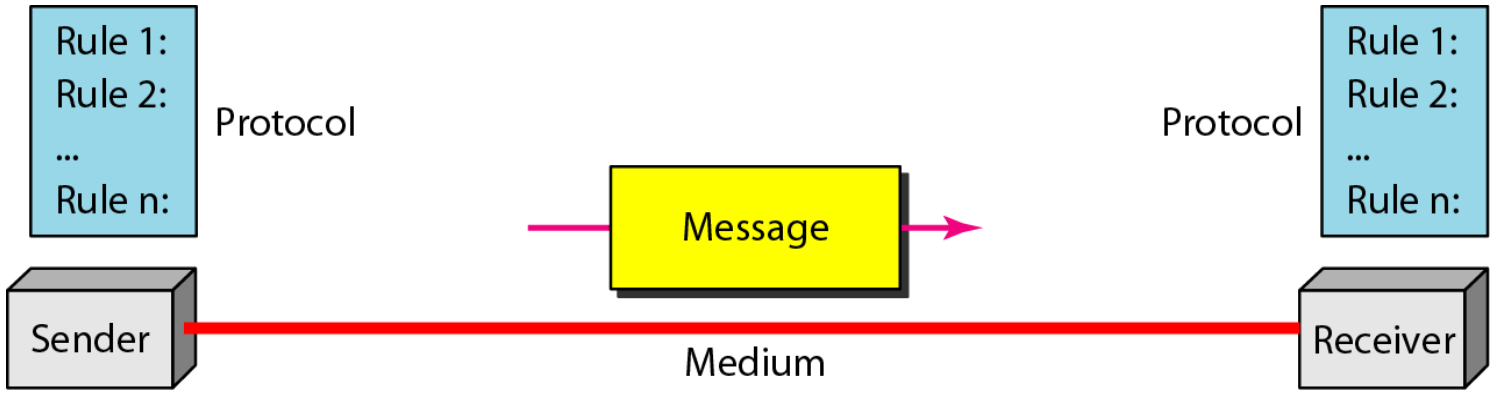
# Data Communication & Networking

Platform Technologies

*Partially Based on Data Communications & Networking, 4th Edition,Behrouz A. Forouzan and CCNA Routing and Switching Essentials v6.0*

# Data Communication

- 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.

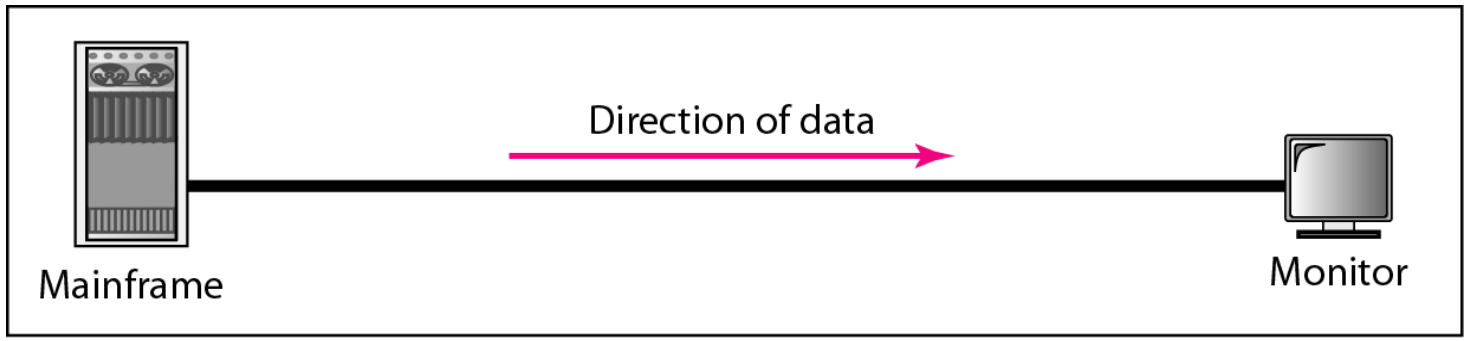



*Components of a data communication system*

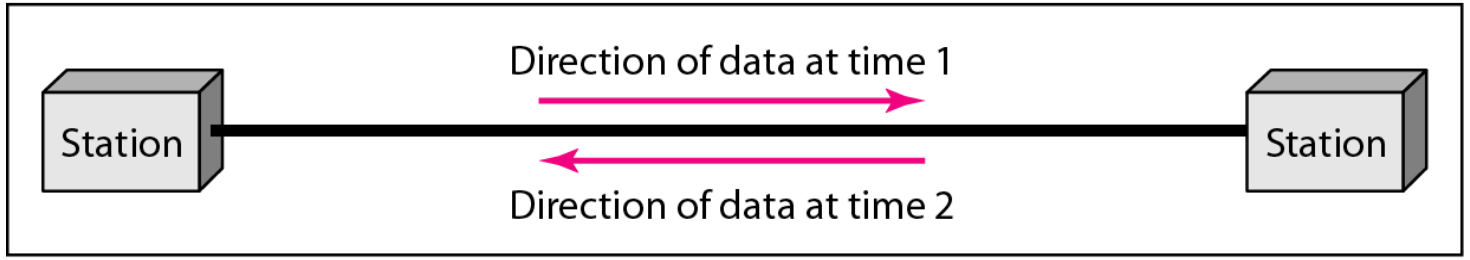
# Data Communication Basics

- It is essential to understand some of the basic communication methods that can be used to interconnect systems.
- Characteristics of communication methods:
  - Data Flow - Simplex, Duplex & Semi Duplex
  - Data Transfer - Serial vs. Parallel
  - Synchronous vs. Asynchronous
  - Data Throughput

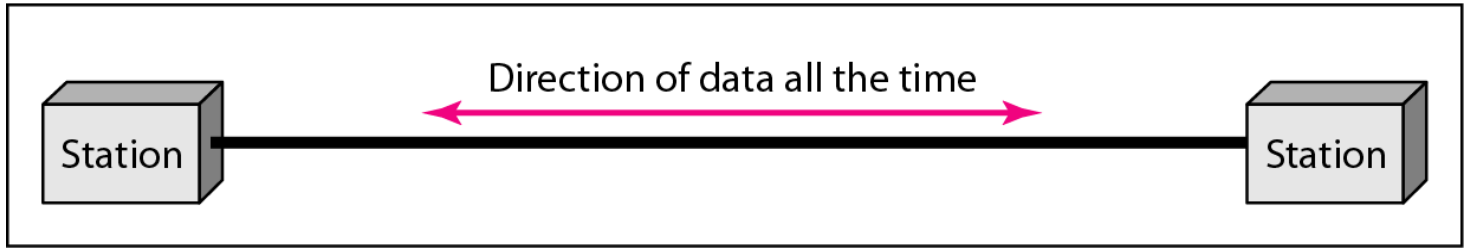
# Data Flow




a. Simplex

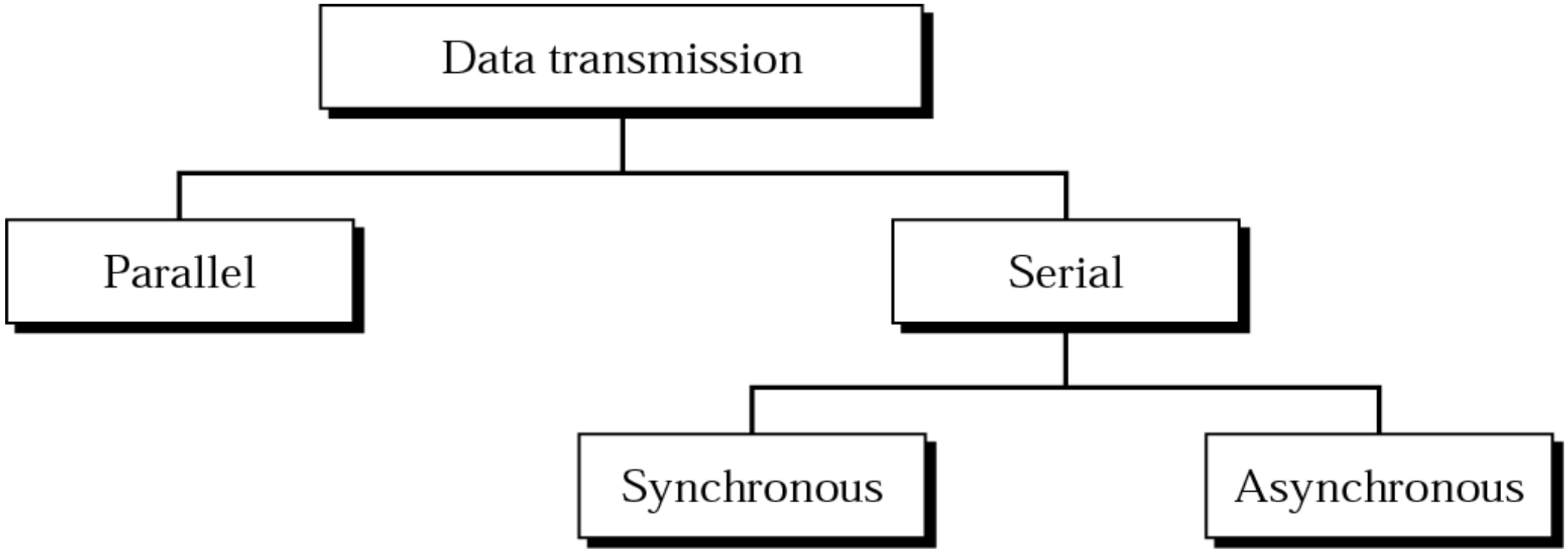



b. Half-duplex



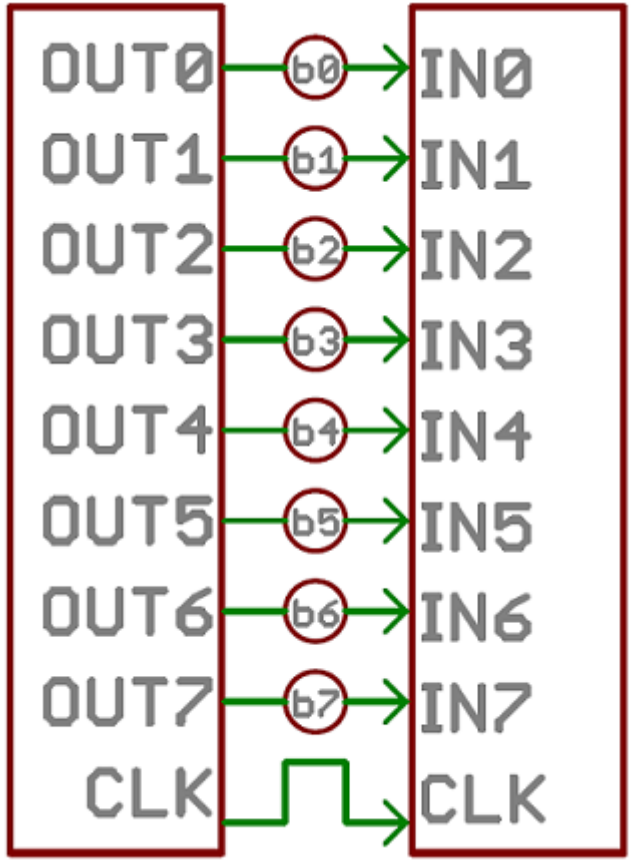

c. Full-duplex

# Types of Data Transfer



# Parallel Communication

- Parallel interfaces transfer multiple bits at the same time.
- They usually require buses of data - transmitting across eight, sixteen, or more wires.
- It's fast, straightforward, and relatively easy to implement.
- But requires many more input/output (I/O) lines.

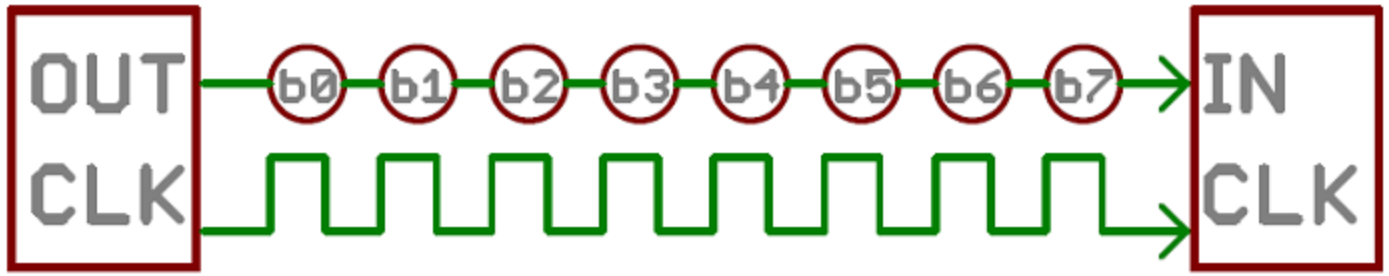


# Parallel Communication

- One bit data per wire
- Multiple data, control, and possibly power wires
- High data throughput with short distances
- Typically used when connecting devices on same IC or same circuit board
  - Bus must be kept short, because long parallel wires result in high capacitance values which requires more time to charge/discharge, and data misalignment between wires increases as length increases
- Higher cost, bulky

# Serial Communication

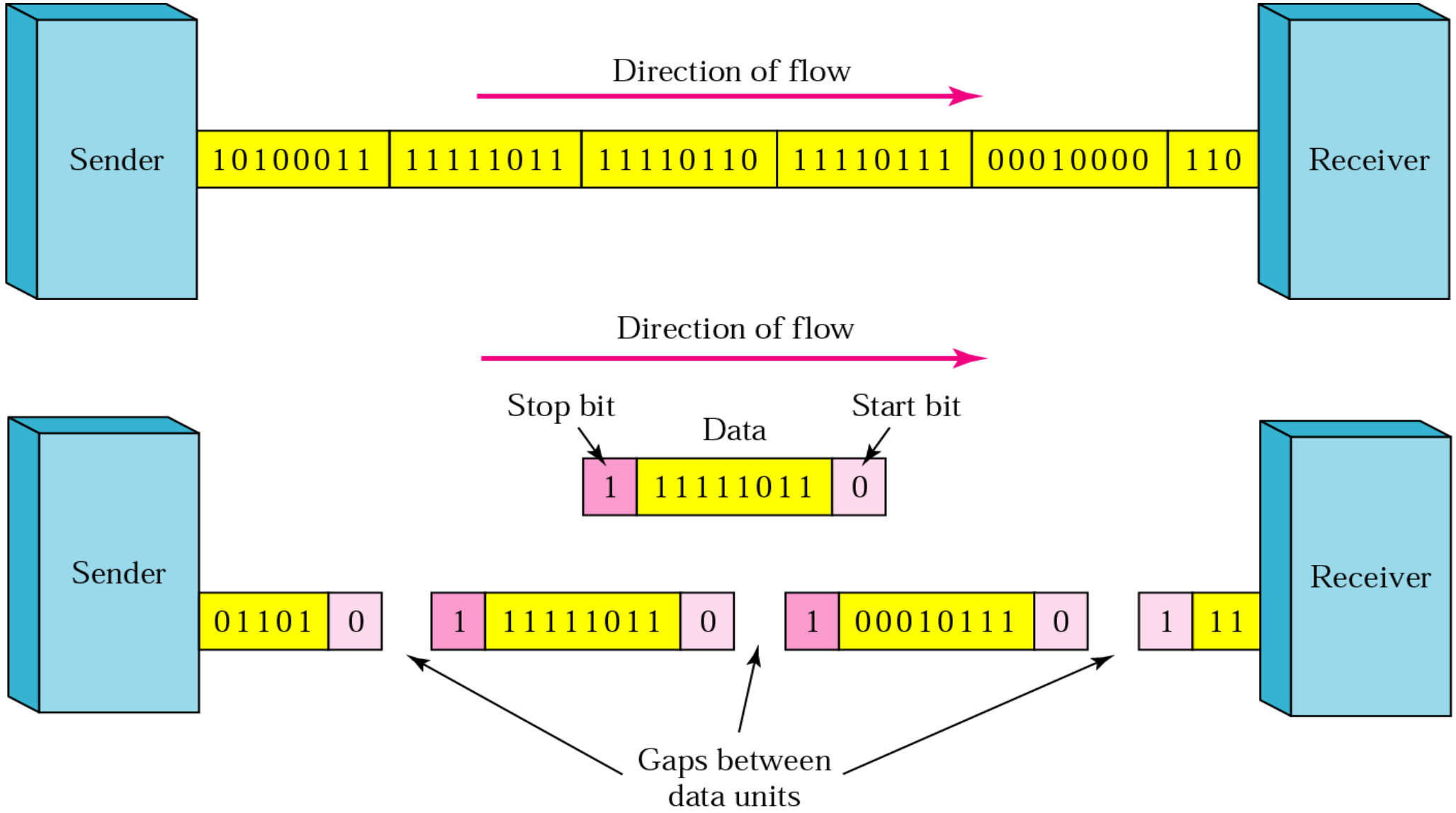
- Serial communication is the process of sending/receiving data in one bit at a time.
- Serial interfaces stream their data, one single bit at a time.
- These interfaces can operate on as little as one wire, usually never more than four.



# Serial Communication

- Words transmitted one bit at a time
- Single data wire, possibly also control and power wires
- Higher data throughput with long distances
  - Less average capacitance, so more bits per unit of time
- Cheaper, less bulky
- More complex interfacing logic and communication protocol
  - Sender needs to decompose word into bits
  - Receiver needs to recompose bits into word
  - Control signals often sent on same wire as data increasing protocol complexity

# Synchronous vs. Asynchronous Serial Transfer



# Advantages of Serial over Parallel

- A serial connection requires fewer interconnecting cables and hence occupies less space.
  - The extra space allows for better isolation of the channel from its surroundings.
  - Crosstalk is not a much significant issue, because there are fewer conductors in proximity.
- In many cases, serial is a better option because it is cheaper to implement.
  - Many devices and sensors relevant to control systems have serial interfaces, as opposed to parallel ones, so that they have fewer pins and are therefore less expensive.

# Serial Communication Protocols

- There are various protocols that can be used with digital control systems for serial communication.
  - USB (Universal Serial Bus)
  - UART (Universal Asynchronous Receiver/Transmitter)
  - SPI (Serial Peripheral Interface)
  - I2C (Inter-Integrated Circuits)
  - CAN (Controller Area Network)
  - 1-wire

# Advanced Communication Principles

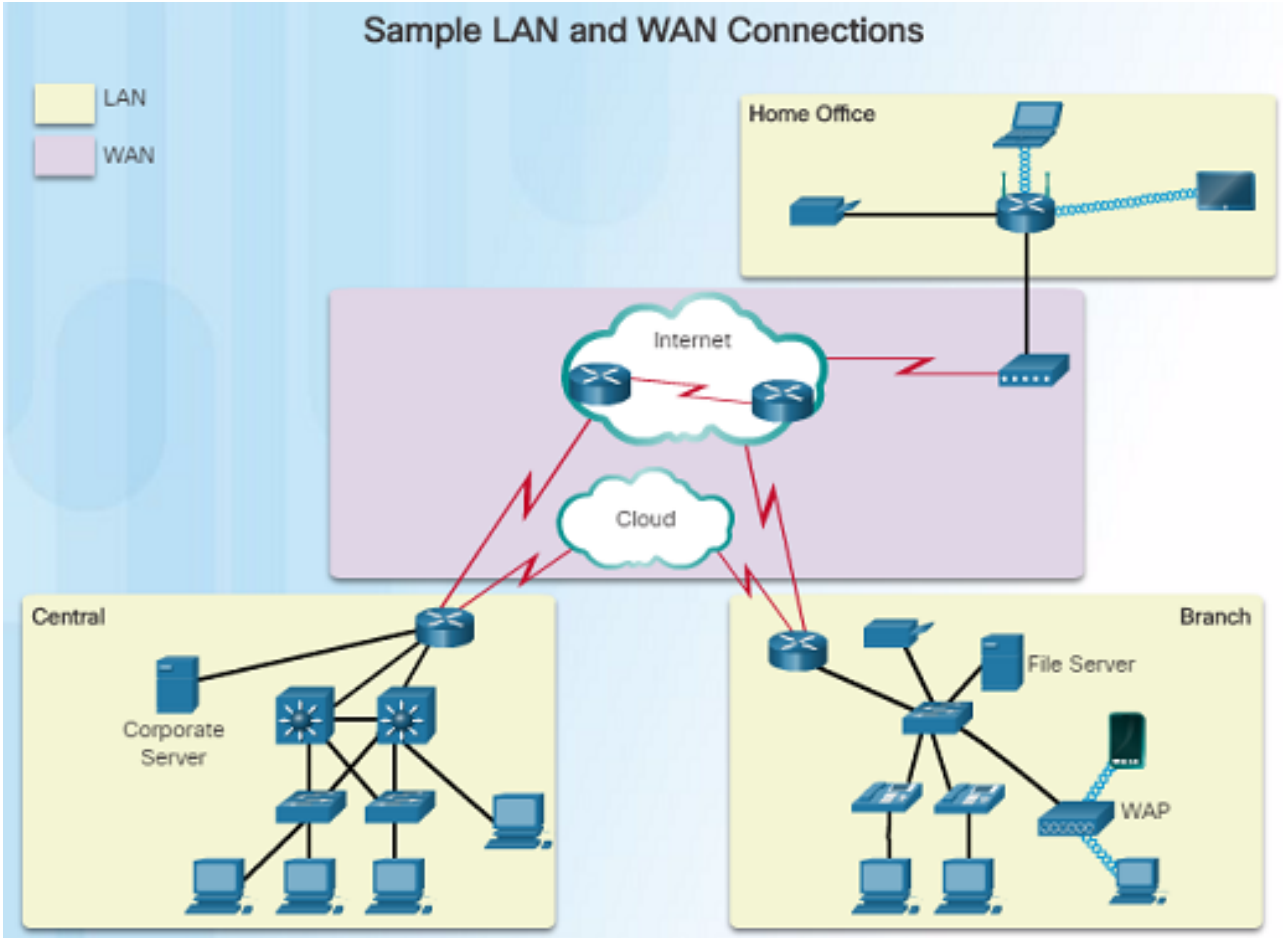
- Layering
  - Break complexity of communication protocol into pieces easier to design and understand
  - Lower levels provide services to higher level
    - Lower level might work with bits while higher level might work with packets of data
  - Physical layer
    - Lowest level in hierarchy
    - Medium to carry data from one actor (device or node) to another
- Wireless communication
  - No physical connection needed for transport at physical layer

# Networking

- A network is a **set of devices** (often referred to as **nodes**) connected by communication links.
- A node can be a computer 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.
- Networks are relied on for web applications, IP telephony, video conferencing, interactive gaming, e-commerce, and much more.

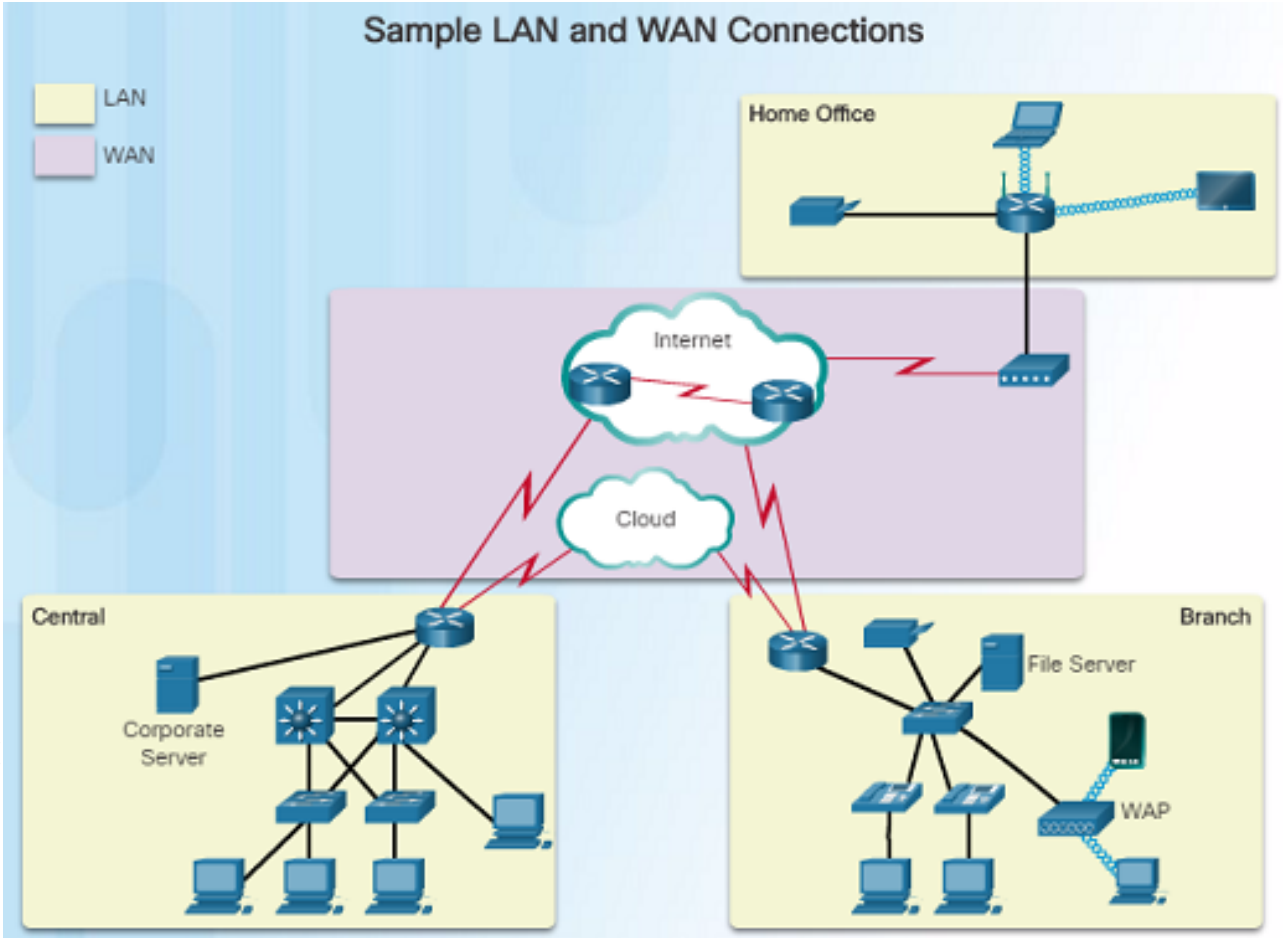
# Connect to a Network

- Home office devices might connect as follows:
  - Laptops and tablets connect wirelessly to a home router.
  - A network printer connects using an Ethernet cable to the switch port on the home router
  - The home router connects to the Internet service provider cable modem using an Ethernet cable.
  - The cable modem connects to the ISP network.



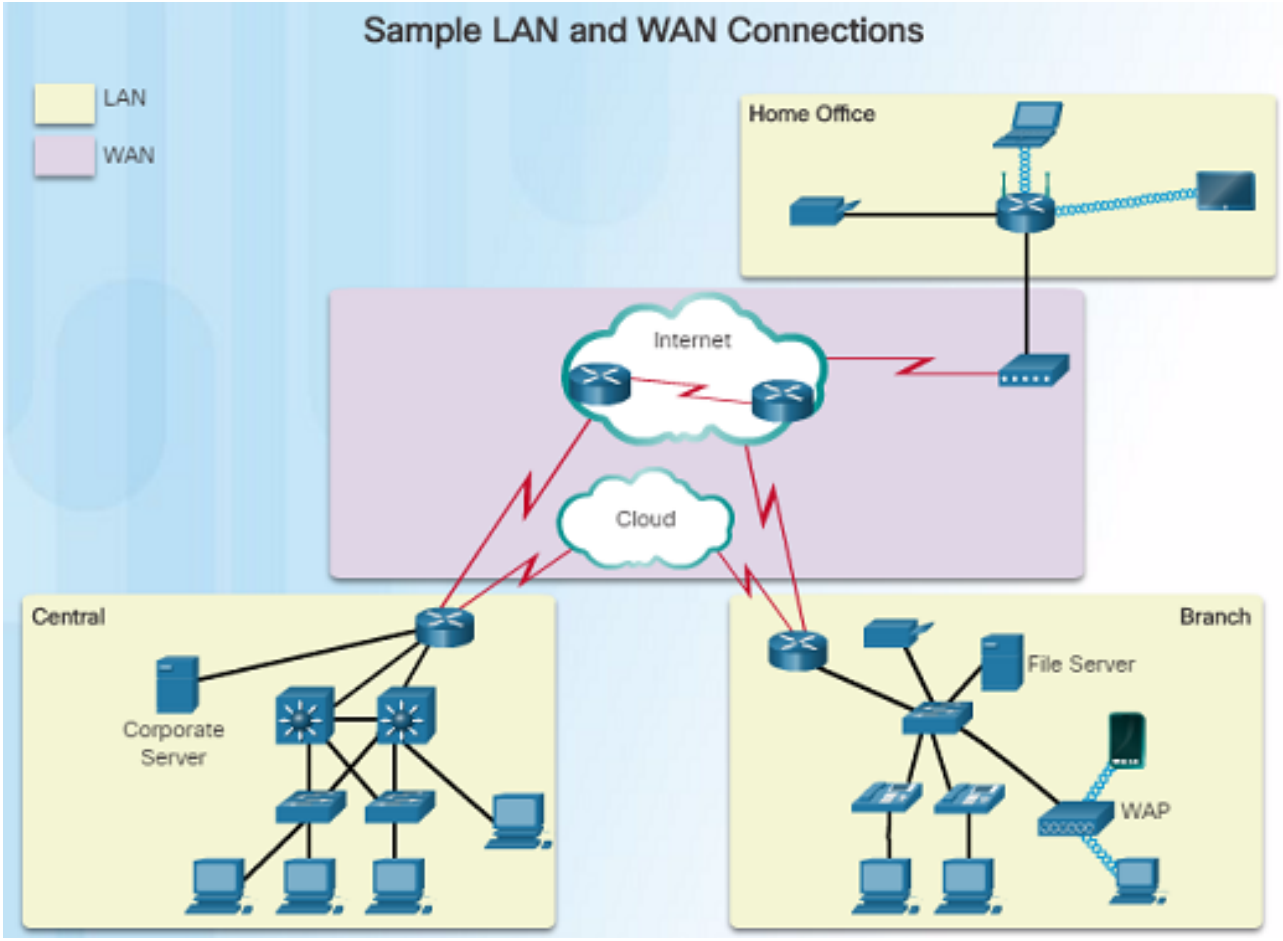
# Connect to a Network

- Branch site devices might connect as follows:
  - Desktop PCs, VoIP phones, and corporate resources such as file servers and printers connect to Layer 2 switches using Ethernet cables.
  - Laptops and smartphones connect wirelessly to wireless access points (WAPs).
  - The WAPs connect to switches using Ethernet cables.
  - Layer 2 switches connect to an Ethernet interface on the edge router using Ethernet cables.
  - The edge router connects to a WAN service provider.



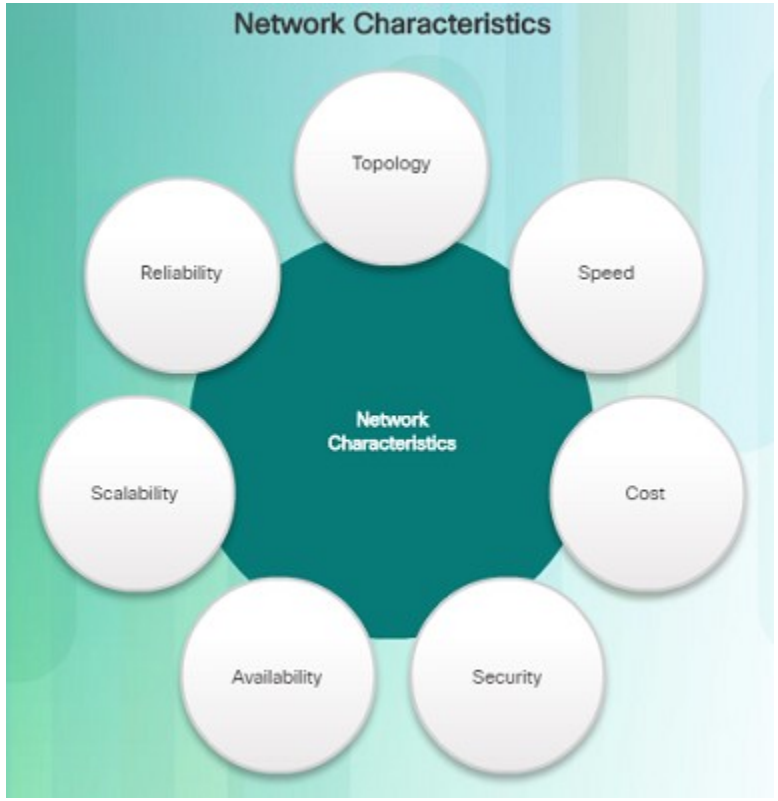
# Connect to a Network

- Central site devices might connect as follows:
  - Desktop PCs and VoIP phones connect to Layer 2 switches using Ethernet cables.
  - Layer 2 switches connect redundantly to multilayer Layer 3 switches using Ethernet fiber-optic cables.
  - Layer 3 multilayer switches connect to an Ethernet interface on the edge router using Ethernet cables.
  - The corporate website server connects to the edge router interface.
  - The edge router connects to a WAN SP and also to an ISP for backup purposes.



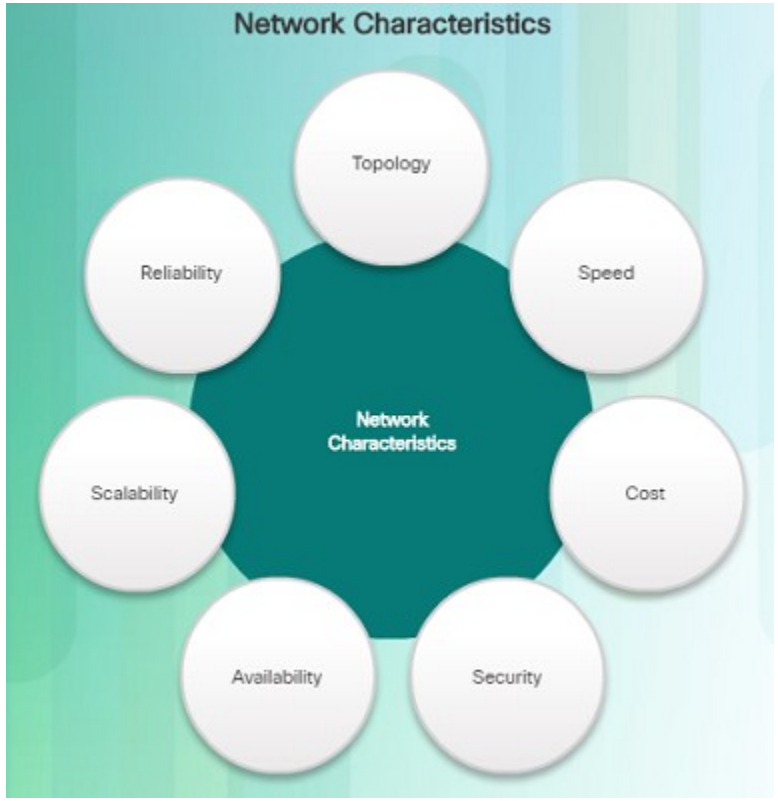
# Characteristics of a Network

- Characteristics referred to when discussing networks:
  - Topology
    - Physical topology – arrangement of the cables, network devices, and end systems
    - Logical topology –how the network devices appear connected to network users
  - Speed
    - measure of the data rate in bits per second (b/s) of a given link
  - Cost
    - general expense for purchasing of network components as well as installation and maintenance of the network



# Characteristics of a Network

- Security
  - indicates how protected the network is, including the information that is transmitted over the network
- Availability
  - refers to the likelihood that the network is available for use when it is required
- Scalability
  - indicates how easily the network can accommodate more users and data transmission requirements as they increase
- Reliability
  - indicates the dependability of the components that make up the network including the routers, switches, PCs, and servers; often measured as MTBF (mean time between failures)

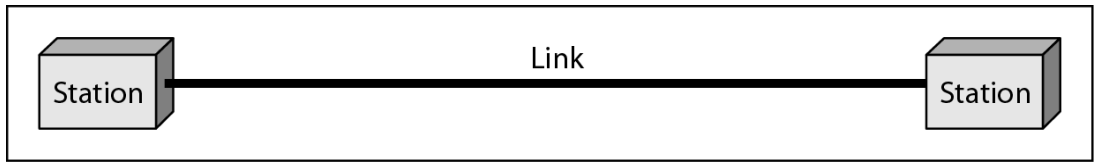


# Physical Structures of Networks

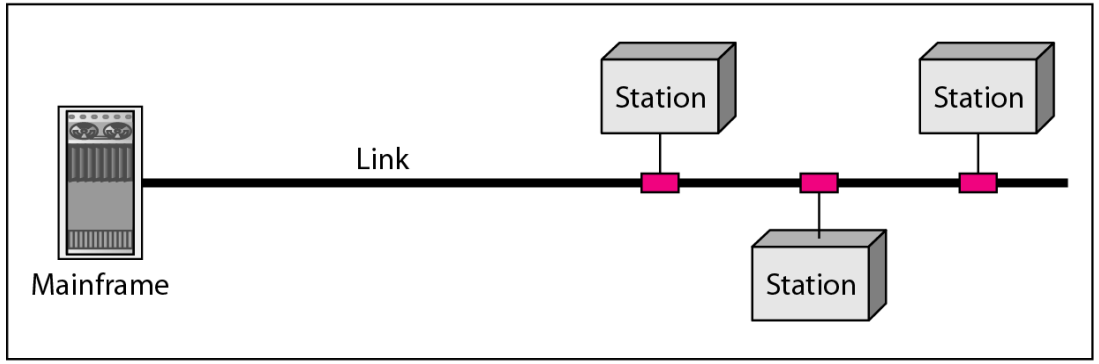
- Type of Connection
  - Point to Point - single transmitter and receiver
  - Multipoint - multiple recipients of single transmission
- Physical Topology
  - Connection of devices
  - Type of transmission - unicast, mulitcast, broadcast

# Type of Connection

- Point-to-point networks
  - Each node connected to every node
  - Simple and reliable
  - Costly due to many wires required
- Multipoint networks
  - Nodes are connected via bus or other topologies
  - Less wiring and hence cheaper
  - Easily extendable by adding new nodes to network
  - Complex network protocol

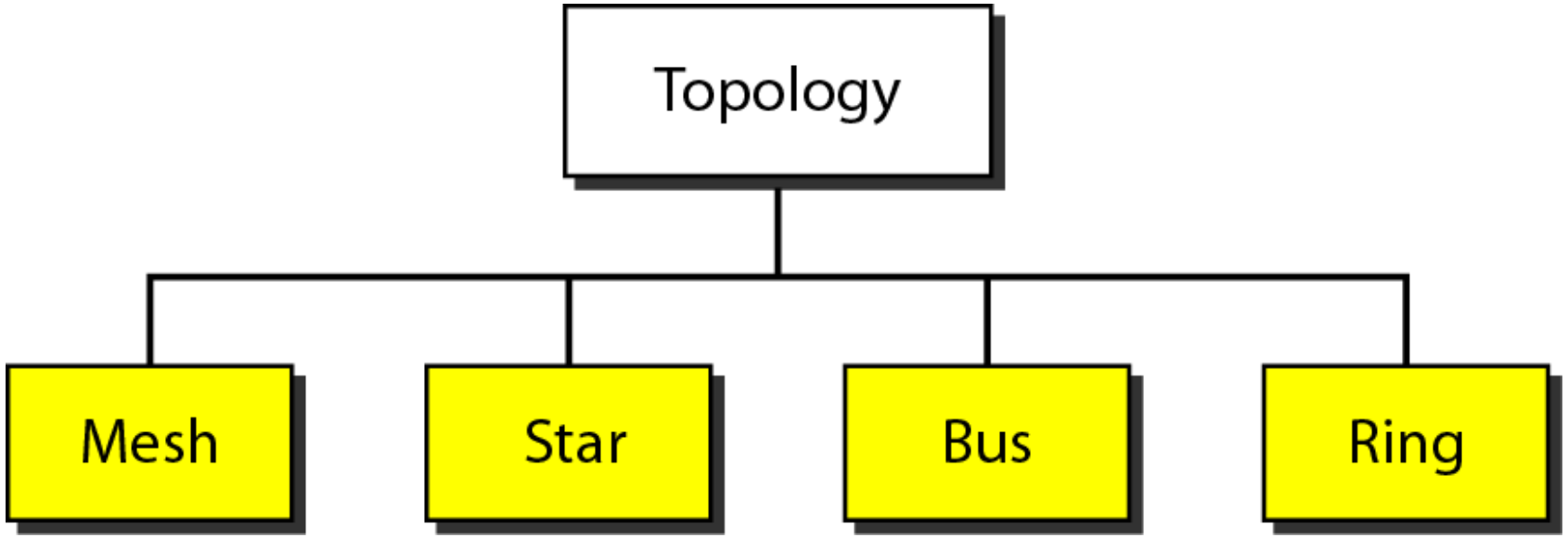


a. Point-to-point



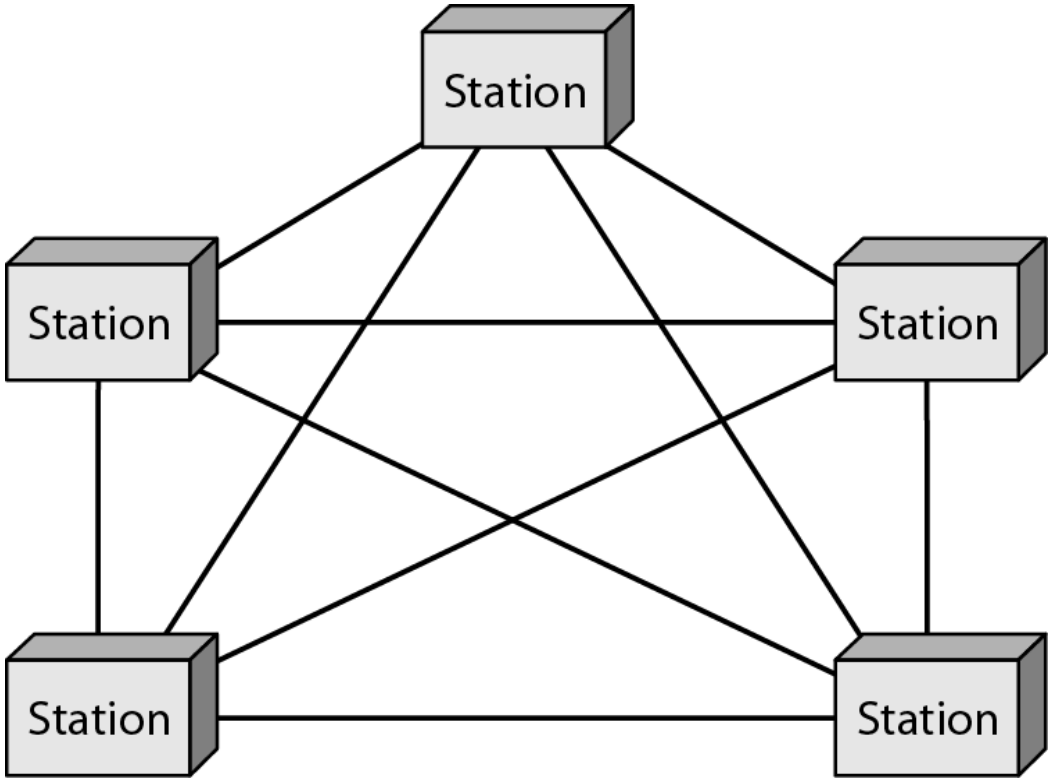
b. Multipoint

# Physical Topology

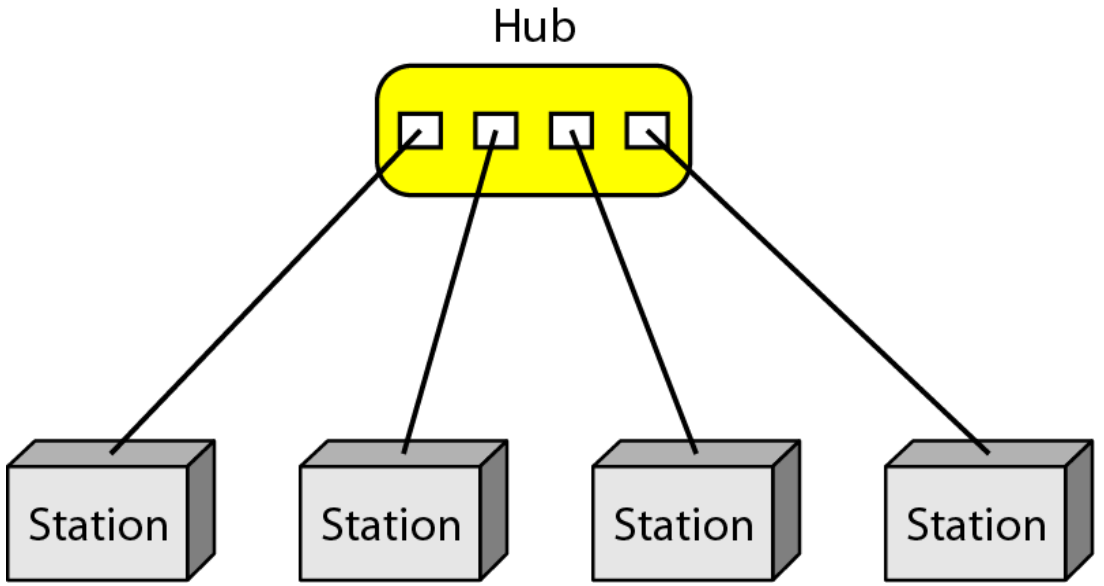


# Physical Topology

**A fully connected mesh topology connecting five stations**

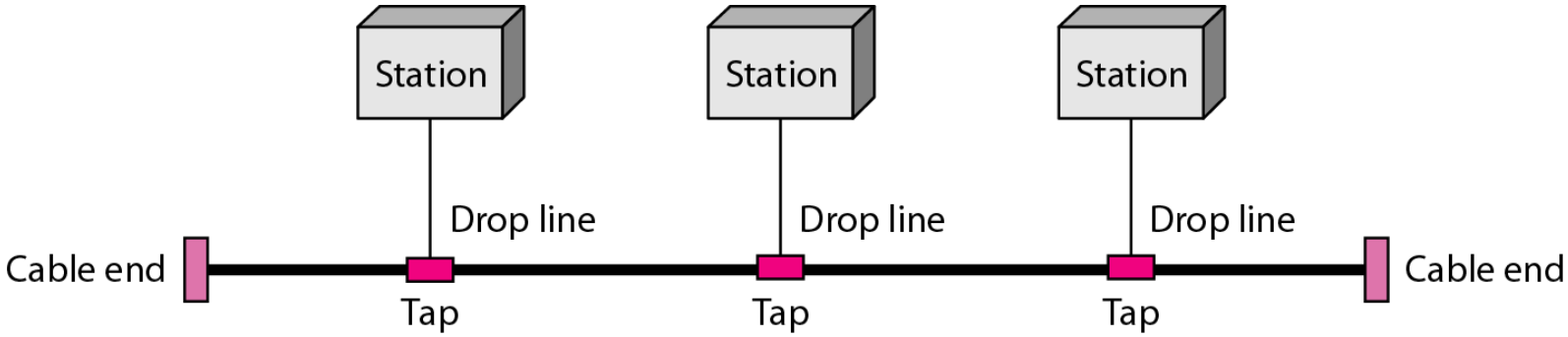



**A star topology connecting four stations**

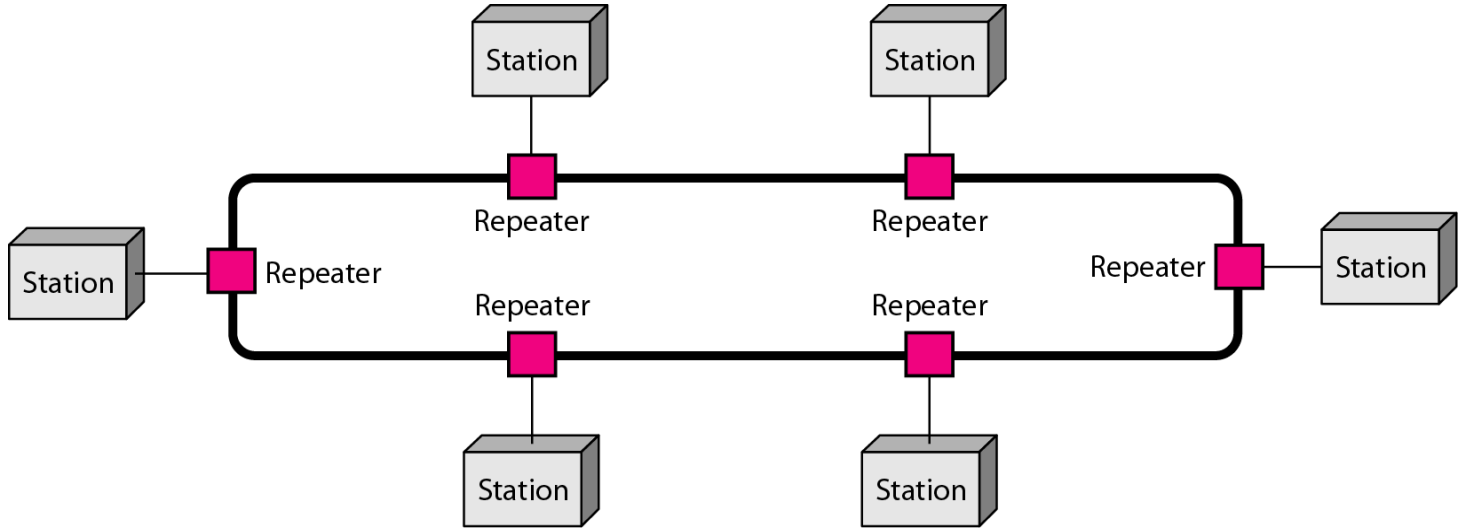


# Physical Topology

**A bus topology connecting three stations**

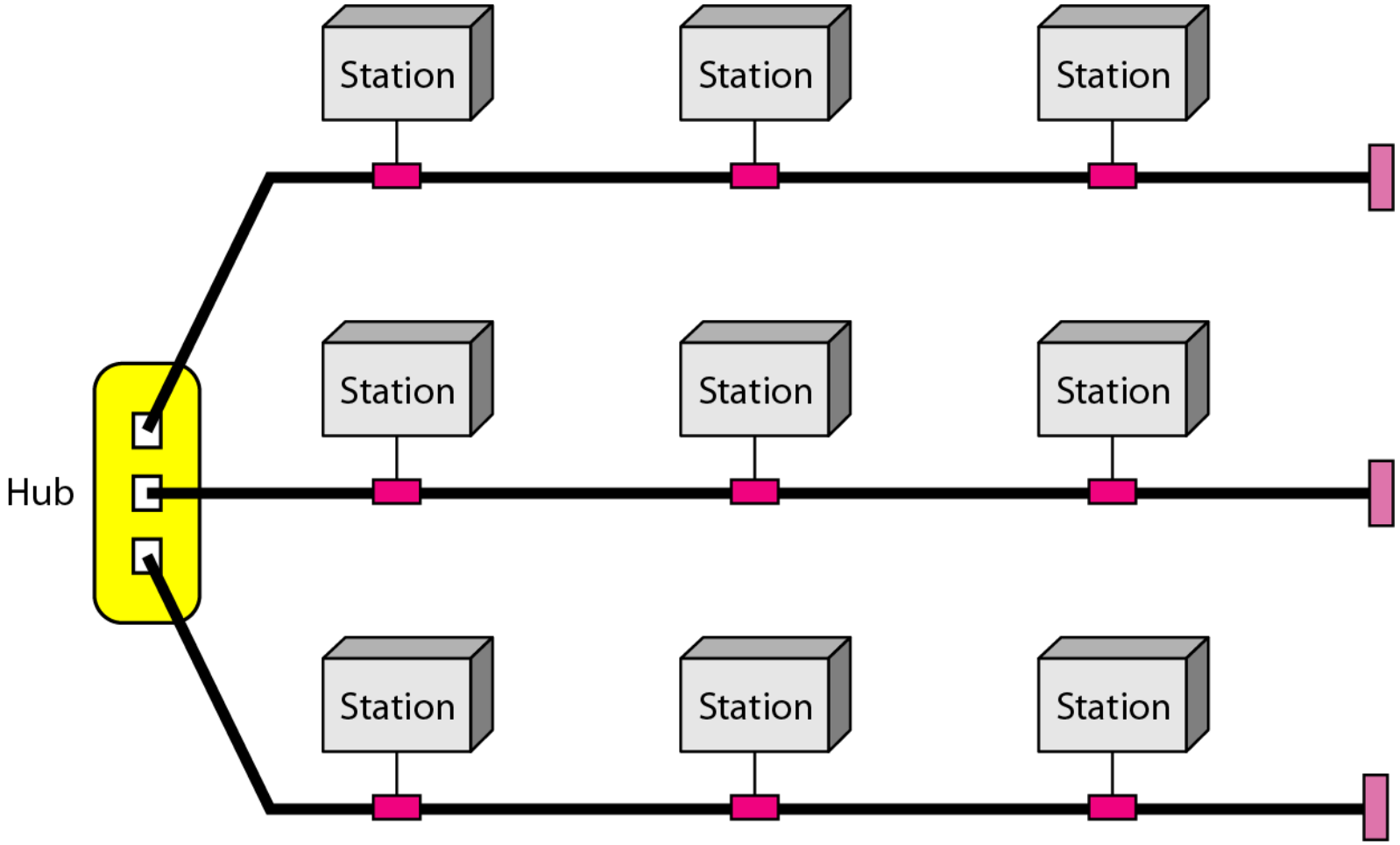



**A ring topology connecting six stations**



# Physical Topology

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

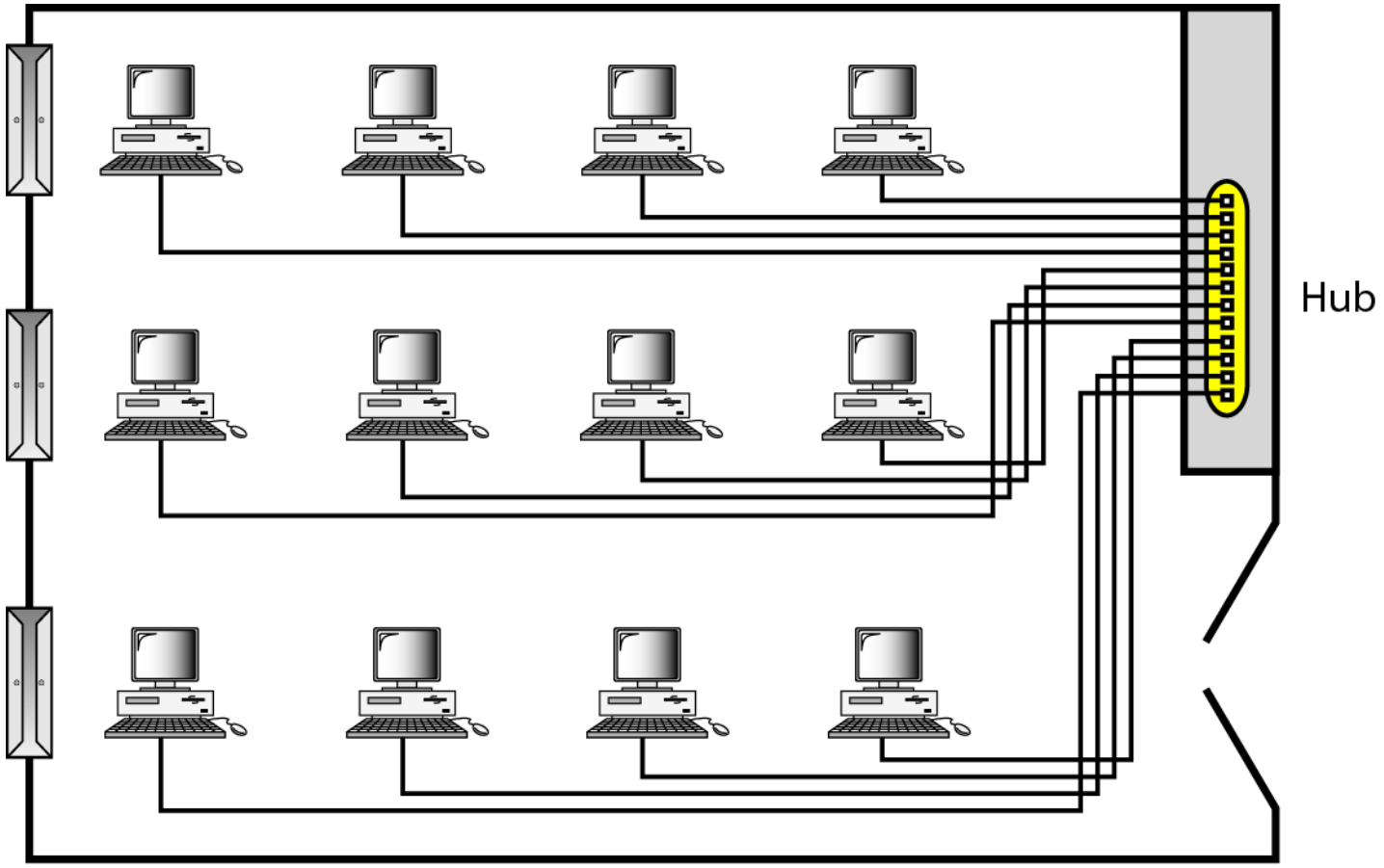


# Categories of Networks

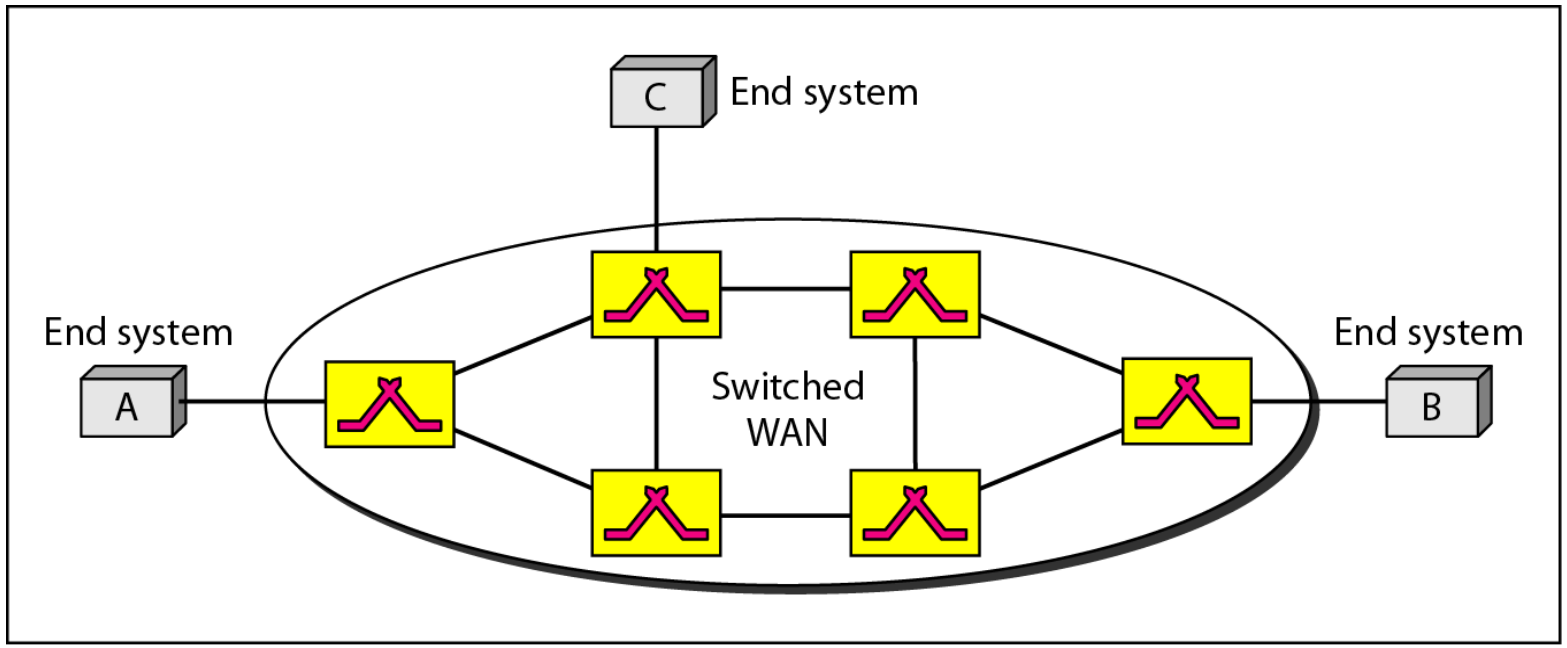
- Local Area Network (LAN)
  - Short distances
  - Designed to provide local interconnectivity
- Wide Area Network (WAN)
  - Long distances
  - Provide connectivity over large areas
- Personal Area Network (PAN)
  - Network organized around an individual person within a single building
- Metropolitan Area Network (MAN)
  - Provide connectivity over areas such as a city, a campus

# Local Area Network (LAN)

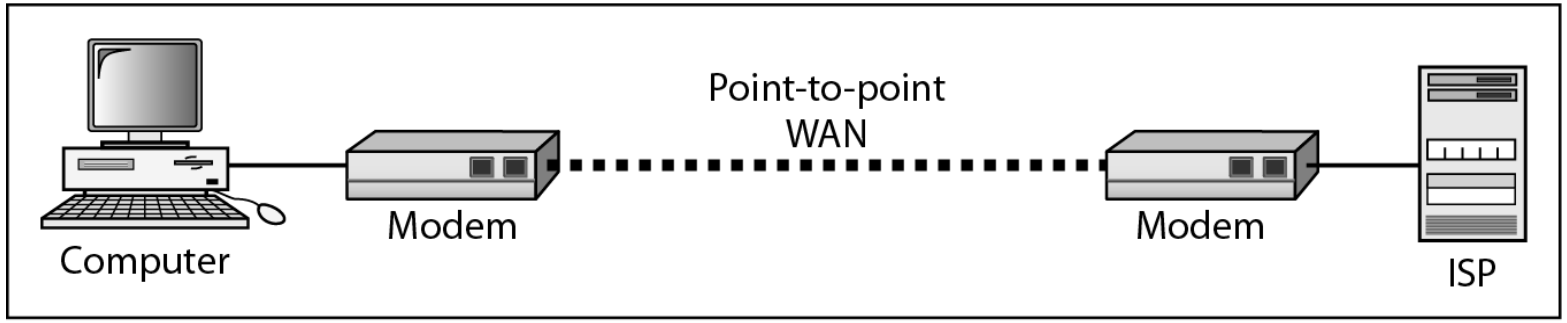
- An isolated LAN connecting 12 computers to a hub in a closet



# Wide Area Network (WAN)



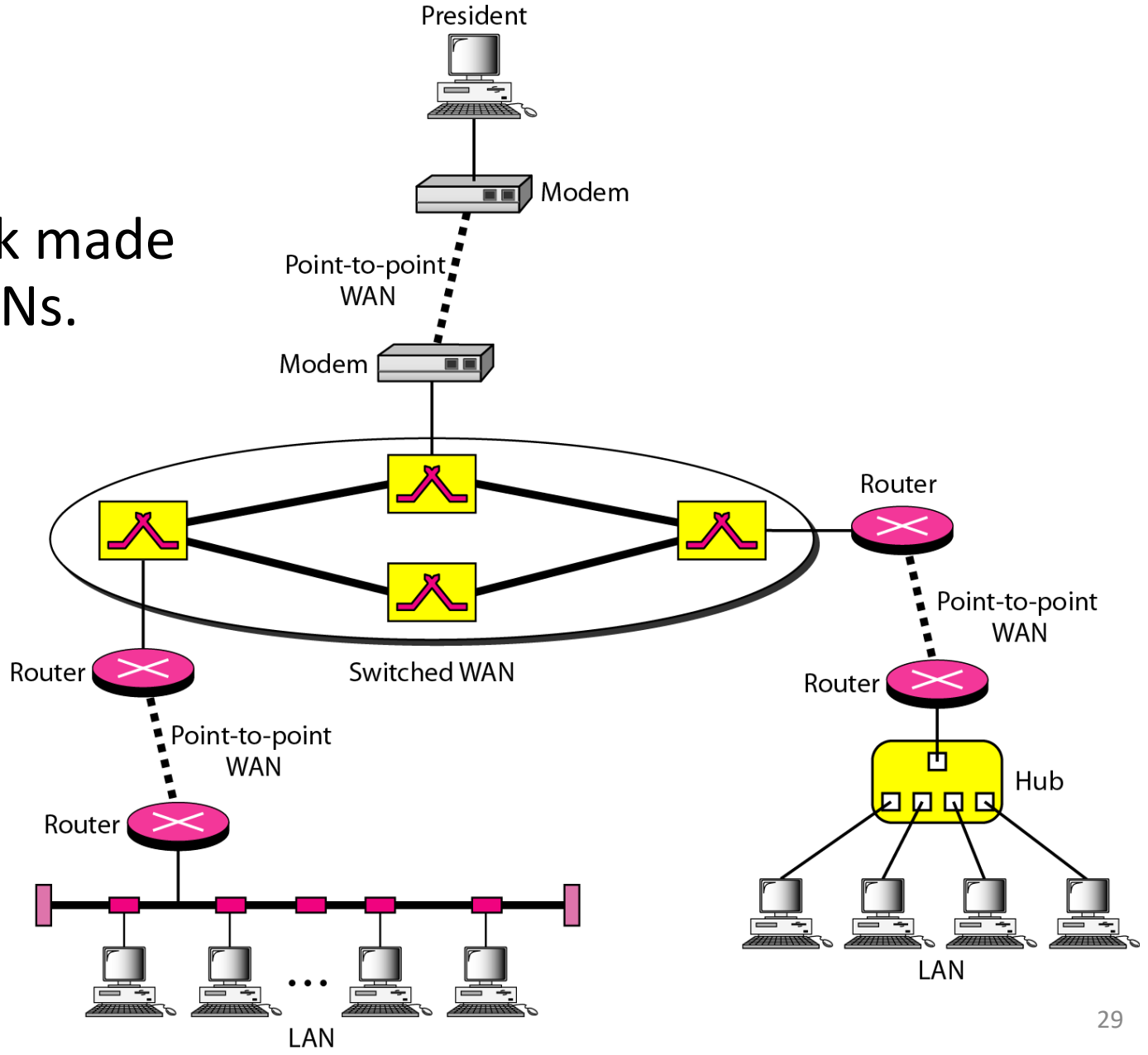

a. Switched WAN




b. Point-to-point WAN

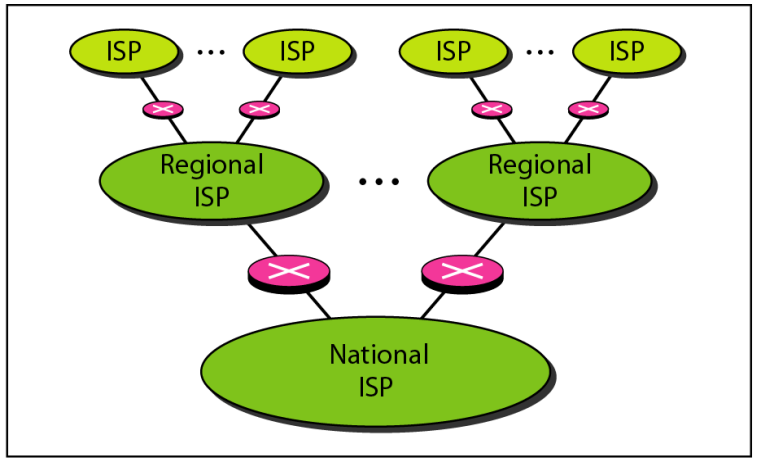
# LANs and WANs

- A heterogeneous network made of two LANs and four WANs.

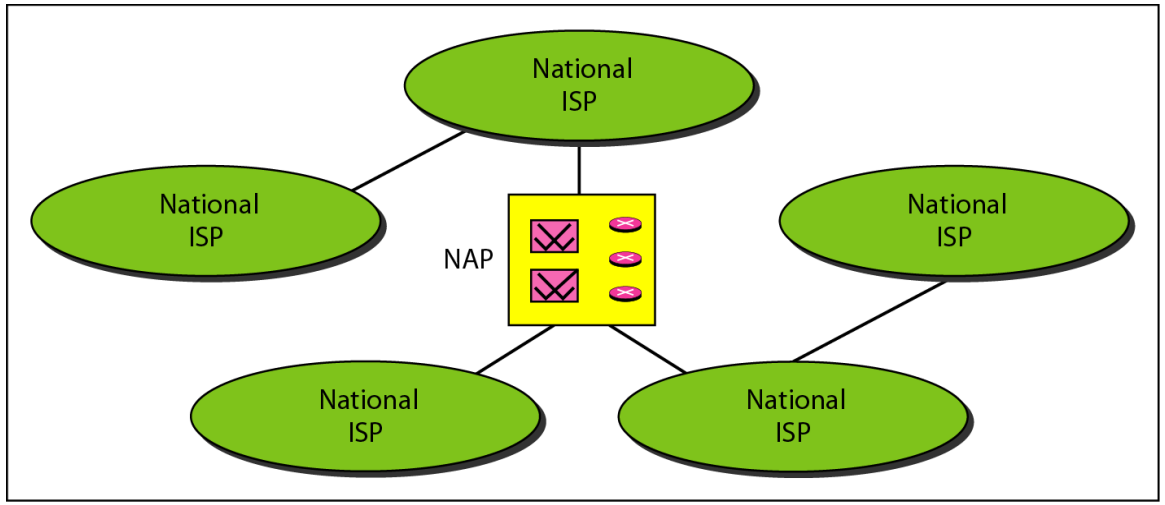


# The Internet

- The Internet has revolutionized many aspects of our daily lives.
- It has affected the way we do business as well as the way we spend our leisure time.
- The Internet is a communication system that has brought a wealth of information to our fingertips and organized it for our use.



a. Structure of a national ISP



b. Interconnection of national ISPs