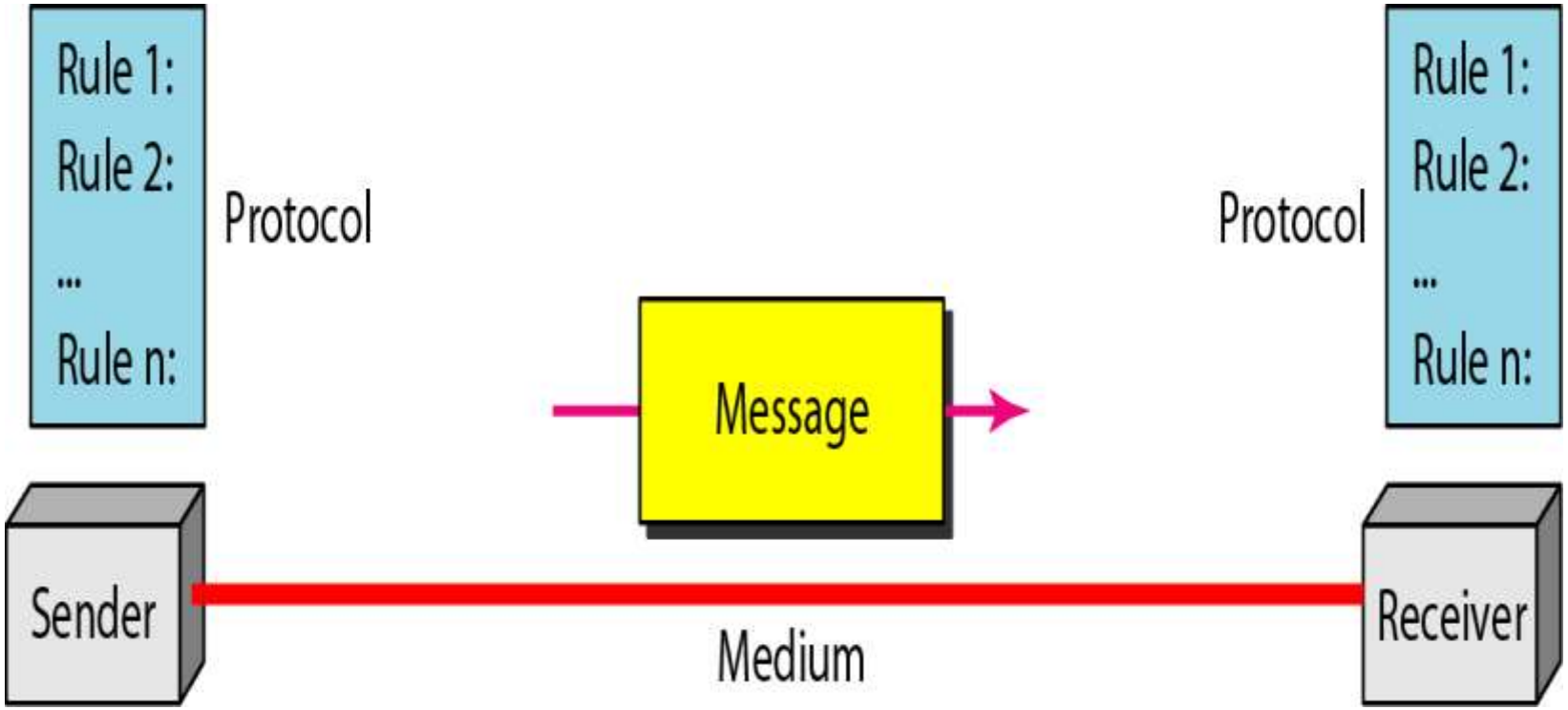
# Chapter 1

# Introduction

## Components of a data communication system

The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data.

Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.



1. **Message**. The message is the information (data) to be communicated.

---Popular forms of information include text, numbers, pictures, audio, and video.

2. **Sender.** The sender is the device that sends the data message.

--- It can be a computer, telephone handset, video camera, and so on.

3. **Receiver**. The receiver is the device that receives the message.

---It can be a computer, telephone handset, television, and so on.

4. **Transmission medium**. The transmission medium is the physical path by which a message travels from sender to receiver.

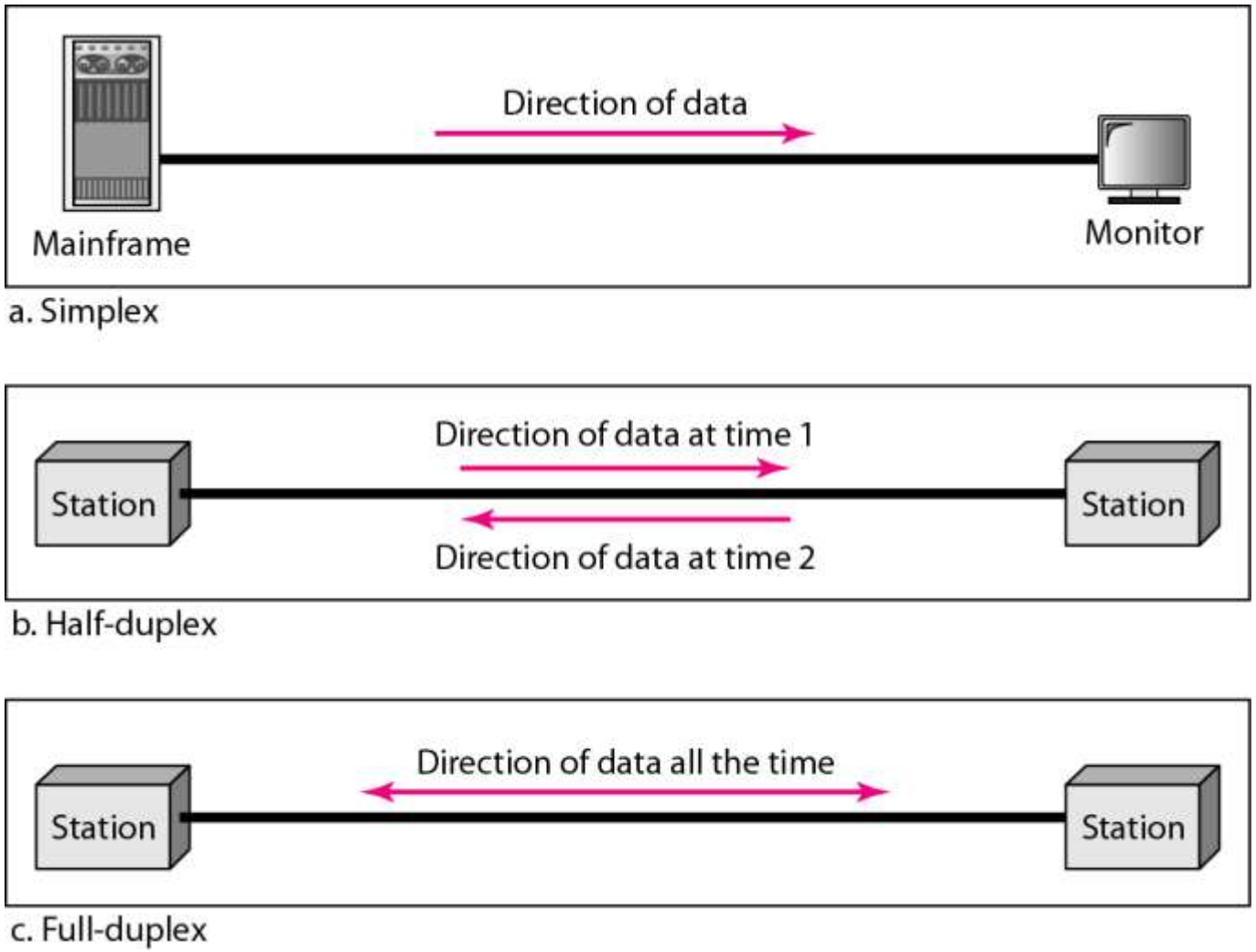
---Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves

5. **Protocol**. A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating.

---just as a person speaking French cannot be understood by a person who speaks only Japanese.

A protocol is a set of rules that govern data communications. It determines **what** is communicated, **how** it is communicated and **when** it is communicated. The key elements of a protocol are syntax, semantics and timing

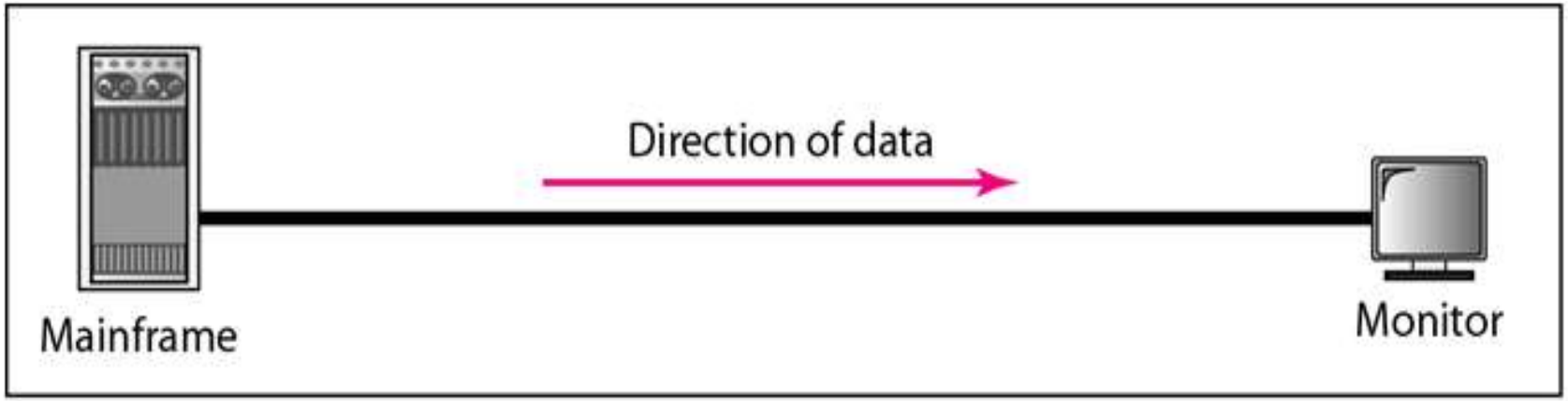
*Data flow (simplex, half-duplex, and full-duplex)*



## *Simplex:*

In simplex mode, the communication is unidirectional, as on a one-way street. Only one of the two devices on a link can transmit; the other can only receive.

**Examples**:- Keyboards and traditional monitors are examples of simplex devices. The keyboard can only introduce input; the monitor can only accept output. The simplex mode can use the entire capacity of the channel to send data in one direction.

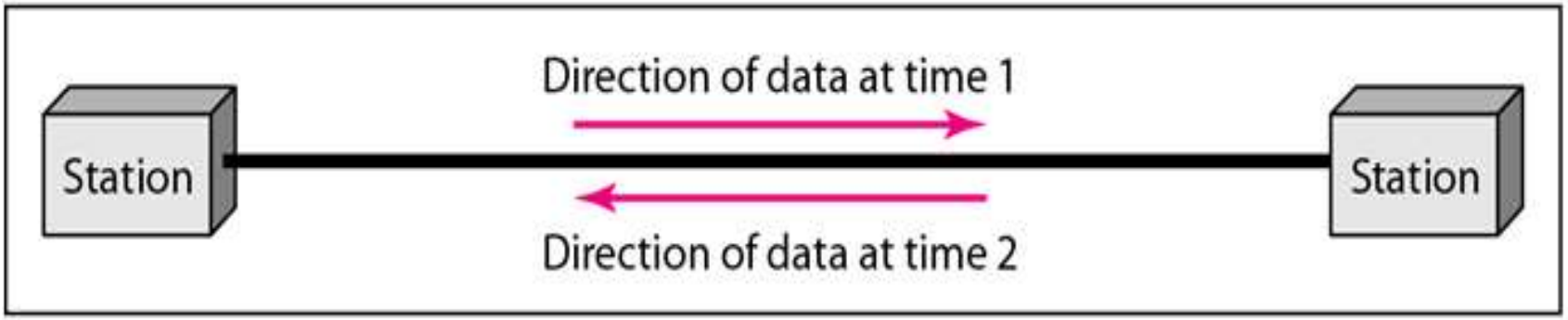



a. Simplex

***Half-Duplex:***

In half-duplex mode, each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa.

**Examples**:-When cars are traveling in one direction, cars going the other way must wait. In a half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time. Walkie-talkies is half-duplex systems.

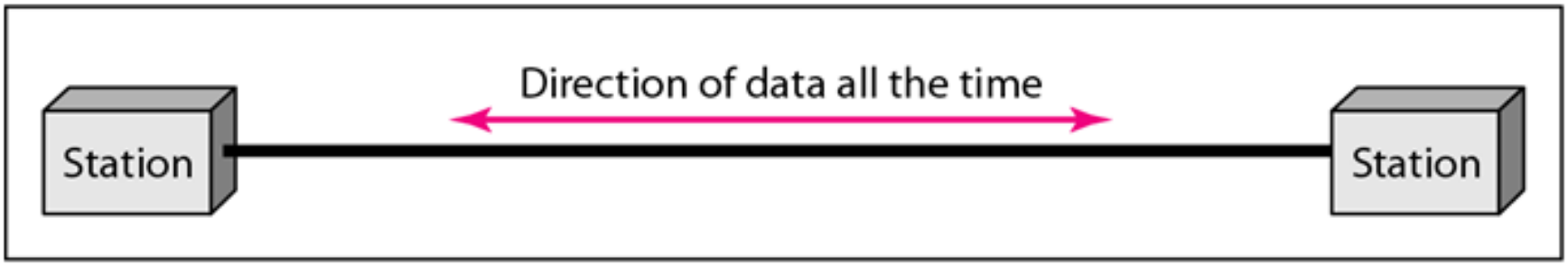



b. Half-duplex

***Full-Duplex:***

In full-duplex both stations can transmit and receive simultaneously. The full-duplex mode is like a two-way street with traffic flowing in both directions at the same time. In full-duplex mode, signals going in one direction share the capacity of the link: with signals going in the other direction.

**Example**:- full-duplex communication is the telephone network. When two people are communicating by a telephone line, both can talk and listen at the same time. The full-duplex mode is used when communication in both directions is required all the time. The capacity of the channel, however, must be divided between the two directions.




c. Full-duplex

# COMPUTER NETWORKS

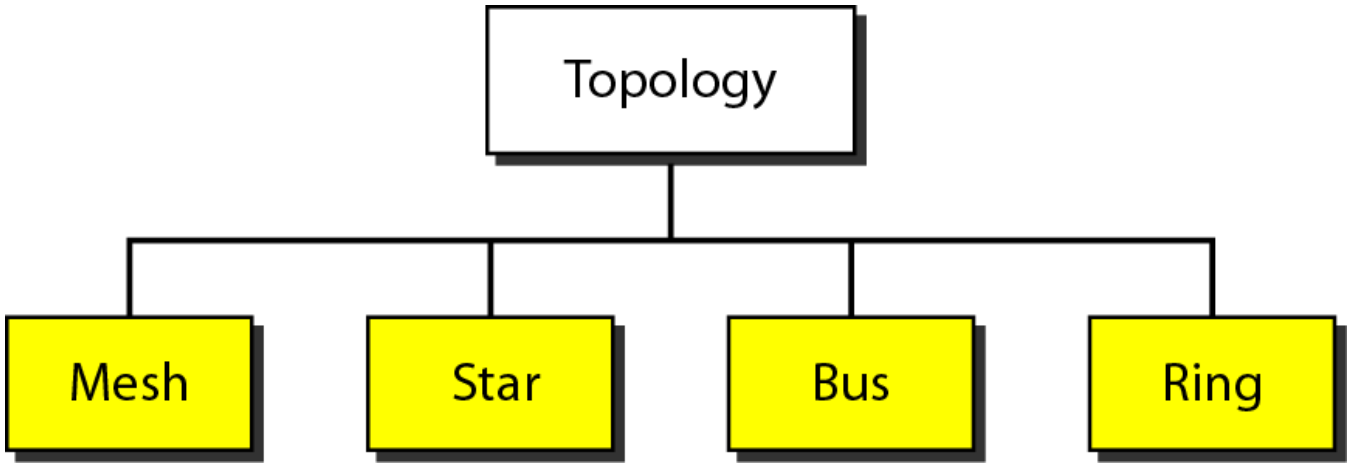
**Computer network** consists of two or more computers that are linked in order to share resources, exchange data files or to allow electronic communication. The computers on a network may be linked through cables, telephone lines, radio waves, satellites or infrared light beams.

There are two aspects of computer networks – **hardware** and **software**.

**Hardware** includes physical connection between two machines by using adaptors, cables, routers, bridges etc.

**software** includes a set of protocols. Protocols define a formal language among various components. It makes hardware usable by applications.

## *Categories of topology*



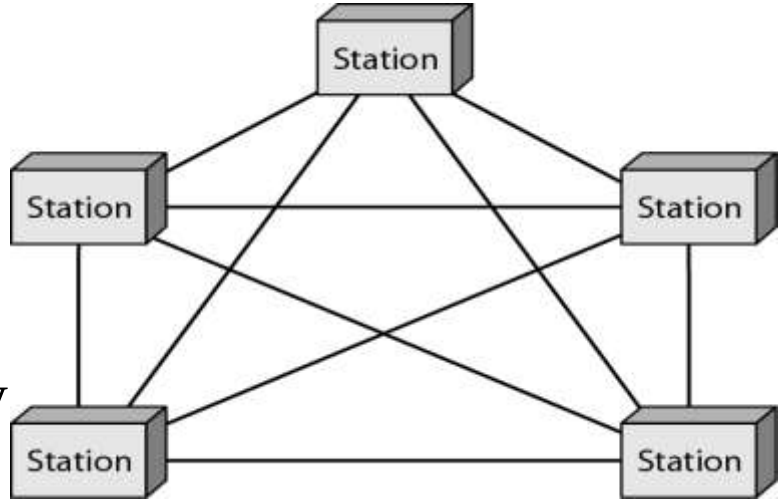

➢The term physical topology refers to the way in which a network is laid out physically. One or more devices connect to a **link**; two or more links form a **topology**.

➢The topology of a network is the geometric representation of the relationship of all the links and linking devices (usually called nodes) to one another.

➢There are four basic topologies possible: mesh, star, bus, and ring.

## *A fully connected mesh topology (five devices)*

- In mesh topology every device has a dedicated point-to-point link to every other device.
- The link carries traffic only between the two devices it connects.
- Duplex-mode
- Advantages:
  - guaranteed dedicated links
  - eliminates traffic problems
  - privacy and security
  - this makes fault identification easy
- Disadvantages:
  - cabling and number of IO ports required
  - wiring is greater than available space
  - hardware is required for each link – expensive



## *A star topology connecting four stations*

•In star topology, each device has a dedicated point-to-point link only to a central controller called hub.

•The controller acts as an exchange: if one device wants to send data to another , it sends the data to controller, which then relays the data to the another connected device.

•Advantages:

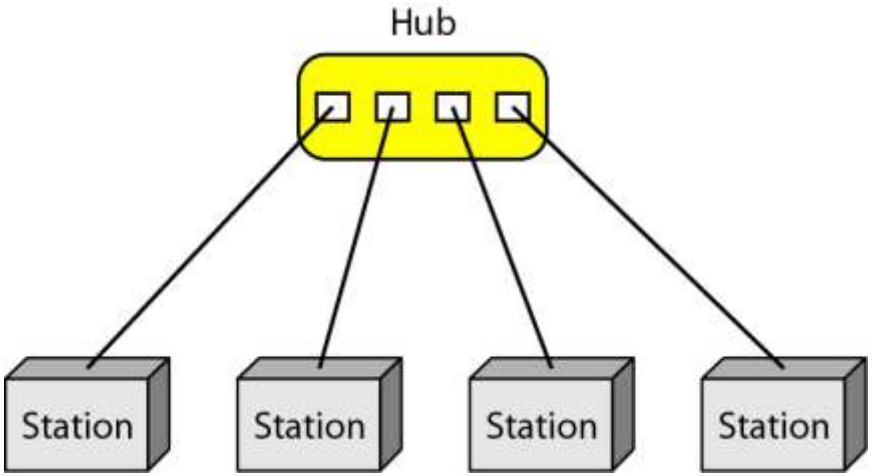
less expensive

robustness – if one link fails, only that link is affected, other links remain active.

•Disadvantages:

dependency of the whole topology on one single point.

star requires less than mesh, each node is linked to the hub. So more cabling is required .



***A bus topology connecting three stations***

•A bus topology is a multipoint .

•One long cable acts as a backbone to link all the devices in the network.

•Nodes are connected by bus cable by drop line and taps.

a drop line is a connection running between the device and the main cable

a tap is a connector that either splices or punctures.

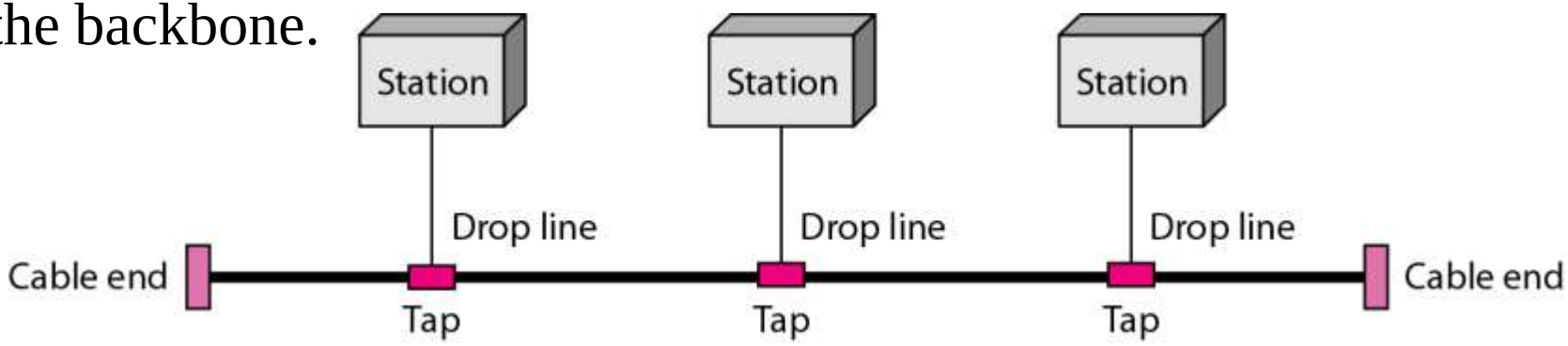
•Advantages:

easy of installation

•Disadvantages:

difficult reconnection

addition of new devices require modification or replacement of the backbone.



***A ring topology connecting six stations***

•In ring topology each device has a point-to-point connection with only the two devices on either side of it.

•A signal is passed along a ring in one direction, from device to device until it reaches its destination.

•Advantages:

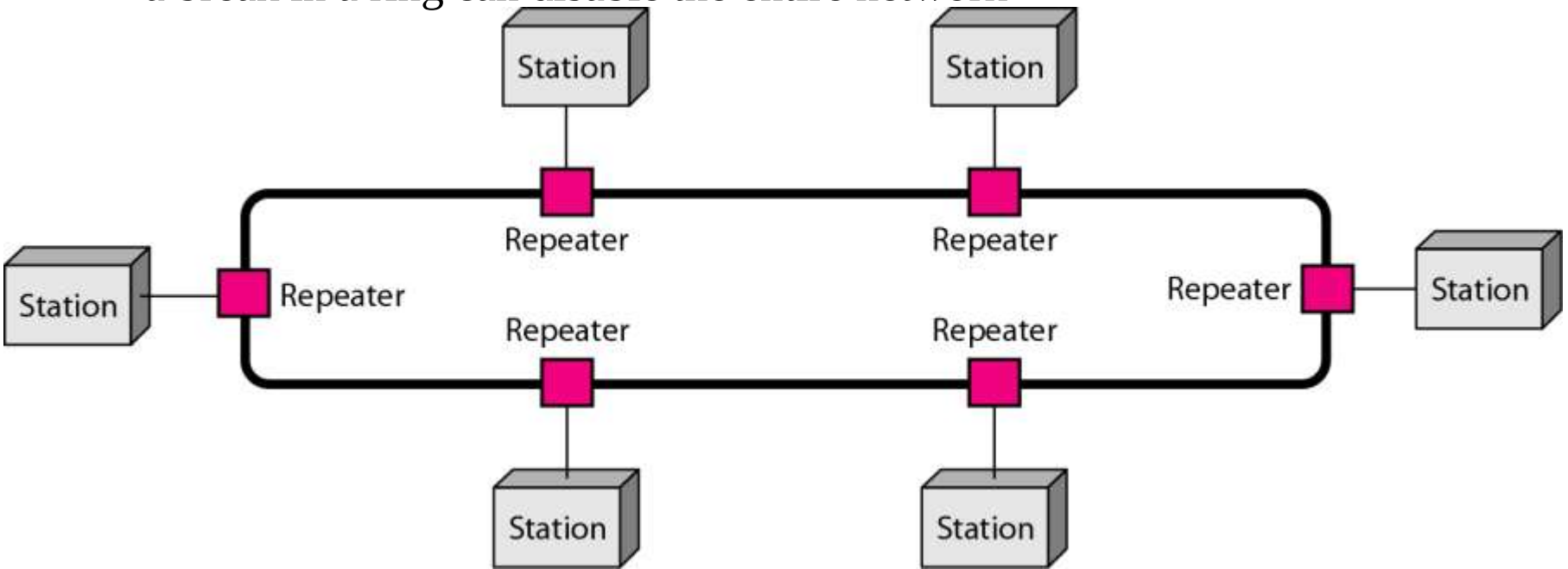
easy to install and reconfigure

to add or delete a device requires changing only two connections. The only constraints are media and traffic.

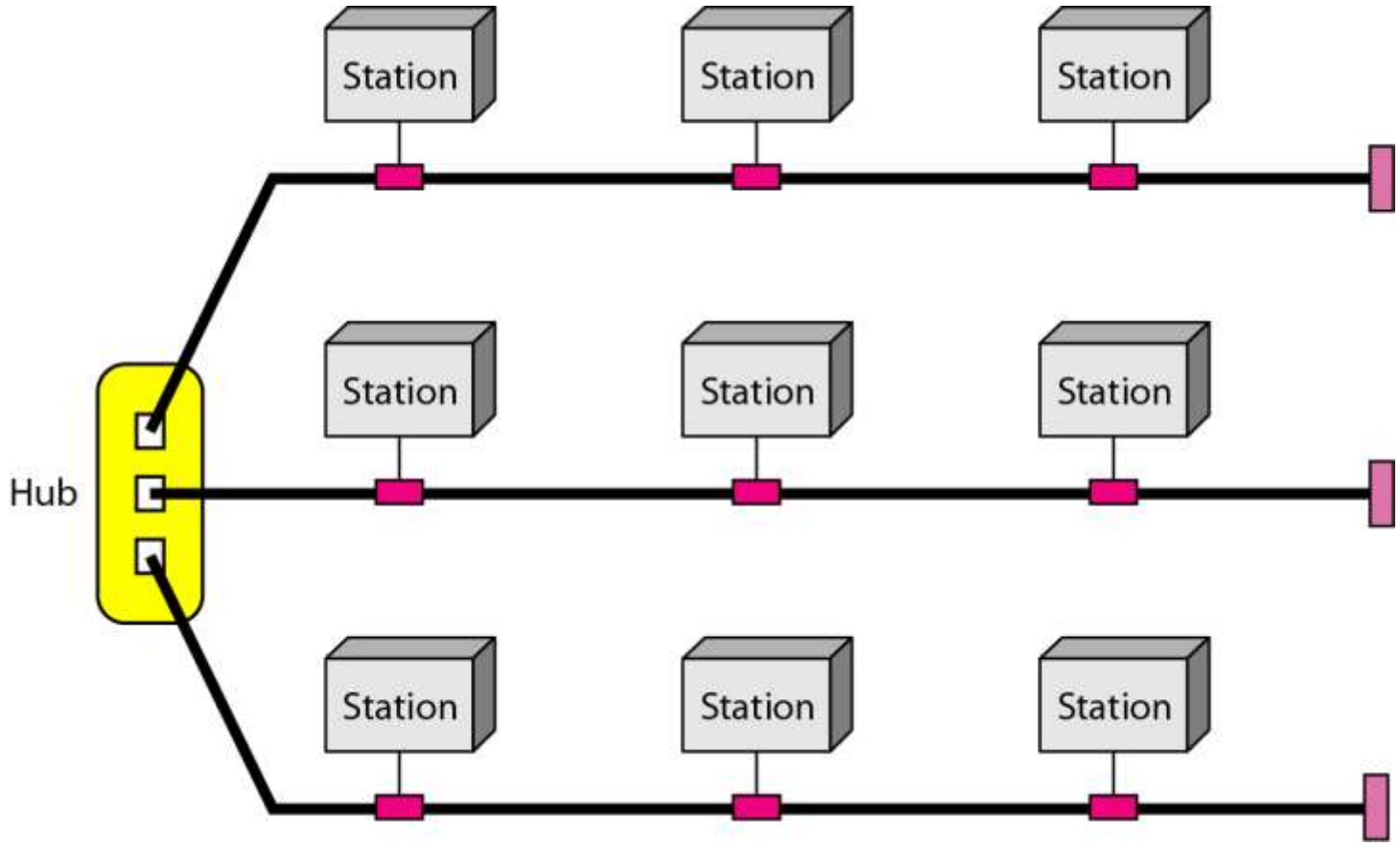
•Disadvantages;

unidirectional

a break in a ring can disable the entire network



*A hybrid topology: a star backbone with three bus networks*

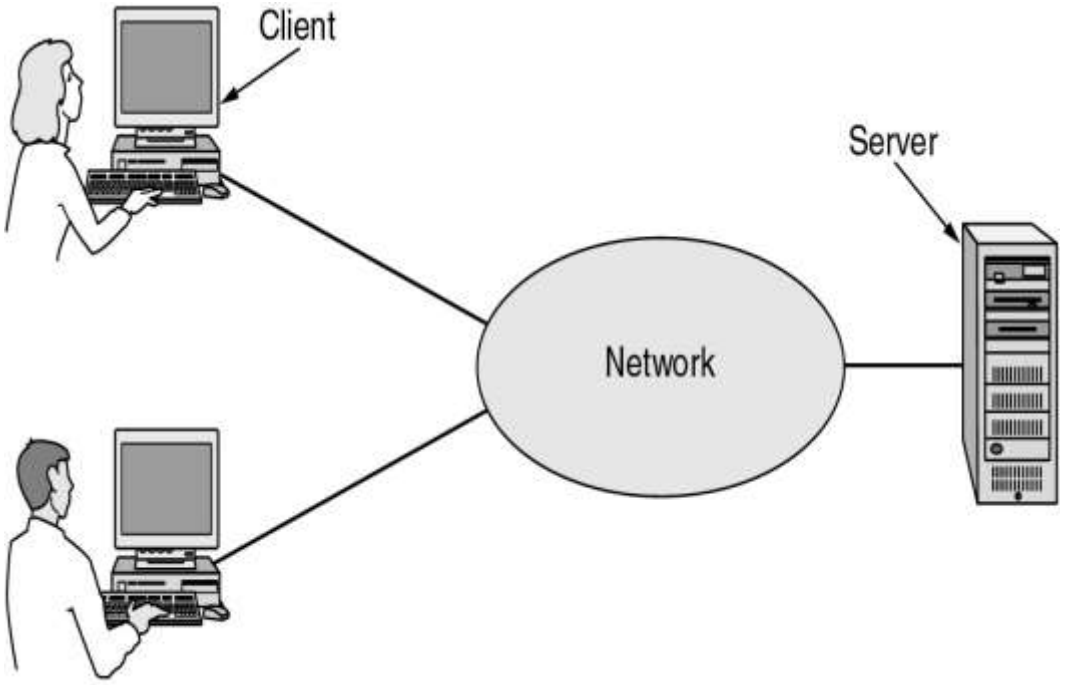


# Uses of Computer Networks

- Business Applications
- Home Applications
- Mobile Users

# Business Applications of Networks

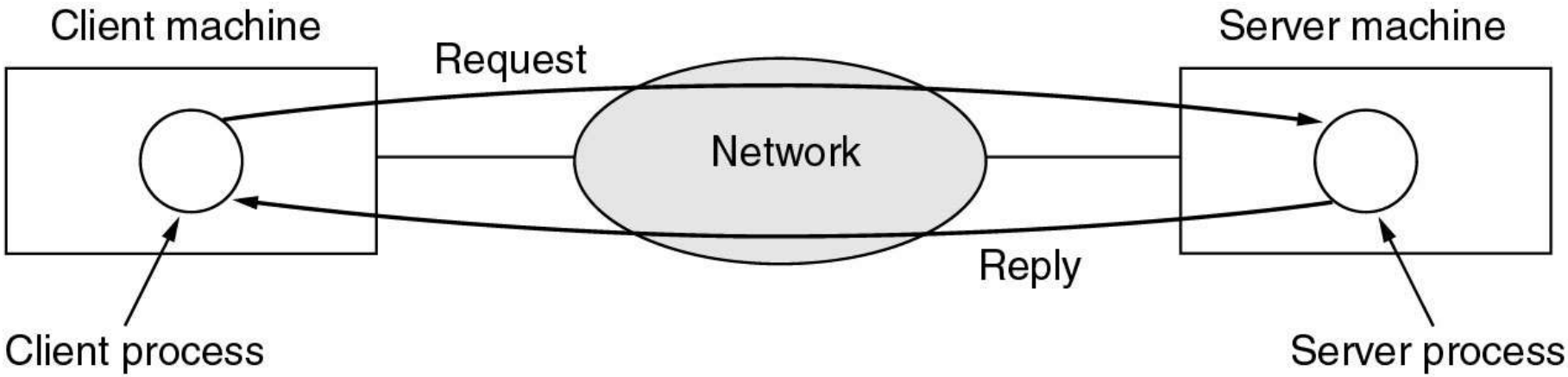
- Resource sharing
- High reliability
- Saving money
- scalability




**Client-server model**

# Business Applications of Networks (2)

- The client-server model involves requests and replies.



# Home Network Applications

1. **Access to remote information**
   - Many people pay their bills, manage bank accounts, handle their investments electronically.
   - Home shopping.
   - On-line newspaper which can be personalized.
   - Access to information system like world wide web, which contains information about arts,business,cooking,government,health,history,science,sports,travel,……..
   - All the above applications involve in interactions between a person and remote database.
2. **Person-to-person communication**
   - Electronic mail or email which allow users to communicate with no delay
   - Videoconference- which makes possible
3. **Interactive entertainment**
   - Huge and growing industry.
     - Video
     - Game playing
4. **Electronic commerce**

Cont.

**Electronic Commerce**, commonly known as **E-commerce** or **eCommerce**, is trading in products or services using computer networks, such as the Internet

**E-commerce** facilitates home shopping, catalogue of company products.

It is also popularly employed for bill payments , banking, investments, ……

| Tag | Full name | Example |
|---|---|---|
| B2C | Business-to-consumer | Ordering books on-line |
| B2B | Business-to-business | Car manufacturer ordering tires from supplier |
| G2C | Government-to-consumer | Government distributing tax forms electronically |
| C2C | Consumer-to-consumer | Auctioning second-hand products on-line |
| P2P | Peer-to-peer | File sharing |

Some forms of e-commerce

## Mobile Network Users

Many professionals uses desktop computers at office and want to be connected to the office network while travelling and at home also. This is possible by wireless networks, hence use of laptop, notebook computers and personal digital assistants(PDAs) is increased.

Wireless networks are used in:- taxis, military applications, airports, banking, weather reporting

- Combinations of wireless networks and mobile computing.

| Wireless | Mobile | Applications |
|---|---|---|
| No | No | Desktop computers in offices |
| No | Yes | A notebook computer used in a hotel room |
| Yes | No | Networks in older, unwired buildings |
| Yes | Yes | Portable office; PDA for store inventory |

# Network Hardware

- Local Area Networks
- Metropolitan Area Networks
- Wide Area Networks

There are two types of transmission technology:

1. Broadcast Networks

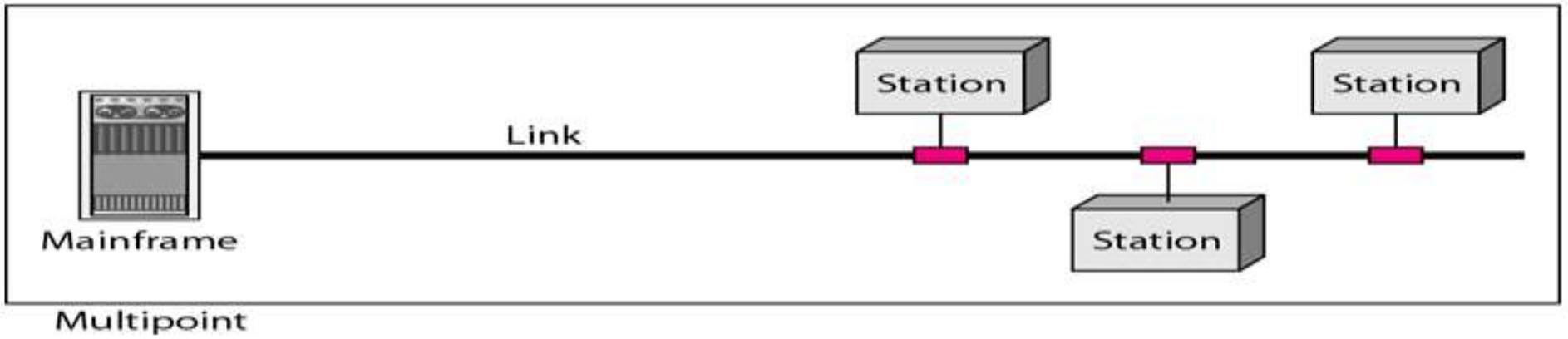
This has a single communication channel that is shared by all the machines on the network.

The data transmitted is converted in small packets form. Each packet contains address field of the destination station.

Ex:- a person standing at corridor “watson, come here. I want you”

sending same packets to all the stations within a network is called as **broadcasting**.

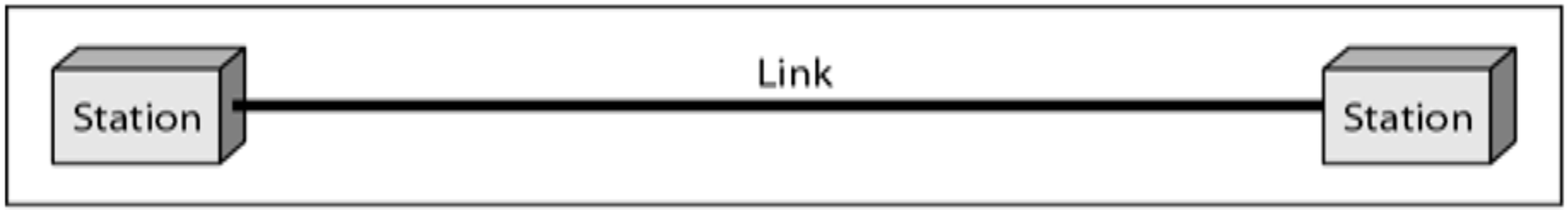
When data packets are sent to a specific group of stations it is called as **multicasting**. This is a selective process



# 2. Point-to-point Network

Point-to-point connections use an actual length of wire or cable to connect the two ends, but other options, such as microwave or satellite links, are also possible. When you change television channels by infrared remote control, you are establishing a point-to-point connection between the remote control and the television's control system.

This network provides a dedicated link between any two stations . Such a transmission is called **unicasting**.




Point-to-point

- Classification of interconnected processors by scale.

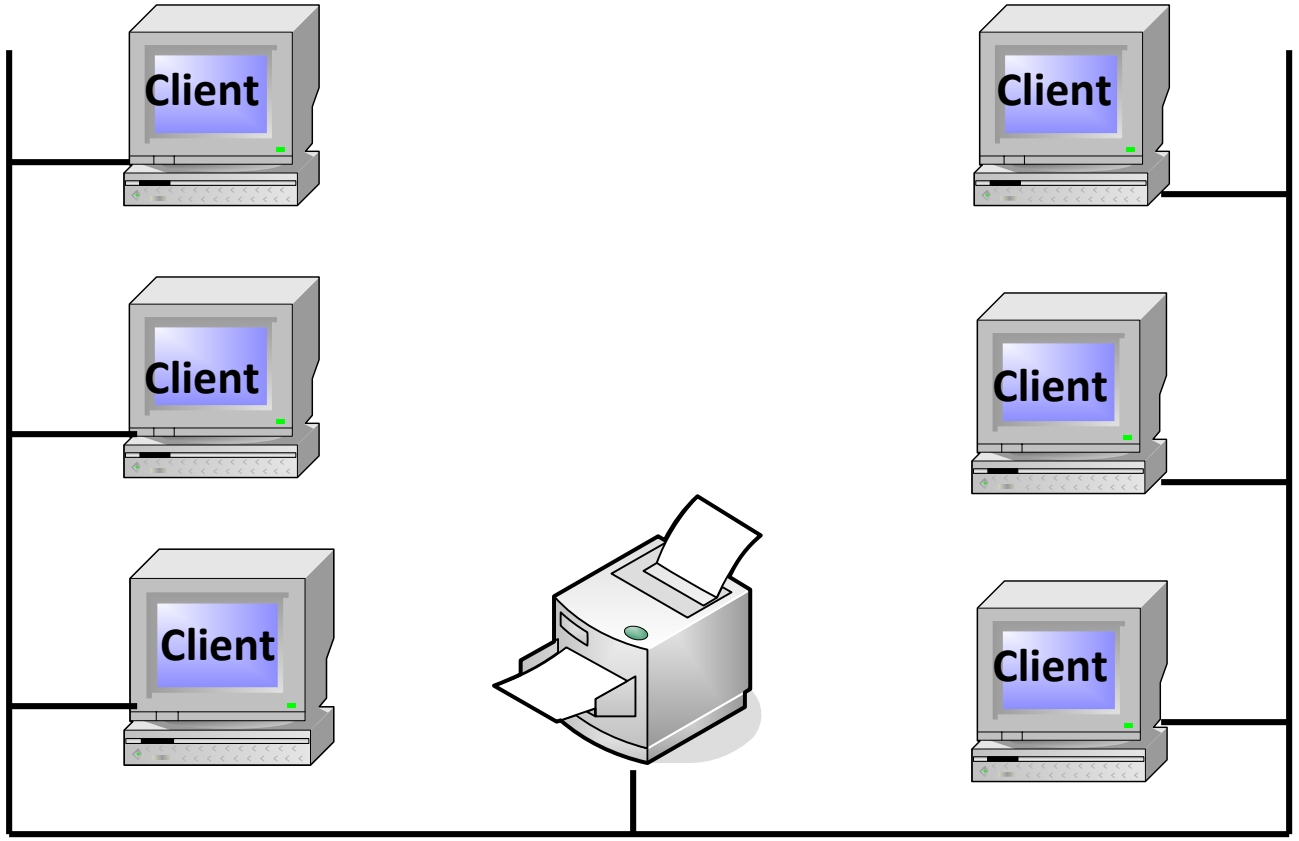
| Interprocessor distance | Processors located in same | Example |
|---|---|---|
| 1 m | Square meter | Personal area network |
| 10 m | Room | Local area network |
| 100 m | Building | |
| 1 km | Campus | |
| 10 km | City | Metropolitan area network |
| 100 km | Country | Wide area network |
| 1000 km | Continent | |
| 10,000 km | Planet | The Internet |

•Personal area network is sending a message over a very short distance

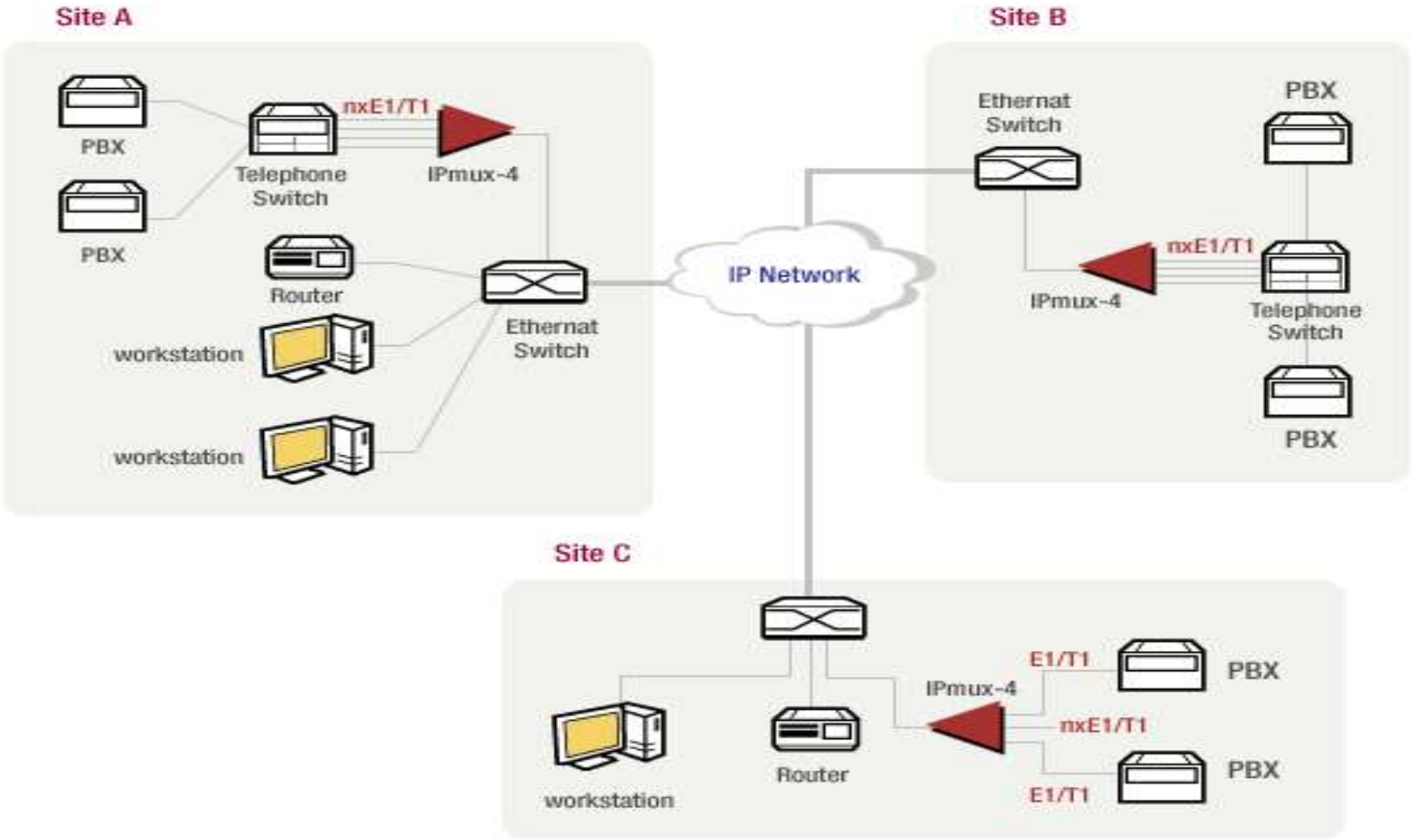
•Computers that communicate by exchanging messages over longer cables. LAN MAN WAN

•The connection of two or more networks is called an internetwork.

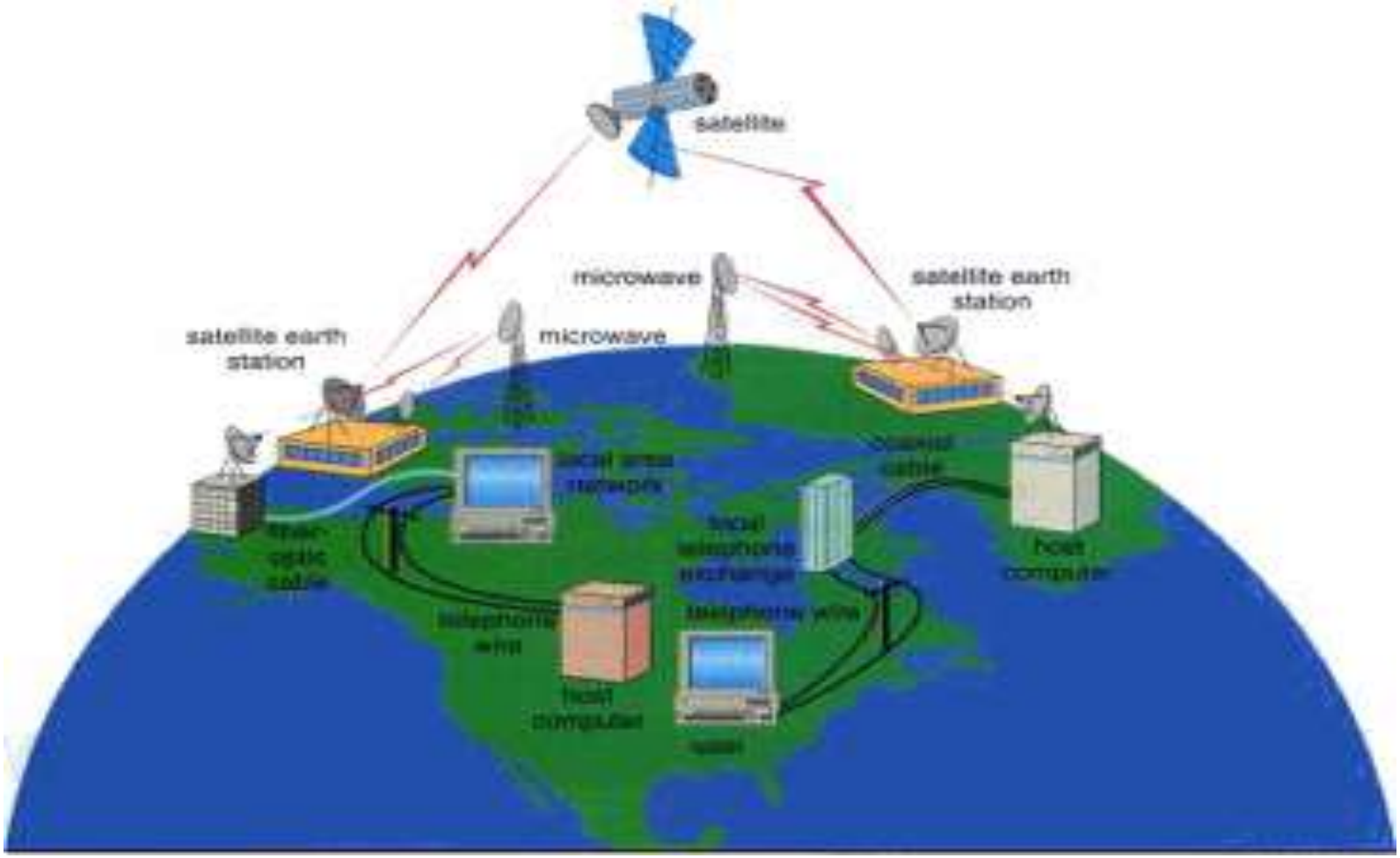
# The Local Network (LAN)



# Metropolitan Area Network (MAN)



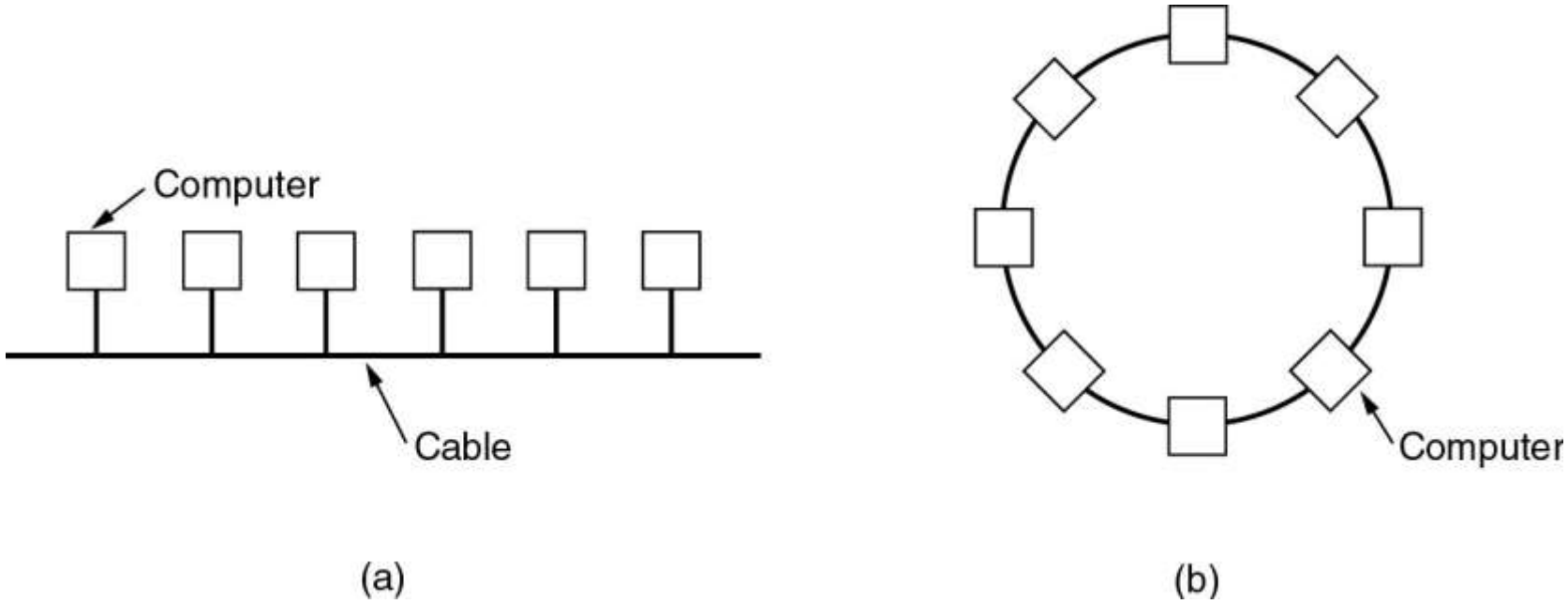
- Wide Area Network



# Local Area Networks(LANs)

- LANS are privately-owned networks within a single building or campus of up to few kilometers in size.
- LANS are distinguished based on
  - Their size
  - Their transmission technology
  - Their topology
- LANS are restricted in size
- LANS use a transmission technology consisting of a single cable to which all machines are attached like telephone company lines once used in rural areas.
- LANS run at speeds of 10 to 100 Mbps, have low delay and make very few errors.

# Local Area Networks




Two broadcast networks

- (a) Bus
- (b) Ring

**Bus topology**

1.In bus network, at any instant one machine is the master and is allowed to transmit. All other machines are required to refrain.

2. **when two or more machines want to transmit simultaneously?**

The mechanism is IEEE 802.3 (ETHERNET) is a bus-based broadcast network with decentralized control operation at 10 or 100 Mbps.

3.Computers on ETHERNET can transmit whenever they want to, if two or more packets collide, each computer waits for random time and tries again later.

**Ring topology**

1.In this each bit propagates around on its own, not waiting for the rest of the packets .

2. In this each bit circumnavigates the entire ring.

3. IEEE 802.5( IBM token ring) is a popular ring-based LAN operated at 4 and 16 Mbps.

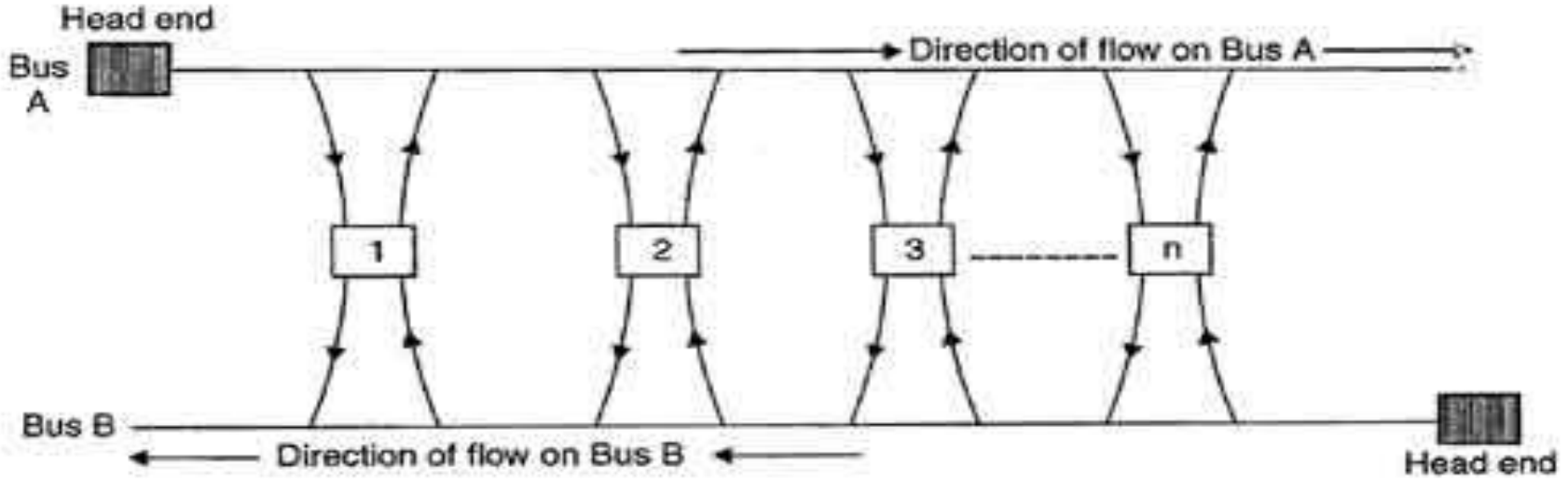
# Metropolitan Area Networks

- MAN is basically a bigger version of a LAN and normally uses similar technology.
- It might cover a group of near by offices, may be either private or public
- A MAN  just has one or two cables and does mot have any switching elements
- The main reason for even distinguishing MAN's is that a standard has been adopted and this standard is now being implemented
- It is called DQDB (distributed queue dual bus, 802.6)

DQDB consists of two unidirectional buses to which all computers are connected .

Each bus has **head end**. A device that initiates transmission activity.

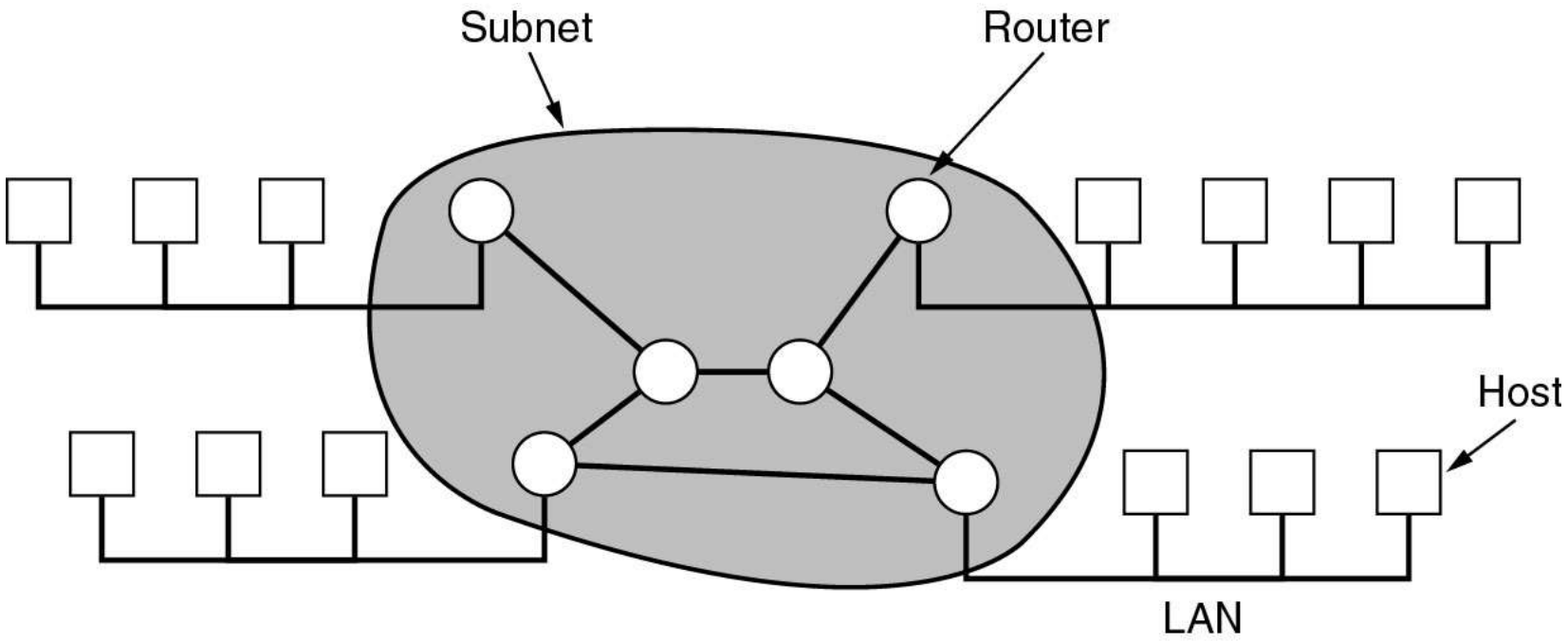
The key aspect of MAN is a broadcast medium to which all computers are attached.




Architecture of DQDB

# Wide Area Networks

- Relation between hosts on LANs and the subnet.



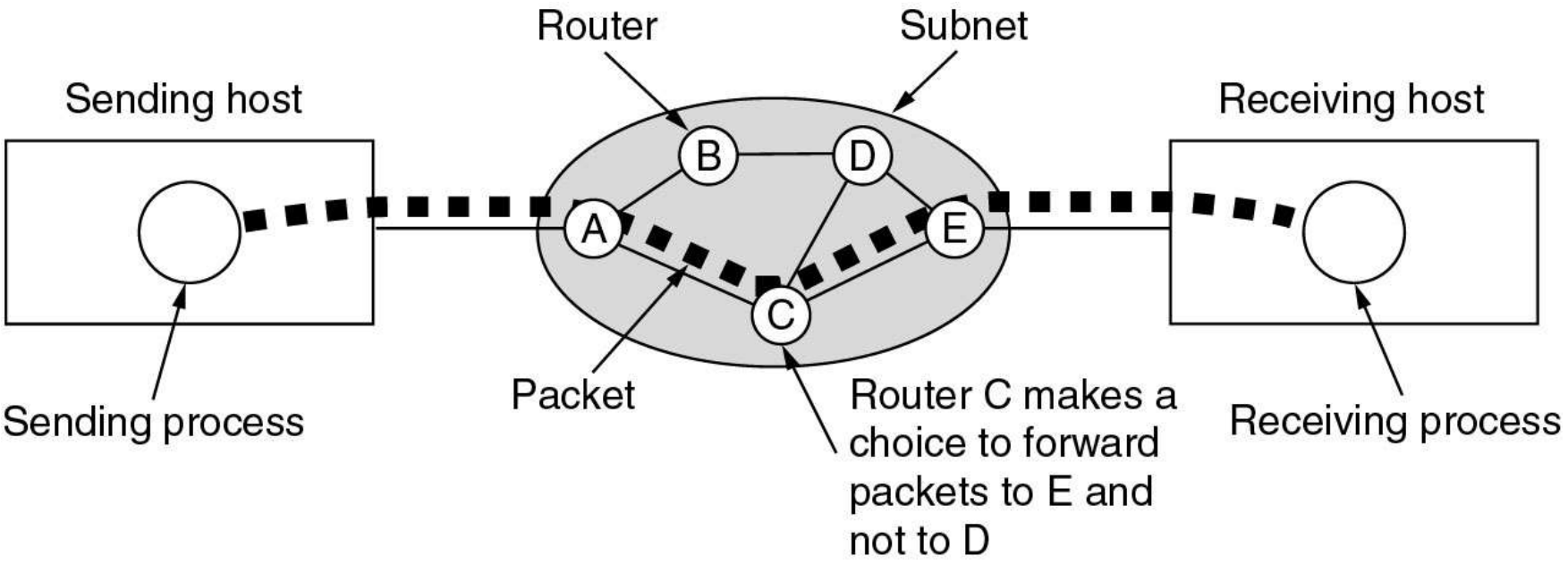
# Wide Area Networks

- WANs spans a large geographical area, often a country or continent.
- It contains collection of machines for running user applications, called **hosts** or **end user.**
- The hosts are connected by communication subnet or **subnet**. The subnet carries message from host to host.
- For communication aspect – subnet

  application aspect - hosts

- In WAN the subnets consists of two distinct components: transmission lines and switching elements.
- Transmission lines are circuits or channels
- Switching elements are specialized computers used to connect two or more transmission lines. These are called **routers**
- Each host is connected to LAN on which a router is present, or in some cases host can be connected directly connected to router.
- The collection of communication lines and routers form the subnet.

- If two routers do not share a cable or not wish to communicate , they must do this indirectly ie., via other router.
- When the packet is send from one router to another via one or more intermediate routers , the packet is received at each router and stores until required output line is free and then forward.
- A subnet using  this principle is called point-to-point , store-and-forward, or packet-switching subnet.



# NetworkSoftware

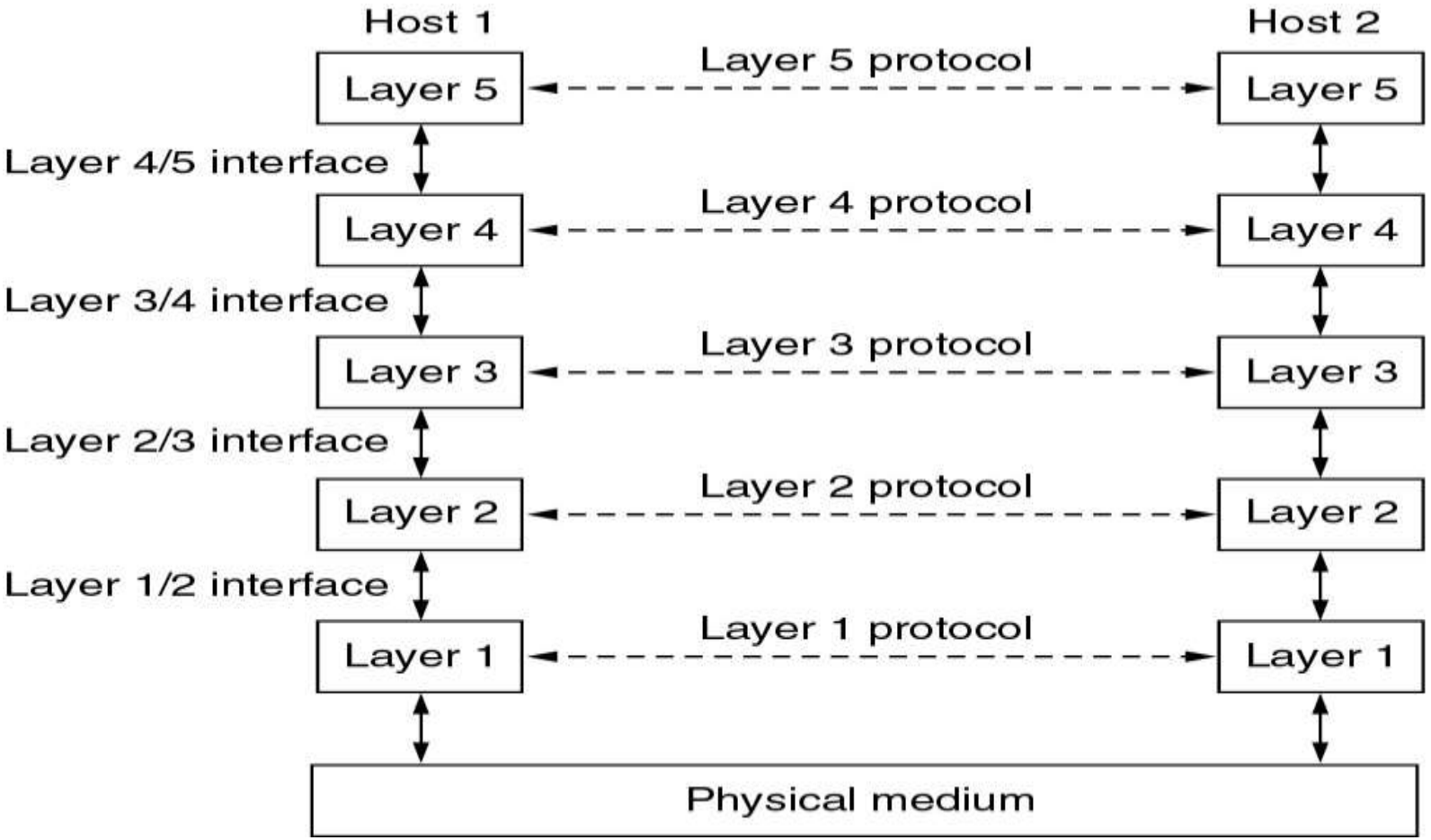
The first computer designed with the hardware as the major concern and the software as an afterthought. This no longer works. Network software is now highly structured.

- Protocol Hierarchies
- Design Issues for the Layers
- Connection-Oriented and Connectionless Services
- Service Primitives
- The Relationship of Services to Protocols

# Protocol Hierarchies

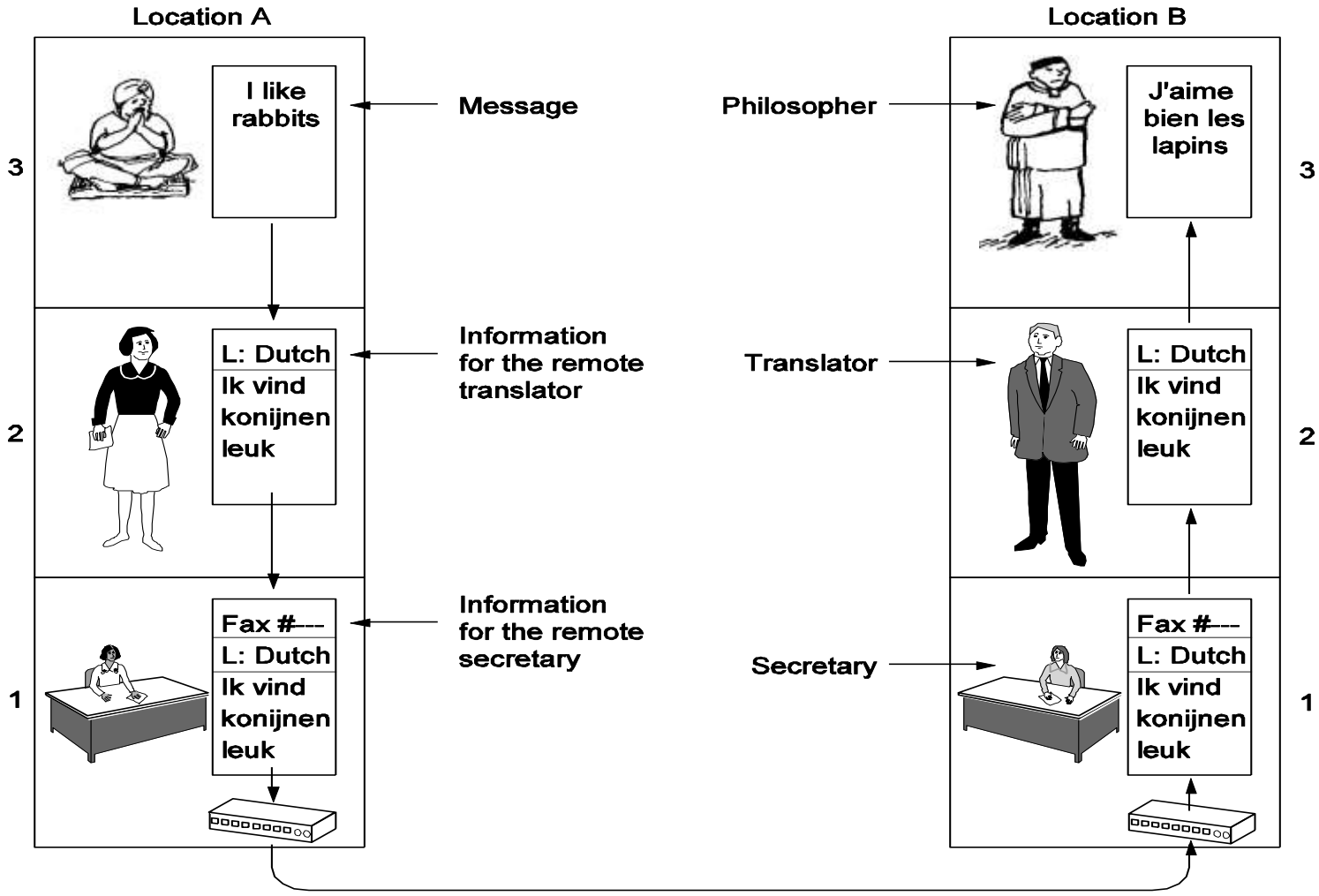
- To reduce the design complexity, most networks are organized as a series of layers or levels. Each one built upon the one below it.
- The number of layers, name of each layer, contents of each layer and the function of each layer differ from network to network.
- Layer *n* on one machine carries on a conversation with layer n on another machine. The rules and conventions used in this conversation are collectively known as the layer n **protocol.**

# Protocol Hierarchies



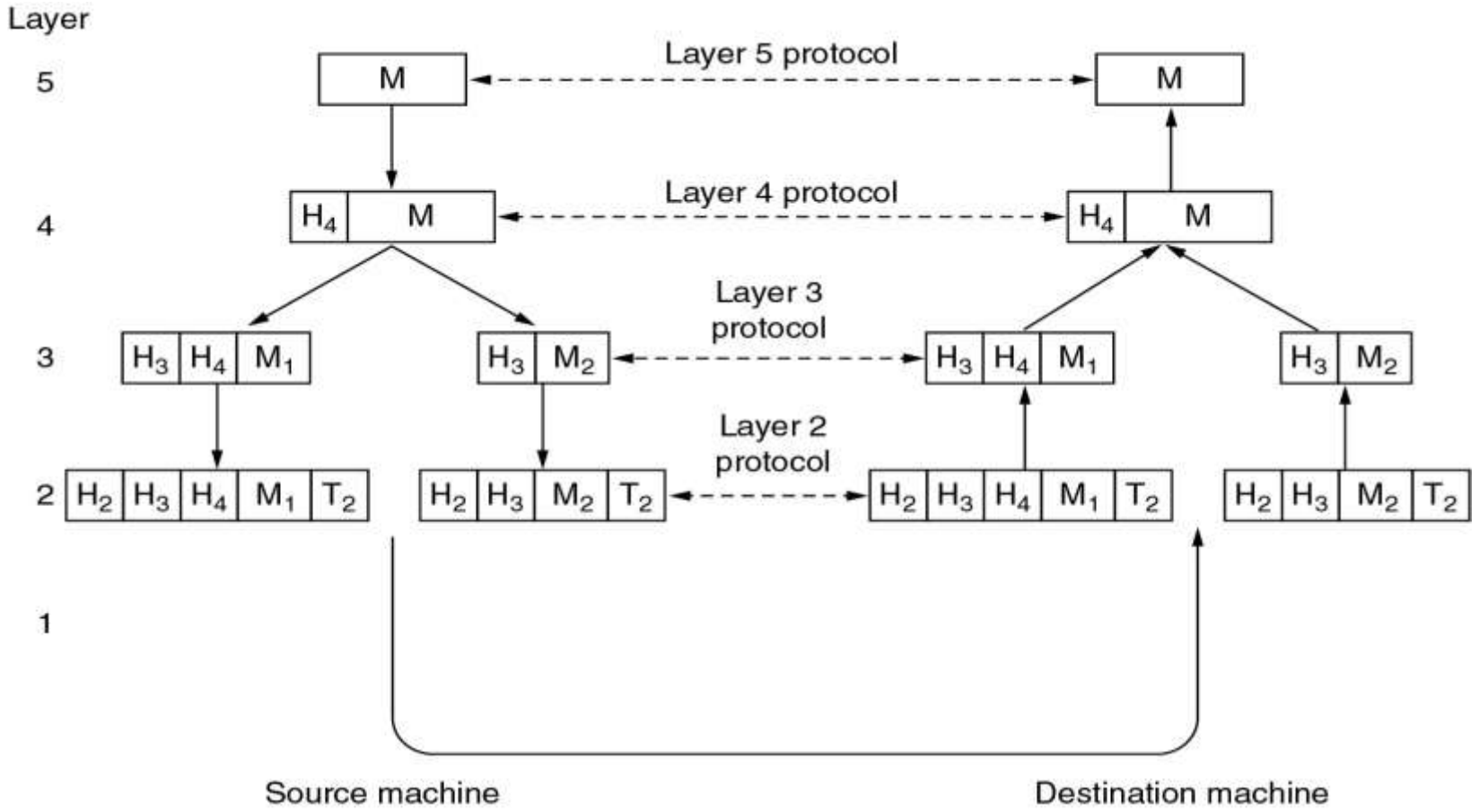

- Between each pair of adjacent layers there is an **interface.**
- A set of layers and protocols is called a **network architecture**.
- A list of protocols used by a certain system , one protocol per layer, is called a **protocol stack**.

# Protocol Hierarchies (2)




- The philosopher-translator-secretary architecture.

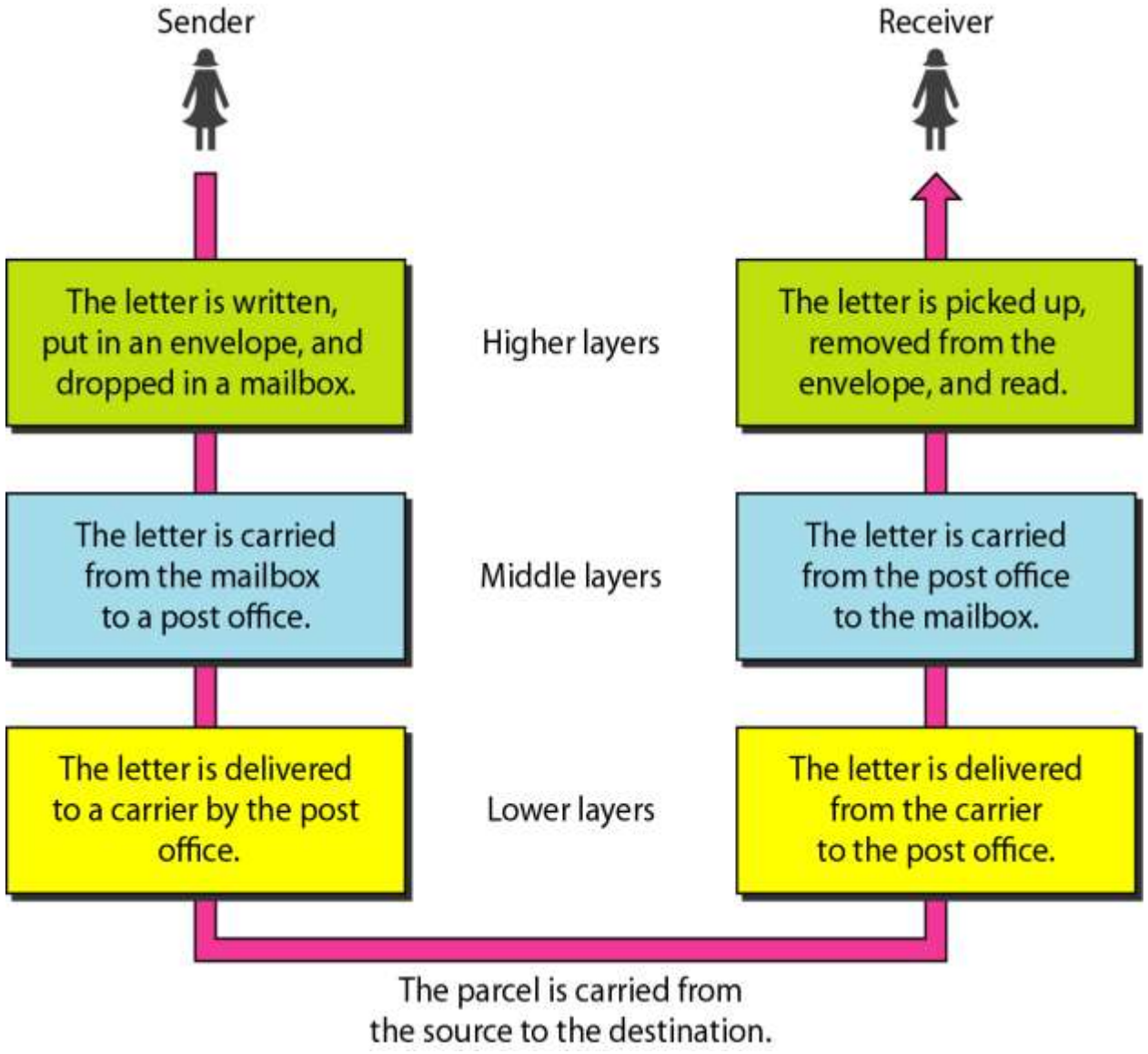
# Protocol Hierarchies (3)




- Example information flow supporting virtual communication in layer 5.

# Tasks involved in sending a letter

We use the concept of layers in our daily life. As an example, let us consider two friends who communicate through postal mail.



# Design Issues for the Layers

- Addressing – each layer needs a mechanism for identifying senders and receivers.
- The rules of data transfer – simplex, half-duplex, full-duplex
- Error Control – error-correction and error-detection
- Flow Control - The communication channels must preserve the order of messages sent on them – disassembling, transmitting, and then reassembling.
- Multiplexing – inconvenient or expensive to set up a connection for each pair of communication process.
- Routing – multiple paths between source and destination , a route must be chosen

# Connection-Oriented and Connectionless Services

- **Connection-oriented** is modeled after the **telephone system.**
- To talk to someone, you pick up the phone, dial the number, talk, and then hang up.
- To use a connection-oriented network service, the service user first establish a connection, uses the connection, and then releases the connection.
- **Connectionless** service is modeled after **postal system.**
- Each message carries the full destination address, and each one routed through the system independent of all the routers.
- When two messages sent to the same destination, the first one sent will be first one to arrive. If first one is delayed the second one arrives first.
- With connection-oriented service this is not possible.

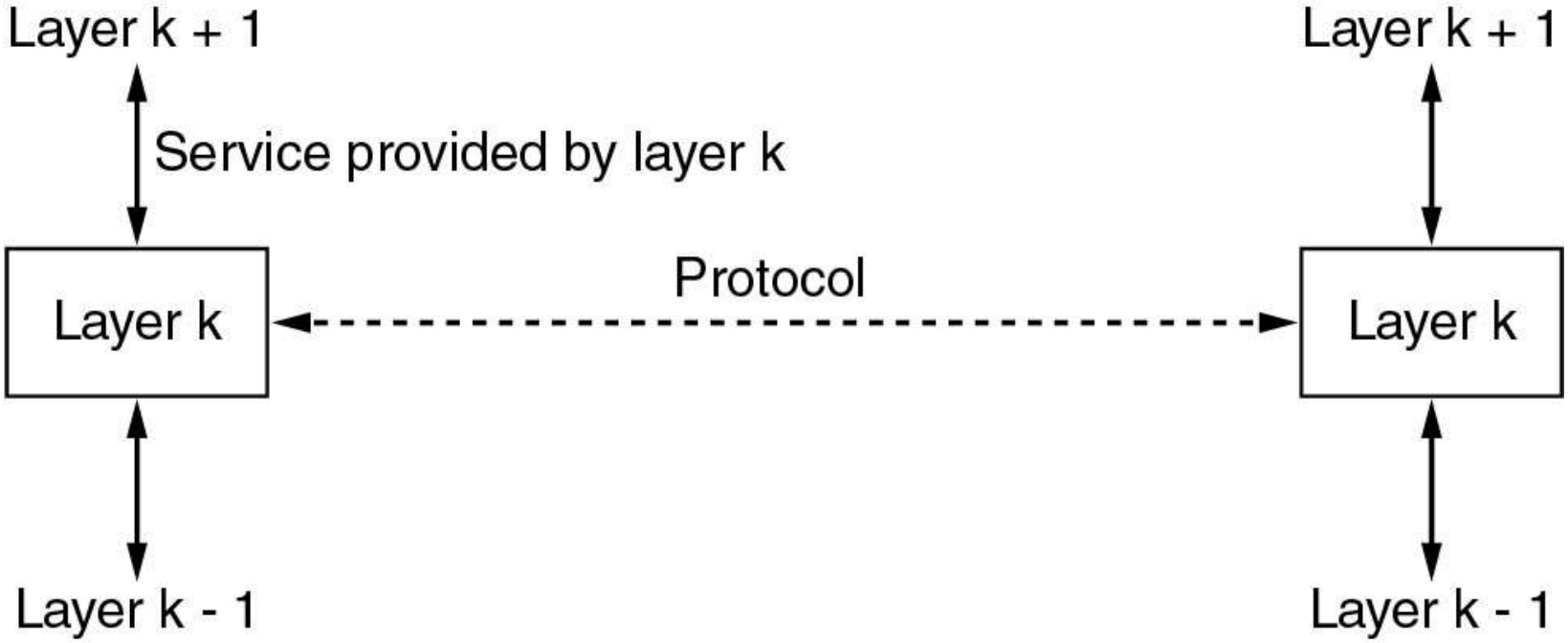
# Service Primitives

| Primitive | Meaning |
|---|---|
| LISTEN | Block waiting for an incoming connection |
| CONNECT | Establish a connection with a waiting peer |
| RECEIVE | Block waiting for an incoming message |
| SEND | Send a message to the peer |
| DISCONNECT | Terminate a connection |

- Five service primitives for implementing a simple connection-oriented service.

# Services to Protocols Relationship

- The relationship between a service and a protocol.
- A service is a set of primitives(operations)that a layer provides to the layer above it
- A protocol is a set of rules governing the format and meaning of the frames, packets, or messages that are exchanged by the peer entities within the layer



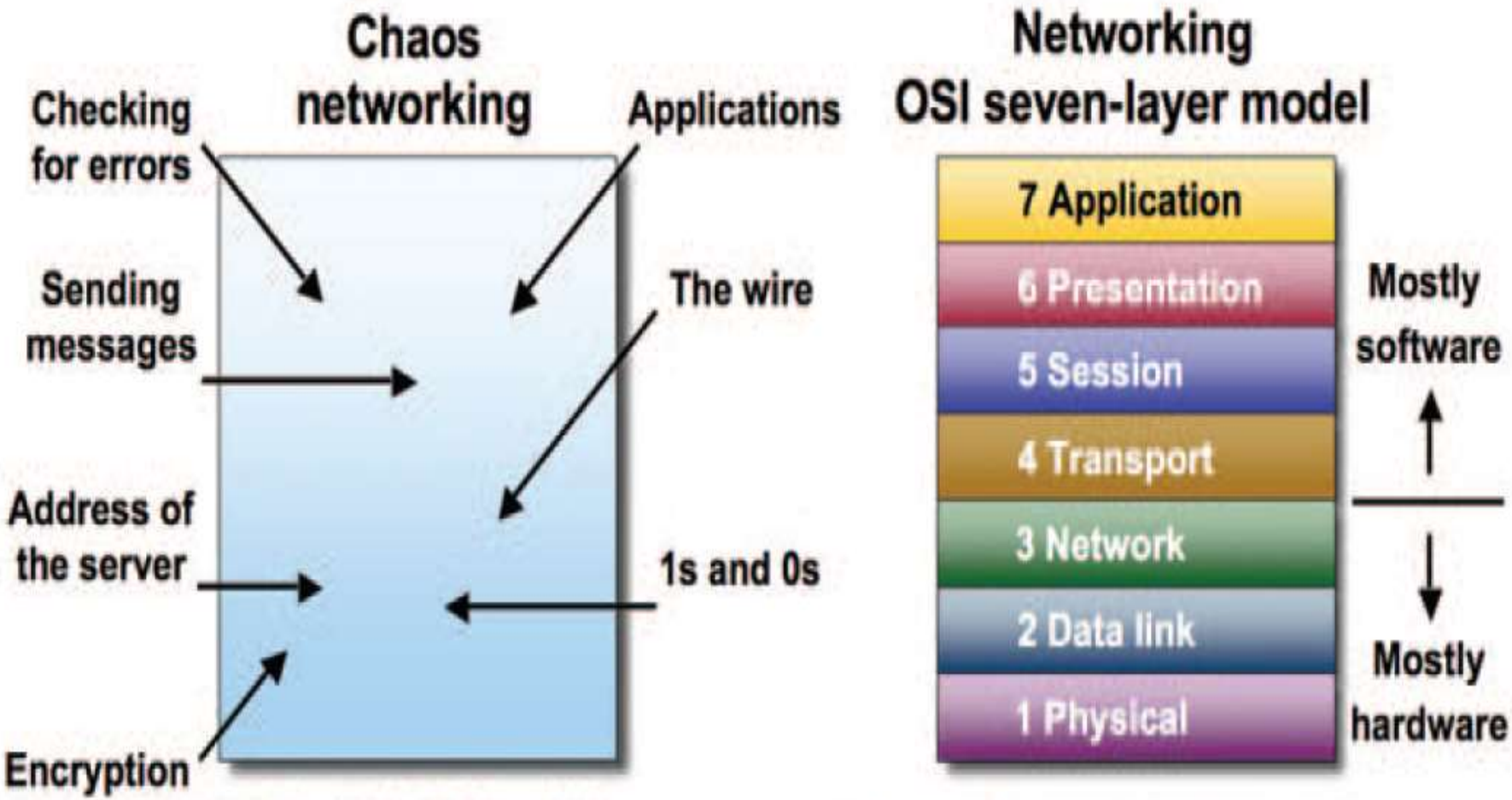
# Reference Models

- The OSI Reference Model
- The TCP/IP Reference Model

# The OSI Reference Model

- 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** model.
- In late 1970s an open system is a set of protocols that allow any two different systems to communicate
- It divides the communications processes into seven layers.

- The main concept of OSI is that the **process of communication** between two endpoints in a telecommunication network can be divided into seven distinct groups of related functions, or layers.
- Each communicating user or program is at a computer that can provide those seven layers of function.
- The seven layers of function are provided by a combination of applications, operating systems, network card device drivers and networking hardware that enable a system to put a signal on a network cable or out over Wi-Fi or other wireless protocol).



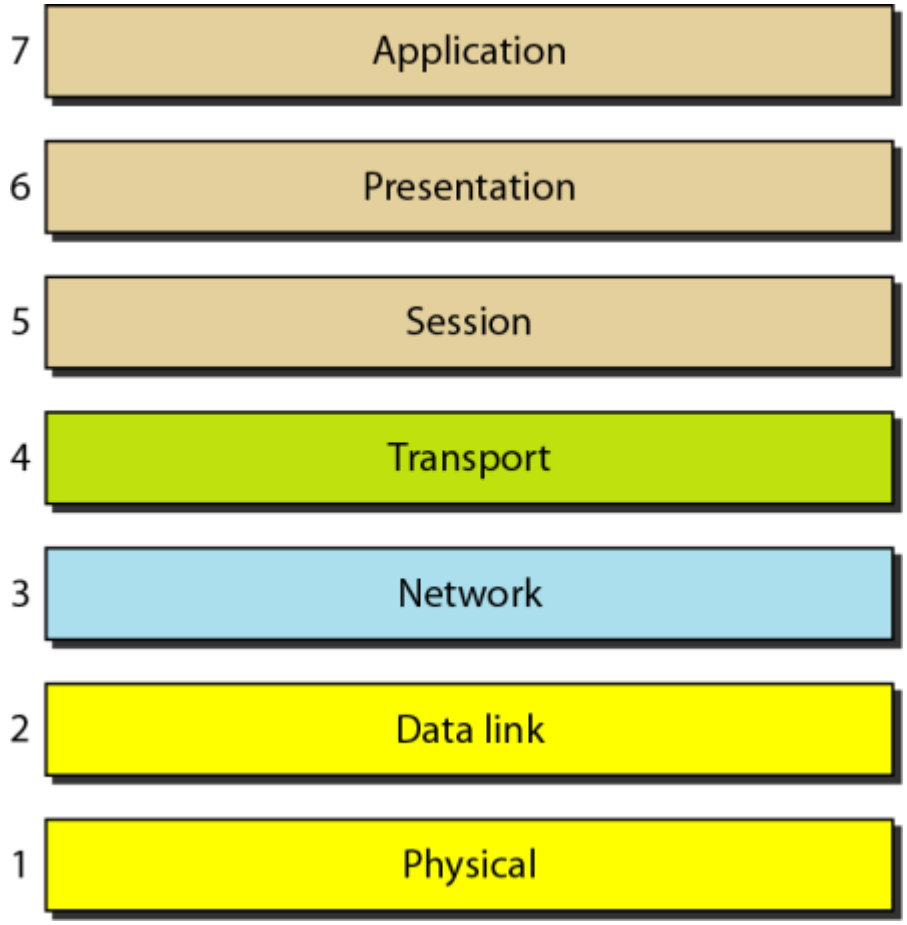

Without the OSI model, networks would be very difficult to understand and implement.

With the OSI model, networks can be broken up into manageable pieces. The OSI model provides a common language to explain components and their functionality.

**The OSI model has seven layers. The principles that were applied to arrive at the seven layers are:**

1. A layer should be created where a different level of 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 layers boundaries should be chosen to minimize the information flow across the interfaces.
5. The number of layers large enough that distinct functions need not be thrown together in the same layer out of necessity, and small enough that the architecture does not become unwieldy.

*Seven layers of the OSI model*

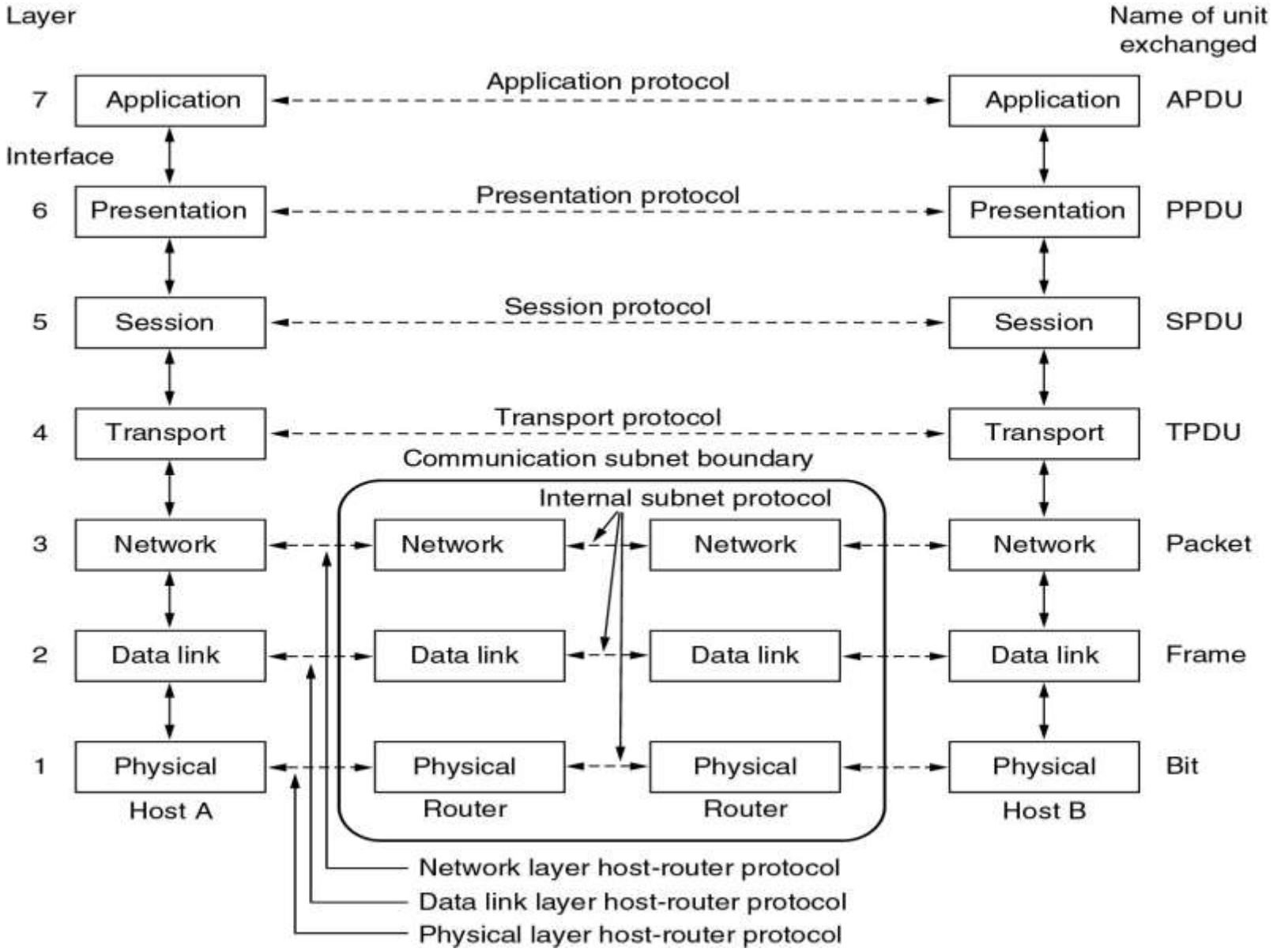


# 7 Layers

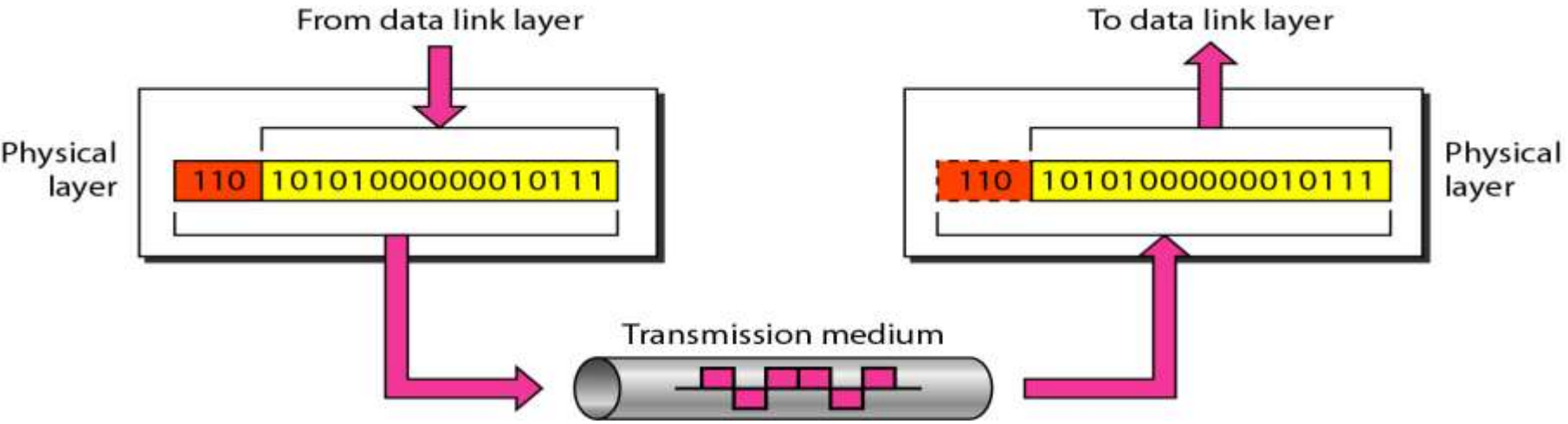
7. Application Layer
6. Presentation Layer
5. Session Layer
4. Transport Layer
3. Network Layer
2. Data Link Layer
1. Physical Layer

All
People
Seem
To
Need
Data
Processing

# The OSI reference model.

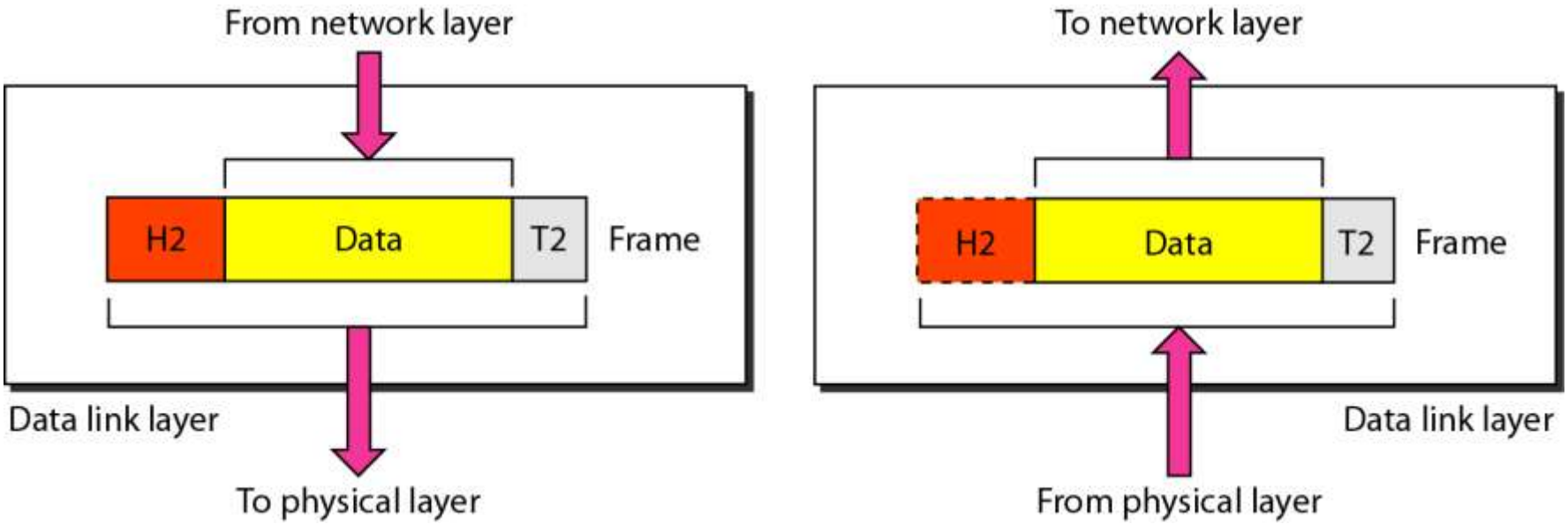


# *Physical layer*




- Converts **bits** into electronic signals for outgoing messages
- Converts electronic signals into bits for incoming messages
- The physical layer is concerned with transmitting raw bits over a communication channel. The design issues have to do with making sure that when one side sends a 1 bit, it is received by the other side as a 1 bit, not as a 0 bit.
- The design issues are
  - **Transmission medium**
  - **Synchronization of bits**
  - **Physical topology**
  - **Transmission mode**
- The bottom layer of the OSI model

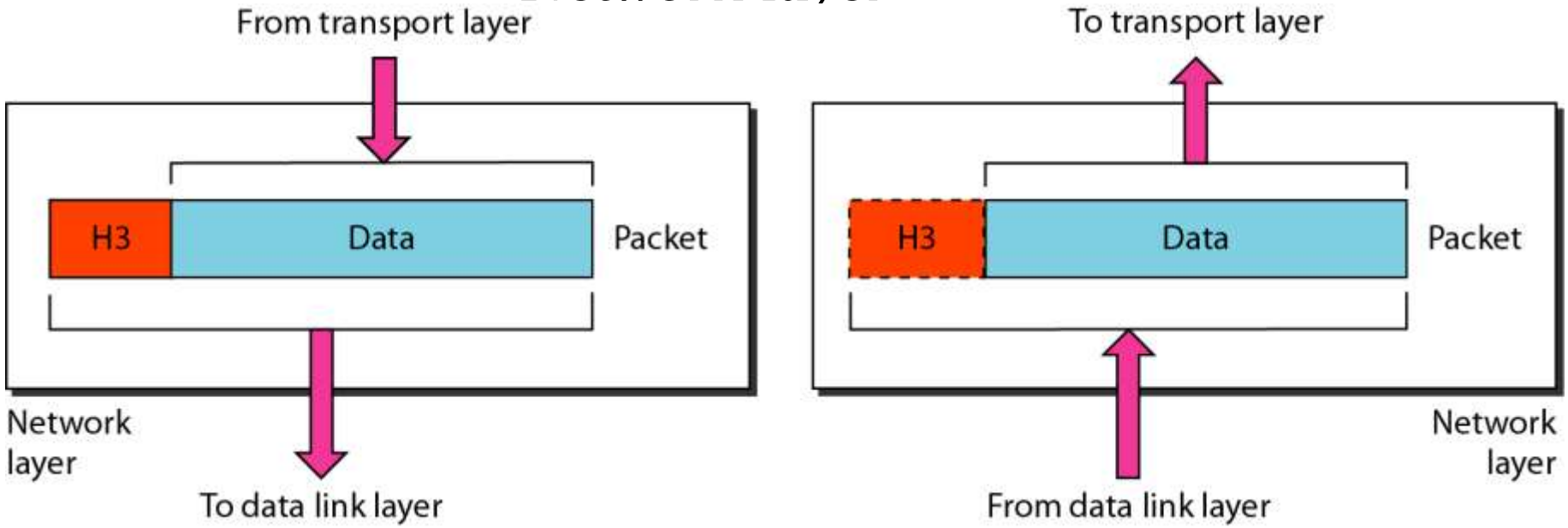
# *Data link layer*




- 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 a few thousand bytes) and transmits the frames sequentially.

- At the receiving end, this layer packages raw data from the physical layer into data frames for delivery to the Network layer
- At the sending end this layer handles conversion of data into raw formats that can be handled by the Physical Layer
- If the service is reliable, the receiver confirms correct receipt of each frame by sending back an **acknowledgement frame**
- The physical layer accepts and transmits stream of bits, the data link layer should create and recognize frame boundaries. This can be accomplished by attaching **special bit patterns to the beginning and ending of frame.**
- A duplicate frame could be sent if the acknowledgement frame from receiver back to the sender were lost.

# *Network layer*



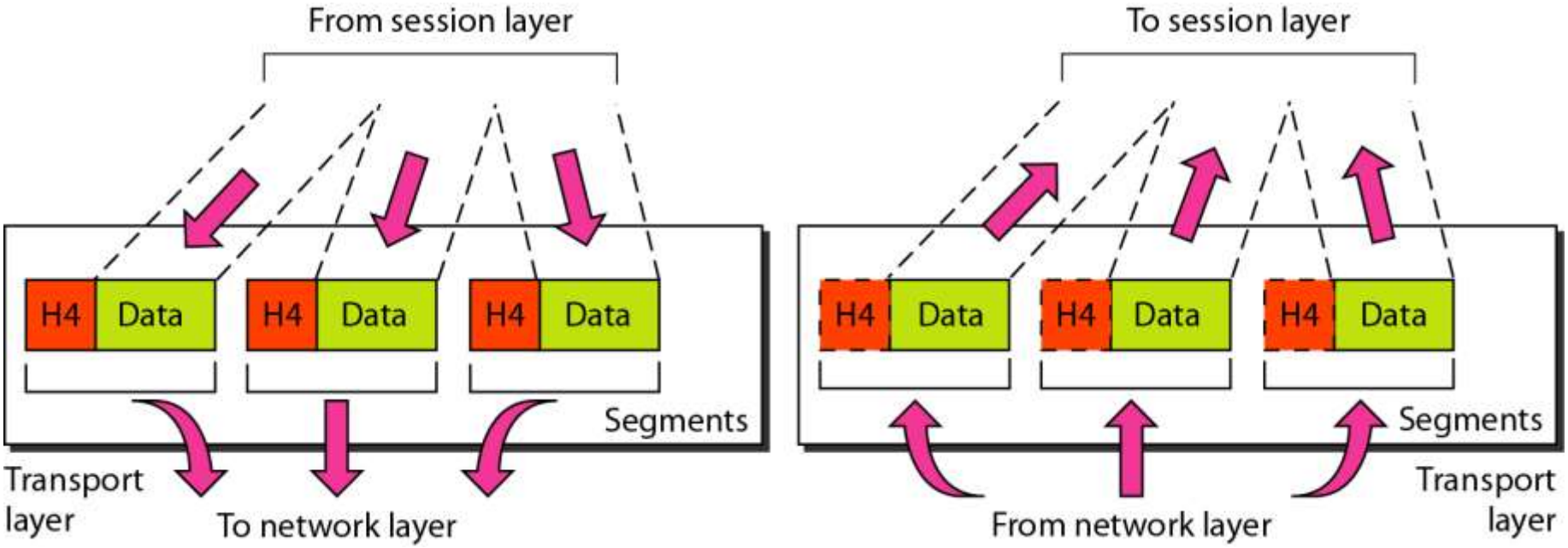

•The network layer controls the operation of the **subnet**.

•The network layer is responsible for the delivery of individual **packets** from the source host to the destination host.

•The network layer controls the operation of the subnet. 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 determined at the **start of each conversation.**
- If too many packets are present in the subnet at the same time, they will get in one another's way, forming bottlenecks. The **control of such congestion** also belongs to the network layer.
- When a packet has to travel from one network to another to get to its destination, many problems can arise. 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

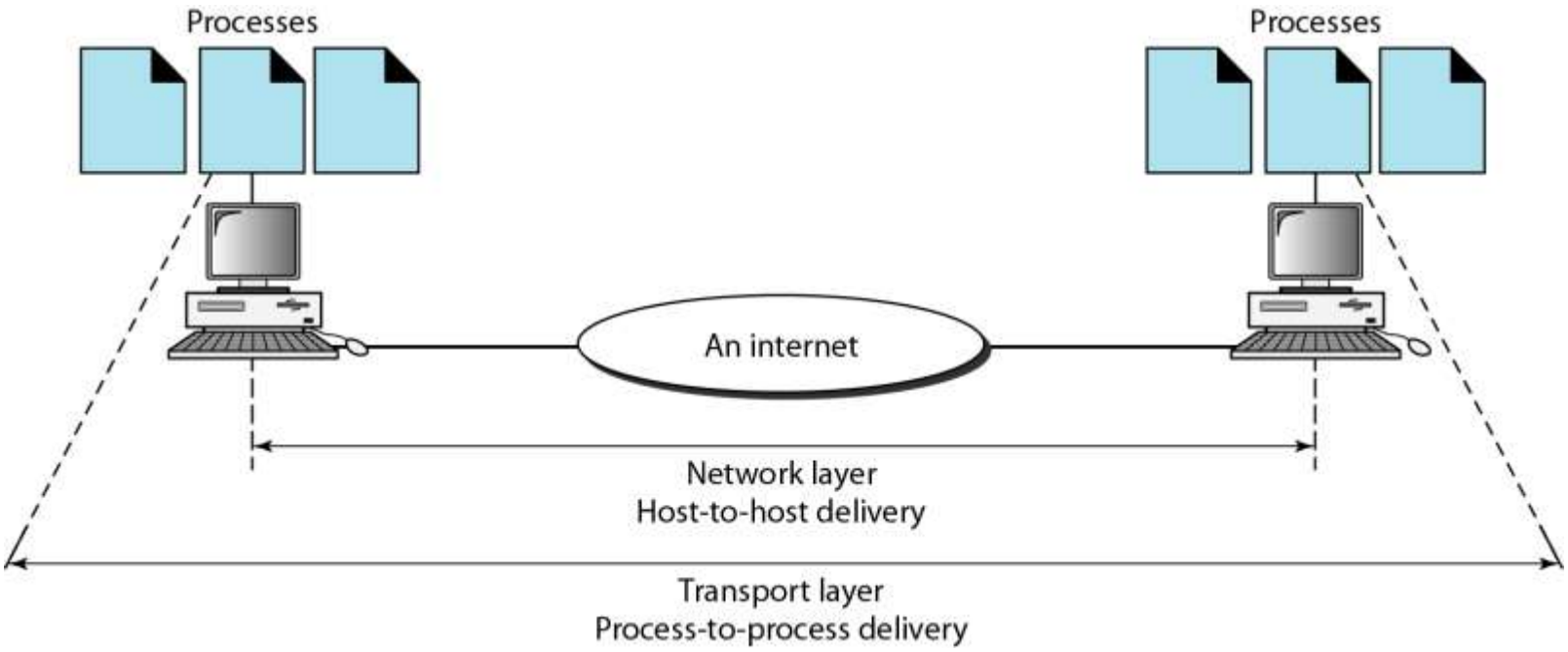
# *Transport layer*



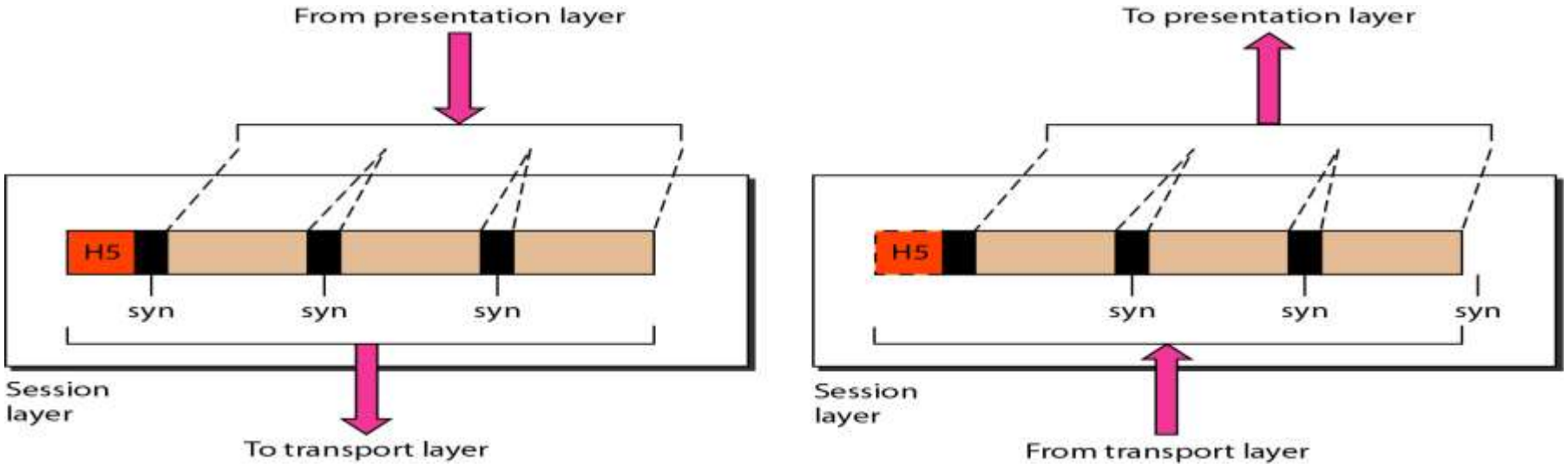

- **Manages the transmission** of data across a network
- Manages the flow of data between parties by segmenting long data streams into smaller data chunks (based on allowed “packet” size for a given transmission medium)
- Reassembles chunks into their original sequence at the receiving end
- Provides **acknowledgements of successful transmissions** and requests **resends for packets** which arrive with **errors**

•The basic function of the transport layer is to accept data from above, split it up into smaller units if need be, pass these to the network layer, and ensure that the pieces all arrive correctly at the other end.
•The transport layer is responsible for the delivery of a message from one process to another.
•**If** transport connection requires a high throughput, the transport layer might create multiple network connections.(if expensive multiple several transport connections onto the same network connection).
•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 type of service is determined when the **connection is established**.
•The transport layer is a **true end-to-end layer**, all the way from the source to the destination.
•The difference between layer 1 through 3 , which are chained, and layer 4 through 7, which are end-to-end

*Reliable process-to-process delivery of a message*



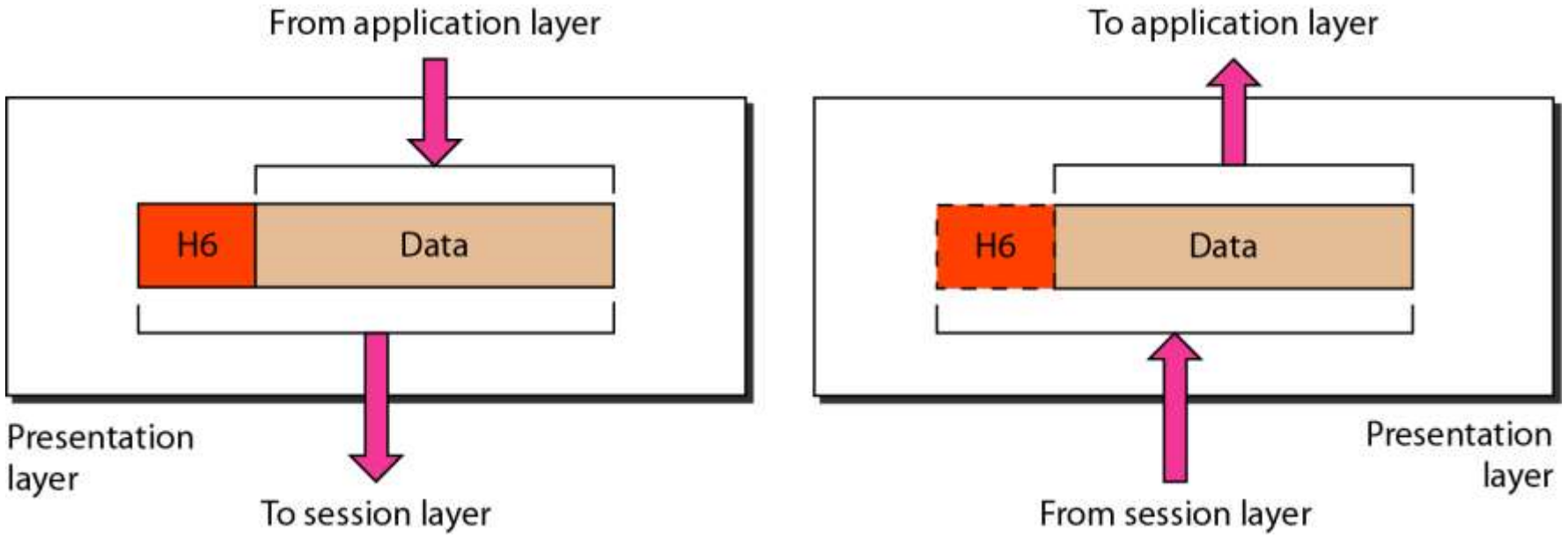
# *Session layer*




•The session layer allows users on different machines to establish sessions between them.

•Sessions offer various services, including **dialog control** (keeping track of whose turn it is to transmit), **token management** (preventing two parties from attempting the same critical operation at the same time), and **synchronization** (check pointing long transmissions to allow them to continue from where they were after a crash).

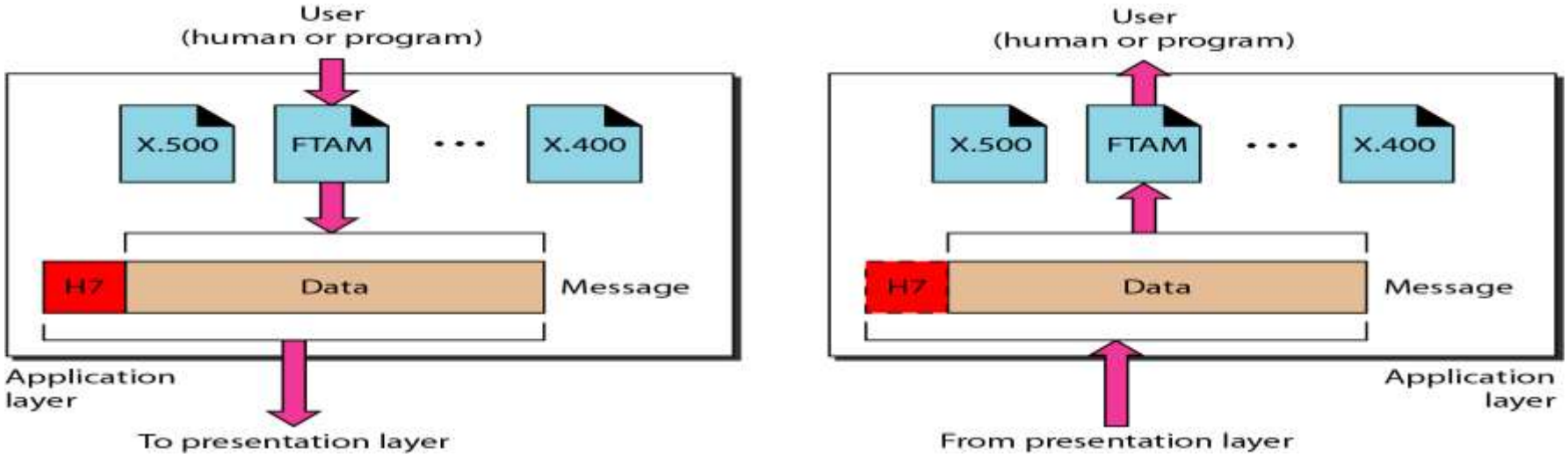
# *Presentation layer*




•The presentation layer is concerned with the **syntax** and **semantics** of the information transmitted.

•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, along with a standard encoding to be used "on the wire." The presentation layer manages these abstract data structures and allows higher-level data structures (e.g., banking records), to be defined and exchanged.

# *Application layer*

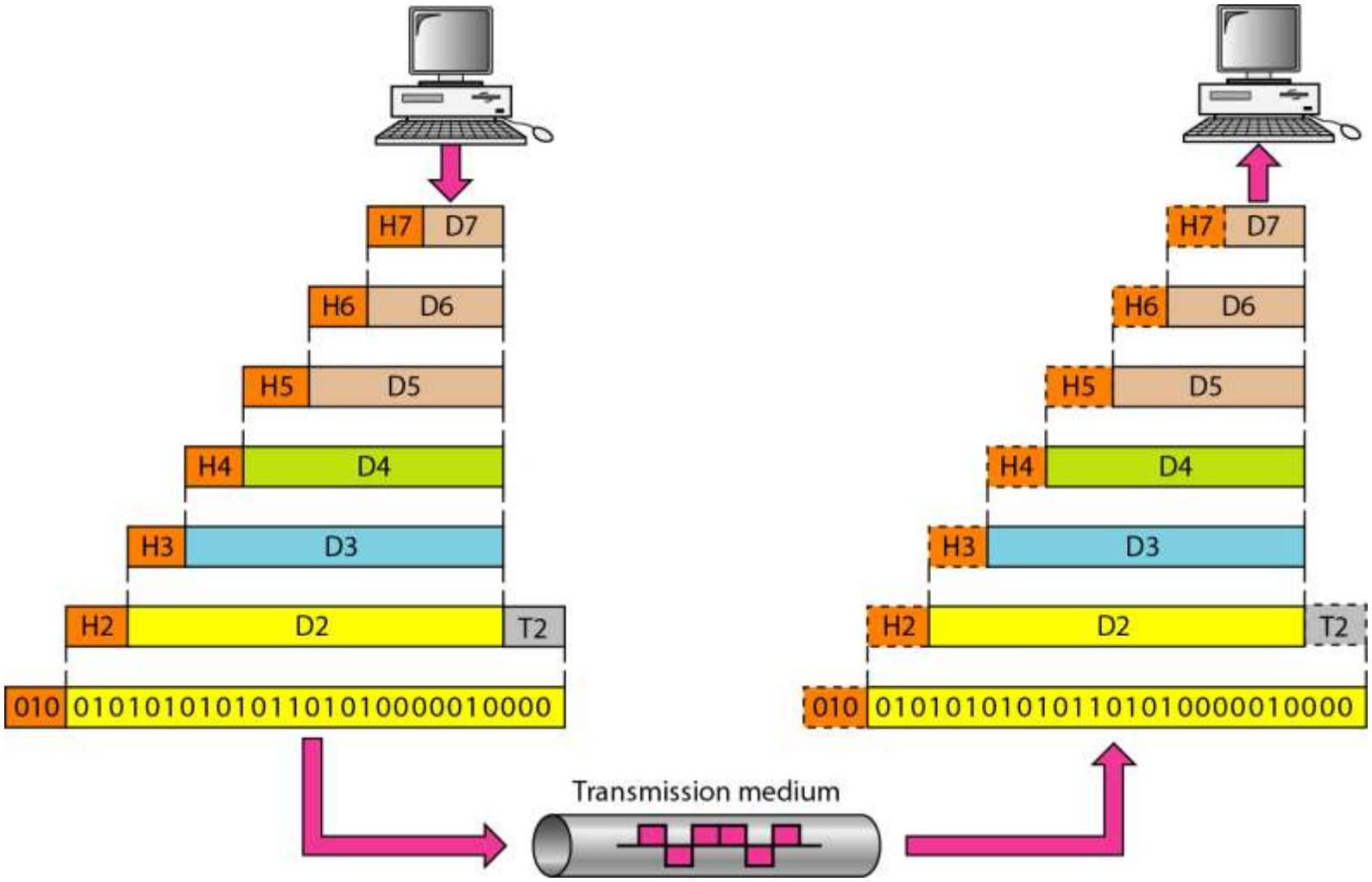



•The application layer is responsible for **providing services to the user**.

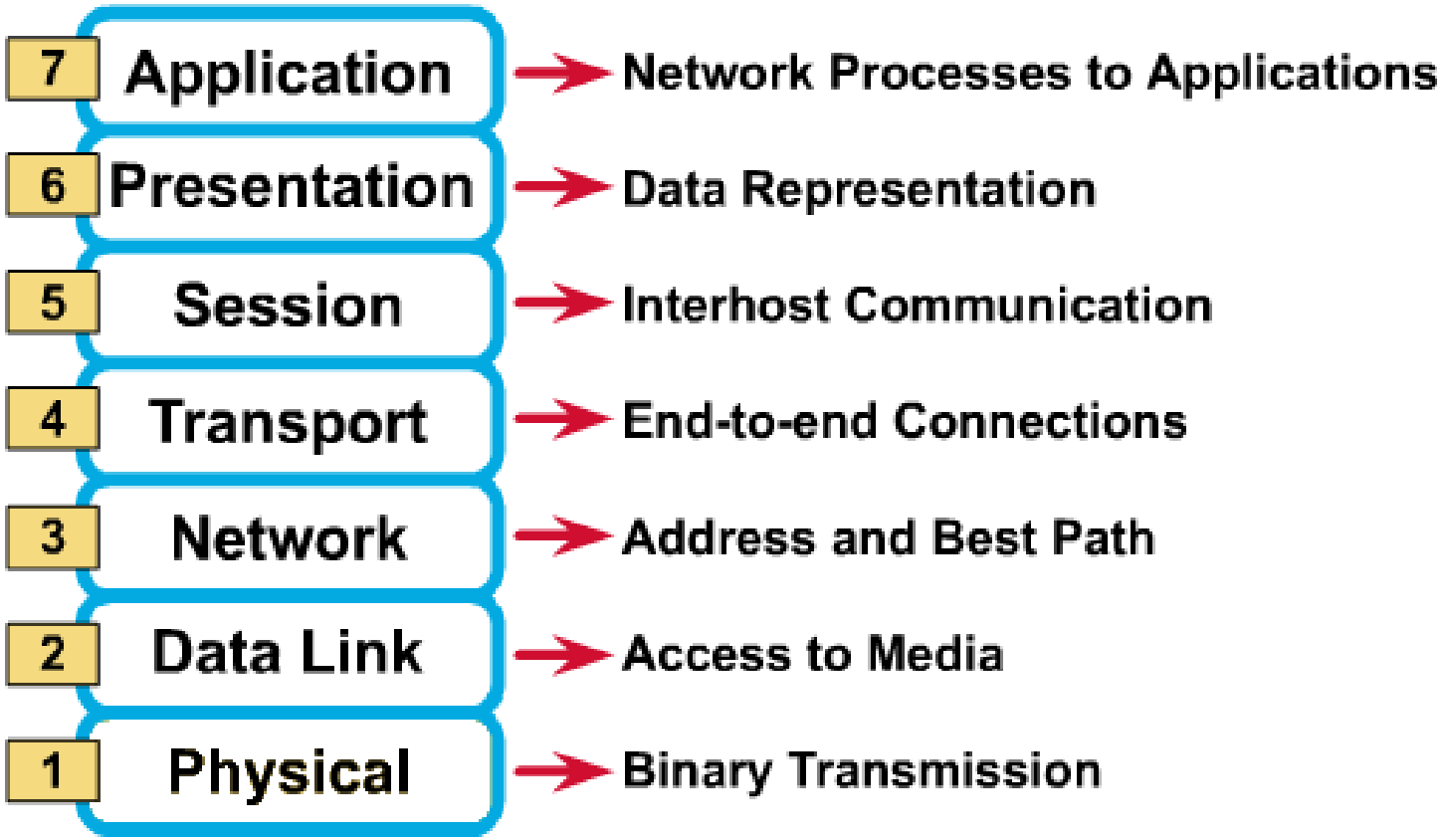
•The application layer contains a variety of protocols that are commonly needed by users. One widely-used application protocol is HTTP (Hypertext Transfer Protocol), which is the basis for the World Wide Web. When a browser wants a Web page, it sends the name of the page it wants to the server using HTTP. The server then sends the page back. Other application protocols are used for file transfer, electronic mail, and network news.

•Network virtual terminal

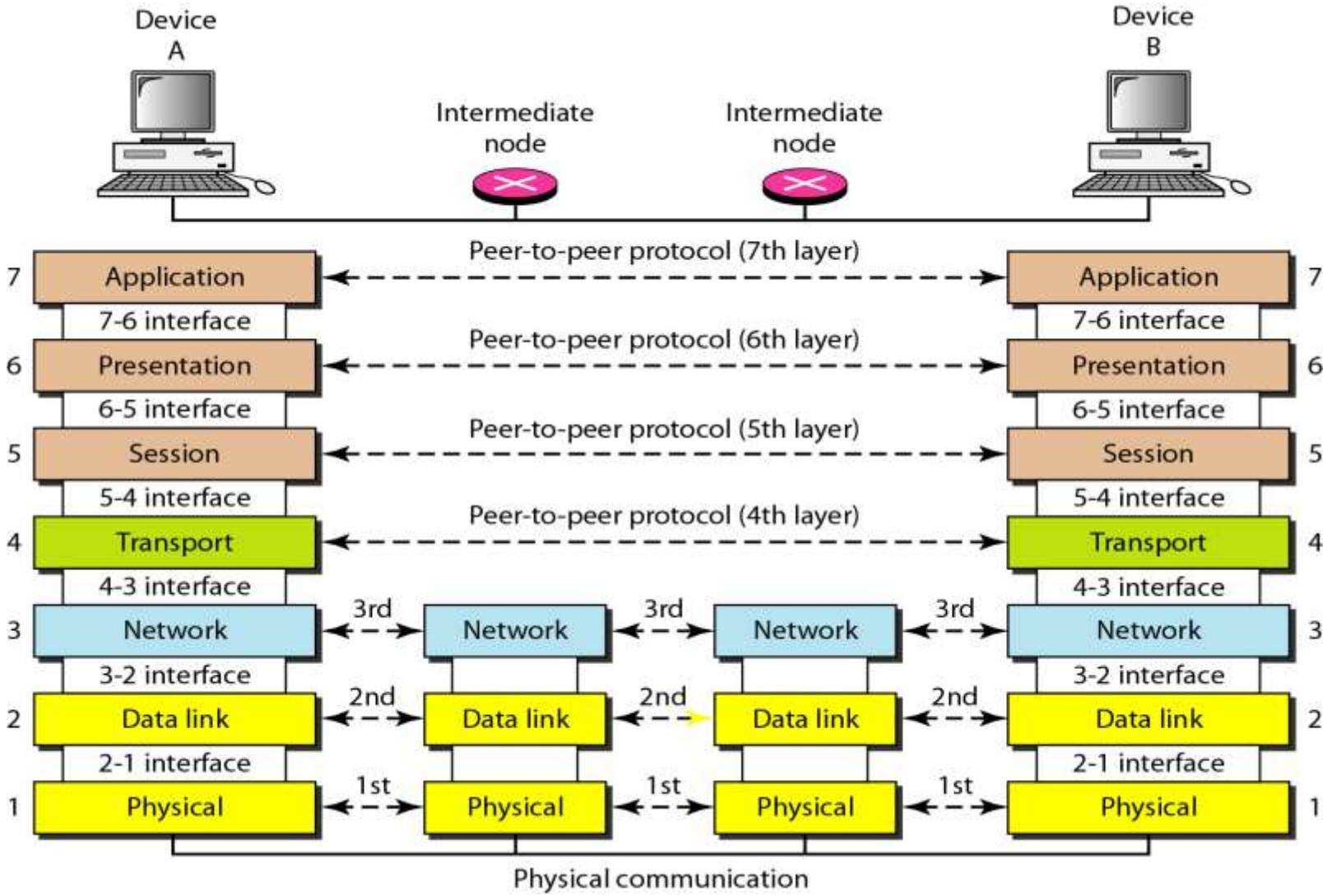
*An exchange using the OSI model*



# THE SEVEN OSI REFERENCE MODEL LAYERS



*The interaction between layers in the OSI model*



# The TCP/IP reference model

The TCP/IP reference model was developed prior to OSI model. The major design goals of this model were,

1. To connect multiple networks together so that they appear as a single network.

2. To survive after partial subnet hardware failures.

3. To provide a flexible architecture.

**Transmission control protocol/ information protocol**

Unlike OSI reference model, TCP/IP reference model has only 4 layers. They are,

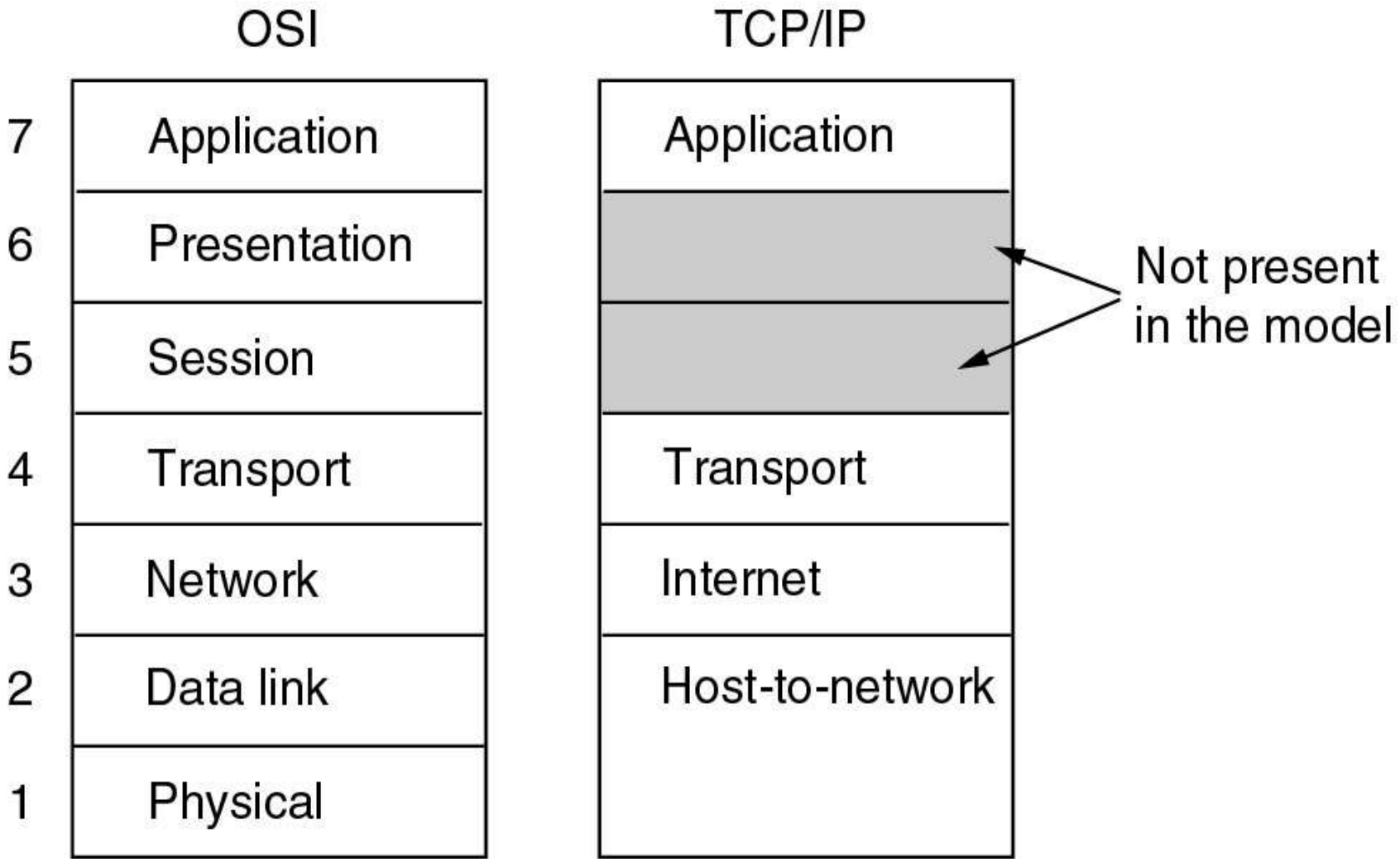
1. Host-to-Network Layer

2. Internet Layer

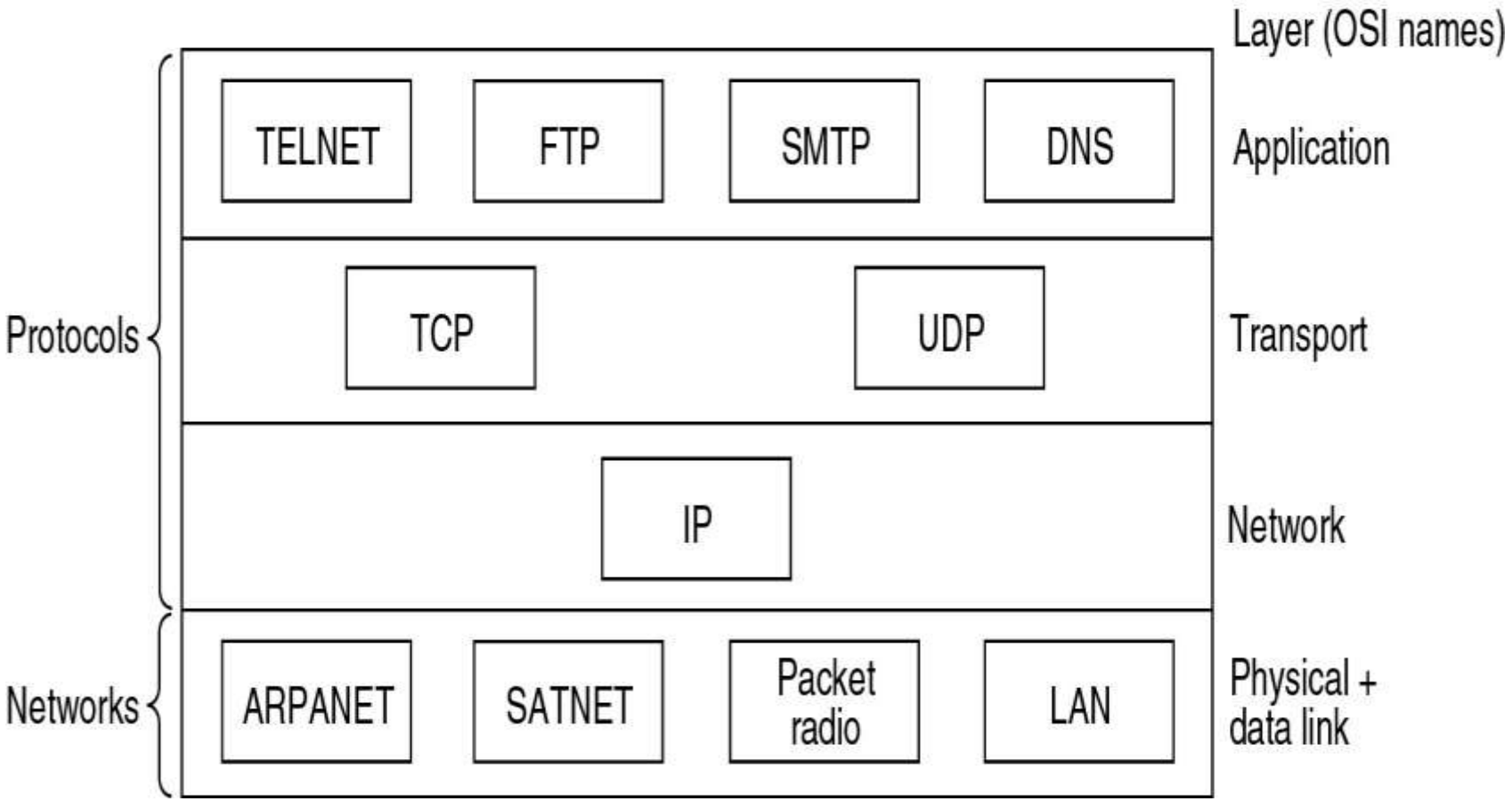
3. Transport Layer

4. Application Layer

- The TCP/IP reference model.



- Protocols and networks in the TCP/IP model initially.



# Internet layer

- Its job is to permit hosts to inject packets into any network and have they travel independently to the destination (potentially on a different network).
- They may even arrive in a different order than they were sent, in which case it is the job of higher layers to rearrange them, if in-order delivery is desired.
- The internet layer defines an official packet format and protocol called **IP (Internet Protocol).**
- The job of the internet layer is to deliver IP packets where they are supposed to go.
- Packet routing is clearly the major issue here, as is avoiding congestion.

# Transport layer

- It is designed to allow peer entities on the source and destination hosts to carry on a conversation, just as in the OSI transport layer.
- Two end-to-end transport protocols have been defined here.
- **TCP** (Transmission Control Protocol), is a reliable connection-oriented protocol that allows a byte stream originating on one machine to be delivered without error on any other machine in the internet.
  - It fragments the incoming byte stream into discrete messages and passes each one on to the internet layer. At the destination, the receiving TCP process reassembles the received messages into the output stream.

    TCP also handles flow control
- **UDP** (User Datagram Protocol), is an unreliable, connectionless protocol 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(transmitting speech or video.)

# Application layer

- The TCP/IP model does not have session or presentation layers. On top of the transport layer is the application layer. It contains all the higher-level protocols.
- The early ones included virtual terminal (TELNET), file transfer (FTP), and electronic mail (SMTP).
- The virtual terminal protocol allows a user on one machine to log onto a distant machine and work there.
- The file transfer protocol provides a way to move data efficiently from one machine to another.
- Electronic mail was originally just a kind of file transfer, but later a specialized protocol (SMTP) was developed for it. Many other protocols have been added to these over the years: the Domain Name System (DNS) for mapping host names onto their network addresses, and HTTP, the protocol for fetching pages on the World Wide Web, and many others.

- **Telnet** is a network protocol used on the Internet or local area networks to provide a bidirectional interactive text-oriented communication facility using a virtual terminal connection.
- The term *telnet* may also refer to the software that implements the client part of the protocol. Telnet client applications are available for virtually all computer platforms. *To telnet* means to establish a connection with the Telnet protocol, either with command line client or with a programmatic interface.
- The Telnet program runs on your computer and connects your PC to a server on the network. You can then enter commands through the Telnet program and they will be executed as if you were entering them directly on the server .This enables you to control the server and communicate with other servers on the network.
- To start a Telnet session, you must log in to a server by entering a valid username and password. Telnet is a common way to remotely control Web servers.

- The **File Transfer Protocol** (**FTP**) is a standard network protocol used to transfer computer files from one host to another host over a TCP-based network, such as the Internet.
- FTP is built on a client-server architecture and uses separate control and data connections between the client and the server.
- The first FTP client applications were command-line applications developed before operating systems had graphical user interfaces, and are still shipped with most Windows, Unix, and Linux operating systems. Many FTP clients and automation utilities have since been developed for desktops, servers, mobile devices, and hardware, and FTP has been incorporated into productivity applications, such as Web page editors

- **Simple Mail Transfer Protocol** (**SMTP**) is an Internet standard for electronic mail (e-mail) transmission
- Short for ***S**imple **M**ail **T**ransfer **P**rotocol*, a protocol for sending e-mail messages between servers.
- Most e-mail systems that send mail over the Internet use SMTP to send messages from one server to another; the messages can then be retrieved with an e-mail client using either POP or IMAP.
- In computing, the **Post Office Protocol** (**POP**) is an application-layer Internet standard protocol used by local e-mail clients to retrieve e-mail from a remote server over a TCP/IP connection.
- Virtually all modern e-mail clients and servers support POP and IMAP (**Internet Message Access Protocol)** are the two most prevalent Internet standard protocols for e-mail retrieval ,with many webmail service providers such as Gmail, Outlook.com and Yahoo! Mail also providing support for either IMAP or POP3 to allow mail to be downloaded.

- The **Domain Name System** (**DNS**) is a hierarchical distributed naming system for computers, services, or any resource connected to the Internet or a private network. It associates various information with domain names assigned to each of the participating entities.
- The Domain Name System distributes the responsibility of assigning domain names and mapping those names to IP addresses by designating authoritative name servers for each domain. Authoritative name servers are assigned to be responsible for their supported domains. This mechanism provides distributed and fault tolerant service and was designed to avoid the need for a single central database.

# Host-to-Network Layer:

- The TCP/IP reference model does not really say much about what happens here, except to point out that the host has to connect to the network using some protocol so it can send IP packets to it.
- This protocol is not defined and varies from host to host and network to network.

- The **Advanced Research Projects Agency Network** (**ARPANET**) was one of the world's first operational packet switching networks, the first network to implement TCP/IP, and was the main progenitor of what was to become the global Internet.
- The network was initially funded by the Advanced Research Projects Agency (ARPA, later DARPA) within the U.S. Department of Defense for use by its projects at universities and research laboratories in the US.
- The packet switching of the ARPANET, together with TCP/IP, would form the backbone of how the Internet works.

- SATNet - Satellites Network
- The SATNet network is providing the first network for sharing ground stations in between the members of the community of CubeSat developers.

- **Packet radio** is a form of packet switching technology used to transmit digital data via radio or wireless communications links. It uses the same concepts of data transmission via Datagram .
- A **datagram** is a basic transfer unit associated with a packet-switched network. The delivery, arrival time, and order of arrival need not be guaranteed by the network.

# Comparing OSI and TCP/IP Models

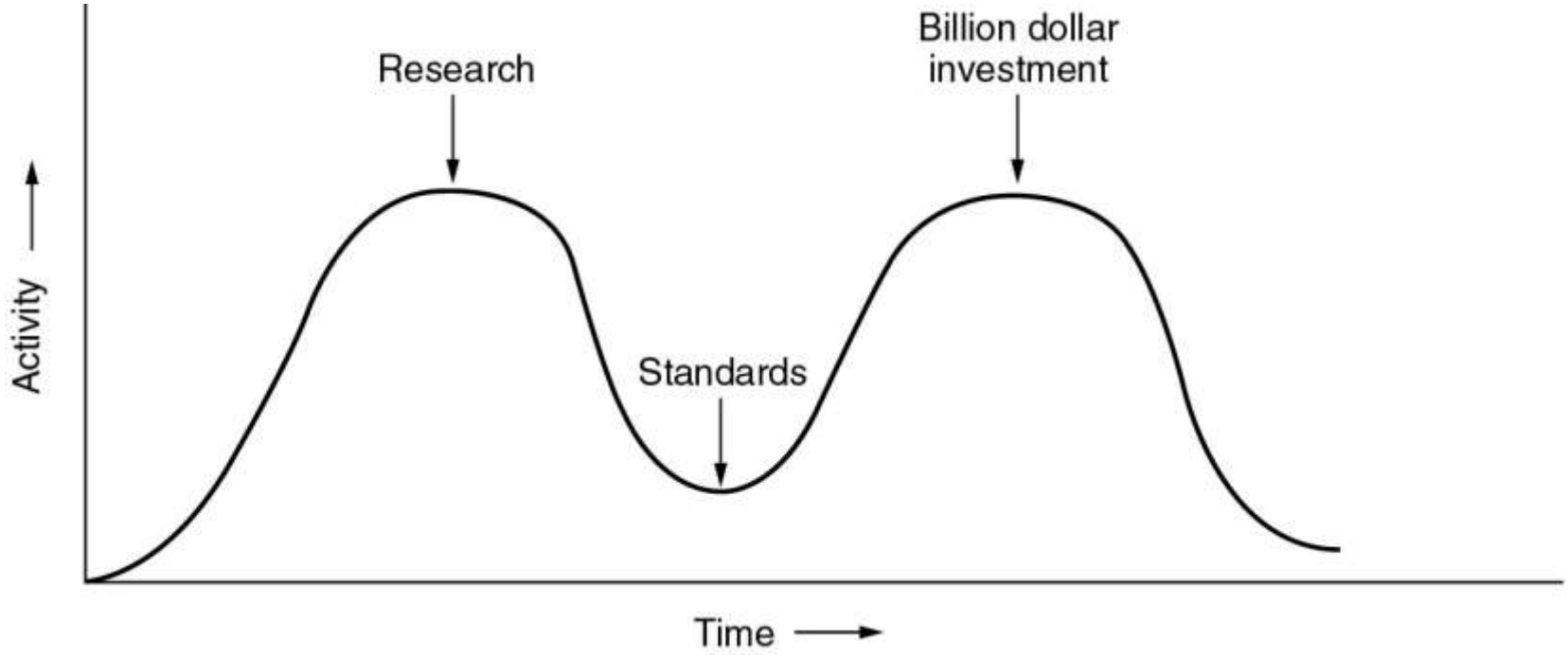
Concepts central to the OSI model

- Services
- Interfaces
- Protocols

# A Critique of the OSI Model and Protocols

- Bad timing
- Bad technology
- Bad implementations
- Bad politics

# Bad Timing

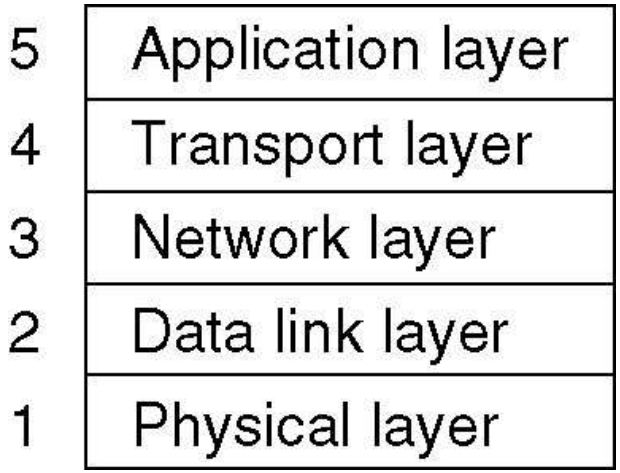
- 
Research
Billion dollar investment
Standards
Activity
Time

# A Critique of the TCP/IP Reference Model

- Problems:
- Service, interface, and protocol not distinguished
- Not a general model
- Host-to-network “layer” not really a layer
- No mention of physical and data link layers
- Minor protocols deeply entrenched, hard to replace

# Hybrid Model

- The hybrid reference model to be used in this book.

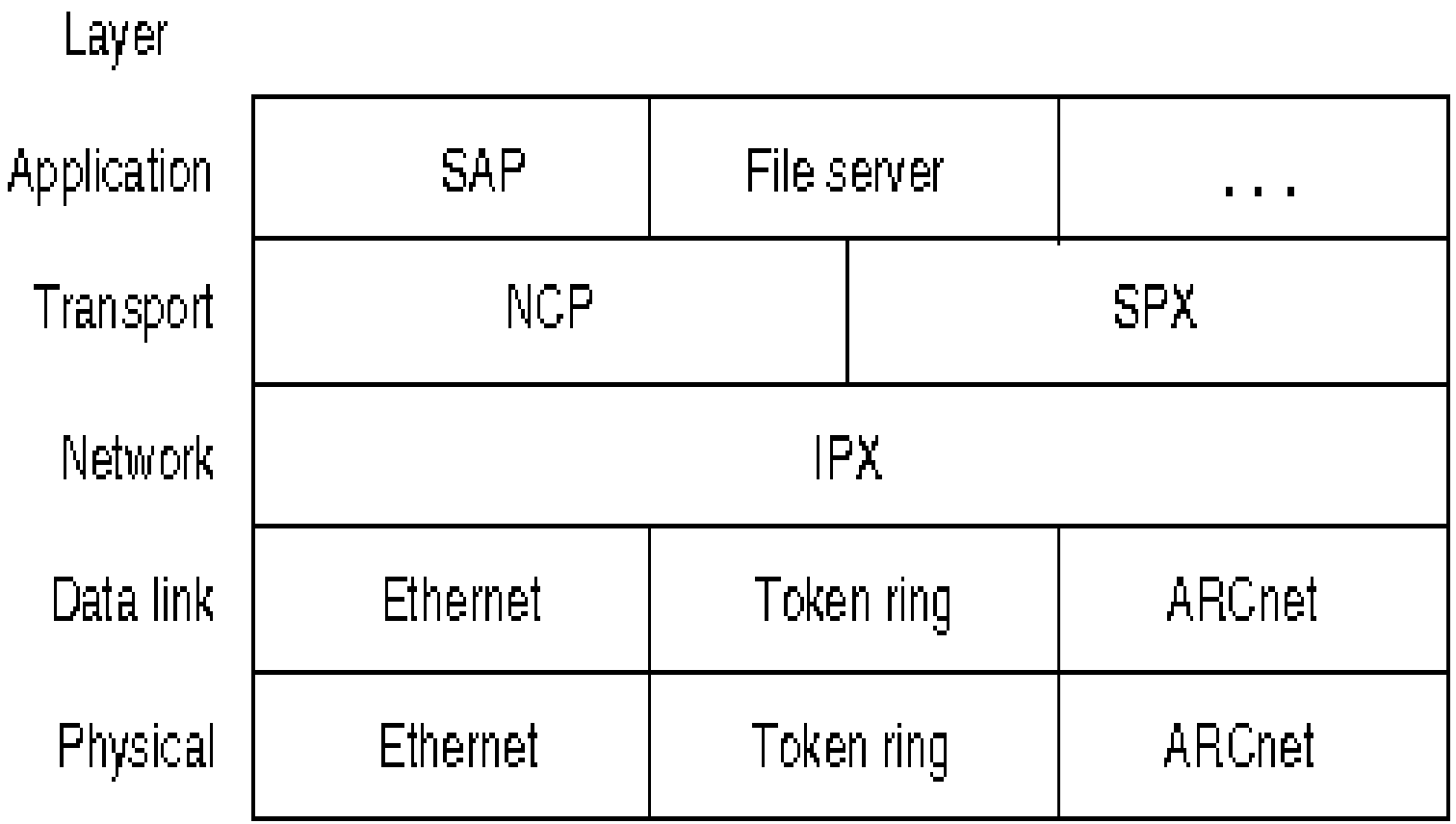


# Example networks

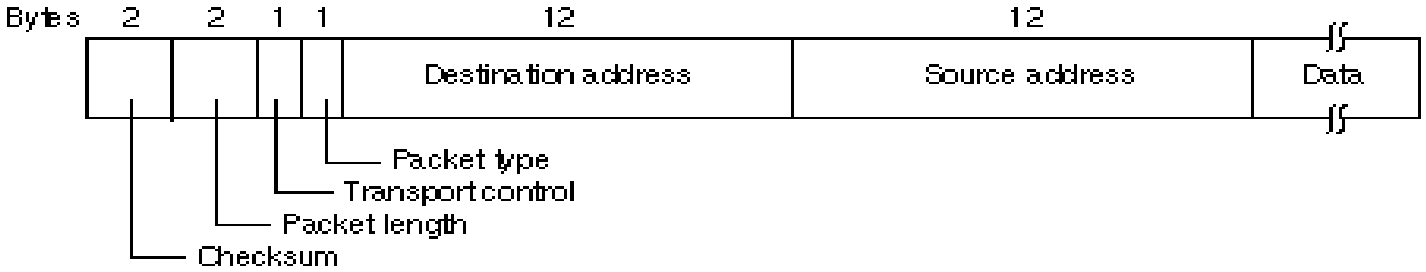
- Novell NetWare
- ARPANET
- INTERNET

# Novell NetWare

- The most popular network system in the PC world is Novell NetWare.
- It is designed to be used by the companies downsizing from a mainframe to a network of PCs.
- This is based on client-server model – PCs operate as servers, providing file services, database service, and other services to clients.
- The physical and data link layers can be chosen from among various industry standards, including Ethernet, IBM token ring ,and ARC net.


Layer
Application
SAP
File server
. . .
Transport
NCP
SPX
Network
IPX
Data link
Ethernet
Token ring
ARCnet
Physical
Ethernet
Token ring
ARCnet

- The network layer runs an unreliable connectionless internetwork protocol called IPX(internet packet exchange)
  - It passes packets transparently from source to destination, even if the source and destination are on different networks.
  - IPX is similar to IP, expect that uses 10-byte addresses instead of 4-byte addresses.
  - NCP (Network core protocol) is a connection-oriented transport protocol.
  - SPX(sequenced packet exchange) is also available, but provides only transport.
- The format of an IPX packet is:




- SAP ( service advertising protocol)
  - The packets are collected by special agent processes running on the router machine. The agents use the information contained in them to construct database of which servers are running where.
  - When a client machine is booted, it broadcast a request asking where the nearest server is, the agent on local router machine sees the request looks in database for best server.
  - The choice of server is send back to the client. The client establishes a NCP connection with server. Using this the client and server negotiates the maximum packet size.

- **Ethernet** is a family of computer networking technologies for local area networks (LANs) and metropolitan area networks(MANs).
- Systems communicating over Ethernet divide a stream of data into shorter pieces called frames.
- Each frame contains source and destination addresses and error-checking data so that damaged data can be detected and re-transmitted.

- **Token ring** local area network (LAN) technology is a protocol which resides at the data link layer (DLL) of the OSI model. It uses a special three-byte frame called a token that travels around the ring. Token-possession grants the possessor permission to transmit on the medium. Token ring frames travel completely around the loop.
- Initially used only in IBM computers, it was eventually standardized with protocol **IEEE 802.5**.
- The data transmission process goes as follows:
- Empty information frames are continuously circulated on the ring. When a computer has a message to send, it seizes the token. The computer will then be able to send the frame.
- The frame is then examined by each successive workstation. The workstation that identifies itself to be the destination for the message copies it from the frame and changes the token back to 0.
- The frame continues to circulate as an "empty" frame, ready to be taken by a workstation when it has a message to send.
- The token scheme can also be used with bus topology LANs

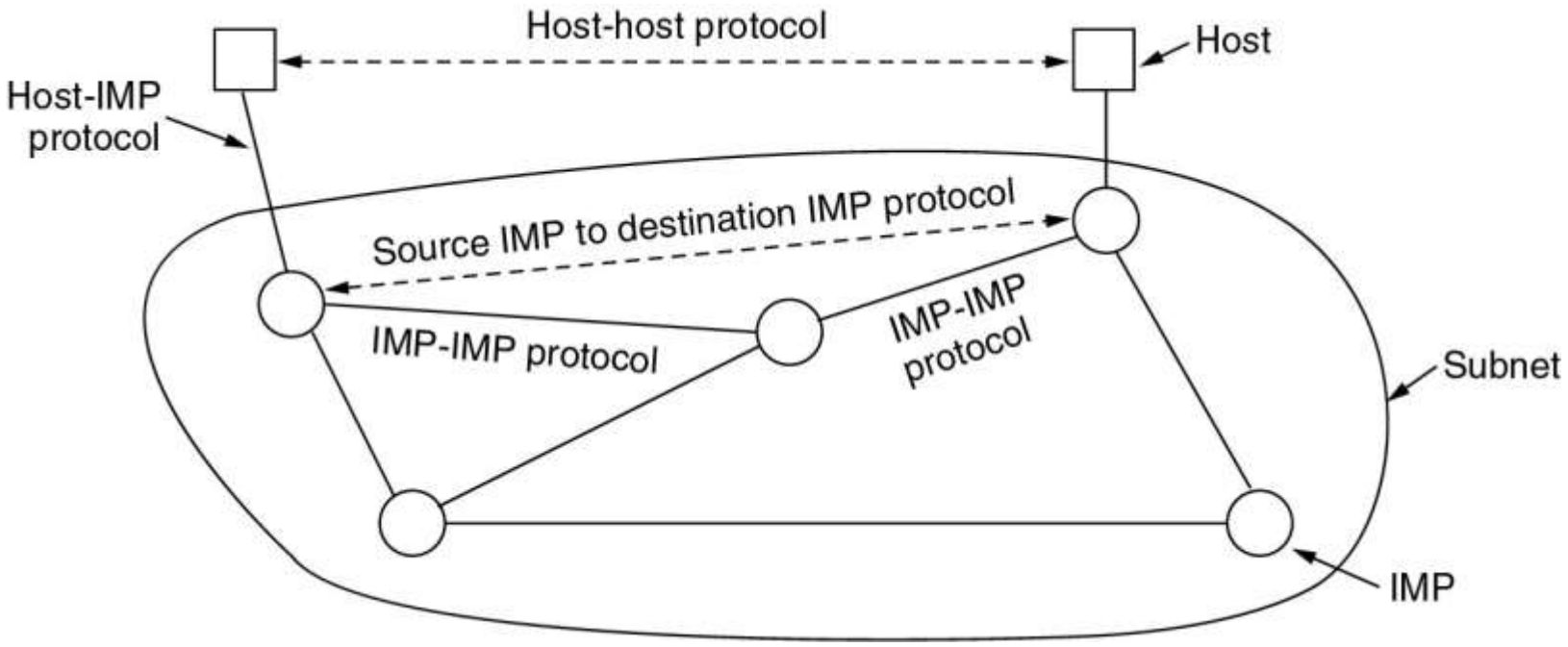
- ARCNET is a widely-installed local area network (LAN) technology that uses a *token-bus* scheme for managing line sharing among the workstations and other devices connected on the LAN.
- The LAN server continuously circulates empty message frames on a bus (a line in which every message goes through every device on the line and a device uses only those with its address). When a device wants to send a message, it inserts a "token" (this can be as simple as setting a token bit to 1) in an empty frame in which it also inserts the message.
- When the destination device or LAN server reads the message, it resets the token to 0 so that the frame can be reused by any other device. The scheme is very efficient when traffic increases since all devices are afforded the same opportunity to use the shared network

# The ARPANET

- Advanced research projects agency(ARPA) had a mission of advancing technology that might be useful to the military.
- ARPA decided that the network should be packet-switched network, consisting of subnet and host computers.
- The subnet would consists of minicomputers called IMPs( interface message processors) connected by the transmission lines.
- The subnet was to be datagram subnet, so if some lines and IMPs were destroyed, messages could be automatically rerouted along alternative paths.

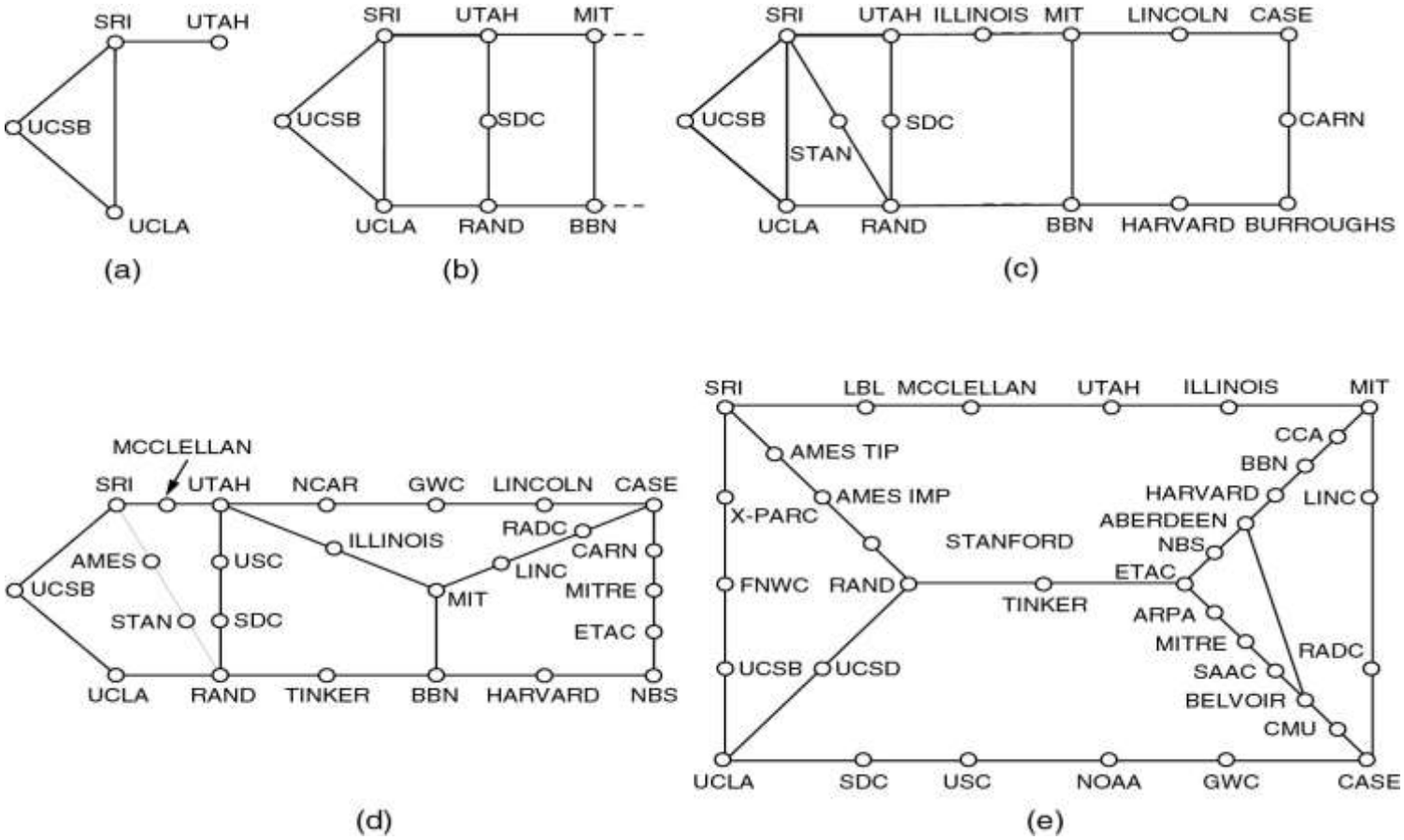
# The ARPANET

- The original ARPANET design.



- The software was split into two parts: subnet and host.
- The subnet software consisted of the IMP end of the host-IMP connection, the IMP-IMP protocol, and a source IMP to destination IMP protocol designed to improve reliability.
- outside the subnet, software was also needed namely , the host end of the host-IMP connection, the host-host protocol, and the application software.
- Later the IMP software was changed to allow terminals to connect directly to a special IMP, called a TIP(terminal interface processor).

# The ARPANET




- Growth of the ARPANET (a) December 1969. (b) July 1970.
- (c) March 1971. (d) April 1972. (e) September 1972.

# Internet Usage

- Internet refers to collection of different physical networks like LAN, MAN,WAN in order to transmit data from one computer to another computer. (or)
- Internet is network of networks
- E-mail
- News
- Remote login
- File transfer

# Architecture of the Internet

- Overview of the Internet.