Computer Networks
Lecture _1

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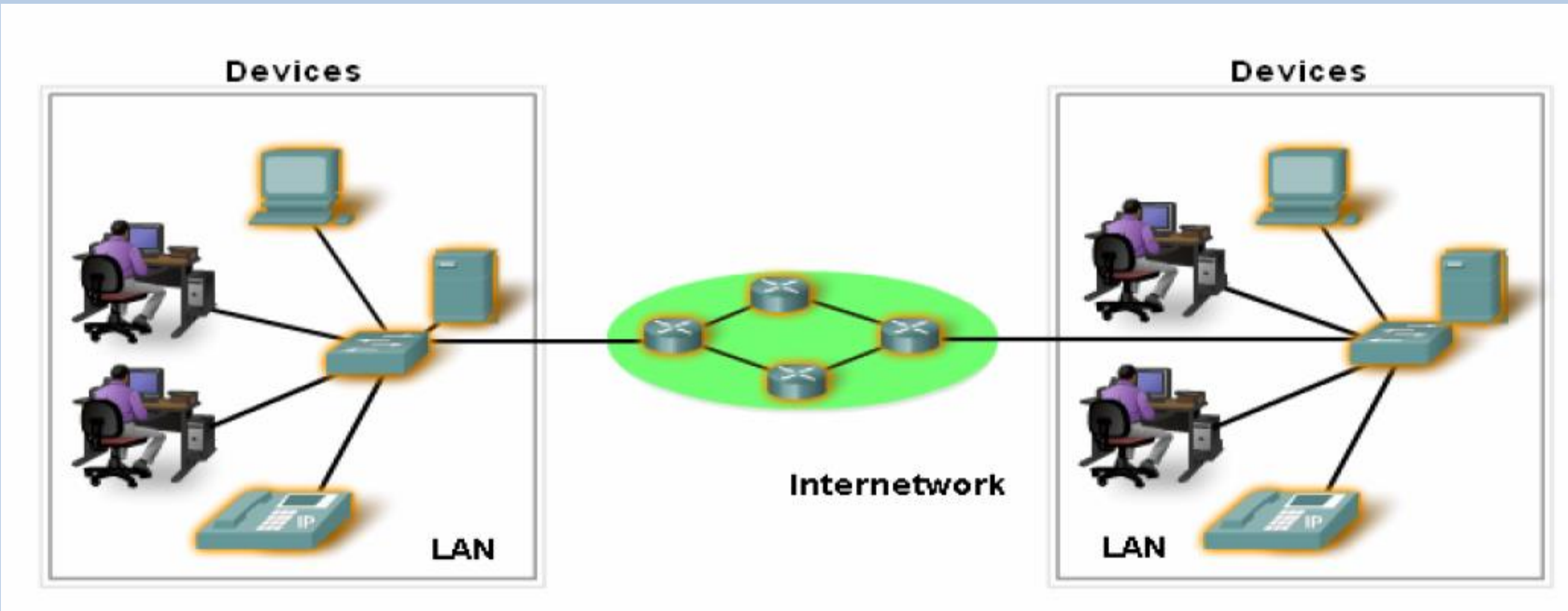
Computer network

- It is possible to connect a **number of computers** and other **electronic devices** to form what is called a **computer network**.
- The computers and devices which are part of the network can "talk" to each other and **exchange information**. In addition to the computers and devices which are connected, other devices are often needed for the network to operate properly.
- Examples for such devices include hubs and switches. A network using one technology can be connected to another one using a different technology with a component which is known as router.
- **A network is a group of two or more computer systems linked together through communication channels .**

Computer network



Uses of Computer Networks

- **Communication is almost as important to us as our reliance on air, water, food, and shelter.**

Applications help us to

- Chatting
- Download Files
- Purchasing
- Read News
- See & speak to others
- Education
- Sharing
- Many other things

Uses of Computer Networks

1- Business Applications

- Most companies have a substantial number of computers. For example, a company may have a computer for each worker and use them to **design products**, **write brochures**, and do the **payroll**.
- The goal is to make all **programs, equipment, and especially data** available to **anyone** on the network without regard to the physical location of the resource or the user as shown in Figure 1.1.

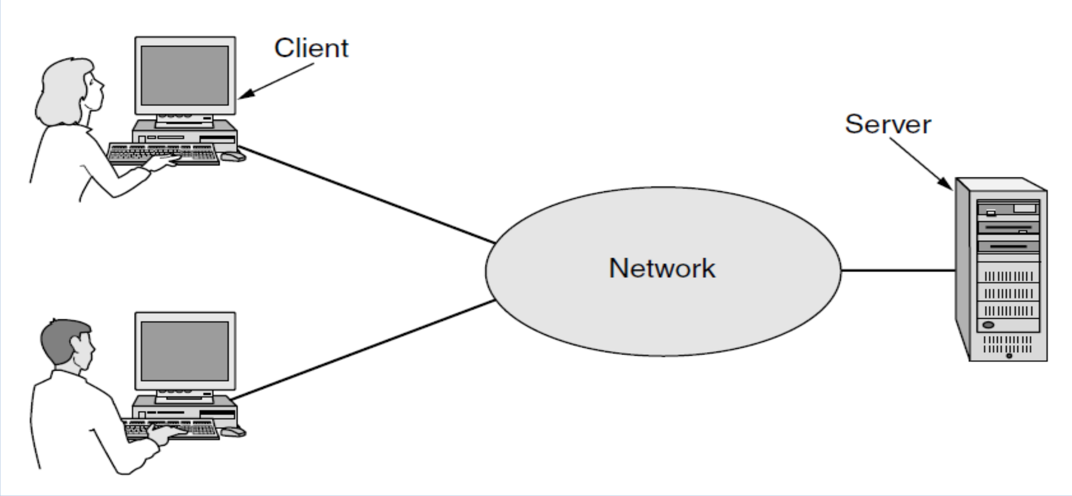
Uses of Computer Networks

- In the simplest of terms, one can imagine a company's information system as consisting of **one or more databases** with company information and some number of **employees** who need to access them remotely., This called client/server model.

- In this model, the **data** are stored on **powerful computers** called **servers**. Often these are centrally housed and maintained by a system **administrator**. In contrast, the **employees** have simpler machines, called **clients**, on their desks, with which they **access remote data.**

Client/server model

- In the client/server model, the **device requesting the information is called a client** and the **device responding to the request is called a server**. The client and server machines are connected by a **network**, as illustrated in Figure 1.2.

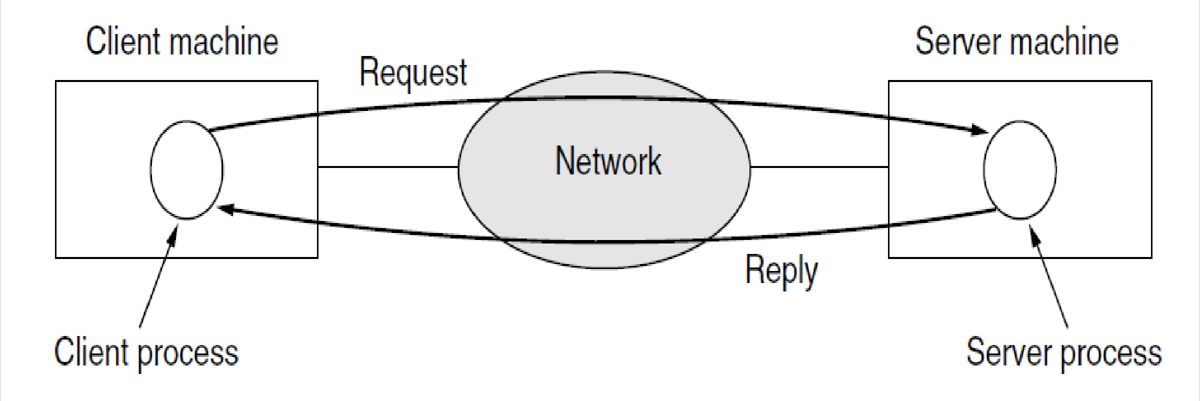


Client/server model

- The most popular realization is that of a **Web application**, in which the server generates Web pages based on its database in response to client requests that may update the database.
- The client-server model is **applicable** when the client and server are both in the **same building** (and belong to the same company), but also when they are **far** apart.

Client/server model

- If we look at the client-server model in detail, we see that **two processes** (i.e., **running programs**) are involved, **one on the client machine** and **one on the server machine**. Communication takes the form of the **client process sending a message over the network to the server process**. **The client process then waits for a reply message.** When the server process gets the request, it performs the requested work or looks up the requested data and sends back a reply. These messages are shown in Figure 1.3.



Uses of Computer Networks

2- Home Applications

- Home users can **access information**, **communicate with other people**, and **buy products** and **services with e-commerce**.

- Information available includes the **arts, business, cooking, government, health, history, hobbies, recreation, science, sports, travel, and many** others.

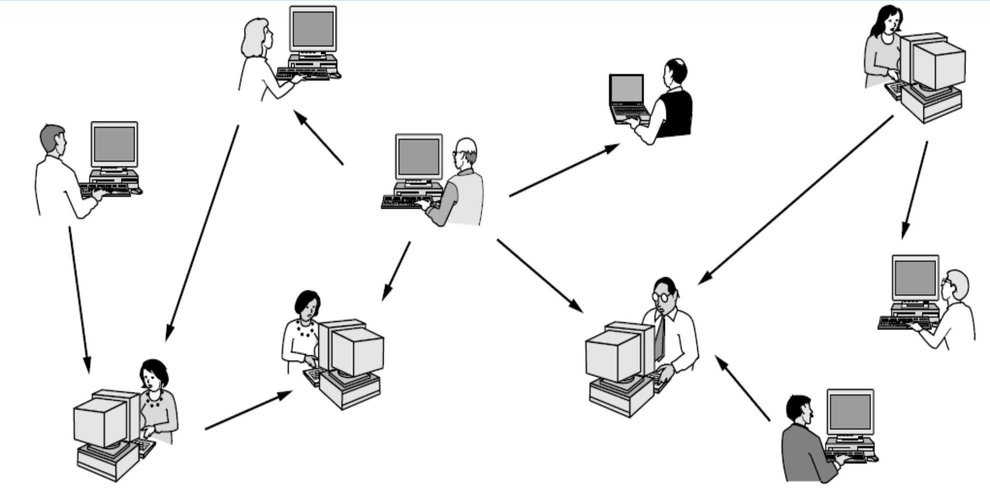
- Popular model for accessing information that goes by the name of **Peer-to-Peer** communication.

Peer-to-Peer network

- In a **peer-to-peer network**, two or more computers are connected via a network and can share resources (such as printers and files) without having a **dedicated server**.

- Every connected end device (**known as a peer**) can function as **either a server or a client**. One computer might assume the **role of server for one transaction** while **simultaneously serving as a client for another**.

Peer-to-Peer network



- Unlike the client/server model, which uses dedicated servers, peer-to-peer networks **decentralize the resources on a network**. Instead of locating information to be shared on dedicated servers, information can be located anywhere on any connected device.
- It is **difficult to enforce security and access policies** in networks containing more than just a few computers.

Uses of Computer Networks

3- Mobile Users

- People on the go often **want to use their mobile devices to read and send email, tweet, watch movies, download music, play games, or simply to surf the Web for information**. They want to do all of the things they do at home and in the office. **Naturally, they want to do them from anywhere on land, sea or in the air.**
- **Connectivity** to the Internet enables many of these mobile uses. Since having a **wired connection is impossible** in **cars, boats, and airplanes**, there is a lot of interest in **wireless networks.**
- **Example: Smart phones, GPS, mobile-commerce, Sensor networks .**

Uses of Computer Networks

4- Social Issues

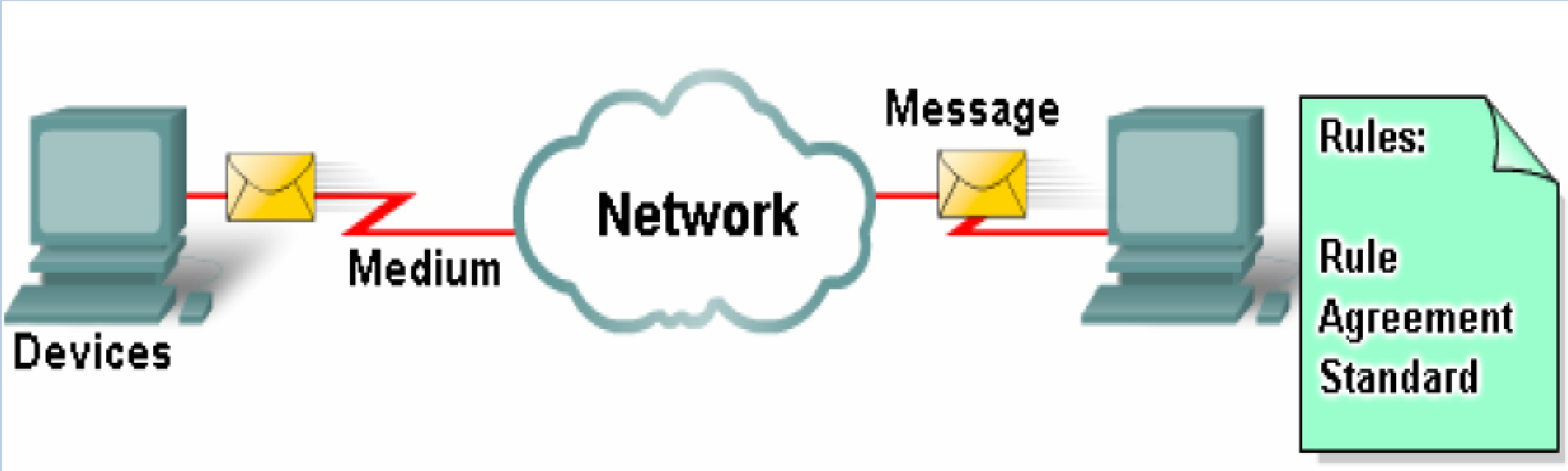
- Social networks, message boards, content sharing sites, and a host of other applications allow people to share their views with like-minded individuals. As long as the subjects are restricted to technical topics or hobbies like gardening, not too many problems will arise. These problems such as Copyright, versus, cookies, spam, …etc.

Networks

- A network is a **set of devices** (often referred to as nodes) connected by **communication links**.
- 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.

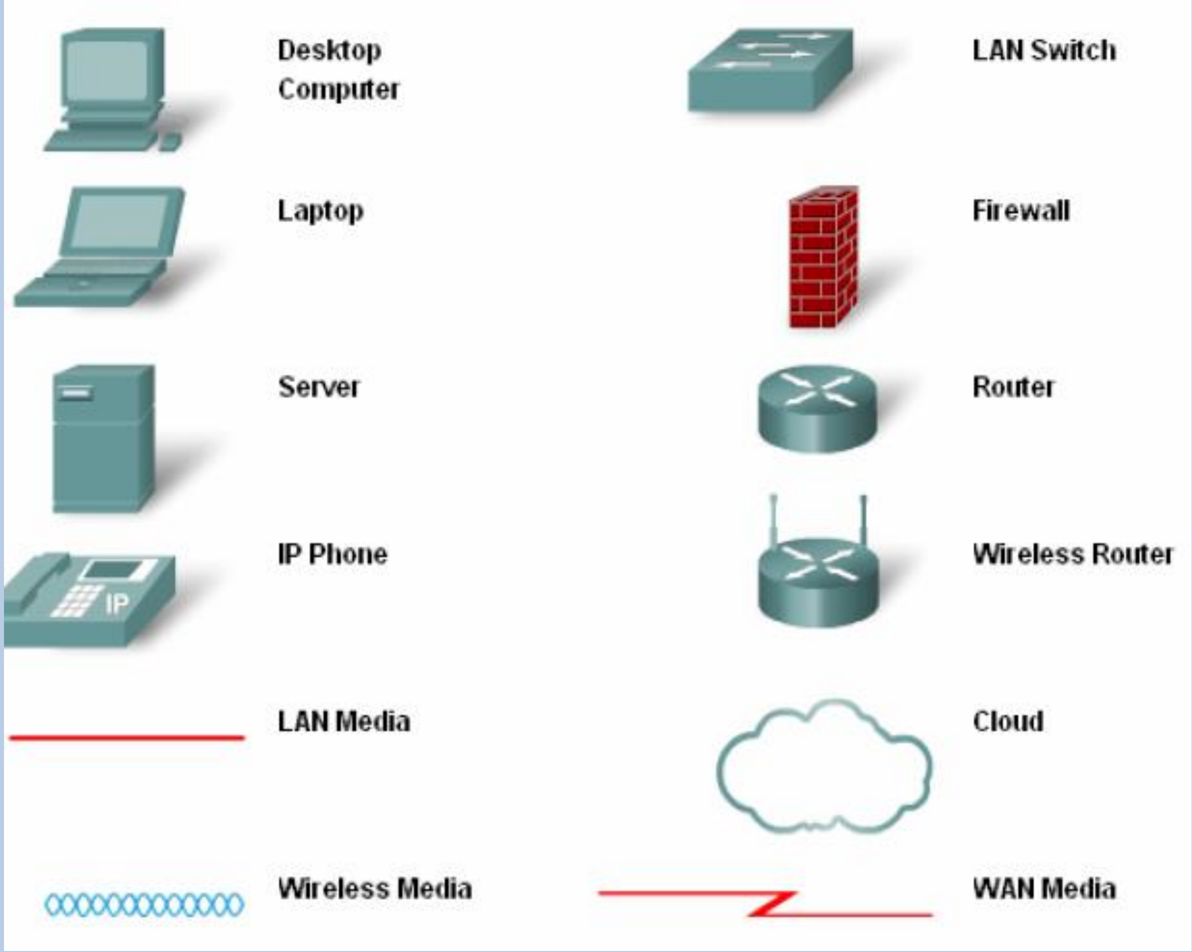
- Most networks use **distributed processing**, in which a **task is divided among multiple computers**. Instead of one single large machine being responsible for all aspects of a process, separate computers (usually a personal computer or workstation) handle a subset.

The Elements of Computer Network

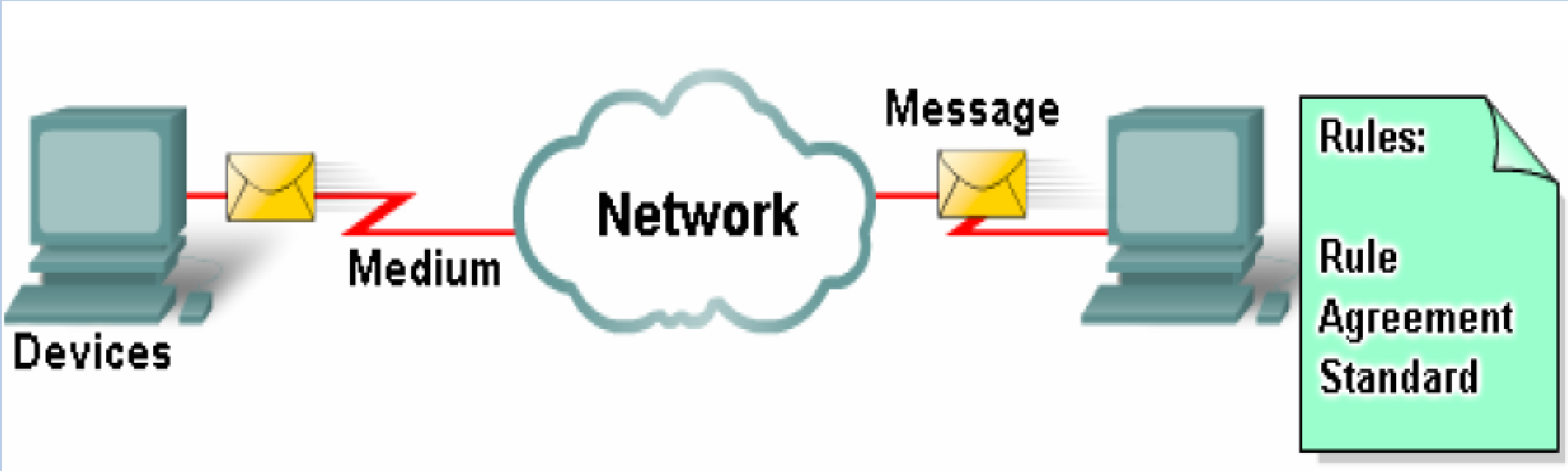


- The **devices must be interconnected**. Network connections can be **wired** or **wireless**. In **wired connections,** the **medium** is either **copper**, which carries electrical signals, or **optical fiber**, which carries light signals. In **wireless connections**, the medium is the **Earth's atmosphere**, or **space**, and the signals are **microwaves**.

The Elements of Computer Network

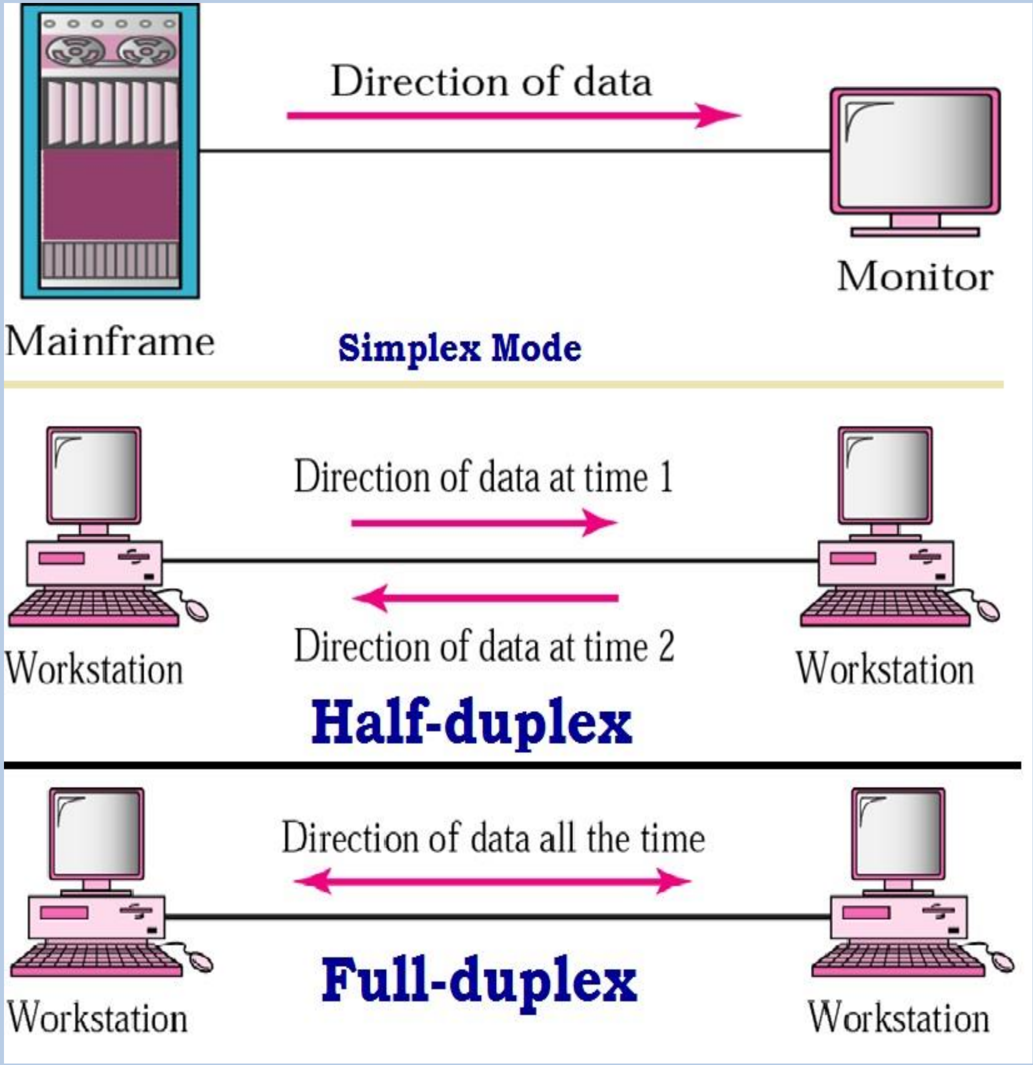


The Elements of Computer Network



- Devices interconnected by medium to provide services must be governed by **rules**, or **protocols**.
- The **Protocols** are the rules that the networked devices use to communicate with each other. The industry standard in networking today is a set of protocols called **TCP/IP** (Transmission Control Protocol/Internet Protocol).

Data Flow



Direction of data
Monitor
Mainframe
Simplex Mode
Direction of data at time 1
Direction of data at time 2
Workstation
Workstation
Half-duplex
Direction of data all the time
Full-duplex
Workstation
Workstation

Network Criteria

a) Performance

- Performance can be measured in many ways, including **transit time** and **response time**.
- **Transit time** is the amount of time required for a message to travel from one device to another.
- **Response time** is the elapsed time between an inquiry and a response.
- The performance of a network depends on a number of factors, including the number of users, the type of transmission medium, the capabilities of the connected hardware, and the efficiency of the software.

Network Criteria

- **Performance** is often evaluated by two networking metrics: throughput and delay.
- We often need more throughput and less delay. However, these two criteria are often contradictory. If we try to send more data to the network, we may increase throughput but we increase the delay because of traffic congestion in the network.

Network Criteria

b) Reliability

- In addition to accuracy of delivery, network reliability is measured by the frequency of failure, the time it takes a link to recover from a failure, and the network's robustness in a catastrophe.

c) Security

- Network security issues include protecting data from unauthorized access, protecting data from damage and development, and implementing policies and procedures for recovery from breaches and data losses.

Categories of Networks

- **Categories of Networks**
  - **Connection Type**
    - Point-to-point
    - Multipoint.
  - **Topology**
    - Mesh
    - Bus
    - Star
    - Ring.
  - **Distance**
    - PAN
    - LAN
    - MAN
    - WAN

Classifications Based on Type of Connection

A link is a communications channel that transfers data from one device to another.

1. **Point-to-Point**: A point-to-point connection provides a dedicated link between two devices.

a) Point-to-point

The entire capacity of the link is reserved for transmission between those two devices

Classifications Based on Type of Connection

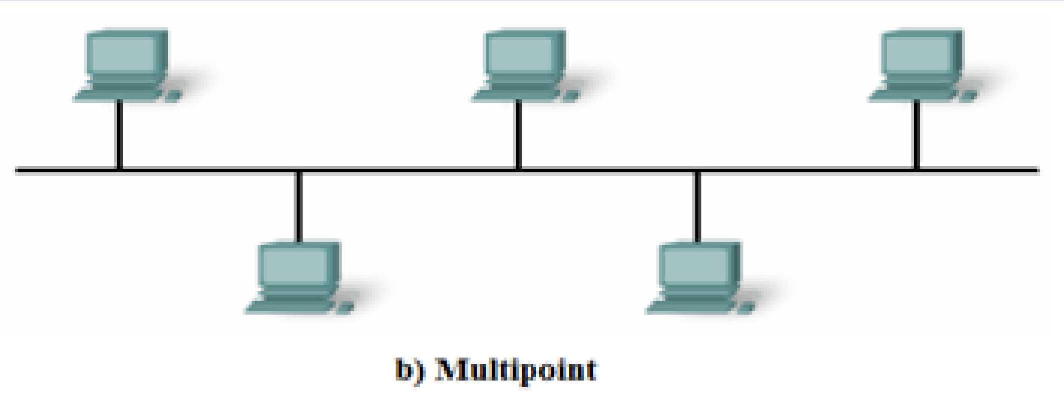
- The short messages called packets in certain contexts, may have to first visit one or more intermediate machines. Often multiple routes, of different lengths, are possible, so finding good ones is important in point-to-point networks.

- When you change television channels by infrared remote control, you are establishing a point-to-point connection between the remote control and the television's control system.

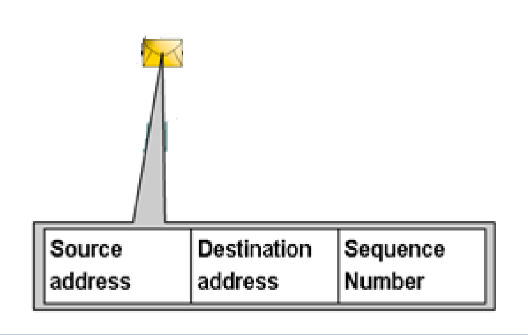
- Point-to-point transmission with exactly one sender and exactly one receiver is sometimes called unicasting.

Classifications Based on Type of Connection

2- Multipoint network (also called **broadcast)**: 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.

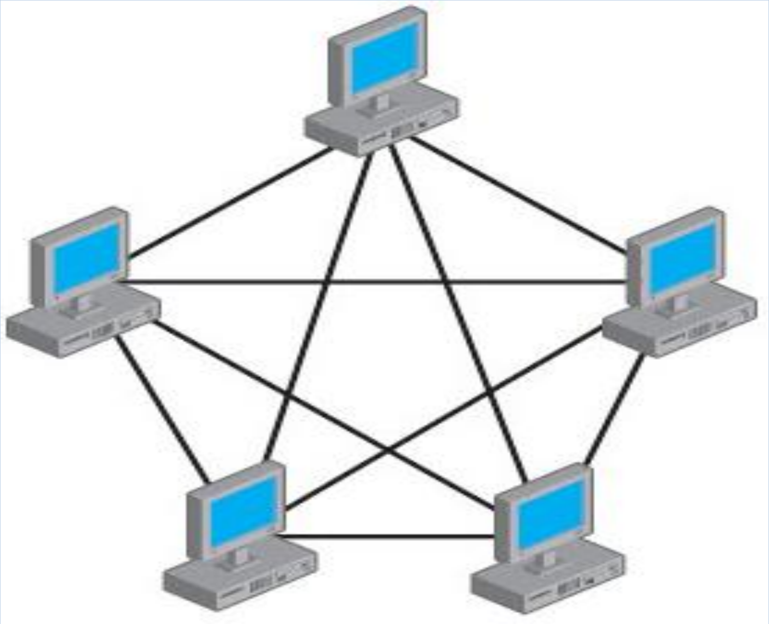


Classifications Based on Topology

- The term topology refers to the way in which a network is laid out **physically**. ***Two or more devices connect to a link***; two or more links form a topology.
- The topology of a network is the **geometric representation** of the relationship of all the links and linking devices (usually called nodes) to one another.
- There are four basic topologies possible: **mesh**, **bus**, **star**, and **ring**.

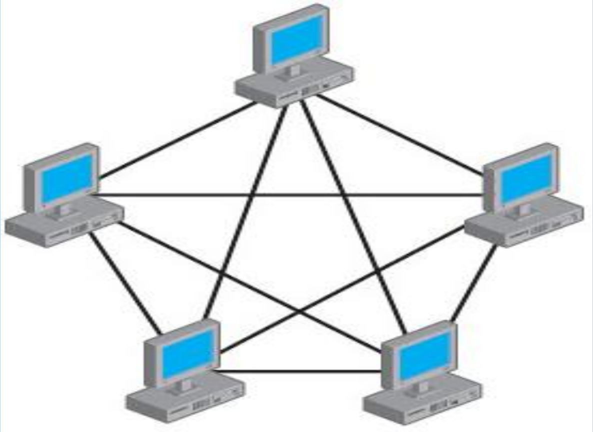
Classifications Based on Topology (Mesh)

- In a mesh topology, every device has a dedicated point-to-point link to every other device.
- The term dedicated means that the link carries traffic only between the two devices it connects.



Classifications Based on Topology (Mesh)

- In a **fully connected mesh** network, we need ***n(n - 1)*** physical links (Simple mode).
- However, if each physical link allows communication in both directions (duplex mode), we can divide the number of links by 2. In other words, we can say that in a mesh topology, we need ***n(n - 1)/2***.



Classifications Based on Topology (Mesh)

A mesh offers several advantages over other network topologies.

- **First**, the use of **dedicated links guarantees** that each connection can **carry its own data load**, thus **eliminating the traffic problems** that can occur when links must be shared by multiple devices.
- **Second**, a mesh topology is **robust**. If one link becomes unusable, it does not incapacitate the entire system.
- **Third**, there is the advantage of **privacy or security**. When every message travels along a dedicated line, only the intended recipient sees it. Physical boundaries prevent other users from gaining access to messages.
- **Finally**, point-to-point links make **fault identification** and **fault isolation easy**.

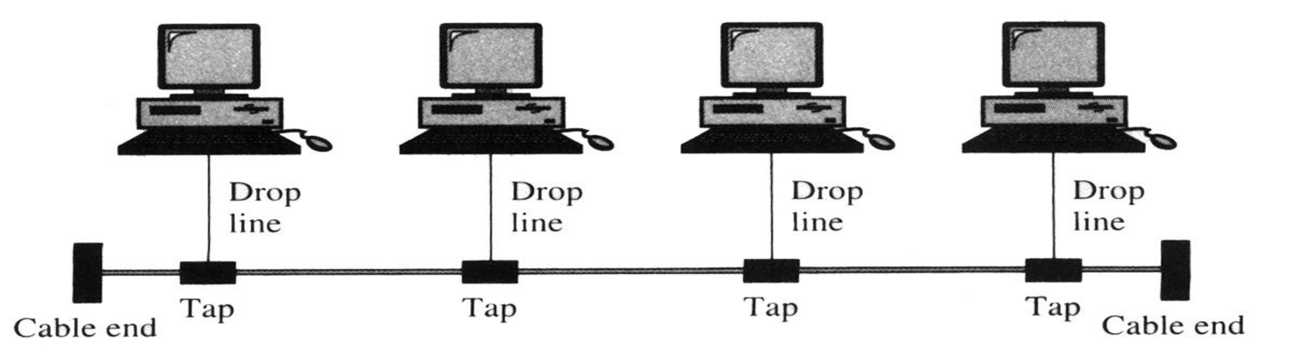
Classifications Based on Topology (Mesh)

- The main **disadvantages** of a mesh are related to the amount of cabling and the number of I/O ports required.
- **First**, because **every device must be connected to every other device**, **installation and reconnection are difficult**.
- **Second**, the sheer **bulk of the wiring** can be greater than the available space (in walls, ceilings, or floors) can accommodate.
- **Finally**, the hardware required to connect each link (I/O ports and cable) can be prohibitively **expensive**. For these reasons a mesh topology is usually implemented in a **limited fashion.**

Classifications Based on Topology (Bus)

- Nodes are connected to the **bus cable** by drop lines and taps. A drop line is a connection running between the device and the main cable. A **tap is a connector**.

Bus is multipoint



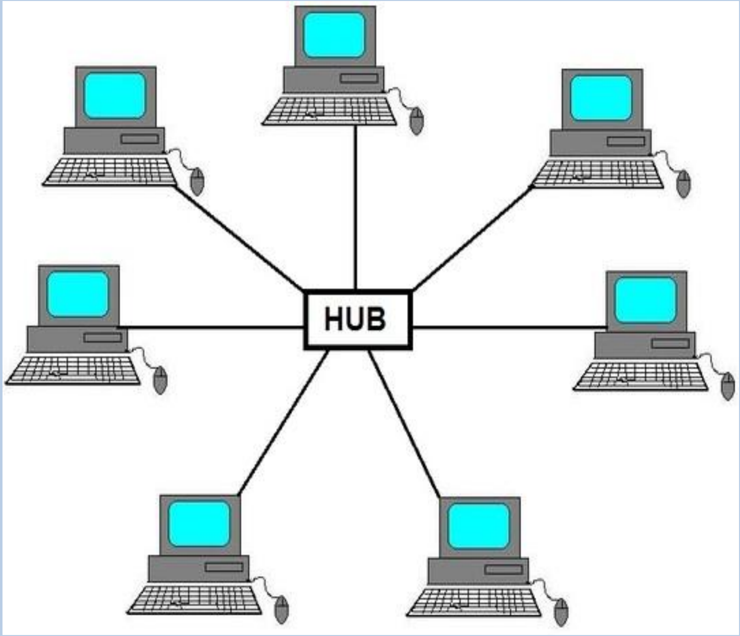
As a signal travels along the backbone, some of its energy is transformed into heat. Therefore, it **becomes weaker and weaker as it travels farther and farther**. For this reason there is a limit on the number of taps a bus can support and on the distance between those taps.

Classifications Based on Topology (Bus)

- **Advantages** of a bus topology include **ease of installation**. A bus uses **less** cabling than mesh or star topologies.
- **Disadvantages** include **difficult reconnection and fault isolation**.
- A bus is usually designed to be optimally efficient at installation. It can therefore be **difficult to add new devices**.
- **Signal reflection** at the taps can cause degradation in quality. This degradation can be controlled by **limiting the number and spacing of devices connected to a given length of cable**. **Adding new devices** may therefore **require modification or replacement of the backbone**.

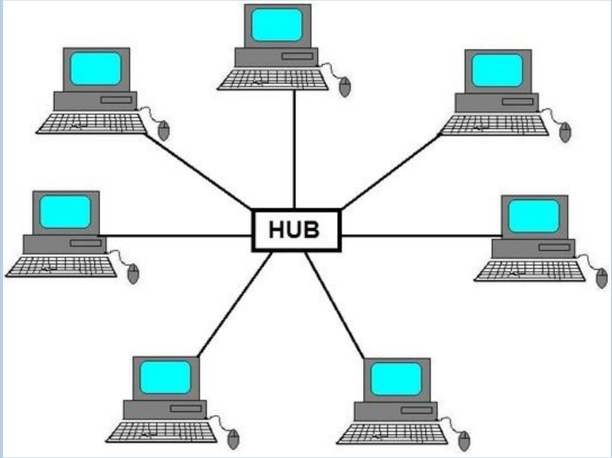
Classifications Based on Topology (Star)

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



Classifications Based on Topology (Star)

- The devices are **not directly linked to one another**. Unlike a mesh topology, a star topology does not allow direct traffic between devices. The **controller acts as an exchange**: If one device wants to send data to another, it sends the data to the controller, which then relays the data to the other connected device.



Classifications Based on Topology (Star)

- **Advantages:** A star topology is **less expensive** than a mesh topology.
- In a star, each device needs **only one link** and **one I/O port** to connect it to any number of others. This factor also makes it **easy to install** and reconfigure. Far **less cabling** needs to be **additions** and **deletions** involve **only one connection**: between that device and the hub.
- **Other advantages** include robustness. **If one link fails**, only that link is affected. All other links remain active. This factor also lends itself to **easy fault identification** and **fault isolation**. As long as the hub is working, it can be used to monitor link problems and by pass defective links.
-

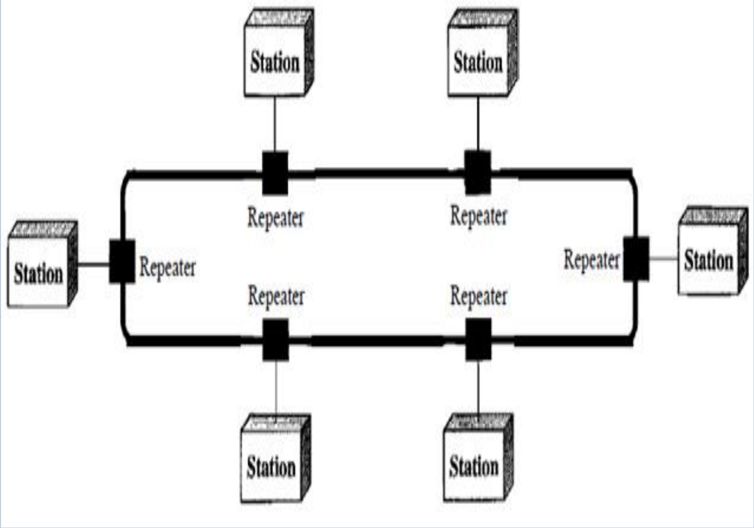
Classifications Based on Topology (Star)

- One **big** **disadvantage** of a star topology is the dependency of the whole topology on one single point, the **hub**. If the **hub goes down**, the whole system is dead.
- Although a star requires far **less cable than a mesh**, each node must be linked to a central hub. For this reason, often **more cabling is required in a star than in some other topologies** (such as ring or bus).

Classifications Based on Topology (Ring)

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

A signal is passed along the ring in one direction, from device to device, until it reaches its destination. Each device in the ring incorporates a **repeater**. When a device receives a signal intended for another device, its repeater regenerates the bits and passes them along.



Classifications Based on Topology (Ring)

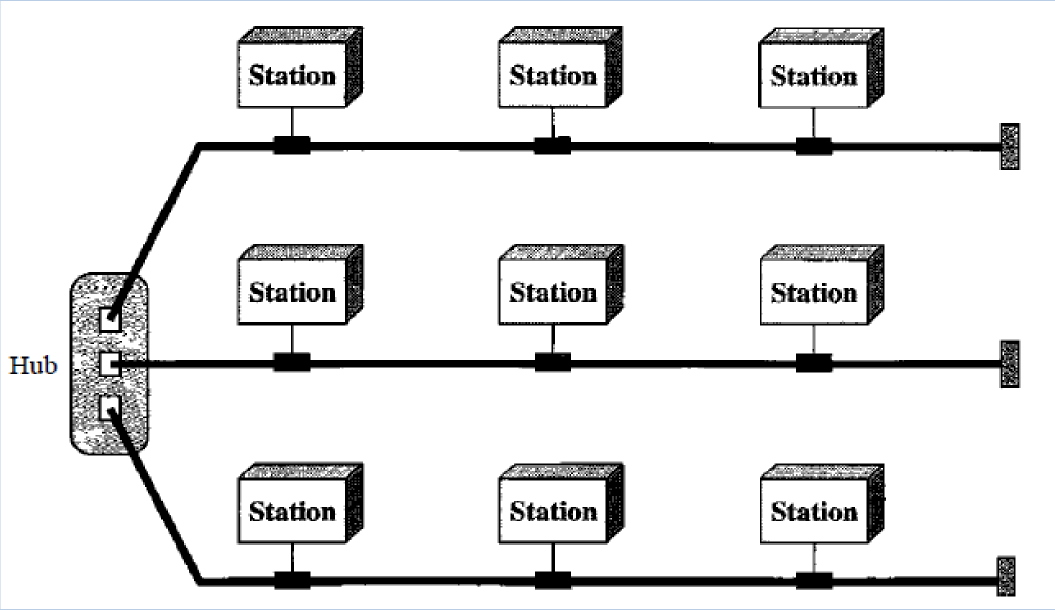
- **Disadvantages:**
- A ring is relatively **easy to install and reconfigure**. Each device is linked to only its immediate neighbors (either physically or logically). To add or delete a device requires changing only two connections.
- In addition, **fault isolation** is simplified.
- Generally in a ring, a signal is circulating at all times. If one device **does not receive a signal** within a **specified period**, it can issue an **alarm**. The alarm alerts the network operator to the problem and its location.

Classifications Based on Topology (Ring)

- However, unidirectional traffic can be a **disadvantage**.
- In a simple ring, a break in the ring (such as a disabled station) can disable the entire network. This weakness can be solved by using a **dual ring** or a switch capable of closing off the break.

Classifications Based on Topology (Hybrid)

- A network can be hybrid. For example, we can have a main star topology with each branch connecting several stations in a bus topology.



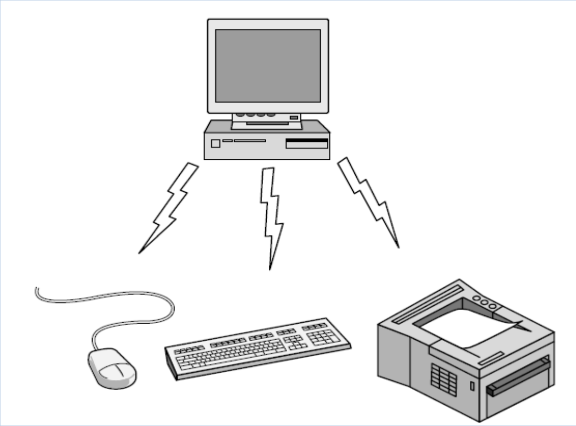
Classifications Based on Distance

- Distance is important as a classification metric because different technologies are used at different scales. The Table (1.1) display the classification of multiple processor systems by their rough physical size.

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

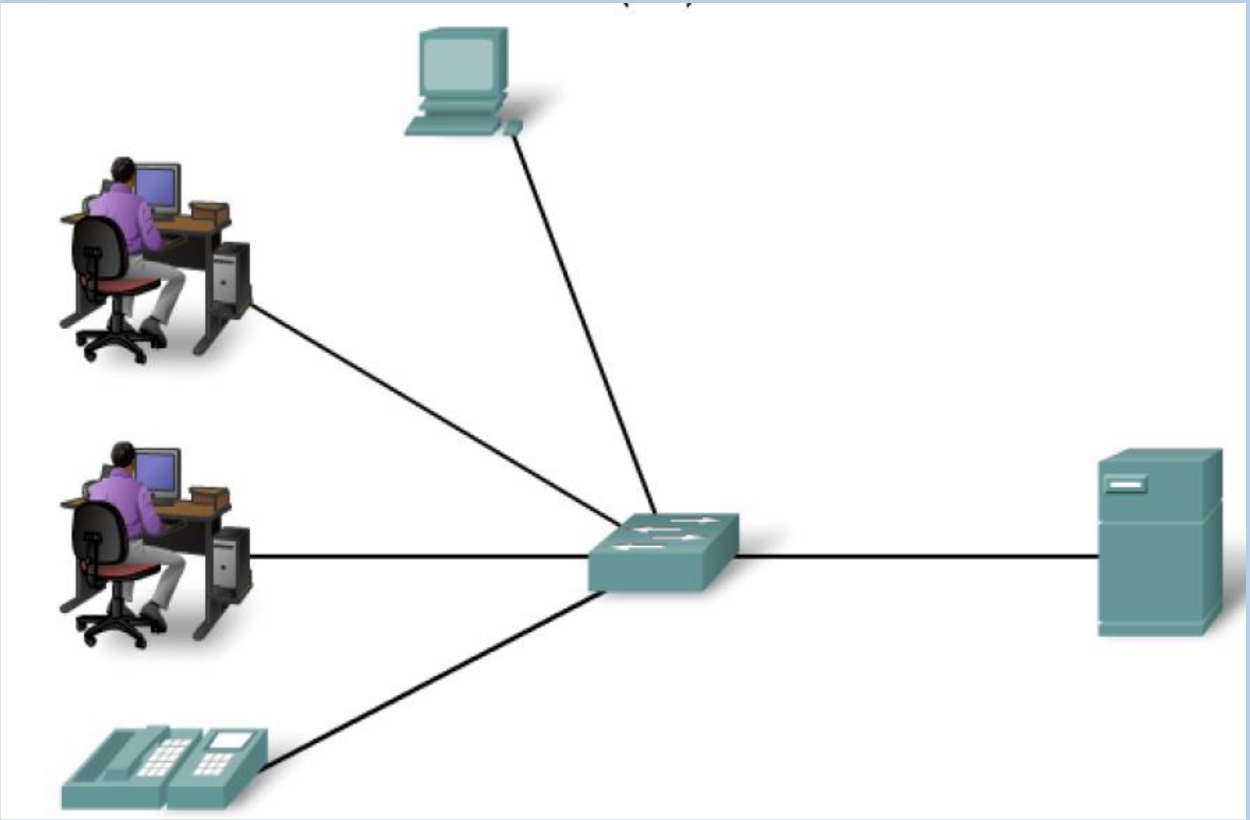
Classifications Based on Distance (PANs)

- PANs (Personal Area Networks) let devices communicate over the range of a person. A common example is a (wire or wireless) network that connects a computer with its peripherals. Almost every computer has an attached monitor, keyboard, mouse, and printer.
- One example, short-range wireless network called **Bluetooth.**



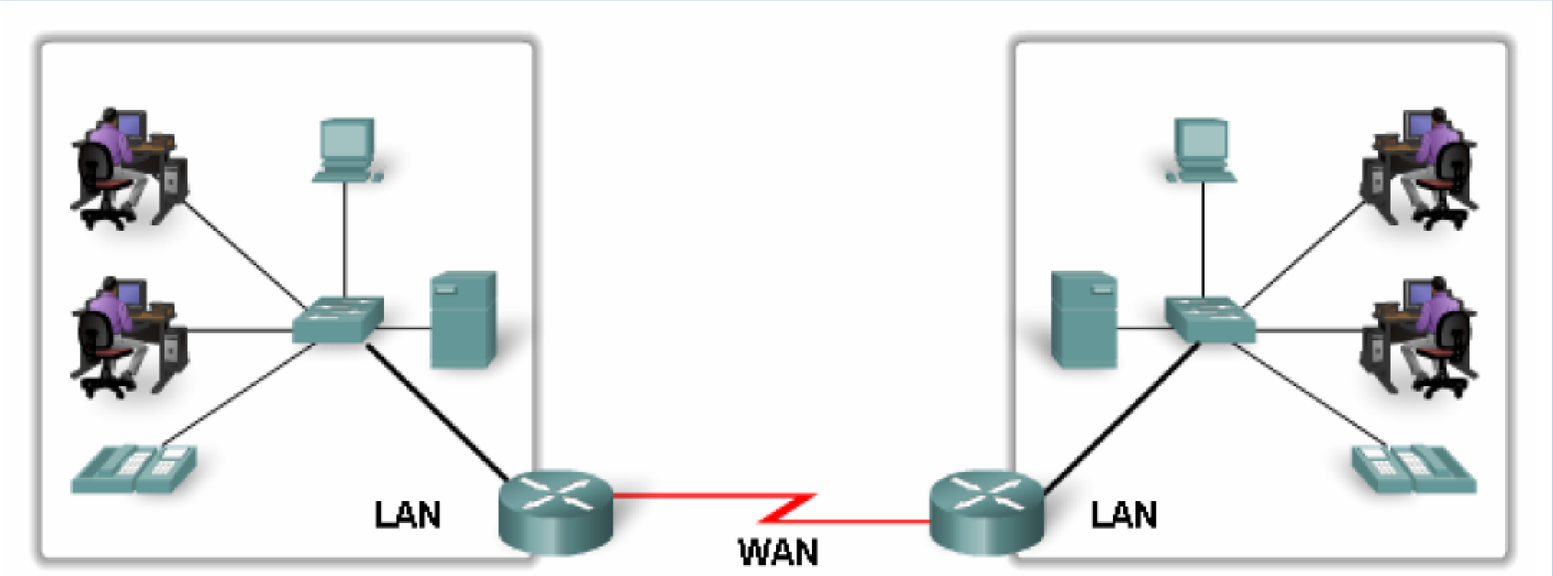
Classifications Based on Distance (LAN)

- A local area network (LAN) is usually privately owned and links the devices in a single office, building, or campus.



Classifications Based on Distance (WAN)

- 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.



Classifications Based on Distance (MAN)

- A metropolitan area network (MAN) is a network with a **size between a LAN and a WAN**. It normally covers the area inside a town or a city.
- Example is the telephone company network and cable TV network.