CS – 20 NETWORK TECHNOLOGY AND ADMINISTRATION

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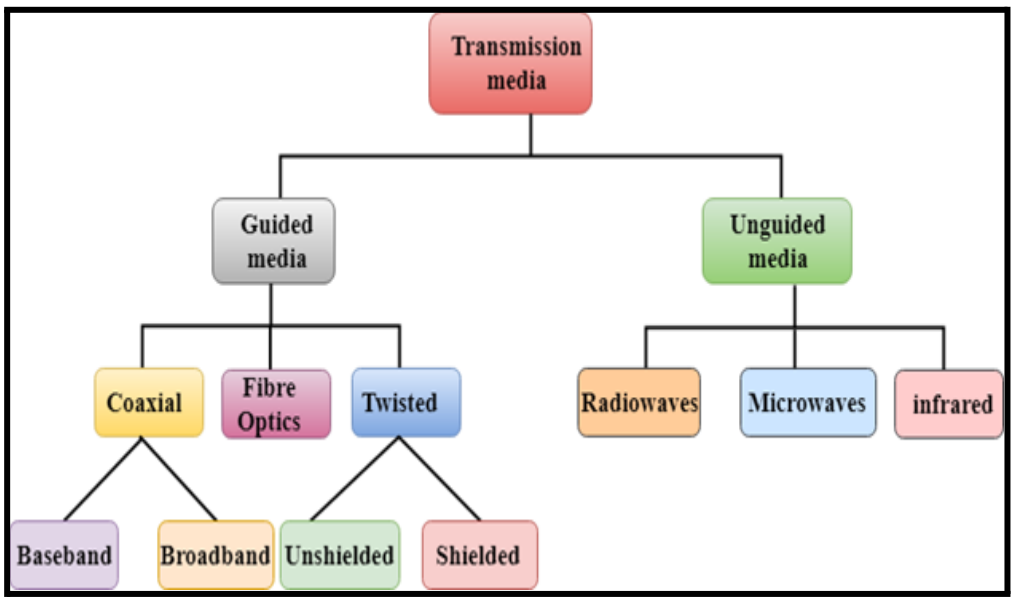
- Transmission Media.

  Transmission media refers to the **physical pathways** or **communication channels** through which data, voice, and video signals are transmitted from one device to another in a network. It is a medium that enables the propagation of electromagnetic signals between devices in a communication system. Transmission media can be either **guided** (wired) or **unguided** (wireless), depending on whether the signals are transmitted over a physical medium (like cables) or through the air.

Types of Transmission Media

Transmission media can be broadly classified into two categories: **guided (wired)** and **unguided (wireless)** media.



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1. Guided Transmission Media (Wired Media)

- **Definition**: Guided transmission media involves the transmission of data over a physical medium, where the signals are confined and directed along specific paths such as cables. These media offer **controlled, high-speed, and reliable transmission**.

- **Types of Guided Media**:

  - **Twisted Pair Cable**:
    - Consists of pairs of insulated copper wires twisted together to reduce interference.
    - Used in telecommunication networks and LANs (Local Area Networks).
    - Types: **Unshielded Twisted Pair (UTP)** and **Shielded Twisted Pair (STP)**.
  - **Coaxial Cable**:
    - Contains a central conductor, insulating layer, metallic shield, and outer cover.
    - Used for cable TV networks and early Ethernet networks.
  - **Fiber Optic Cable**:
    - Uses light signals to transmit data through glass or plastic fibers.
    - Offers high-speed, long-distance, and secure transmission.
    - Used in high-speed internet, telecommunication, and data centers.

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2. Unguided Transmission Media (Wireless Media)

- **Definition**: Unguided transmission media transmits data **wirelessly** through electromagnetic waves without the use of physical conduits. These media allow **mobility, flexibility, and long-distance communication**.

- **Types of Unguided Media**:

  - **Radio Waves**:

        - Uses low-frequency electromagnetic waves.
        - Suitable for long-distance communication like AM/FM radio, television broadcasts, and Wi-Fi.
    - **Microwaves**:
        - Uses high-frequency electromagnetic waves.
        - Requires line-of-sight transmission and is used in satellite communication, mobile networks, and point-to-point connections.
    - **Infrared (IR)** :
        - Uses short-range signals for communication within close proximity.
        - Common in remote controls and short-range devices like infrared data transmission systems.
    - **Satellite Communication**:
        - Uses satellites in space to transmit signals over large distances.
        - Used for global communication, GPS, and TV broadcasting.

Different Frequency Ranges :

Frequency refers to how many times a signal repeats per second, measured in **Hertz (Hz)**. Different frequency ranges are used in communication systems to transmit data, and each range is suitable for specific types of communication, such as radio, television, or mobile phones.

Designation	Abbreviation	Frequencies	Wavelengths
Very Low Frequency	VLF	3 kHz - 30 kHz	100 km - 10 km
Low Frequency	LF	30 kHz - 300 kHz	10 km - 1 km
Medium Frequency	MF	300 kHz - 3 MHz	1 km - 100 m
High Frequency	HF	3 MHz - 30 MHz	100 m - 10 m
Very High Frequency	VHF	30 MHz - 300 MHz	10 m - 1 m
Ultra High Frequency	UHF	300 MHz - 3 GHz	1 m - 100 mm
Super High Frequency	SHF	3 GHz - 30 GHz	100 mm - 10 mm
Extremely High Frequency	EHF	30 GHz - 300 GHz	10 mm - 1 mm

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1. Low Frequency (LF)

- **Range**: 30 kHz to 300 kHz
- **Used For**: Long-distance communication over water or ground, like **maritime communication** and **submarine communication**.
- **Characteristics**: Signals can travel very far, but data speed is very slow.

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2. Medium Frequency (MF)

- **Range**: 300 kHz to 3 MHz
- **Used For**: **AM radio broadcasting**.
- **Characteristics**: Can travel long distances, especially at night, and is used for radio signals.

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3. High Frequency (HF)

- **Range**: 3 MHz to 30 MHz
- **Used For**: **Shortwave radio** and **citizen’s band (CB) radios**.
- **Characteristics**: Can bounce off the earth's atmosphere and travel long distances.

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4. Very High Frequency (VHF)

- **Range**: 30 MHz to 300 MHz
- **Used For**: **FM radio**, **television broadcasting**, and **two-way radios** (walkie-talkies).
- **Characteristics**: Used for line-of-sight communication (signals need a clear path without obstructions).

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5. Ultra High Frequency (UHF)

- **Range**: 300 MHz to 3 GHz
- **Used For**: **Television signals**, **mobile phones**, **Wi-Fi**, and **GPS**.
- **Characteristics**: Good for short-range communication with high data rates, commonly used in modern devices.

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6. Super High Frequency (SHF)

- **Range**: 3 GHz to 30 GHz
- **Used For**: **Microwave communication**, **Wi-Fi**, **satellite communication**, and **radar**.
- **Characteristics**: High data speed, but signals don't travel far and need direct line-of-sight.

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7. Extremely High Frequency (EHF)

- **Range**: 30 GHz to 300 GHz
- **Used For**: **Advanced communication systems** like **satellite links** and **future 5G networks**.
- **Characteristics**: Very high-speed data transmission, but signals can be easily blocked by obstacles.

Multiplexing & De-multiplexing

- **Multiplexing**: Multiplexing is a method used in communication systems to combine multiple signals or data streams into one signal for transmission over a shared medium. It allows multiple users or devices to share the same communication channel efficiently.
- **De-multiplexing**: De-multiplexing is the reverse process of multiplexing. At the receiving end, the combined signal is separated back into the original individual signals or data streams, allowing each receiver to get its specific data.

Multiplexing increases the efficiency of communication channels by allowing multiple signals to be transmitted simultaneously, saving bandwidth and reducing costs.

Types of Multiplexing

1. FDM (Frequency Division Multiplexing)

- **Definition**: In **Frequency Division Multiplexing (FDM)**, multiple signals are transmitted over different frequency bands within the same communication channel. Each signal is modulated onto a different carrier frequency, and the combined signal is sent over the medium. The receiver uses filters to separate the different frequency bands.

- **Example**:

    - **Radio broadcasting**: Different radio stations operate on different frequency bands, allowing multiple stations to broadcast simultaneously without interference.
    - **Cable TV**: Different TV channels are sent on different frequencies through a single cable.

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2. TDM (Time Division Multiplexing)

- **Definition**: In **Time Division Multiplexing (TDM)**, multiple signals share the same communication channel by dividing the transmission time into separate time slots. Each signal is assigned a specific time slot for transmission, and the process is repeated cyclically.

- **Example**:

    - **Telecommunications**: Traditional telephone systems use TDM to allow multiple voice calls to be transmitted over a single physical line.
    - **Digital TV**: Multiple digital TV channels can be transmitted in different time slots on the same frequency.

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3. CDM (Code Division Multiplexing)

- **Definition**: **Code Division Multiplexing (CDM)**, also known as **Code Division Multiple Access (CDMA)**, allows multiple signals to share the same frequency channel by assigning a unique code to each signal. All signals are transmitted simultaneously over the same channel, and the receiver uses the assigned code to separate the desired signal from the others.

- **Example**:

    - **Cellular networks**: CDMA is used in mobile communication systems, where multiple users share the same frequency band by using different codes to distinguish their signals.

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4. WDM (Wavelength Division Multiplexing)

- **Definition**: **Wavelength Division Multiplexing (WDM)** is a type of multiplexing used in fiber-optic communication, where different signals are transmitted over the same fiber-optic cable by using different **wavelengths (colors)** of light. Each wavelength carries a separate data stream, allowing multiple signals to be sent simultaneously over the same fiber.

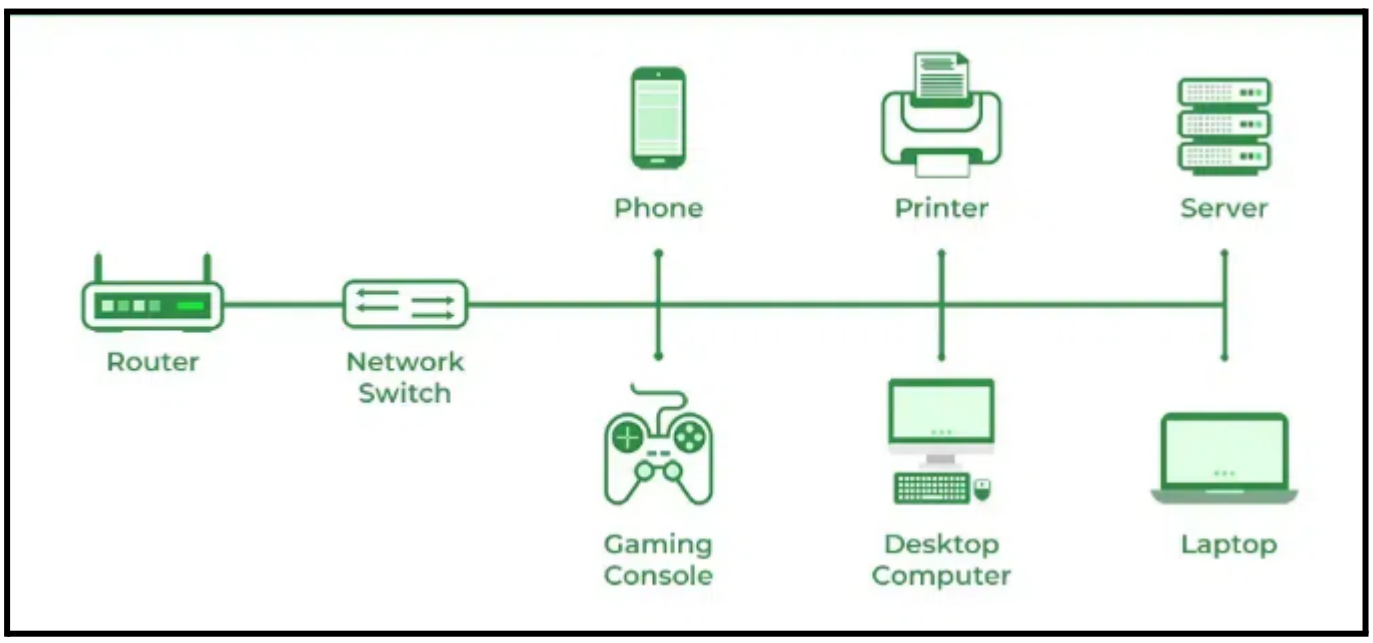
- **Example**:

    - **Fiber-optic communication**: WDM is widely used in high-speed optical networks, such as the internet backbone, to carry large amounts of data over long distances.

Switching Technology

Switching Technology refers to the methods used in communication networks to route data from a source to its destination efficiently. When data is transmitted over a network, switching techniques determine how the data will travel through intermediate devices (switches or routers) to reach its target.

Switching is essential for managing the flow of data in a network, especially when multiple devices are sharing the same communication channels.



Types of Switching Technologies

1. Circuit Switching

In **Circuit Switching**, a dedicated communication path or circuit is established between the source and the destination before data transmission begins. This path remains reserved for the entire duration of the communication and is released once the session ends.

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2. Message Switching

In **Message Switching**, the entire message is treated as a single data unit and is transferred from one switch to another. There is no dedicated path; instead, each switch temporarily stores the entire message before forwarding it to the next switch (a method known as "store-and-forward").

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3. Packet Switching

Packet Switching divides data into smaller, manageable packets. Each packet is transmitted independently over the network, and the packets may take different paths to reach the destination. At the destination, the packets are reassembled into the original message.

Cable Network Devices

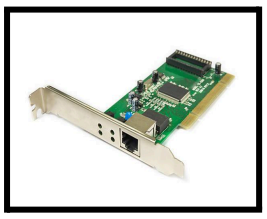
Cable Network Devices are hardware components used to connect and manage data transmission over cable-based networks (like Ethernet or coaxial cables). These devices enable communication between computers, servers, and other network-enabled devices, ensuring that data is sent, received, and managed efficiently.

They are essential for wired networking setups, such as Local Area Networks (LANs), wide-area networks (WANs), and internet access via cable modems.

Layer 1 Devices (Physical Layer Devices)

The **Physical Layer** (Layer 1) of the OSI model is responsible for the transmission of raw data over a communication medium. Devices at this layer handle the electrical, mechanical, and procedural aspects of the communication.

Here are common Layer 1 devices:



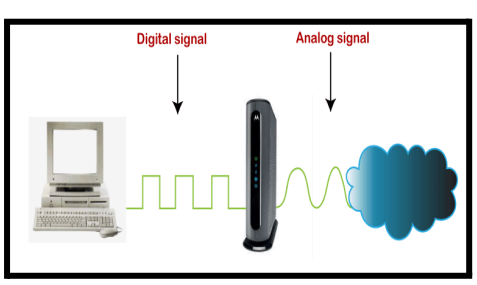
1. LAN Card (Network Interface Card - NIC)

A **LAN Card**, also known as a **Network Interface Card (NIC)**, is a hardware component that allows a computer or device to connect to a local area network (LAN). It enables data to be transmitted and received over a network via Ethernet cables.

Converts digital data from a computer into electrical signals for transmission over the network.

Receives data from the network and converts it back into digital form for the computer.
Can be wired (Ethernet) or wireless (Wi-Fi).

Assigned a unique **MAC (Media Access Control)** address to identify the device on the network.



2. Modem (Modulator-Demodulator)

: A **Modem** is a device that modulates digital data from a computer into analog signals for transmission over telephone lines or cable systems and demodulates incoming analog signals back into digital data for the computer.

- **Types**:
  - **Dial-up Modem**: Converts digital signals to analog for traditional phone lines.
  - **Cable Modem**: Transmits digital data over cable television lines.
  - **DSL Modem**: Used for high-speed internet access over telephone lines.
- **Function**:
  - **Modulation**: Converts digital data into analog signals for transmission.
  - **Demodulation**: Converts received analog signals back into digital form.

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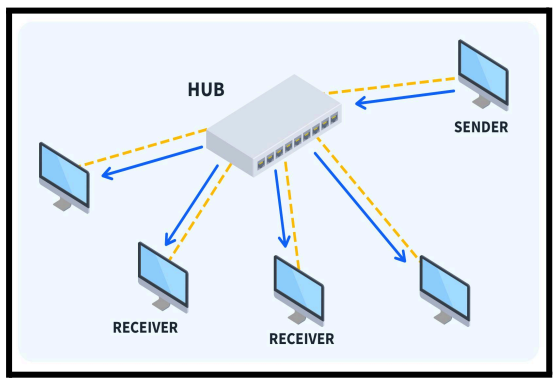
3. DSL & ADSL (Digital Subscriber Line & Asymmetric Digital Subscriber Line)

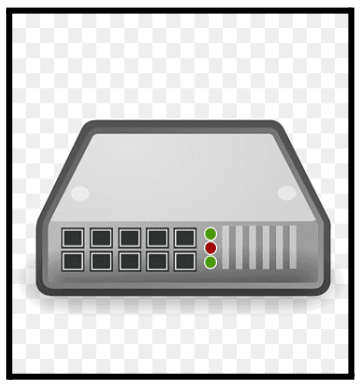
- **DSL (Digital Subscriber Line)**: A high-speed internet technology that transmits digital data over telephone lines. It provides internet access while allowing voice calls over the same line simultaneously.

  DSL Provides internet access by utilizing unused frequency bands of telephone lines.

- **ADSL (Asymmetric Digital Subscriber Line)**: A type of DSL where the download speed is higher than the upload speed, making it suitable for typical internet usage like browsing and video streaming.

  ADSL Focuses on higher download speeds because most users download more data than they upload.





4. Hub (Active, Passive, Smart Hub)

A **Hub** is a basic networking device that connects multiple computers or devices in a LAN. It broadcasts data received on one port to all other ports, so every device connected to the hub receives the data, regardless of whether it is the intended recipient.

Types of Hubs:

1. **Active Hub**:

   An **Active Hub** amplifies and regenerates the signal it receives before broadcasting it to other connected devices.

   Extends the range of a network by amplifying weak signals, ensuring that the data can travel longer distances without degradation.

2. **Passive Hub**:

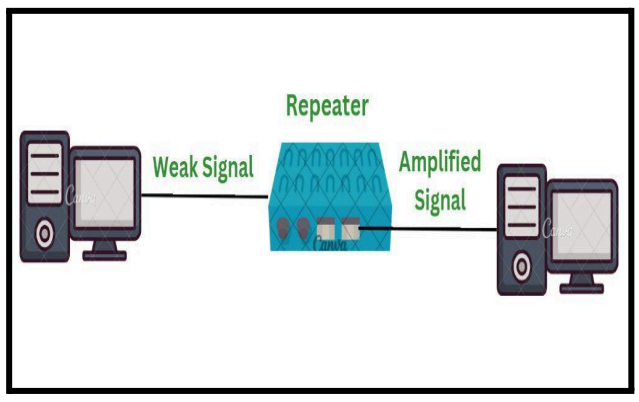
   A **Passive Hub** simply broadcasts the received data to all ports without amplifying or processing the signals.

   Used in small networks where signal strength and distance are not issues.

3. **Smart Hub**:

   A **Smart Hub** is an advanced hub that can perform additional tasks like traffic monitoring, diagnostics, and management of data transmission.

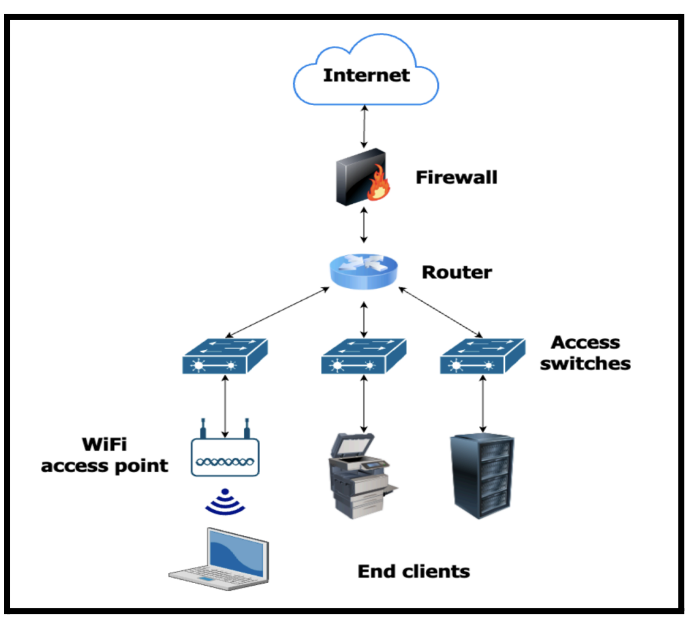
   Allows network administrators to manage and control the network more efficiently.



5. Repeater

A **Repeater** is a device that regenerates and amplifies weak or distorted signals over long distances. It is used to extend the transmission range of a network by boosting the signal strength.

- **Types of Repeaters**:
  - **Analog Repeater**: Amplifies analog signals.
  - **Digital Repeater**: Regenerates digital signals, ensuring that noise or distortion does not get amplified along with the signal.



Layer 2 Devices (Data Link Layer Devices)

Layer 2 Devices operate at the **Data Link Layer** (Layer 2) of the OSI model. The Data Link Layer is responsible for node-to-node data transfer, framing, and addressing within a local network. Layer 2 devices ensure reliable data transmission between devices on the same network segment, handle errors, and manage the physical addressing system (using MAC addresses).

These devices work with **MAC (Media Access Control)** addresses, helping in **frame forwarding**, **collision detection**, and **error correction** in data transmission.

Types of Layer 2 Devices

1. Switch (Manageable and Non-Manageable)

A **Switch** is a device that connects multiple devices in a network and operates at the Data Link Layer. It reads the MAC addresses of incoming data frames and forwards them to the correct destination device. Unlike a hub, a switch sends data only to the intended recipient, reducing network congestion.

Types of Switches:

- **Non-Manageable Switch**:

  A **Non-Manageable Switch** is a basic, plug-and-play device with no configuration options. It simply forwards data based on MAC addresses.

  It automatically learns the MAC addresses of devices in the network and forwards data to the appropriate port. It does not have the ability to be customized or monitored.

  Simple to use, no setup required.

  Suitable for small networks or home setups.

  No control over network performance or security.

- **Manageable Switch**:

  A **Manageable Switch** allows network administrators to configure and manage the device. It provides advanced features such as traffic management, VLAN support, port monitoring, and security settings.

  It can be configured via a web interface or command-line interface (CLI) to control data flow, manage bandwidth, and segment networks into Virtual LANs (VLANs).

  Full control over network performance.

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2. Bridge (Source Route, Transactional)

A **Bridge** is a Layer 2 device used to connect and filter traffic between two or more network segments. It helps divide larger networks into smaller segments, reducing congestion and improving network performance. The bridge makes decisions based on MAC addresses, learning the addresses of devices in different segments and forwarding data accordingly.

Types of Bridges:

Source Route Bridge:

A **Source Route Bridge** is a type of bridge that uses a **source-routing** method to determine the path for data packets between network segments. The source device specifies the route the data should take through the network when it is transmitted.

The source device adds routing information to the data packet, which is then used by the source route bridge to forward the data along the specified path.

Used mainly in Token Ring networks.

Less common today but was important in older network setups.

Transactional Bridge:

A **Transactional Bridge** works by examining frames at the Data Link Layer and forwarding them based on destination addresses. It keeps track of ongoing transactions to ensure data consistency and integrity.

It forwards data between segments based on MAC addresses but is designed to manage data flow with better reliability for transaction-based communications.

More advanced than simple bridges and can be used in scenarios where network transactions need to be carefully managed.

Ensures that data is transmitted reliably by checking for errors and controlling data flow between segments.

Layer 3 Devices (Network Layer Devices)

Layer 3 Devices operate at the **Network Layer** of the OSI model. The primary role of Layer 3 devices is to manage routing and forwarding of data between different networks or subnets. Devices at this layer use **IP addresses** (Internet Protocol) to determine the best path for data to travel from the source to the destination.

Layer 3 devices are essential for communication between different networks, and they ensure that data is directed to the correct destination across large, complex networks, such as the internet.

Types of Layer 3 Devices

1. Router

A **Router** is a Layer 3 device that forwards data packets between different networks, typically between a local network (LAN) and a wide-area network (WAN), such as the internet. It uses **IP addresses** to make decisions about how to route the data.

Routers examine the destination IP address of incoming data packets and determine the best route for them to reach their destination.

Routers can also perform tasks like **NAT (Network Address Translation)**, **firewalling**, and **routing protocols**.

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2. Layer 3 Switch

A **Layer 3 Switch**, also called a **Multilayer Switch**, combines the functionality of both a **switch** and a **router**. It can perform switching (Layer 2) as well as routing (Layer 3) tasks.

A Layer 3 switch can forward packets based on IP addresses, just like a router, but it also has the ability to switch packets at high speeds, similar to a regular Layer 2 switch. It is typically used in larger networks for **VLAN routing**, **inter-VLAN communication**, and high-performance data forwarding.

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3. Brouter (Bridge Router)

A **Brouter** is a hybrid device that combines the features of both a **bridge** (Layer 2) and a **router** (Layer 3). It can operate as a bridge within a single network and as a router between different networks.

A brouter forwards packets based on both **MAC addresses** (like a bridge) and **IP addresses** (like a router). When a brouter receives data, it examines whether the data is intended for the same network (and bridges it) or needs to be routed to another network.

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4. Gateway

A **Gateway** is a device that acts as an entry/exit point to a network, enabling communication between networks using different protocols. It operates at higher layers of the OSI model, typically at Layer 3 and above.

Gateways translate data between different protocols (such as from **IP** to **IPX** or **TCP/IP** to **ATM**), making it possible for different types of networks to communicate. Gateways are typically used when networks with different architectures need to be connected.
It provides protocol conversion between different networks.

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5. Network Printer

A **Network Printer** is a printer that is directly connected to a network, allowing multiple devices to send print jobs over the network.

It operates at the Network Layer, as it is assigned an **IP address** and can communicate with other devices on the same network.

A network printer allows multiple users on a local network to send print jobs to the printer via a network connection (wired or wireless). It does not require a direct connection to each device that needs to print. Instead, devices communicate with the printer via IP-based protocols like **IPP (Internet Printing Protocol)** or **SMB**.

Wireless Network Devices

Wireless Network Devices are hardware components that allow devices to connect to a network without the need for physical cables. These devices use **radio waves** to transmit and receive data, making them an essential part of modern networks, especially in homes, offices, and large-scale environments that require mobility or convenience.

Wireless networks are commonly based on standards like **Wi-Fi** (IEEE 802.11) for local area networks (LANs). Devices such as **wireless switches**, **wireless routers**, and others make it possible for users to connect to the internet or local networks wirelessly, providing flexibility and ease of access.

Types of Wireless Network Devices

1. Wireless Switch

A **Wireless Switch** is a device that manages and controls wireless access points (APs) within a network. It connects to the wireless access points and coordinates the flow of data between them and the wired network. The wireless switch centralizes the management of multiple APs, improving the network's efficiency and security.

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2. Wireless Router

A **Wireless Router** is a device that provides wireless connectivity between a local area network (LAN) and the internet. It combines the functions of a **router** (for routing data between networks) and a **wireless access point** (for enabling Wi-Fi connections). A wireless router typically has both wired (Ethernet) and wireless (Wi-Fi) capabilities.

Access Point (AP)

An **Access Point (AP)** is a device that allows wireless devices to connect to a wired network using Wi-Fi or related standards. It acts as an interface between the wireless devices (such as smartphones, laptops, or tablets) and the wired network (such as a local area network or LAN). The Access Point provides the necessary infrastructure for wireless devices to communicate with each other and with the network.

In essence, it "extends" the range of the network, allowing devices to connect wirelessly from a broader area than what the router or the main network can cover.