1. What is a Topology?

- **Definition:** A network topology defines the physical and logical layout of a network. It describes how nodes (computers, switches, routers, etc.) are interconnected and how data flows between them.
- **Two Key Types:**

1. **Physical Topology:** Refers to the actual, tangible layout of the network—the wires, cables, and physical placement of devices. *"How is it actually cabled?"*

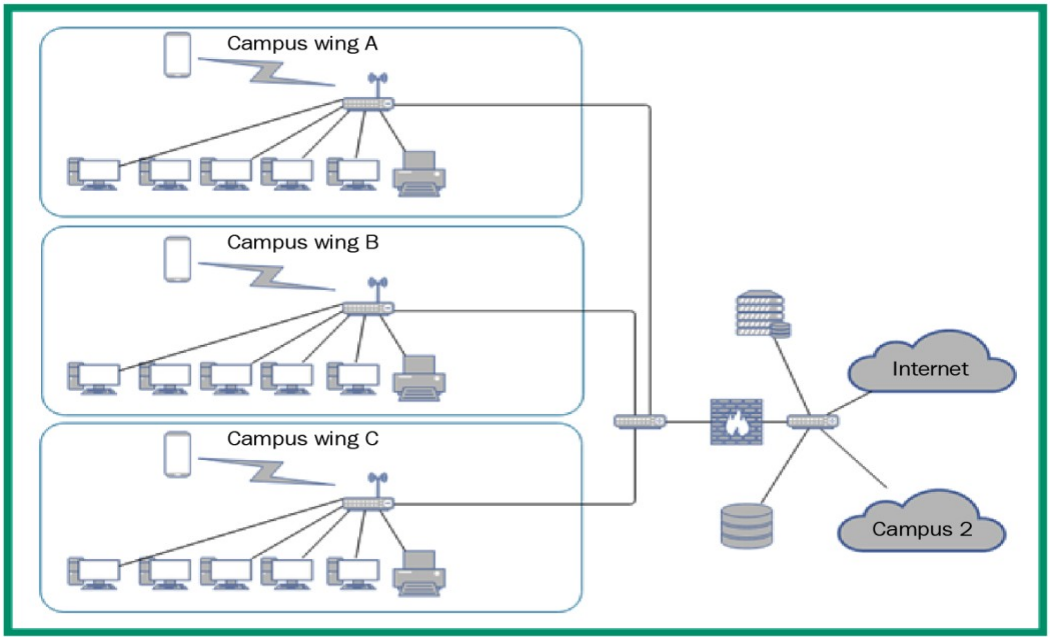

Figure 1: Physical network topology

2. **Logical Topology:** Refers to the logical path data signals take through the physical topology. It's about how data moves through the network, regardless of its physical design. *"How does the data think it is moving?"*

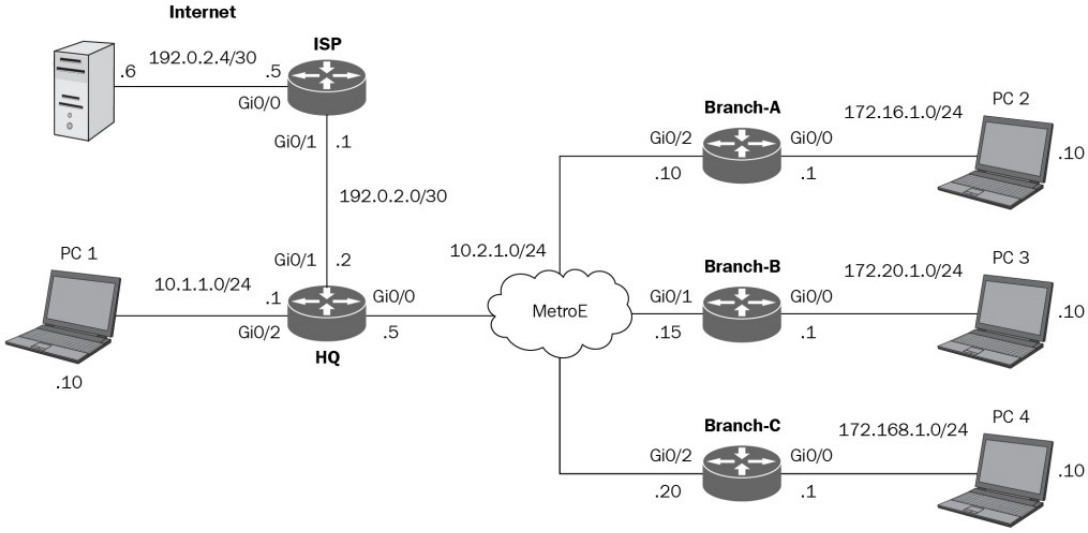

Figure 2: Logical network topology

Key Point: A network's physical and logical topologies can be different. For example, a network can be physically wired as a **Star** but behave logically as a **Bus** (this was common in early Ethernet hubs).

2. Types of Network Topologies

a. Bus Topology

- **Layout:** All devices are connected to a single central cable (the *bus* or *backbone*) using drop cables and taps.

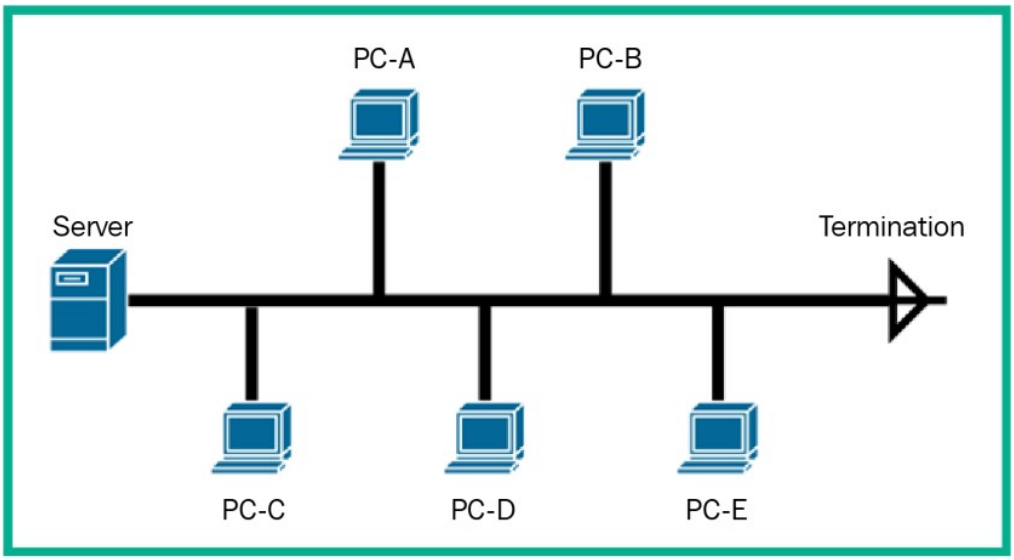

Figure 3: Bus topology

- **Data Flow:** A data signal is sent to all devices on the backbone. Only the device the signal is addressed to accepts it. Others discard it.

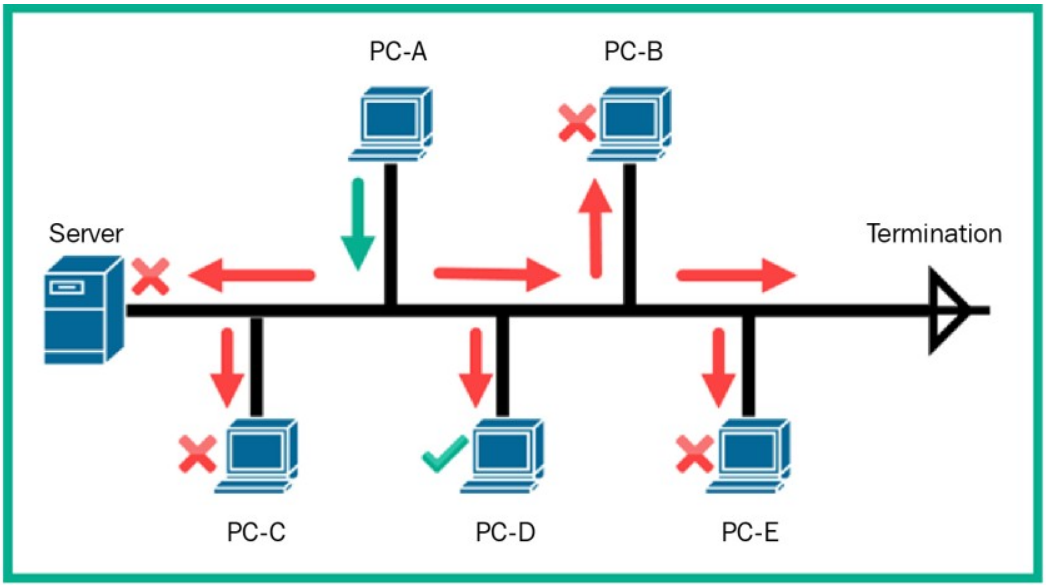

Figure 4: Shared Ethernet on a bus topology

- **Termination:** The bus cable **must be terminated at both ends** to prevent signal bounce (echo).

- **Pros:**
    - Simple and inexpensive to install for small networks.
    - Requires less cabling than a star.
- **Cons:**
    - **A single point of failure:** A break in the main cable brings down the **entire network**.
    - Difficult to troubleshoot and isolate problems.
    - Performance degrades significantly as more devices are added (due to collisions).
    - **Not a practical choice for modern networks.**

b. Ring Topology

- **Layout:** Each device is connected to two other devices, forming a circular data path. Data travels in one direction (unidirectional) or both directions (bidirectional).

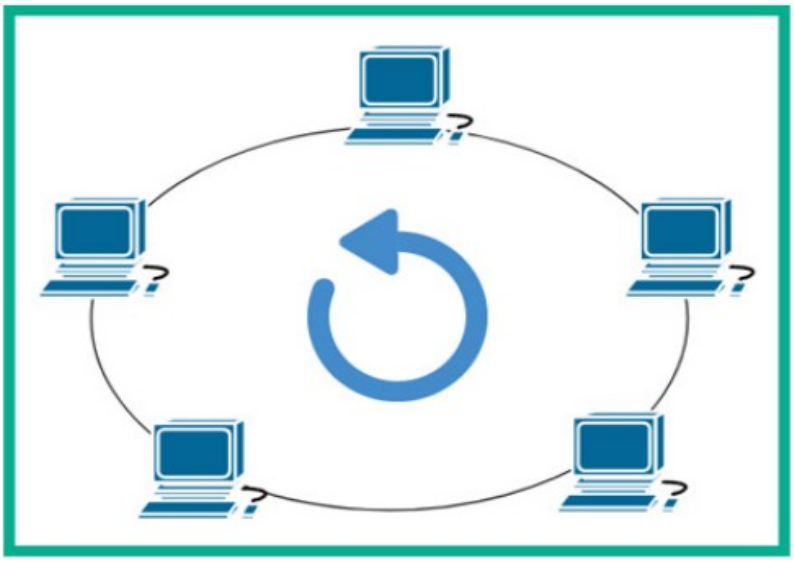

Figure 5: Ring topology

- **Data Flow:** Data is passed from one device to the next around the ring until it reaches its destination. Often uses a **token** to control transmission and prevent collisions (Token Ring).

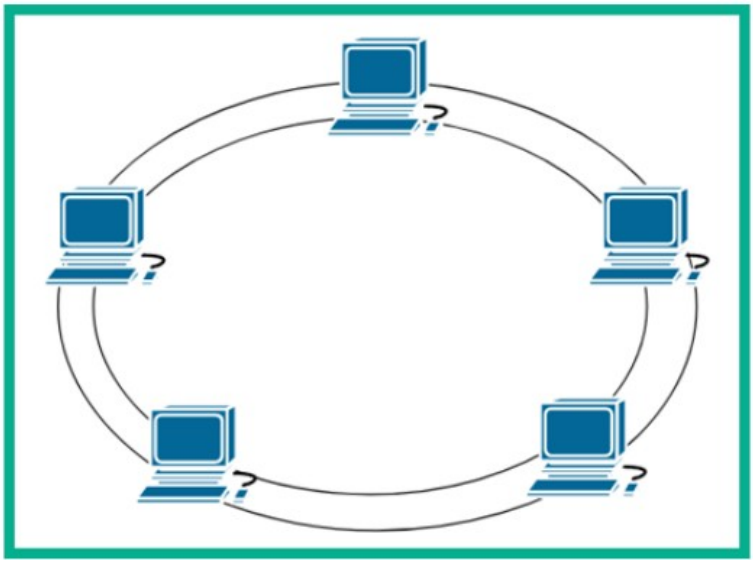

Figure 6: Dual Ring Topology

- **Pros:**
    - Orderly network performance; no collisions.
    - Equal access to the network for all devices.
- **Cons:**
    - **A single point of failure:** A failed node or cable break can disrupt the **entire ring**.
    - Difficult to troubleshoot.
    - Adding or removing devices requires disrupting the network.

c. Star Topology

- **Layout:** The most common topology. All nodes connect to a central device, such as a **switch** or a **hub**.

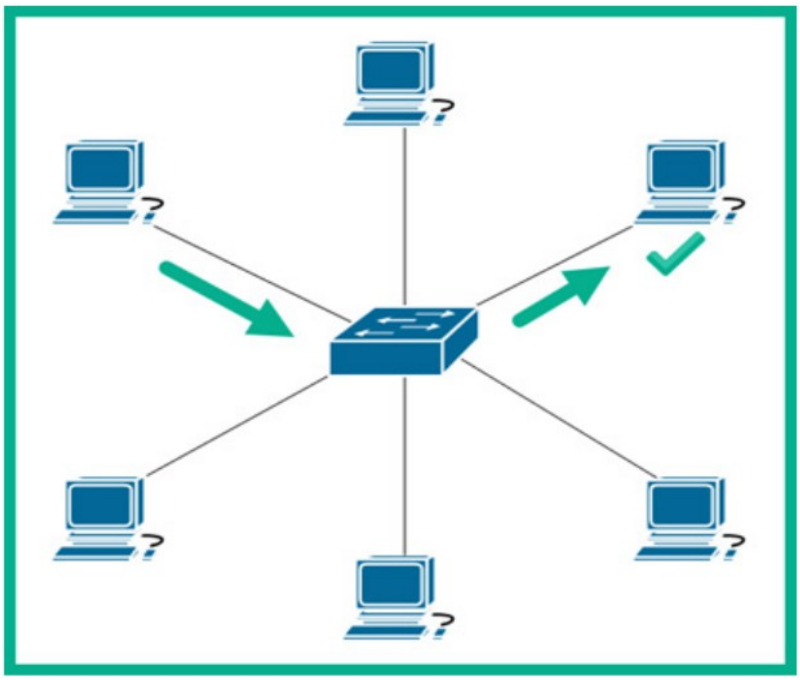

Figure 7: Star Topology

- **Data Flow:** Data sent from a node goes to the central device, which then forwards it to the destination node.
- **Pros:**
    - **Easy to troubleshoot and manage.** Fault isolation is simple—a failed cable or node only affects one device.
    - Easy to add or remove devices without disrupting the network.
    - Scalable; you can add more switches to grow the network.
- **Cons:**
    - **Single point of failure:** If the central device fails, **all devices connected to it lose connectivity**.

    - Requires more cable than a bus topology.
- **Modern Use:** The **de facto standard** for wired Ethernet LANs (Local Area Networks).

d. Mesh Topology

- **Layout:** Every node has a direct connection to every other node. Highly redundant but extremely expensive to implement.
    - Formula for connections: `n(n-1)/2` (e.g., 10 devices require 45 connections).

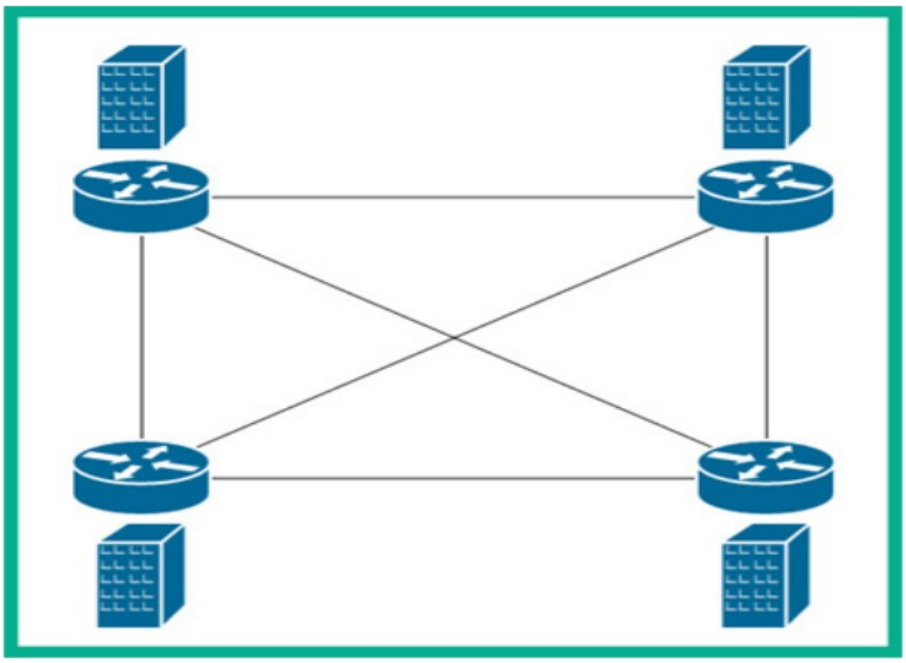

Figure 8: Mesh topology

- **Pros:**
    - **Extremely fault-tolerant.** Provides multiple paths for data, ensuring connectivity even if links fail.
    - High performance and privacy.
- **Cons:**
    - **Extremely high cost** and complex installation due to massive cabling requirements.
    - Complex to manage and troubleshoot.
- **Modern Use:** Used in critical network backbones, such as the **Internet core** and **WANs** (Wide Area Networks).

e. Hybrid Topology

- **Layout:** A combination of two or more different topologies.
- **Examples:**
    - **Star-Bus:** Multiple star networks are connected via a bus backbone.

- **Star-Ring:** Looks like a star physically, but the central devices are connected in a ring.

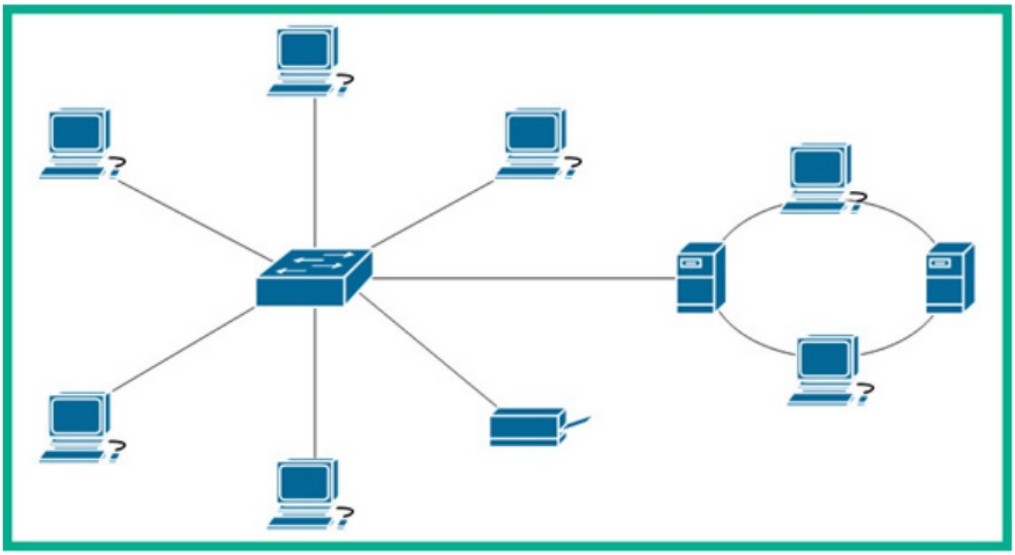

Figure 9: Hybrid topology

- **Pros:** Offers flexibility and allows networks to be designed to meet specific needs.
- **Cons:** Can be complex to design and implement.

f. Hub and Spoke Topology

- **Layout:** A variation of the star topology where a central core site (the "hub") is connected to multiple remote sites (the "spokes"). Spokes are not directly connected to each other.
- **Operation:** All communication between spokes must go through the hub.

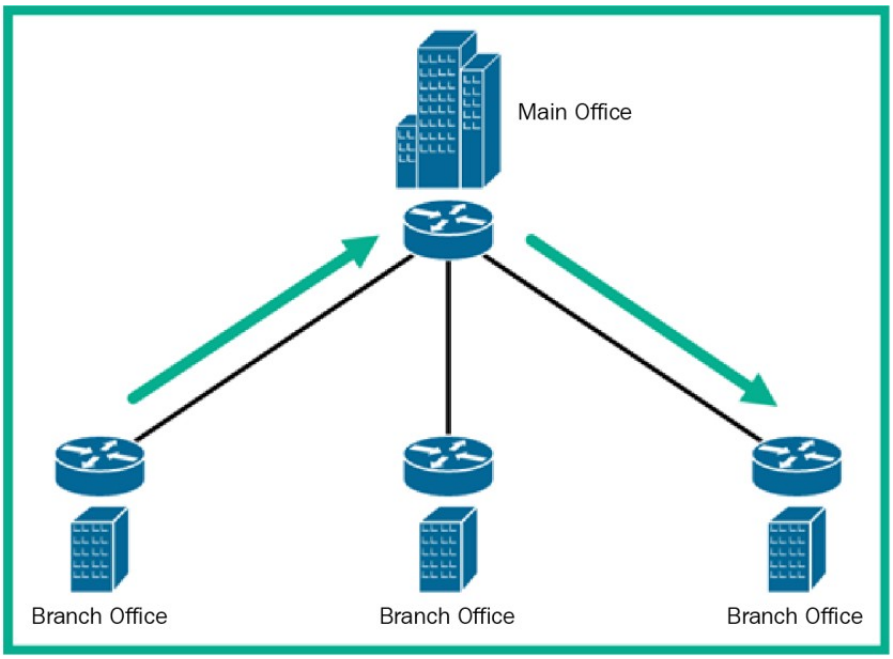

Figure 10: Hub and spoke topology

- **Pros:**
    - **Cost-Effective for WANs:** Reduces the number of required leased lines.
    - **Centralized Security and Management:** All traffic can be inspected at the hub.
- **Cons:**
    - The hub is a **critical single point of failure**.
    - Can create latency, as all inter-spoke traffic must traverse the hub.
- **Modern Use:** Extremely common in **WAN** designs for connecting branch offices to a central headquarters.

2.1. Importance of Topology Diagrams:

- **Troubleshooting:** Essential for pinpointing the location and scope of network issues.
- **Planning & Scalability:** Helps plan for network growth and new device integration.
- **Resource Management:** Aids in managing cables, devices, and network resources efficiently.

3. Discovering Network Types

- Network types are used to define the geographic boundary or limitation of a network and help network professionals understand the relationship between the connected devices within the network.

3.1. Network Types Defined by Device Relationship

A. Peer-to-Peer Network

- **Definition:** A decentralized model where each client is logically connected and shares resources directly with other clients **without a centralized, dedicated server**.
- **Operation:** The client sharing a resource (e.g., a printer) temporarily acts as a server. There is no centralized management of resources or security.

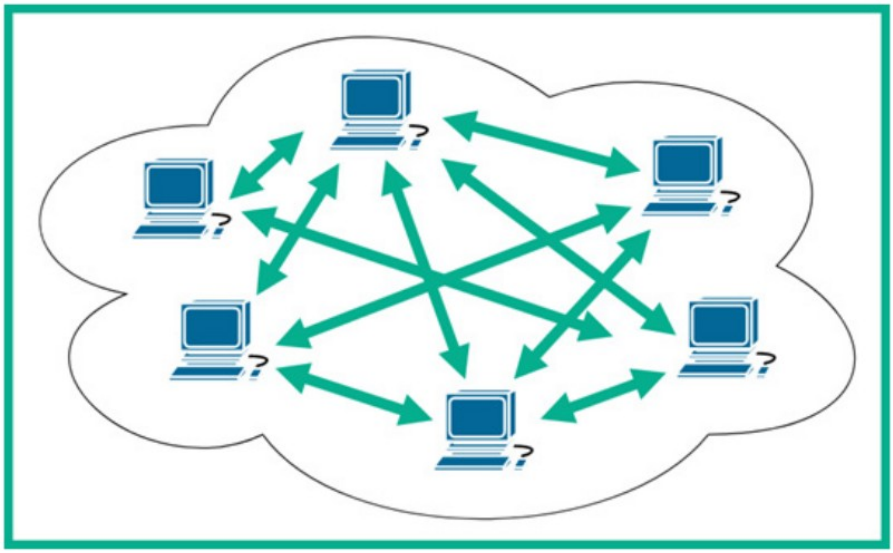

Figure 11: Peer-to-peer model

- **Characteristics:**
    - Commonly implemented as **workgroups** in small organizations.
    - **Lacks scalability** and becomes challenging to manage as the network grows.
    - **Security is a major concern** as each node manages its own security posture.
- **Real-World Example:** File sharing using a **torrent**. Users (**leechers**) download files from other users (**seeds** or **seeders**) who have the complete file.

B. Client-Server Network

- **Definition:** A centralized model containing **dedicated devices (servers)** that provide resources or services to client devices on the network.
- **Operation:** Clients request services, and servers respond to those requests. Resources are centrally managed and accessible.

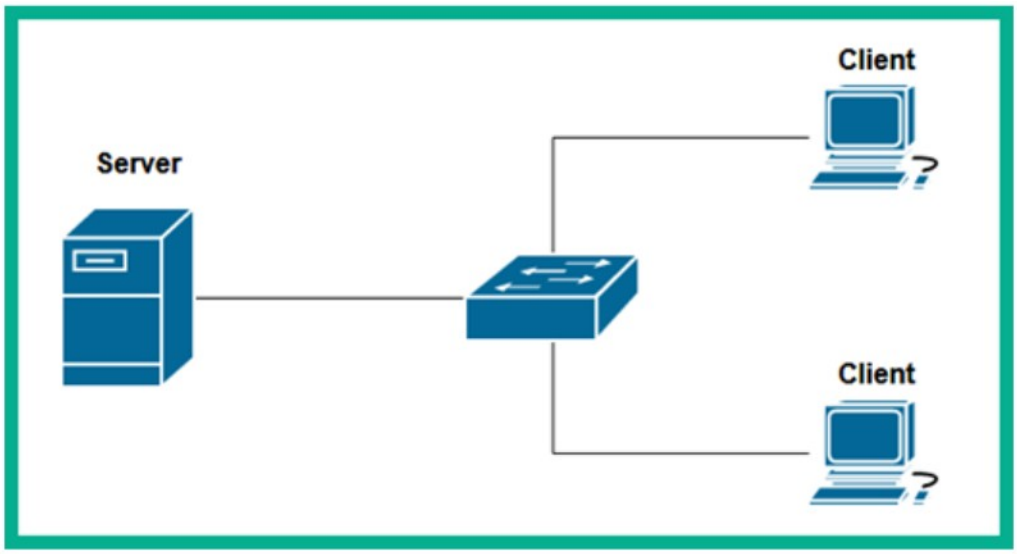

Figure 12: Client-server model

- **Characteristics:**
    - **Supports scalability** for growing organizations.
    - Provides centralized security, management, and backups.
    - The preferred model for modern organizations of all sizes.

3.2. Network Types Defined by Geographic Scope

A. Personal Area Network (PAN)

- **Scope:** A **very small network** created by a user to interconnect their personal devices over a short distance.
- **Technology:** Can be wired or wireless (e.g., Bluetooth).
- **Key Point:** Not designed to connect to a larger network; each device manages its own security.

Figure 13: Personal area network

- **Examples:** Connecting a laptop, smartphone, and wireless printer at home; a Bluetooth connection between a phone and headphones.

B. Local Area Network (LAN)

- **Scope:** A network within a **single geographic location**, such as a building or office.
- **Components:** Workstations, servers, printers, switches, routers, and firewalls.
- **Key Function:** The router acts as the **default gateway**, forwarding traffic to remote networks. Without it, clients cannot communicate outside their immediate network.
- **Example:** A small office network where all devices are interconnected and can share resources.

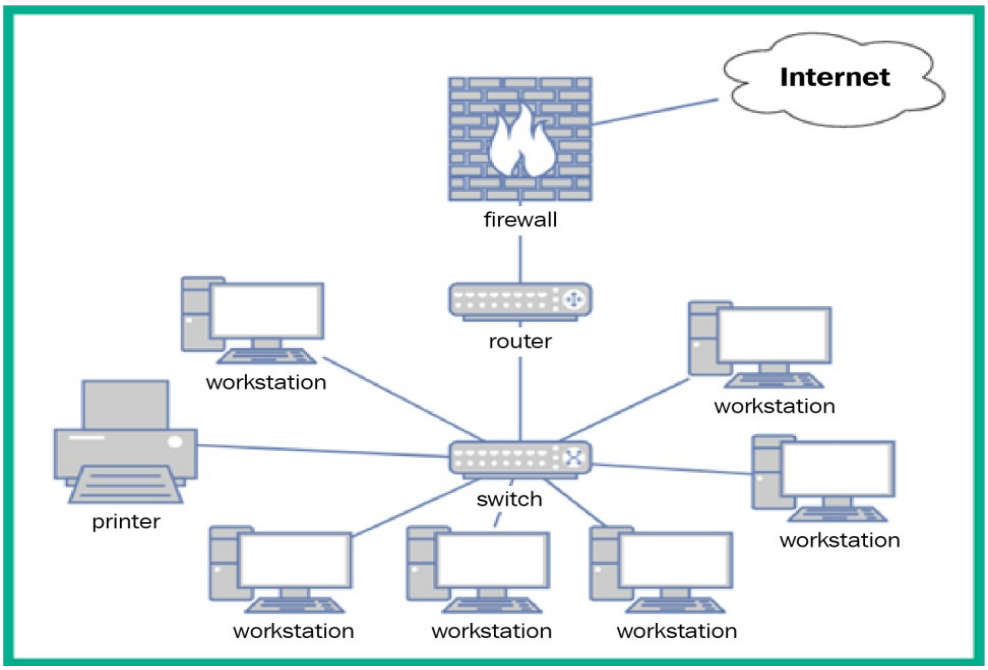

Figure 14: LAN network model

C. Wide Area Network (WAN)

- **Scope:** Used to **extend a LAN** over a **large geographic distance** to interconnect remote offices.
- **Operation:** Implemented by a **Managed Service Provider (MSP)** or **Internet Service Provider (ISP)**. Traffic within a WAN connection remains private.
- **Common Topology:** Often implemented in a **hub-and-spoke** model, where branch offices (spokes) connect to a main office (hub).
- **Internet Access Models:**
    1. Each office has its own internet connection (less cost-efficient).
    2. **Redistribution:** A single internet connection at the main office is redistributed to branch offices via the WAN (cost-efficient for same-country branches).

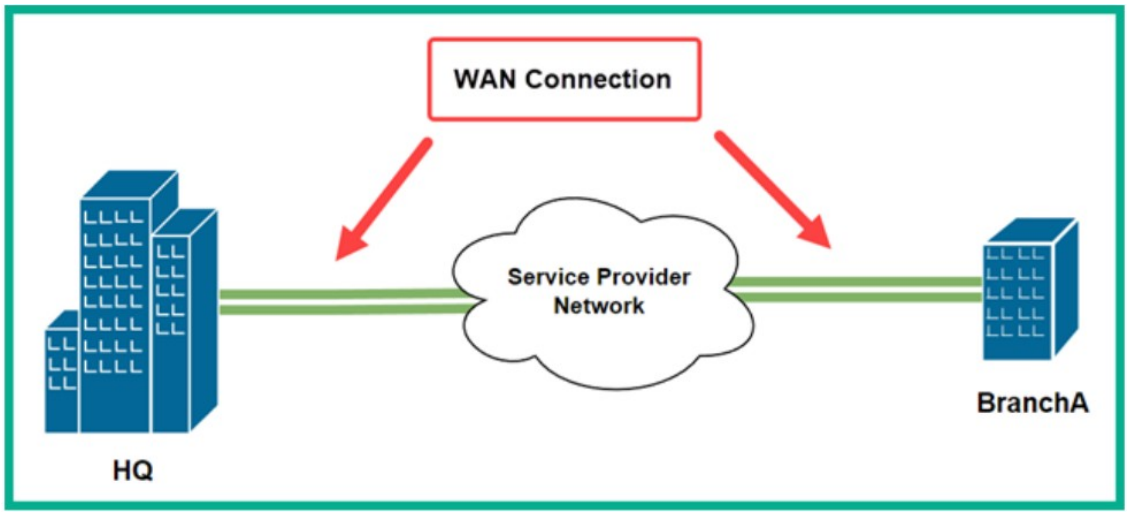

Figure 15: Wide Area Network

D. Metropolitan Area Network (MAN)

- **Scope:** Spans a **single city**. Used to interconnect all branch offices of an organization within that city.
- **Key Point:** Limited to a single city and typically a single organization. Sometimes offered by cities to residents as an incentive.

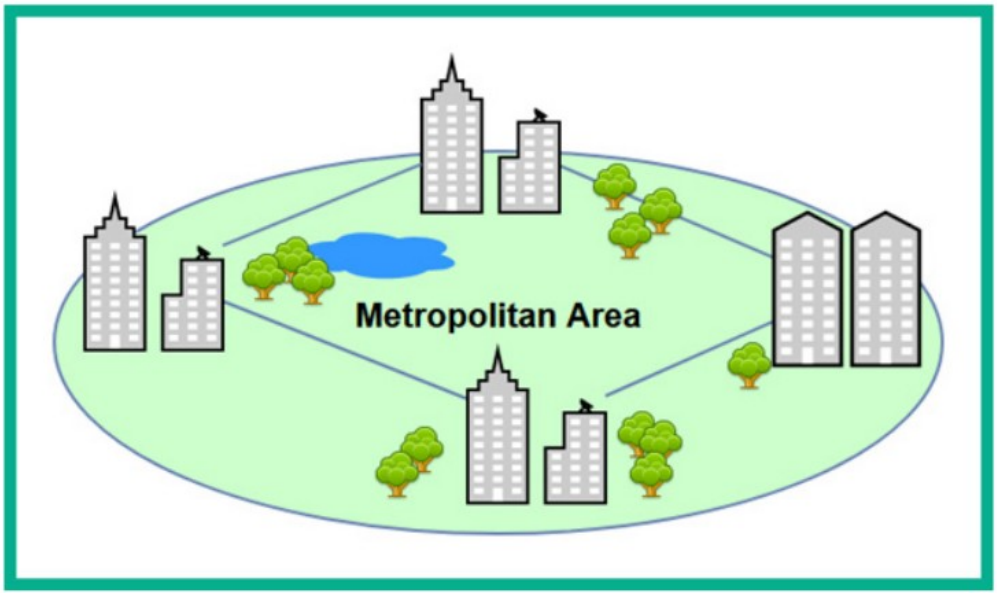

Figure 16: Metropolitan area network type

E. Wireless Local Area Network (WLAN)

- **Definition:** A **wireless implementation of a LAN**.
- **Components:**
  - **Wireless Router:** A multilayer device (switch, AP, router) common in homes/small businesses. It routes between wireless and wired networks on different IP subnets.
  - **Access Point (AP):** A layer 2 device that provides wireless connectivity and is connected to a wired switch.
- **Technology:** Generates signals using radio frequencies on the 2.4 GHz, 5 GHz, and 6 GHz bands based on IEEE 802.11 standards.

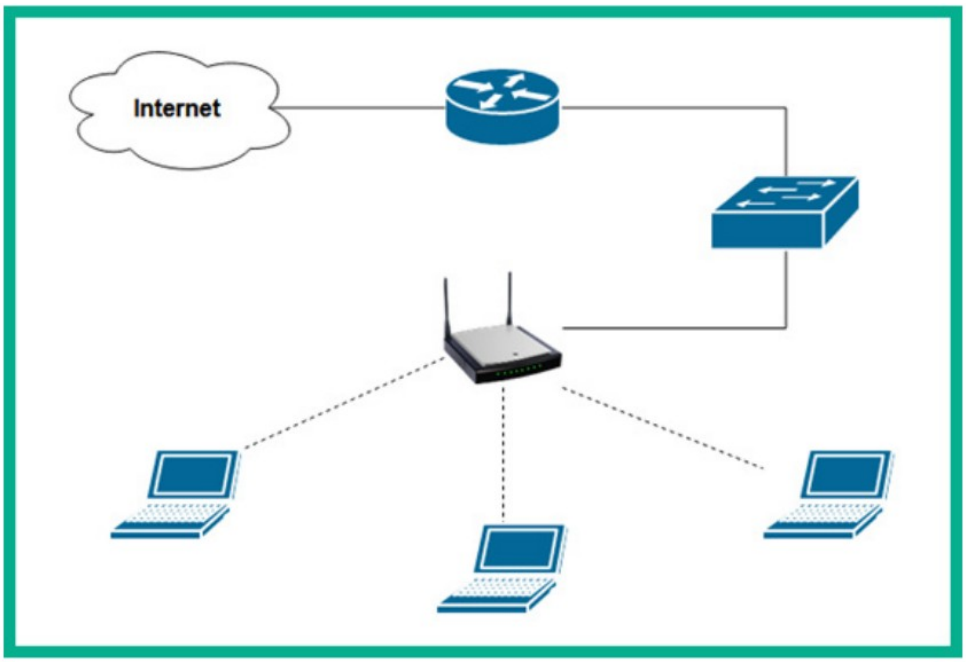

Figure 17: WLAN network type