Unit 1

Introduction to Computer Networks

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Introduction

- Each of the past three centuries was dominated by a single new technology.
- The 18th century was the era of the great mechanical systems accompanying the Industrial Revolution.
- The 19th century was the age of the steam engine.
- During the 20th century, the key technology was information gathering, processing, and distribution.
- Among other developments, we saw the installation of worldwide telephone networks, the invention of radio and television, the birth and unprecedented growth of the computer industry, the launching of communication satellites, and, of course, the Internet.
- As a result of rapid technological progress, these areas are rapidly converging in the 21st century and the differences between collecting, transporting, storing, and processing information are quickly disappearing.

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- The old model of a single computer serving all of the organization's computational needs has been replaced by one in which a large number of separate but interconnected computers do the job. These systems are called **computer networks**.
- **Computer network** means a collection of autonomous computers interconnected by a single technology.
- Two computers are said to be interconnected if they are able to exchange information.
- The computers on a network may be linked through cables, telephone links, radio waves, satellites, or infrared light beams.
- Devices in a Network are connected using wired or wireless transmission media such as cable or air.

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Basic Set of Rules for Computer Network

- Information must be delivered reliably
- Information must be delivered consistently [unchanging]
- Multiple computers must be able to identify each other

Benefits of computer network:

- Network can increase efficiency
- It can help Standardize Policies, Procedures and Processes
- It Ensures Information consistency and Integrity
- It Ensures information security

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Uses of network

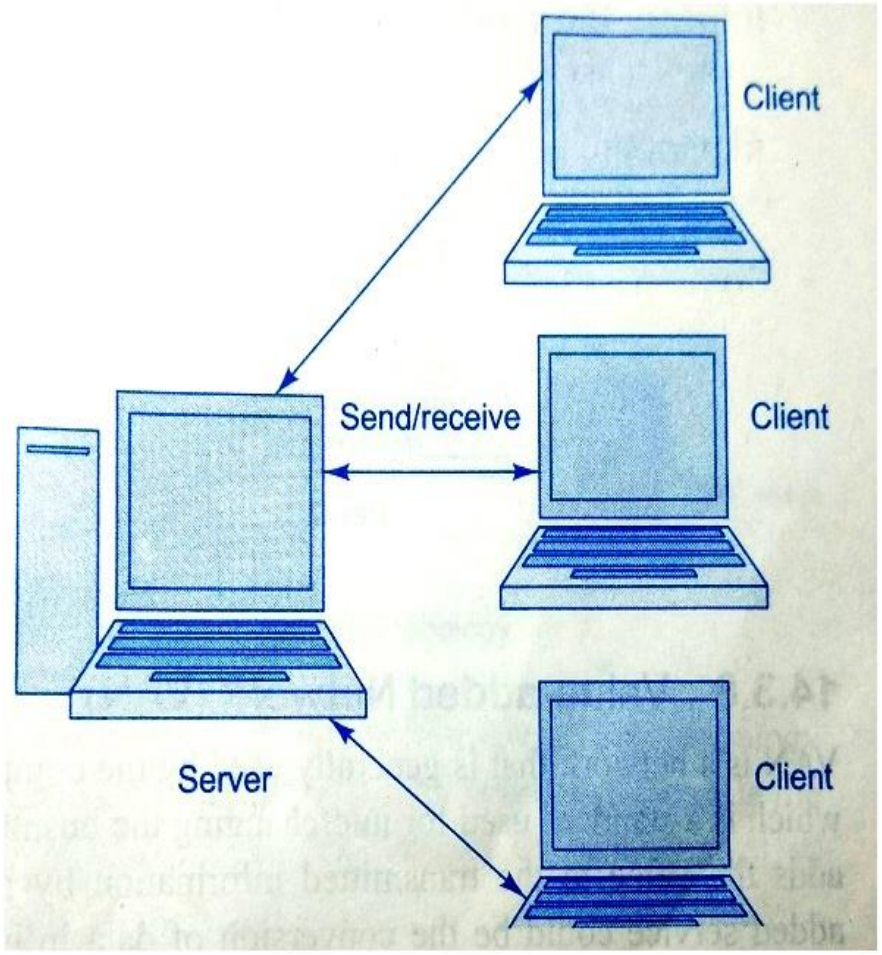
- Simultaneous access to data

  Ex: data files, Software, hardware resources

- File Server contain documents which are used by other computers
- Personal communications

  Ex: email, conferencing, voice over IP

- Easy data backup



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Applications of Networks

- **Resource Sharing**
  - ✓ Hardware (computing resources, disks, printers)
  - ✓ Software (application software)
- **Information Sharing**
  - ✓ Easy accessibility from anywhere (files, databases)
  - ✓ Search Capability (WWW)
- **Communication**
  - ✓ Email
  - ✓ Message broadcast
- **Remote computing**
- **Distributed processing (GRID Computing)**

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Network Hardware

Network Hardware can classify either by ***transmission technology*** or by ***scale***

- There are two types of transmission technology that are in widespread use: **broadcast** links and **point-to-point** links.
- Point-to-point transmission with exactly one sender and exactly one receiver is sometimes called **unicasting**.
- *In contrast, on a broadcast network, the communication channel is shared by all the machines on the network; packets sent by any machine are received by all the others. An address field within each packet specifies the intended recipient. Upon receiving a packet, a machine checks the address field. If the packet is intended for the receiving machine, that machine processes the packet; if the packet is intended for some other machine, it is just ignored.*
- Broadcast systems usually allow the possibility of addressing a packet to *all* destinations by using a special code in the address field. This mode of operation is called **broadcasting**.
- Some broadcast systems also support transmission to a subset of the machines, which known as **multicasting**.

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- An alternative criterion for classifying networks is by ***scale***.
- Distance is important as a classification metric because different technologies are used at different scales.

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

Classification of interconnected processors by scale.

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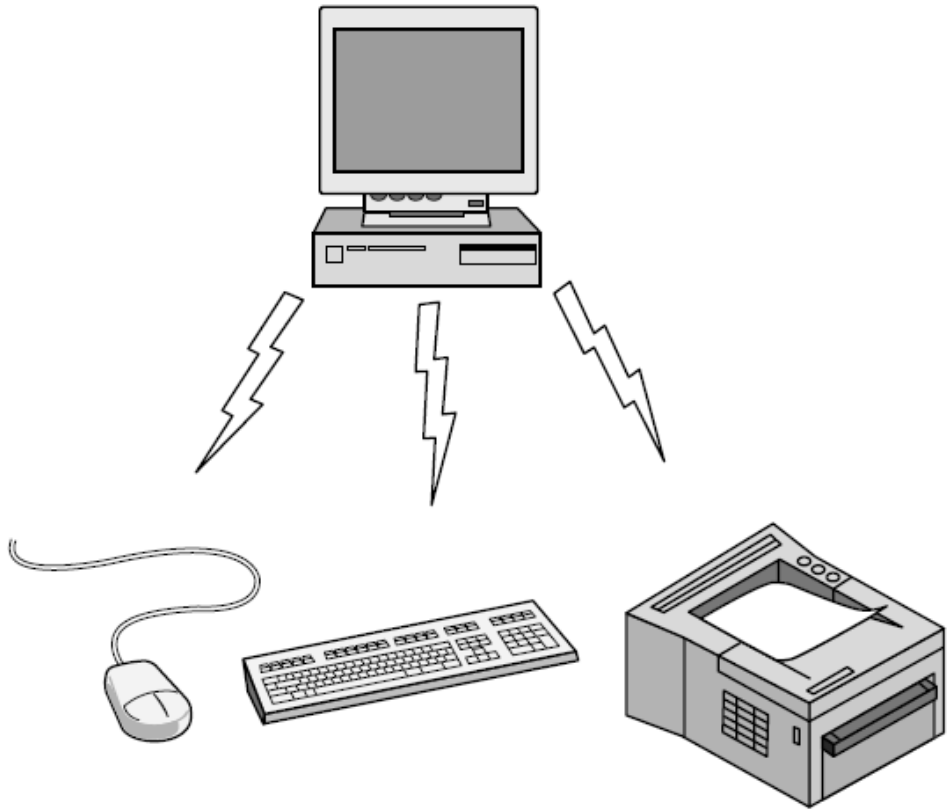
Personal Area Networks

- **PANs** (**Personal Area Networks**) let devices communicate over the range of a person. A common example is a wireless network that connects a computer with its peripherals.
- Almost every computer has an attached monitor, keyboard, mouse, and printer. Without using wireless, this connection must be done with cables.
- Also short-range wireless network called **Bluetooth**

  to connect these components without wires.
  - Bluetooth networks use the master-slave paradigm

Bluetooth PAN configuration

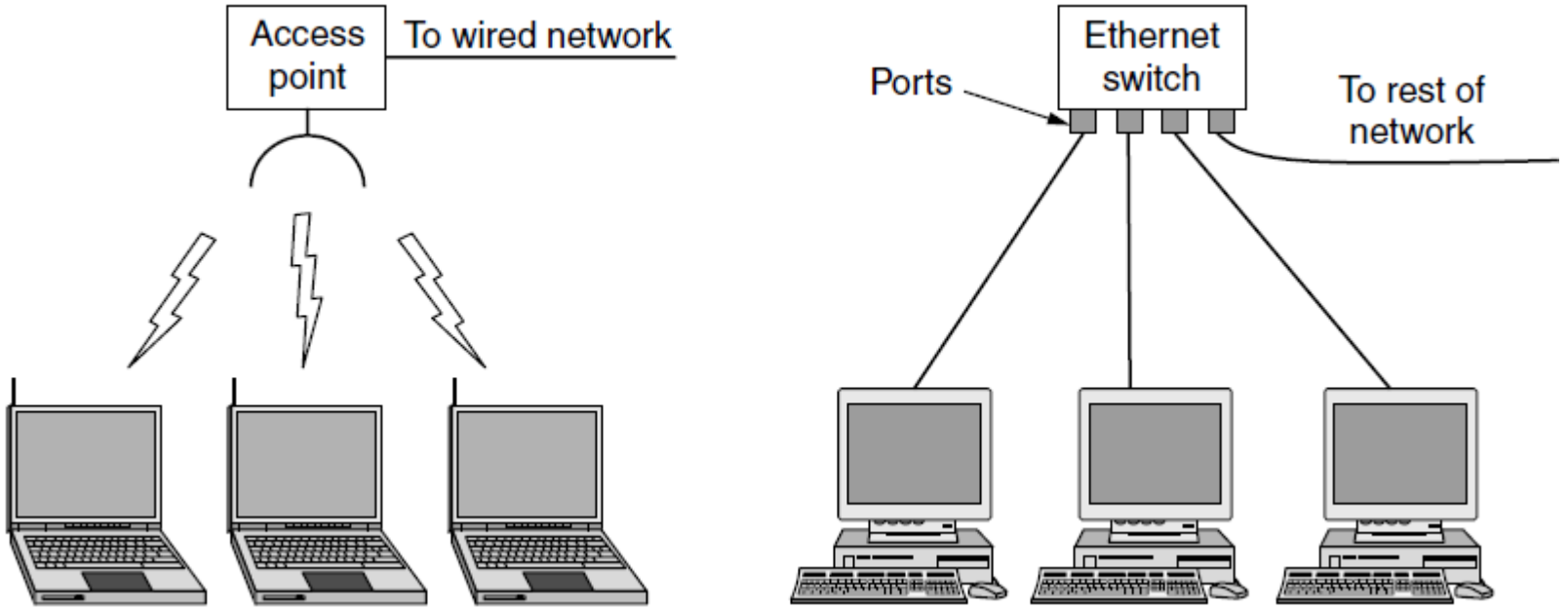


Local Area Networks

- A LAN is a privately owned network that operates within and nearby a single building like a home, office or factory.
- When LANs are used by companies, they are called **enterprise networks**.
- Wireless LANs are very popular these days where it is too much trouble to install cables.
- In these systems, every computer has a ***radio modem*** and an ***antenna*** that it uses to communicate with other computers.
- This device, called an **AP** (**Access Point**), **wireless router**, or **base station**, relays packets between the wireless computers and also between them and the Internet.
- There is a standard for wireless LANs called **IEEE 802.11**, popularly known as **WiFi.**
- It runs at speeds anywhere from 11 to hundreds of Mbps.
- Wired LANs use a range of different transmission technologies like copper wires, optical fiber etc., and LANs are restricted in size
- The topology of many wired LANs is built from point-to-point links. IEEE 802.3, popularly called **Ethernet**

Features

- Local Area Network is a group of computers connected to each other in a small area such as building, office.
- LAN is used for connecting two or more personal computers through a communication medium such as twisted pair, coaxial cable, etc.
- It is less costly as it is built with inexpensive hardware such as hubs, network adapters, and ethernet cables.
- The data is transferred at an extremely faster rate in Local Area Network.
- Local Area Network provides higher security.



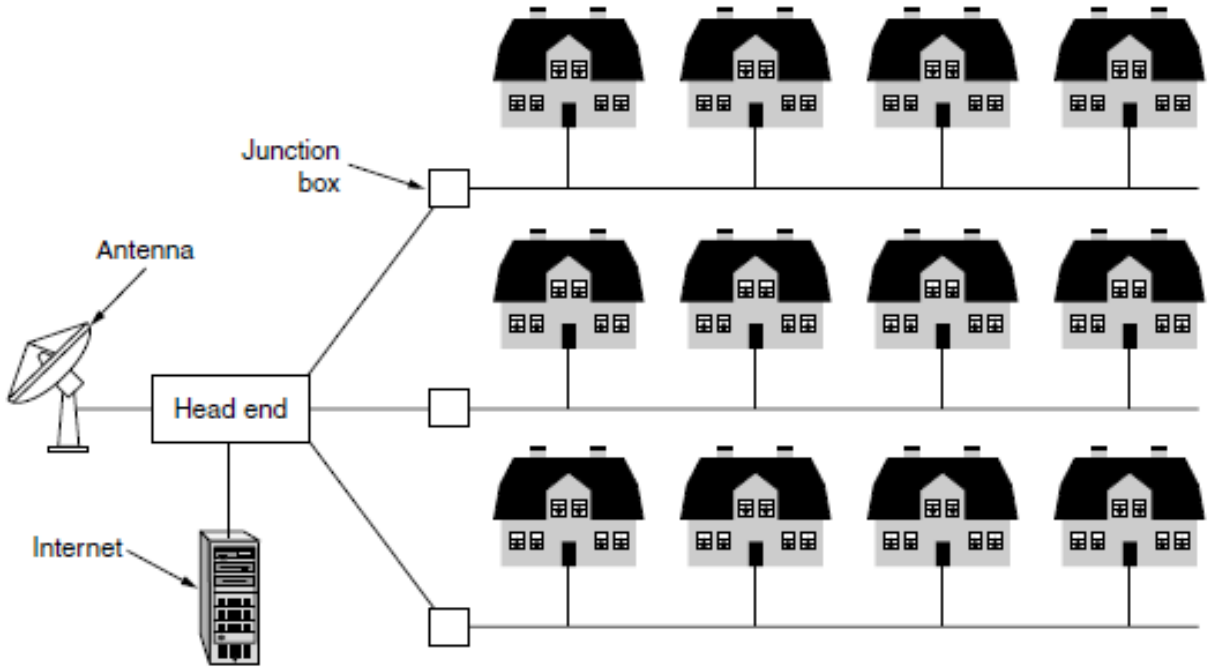
Wireless and wired LANs. (a) 802.11. (b) Switched Ethernet.

Metropolitan Area Networks

A **MAN** (**Metropolitan Area Network**) covers a city.

- Design to extend over a large area.
- Connecting number of LAN's to form larger network, so that resources can be shared.
- Networks can be up to 5 to 50 km.
- Owned by organization or individual.
- Data transfer rate is low compare to LAN.

Example: Organization with different branches located in the city.



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Uses Of Metropolitan Area Network:

- MAN is used in communication between the banks in a city.
- It can be used in an Airline Reservation.
- It can be used in a college within a city.
- It can also be used for communication in the military.

Wide Area Networks

- A **WAN** (**Wide Area Network**) spans a large geographical area, often a country or continent
- The network that connects these hosts is then called the **communication subnet**, or just **subnet** for short.
- The job of the subnet is to carry messages from host to host
- In most WANs, the subnet consists of two distinct components: transmission lines and switching elements. **Transmission lines** move bits between machines.
- **Switching elements**, or just **switches**, are specialized computers that connect two or more transmission lines.
  - When data arrive on an incoming line, the switching element must choose an outgoing line on which to forward them.
  - These switching computers have been called by the name **router** (Unfortunately, some people pronounce it ‘‘rooter’’)

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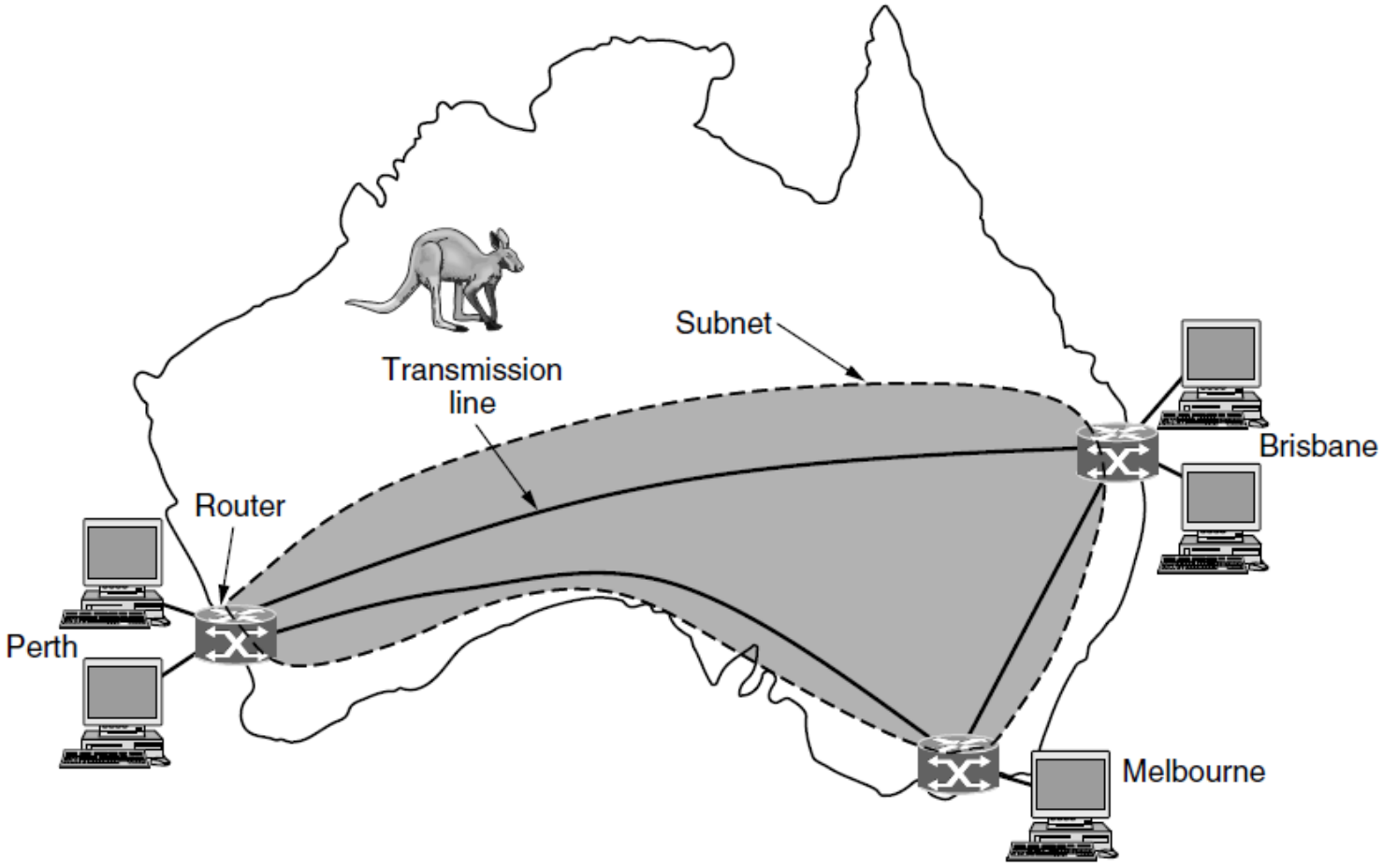
Originally subnet is the collection of routers and communication lines that moves packets from the source host to the destination host.

- In a WAN, the hosts and subnet are owned and operated by different people.
- The WAN in Fig. is a network that connects offices in Perth, Melbourne, and Brisbane. Each of these offices contains computers intended for running user (i.e., application) programs.



WAN that connects three branch offices in Australia.

Features of WAN

- A Wide Area Network is a network that extends over a large geographical area such as states or countries.
- A Wide Area Network is quite bigger network than the LAN.
- A Wide Area Network is not limited to a single location, but it spans over a large geographical area through a telephone line, fibre optic cable or satellite links.
- The internet is one of the biggest WAN in the world.
- A Wide Area Network is widely used in the field of Business, government, and education.

Network Topologies

- Logical layout of wires and equipment is called ***topology***.

Topology: Shape of the network

- The way in which devices are interconnected to form a network is called **network topology**.
- Some of the factors that affect choice of topology for a network are

✓ Cost
✓ Scalability
✓ Flexibility
✓ Reliability
✓ Ease of installation
✓ Ease of maintenance

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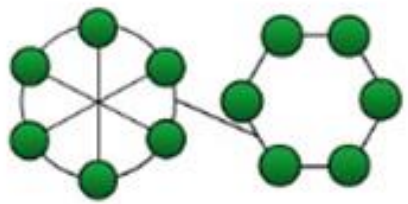
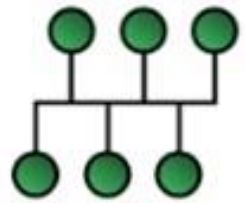
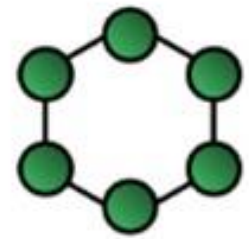


HYBRID Topology

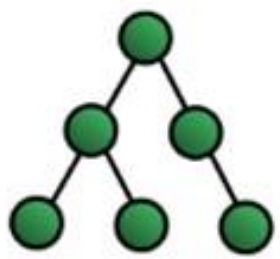


BUS Topology

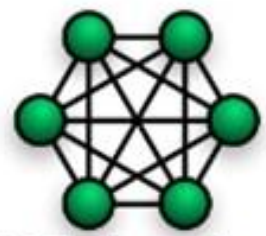
Network Topology



RING Topology



TREE Topology



MESH Topology

STAR Topology

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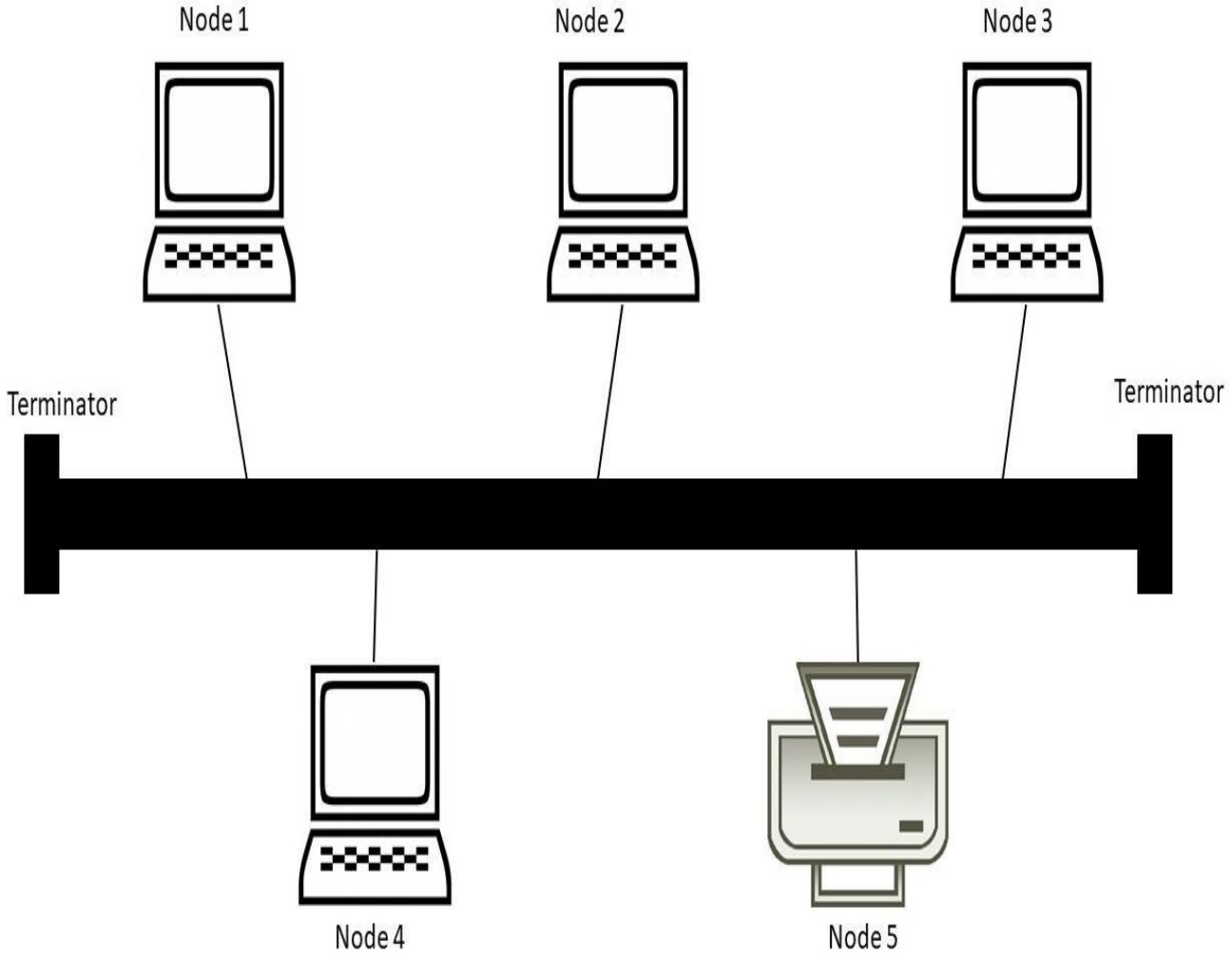
Bus Topology

- It is also called linear bus
- One wire connects all nodes



Advantages:

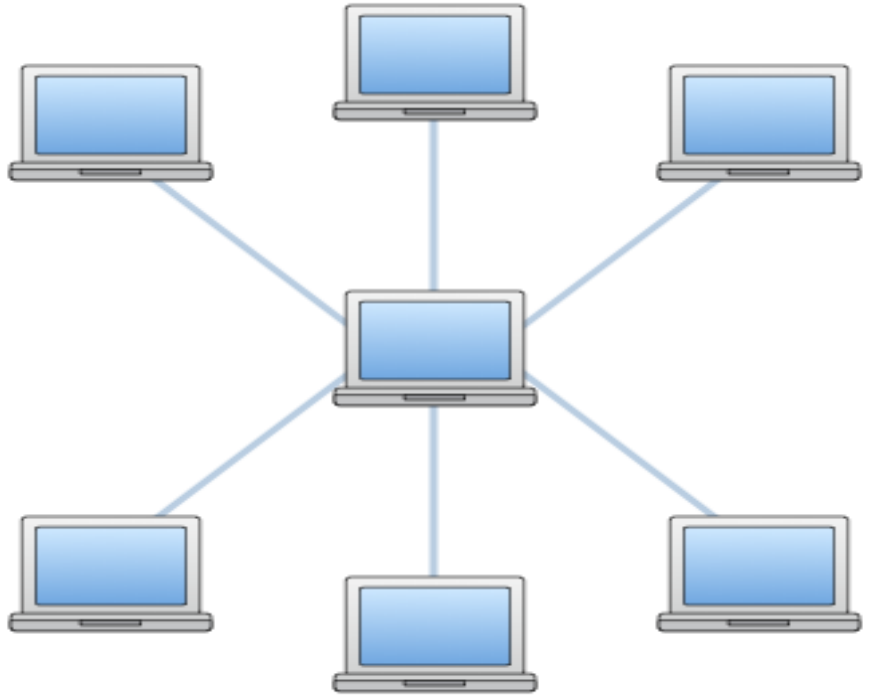
- Easy to setup
- Require less hardware
- Low cost

Disadvantages:

- Slow
- Easy to crash
- If one system effected remaining systems cannot communicate with each other

Star Topology

- A star topology is a topology for a Local Area Network (LAN) in which server is connected to each node individually.
- Server is also called the central node.
- Any exchange of data between two nodes must take place through the server.



Advantages

- Failure of one node does not affect the network
- Troubleshooting is easy as faulty node can be detected from central node immediately

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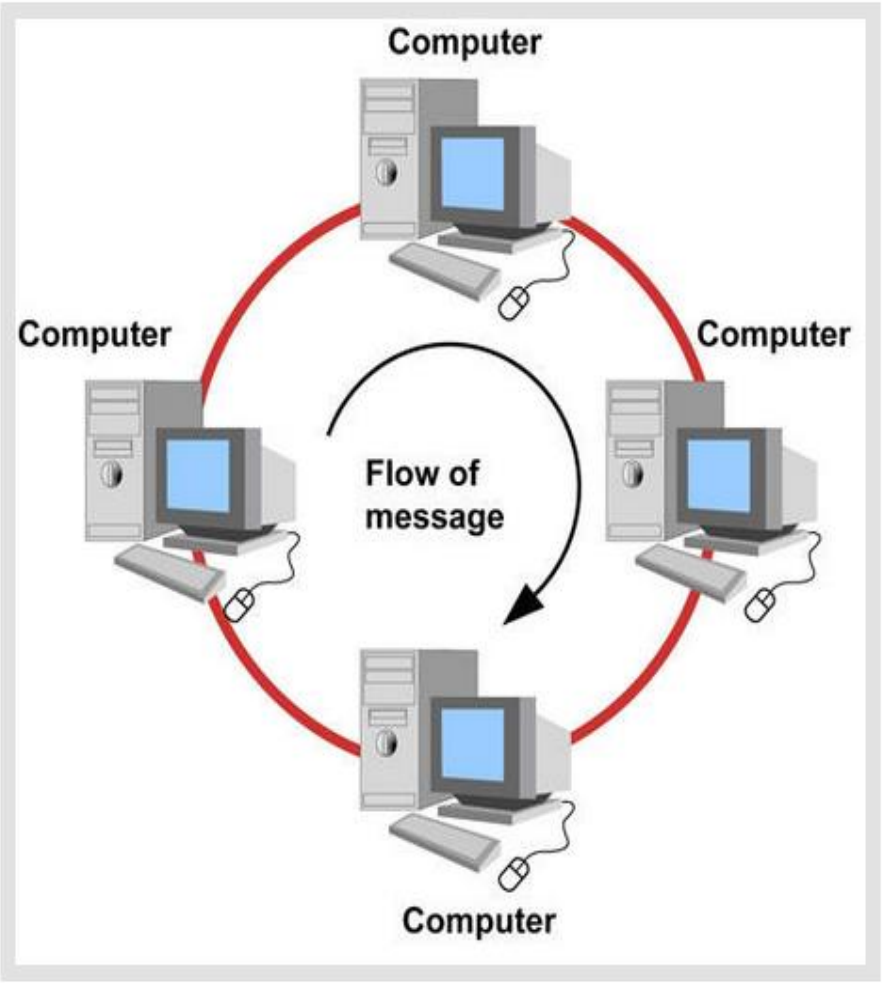
Ring Topology

- In ring topology each terminal is connected to exactly two nodes, giving the network a circular shape.
- Data travels in only one pre-determined direction.



Advantages:

- Very high transmission speeds possible
- Small cable segments are needed to connect two nodes

Disadvantages :

- Failure of single node brings down the whole network
- Troubleshooting is difficult as many nodes may have to be inspected before faulty one is identified
- Difficult to remove one or more nodes while keeping the rest of the network intact

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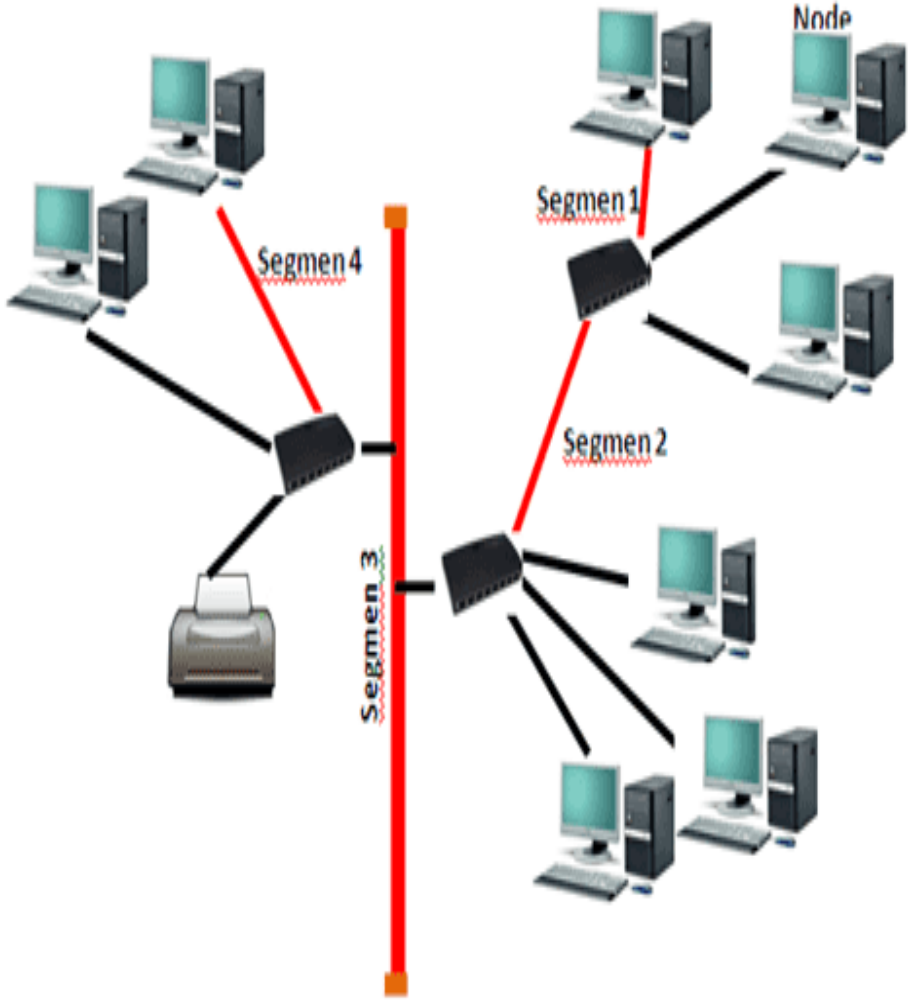
Tree Topology

- Tree topology has a group of star networks connected to a linear bus backbone cable.
- It incorporates features of both star and bus topologies.
- Tree topology is also called hierarchical topology.



Advantages

- Existing network can be easily expanded
- Easier installation and maintenance
- Well suited for temporary networks

Disadvantages

- Failure of backbone cable brings down entire network
- Insecure network
- Maintenance difficult for large networks

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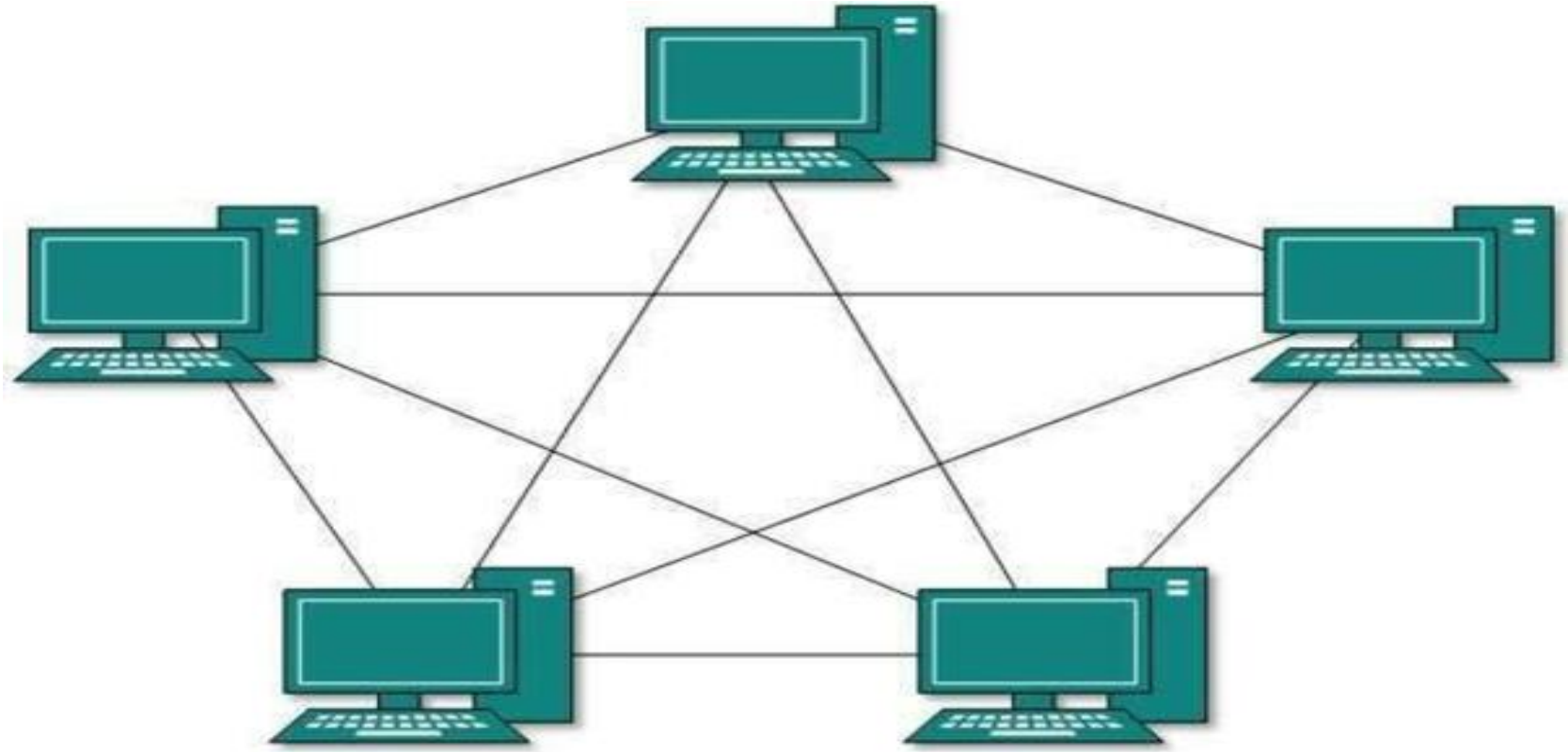
Mesh Topology

- In this type of topology, a host is connected to one or multiple hosts.
- This topology has hosts in point-to-point connection with every other host
- It provides the most reliable network structure among all network topologies.



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Hybrid Topology

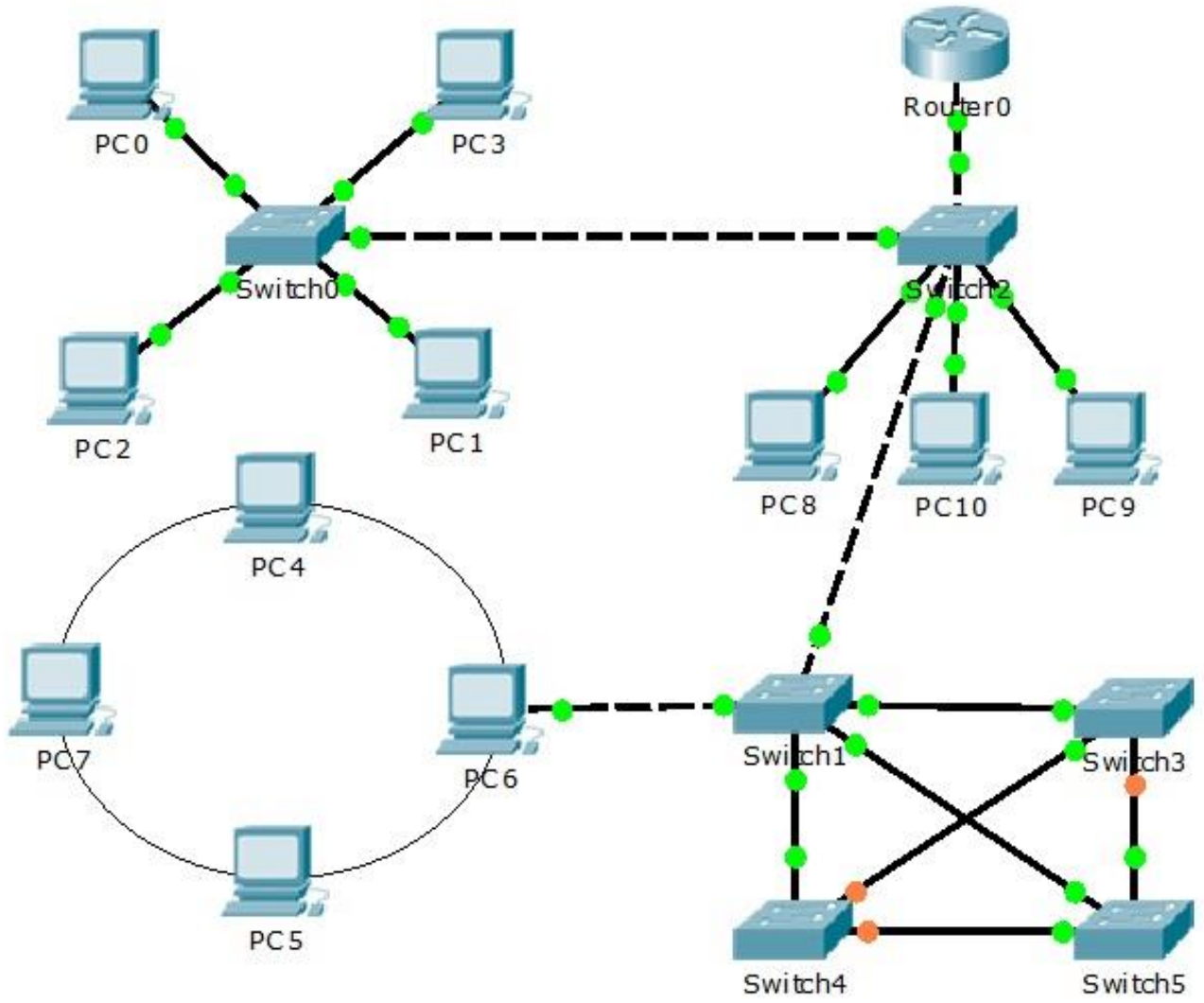
It is the combination of two or more different topologies.

Advantages:

- It is extremely flexible.
- It is very reliable.
- Error detecting and troubleshooting are easy.
- Handles a large volume of traffic.
- It is used to create large networks.

Disadvantages:

- It is a type of network expensive.
- The design of a hybrid network is very complex.
- There is a change in the hardware to connect one topology with another topology.



REFERENCE MODELS

- The two important network architectures:

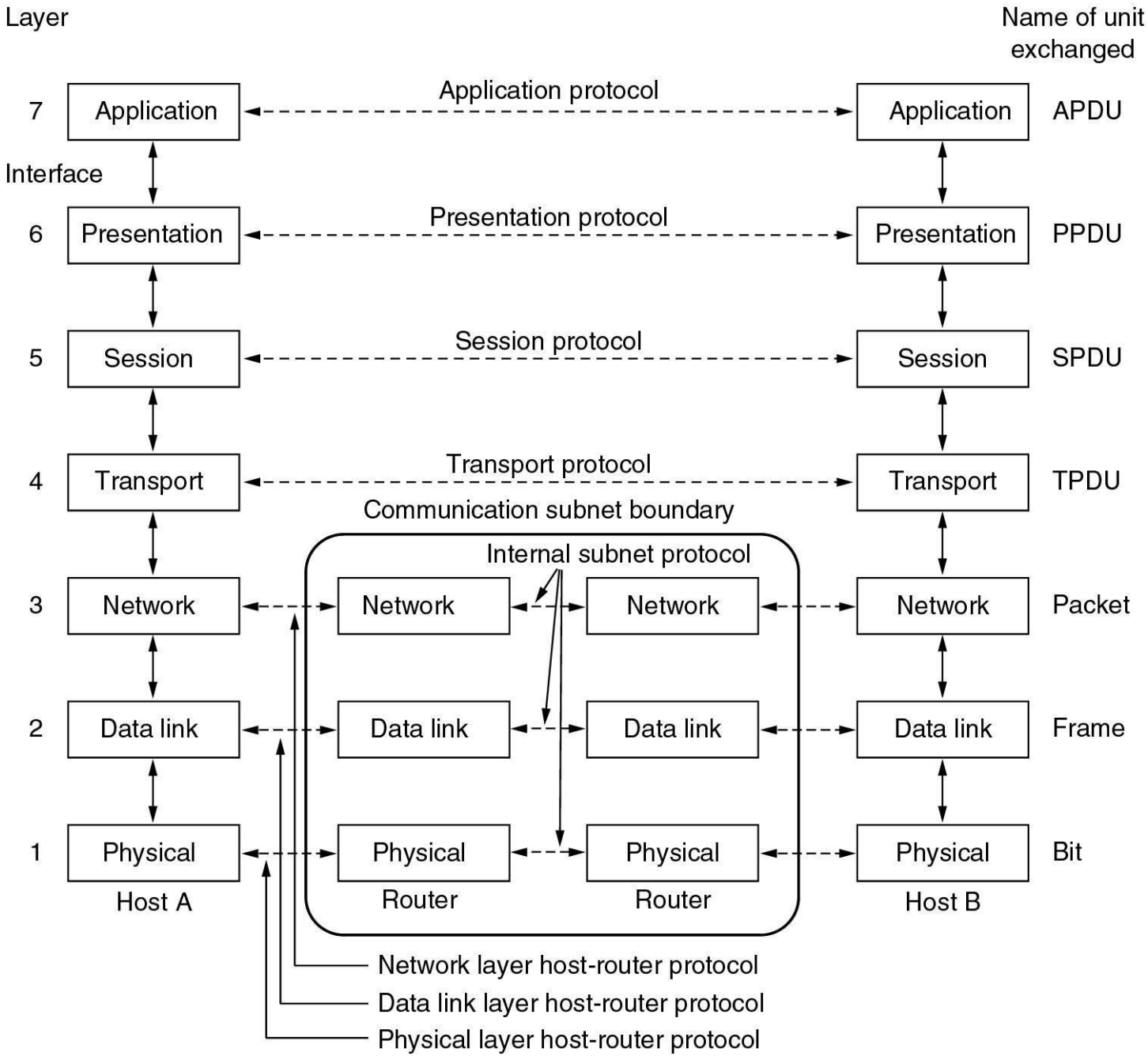
The OSI reference model and The TCP/IP reference model.

OSI REFERENCE MODEL

- This model is based on a proposal developed by the International Standards Organization (ISO) as a first step toward international standardization of the protocols used in the various layers (1983).
- It was revised in 1995.
- The model is called the ISO OSI (Open Systems Interconnection) Reference Model because it deals with connecting open systems.
- The OSI model has 7 layers.
- OSI model itself is not a network architecture because it does not specify the exact services and protocols to be used in each layer. It just tells what each layer should do.

The design principle of the OSI reference model:

- A layer should be created where a different abstraction is needed
- Each layer should perform a well defined function
- The function of each layer can be chosen as an international standard
- The layer boundaries should be chosen to minimize the information flow across the interfaces


Layer
Name of unit exchanged
7
Application
Application protocol
Application
APDU
Interface
6
Presentation
Presentation protocol
Presentation
PPDU
5
Session
Session protocol
Session
SPDU
4
Transport
Transport protocol
Transport
TPDU
Communication subnet boundary
Internal subnet protocol
3
Network
Network
Network
Network
Packet
2
Data link
Data link
Data link
Data link
Frame
1
Physical
Physical
Physical
Physical
Bit
Host A
Router
Router
Host B
Network layer host-router protocol
Data link layer host-router protocol
Physical layer host-router protocol

Physical Layer:

- The Physical Layer is concerned with transmitting raw bits over a communication channel.
- It has to make sure that when one side sends a I bit, it is received by the other side as a ‘1’ bit, not as a ‘0’ bit.

Functions of Physical Layer:

- Physical characteristics of interfaces and media defines the characteristics of interface between the devices and the transmission medium
- *Representation of bits* - conversion between representation of bits and corresponding signals
- *Transmission rate* - number of bits sent each second, the duration of a bit
- *Synchronization of bits* - the synchronization between sender and receiver clocks

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Data Link Layer:

- The main task of The Data Link Layer is to transform a raw transmission facility into a line that appears free of undetected transmission errors to the network layer.
- The Data Link Layer executes this task by having the sender break up the input data into data frames (typically a few hundred or a few thousand bytes) and transmit the frames sequentially.
- If the service is reliable, the receiver confirm correct receipt of each frame by sending back an acknowledgement frame.

- ***Medium access control sublayer:*** which is the part of the data link layer in the broadcast networks, deals how to control access to the shared channel.

Functions of Data Link Layer:

- Framing
- Physical addressing
- Flow control
- Error control
- Access control

Network Layer:

- The Network Layer controls the operation of the subnet.
- A key design issue is determining how packets are routed from source to destination.
- The Network Layer controls the congestions when too many packets are present in the subnet at the same time;
- More generally, the quality of service provided (delay, transit time, jitter, etc.) is also a network layer issue.
- Converting the addresses and packet sizes between networks is also a job of 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 to allow heterogeneous networks to be interconnected.

Functions of Network Layer:

- Logical addressing
- Routing

Transport Layer:

- The Transport Layer’ s basic function is to accept data from above, pass these to the network layer, and ensure that the pieces all arrive correctly at the other end.
- The Transport Layer also determines what type of service to provide to the session layer.
- The transport layer is a true end-to-end layer, all the way from the source to the destination.

Functions of Transport Layer:

- Port addressing
- Segmentation and reassembly
- Connection control

Session Layer:

- The Session Layer allows users on different machine to establish sessions between them.
- Sessions offer various services:
  - Dialog control (keeping track of whose turn it is to transmit);
  - Token management (preventing two parties from attempting the same critical operation at the same time);
  - Synchronization (check pointing long transmissions to allow them to continue from where they were after a crash).

Functions of Session Layer:

- It allows two applications running on different computers to establish a connection called a session.
- It performs name recognition and security.
- It provides synchronization by placing checkpoints in the data stream.
- It implements dialog control between communicating processes.

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Presentation Layer:

- Unlike lower layers, which are mostly concerned with moving bits around, 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 to be defined and exchanged.

Functions of Presentation Layer:

- **Data compression** — reduction in the size of data to achieve faster transmission over the network
- **Data encryption** — translation of data from a format used by application layer into a common format and vice-versa.
- **Protocol translation** — conversion of data from one protocol to another to transfer between different platforms or operating systems.

Application Layer:

- The Application Layer contains a variety of protocols that are commonly needed by users.
- One widely used application protocol is HTTP (Hyper Text Transfer Protocol) which is the basis for 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.

Functions of Application Layer:

- Mail services - basis for email forwarding and storage
- File transfer and access
- Remote login
- Accessing the world wide web

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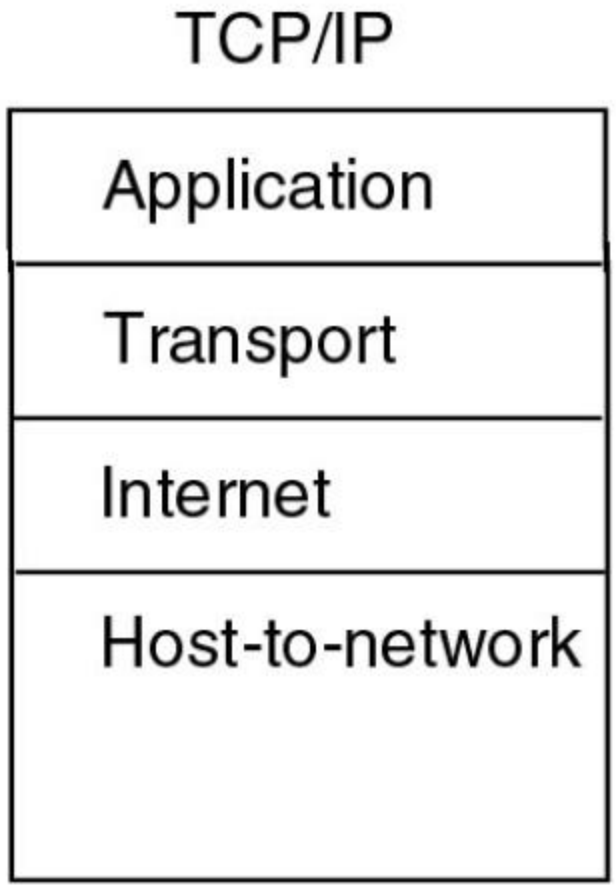
THE TCP / IP REFERENCE MODEL

- TCP/IP reference model originates from ARPANET and now is used in the worldwide Internet.
- The ARPANET was a research network sponsored by the DOD (U.S. Department of Defense) that connected hundreds of universities and government installations, using leased telephone lines.
- When satellite and radio networks were added later, the existing protocols had trouble interworking with them, so a new reference architecture was needed. This architecture later became known as the TCP/IP Reference Model, after its two primary protocols.
- It was first defined in 1974. A later perspective is give in 1985.
- Furthermore, a flexible architecture was needed since applications with divergent requirements were envisioned, ranging from transferring files to real time speech transmission.

- The TCP/IP Reference Model includes 4 layers.



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Host – to – Network Layer:

- Host-to-Network Layer allow the host to connect to the network using some protocol so it can send IP packets to it.
- Protocols used here are not defined and vary from host to host and network to network.

Internet Layer:

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

Transport Layer:

- TCP/IP internet layer is similar in functionality to the OSI network layer
- This layer is designed to allow peer entities on the source and destination hosts to carry on a conversation, just as in the OSI transport layer.

➢ Two end-to-end transport protocols have been defined here.

➢ TCP (Transmission Control Protocol)

➢ UDP (User Datagram Protocol)

Transmission Control Protocol

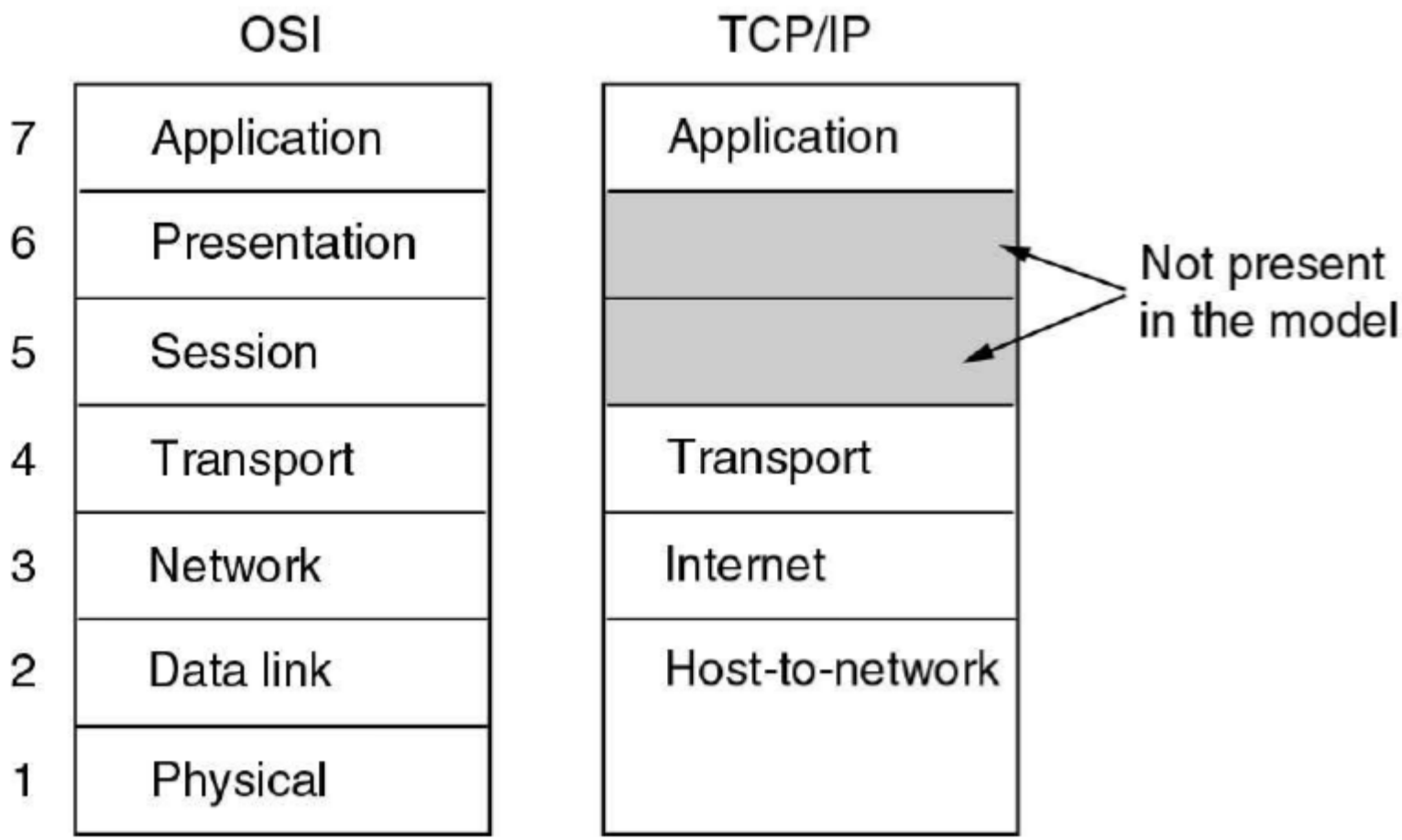
- TCP is a reliable connection-oriented protocol that allows a byte stream originating on one machine to be delivered without error on any other machine in the internet.
- It fragments the incoming byte stream into discrete messages and passes each one on to the internet layer.
- At the destination, the receiving TCP process reassembles the received messages into the output stream.
- TCP also handles flow control to make sure a fast sender cannot swamp a slow receiver with more messages than it can handle.

User Datagram Protocol

- UDP 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, such as transmitting speech or video.

Application Layer:

- It contains all the higher-level protocols such as virtual terminal (TELNET), file transfer (FTP) and electronic mail (SMTP), DNS, NNTP and HTTP.
- 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.
- Domain Name System (DNS) for mapping host names onto their network addresses.
- NNTP, the protocol for moving USENET news articles around
- HTTP, the protocol for fetching pages on the World Wide Web, and many others.


OSI
TCP/IP
7
Application
6
Presentation
5
Session
4
Transport
3
Network
2
Data link
1
Physical
Application
Transport
Internet
Host-to-network
Not present
in the model

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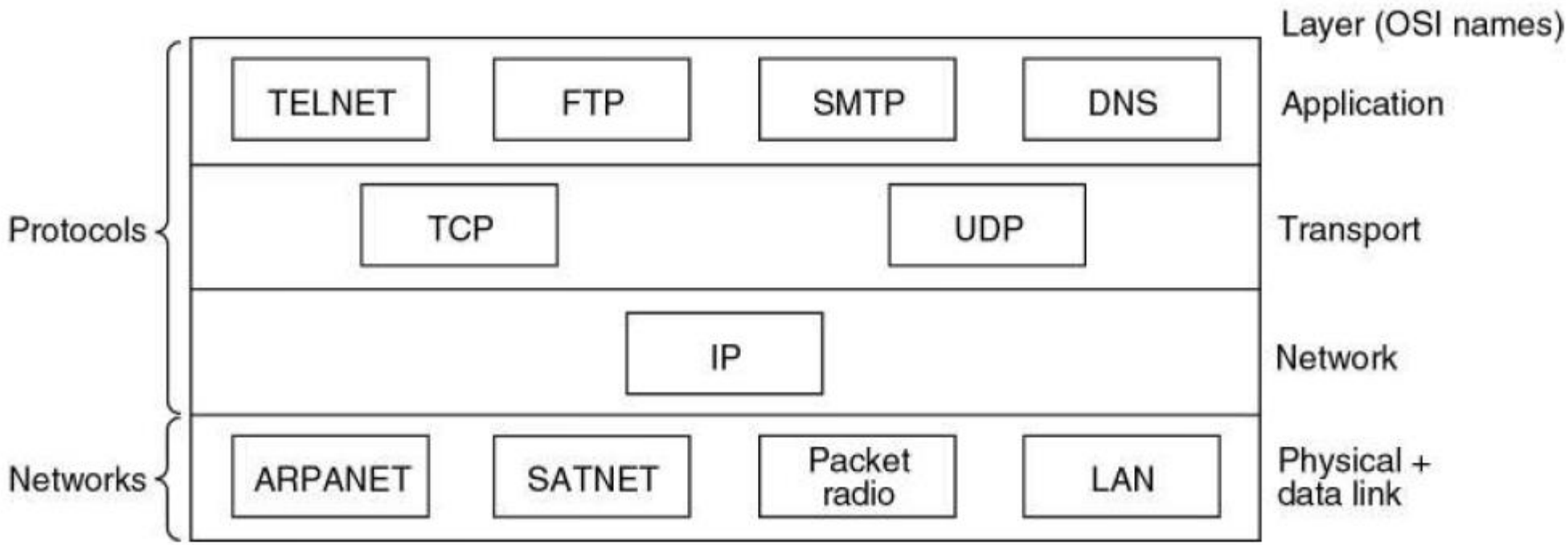

Protocols and networks in the TCP/IP model initially.

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- COMPARISON OF THE OSI AND TCP / IP REFERENCE MODEL

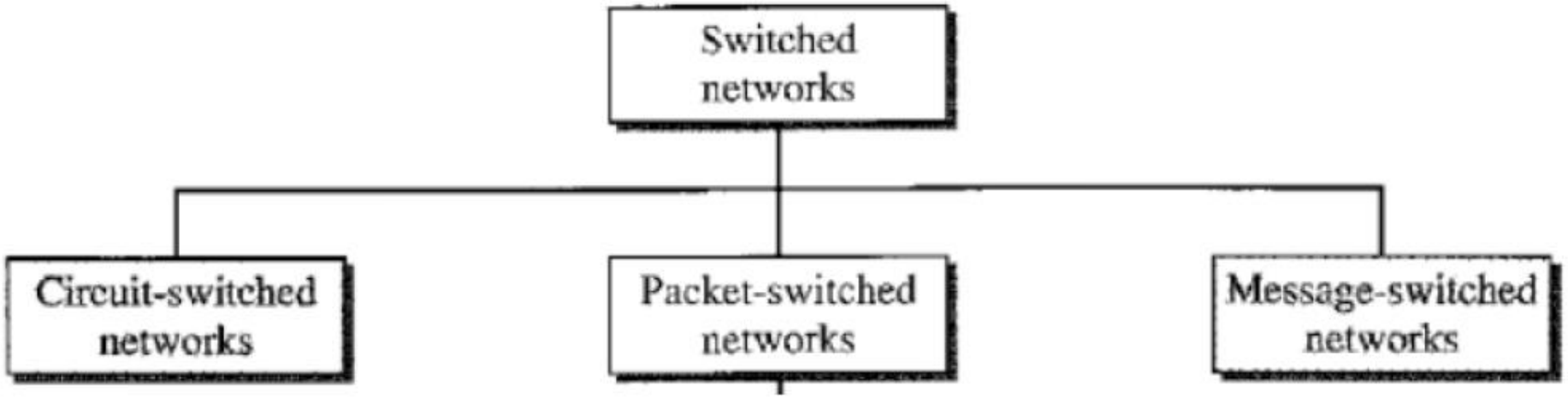
OSI(Open System Interconnection)	TCP/IP(Transmission Control Protocol / Internet Protocol)
1. OSI is a generic, protocol independent standard, acting as a communication gateway between the network and end user.	1. TCP/IP model is based on standard protocols around which the Internet has developed. It is a communication protocol, which allows connection of hosts over a network.
2. In OSI model the transport layer guarantees the delivery of packets.	2. In TCP/IP model the transport layer does not guarantees delivery of packets. Still the TCP/IP model is more reliable.
3. Follows vertical approach.	3. Follows horizontal approach.
4. OSI model has a separate Presentation layer and Session layer.	4. TCP/IP does not have a separate Presentation layer or Session layer.
5. Transport Layer is Connection Oriented.	5. Transport Layer is both Connection Oriented and Connection less.
6. Network Layer is both Connection Oriented and Connection less.	6. Network Layer is Connection less.

- COMPARISON OF THE OSI AND TCP / IP REFERENCE MODEL

OSI(Open System Interconnection)	TCP/IP(Transmission Control Protocol / Internet Protocol)
7. OSI is a reference model around which the networks are built. Generally it is used as a guidance tool.	7. TCP/IP model is, in a way implementation of the OSI model.
8. Network layer of OSI model provides both connection oriented and connectionless service.	8. The Network layer in TCP/IP model provides connectionless service.
9. OSI model has a problem of fitting the protocols into the model.	9. TCP/IP model does not fit any protocol
10. Protocols are hidden in OSI model and are easily replaced as the technology changes.	10. In TCP/IP replacing protocol is not easy.
11. OSI model defines services, interfaces and protocols very clearly and makes clear distinction between them. It is protocol independent.	11. In TCP/IP, services, interfaces and protocols are not clearly separated. It is also protocol dependent.
12. It has 7 layers	12. It has 4 layers

Basics of Packet Switching, Circuit Switching and Virtual Circuit switching

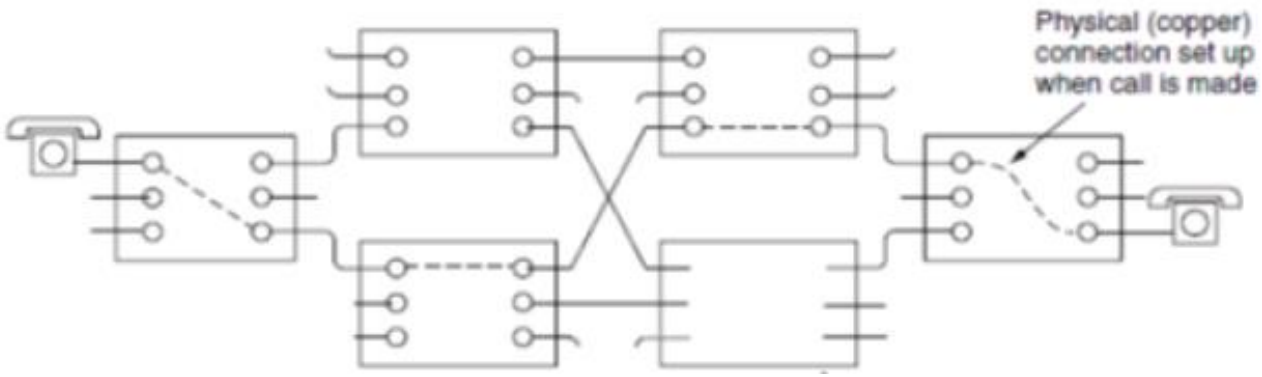
Taxonomy of switched networks



- The phone system is divided into two principal parts: outside plant (the local loops and trunks, since they are physically outside the switching offices) and inside plant (the switches), which are inside the switching offices.
- Two different switching techniques are used nowadays: circuit switching and packet switching.

CIRCUIT SWITCHING:

- When you or your computer places a telephone call, the switching equipment within the telephone system seeks out a physical path all the way from your telephone to the receiver's telephone.
- This technique is called circuit switching.
- A switching technology that establishes an electrical connection between stations using a dedicated path.
- Each of the six rectangles represents carrier switching office(end office, toll office etc.).
- When a call passes through a switching office, a physical connection is (conceptually) established between the line on which the call came in and one of the output lines, as shown below:



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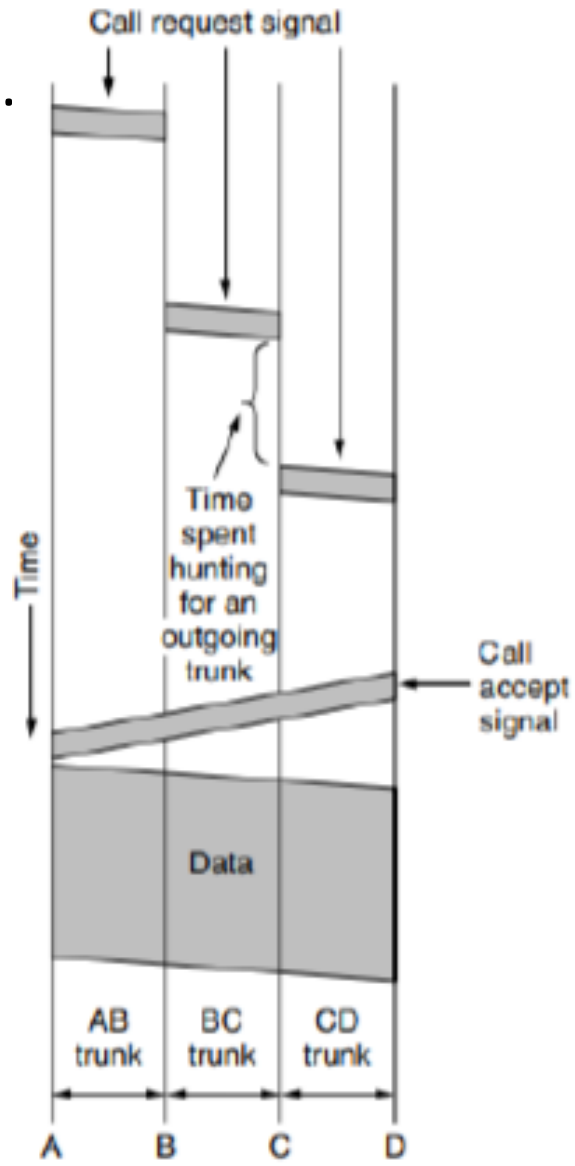
- Parts of the physical path between the two telephones may, in fact, be microwave or fiber links onto which thousands of calls multiplexed.
- An important property of circuit switching is the need to set up an end-to-end path before any data can be sent. The elapsed time between the end of dialing and the start of ringing can be easily be 10 sec, more on long distance or international calls.



Timing of Events in Circuit Switching

PACKET SWITCHING:

- Packet switching networks place a tight on upper limit on block size, allowing packets to be buffered in router main memory instead of on disk.
- By making sure that no user can monopolize any transmission line very long, packets switching networks are well suited for handling interactive traffic.
- A further advantage of packet switching over message switching is shown the first packet of a multi-packet message can be forwarded before the second one has fully arrived, reducing delay and improving throughput.
- For these reasons, computer networks are usually packet switched, occasionally circuit switched, but never message switched.
- Circuit switching requires that a circuit be set up end-to-end before communication begins. Packet switching does not requires any advance setup.
- Result of the connection setup with circuit switching is the reservation of bandwidth all the way from the sender to receiver. All packets follow this path.
- With packet switching there is no path, so different packets can follow different paths depending on network conditions at the time they are sent.

- Packet switching is more fault tolerant than circuit switching.
- If a circuit has been reserved for a particular user and there is no traffic to send the bandwidth of that circuit is wasted. It cannot be used for other traffic. Packet switching does not waste bandwidth and thus is more efficient from a system-wide perspective.
- Packet switching uses store and forward transmission.
- With circuit switching, the bits just flow through the wire continuously.
- Another difference is that circuit switching is completely transparent.
- The sender and receiver can use any bit rate, format, or framing method they want to, the carrier does not know or care. With packet switching, the carrier determines the basic parameters.
- A final difference between circuit and packet switching is the charging algorithm.
- With circuit switching, charging has historically been based on distance and time.
- For mobiles phones, distance usually does not play a role, except for international calls, and time plays only a minor role.

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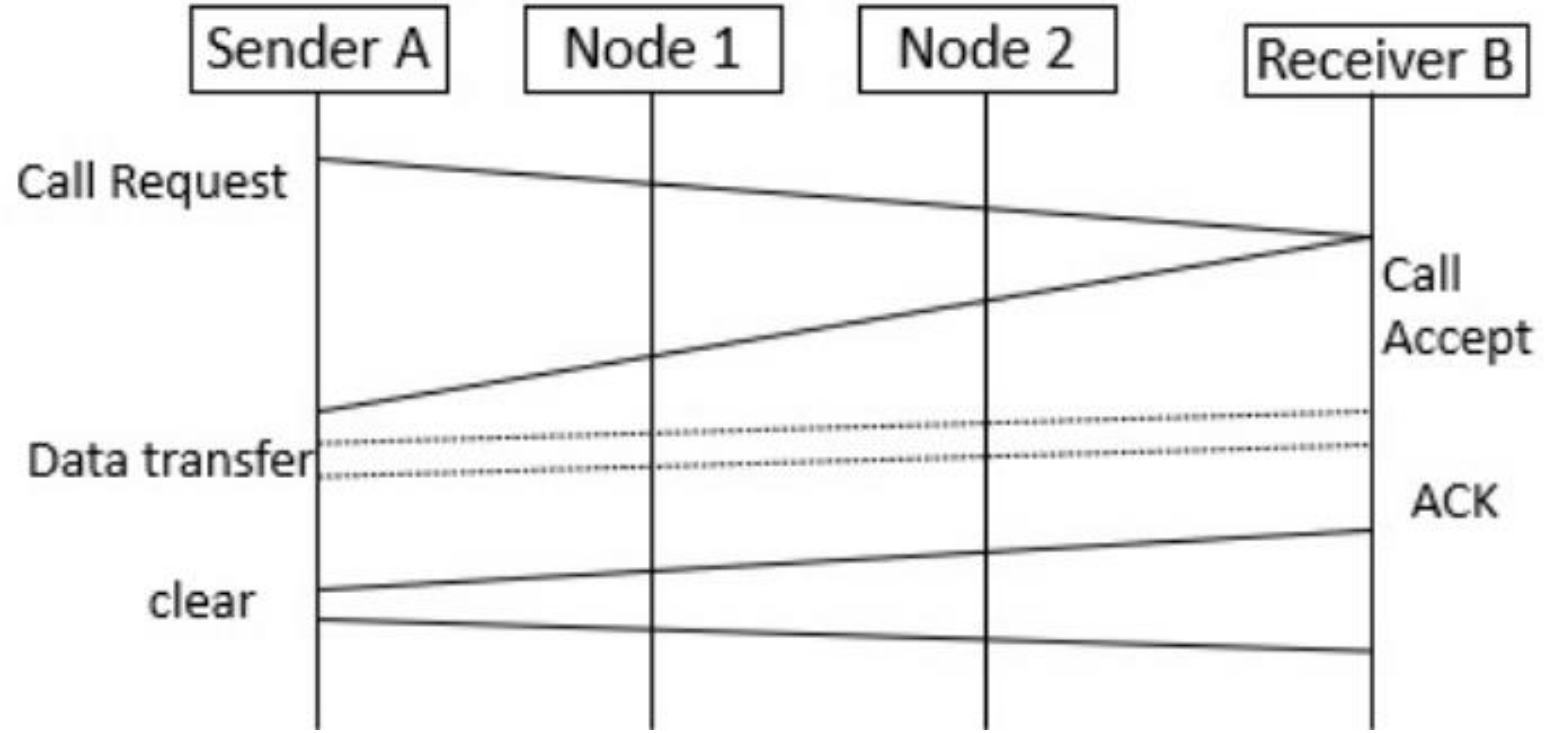
- **PACKET SWITCHING VS CIRCUIT SWITCHING:**

Item	Circuit switched	Packet switched
Call setup	Required	Not needed
Dedicated physical path	Yes	No
Each packet follows the same route	Yes	No
Packets arrive in order	Yes	No
Is a switch crash fatal	Yes	No
Bandwidth available	Fixed	Dynamic
Time of possible congestion	At setup time	On every packet
Potentially wasted bandwidth	Yes	No
Store-and-forward transmission	No	Yes
Transparency	Yes	No
Charging	Per minute	Per packet

Virtual Circuit Switching:

- It is a network where a virtual connection is established between source and the destination. Through this network, packets will be transferred during any call. The path established between two points appears as a dedicated physical circuit. Therefore, it is called a virtual circuit. It is a type of packet switching.
- It is a connection-oriented service, where the first packet goes and reserves the resources for the subsequent packets.



Step 1 − Sender A establishes a call request connection to connect with the receiver.

Step 2 − Receiver B establishes a call accepting connection to connect with sender.

Step 3 − Data will be transferred whenever the router is established.

Step 4 − Node 1 and Node 2 are intermediate nodes between sender and receiver, the data will be transferred by connecting two nodes virtually.

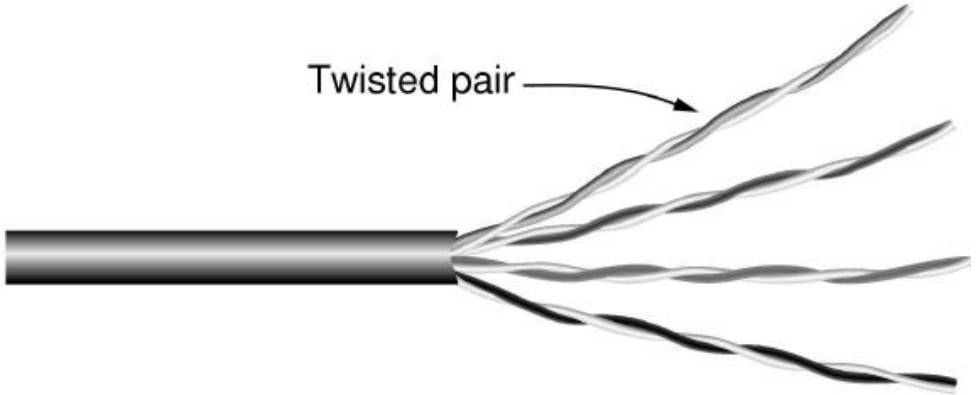
Step 5 − After transmitting the data, an ACK will be sent by the receiver by saying a message is received.

Step 6 − A clear signal will be sent if the user wants to terminate the connection.

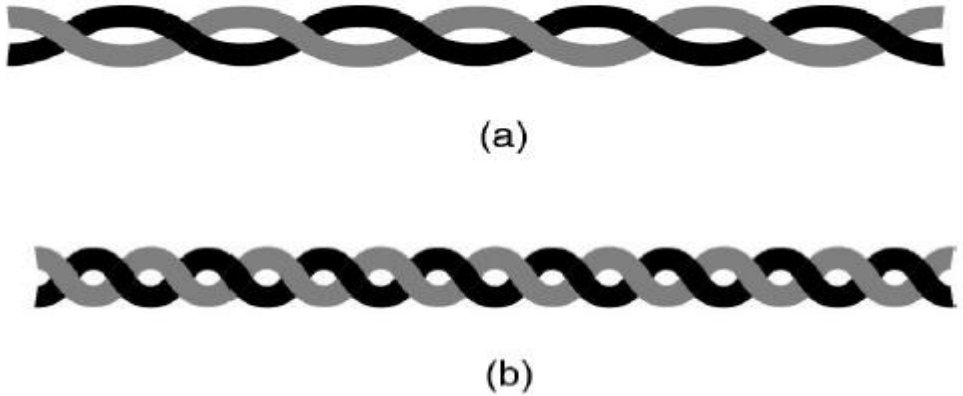
GUIDED TRANSMISSION MEDIA

Twisted Pair

- A twisted pair consists of two insulated copper wires, typically about 1 mm thick. The wires are twisted together in a helical form, just like a DNA molecule.
- Twisted pairs can run several kilometers without amplification, but for longer distances, repeaters are needed.



- a) Category3UTP.
- b) Category5UTP.



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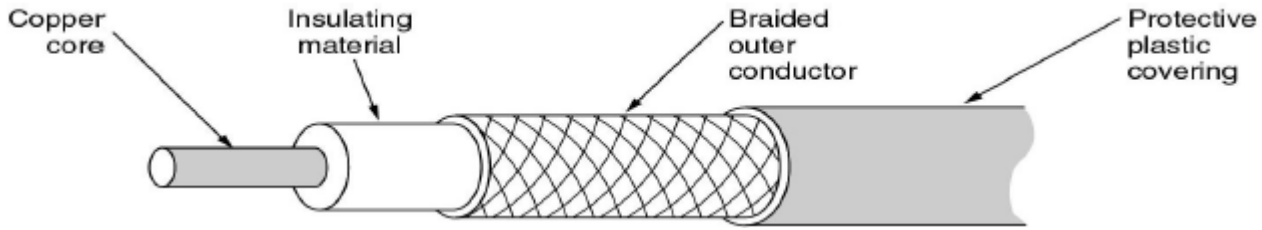
Twisted pairs can be used for transmitting either analog or digital signals.

- Full-Duplex, Half-Duplex, Simplex
- Types
  - Category 5 (100Mbps, 1Gbps)
  - Category 6 (10Gbps)
  - Category 7 (Shielded Twisted Pair)

Coaxial Cable

- A coaxial cable consists of a stiff copper wire as the core,
- surrounded by an insulating material.
- The insulator is encased by a cylindrical conductor, often as a closely-woven breaded mesh.
- The outer conductor is covered in a protective plastic



- Two types: 50-ohm (digital), 75-ohm (analog and digital)
- High bandwidth and excellent noise immunity
- Used to be widely used for long-distance lines.

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Fiber Optics

- In the race between computing and communication, communication won
- Original IBM PC at 4.77 MHz in 1981→ four-core CPU at 3GHz → (16 per decade) and physical limits 45Mpbs (T3 line) → 100Gbps (optical communication) → 16 per decade and error rate almost zero and almost no limits
- An optical transmission system:

  the light source → the transmission medium → the detector.

Two types of fiber optics

- Multimode: many different rays
- Unimode: singlerays, longer distance

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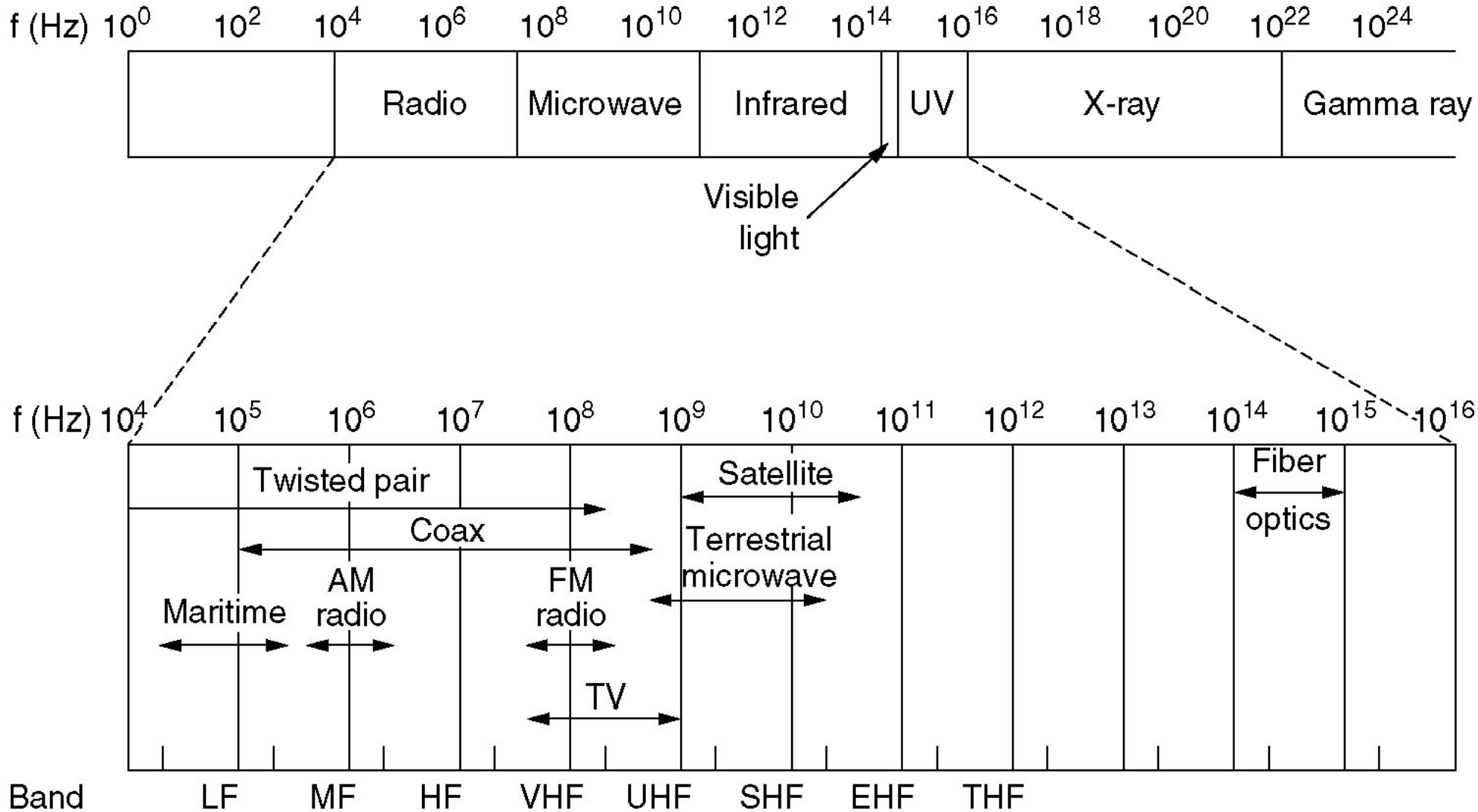
Wireless transmission

- The electromagnetic spectrum
- Radio transmission
- Microwave transmission
- Infrared and millimeter waves
- Light wave transmission

- The electromagnetic spectrum and its uses for communication.



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- LF(Low), MF(Medium), HF(High),
- VHF(Very), UHF(Ultra), SHF(Super),
- EHT(Extremely), THF(Tremendously), (IHF(Incredibly),
- AHF(Astonishingly), PHF(Prodigiously))

The wider the band, the higher the data rate.

- To prevent total chaos, there are national and international agreements about who gets to use which frequencies.
- Most transmissions use a narrow frequency band. (GSM)

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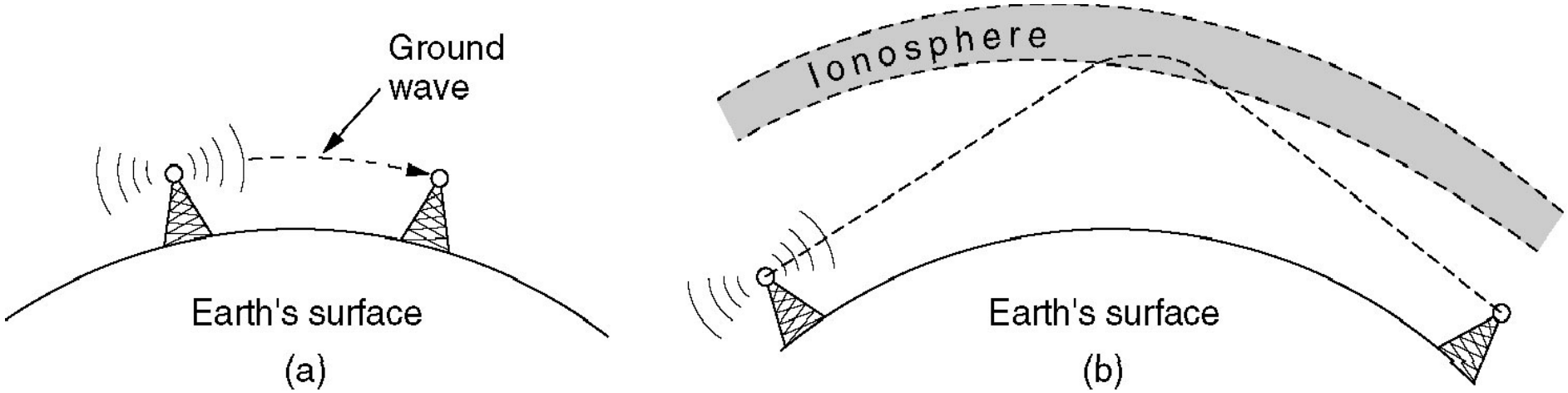
Radio Transmission

- Radio waves are easy to generate, can travel long distances, and can penetrate buildings easily, so they are widely used for communication
- Radio waves also are omnidirectional, meaning that they travel in all directions from the source, so the transmitter and receiver do not have to be carefully aligned physically.
- Due to radio's ability to travel long distances, interference between users is a problem. For this reason, all governments tightly license the use of radio transmitters
  - A) In the VLF, LF, and MF bands, radio waves follow the curvature of the earth.
  - B) In the HF band, they bounce off the ionosphere.



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Microwave Transmission

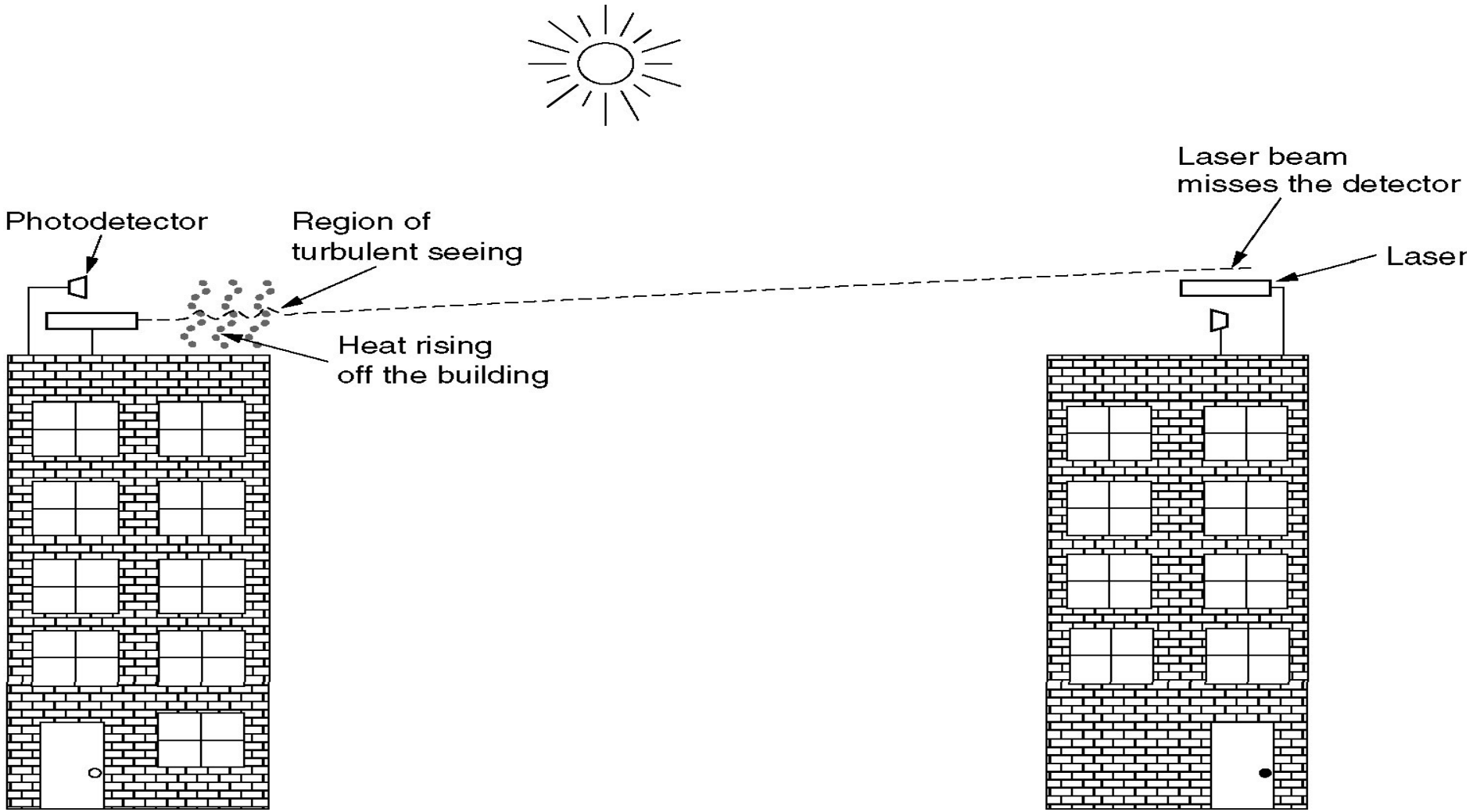
- Above 100MHz, the waves travel in straight lines and can therefore be narrowly focused.
- **The higher the transmission towers are, the further apart they can be.** For 100-m high towers, repeaters can be spaced 80km apart.
- Microwave can cause **multipath fading** or be **absorbed by rain**.
- Microwave communication is so widely used for long- distance telephone communication, cellular telephones, television distribution, and other uses, that a severe shortage of spectrum has developed.
- Microwave has some advantages over fiber: no right of way problem, being inexpensive.

Infrared and millimeter waves

- Infrared and millimeter waves can not pass through solid objects.
- Infrared can be used for indoor wireless LANs, remote controllers.
- Infrared can not be used outdoors for the sun shines as brightly in the infrared as in the visible spectrum.
- Advantage: More secure.

Lightwave Transmission

- Convection currents can interfere with laser communication systems.
- A bidirectional system with two lasers is pictured here.



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- **Laser:** Mounted on the right-side building, emits a narrow, focused light beam intended for communication or detection.
- **Photodetector:** Positioned on the left-side building to receive the laser beam.
- The **dashed line** represents the intended straight path of the laser beam.
- However, due to distortion in the atmosphere, the beam deviates and misses the photodetector.

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That's all about

UNIT 1

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