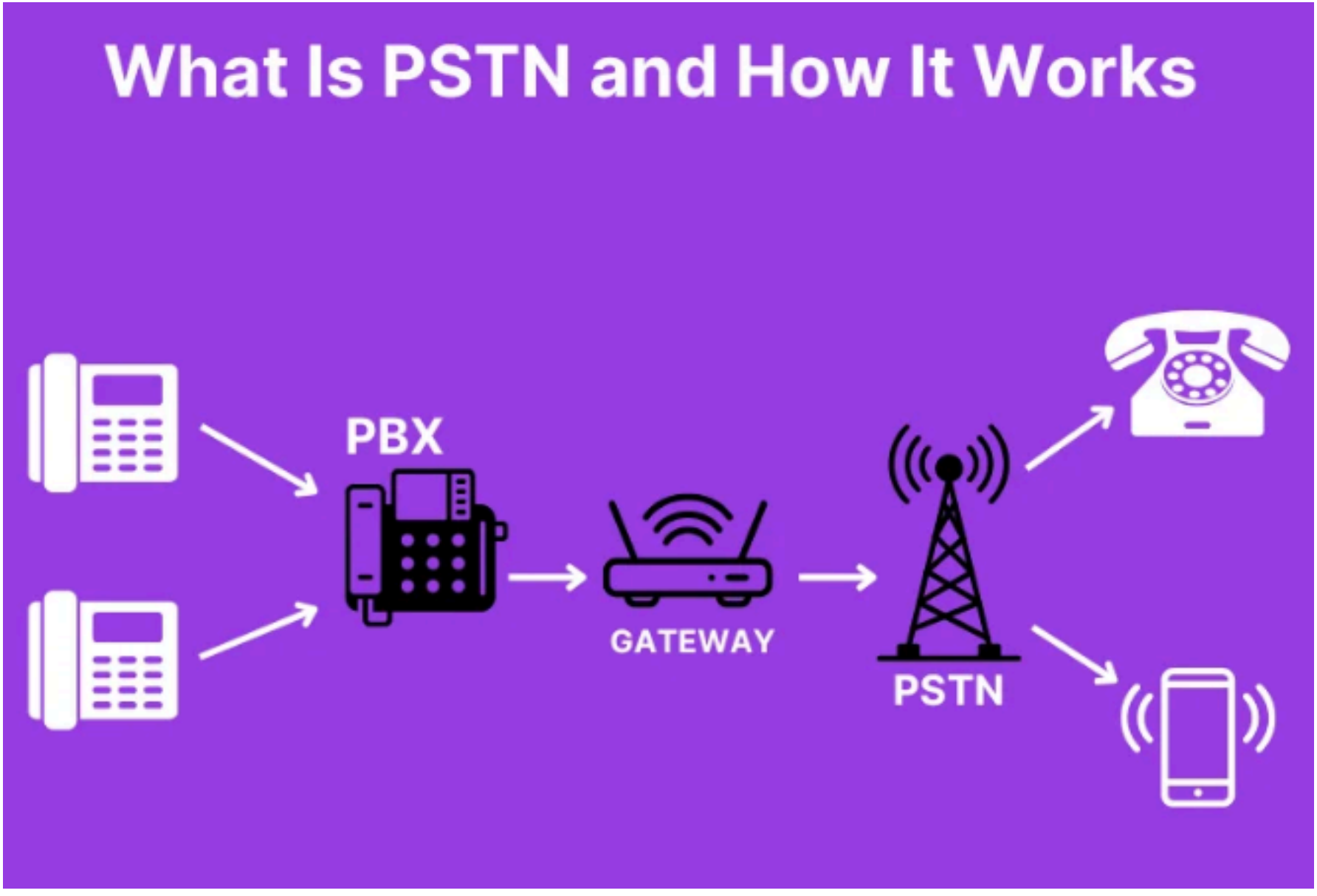
Module-3
Telecommunication Networks

Types of networks: PSTN, Cellular, Satellite, Internet

- Network topologies: Star, Mesh, Ring, Hybrid

- Overview of Switching and Routing

Types of networks: PSTN



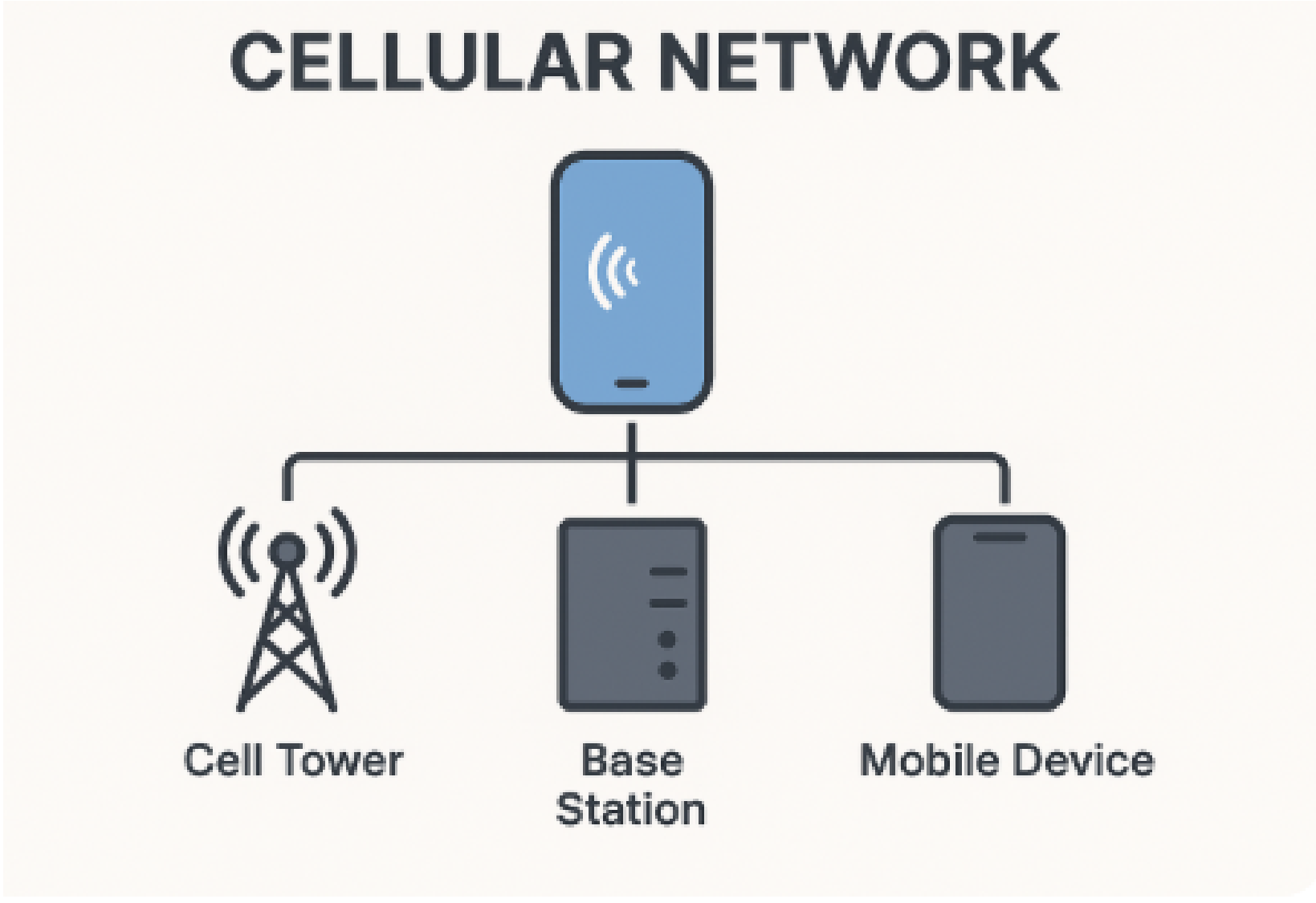
Types of networks: PSTN

- **PSTN**, or public switched telephone network, is a communication infrastructure that carries voice and data worldwide. It connects landline phones, fiber, fiber optic cables, cellular networks, microwave transmission links, and undersea telephone cables, forming a global communication network operated by telephony operators.
- In its early days, the PSTN lines relied on twisted pair **copper wires** to transmit analog voice signals. Over time, the PSTN has undergone a significant modernization. The modern PSTN uses fiber optic cables and Voice Over Internet Protocol (VoIP) technologies.
- **Infrastructure of PSTN: Key Components**
- 1-**Telephone lines**
- 2- **Local exchange:** The local exchange or central office (CO) manages local calls and connects multiple phone lines within a city or region.
- **3- Switching centers:** The switching center connects calls between different local exchanges, regions, or countries.
- **4- Trunks:** Trunks are the main transmission lines between switching centers and local exchanges or between different switching centers.

Types of networks: PSTN

- 5-**International gateways and submarine cables:** The PSTN relies on undersea cables and satellite systems for international calls.
- **6- Signaling systems:** PSTN uses signaling protocols or “rules of conversation” that manage the connection between two phones. The network, phones, and exchanges don’t automatically connect when you make a call.
- **7-End-user devices:** End-user devices are the gadgets you use to make and receive calls. They include old school phones, fax machines, answering machines, public payphones, caller ID services, and modems.

Types of networks: Cellular



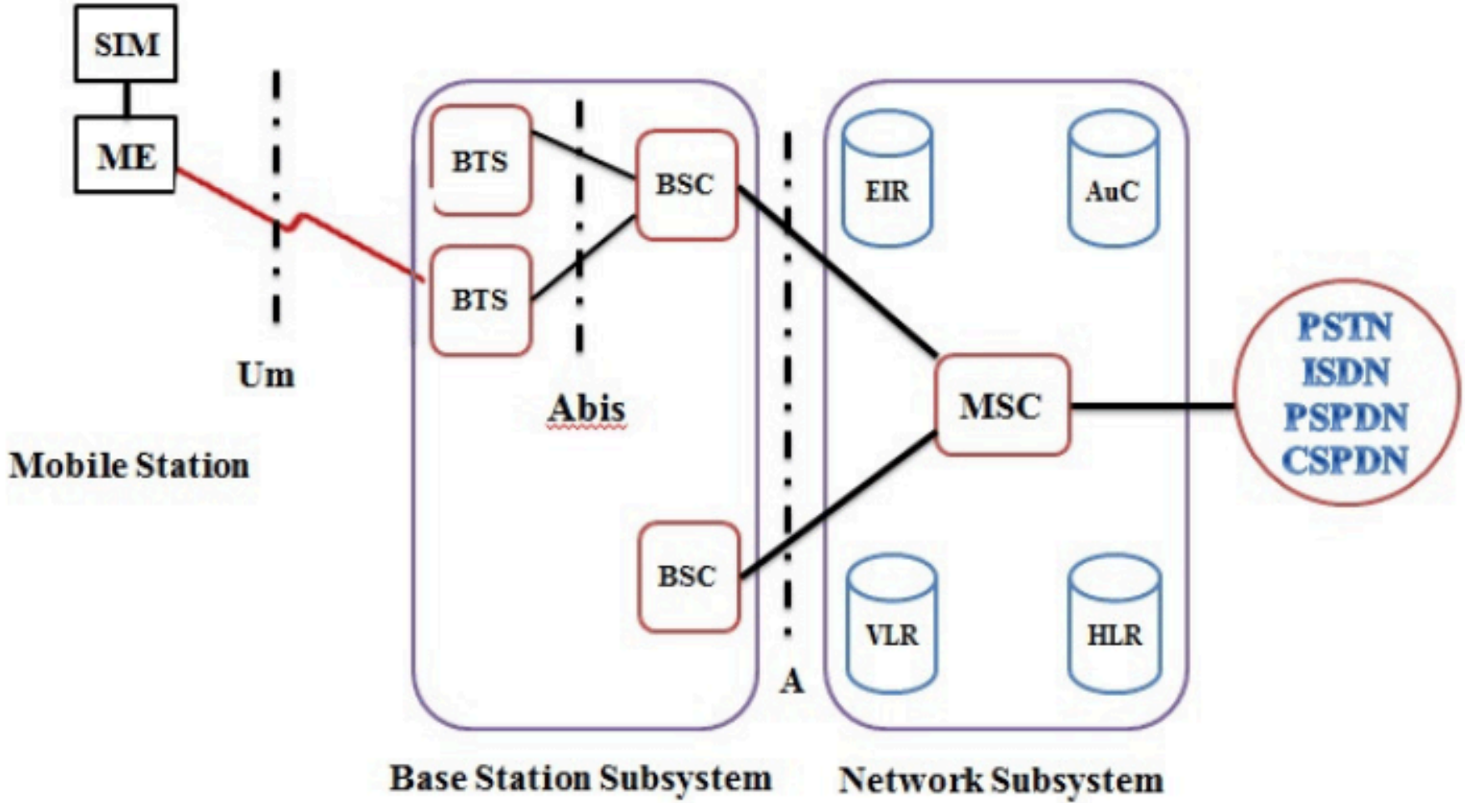
Types of networks: Cellular

- **What is a Cellular Network?**

  A **cellular network** is a wireless communication network divided into small geographic areas called **cells**. Each cell has its own radio tower (base station), allowing mobile phones to communicate without interference. As a user moves, the call or data session is **handed over** from one cell to another smoothly.
- This system enables:
- Wide-area mobile communication
- Efficient frequency reuse
- Mobility for users

Types of networks: Cellular

Basic Blocks / Components of a Cellular Network



Basic Blocks / Components of a Cellular Network

1. Mobile Device (User Equipment – UE)

- Examples: Smartphones, tablets, data cards.
- Connects to the nearest cell tower using radio signals.
- Converts voice/data into radio waves and vice versa.

2. Cell Tower (Base Transceiver Station – BTS)

- The physical tower with antennas.
- Handles radio communication with mobile devices.
- Covers a geographical "cell" area.

Functions:

- Sends/receives radio signals.
- Controls frequency and power levels.
- Ensures connectivity within the cell.

Basic Blocks / Components of a Cellular Network

3. Base Station Controller (BSC) / Radio Network Controller (RNC)

- (Depends on 2G/3G/4G technology)
- Responsible for:
- Managing multiple BTS units.
- Handover management (switching user between towers).
- Frequency allocation.
- Power control.

4. Mobile Switching Center (MSC)

- Acts as the **central switching office**.
- Functions:
- Connects calls between mobile and landline networks.
- Handles call setup and routing.
- Manages user authentication and mobility.
- Acts like the brain of the cellular network.

Basic Blocks / Components of a Cellular Network

5. Home Location Register (HLR)

- A database storing **subscriber information**.
- Contains:
- User's phone number
- SIM details
- Services allowed (SMS, data, roaming)
- Current location area

6. Visitor Location Register (VLR)

- Temporary database for users roaming in another network area.
- Stores:
- Current cell location
- Temporary identity information
- Works closely with the MSC.

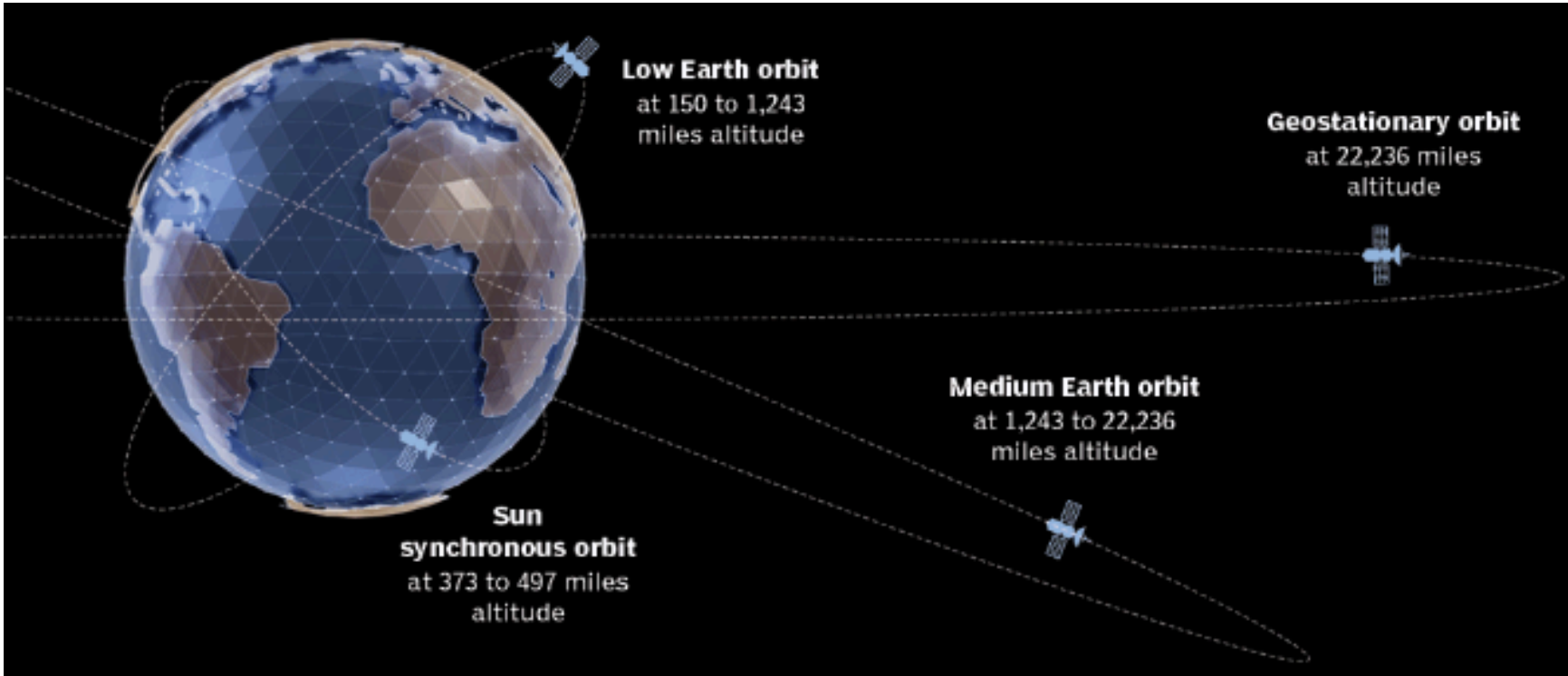
Basic Blocks / Components of a Cellular Network

- **EIR-**Equipment Identity Register-is a **database in the GSM network** that stores information about mobile devices based on their **IMEI number** (International Mobile Equipment Identity). EIR ensures **security and fraud prevention** in GSM networks.
- **AUC in GSM** (Authentication Center): is a **security database** in the GSM network responsible for **authenticating subscribers** and ensuring **secure communication**.
  It works closely with the **HLR** to protect the network from fraud and unauthorized access.

- **PSPDN: Public Switched Packet Data Network**
- Connection Type-No dedicated path; data sent in packets
- Transmission Style-Data divided into packets and routed independently
- Efficiency- More efficient (channel shared by many users)

- **CSPDN: Circuit Switched Public Data Network**
- Connection Type-Dedicated end-to-end path during entire session
- Transmission Style-Continuous data stream on reserved circuit
- Efficiency-Less efficient (channel busy even during silence)

Types of networks: Satellite



	SSO	LEO	MEO	GEO
USE CASES	Environmental monitoring	Research, observation, communication	GPS, navigation	Weather observation, navigation
COVERAGE AREA	Global, strip by strip	1/3 of the Earth's surface	Global	Global
ORBITAL PERIOD	90 to 120 minutes	Two or three hours	Four to six hours	24 hours

Types of networks: Satellite

- Satellite network architecture components
- A satellite network architecture has three main segments:
- **Space:** The space segment is the part of the satellite network present in space. It consists of the launch vehicle, orbiting satellite and communication links between the satellite and the Earth.
- **Ground**: The ground segment functions like a satellite interface. It consists of all the ground equipment that helps to communicate with the orbiting satellite, such as the following:

  Ground stations/Antennas/Terrestrial networks/User terminals.
- **Control**: The control segment is also found on Earth and isn't carried by the satellite. It consists of the components that control, monitor and maintain the satellite's health and performance throughout its lifecycle.
- The control segment includes the following components:

  1-TTC System

  2- AOC System

  3-Thermal control

Types of networks: Satellite

- **Satellite network use cases:**
- **Navigation-**GPS tracking and instant location sharing have made life easier and safer.
- **Internet access:** Satellite networks enable faster internet access in rural areas, supporting rural education and telemedicine capabilities.
- **Military.** Satellites have historically been included in military applications.
- **Satellite IoT.** Satellite IoT ensures reliable data exchange in remote or less-populated areas where terrestrial networks are unreliable.
- **Advanced imagery.** Satellite networks provide clear and processed images of areas less visited by humans.
- **Weather prediction and environmental monitoring.** Satellites take accurate and extensive photographs of features of the Earth. This type of data helps forecast the weather.
- **Space research.** Satellites embedded with advanced equipment regularly monitor space and the solar system
- **SARSAT:**

Types of networks: Internet

Types of networks: Internet

- The Internet is a global system of interconnected networks. It works through several essential **blocks (components)**.
  1- End Devices (Hosts)
- These are the devices that users interact with.
- **Examples-** Computers/Smartphones/Servers/IoT devices
- **Role-** Generate data (requests, messages, files)./Receive data (web pages, videos, emails)./Act as clients or servers.
  2-Network Interface (LAN/Wi-Fi Adapter)
- **Role:** Connects the device to a local network (wired or wireless)./Converts digital data into signals suitable for transmission./Uses MAC addressing for local communication.
  3-Switches (LAN Switches)
- **Role:** Connect devices inside a local network./Forward data frames based on **MAC addresses**./Provide efficient LAN communication within homes, offices, campuses.

Types of networks: Internet

4- **Routers**

- **Role:** Connect different networks (LAN → Internet)./Forward packets based on **IP addresses**./Decide the best route for data using routing tables./Act as gateways between home networks and ISP networks.

5- **Modem**

- **Role:** Converts digital data into analog signals (and vice versa) for transmission over telephone, cable, or fiber lines./Connects the router to the ISP infrastructure./Supports DSL, Cable, or Fiber technologies.

6-ISP (Internet Service Provider)

- **Examples:**Jio, Airtel, BSNL, ACT, Comcast, AT&T, etc.
- **Role:** Provides Internet access to users./Manages large-scale routing infrastructure./Maintains backbone connections, DNS servers, IP addressing.

Types of networks: Internet

7-Network Backbone (Core Network)

- **Role:** High-speed fiber-optic networks connecting major ISPs and data centers.
- Uses high-capacity routers and switches./Ensures long-distance data transport across countries and continents./Forms the core of the Internet.

8- **DNS (Domain Name System)**

- **Role:** Converts domain names (like *google.com*) into **IP addresses**./Works like a phone directory of the Internet./Enables user-friendly browsing.

9-**Servers**

- **Types:** Web servers/Email servers/Cloud storage servers/Application servers
- **Role;** Host websites, applications, databases./Respond to user requests./Store and deliver content (e.g., YouTube videos, Gmail emails).

10-**Internet Protocols**

- **Main Protocols: HTTP/HTTPS** – Web pages/**TCP/UDP** – Transport/**IP** – Routing/**FTP** – File transfer/**SMTP/POP/IMAP** – Email
- **Role:** Define rules for communication./Ensure reliable transfer, addressing, and security.

Network topologies: Star, Mesh, Ring, Hybrid

- **Definition of Network Topologies**
- **Network topology** refers to the **physical or logical arrangement** of computers, cables, nodes, and devices in a communication network.(It shows how computers are connected and how data flows between them.)
- There are two types:
- **Physical topology** – actual layout of cables and devices
- **Logical topology** – how data moves through the network

Role of Network Topologies-

- Network topologies play an important role in designing, managing, and understanding a network.

1-Determines Data Flow

- Defines how data travels between nodes.
- Helps decide the best routing path.

2- **Affects Performance**

- Topology impacts speed, traffic handling, and efficiency.
- Example: Star topology reduces collisions.

Network topologies: Star, Mesh, Ring, Hybrid

3-**Simplifies Network Troubleshooting**

- Clear layout helps identify faults quickly.
- In Bus topology, cable fault stops entire network.

4-**Impacts Cost and Installation**

- Some topologies are cheap (Bus), while others cost more (Mesh).
- Helps plan budget and resources.

5-**Provides Scalability**

- Topology determines how easily devices can be added or removed.
- Example: Star topology is easier to expand.

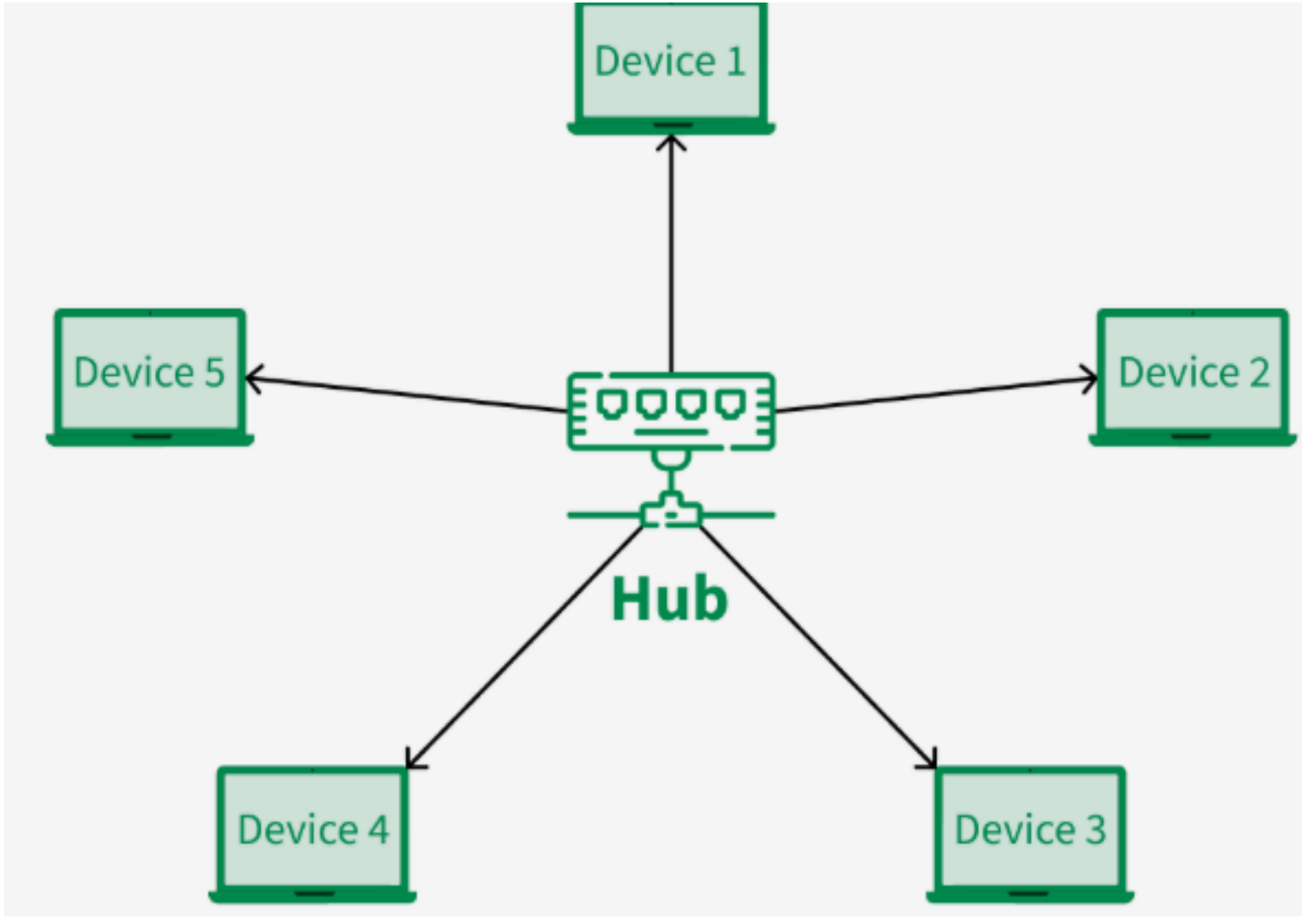
6-**Affects Reliability and Stability**

- Mesh topology offers high reliability
- Bus topology has low reliability

7-**Helps in Network Management**

- Better control over communication
- Efficient monitoring and maintenance

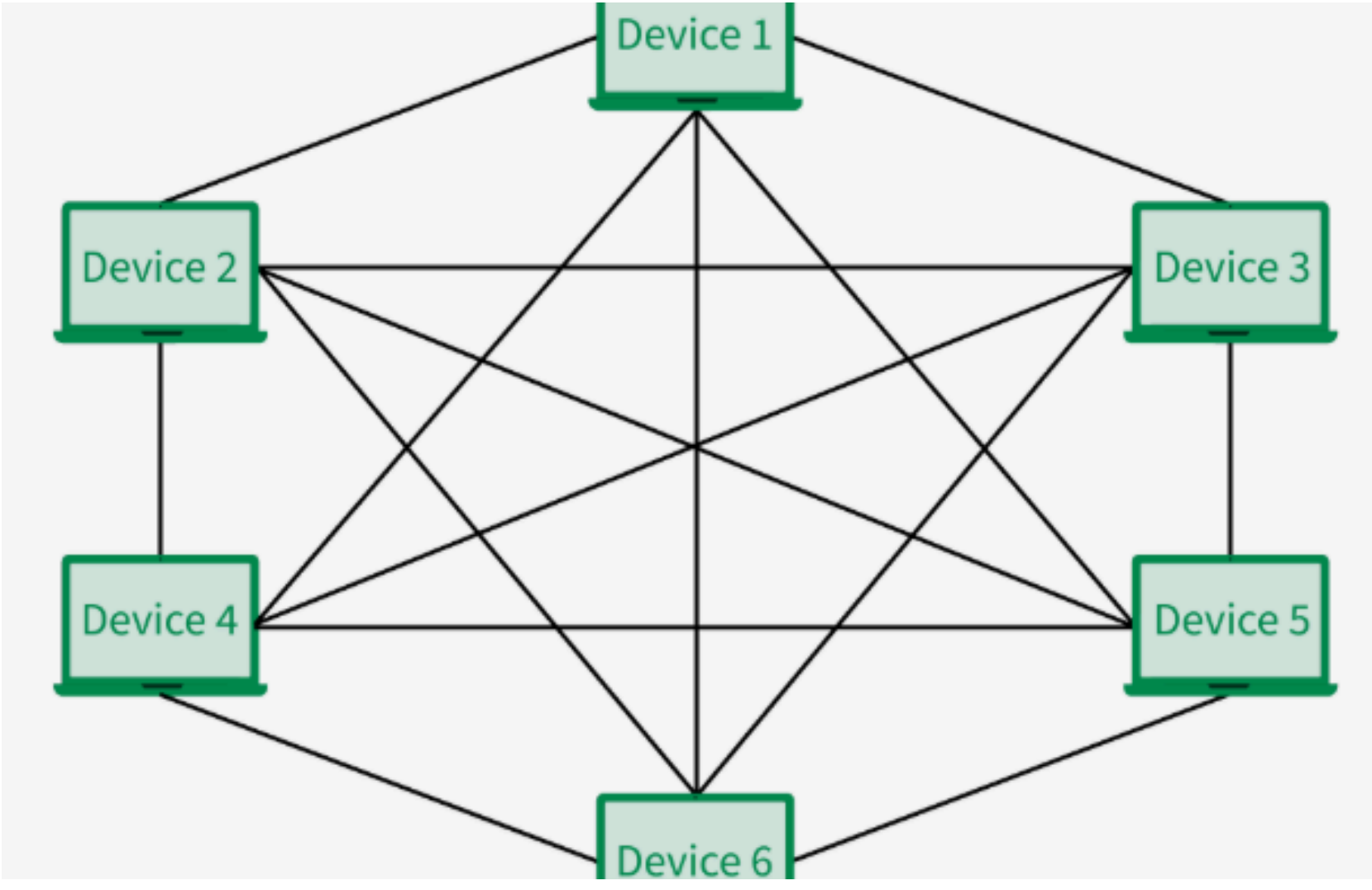
Network topologies: Star



Network topologies: Star

- **Star Topology**
- **Definition**
- Star topology is a network layout where **all devices are connected to a central device** (switch or hub).
- The hub can be passive (no broadcasting device) /active (repeater) in nature
- **Advantages of Star Topology**
- If N devices are connected to each other in a star topology, then the number of cables required to connect them is N. So, it is easy to set up.
- Each device requires only 1 port i.e. to connect to the hub, therefore the total number of ports required is N.
- It is Robust. If one link fails only that link will affect and not other than that.
- Easy to fault identification and fault isolation.
- Star topology is cost-effective as it uses inexpensive coaxial cable.
- **Disadvantages of Star Topology**
- If the concentrator (hub) on which the whole topology relies fails, the whole system will crash down.
- The cost of installation is high.
- Performance is based on the single concentrator i.e. hub.

Network topologies: Mesh



Network topologies: Mesh

- In a mesh topology, every device is connected to another device via a particular channel.
- In Mesh Topology, the protocols used are AHCP (Ad Hoc Configuration Protocols), DHCP (Dynamic Host Configuration Protocol), etc.
- Suppose, the N number of devices are connected with each other in a mesh topology, the total number of ports that are required by each device is N−1*N*−1. In Figure , there are 6 devices connected to each other, hence the total number of ports required by each device is 5. The total number of ports required = N * (N-1)= N * (N-1).
- Suppose, N number of devices are connected with each other in a mesh topology, then the total number of dedicated links required to connect them is NC2*NC*2 i.e. N * (N-1)/2N * (N-1)/2. In Figure, there are 6 devices connected to each other, hence the total number of links required is 6 * 5/2 = 156 * 5/2 = 15.
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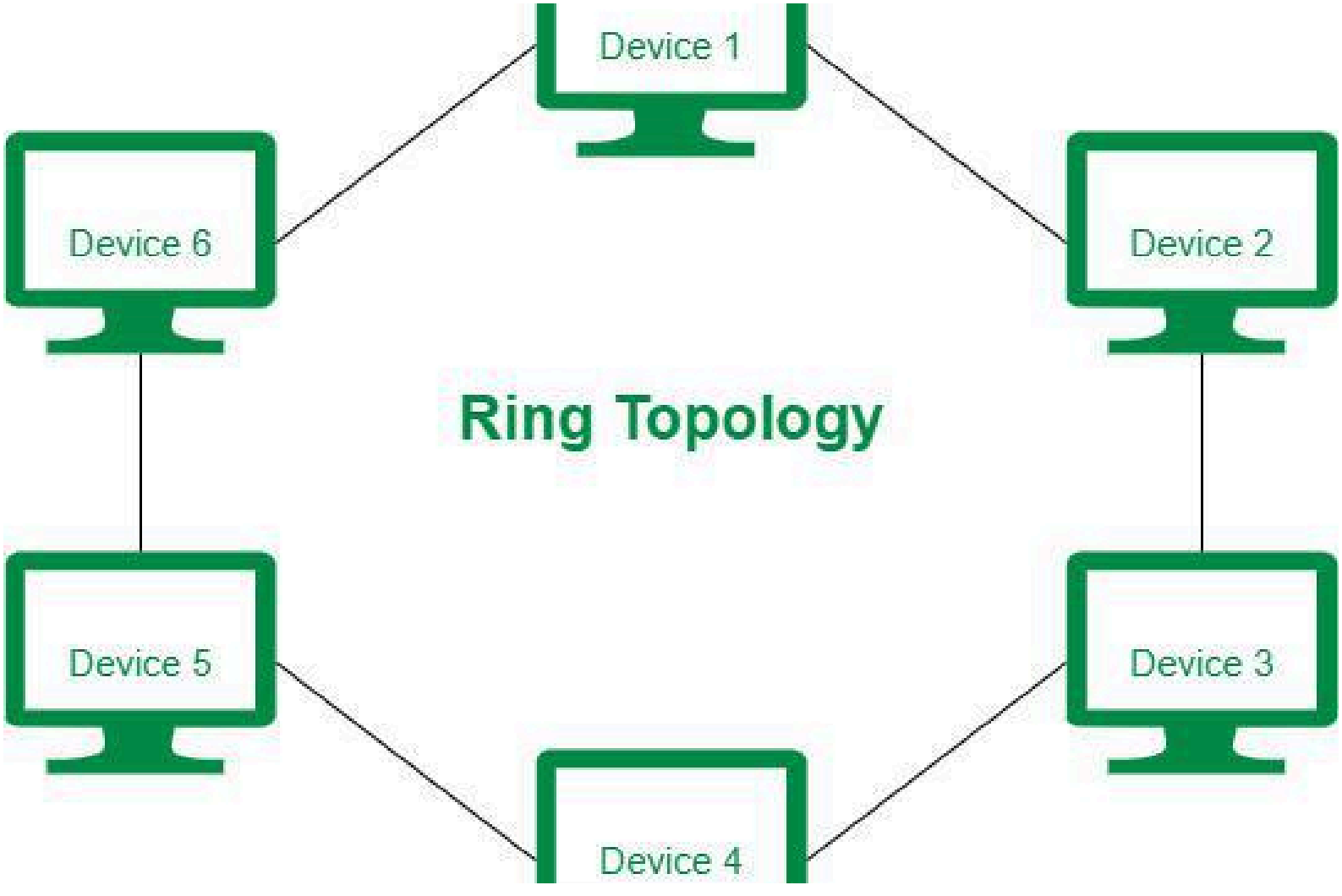
Network topologies: Mesh

- **Advantages of Mesh Topology**
- Communication is very fast between the nodes.
- Mesh Topology is robust.
- The fault is diagnosed easily. Data is reliable because data is transferred among the devices through dedicated channels or links.
- Provides security and privacy.
- **Disadvantages of Mesh Topology**
- Installation and configuration are difficult.
- The cost of cables is high as bulk wiring is required, hence suitable for less number of devices.
- The cost of maintenance is high.
- A common example of mesh topology is the internet backbone, where various internet service providers are connected to each other via dedicated channels.

Network topologies: Ring



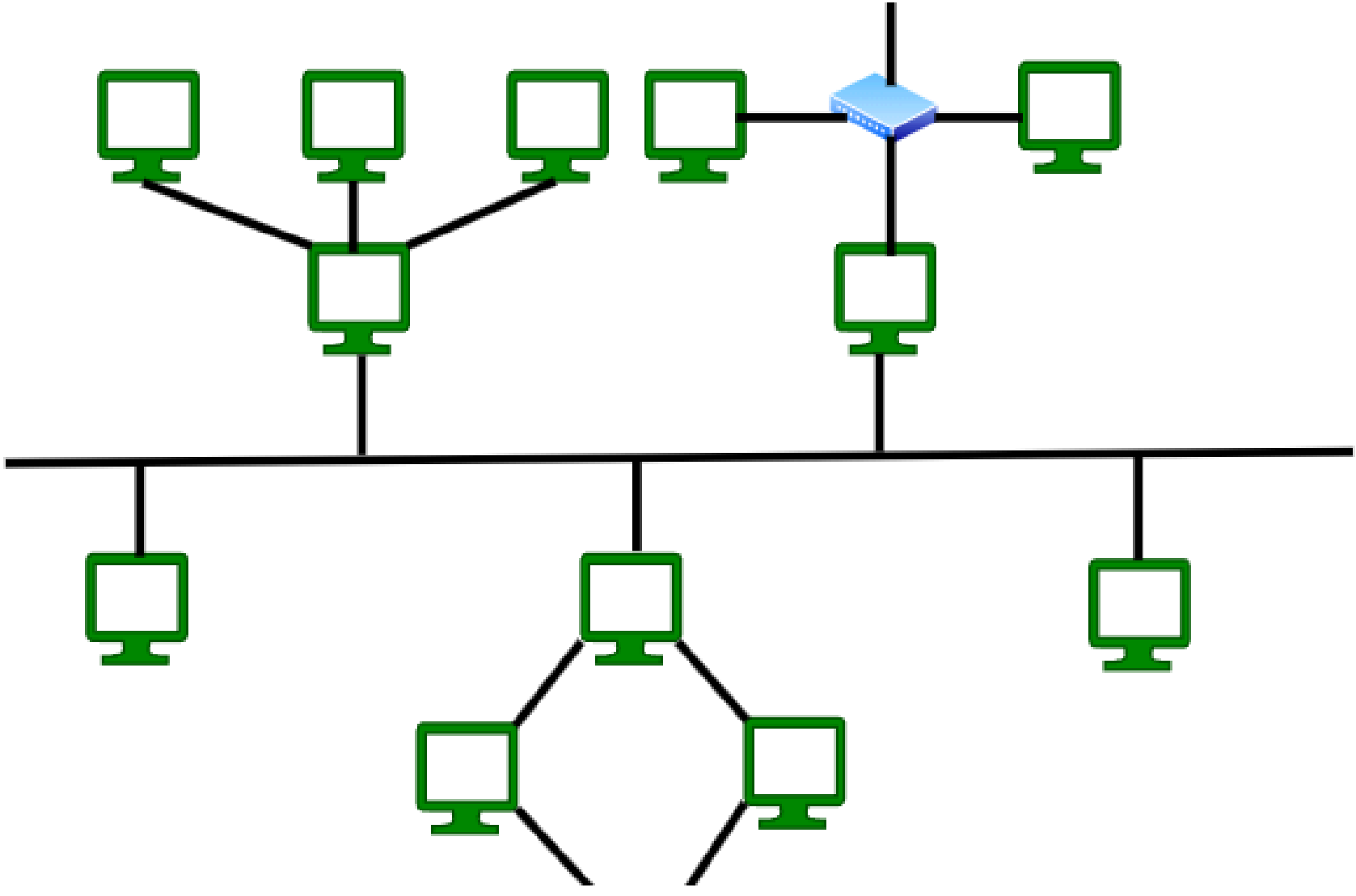
Network topologies: Ring

- In a Ring Topology, it forms a ring connecting devices with exactly two neighboring devices.
- A number of repeaters are used for Ring topology with a large number of nodes, because if someone wants to send some data to the last node in the ring topology with 100 nodes, then the data will have to pass through 99 nodes to reach the 100th node.
- Hence to prevent data loss repeaters are used in the network.
- In-Ring Topology, the Token Ring Passing protocol is used by the workstations to transmit the data where, Token passing is a network access method in which a token is passed from one node to another node & Token is a frame that circulates around the network.

Network topologies: Ring

- **Operations of Ring Topology**
- One station is known as a monitor station which takes all the responsibility for performing the operations.
- To transmit the data, the station has to hold the token. After the transmission is done, the token is to be released for other stations to use.
- When no station is transmitting the data, then the token will circulate in the ring.
- **Advantages of Ring Topology**
- The data transmission is high-speed.
- The possibility of collision is minimum in this type of topology.
- Cheap to install and expand.
- **Disadvantages of Ring Topology**
- The failure of a single node in the network can cause the entire network to fail.
- Troubleshooting is difficult in this topology.
- Less secure.

Network topologies: Hybrid



Network topologies: Hybrid

- Hybrid Topology is the combination of all the various types of topologies we have studied above.
- Hybrid Topology is used when the nodes are free to take any form. It means these can be individuals such as Ring or Star topology or can be a combination of various types of topologies
- **Advantages of Hybrid Topology**
- This topology is very flexible.
- The size of the network can be easily expanded by adding new devices.
- **Disadvantages of Hybrid Topology**
- It is challenging to design the architecture of the Hybrid Network.
- Hubs used in this topology are very expensive.
- The infrastructure cost is very high as a hybrid network requires a lot of cabling and network devices .
- *A common example of a hybrid topology is a university campus network. The network may have a backbone of a star topology, with each building connected to the backbone through a switch or router. Within each building, there may be a bus or ring topology connecting the different rooms and offices.*

Overview of Switching and Routing

- **Overview of Switching**
- **Switching** is the process of **forwarding data within a network** (usually a LAN) based on **MAC addresses**.
- **Where switching works?**
- **Data Link Layer (Layer 2)** of OSI model
- **Devices Used: Switches /** (Old) Hubs, Bridges
- **Key Functions of Switching**

1. Frame Forwarding

- A switch receives a frame and sends it only to the **specific destination device** using its MAC address.

2. MAC Address Learning

- Switch maintains a **MAC address table**.
- Learns which device is connected to which port.

3. Reducing Network Congestion

- Each port has its own bandwidth → fewer collisions.

4. LAN Segmentation

- Divides big networks into smaller segments for better performance.

Overview of Switching and Routing

- **Types of Switching**
- **Circuit Switching-**Dedicated path/Used in telephone networks
- **Packet Switching-**Data broken into packets/Used in Internet networks
- **Message Switching-**Entire message stored & forwarded/Slow; rarely used now
  Overview of Routing
- **Routing** is the process of **selecting the best path** for data to travel from **source to destination across different networks**.
- **Where routing works?**
- **Network Layer (Layer 3)** of OSI model
- **Devices Used: Routers**/Layer 3 Switches/Gateways
- **Key Functions of Routing**
  1. Path Selection-Chooses the most efficient route using routing algorithms.
  2. Packet Forwarding-Sends packets toward the next hop until they reach destination.
  3. Managing IP Addresses-Works with **IP addressing** (IPv4/IPv6).
  4. Connecting Multiple Networks
- Example: Connecting home LAN to the Internet.

Overview of Switching and Routing

- **Routing Table**
- Routers maintain a **routing table** containing:
  Destination networks/Next-hop addresses/Best path metrics/Interface details

- **Types of Routing**
  1. Static Routing
- Manually configured by admin
- Simple but not automatic
  2. Dynamic Routing
- Router learns routes automatically
- Uses routing protocols:

Overview of Switching and Routing

Switching vs Routing

Feature	Switching	Routing
Layer	Data Link (Layer 2)	Network Layer (Layer 3)
Uses	MAC Address	IP Address
Purpose	Communication inside a LAN	Communication between networks
Device	Switch	Router
Routing Table	MAC table	IP routing table