3...

Network Connectivity Devices and Technologies

Learning Objectives...

- To understand the Categories of Connectivity Devices.
- To learn the concept of Hub, Switch, Router, Repeaters, Bridges, Gateways, Modem.
- To study Network security devices and Ethernet and wireless technologies.

3.1 CATEGORIES OF CONNECTIVITY DEVICES

- There are a number of connecting devices to build or establish a network, out of which some devices are shown in Fig. 3.1:

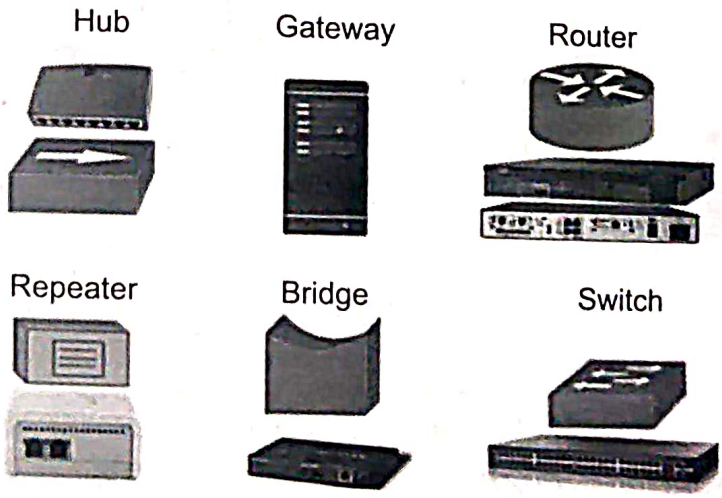


Fig. 3.1

3.2 HUB

- A hub is a basic device used to connect multiple computers or other network devices in a Local Area Network (LAN). It is a hardware device, which is used to create network.

- It operates at the physical layer (Layer 1) of the OSI model and is used to transmit data packets to all devices on the network.
- Transmission mode of Hub is half duplex.
- Hubs transmit data packets to all devices connected to them.
- There are two main types of hubs:

1. **Passive Hub:**
   - Does not amplify or regenerate the signal.
   - Simply connects all the network devices together and passes on the signal.
   - Relies on the connected devices to manage the data traffic.
2. **Active Hub:**
   - Amplifies and regenerates the signal before passing it on to other devices.
   - Requires an external power source.
   - Helps in extending the distance over which data can travel in the network by boosting the signal strength.

- A third, less common type is:

3. **Intelligent Hub (Smart Hub):**
   - Provides additional features such as remote management and monitoring of the network traffic.
   - Can include features like switching and routing, making them more versatile than basic hubs.
   - Often used in more complex network environments where network performance and monitoring are crucial.

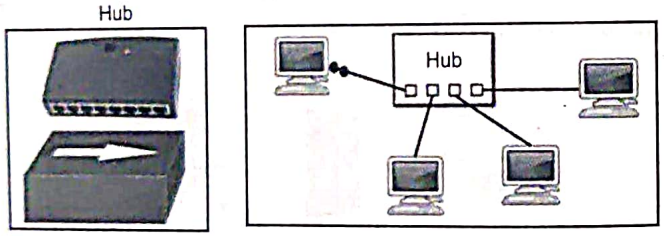


Fig. 3.2

3.3 SWITCH

- It is a hardware device, which is used to create network. A switch is a basic device used to connect multiple computers or other network devices.
- It operates at the data link layer (Layer 2) of the OSI model.
- Transmission mode of Switch is both half duplex and full duplex, but mostly operates in full duplex.
- Switches maintain a MAC address table that maps each connected device's MAC address to the corresponding port on the switch.
- Switches examine the data packets (frames) they receive and forward them only to the specific device for which the data is intended.

- Switches can be easily scaled to support larger networks by adding more switches and connecting them together, allowing for flexible network expansion.

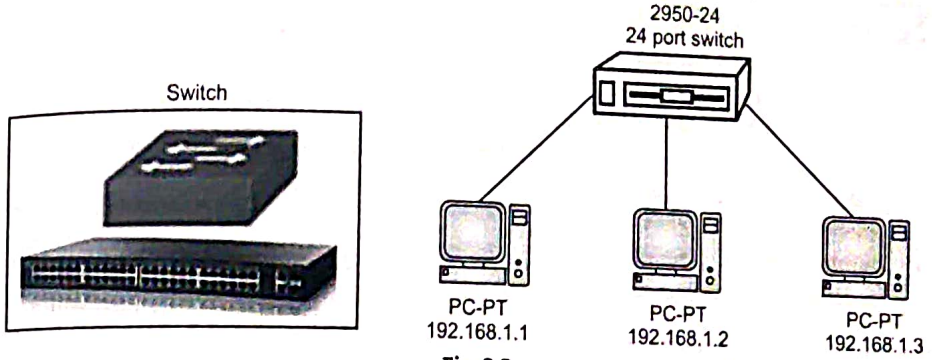


Fig. 3.3

3.4 ROUTER

- Routers connect multiple networks, such as different LANs or a LAN to a WAN (Wide Area Network), facilitating communication between them. It is a hardware device, which is used to create network.
- It operates at the network layer (Layer 3) of the OSI model.
- Transmission mode of Router is full duplex.
- Routers use IP addresses to determine the best path for forwarding data packets to their destination.
- They maintain routing tables that store information about network paths and use routing algorithms to find the most efficient route.
- Routers support both dynamic and static routing, in dynamic routing, routers use protocols like OSPF (Open Shortest Path First), RIP (Routing Information Protocol), and BGP (Border Gateway Protocol) to automatically update routing tables, in static routing, routes are manually configured.
- Routers support subnetting, allowing the division of a larger network into smaller, more manageable subnets. They also support VLANs (Virtual Local Area Networks), which can segment network traffic for better organization and security.

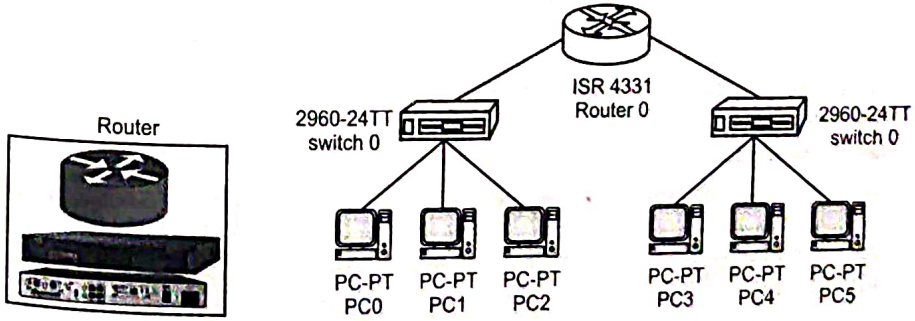


Fig. 3.4

- Routers can provide remote access capabilities and support VPN (Virtual Private Network) connections, enabling secure access to the network from remote locations.

3.5 REPEATERS

- A repeater in networking is a device used to regenerate or amplify a signal as it travels through a network.
- A repeater is like a signal booster.
- As network signals travel through cables or transmission media, they lose strength and become weaker, so repeaters simplify the signals, ensuring they remain strong enough to reach their destinations.
- Its primary function is to extend the range or distance over which data can be transmitted. Fig. 3.5 shows how it works.

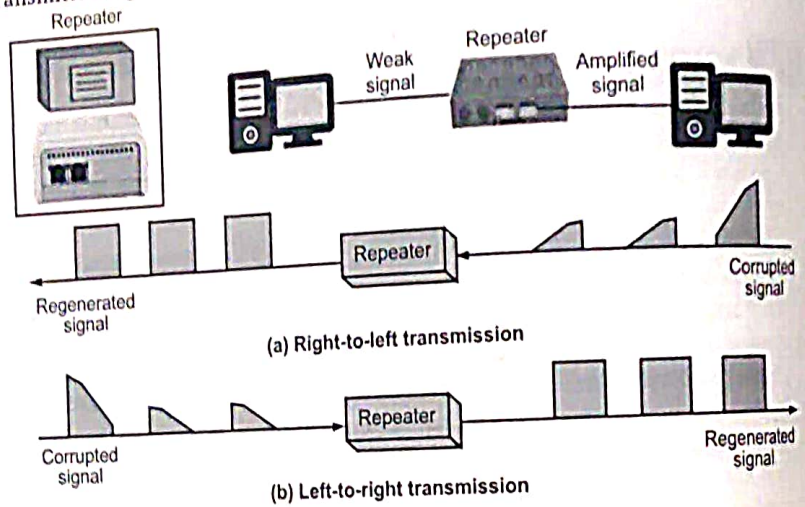


Fig. 3.5

1. **Signal Regeneration:** As data travels through a network cable, the signal can degrade or weaken due to distance, interference, or other factors. A repeater takes the weakened signal, regenerates it to its original strength, and retransmits it.
2. **Extending Network Coverage:** By placing repeaters at appropriate intervals, you can extend the physical distance over which data can travel without degradation. This is particularly useful in large networks, long-distance data transmission, and wireless networks.

Types of Repeaters:

(i) Analog Repeaters: Used in analog signal transmission, common in older telephone systems.
(ii) Digital Repeaters: Used in digital networks to regenerate digital signals.
(iii) Wireless Repeaters: Extend the range of wireless networks by receiving and retransmitting wireless signals.

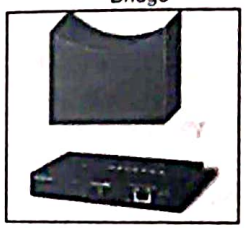
Applications:

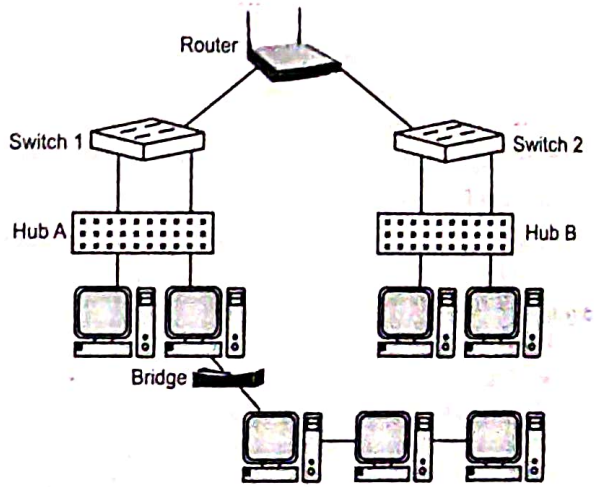
(i) **Wired Networks:** Extending the reach of Ethernet or other wired networks beyond the maximum cable length.
(ii) **Wireless Networks:** Boosting the range of Wi-Fi signals in large areas or buildings.

- Repeaters are essential for maintaining the integrity and performance of data transmission over long distances or in environments where signal degradation is a concern.

3.6 BRIDGES

- A bridge in networking is a device that connects two or more network segments, allowing them to function as a single network.
- It helps to manage traffic by filtering data and deciding whether to forward it to another segment.





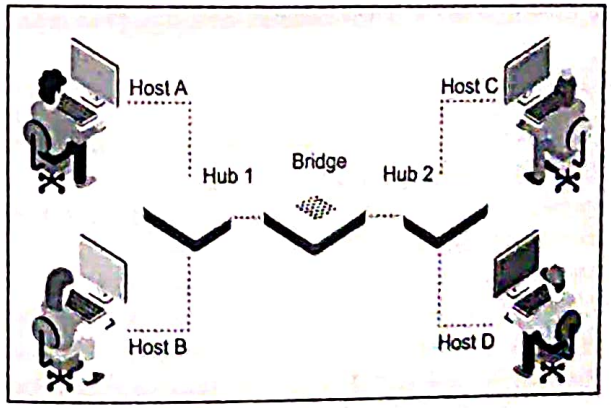


Fig. 3.6

- Bridges reduce network congestion by dividing large networks into smaller, more manageable sections.
- They work at the data link layer (Layer 2) of the OSI model.
- Overall, bridges improve network performance and efficiency by ensuring data is sent only where it needs to go.

3.6.1 Types of Bridge

1. **Transparent Bridge:**
   - **Function:** Learns the MAC addresses of devices on each segment and forwards frames based on this information.
   - **Usage:** Common in Ethernet networks.
2. **Source-Route Bridge:**
   - **Function:** Used primarily in Token Ring networks, where the source device determines the entire route to the destination.
   - **Usage:** Token Ring networks.
3. **Translational Bridge:**
   - **Function:** Connects networks of different types (e.g., Ethernet to Token Ring) and translates the data frames between the two.
   - **Usage:** When connecting networks of different architectures.
4. **Remote Bridge:**
   - **Function:** Connects LAN segments over long distances using telecommunications links.
   - **Usage:** Connecting branch offices or different geographic locations.
5. **Multiport Bridge:**
   - **Function:** Similar to a switch, it has multiple ports to connect several segments and uses MAC addresses to forward traffic.
   - **Usage:** Larger network environments with multiple segments.

- Each type of bridge has its specific use cases, benefits, and limitations, and is chosen based on the particular needs of the network design and the type of network being connected.

3.7 GATEWAYS

- A gateway is a node that serves as an access point or intermediary between different networks, often with different protocols.
- Gateways operate at various layers of the OSI model, but they are commonly associated with the network layer (Layer 3).
- Here are the main functions and characteristics of gateways:

(a) **Protocol Translation:** Gateways can translate protocols used in one network into protocols used in another, enabling communication between networks that use different protocols. This is essential for integrating disparate systems, such as connecting an IP-based network with a non-IP-based network.

(b) **Network Interconnection:** Gateways connect different networks, allowing devices on separate networks to communicate. This can include connecting a Local Area Network (LAN) to a Wide Area Network (WAN) or connecting networks within different organizations.

(c) **Data Format Translation:** Besides protocol translation, gateways can also handle data format translation, converting data from one format to another as it passes between networks. This ensures that the data is usable on both sides of the gateway.

(d) **Application Layer Gateways:** These gateways operate at the application layer (Layer 7) and are used to manage specific types of traffic such as email, voice, and video. Examples include email gateways that filter spam and virus-infected messages.

(e) **Firewall and Security:** Many gateways include firewall capabilities to filter traffic and enforce security policies, protecting the network from unauthorized access and cyber threats.

(f) **Routing:** Gateways can also perform routing functions, determining the best path for data to travel across interconnected networks. This is particularly important in complex network architectures.

(g) **VoIP Gateways:** These gateways convert voice traffic from traditional phone networks (PSTN) into data packets for transmission over IP networks (VoIP) and vice versa.

(h) **Internet Gateways:** An internet gateway connects a local network to the internet, providing access to external web resources. It often includes features like NAT (Network Address Translation), DHCP (Dynamic Host Configuration Protocol), and DNS (Domain Name System) services.

(i) **Cloud Gateways:** These gateways facilitate the integration and management of data traffic between on-premises networks and cloud services, ensuring seamless communication and data transfer.

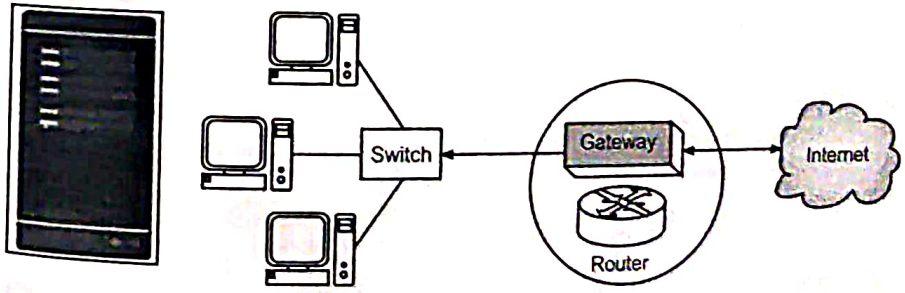


Fig. 3.7

- Overall, gateways are versatile devices that play a critical role in ensuring seamless communication and interoperability between different networks and systems. They enable connectivity and data exchange across diverse network environments, supporting a wide range of applications and services.

3.8 MODEM

- A modem (short for modulator-demodulator) is a device that converts digital data from a computer or other digital device into analog signals that can be transmitted over telephone lines, cable systems, or other analog communication mediums, and vice versa.
  - **Modulation and Demodulation:** The primary function of a modem is to modulate digital data into analog signals for transmission over an analog medium and to demodulate incoming analog signals back into digital data that can be understood by digital devices.
  - **Connection Interface:** Modems typically connect to a computer or a router using Ethernet or USB interfaces. The modem acts as a bridge between the local network and the wider internet.
  - **Data Transmission Speeds:** The speed of a modem depends on the type and technology used. For example, fiber optic modems can support gigabit speeds, while older dial-up modems are much slower.
  - **Error Correction and Compression:** Modems often include features for error correction and data compression to improve the efficiency and reliability of data transmission.
  - **Configuration and Management:** Modems can usually be configured and managed through a web interface, allowing users to set up connections, monitor performance, and troubleshoot issues.
- Overall, modems are essential devices for connecting local networks to the broader internet, enabling data transmission over various types of communication mediums.
- They play a crucial role in ensuring that digital data can be transmitted efficiently and reliably across different types of networks.

Types of Modems:

1. Dial-Up Modems
2. DSL Modems
3. Cable Modems
4. Fiber Optic Modems
5. Wireless Modems

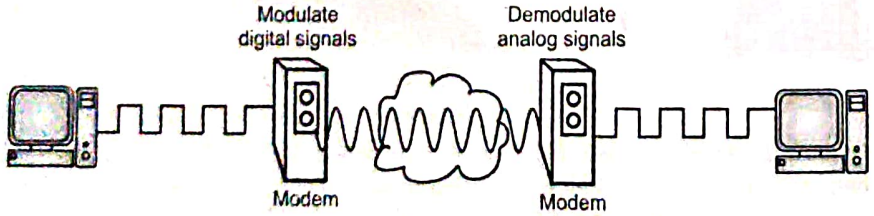


Fig. 3.8

3.9 NETWORK SECURITY DEVICES

3.9.1 Firewalls

- A firewall is a network security device or software that monitors and controls incoming and outgoing network traffic based on predetermined security rules.
- Firewalls are essential for protecting networks from unauthorized access, cyberattacks, and other security threats.
- Firewalls analyse network traffic and decide whether to allow or block specific traffic based on security rules.
- It controls incoming and outgoing traffic based on predefined rules.
- These rules can be based on IP addresses, ports, protocols, and other criteria.
- Table 3.1 illustrates how it maintains the table.

Table 3.1

Sr. No.	Source IP	Det. IP	Source Port	Dest. Port	Action
1.	192.168.21.0	--	--	--	deny
2.	--	--	--	23	deny
3.	--	192.168.21.3	--	--	deny
4.	--	192.168.21.0	--	>1023	Allow

- Firewall is a device that can be either hardware or software.
- It works on network and transport layers.
- It can block IP address, services like http, https, etc.

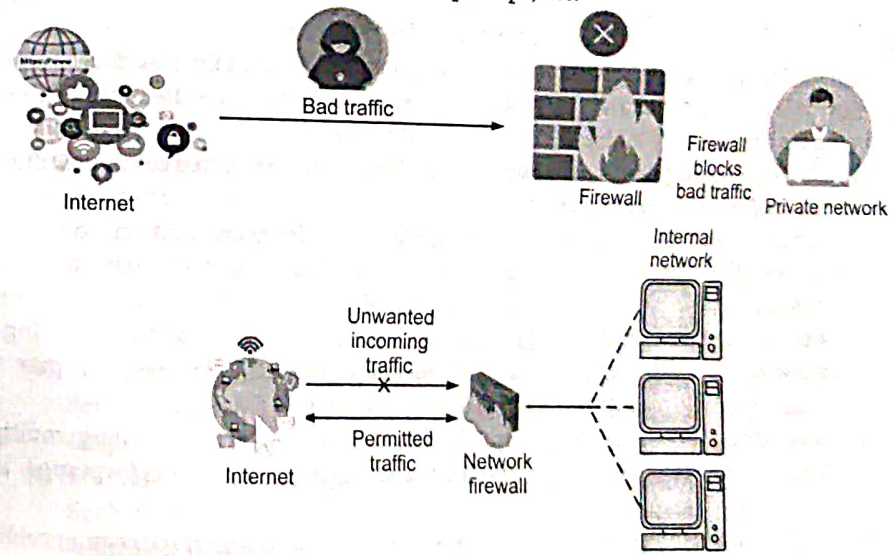


Fig. 3.9

- **Access Control:** Firewalls enforce access control policies, determining which users or devices can access specific network resources, this helps prevent unauthorized access and data breaches.
- **Application Control:** Advanced firewalls can control access to specific applications and services, enforcing policies based on the application rather than just IP addresses and ports.
- Firewalls are a critical component of a comprehensive network security strategy, providing a first line of defence against cyber threats and helping to ensure the integrity, confidentiality, and availability of network resources.

Types of Firewalls:

1. Packet-Filtering Firewalls
2. Stateful Inspection Firewalls
3. Proxy Firewalls
4. Next-Generation Firewalls (NGFWs)

3.9.2 Proxy Server

- A proxy server is an intermediary server that sits between client devices and target servers.
- It manages requests and responses to improve performance, security, and privacy.
- It hides the client's IP address from the target server.
- Proxy servers play a crucial role in managing and securing network traffic, improving performance, and enhancing privacy.
- They are widely used in both enterprise and personal environments to achieve a variety of networking goals.
- Here are the main functions and features of proxy servers:
  1. **Traffic Routing:** Proxy servers receive requests from client devices, forward them to the target servers, and then relay the responses back to the clients. This process hides the client's IP address from the target server.
  2. **Content Caching:** Proxy servers can cache frequently requested content, reducing the load on target servers and speeding up response times for clients.
  3. **Security and Privacy:** By hiding client IP addresses and acting as an intermediary, proxy servers can protect clients from direct exposure to threats and enhance privacy. They can also perform SSL/TLS encryption and decryption
  4. **Access Control and Filtering:** Proxies can enforce access policies, blocking or allowing requests based on predefined rules. This can be used for parental controls, employee internet usage policies, and content filtering.
  5. **Load Balancing:** Reverse proxies distribute incoming traffic among multiple backend servers, balancing the load and improving the performance and reliability of services.
  6. **Logging and Monitoring:** Proxy servers can log requests and responses, providing valuable data for monitoring network activity, troubleshooting issues, and auditing purposes.

7. **Bypassing Restrictions:** Clients can use proxy servers to bypass geographic restrictions, censorship, and firewall rules by masking their IP addresses.

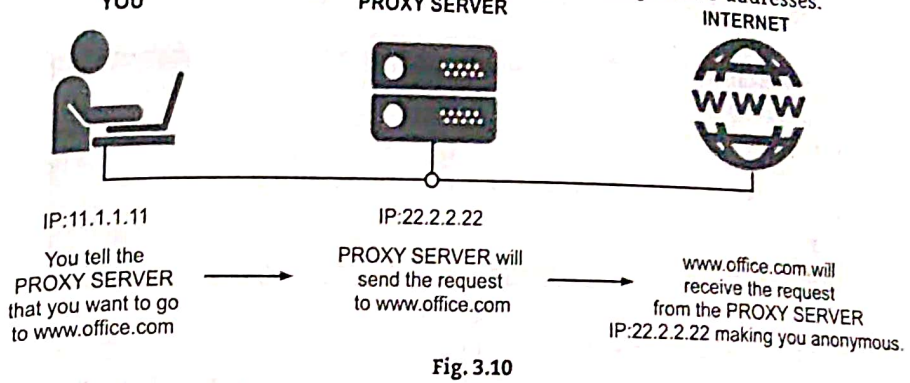


Fig. 3.10

Types of Proxy Servers:

1. Forward Proxy
2. Reverse Proxy
3. Transparent Proxy
4. Anonymous Proxy
5. High Anonymity Proxy (Elite Proxy)

3.10 ETHERNET AND WIRELESS TECHNOLOGIES

3.10.1 Ethernet

- Ethernet is a widely used wired technology for Local Area Networks (LANs).
- It defines a number of wiring and signalling standards for the physical layer of the OSI model, as well as a common addressing format and protocol for the data link layer.
- Ethernet allows devices like computers, printers, and servers to communicate within a network.
- Key characteristics of Ethernet include:
  - **(a) Speed:** Ethernet speeds range from 10 Mbps (megabits per second) to 400 Gbps (gigabits per second), with common speeds being 100 Mbps (Fast Ethernet), 1 Gbps (Gigabit Ethernet), and 10 Gbps (10 Gigabit Ethernet).
  - **(b) Topology:** Ethernet typically uses a star or bus topology. In a star topology, each device connects to a central hub or switch. In a bus topology, all devices share a single communication line.
  - **(c) Frames:** Data on an Ethernet network is transmitted in packets called frames. Each frame contains the source and destination MAC (Media Access Control) addresses, data payload, and error-checking information.
  - **(d) Medium Access Control (MAC):** Ethernet uses the Carrier Sense Multiple Access with Collision Detection (CSMA/CD) protocol to manage how devices share the

communication channel. This protocol helps prevent collisions and ensures that data is transmitted smoothly.

(e) **Cabling:** Ethernet typically uses twisted-pair cables (such as Cat5e, Cat6) or fiber optic cables for higher speeds and longer distances.

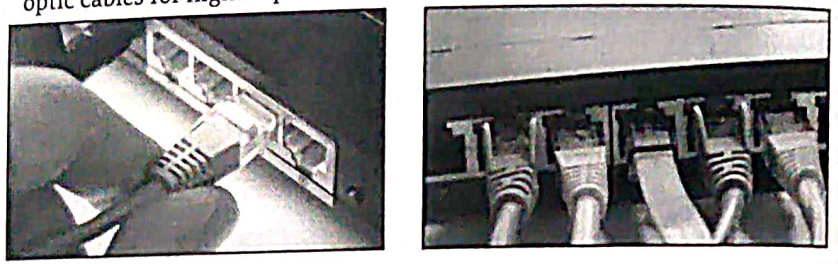


Fig. 3.11

- Ethernet has evolved over the years to support faster speeds, more efficient data transmission, and better scalability, making it a foundational technology for modern networking.

3.9.2 Wireless Technologies

- Wireless technologies in networking enable devices to communicate without physical connections, offering flexibility and mobility.
- Here are some key wireless technologies:

1. **Wi-Fi (Wireless Fidelity):**
   - **Standards:** IEEE 802.11 family (a/b/g/n/ac/ax).
   - **Frequency Bands:** Typically, 2.4 GHz and 5 GHz, with newer standards using 6 GHz.
   - **Speed:** Varies by standard, from 54 Mbps (802.11g) to several Gbps (802.11ax).
   - **Usage:** Home and office networking, public hotspots.
2. **Bluetooth:**
   - **Standard:** IEEE 802.15.1.
   - **Frequency Band:** 2.4 GHz.
   - **Range:** Short range, typically up to 100 meters.
   - **Usage:** Personal Area Networks (PANs), connecting peripherals (keyboards, mice, headphones).
3. **Cellular Networks:**
   - **Generations:** 2G, 3G, 4G (LTE), 5G.
   - **Frequency Bands:** Various, depending on the technology and region.
   - **Speed:** Varies by generation, with 5G offering up to several Gbps.
   - **Usage:** Mobile phone connectivity, mobile internet.
4. **WiMAX (Worldwide Interoperability for Microwave Access):**
   - **Standard:** IEEE 802.16.
   - **Frequency Bands:** 2.3 GHz, 2.5 GHz, 3.5 GHz, 5.8 GHz.

   - **Speed:** Up to 1 Gbps.
   - **Usage:** Broadband internet access, especially in areas without wired infrastructure.
5. **NFC (Near Field Communication):**
   - **Range:** Very short, typically a few centimetres.
   - **Usage:** Contactless payments, data exchange between devices.
6. **LoRa (Long Range):**
   - **Standard:** LoRaWAN.
   - **Frequency Bands:** Sub-GHz bands (e.g., 433 MHz, 868 MHz, 915 MHz).
   - **Usage:** Internet of Things (IoT) applications, long-range communication with low power consumption.
7. **Zigbee:**
   - **Standard:** IEEE 802.15.4.
   - **Frequency Bands:** 2.4 GHz, 868 MHz, 915 MHz.
   - **Usage:** Smart home devices, IoT applications, low-power and low-data-rate communication.

- These technologies cater to different networking needs, from high-speed data transfer and internet connectivity to low-power communication for IoT devices.

Summary

- Hub, Gateway, Router, Repeater, Bridge, Switch are connecting devices to build or establish a network.
- A hub is a basic device used to connect multiple computers or other network devices in a Local Area Network (LAN). There are two main types of Hubs: Passive and Active Hub.
- A switch is a basic device used to connect multiple computers or other network devices.
- Routers connect multiple networks, such as different LANs or a LAN to a WAN (Wide Area Network), facilitating communication between them.
- A repeater in networking is a device used to regenerate or amplify a signal as it travels through a network.
- A bridge in networking is a device that connects two or more network segments, allowing them to function as a single network.
- A gateway is a node that serves as an access point or intermediary between different networks, often with different protocols.
- A modem (short for modulator-demodulator) is a device that converts digital data from a computer or other digital device into analog signals that can be transmitted over telephone lines, cable systems, or other analog communication mediums, and vice versa.

- A firewall is a network security device or software that monitors and controls incoming and outgoing network traffic based on predetermined security rules.
- A proxy server is an intermediary server that sits between client devices and target servers.
- Ethernet defines a number of wiring and signalling standards for the physical layer of the OSI model, as well as a common addressing format and protocol for the data link layer.

Check Your Understanding

1. Which of the following devices operates at the physical layer (Layer 1) of the OSI model?
   (a) Router (b) Switch
   (c) Hub (d) Bridge
2. Which type of hub can monitor traffic and provide statistics?
   (a) Passive hub (b) Active hub
   (c) Intelligent hub (d) None of the above
3. A switch operates at which OSI layer?
   (a) Layer 1 (b) Layer 2
   (c) Layer 3 (d) Layer 4
4. Which of the following devices can break up broadcast domains?
   (a) Hub (b) Repeater
   (c) Router (d) Switch
5. What is the main function of a repeater?
   (a) Filtering traffic
   (b) Breaking broadcast domains
   (c) Amplifying and regenerating signals
   (d) Assigning IP addresses
6. Which type of bridge selects the path based on the source of the data?
   (a) Transparent Bridge (b) Source Routing Bridge
   (c) Translational Bridge (d) Remote Bridge
7. Which device connects different network architectures such as Ethernet and Token Ring?
   (a) Router (b) Gateway
   (c) Bridge (d) Switch
8. What does a firewall primarily provide?
   (a) Speed enhancement (b) IP address assignment
   (c) Network security (d) Data compression

9. Which device stores and forwards web requests to reduce load on the main server?
   (a) Modem (b) Switch
   (c) Proxy Server (d) Bridge
10. Which device connects a LAN to the internet via telephone lines?
    (a) Modem (b) Hub
    (c) Bridge (d) Switch

Answers

1. (c)	2. (c)	3. (b)	4. (c)	5. (c)	6. (b)	7. (b)	8. (c)	9. (c)	10. (a)

Practice Questions

Q.I Answer the following questions in short:

1. What OSI layer does a switch operate on?
2. Define a passive hub.
3. Name any two types of bridges.
4. What is the primary function of a router?
5. What is the difference between a modem and a router?
6. What layer does a bridge operate on?
7. Name any two network security devices.
8. What is the purpose of a repeater in networking?
9. What does a proxy server do?
10. Define a smart hub.
11. List out the wireless technologies.

Q.II Answer the following questions in detail:

1. Explain the differences among a hub, switch, and router in terms of OSI model layers and functionality.
2. Describe the different types of hubs and their uses.
3. Discuss the different types of bridges and explain their specific use cases.
4. What is a gateway and how does it work?
5. Explain how a firewall protects a network.
6. Describe the role of a proxy server in network security and performance.
7. Discuss Ethernet and wireless technologies.
8. Describe how a modem works and its role in internet connectivity.
9. Discuss how different network connectivity devices work together in a typical enterprise network setup.
10. Explain repeater with its functionality, types and applications.

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5...

Routing Protocols

Learning Objectives...

- To understand the Structure of Router.
- To learn the concept of Routing Tables and Types of Routing.
- To study about Intra and Inter Domain Routing.
- To understand the concept of Distance Vector Routing, RIP, OSPF, EIGRP & BGP.

5.1 STRUCTURE OF A ROUTER

- A router is a networking device that directs data packets among different networks, ensuring they reach their correct destinations. Its structure typically includes several key components:

1. **Central Processing Unit (CPU):** The brain of the router, responsible for executing instructions and managing network traffic. It handles routing algorithms, processes incoming and outgoing packets, and manages overall router operations.
2. **Memory:**
   - **RAM (Random Access Memory):** Temporary storage used for processing data and storing routing tables, packet buffers, and running processes.
   - **ROM (Read-Only Memory):** Stores the router's firmware and basic operating system code that is used to start up and run the router.
3. **Routing Table:** A database maintained by the router that contains information about the network topology, including routes to various network destinations. It is used by the router to make decisions about where to forward packets.
4. **Network Interfaces:**
   - **Ethernet Ports:** Physical connections for wired network connections. These ports connect the router to Local Area Networks (LANs) or other devices.
   - **Wireless Interfaces:** For routers with wireless capabilities, these components handle communication with wireless devices using standards like Wi-Fi.
   - **WAN Port:** A specific port for connecting to an external network, typically the Internet.
5. **Switching Fabric:** The internal network within the router that moves data between different ports and interfaces. It ensures that packets are directed to the correct output port.

6. **Power Supply:** Provides electrical power to all components of the router. This could be an internal power supply or an external adapter, depending on the router design.
7. **Cooling System:** Some routers, especially high-performance or enterprise models, have cooling systems (like fans) to dissipate heat generated by the internal components.
8. **LED Indicators:** Lights on the router that show the status of various functions, such as power, network activity, and connectivity.
9. **Management Interface:** Often includes a web-based or command-line interface for configuring and managing the router's settings, monitoring performance, and troubleshooting.
10. **Firmware/Operating System:** The software that controls the router's hardware and enables its functionality. This software includes the operating system and the network protocols necessary for routing.

- Each of these components plays a crucial role in ensuring that the router efficiently and effectively directs data between networks.

5.2 ROUTING TABLES

- A routing table is a fundamental component of a router or a networked computer that stores the routes (paths) to various network destinations. It is used to determine the best path for forwarding data packets to their destination.

Key Components of a Routing Table:

1. **Destination Network:**
   - This is the IP address of the network to which the packet is destined. The routing table will have entries for different network addresses.
2. **Subnet Mask:**
   - The subnet mask is used to specify the network portion of an IP address. It helps in determining the range of IP addresses within a particular network.
3. **Gateway (Next Hop):**
   - The gateway is the IP address of the next hop, which is usually the next router in the path towards the destination network. If the packet's destination is not within the local network, it must be forwarded to another router (gateway).
4. **Interface:**
   - The interface is the network interface (such as Ethernet port) through which the packet should be sent. Each entry in the routing table specifies the interface used to reach the next hop.
5. **Metric:**
   - The metric is a value that indicates the cost of using a particular route. It could be based on hop count, bandwidth, delay, or other factors. Lower metrics are preferred, as they indicate a more optimal route.

6. **Route Type:**
   - This indicates how the route was learned: either dynamically via routing protocols (like OSPF, BGP, RIP) or statically configured by a network administrator.

Example of a Routing Table Entry:

Destination Network	Subnet Mask	Gateway	Interface	Metric
192.168.1.0	255.255.255.0	192.168.1.1	eth0	10
10.0.0.0	255.0.0.0	10.0.0.1	eth1	20
0.0.0.0	0.0.0.0	192.168.1.254	eth0	10

Routing Table Lookup Process:

1. **Packet Arrival:** When a data packet arrives at a router, the router examines the destination IP address of the packet.
2. **Matching Process:** The router compares the destination IP address against the entries in its routing table. It uses the subnet mask to determine the most specific match.
3. **Forwarding Decision:** Once a match is found, the router determines the next hop and the interface to forward the packet.
4. **Packet Forwarding:** The packet is sent to the determined interface, towards the next hop or final destination.

Types of Routes in the Routing Table:

(i) **Directly Connected Routes:** These are networks directly connected to one of the router's interfaces.
(ii) **Static Routes:** Manually configured routes by a network administrator.
(iii) **Dynamic Routes:** Routes learned and updated automatically via routing protocols.

5.3 TYPES OF ROUTING

- **Static** and **dynamic** routing are two fundamental methods used to determine the path that data packets take to reach their destination within a network. Each method has its advantages and disadvantages, and they are often used in different scenarios depending on the network's size, complexity, and requirements.

5.3.1 Static Routing

- Static routing involves manually configuring routes on a router. These routes do not change unless manually updated by a network administrator.

Key Features of Static Routing:

1. **Manual Configuration:** Routes are manually configured by the network administrator. The administrator must define the path that packets should take to reach a particular destination.
2. **Simplicity:** Static routing is straightforward and easy to implement in small networks with simple topologies.

3. **No Overhead:** Static routing does not generate routing protocol traffic, meaning it does not consume bandwidth or router processing power for exchanging routing information.
4. **Predictability:** Since routes are manually configured and do not change, network behaviour is predictable and stable.
5. **Security:** Static routes are more secure because they do not expose the network to routing updates from other networks, which could potentially be malicious.

Disadvantages of Static Routing:

1. **Lack of Scalability:** Static routing is impractical for large or complex networks, as it requires manual updates for every route, which can be time-consuming and prone to human error.
2. **No Automatic Failover:** If a link goes down, a static route does not automatically find an alternative path. The administrator must manually configure a new route, leading to potential downtime.
3. **Maintenance:** As the network grows or changes, maintaining static routes becomes increasingly difficult and error-prone.

Configuration:

Router>**enable**
Router# **configure terminal**
Router(config)#**ip route [destination_network] [subnet_mask] [next_hop_ip | exit_interface]**

For example,

To add a static route to network **192.168.2.0** via the next hop **10.0.0.0**
Router(config)# **ip route 192.168.2.0 255.255.255.0 10.0.0.0**
Router(config)# exit

5.3.2 Dynamic Routing

- Dynamic routing involves the use of routing protocols to automatically discover and maintain routes in the network. Routers using dynamic routing exchange routing information with each other, allowing them to automatically adjust to changes in the network topology.

Key Features of Dynamic Routing:

1. **Automatic Route Discovery:** Routers using dynamic routing protocols automatically discover routes to all destinations in the network. They dynamically adjust routes in response to changes such as link failures or topology changes.
2. **Scalability:** Dynamic routing is well-suited for large and complex networks, as it can automatically scale to accommodate network growth and changes.
3. **Automatic Failover:** If a route becomes unavailable, dynamic routing protocols automatically find an alternative path, minimizing downtime and ensuring network resilience.

4. **Load Balancing:** Some dynamic routing protocols support load balancing, where traffic is distributed across multiple routes with equal or unequal costs.
5. **Routing Protocols:** Common dynamic routing protocols include OSPF (Open Shortest Path First), EIGRP (Enhanced Interior Gateway Routing Protocol), RIP (Routing Information Protocol), and BGP (Border Gateway Protocol).

Disadvantages of Dynamic Routing:

1. **Complexity:** Dynamic routing is more complex to configure and manage than static routing, requiring a deeper understanding of routing protocols and their configuration.
2. **Resource Consumption:** Dynamic routing protocols consume bandwidth and processing power as routers exchange routing information and calculate optimal paths.
3. **Potential Instability:** In certain situations, dynamic routing protocols can lead to routing loops or route flapping (frequent changes in route availability), which can cause network instability if not properly managed.
4. **Security Concerns:** Dynamic routing protocols are susceptible to attacks, such as route injection or spoofing, if not properly secured. For example, attackers could inject incorrect routing information to disrupt network traffic.

Configuration for RIP dynamic routing:

Router>**enable**
Router# **configure terminal**
Router(config)#**router rip**
Router(config-router)# **network 192.168.1.0**
Router(config-router)# **network10.0.0.0**
Router(config-router)#**exit**
Router(config)#

5.3.3 Comparison of Static and Dynamic Routing

Table 5.1

Feature	Static Routing	Dynamic Routing
Configuration	Manual	Automatic (using routing protocols)
Scalability	Low (best for small networks)	High (suitable for large, complex networks)
Flexibility	Low (requires manual updates)	High (adapts automatically to changes)
Failover Support	None (manual intervention required)	Automatic (finds alternative paths)

Contd ...

Complexity	Simple to configure but hard to maintain as the network grows	More complex to configure but easier to manage in large networks
Overhead	None (no routing protocol traffic)	High (routing protocols generate traffic)
Predictability	High (routes are fixed and predictable)	Variable (routes can change dynamically)
Security	High (no external route updates)	Lower (requires secure protocol configuration)

When to Use Static vs. Dynamic Routing:

Static Routing is ideal for:

(i) Small networks with a simple topology.
(ii) Environments where the network topology is stable and does not change frequently.
(iii) Situations where you need to control specific routes manually for security or policy reasons.

Dynamic Routing is ideal for:

(i) Large or complex networks where manual configuration would be impractical.
(ii) Environments were network topology changes frequently.
(iii) Networks that require automatic failover and load balancing.

- In many real-world networks, static and dynamic routing are used together. For example, static routing might be used for default routes or specific critical paths, while dynamic routing manages the broader network.

5.4 INTRA AND INTER DOMAIN ROUTING

- In networking, intra-domain and inter-domain routing are two essential concepts that define how data packets are routed within and between different networks.

5.4.1 Intra-Domain Routing

- **Definition:** Intra-domain routing refers to the process of routing data within a single Autonomous System (AS), which is a network or a group of networks under a common administration and with a common routing policy.
- **Protocols:** Common intra-domain routing protocols include:
  (a) **OSPF (Open Shortest Path First):** A link-state routing protocol that uses Dijkstra's algorithm to find the shortest path.
  (b) **RIP (Routing Information Protocol):** A distance-vector routing protocol that uses hop count as a routing metric.
  (c) **EIGRP (Enhanced Interior Gateway Routing Protocol):** A Cisco proprietary hybrid protocol that uses both distance-vector and link-state features.

- **Characteristics:**
  1. Routing within a single AS.
  2. **Optimization:** The focus is on optimizing routes within the AS, such as minimizing latency or maximizing bandwidth.
  3. **Hierarchical Structure:** Intra-domain routing protocols often divide the network into areas to reduce complexity and improve efficiency (e.g., OSPF areas).

5.4.2 Inter-Domain Routing

- **Definition:** Inter-domain routing is the process of routing data between different autonomous systems. This is essential for ensuring that data can travel across different networks, each with its own routing policies.
- **Protocols:** The primary protocol used for inter-domain routing is:
  (a) **BGP (Border Gateway Protocol):** A path-vector protocol that makes routing decisions based on paths, network policies, and rule-sets configured by the network administrator. BGP is responsible for maintaining the routing table between different autonomous systems.
- **Characteristics:**
  1. Routing between multiple ASes.
  2. **Policy-Based Routing:** BGP allows for complex routing policies, including route filtering and path selection based on various criteria, such as AS path length, route origin, or community values.
  3. **Scalability:** BGP is highly scalable and can handle a vast number of routes, making it suitable for the global Internet.

Key Differences between Intra and Inter Domain Routing:

(a) **Scope:** Intra-domain routing is limited to a single AS, while inter-domain routing involves multiple ASes.
(b) **Protocols:** Different protocols are used, with OSPF, RIP, and EIGRP being common for intra-domain, and BGP for inter-domain.
(c) **Routing Objectives:** Intra-domain routing focuses on efficiency within the AS, while inter-domain routing is more concerned with maintaining global reachability and enforcing routing policies across different ASes.

- These concepts are fundamental to understanding how the internet functions as a whole, with intra-domain routing managing traffic within networks, and inter-domain routing ensuring that networks can communicate with each other globally.

5.5 DISTANCE VECTOR ROUTING (DVR)

- DVR is a dynamic routing algorithm used in computer networks to determine the best path for data packets to travel from one node (router) to another. This method relies on each router sharing information with its immediate neighbours to build a routing table that directs packets across the network.

Key Concepts:

1. **Distance Vector:** Each router maintains a distance vector (a table) that contains the best-known distance (in terms of hop count, cost, or other metrics) to reach every possible destination and the direction (next hop) to reach that destination.
2. **Routing Table:** Each router has a routing table that stores:
   (i) The destination network.
   (ii) The distance to that network.
   (iii) The next hop to reach the destination.
3. **Initial Setup:** Initially, each router knows only the distance to itself (which is zero) and assumes the distance to all other routers is infinite.
4. **Exchange of Information:**
   (i) Routers periodically exchange their distance vectors with their immediate neighbors.
   (ii) When a router receives a distance vector from a neighbor, it compares the newly received information with its current routing table to see if there's a shorter path to any destination.
   (iii) If a shorter path is found, the router updates its routing table and informs its neighbors.
5. **Bellman-Ford Algorithm:**
   - Distance Vector Routing is based on the Bellman-Ford algorithm, which helps in updating the routing tables.
   - The algorithm operates in a distributed manner, and each router independently calculates its own routing table.
6. **Convergence:**
   - The process continues until the network converges, meaning all routers have consistent routing information.
   - Convergence can be slow, especially in large networks, and issues like routing loops can occur during this process.
7. **Count to Infinity Problem:**
   - A common issue with DVR is the "Count to Infinity" problem, were incorrect routing information loops between routers, causing delays in network convergence.
   - Various solutions, such as split horizon, route poisoning, and hold-down timers, are used to mitigate this problem.

Advantages of DVR:

1. **Simplicity:** Easy to implement and understand.
2. **Autonomous:** Each router operates independently.

Disadvantages of DVR:

1. **Slow Convergence:** Takes time for the network to stabilize after a change.
2. **Routing Loops:** Vulnerable to loops during the convergence process.
3. **Scalability:** Not ideal for large networks due to the slow convergence and excessive routing table size.

For Example,

- Imagine a network where each router only knows about its direct neighbors. By exchanging routing tables, each router gradually learns about the entire network and can find the shortest path to any destination. For instance, if router A wants to send data to router D, and the shortest path goes through routers B and C, the routing table at A will eventually reflect this path after several exchanges with its neighbours.

5.6 RIP (ROUTING INFORMATION PROTOCOL)

- RIP is one of the oldest distance-vector routing protocols used in computer networks. It is an Interior Gateway Protocol (IGP) designed to route data within an Autonomous System (AS). Here's an overview of RIP:

Key Features:

1. **Distance Vector Protocol:** RIP uses the distance-vector algorithm to determine the best path to a destination. It considers the number of hops (routers) to reach the destination, with each hop being assigned a cost of 1.
2. **Maximum Hop Count:** The maximum number of hops allowed in a RIP network is 15. If a route has more than 15 hops, it is considered unreachable.
3. **Updates and Timers:**
   (i) **Routing Updates:** RIP routers broadcast their routing tables to neighboring routers every 30 seconds. This helps keep the routing information updated across the network.
   (ii) **Timers:** RIP uses several timers, including the update timer (30 seconds), invalid timer (180 seconds), and hold-down timer (180 seconds) to manage the stability of the network.
4. **Versions:**
   (i) **RIPv1:** The original version, which is classful (doesn't support subnet information).
   (ii) **RIPv2:** An enhanced version that supports classless inter-domain routing (CIDR), multicast updates, and authentication.
5. **Convergence:** RIP has slower convergence compared to other modern protocols. Convergence is the time taken by the routers to update their routing tables and reach a consistent state after a network change.
6. **Split Horizon and Poison Reverse:** To prevent routing loops, RIP employs techniques like split horizon (a router does not advertise a route back to the interface from which it was learned) and poison reverse (advertising a route with an infinite metric to indicate it is unreachable).

Use Cases:

(i) **Small Networks:** Due to its simplicity and limitations like the maximum hop count, RIP is best suited for small to medium-sized networks.

(ii) **Educational Purposes:** RIP is often used in educational environments to teach the basics of routing protocols.

Limitations:

(i) **Scalability:** RIP is not suitable for large networks due to its hop count limitation.

(ii) **Slow Convergence:** Compared to more modern routing protocols like OSPF (Open Shortest Path First) or EIGRP (Enhanced Interior Gateway Routing Protocol), RIP converges slowly.

(iii) **Broadcasts:** RIPv1 uses broadcast routing updates, which can lead to unnecessary traffic on the network.

- Overall, RIP is a foundational protocol that laid the groundwork for more advanced routing protocols used in today's networks.

Configuration:

```
Router>enable
Router# configure terminal
Router(config)#router rip
Router(config-router)# network 192.168.1.0
Router(config-router)# network10.0.0.0
Router(config-router)#exit
Router(config)#
```

5.7 OPEN SHORTEST PATH FIRST (OSPF)

- OSPF is a dynamic routing protocol used in Internet Protocol (IP) networks. It belongs to the group of Interior Gateway Protocols (IGPs), meaning it operates within a single Autonomous System (AS). OSPF is widely used in large enterprise networks due to its scalability, fast convergence, and support for complex topologies.

Key Features of OSPF:

1. **Link-State Routing Protocol:** OSPF is a link-state protocol, meaning it builds a complete map (or topology) of the network by exchanging link-state advertisements (LSAs) with neighboring routers. Each router then uses this map to independently calculate the shortest path to every destination using Dijkstra's algorithm.
2. **Hierarchical Design:** OSPF networks can be structured hierarchically into areas, which helps reduce routing overhead and limits the scope of LSAs. The main area, called Area 0 or the backbone area, interconnects all other areas.
3. **Support for VLSM and CIDR:** OSPF supports Variable Length Subnet Masking (VLSM) and Classless Inter-Domain Routing (CIDR), allowing for more efficient IP address allocation.

4. **Fast Convergence:** OSPF quickly adapts to changes in the network topology (like link failures) by recalculating routes almost immediately.
5. **Equal-Cost Multi-Path (ECMP):** OSPF can distribute traffic across multiple paths that have the same cost, improving load balancing.
6. **Authentication:** OSPF includes features for authenticating the routing information exchanged between routers, enhancing security.
7. **Metric Calculation:** OSPF uses a cost metric based on link bandwidth to determine the shortest path. Lower cost routes are preferred.
8. **Neighbour Relationships:** OSPF routers establish neighbor relationships with directly connected routers to exchange routing information.

OSPF Operation:

1. **Router ID (RID):** Each OSPF router is identified by a unique Router ID, usually an IP address assigned to a loopback interface.
2. **Hello Protocol:** OSPF routers send Hello packets to discover and maintain neighbor relationships. These packets are sent periodically to ensure the link is active.
3. **Database Exchange:** After establishing neighbour relationships, routers exchange their link-state databases to ensure all routers have a consistent view of the network.
4. **Route Calculation:** Once the database exchange is complete, routers use Dijkstra's algorithm to calculate the shortest path to each destination.
5. **Flooding:** When a network change occurs, OSPF routers flood LSAs throughout the network to update the topology map.

OSPF Areas:

(i) **Area 0 (Backbone Area):** The central area that connects all other areas. All OSPF areas must connect to Area 0.

(ii) **Regular Areas:** Non-backbone areas that connect to Area 0.

(iii) **Stub Areas:** Areas that do not receive external route advertisements, reducing routing table size.

(iv) **Totally Stubby Areas:** A variant of stub areas where even internal OSPF routes from other areas are not propagated.

(v) **Not-So-Stubby Area (NSSA):** Allows external routes to be injected in a limited fashion.

OSPF vs. Other Protocols:

- Compared to other IGPs like RIP (Routing Information Protocol), OSPF is more complex but offers faster convergence, better scalability, and support for larger networks.
- Overall, OSPF is a powerful and flexible protocol, suitable for large and complex networks where fast convergence and efficient routing are essential.

Configuration:

```
Router>enable
Router# configure terminal
/* Router(config)#router ospf [process-id] */
Router(config)#router ospf 1
Router(config-router)#network 192.168.1.0 0.0.0.255 area 0
Router(config-router)#network10.0.0.0 0.255.255.255 area 0
Router(config-router)#exit
Router(config)#
```

5.8 EIGRP (ENHANCED INTERIOR GATEWAY ROUTING PROTOCOL)

- EIGRP is a dynamic routing protocol used in IP networks, developed by Cisco Systems. It's an advanced version of the Interior Gateway Routing Protocol (IGRP) and is primarily used within an Autonomous System (AS). EIGRP is known for its efficiency, scalability, and faster convergence compared to other routing protocols like RIP.

Key Features of EIGRP:

1. **Hybrid Routing Protocol:** EIGRP is often referred to as a hybrid routing protocol because it incorporates characteristics of both distance-vector and link-state protocols. It uses distance-vector calculations but also maintains a topology table like a link-state protocol.
2. **DUAL Algorithm:** EIGRP uses the Diffusing Update Algorithm (DUAL) to ensure loop-free and efficient routing. DUAL allows EIGRP to quickly converge and find backup routes without causing routing loops.
3. **Classless Protocol:** EIGRP supports Classless Inter-Domain Routing (CIDR), which allows for more efficient IP address utilization through Variable-Length Subnet Masking (VLSM).
4. **Fast Convergence:** EIGRP can quickly adapt to changes in the network, such as link failures, by recalculating routes almost instantly using DUAL.
5. **Equal and Unequal-Cost Load Balancing:** EIGRP supports both equal-cost and unequal-cost load balancing, allowing it to distribute traffic across multiple paths with different metrics.
6. **Scalability:** EIGRP is highly scalable and can handle large and complex networks with thousands of routes, making it suitable for large enterprise environments.
7. **Neighbour Discovery:** EIGRP routers establish neighbor relationships by exchanging Hello packets. Neighbors share routing information, and EIGRP ensures that only the necessary information is sent to minimize network traffic.

8. **Partial Updates:** Unlike some distance-vector protocols that send periodic full updates, EIGRP sends updates only when a change occurs, and only the affected part of the routing table is updated. This reduces bandwidth usage and improves efficiency.
9. **Metric Calculation:** EIGRP uses a composite metric based on several factors, including bandwidth, delay, load, and reliability. The metric calculation can be fine-tuned to meet specific network requirements.
10. **Support for Multiple Protocols:** Although primarily used for IP networks, EIGRP also supports routing for other network layer protocols like IPX and AppleTalk, though these are less common today.

EIGRP Operation:

- **Router ID:** Each EIGRP router is identified by a unique Router ID, which is usually an IP address from a configured interface.
- **Neighbour Table:** EIGRP maintains a table of neighboring routers that it has established adjacency with. This table is used to track the status and availability of neighbors.
- **Topology Table:** EIGRP maintains a topology table that contains all the routes advertised by neighboring routers. The DUAL algorithm uses this table to select the best path and backup paths.
- **Routing Table:** The best routes from the topology table are placed in the routing table and are used to forward traffic.
- **Reliable Transport Protocol (RTP):** EIGRP uses RTP to ensure the reliable delivery of routing updates between routers.
- **Successor and Feasible Successor:** The successor is the best route to a destination, while the feasible successor is a backup route that meets certain feasibility conditions. If the successor fails, the feasible successor is immediately promoted, leading to fast convergence.

EIGRP Metric Components:

(a) **Bandwidth:** The minimum bandwidth along the path to the destination.
(b) **Delay:** The cumulative delay along the path.
(c) **Load:** The load on the links, reflecting how busy they are.
(d) **Reliability:** The reliability of the links, indicating how often they fail.

EIGRP vs. Other Routing Protocols:

- Compared to RIP, EIGRP is faster and more efficient, supporting larger networks.
- Unlike OSPF, EIGRP uses a simpler metric system and can provide unequal-cost load balancing, but it is Cisco-proprietary, meaning it is only natively supported on Cisco devices.
- Overall, EIGRP is a robust and versatile routing protocol suitable for enterprise networks, especially those using Cisco equipment, offering a good balance of performance, efficiency, and scalability.

Configuration:

```
Router>enable
Router# configure terminal
/* Router(config)#router eigrp [Autonomous System-no] */
Router(config)#router eigrp 1
Router(config-router)#network192.168.1.0 0.0.0.255
Router(config-router)#network10.0.0.0 0.255.255.255
Router(config-router)#exit
Router(config)#
```

5.9 BORDER GATEWAY PROTOCOL (BGP)

- BGP is a standardized exterior gateway protocol used to exchange routing information between Autonomous Systems (ASes) on the internet. BGP is essential for the functioning of the global internet, as it determines how data packets are routed across different networks that are under separate administrative control.

Key Features of BGP:

1. **Path Vector Protocol:** BGP is a path vector protocol, which means it maintains the path (sequence of ASes) information that data must traverse to reach a destination. This helps prevent routing loops by rejecting paths that contain the AS number of the originating router.
2. **Inter-Domain Routing:** BGP is used for inter-domain routing, which involves routing between different autonomous systems, unlike protocols like OSPF and EIGRP, which are used within an AS (intra-domain routing).
3. **Scalability:** BGP is highly scalable and can handle the vast number of routes on the internet. It is designed to work efficiently in large and complex networks with multiple layers of hierarchy.
4. **Policy-Based Routing:** BGP allows for extensive routing policies based on various attributes, such as AS path, next-hop IP address, or multiple path metrics. This flexibility enables network administrators to define routing decisions based on business agreements, security policies, or network performance requirements.
5. **Reliable Transport:** BGP uses TCP (port 179) as its transport protocol, ensuring reliable delivery of routing updates. TCP's reliability mechanisms are crucial for maintaining BGP's stability.
6. **Incremental Updates:** Unlike some protocols that periodically exchange entire routing tables, BGP only sends updates when there is a change in the network. This reduces bandwidth usage and minimizes the processing load on routers.
7. **Route Aggregation:** BGP supports route aggregation, allowing multiple IP prefixes to be combined into a single summary route. This reduces the size of the routing table and improves efficiency.

8. **Multi-Protocol Extensions:** BGP is not limited to IPv4; it supports multiple address families through extensions, such as IPv6, multicast, and VPNs (Virtual Private Networks).
9. **Support for Load Balancing:** BGP can support load balancing across multiple links between ASes, allowing for efficient use of available bandwidth and improving redundancy.
10. **BGP Communities:** BGP communities are a mechanism for tagging routes with specific

Configuration:

R0 – AS 100

```
Router>enable
Router# configure terminal
/* Router(config)#router bgp [Autonomous System-no] */
Router(config)#router bgp 100
Router(config-router)#network 10.0.0.0 mask 255.0.0.0
Router(config-router)#network 20.0.0.0 mask 255.0.0.0
Router(config-router)#network 192.168.1.0 mask 255.255.255.0
Router(config-router)#neighbor 20.0.0.2 remote-as 300
Router(config-router)#neighbor 10.0.0.2 remote-as 200
Router(config-router)#exit
Router(config)
```

Summary:

Table 5.2

Feature	Static Routing	RIP (Routing Information Protocol)	OSPF (Open Shortest Path First)	EIGRP (Enhanced Interior Gateway Routing Protocol)	BGP (Border Gateway Protocol)
Type	Manual/Static	Distance-Vector	Link-State	Hybrid (Distance-Vector and Link-State)	Path-Vector
Metric/Algorithm	N/A	Hop Count	Link-State Database, Dijkstra's Algorithm	DUAL (Diffusing Update Algorithm)	Path Attributes
Scalability	Low	Limited (15 hops)	High	High	Very High
Convergence Speed	Immediate	Slow	Fast	Fast	Slow

Contd. ...

Complexity	Low	Low	Medium	Medium	High
Configuration	Manual, static routes added individually	Simple, automatic updates	Requires configuration of areas and routers	Requires configuration of AS and networks	Complex, policy-based configuration
Updates	Manual	Periodic (every 30 seconds)	Triggered by changes, incremental updates	Incremental updates and automatic summarization	Policy-based updates, manual intervention
Support for VLSM	No	RIP v1: No; RIP v2: Yes	Yes	Yes	Yes
Supports CIDR	No	No	Yes	Yes	Yes
Hierarchical Design	No	No	Yes (Areas)	No	No
Routing Updates	None (manually configured)	Periodic updates broadcasted to all neighbors	Link-State advertisements (LSAs)	Diffusing updates only to affected routers	Path information with attributes, exchanged between ASes
Best Used For	Small, simple networks or specific, stable routes	Small to medium-sized networks	Medium to large enterprise networks	Medium to large networks, particularly Cisco-centric	Internet routing, inter-domain routing

Key Points:

- **Static Routing:** Best for small or simple networks where manual control is preferred and routes don't change often.
- **RIP:** Suitable for small networks with its simple configuration and periodic updates. Limited scalability due to hop count constraint.
- **OSPF:** Ideal for larger networks with its hierarchical design and fast convergence. Requires more complex configuration but scales well.
- **EIGRP:** Provides efficient routing with fast convergence and good scalability, particularly in Cisco environments.
- **BGP:** The protocol of choice for Internet routing and large-scale networks, offering complex routing policies and extensive scalability.

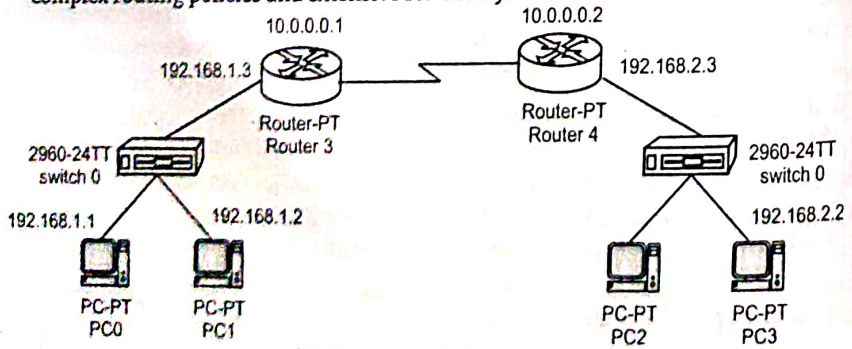

Fig. 5.1: Network Diagram

Configuration:

Table 5.3

Router	Static	RIP	OSPF	EIGRP	BGP
Router 0	Router(config)# **ip route 192.168.2.0 255.255.255.0 10.0.0.0**	Router(config)#**router rip** Router(config-router)# **network 192.168.1.0** Router(config-router)# **network10.0.0.0**	Router(config)#**router ospf 1** Router(config-router)# **network 192.168.1.0 0.0.0.255 area 0** Router(config-router)# **network10.0.0.0 0.255.255.255 area 0**	Router(config)#**router eigrp 1** Router(config-router)# **network 192.168.1.0 0.0.0.255** Router(config-router)# **network10.0.0.0 0.255.255.255**	Router(config)#**router bgp 100** Router(config-router)#**network 10.0.0.0 mask 255.0.0.0** Router(config-router)#**network 192.168.1.0 mask 255.255.255.0** Router(config-router)#**neighbor 10.0.0.2 remote-as 200**
Router 1	Router(config)# **ip route 192.168.1.0 255.255.255.0 10.0.0.0**	Router(config)#**router rip** Router(config-router)# **network 192.168.2.0** Router(config-router)# **network10.0.0.0**	Router(config)#**router ospf 1** Router(config-router)# **network 192.168.2.0 0.0.0.255 area 0** Router(config-router)# **network10.0.0.0 0.255.255.255 area 0**	Router(config)#**router eigrp 1** Router(config-router)# **network 192.168.2.0 0.0.0.255** Router(config-router)# **network10.0.0.0 0.255.255.255**	Router(config)#**router bgp 100** Router(config-router)#**network 10.0.0.0 mask 255.0.0.0** Router(config-router)#**network 192.168.2.0 mask 255.255.255.0** Router(config-router)#**neighbor 10.0.0.1 remote-as 100**
PC0	IP Address: 192.168.1.1 Gateway: 192.168.1.3	IP Address: 192.168.1.1 Gateway: 192.168.1.3	IP Address: 192.168.1.1 Gateway: 192.168.1.3	IP Address: 192.168.1.1 Gateway: 192.168.1.3	IP Address: 192.168.1.1 Gateway: 192.168.1.3
PC1	IP Address: 192.168.1.2 Gateway: 192.168.1.3	IP Address: 192.168.1.2 Gateway: 192.168.1.3	IP Address: 192.168.1.2 Gateway: 192.168.1.3	IP Address: 192.168.1.2 Gateway: 192.168.1.3	IP Address: 192.168.1.2 Gateway: 192.168.1.3

Contd. ...

PC2	IP Address: 192.168.2.1 Gateway: 192.168.2.3	IP Address: 192.168.2.1 Gateway: 192.168.2.3	IP Address: 192.168.2.1 Gateway: 192.168.2.3	IP Address: 192.168.2.1 Gateway: 192.168.2.3	IP Address: 192.168.2.1 Gateway: 192.168.2.3
PC3	IP Address: 192.168.2.2 Gateway: 192.168.2.3	IP Address: 192.168.2.2 Gateway: 192.168.2.3	IP Address: 192.168.2.2 Gateway: 192.168.2.3	IP Address: 192.168.2.2 Gateway: 192.168.2.3	IP Address: 192.168.2.2 Gateway: 192.168.2.3

Summary

- A router is a networking device that directs data packets among different networks, ensuring they reach their correct destinations.
- The routing table is essential for routers to make efficient forwarding decisions. It contains all the information needed to direct packets to their destination across interconnected networks. Proper configuration and maintenance of routing tables are crucial for the smooth operation of any network.
- Static and dynamic routing are two fundamental methods used to determine the path that data packets take to reach their destination within a network.
- Intra-domain and inter-domain routing are two essential concepts that define how data packets are routed within and between different networks.
- Distance Vector Routing is a foundational routing protocol that helps routers determine optimal paths based on distance metrics, although it has limitations in large and rapidly changing networks.
- RIP (Routing Information Protocol) is one of the oldest distance-vector routing protocols used in computer networks.
- OSPF (Open Shortest Path First) is a dynamic routing protocol used in Internet Protocol (IP) networks.
- EIGRP (Enhanced Interior Gateway Routing Protocol) is a dynamic routing protocol used in IP networks, developed by Cisco Systems.
- BGP (Border Gateway Protocol) is a standardized exterior gateway protocol used to exchange routing information between Autonomous Systems (ASes) on the internet.

Check Your Understanding

1. Which component of a router stores routing information?
   (a) CPU (b) Flash
   (c) Routing Table (d) NVRAM

2. Which type of routing requires manual configuration of paths?
   (a) Dynamic Routing (b) Static Routing
   (c) Default Routing (d) Border Routing
3. Which of the following is a Distance Vector routing protocol?
   (a) OSPF (b) EIGRP
   (c) RIP (d) BGP
4. Which protocol uses link-state routing?
   (a) RIP (b) OSPF
   (c) BGP (d) RIPv2
5. Which protocol is used for inter-domain routing?
   (a) RIP (b) OSPF
   (c) EIGRP (d) BGP
6. What is the administrative distance of a directly connected route?
   (a) 1 (b) 0
   (c) 110 (d) 120
7. What metric does RIP use to determine the best path?
   (a) Bandwidth (b) Hop Count
   (c) Delay (d) Cost
8. Which of the following protocols supports VLSM (Variable Length Subnet Masking)?
   (a) RIP v1 (b) RIP v2
   (c) Static Routing only (d) None
9. Which of the following routing protocols is proprietary to Cisco?
   (a) OSPF (b) RIP
   (c) EIGRP (d) BGP
10. What type of routing is OSPF categorized under?
    (a) Distance Vector (b) Static
    (c) Link-State (d) Path Vector

Answers

1. (c)	2. (b)	3. (c)	4. (b)	5. (b)	6. (b)	7. (b)	8. (b)	9. (c)	10. (c)

Practice Questions

Q.I Answer the following questions in short:

1. What is the main function of a router?
2. Define a routing table.
3. What is static routing?

4. Name one advantage of static routing.
5. What is dynamic routing?
6. Name two dynamic routing protocols.
7. Differentiate between intra-domain and inter-domain routing.
8. Which protocol is used for inter-domain routing?
9. What metric does RIP use?
10. How often does RIP send updates?
11. What is the primary benefit of OSPF over RIP?
12. Name one key feature of EIGRP.

Q.II Answer the following questions in detail:

1. Explain the internal structure of a router and its main components.
2. Describe the role and structure of a routing table in a router.
3. Compare and contrast static and dynamic routing.
4. Explain the classifications of routing: intra-domain vs. inter-domain.
5. Describe how distance vector routing works and its limitations.
6. Detail the operation of RIP and its major features.
7. Explain the differences between RIP v1 and RIP v2.
8. Describe the OSPF routing protocol and its advantages over RIP.
9. Compare OSPF and EIGRP in terms of metrics, speed, and scalability.
10. Explain how EIGRP works and its main components (DUAL, metrics, etc.).
11. Describe the BGP protocol and its role in inter-domain routing on the internet.
12. Discuss the pros and cons of using static routing in a large enterprise network.
13. Explain OSPF protocol with its key features and configuration.
14. Explain RIP protocol with its key features and configuration.
15. Explain BGP protocol with its key features and configuration.
16. Explain EIGRP protocol with its key features and configuration
17. Explain RIP with its key features and configuration.