Chapter 1

Introduction

DATA COMMUNICATIONS

The term telecommunication 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.

Topics discussed in this section:

- Components of a data communications system
- Data Flow

DATA COMMUNICATIONS

The effectiveness of data communication depends on four fundamental characteristics:

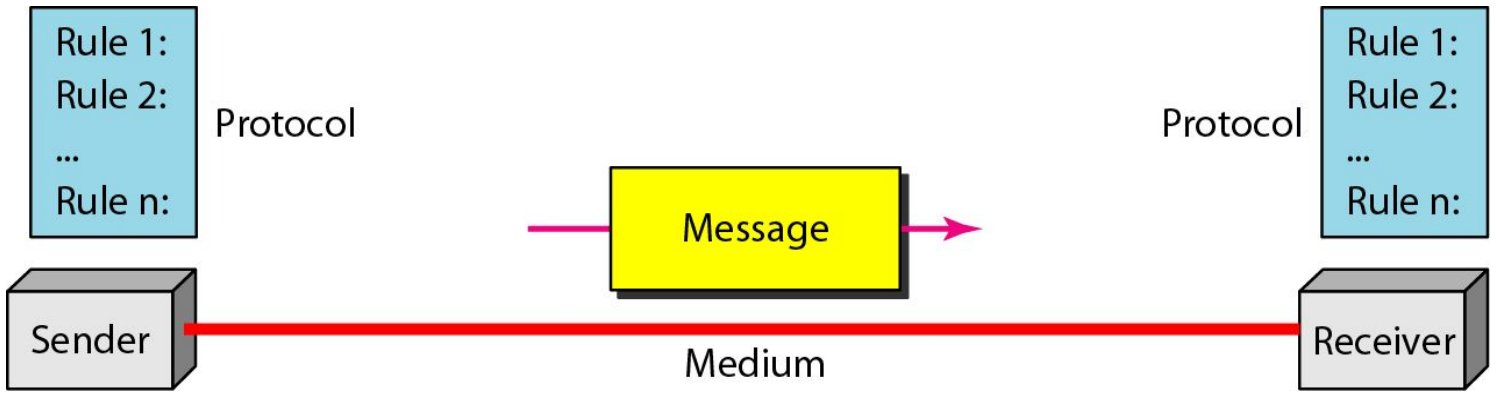
-- delivery

-- accuracy

-- timeliness

-- jitter

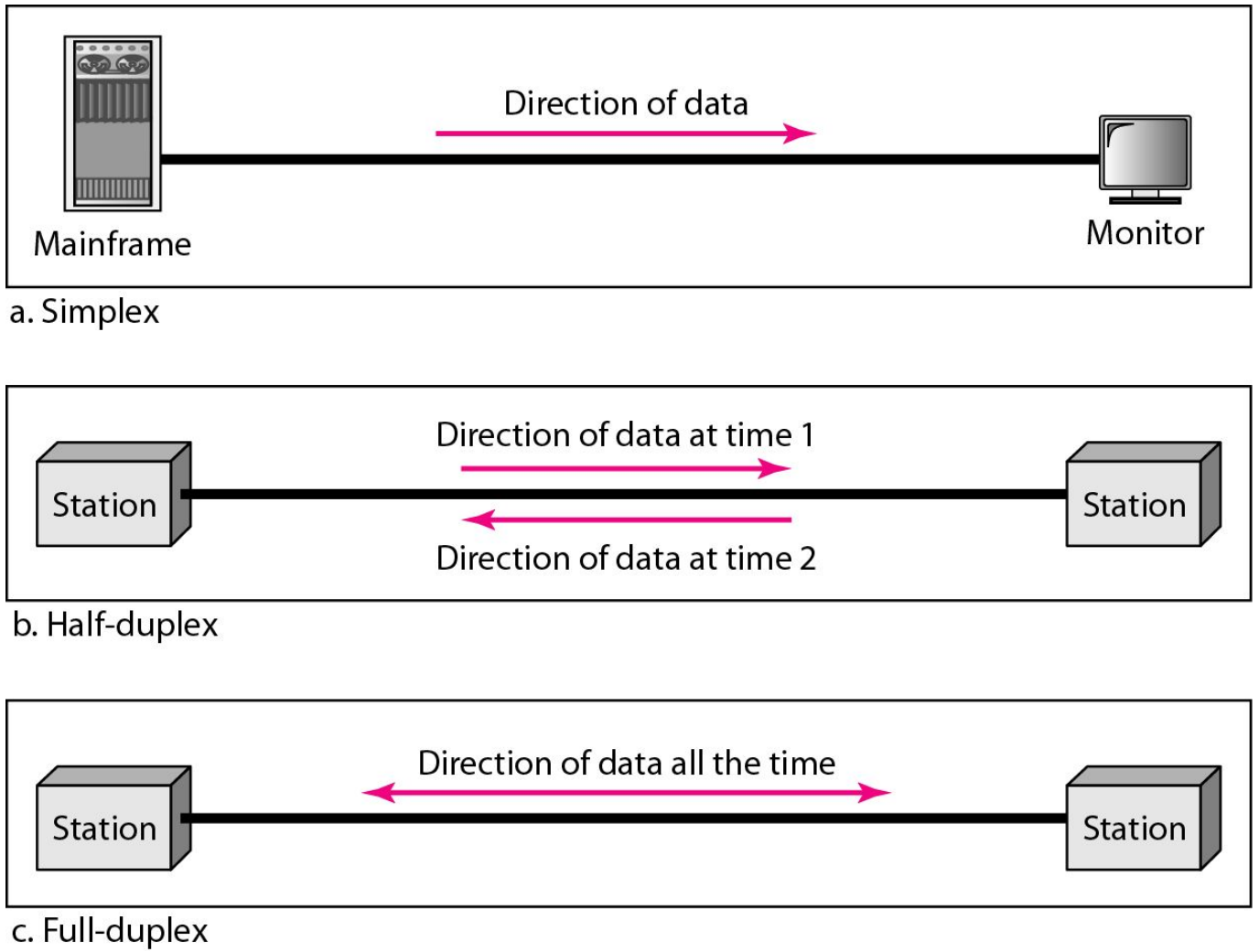
Figure 1.1 *Components of a data communication system*



DATA REPRESENTATIONS

- Text
- Numbers
- Images
- Audio
- Video

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



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. A link can be a cable, air, optical fiber, or any medium which can transport a signal carrying information.

Topics discussed in this section:

- Network Criteria
- Physical Structures
- Categories of Networks

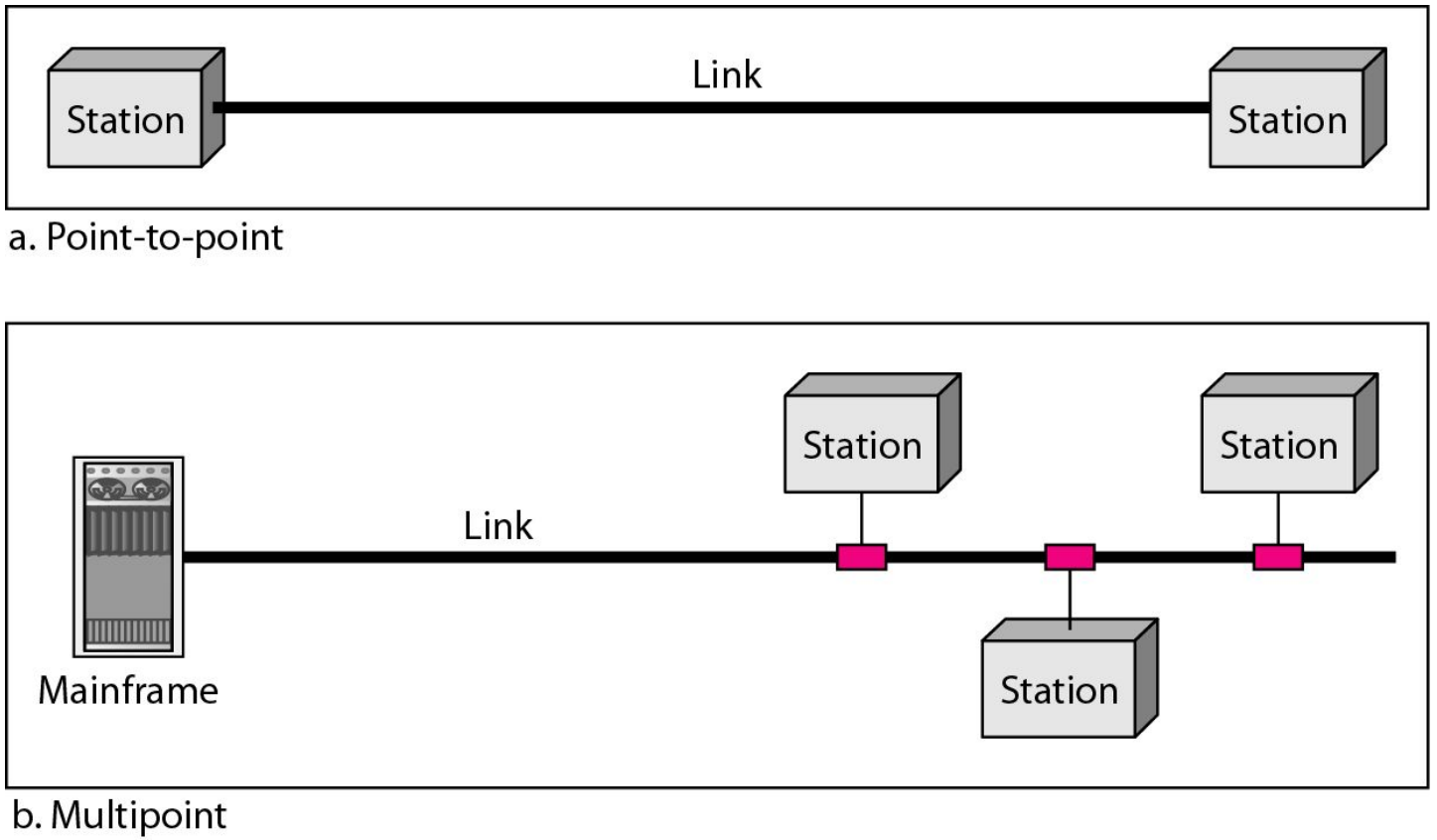
Network Criteria

- **Performance**
  - **Measured in terms of Delay and Throughput**
  - **Measured in accordance with transit and response time**
  - **Performance of network is dependent on**
    - **Number of users,**
    - **Types of transmission medium used,**
    - **Capabilities of connected hardware,**
    - **Efficiency of software.**
- **Reliability**
  - **Failure rate of network components**
  - **Measured in terms of availability/robustness**
- **Security**
  - **Data protection against corruption/loss of data due to:**
    - **Errors**
    - **Malicious users**

Physical Structures

- **Type of Connection**
  - **Point to Point - single transmitter and receiver**
  - **Multipoint - multiple recipients of single transmission**
- **Physical Topology**
  - **Connection of devices**
  - **Type of transmission - unicast, mulitcast, broadcast**

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



Network Topology

- The term network topology refers to the way in which a network is laid out physically.
- The topology of a network is the geometrical representation of the relationship of all the links and linking devices (usually called nodes) to one another.
- There are 4 basic topologies possible --

Figure 1.4 *Categories of topology*

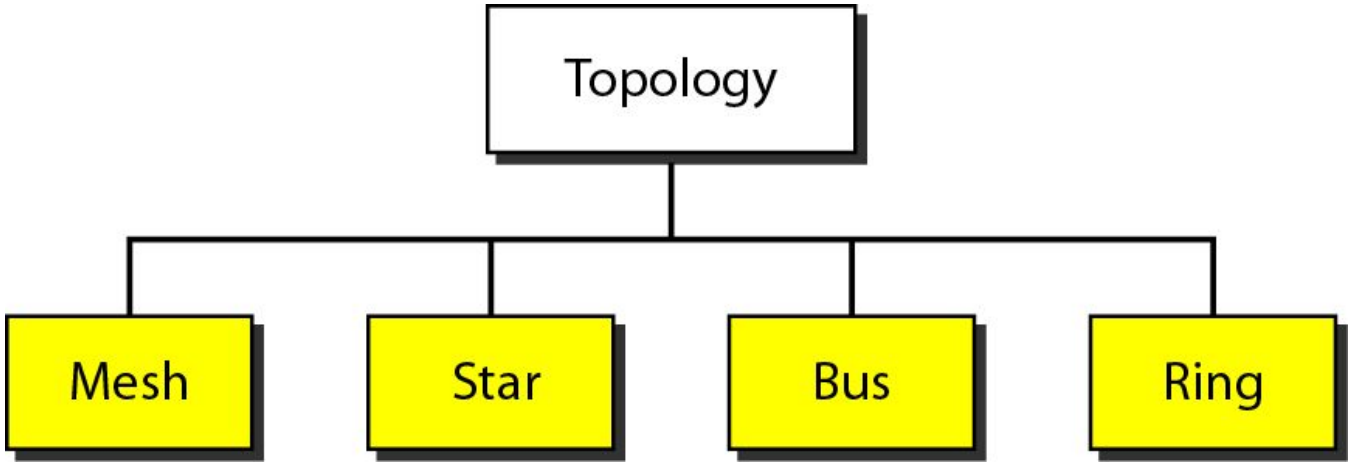
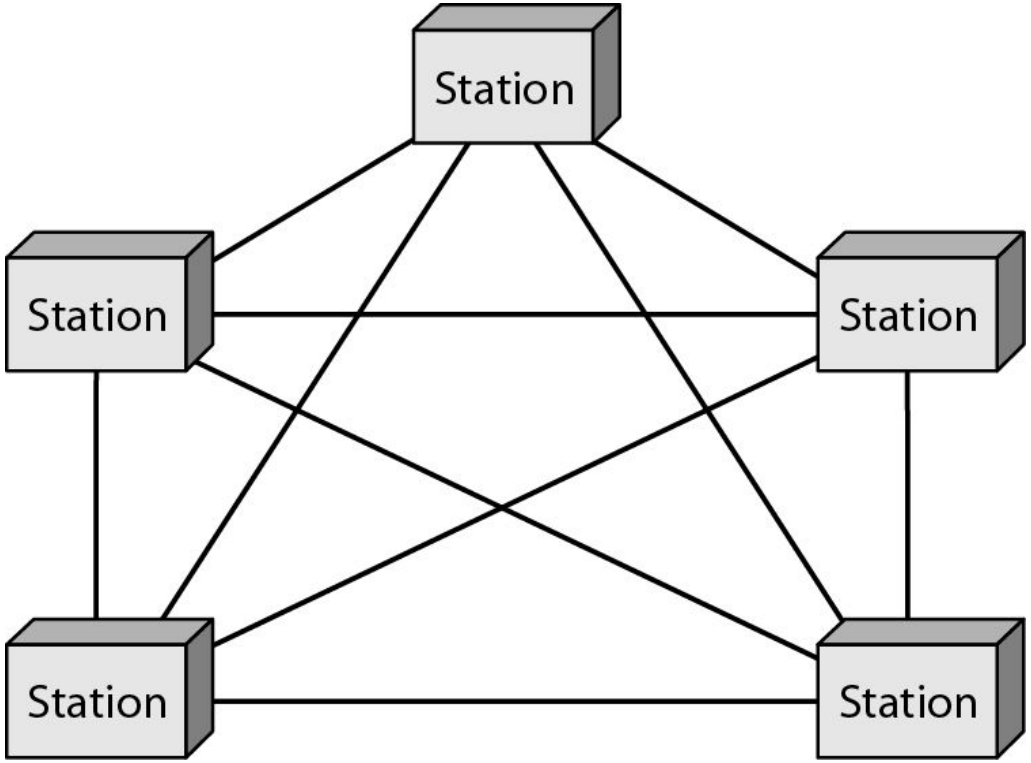


Figure 1.5 *A fully connected mesh topology (five devices)*



- In this 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, Node 1 must be connected to every other (n-1) nodes, likewise Node 2 must be connected to every other (n-1) nodes … and finally Node N must be connected to every other (n-1) nodes. Hence, total number of physical links will be n(n-1).
- If each physical link allows communication in both directions (duplex mode), we can divide the number of links by 2, i.e., in mesh topology, we need n(n-1)/2 duplex mode links.
- To accommodate these many links, every device on network must have n-1 I/O ports to be connected to the other n-1 stations.

Advantages of Mesh Topology

-- the use of dedicated links guarantees that each connection can carry its own data load, thus eliminates traffic problems.

-- mesh links are robust, because, if one link becomes unusable (broken), it does not incapacitate the entire system.

-- privacy/security, because, when every message travels along a dedicated link, only the intended recipients receives it.

Disadvantages of Mesh Topology

-- amount of cabling and number of I/O ports required is very high.

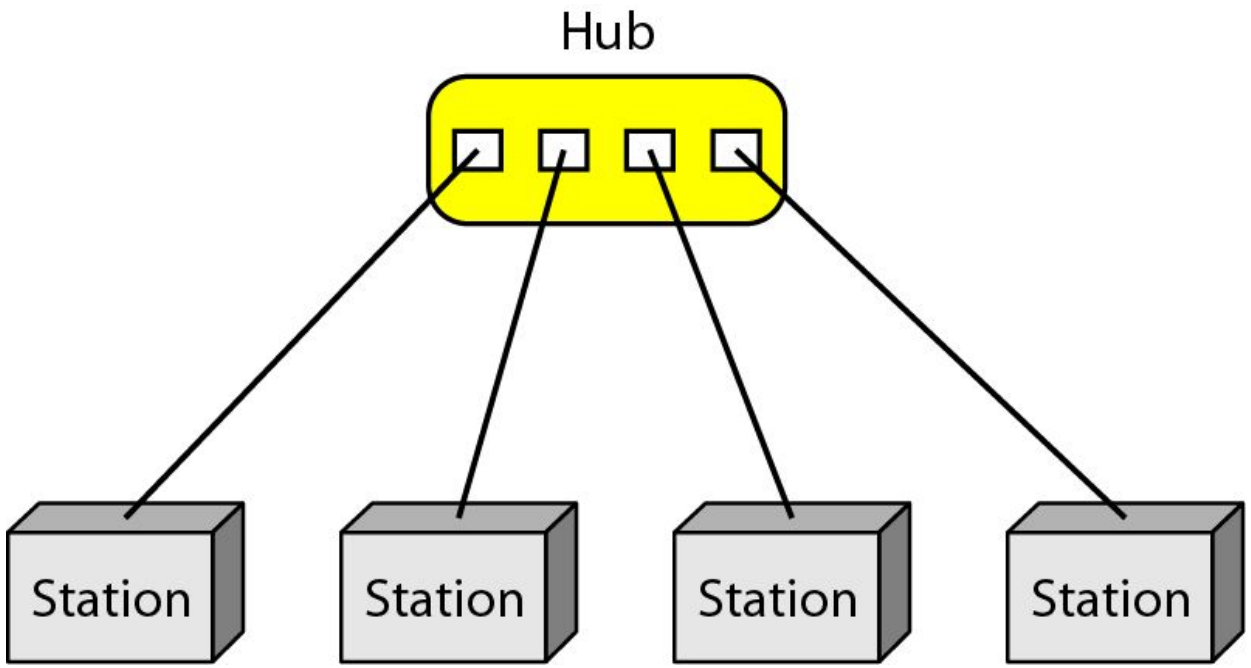
-- installation and reconnections are difficult.

-- hardware requirements are very high.

* 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

- Assume six devices are arranged in a mesh topology. How many cables are needed? How many ports are needed for each device?

Figure 1.6 *A star topology connecting four stations*



- 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.

Advantages of Star topology

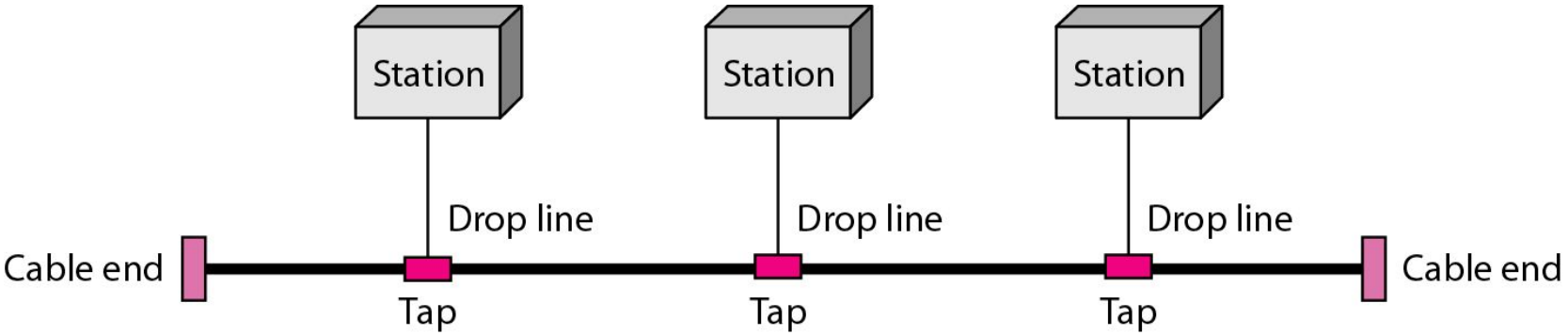
- A star topology is less expensive than a mesh topology. In a star, each device needs only one link and one I/O port to connect it to any number of others.
- This factor also makes it easy to install and reconfigure. Far less cabling needs to be housed.
- Other advantages include robustness. If one link fails, only that link is affected. All other links remain active. This factor leads to easy fault identification and fault isolation.

Disadvantages of Star topology

- 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.

* The star topology is used in local-area networks (LANs). High-speed LANs often use a star topology with a central hub.

Figure 1.7 *A bus topology connecting three stations*



- A bus topology is based on multipoint connections. One long cable acts as a backbone to link all the devices in a network.
- Nodes are connected to the bus cable by drop lines and taps.
- A drop line is a connection 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.

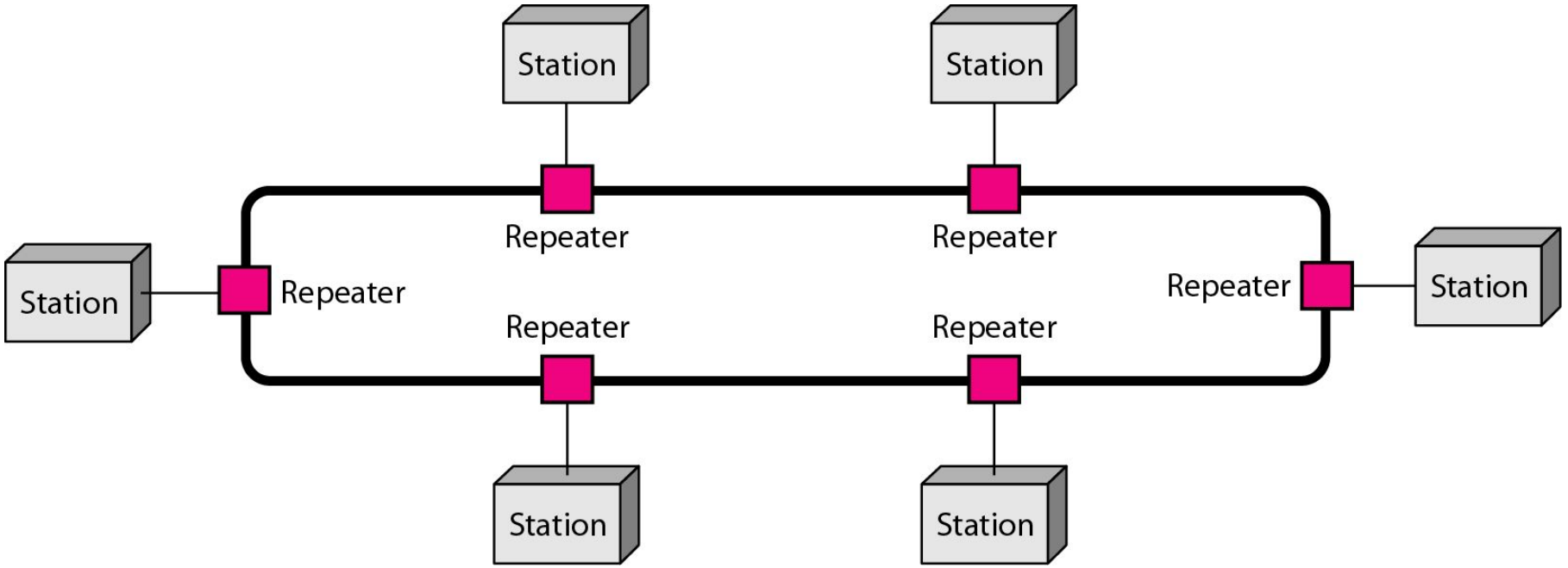
Advantages of Bus Topology

- Ease of installation.
- A bus uses less cabling than mesh or star topologies.

Disadvantages of Bus Topology

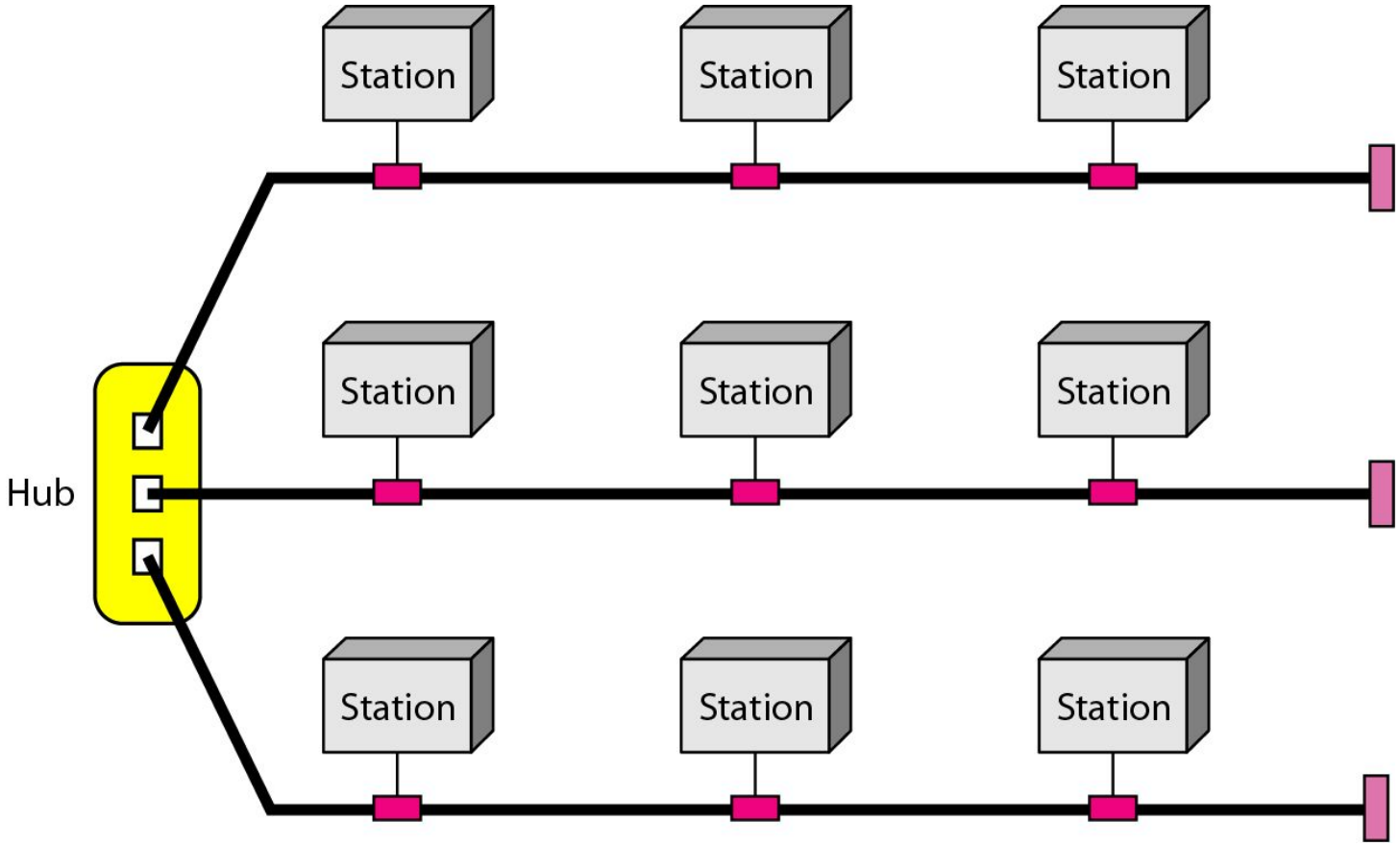
- difficult reconnection and fault isolation.
- difficulty in adding new devices in the system.
- signal reflection at the taps can cause degradation in quality.
- this degradation can be controlled by limiting the number and spacing of devices connected to a given length of cable.
- adding new devices may therefore require modification or replacement of the backbone.
- 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.

Figure 1.8 *A ring topology connecting six stations*



- 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.

Figure 1.9 *A hybrid topology: a star backbone with three bus networks*



Categories of Networks

- Local Area Networks (LANs)
  - Short distances
  - Designed to provide local interconnectivity
- Wide Area Networks (WANs)
  - Long distances
  - Provide connectivity over large areas
- Metropolitan Area Networks (MANs)
  - Provide connectivity over areas such as a city, a campus

1-4 PROTOCOLS

A protocol is synonymous with rule. It consists of a set of rules that govern data communications. It determines what is communicated, how it is communicated and when it is communicated. The key elements of a protocol are syntax, semantics and timing

Topics discussed in this section:

- **Syntax**
- **Semantics**
- **Timing**

Elements of a Protocol

- Syntax
  - Structure or format of the data
  - Indicates how to read the bits - field delineation
- Semantics
  - Interprets the meaning of the bits
  - Knows which fields define what action
- Timing
  - When data should be sent and what
  - Speed at which data should be sent or speed at which it is being received.

- Name the four basic network topologies, and cite an advantage of each type.

- What is the difference between half-duplex and full-duplex transmission modes?

- For n devices in a network, what is the number of cable links required for a mesh, bus, and star topology?

Star: N
Mesh: Simplex - N(N-1); Duplex - N(N-1)/2
Bus: N+1

- For each of the following four networks, discuss the consequences if a connection fails.

  - Five devices arranged in a mesh topology.
    - If one connection fails, the other connections will still be working
  - Five devices arranged in a star topology (not counting the hub).
    - The other devices will still be able to send data through the hub; there will be no access to the device which has the failed connection to the hub.
  - Five devices arranged in a bus topology.
    - All transmission stops if the failure is in the bus. If the drop-line fails, only the corresponding device cannot operate.