20EC602 :COMPUTER NETWORKS AND SECURITY

- Examination Scheme :
  - In Semester: 50 Marks
  - End Semester: 50 Marks
- Credits: 3
- Prerequisite:

  20EC401 Digital Electronics

20EC602: COMPUTER NETWORKS AND SECURITY

Course Objectives:

1. To introduce network models and functions of each layer
2. To introduce networking protocols, architectures, and applications
3. To describe basic concepts of the threats for data and network and security mechanism
4. To provide theoretical and practical base regarding computer networks issues
5. To outline the basic network configurations

20EC602: COMPUTER NETWORKS AND SECURITY

- Course Outcomes:
- CO1 - Explain the principles of computer networking
- CO2 -Analyze networking protocols, inter-networking devices and their functions
- CO3 -Illustrate computer network applications based on Client-Server architecture
- CO4 -Identify the threats to the data and network and apply techniques to resolve them

Unit I: Physical Layer and Data Link Layer (10)

- Networks models:
  - OSI model, Layers in OSI model
  - TCP / IP protocol suite
- Addressing
- Network performance measurement criterion
- Data link control: Framing, Flow Control (Stop and Wait and Sliding Window Protocols), Error control (CRC), HDLC and PPP
- Multiple access: Random access (Aloha, CSMA, CSMA/CD, CSMA/CA) protocols.

1.1 Data Communication

Communication: Sharing Information

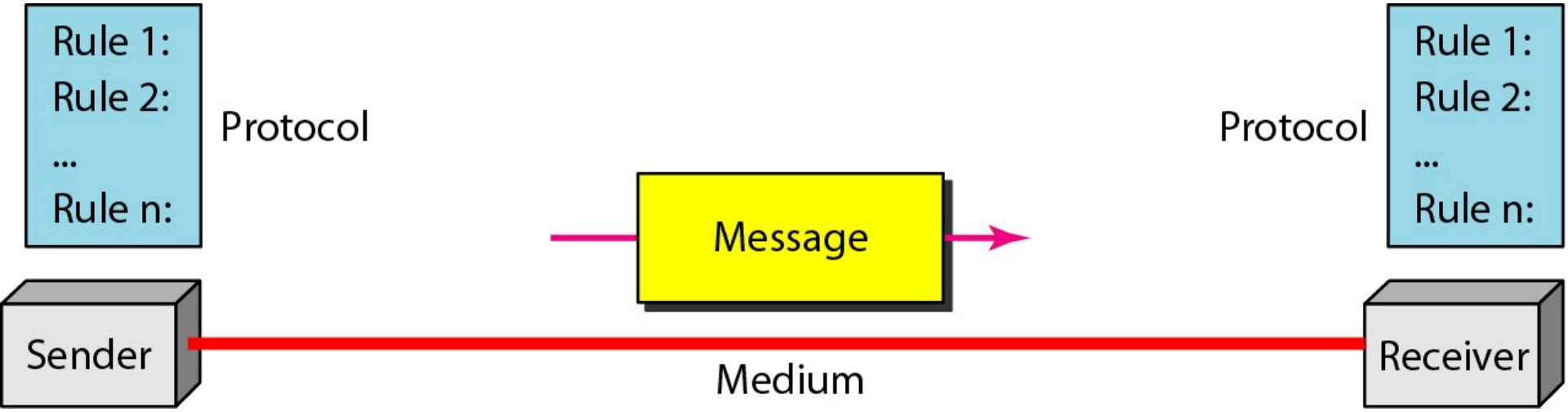
Local Communication : Face –to-face

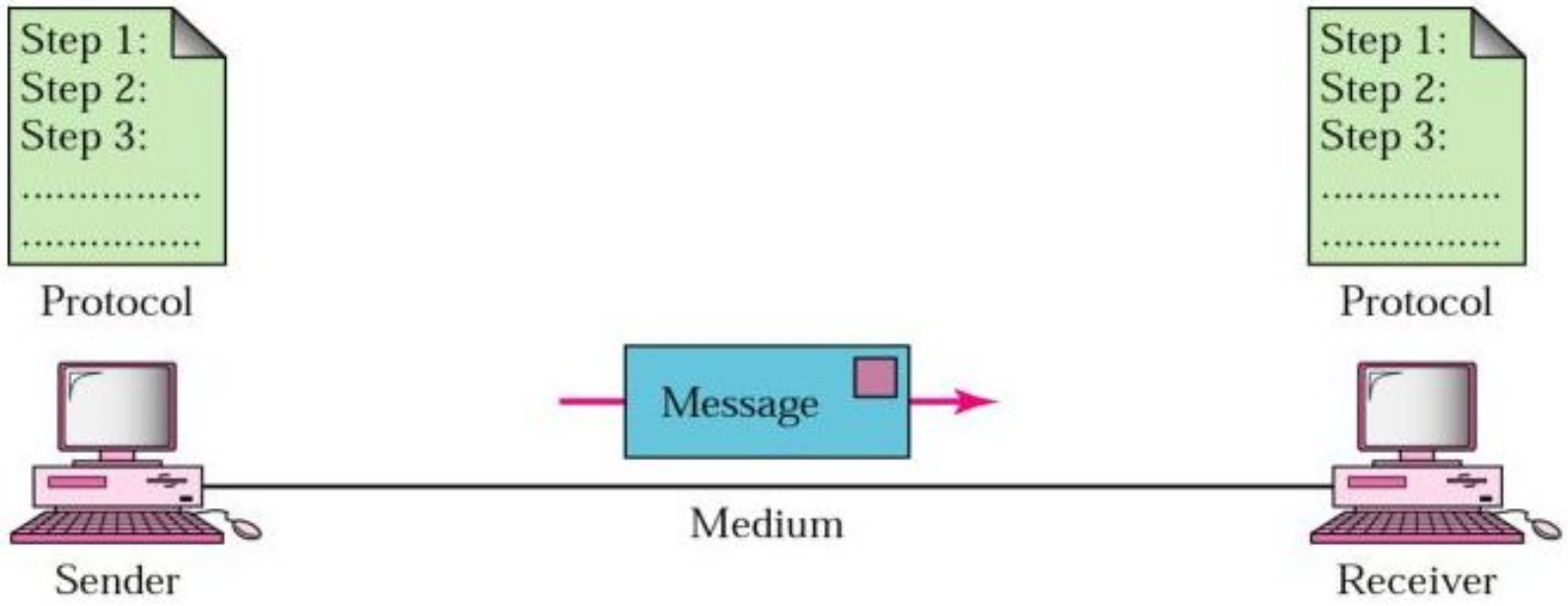
Remote Communication: Distance

DATA COMMUNICATIONS

- The term telecommunication means communication at a distance.
  Ex. Telephony, Telegraphy, Television
- The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data.
- Data communications: the exchange of data between two devices via some form of transmission medium such as a wire cable.

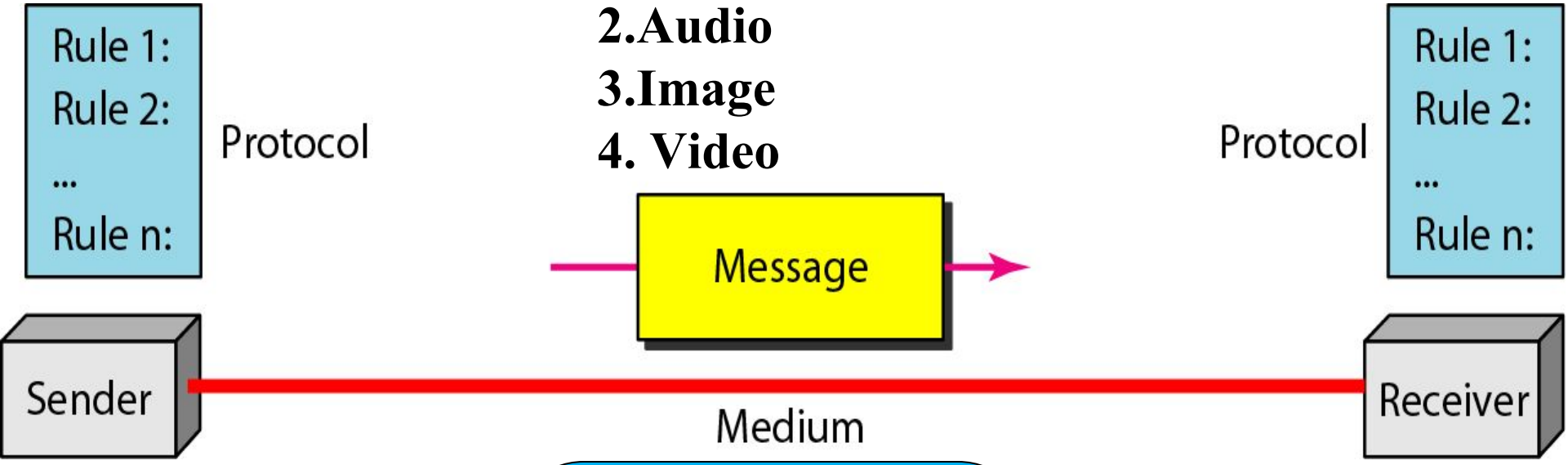
Five Components of Data Communication System:




Step 1:
Step 2:
Step 3:
.....
.....
Protocol
Step 1:
Step 2:
Step 3:
.....
.....
Protocol
Message
Medium
Sender
Receiver

Five Components of Data Communication System:

Message:
1.Text/Numbers
2.Audio
3.Image
4. Video



Sender: Computer/ Telephone/ Camera

Transmission Medium:
1.Twisted Pair Wire
2. Co-axial Cable
3.Fibre Optic Cable
4.Radio Waves

Receiver: Computer/ Telephone/TV

Fundamental Characteristics of Data Communication System:

1. Delivery: The system must deliver data to the correct destination. Data must be received by the intended device or user and only by that device or user.

2. Accuracy: The system must deliver the data accurately.

Data that have been altered in transmission and left uncorrected are unusable.

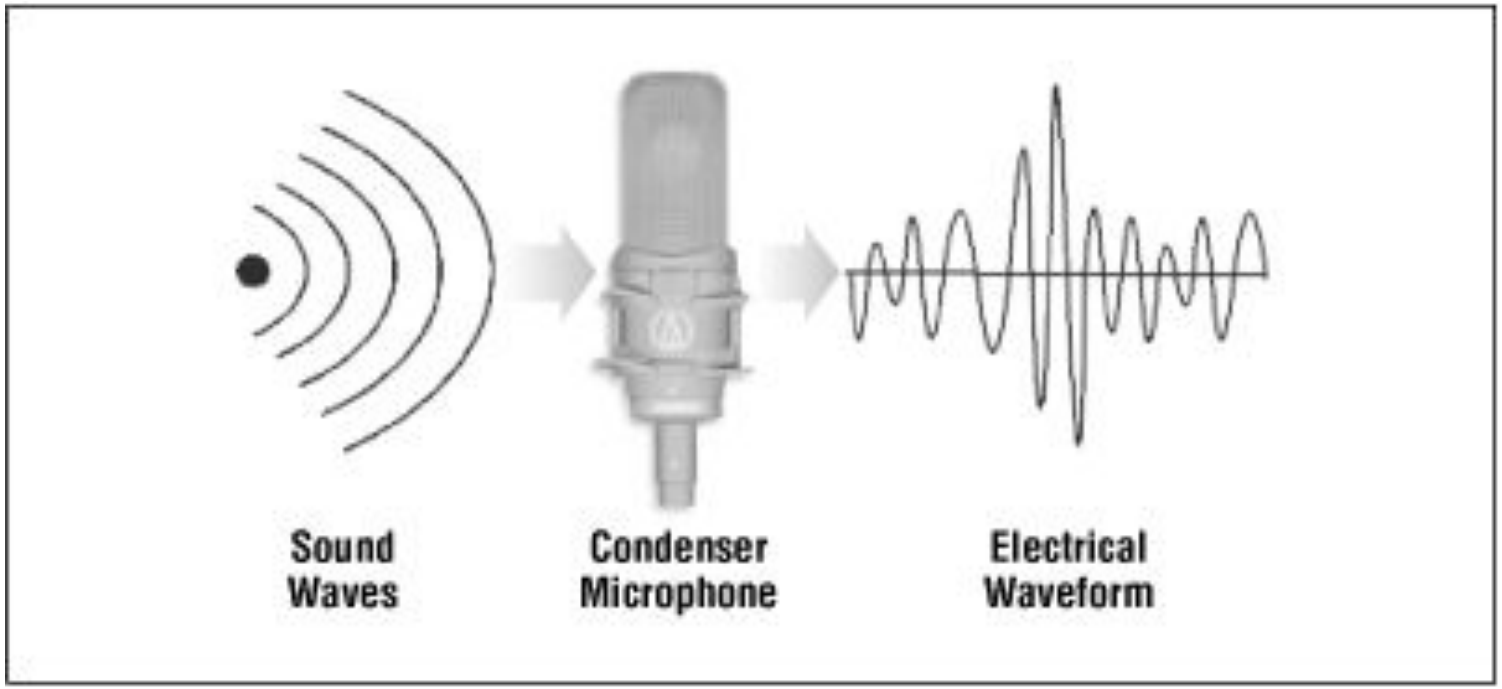
3. Timeliness: The system must deliver data in a timely manner. Data delivered late are useless. In the case of video and audio, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called real-time transmission.

4. Jitter: Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets.

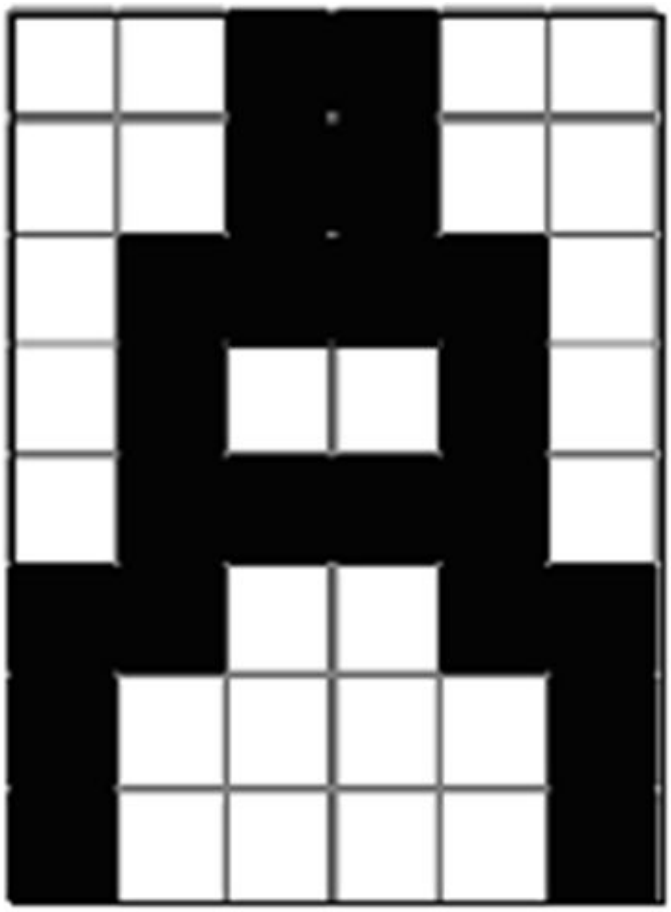
Data Representation in Data Communication System:

- Text:
  Represented as Bit Pattern of 0's & 1's
  American Standard Code for Information Interchange Code (ASCII)
- Numbers: Binary Bit Pattern
- Images: Represented as Bit Patterns
- Audio
- Video

Data Representation in Data Communication System: Example –Audio Information



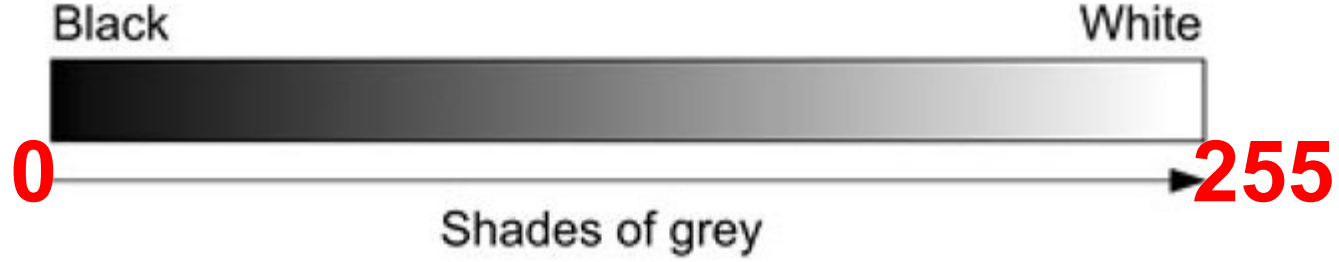
Data Representation in Data Communication System: Example Binary Image –It takes only two pixel values i.e, Black (0) and White (1).



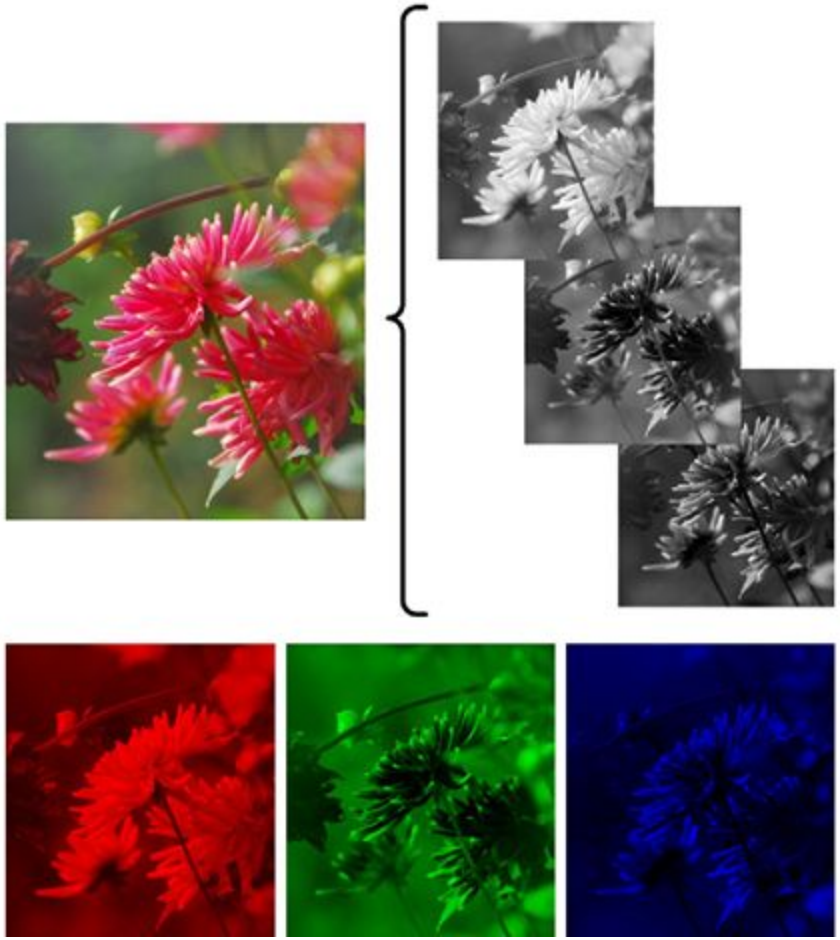
0	0	1	1	0	0
0	0	1	1	0	0
0	1	1	1	1	0
0	1	0	0	1	0
0	1	1	1	1	0
1	1	0	0	1	1
1	0	0	0	0	1
1	0	0	0	0	1

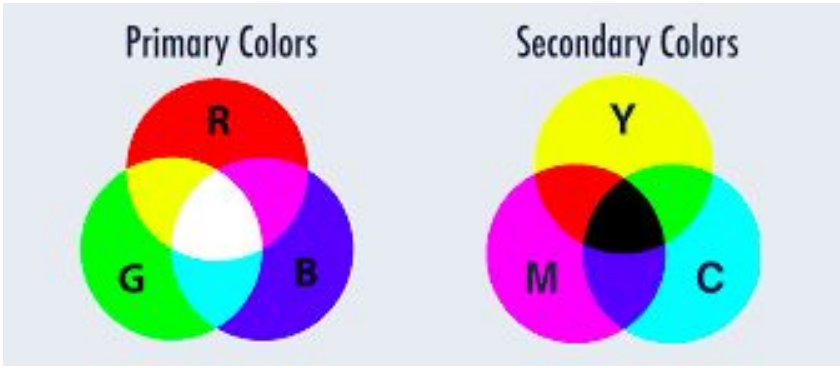
0
0
0
0
⋮
48 X 1 Matrix
1
1

Data Representation in Data Communication System: Example Gray Scale Image –A gray scale image contains 8 bits/pixel data, which has 256 different grey levels.

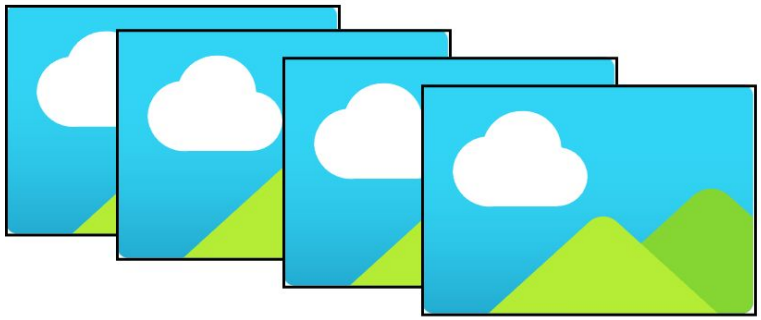


Data Representation in Data Communication System: Example Colour Image –A color image consisting of three images; red, green and blue

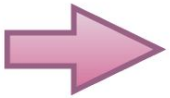


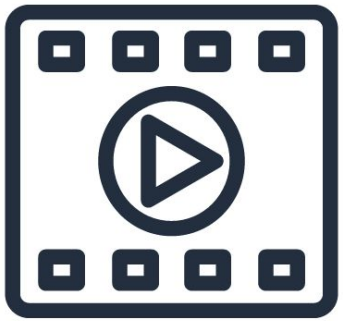


Data Representation in Data Communication System: Example Video Information



Frames





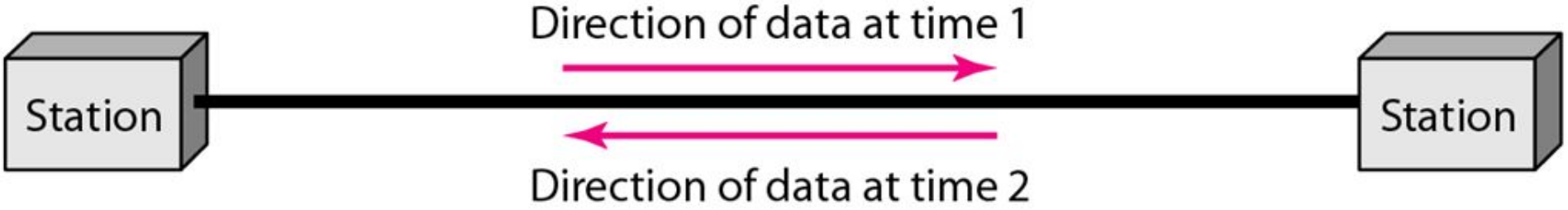
Video

Data Flow in Data Communication System:

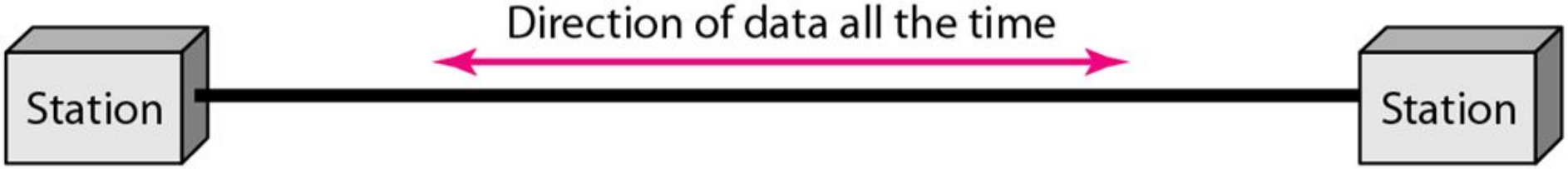
Simplex

Data Flow in Data Communication System:

Half Duplex



Full Duplex



COMPUTER NETWORKS

- A computer network is a set of interconnected devices (nodes) connected by communication links that exchange data or resources with each other.
- A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.

COMPUTER NETWORKS : Basic Building Blocks

- Nodes: are devices connected to a network

1. Host: Desktop/Laptop/Server/Printer/Cellphone
2. Connecting Devices: Router/Switches/Modem/Hub

- Links (Transmission Channel)

1. It connects two nodes
2. Data Communication is possible through a link
3. Communication Protocol: The way these link carry the information
4. Wired (Wires/Cables) or Wireless

COMPUTER NETWORKS

- Computer network=>Hardware+software
- Hardware=>Nodes & links
- Software=> Communication Protocol
- Once the connection is established between two nodes, the communication protocol (for that particular service request) is used to exchange data between networked nodes

  Ex. Simple Mail Transfer Protocol(SMTP)

  Hyper Text Transfer Protocol(http)

  File Transfer Protocol(FTP)

Distributed Processing:

- A Task is divided among multiple computers
- Instead of a one single computer completing whole task, separate computers/workstations handle a subset of that task.

Network Criteria:

- Performance
  - Transit Time: Time required by a message to travel from one device to other
  - Response Time: Time elapsed between an inquiry & a response
- Reliability
  - Accuracy
  - Frequency of failure
  - Time it takes, a link, to recover, from failure
- Security
  - Data protection from unauthorized access, damage
  - Data recovery from breaches & data loss

Physical Structures: Type of connection

- A network is two or more devices connected through links
- A link is communication pathway that transfers data from one device to another
- For communication to occur, two devices must be connected in some way to the same link at the same time
- Types of Connection:
  1. point-to-point connection
  2. multipoint connection

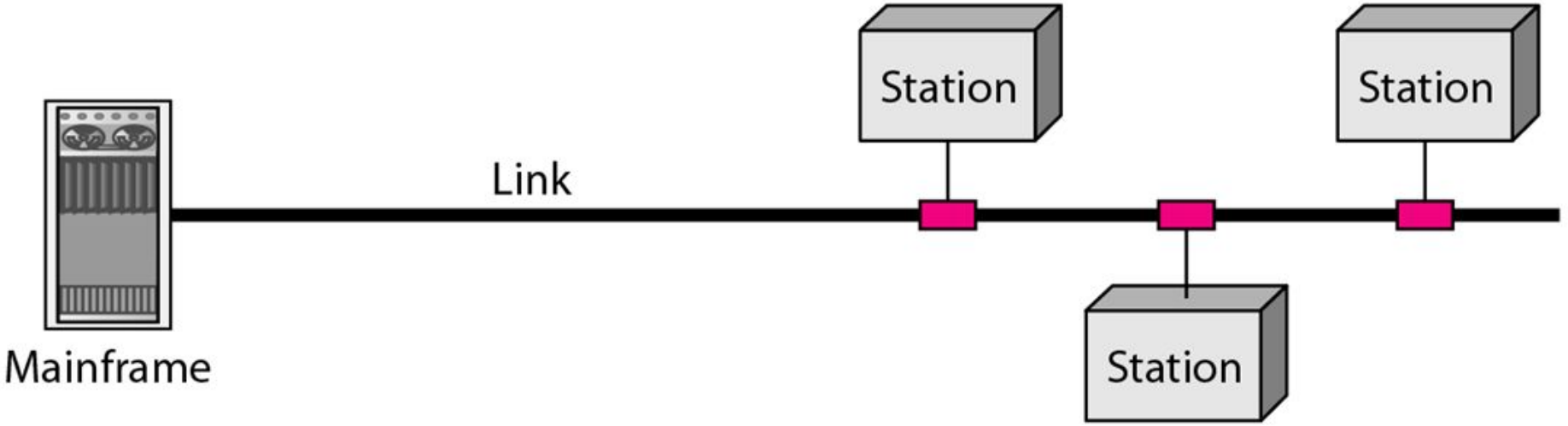
Physical Structures: Type of connection

1.Point-to-Point Connection:

- Provides dedicated link between two devices.
- The entire capacity of the link is fully utilized for Transmission between those two devices only.
- Ensures Security & Privacy of Data
- Use an actual length of wire/cable to connect two devices
- Example: Telephone Call

Physical Structures: Type of connection

2. Multi-Point Connection:



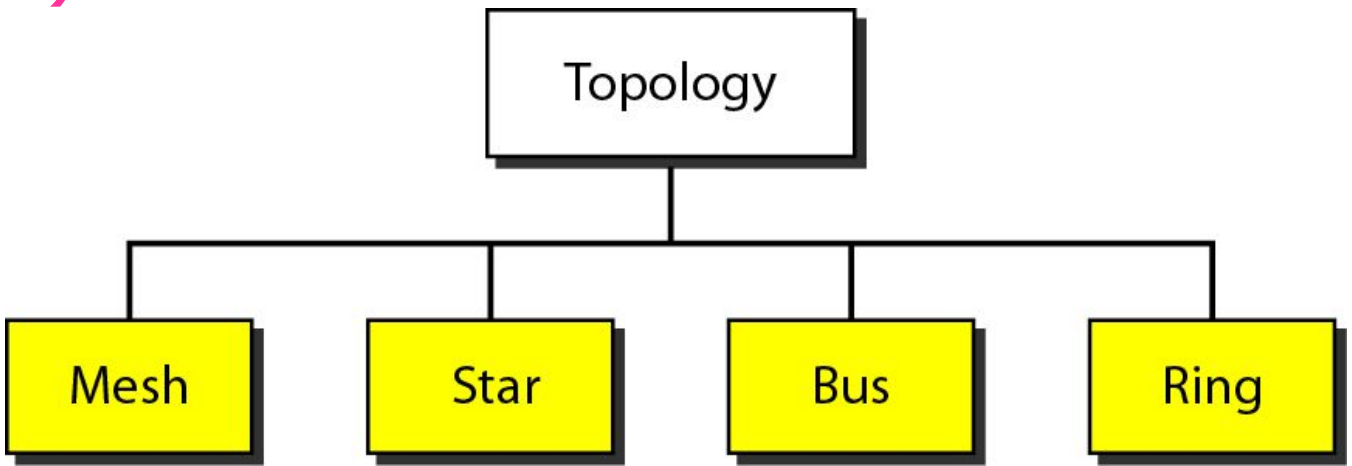
- More than two devices share the single link
- The capacity of channel is shared :

  Spatially (space) or Temporally (Time sharing)

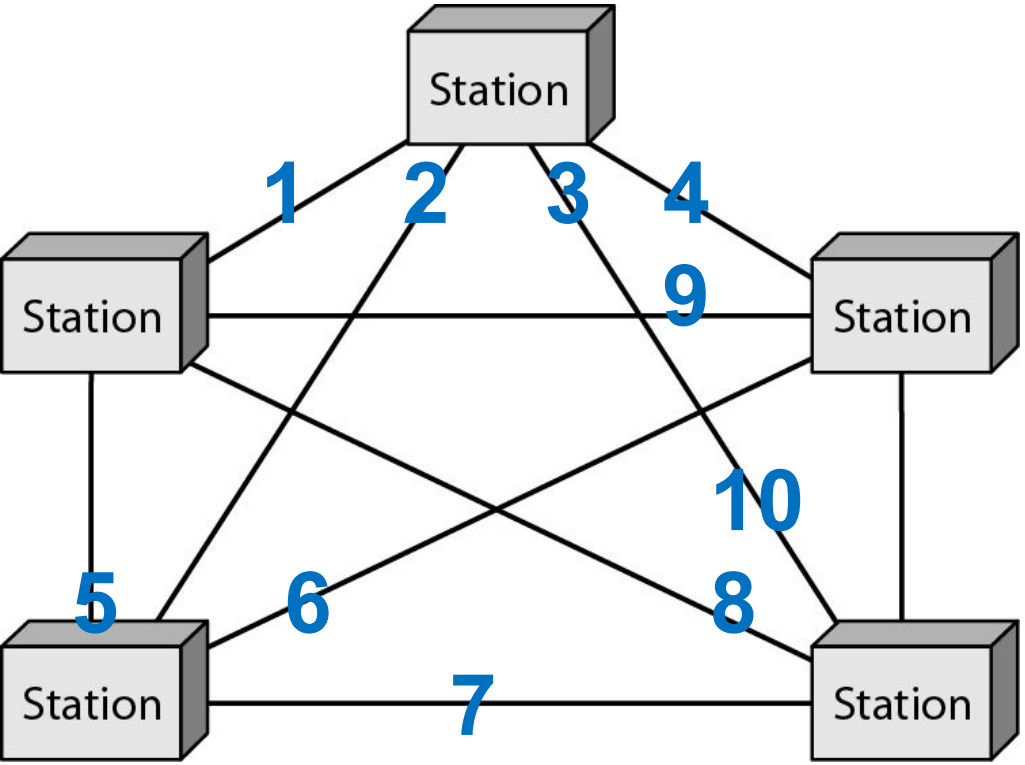
Physical Structures: Physical Topology

- Physical Topology: The way in which the network is laid out physically
- Two or more devices connect to a link;

  two or more links forms the basis for topology
- Topology : Geometric representation of relationship of all the links and linking devices (nodes) to one another



Mesh Topology



A fully connected mesh topology (five devices)
n=5; 10 links

- Every Device has dedicated point-to-point link to every other device
- Number of physical links

{n*(n-1)} ---Half Duplex

or

{n*(n-1)}/2---Full Duplex

Each Device: (n-1) Input / Output Ports

Mesh Topology : Advantages

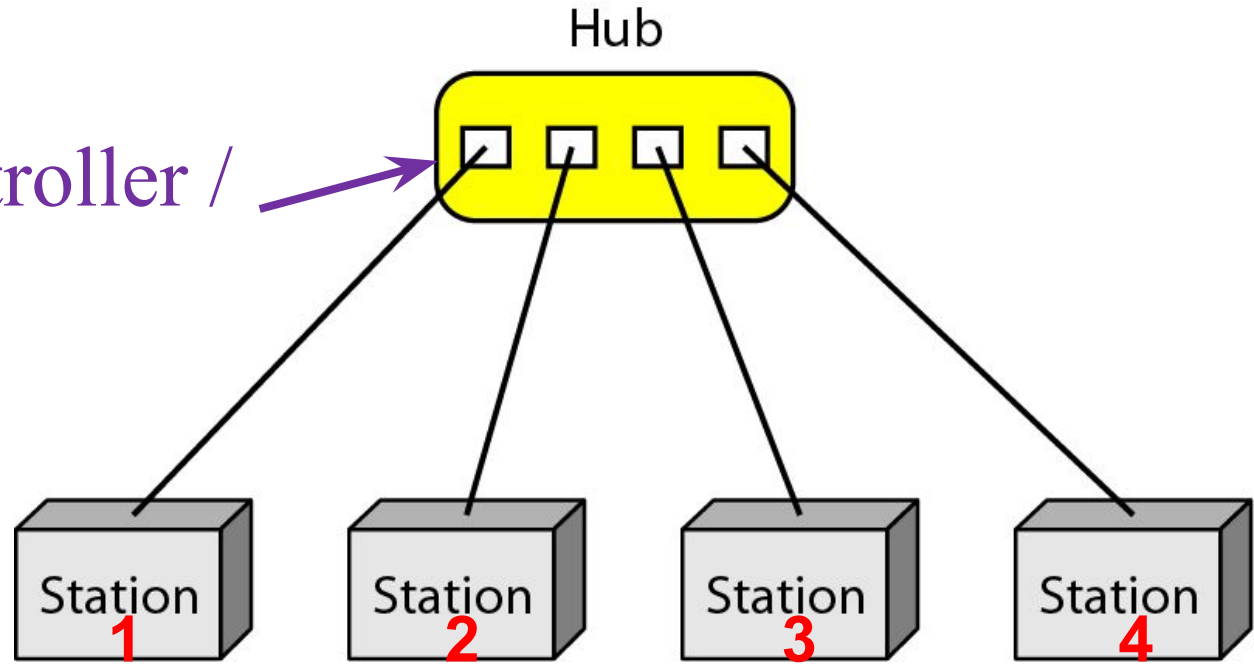
- The dedicated links guarantees that each connection can carry its own data load.
- This dedicated link also ensures security & privacy of data sent
- It eliminates the traffic congestion problems that can occur when the link is shared by multiple devices
- Robust: If one link becomes unusable, there is alternative path for data transmission
- Point-to-Point links make fault identification and fault finding , immediate & easy

Mesh Topology : Dis-advantages

- Amount of cabling required: every device is to be connected to every other device
- Number of I/O ports required
- Expensive: cost of I/O ports & cables

Star Topology:

Hub / Controller / Exchange



- Each Device has dedicated point to point link only to central controller called a Hub
- The devices are not directly linked to one another
- Direct Traffic between devices is not allowed
- Device to Device data transmission is possible through controller/Hub ONLY

Star Topology:

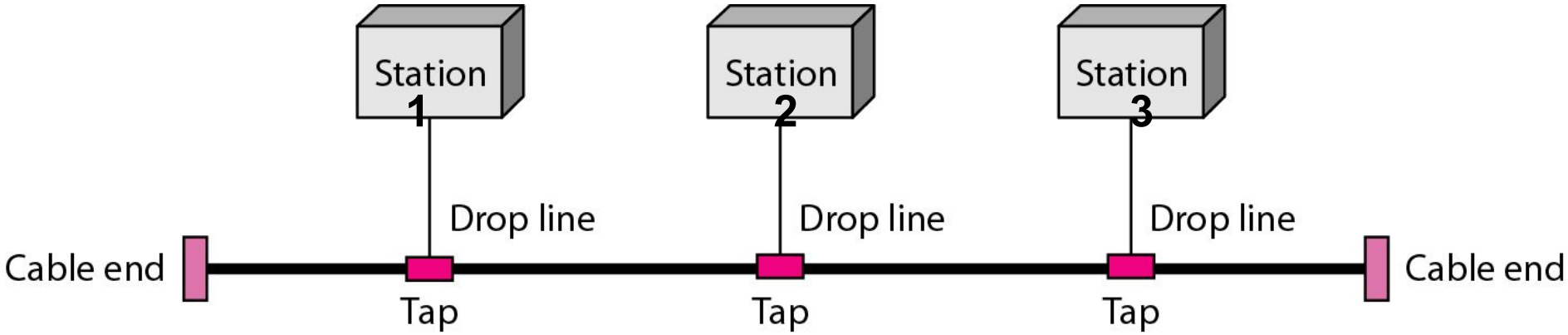
Advantages

- Less Expensive than a mesh topology
- Each device needs only one link & one I/O Port
- Easy to install & reconfigure
- Less Cabling
- Robust
- Easy fault finding

Disadvantage

- Dependency on one single point-Hub

Bus Topology



- Uses Multi-Point Connection
- One long cable acts as backbone to link all devices in the network
- Nodes are connected to Bus cable by drop-lines and taps
- Limit on Number of Taps & Distance between Taps

Bus Topology

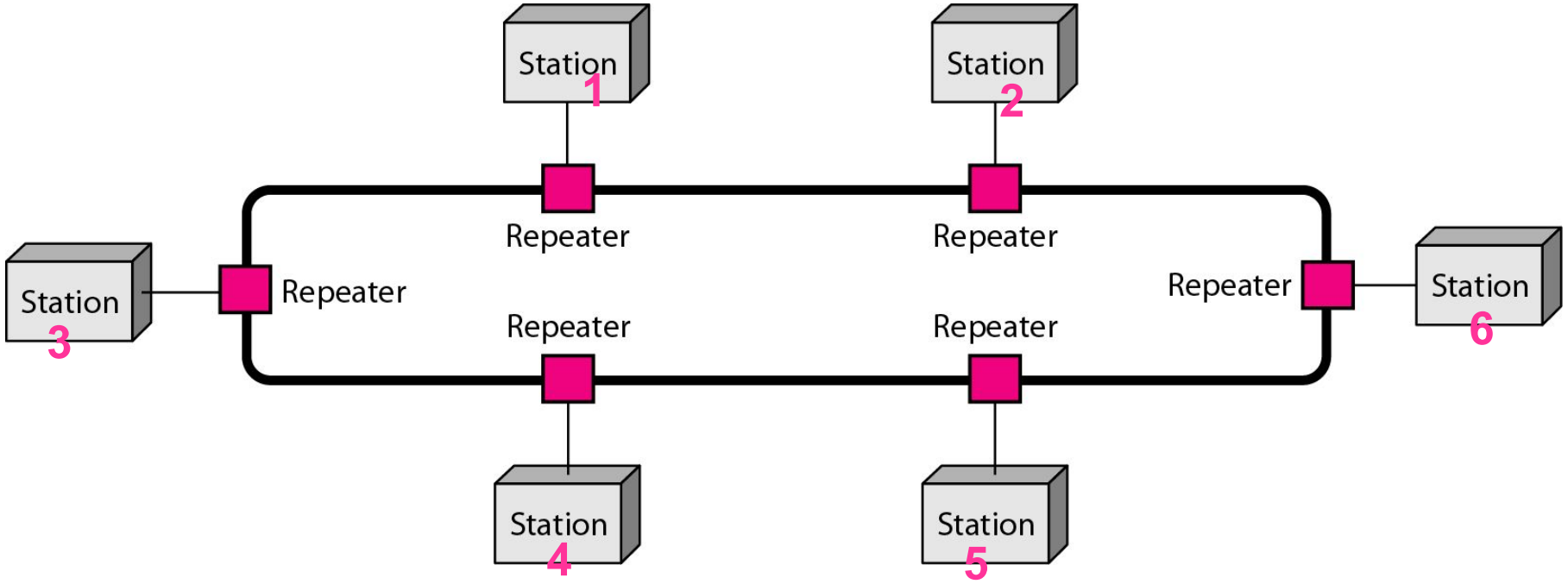
Advantages

- Easy Installation
- Less Cabling

Disadvantages

- Difficult to add new devices
- Signal reflection at taps causes degradation in quality
- A fault/break in bus cable stops all transmission

Ring Topology



- Each Device has a dedicated point-to-point connection with only two devices on either side of it.
- The signal is passed along the ring in ONE Direction

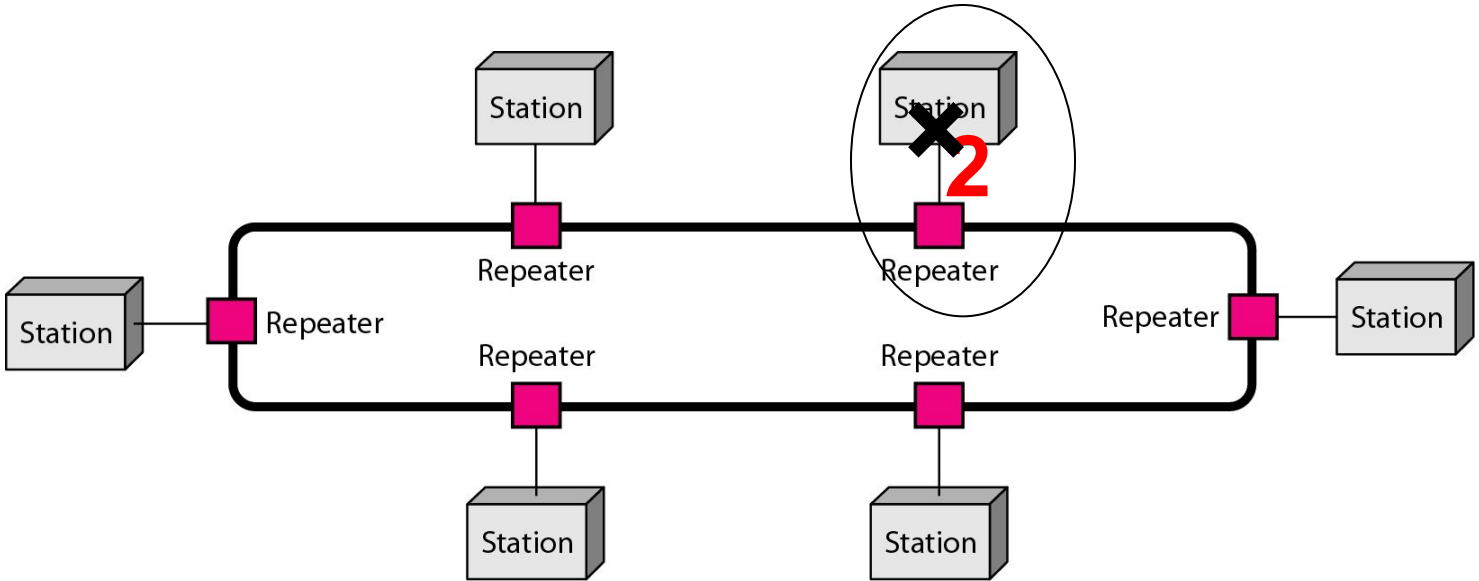
Ring Topology

Advantage

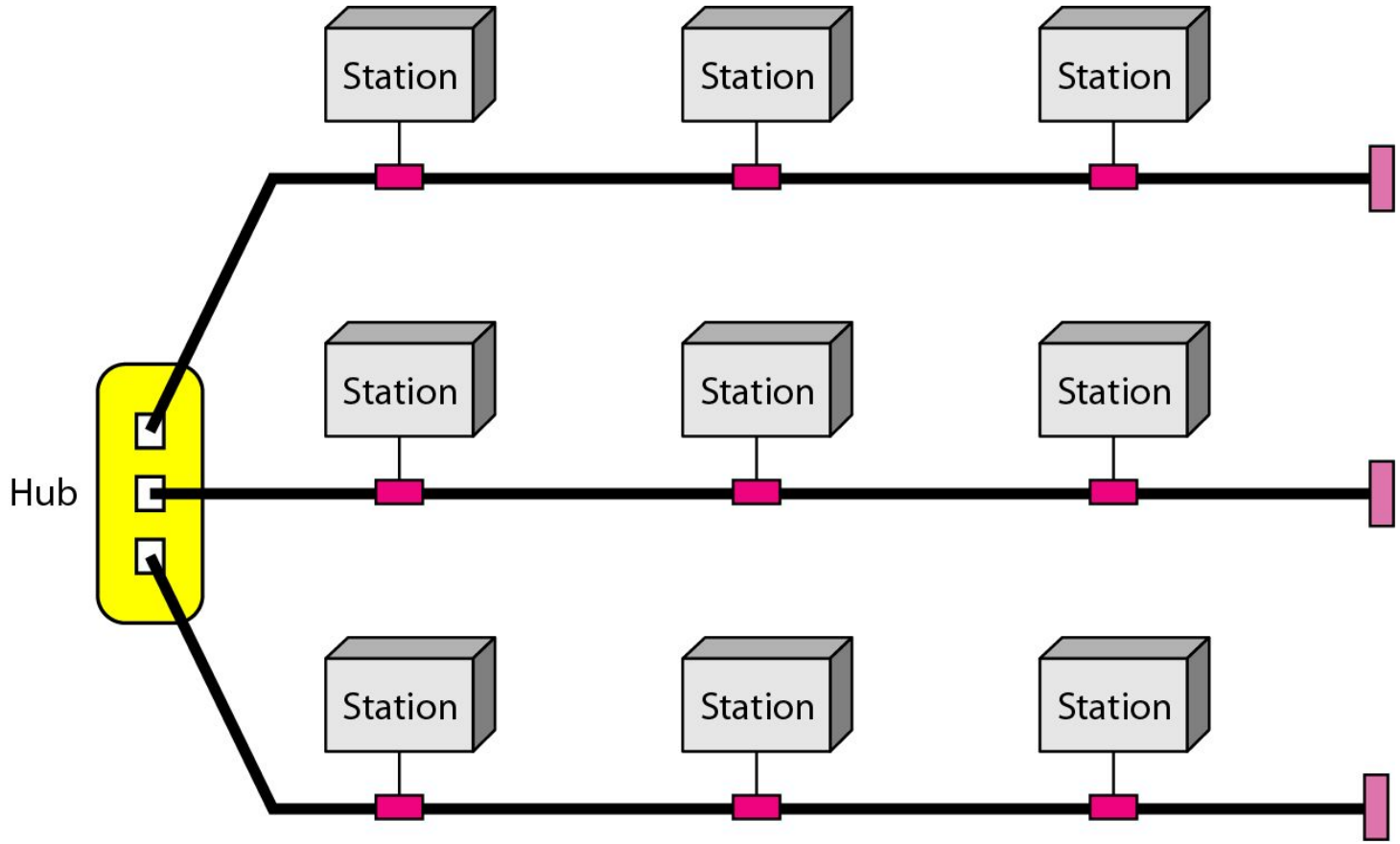
- Easy to install
- Easy to add/delete a device
- Easy fault finding

Disadvantage

- Unidirectional Traffic



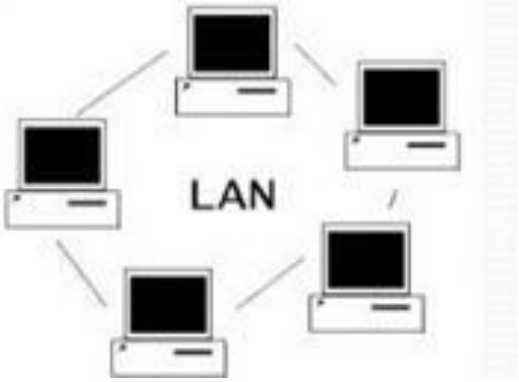
Hybrid Topology

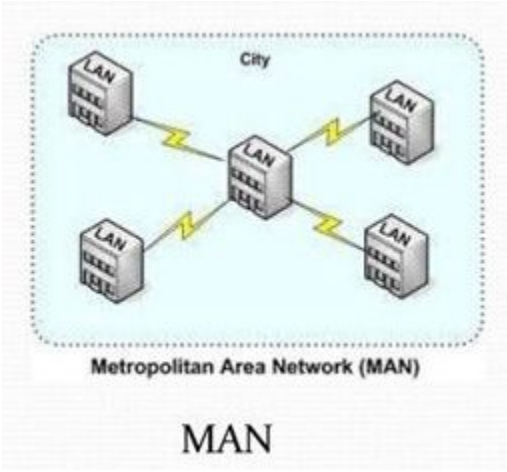


Example: The star topology with each branch Connecting several stations in a bus topology

NETWORK TYPES

- Size
- Geographical coverage
- Ownership Type (Private / Public)
  - Local Area Network (LAN)
  - Metropolitan Area Network (MAN)
  - Wide Area Network (WAN)

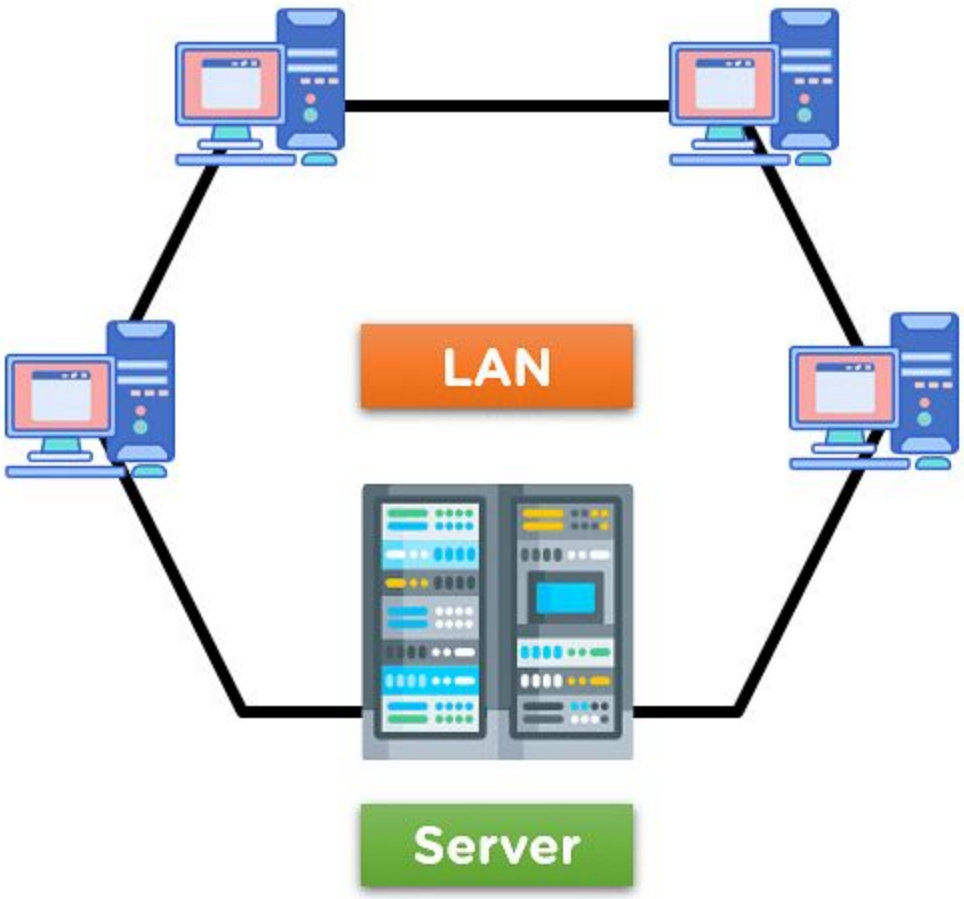




Local Area Network (LAN)

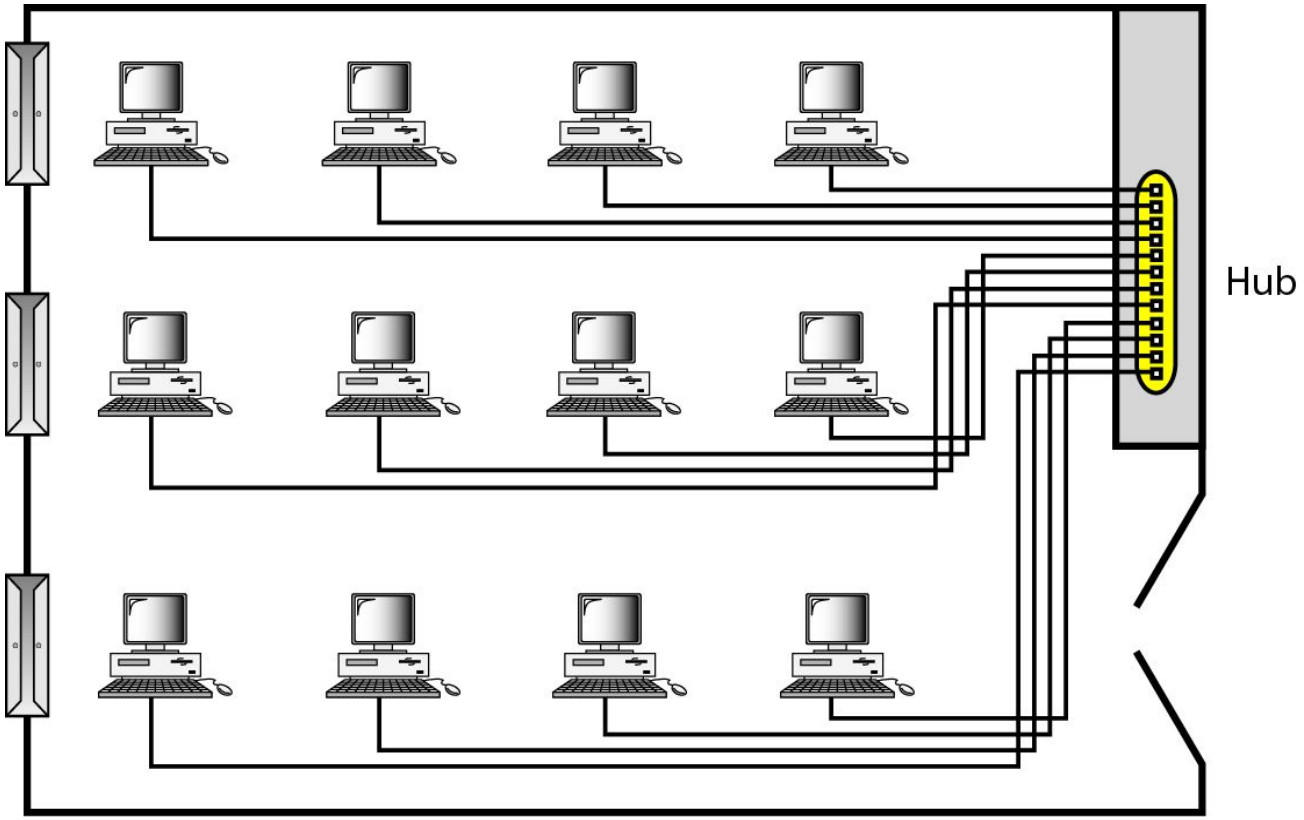
- is usually privately owned
- Covers area upto 1 KM
- connects some hosts in a single office, building, or campus.
- Depending on the needs of an organization, a LAN can be as simple as two PCs and a printer in someone's home office, or it can extend throughout a company and include audio and video devices.
- Each host in a LAN has an identifier, an address, that uniquely defines the host in the LAN. A packet sent by a host to another host carries both the source host's and the destination host's addresses.

Local Area Network (LAN)



- The data transmit speed in the LAN network is relatively higher than the other network types, MAN and WAN.
- LAN uses private network addresses for network connectivity for data and service exchange
- LAN uses cable for network connection, maintaining data Security.

Local Area Network (LAN)



Local Area Network (LAN)

- LANs are designed to allow resources to be shared between personal computers or workstations.
- The resources to be shared can include hardware (e.g., a printer), software (e.g., an application program), or data.
- LANs are distinguished from other types of networks by their transmission media and topology.
- In general, a given LAN will use only one type of transmission medium.
- LAN topologies are bus, ring, and star.
- Now a days, LANs speeds are normally 100 or 1000 megabits per second (Mbps)

Metropolitan Area Network (MAN)

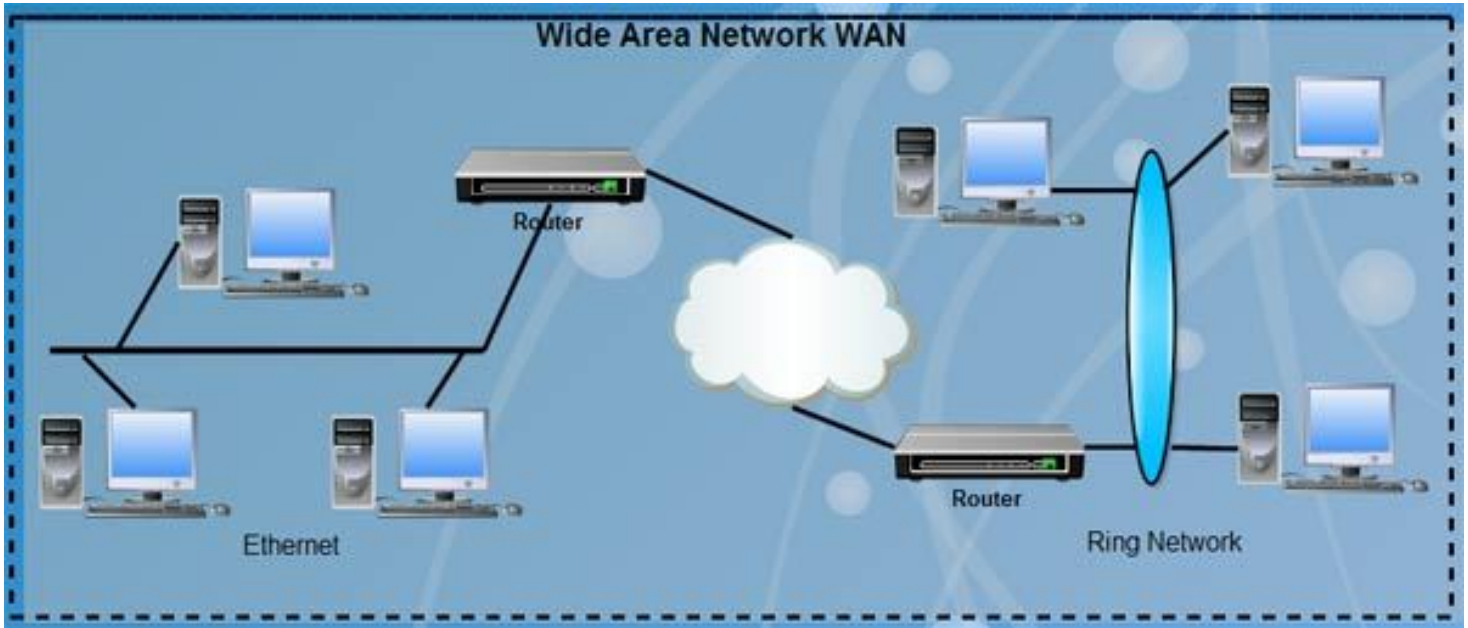
- MAN covers an entire town area or a portion of a city, from a few tens to a maximum of hundred kilometers
- Data transmission speed is relatively high due to the installation of optical cables and wired connections.

Wide Area Network (WAN)

- No limit on coverage area
- A wide area network (WAN) provides long-distance transmission of data, image, audio, and video information over large geographic areas that may comprise a country, a continent, or even the whole world.
- A LAN interconnects hosts;a WAN interconnects connecting devices such as switches, routers, or modems.
- Ownership: A WAN is normally created and run by communication companies and leased by an organization that uses it.

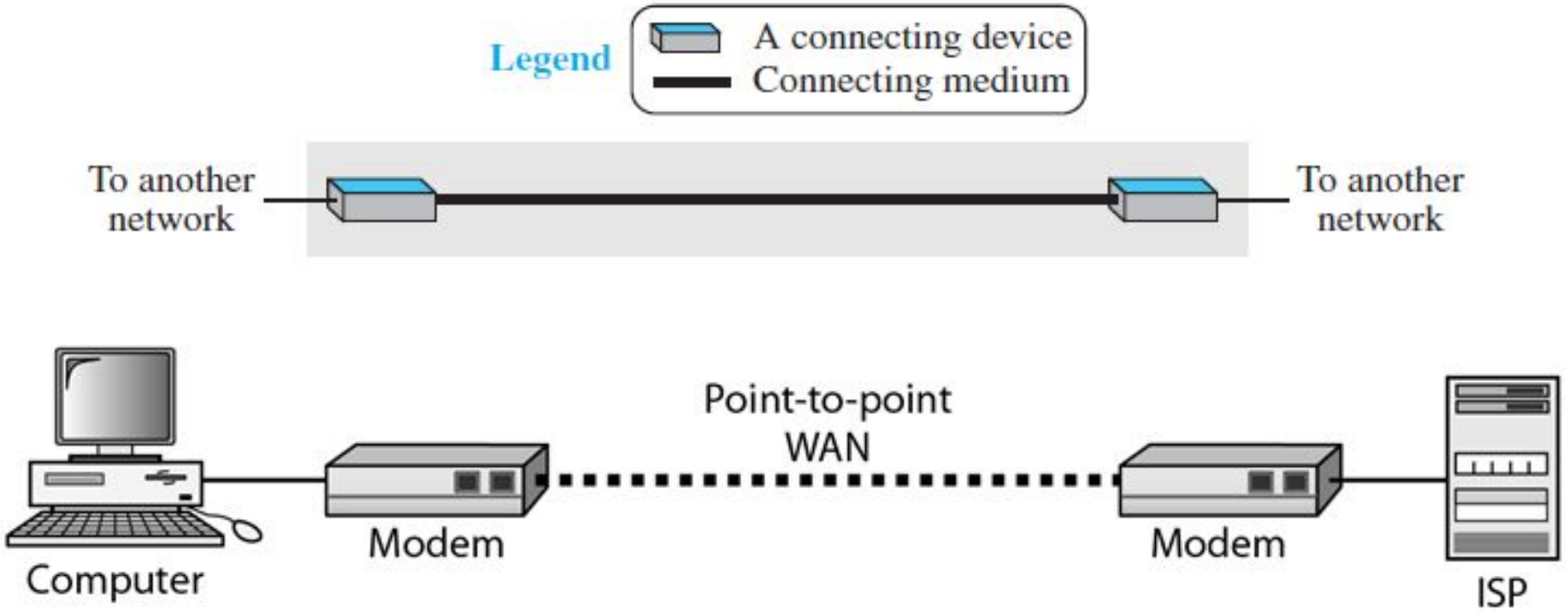
Wide Area Network (WAN)

- The WAN network can be made up of multiple LAN and MAN networks.
- The speed of the WAN data transfer is lower than in comparison to LAN and MAN networks due to the large distance covered.
- The WAN network uses a satellite medium to transmit data between multiple locations and network towers.



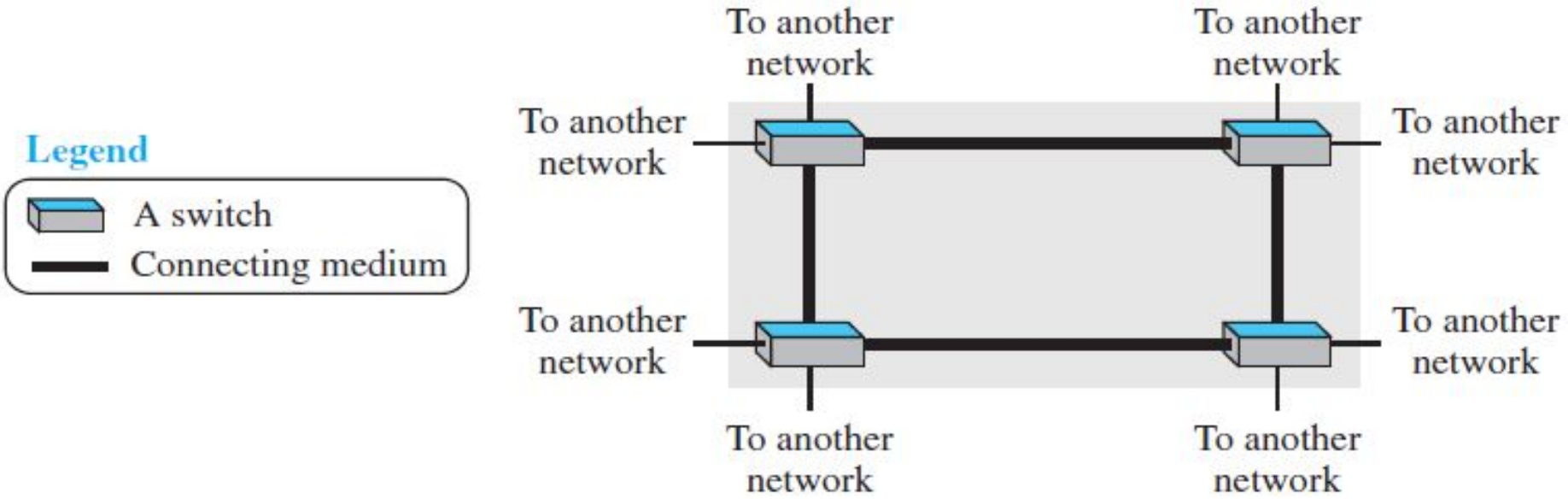
point-to-point WANs

- A point-to-point WAN is a network that connects two communicating devices through a transmission media (cable or air).



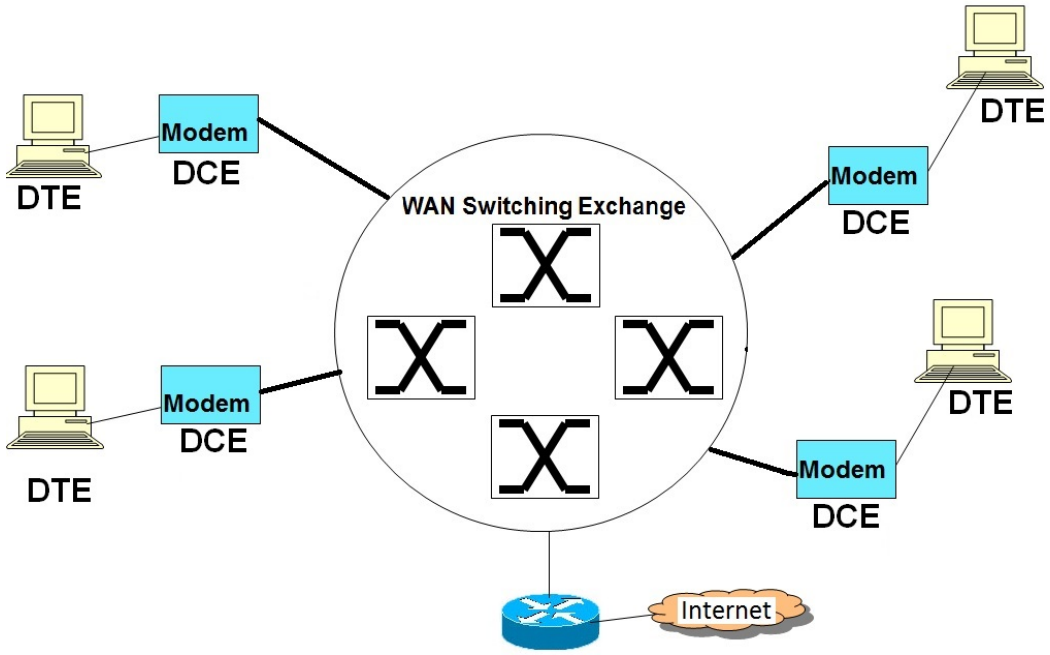
Switched WAN

- A switched WAN is a network with more than two ends.
- A switched WAN is a combination of several point-to-point WANs that are connected by switches.



Switched WAN

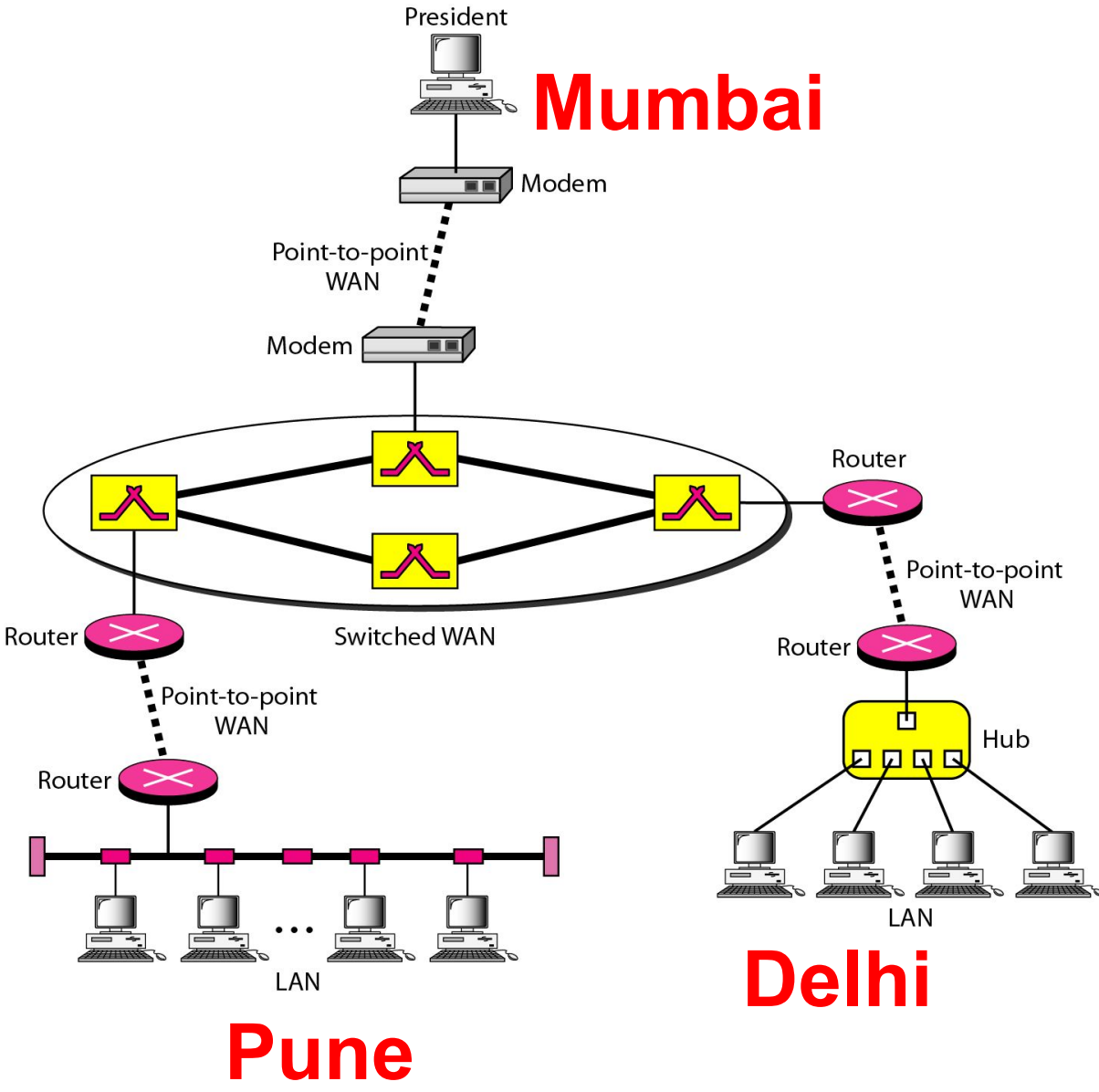
- a switched WAN network is used to connect multiple end nodes through a common WAN network.
- The end nodes connect to a switched WAN network to either reach other nodes connected to the switched network or to connect to the public Internet.



Internetwork

- When two or more networks are connected, they make an internetwork or internet.

(lowercase i)

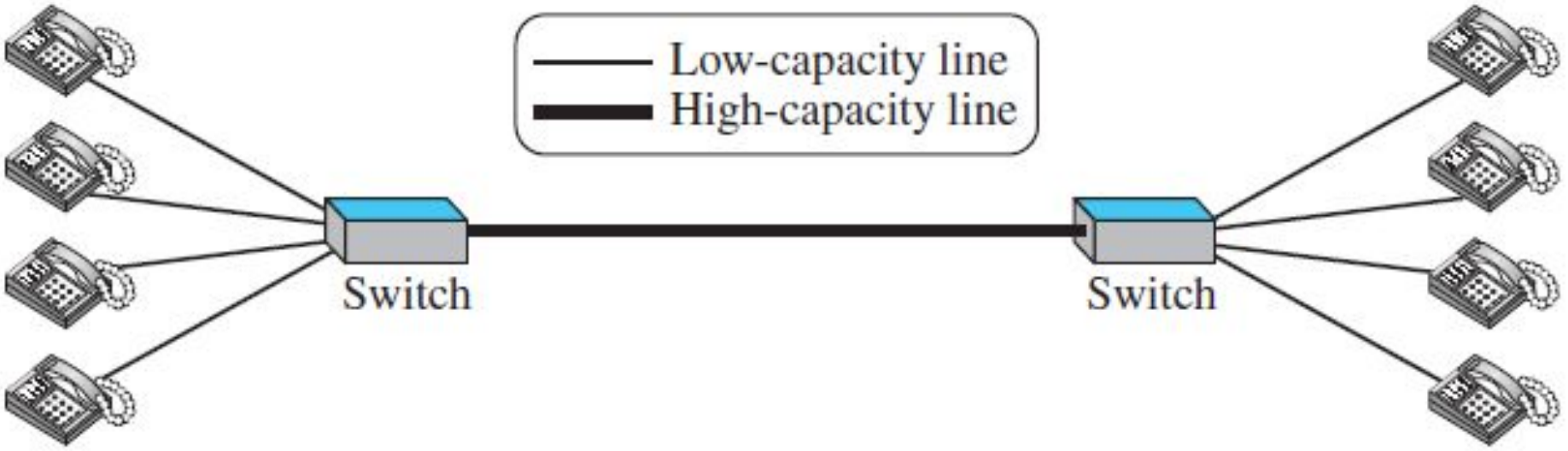


Switching

- An internet is a switched network in which a switch connects at least two links together.
- A switch needs to forward data from a network to another network when required.
- Types of switched networks:
  1. Circuit-switched Networks
  2. Packet-switched Networks

Circuit-Switched Network

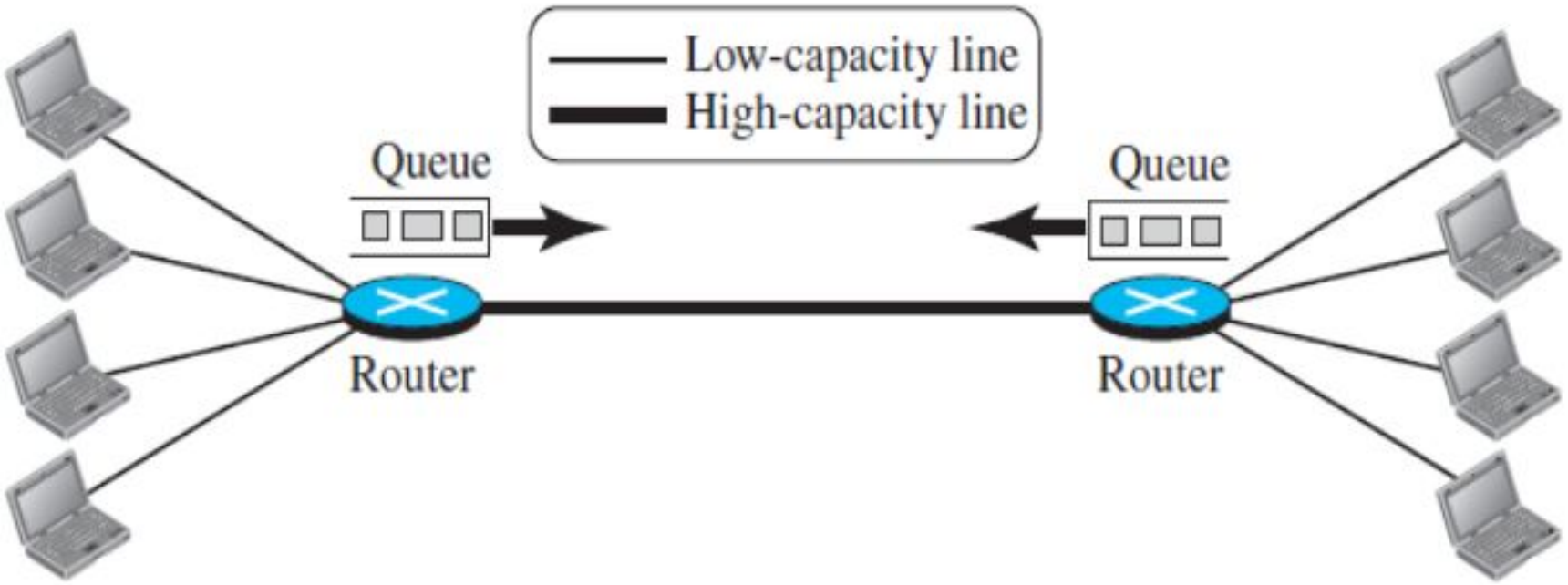
- a dedicated connection, called a circuit, is always available between the two end systems; the switch can only make it active or inactive.
- Example shows a very simple switched network that connects four telephones to each end.



Packet-Switched Network

- In a computer network, the communication between the two ends is done in blocks of data called packets.
- Instead of the continuous communication, there is exchange of individual data packets between the two computers.
- This allows us to make the switches function for both storing and forwarding because a packet is an independent entity that can be stored and sent later.

Packet-Switched Network

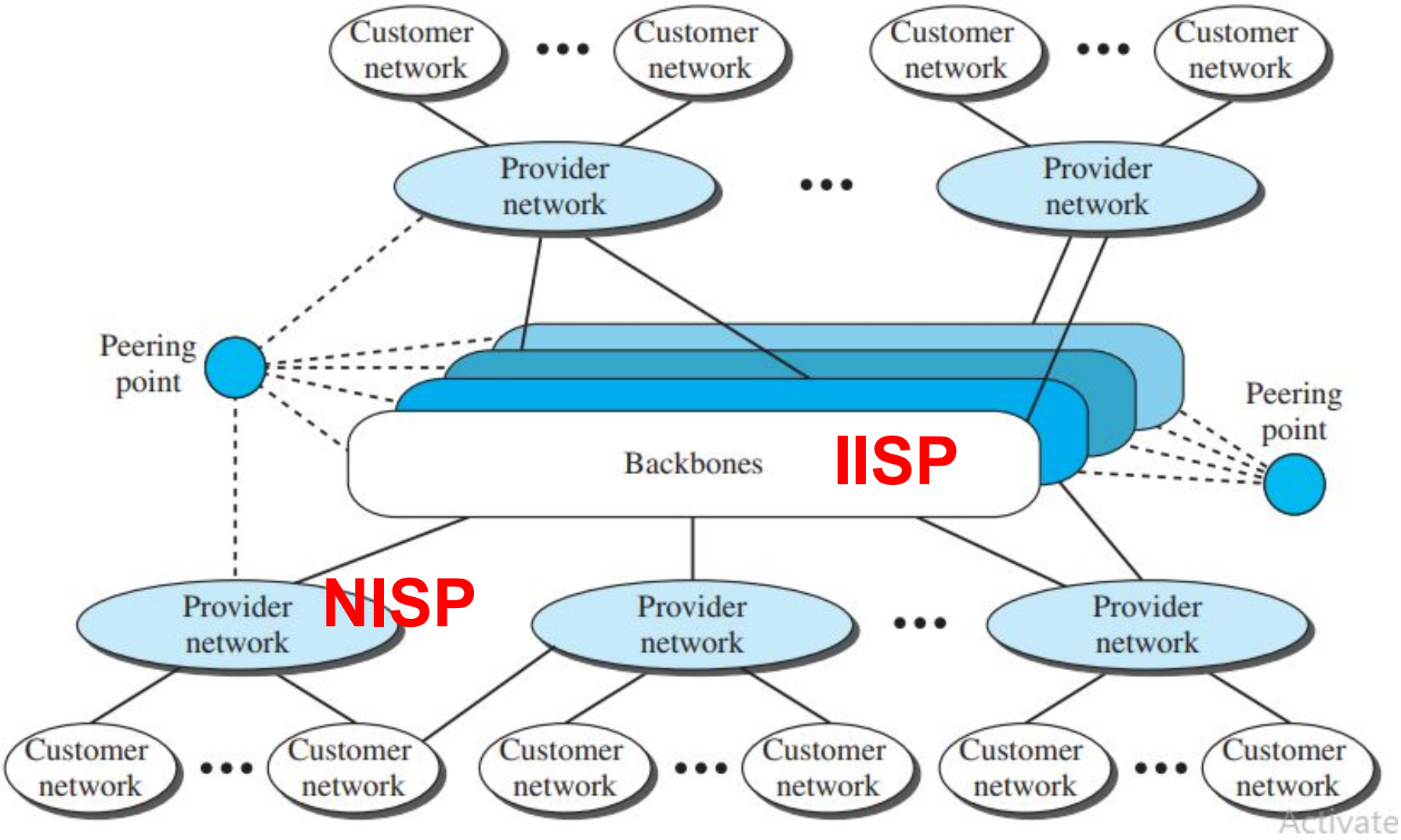


A router in a packet-switched network has a queue that can store and forward the packet.

The Internet

- A network is a group of connected communicating devices such as computers and printers.
- An internet (lowercase letter i) is two or more networks that can communicate with each other.
- The Internet (uppercase letter I), a collaboration of more than hundreds of thousands of interconnected networks.
- Private individuals as well as various organizations such as government agencies, schools, research facilities, corporations, and libraries in more than 100 countries use the Internet.
- It is made up of many wide- and local-area networks joined by connecting devices and switching stations.

The Internet



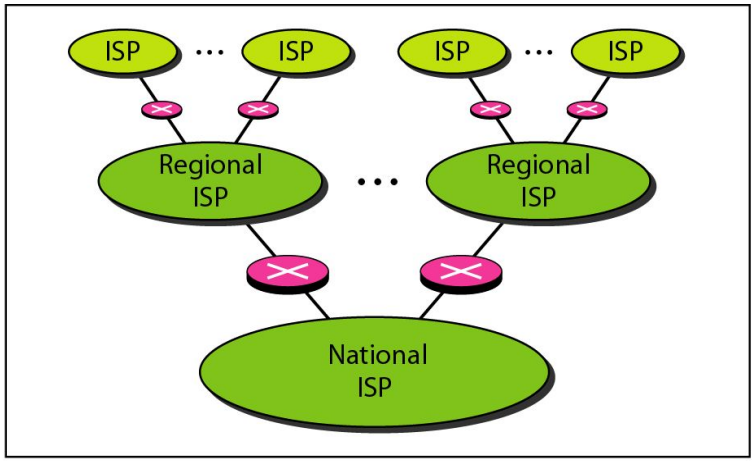
National Internet Service Providers (13)

- Ortel Communications Limited
- Ishan Netsol Pvt Ltd.
- Tata Communications Ltd.
- IKF Technologies Ltd
- Hughes Communications India Ltd.
- Tikona Infinet Limited

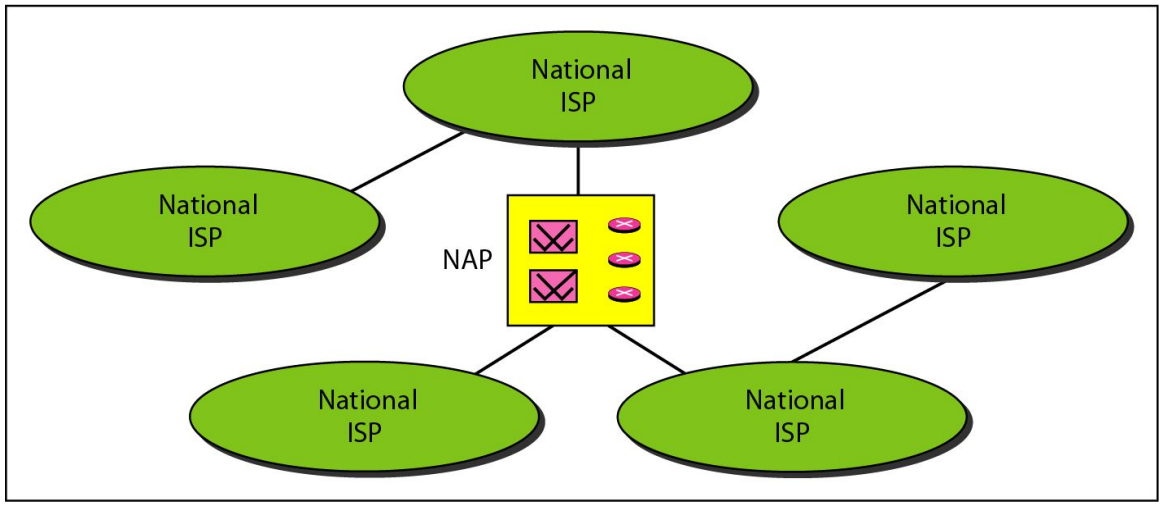
Regional Internet Service Providers (53)

https://trai.gov.in/

Figure 1.13 *Hierarchical organization of the Internet*



a. Structure of a national ISP



b. Interconnection of national ISPs

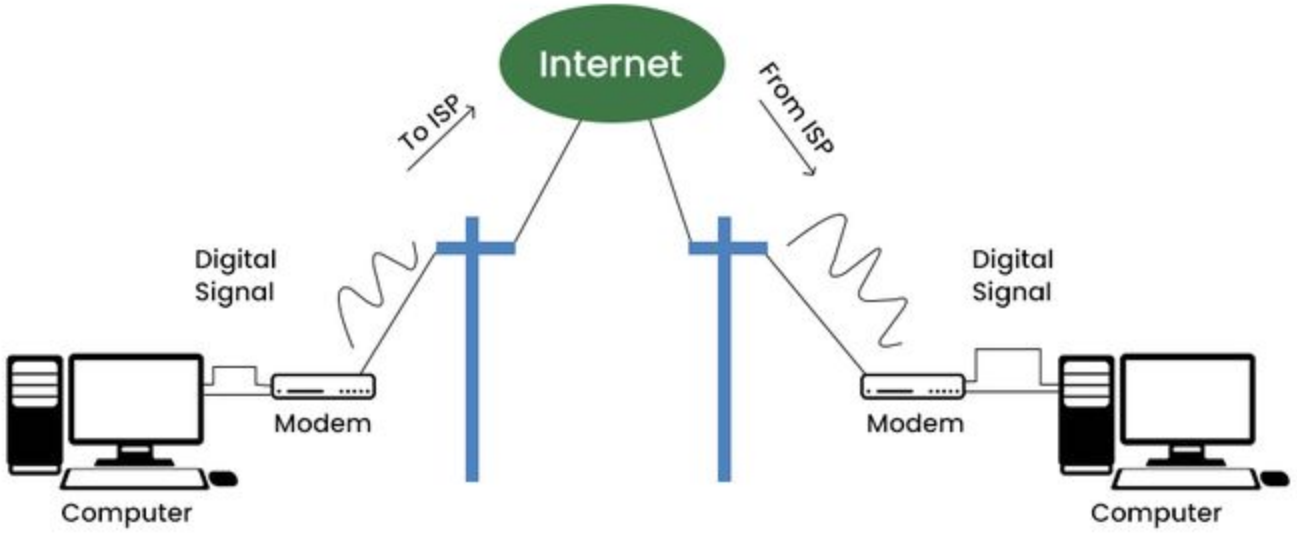
Accessing the Internet

- There are many connections that can be used for internet access.

1. Using Telephone Network
   - Dial-up service
   - Digital Subscriber Line Service
2. Using Cable Networks
3. Using Wireless Networks
4. Direct Connection to the Internet

- The user, however, needs to be physically connected to an ISP.
- All the connections have their own speed range.

Accessing the Internet :Dial Up Connection

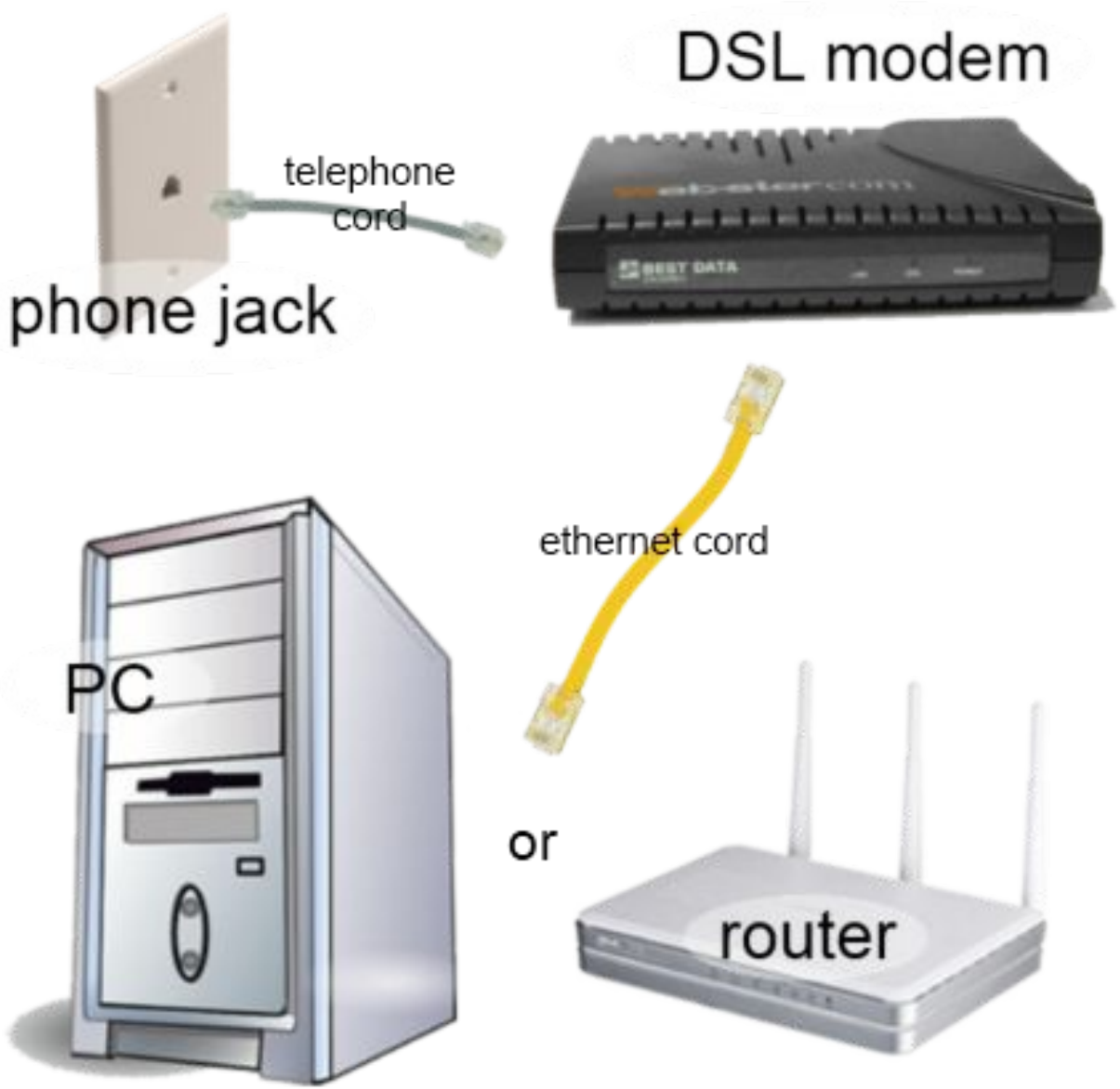


- A Dial Up Connection is established between computer and the ISP server using a modem.
- We need to add, to the telephone line, a modem that converts data to voice.
- The software installed on the computer dials the ISP and imitates making a telephone connection.
- In this connection, we can use either an internet connection or telephone at a time.

Accessing the Internet : Digital Subscriber Line Service

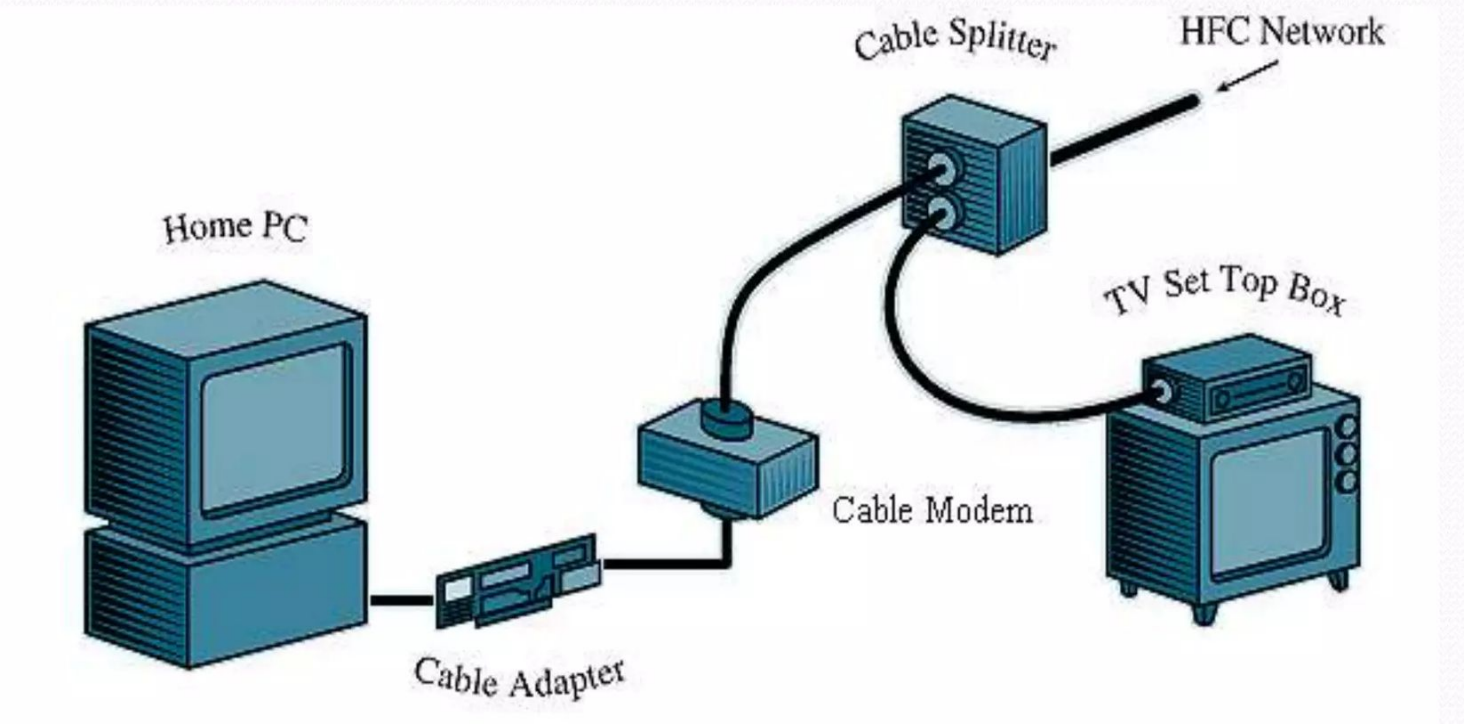
- It provides an internet connection through the telephone line(network).
- DSL is a form of broadband communication that is always on, there is no need to dial a phone number to connect.
- A DSL modem receives signals via telephone lines and converts them digitally.
- This data can be transferred to you wirelessly or via an Ethernet cable.
- The DSL service also allows the line to be used simultaneously for voice and data communication

Accessing the Internet : Digital Subscriber Line Service



Accessing the Internet : Using Cable Networks

- We use cable TV services instead of antennas to receive TV Broadcasting
- We can also use this cable service for accessing Internet



Accessing the Internet : Using Cable Networks

- It is known as an "always-on" service which means that your computer is always connected to the Internet, unlike dial-up service where you had to log on with user name and passwords.
- Plug the PC into modem with an Ethernet cable, and then your modem into your normal television outlet on the wall using a coaxial cable (the same type as used by your television).
- Data is sent over the same coaxial cable that the TV signal comes into home.
- We can be surfing the Internet and be watching TV at the same time without any problems.

Accessing the Internet : Using Cable Networks

- Hybrid Fiber Coax (HFC) System: The system uses a combination of fiber cables and coaxial cables.
- When you get a television signal from your cable company, all of the video and audio information for a particular channel takes up a "slice" of bandwidth.
- It is possible to take one of these channels and use it for Internet access, and none of the other channels will be affected.
- Cable companies take a slice of bandwidth and use it to exchange data with your computer.

Accessing the Internet : Using Wireless Networks

Accessing the Internet : Using Wireless Networks (Wi-Fi)

- Wireless Internet access, is a local area network (LAN) run by radio waves rather than wires.
- Wireless Internet is typically provided by Wireless Internet Service Providers (WISP) that broadcast wireless Internet signals in a specific geographical location.
- Wi-Fi is a Wireless Networking technology that allows devices such as computers (laptops and desktops), mobile devices (smart phones), and other equipment (printers and video cameras) to interface with the Internet.
- It allows these devices--and many more--to exchange information with one another, creating a network.
- Internet connectivity occurs through a wireless router.
- When we access Wi-Fi, we are connecting to a wireless router that allows your Wi-Fi-compatible devices to interface with the Internet.

Wireless Router

- A port to connect to your cable or DSL modem
- A Router
- An Ethernet Hub
- A firewall
- A Wireless Access Point

A wireless router allows you to use wireless signals or ethernet cables to connect your computers and mobile devices to one another, to a printer and to the internet.

Wireless Router

- They are the hardware devices that Internet service providers use to connect you to their cable or DSL Internet network.
- A wireless router, also called a Wi-Fi router, combines the networking functions of a wireless access point and a router.
- A router connects local networks to other local networks or to the Internet.
- A wireless access point connects devices to the network wirelessly, using radio frequencies in the 900 MHz and 2.4, 3.6, 5, and 60 GHz frequency bands.

Wireless Service Providers in India

M/s Reliance JIO Infocomm Limited	All India
M/s Reliance Communications Ltd	All India (except Assam & NE)
M/s Mahanagar Telephone Nigam Ltd.	Delhi, Mumbai
Vodafone Idea Ltd.	All India
Bharat Sanchar Nigam Ltd.	All India (except Delhi & Mumbai)
Bharti Airtel Limited	All India

Bluetooth

hotspot

Direct connection to Internet

- A large organization can itself become a local ISP and be connected to the Internet.
- This can be done if that organization leases a high-speed WAN from a carrier provider and connects itself to a regional ISP.

Internet Protocols :Rules

- A protocol is a set of rules that governs data communications over the network.
- It can also be defined as a communication standard followed by the two key parties(sender and receiver) and the intermediate devices in a computer network to communicate with each other.
- A protocol defines

1.what is transmitted- Data (Image/Text/Data/Audio/video)

2.how it is transmitted (commands are used to send and receive data)

3.how data transfers are confirmed

Internet Protocols :Rules

- In simple terms , **a protocol** is similar to a language . Every language has its own rules and vocabulary . Protocol have their own rules , specifications and implementation . If 2 people share the same language , they can communicate very easily and effectively.
- Similarly two hosts implementing the same protocol can connect and communicate easily with each other . Hence protocols provide a common language for network device participating in data communication.
- The internet protocols, may be broken up into four categories -

❖ 1. Link layer- PPP,DSL,WIFI etc.

❖ 2. Internet layer — IP4,IP6.

❖ 3. Transport layer — TCP,UDP etc.

❖ 4. Application layer — HTTP,IMAP,FTP etc.

Internet Protocols :

- Protocols use a specific model for their implementation like

1. The OSI (Open Systems Interface) Model
2. TCP/IP (Transmission Control Protocol / Internet Protocol) Model

- There are different layers (for instance, data, network, transport, and application layer, etc.) in these models, where these protocols are implemented.

Internet Protocols :Levels

Levels of a Protocol

There are mainly three levels of a protocol, they are as follows:

- **Hardware Level:** In this level, the protocol enables the hardware devices to connect and communicate with each other for various purposes.
- **Software Level:** In the software level, the protocol enables different software to connect and communicate with each other to work collaboratively.
- **Application Level:** In this level, the protocol enables the application programs to connect and communicate with each other for various purposes.

Hence protocols can be implemented at the hardware, software, and application levels.

Internet Protocols :Types

- **Standard Protocols :**

1. A standard protocol is a mandated protocol for all devices.

2. It supports multiple devices and acts as a standard.

3. Standard protocols are not vendor-specific i.e. they are not specific to a particular company or organization.

4.They are developed by a group of experts from different organizations .

5. These protocols are publicly available, and we need not pay for them.

6. Some of the examples of Standard Protocols are *FTP, DNS, DHCP, SMTP, TELNET, TFTP, etc.*

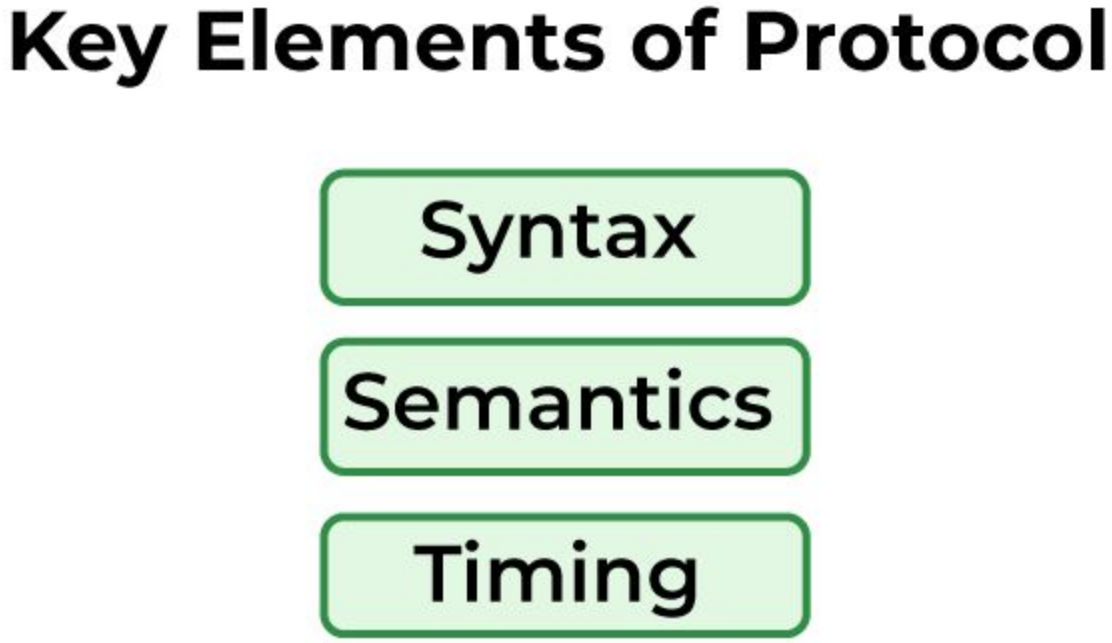
- **Proprietary Protocols :**

1. Proprietary protocols are developed by an individual organization for their specific devices.

2. We have to take permission from the organization if we want to use their protocols.

3. It supports only specific devices. We may have to pay for these protocols.

Internet Protocols :



Internet Protocols :Key Elements

- Syntax:

1.Refers to the structure or format of the data

2.The order in which data is presented.

3.For example:

A Data Packet has 32 Bits.

Address of sender	Address of Receiver	Data/Message
8 Bits	8 Bits	16 Bits

Address of sender	Address of Receiver	Check Sum	Data/Message
8 Bits	8 Bits	8 Bits	8 Bits

Internet Protocols :Key Elements

- Semantics:

1.Refers to the meaning of each section of bits mentioned in Syntax.

2. How is a particular pattern to be interpreted:
   Does the address identify route to be taken
   or
   it is destination address

3. what action is to be taken based on that interpretation?
   if destination address :discard the packet

Internet Protocols :Key Elements

- Timing:

1. The term timing refers to two characteristics:

   -when data should be sent and

   -how fast they can be sent.

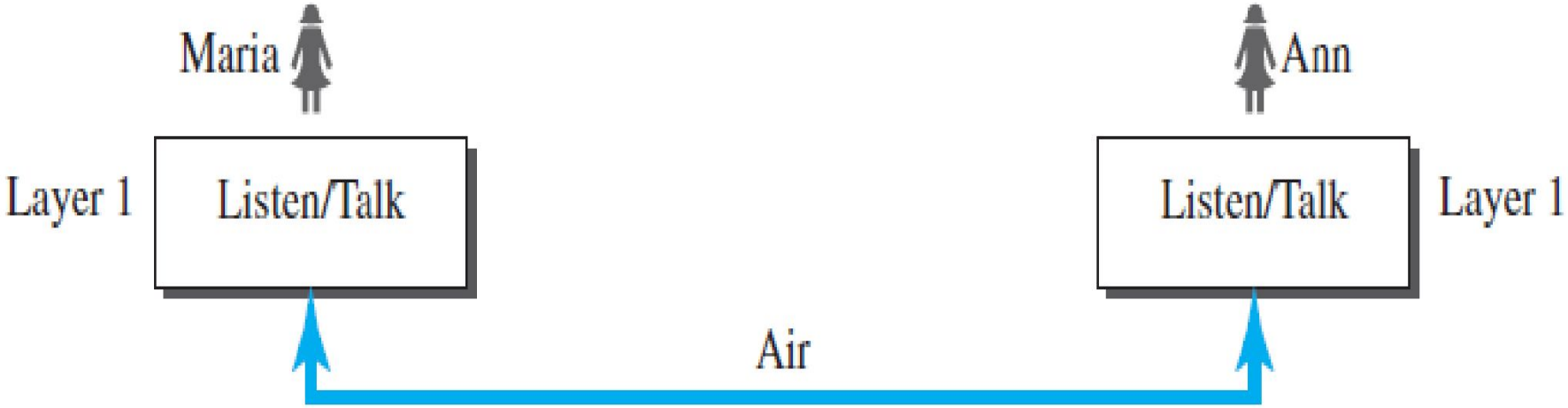
2. For example, if a sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps, the transmission will overload the receiver and some data will be lost.

Protocol Layering

- Computer network=>Hardware+software
- Hardware=>Nodes & links
- Software=> Communication Protocol
- In Data Communications & Networking, a protocol defines the rules that the sender, receiver and all intermediate devices need to follow to be able to communicate effectively

Protocol Layering:

Communication takes place in one layer, face to face, in the same language

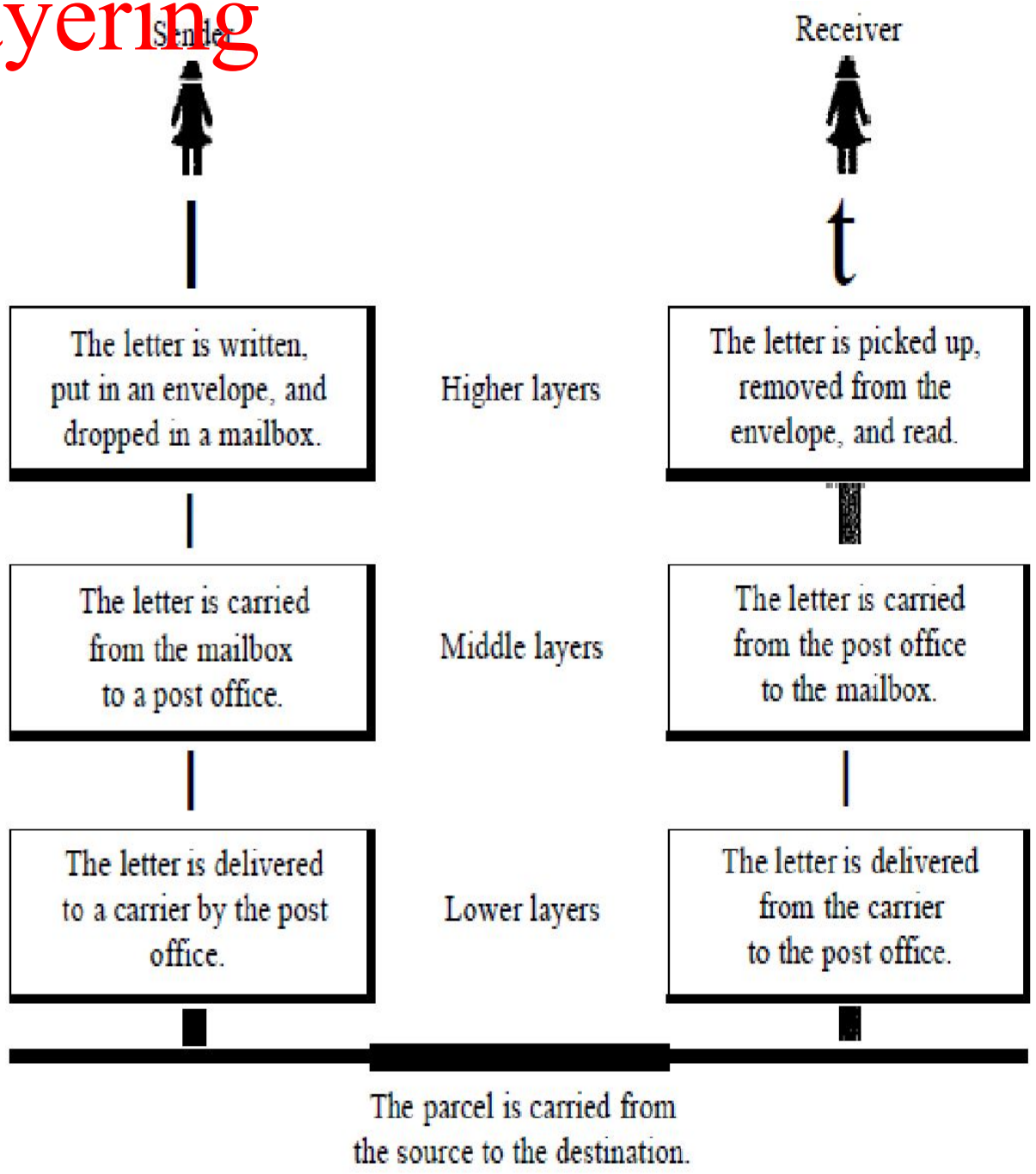


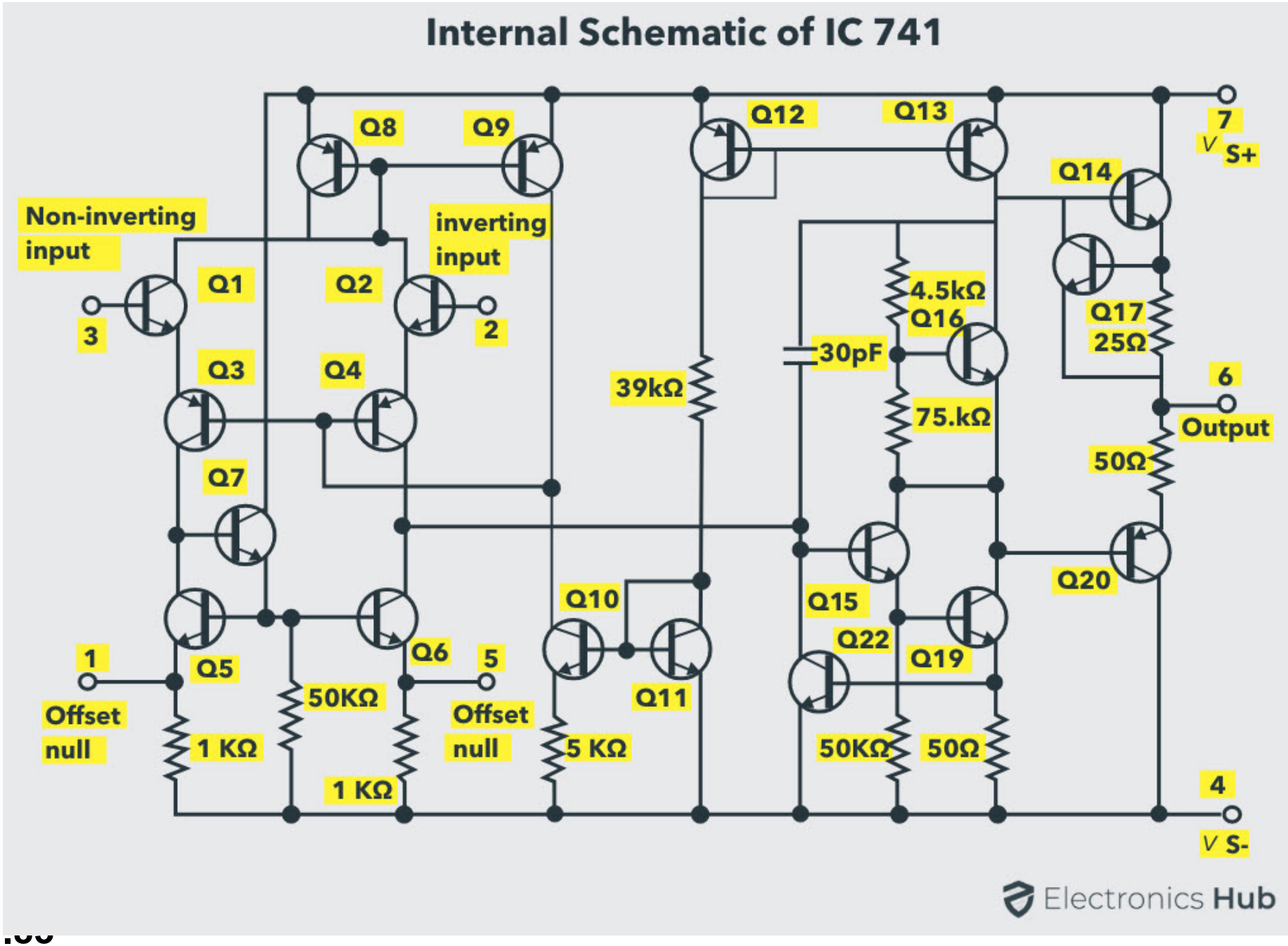
Protocol to be followed:

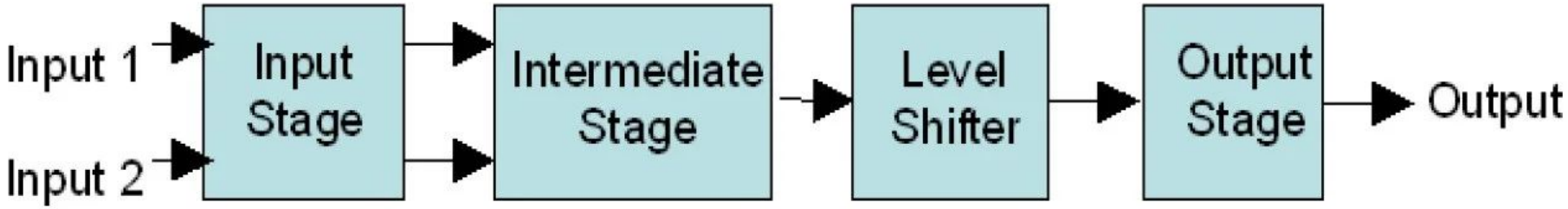
Different task : Different protocol

1. greet each other
2. vocabulary to the level of their commitment
3. each party knows that she should refrain from speaking when the other party is speaking.
4. the conversation should be a dialog, not a monolog: both should have the opportunity to talk.
5. exchange some nice words when they leave.

Protocol Layering




Internal Schematic of IC 741
Non-inverting input
3
inverting input
2
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
Q9
Q10
Q11
Q12
Q13
Q14
Q15
Q16
Q17
Q19
Q20
Q22
1
Offset null
5
Offset null
1 KΩ
50KΩ
1 KΩ
5 KΩ
39kΩ
30pF
4.5kΩ
75.kΩ
50KΩ
50Ω
25Ω
50Ω
7
V S+
6
Output
4
V S-
Electronics Hub



Dual-input balanced output differential amplifier

Dual input unbalanced output differential amplifier

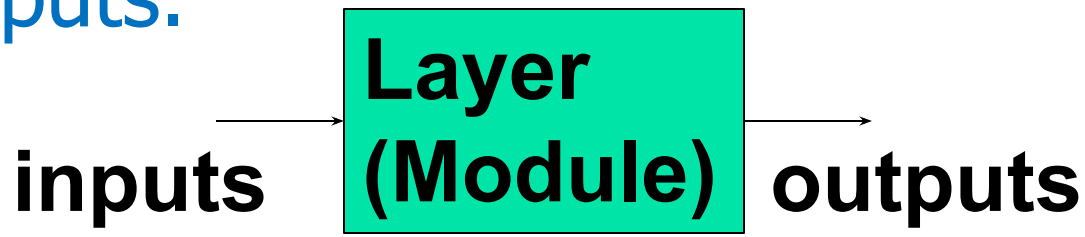
Emitter follower with constant current source

Complementary symmetry push-pull amplifier

Software Modular Programming

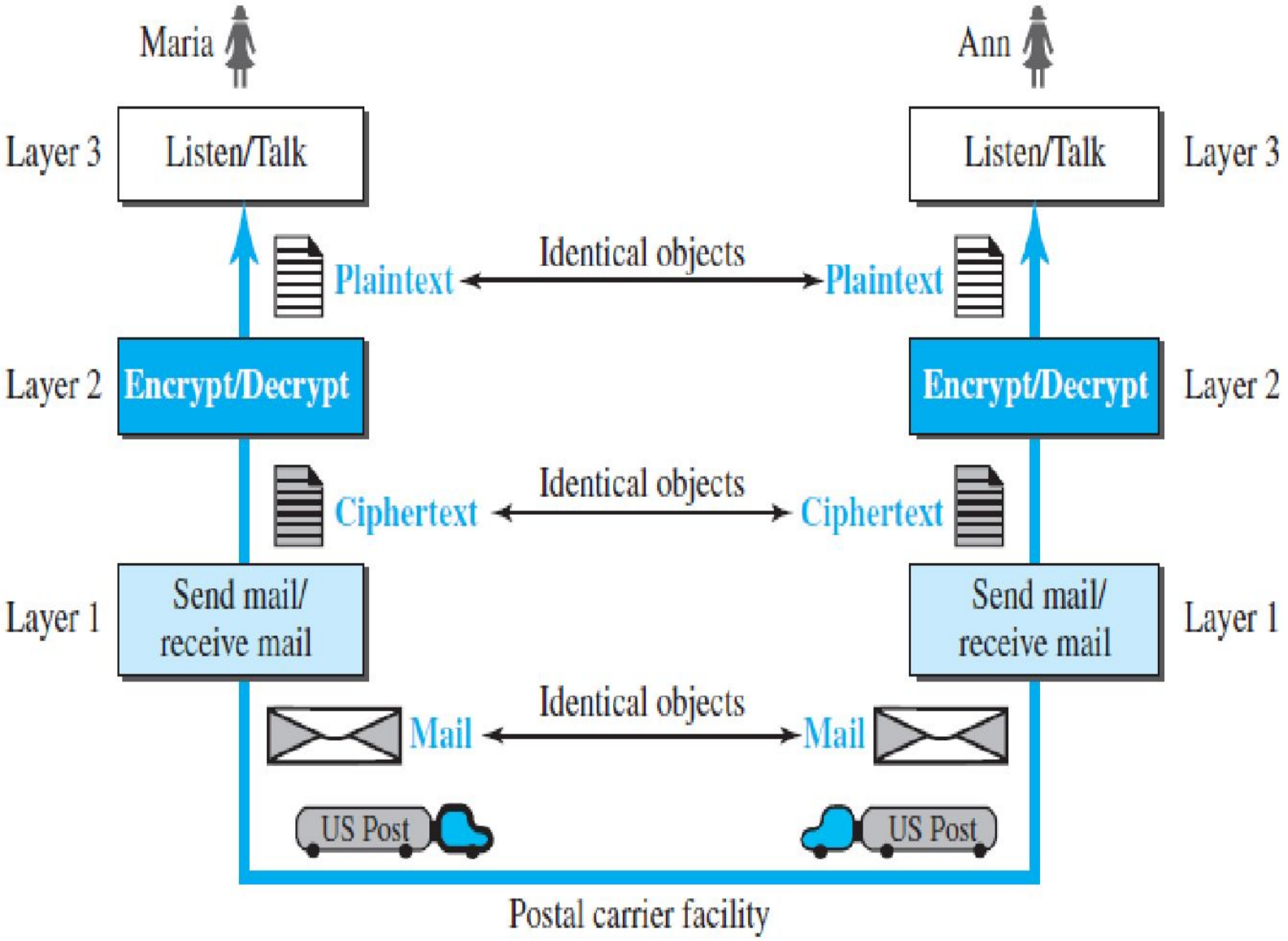
Protocol layering

- Protocol layering enables us to divide a complex task into several smaller and simpler tasks.
- Modularity ,means independent layers, is feature of protocol layering.
- A layer (module) can be defined as a black box with inputs and outputs, without concern about how inputs are changed to outputs.



Analogy : sorting program

Protocol Layering



Protocol layering: Advantages

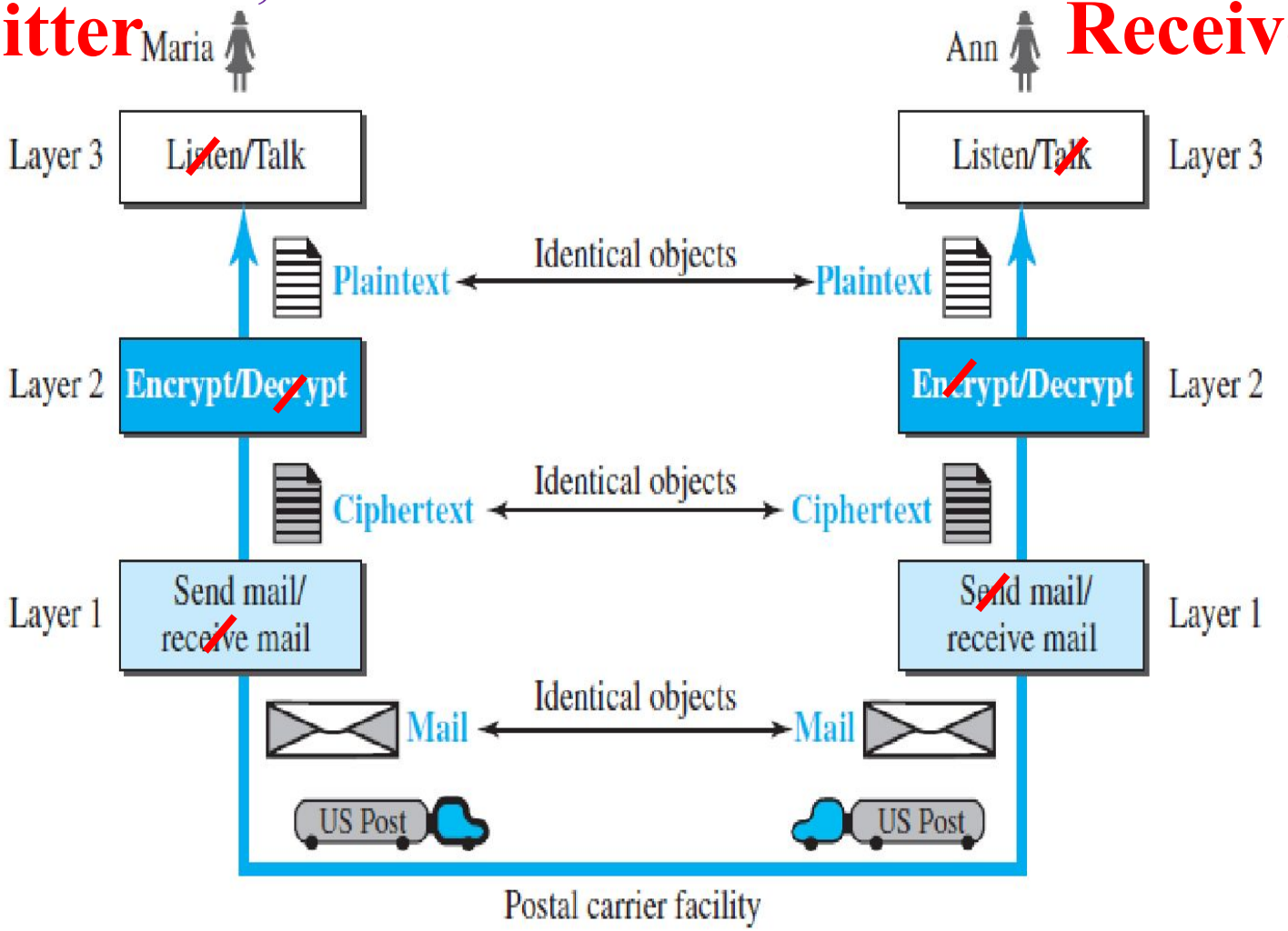
1. Allows to separate (isolate) services from the implementation.

- A layer needs to be able to receive a set of services from the lower layer and to give the services to the upper layer; we don't care about how the layer is implemented.
- Communication does not always use only two end systems; there are intermediate systems that need only some layers, but not all layers.

2. If we did not use protocol layering, we would have to make each intermediate system as complex as the end systems, which makes the whole system more expensive.

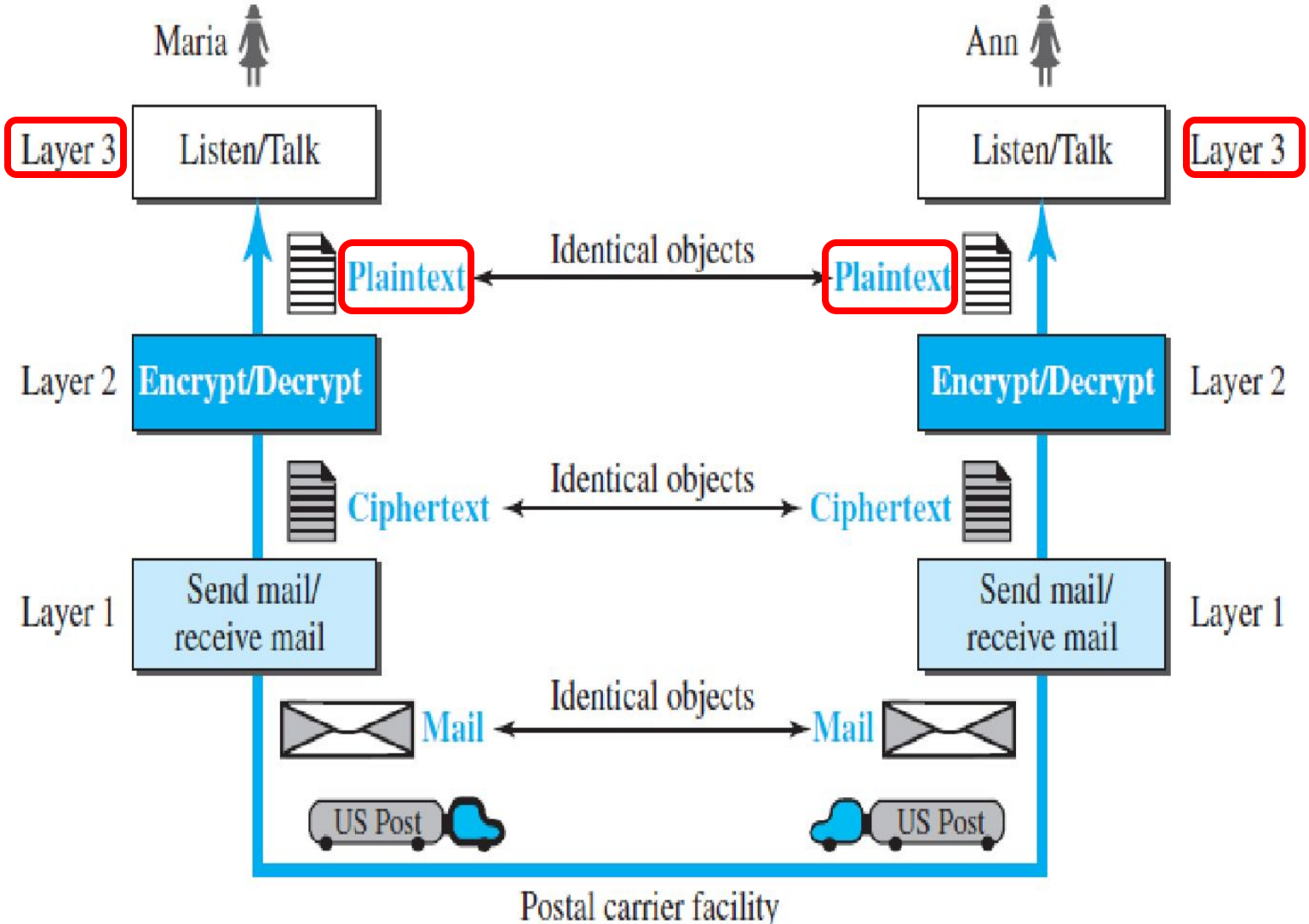
Principles of Protocol Layering

- **First Principle :** If we want bi-directional communication, we need to make each layer so that, it is able to perform two opposite tasks, one in each direction.



Principles of Protocol Layering

- **Second Principle:** The two objects under each layer at both sites should be identical.



Logical Connections

- After following the above two principles, we can think about logical connection between each layer .
- There is a logical (imaginary) connection at each layer through which they can send the object created from that layer.
- This means that we have layer-to-layer communication.

Logical Connections: Principle 1 & 2