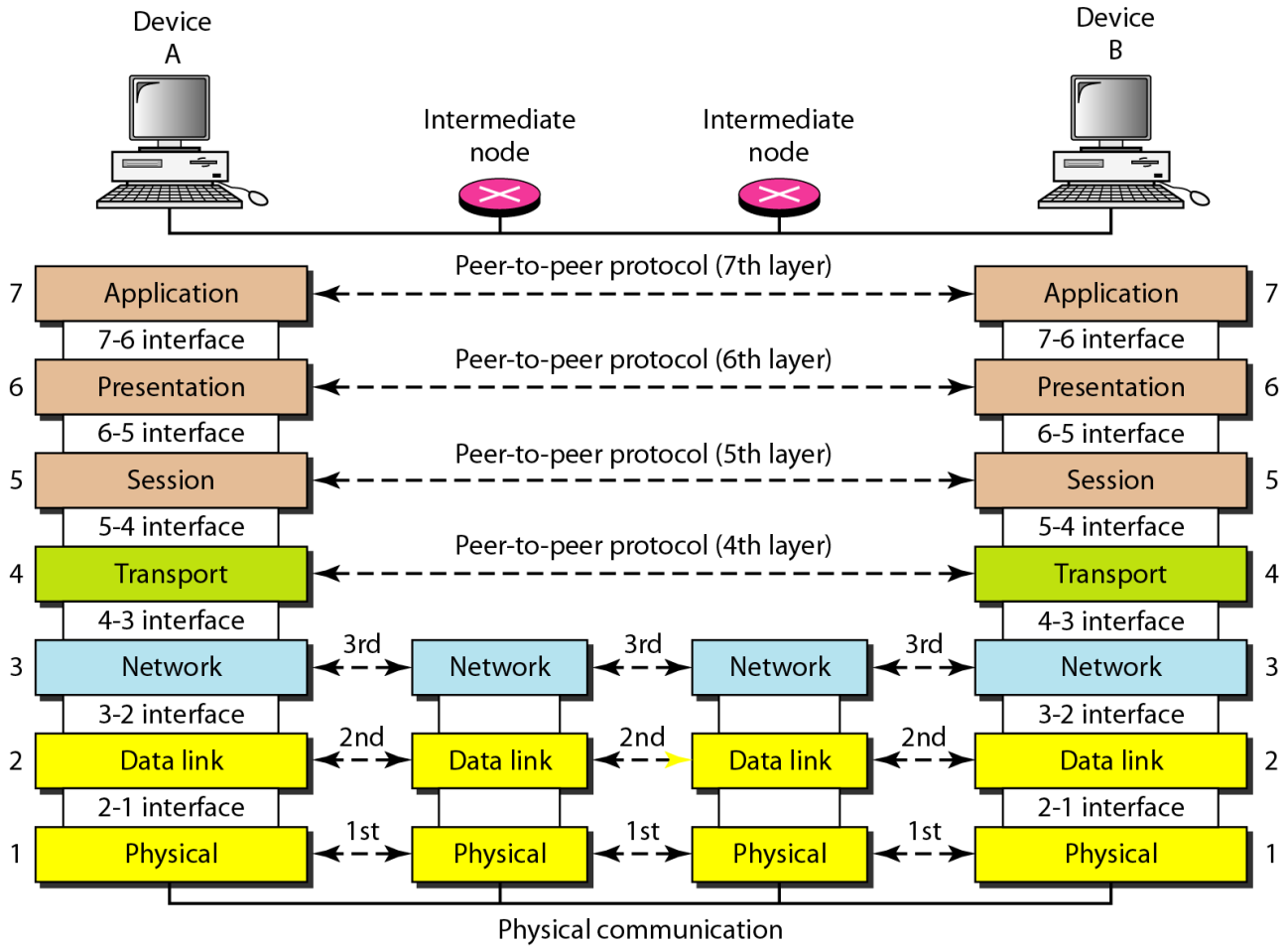


# An exchange using the OSI model

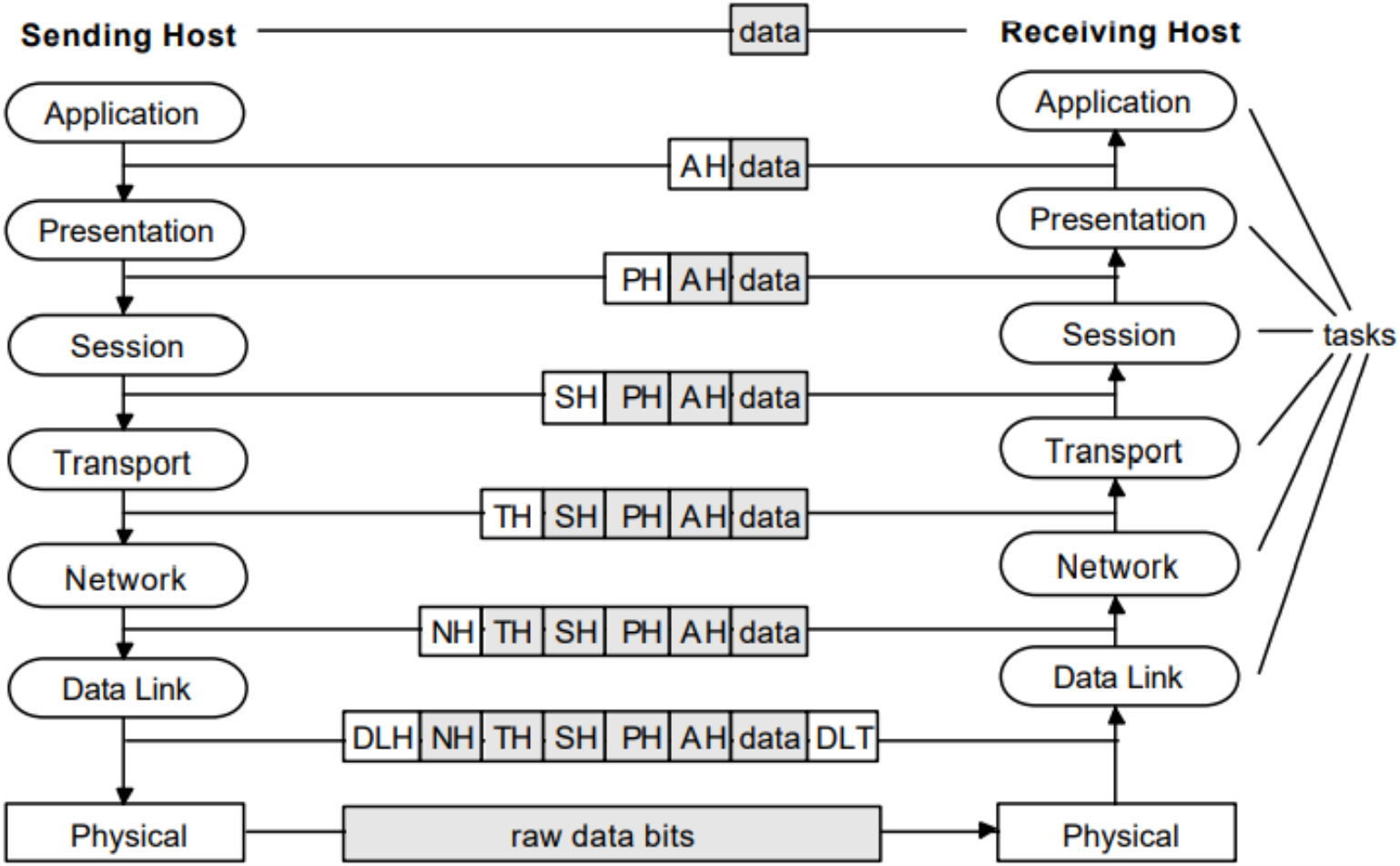



- ✓ Each layer in the sending device adds its own information to the message it receives from the layer just above it and passes the whole package to the layer just below it.
- ✓ At the receiving machine, the message is unwrapped layer by layer. For example, layer 2 removes the data meant for it, then passes the rest to layer 3. Layer 3 then removes the data meant for it and passes the rest to layer 4, and so on

# The interaction between layers in the OSI model




Although actual communication takes place only at the physical layer, it is often useful to think of virtual communication between corresponding layers. For example, we can use an imaginary line of communication between the presentation layer on host A and the same layer on host B. This would be characterized by the presentation protocol




Each layer at transmitting end performs a tasks by adding an additional piece of information to the message (called header) and the same layer removes the additional piece of information on the receiving end.

# Physical Layer

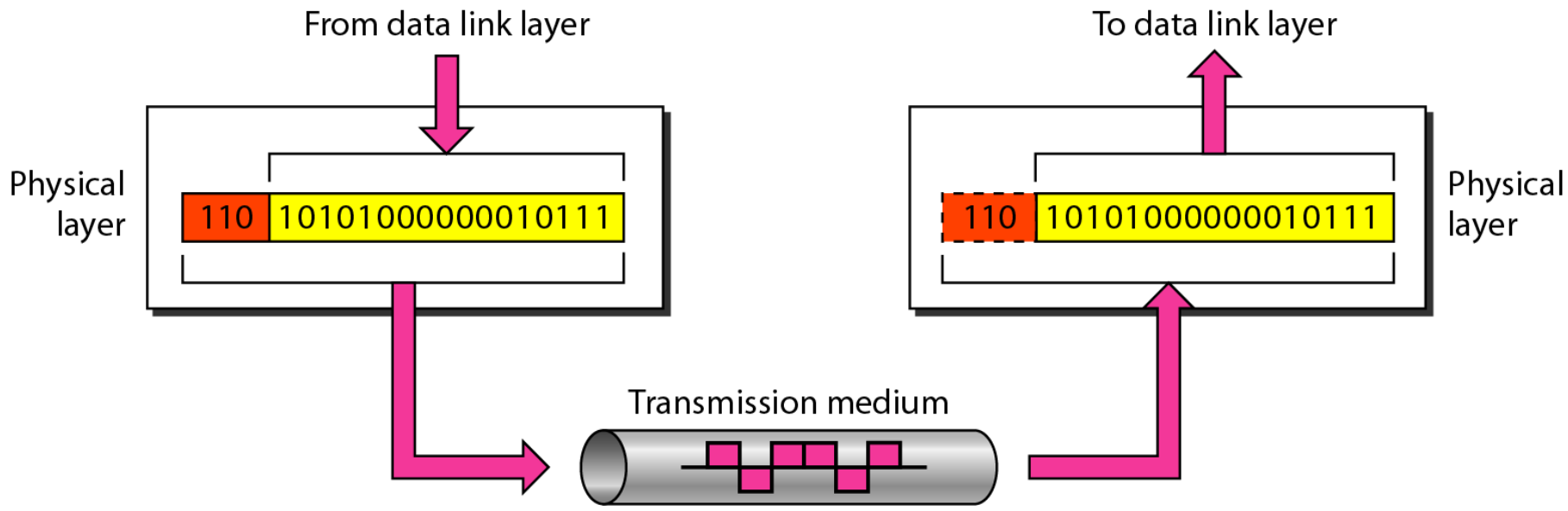
❖The physical layer is concerned with the transmission of raw data bits over communication lines.

❖The physical form (e.g., voltages, frequencies, timing) in which data bits (binary values 0 and 1) are represented. Actually it deals with shape of raw digital pulse i.e. types of **line coding**.

❖The type of modulation (ASK, FSK, PSK, QPSK, 16-QAM etc.) to be used for transmitting digital data over analog transmission lines.

❖Interface to a transmission medium for example connector (RJ 45, BNC), MODEM/OLTE but not the physical transmission medium.

# Physical layer




- ✓ The physical layer also defines the direction of transmission between two devices: simplex, half-duplex, or full-duplex.
- ✓ In simplex mode, only one device can send; the other can only receive. The simplex mode is a one-way communication. In the half-duplex mode, two devices can send and receive, but not at the same time. In a full-duplex (or simply duplex) mode, two devices can send and receive at the same time.

# Data link layer

Data link layer is divided into two sublayer: Logical Link Control (LLC) and Medium Access Control (MAC)

## Basic functions of LLC

✓In data link layer the sender breakup the input data into frames (typically few hundred or few thousand bytes) and transmits the frame sequentially.

✓Frames are constructed from data string by adding special bit patterns to the beginning and end of each segment. This allows the receiving end to detect where each frame begins and where it ends.

✓**Error detection:** Some form of error check is included in the frame header. This is constructed by the 'transmitting end' based on the contents of the frame, and checked by the receiving end.

✓When a frame arrives and is corrupted or is lost for any reason in the network, it is retransmitted. The receiver confirms correct receipt of each frame by sending back an acknowledgement frame.

**Error correction:** In case of multimedia traffic (image, video, voice etc.) the receiver corrects the frame used some complex algorithm like convolutional encoding, Linear block code, R-S code etc.

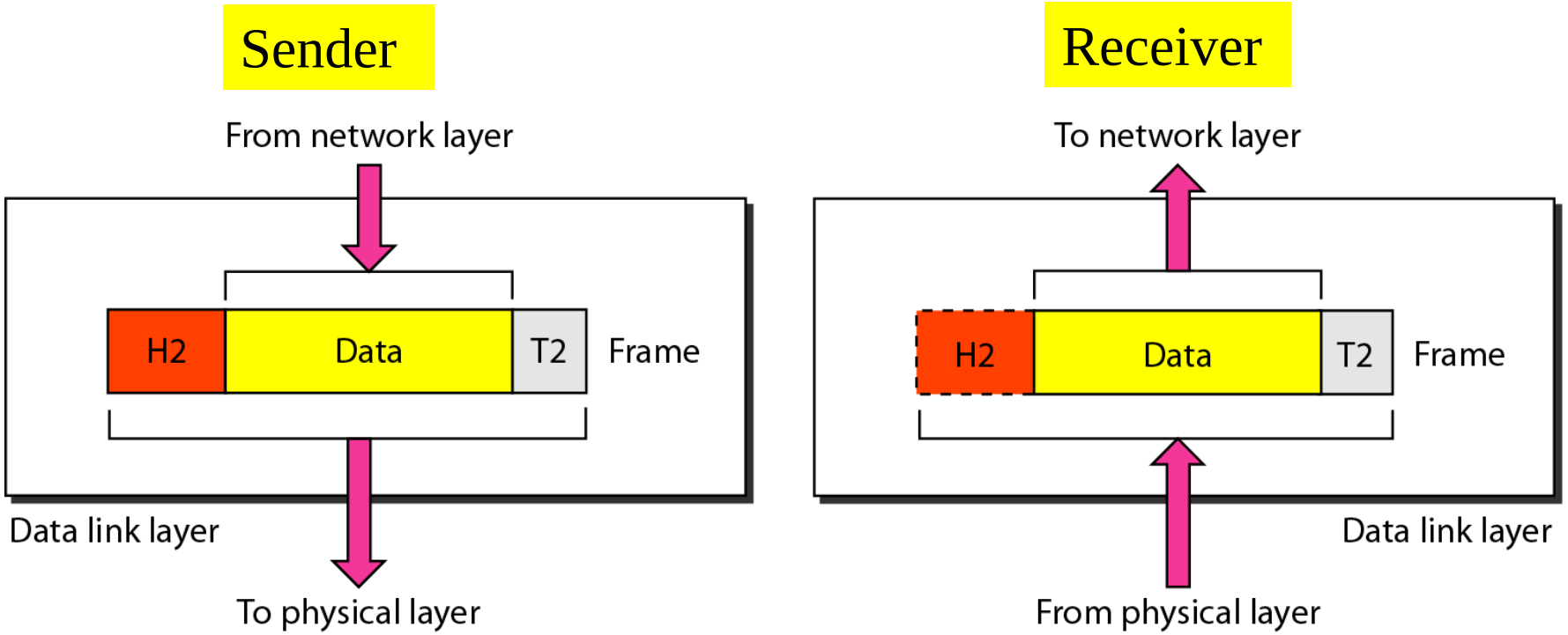
✓**Flow control:** In general, not all communication devices in a network operate at the same speed. Flow control provides a means of avoiding a slow receiver from being swamped by data from a fast transmitter using some buffer.

✓If sender fails to get ack (in case of noise) then the sender sends the same packet, therefore there will be duplication of packet at the receiver. The situation is tackled by this layer.

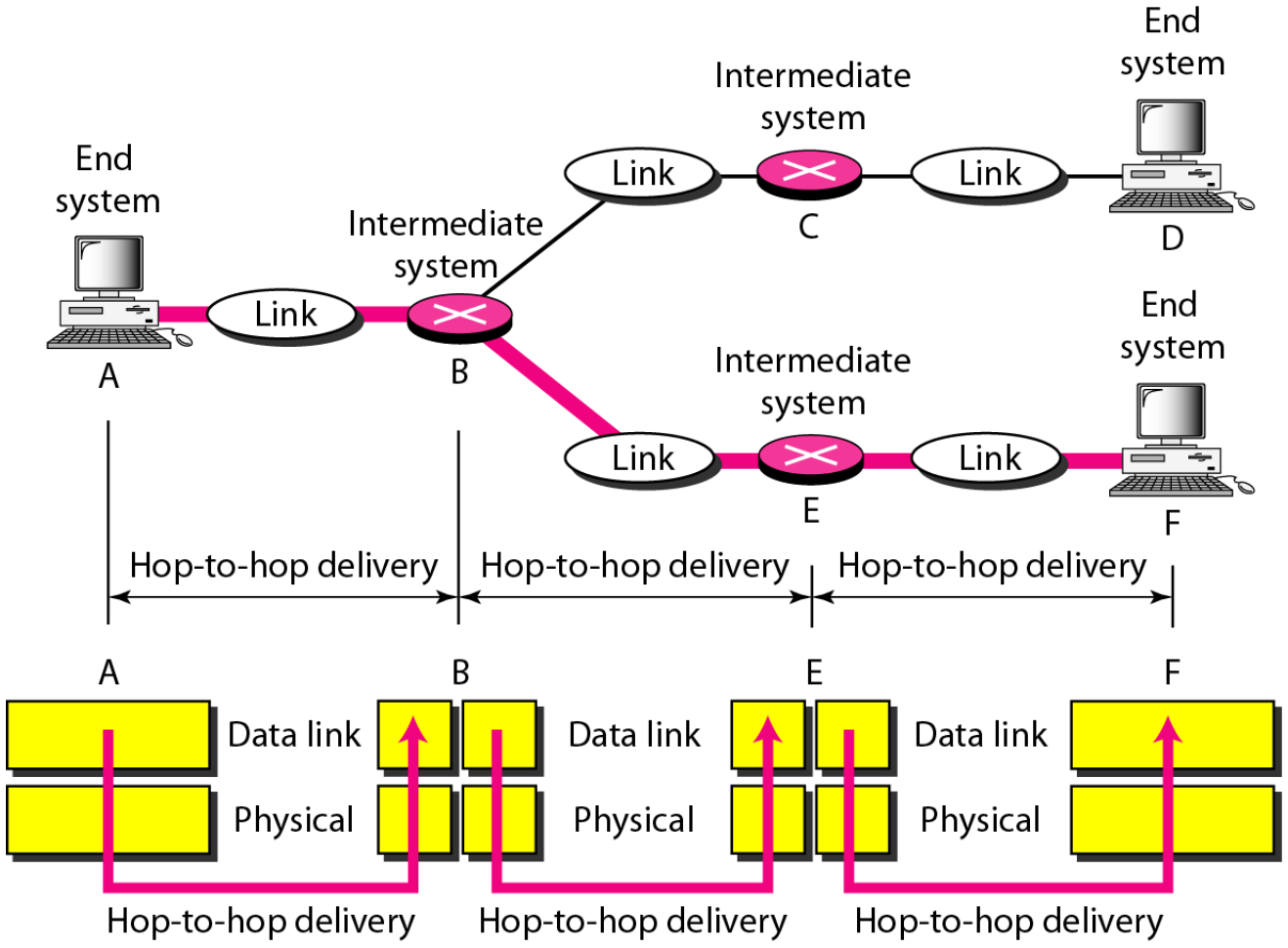
All the above jobs are done by LLC sub-layer.

✓Channel sharing among users are done at MAC sub-layer.

# Data link layer



# Hop-to-hop delivery of Data Link Layer



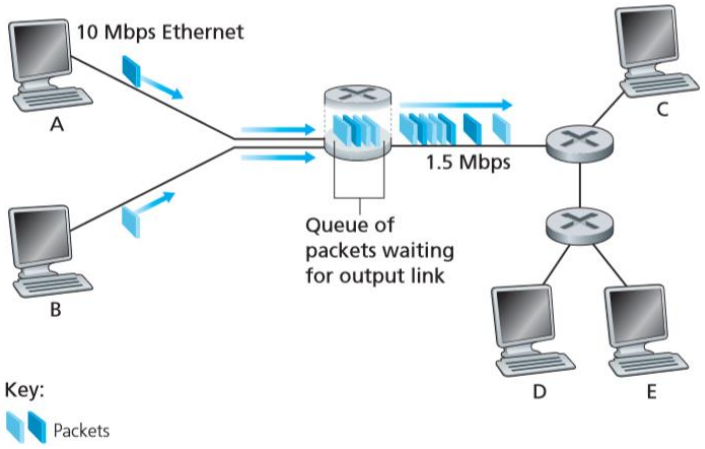
# The Network Layer

✓At this layer, the unit of data exchanged among nodes is typically called a *packet* rather than a frame, although they are fundamentally the same thing. The *network* layer handles routing of packets among nodes within a packet-switched network.

✓Routing of packet is done by routing table of router.

✓Correct ordering of packets to reflect the original order of data.

✓The control of 'traffic congestion' also belongs to the network layer.
✓The quality of service provided (delay, jitter etc.) is also network layer issue. Sum of delays is called latency.

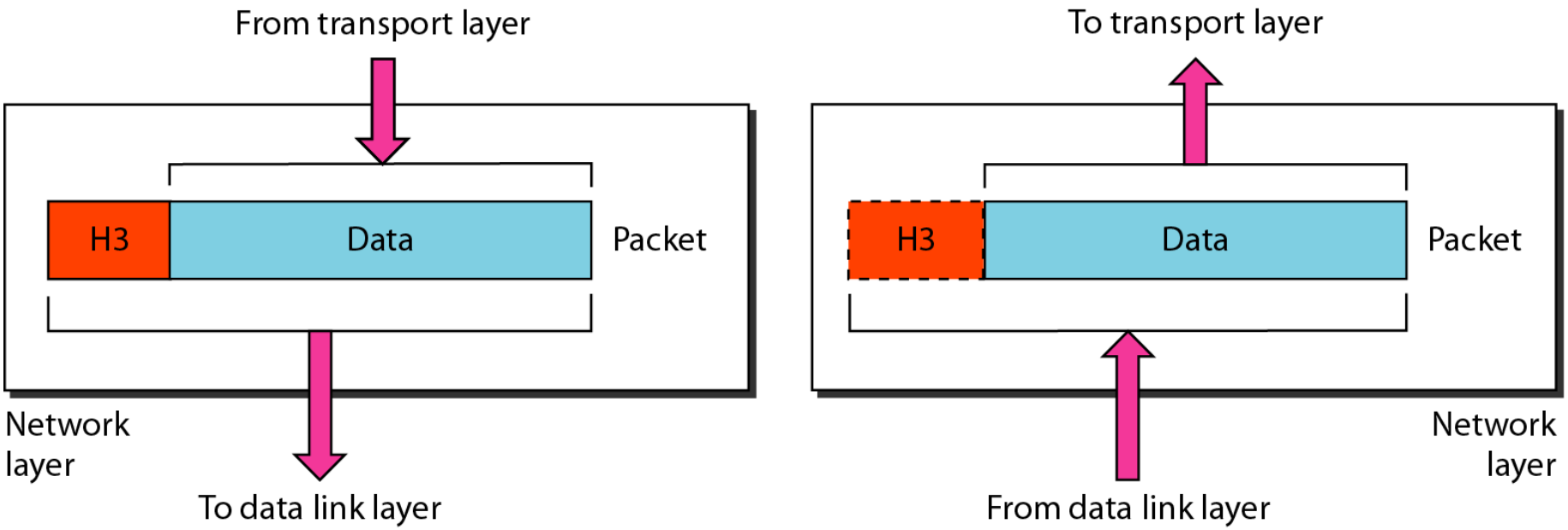


✓The *physical addressing* implemented by the data link layer handles the addressing problem locally. MAC Address ensure that physical address of the computer is unique.

✓If a packet passes the network boundary, we need another addressing system to help distinguish the source and destination systems (area wise addressing). IP Address is a ***logical address*** of the computer and is used to uniquely locate computer connected via a network.

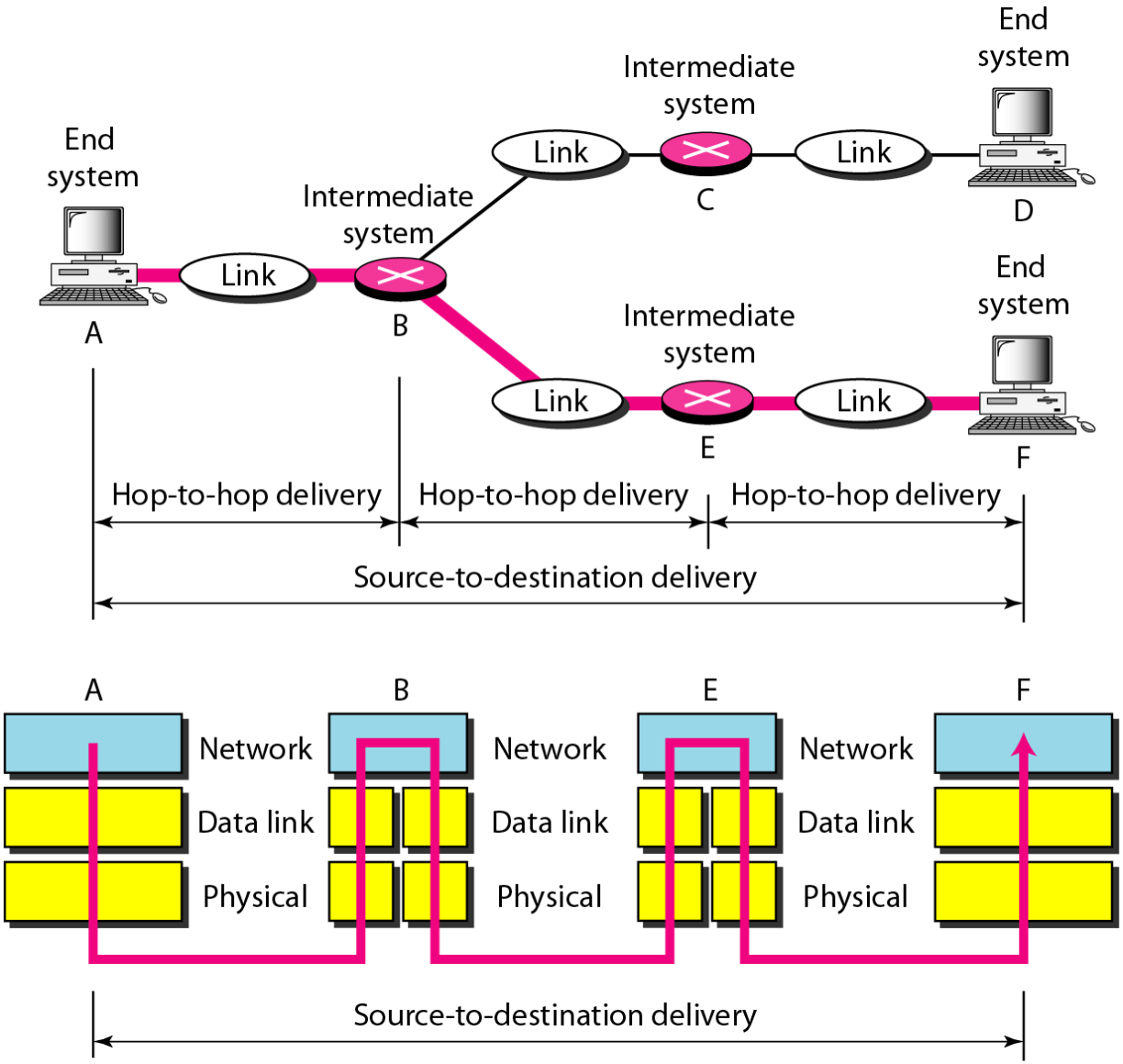
✓The network layer adds a header to the packet coming from the upper layer that, among other things, includes the *logical addresses* of the sender and receiver.

# Network layer



✓When a packet has to travel from one network to another to get its destination, many problems can arise. The addressing used by the second network may be different from that used by the first network. The second one may not accept the packet at all because it is too large. The protocol may differ and so on. It is up to the network layer to overcome all these problems to allow heterogeneous networks to be interconnected .

# Source-to-destination delivery



# The Transport Layer

✓Efficient and cost-effective delivery of data across the network from one host to another. The transport layer and higher layers typically run only on the end hosts and not on the intermediate switches or routers.

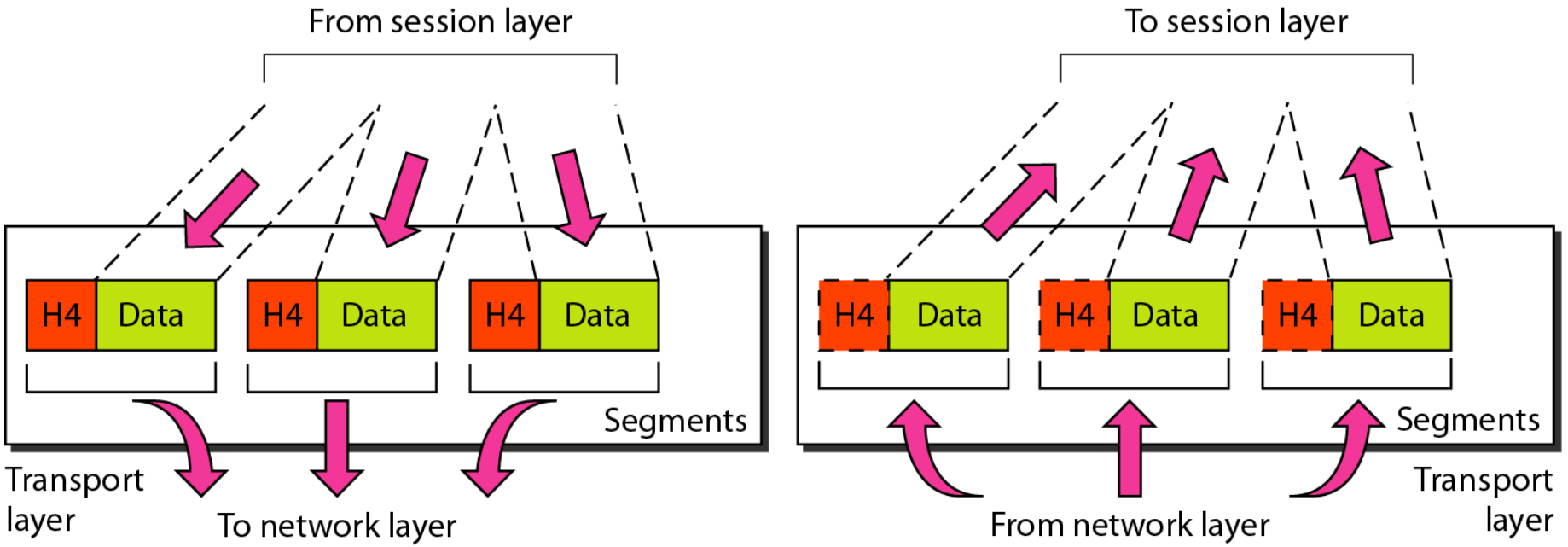
✓Divides the application data into **segments** of appropriately sized for the layers below it.

✓End to end flow control and error control i.e between hosts.

✓Splitting of data across multiple network connections, if necessary, to improve **throughput**, and recombining at the other end.

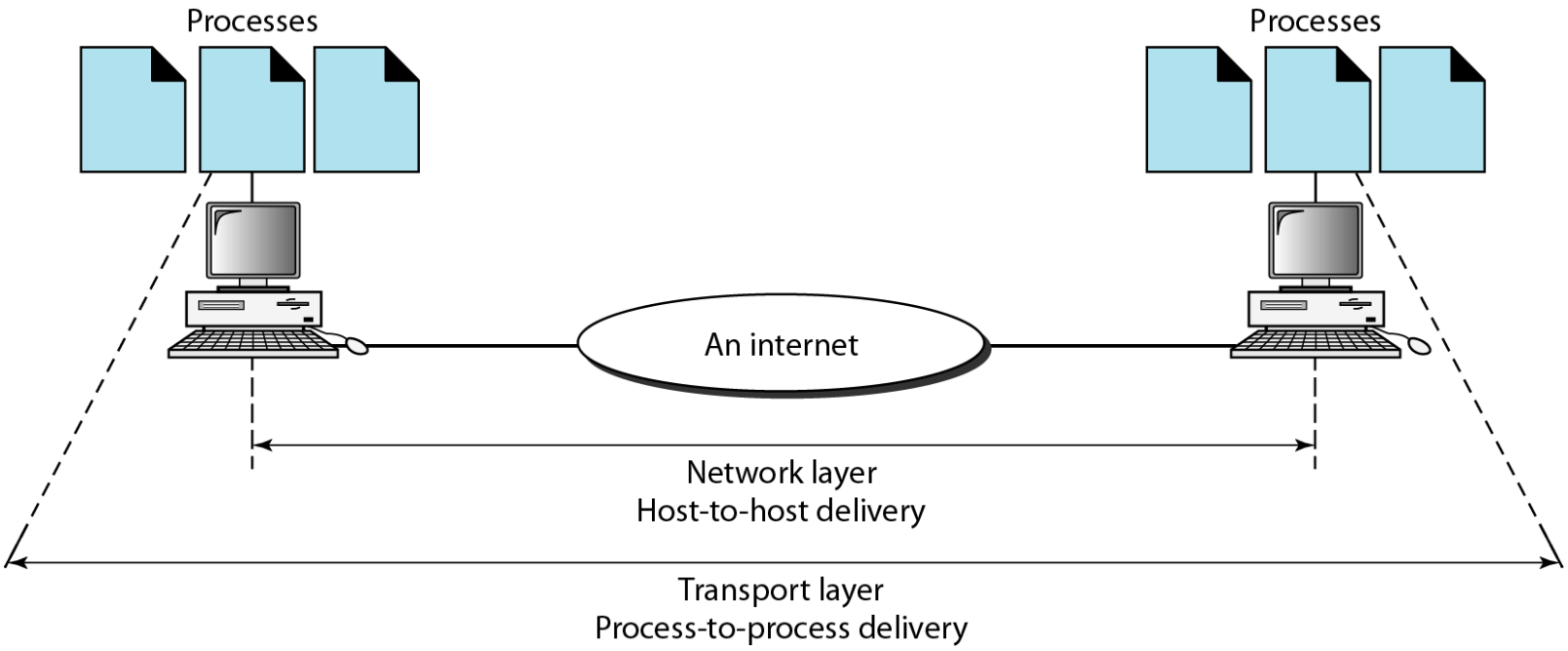
✓TCP and UDP are the example of protocol of this layer

# Transport layer




In the Internet there are two transport protocols, TCP and UDP, either of which can transport application-layer messages. TCP provides a connection-oriented service to its applications. The UDP protocol provides a connectionless service to its applications.

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



# The Session Layer

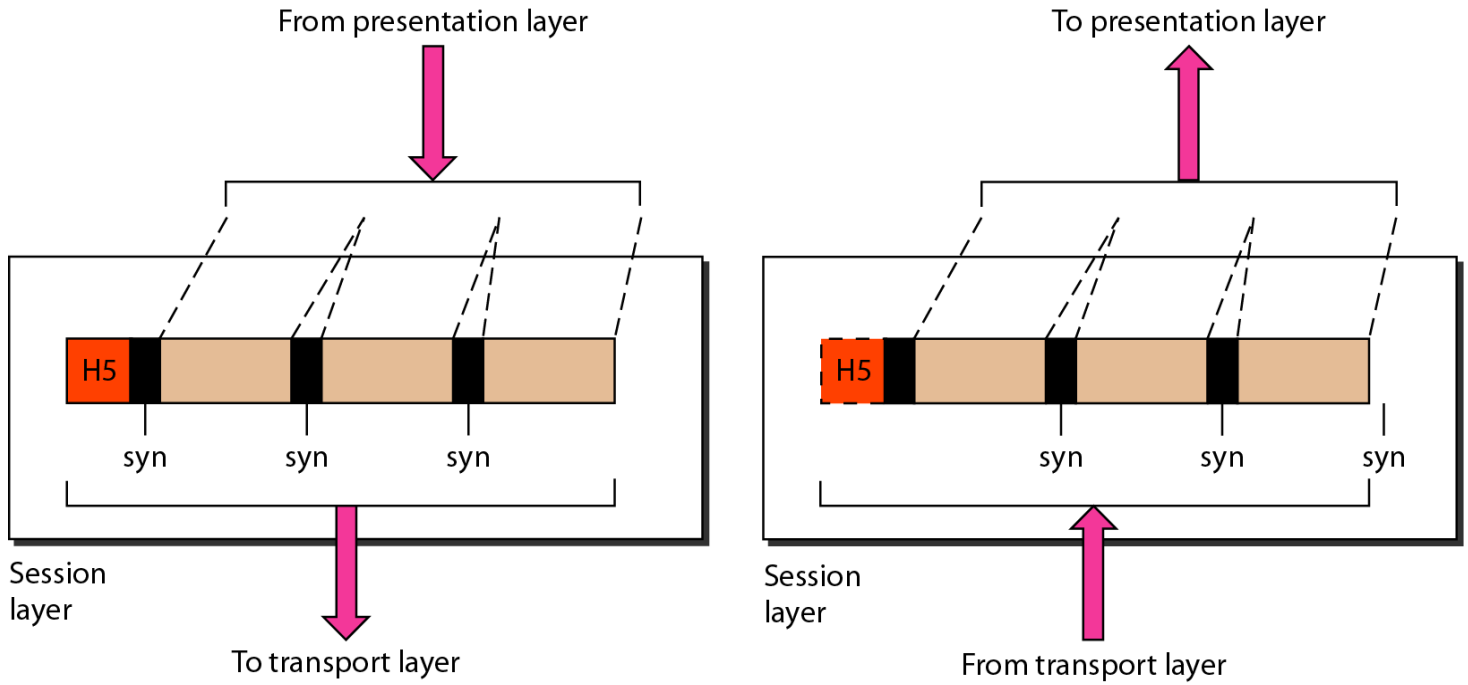
❖The session layer controls the dialogues (connections) between end terminals.

❖It establishes, manages and terminates the connections between the local and remote application.

❖It provides for full duplex, half duplex or simplex operation, and establishes checkpointing, adjournment, termination, and restart procedures.

❖Correct ordering of messages when this function is not performed by the transport layer.

The session layer provides: checkpoints or synchronization points to a stream of data, which is not usually used in the Internet Protocol Suite. During long transmissions sometimes a host becomes disconnected in the midst of communication then checkpointing allow them to continue from where they were crashed.




❖You can use your computer to open a browser window to your favorite Web site, then open a second window to the same server and follow different links in each browser. The window can act independently because the Web server and your computer have two independent sessions.

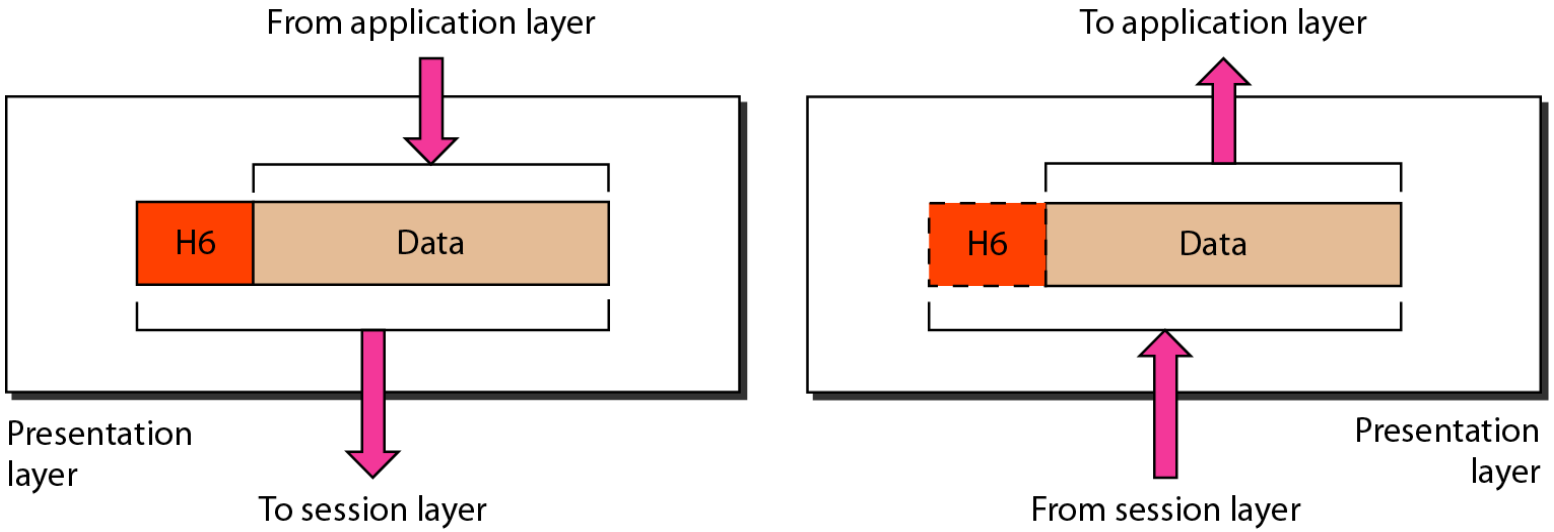
# The Presentation Layer

❖The *presentation* layer is concerned with the format of data exchanged between peers, for example, whether an integer is 16, 32, or 64 bits long and whether the most significant byte is transmitted first or last, or how a video stream is formatted.

❖More explicitly, this layer is responsible for data translation into a standard format. Examples are ASCII (American Standard Code for Information Interchange, 7-bit character encoding) text, EBCDIC (Extended Binary Coded Decimal Interchange Code, 8-bit character encoding), JPEG pictures, MPEG video and MP3 music formats. Conversion between the binary representation of application data and a common format for transmission between peer applications.

❖For example, the Presentation Layer can apply sophisticated compression techniques so fewer bytes of data are required to represent the information when it's sent over the network.

❖This layer is also responsible for encryption and decryption for security purposes, as well as data compression. It is sometimes called the syntax layer.



# Application layer

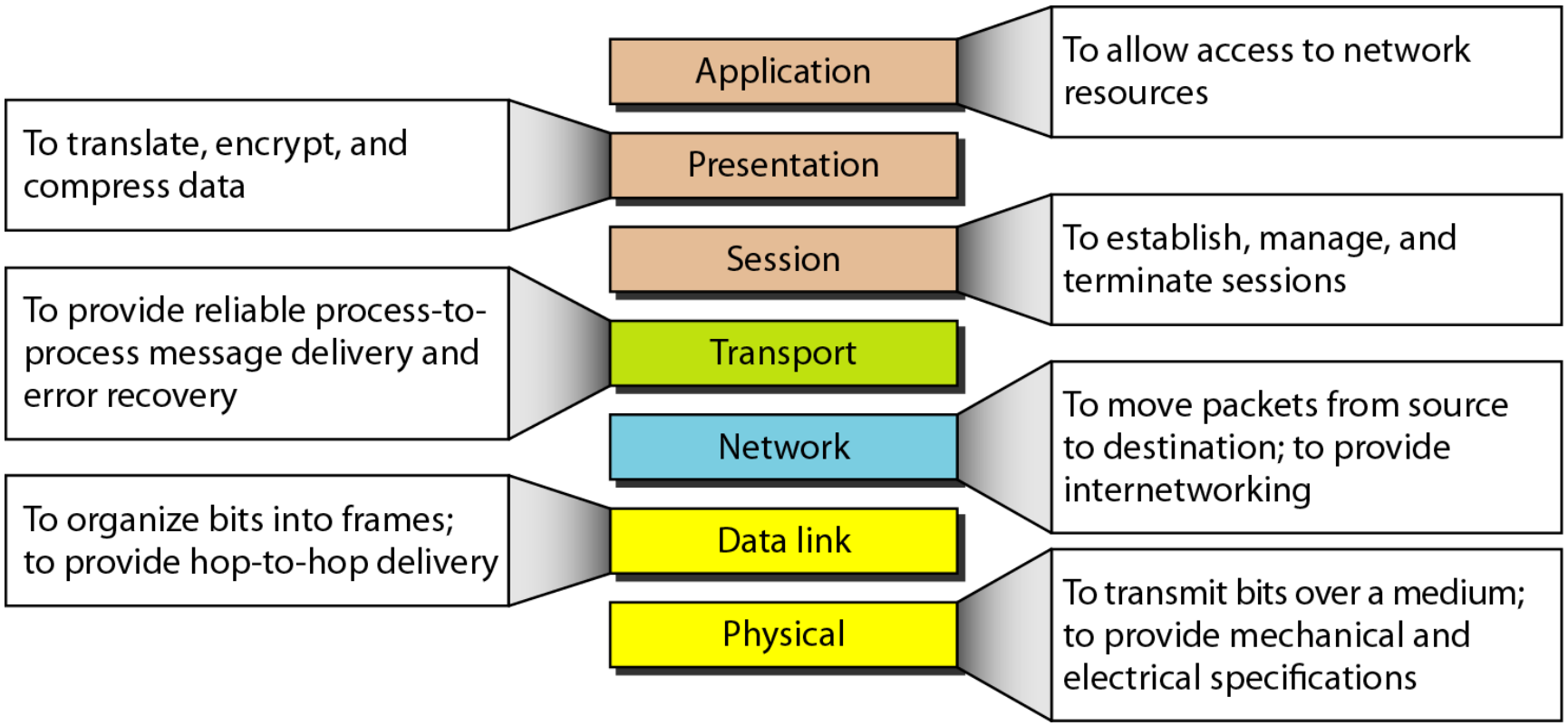
❖The application layer is where network applications and their application-layer protocols reside. File transfer, web browser, e-mail etc. are applications and implemented using some application layer protocols.

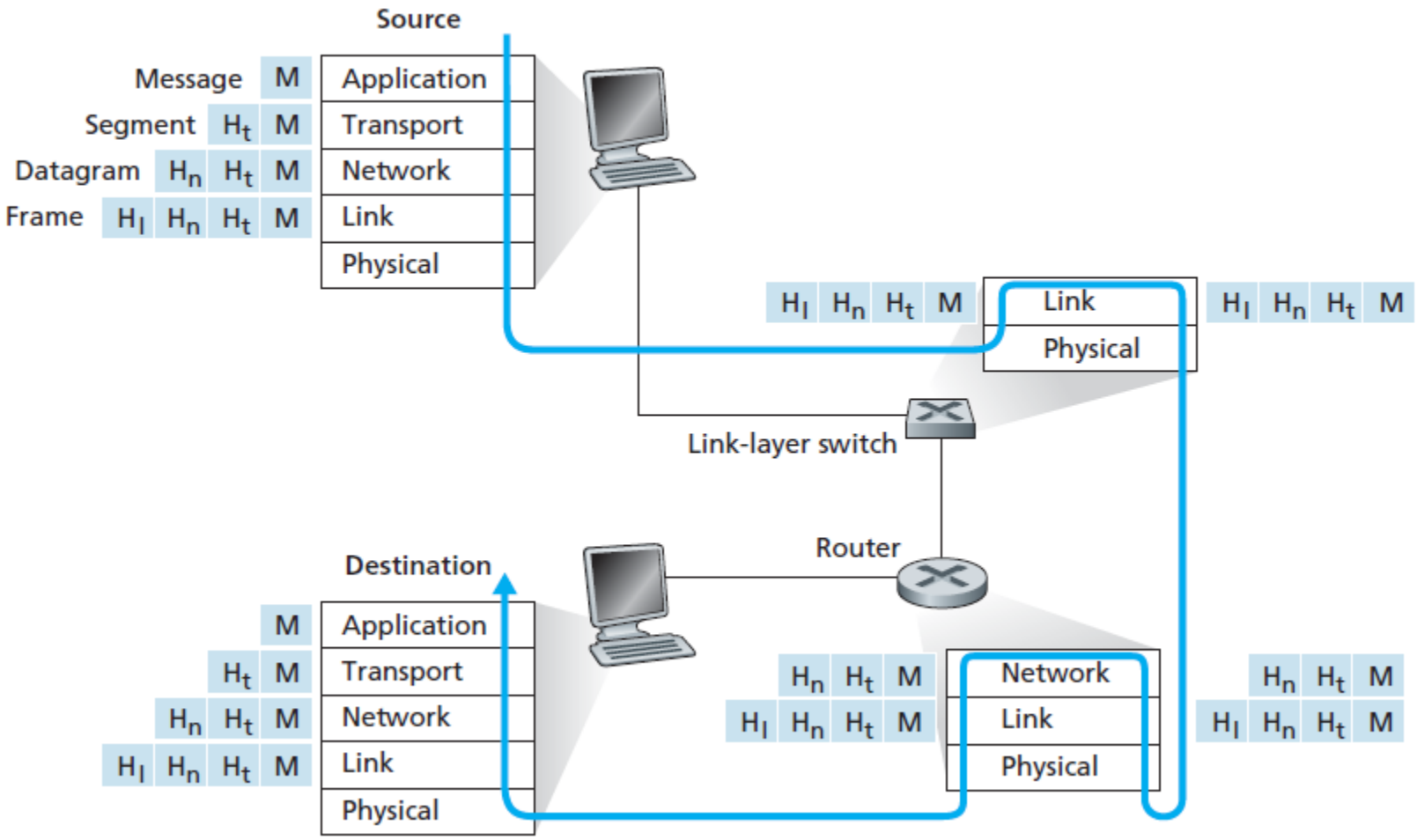
❖The Internet's application layer includes many protocols, such as the HTTP protocol (which provides for Web document request and transfer), SMTP (which provides for the transfer of e-mail messages), and FTP (which provides for the transfer of files between two end systems). This layer provides a consistent interface to the network for all computer software i.e. provides OSI environment.

❖The application in one end system using its protocol exchanges packets of information with the application in another end system. We'll refer to this packet of information at the application layer as a ***message***.

❖This layer also provides security like cryptography, Digital signature, Firewall etc.

# Summary of layers






Hosts, routers, and link-layer switches; each contains a different set of layers, reflecting their differences in functionality.