

# Unit I

## Chapter 1

Reference: Data Communication and  
Networking, Behrouz A Forouzan,  
**McGraw Hill, 5th Edition,**  
2008.

# Unit I partial Syllabus

Data Communications, Networks, Network Types, Network Models – Protocol layering, TCP/IP Protocol Suite, The OSI Model, Physical layer: Transmission impairment, Data Rate Limits, Performance.

# 1. Data Communications

- The term ***telecommunication***, which includes telephony, telegraphy, and television, means communication at a distance.
- The word ***data*** refers to information presented in whatever form is agreed upon by the parties creating and using the data.
- **Data communications** are the exchange of data between two devices via some form of transmission medium such as a wire cable.
- For data communications to occur, the communicating devices must be part of a communication system made up of a **combination of hardware (physical equipment) and software (programs)**.
- The effectiveness of a data communications system depends on four fundamental characteristics: **delivery, accuracy, timeliness, and jitter**.

# 1. Data Communications contd.

- **Fundamental Characteristics :**

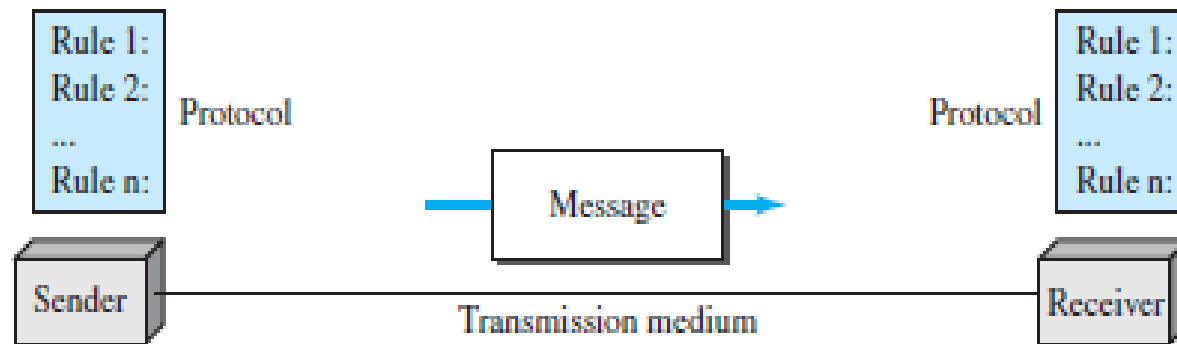
- **Delivery.** The system must deliver data to the correct destination. Data must be **received by the intended device or user** and only by that device or user.
- **Accuracy.** The system must deliver the data accurately. Data that have been **altered** in transmission and left uncorrected are unusable.
- **Timeliness.** The system must deliver data in a timely manner. **Data delivered late are useless.** In the case of **video and audio**, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called **real-time transmission**.
- **Jitter.** Jitter refers to the **variation in the packet arrival time**. It is the **uneven delay** in the delivery of audio or video packets. For example, let us assume that video packets are sent every 30 ms. If some of the packets arrive with 30-ms delay and others with 40-ms delay, an uneven quality in the video is the result.

# 1.1.1 Components

- A data communications system has five components:
- **1. Message.** The message is the **information (data) to be communicated**. Popular forms of information include text, numbers, pictures, audio, and video.
- **2. Sender.** The sender is the **device that sends the data message**. It can be a computer, workstation, telephone handset, video camera, and so on.
- **3. Receiver.** The receiver is the device that **receives the message**. It can be a computer, workstation, telephone handset, television, and so on.
- **4. Transmission medium.** The transmission medium is the **physical path by which a message travels** from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.
- **5. Protocol.** A protocol is a **set of rules that govern data communications**. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating.

# 1.1.1 Components Contd.

**Figure 1.1** *Five components of data communication*



# 1.1.2 Data Representation

- Information today comes in different forms such as text, numbers, images, audio, and video.
- **Text**
  - In data communications, text is represented as a bit pattern, a sequence of bits (0s or 1s).
  - Different sets of **bit patterns** have been designed to represent text symbols.
  - Each set is called a code, and the process of representing symbols is called **coding**.
  - Today, the prevalent coding system is called Unicode, which uses 32 bits to represent a symbol or character used in any language in the world.
  - The American Standard Code for Information Interchange (**ASCII**), developed some decades ago in the United States, now constitutes the first 127 characters in **Unicode** and is also referred to as Basic Latin.
- **Numbers**
  - Numbers are also represented by bit patterns.
  - However, a code such as ASCII is not used to represent numbers; the number is directly converted to a **binary number** to simplify mathematical operations.

# 1.1.2 Data Representation Contd.

- ***Images***

- Images are also represented by **bit patterns**.
- In its simplest form, an image is composed of a matrix of **pixels** (picture elements), where each pixel is a small dot.
- The size of the pixel depends on the **resolution**.
- For example, an image can be divided into 1000 pixels or 10,000 pixels. In the second case, there is a better representation of the image (better resolution), but more memory is needed to store the image.
- After an image is divided into pixels, each pixel is assigned a bit pattern.
- The size and the value of the pattern depend on the image.



# 1.1.2 Data Representation Contd.

- For an image made of only **black-and-white dots** (e.g., a chessboard), a **1-bit pattern** is enough to represent a pixel.
- If an image is not made of pure white and pure black pixels, we can increase the size of the bit pattern to include gray scale. For example, to show four levels of gray scale, we can use 2-bit patterns. A **black pixel can be represented by 00, a dark gray pixel by 01, a light gray pixel by 10, and a white pixel by 11.**
- There are several methods to represent color images. One method is called **RGB**, so called because each color is made of a combination of three primary colors: **red, green, and blue**. The intensity of each color is measured, and a bit pattern is assigned to it.
- Another method is called **YCM**, in which a color is made of a combination of three other primary colors: **yellow, cyan, and magenta**.

# 1.1.2 Data Representation Contd.

- ***Audio***

- Audio refers to the recording or broadcasting of sound or music.
- Audio is by nature different from text, numbers, or images.
- It is **continuous**, not discrete. Even when we use a microphone to change voice or music to an electric signal, we create a continuous signal.

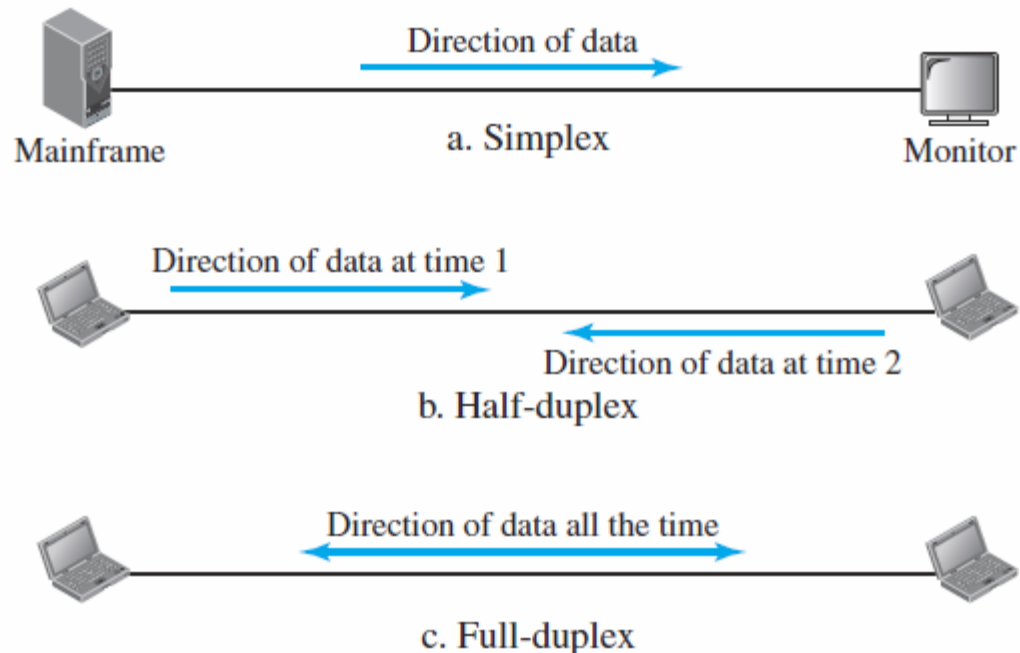
- ***Video***

- Video refers to the recording or broadcasting of a picture or movie.
- Video can either be produced as a continuous entity (e.g., by a TV camera), or it can be a combination of images, each a discrete entity, arranged to convey the idea of motion.

# 1.1.3 Data Flow

- Communication between two devices can be simplex, half-duplex, or full-duplex as shown in Figure 1.2.

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



# 1.1.3 Data Flow Contd.

- ***Simplex***
  - In **simplex mode**, the communication is **unidirectional**.
  - **Only one** of the two devices on a link **can transmit**; the other can only receive.
  - **Keyboards and traditional monitors** are examples of simplex devices.
  - The keyboard can only introduce input; the monitor can only accept output.
  - The simplex mode can **use the entire capacity of the channel** to send data in one direction.

# 1.1.3 Data Flow Contd.

- ***Half-Duplex***
  - In **half-duplex mode**, each station can both transmit and receive, but not at the same time.
  - When one device is sending, the other can only receive, and vice versa (see Figure 1.2b).
  - In a half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time.
  - Walkie-talkies and CB (citizens band) radios are both half-duplex systems.
  - The half-duplex mode is used in cases where there is no need for communication in both directions at the same time; the entire capacity of the channel can be utilized for each direction.

# 1.1.3 Data Flow Contd.

- **Full-Duplex**
  - In **full-duplex mode** (also called *duplex*), *both stations can transmit and receive simultaneously* (see Figure 1.2c).
  - In full-duplex mode, signals going in one direction **share the capacity** of the link with signals going in the other direction.
  - This sharing can occur in **two ways**:
    - Either the link must **contain two physically separate transmission paths**, one for sending and the other for receiving; or the **capacity of the channel is divided** between signals traveling in both directions.
  - One common example of full-duplex communication is the **telephone network**.
  - The full-duplex mode is used when communication in both directions is required all the time.

# 1.2 NETWORKS

- A **network** is the **interconnection of a set of devices capable of communication**.
- In this definition, a device can be a **host** (or an *end system*) *such as a* large computer, desktop, laptop, workstation, cellular phone, or security system.
- A device in this definition can also be a connecting device such as a **router**, which connects the network to other networks, a switch, which connects devices together, a modem (modulator-demodulator), which changes the form of data, and so on.
- These devices in a network are connected using **wired or wireless transmission media** such as cable or air.
- When we connect two computers at home using a plug-and-play router, we have created a network, although very small.

# 1.2.1 Network Criteria

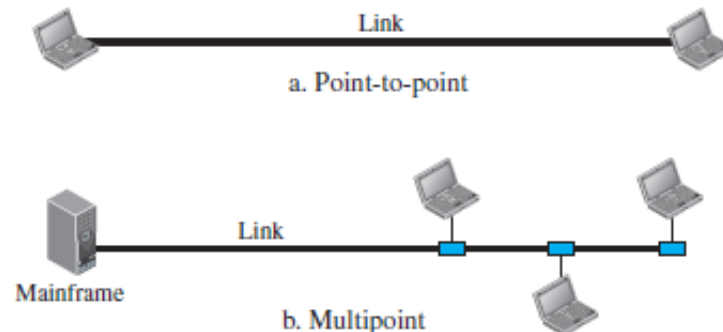
- A network must be able to meet a certain number of criteria. The most important of these are performance, reliability, and security.
- **Performance**
  - Performance can be measured in many ways, including **transit time and response time**.
  - **Transit time** is the amount of time required for 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**.
  - Performance is often evaluated by two networking metrics: **throughput** and **delay**.
  - We often need **more throughput and less delay**.
- **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.
- **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.



# 1.2.2 Physical Structures

- **Type of Connection**
  - A network is two or more devices connected through links.
  - A **link** is a communications pathway that transfers data from one device to another.
  - For communication to occur, two devices must be connected in some way to the same link at the same time.
  - There are two possible types of connections: **point-to-point** and **multipoint**.
- **Point-to-Point**
  - A point-to-point connection provides a **dedicated link between two devices**.
  - The entire capacity of the link is reserved for transmission between those two devices.
  - Most point-to-point connections use an **actual length of wire or cable** to connect the two ends, but other options, such as **microwave or satellite links**, are also possible.
  - When we change **television** channels by **infrared remote control**, we are establishing a point-to-point connection between the remote control and the television's control system.

**Figure 1.3** *Types of connections: point-to-point and multipoint*



# 1.2.2 Physical Structures Contd.

- ***Multipoint***

- A multipoint (also called multidrop) connection is one in which more than **two specific devices share a single link** (see Figure 1.3b).
- In a multipoint environment, the capacity of the channel is shared, either spatially or temporally.
- If several devices can use the link simultaneously, it is a **spatially shared** connection.
- If users must take turns, it is a **timeshared connection**.

# 1.2.2 Physical Structures Contd.

- ***Physical Topology***

- The term physical 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, star, bus, and ring.**

# 1.2.2 Physical Structures Contd.

- **Mesh Topology**

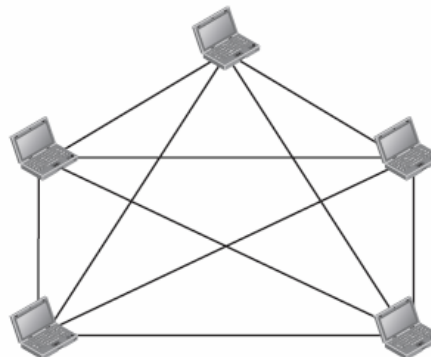
- In a mesh topology, every device has a **dedicated point-to-point link** to every other device.
- The term dedicated means that the link carries traffic only between the two devices it connects.
- To find the number of physical links in a fully connected **mesh network** with  $n$  nodes, we first consider that each node must be connected to every other node.
- Node 1 must be connected to  $n - 1$  nodes, node 2 must be connected to  $n - 1$  nodes, and finally node  $n$  must be connected to  $n - 1$  nodes.
- We need  **$n(n - 1)$  physical links**.
- 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  **$n(n - 1) / 2$  duplex-mode links**.
- To accommodate that many links, every device on the network must **have  $n - 1$  input/output (I/O) ports** (see Figure 1.4) to be connected to the other  $n - 1$  stations.

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**Figure 1.4** A fully connected mesh topology (five devices)

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$n = 5$   
10 links.



# 1.2.2 Physical Structures Contd.

- 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**. Traffic can be routed to avoid links with suspected problems. This facility enables the network manager to discover the precise location of the fault and aids in finding its cause and solution.

## 1.2.2 Physical Structures Contd.

- 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, for example, as a **backbone** connecting the main computers of a hybrid network that can include several other topologies.
- One practical example of a mesh topology is the connection of **telephone regional offices** in which each regional office needs to be connected to every other regional office.

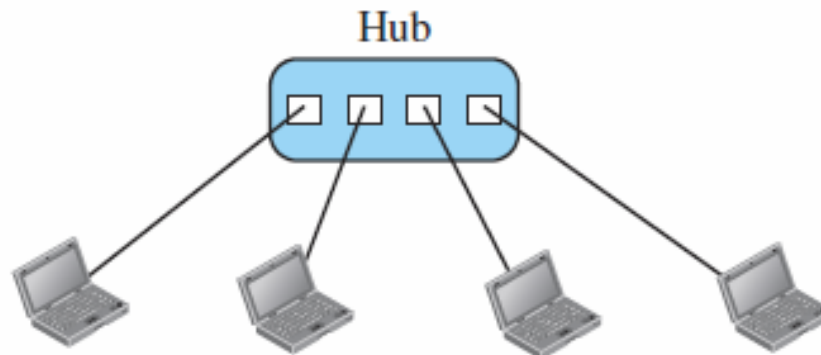
## 1.2.2 Physical Structures Contd.

- **Star Topology**
- In a star topology, **each device has a dedicated point-to-point link only to a central controller**, usually called a **hub**.
- 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 (see Figure 1.5) .

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**Figure 1.5** *A star topology connecting four stations*

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# 1.2.2 Physical Structures Contd.

- **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 housed, and additions, moves, and deletions involve only one connection: between that device and the hub.
- It is **robust** i.e 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 bypass defective links.

- **Disadvantage** of a star topology

- 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**).

- The star topology is used in local-area networks (LANs)



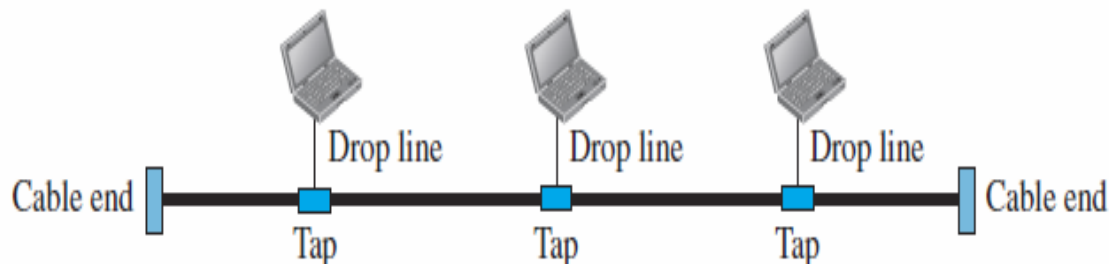
# 1.2.2 Physical Structures Contd.

- **Bus Topology**
- A **bus topology**, is multipoint.
- One long cable acts as a **backbone to link all the devices in a network** (see Figure 1.6).
- 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 that either **splices into the main cable** or punctures the sheathing of a cable to create a contact with the metallic core.
- 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.

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**Figure 1.6** *A bus topology connecting three stations*

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# 1.2.2 Physical Structures Contd.

- **Advantages of a bus topology**
  - **Ease of installation.** Backbone cable can be laid along the most efficient path, then connected to the nodes by drop lines of various lengths.
  - A bus uses **less cabling** than mesh or star topologies.
  - In a star, for example, four network devices in the same room require four lengths of cable reaching all the way to the hub. In a bus, this redundancy is eliminated. Only the backbone cable stretches through the entire facility.
  - Each drop line has to reach only as far as the nearest point on the backbone.
- **Disadvantages**
  - **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.
  - In addition, a **fault or break in the bus cable stops all transmission**, even between devices on the same side of the problem.
  - The **damaged area reflects signals back** in the direction of origin, creating noise in both directions.
- Bus topology was the one of the first topologies used in the design of early local area networks.

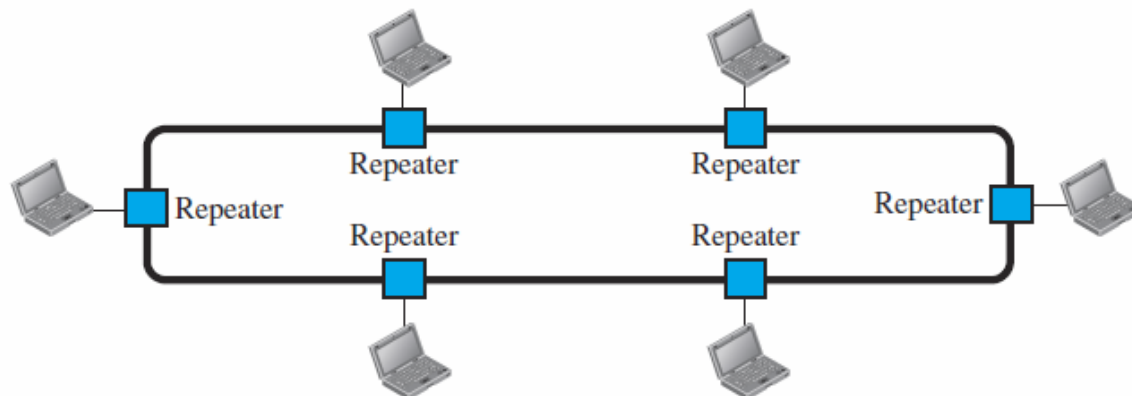
# 1.2.2 Physical Structures Contd.

- **Ring Topology**
- 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 (see Figure 1.7).
- A ring is relatively **easy to install and reconfigure.**
- Each device is **linked to only its immediate neighbors** (either physically or logically).

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**Figure 1.7** *A ring topology connecting six stations*

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# 1.2.2 Physical Structures Contd.

- **Advantages**
  - To add or delete a device requires **changing only two connections**.
  - The only constraints are **media and traffic considerations** (maximum ring length and number of devices).
  - 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.
- 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.
- Ring topology was prevalent when IBM introduced its local-area network, **Token Ring**.
- Today, the need for higher-speed LANs has made this topology less popular.

# 1.3 NETWORK TYPES

- Criteria of distinguishing one type of network from another is size, geographical coverage, and ownership.
  - Local Area Network
  - Wide Area Network
  - Switching
  - The Internet
  - Accessing the Internet

# 1.3.1 Local Area Network

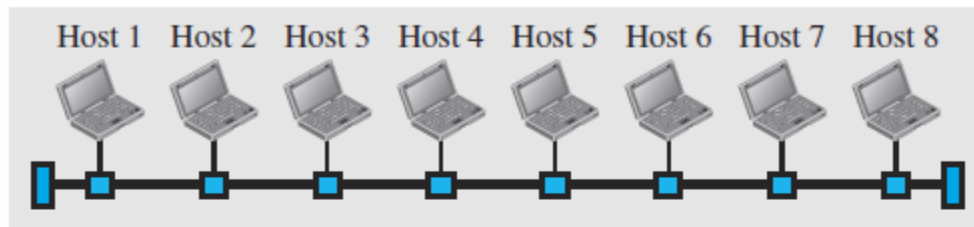
- A local area network (LAN) is usually **privately owned** and connects some hosts in a **single office, building, or campus**.
- Depending on the needs of an organization, a LAN can be as simple as two PCs and a printer in someone's **home office**, or it can extend throughout a company and include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

# 1.3.1 Local Area Network Contd.

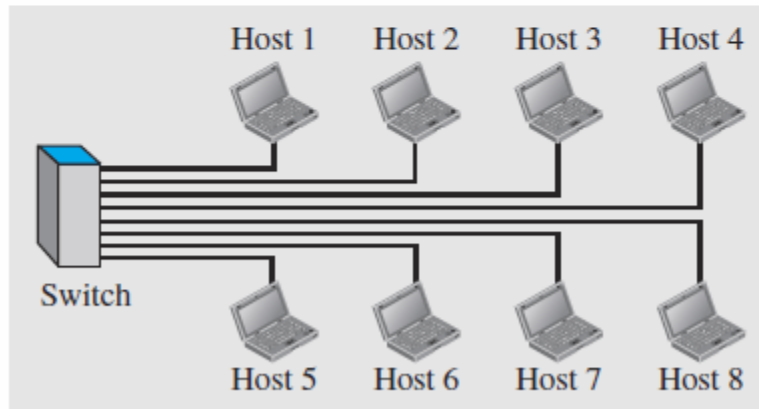
- In the **past**, all hosts in a network were connected through a common cable, which meant that a packet sent from one host to another was **received by all hosts**. The intended recipient kept the packet; the others dropped the packet.
- Today, most LANs use a smart connecting switch, which is able to **recognize the destination address** of the packet and guide the packet to its destination without sending it to all other hosts.
- The **switch** alleviates the traffic in the LAN and **allows more than one pair to communicate with each other at the same time** if there is no common source and destination among them.
- Note that the above definition of a LAN does not define the minimum or maximum number of hosts in a LAN.
- Figure 1.8 shows a LAN using either a common cable or a switch.

# 1.3.1 Local Area Network Contd.

**Figure 1.8** *An isolated LAN in the past and today*

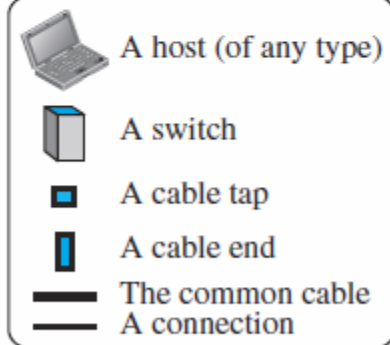


a. LAN with a common cable (past)



b. LAN with a switch (today)

## Legend





## 1.3.2 Wide Area Network

- A wide area network (WAN) is also **an interconnection of devices capable of communication.**
- However, there are some **differences between a LAN and a WAN.**
- A LAN is normally **limited in size**, spanning an office, a building, or a campus; a **WAN has a wider geographical span**, spanning a town, a state, a country, or even the world.
- A LAN **interconnects hosts**; a WAN **interconnects connecting devices** such as switches, routers, or modems.
- A LAN is normally **privately owned** by the organization that uses it; a WAN is normally created and **run by communication companies** and **leased by an organization** that uses it.
- We see two distinct examples of WANs today: **point-to-point WANs** and **switched WANs.**

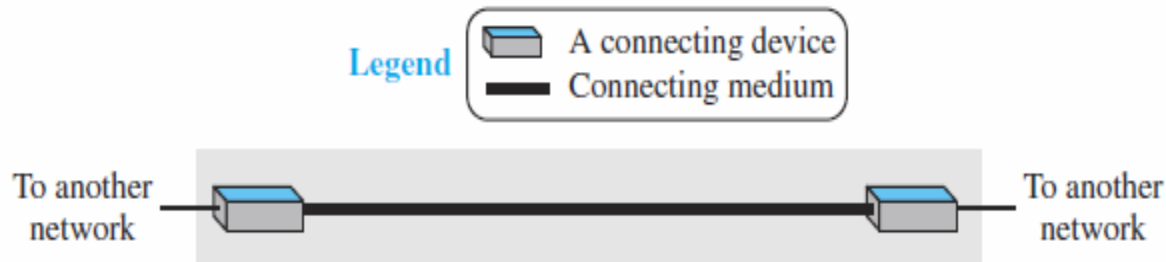
# 1.3.2 Wide Area Network Contd.

- ***Point-to-Point WAN***
- A point-to-point WAN is a network that connects two communicating devices through a transmission media (cable or air).
- Figure 1.9 shows an example of a point-to-point WAN.

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**Figure 1.9** *A point-to-point WAN*

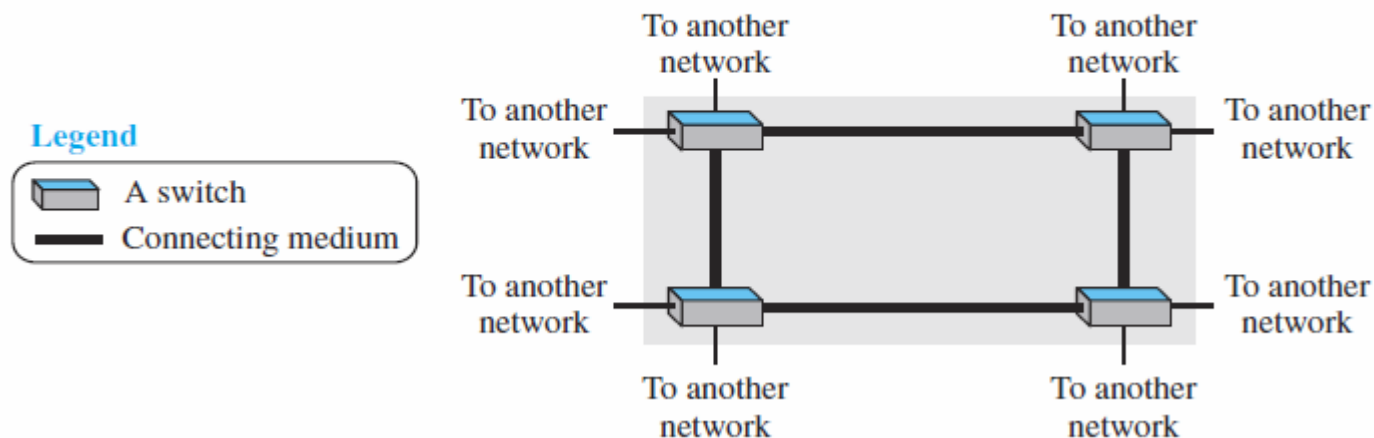
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## 1.3.2 Wide Area Network Contd.

- **Switched WAN**
- A switched WAN is a network with more than two ends.
- A switched WAN, is used in the backbone of global communication today.
- We can say that a switched WAN is a combination of several point-to-point WANs that are connected by switches.
- Figure 1.10 shows an example of a switched WAN.

**Figure 1.10** *A switched WAN*

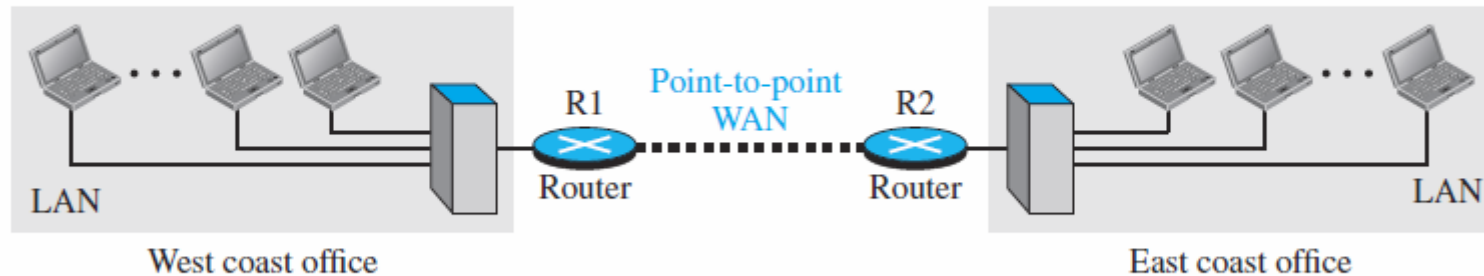


## 1.3.2 Wide Area Network Contd.

- ***Internetwork***
- When **two or more networks are connected**, they make an internetwork, or internet.
- As an example, assume that an organization has two offices, one on the east coast and the other on the west coast. Each office has a LAN that allows all employees in the office to communicate with each other.
- To make the communication between employees at different offices possible, the management leases a point-to-point dedicated WAN from a service provider, such as a telephone company, and connects the two LANs.
- Now the company has an internetwork, or a **private internet**. *Communication* between offices is now possible. Figure 1.11 shows this internet.

## 1.3.2 Wide Area Network Contd.

**Figure 1.11** *An internetwork made of two LANs and one point-to-point WAN*

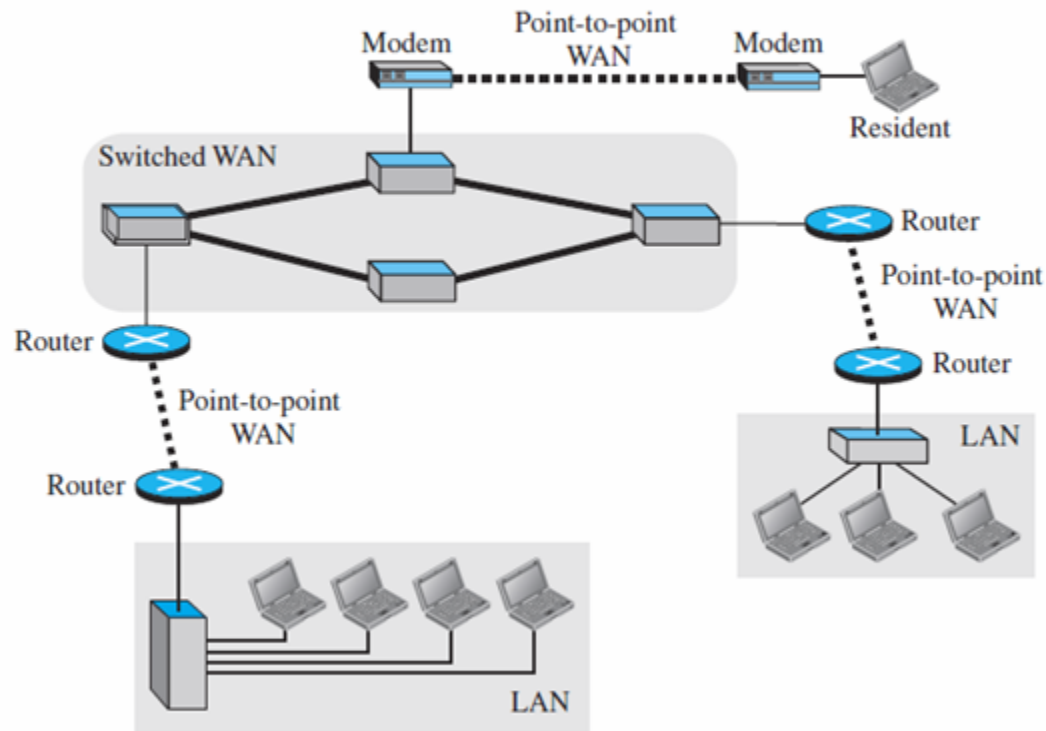


## 1.3.2 Wide Area Network Contd.

- When a host in the west coast office sends a message to another host in the same office, the router blocks the message, but the switch directs the message to the destination.
- On the other hand, when a host on the west coast sends a message to a host on the east coast, router R1 routes the packet to router R2, and the packet reaches the destination.
- Figure 1.12 shows another internet with several LANs and WANs connected.
- One of the WANs is a switched WAN with four switches.

# 1.3.2 Wide Area Network Contd.

**Figure 1.12** *A heterogeneous network*



# 1.3.3 Switching

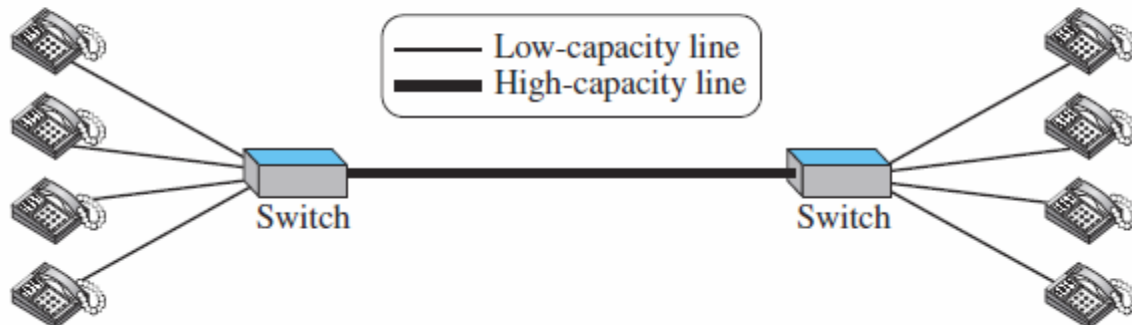
- An internet is a switched network in which a switch connects at least two links together.
- A switch needs to **forward data from a network** to another network when required.
- The two most common types of switched networks are **circuit-switched and packet-switched networks**.
- ***Circuit-Switched Network***
- In a circuit-switched network, a **dedicated connection**, called a **circuit**, is always available between the two end systems; the switch can only make it active or inactive.
- Figure 1.13 shows a very simple switched network that connects four telephones to each end.
- We have used telephone sets instead of computers as an end system because circuit switching was very common in telephone networks in the past, although part of the telephone network today is a packet-switched network.



## 1.3.3 Switching Contd.

- In Figure 1.13, the four telephones at each side are connected to a switch.
- The switch connects a telephone set at one side to a telephone line connecting two switches is a high-capacity communication line that can handle four voice communications at the same time; the capacity can be shared between all pairs of telephone sets.
- The switches used in this example have forwarding tasks but no storing capability.

**Figure 1.13** *A circuit-switched network*



# 1.3.3 Switching Contd.

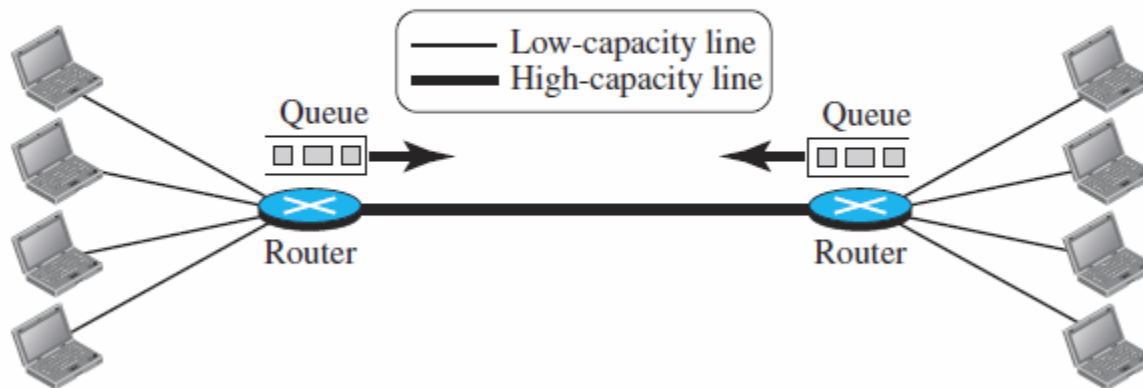
- Let us look at two cases.
  - In the first case, all telephone sets are busy; four people at one site are talking with four people at the other site; the capacity of the thick line is fully used.
  - In the second case, only one telephone set at one side is connected to a telephone set at the other side; only one-fourth of the capacity of the thick line is used.
- This means that a circuit-switched network is **efficient only when it is working at its full capacity**; most of the time, it is inefficient because it is working at partial capacity.
- The reason that we need to make the capacity of the thick line four times the capacity of each voice line is that we do not want communication to fail when all telephone sets at one side want to be connected with all telephone sets at the other side.

## 1.3.3 Switching Contd.

- ***Packet-Switched Network***
- In a computer network, the communication between the two ends is done in blocks of data called **packets**.
- In other words, instead of the continuous communication we see between two telephone sets when they are being used, we see the **exchange of individual data packets** between the two computers.
- This allows us to make the switches function for both **storing and forwarding** because a packet is an independent entity that can be stored and sent later.
- Figure 1.14 shows a small packet-switched network that connects four computers at one site to four computers at the other site.

## 1.3.3 Switching Contd.

**Figure 1.14** *A packet-switched network*



## 1.3.3 Switching Contd.

- A **router** in a packet-switched network has a **queue** that can store and forward the packet.
- Now assume that the capacity of the thick line is only twice the capacity of the data line connecting the computers to the routers.
- If only two computers (one at each site) need to communicate with each other, there is no waiting for the packets.
- However, if packets arrive at one router when the thick line is already working at its full capacity, the packets should be stored and forwarded in the order they arrived.
- The two simple examples show that a packet-switched network is **more efficient than a circuit switched network**, but the **packets may encounter some delays**.

## 1.3.4 The Internet

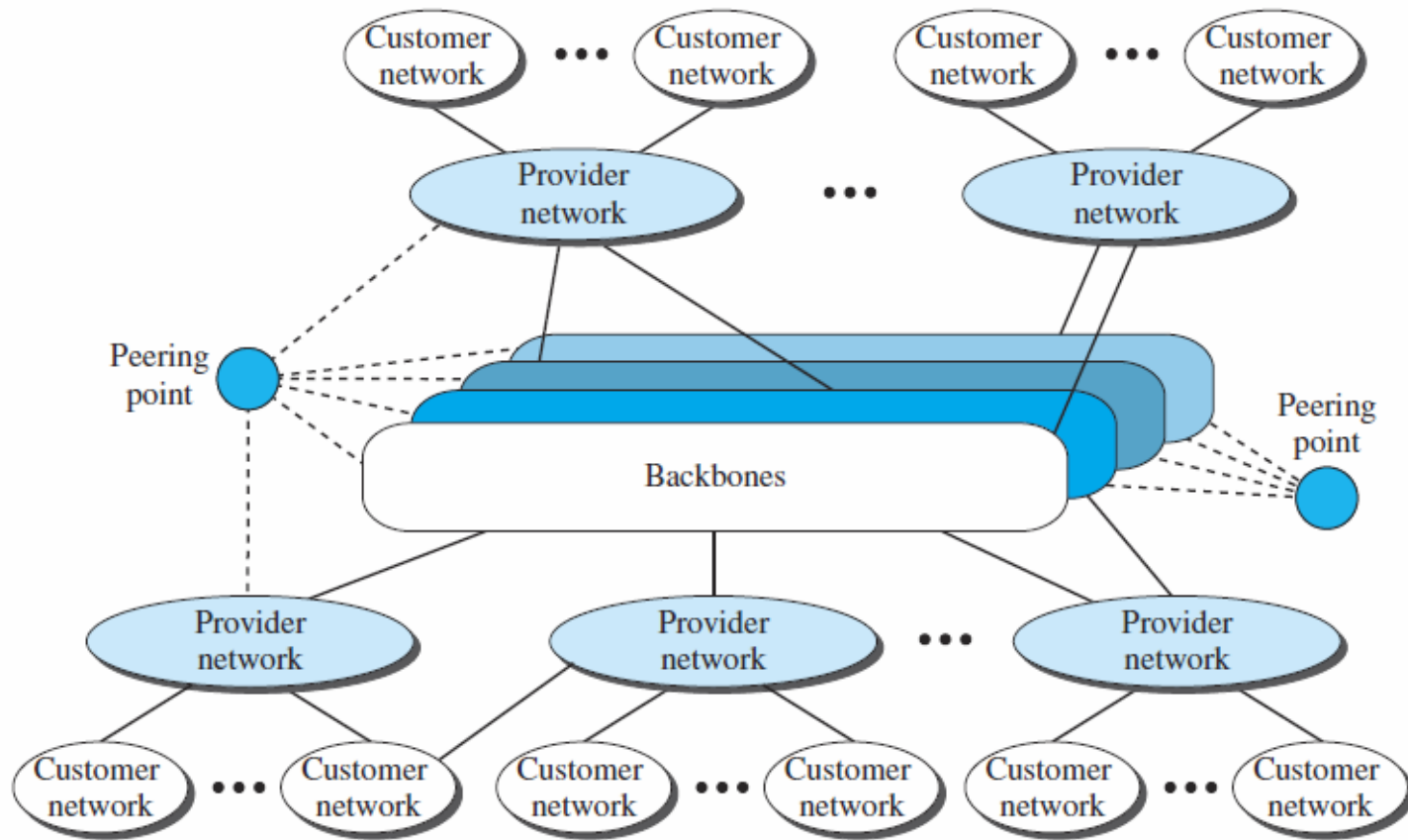
- An **internet** (lowercase i ), is two or more networks that can communicate with each other.
- The most notable internet is called the **Internet** (uppercase I ), and is composed of thousands of interconnected networks.
- Figure 1.15 shows a conceptual (not geographical) view of the Internet.
- The figure shows the Internet as several **backbones, provider networks, and customer networks**.
- At the top level, the **backbones are large networks owned by some communication companies** such as Sprint, Verizon (MCI), AT&T, and NTT.
- The backbone networks are connected through some **complex switching systems, called peering points**.

## 1.3.4 The Internet Contd.

- At the **second level**, there are smaller networks, called **provider networks**, that use the services of the backbones for a fee.
- The provider networks are **connected to backbones** and sometimes to **other provider networks**.
- The **customer networks** are networks at the edge of the Internet that actually use the services provided by the Internet.
- They **pay fees to provider networks** for receiving services.
- Backbones and provider networks are also called **Internet Service Providers (ISPs)**.
- The **backbones** are often referred to as **international ISPs**; the **provider networks** are often referred to as **national or regional ISPs**.

## 1.3.4 The Internet Contd.

**Figure 1.15** *The Internet today*





## 1.3.4 The Internet Contd.

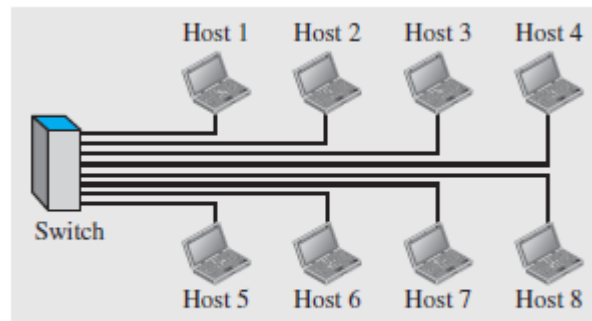
- The Internet today is an internetwork that allows **any user to become part of it.**
- The **user**, however, needs to be **connected to an ISP.**
- ***Using Telephone Networks***
- Today most residences and small businesses have telephone service, which means they are **connected to a telephone network.**
- Since most telephone networks have already connected themselves to the Internet, one option for residences and small businesses to **connect to the Internet is to change the voice line** between the residence or business and the telephone center to a point-to-point WAN.
- This can be done in **two ways.**
- ☐ **Dial-up service.**
  - The first solution is to add to the telephone line a **modem** that converts data to voice.
  - The **software installed on the computer dials the ISP** and imitates making a telephone connection.
  - Unfortunately, the dial-up service is **very slow**, and when the line is used for Internet connection, it **cannot be used for telephone (voice) connection.** It is only useful for small residences.

# 1.3.4 The Internet Contd.

- ☐ DSL Service.
  - Since the advent of the Internet, some telephone companies have upgraded their telephone lines to provide higher speed Internet services to residences or small businesses.
  - The DSL service also allows the line to be **used simultaneously for voice and data communication.**
- ***Using Cable Networks***
  - A residence or a small business can be **connected to the Internet** by using **cable service.**
  - It provides a higher speed connection, but the **speed varies depending on the number of neighbors** that use the same cable.
- ***Using Wireless Networks***
  - A household or a small business can use a combination of **wireless and wired connections** to access the Internet.
  - With the growing wireless WAN access, a household or a small business can be connected to the Internet through a **wireless WAN.**
- ***Direct Connection to the Internet***
  - A **large organization** or a large corporation can itself become a **local ISP** and be connected to the Internet.
  - This can be done if the organization or the corporation **leases a high-speed WAN** from a carrier provider and connects itself to a regional ISP.
  - For example, a large university with several campuses can create an internetwork and then connect the internetwork to the Internet

# Practice Questions

- Identify the five components of a data communications system.
- What are the three criteria necessary for an effective and efficient network?
- What are the advantages of a multipoint connection over a point-to-point one?
- What are the two types of line configuration?
- Categorize the four basic topologies in terms of line configuration.
- What is the difference between half-duplex and full-duplex transmission modes?
- Name the four basic network topologies, and cite an advantage of each type.
- In a LAN with a link-layer switch (Figure 1.8b), Host 1 wants to send a message to Host 3. Since communication is through the link-layer switch, does the switch need to have an address? Explain.



**Figure 1.8** b. LAN with a switch (today)

# Practice Questions Contd.

- For  $n$  devices in a network, what is the number of cable links required for a mesh, ring, bus, and star topology?
- What are some of the factors that determine whether a communication system is a LAN or WAN?
- What is an internet? What is the Internet?
- Why are protocols needed?
- How many point-to-point WANs are needed to connect  $n$  LANs if each LAN should be able to directly communicate with any other LAN?
- When we use local telephones to talk to a friend, are we using a circuit switched network or a packet-switched network?
- When a resident uses a dial-up or DLS service to connect to the Internet, what is the role of the telephone company?
- What is the first principle we discussed in this chapter for protocol layering that needs to be followed to make the communication bidirectional?

# Problems

- What is the maximum number of characters or symbols that can be represented by Unicode?
- A color image uses 16 bits to represent a pixel. What is the maximum number of different colors that can be represented?
- Assume six devices are arranged in a mesh topology. How many cables are needed? How many ports are needed for each device?
- For each of the following four networks, discuss the consequences if a connection fails.
  - a. Five devices arranged in a mesh topology
  - b. Five devices arranged in a star topology (not counting the hub)
  - c. Five devices arranged in a bus topology
  - d. Five devices arranged in a ring topology
- We have two computers connected by an Ethernet hub at home. Is this a LAN or a WAN? Explain the reason.

# Problems Contd.

- In the ring topology, what happens if one of the stations is unplugged?
- In the bus topology, what happens if one of the stations is unplugged?
- Performance is inversely related to delay. When we use the Internet, which of the following applications are more sensitive to delay?
  - a. Sending an e-mail
  - b. Copying a file
  - c. Surfing the Internet
- When a party makes a local telephone call to another party, is this a point-to-point or multipoint connection? Explain the answer.
- Compare the telephone network and the Internet. What are the similarities? What are the differences?

END of Chapter 1