Unit 7
Data Communications and Networking

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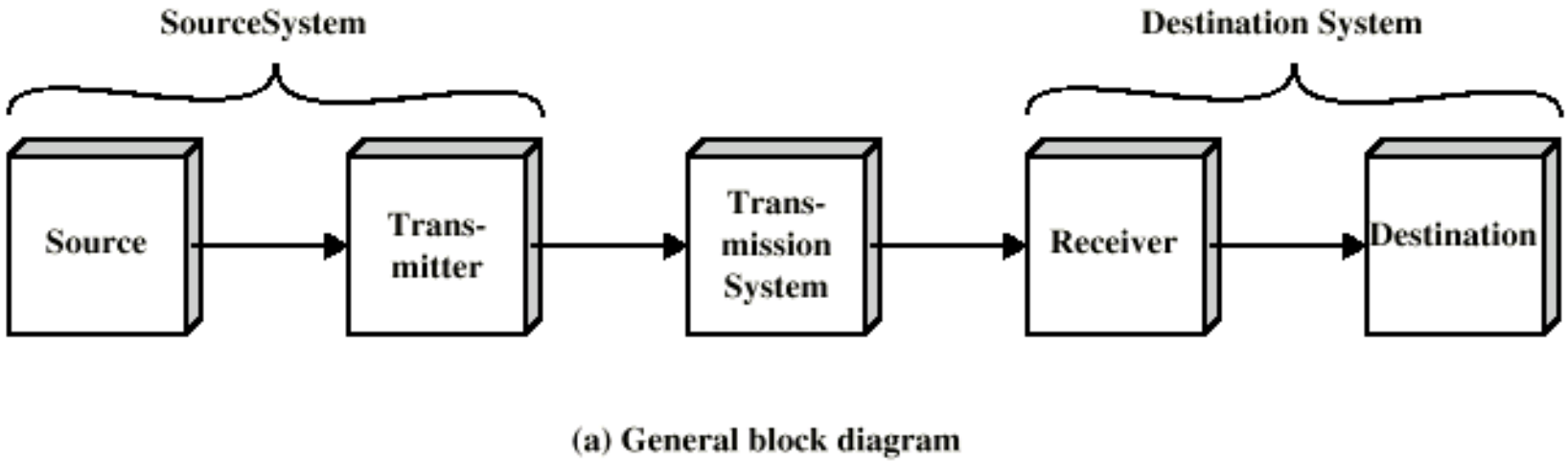
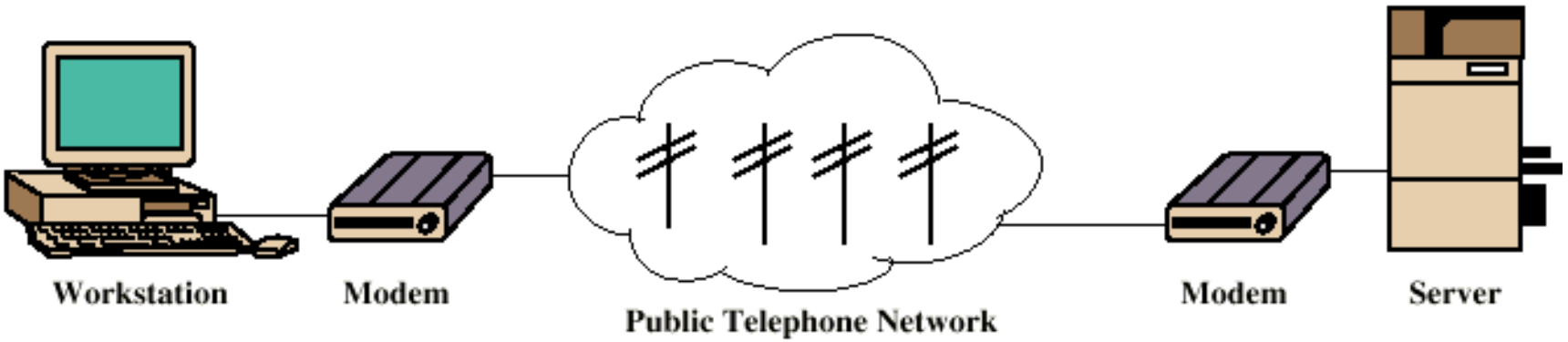
Communications

- Data communication—examines how data, in the form of energy, travel across some medium from a source to a destination.

A Simplified Communications Model



(a) General block diagram



(b) Example

Why study communications?

- Why should we study communications?

What are transmitted via Communication Media?

- Voice – encoded signals
- Video – encoded images
- Data – character streams

Communication Applications

- Voice – telephone, FAX, Video Conferencing, Cellular phones, etc.
- Video & Audio – television, VCR, DVD, etc.
- Data – LAN, WAN, Internet, etc.

Networking

- Networking—computers communicate with each other via networks.
- Computer network—a communication system for connecting computers using a single transmission technology.

Network Topologies

Objectives

- Describe the basic and hybrid LAN physical topologies, and their uses, advantages and disadvantages.

- Describe the backbone structures that form the foundation for most LANs

Simple Physical Topologies

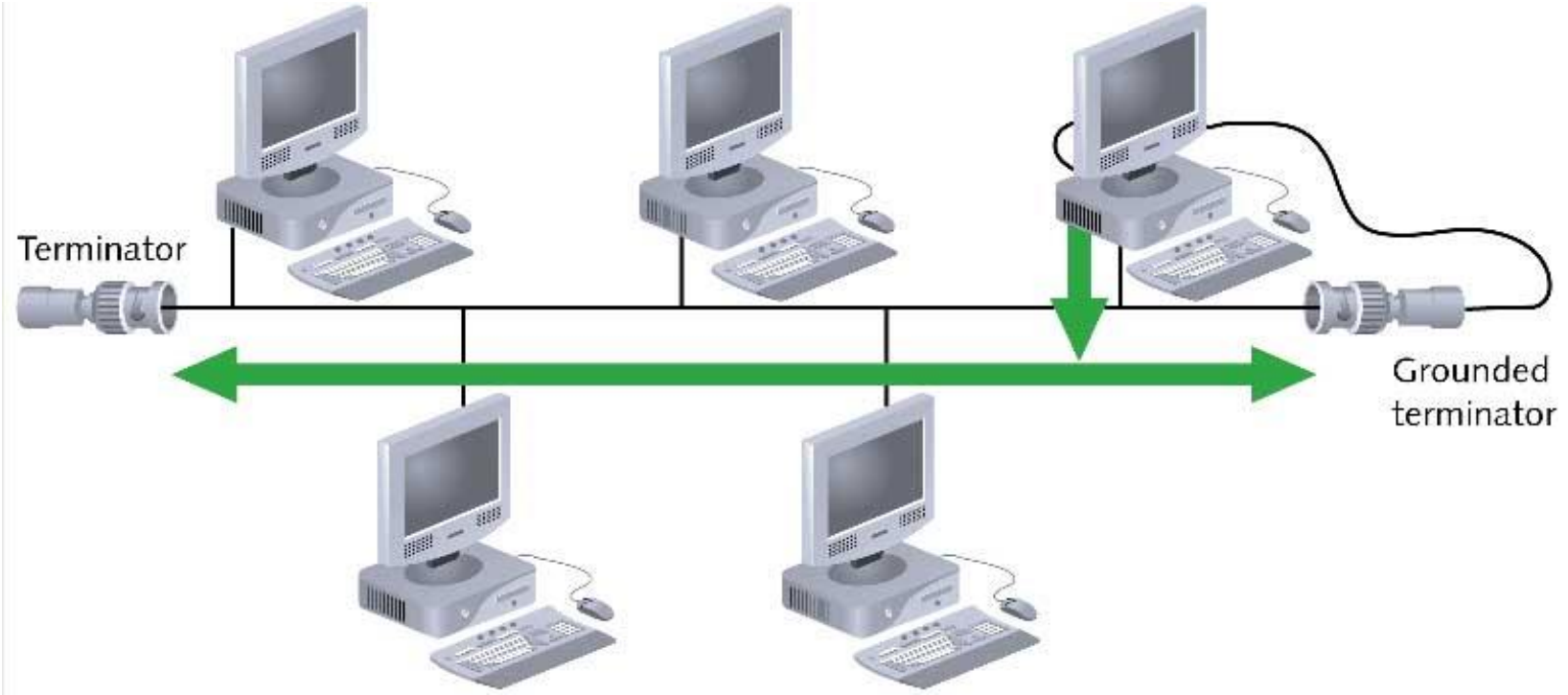
- Physical topology: physical layout of nodes on a network
- Four fundamental shapes:
  - Bus
  - Ring
  - Star
  - Mesh
- May create hybrid topologies
- Topology integral to type of network, cabling infrastructure, and transmission media used

Why we need a topology

Choosing one topology over another can impact :

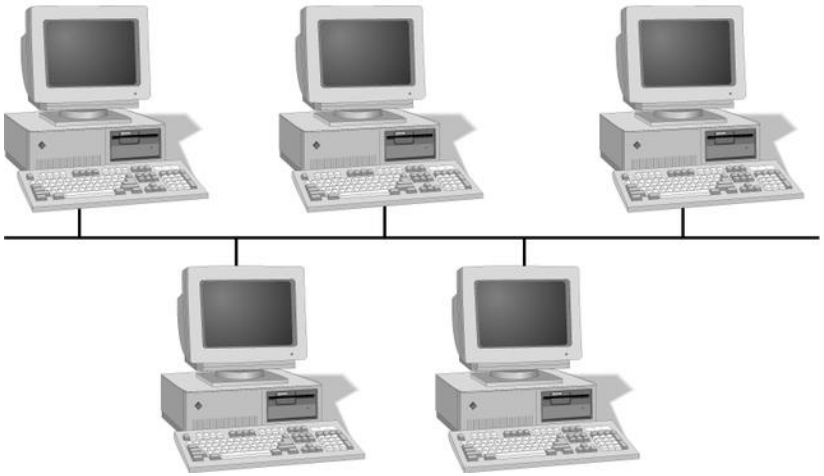
- type of equipment the network needs
- capabilities of the equipment
- network’s growth
- way a network is managed

Bus



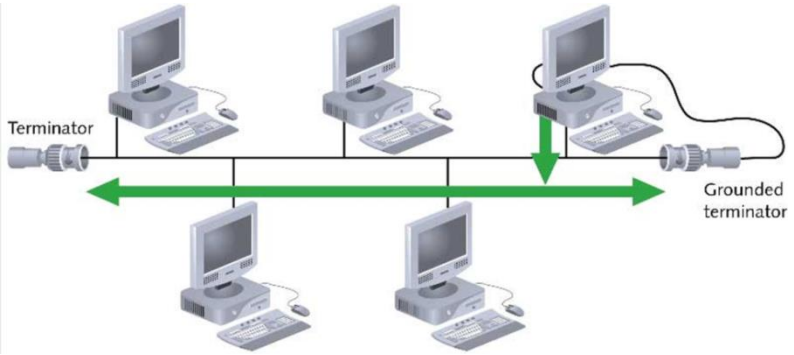
Simple Physical Topologies

- A **Bus topology** consists of a single cable—called a **backbone**— connecting all nodes on a network without intervening connectivity devices



Bus (continued)

- Devices share responsibility for getting data from one point to another
- Terminators stop signals after reaching end of wire
  - Prevent signal bounce
- Inexpensive, not very scalable
- Difficult to troubleshoot, not fault-tolerant



Bus

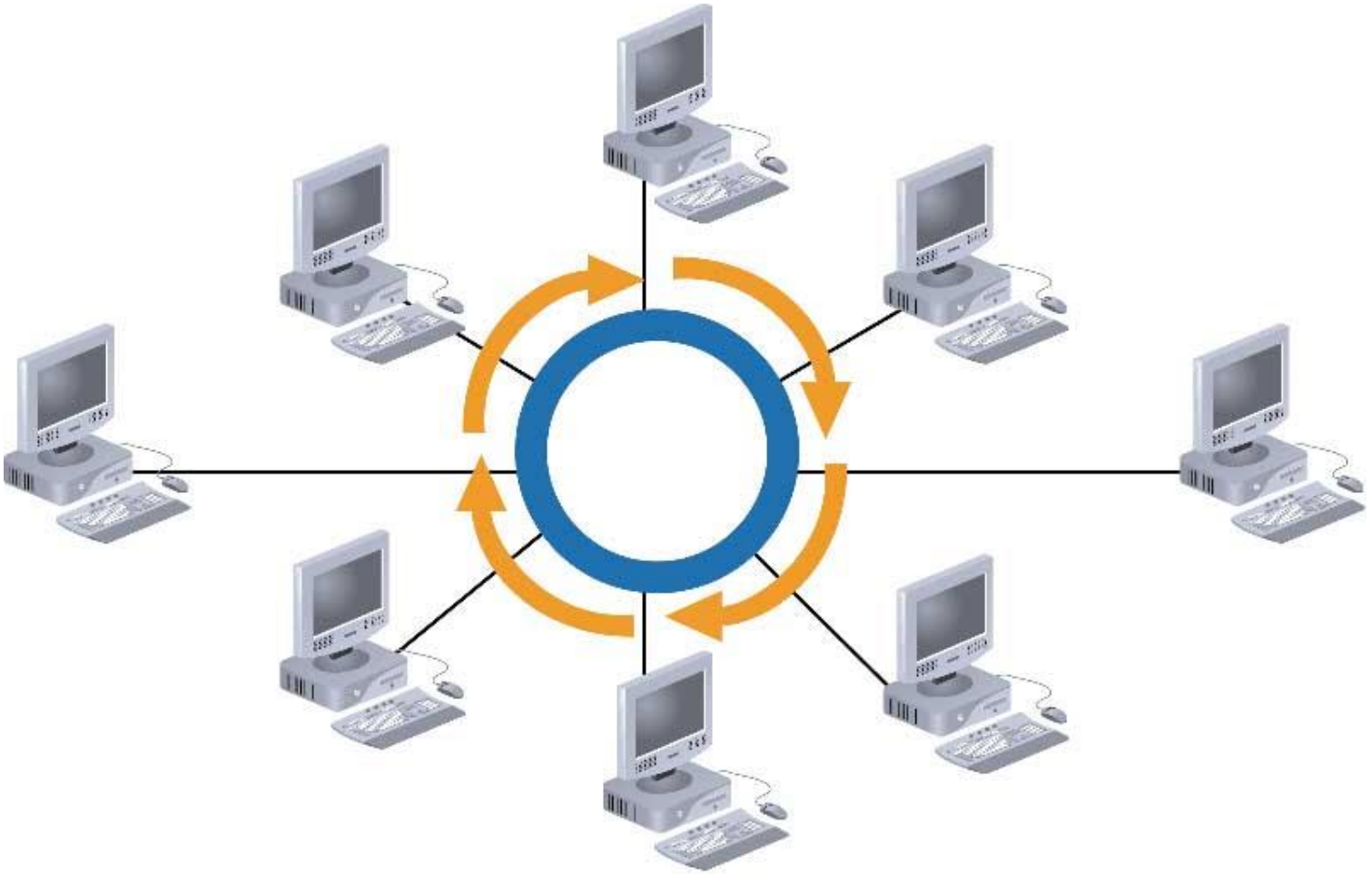
Advantages

- Works well for small networks
- Easy to install
- Relatively inexpensive to implement

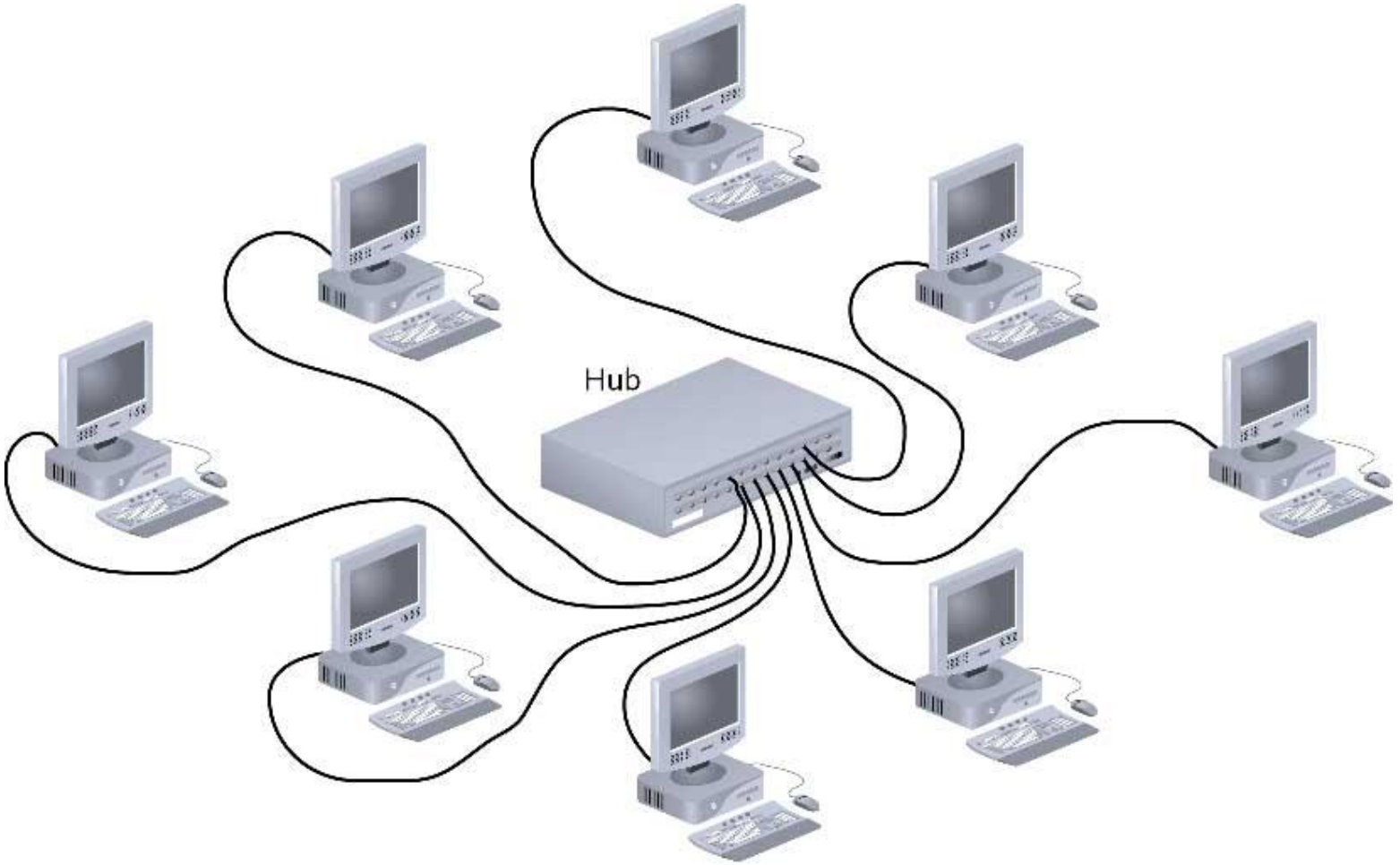
Disadvantage

- Management costs can be high
- Network disruption when computers are added or removed
- A break in the cable will prevent all systems from accessing the network.
- Difficult to troubleshoot

Ring



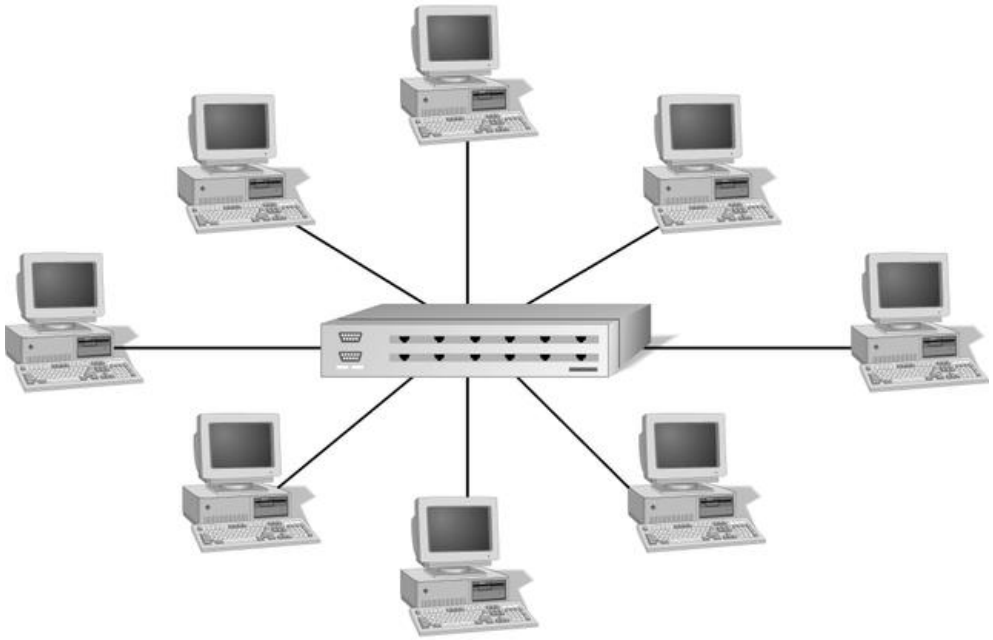
Star



Simple Physical Topologies

Star topology

– Every node on the network is connected through a central device called **hub or switch**.



Star (continued)

- Any single cable connects only two devices
  - Cabling problems affect two nodes at most
- Requires more cabling than ring or bus networks
  - More fault-tolerant
- Easily moved, isolated, or interconnected with other networks
  - Scalable
- Supports max of 1024 addressable nodes on logical network

Star

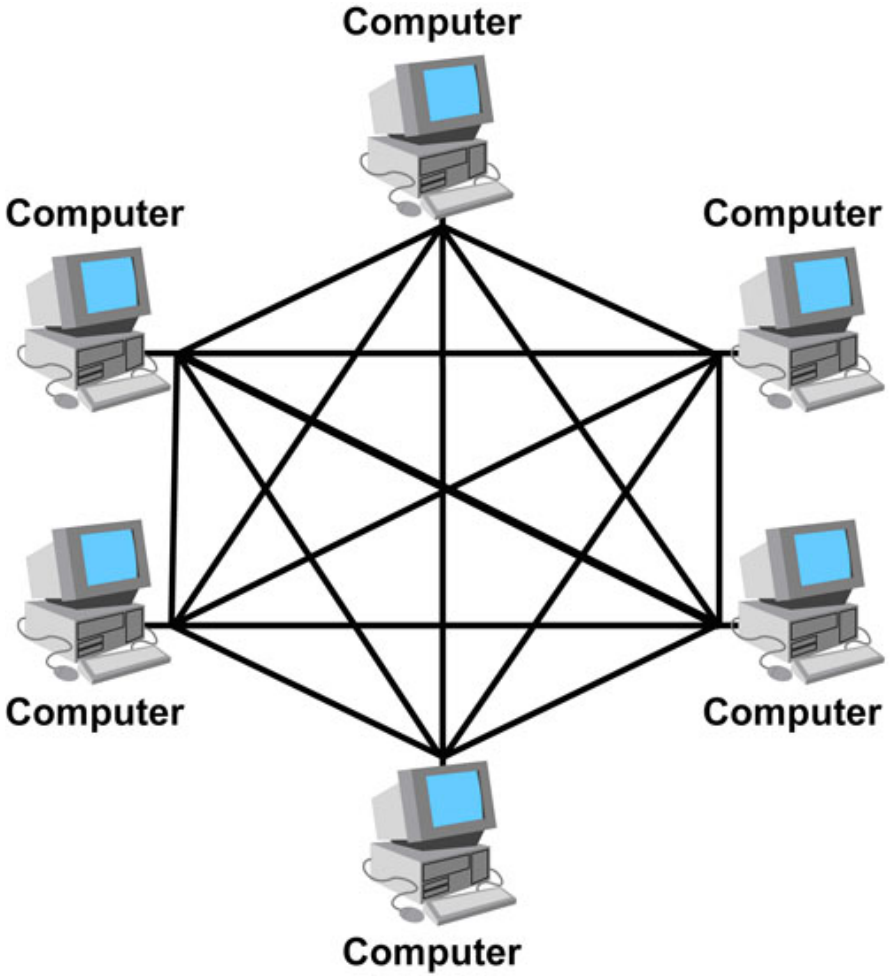
Advantages

- Good option for modern networks
- Low startup costs
- Easy to manage
- Offers opportunities for expansion
- Most popular topology in use; wide variety of equipment available

Disadvantage

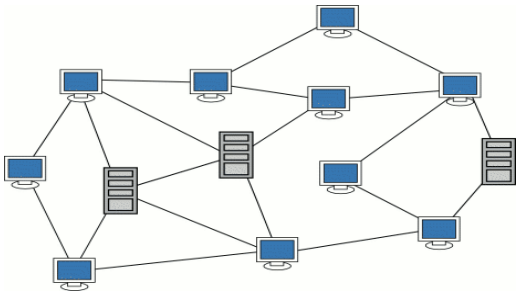
- Hub is a single point of failure
- Requires more cable than the bus

Mesh


Computer
Computer
Computer
Computer
Computer
Computer
Computer

Simple Physical Topologies

- Mesh Topology: Each computer connects to every other.
- High level of redundancy.
- Rarely used.
  - Wiring is very complicated
  - Cabling cost is high
  - Troubleshooting a failed cable is tricky
  - A variation hybrid mesh – create point to point
- connection between specific network devices, often
- seen in WAN implementation.



Mesh

Advantages

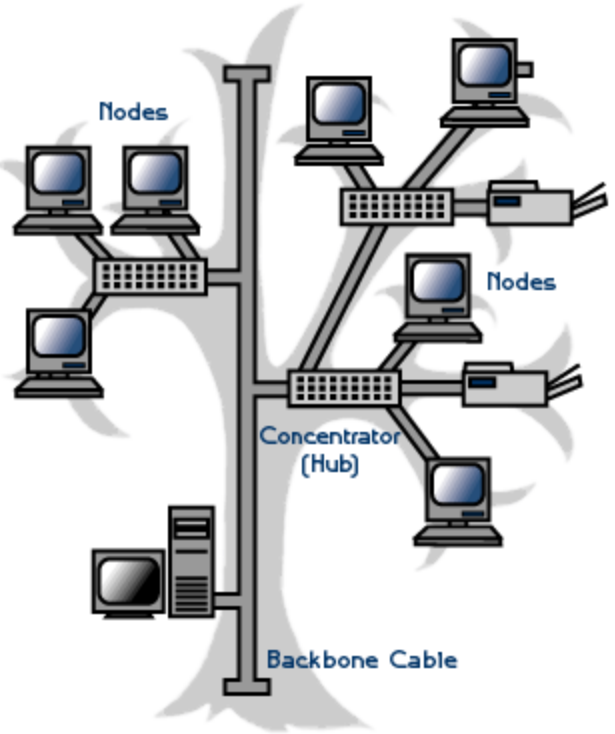
- Robust
- There is the advantage of privacy or security
- The network can be expanded without disruption to current uses
- Point to point links make fault identification and fault isolation easy

Disadvantage

- Requires more cable than the other LAN topologies
- Complicated implementation
  - Installation and reconnection are difficult.
  - Sheer bulk of wiring can be greater than the available space can accommodate
  - Expensive

Hybrid Physical Topologies

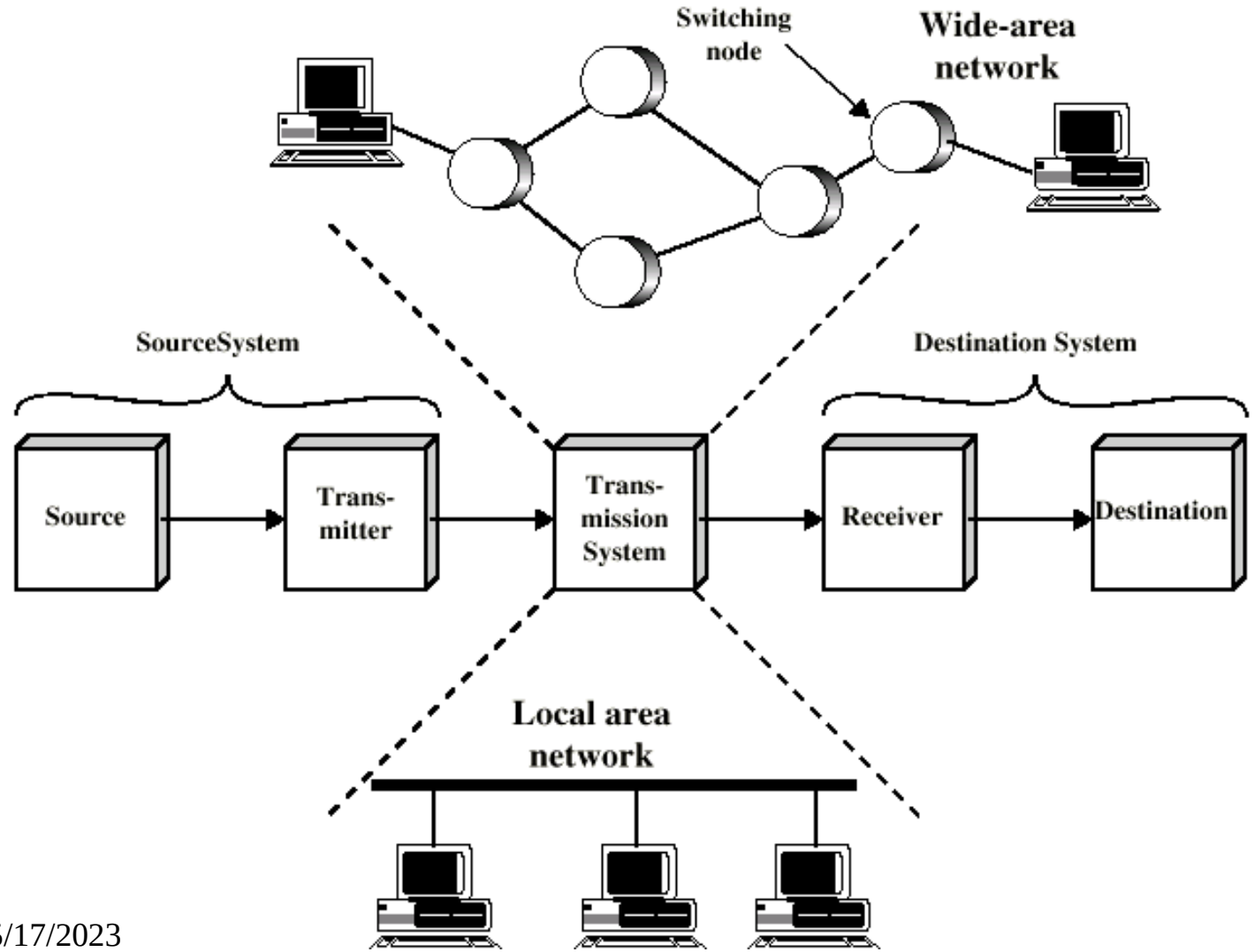
- One example of **Hybrid Topology is Tree topology**
- **Tree topology** is a combination of Bus and Star topology.
- It consists of groups of star-configured workstations connected to a linear bus backbone cable.
- If the backbone line breaks, the entire segment goes down
- An example of this network could be cable -



Choosing a Topology

- **BUS**
  - network is small
  - network will not be frequently reconfigured
  - least expensive solution is required
  - network is not expected to grow much
- **STAR**
  - it must be easy to add/remove PCs
  - it must be easy to troubleshoot
  - network is large
  - network is expected to grow in the future
- **RING**
  - network must operate reasonably under heavy load
  - higher speed network is required
  - network will not be frequently reconfigured

A Simplified Network Model



Protocols

- Definition – all parties involved in a communication must agree in a set of rules to be used when exchanging messages. Thus, the set of rules which both the sender and the receiver all comply with is called *protocol*.
- A protocol specifies the message format, meanings, and the procedures is known as a communication protocol.
- A communication application doesn't communicate with the communication hardware directly.

Key Elements of a Protocol

- Syntax
  - Data formats
  - Signal levels
- Semantics
  - Control information
  - Error handling
- Timing
  - Speed matching
  - Sequencing

Why Protocols?

- Used for communications between entities in a system
- Must speak the same language
- Entities
  - User applications
  - e-mail facilities
  - terminals
- Systems
  - Computer
  - Terminal
  - Remote sensor

Communication Reference Models

- In summary, we need a communication reference model to describe the relationship between various software and hardware.
- A reference model describes the layering relationship of software and hardware involved in the communication.
- A layered protocol performs specific functions and communicates with the layers directly above and below it.

Communication Reference Models

- The purpose of layering the protocol is to separate specific functions and to make their implementation transparent to other components.
- Advantage of layered approach: independent design and testing of each communication software component
- Disadvantage: overly layering can affect performance negatively.

A Communications Model

- Source
  - generates data to be transmitted
- Transmitter
  - Converts data into transmittable signals
- Transmission System
  - Carries data
- Receiver
  - Converts received signal into data
- Destination
  - Takes incoming data

Protocol Architecture

- Task of communication broken up into modules
- For example file transfer could use three modules
  - File transfer application
  - Communication service module
  - Network access module

Protocol Data Units (PDU)

- At each layer, protocols are used to communicate
- Control information is added to user data at each layer
- Transport layer may fragment user data
- Each fragment has a transport header added
  - Destination SAP
  - Sequence number
  - Error detection code
- This gives a transport protocol data unit

Standards

- Required to allow for interoperability between equipment
- Advantages
  - Ensures a large market for equipment and software
  - Allows products from different vendors to communicate
- Disadvantages
  - Freeze technology
  - May be multiple standards for the same thing

Categories of Protocols

- Proprietary system– designed and developed for supporting the communications of machines manufactured by a specific vender
- System Network Architecture (SNA) was designed and developed for connecting IBM main frame computers and peripherals (workstations, printers, tape drives, etc.)
- NetBEUI – Microsoft's protocol for simple Windows networks
- IPX/SPX (Internetwork Packet Exchange and Sequenced Packet exchange) – support Novell NetWare products

Categories of Protocols

- Open systems– publicly proposed and evaluated protocols for supporting the internetworking of heterogeneous machine
- Open System Interconnect (OSI) was developed by ISO
- TCP/IP was designed by IETF (Internet Engineering Task Force), another volunteer organization for the engineering issues of the Internet.

Examples of Protocol Stacks

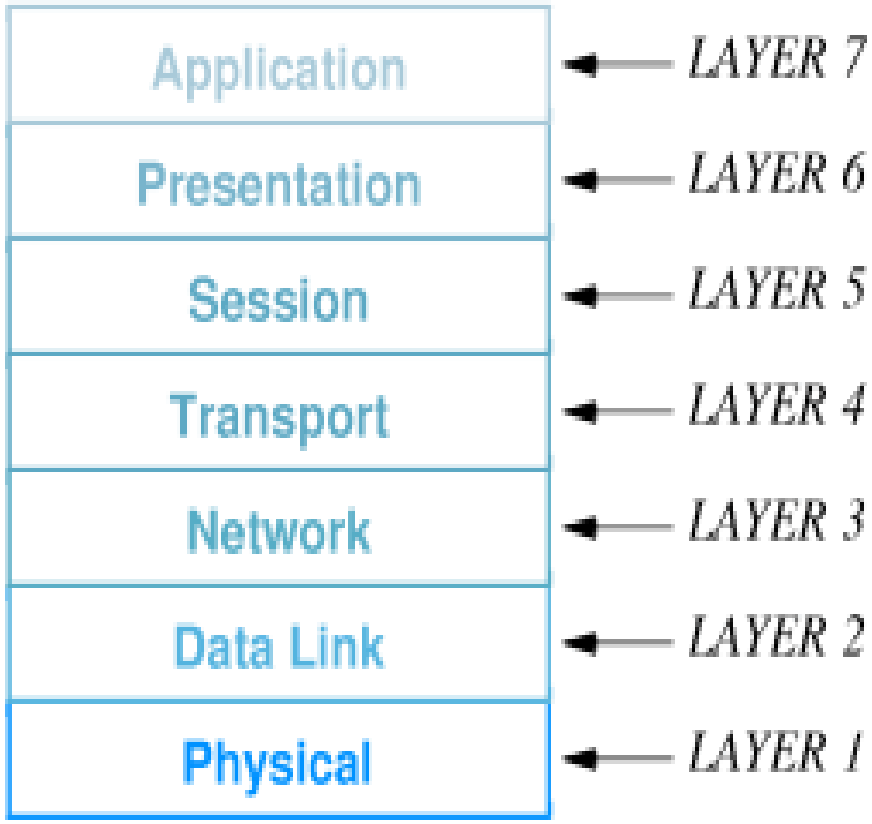
Vendor	Stack
Novell Corporation	Netware
Banyan System Corporation	VINES
Apple Computer Corporation	AppleTalk
Digital Equipment Corporation	DECNET
IBM	SNA
(many vendors)	TCP/IP

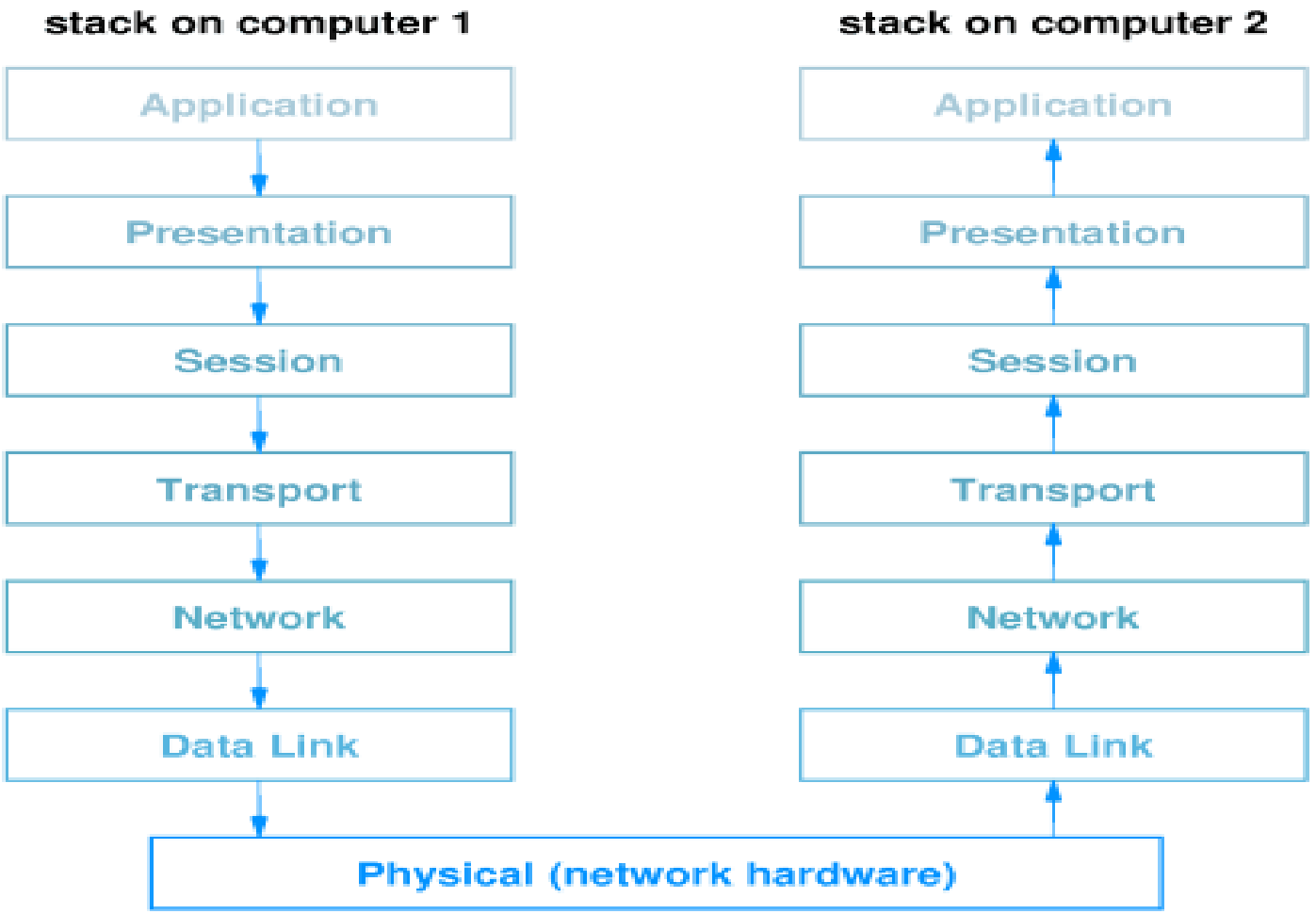
OSI Model

- Open Systems Interconnection (OSI)
- Developed by the International Organization for Standardization (ISO)
- Seven layers
- A theoretical system delivered too late!
- TCP/IP is the de facto standard

OSI Layers

- Application
- Presentation
- Session
- Transport
- Network
- Data Link
- Physical


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


stack on computer 1
stack on computer 2
Application
Presentation
Session
Transport
Network
Data Link
Application
Presentation
Session
Transport
Network
Data Link
Physical (network hardware)

Physical Layer

- Corresponds to basic hardware.
- Example: NIC, modem, cable
- Topics include transmission media, data encoding, modulation/demodulation, multiplexing, switching(layer 1)-- circuit switching.

Data Link Layer

- Specifies how to organize data into frames and how to transmit frames over a network.
- Detail topics include the format of a data frame, i.e., framing, error detection/correction, frame level error recovery.

Network Layer

- Specifies how to assign addresses and how to forward packets to its destination.
- Detail topics include fragmentation, assembly, routing, flow control.

Transport Layer

- The basic function of the transport layer is to accept data from the session layer, split it up into smaller units, if needed, pass them to the network layer, and ensure that the pieces all arrive correctly at the other end.
- The transport layer also determines the type of services, connection-oriented or connectionless.
- Congestion(N/W Traffic) control

Session Layer

- Allows users on different machines to establish sessions between them.
- Major functions include managing dialog.
- Session layer determines whether traffic can only go in one direction or both directions at the same time.

Presentation Layer

- Controls the encoding and decoding of data, data compression.

Application Layer

- Controls the interface with users.
- Application, presentation, session layers are usually implemented together instead of using laying architecture.

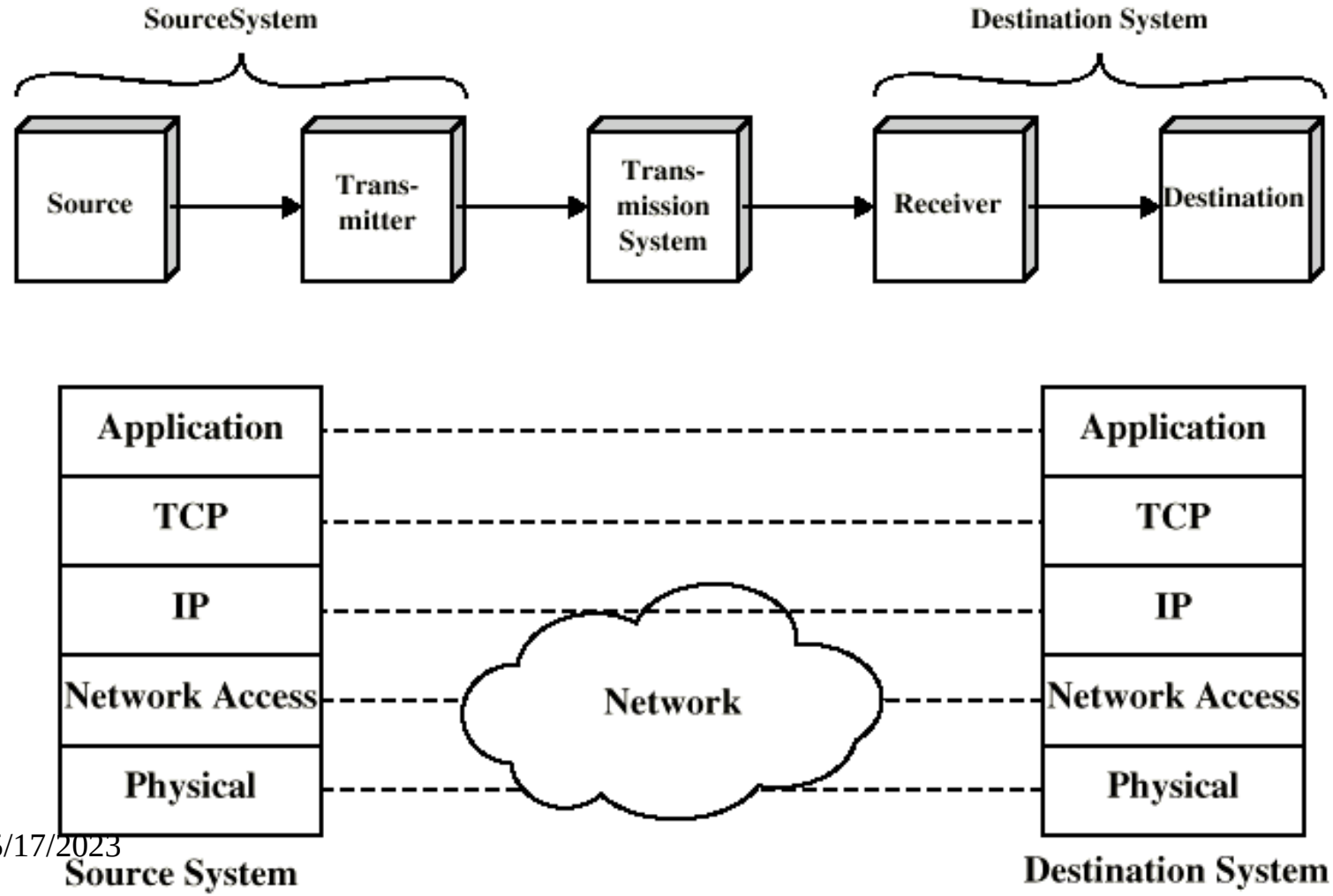
Home-Work

- How data is transmitted from sender to receiver in OSI reference model. Explain with suitable example.

TCP/IP Protocol Architecture

- Developed by the US Defense Advanced Research Project Agency (DARPA) for its packet switched network (ARPANET)
- Used by the global Internet
- No official model but a working one.
  - Application layer
  - Transport layer: host-to-host (application to application)
  - Internet layer: network routing and congestion control
  - Network access layer: access transmission medium
  - Physical layer

TCP/IP Protocol Architecture Model



What is TCP/IP?

- TCP/IP stands for Transmission Control Protocol/Internet Protocol and is actually a set of standards that describe how data is to be transferred between computers.
- TCP/IP is the common tongue that all computers must speak to communicate via Internet.
- There are implementations for UNIX, Windows, Macintosh, and just about any computer operating systems you can think of.
- TCP/IP is implemented as part of an Operating System.

Physical Layer

- Physical interface between data transmission device (e.g. computer) and transmission medium or network
- Characteristics of transmission medium
- Signal levels
- Data rates
- etc.

Network Access Layer

- Exchange of data between end system and network
- Destination address provision
- Invoking services like priority

Internet Layer (IP)

- Systems may be attached to different networks
- Routing functions across multiple networks
- Implemented in end systems and routers

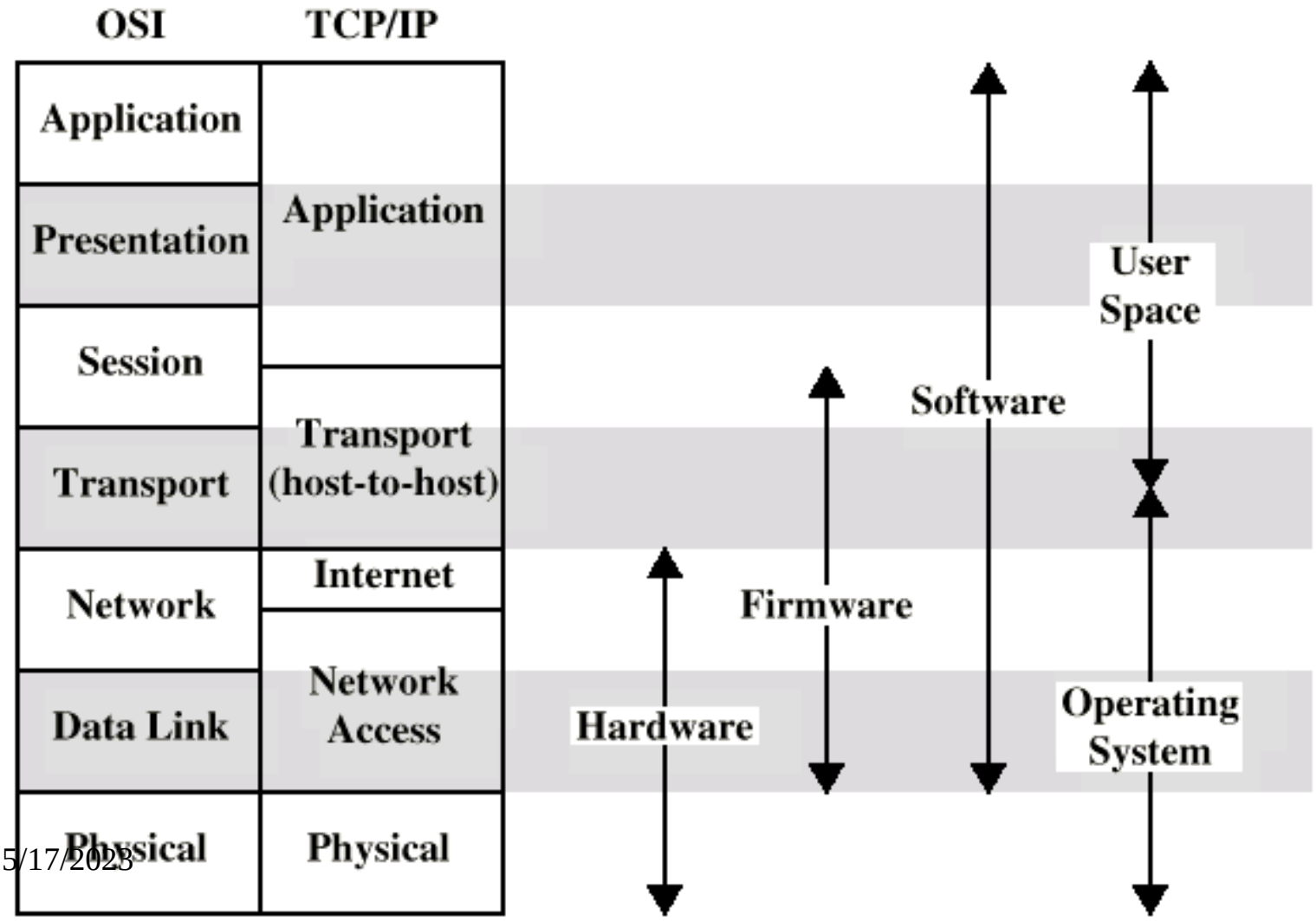
Transport Layer (TCP)

- Reliable delivery of data
- Ordering of delivery

Application Layer

- Support for user applications
- e.g. http, SMPT

OSI v TCP/IP

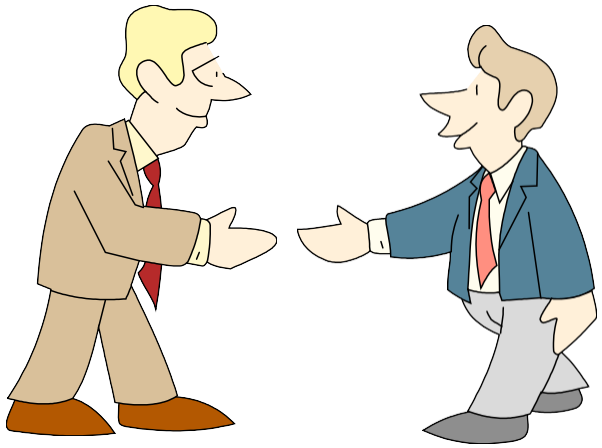

OSI
TCP/IP
Application
Presentation
Session
Transport
Network
Data Link
Physical
Application
Transport (host-to-host)
Internet
Network Access
Physical
Hardware
Firmware
Software
User Space
Operating System

Let’s Ask Ourselves a Question

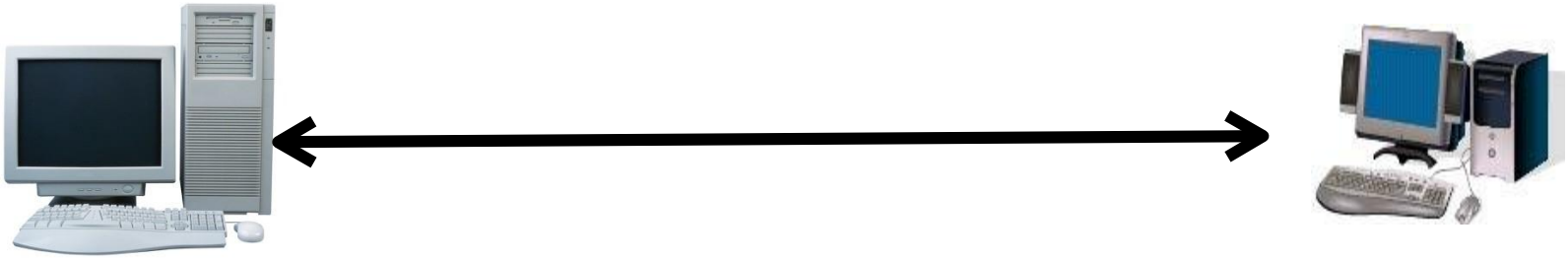
“What is the first thing we do when we meet someone?”

We Observe Some "Protocol"

We greet each other with a hand shake….begin conversation… How are you?



Computers Observe Protocol



While two computers don't shake hands physically, they do observe some rules—conventions—to begin conversation or communication.

That is what a protocol is about.

What is a Communications Protocol?

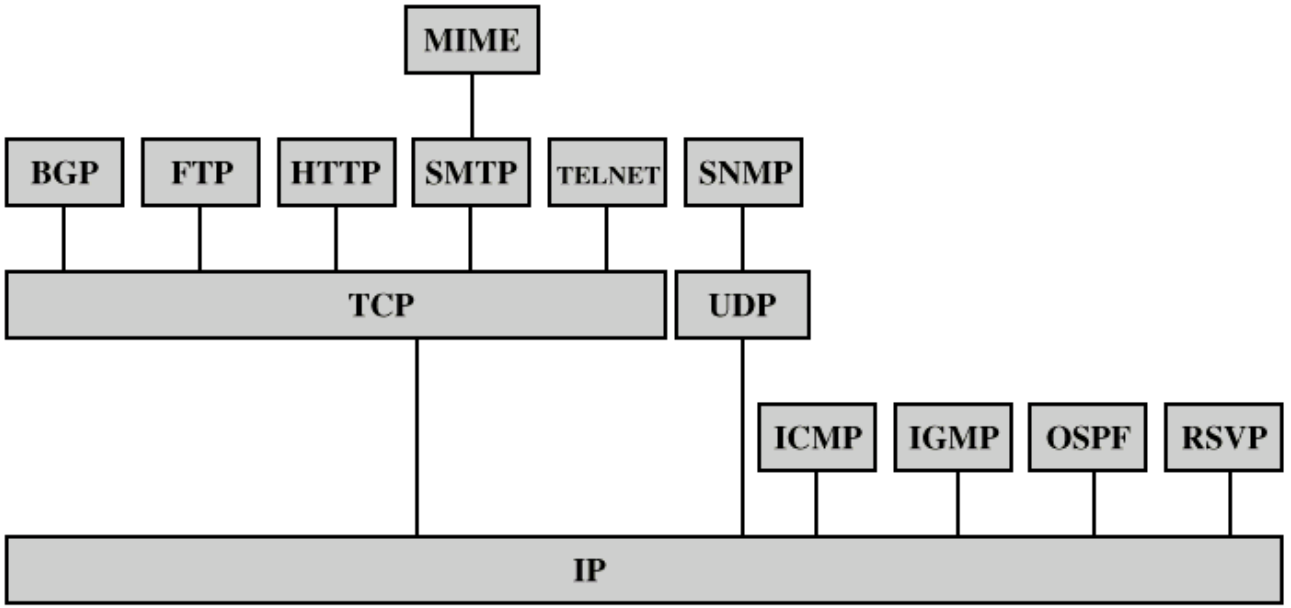
- A protocol is *“a set of conventions that govern the interaction of processes, devices, and other components within a system*.”

Ref. IEEE 610 Std.

Parts of a Communications Protocol

- **Syntax** is the data and data format rules; these form the *Protocol Data Unit (PDU).*
- **Semantics** are the transfer rules for PDUs. They contain control information-error handling rules.
- **Timing** deals with performance requirements for the transfer.

Some TCP/IP protocols



BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP = Internet Protocol
MIME = Multi-Purpose Internet Mail Extension
OSPF = Open Shortest Path First
RSVP = Resource ReSerVation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
TCP = Transmission Control Protocol
UDP = User Datagram Protocol

Port Number used by Protocols

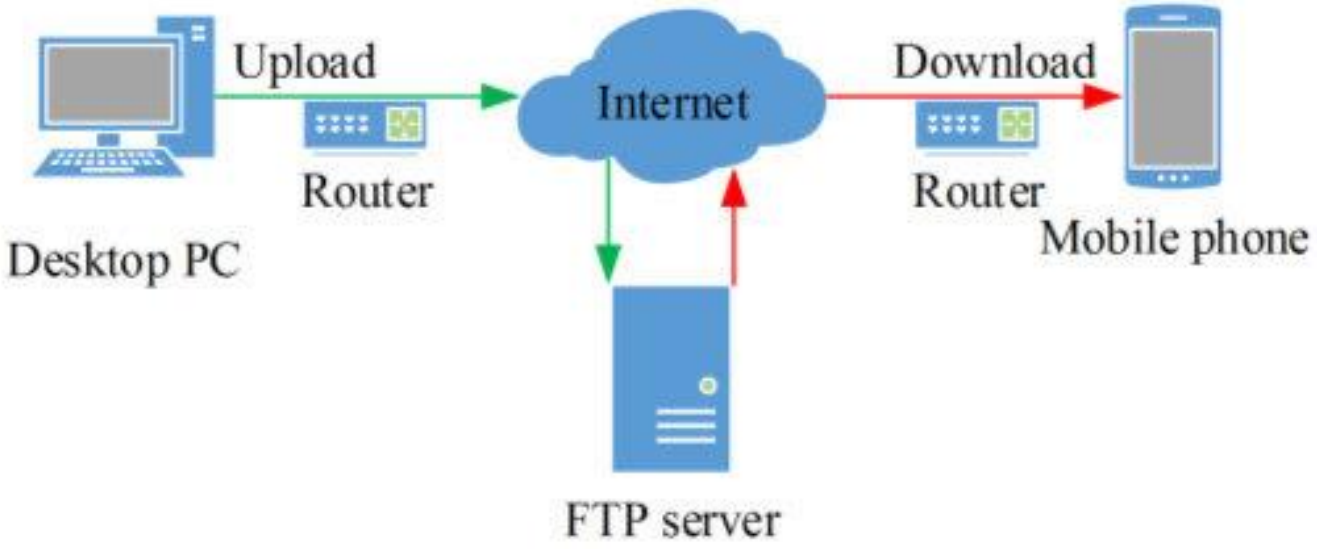
Port Number	Protocol
20, 21	File Transfer Protocol (FTP)
22	Secure Shell (SSH)
23	Telnet Protocol
25	Simple Mail Transfer Protocol (SMTP)
53	Domain Name System (DNS)
67, 68	Dynamic Host Configuration Protocol (DHCP)
80	HyperText Transfer Protocol (HTTP)
110	Post Office Protocol (POP3)
137	NetBIOS Name Service
143	Internet Message Access Protocol (IMAP4)
443	Secure HTTP (HTTPS)
445	Microsoft-DS (Active Directory)

FTP

- FTP (File Transfer Protocol) is a network protocol for transmitting files between computers over Transmission Control Protocol/Internet Protocol (TCP/IP) connections.
- Within the TCP/IP suite, FTP is considered an application layer protocol.

- In an FTP transaction, the end user's computer is typically called the local host.
- The second computer involved in FTP is a remote host, which is usually a server.
- Both computers need to be connected via a network and configured properly to transfer files via FTP.
- Servers must be set up to run FTP services, and the client must have FTP software installed to access these services.

FTP


Upload
Internet
Download
Router
Router
Desktop PC
Mobile phone
FTP server

Networking Devices

Introduction

- LANs do not normally operate in isolation but they are connected to one another or to the Internet.
- To connect LANs, connecting devices are needed

Functions of network devices

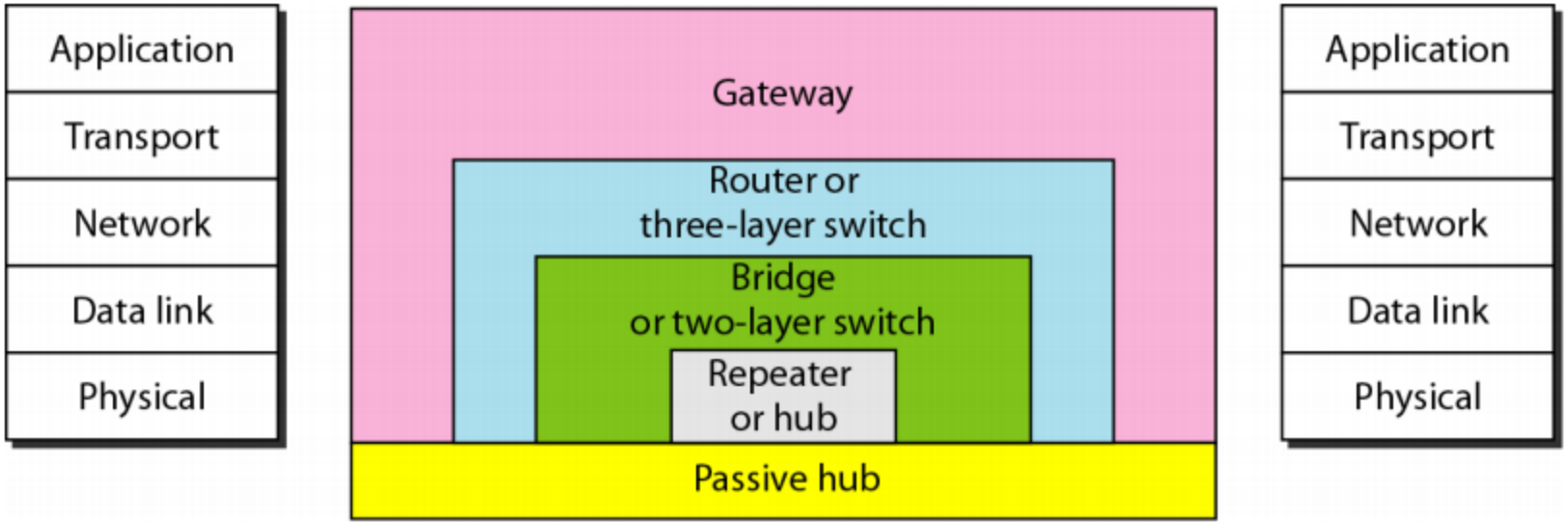
- Separating (connecting) networks or expanding network
  - e.g. repeaters, hubs, bridges, routers,switches, gateways
- Remote access
  - e.g. 56K Modems and ADSL modems

Networking Devices

- Repeaters
- Hubs
- Switches
- Bridges
- Routes
- Gateways
- Network Interface Cards (NICs)
- Wireless access points
- Modems

CONNECTING DEVICES

- Connecting devices are divided into five different categories based on the layer in which they operate in a network.



Five categories of connecting devices

HUB

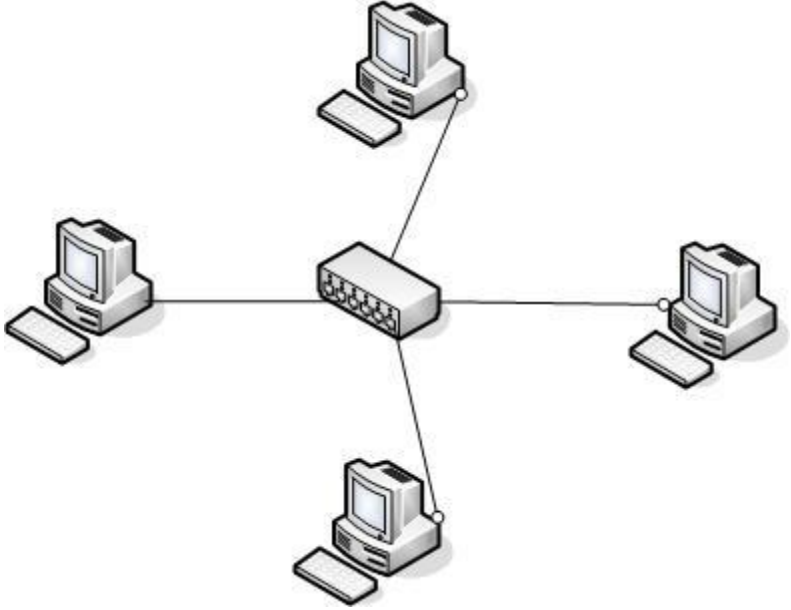
- A hub is used as a central point of connection among media segments.
- A Hub is a hardware device used to connect several computers together. A hub contains multiple ports
- Cables from network devices plug in to the ports on the hub.

Types of HUBS :

– A **passive hub** is just a connector. It connects the wires coming from different branches.

- The signal pass through a passive hub without regeneration or amplification.
- Connect several networking cables together

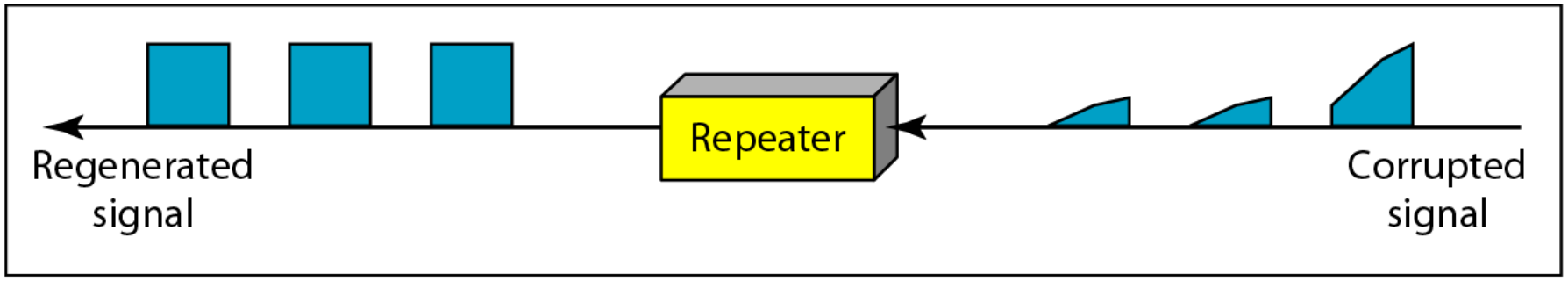
– **Active hubs or Multiport repeaters-** They regenerate or amplify the signal before they are retransmitted.



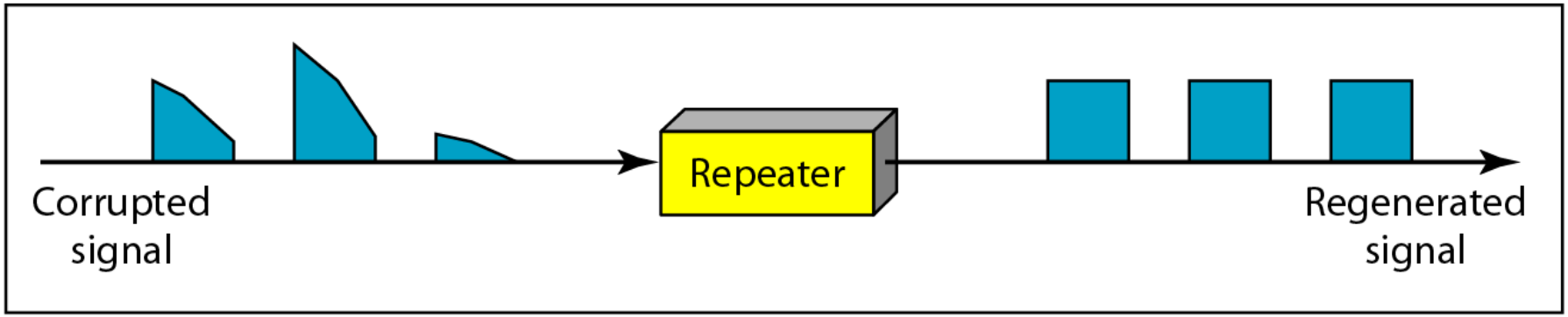
Repeater

- A **physical layer** device the acts on **bits** not on **frames** or packets
- Can have two or more interfaces
- When a bit (0,1) arrives, the repeater receives it and **regenerates** it, the transmits it onto all other interfaces
- Used in LAN to **connect cable segments** and **extend** the **maximum cable length** ➔ extending the **geographical LAN range**
  - Ethernet 10base5 – Max. segment length 500m – 4 repeaters (5 segments) are used to extend the cable to **2500m**)
  - Ethernet 10Base2- Max. segment length 185m - 4 repeaters (5 segments) are used to extend the cable to **925m**
- Repeaters do not implement any **access method**
  - If any two nodes on any two connected segments transmit at the same time **collision** will happen

Figure 15.3 *Function of a repeater*



a. Right-to-left transmission.



b. Left-to-right transmission.

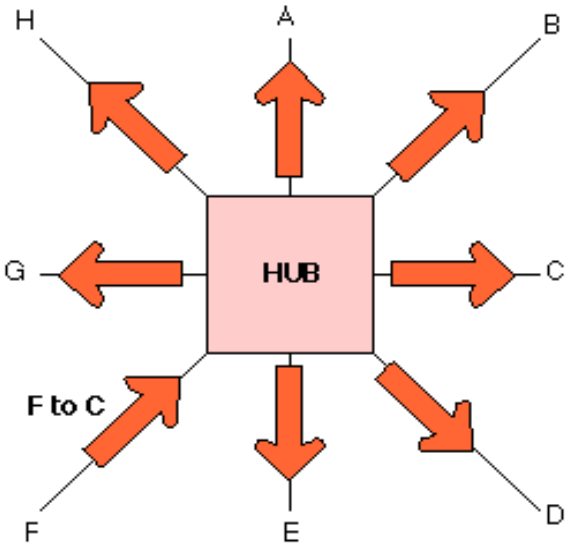
Bridge

- Acts on the **data link** layer (MAC address level)
- Used to **divide** (segment) the LAN into smaller LANs segments, or to **connect** LANs that use identical physical and data link layers
- Each LAN segment is a **separate collision domain**
- Bridge does not send the received frame to all other interfaces like hubs and repeaters, but it performs **filtering** which means:
  - Whether a frame should be **forwarded** to another interface that leads to the destination or **dropped**
- This is done by a bridge table (**forwarding table**) that contains entries for the nodes on the LAN
  - The bridge table is **initially empty** and **filled automatically** by **learning from frames movements** in the network
  - An entry in the bridge table consists of : Node LAN (**MAC) Address, Bridge Interface to which the node is connected to**, **the record creation time**

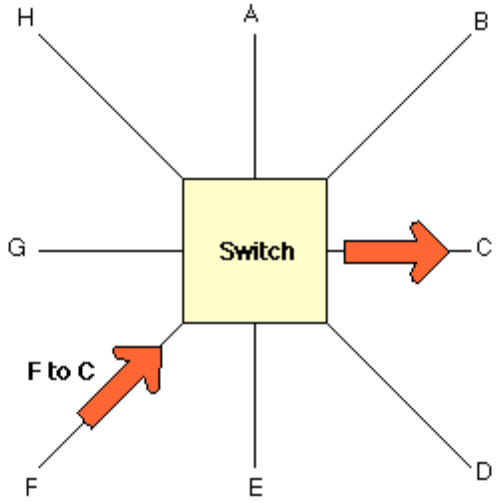
Address	Interface	Time
62-FE-F7-11-89-A3	1	9:32
7C-BA-B2-B4-91-10	3	9:36
...	...	...

- A bridge runs **CSMA/CD before sending a frame** onto the link not like the hub or repeater
- Bridge frame handling is done in **software**

Bridges (Switches) Vs. Hubs



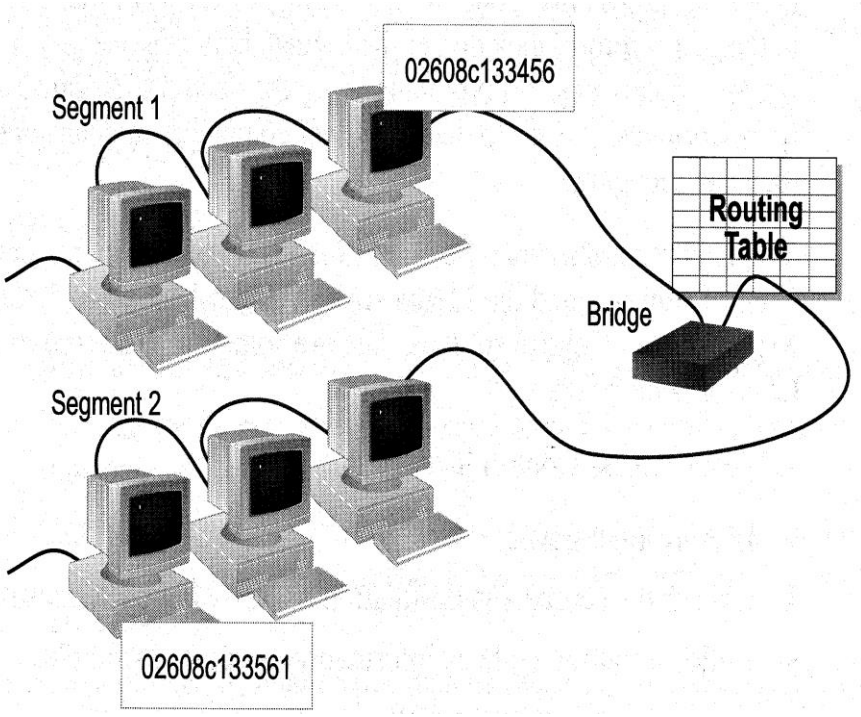
A Hub sending a packet form F to C.



A Switch sending a packet from F to C

How Bridges Work

- Bridges work at the Media Access Control Sub-layer of the OSI model
  - Routing table is built to record the segment no. of address
  - If destination address is in the same segment as the source address, stop transmit
  - Otherwise, forward to the other segment



Differences Between Bridges and Repeaters

	Repeater	Bridge
OSI Layer	Physical Layer	Data Link Layer
Data Regeneration	Regenerate data at signal level	Regenerate data at Packet level
Reduce Network Traffic	No	Yes

Switches

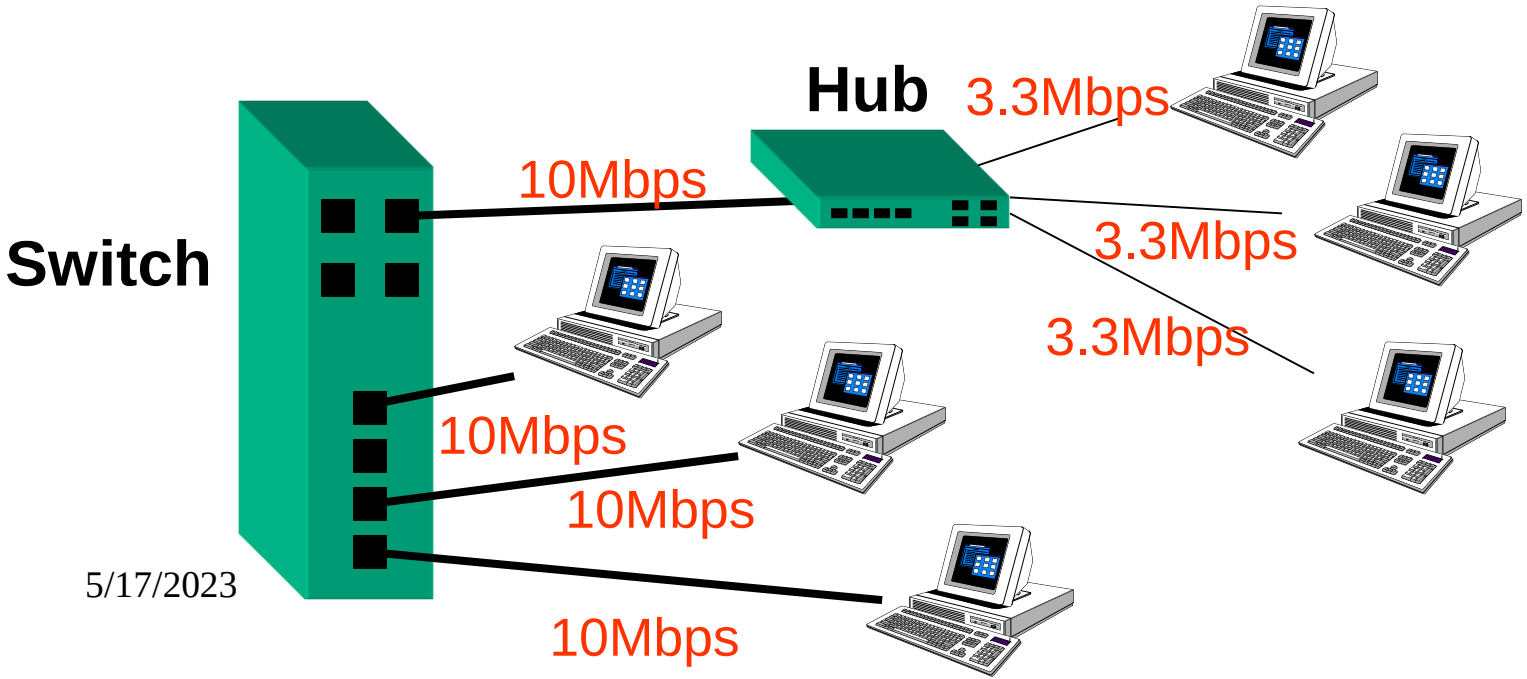
- Switches operate at the Data Link layer (layer 2) of the OSI model
- Can interpret address information
- Switches resemble bridges and can be considered as multiport bridges

- By having multiports, can better use limited bandwidth and prove more cost-effective than bridge

- Switches divide a network into several isolated channels
- Packets sending from 1 channel will not go to another if not specify
- Each channel has its own capacity and need not be shared with other channels

Forward only to the port that connects to the destination device

- knows MAC address
- Match the MAC address in the data it receives



Advantages of Switches

- Switches divide a network into several isolated channels (or collision domains)
  - Reduce the possibility of collision
    - Collision only occurs when two devices try to get access to one channel
    - Can be solved by buffering one of them for later access
  - Each channel has its own network capacity
    - Suitable for real-time applications, e.g. video conferencing
  - Since isolated, hence secure
    - Data will only go to the destination, but not others

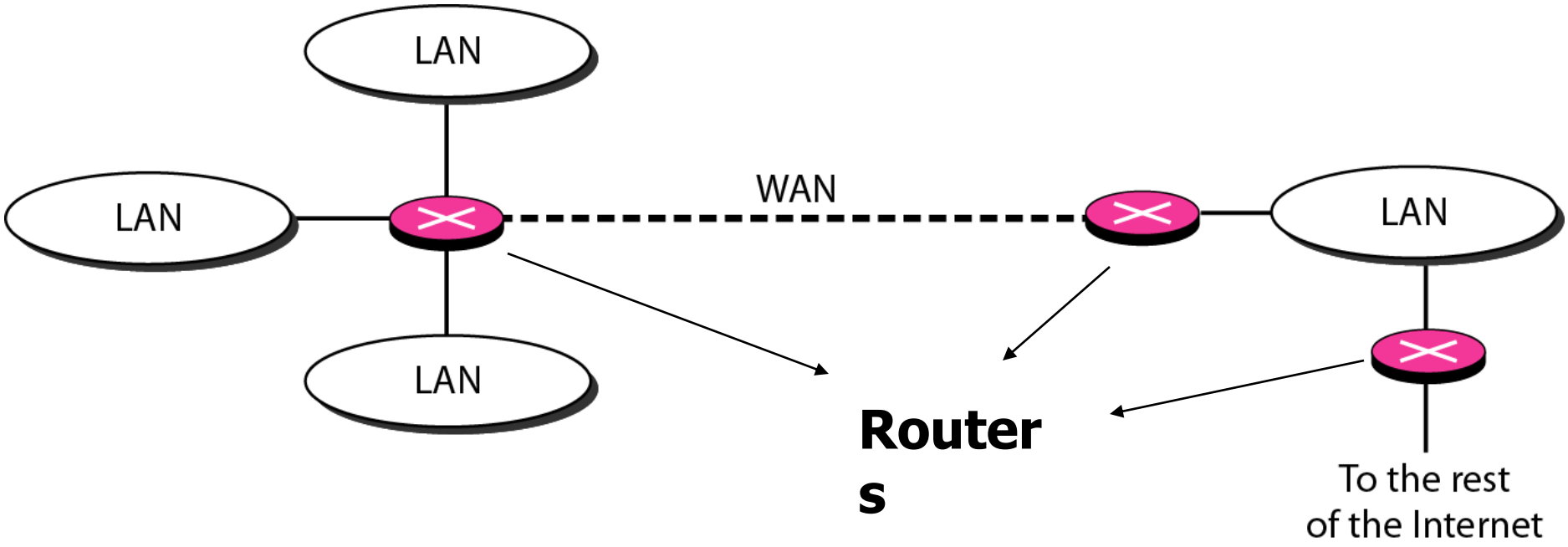
Routers

- Operates at network layer = deals with **packets** not **frames**
- Connect LANs and WANs with similar or different protocols together
- Switches and bridges **isolate collision domains** but forward broadcast messages to **all LANs** connected to them. Routers **isolate both** *collision* domains and *broadcast* domains
- Acts like normal stations on a network, but have **more than one** network address (an address to each connected network)
- Deals with global address (network layer address (IP)) not local address (MAC address)
- Routers **Communicate with each other** and exchange routing information
- Determine best route using **routing algorithm** by special software installed on them
- **Forward traffic if information on destination** is available otherwise **discard** it (not like a switch or bridge)

Advantages and Disadvantages of Routers

- **Advantages**
  - Routers provide sophisticated routing, flow control, and traffic isolation
  - Routers are configurable, which allows network manager to make policy based on routing decisions
  - Routers allow active loops so that redundant paths are availabl
- **Disadvantages**
  - Routers are protocol-dependent devices that must understand the protocol they are forwarding.
  - Routers can require a considerable amount of initial configuration.
  - Routers are relatively complex devices, and generally are more expensive than bridges

Figure 15.11 *Routers connecting independent LANs and WANs*



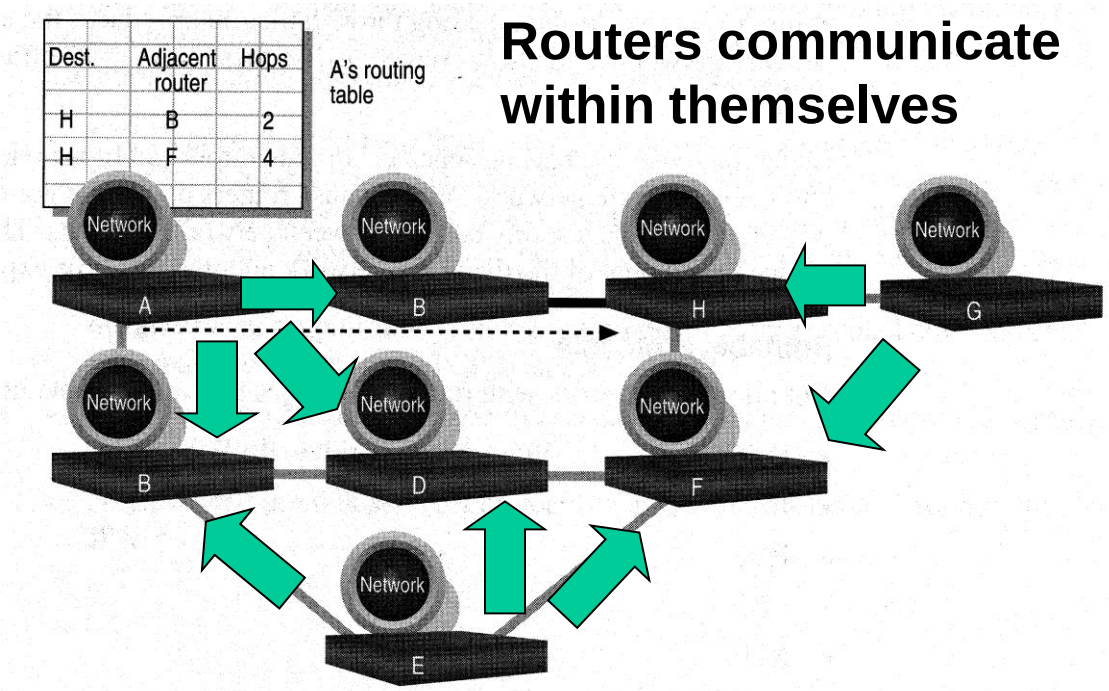
How Routers Work

- As packets are passed from routers to routers, Data Link layer source and destination addresses are stripped off and then recreated
- Enables a router to route a packet from a TCP/IP Ethernet network to a TCP/IP token ring network
- Only packets with known network addresses will be passed - hence reduce traffic
- Routers can listen to a network and identify its busiest part
- Will select the most cost effective path for transmitting packets

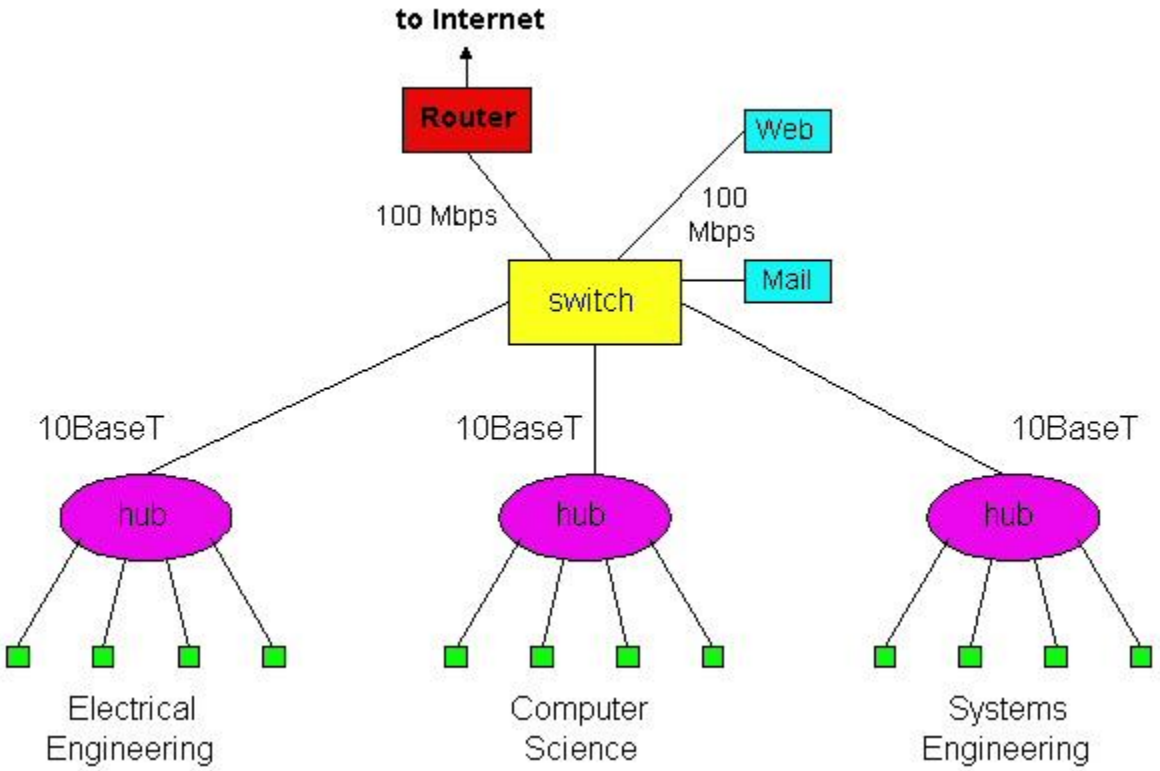
How Routing Table is formed

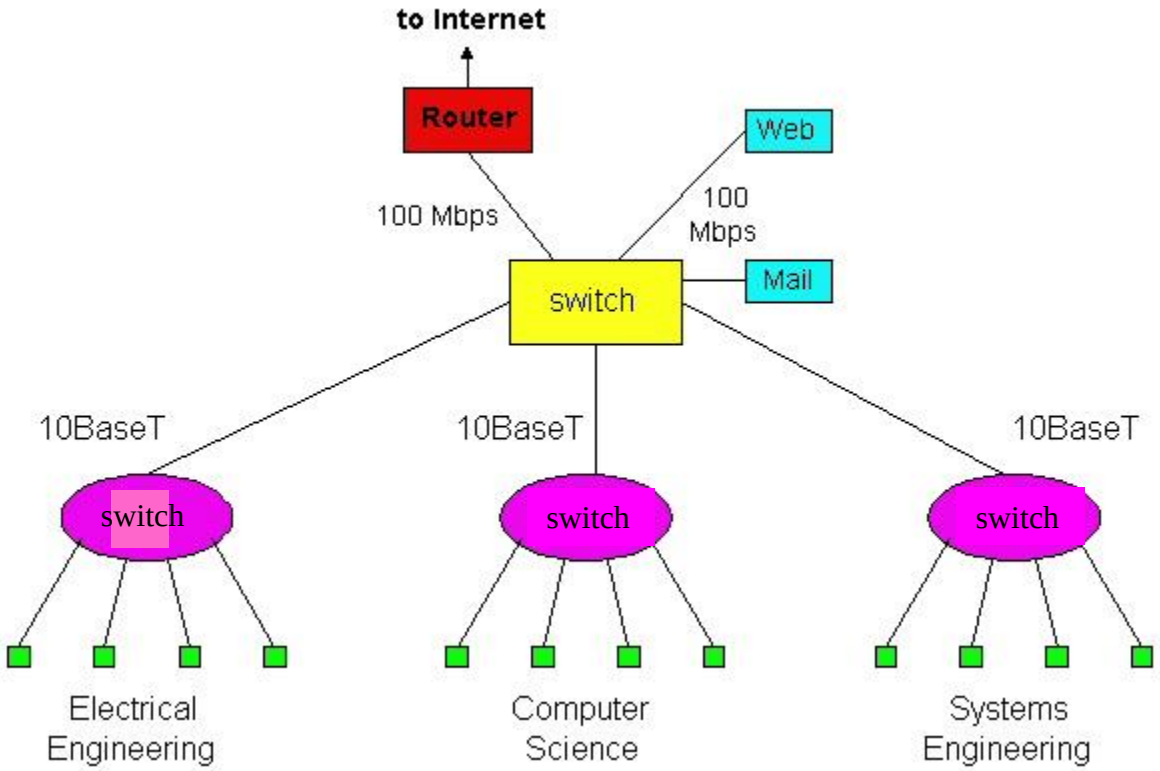
- Routing table is formed based on communications between routers using "Routing Protocols"
  - Routing Protocols ≠ Routable Protocol

- Routing Protocols collect data about current network status and contribute to selection of the best path



An Institutional Network Using Hubs, Ethernet Switches, and a Router




to Internet
Router
Web
100 Mbps
100 Mbps
switch
Mail
10BaseT
10BaseT
10BaseT
switch
switch
switch
Electrical Engineering
Computer Science
Systems Engineering

Static and Dynamic Routers

Static Routers	*Dynamic Routers*
Manual configuration of routes	Manual configuration of the first route. Automatic discovery of new routes
Always use the same route	Can select the best route
More secure	Need manual configuration to improve security

Summary comparison

	hubs	bridges	routers	switches
traffic isolation	no	yes	yes	yes
plug & play	yes	yes	no	yes
optimal routing	no	no	yes	no
cut through	yes	no	no	yes

Ethernet LAN Adapter

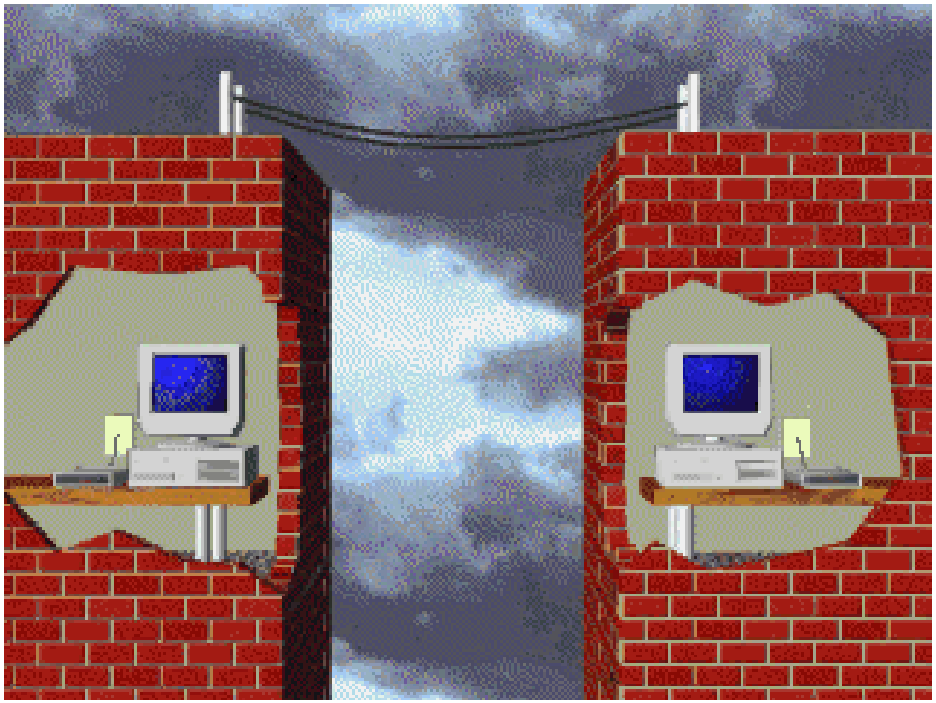
- Ethernet is the name of the most commonly used LAN today. A LAN (Local Area Network) is a network of computers that covers a small area like a room, an office, a building or a campus. It is used in contrast with WAN (wide area network) which spans for much larger geographical areas. Ethernet is a network protocol that controls how data is tra LAN. Technically it the IEI .

GATEWAY

- Device that connects dissimilar networks.
- Operates at the highest level of abstraction.
- Expands the functionality of routers by performing data translation and protocol conversion.
- Needed to convert Ethernet traffic from LAN to San(Systems Network Architecture)traffic legacy system.
- Then routes the SNA traffic to the mainframe.
- When Mainframe answers, Reverse process occurs.
- Establishes an intelligent connection between a local network and external networks with completely different structures.

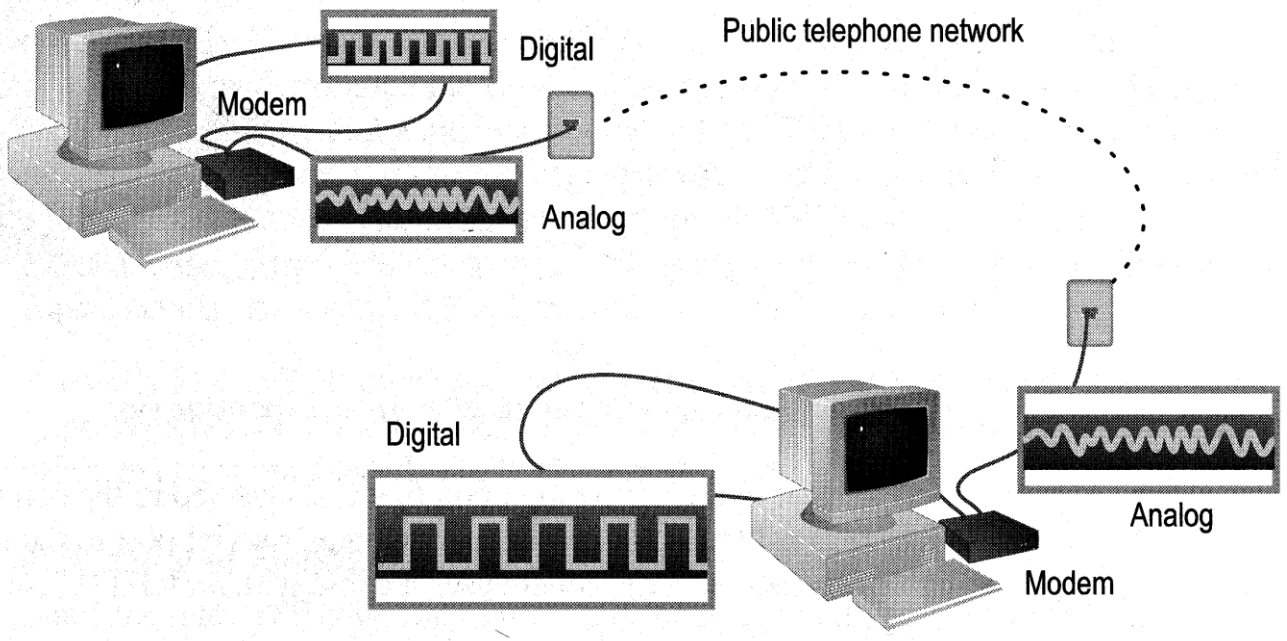
Remote Access Devices

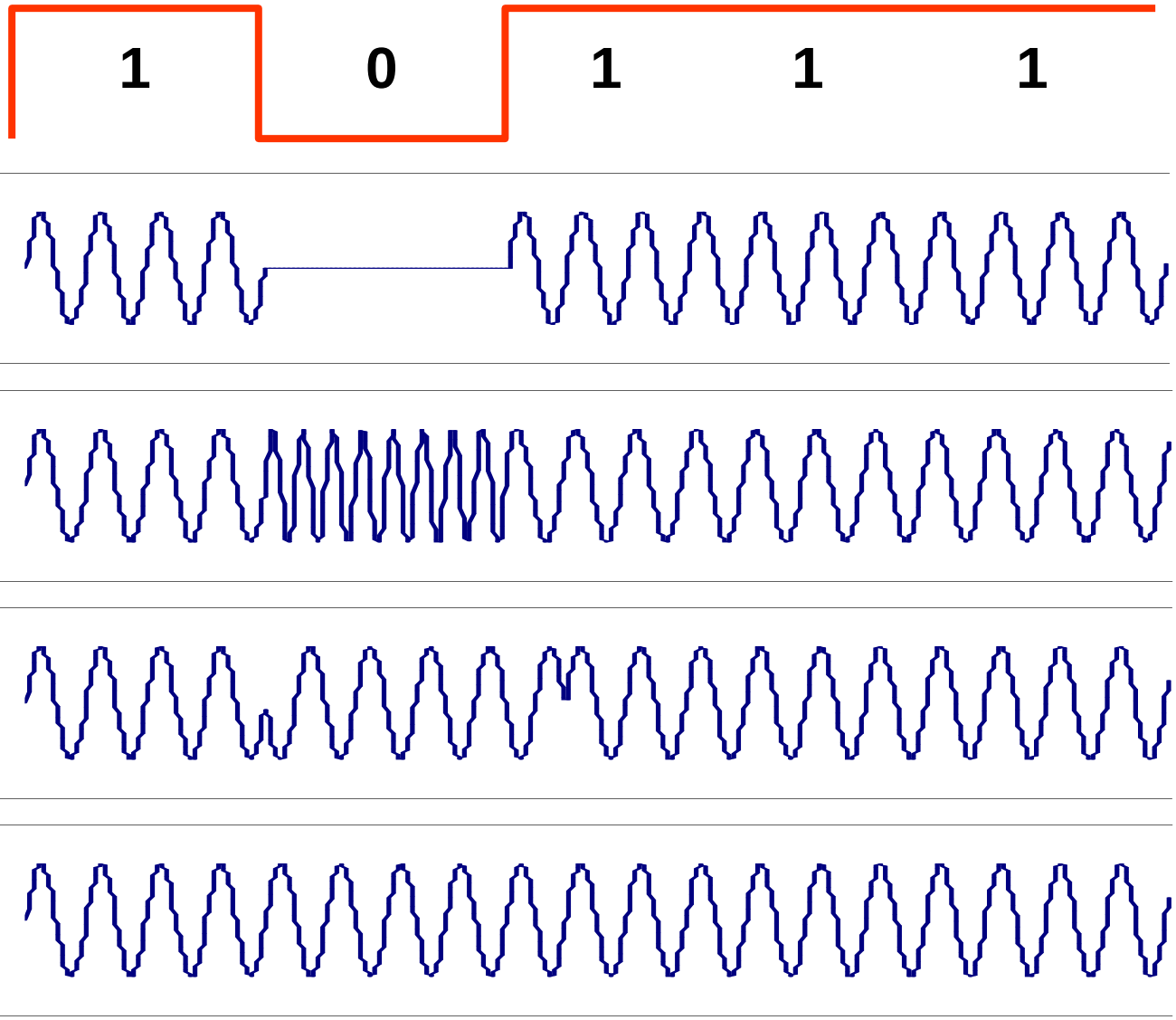
Modems



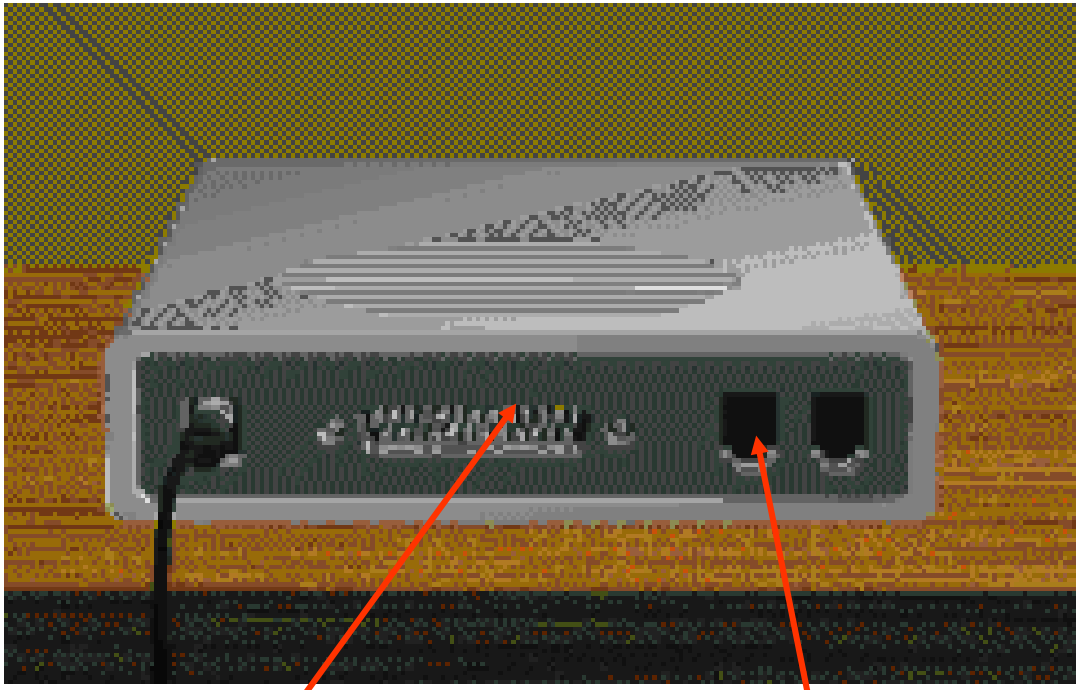
- Allow computers to communicate over a telephone line
- Enable communication between networks or connecting to the world beyond the LAN

- Cannot send digital signal directly to telephone line
- Sending end: MODulate the computer's digital signal into analog signal and transmits
- Receiving end: DEModulate the analog signal back into digital form




1
0
1
1
1
Amplitude Modulation
Frequency Modulation
Phase Modulation
Normal sine wave

- **Modems typically have the following I/O interface:**
  - **A serial RS-232 communication interface**
  - **An RJ-11 telephone-line interface (a telephone plug)**



Modem Standards

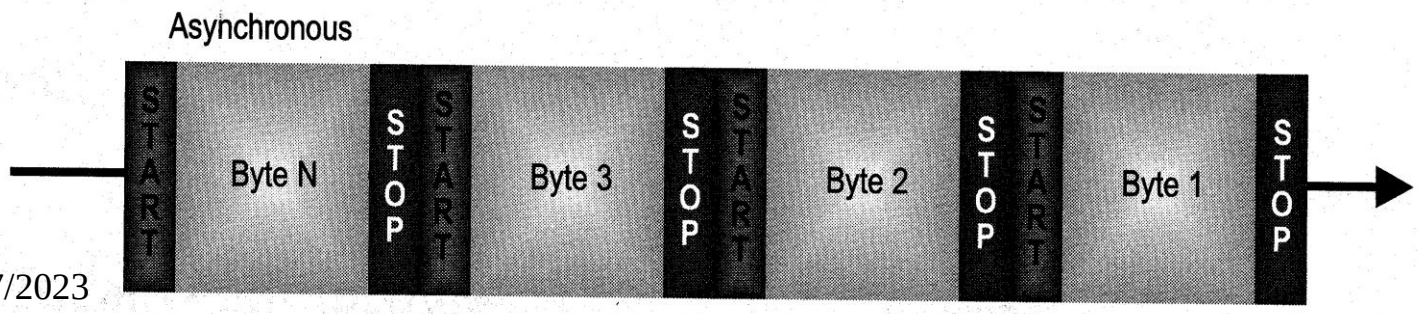
Standard	bps	Introduced	Remarks
V.22bis	2,400	1984	
V.32	9,600	1984	
V.32bis	14,400	1991	
V.32terbo	19,200	1993	Communicate only with another V.32terbo
V.FastClass	28,800	1993	(V.FC)
V.34	28,800	1994	Improved V.FC
V.42bis	115,200	1995	With compression
V.90	56,000	1998	Resolved competition between X2 and Flex56k

Modem Performance Measures

- Baud rate - the number of symbol change per second on the transmission line
- Bit per second (bps) - number of bits transmitted per second
- In the past, they are identical
- With compression technique, a change of signal can mean more than one bits
- 28.8kbaud can mean 115.2kbps when using V.42bis

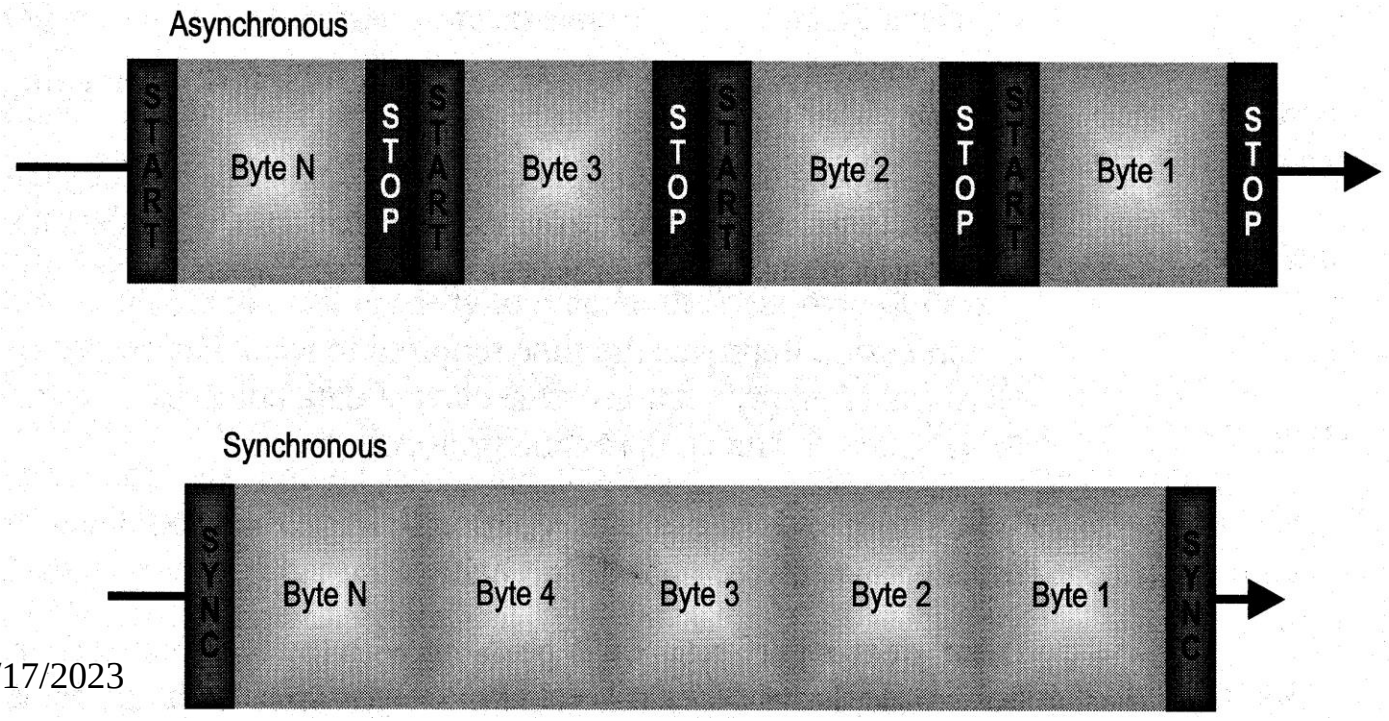
Types of Modem - Asynchronous Modems

- No clocking devices
- Commonly used in telephone networks
- Data is transmitted in a serial stream. Each character is turned into a string of 8 bits
- Each of these characters is separated by one start bit and one or two stop bits



Types of Modem - Synchronous Modems

- Need clocking devices
- Data are transmitted in blocks
- Used in digital networks

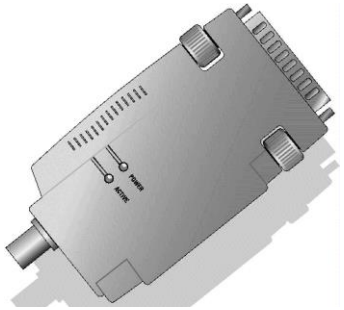


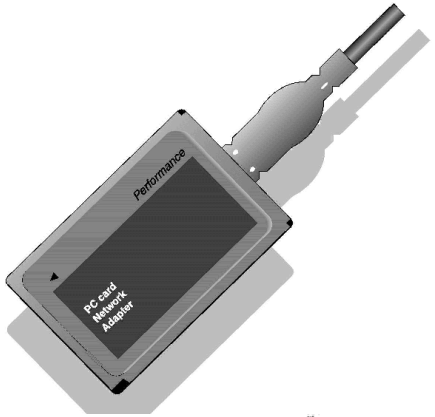
Comparison

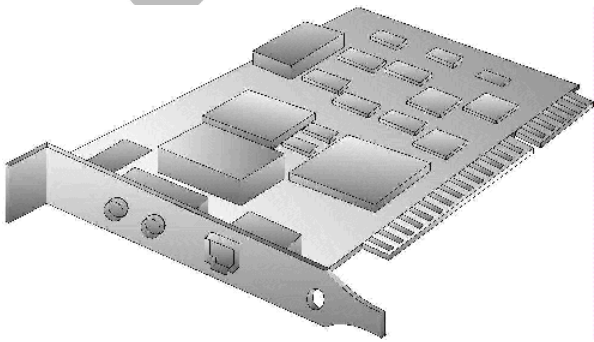
- Asynchronous modems are relatively simple and economic
  - Large overhead - can be up to 20 to 27% of the data traffic
  - Error control is done by using parity bit or higher layer protocols, e.g. MNP, V.42
- Synchronous modems are relatively complicated and expensive
  - Seldom use in home market
  - Less overhead means higher efficiency
  - More sophisticated error control protocol is required

Network cards

- Called Network Interface Cards (NIC)
  - Attached to external port
  - PC card
  - Internal Network card
    - System bus compatibility
      - Peripheral Component Interconnect (PCI)
      - Industry Standard Architecture (ISA)
- System Resources – device conflict
- Media compatibility
  - Twisted pair, coaxial or fiber-optic connection?
- Driver







ISDN adapters

- Integrated Services Digital Networking (ISDN) is a remote access and WAN technology that can be used in place of a Plain old telephone systems dial-up link
- Greater speeds than modem, pick up and drop the line considerable faster.
- Require ISDN terminal adapter
  - Although digital signal, different format with the those used on LAN.
  - Create multiple communication channels on a single line.

Device	Function/Purpose	Key Points
Hub	Connects devices on a twisted-pair network.	A hub does not perform any tasks besides signal regeneration.
Switch	Connects devices on a twisted-pair network.	A switch forwards data to its destination by using the MAC address embedded in each packet.
Bridge	Divides networks to reduce overall network traffic.	A bridge allows or prevents data from passing through it by reading the MAC address.
Router	Connects networks together.	A router uses the software-configured network address to make forwarding decisions.
Gateway	Translates from one data format to another.	Gateways can be hardware or software based. Any device that translates data formats is called a gateway.
CSU/DSU	Translates digital signals used on a LAN to those used on a WAN.	CSU/DSU functionality is sometimes incorporated into other devices, such as a router with a WAN connection.
Network card	Enables systems to connect to the network.	Network interfaces can be add-in expansion cards, PCMCIA cards, or built-in interfaces.
ISDN terminal adapter	Connects devices to ISDN lines.	ISDN is a digital WAN technology often used in place of slower modem links. ISDN terminal adapters are required to reformat the data format for transmission on ISDN links.
System area network card	Used in server clusters to provide connectivity between nodes.	System area network cards are high-performance devices capable of coping with the demands of clustering applications.
WAP	Provides network capabilities to wireless network devices.	A WAP is often used to connect to a wired network, thereby acting as a link between wired and wireless portions of the network.
Modem	Provides serial communication capabilities across phone lines.	Modems modulate the digital signal into analog at the sending end and perform the reverse function at the receiving end.

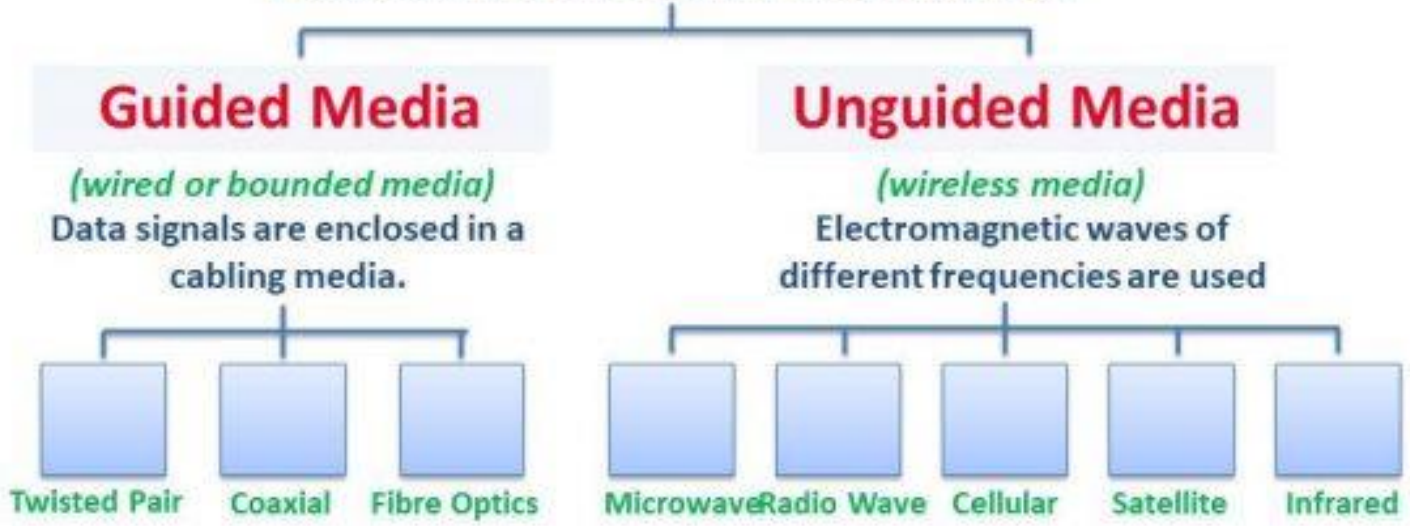
COMMUNICATION CHANNELS

- **computer network** → a group of computers linked to each other that enables the computers to communicate with each other and share their resources, data, and applications.
- These computers are linked to each other with different types of communication channels.
- These **communication channels** are A.K.A communication media or transmission media and it is a path that connects the sender and receiver for transmission of information over a network.
- At a broad level the communication channels are divided into two types:
  - Guided Media
  - Unguided media.

Communication Channels

(Communication Media or Transmission Media)

Communication channel is a path that connects the sender and receiver for transmission of information over a network.

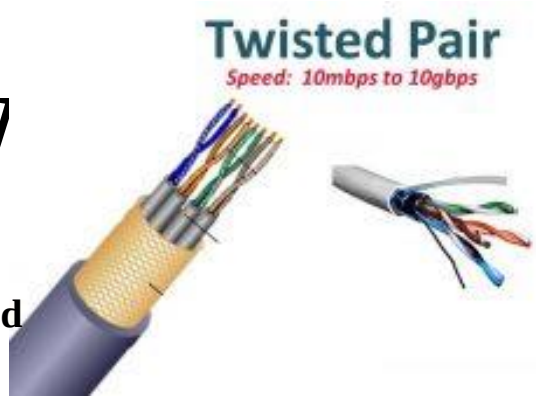


Guided media

- AKA wired or bounded media because the data signals are enclosed in a cabling media.
- the communication devices are directly connected with each other via wires or physical media for data transmission.

- E.g. twisted pair cables, coaxial cables and fiber optics.

Twisted Pair W



Characteristics:

1.The data transmission speed is between **10mbps to 10gbps**

2.It is most popular and is used as communication media in **LAN and Local telephone lines**

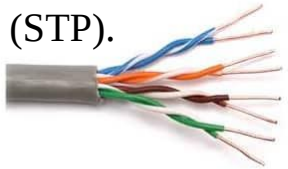
1.It can carry **voice** and **data** signals

2.Signals are transmitted using pairs copper wires which are insulated by plastic that have been physically twisted together.

3.The wires are twisted together in order to reduce noise. *The electrical disturbance that can degrade the communications is called noise.*

4.It is of two types, Unshielded Twisted Pair(UTP) and Shielded Twisted Pair (STP).

5.Twisted pair is comparatively inexpensive and easy to install and maintain.



UTP Cable

Its disadvantages are:

1.It is unsuitable for long distance.

2.Its speed is less than coaxial cable or fiber optics.

STP Cable

Coaxial Cabl

Characteristics:

1.The data transmission speed is around **10 to 100mbps**

2.It is used for video transmissions for televisions or for long-distance telephone lines and LANs for voice and data transmission with very high frequency

1.It is made up of a single solid copper wire core that is covered by insulating material.

2.A copper mesh is used to cover the insulated copper wire. It also protects the cable from noise such as electromagnetic waves.

3.It can carry both analog and digital signals.

4.It carries high-frequency range signals with bandwidth 80 times higher than the twisted-pair wire.

5.It is of two types, thicknet and thinnet.

Its disadvantages are:

1.It is more expensive than twisted pair

2.Not compatible with twisted pair cables.

Fiber Optics

Characteristics:

1. The data transmission speed is more than 100gbps
2. Used for Internet or long distance communication.
3. Here Digital signals are sent as light pulses which are translated back into electrical signals
4. It has a Fine glass strand surrounded by glass cladding and protective layer
5. Glass cladding reflects light back into the core, guiding the light along the wire.
6. Thousands of transmissions can be carried on a single strand.
7. It is secure and has very low signal loss.

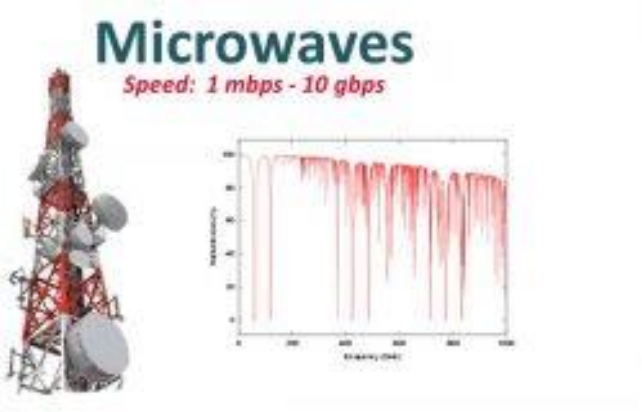
Disadvantages

1. It is very expensive and also difficult to install and modify.
2. It is difficult to repair and one fault can bring down the entire network.

Unguided media

- AKA wireless media.
- It can also be used at each and every place where it is impossible to install cables.
- Here electromagnetic waves of different frequencies are used.
- Some examples of unguided media are:
  - Microwave System,
  - Communication Satellite,
  - Broadcast Radio,
  - Cellular Radio and
  - Infrared.

Microwave



Characteristics:

1. The data transmission speed is between 1mbps to 10gbps
2. It is used for high speed transmission
3. Information is sent via microwaves from ground based transmitting and receiving stations
1. Text, sound, and graphics are converted into microwave pulses and transmitted
2. Microwave stations (a.k.a. repeater stations) must be placed every 50 kilometers to receive, amplify, and then pass the signal along
3. Rader Waves

Its disadvantages are:

1. It cannot pass through obstacles and can only use line of sight transmission. That's why the stations are installed on tall towers and buildings.
2. It also supports limited bandwidth.

Broadcast radio

Characteristics:

1.The data transmission speed is between 1 MBPS to 10 MBPS

2.It is used for cordless phones, AM & FM radio transmission for both voice and data.

3. It can travel over long distances and penetrates buildings easily.

4. Radio transmission requires a transmitter to send broadcast radio signals and a receiver to receive it. The receiver uses an antenna to receive the signals.

5.An example of the short-range broadcast radio communications is Bluetooth, which is used in computers, mobiles, printers etc.

6.It uses short-range radio waves to transmit data at a rate of 1 MBPS among Bluetooth enabled devices

Its disadvantages are:

1.It is unidirectional and insecure means of communication.

2.And has multipath interference such as reflections from water and land bodies.

Cellular Radio

Characteristics:

1.With 4G, the data transmission speed is between 10mbps to 1gbps
2.It is specifically used in wireless modems and cellular telephones.
3.The cellular telephone is also a telephone device that uses high-frequency radio waves to transmit voice and digital data.
4.However, some mobile users connect notebooks or mobile computers to the cellular telephone to access the Web or send and receive the email, etc.
Personal Communications Services (PCS) is a set of technologies used for digital cellular devices like Handheld computers, cellular telephones, etc.

Its disadvantages are:

1.It requires complex infrastructure and a well planned frequency spectrum distribution

Satellite Communication

Characteristics:

1. Is used for global mobile communication, Satellites are placed in space and they orbit the earth.
2. It receives microwave signals from the earth station.
3. Communication satellites magnify the signals and retransmit them back to earth.
4. The data transfer speed of the communication satellite is very high and it avoids the cost of cabling and repeater stations.
5. The transmission from the earth station to a satellite is called uplink. The transmission from the satellite to the earth station is called the downlink.

Its disadvantages are:

1. It is expensive and not easy to repair and maintain
2. Weather and sunspots can also cause signal disturbance.

Infrared (IR) wireless transmission media

Characteristics:

1.It gets speed up to 1GBPS

2.It is used in remote controls for televisions, optical mouse and most other entertainment devices.

3.It sends signals using infrared light wave that is invisible to us and is just above the red end of the color spectrum.

4.Works over a moderate bandwidth 115 kbps and works up to 10 meters.

5.IrDA port is normally fixed in mouse, printer, and digital camera in order to enable them to transfer data from one device to another using infrared light waves.

6.It is also an alternative to short-range raid communication like Bluetooth.

Its disadvantages are:

1.It has short range and low bandwidth and

2.It requires a light of sight transmission.

Homework

1. Show Comparison chart between various guided media.
2. Show comparison chart between various unguided media.