Networking is everywhere:

- Network supports the way we learn.
  Online Education
- Network support the way we communicate.
  WhatsApp Call
- Network support the way we work.
  Work From Home

BASICS OF DATA COMMUNICATION

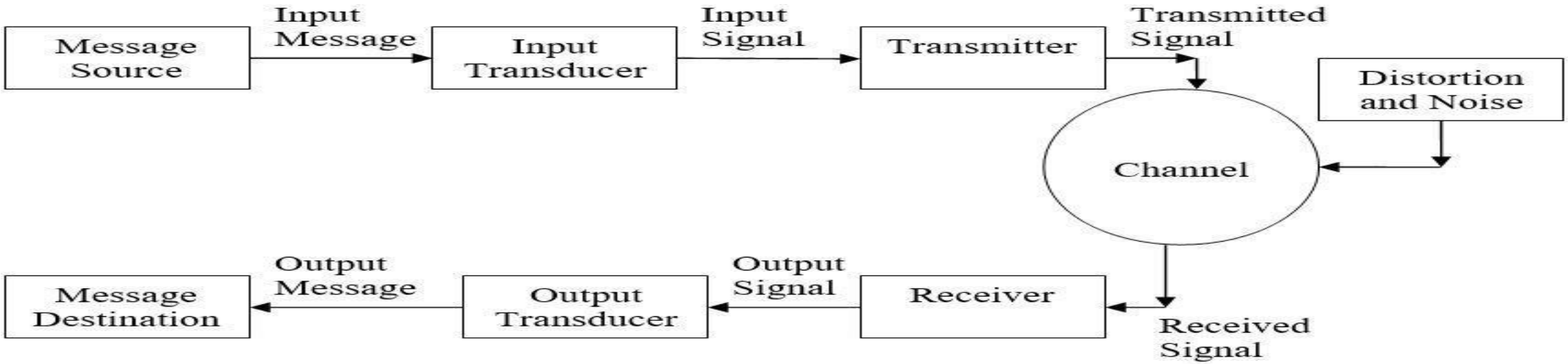


Fig 1 Block Diagram of Data Communication

Fig 2 Example of Data Communication

Data Communication

- **Message Source (Devices used)**: Keyboard, Microphone/Speaker ,Webcam (generates the data)
- **Input Message**: Text, Image, Audio/ Sound, Video
- **Transducer** convert data from one form to another.(i.e. electrical signal).
- **Transmitter** is used for:

1. Amplify Signal :Increases the baseband (original) signal energy or frequency.

Data Communication

2.Modulation: Original message is transmitted through some carrier

i.e.. Frequency ,Phase , Code

3.Encoding:conversion of analog to digital signal

Digitization helps to: 1.Reduce the noise

2. Easy to process and

3. Easy storage

Signal is transmitted on Channel /Medium.

Data Communication

Medium:1.***Wired:*** Twisted Pair Cable

Co-axial

Optical Fibre

2. ***Wireless***: Antenna

Electromagnetic wave

Problems of Channel: During the long distance transmission it introduce the ***Noise*****.**

Attenuation(Amplifier is used to address the issue)

Distortion

Multiple Impairment methods

Data Communication

Receiver: Performs the *demodulation*

decoding :convert it to analog form.

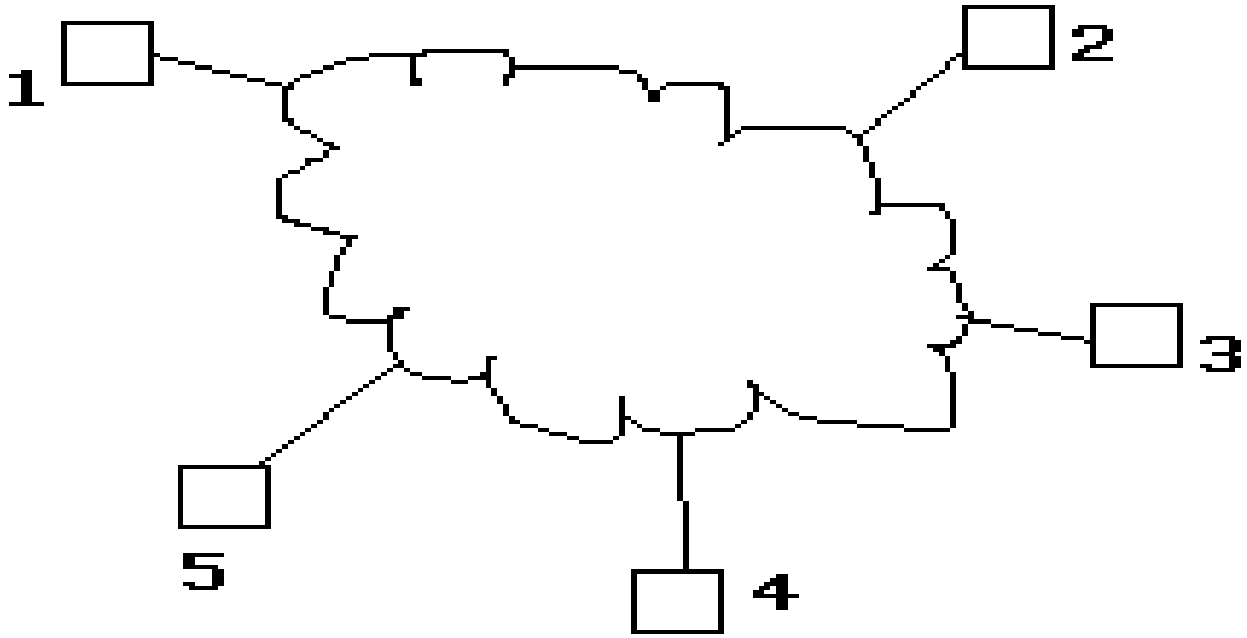
Repeater /Amplifier is used to boost the energy of the signal

Output Transducer: It is used to reconstruct the original signal.

Basics Computer Networks

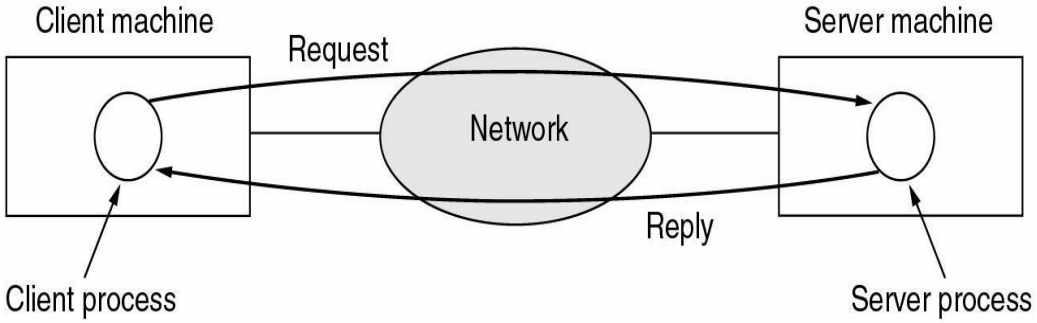
Networks

- ***A Network:*** *A group of devices that can communicate with each other over links.*
- *Each device is called a host. Each host has a unique address.*



Components of Network

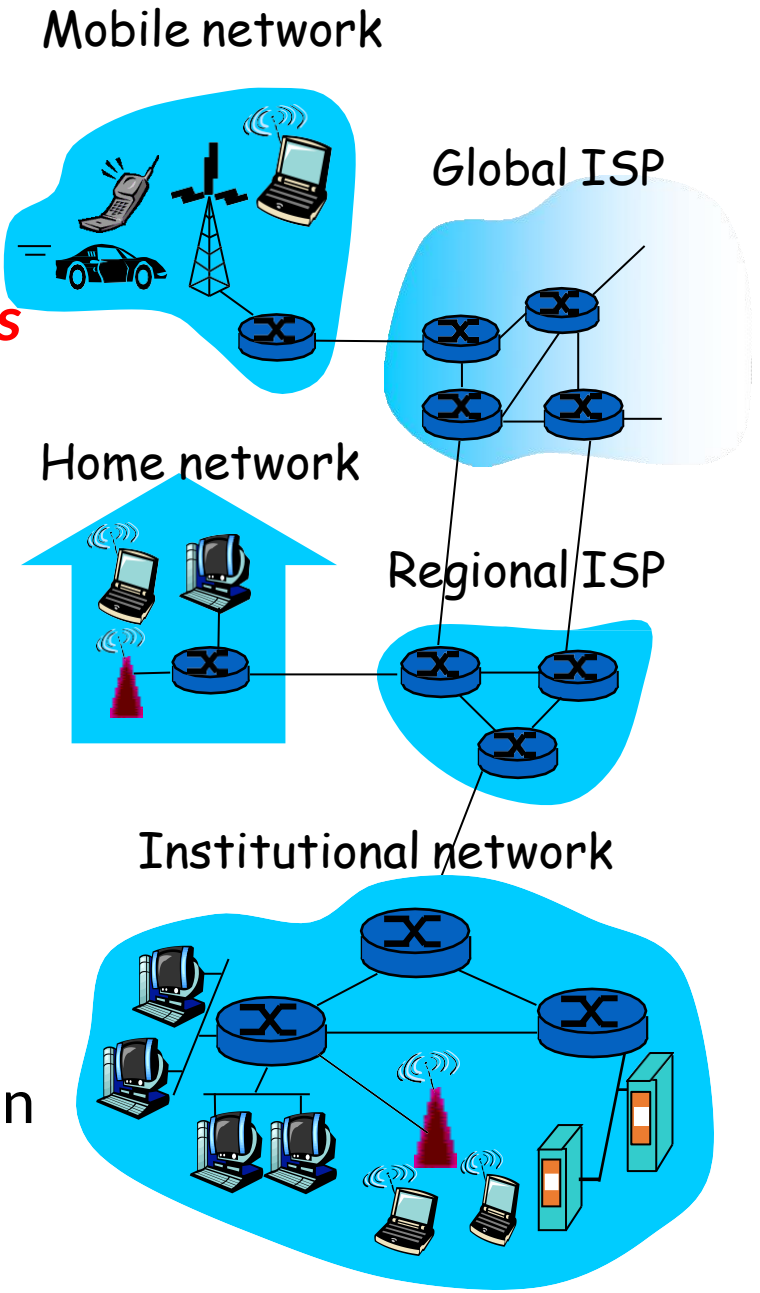
- **Client** : Which gives the Request.
- **Server** : Which gives the Response



- **Modem** : It Indicates Modulator / Demodulator
- **Router** :Which identifies the Path between Client & Server.
- **Channel**: Links are used to exchange the information

What isa Computer Network?

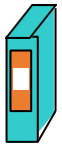
- ❑ Computer Network is a collection ***of interconnected devices***
- ❑ Provides **communication** that is
  - Reliable
  - Fair
  - Efficient
  - From one application to another
- ❑ Automatically **detects and corrects**
  - Data corruption
  - Data loss
  - Duplication
  - Out-of-order delivery
- ❑ Automatically **finds optimal path** from source to destination



What is a ComputerNetwork?(2)

- ***A node can be***
  - Computer
  - Printer
  - Security Camera
  - Switches ,Bridges and Routers


PC


server


wireless laptop


cellular handheld


router


access points

wired links

In short any device who is capable of sending and receiving data generated by any nodes in the network.

What is a ComputerNetwork?(3)

- **Communication link carries the information** .it can be Wired or Wireless
  i.e. Links are used to exchange the information.

- **End Devices**: Starting point or End point.

- Intermediary devices.

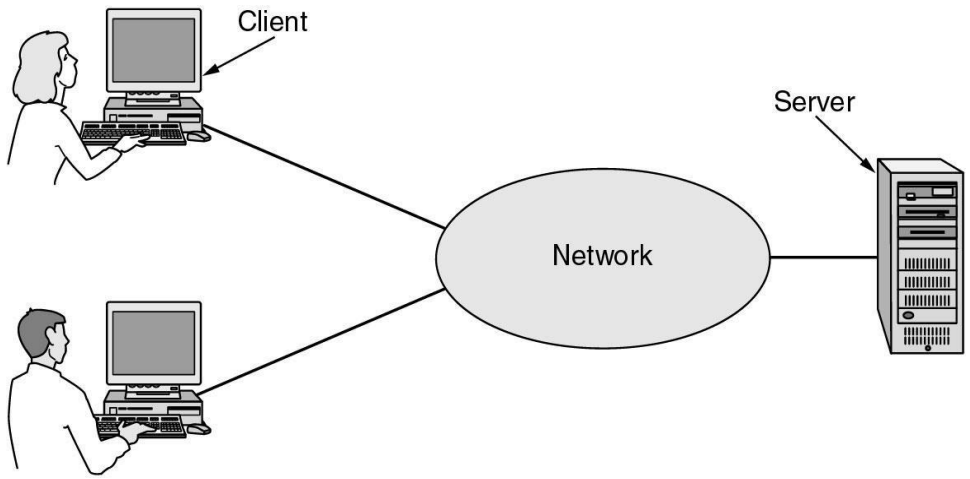
Basic purpose of network is Resource Sharing which saves lots of infrastructure cost.

Uses of Computer Networks

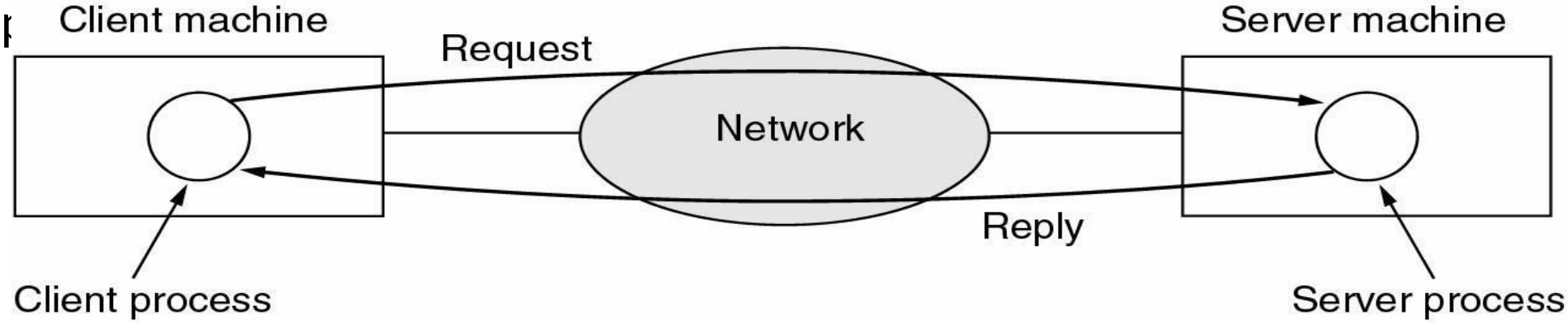
- **Business Applications**
  - online buying
- **Home Applications**
  - mail, chat
- **Mobile Users**
  - wireless: laptops, PDA, mobile, in plane
- **Social Issues**

Business Applications of Networks

- A network with **two clients and one server**.
  - Check bank account
  - Pay bills
  - Reserve ticket



- The **client-server model** involves requests and rep

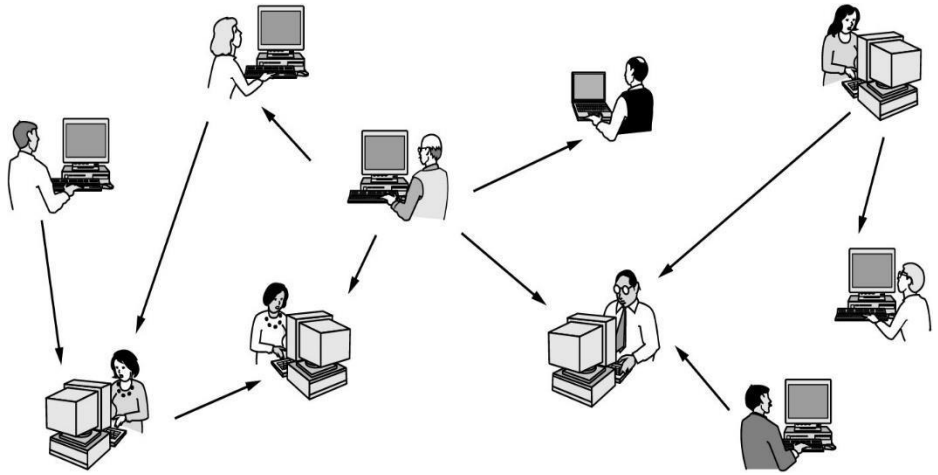


Home Network Applications

- **Access to remote information**
  - Leaning online, downloading
- **Person-to-person communication**
  - chat, phone
- **Interactive entertainment**
  - games, movies, …
- **Electronic commerce**

Home Network Applications (2)

- Peer-to-peer (P2P)
  - BitTorrent, ForstWire



- E-commerce

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

Social Issues

- Discussions about
  - **politics,**
  - **technology,**
  - **…**
- Hack and robbery

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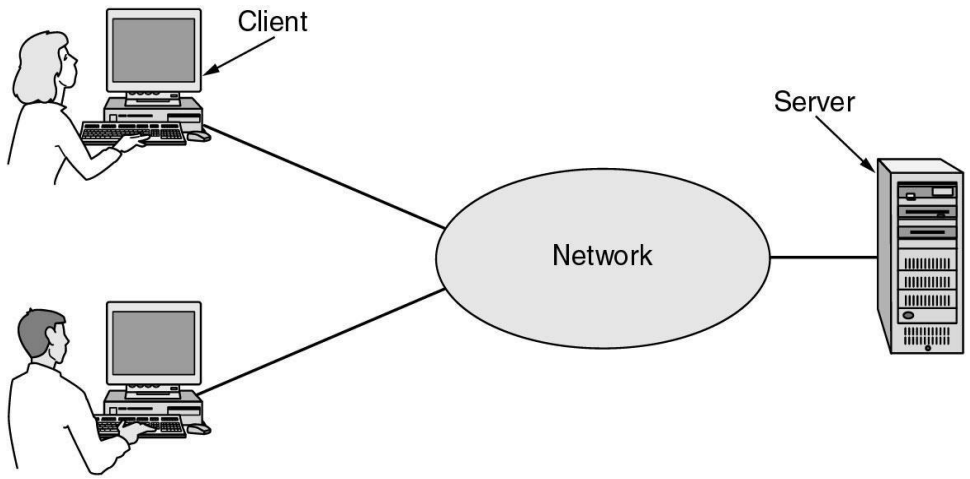

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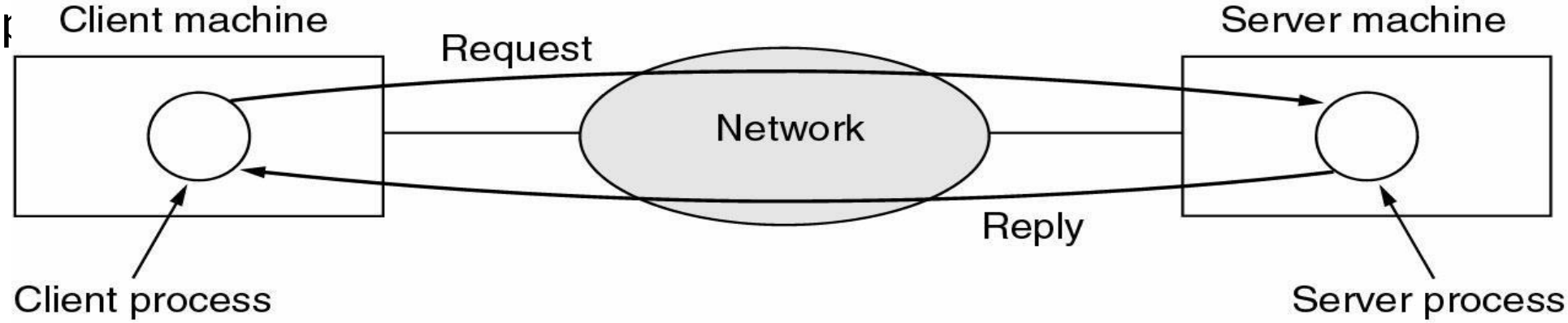

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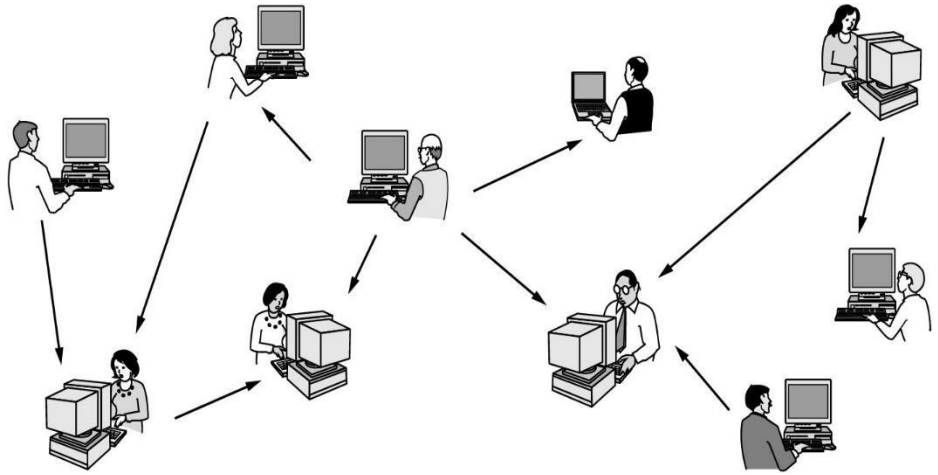

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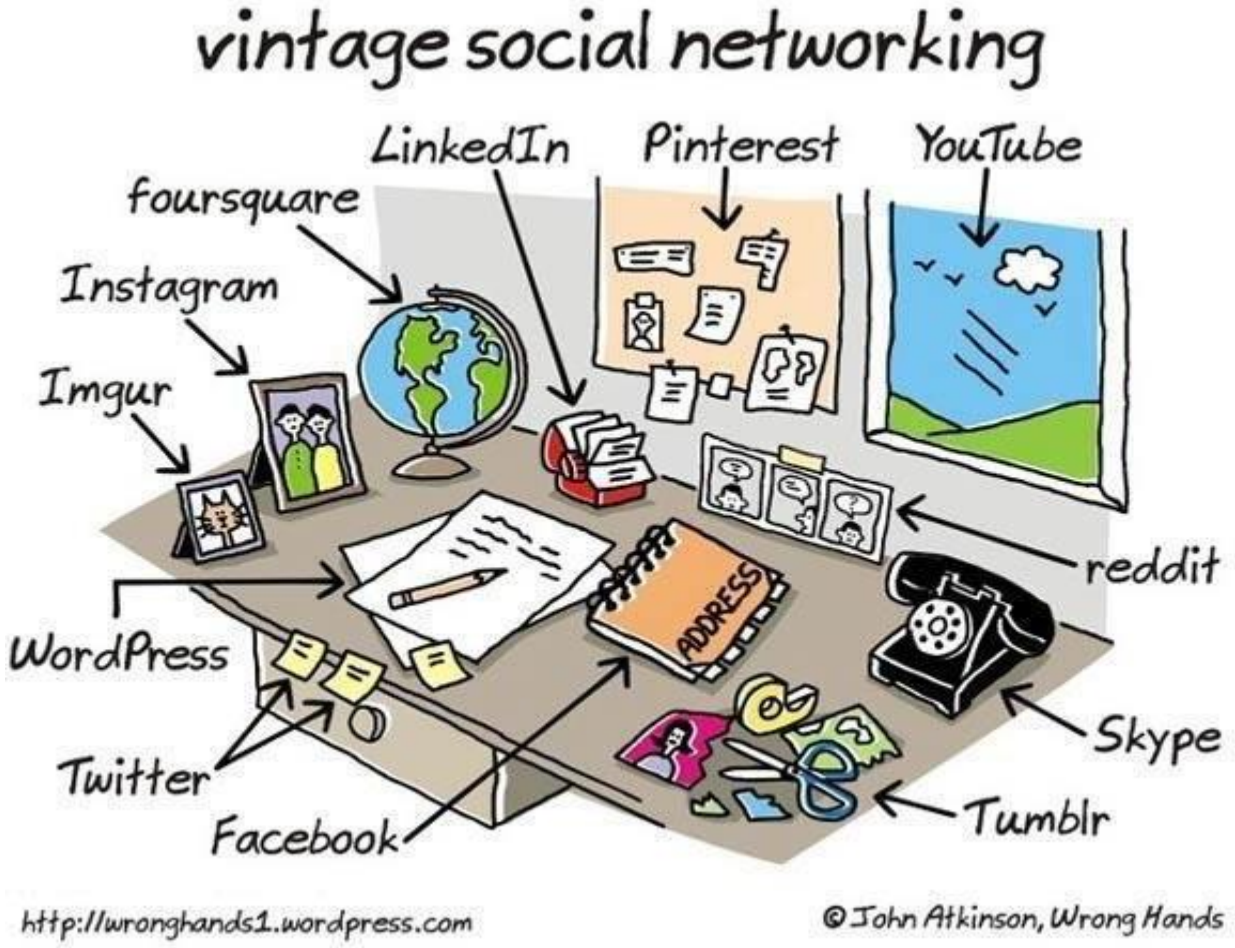


What A Network Includes

- **Transmission hardware**
- **Special-purpose hardware devices**
  - interconnect transmission media
  - control transmission
  - run protocol software
- **Protocol software**
  - encodes and formats data
  - detects and corrects problems

Network Hardware

- **Transmission technology (2 types)**
  - **Broadcast links**
  - **Point-to-point links**
- Scale
  - **Local Area Networks (LAN)**
  - **Metropolitan Area Networks (MAN)**
  - **Wide Area Networks (WAN)**
  - **Wireless Networks**
  - **Home Networks**
  - **Internetworks**
- Media
  - **Wire line**
  - **Wireless**

Classification 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

CONTENT BEYOND SYLLABUS

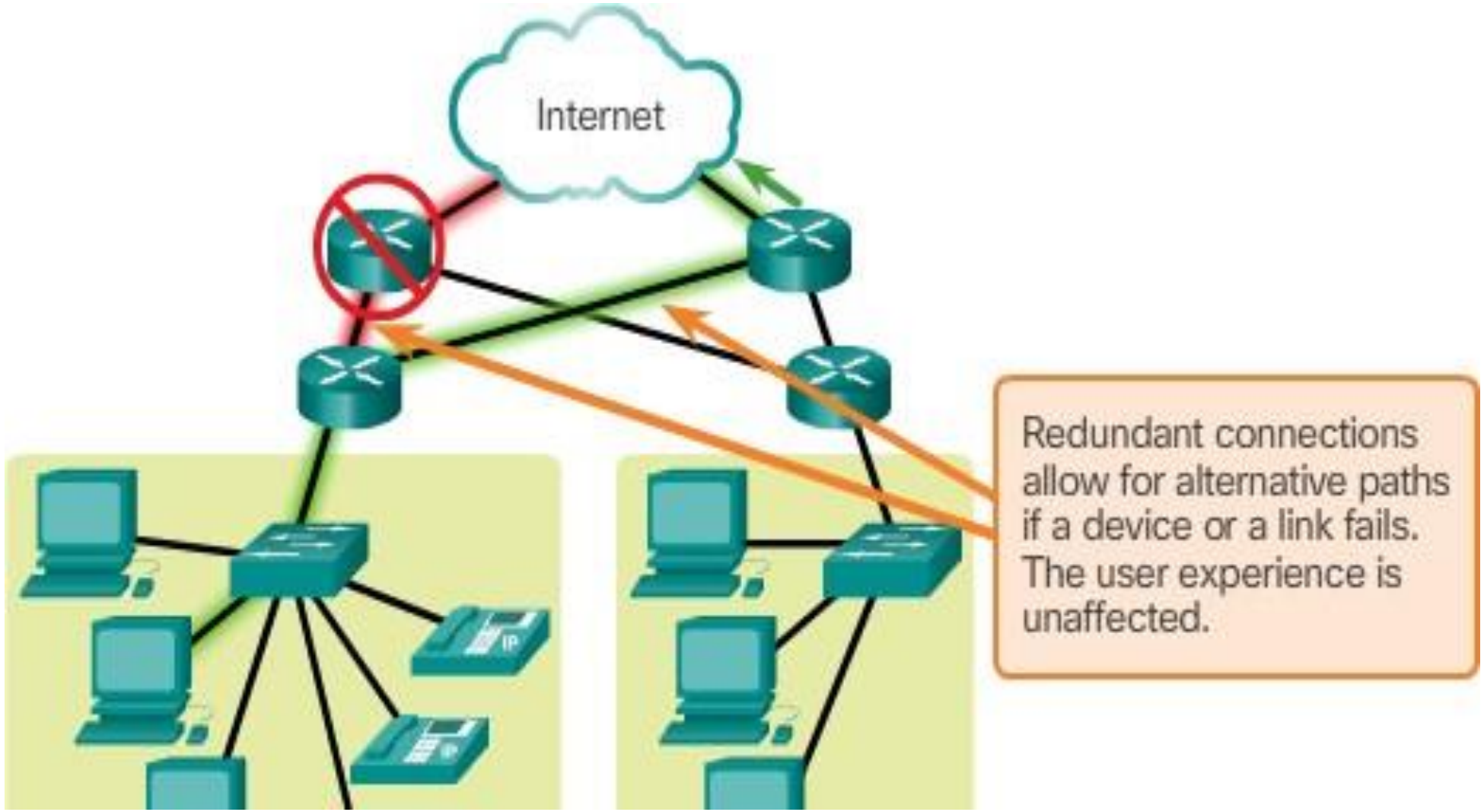
Computer Network (Basic Characteristics)

- ★ Fault Tolerance
- ★ Scalability
- ★ Quality of Service (QoS)
- ★ Security

Fault Tolerance

- The ability of computer network to Continue working despite of failures. Ensure no loss of service.

- Communication is not affected due to alternate route.


Internet
Redundant connections allow for alternative paths if a device or a link fails. The user experience is unaffected.

Scalability

- Grow based on needs
- Have a good performance after growth.
- Best example is Internet: no impact on performance even though new user gets added.

QoS

QoS is an overall performance measure of the computer network.

The ability to:

Set Priorities(Router will give priority to real time data i.e. VOIP over Email) and manages data traffic to reduce data loss , delay etc.

Security

Ability to prevent:

Unauthorized access to individuals accessing an organization‟s networks, data, endpoints, applications or devices, without receiving permission.

Misuse:

- **Virus attack:** people use the computer to send virus to another computer in other damage the system..
- **Fraud:** people use the internet to cheat people.
- **Cyberbullying:** some children make use of the internet to bully their friends and enemies
- **Data piracy:** people use the computer to sell things that ate not theirs on the internet

Forgery:

Security

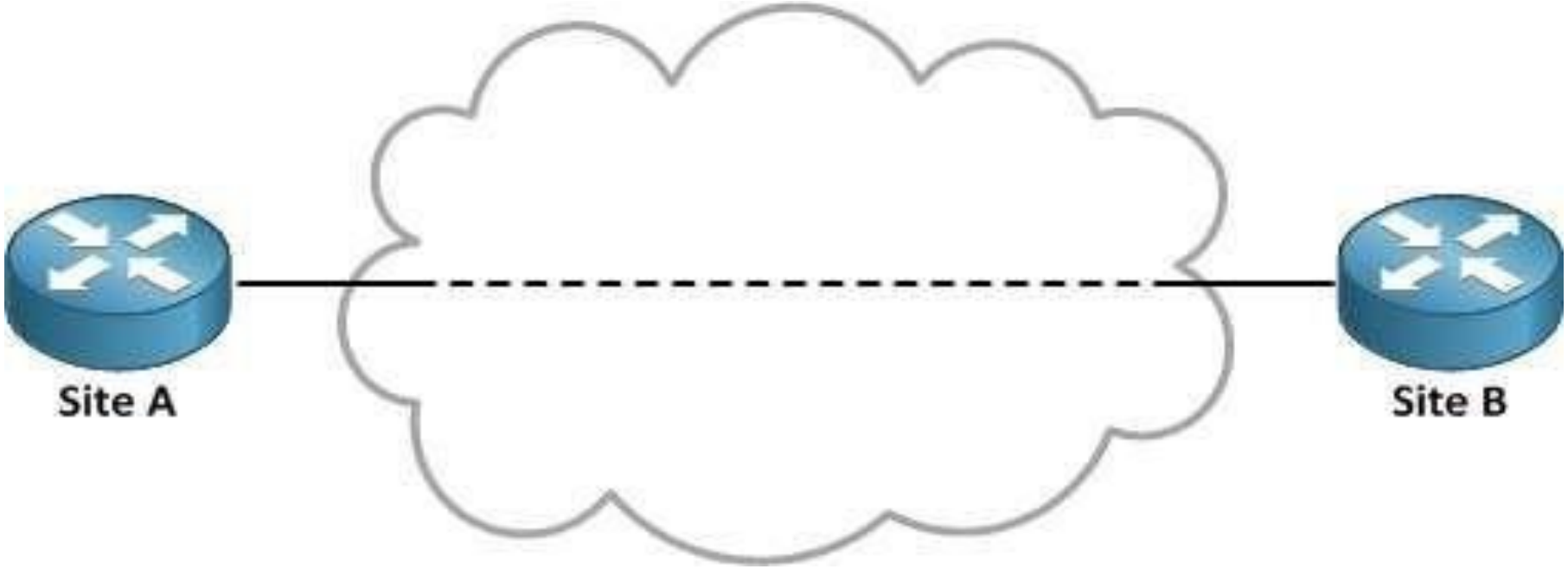
Ability to provide:

- **Confidentiality** (use of encryption and decryption mechanism)
- **Integrity**(no alternation to data)
- **Availability**(available 24x7)

Point -to-Point Connection

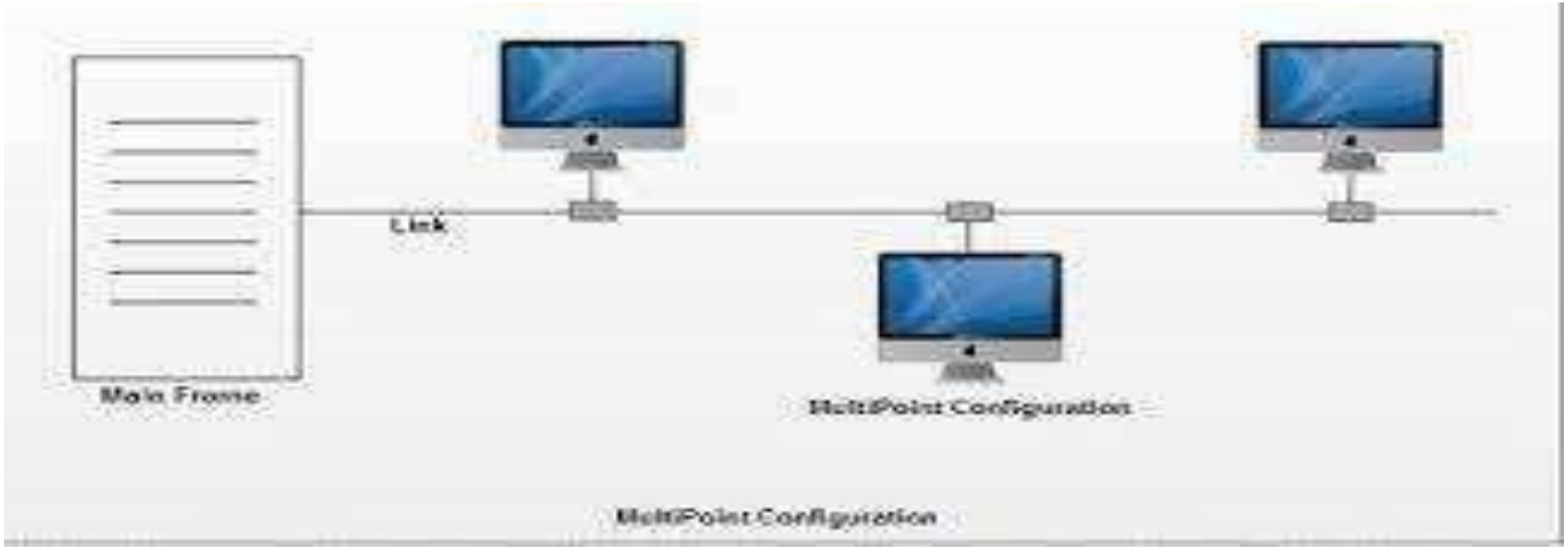
It provides a dedicated links between two devices.

For example, a wired system that connects two computers together can be thought of a point- to-point link.



Multi-Point Connection

It is a link between two or more devices. It is also known as Multi- Point configuration. The networks having multipoint configuration are called Broadcast Network.



Transmission Mode

- It refers to the direction of information flow between two devices.
- Data flow is the flow of data between 2 points.

The direction of the data flow can be described as

- Simplex Mode
- Half-Duplex Mode
- Full-Duplex Mode

Data Flow

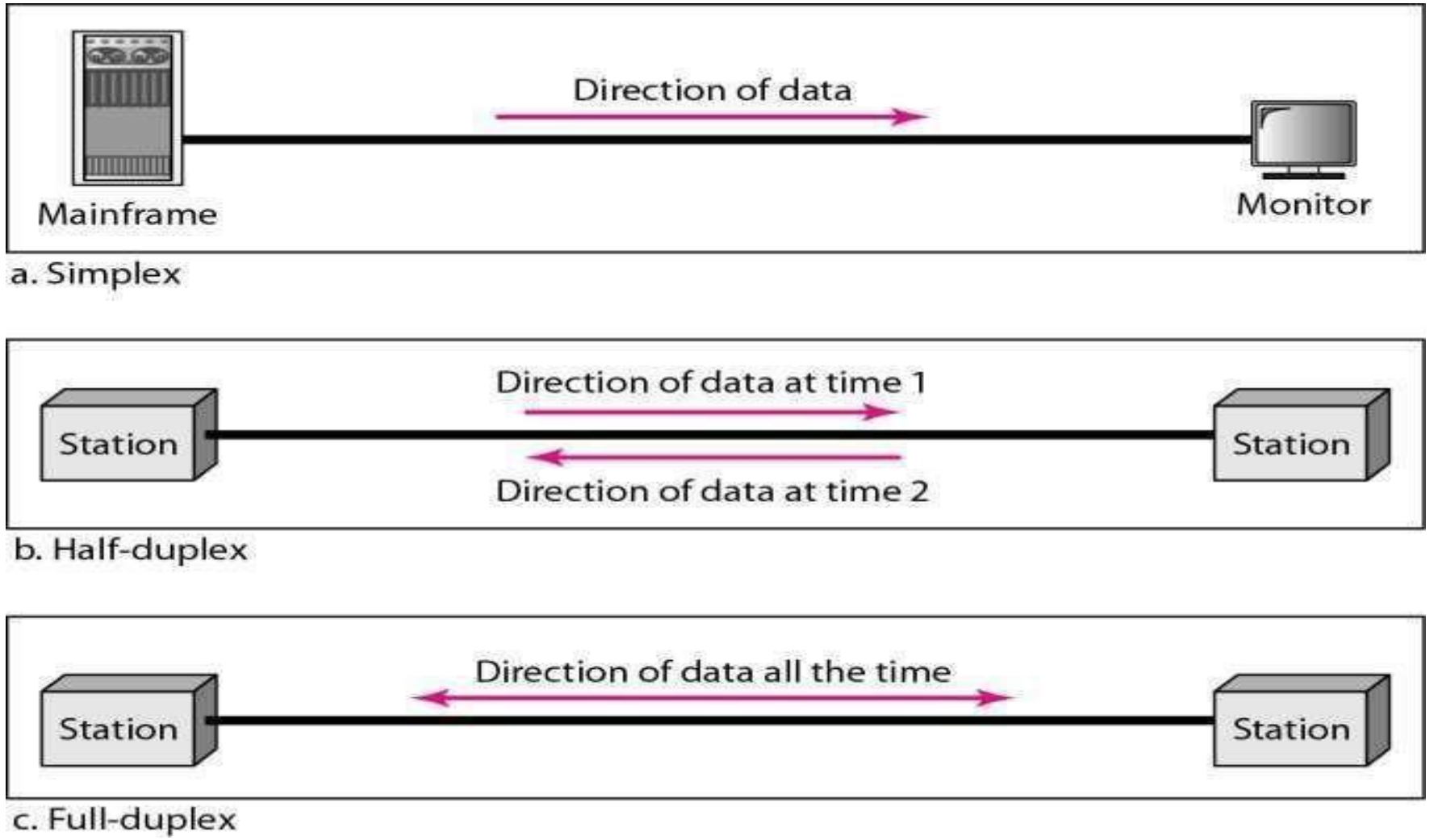


Figure 1.2 *Data flow (simplex, half-duplex, and full-duplex)*

- **Simplex:** Data flows in only one direction on the data communication line (medium).

  Example: Radio and Television broadcasts.

- **Half-Duplex:** Data flows in both directions but only one direction at a time on the data communication line.

  Example: Conversation on walkie-talkies.

- **Full-Duplex:** Data flows in both directions simultaneously. Modems are configured to flow data in both directions.

  Example: Phone Conversation

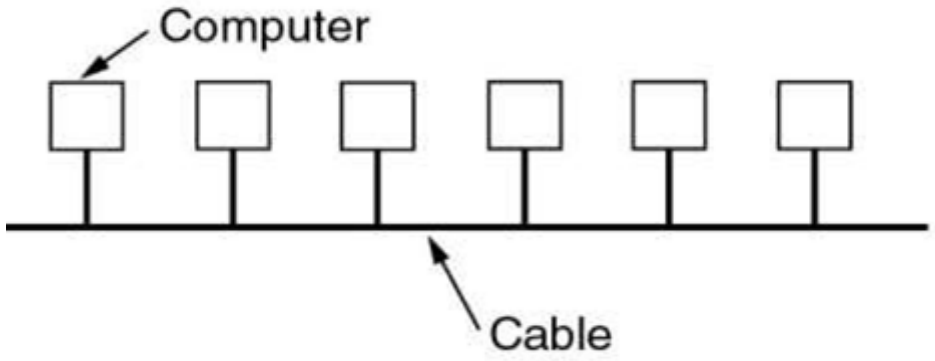
Topology

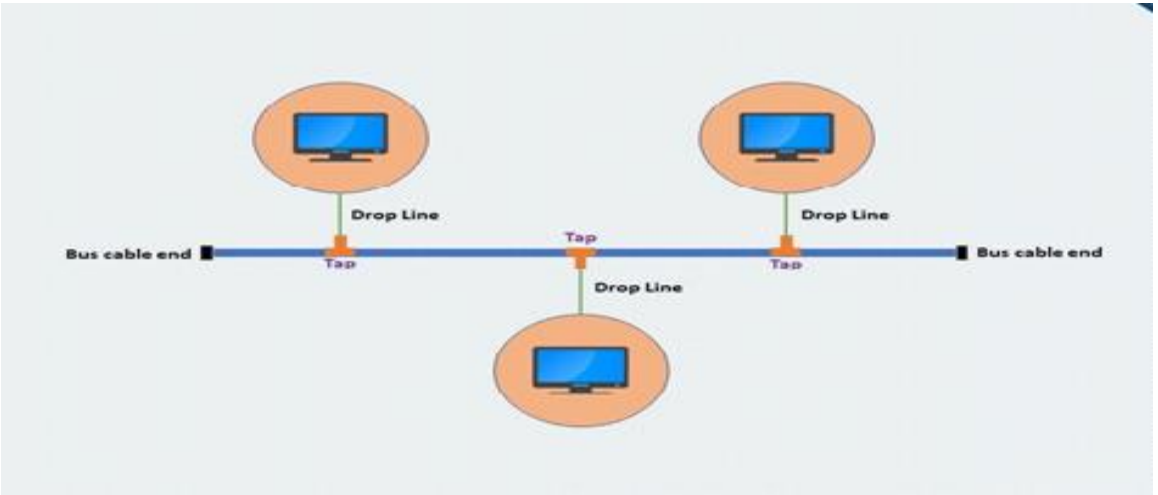
- It defines the Physical (or) Logical arrangement of Links in a Network.
- Topology refers to the layout of connected devices in a network.
- The Topology of the Network is Geometric Representation of the relationship between all Communication links.

1. **BusTopology**
2. **Star Topology**
3. **Tree Topology**
4. **Bus Topology**
5. **Ring Topology**
6. **Hybrid Topology**

Bus Topology

- A Bus topology describes the multipoint configuration.
- One long cable act as a backbone to link all the devices in a network.
- Devices are connected in a bus topology with the help of “Drop lines” and “Tapes”.





Bus Topology

Advantages:

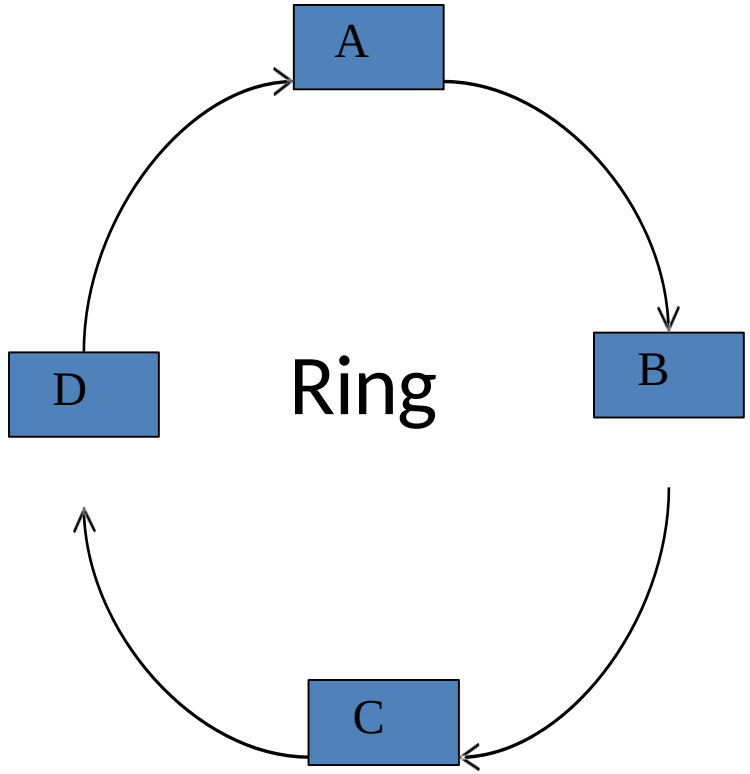
- Less Expensive.
- Suitable for temporary network.
- Node failure does not affect others

Disadvantages:

- Not a fault tolerant.
- Limited cable Length.
- No security

Ring Topology

- A Ring topology is a bus topology in a closed loop.
- Peer-to-peer LAN topology.
- Unidirectional
- Sending and receiving of data takes place with the help of a **Token.**



Ring Topology

Advantages:

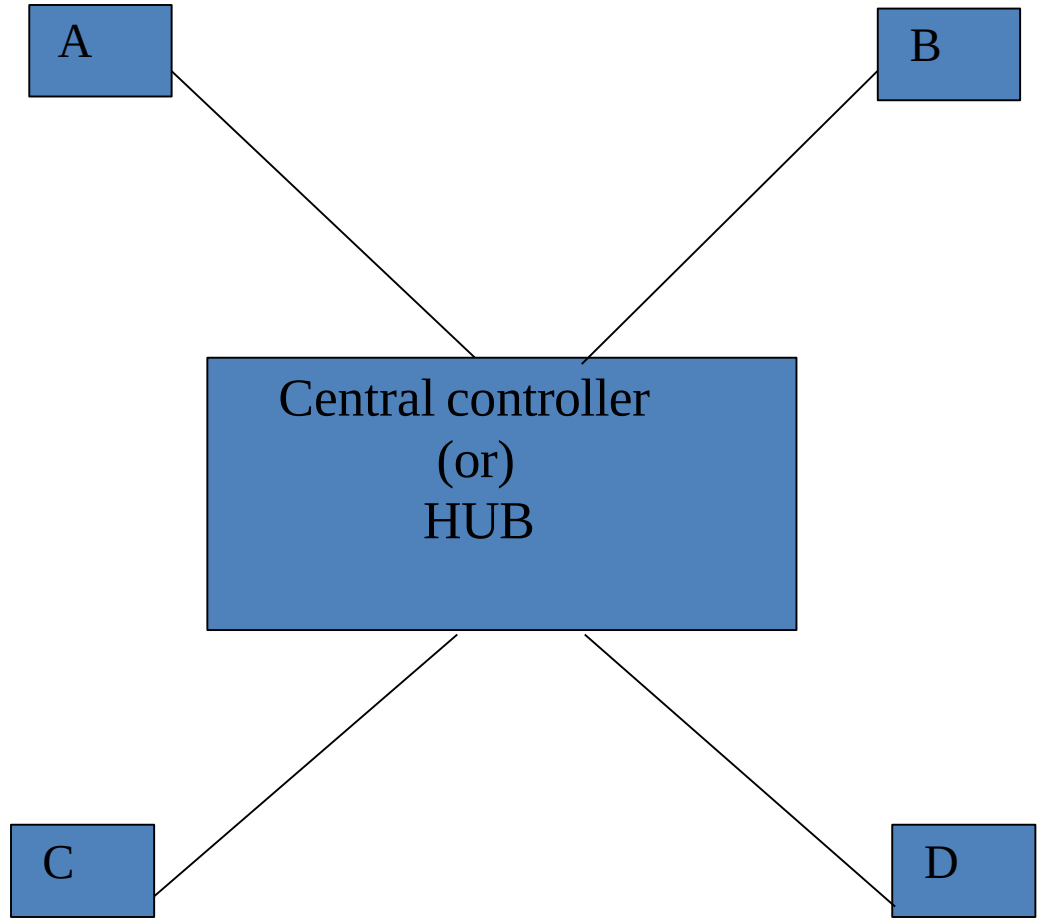
- Easy to install and reconfigure better performance than Bus Topology.
- Can cause bottleneck due to weak link.
- All nodes with equal access.

Disadvantages:

- Unidirectional single point of failure will affect the whole network.
- Increase in load leads to decrease in performance.
- No Security.

Star Topology

- Each device has a dedicated point-to-point link between only a central controller or “HUB” .
- The devices are not directly linked to some other devices.
- If one device wants to send data to another device, it sends to the central controller and the Central controller send to other device.



Star Topology

Advantages :

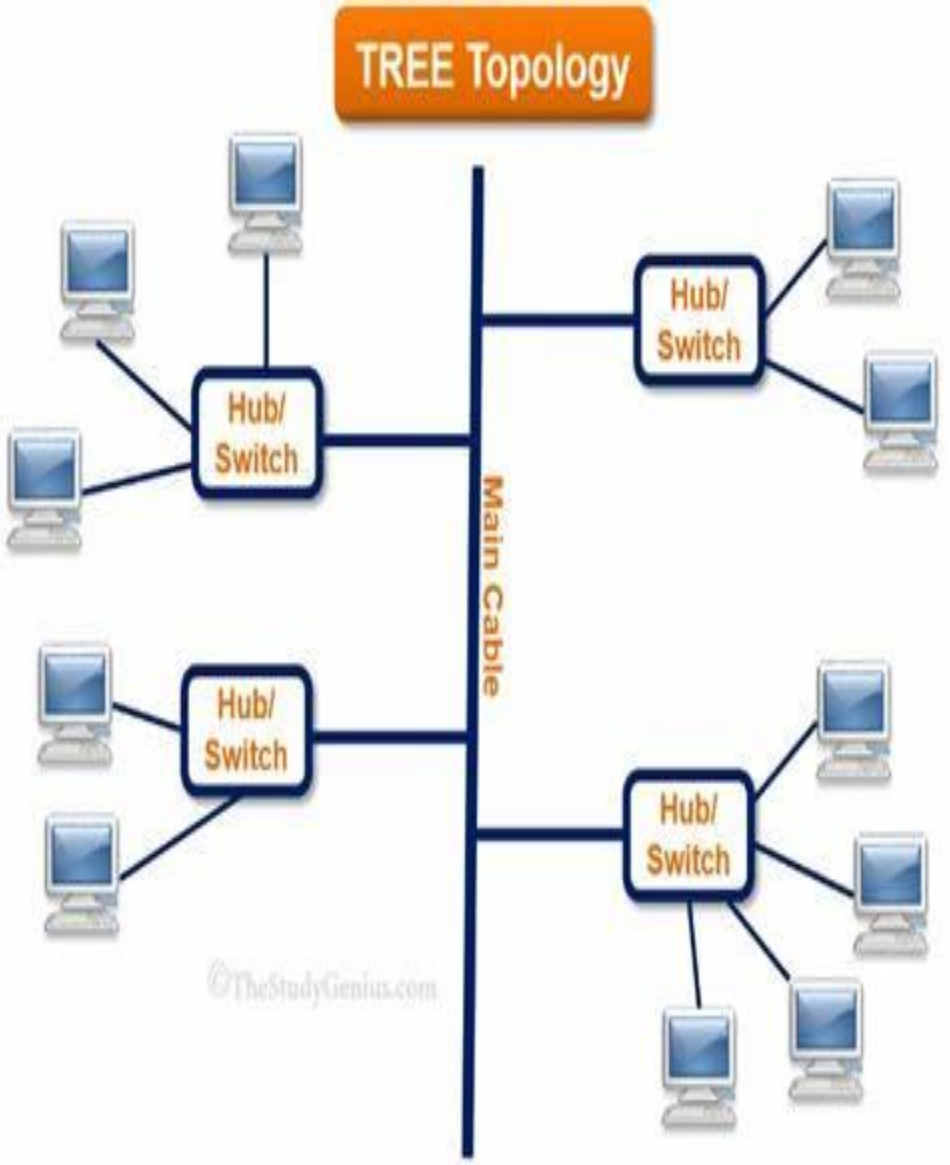
- Easy to design and implement.
- Centralized Administration.
- Scalable.

Disadvantages:

- Each device must connected to controller.
- Bottleneck due overloaded Switch and Hub.
- If central controller failure means network collapse.

Tree Topology

- Tree topology has some variation from star topology.
- The nodes in the tree are linked to central controller.
- The primary HUB in the tree is represented by “Active Hub”.
- The secondary HUB in the tree is represented by “Passive Hub”.



Tree Topology

Advantages :

- It allows more devices to be attached in a single central controller.
- It allows the network to prioritize the communication.

Disadvantages:

- Each device must be linked to controller.
- It require more installation processes.
- If central controller failure means system should fail down.

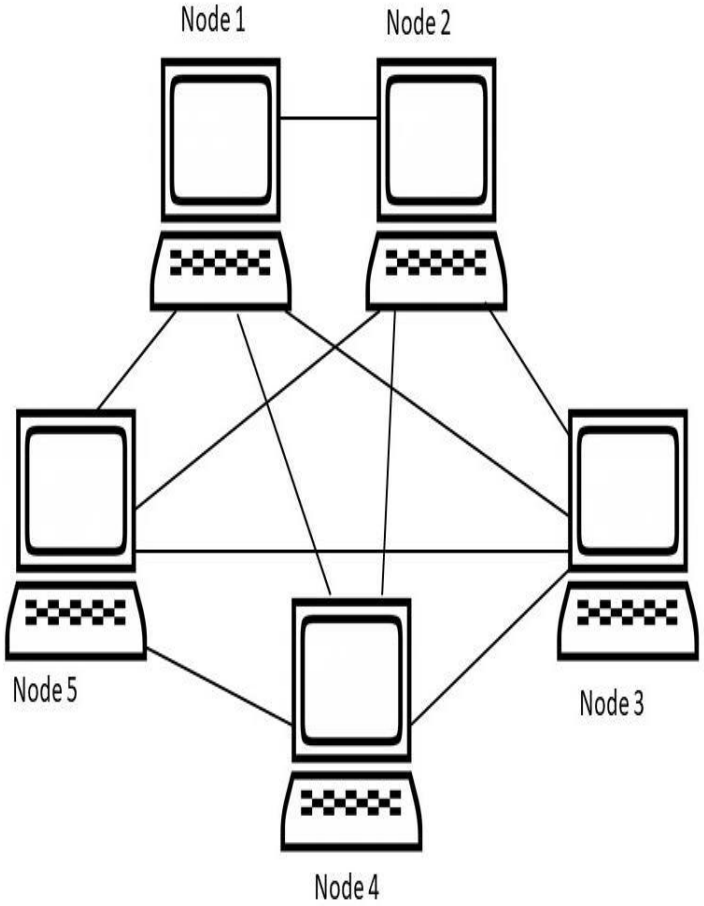
Mesh Topology

- Here every device has a direct point to point link between every otherdevice.
- A fully connected mesh can have n(n-1)/2 physical channels to link n devices.

if n=5 (Number of Nodes)

then 5(5-1)/2 = 10 (Communication Links)

5 Nodesare Connected by using 10 Communication Links



Mesh Topology

Advantages :

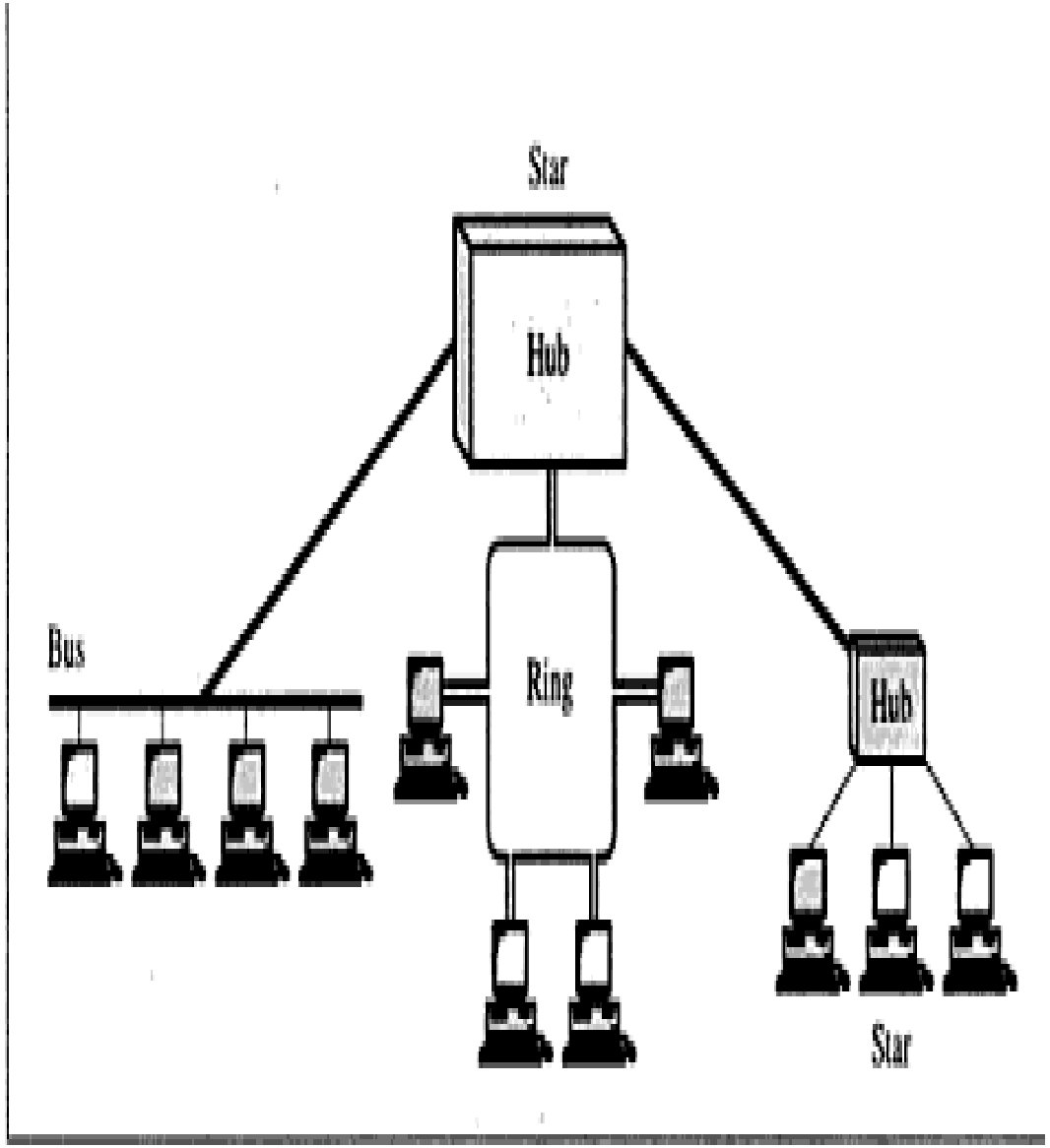
- It eliminate the traffic problem.
- It is robustness.
- It has privacy and security.
- Fault can be easily found.

Disadvantages:

- More number of cables to be used.
- Every devices must be connected to some other devices. So installation process is very difficult.

Hybrid Topology

- Combination of all topology is called hybrid topology.



Categories or Types of Network

There are Three Types:

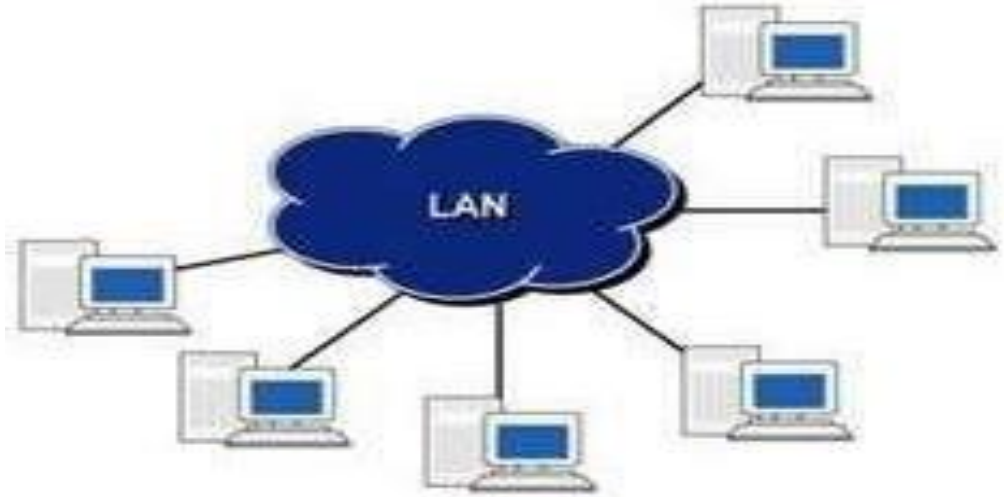
1. **LAN - Local Area Network**
2. **MAN - Metropolitan Area Network**
3. **WAN – Wide Area Network**

LAN - Local Area Network

- LANS are privately-owned networks within a single building or campus of up to few kilometers in size

- **A LAN is Designed by Local Area Connections such as:**

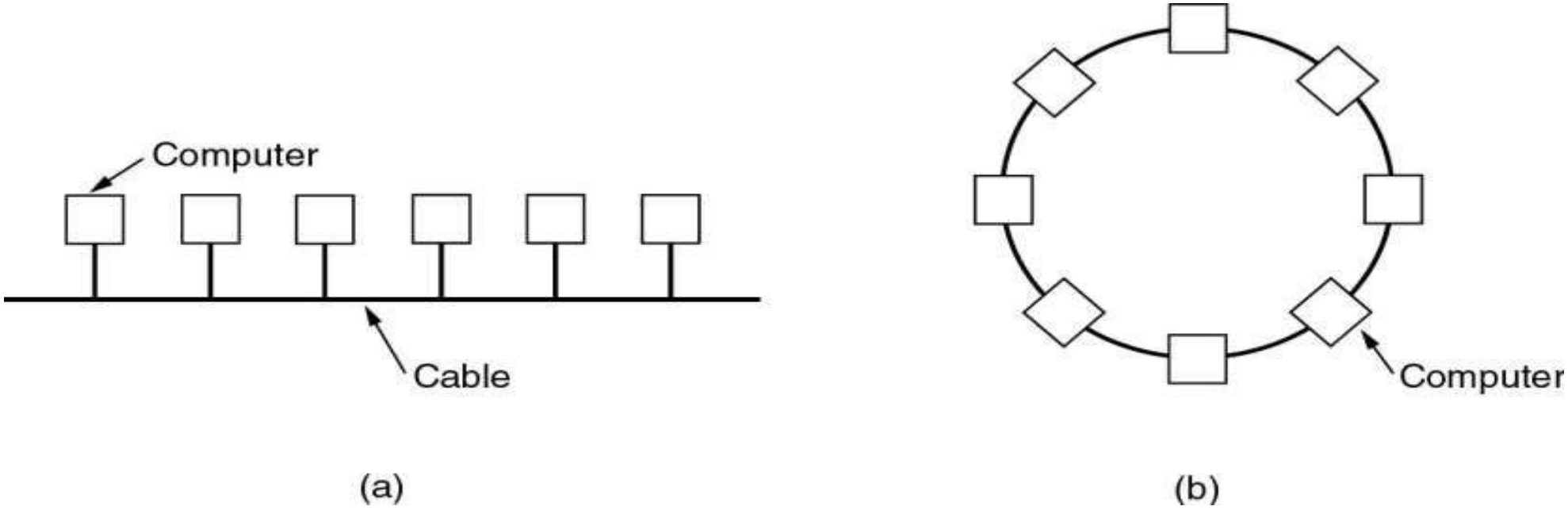
  i) within Building
  ii) within office
  iii) within Campus



LAN - Local Area Network

- 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

LAN - Local Area Network



Topology used here is Bus and Ring

Advantages

1)Sharing of Files.
2)Sharing of Programs.
3)Communication Exchange

Disadvantages

1)Reliability
2)Capacity
3)High Cost

MAN - Metropolitan Area Network

- Interconnects users with computer resources in a geographic area or region larger than that covered by even a large local area network (LAN) but smaller than the area covered by a wide area network (WAN).

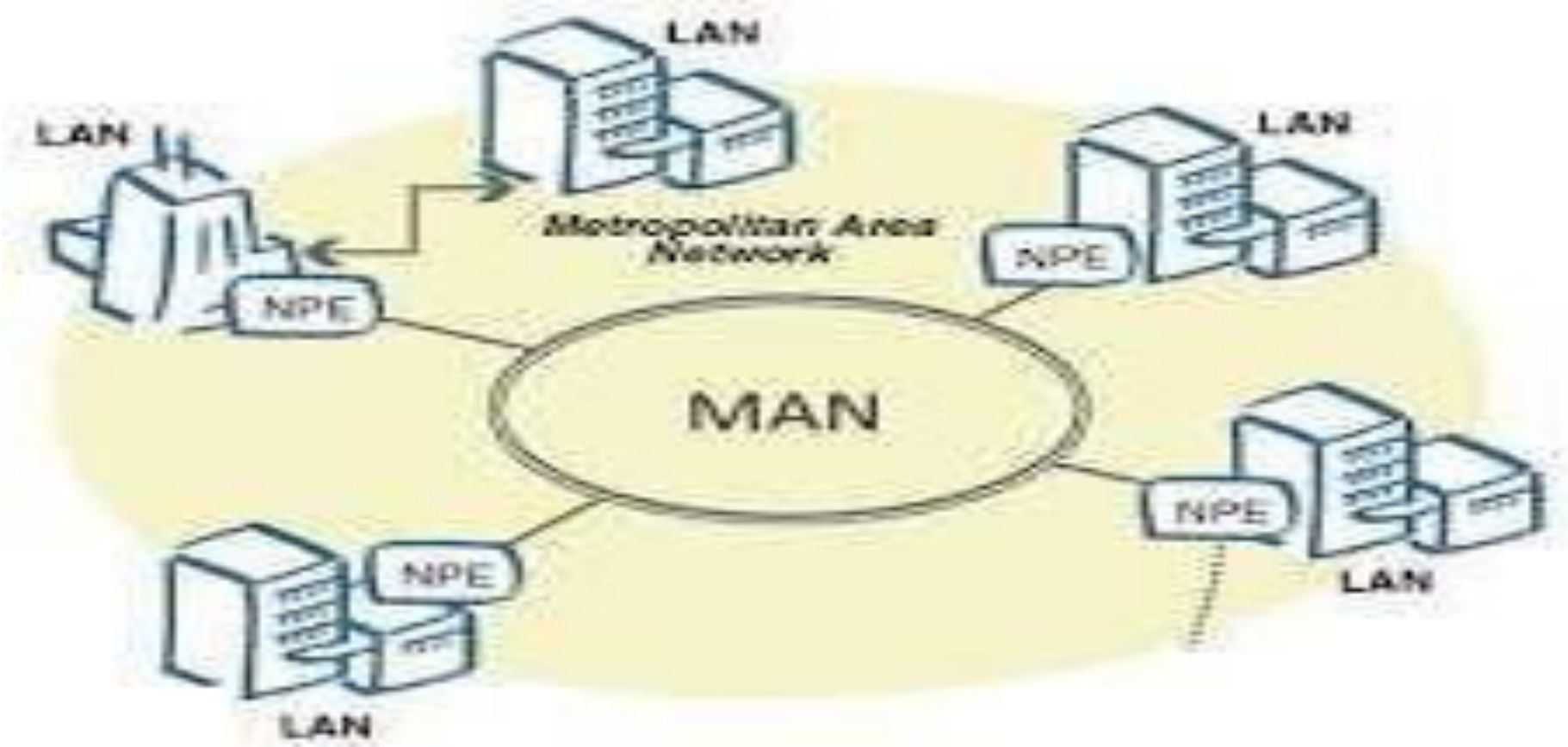
- MAN supports up to 150 Kilometers Distance.

- It uses the standard DQDB (distributed queue dual bus, 802.6)

- **Example:**

  Telephone

  Network Cable TV



DQDB consists of two unidirectional buses to which all computers are connected .
Each bus has **head end** which initiates transmission activity.
The key aspect of MAN is a broadcast medium to which all computers are attached.

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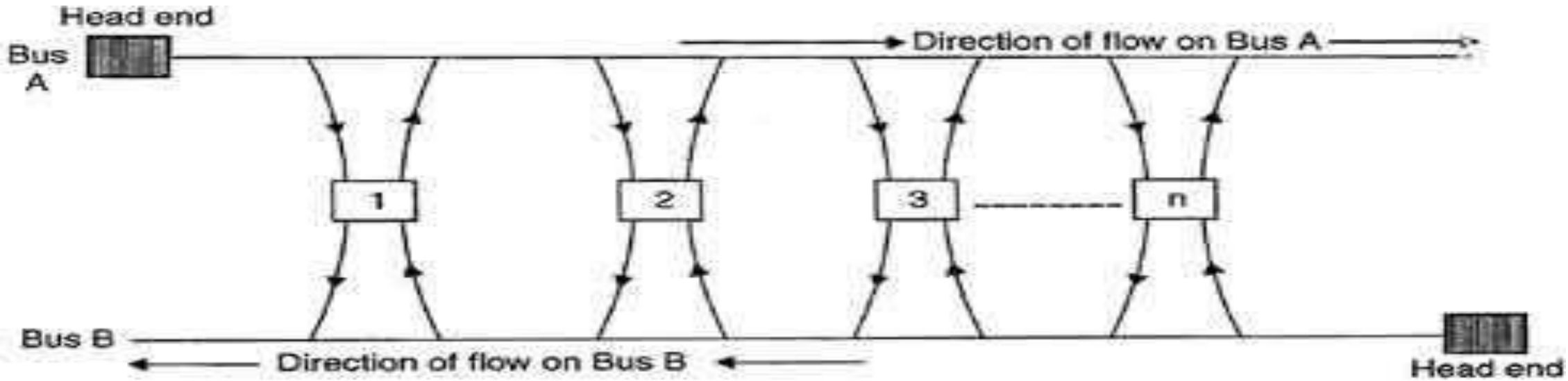


Architecture of DQDB

Advantages

1)High Bandwidth

2)It support Large number of Clients

3)Reduce the Errors.

Disadvantages

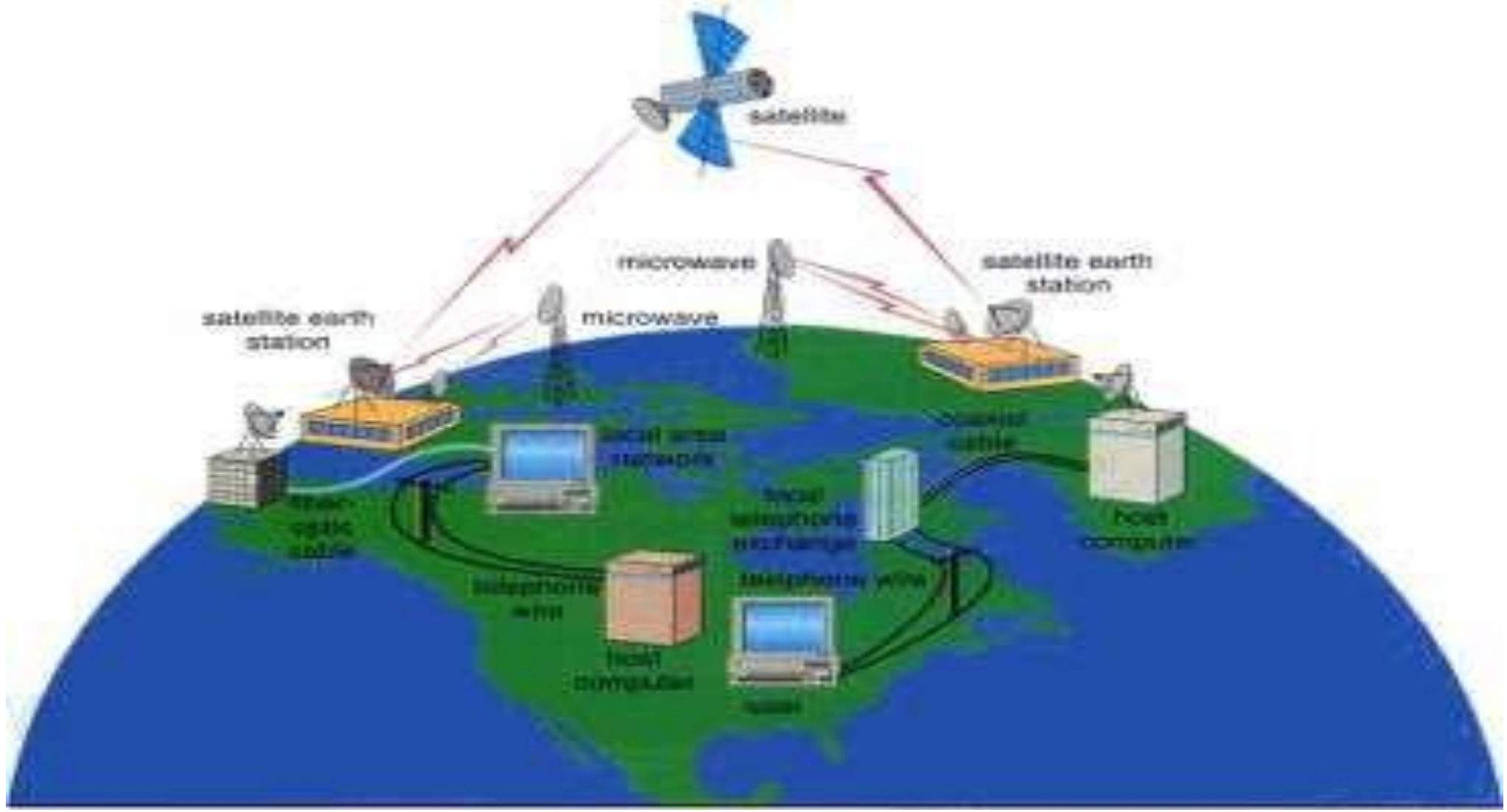
1) Large Space Requirements

2) Slower Data Access

3) High Cost

WAN – Wide Area Network

- 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

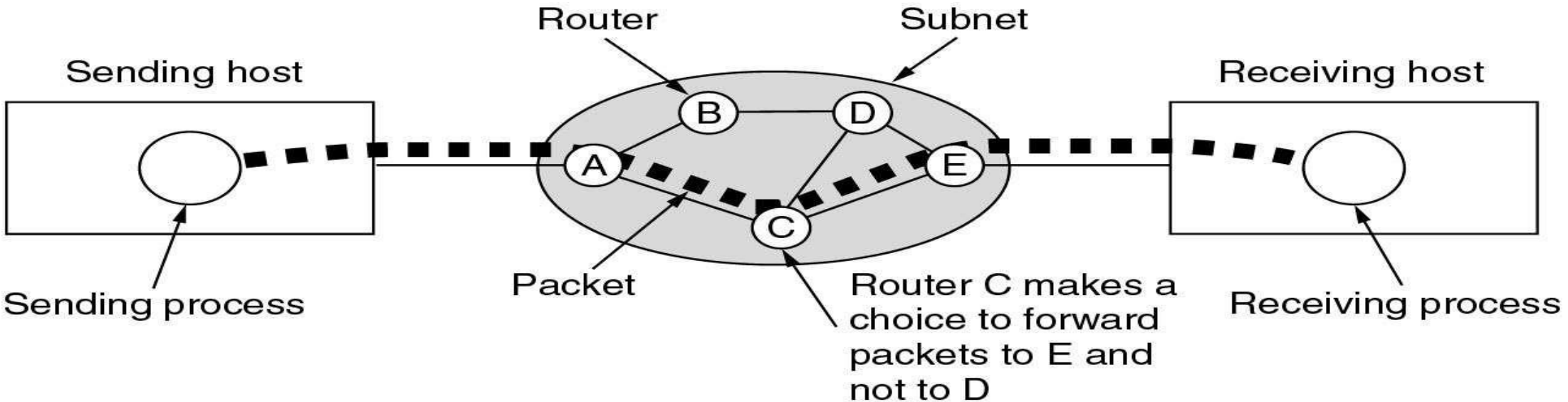

satellite
microwave
satellite earth station
microwave
satellite earth station
local area network
fiber optic cable
coaxial cable
host computer
telephone wire
telephone wire
local computer

WAN – Wide Area Network

- 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 to router.
- **The collection of communication lines and routers form the subnet.**

WAN – Wide Area Network

- 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 uses this principle and it is called as point-to-point , store- and-forward, or packet-switching subnet.



Protocol Architecture

- Each layer of protocol architecture provides some set of rules
- There are 2 widely used protocol architecture

✓TCP/IPArchitecture

✓OSI Model

Protocol

- Protocol is a set of rules that governdata communication
- It represents **what** is communicated, **when** it is communicated and **how** it is communicated.
- There are 3 key elements

✓Syntax

✓Semantics

✓Timing

Syntax

- It represents **structure**, Format of data the order in which it is presented

Data may contain:

- First 8 bit -> SenderAddress
- Second 8 bit -> ReceiverAddress
- Remaining bits-> message stream

SEMANTICS

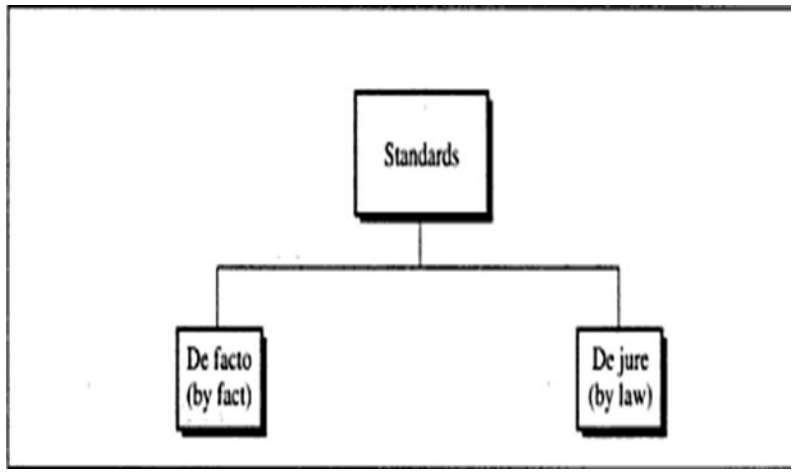
- It refers the **meaning** of each section ofbit

TIMING

- It refers when data sent and how fastit issent (Says Characteristics)
- Ex:100Mbps

Protocol Standard

- It provides **model for the development** of product regardless of individual manufacturer
- It falls in 2 categories



De Facto standard

- Not officially adopted but usedwidespread
- It has 2 categories
- Proprietary->Wholly owned by company
- Non-Proprietary->Group or communiy developed for public

De Jure Standard

- A Standard Legislated by an officially recognized body

- Standard Organizations:
- International Standard Organization
- ANSI
- IEEE

Layering in Computer Network

Layering in Computer Network

- Decomposing the problem in more manageable component(Layers)

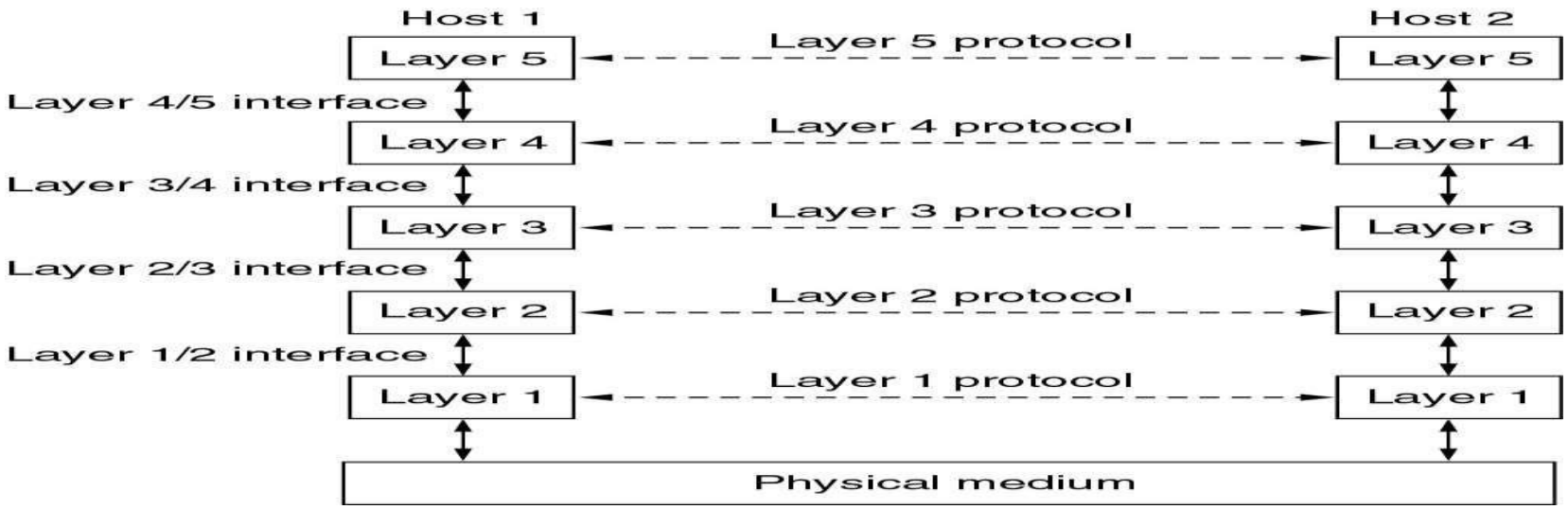
- **Advantages:** 1.It provides more modular design
  2.Easy to troubleshoot

- **Role of Protocols in Layering:**
  - ✓ **Protocols=Rule**
  - ✓ It is a set of rules that governs the data communication
  - ✓ The protocols in each layer governs the activities of the data communications

Protocol Hierarchies

- To reduce the **design complexity**, most networks are organized as a series of layers or levels.
- The number of layers, name of each layer, contents of each layer and the function of each layer differ from network to network.
- The rules and conventions used in this conversation are collectively known as the **Layer 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**.

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.
- **Multiplexin**g – 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

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

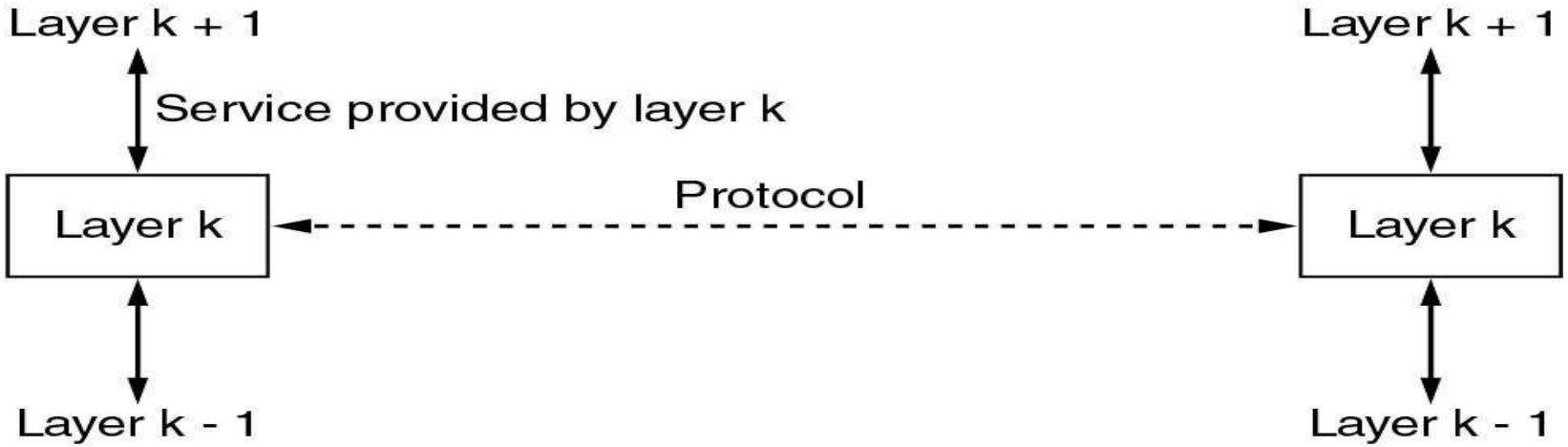
Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

Service Primitives

Listen	When server is ready to accept request of incoming connection, it simply put this primitive into action. **Listen primitive simply waiting for incoming connection request.**
Connect	This primitive is used to connect the server simply by creating or establishing connection with waiting peer.
Accept	This primitive simply accepts incoming connection form peer.
Receive	These primitive afterwards block the server. Receive primitive simply waits for incoming message.
Send	This primitive is put into action by the client to transmit its request that is followed by putting receive primitive into action to get the reply. Send primitive simply sends or transfer the message to the peer.
Disconnect	This primitive is simply used to terminate or end the connection after which no one will be able to send any of the message.

Services to Protocols Relationship

- 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

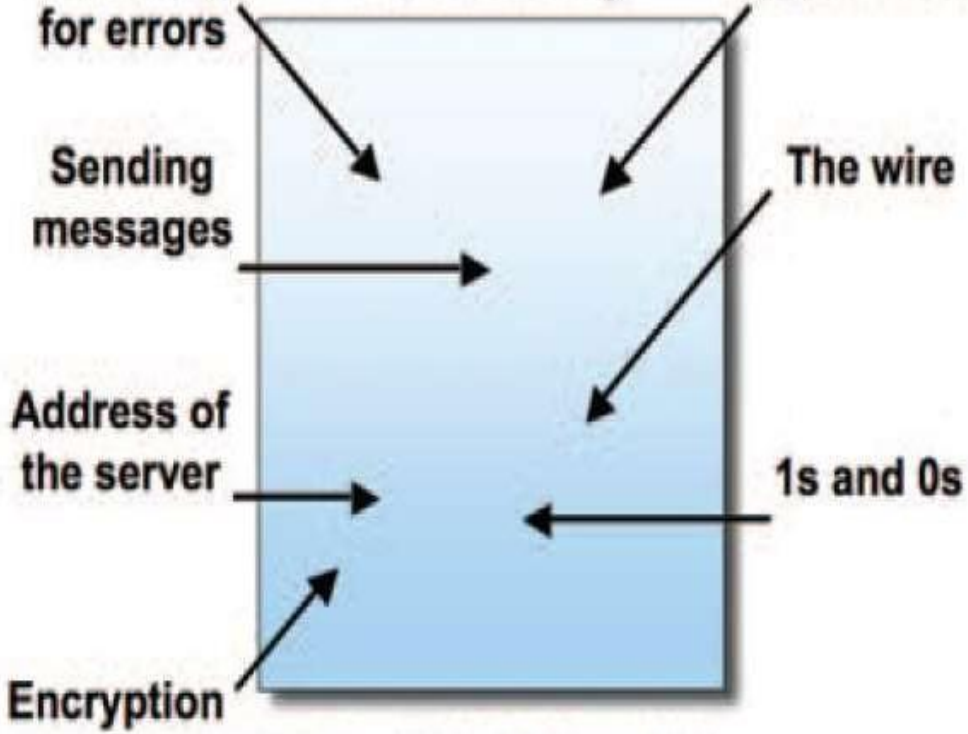


- Available Layer Architectures:
    1. ISO-OSI Reference Model
    2. TCP/IP Model

The OSI Reference Model

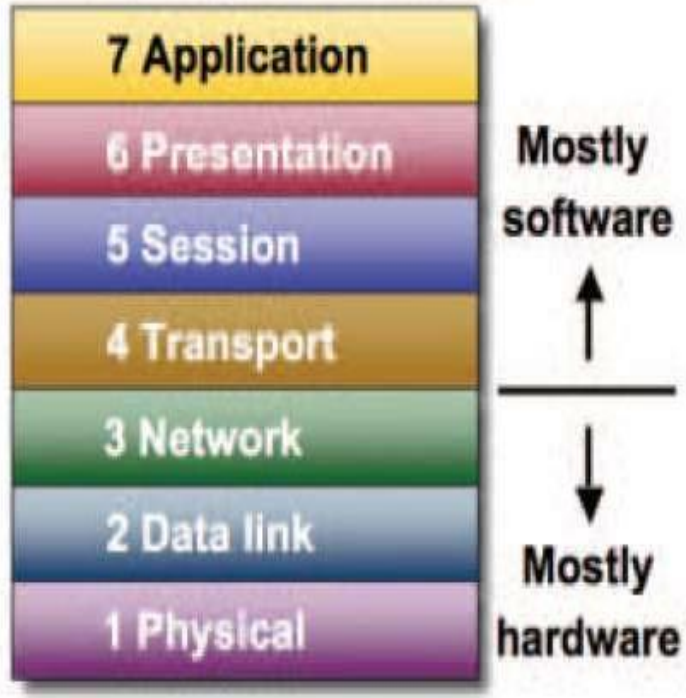
- In 1947, the international standards organization(ISO) is a multinational body dedicated to worldwide agreement on international standards.
- An ISO standard that covers all aspects of network communications is the open systems interconnection model.
- In late 1970s an open system is a set of protocols that allow any two different systems to communicate
- It divides the communications processes into seven layers.

Chaos networking



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

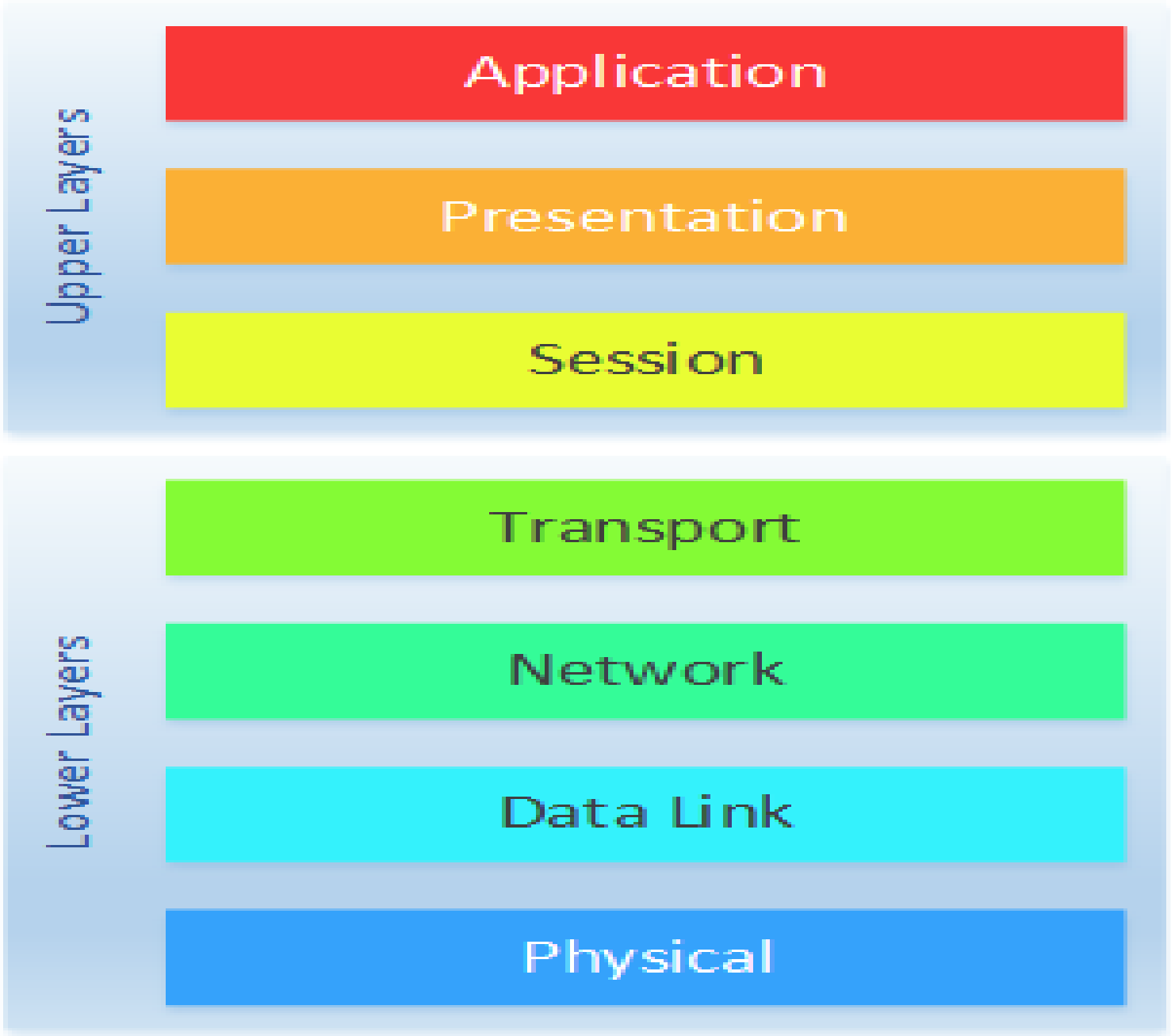
Networking OSI seven-layer model



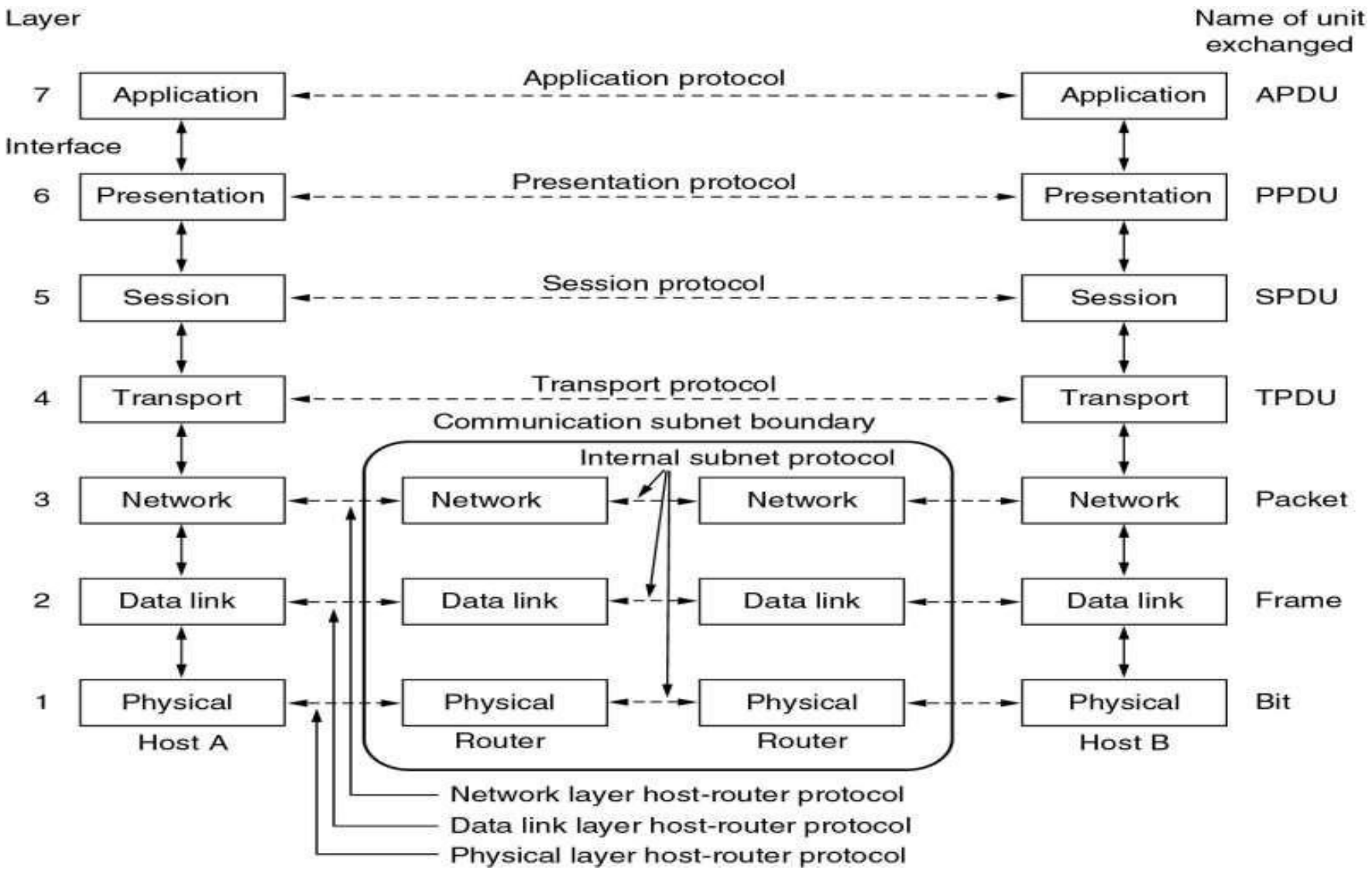
With the OSI model, networks can be broken up into manageable pieces. The OSI model provides a common language to explain components and their functionality.

Layering Principle

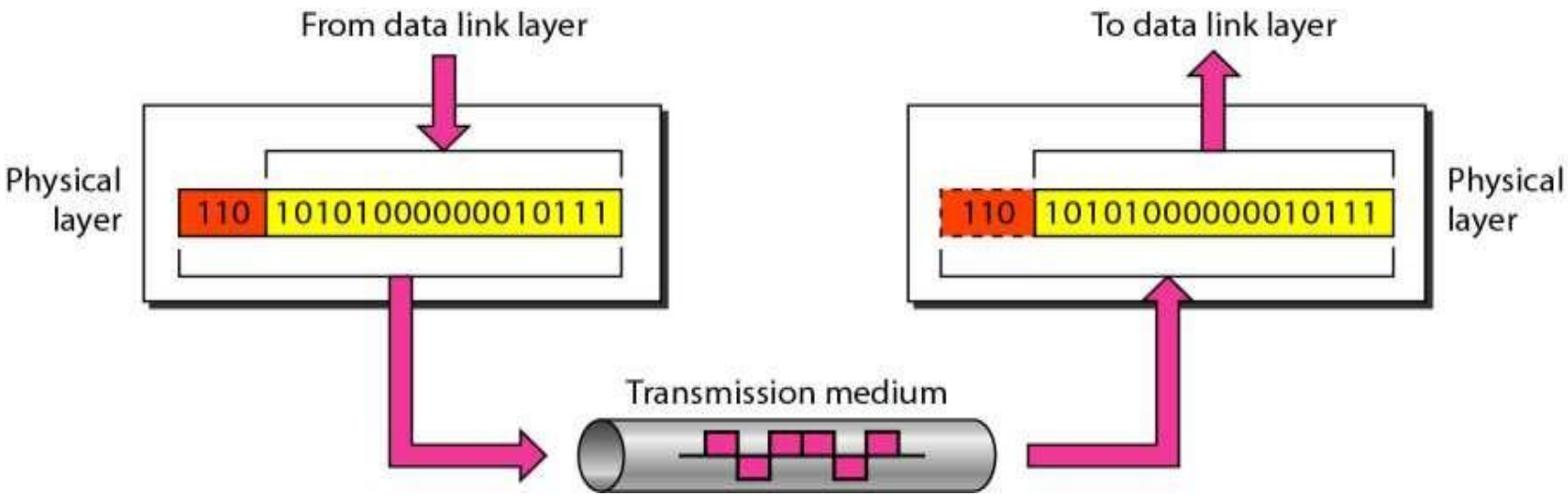
- A layer should be created where a different level of abstraction is needed.
- Each layer should perform a well defined function.
- The function of each layer should be chosen with an eye toward defining internationally standardized protocols.
- The layers boundaries should be chosen to minimize the information flow across the interfaces.
- 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


Upper Layers
Application
Presentation
Session
Lower Layers
Transport
Network
Data Link
Physical

OSI reference model



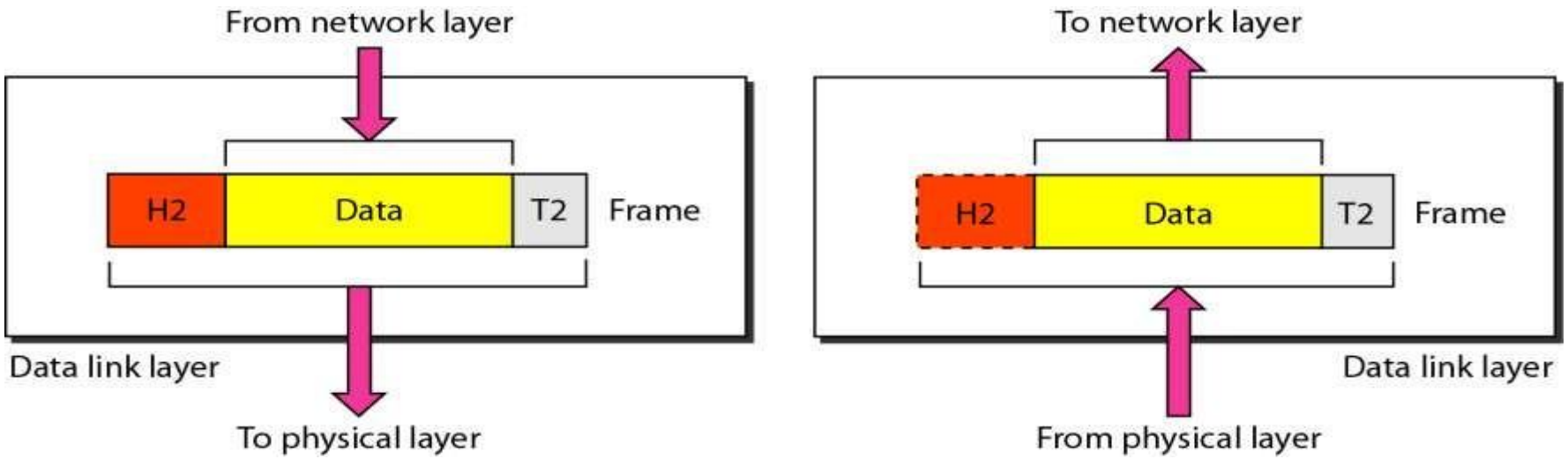
Physical layer



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

Data link layer

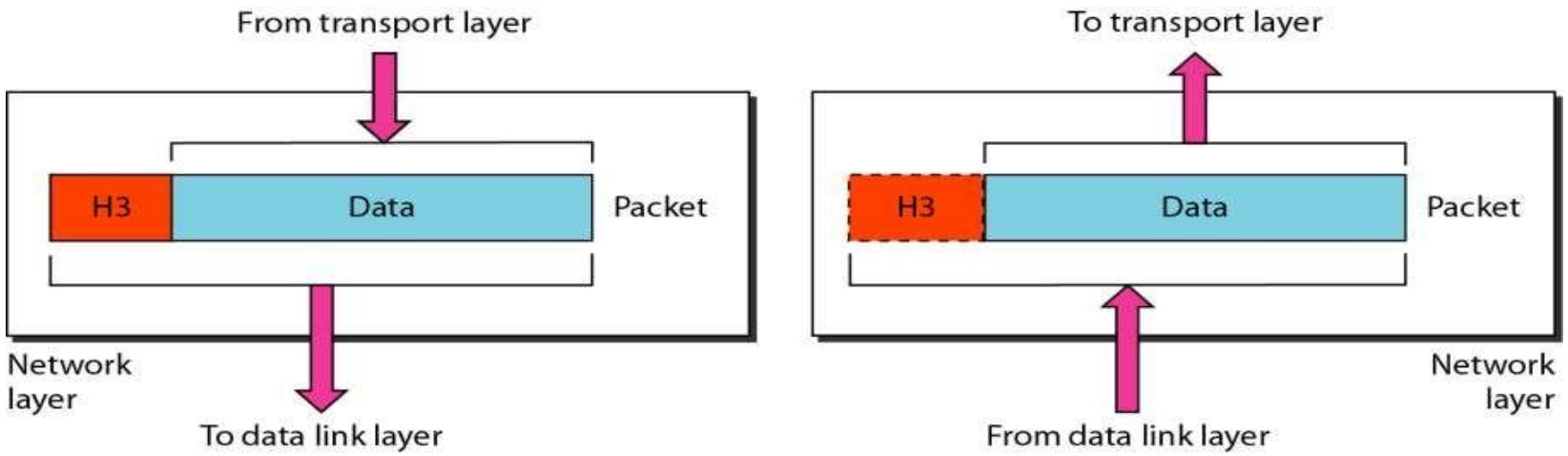


- The main task of the data link layer is to detected transmission errors
- It accomplishes this task by having the sender break up the input data into data frames and transmits the frames sequentially.

Data Link Layer

- 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

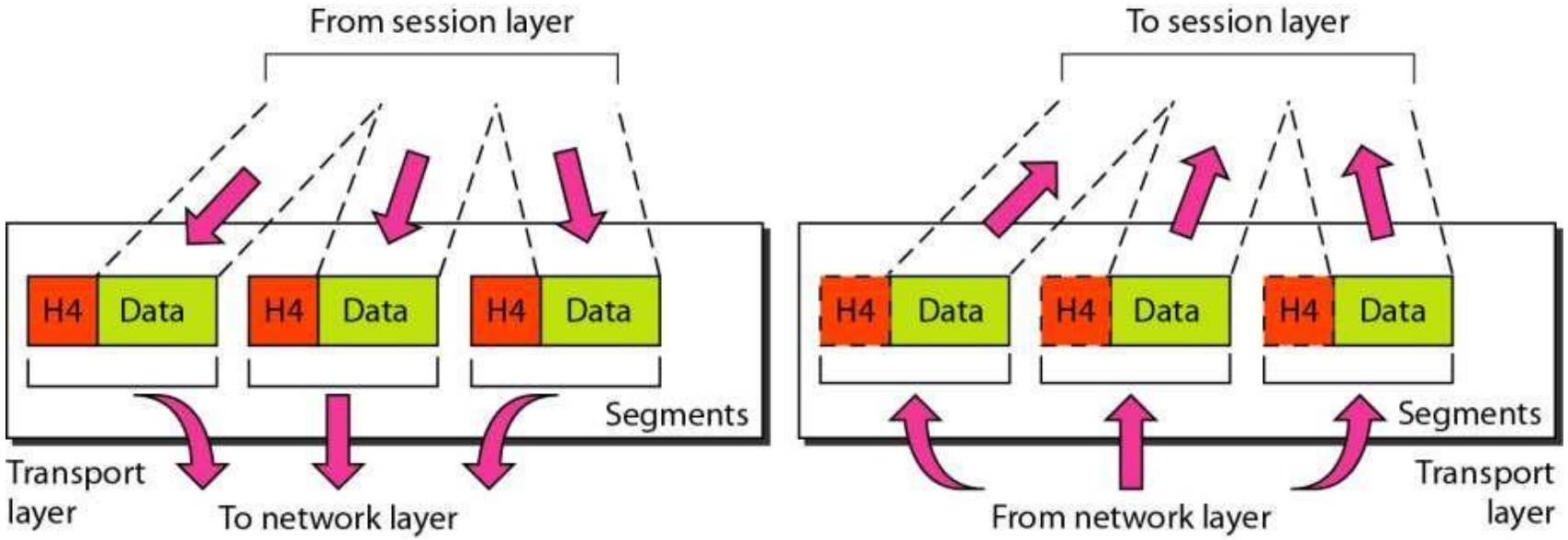


- The network layer controls the operation of the subnet.
- The network layer is responsible for the delivery of individual packets from the source host to the destination host. A key design issue is determining how packets are routed from source to destination.

Network Layer

- Routes can be based on **static tables .**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 leads to **congestion . Hence Congestion Control** 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 data transmission** 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)
- Provides **acknowledgements of successful transmissions** and requests **resends for packets** which arrive with **errors**

Transport Layer

- The basic function of the transport layer is to accept data from above, split it up into smaller units , 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.
- 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**.

Transport Layer

- 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

Session Layer

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

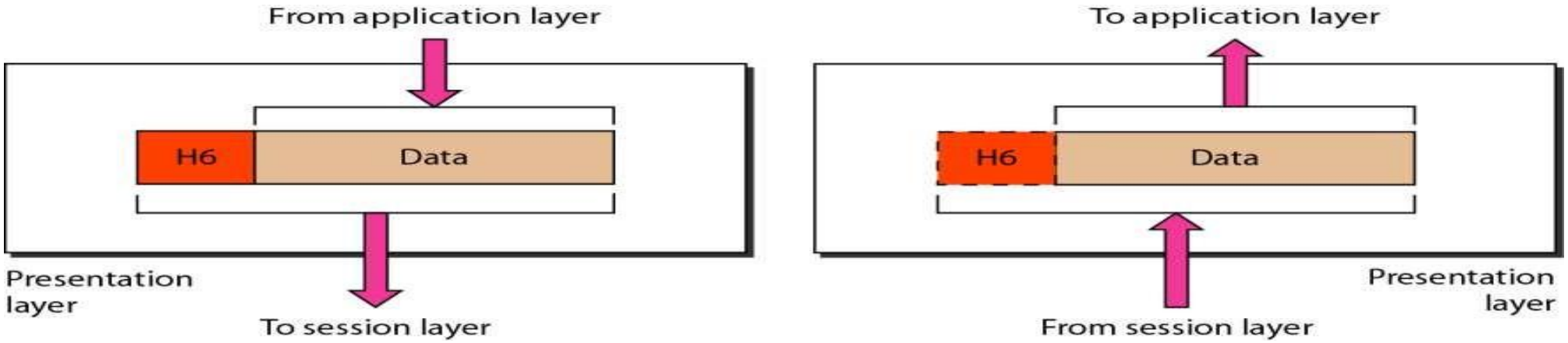
- Various services offer by Session layer are:

  dialog control (keeping track of whose turn it is to transmit),

  token management (preventing two parties from attempting the same operation at the same time),

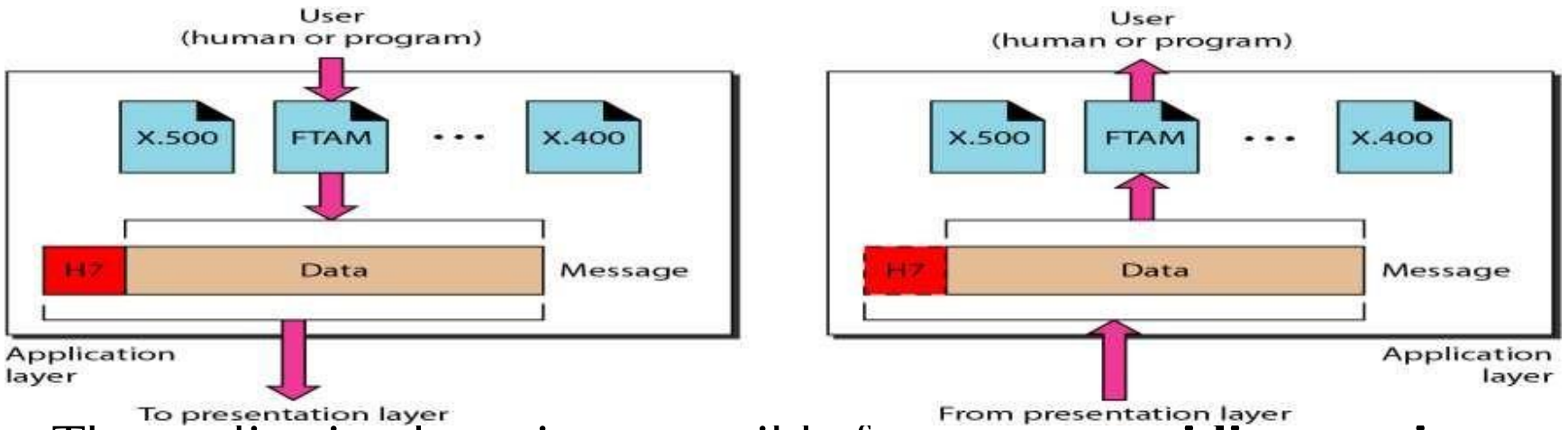
  synchronization (check pointing to continue from where they were after a crash).

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

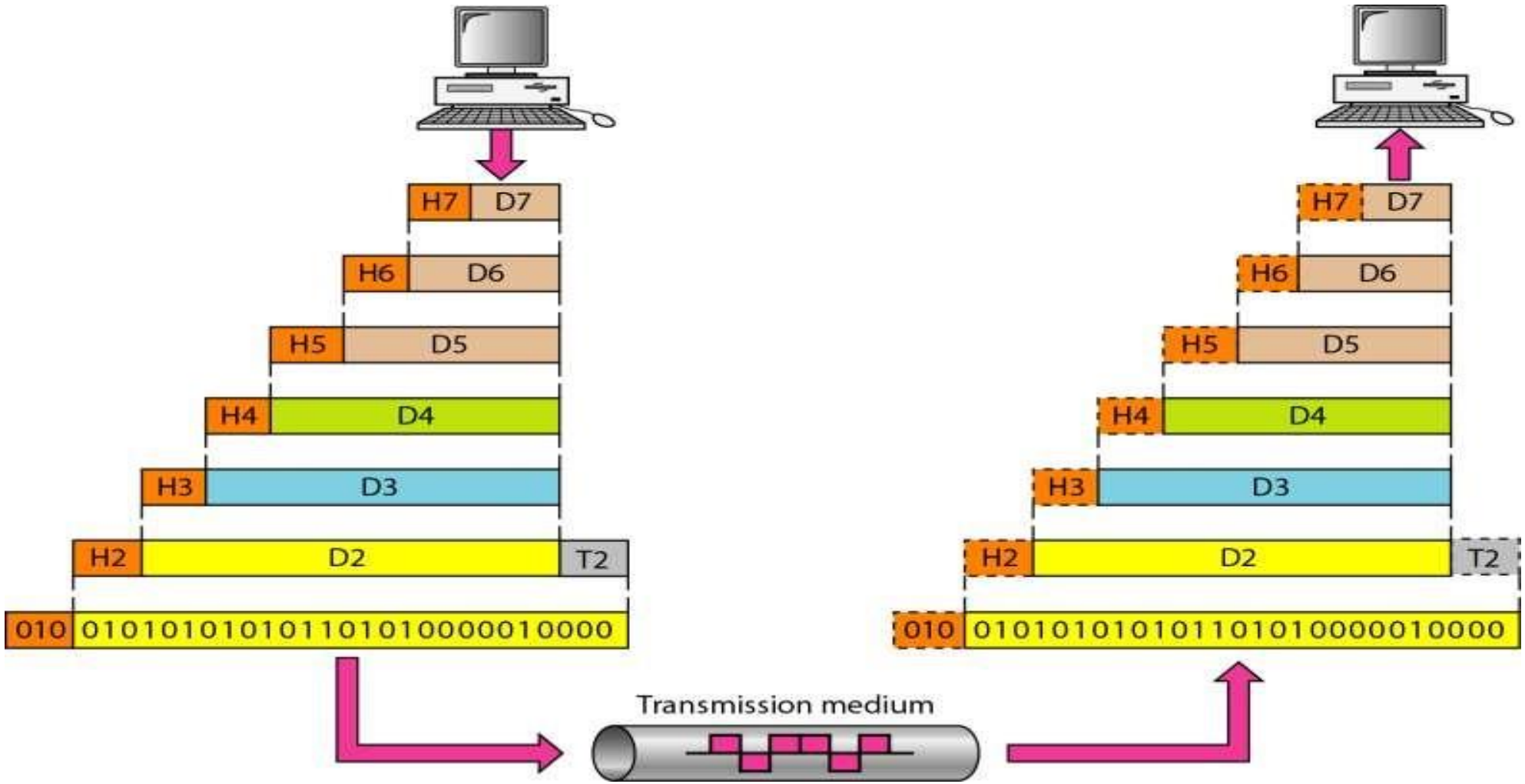
Application layer



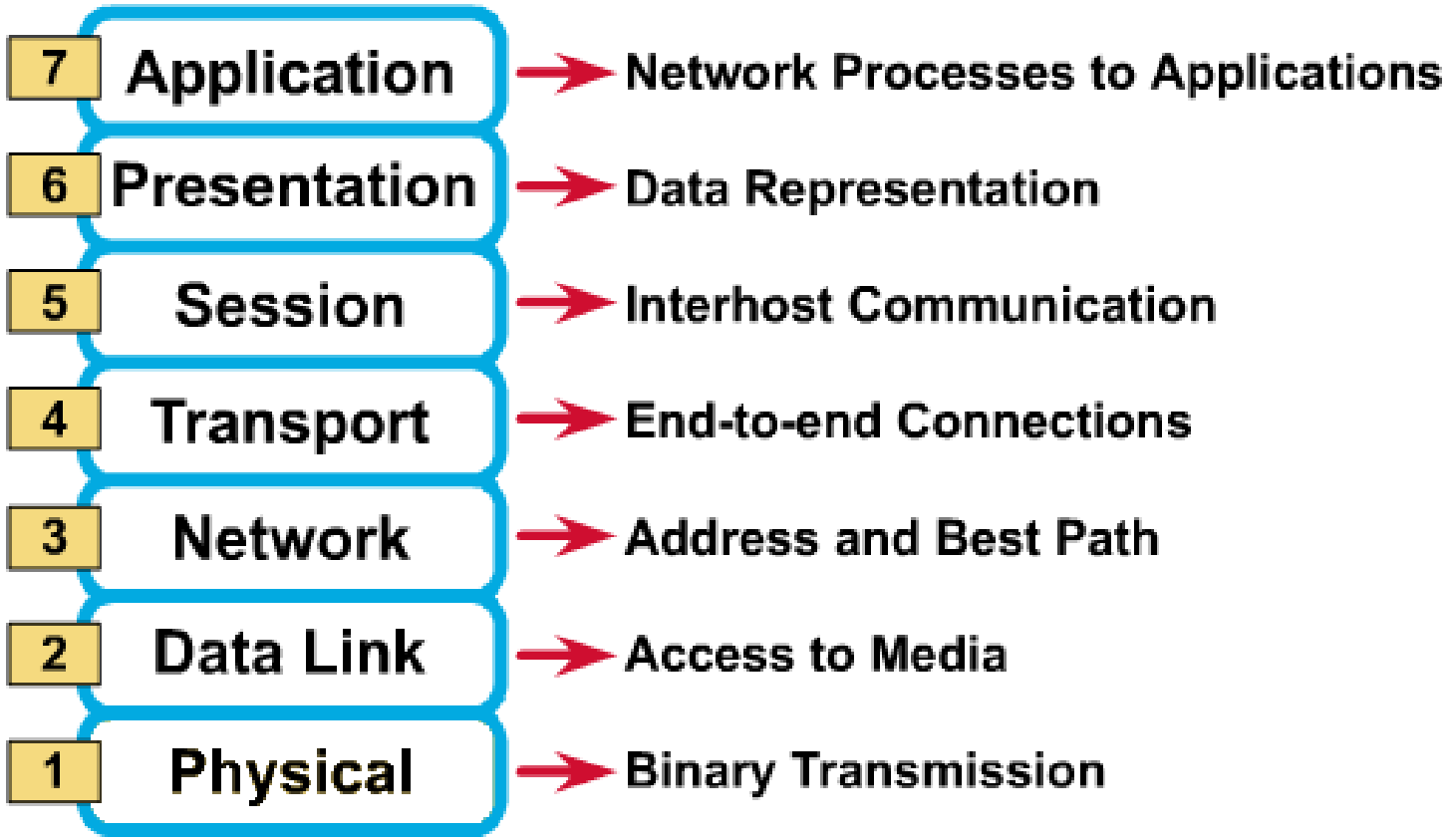
•The application layer is responsible for **providing services to the user**.

•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


H7
D7
H6
D6
H5
D5
H4
D4
H3
D3
H2
D2
T2
010
0101010101011010100000010000
Transmission medium
H7
D7
H6
D6
H5
D5
H4
D4
H3
D3
H2
D2
T2
010
0101010101011010100000010000

THE SEVEN OSI REFERENCE MODEL LAYERS



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.

The TCP/IP reference model

Transmission control protocol/ information protocol

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

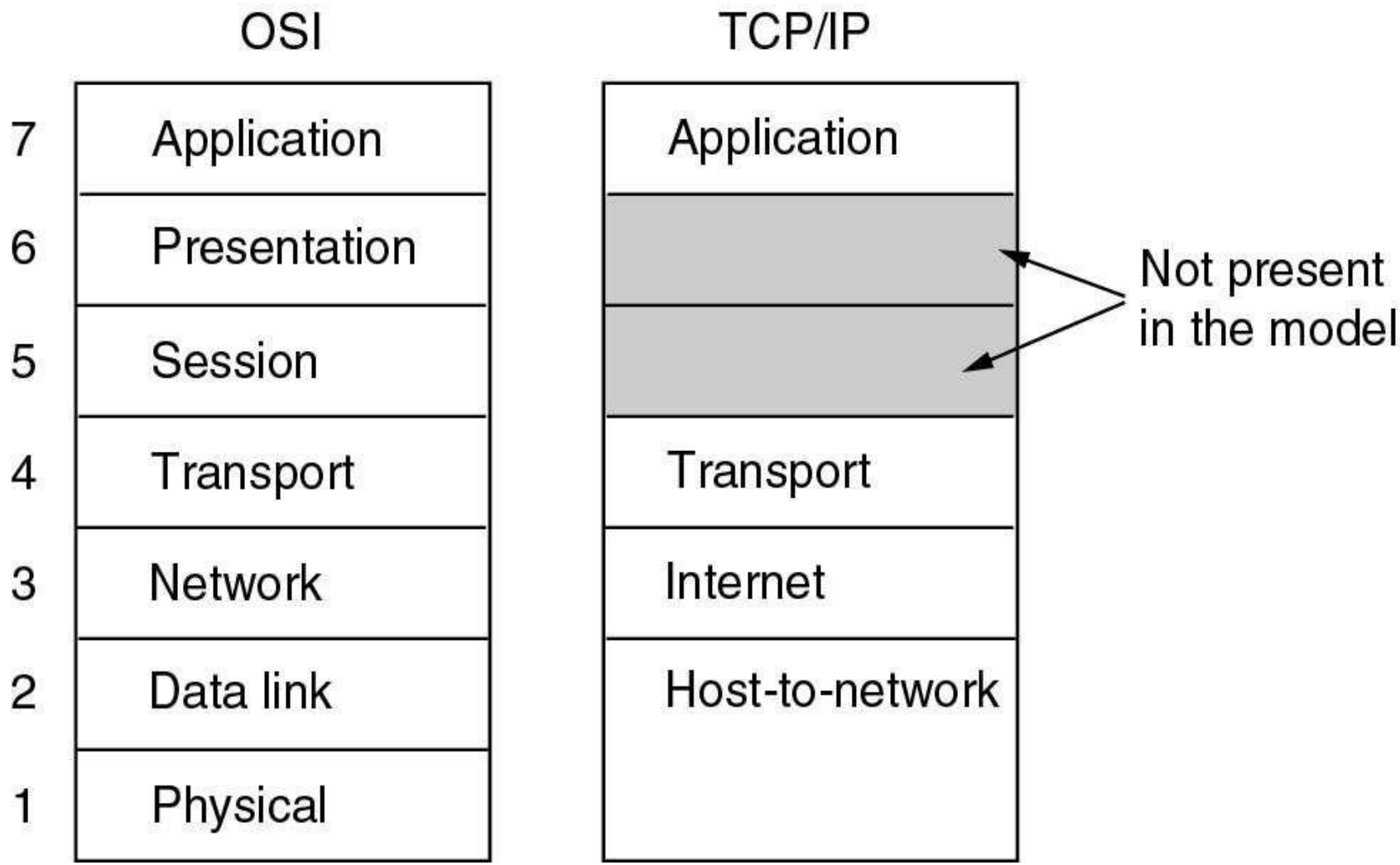
1.Host-to-Network Layer

2.Internet Layer

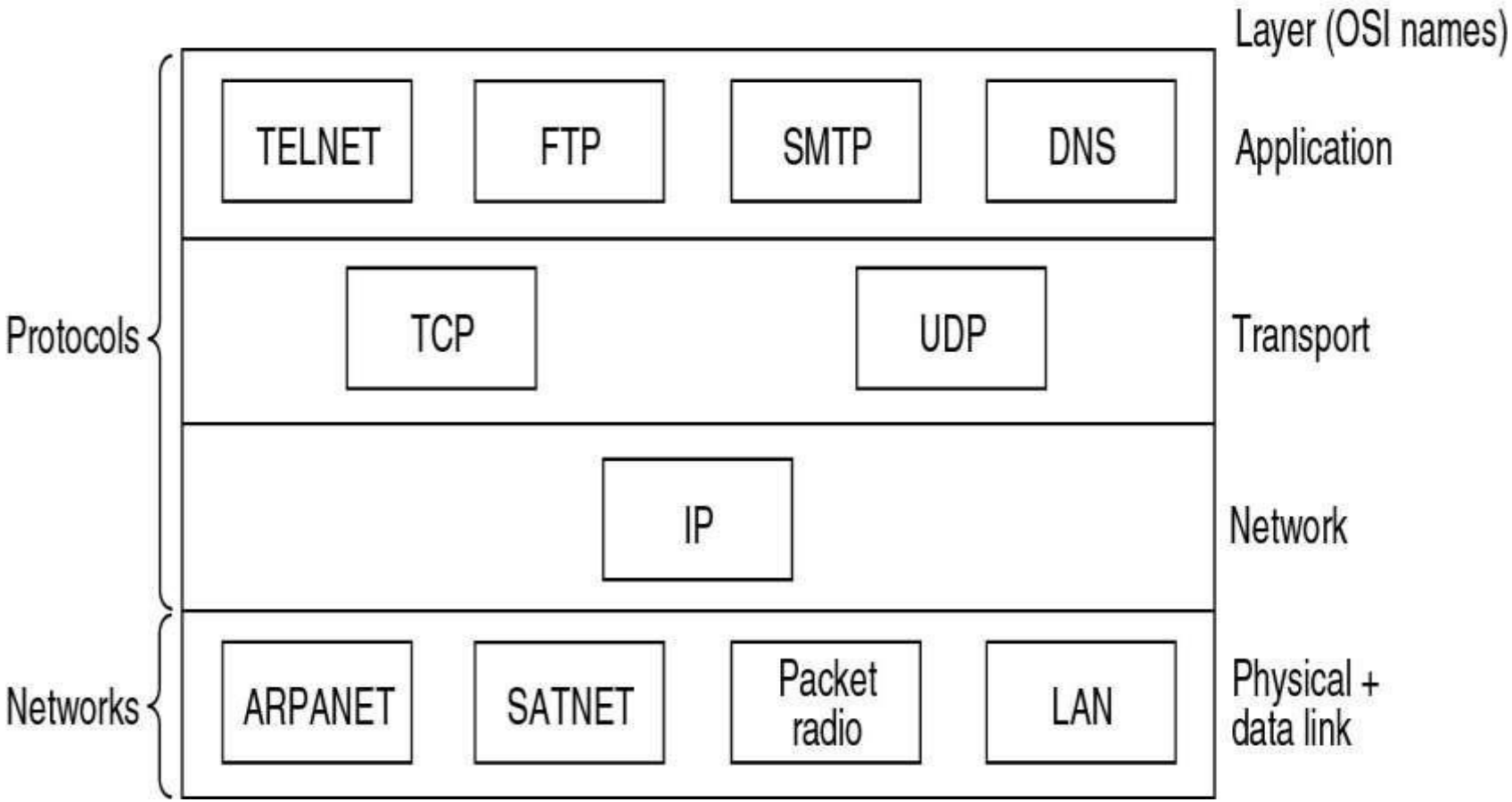
3.Transport Layer

4.Application Layer

The TCP/IP reference model.



Protocols and networks in the TCP/IP model initially.



Internet layer

- It injects packets into any network and they travel independently to the destination
- 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**.

Transmission Control Protocol

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.
  - 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

- On top of the transport layer is the application layer. It contains all the higher-level protocols.
- Protocols included are (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.

ARPANET

- 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

- 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

- **Packet radio** is a form of packet switching technology used to transmit digital data via radio or wireless communications link
- 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

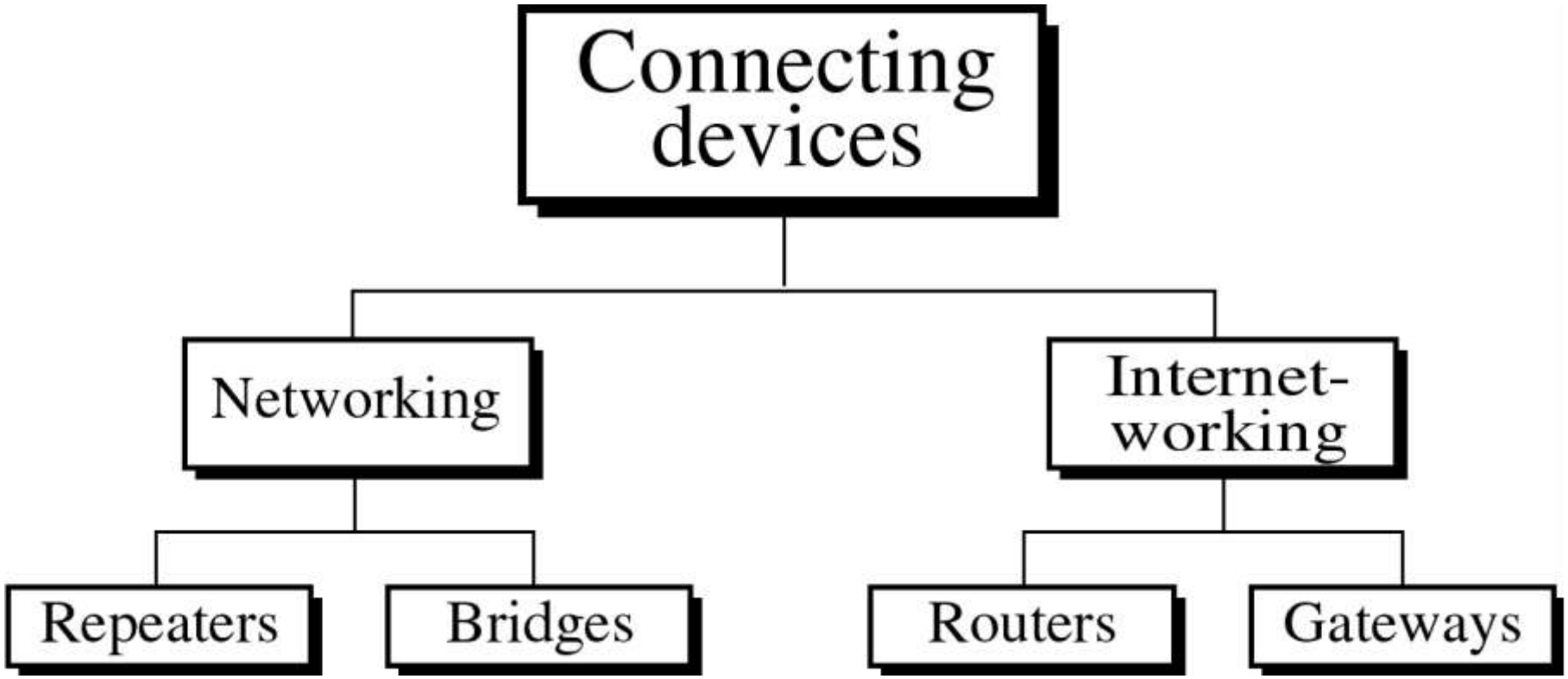
- Bad timing
- Bad technology
- Bad implementations
- Bad politics

A Critique of the TCP/IP Reference Model

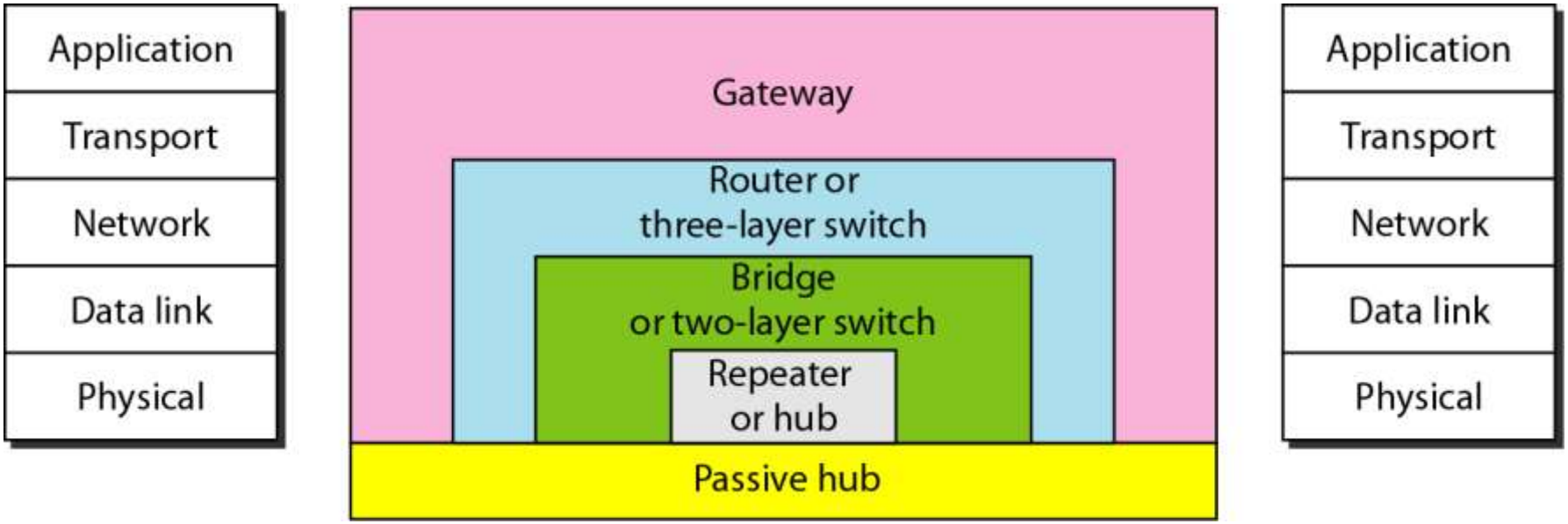
- Service, interface, and protocol not distinguished
- Not a general model
- Host-to-network “layer” not really a layer
- No mention of physical and data link layers
- Minor protocols deeply entrenched, hard to replace

Networking and Internetworking Devices

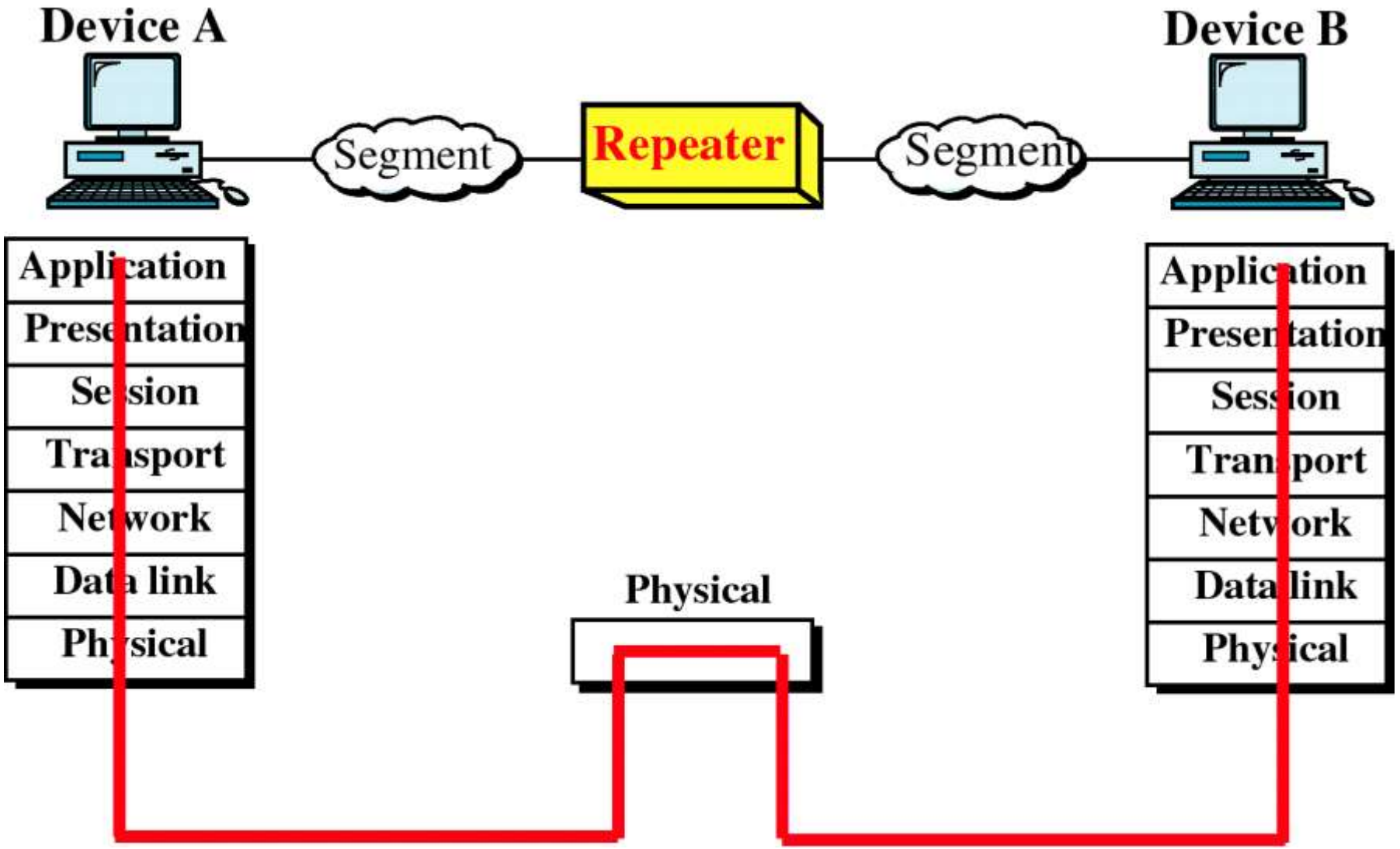
- Repeaters
- Bridges
- Routers
- Gateways
- Routing Algorithms


Connecting devices
Networking
Internet-working
Repeaters
Bridges
Routers
Gateways

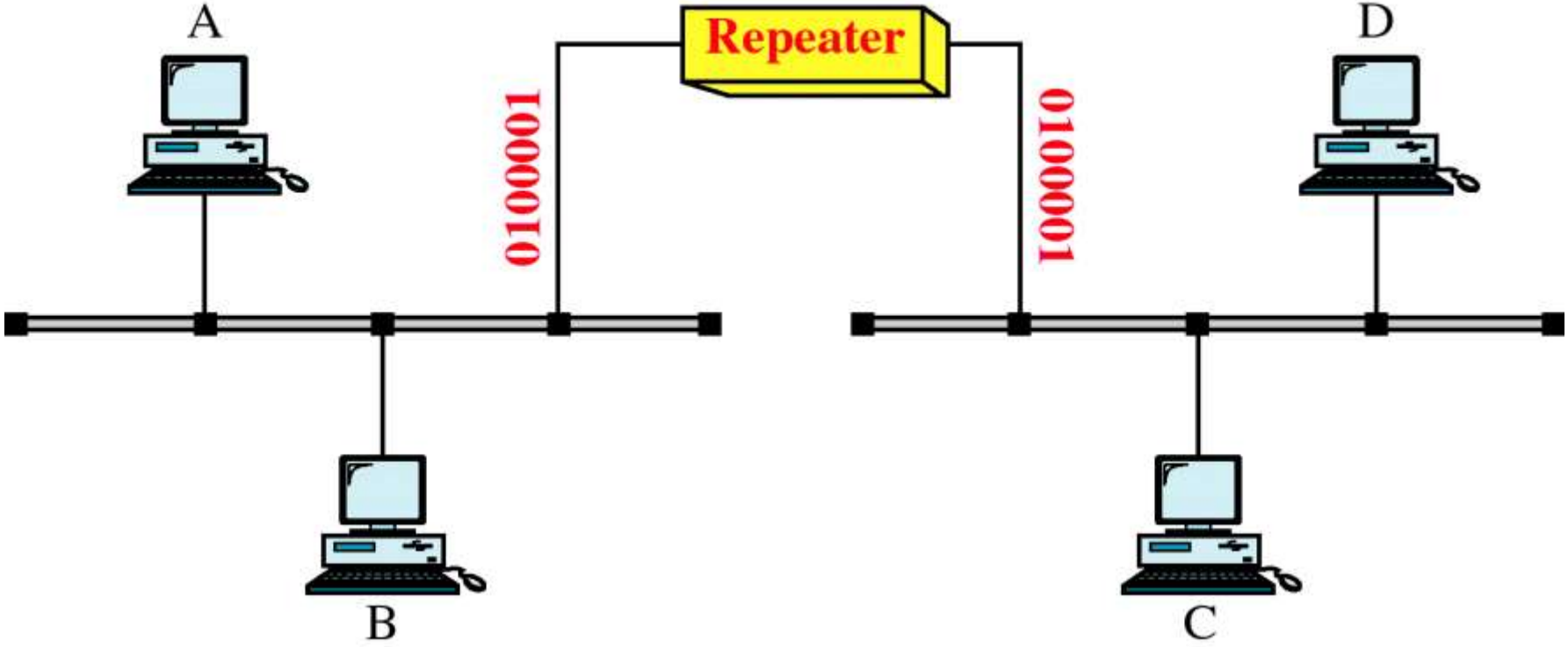
Connecting Devices and the OSI Model



Repeater and OSI Model

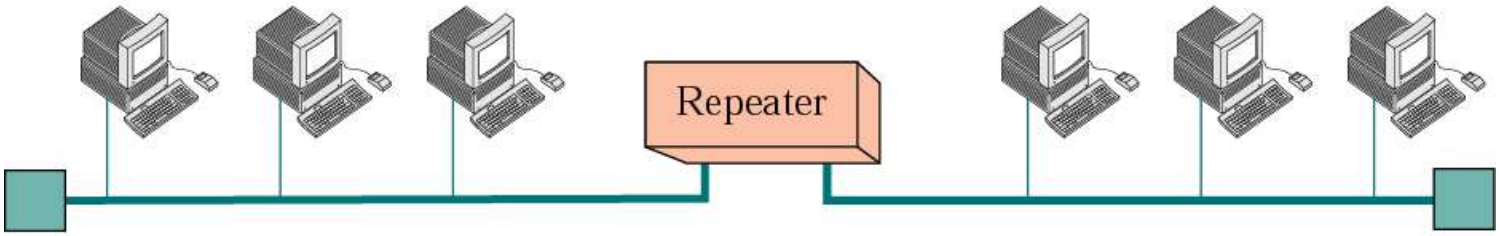


A Repeater



Repeater

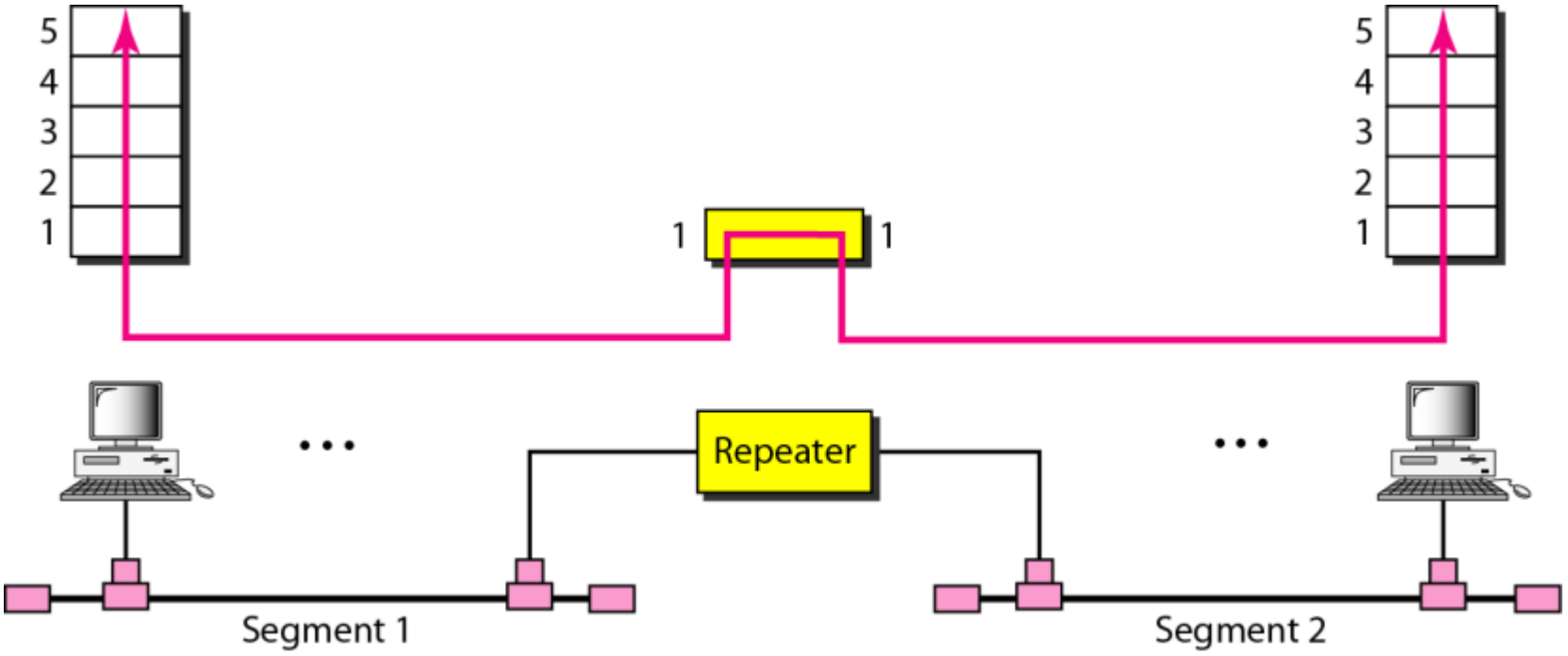
a. Without Repeater



b. With Repeater

- A repeater is an electronic device and operates only in the physical layer of the OSI model.
- A repeater can regenerate the signal and send it to the rest of the network.

A repeater connecting two segments of a LAN



Note

A repeater connects segments of a LAN.

Note

A repeater forwards every frame;
it has no filtering capability.

Note

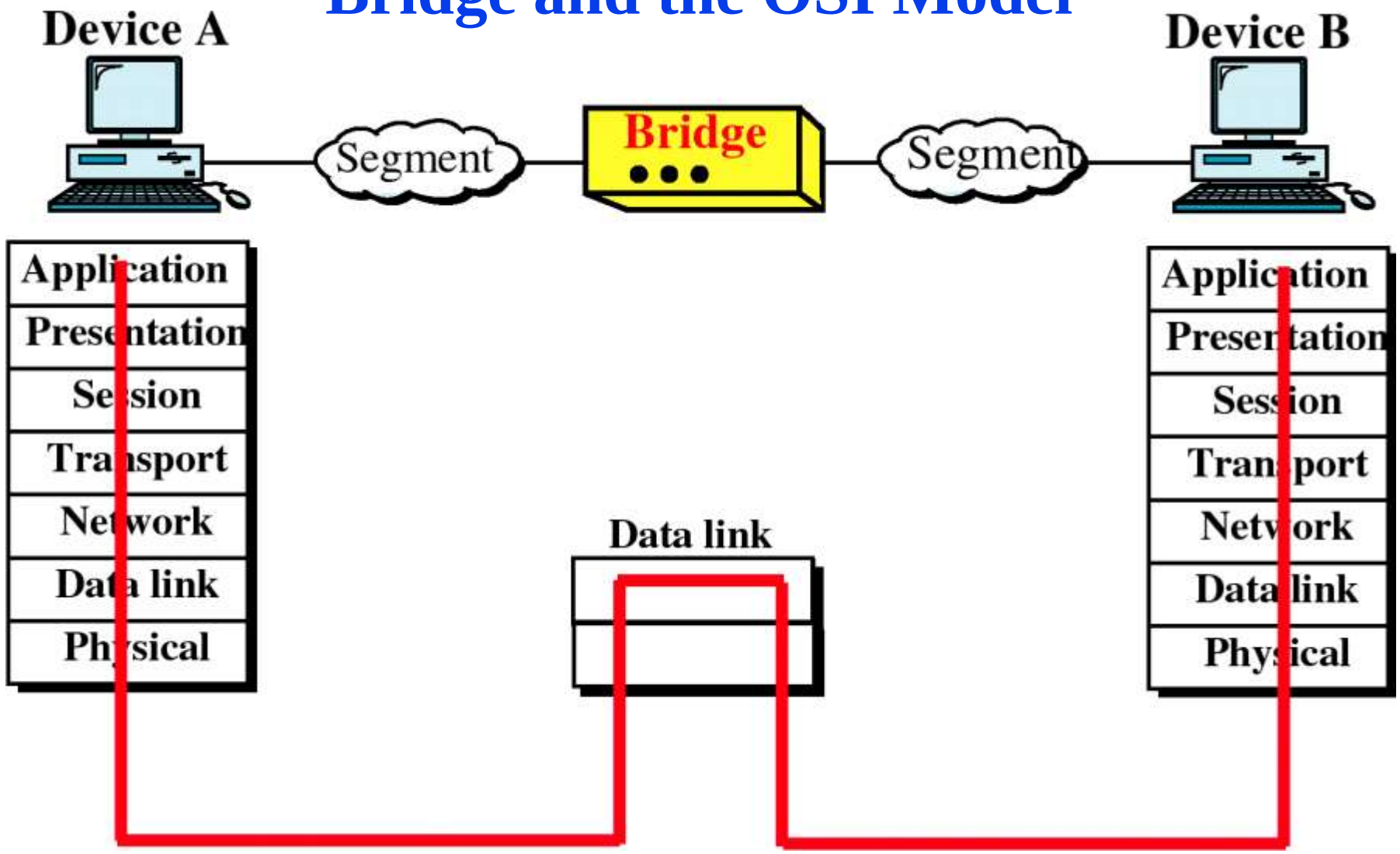
A repeater is a regenerator,
not an amplifier.

Function of a Repeater

(a) Right-to-left transmission.

(b) Left-to-right transmission.

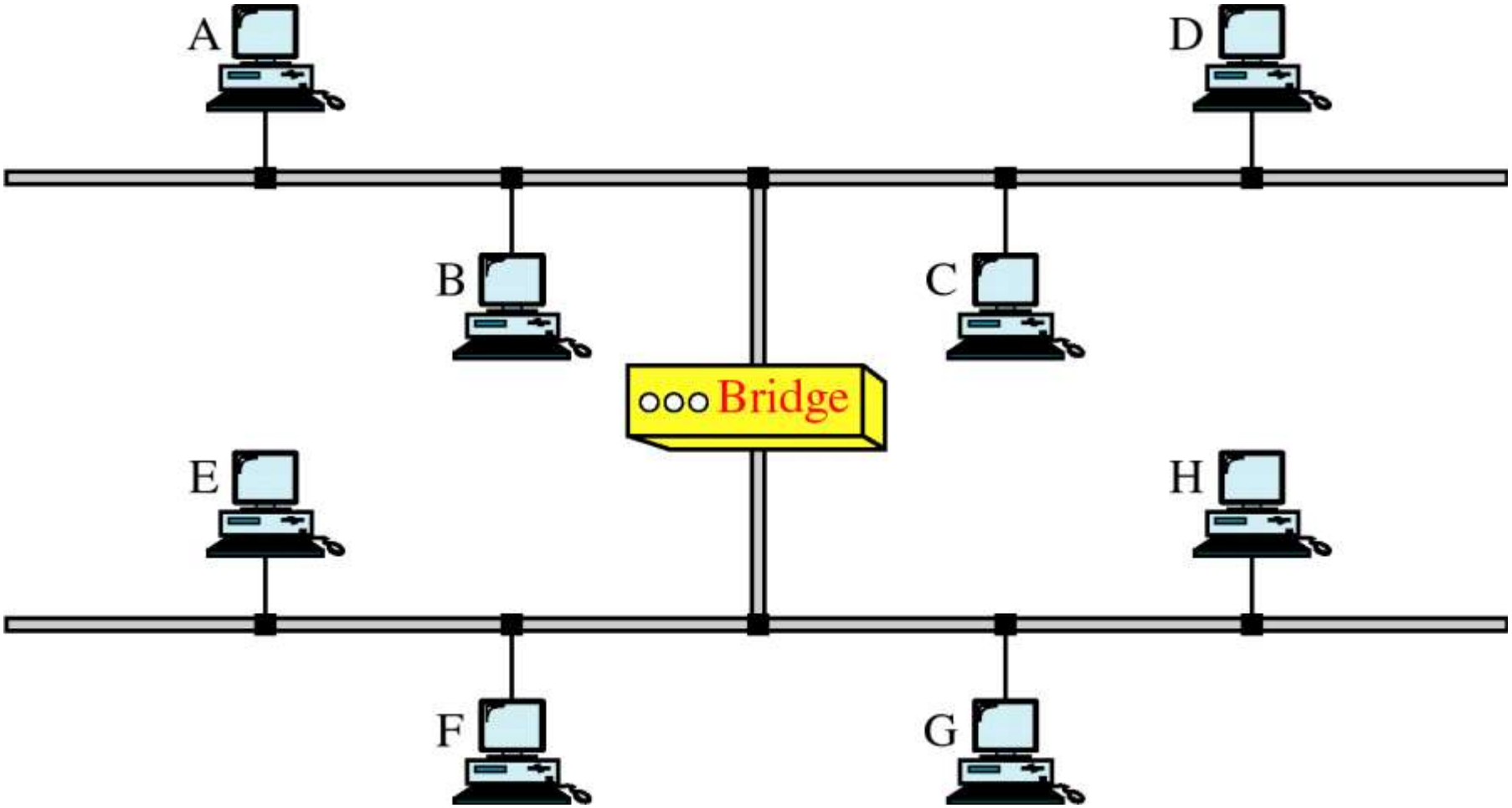
Bridge and the OSI Model



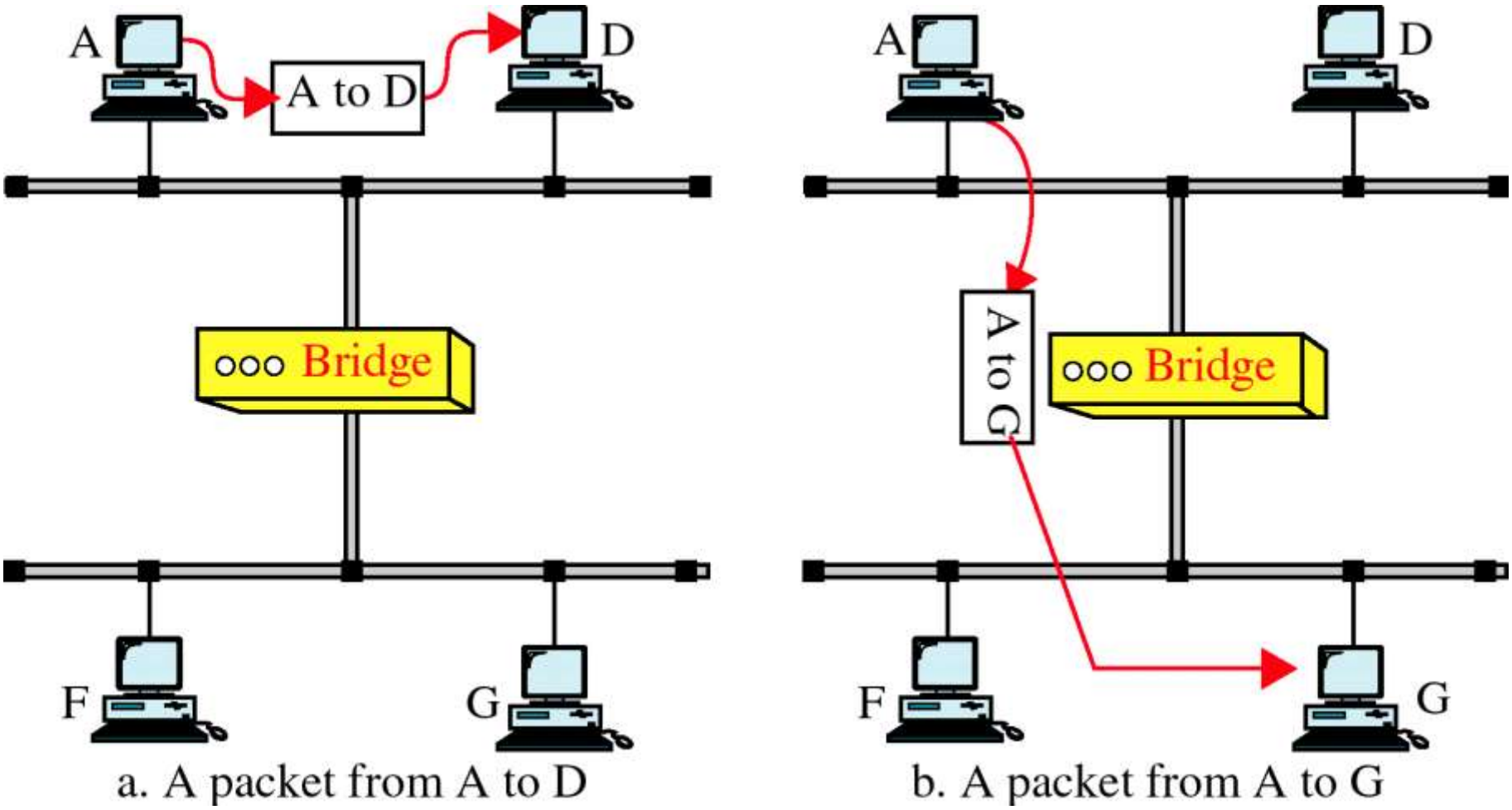
Bridges

- In bus topology, a bridge is a traffic controller.
  - It can divide a long bus into smaller segments so that each segment is independent traffic wise.
  - The bridge uses a table to decide if the frame needs to be forwarded to another segment.
  - With a bridge, two or more pairs of stations can communicate at the same time.

A Bridge



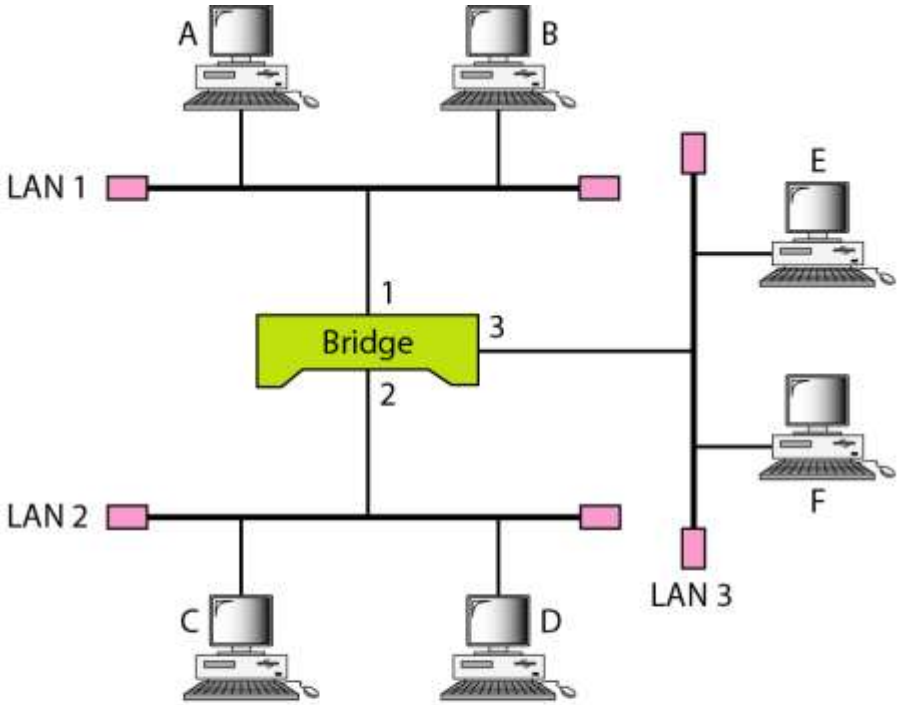
Function of a Bridge



Note

A bridge does not change the physical (MAC) addresses in a frame.

A learning bridge and the process of learning



Address	Port

a. Original

Address	Port
A	1

b. After A sends a frame to D

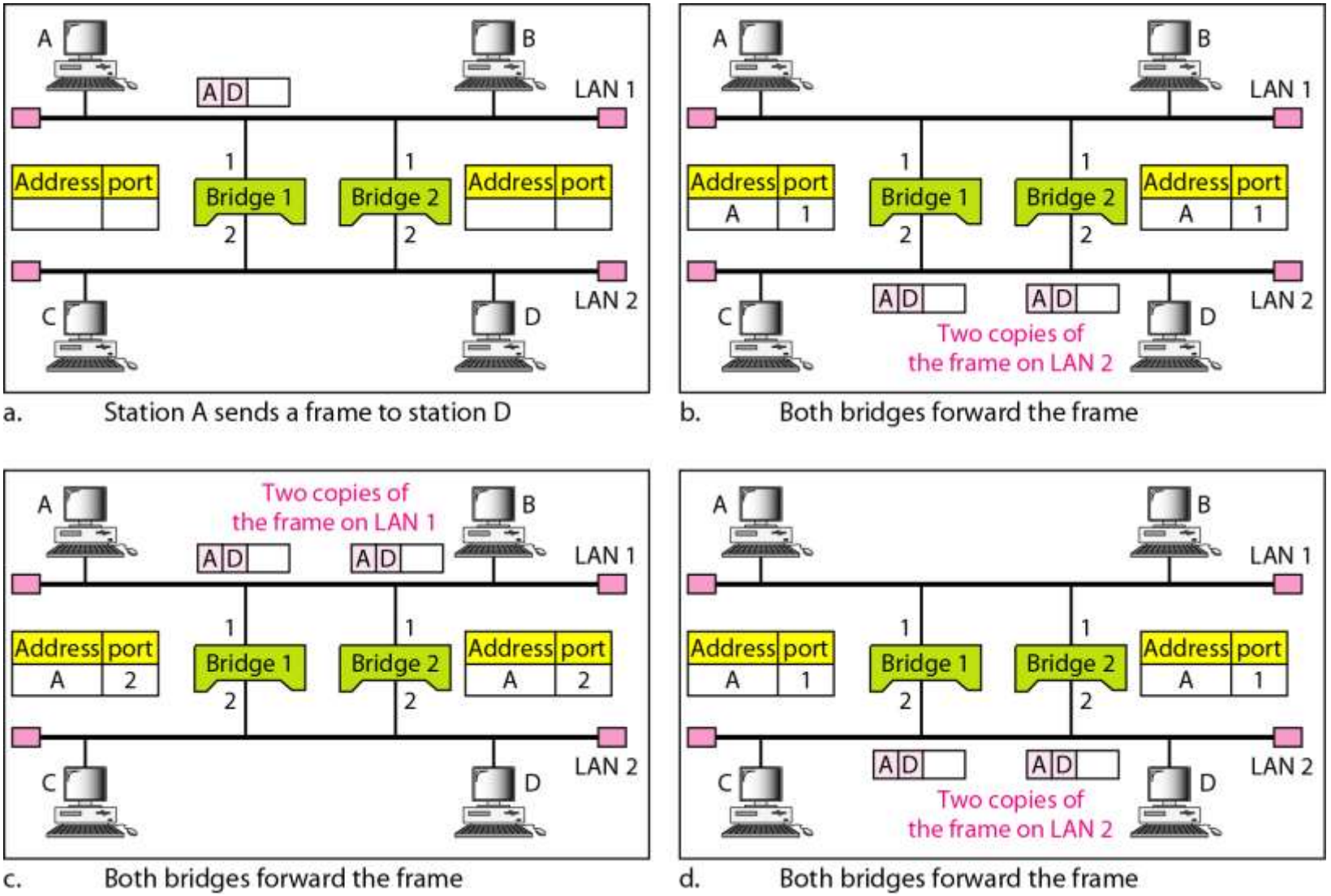
Address	Port
A	1
E	3

c. After E sends a frame to A

Address	Port
A	1
E	3
B	1

d. After B sends a frame to C

Figure 15.7 *Loop problem in a learning bridge*



a. Station A sends a frame to station D

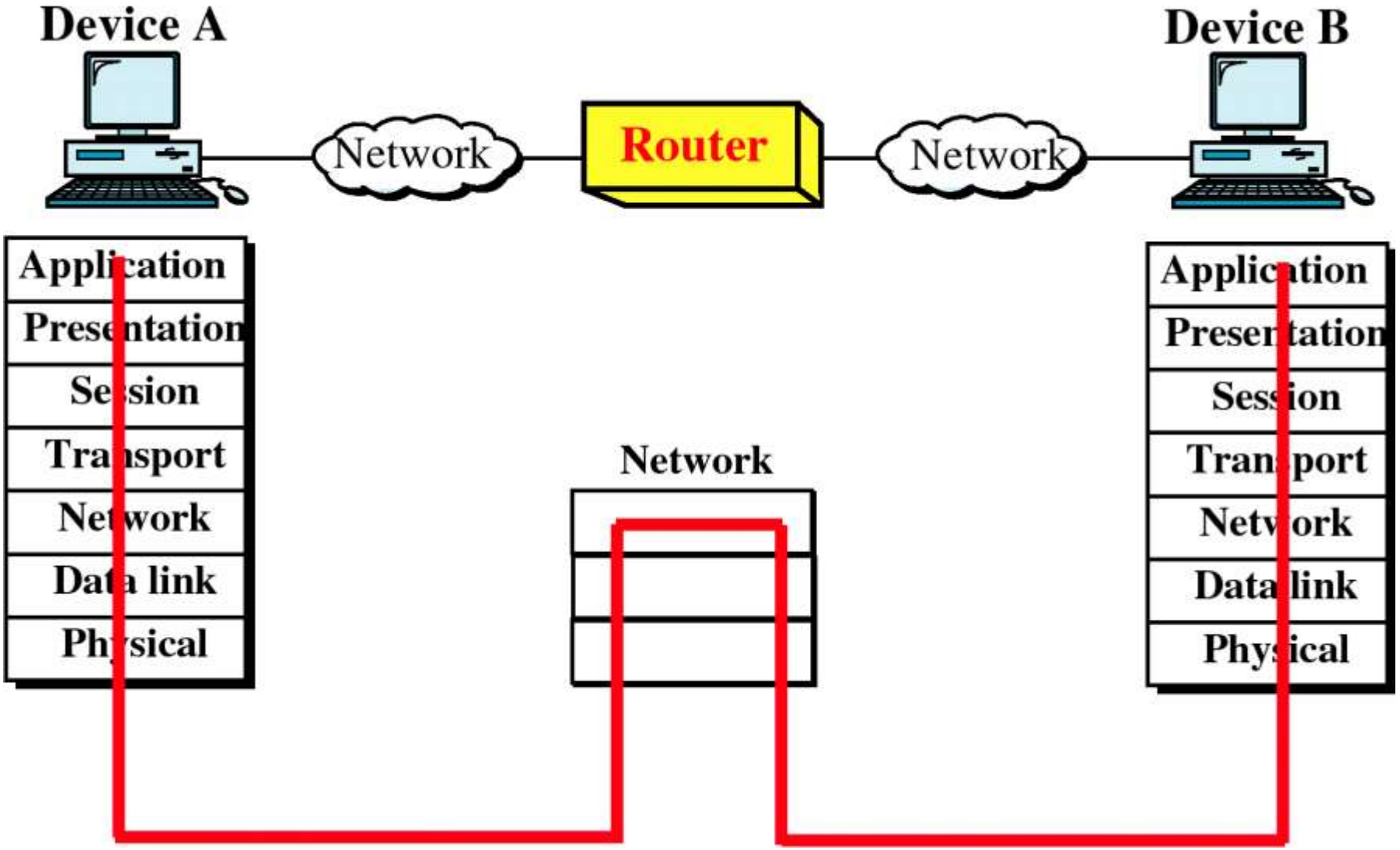
b. Both bridges forward the frame

c. Both bridges forward the frame

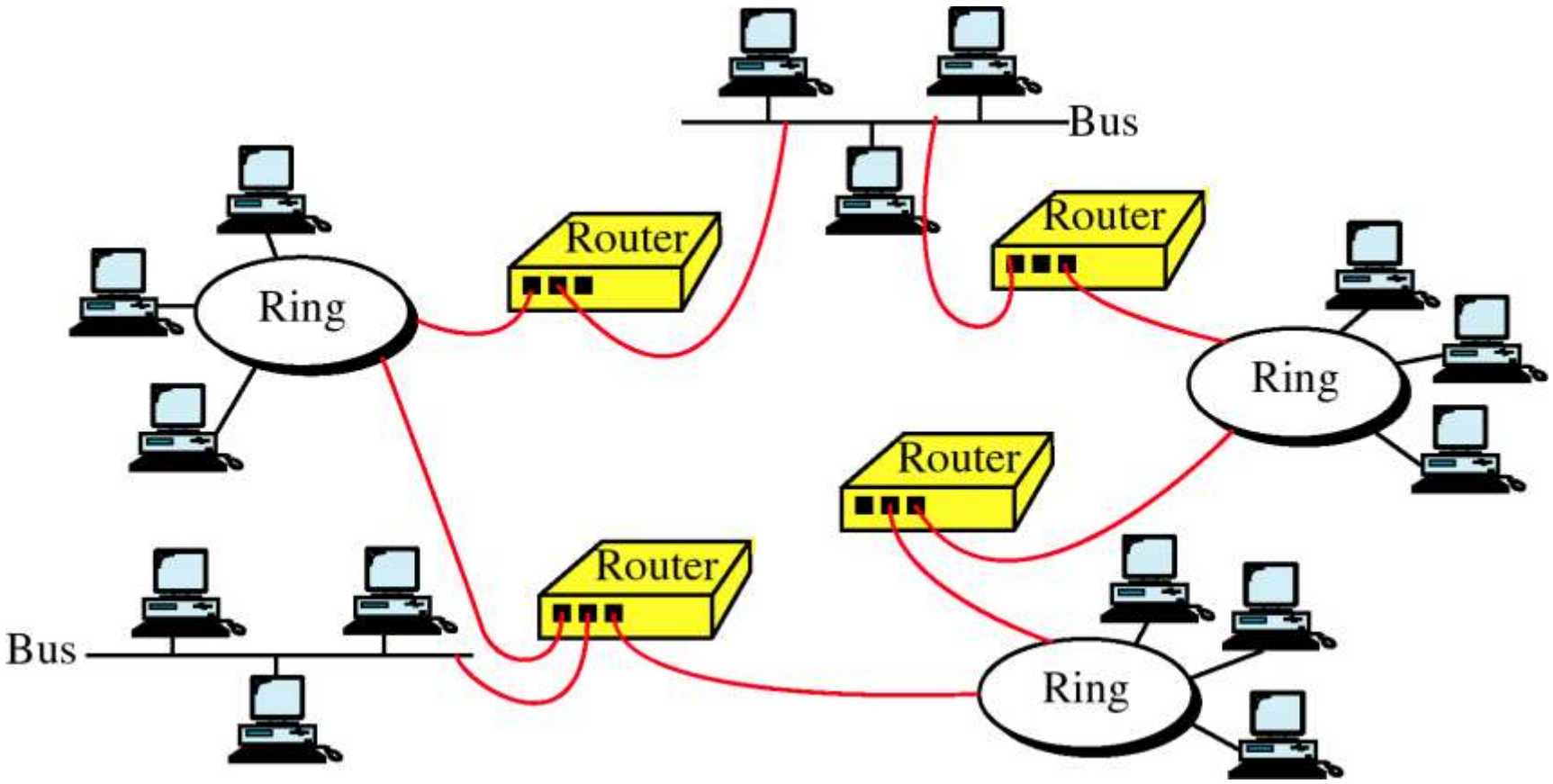
d. Both bridges forward the frame

Bridges operate at the first two layers (physical layer and data-link layer) of the OSI model.

Router and the OSI Model



Routers in an Internet



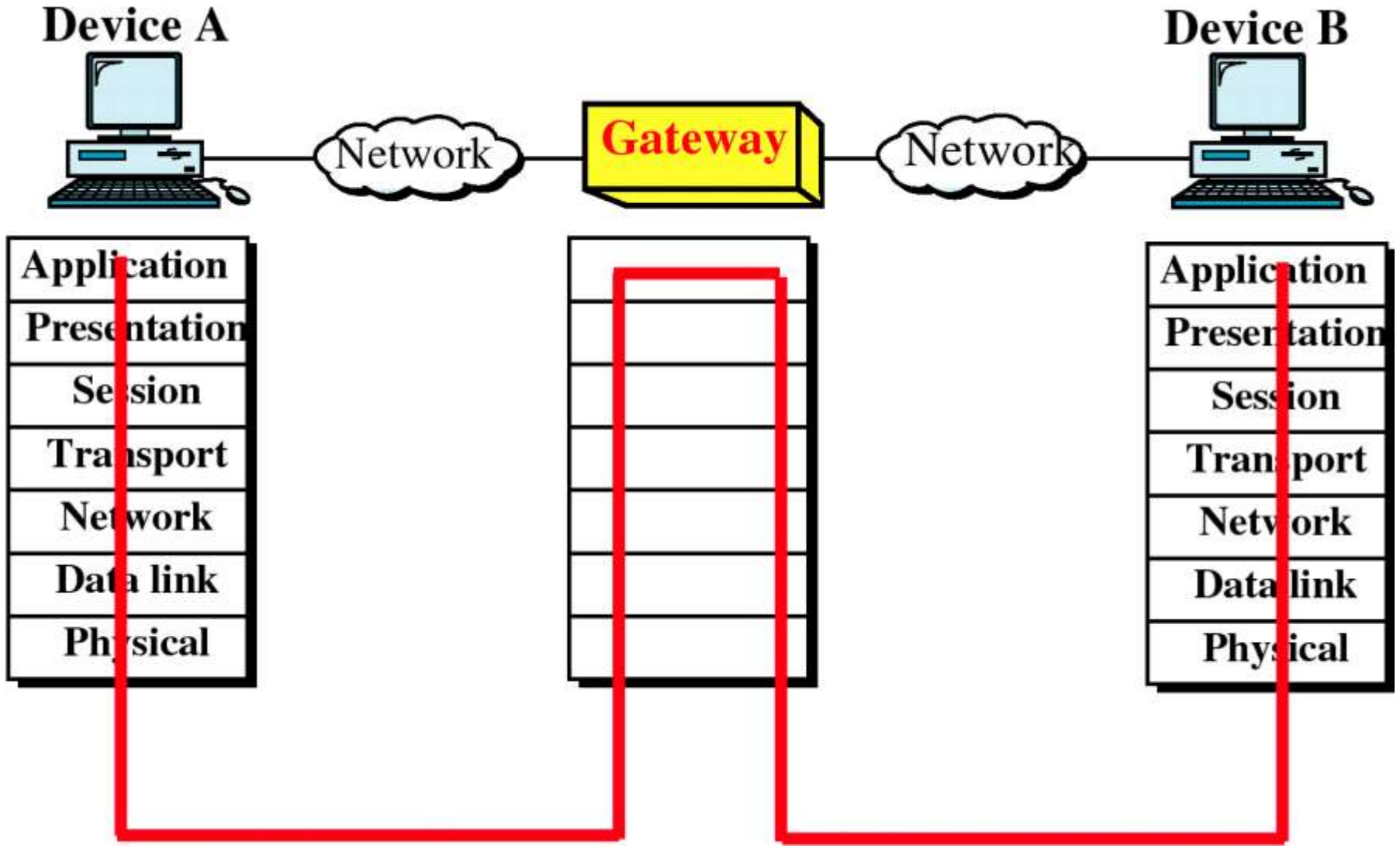
Routers

- Whereas a bridge filters a frame based on the physical address of the frame, a router routes a packet based on the logical address of the packet.
- Whereas a bridge may connect two segments of a LAN, a router can connect two independent networks.

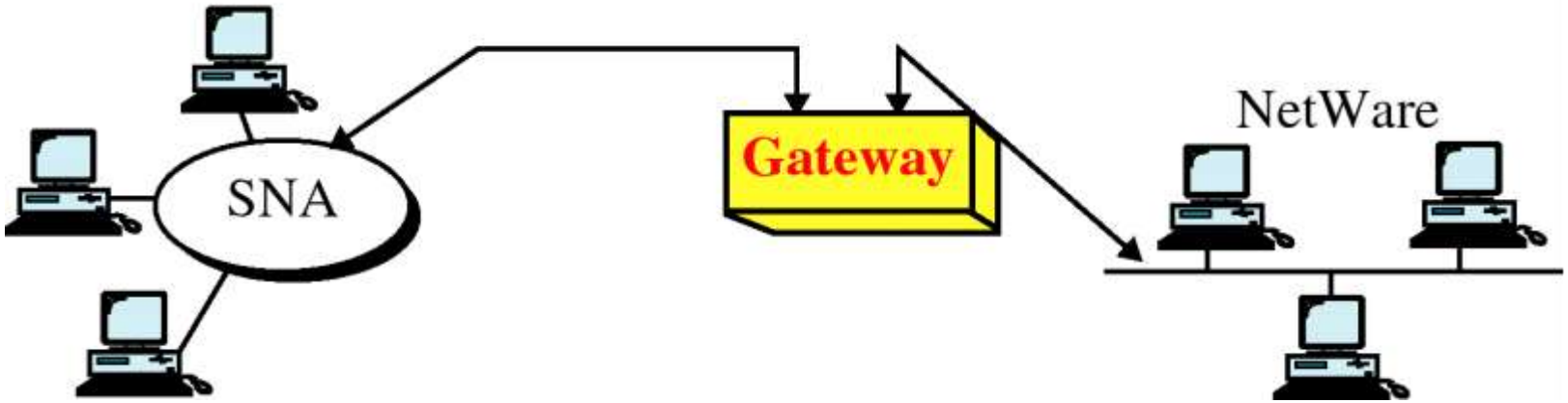
Routers operate at the first three layers (physical, data-link, and network layer)

of the OSI model.

Gateway and the OSI Model



A Gateway



Gateways

- A gateway is usually a computer installed with the necessary software.
- Today the term gateway is used interchangeably with the term router. The distinction between the two terms is disappearing.

BACKBONE NETWORKS

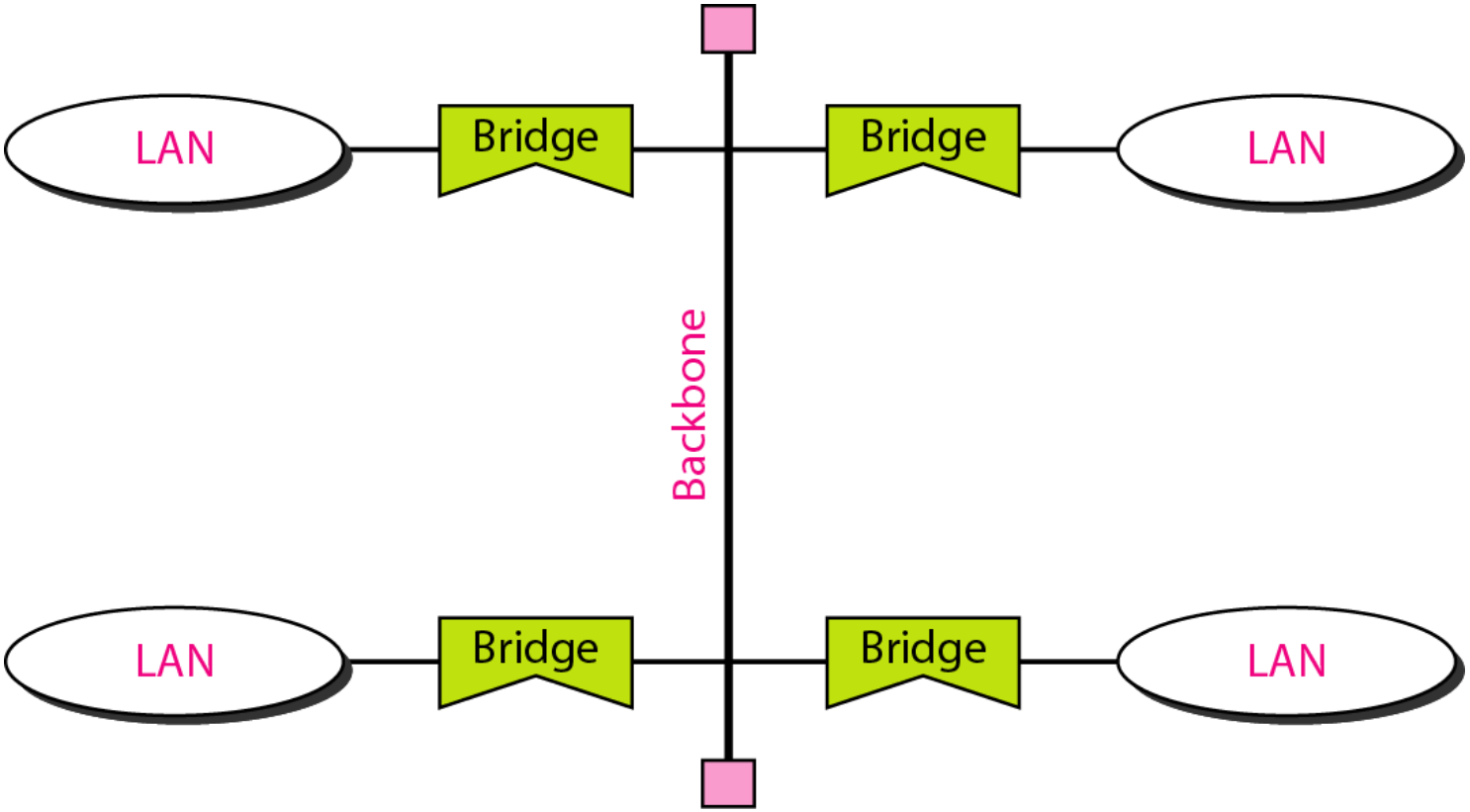
A backbone network allows several LANs to be connected. In a backbone network, no station is directly connected to the backbone; the stations are part of a LAN, and the backbone connects the LANs.

Bus Backbone
Star Backbone
Connecting Remote LANs

Note

In a bus backbone, the topology of the backbone is a bus.

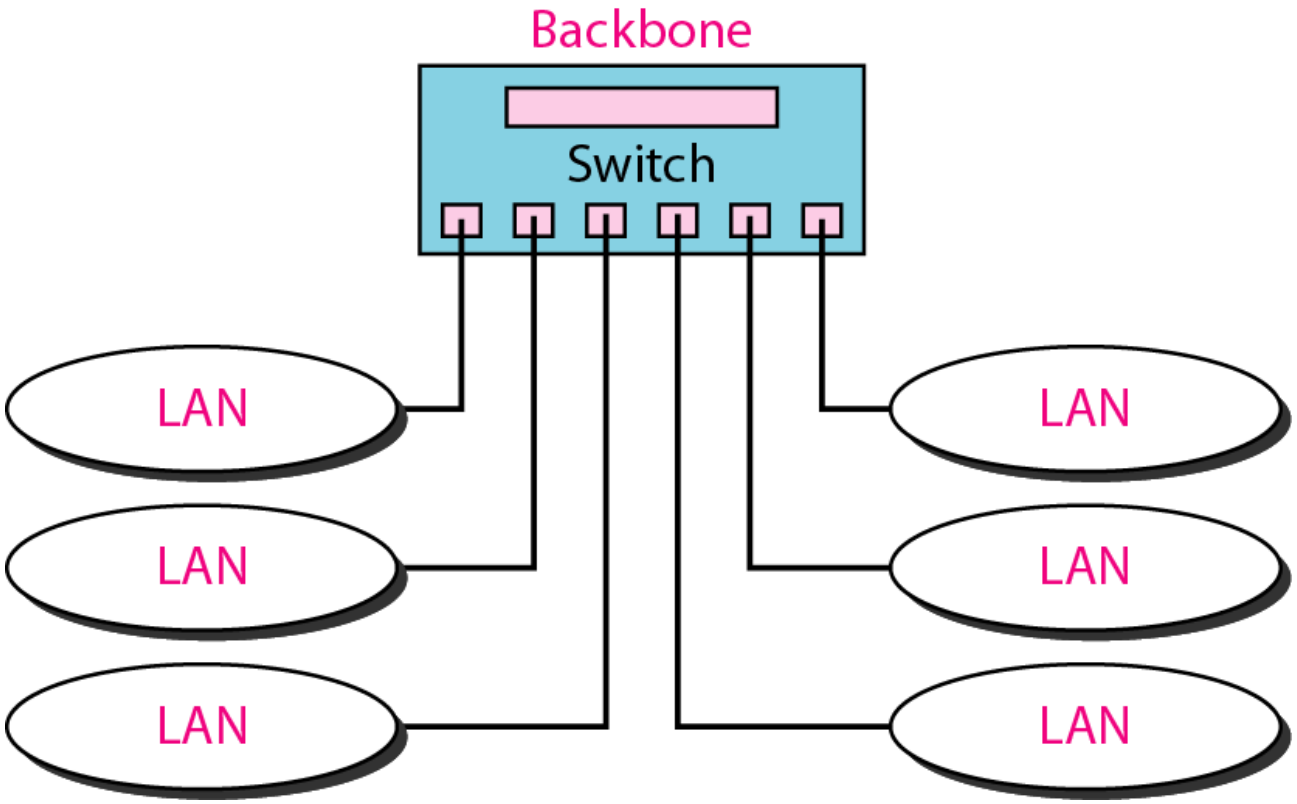
Bus backbone



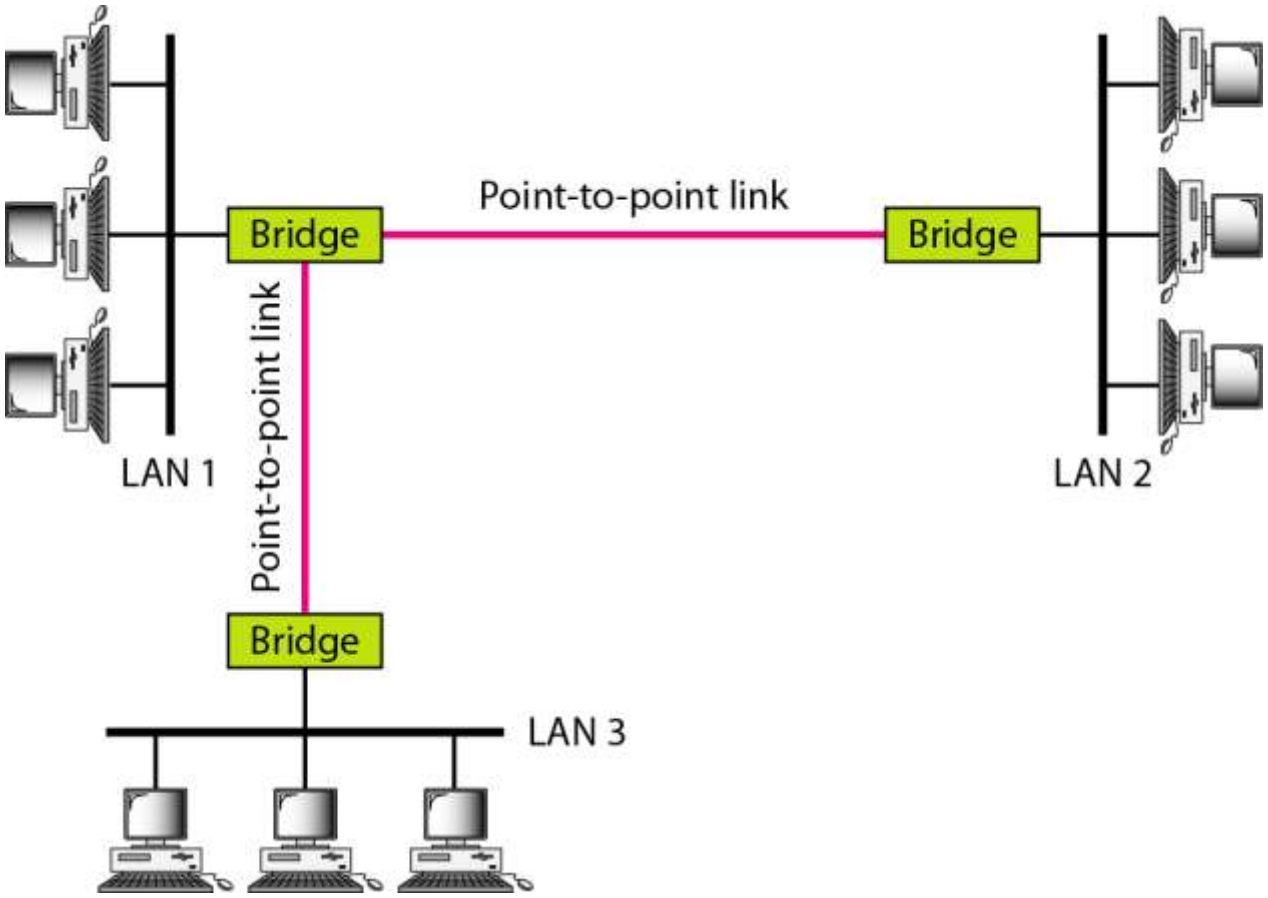
Note

In a star backbone, the topology of the backbone is a star; the backbone is just one switch.

Star backbone



Connecting remote LANs with bridges



Note

A point-to-point link acts as a LAN in a remote backbone connected by remote bridges.