1. What is Computer Network?

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- A computer network is a system of interconnected devices (like computers, servers, routers, and switches) that communicate wi th each other to share data, resources, and services.
- Networks range from small, local networks (like a home Wi-Fi network) to vast, global networks (like the internet).
- These connections can be wired (using cables like Ethernet) or wireless (using radio waves or infrared signals).
- Here are the main types of networks:
  - **Local Area Network (LAN)**: A small, localized network, such as within a home, office, or school.
  - **Wide Area Network (WAN)**: Covers a large geographic area, such as connecting multiple offices in different cities.
  - **Metropolitan Area Network (MAN)**: Spans a city or large campus, typically larger than a LAN but smaller than a WAN.
  - **Personal Area Network (PAN)**: A small network for personal devices, like connecting a phone to a laptop via Bluetooth.
  - **Virtual Private Network (VPN)**: Provides a secure connection over the internet, often used to access a private network remotely.

  Networks use various protocols, like TCP/IP, to define rules for communication. A network's key components include routers, switches, hubs, and access points—all of which help manage data flow across devices.

Classification of interconnected processors by scale

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

Network Types:

- **LAN (Local Area Network):** Limited to a small area (e.g., office, home).
- **WAN (Wide Area Network):** Covers larger areas (e.g., cities, countries). The internet is the largest WAN.
- **PAN (Personal Area Network):** Small network for personal devices.
- **MAN (Metropolitan Area Network):** Spans a city or campus.
- **WLAN (Wireless LAN):** Wireless version of a LAN (e.g., Wi-Fi).

Internet vs. Intranet vs. Extranet:

- **Internet:** Public, global network.
- **Intranet:** Private network within an organization.
- **Extranet:** Extended intranet allowing access to specific external users.

Network Devices

- **Router:** Connects different networks and directs data packets.
- **Switch:** Connects devices within a single network, forwarding data based on MAC addresses.
- **Hub:** Basic device that connects multiple devices in a network (all data is sent to every connected device).
- **Access Point (AP):** Provides wireless connectivity to devices.
- **Firewall:** Secures a network by controlling incoming and outgoing traffic based on security rules.

Network Topologies

- **Bus:** All devices connected to a single cable; easy to set up but can slow down with traffic.
- **Star:** Devices connect to a central hub or switch, common in LANs; easy to manage.
- **Ring:** Devices are connected in a circular layout; if one link fails, the whole network can be affected.
- **Mesh:** Every device connects to every other device; provides high reliability but is expensive.
- **Hybrid:** A combination of multiple topologies.

OSI and TCP/IP Models

- **OSI Model:** Conceptual model with 7 layers (Physical, Data Link, Network, Transport, Session, Presentation, Application) that standardizes networking functions.
- **TCP/IP Model:** Practical model with 4 layers (Link, Internet, Transport, Application) that defines protocols used in the internet.
- **Importance of Layers:** Layers break down complex networking tasks, making troubleshooting easier and allowing interoperability between devices from different vendors.

IP Addressing

- **IP Address:** Unique identifier for each device on a network, either IPv4 (32-bit) or IPv6 (128-bit).
- **Public vs. Private IP Addresses:**
  - **Public:** Globally unique, routable over the internet.
  - **Private:** Used within a local network and not routable over the internet.
- **Subnetting:** Dividing a network into smaller sub-networks, enabling better traffic management and security.
- **Subnet Mask:** Defines the network and host portions of an IP address.

MAC Address

- **MAC (Media Access Control) Address:** Unique physical address for each network interface card (NIC); essential in data link layer functions for device identification on local networks.

Data Transmission and Switching

- **Packet Switching:** Data is broken into packets for transmission; packets can take different paths and are reassembled at the destination.
- **Circuit Switching:** Dedicated communication path is established between devices (used in traditional telephony).
- **Switching Types in LANs:** Includes Unicast (one-to-one), Multicast (one-to-many), and Broadcast (one-to-all).

Protocols and Port Numbers

- **Protocols:** Set rules for data exchange.
  - **HTTP/HTTPS:** Web browsing (ports 80/443).
  - **FTP (File Transfer Protocol):** File transfers (ports 20/21).
  - **SMTP (Simple Mail Transfer Protocol):** Email (port 25).
  - **DNS (Domain Name System):** Resolves domain names to IP addresses (port 53).
  - **DHCP (Dynamic Host Configuration Protocol):** Assigns IP addresses dynamically.
- **TCP vs. UDP:**
  - **TCP (Transmission Control Protocol):** Connection-oriented, reliable.
  - **UDP (User Datagram Protocol):** Connectionless, faster but less reliable.

2. Networking Terminologies

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1. IP Address
An Internet Protocol (IP) address is a unique numerical identifier assigned to devices on a network. It can be IPv4 (e.g., 192.168.1.1) or IPv6 (e.g., 2001:0db8::ff00:0042:8329).

2. Subnet
A subdivision of an IP network that allows logical segmentation of a network into smaller parts for efficient management. Each subnet has its own subnet mask.

3. Default Gateway
The device (usually a router) that connects a local network to external networks or the internet.

4. MAC Address
A Media Access Control (MAC) address is a unique hardware identifier for network devices, typically used at the Data Link Layer (Layer 2) of the OSI model.

5. DHCP (Dynamic Host Configuration Protocol)
A protocol used to automatically assign IP addresses and other network settings to devices in a network.

6. DNS (Domain Name System)
A system that translates human-readable domain names (e.g., www.google.com) into IP addresses (e.g., 172.217.16.196).

7. VLAN (Virtual Local Area Network)
A logical grouping of devices in a network, allowing devices to act as if they are on the same LAN, even if physically separated.

8. Routing
The process of selecting a path for traffic to travel across a network, typically performed by routers.

9. NAT (Network Address Translation)
A method used to remap private IP addresses to public IP addresses, allowing multiple devices in a local network to share a single public IP.

10. OSI Model
A conceptual framework that describes networking systems in seven layers:

- Layer 1: Physical
- Layer 2: Data Link
- Layer 3: Network
- Layer 4: Transport
- Layer 5: Session
- Layer 6: Presentation
- Layer 7: Application

11. Protocol

A set of rules and conventions for communication between network devices (e.g., TCP, UDP, HTTP, FTP).

12. Switch
A networking device that operates at Layer 2 (Data Link) of the OSI model, used to connect devices within a LAN and forward traffic based on MAC addresses.

13. Router
A device that operates at Layer 3 (Network) of the OSI model, used to connect multiple networks and forward packets based on IP addresses.

14. Firewall
A security device or software that monitors and controls incoming and outgoing network traffic based on predefined security rules.

15. Bandwidth
The maximum amount of data that can be transmitted over a network in a given amount of time, typically measured in bits per second (bps).

16. Latency
The time it takes for a data packet to travel from the source to the destination across a network.

17. QoS (Quality of Service)
A set of technologies used to manage and prioritize network traffic to ensure critical applications receive sufficient bandwidth and low latency.

18. Access Control List (ACL)
A set of rules used to control incoming and outgoing traffic in a network based on IP addresses, protocols, or ports.

19. TCP/IP (Transmission Control Protocol/Internet Protocol)
The suite of communication protocols used to interconnect network devices on the internet.

20. ARP (Address Resolution Protocol)
A protocol used to map an IP address to a MAC address within a local network.

21. IPv4 and IPv6
IPv4: 32-bit address format (e.g., 192.168.1.1) with ~4.3 billion possible addresses.
IPv6: 128-bit address format (e.g., 2001:0db8:85a3::8a2e:0370:7334) designed to address IPv4 exhaustion.

22. CIDR (Classless Inter-Domain Routing)
A method of IP addressing that allows more flexible allocation of IP addresses than traditional classful networks, using a suffix to define the subnet (e.g., 192.168.1.0/24).

23. Broadcast Address
An address used to send data to all devices on a network. For example, in a subnet 192.168.1.0/24, the broadcast address is 192.168.1.255.

24. Unicast, Multicast, Broadcast, Anycast
Unicast: One-to-one communication (e.g., device A to device B).

Multicast: One-to-many communication within a group.
Broadcast: One-to-all communication on a local network.
Anycast: One-to-one communication with the nearest device in a group.

25. MTU (Maximum Transmission Unit)
The largest size of a data packet that can be sent over a network without fragmentation.

26. Ethernet
A family of wired networking technologies used in LANs. Ethernet standards are defined by IEEE 802.3.

27. PoE (Power over Ethernet)
A technology that allows Ethernet cables to carry electrical power, enabling devices like IP cameras and phones to receive power and data through a single cable.

28. Ping
A network utility tool used to test connectivity between devices and measure round-trip time for packets.

29. Traceroute
A diagnostic tool that maps the path packets take to reach their destination, showing intermediate routers.

30. BGP (Border Gateway Protocol)
A routing protocol used to exchange routing information between autonomous systems (AS) on the internet.

31. OSPF (Open Shortest Path First)
A link-state routing protocol that calculates the shortest path using Dijkstra's algorithm. Commonly used in enterprise networks.

32. EIGRP (Enhanced Interior Gateway Routing Protocol)
A Cisco-proprietary hybrid routing protocol that uses both distance-vector and link-state methods.

33. MPLS (Multiprotocol Label Switching)
A technique for high-performance traffic routing that uses labels instead of IP addresses to direct packets.

34. WAN (Wide Area Network)
A network that spans large geographical areas, such as the internet or private corporate networks connecting multiple locations.

35. LAN (Local Area Network)
A network confined to a small geographic area, like an office or home.

36. VPN (Virtual Private Network)
A secure method of accessing private networks remotely by encrypting the connection.

37. Packet
A unit of data formatted for transmission across a network, consisting of headers (source/destination) and payload.

38. Frame
A Layer 2 unit of data encapsulation that includes the MAC addresses of the source and destination.

39. Segmentation
The process of dividing data into smaller units (packets/frames) to optimize transmission and improve error handling.

40. SNMP (Simple Network Management Protocol)
A protocol used to monitor and manage network devices.

41. ICMP (Internet Control Message Protocol)
A protocol used for diagnostic and error-reporting messages (e.g., used by ping and traceroute).

42. NAT Overload (PAT)
A variation of NAT that maps multiple private IP addresses to a single public IP address using port numbers (also called Port Address Translation).

43. STP (Spanning Tree Protocol)
A Layer 2 protocol that prevents loops in Ethernet networks by creating a loop-free logical topology.

44. HSRP (Hot Standby Router Protocol)
A Cisco-proprietary protocol that provides high network availability by creating a virtual IP for failover between routers.

45. Proxy Server
An intermediary server that forwards requests between clients and other servers to provide anonymity, caching, or content filtering.

46. Load Balancer
A device or software that distributes incoming network traffic across multiple servers to ensure high availability and performance.

47. Port Number
A logical identifier for specific applications or services (e.g., HTTP: port 80, HTTPS: port 443).

48. VLAN Trunking Protocol (VTP)
A Cisco-proprietary protocol that manages VLAN configurations across multiple switches in a network.

49. DMZ (Demilitarized Zone)
A subnetwork that separates external traffic from an organization's internal network, often used to host public-facing services.

50. Tunneling
The process of encapsulating one protocol within another to secure or facilitate communication over incompatible networks.

3. OSI Model

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OSI

- Open System Interconnection.
- OSI is a conceptual framework that standardizes the functions of a communication system into 7 layers.
- It helps in designing, troubleshooting and understanding networks.

TCP/IP	OSI Layer	Functions	PDUs	Protocols	Devices
Application Layer	Application	Closest to the user; provides network services to applications. Interfaces with software for file transfers, email, and remote login.	Data	HTTP, HTTPS, FTP, SMTP, IMAP, DNS, SNMP	Application firewall, VPN, SSL, Proxies
	Presentation	Encryption, Compress, Conversion, data formatting		SSL/TLS (encryption), JPEG, GIF, ASCII, XML, MPEG.	
	Session	Establishes, manages, and terminates sessions between devices. Handles authentication and re-establishes broken connections.		RPC, TLS. SMB, NFS, SQL	
Transport	Transport	Ensures end-to-end communication, error recovery, and data segmentation. Provides flow control and reliability.	Segment	TCP, UDP	Load balancer, Network firewall
Network	Network	Responsible for logical addressing (IP addresses). Handles routing and forwarding of packets across networks. Ensures data delivery across different networks.	Packet	IPv4, IPv6, ICMP (Ping), RIP, OSPF, EIGRP, BGP	Routers, L3 Switches
Physical	Data Link	Error free data transfer handles physical addressing (MAC Addresses). Managing data framing and flow control.	Frame	Ethernet, Wi-Fi (IEEE 802.11), PPP (Point-to-Point Protocol), ARP, STP	Switches, bridges, NICs
	Physical	Defines hardware specifications, electrical signals, media types, and data rates. Responsible for the transmission of raw bits over a physical medium.	Bits	Ethernet (physical aspects), USB, Bluetooth, IEEE 802.3 (physical signalling).	RJ45, hubs, repeaters, cables (Ethernet, fibre optics, coaxial)

In short,

Layer	Function	Protocols/Technologies	Devices/Applications
7. Application	User interaction, network services	HTTP, HTTPS, FTP, SMTP, DNS	Browsers, Email, Apps
6. Presentation	Data formatting, encryption, compression	SSL/TLS, JPEG, ASCII, XML	Encryption tools, codecs
5. Session	Session management, synchronization	SMB, NFS, SQL	Video conferencing apps
4. Transport	End-to-end communication, error recovery	TCP, UDP	Firewalls (Layer 4)
3. Network	Logical addressing, routing	IPv4, IPv6, ICMP, OSPF, BGP	Routers, Layer 3 switches
2. Data Link	MAC addressing, error detection	Ethernet, ARP, PPP, STP	Switches, NICs
1. Physical	Bit transmission, physical connections	Ethernet (cabling), IEEE 802.3	Hubs, cables, repeaters

1. Physical Layer (Layer 1)

- Function:
  - Deals with the physical transmission of raw binary data (bits) over media.
  - Specifies hardware elements like cables, switches, and NICs.
  - Handles the physical transmission of raw binary data (bits) over media like cables, fiber optics, or wireless signals.

    - Defines hardware specifications, voltages, signal timings, data rates, and physical connections.
- Key Processes:
    - Bit synchronization.
    - Physical topology setup (star, mesh, etc.).
    - Signal modulation and demodulation.
- Real-World Applications:
    - Ethernet cables: Transmitting bits as electrical signals over Cat5e or Cat6 cables.
    - Fiber optics: Transmitting light signals for high-speed communication.
    - Wi-Fi radios: Transmitting electromagnetic waves for wireless communication.
- Examples:
    - Cabling: Ethernet (Cat5e, Cat6), fiber optic cables.
    - Example: Transmitting bits as electrical signals via Cat6 cable.
    - Wireless: Wi-Fi (802.11 standards), Bluetooth.
    - Example: A smartphone communicating with a router via wireless signals.
    - Media Converters: Convert Ethernet to fiber and back.
- Devices:
    - Network Interface Cards (NICs).
    - Hubs.
    - Media converters.
    - Wi-Fi radios.

2. Data Link Layer (Layer 2)

- Function:
    - Provides reliable data transfer by creating and managing frames.
    - Uses MAC addresses for local device identification.
    - Detects and sometimes corrects errors in transmitted frames.
    - Provides error detection/correction, framing, and MAC addressing.
    - Ensures that data is transmitted without errors within a local network.
    - Operates in two sublayers:
        - LLC (Logical Link Control): Error handling, flow control.
        - MAC (Media Access Control): Manages access to shared media.
- Key Processes:
    - Error detection using CRC (Cyclic Redundancy Check).
    - MAC address-based frame forwarding.
    - VLAN management.
- Real-World Applications:
    - Switches: Forward frames between devices using MAC addresses.
    - Wi-Fi protocols: Manage communication between access points and devices.
    - VLANs: Used for network segmentation in switches.
- Example:
    - Switching: A switch forwards data frames to the correct device using its MAC address.
        - Example: Device A sends a file to Device B in the same LAN. The switch uses its MAC address table to deliver the frame directly to Device B.
    - ARP (Address Resolution Protocol): Resolves IP addresses to MAC addresses.
        - Example: A computer uses ARP to find the MAC address of the default gateway.
- Devices:
    - Switches.
    - Wireless Access Points (APs).
- Protocols:
    - Ethernet (802.3).
    - Wi-Fi (802.11).
    - ARP

3. Network Layer (Layer 3)

- Function:
    - Handles logical addressing (IP addresses), routing, and packet forwarding across networks.
    - Ensures data travels efficiently from source to destination, even across multiple networks.
- Key Processes:
    - Path determination using routing protocols (OSPF, BGP).
    - Logical addressing with IPv4/IPv6.
    - Packet fragmentation and reassembly.
- Examples in Action:
    - Routing: A router determines the best path for a packet using its routing table.
    - Example: Sending an email from your home PC to a server in another country involves several routers deciding the best path for the data packets.
    - IP Addressing: Each device gets a unique IP address.
    - Example: A router assigns IP addresses to devices using DHCP.
- Devices:
    - Routers.
    - Layer 3 Switches.

- Protocols:
    - IPv4, IPv6.
    - OSPF, EIGRP, BGP.
    - ICMP (Ping, Traceroute).

4. Transport Layer (Layer 4)

- Function:
    - Ensures reliable delivery of data across networks.
    - Splits data into segments and reassembles them at the destination.
    - Provides flow control and error recovery.
- Key Processes:
    - Segmentation of data into manageable chunks.
    - Connection-oriented communication (TCP) or connectionless communication (UDP).
    - Acknowledgment and retransmission (TCP).
- Real-World Applications:
    - TCP: Used for web browsing (HTTP/HTTPS), email (SMTP), and file transfers (FTP).
    - UDP: Used for live video streaming, VoIP, and gaming.
- Examples in Action:
    - TCP (Transmission Control Protocol):
        - Example: When downloading a file, TCP ensures the file is received in the correct order with no data loss.
    - UDP (User Datagram Protocol):
        - Example: During a Zoom video call, UDP delivers audio and video packets without delays caused by retransmissions.
- Devices:
    - Firewalls (for filtering Layer 4 traffic).
- Protocols:
    - TCP (web browsing, email).
    - UDP (streaming, gaming).

5. Session Layer (Layer 5)

- Function:
    - Establishes, maintains, and terminates communication sessions.
    - Manages sessions between applications.
- Key Processes:
    - Session establishment and termination.
    - Synchronization of session activities.
    - Session recovery in case of interruptions.
- Real-World Applications:
    - Web conferencing: Maintains sessions for tools like Zoom and Microsoft Teams.
    - File sharing: SMB or NFS protocols ensure a session is active for file transfers.
    - Authentication: Keeps track of login sessions for apps like Gmail.
- Example:
    - Web conferencing: Ensures an active session during a Zoom call.
    - Login sessions: Maintains a user session when logged into an email account like Gmail.
- Protocols:
    - SMB (file sharing).
    - SQL (database access).

6. Presentation Layer (Layer 6)

- Function:
    - Formats data to be readable by the application layer.
    - Handles encryption, decryption, and data compression.
- Key Processes:
    - Data format conversion (e.g., from EBCDIC to ASCII).
    - Data compression to save bandwidth.
    - Data encryption for security.
- Real-World Applications:
    - SSL/TLS: Encrypts data for secure web communication (HTTPS).
    - File formats: Translates data formats (JPEG for images, MP4 for videos).
    - Character encoding: Converts text formats (ASCII, Unicode).
- Examples in Action:
    - Encryption: HTTPS encrypts your data using SSL/TLS during online banking.
    - Compression: Streaming services like Netflix compress video data before transmission to optimize bandwidth usage.
- Protocols:
    - SSL/TLS (secure web traffic).
    - JPEG, MP4 (multimedia).

7. Application Layer (Layer 7)

- Function:
    - Interfaces directly with end-users and provides network services.

    - Enables data exchange between applications.
    - Interfaces with software to initiate data communication.
- Key Processes:
    - DNS resolution of domain names to IP addresses.
    - File transfers, email services, and web browsing.
    - HTTP/HTTPS communication between browsers and web servers.
- Real-World Applications:
    - Web browsers: Use HTTP/HTTPS for accessing websites.
    - Email clients: Use SMTP, POP3, or IMAP for email communication.
    - DNS: Resolves domain names into IP addresses.
    - File transfers: Use FTP or SFTP for uploading and downloading files.
- Examples in Action:
    - Web Browsing: When you access www.google.com, your browser uses HTTP/HTTPS to request the web page.
    - Email: SMTP is used to send emails, while POP3 or IMAP retrieves them.
- Protocols:
    - HTTP/HTTPS.
    - DNS, FTP, SMTP, IMAP, SNMP

Layer	Function	Real-World Example
1. Physical	Transmission of bits as signals	Ethernet cables, Wi-Fi signals
2. Data Link	Reliable frame delivery	Switch forwarding data within a VLAN
3. Network	Routing packets across networks	Router sending packets between LAN and internet
4. Transport	Reliable data delivery, segmentation	Streaming YouTube videos (UDP), downloading files (TCP)
5. Session	Session management	Maintaining a Zoom call or active web login
6. Presentation	Data formatting, encryption, compression	SSL/TLS for secure web browsing, JPEG image compression
7. Application	User interaction with network services	Browsing a website, sending an email

4. Networking devices

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Hub

- Purpose:
  - A basic device that connects multiple devices in a network and forwards data to all connected devices.
  - Operates at the Physical Layer (Layer 1).
- Working:
  - Does not filter data or maintain a MAC address table.
  - Sends data to all ports, resulting in higher collision rates.
- Usage:
  - Rarely used in modern networks due to inefficiency.
  - Early network setups (now replaced by switches).
- Common Models:
  - Netgear: DS108.
  - TP-Link: TL-SF1008D (unmanaged).

Switch

- Purpose:
  - Connects devices within a LAN and forwards traffic based on MAC addresses.
  - Operates at the Data Link Layer (Layer 2) and sometimes at Layer 3 for advanced switches.
- Working:
  - Maintains a MAC address table to direct frames to the correct port.
  - Prevents broadcast storms using Spanning Tree Protocol (STP).
  - Supports VLANs for network segmentation.
- Architecture:
  - Backplane: High-speed circuitry for data switching.
  - Ports: Gigabit Ethernet, 10G Ethernet, or fiber ports.
  - Power Supply: Supports PoE (Power over Ethernet) for powering devices like IP cameras.
- Usage:
  - Connecting computers, printers, and servers in LANs.
  - Creating isolated virtual networks (VLANs).
  - Aggregating access switches in larger networks.
- Common Models:
  - Cisco: Catalyst 9200, Catalyst 9300, Nexus 9000 series.
  - Arista: 7050X, 7500R series.
  - HPE Aruba: 2930M, 5400R series.
  - Juniper: EX series (e.g., EX3400, EX4300).

Router

- Purpose:
  - Connects multiple networks and routes data packets based on their IP addresses.
  - Operates at the Network Layer (Layer 3) of the OSI model.
  - Enables communication between devices on different subnets.
- Working:
  - Uses a routing table to determine the best path for data.
  - Employs routing protocols like OSPF, EIGRP, BGP to dynamically update routes.

    - Performs NAT (Network Address Translation) for IP address management.
- Architecture:
    - Control Plane: Handles routing decisions (via routing protocols).
    - Data Plane: Forwards packets based on routing decisions.
    - Interfaces: Ethernet, serial, or fiber connections.
- Usage:
    - Internet connectivity for enterprises.
    - Routing traffic between branch offices and data centers.
    - Segmenting large networks into subnets.
- Common Models:
    - Cisco: ISR 1100, ISR 4000, ASR 1000 series.
    - Juniper: MX Series (e.g., MX480, MX960).
    - MikroTik: CCR (Cloud Core Routers).
    - HPE/Aruba: MSR Series

Firewall

- Purpose:
    - Monitors and controls incoming and outgoing network traffic based on security rules.
    - Operates at Layer 4 (Transport) and can also inspect higher layers (Layer 7).
- Working:
    - Packet filtering (stateless or stateful).
    - Deep Packet Inspection (DPI) for Layer 7 security.
    - Works as a physical appliance or software-based firewall.
- Usage:
    - Enforcing security policies in enterprise environments.
    - Protecting sensitive data in DMZs (Demilitarized Zones).
    - Blocking malicious traffic.
- Common Models:
    - Cisco: ASA 5500-X, Firepower series.
    - Fortinet: FortiGate series.
    - Palo Alto: PA-220, PA-3200 series.
    - Sophos: XGS series.

Access Point (AP)

- Purpose:
    - Extends a wired network by creating a wireless connection.
    - Operates at the Data Link Layer (Layer 2).
- Working:
    - Bridges the wired and wireless segments of the network.
    - Supports wireless standards like 802.11 a/b/g/n/ac/ax (Wi-Fi 6).
- Usage:
    - Expanding wireless coverage in offices and homes.
    - Enabling mobility for wireless clients like laptops and phones.
- Common Models:
    - Cisco: Aironet series, Catalyst 9100 series.
    - Ubiquiti: UniFi APs.
    - HPE Aruba: Instant On APs, 500 Series.

Modem

- Purpose:

    - Converts digital data to analog signals and vice versa for internet access.
    - Connects a LAN to the internet via DSL, cable, or fiber.
- Working:
    - Uses modulation/demodulation to transmit data over telephone or cable lines.
- Usage:
    - Home broadband internet connections.
    - Connecting ISPs to customer premises.
- Common Models:
    - Netgear: CM500, CM1000 (cable modems).
    - TP-Link: Archer series.

Load Balancer

- Purpose:
    - Distributes traffic among multiple servers to ensure high availability and performance.
    - Operates at Layer 4 (Transport) or Layer 7 (Application).
- Working:
    - Uses algorithms like round-robin, least connections, and weighted distribution.
    - Handles SSL termination and session persistence.
- Usage:
    - Web applications with high traffic.
    - Ensuring redundancy for server farms.
- Common Models:
    - F5 Networks: BIG-IP series.
    - Citrix: ADC (formerly NetScaler).
    - AWS: Elastic Load Balancer (ELB).

Gateway

- Purpose:
    - Acts as a bridge between two networks using different protocols.
    - Converts data formats for compatibility.
- Usage:
    - IoT environments (protocol translation).
    - Connecting enterprise networks to cloud services.
- Common Models:
    - Cisco: Meraki MX series.
    - Fortinet: Secure SD-WAN gateways.

Network Interface Card (NIC)

- Purpose:
    - Provides a hardware interface between a device and a network.
    - Operates at Layer 2 (Data Link) and Layer 1 (Physical).
- Working:
    - Assigns a unique MAC address to the device.
    - Handles data framing and error checking.
- Usage:
    - Ethernet or Wi-Fi connectivity in computers, servers, and IoT devices.
- Common Models:
    - Intel: Ethernet Server Adapter X710 series.
    - TP-Link: TG-3468 (for desktops).

Proxy Server

- Purpose:
  - Acts as an intermediary for requests between clients and servers.
  - Provides content filtering, caching, and anonymity.
- Usage:
  - Enterprise internet security.
  - Accelerating web requests via caching.
- Common Software:
  - Squid,
  - HAProxy,
  - NGINX (reverse proxy).

Real-World Workflow Example: - When you visit www.google.com:

- **Physical Layer**: Electrical signals travel through Ethernet cable or Wi-Fi signals to your router.
- **Data Link Layer**: Your computer's NIC encapsulates data in frames and forwards it to the local switch.
- **Network Layer**: Your router assigns your packet a source IP and forwards it to Google's IP address.
- **Transport Layer**: TCP ensures the request packet reaches Google's server reliably.
- **Session Layer**: Maintains an active session for the browser and server communication.
- **Presentation Layer**: SSL/TLS encrypts your data for secure transmission (HTTPS).
- **Application Layer**: Your browser sends an HTTP GET request to fetch the Google homepage.

5. IP Address

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What is an IP Address?

- An IP address (Internet Protocol address) is a unique identifier assigned to a device on a network to enable communication.
- It serves two key purposes:
  - Identification: Identifies the device on the network.
  - Location Addressing: Helps route data to and from the device.
- IP addresses exist in two main versions: IPv4 and IPv6.

IPv4 (Internet Protocol Version 4)

Basics:

- 32-bit address represented in decimal as four octets (e.g., 192.168.1.1).
- Provides approximately 4.3 billion unique addresses (2^{32}).
- Widely used but facing exhaustion due to the growing number of connected devices.

IPv4 Structure:

Each IPv4 address consists of:

- Network ID: Identifies the network to which the device belongs.
- Host ID: Identifies the specific device (host) within that network.

Example: In 192.168.1.1:

- Network ID: 192.168.1
- Host ID: 1

IPv4 Address Classes:

To manage address allocation, IPv4 is divided into **classes**:

Class	Address Range	Default Subnet Mask	Usage
A	0.0.0.0 - 127.255.255.255	255.0.0.0	Large networks
B	128.0.0.0 - 191.255.255.255	255.255.0.0	Medium-sized networks
C	192.0.0.0 - 223.255.255.255	255.255.255.0	Small networks
D	224.0.0.0 - 239.255.255.255	N/A	Multicasting
E	240.0.0.0 - 255.255.255.255	N/A	Reserved for future use

IPv4 Private IP Ranges:

Private IPs are used within local networks and are **not routable** on the internet.

Class	Private Range	Example
A	10.0.0.0 - 10.255.255.255	10.0.1.1
B	172.16.0.0 - 172.31.255.255	172.16.5.1
C	192.168.0.0 - 192.168.255.255	192.168.1.1

IPv4 Subnetting:

Subnetting divides a large network into smaller, manageable networks to optimize resource utilization and improve security.

- **CIDR Notation**: IPv4 addresses are often written with a suffix indicating the subnet mask. Example: `192.168.1.1/24` means the first 24 bits are for the network ID.

Subnet Mask	CIDR	Hosts per Subnet
255.0.0.0	/8	~16 million
255.255.0.0	/16	~65,000
255.255.255.0	/24	254

IPv6 (Internet Protocol Version 6)

- Basics:
  - 128-bit address represented in hexadecimal and separated by colons (e.g., 2001:0db8:85a3:0000:0000:8a2e:0370:7334).
  - Provides 3.4 x 10^{38} unique addresses, solving the IPv4 exhaustion problem.
- IPv6 Structure:
  - Global Routing Prefix: Identifies the network portion.
  - Subnet ID: Defines subnets within the network.
  - Interface ID: Uniquely identifies a device within the subnet.
- Example: 2001:0db8:85a3:0000:0000:8a2e:0370:7334
  - Global Routing Prefix: 2001:0db8:85a3
  - Subnet ID: 0000:0000
  - Interface ID: 8a2e:0370:7334
- IPv6 Features:
  - Larger Address Space: Can assign unique addresses to billions of devices.
  - Simplified Header: Improves routing efficiency.
  - No Broadcasts: Replaced with multicast and anycast.
  - Built-in Security: Native support for IPsec encryption.
  - Stateless Address Autoconfiguration (SLAAC): Devices can generate their own IPv6 addresses without DHCP.
- IPv6 Address Types:
  - Unicast: One-to-one communication (e.g., a device sending data to a specific server).
    - Example: 2001:db8::1.
  - Multicast: One-to-many communication (e.g., streaming live video to multiple viewers).
    - Example: ff02::1 (all nodes in a network).
  - Anycast: One-to-nearest communication (e.g., a request to the nearest DNS server).
- IPv6 Compression:
- To simplify notation, IPv6 supports:
  - **Omitting leading zeros**: 2001:0db8:0000:0000:8a2e:0370:7334 → 2001:db8:0:0:8a2e:370:7334.
  - **Double colons (::)**: For consecutive zeros.
    Example: 2001:0db8:0000:0000:0000:0000:0000:0001 → 2001:db8::1.

Comparison of IPv4 and IPv6

Feature	IPv4	IPv6
Address Size	32-bit	128-bit
Address Format	Decimal (e.g., 192.168.1.1)	Hexadecimal (e.g., 2001:db8::1)
Address Space	~4.3 billion addresses	340 undecillion (~10^{38}) addresses
Header	Complex, variable size	Simplified, fixed size
Broadcast	Yes	No (uses multicast)
Security	Optional (IPsec)	Mandatory (IPsec)
Configuration	Manual/DHCP	SLAAC or DHCPv6

6. Subnetting

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- Subnetting is the process of dividing a larger network (IP range) into smaller, more manageable segments called subnets.
- This improves efficiency, security, and performance by reducing congestion and isolating traffic.

Why Subnetting?

- **Efficient IP Utilization**: Prevents wastage of IP addresses by assigning only the required range to each subnet.
- **Improved Network Performance**: Reduces broadcast traffic, as broadcasts are limited to individual subnets.
- **Enhanced Security**: Segments networks for better traffic control and isolation.
- **Simplified Management**: Makes large networks easier to troubleshoot and manage.

How Subnetting Works

- A subnet is created by borrowing bits from the host portion of an IP address to create additional network IDs.
- Key Components in Subnetting:
    - *Subnet Mask*: Defines how the IP address is split between the network and host portions.
        - Example: 255.255.255.0 (or /24) means the first 24 bits are for the network, and the remaining 8 bits are for hosts.
    - *Network ID:* Identifies the subnet.
    - *Host Range*: Identifies devices within the subnet.
    - *Broadcast Address*: Used to send data to all devices within the subnet.

7. Basics of Switching

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Definition

- A switch is a network device that operates at the data link layer (Layer 2) of the OSI model. It is used to connect multiple devices within the same network, allowing them to communicate efficiently.

Functionality

- Frame Forwarding: Switches receive data frames and forward them to the appropriate destination devices based on MAC (Media Access Control) addresses.
- MAC Address Table: Switches maintain a MAC address table (or CAM table) that maps MAC addresses to physical ports. This table is used to determine where to forward incoming frames.
- Collision Domains: Each port on a switch represents a separate collision domain, reducing collisions and improving overall network performance compared to hubs.

Types of Switches

- Unmanaged Switches: Simple, plug-and-play devices with no configuration options. They are suitable for small networks or home use.
- Managed Switches: These switches offer advanced features like VLANs, QoS (Quality of Service), SNMP (Simple Network Management Protocol), and more. They are suitable for larger and more complex networks.
- Layer 3 Switches: These switches can perform both Layer 2 switching and Layer 3 routing functions. They are used in enterprise networks to enable inter-VLAN routing and advanced routing protocols.

Switching Methods

- Store-and-Forward: The switch receives the entire frame, checks it for errors, and then forwards it. This method ensures data integrity but introduces a small delay.
- Cut-Through: The switch starts forwarding the frame as soon as it reads the destination MAC address, resulting in lower latency but potentially forwarding corrupted frames.
- Fragment-Free: A compromise between store-and-forward and cut-through, this method reads the first 64 bytes of the frame (where most errors occur) before forwarding it.

Benefits of Switching

- Improved Performance: Switches reduce collisions and increase bandwidth by creating dedicated communication paths between devices.
- Enhanced Security: Managed switches offer features like VLANs, port security, and access control lists (ACLs) to enhance network security.
- Scalability: Switches can easily be added to expand the network and connect additional devices.

8. Basic Configuration(CLI)

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1. **Setting the MOTD (Message of The Day)**

```
Switch#conf
Switch#configure t
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#?
Configure commands:
  access-list        Add an access list entry
  banner             Define a login banner
  boot               Boot Commands
  cdp                Global CDP configuration subcommands



 Switch(config)#
 Switch(config)#
 Switch(config)#banner
 Switch(config)#banner mo
 Switch(config)#banner motd x
 Enter TEXT message.  End with the character 'x'.
 Welcome to Jeetu's networking basics!!!

 x

 Switch(config)#exit
 Switch#
 %SYS-5-CONFIG_I: Configured from console by console

 Switch#exit
```

Verify:

```
Welcome to Jeetu's networking basics!!!


Switch>
```

2. **Setting password on switch within cisco packet tracer**

```
Switch>enable
Switch#configure ter
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#line con
Switch(config)#line console 0
Switch(config-line)#password pass@word1
Switch(config-line)#login
Switch(config-line)#exit
Switch(config)#exit
Switch#
%SYS-5-CONFIG_I: Configured from console by console
exit
```

Verify:

```
Switch con0 is now available



Press RETURN to get started.


 User Access Verification

 Password:

 Switch>
```

3. **Removing the password from the switch**

```
User Access Verification

Password:

Switch>en
Switch>enable
Switch#conf t
Switch#conf t
Switch#conf terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#line con
Switch(config)#line console 0
Switch(config-line)#no pass
Switch(config-line)#no password
Switch(config-line)#exit
Switch(config)#exit
Switch#
%SYS-5-CONFIG_I: Configured from console by console

Switch#exit
```

Verify: exit and then login again to same switch

4. **Configuring username and password on switch**

```
Switch>en
Switch>enable
Switch#conf
Switch#configure t
Switch#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#line con
Switch(config)#line console 0
Switch(config-line)#log
Switch(config-line)#login
Switch(config-line)#login loca
Switch(config-line)#login ?
  local  Local password checking
  <cr>
Switch(config-line)#login local
Switch(config-line)#exit
Switch(config)#
Switch(config)#usernam
Switch(config)#username jeetu passwo
Switch(config)#username jeetu password pass@word1
Switch(config)#exit
Switch#
%SYS-5-CONFIG_I: Configured from console by console

Switch#
```

Verify:

```
Welcome to Jeetu's networking basics!!!



User Access Verification

Username: jeetu
Password:

Switch>
```

5. **Configuring secret (way to lock the enable mode on switch)**

```
Switch(config)#en
Switch(config)#enabl
Switch(config)#enable ?
  password  Assign the privileged level password
  secret    Assign the privileged level secret
Switch(config)#enable sec
Switch(config)#enable secret ?
  0       Specifies an UNENCRYPTED password will follow
  5       Specifies an ENCRYPTED secret will follow
  LINE    The UNENCRYPTED (cleartext) 'enable' secret
  level   Set exec level password
Switch(config)#enable secret secrettext
Switch(config)#exit
Switch#
%SYS-5-CONFIG_I: Configured from console by console

Switch#exit

Username: jeetu
Password:
```

Type password "pass@word1" to login.

```
Switch>en
Switch>enable conf
Switch>enable
Password:
Switch#
Switch#
```

Type secret "secrettext" to enable admin access.

Viewing the secret value (encrypted)

```
Switch#show ru
Switch#show running-config | inc
Switch#show running-config | include secret
enable secret 5 $1$mERr$P3fI0.mdYeT9UhYzM81TP.
Switch#
Switch#exit
```

6. **Saving the configuration to NVRAM:**

```
Switch#wr
Switch#write
Building configuration...
[OK]
```

7. **Showing the MAC table**

On switch – before pinging 2 machines

```
Switch>en
Switch>enable
Switch#
Switch#sh
Switch#show ma
Switch#show mac-
Switch#show mac-address-table
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----
```

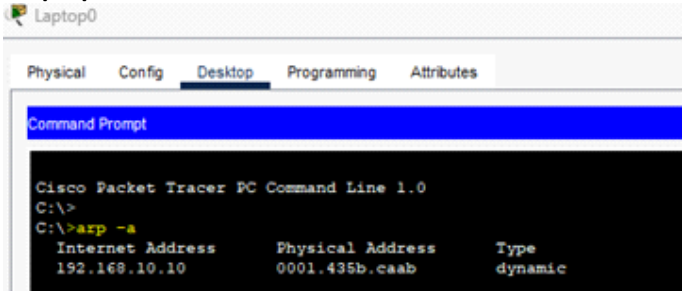
On switch – After pinging

```
Switch#show mac-address-table
          Mac Address Table
-------------------------------------------

Vlan    Mac Address       Type        Ports
----    -----------       --------    -----

   1    0001.435b.caab    DYNAMIC     Fa0/1
   1    00d0.d345.5a18    DYNAMIC     Fa0/2
Switch#
```

On PC/Laptop



9. VLAN

Sunday, January 12, 2025 8:10 PM

- Virtual Local Area Networks
- A VLAN is a logical grouping of devices within a larger physical network.
- Devices within the same VLAN can communicate with each other as if they were on the same physical network, even if they are not.
- VLANs enable the segmentation of a network into smaller, isolated segments, which helps in managing network traffic more efficiently and securely.

Benefits of VLANs:

- **Improved Security:** By segmenting the network, sensitive data can be isolated from the rest of the network, reducing the risk of unauthorized access.
- **Enhanced Performance**: VLANs reduce the size of broadcast domains, decreasing unnecessary traffic and improving overall network performance.
- **Simplified Management:** VLANs make it easier to manage and configure the network by logically grouping devices based on function, department, or application.
- **Flexibility**: VLANs provide the flexibility to move devices and add or remove segments without changing the physical network layout.

Types of VLANs:

- Default VLAN: All ports are initially part of the default VLAN (usually VLAN 1).
- Data VLAN: Used to separate user-generated data traffic. Each VLAN can represent different departments or groups.
- Voice VLAN: Dedicated to voice traffic from IP phones, ensuring prioritization and minimal delay.
- Management VLAN: Used for network device management, keeping management traffic isolated.
- Native VLAN: Used for untagged traffic on a trunk port (default is VLAN 1, but it can be changed).
- Guest VLAN: Provides internet access to visitors without granting access to the internal network.
- Security VLAN: Segregates and protects sensitive data and devices.

VLAN Tagging:

- IEEE 802.1Q: The most common VLAN tagging standard. It inserts a VLAN tag into the Ethernet frame header, allowing devices to understand VLAN membership.

Inter-VLAN Routing:

To allow communication between VLANs, inter-VLAN routing is required. This can be achieved using:

- Router-on-a-Stick: A single router interface configured with sub interfaces for each VLAN.
- Layer 3 Switch: A switch with routing capabilities that can handle inter-VLAN routing more efficiently.

VLAN ranges

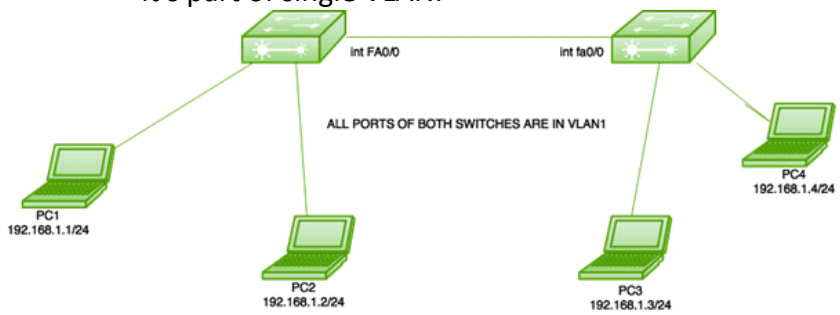
- VLAN 0, 4095: These are reserved VLAN which cannot be seen or used.
- VLAN 1: It is the default VLAN of switches. By default, all switch ports are in VLAN. This

VLAN can't be deleted or edit but can be used.

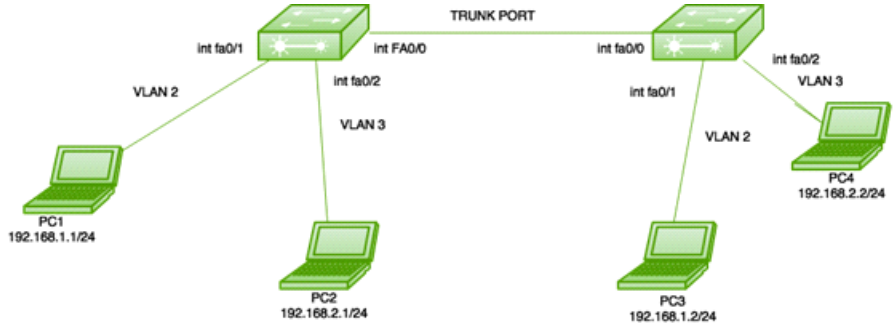
- VLAN 2-1001: This is a normal VLAN range. We can create, edit and delete these VLAN.
- VLAN 1002-1005: These are CISCO defaults for FDDI and token rings. These VLAN can't be deleted.
- VLAN 1006-4094: This is the extended range of VLAN.

Types of connections in VLAN:

- **Access link**
  - It connects PC/Laptops and Switches together.
  - It's part of single VLAN.



- **Trunk Link**
  - It connects 2 or more switches together.
  - It allows 2 VLANs of different switches to communicate to each other.



Listing existing VLAN:

```
SW1#show vlan

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                                Fa0/5, Fa0/6, Fa0/7, Fa0/8
                                                Fa0/9, Fa0/10, Fa0/11, Fa0/12
                                                Fa0/13, Fa0/14, Fa0/15, Fa0/16
                                                Fa0/17, Fa0/18, Fa0/19, Fa0/20
                                                Fa0/21, Fa0/22, Fa0/23, Fa0/24
                                                Gig0/1, Gig0/2
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active
```

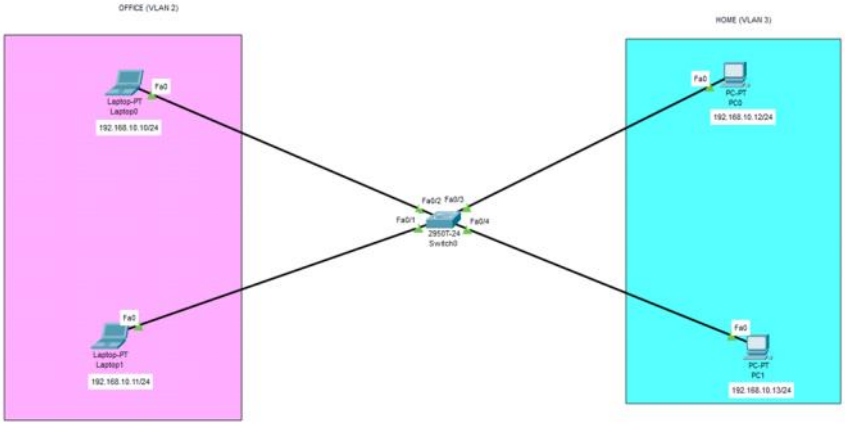
To create VLAN:

```
SW1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
SW1(config)#
SW1(config)#vlan 10
SW1(config-vlan)#vl
SW1(config-vlan)#v
SW1(config-vlan)#v
SW1(config-vlan)#nam
SW1(config-vlan)#name marketing
SW1(config-vlan)#exit
```

Deleting VLAN

```
SW1(config)#
SW1(config)#no vlan 10
```

Home-office VLAN:



Commands to create VLANs:

```
Switch#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#vlan 2
Switch(config-vlan)#name
% Incomplete command.
Switch(config-vlan)#
Switch(config-vlan)#name office
Switch(config-vlan)#exit
Switch(config)#
Switch(config)#vlan 3
Switch(config-vlan)#name home
Switch(config-vlan)#exit
```

Configure VLANs for FA ports:

```
Switch(config)#interface fastethernet 0/1
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 2
Switch(config-if)#exit
Switch(config)#
Switch(config)#interface fastethernet 0/2
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 2
Switch(config-if)#exit
Switch(config)#
Switch(config)#interface fastethernet 0/3
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 3
Switch(config-if)#exit
Switch(config)#
Switch(config)#interface fastethernet 0/4
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 3
Switch(config-if)#exit
Switch(config)#
Switch(config)#exit
Switch#
```

Verify:

```
Switch#show vlan

VLAN Name                              Status
---- --------------------------------- ---------
1    default                           active
2    office                            active
3    home                              active
```

```
C:\>ping 192.168.10.13

Pinging 192.168.10.13 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 192.168.10.13:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

```
Cisco Packet Tracer PC Command Line 1.0
C:\>ping 192.168.10.11

Pinging 192.168.10.11 with 32 bytes of data:

Reply from 192.168.10.11: bytes=32 time<1ms TTL=128
Reply from 192.168.10.11: bytes=32 time<1ms TTL=128
Reply from 192.168.10.11: bytes=32 time<1ms TTL=128
Reply from 192.168.10.11: bytes=32 time<1ms TTL=128

Ping statistics for 192.168.10.11:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	Laptop0	Laptop1	ICMP		0.000	N	0	(edit)	
	Failed	Laptop0	PC1	ICMP		0.000	N	1	(edit)	
	Successful	PC0	PC1	ICMP		0.000	N	2	(edit)	

10. Router-on-a-Stick

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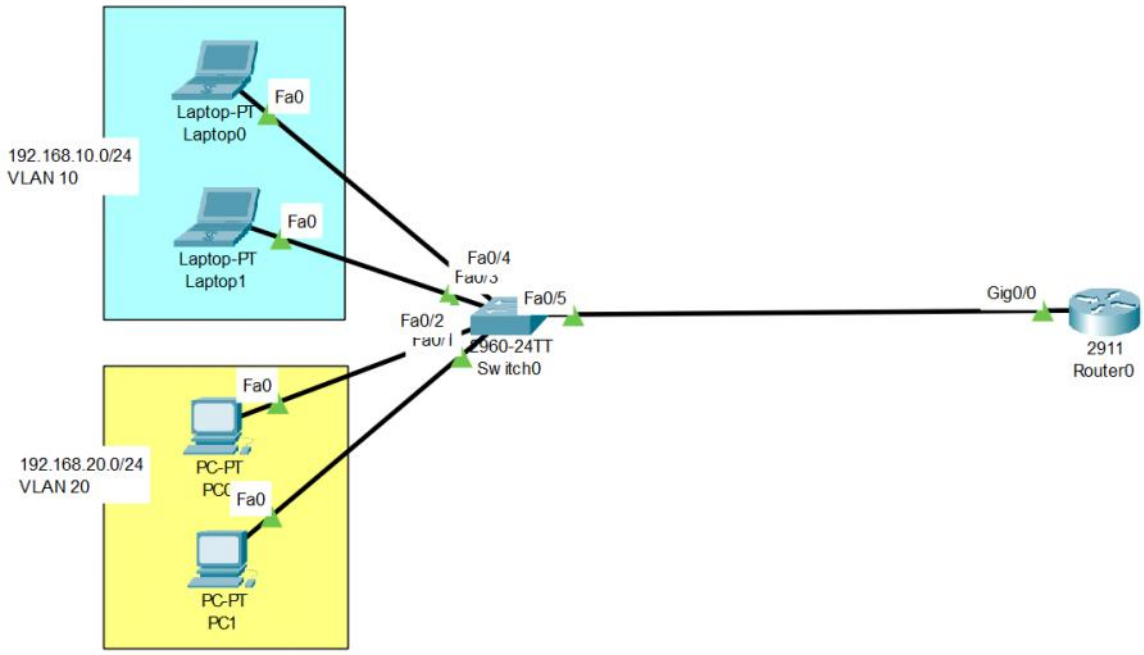
- Router-on-a-Stick is a network configuration that uses a single physical router interface to route traffic between multiple VLANs.
- This method employs sub interfaces—virtual interfaces within a physical interface—to handle traffic for each VLAN.
- It's an efficient way to enable inter-VLAN communication without requiring multiple physical interfaces on the router.



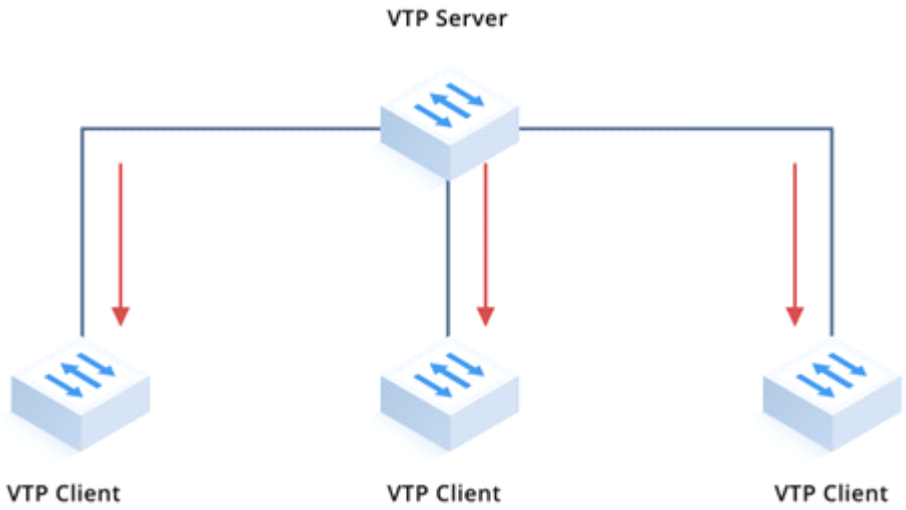
How it Works:

- Single Physical Interface: The router uses one physical interface connected to a switch.
- Sub interfaces: The physical interface is divided into multiple sub interfaces, each representing a VLAN. These sub interfaces are configured with unique IP addresses corresponding to their VLANs.
- 802.1Q Trunking: The switch port connected to the router is configured as a trunk port using 802.1Q encapsulation. This allows the trunk port to carry traffic for multiple VLANs and tag frames with VLAN IDs.
- Routing: The router performs routing between the sub interfaces, enabling communication between devices in different VLANs.

11. VTP - VLAN Trunking Protocol

Sunday, January 12, 2025 9:01 PM

- VTP - VLAN Trunking Protocol
- VTP is a Cisco proprietary protocol used for managing VLANs across a network of switches.
- It simplifies VLAN administration by propagating VLAN information to all switches in a VTP domain.
- VTP helps you simplify the management of VLAN database across multiple switches.
- If you create VLAN on a single switch, then it gets replicated on all the switches by using VTP.



Key Concepts of VTP:

1. **VTP Domain**: A collection of switches that share VLAN information. All switches in a VTP domain must have the same domain name.
2. **VTP Modes**:
   - Server Mode: In this mode, switches can create, modify, and delete VLANs for the entire VTP domain. These changes are propagated to all other switches in the domain.
   - Client Mode: Switches in client mode receive VLAN updates from VTP servers but cannot create, modify, or delete VLANs. They rely on the VTP server for VLAN information.
   - Transparent Mode: Switches in transparent mode do not participate in VTP. They do not send or receive VTP updates but can create, modify, and delete VLANs locally.
3. **VTP Advertisements**: VTP propagates VLAN information through VTP advertisements. These advertisements contain VLAN names, IDs, and configuration details.
4. **VTP Pruning**: VTP pruning reduces unnecessary VLAN traffic by limiting the VLAN traffic sent to switches that do not have ports in those VLANs. This conserves bandwidth and improves network efficiency.
5. **VTP Versions**: There are three versions of VTP:
   - VTPv1: The original version with basic VLAN propagation features.
   - VTPv2**:** Introduced enhancements, including support for Token Ring VLANs and consistency checks.

- VTPv3: Offers additional features such as support for extended VLANs, improved security, and enhanced stability.

Before configuring:

```
S1#show vtp status
VTP Version capable             : 1 to 2
VTP version running             : 1
VTP Domain Name                 :
VTP Pruning Mode                : Disabled
VTP Traps Generation            : Disabled
Device ID                       : 0060.2FC4.8C00
Configuration last modified by 0.0.0.0 at 0-0-00 00:00:00
Local updater ID is 0.0.0.0 (no valid interface found)

Feature VLAN :
--------------
VTP Operating Mode                : Server
```

Enabling trunk mode on Switch 1:

```
S1(config)#inte
S1(config)#interface fa
S1(config)#interface fastEthernet 0/1


S1(config-if)#switchport mode tr
S1(config-if)#switchport mode trunk

S1(config-if)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to down

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up

S1(config-if)#exit
S1(config)#exit
```

Verifying VLAN mode on interface FA0/1 Switch 2:

```
S2#
S2#sh
S2#show int
S2#show interfaces fa
S2#show interfaces fastEthernet 0/1 sw
S2#show interfaces fastEthernet 0/1 switchport
Name: Fa0/1
Switchport: Enabled
Administrative Mode: dynamic auto
Operational Mode: trunk
Administrative Trunking Encapsulation: dot1q
Operational Trunking Encapsulation: dot1q
Negotiation of Trunking: On
Access Mode VLAN: 1 (default)
Trunking Native Mode VLAN: 1 (default)
Voice VLAN: none
```

Checking VLAN mode on interface FA0/2 – before changing:

```
S2#show interfaces fastEthernet 0/2 switchport
Name: Fa0/2
Switchport: Enabled
Administrative Mode: dynamic auto
Operational Mode: static access
Administrative Trunking Encapsulation: dotlq
```

Changing mode on interface FA0/2:

```
S2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
S2(config)#in
S2(config)#interface fa
S2(config)#interface fastEthernet 0/2
S2(config-if)#swi
S2(config-if)#switchport mo
S2(config-if)#switchport mode tru
S2(config-if)#switchport mode trunk

S2(config-if)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/2, changed state to down

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/2, changed state to up

S2(config-if)#exit
S2(config)#
```

Verify on S2 after changes:

```
S2#show interfaces fastEthernet 0/2 switchport
Name: Fa0/2
Switchport: Enabled
Administrative Mode: trunk
Operational Mode: trunk
```

Verifying switch port on switch 3:

```
S3#show interfaces fastEthernet 0/1 sw
S3#show interfaces fastEthernet 0/1 switchport
Name: Fa0/1
Switchport: Enabled
Administrative Mode: dynamic auto
Operational Mode: trunk
Administrative Trunking Encapsulation: dotlq
```

Checking trunk mode on all 3 switches:
S1: # show interfaces trunk

```
S1>en
S1>enable
S1#sh
S1#show in
S1#show interfaces tru
S1#show interfaces trunk
Port        Mode         Encapsulation  Status        Native vlan
Fa0/1       on           802.1q         trunking      1
```

S2: # show interfaces trunk

```
S2#
S2#sh
S2#show in
S2#show interfaces tr
S2#show interfaces trunk
Port        Mode         Encapsulation  Status        Native vlan
Fa0/1       auto         n-802.1q       trunking      1
Fa0/2       on           802.1q         trunking      1
```

S3: # show interfaces trunk

```
S3#
S3#sw
S3#sh
S3#show inte
S3#show interfaces tr
S3#show interfaces trunk
Port        Mode         Encapsulation  Status        Native vlan
Fa0/1       auto         n-802.1q       trunking      1
```

Switching to switch 1 and configuring VTP on it:

```
S1#show vtp stat
S1#show vtp status
VTP Version capable             : 1 to 2
VTP version running             : 1
VTP Domain Name                 :
VTP Pruning Mode                : Disabled
VTP Traps Generation            : Disabled
Device ID                       : 0060.2FC4.8C00
Configuration last modified by 0.0.0.0 at 0-0-00 00:00:00
```

Changing VTP domain on Switch S1:

```
S1#conf terminal
Enter configuration commands, one per line.  End with CNTL/Z.
S1(config)#vt
S1(config)#vtp dom
S1(config)#vtp domain ltimb372
Changing VTP domain name from NULL to ltimb372
S1(config)#exit
S1#
%SYS-5-CONFIG_I: Configured from console by console

S1#show vtp status
VTP Version capable             : 1 to 2
VTP version running             : 1
VTP Domain Name                 : ltimb372
VTP Pruning Mode                : Disabled
VTP Traps Generation            : Disabled
Device ID                       : 0060.2FC4.8C00
Configuration last modified by 0.0.0.0 at 0-0-00 00:00:00
Local updater ID is 0.0.0.0 (no valid interface found)

Feature VLAN :
--------------
VTP Operating Mode              : Server
Maximum VLANs supported locally : 255
```

Checking VTP domain status on switch s2:

```
S2>en
S2#sh
S2#show vtp stat
S2#show vtp status
VTP Version capable             : 1 to 2
VTP version running             : 1
VTP Domain Name                 : ltimb372
VTP Pruning Mode                : Disabled
VTP Traps Generation            : Disabled
Device ID                       : 00E0.F7C5.2700
Configuration last modified by 0.0.0.0 at 0-0-00 00:00:00
Local updater ID is 0.0.0.0 (no valid interface found)
```

Checking VTP domain status on switch s3:

```
S3>en
S3>enable
S3#sh
S3#show vtp stat
S3#show vtp status
VTP Version capable             : 1 to 2
VTP version running             : 1
VTP Domain Name                 : ltimb372
VTP Pruning Mode                : Disabled
VTP Traps Generation            : Disabled
Device ID                       : 0030.F241.E900
Configuration last modified by 0.0.0.0 at 0-0-00 00:00:00
Local updater ID is 0.0.0.0 (no valid interface found)
```

Creating VLAN on Switch S1:

```
S1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
S1(config)#vla
S1(config)#vlan  100
S1(config-vlan)#name vtplanblue
S1(config-vlan)#exit
S1(config)#
S1(config)#vlan  101
S1(config-vlan)#name vtplangreen
S1(config-vlan)#exit
S1(config)#exit
S1#
%SYS-5-CONFIG_I: Configured from console by console
```

Listing VLANs on S1:

```
S1#show vl
S1#show vlan

VLAN Name                              Status    Ports
---- --------------------------------- --------- -------------------------------
1    default                           active    Fa0/2, Fa0/3, Fa0/4, Fa0/5
                                                 Fa0/6, Fa0/7, Fa0/8, Fa0/9
                                                 Fa0/10, Fa0/11, Fa0/12, Fa0/13
                                                 Fa0/14, Fa0/15, Fa0/16, Fa0/17
                                                 Fa0/18, Fa0/19, Fa0/20, Fa0/21
                                                 Fa0/22, Fa0/23, Fa0/24, Gig0/1
                                                 Gig0/2
100  vtplanblue                        active
101  vtplangreen                       active
1002 fddi-default                      active
1003 token-ring-default                active
```

Listing VLANs on S2:

```
S2#
S2#sh
S2#show vtp
S2#show vtp ?
  counters  VTP statistics
  password  VTP password
  status    VTP domain status
S2#show vtp stat
S2#show vtp status
VTP Version capable             : 1 to 2
VTP version running             : 1
VTP Domain Name                 : ltimb372
VTP Pruning Mode                : Disabled
VTP Traps Generation            : Disabled
Device ID                       : 00E0.F7C5.2700
```

Listing VLANs on Switch S2:

```
S2#show vlan

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/3, Fa0/4, Fa0/5, Fa0/6
                                                Fa0/7, Fa0/8, Fa0/9, Fa0/10
                                                Fa0/11, Fa0/12, Fa0/13, Fa0/14
                                                Fa0/15, Fa0/16, Fa0/17, Fa0/18
                                                Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                                Fa0/23, Fa0/24, Gig0/1, Gig0/2
100  vtplanblue                       active
101  vtplangreen                      active
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active
```

12. STP - Spanning Tree Protocol

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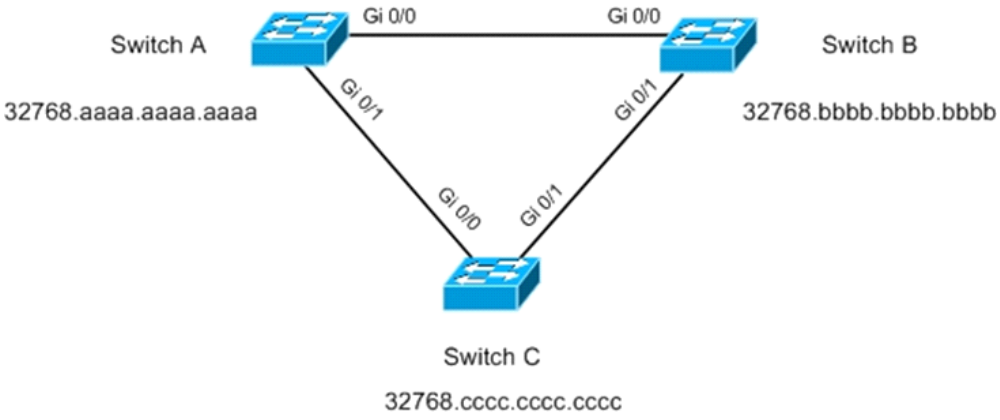
- Spanning Tree Protocol (STP) is a network protocol standardized as IEEE 802.1D.
- It ensures a loop-free topology for any bridged Ethernet local area network.
- The primary goal of STP is to prevent broadcast storms and ensure there are no loops in the network, which can cause severe network congestion and degraded performance.



Key Concepts of STP:

- Bridge: In the context of STP, a bridge is a device that connects different segments of a network. Switches are essentially multiport bridges.
- Bridge ID: Each bridge (switch) in the network is assigned a unique Bridge ID, which is used to identify and select the root bridge. The Bridge ID consists of a priority value and the switch's MAC address.
- Root Bridge: The switch with the lowest Bridge ID is elected as the root bridge. All path calculations are made from the perspective of the root bridge.
- Path Cost: Each network link has an associated cost, determined by the speed of the link. Lower-speed links have higher costs, and higher-speed links have lower costs.
- BPDU (Bridge Protocol Data Unit): STP uses BPDUs to exchange information between switches and ensure a loop-free topology. BPDUs contain information about the bridge IDs, root bridge, and path costs.

STP Operations:

- Root Bridge Election: All switches exchange BPDUs to elect the root bridge. The switch with the lowest Bridge ID becomes the root bridge.
- Path Selection: Each switch calculates the best path to the root bridge based on the lowest path cost. The ports that form the shortest path to the root bridge become the root ports.
- Designated Ports: For each network segment, the switch with the lowest path cost to the root bridge has its port designated as the designated port. This port forwards traffic towards the root bridge.
- Blocking Ports: To prevent loops, some ports are placed in a blocking state. These ports do not forward traffic but can still receive BPDUs.
- Port States: STP ports transition through several states—Blocking, Listening, Learning, Forwarding, and Disabled—based on their role in the network.

Port States in STP:

- Blocking: The port does not forward frames, but it can receive BPDUs.
- Listening: The port does not forward frames and listens to BPDUs to determine the

network topology.

- Learning: The port learns MAC addresses and builds the MAC address table, but does not forward frames.
- Forwarding: The port forwards frames and is fully operational.
- Disabled: The port is administratively shut down and does not participate in STP.

Enhancements to STP:

- RSTP (Rapid Spanning Tree Protocol): IEEE 802.1w, an evolution of STP, provides faster convergence and improved performance.
- MSTP (Multiple Spanning Tree Protocol): IEEE 802.1s, allows multiple spanning trees to coexist, optimizing network resources and traffic flow.
- PVST+ (Per VLAN Spanning Tree Plus): Cisco proprietary protocol that runs a separate instance of STP for each VLAN, providing VLAN-based load balancing.

Path cost for different port speed and STP variation:

Data rate	Original STP cost	RSTP/MSTP cost
4 Mbit/s	250	5,000,000
10 Mbit/s	100	2,000,000
16 Mbit/s	62	1,250,000
100 Mbit/s	19	200,000
1 Gbit/s	4	20,000

13. Backing up switch to TFTP server

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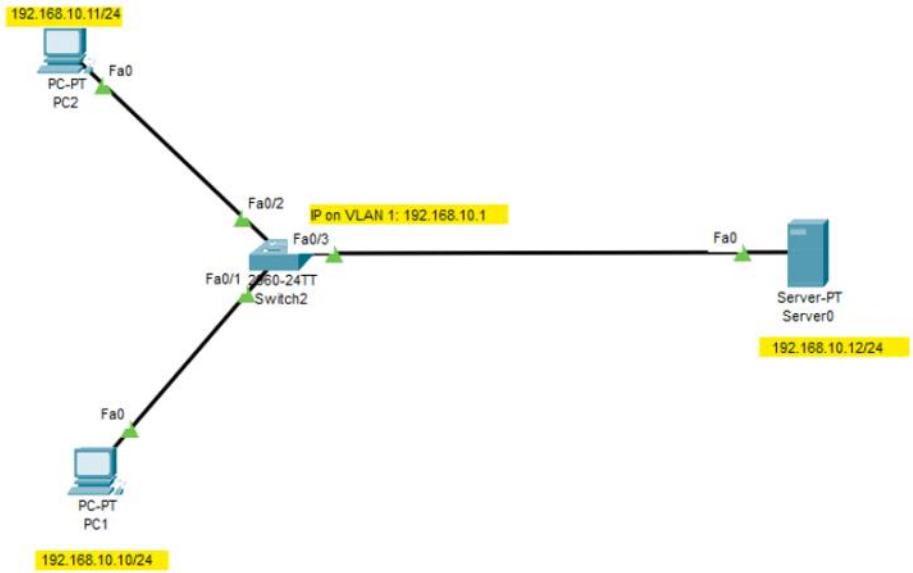


Setting IP address for VLAN on switch:

```
S1(config)#int
S1(config)#interface vlan
S1(config)#interface vlan 1
S1(config-if)#ip add
S1(config-if)#ip address 192.168.10.1 255.255.255.0
S1(config-if)#no shut
S1(config-if)#no shutdown
```

Viewing current config:

```
S1#show int vlan 1
Vlan1 is up, line protocol is up
  Hardware is CPU Interface, address is 0002.4a56.d8cb (bia 0002.4a56.d8cb)
  Internet address is 192.168.10.1/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 1000000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
```

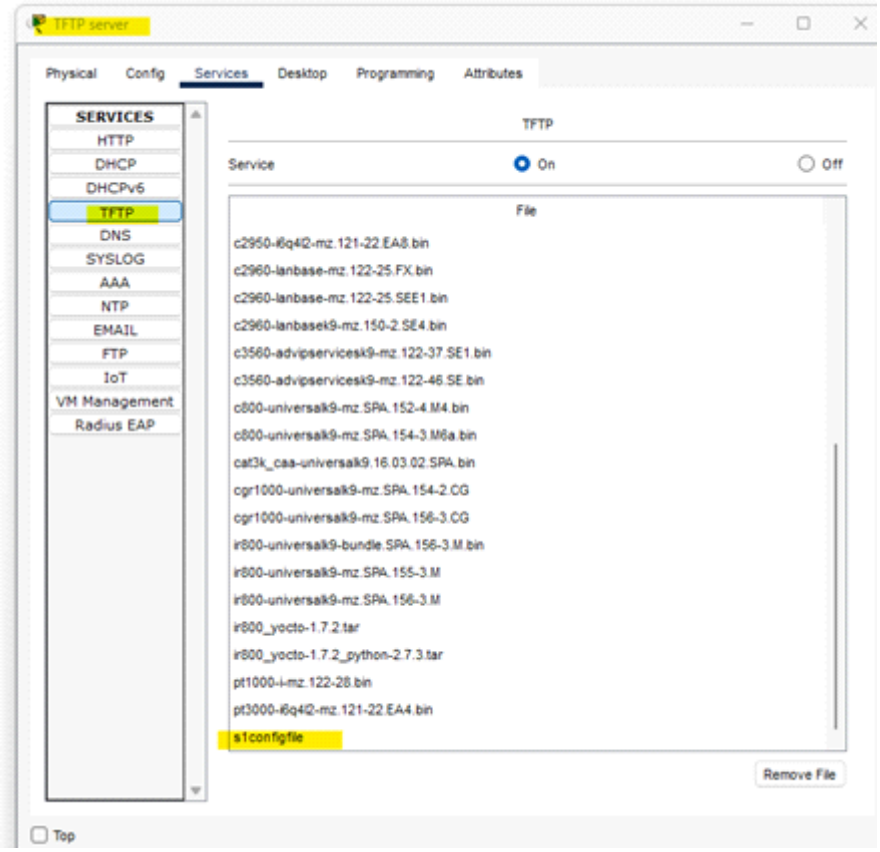
Backing up TFTP server:

```
S1#cop
S1#copy run
S1#copy running-config tf
S1#copy running-config tftp:
Address or name of remote host []? 192.168.10.10
Destination filename [S1-confg]? s1configfile

Writing running-config....!!
[OK - 1090 bytes]

1090 bytes copied in 3.001 secs (363 bytes/sec)
S1#
```

Verifying TFTP service on TFTP server:



After backup, make some changes on the switch (say changing the IP address on VLAN 1)

```
S1#con
S1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
S1(config)#int
S1(config)#interface vla
S1(config)#interface vlan 1
S1(config-if)#ip addres
S1(config-if)#ip address 192.168.10.100 255.255.255.0
S1(config-if)#no shut
S1(config-if)#exit
S1(config)#exit
S1#
%SYS-5-CONFIG_I: Configured from console by console
```

Verifying the IP address:

```
S1#show interfaces vla
S1#show interfaces vlan 1
Vlan1 is up, line protocol is up
  Hardware is CPU Interface, address is 0002.4a56.d8cb (bia 0002.4a56.d8cb)
  Internet address is 192.168.10.100/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 1000000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 21:40:21, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
  Queueing strategy: fifo
```

14. Recovering switch data from the TFTP server

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Run below command on switch:

```
S1#
S1#cop
S1#copy tftp run
S1#copy tftp running-config
Address or name of remote host []? 192.168.10.10
Source filename []? slconfigfile
Destination filename [running-config]?

Accessing tftp://192.168.10.10/slconfigfile....
Loading slconfigfile from 192.168.10.10: !
[OK - 1090 bytes]

1090 bytes copied in 3.007 secs (362 bytes/sec)
S1#
%SYS-5-CONFIG_I: Configured from console by console
```

Verifying the configuration:

```
S1#show interfaces vlan 1
Vlan1 is up, line protocol is up
  Hardware is CPU Interface, address is 0002.4a56.d8cb (bia 0002.4a56.d8cb)
  Internet address is 192.168.10.1/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 1000000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  ARP type: ARPA, ARP Timeout 04:00:00
  Last input 21:40:21, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
```

15. Routers

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- A router is a network device that forwards data packets between computer networks.
- Routers play a critical role in directing traffic on the internet and within private networks.
- They work at the network layer (Layer 3) of the OSI model and use IP addresses to determine the best path for forwarding packets.

Key Functions of Routers

- Packet Forwarding: Routers examine incoming data packets and forward them to their appropriate destination based on their IP addresses.
- Routing: Routers use routing tables and routing protocols to determine the optimal path for data packets to reach their destination.
- Network Address Translation (NAT): Routers translate private IP addresses to a public IP address, allowing multiple devices on a local network to share a single public IP address.
- Subnetting: Routers divide larger networks into smaller subnets, improving network performance and management.
- Security: Routers can filter traffic, block malicious packets, and provide firewall functions to enhance network security.

Importance of Routers

- Connectivity to ISP: Routers connect local networks to the Internet Service Provider (ISP), enabling internet access for all devices on the network. They handle the public IP address provided by the ISP and manage the distribution of internet traffic.
- Connecting Switches and Other Routers: Routers link multiple switches and other routers within a network, creating a cohesive and efficient communication system. They ensure data packets are routed correctly between different segments of the network.

Connectivity to ISP

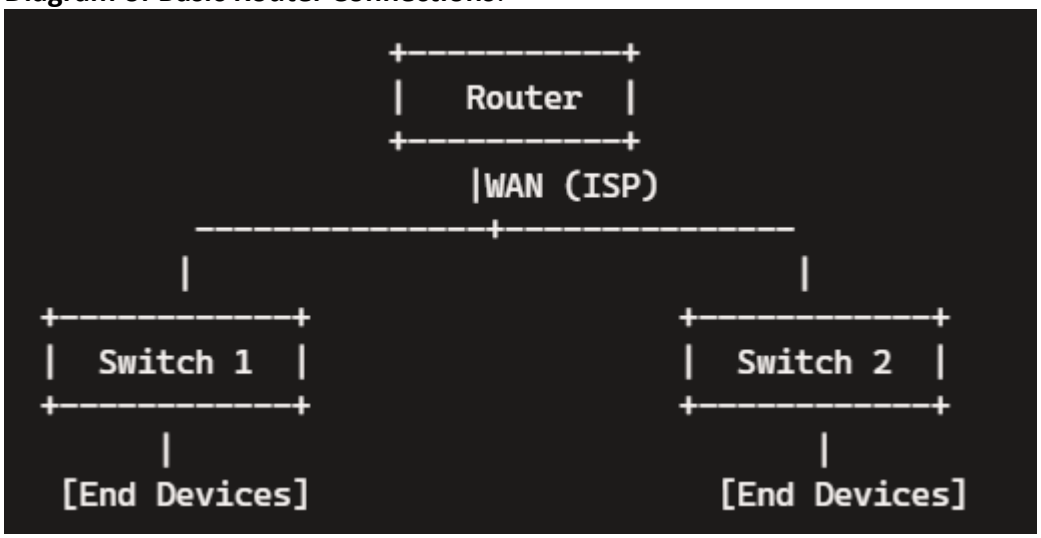
- WAN Interface: The router's Wide Area Network (WAN) interface connects to the ISP's modem or external router. This interface uses a public IP address provided by the ISP.
- DHCP: The router typically receives an IP address dynamically from the ISP using the Dynamic Host Configuration Protocol (DHCP).
- PPP (Point-to-Point Protocol): Some routers use PPP for authentication and communication with the ISP.

Connectivity to Switches and Other Routers

- LAN Interfaces: Routers have Local Area Network (LAN) interfaces that connect to switches or directly to end devices within the local network. These interfaces use private IP addresses.
- Routing Protocols: Routers use routing protocols (e.g., OSPF, EIGRP, BGP) to exchange routing information with other routers, enabling dynamic routing and optimal path selection.
- Inter-VLAN Routing: Routers can perform inter-VLAN routing, allowing communication between different VLANs on a network.
- Redundancy and Load Balancing: Routers can be configured for redundancy (e.g., using HSRP or VRRP) to ensure network availability, and for load balancing to distribute

traffic efficiently across multiple paths.

Diagram of Basic Router Connections:



16. IP Routing

Sunday, January 12, 2025 10:43 PM

- IP routing is the process of forwarding data packets from one network to another based on their IP addresses.
- Routers use routing tables and protocols to determine the best path for packets to reach their destination.

Key Concepts:

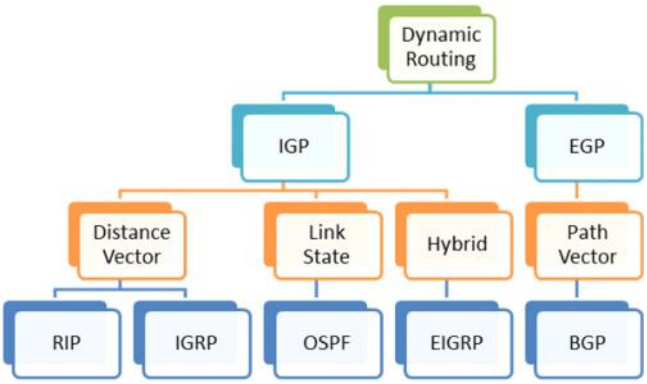
- Routing Table: A data structure stored in a router that lists the routes to different network destinations. It includes information such as destination IP addresses, subnet masks, next-hop addresses, and interface information.
- Routing Protocols: Protocols used by routers to dynamically exchange routing information and update their routing tables. Common routing protocols include:
  - RIP (Routing Information Protocol): A distance-vector protocol that uses hop count as a metric.
  - OSPF (Open Shortest Path First): A link-state protocol that uses cost as a metric and converges quickly.
  - EIGRP (Enhanced Interior Gateway Routing Protocol): A Cisco proprietary protocol that combines the best features of distance-vector and link-state protocols.
  - BGP (Border Gateway Protocol): A path-vector protocol used for routing between different autonomous systems on the internet.
- Static Routing: Manually configured routes that do not change unless manually updated. Suitable for small networks or specific routing requirements.
- Dynamic Routing: Automatically updated routes based on network topology changes, using routing protocols.

Routing Process:

- Packet Reception: The router receives a data packet on one of its interfaces.
- Destination IP Address: The router examines the destination IP address in the packet header.
- Routing Table Lookup: The router searches its routing table for the best match to the destination IP address.
- Forwarding Decision: Based on the routing table entry, the router determines the next-hop address and the outgoing interface.
- Packet Forwarding: The router forwards the packet to the next-hop router or the destination device through the appropriate interface.

Routing Protocol:

- Routing protocols are used by routers to dynamically exchange routing information and update their routing tables.
- They help routers determine the best path for data packets to reach their destination.
- There are three main categories of routing protocols:
  - Distance-vector,
  - Link-state, and
  - Path-vector.
- Here's an overview of the different types of routing protocols:



- **Distance-Vector Routing Protocols (DVR)**
  - Distance-vector routing protocols calculate the best path to a destination based on the distance (usually the number of hops) and direction (vector) to the destination.
  - They periodically send the entire routing table to their directly connected neighbors.
    - RIP (Routing Information Protocol): Uses hop count as the metric. Simple and easy to configure, but limited scalability due to a maximum hop count of 15.
    - IGRP (Interior Gateway Routing Protocol): Cisco proprietary protocol, now largely obsolete, used bandwidth, delay, load, and reliability as metrics.

- **Link-State Routing Protocols (LSR)**
  - Link-state routing protocols maintain a complete map of the network topology and calculate the best path to each destination based on this map. They use more complex algorithms and provide faster convergence compared to distance-vector protocols.
    - OSPF (Open Shortest Path First): A widely used link-state protocol that uses cost as the metric, based on link speed. It supports large and complex networks with hierarchical design and fast convergence.
    - IS-IS (Intermediate System to Intermediate System): Similar to OSPF, it uses a link-state algorithm and is often used in large service provider networks.

- **Path-Vector Routing Protocols (PVR)**
  - Path-vector routing protocols are used for routing between different autonomous systems (AS). They maintain the path information that gets updated dynamically as network topology changes.
    - **BGP (Border Gateway Protocol)**: The standard exterior gateway protocol used for routing between different autonomous systems on the internet. It uses path attributes to make routing decisions and ensures stable and efficient routing across the global internet.

Protocol	Type	Metric(s)	Use Case
RIP	Distance-Vector	Hop count	Small to medium-sized networks
IGRP	Distance-Vector	Bandwidth, Delay, Load, Reliability	Obsolete, previously used in enterprise networks
OSPF	Link-State	Cost (based on link speed)	Large, complex networks with hierarchical design
IS-IS	Link-State	Cost	Large service provider networks
BGP	Path-Vector	Path attributes	Inter-domain routing (internet)

17. Router Metrics

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- Routing metrics are values used by routing protocols to determine the best path for data packets to travel from a source to a destination.
- Different routing protocols use different metrics, and understanding these metrics helps in optimizing network performance and reliability.

Here are some common routing metrics:

- Hop Count:
  - Definition: The number of routers (hops) a packet must pass through to reach its destination.
  - Used by: RIP (Routing Information Protocol).
  - Characteristics: Simple and easy to understand, but may not reflect the actual path quality.

- Bandwidth:
  - Definition: The data capacity of a link, typically measured in bits per second (bps).
  - Used by: EIGRP (Enhanced Interior Gateway Routing Protocol).
  - Characteristics: Higher bandwidth links are preferred, as they can handle more traffic.

- Delay:
  - Definition: The time it takes for a packet to travel from the source to the destination, typically measured in milliseconds (ms).
  - Used by: EIGRP.
  - Characteristics: Routes with lower delay are preferred, as they provide faster delivery of packets.

- Cost:
  - Definition: An arbitrary value assigned to links, often based on link speed or administrative preferences.
  - Used by: OSPF (Open Shortest Path First), IS-IS (Intermediate System to Intermediate System).
  - Characteristics: Administrators can assign costs to influence routing decisions, with lower costs being preferred.

- Reliability:
  - Definition: The likelihood of a link failure, typically represented as a percentage or a number between 0 and 255.
  - Used by: EIGRP.
  - Characteristics: More reliable links are preferred, as they provide more stable connections.

- Load:
  - Definition: The amount of traffic currently being handled by a link, often represented as a percentage or a value between 0 and 255.
  - Used by: EIGRP.
  - Characteristics: Links with lower load are preferred, as they have more available

capacity.

- MTU (Maximum Transmission Unit):
  - Definition: The maximum size of a packet that can be transmitted over a link without fragmentation.
  - Used by: OSPF (in the calculation of path cost).
  - Characteristics: Higher MTU values can improve efficiency by reducing the number of packets needed to transmit data.

- Metric Combinations:
  - Definition: Some protocols combine multiple metrics to calculate a composite metric.
  - Used by: EIGRP combines bandwidth, delay, load, and reliability into a composite metric.
  - Characteristics: Provides a more comprehensive evaluation of link quality by considering multiple factors.

Example of Metric Configuration in EIGRP:

```
Router(config)# interface fastethernet 0/1
Router(config-if)# bandwidth 10000
Router(config-if)# delay 100
Router(config-if)# reliability 255
Router(config-if)# load 1
```

Metric	Description	Protocol	Characteristics
Hop Count	Number of routers a packet passes through	RIP	Simple, may not reflect path quality
Bandwidth	Data capacity of a link (bps)	EIGRP	Higher bandwidth preferred
Delay	Time for packet travel (ms)	EIGRP	Lower delay preferred
Cost	Arbitrary value based on link speed/preference	OSPF, IS-IS	Lower cost preferred
Reliability	Likelihood of link failure	EIGRP	More reliable links preferred
Load	Current traffic on a link	EIGRP	Lower load preferred
MTU	Maximum packet size for a link	OSPF	Higher MTU improves efficiency

18. Routing Terminologies

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Routing involves many specific terms and concepts. Understanding these terminologies is essential for grasping how routers function and how they make decisions about data packet forwarding. Here are some key routing terminologies:

1. **Router**: A network device that forwards data packets between different networks based on their IP addresses.
2. **Routing Table**: A data structure in a router that lists routes to various network destinations, including information on how to reach them.
3. **Static Routing**: A type of routing where routes are manually configured and do not change unless manually updated.
4. **Dynamic Routing**: Routing that uses algorithms and protocols to automatically update routing tables based on changes in the network topology.
5. **Routing Protocol**: A protocol used by routers to exchange routing information and update their routing tables. Examples include RIP, OSPF, EIGRP, and BGP.
6. **Hop**: A single step from one router to the next in the path from source to destination.
7. **Hop Count**: A metric used by some routing protocols to measure the number of hops (routers) a packet must traverse to reach its destination.
8. **Next Hop**: The next router or gateway to which a data packet is forwarded along its path to the destination.
9. **Subnet**: A logically segmented portion of a larger network, often created to improve performance and manageability.
10. **Subnet Mask**: A 32-bit number used to differentiate the network portion of an IP address from the host portion.
11. **Autonomous System (AS)**: A collection of IP networks and routers under the control of a single organization that presents a common routing policy to the internet.
12. **Interior Gateway Protocol (IGP)**: A type of routing protocol used for routing within an autonomous system. Examples include OSPF and EIGRP.
13. **Exterior Gateway Protocol (EGP)**: A type of routing protocol used for routing between different autonomous systems. The primary EGP is BGP.
14. **Administrative Distance (AD)**: A metric used to rate the trustworthiness of a routing information source. Lower values indicate higher trustworthiness.
15. **Metric**: A value used by routing protocols to determine the best path for data packets. Metrics can include hop count, bandwidth, delay, reliability, and load.
16. **Convergence**: The process by which all routers in a network come to agree on the best routes after a change in the network topology.
17. **Default Route**: A route used when there is no specific route to the destination in the routing table. Often represented as 0.0.0.0/0.
18. **Route Redistribution**: The process of sharing routes between different routing protocols within a network.
19. **Link-State Routing Protocol**: A type of routing protocol that maintains a complete map of the network topology and calculates the best path using algorithms like Dijkstra's. Examples include OSPF and IS-IS.
20. **Distance-Vector Routing Protocol**: A type of routing protocol that calculates the best path based on the distance (number of hops) and direction. Examples include RIP and IGRP.
21. **Path-Vector Routing Protocol**: A type of routing protocol used for inter-domain routing that maintains the path information. Example: BGP.

22. **Route Flapping**: A condition where routes are repeatedly added and removed from the routing table, causing instability.
23. **VLSM (Variable Length Subnet Masking)**: A technique that allows for the use of different subnet masks within the same network, enabling more efficient IP address allocation.
24. **CIDR (Classless Inter-Domain Routing)**: A method for allocating IP addresses and routing that allows for more flexible subnetting than the traditional class-based system.

19. Routing Terminologies - 2

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- **Administrative Distance (AD)**:
  - **Definition**: Administrative Distance (AD) is a value that rates the trustworthiness of the source of a routing information. It helps routers decide which route to install in the routing table when there are multiple routes to the same destination from different routing protocols.
  - **Value Range**: The AD values range from 0 to 255, with lower values being more trusted.
  - **Example**: Directly connected routes have an AD of 0, static routes usually have an AD of 1, and EIGRP routes have an AD of 90.

- **Metric**:
  - **Definition**: A metric is a value used by routing protocols to determine the best path to a destination. Metrics can include various factors like hop count, bandwidth, delay, and more.
  - **Purpose**: Metrics help routers select the most efficient route for data packets.

- **Hop**:
  - **Definition**: A hop refers to the movement of a data packet from one router to the next in its path from source to destination.
  - **Hop Count**: The hop count is a metric used by distance-vector protocols (like RIP) to measure the number of hops to the destination. Each hop is counted as one.
  - **Example**: If a data packet traverses three routers to reach its destination, the hop count is three.

- **Bandwidth & Delay**:
  - **Bandwidth**:
    - **Definition**: Bandwidth is the data capacity of a network link, usually measured in bits per second (bps).
    - **Usage**: Higher bandwidth links are preferred in routing decisions, as they can handle more traffic.
    - **Example**: EIGRP uses bandwidth as part of its composite metric to determine the best path.
  - **Delay**:
    - **Definition**: Delay is the time taken for a packet to travel from the source to the destination, typically measured in milliseconds (ms).
    - **Usage**: Routes with lower delay are preferred, as they provide faster delivery of packets.
    - **Example**: EIGRP also uses delay as part of its composite metric.

- **Load & Reliability**:
  - **Load**:
    - **Definition**: Load refers to the amount of traffic currently being handled by a network link, often represented as a percentage or a value between 0 and 255.
    - **Usage**: Links with lower load are preferred, as they have more available capacity.
    - **Example**: EIGRP can consider load when calculating its composite metric.
  - **Reliability**:
    - **Definition**: Reliability is the likelihood of a link failure, typically represented as a

percentage or a value between 0 and 255.

- **Usage**: More reliable links are preferred, as they provide more stable connections.
- **Example**: EIGRP can also consider reliability when calculating its composite metric.

20. Static Routing

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Static routing is a type of network routing method where the routes are manually configured by a network administrator.
Unlike dynamic routing, which uses protocols to discover routes automatically, static routing requires the manual entry of route information into the routing table.

Key Characteristics of Static Routing:

1. **Manual Configuration**: Routes are manually added, modified, or deleted by the network administrator.
2. **Fixed Paths**: Once configured, static routes do not change unless manually updated, providing predictable and consistent routing paths.
3. **No Overhead**: Static routing does not require the resources and overhead associated with dynamic routing protocols, such as CPU and memory usage for running algorithms and exchanging routing information.
4. **Control**: Provides greater control over routing decisions, allowing administrators to define specific paths for data packets.

Advantages of Static Routing:

1. **Simplicity**: Easy to configure and manage for small networks with simple topologies.
2. **Predictability**: Since routes are fixed, the behaviour of the network is predictable.
3. **Low Overhead**: No need for routing protocol processes, reducing CPU and memory usage on routers.
4. **Security**: Static routes are less susceptible to certain types of routing attacks since they do not rely on routing protocol messages.

Disadvantages of Static Routing:

1. **Scalability**: Manual configuration becomes impractical and error-prone for large or frequently changing networks.
2. **Maintenance**: Requires ongoing manual updates to the routing table when network changes occur.
3. **Lack of Fault Tolerance**: Static routes do not automatically adapt to network failures or topology changes. Manual intervention is required to re-route traffic.

21. Default Routing

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- Default routing is a type of static routing that directs packets with destinations that are not explicitly listed in the routing table to a specific gateway or router.
- It serves as a catch-all route when no other specific route matches the destination IP address.
- Default routes are crucial for simplifying routing tables, especially in scenarios where specifying routes to every possible destination would be impractical.

Key Characteristics of Default Routing:

1. **Simplifies Routing**: Default routing reduces the complexity of the routing table by providing a single route for all unspecified destinations.
2. **Catch-All Route**: It acts as a catch-all route for packets that do not match any other route in the routing table.
3. **Use in Stub Networks**: Default routing is particularly useful in stub networks, where a network segment has only one path to access external networks.
4. **Configurable on Both Routers and Hosts**: Default routes can be configured on both routers and individual network hosts.

To configure a default route on a Cisco router, you use the following command:

Router(config)# *ip route 0.0.0.0 0.0.0.0 [next-hop IP address or exit interface]*

Example Scenario:

Imagine you have a network with three routers: R1, R2, and R3. R1 is connected to the internet, and R2 and R3 are internal routers.

To configure a default route on R2 and R3 to send all non-local traffic to R1, you would use the following commands:

- On R2:
  - R2(config)# ip route 0.0.0.0 0.0.0.0 [R1's IP address]

- On R3:
  - R3(config)# ip route 0.0.0.0 0.0.0.0 [R1's IP address]

Benefits of Default Routing:

1. **Simplified Configuration**: Reduces the need to manually configure routes to every possible destination, saving time and effort.
2. **Efficient for Stub Networks**: Ideal for networks with a single exit point, such as branch offices or home networks.
3. **Reduces Routing Table Size**: Minimizes the number of entries in the routing table, making it easier to manage and process.

22. Dynamic Routing

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- Dynamic routing is a method of routing that uses algorithms and protocols to automatically update routing tables based on changes in the network topology.
- Unlike static routing, which requires manual configuration, dynamic routing protocols continuously monitor the network and adjust routes to ensure efficient and reliable data packet delivery.

Key Concepts:

1. **Dynamic Routing Protocols**: Protocols used by routers to exchange routing information and update their routing tables dynamically. Common protocols include RIP, OSPF, EIGRP, and BGP.
2. **Routing Algorithms**: Algorithms used by dynamic routing protocols to calculate the best path for data packets. These include distance-vector, link-state, and path-vector algorithms.
3. **Convergence**: The process by which all routers in a network agree on the best routes after a change in the network topology. Faster convergence improves network stability and performance.
4. **Metrics**: Values used by routing protocols to determine the best path. Metrics can include hop count, bandwidth, delay, load, reliability, and more.

Types of Dynamic Routing Protocols:

1. **Distance-Vector Routing Protocols**:
    - **RIP (Routing Information Protocol)**: Uses hop count as the metric. Simple and easy to configure, but limited scalability due to a maximum hop count of 15.
    - **EIGRP (Enhanced Interior Gateway Routing Protocol)**: Cisco proprietary protocol that uses a composite metric based on bandwidth, delay, load, and reliability.
2. **Link-State Routing Protocols**:
    - **OSPF (Open Shortest Path First)**: Uses a link-state algorithm and cost as the metric, based on link speed. Supports large and complex networks with hierarchical design and fast convergence.
    - **IS-IS (Intermediate System to Intermediate System)**: Similar to OSPF, it uses a link-state algorithm and is often used in large service provider networks.
3. **Path-Vector Routing Protocols**:
    - **BGP (Border Gateway Protocol)**: The standard exterior gateway protocol used for routing between different autonomous systems on the internet. Uses path attributes to make routing decisions and ensures stable and efficient routing across the global internet.

How Dynamic Routing Works:

1. **Neighbor Discovery**: Routers identify and establish communication with neighbouring routers using protocols like Hello (OSPF) or Keepalive (BGP).
2. **Topology Exchange**: Routers exchange routing information with their neighbours. Distance-vector protocols share the entire routing table, while link-state protocols share only changes to the network topology.
3. **Path Calculation**: Routers use their routing algorithms to calculate the best paths to each destination based on the received information and metrics.
4. **Routing Table Update**: Routers update their routing tables with the best paths. This process continues periodically or whenever a change in the network topology is detected.
5. **Convergence**: The network reaches convergence when all routers have a consistent and updated view of the network topology.

Benefits of Dynamic Routing:

1. **Scalability**: Automatically adapts to changes in the network topology, making it suitable for large and complex networks.
2. **Fault Tolerance**: Quickly detects and reroutes traffic around network failures, ensuring continuous connectivity.
3. **Reduced Administrative Overhead**: Eliminates the need for manual route updates, reducing the risk of configuration errors.
4. **Optimized Path Selection**: Uses metrics to determine the most efficient paths, improving network performance.

Example Configuration:

1. **OSPF Configuration**:

```
Plaintext                                                    Copy

Router(config)# router ospf 1
Router(config-router)# network 192.168.10.0 0.0.0.255 area 0
Router(config-router)# network 192.168.20.0 0.0.0.255 area 0
```

2. **EIGRP Configuration**:

```
Plaintext                                                    Copy

Router(config)# router eigrp 1
Router(config-router)# network 192.168.10.0
Router(config-router)# network 192.168.20.0
```

23. Dynamic Routing - RIP

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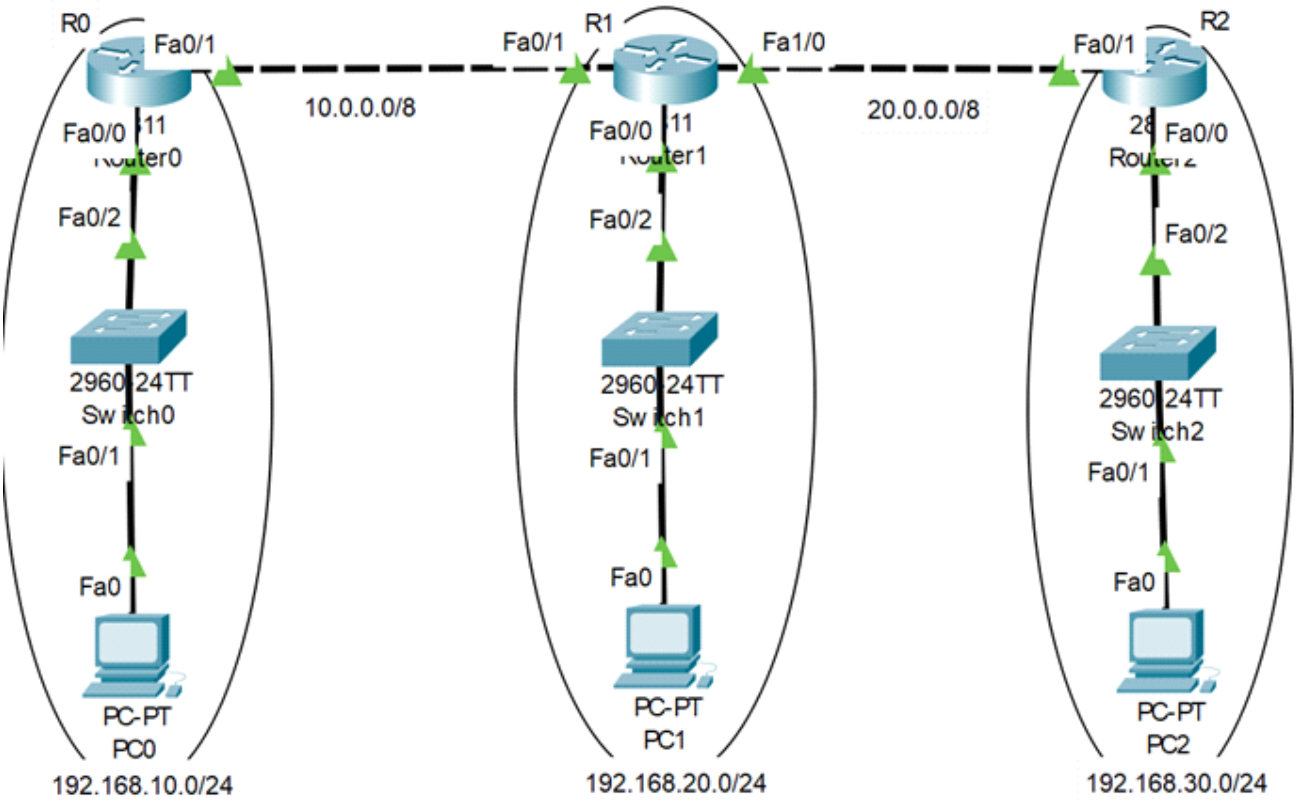
- The Routing Information Protocol (RIP) is one of the oldest and simplest dynamic routing protocols used in computer networks.
- Key Features of RIP:
  - **Distance Vector Protocol**: RIP uses distance vectors to determine the best path to a destination network.
  - **Hop Count Metric**: It uses hop count as the metric for path selection, with a maximum of 15 hops allowed.
  - **Periodic Updates**: RIP routers broadcast their entire routing table to their neighbors every 30 seconds.
  - **Limitations**: Due to its simplicity, RIP is generally used in small to medium-sized networks and is not suitable for larger networks.
- RIP has two main versions used in networking:
  - **RIP Version 1 (RIP v1)**
    - Classful Routing: RIP v1 is a classful routing protocol, which means it does not send subnet mask information in its updates.
    - Broadcast Updates: It sends updates as broadcast packets (255.255.255.255).
    - No VLSM Support: RIP v1 does not support Variable Length Subnet Masks (VLSM).
  - **RIP Version 2 (RIP v2)**
    - Classless Routing: RIP v2 is a classless routing protocol, which means it includes subnet mask information in its updates, supporting VLSM.
    - Multicast Updates: It sends updates as multicast packets (224.0.0.9), reducing unnecessary traffic.
    - Authentication: RIP v2 supports route authentication to enhance security.

Feature	RIP v1	RIP v2
Routing Type	Classful	Classless
Update Type	Broadcast	Multicast
VLSM Support	No	Yes
Authentication	No	Yes

Configuring RIPv2



In RIPv2, you need to write direct connected networks within your routers.
List of total networks:

- 10.0.0.0
- 20.0.0.0
- 192.168.10.0
- 192.168.20.0
- 192.168.30.0

Now adding all these networks to all the routers.

Configuring Router R0:

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R0
R0(config)#
R0(config)#
R0(config)#versio
R0(config)#router rip
R0(config-router)#version 2
R0(config-router)#network 10.0.0.0
R0(config-router)#network 20.0.0.0
R0(config-router)#network 192.168.10.0
R0(config-router)#network 192.168.20.0
R0(config-router)#network 192.168.30.0
R0(config-router)#exit
R0(config)#
R0(config)#
```

Configuring Router R1:

```
R1>en
R1>enable
R1#conf
```

```
R1>en
R1>enable
R1#conf
R1#configure ter
R1#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#router rip
R1(config-router)#version 2
R1(config-router)#network 10.0.0.0
R1(config-router)#network 20.0.0.0
R1(config-router)#network 192.168.10.0
R1(config-router)#network 192.168.20.0
R1(config-router)#network 192.168.30.0
R1(config-router)#exit
R1(config)#
R1(config)#
```

Configuring Router R2:

```
R2>en
R2#conf
R2#configure ter
R2#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#router rip
R2(config-router)#version 2
R2(config-router)#network 10.0.0.0
R2(config-router)#network 20.0.0.0
R2(config-router)#network 192.168.10.0
R2(config-router)#network 192.168.20.0
R2(config-router)#network 192.168.30.0
R2(config-router)#
R2(config-router)#exit
R2(config)#
R2(config)#
```

24. Dynamic Routing - OSPF

Monday, January 13, 2025 10:32 AM

Open Shortest Path First (OSPF) is a widely used link-state routing protocol designed for larger and more complex networks compared to simpler protocols like RIP.

Here's a detailed look at OSPF:

Key Features of OSPF:

1. **Link-State Protocol**: OSPF uses link-state information to build a complete map of the network topology, allowing routers to make informed routing decisions.
2. **Hierarchical Structure**: OSPF supports a hierarchical network design, dividing networks into areas to optimize routing efficiency and reduce overhead.
3. **Fast Convergence**: OSPF quickly detects changes in the network topology and recalculates routes using the Shortest Path First (SPF) algorithm.
4. **VLSM Support**: OSPF supports Variable Length Subnet Masking (VLSM) for more efficient IP address allocation.
5. **Authentication**: OSPF includes support for route authentication to enhance network security.
6. **Multicast Updates**: OSPF sends updates as multicast packets to reduce unnecessary network traffic.

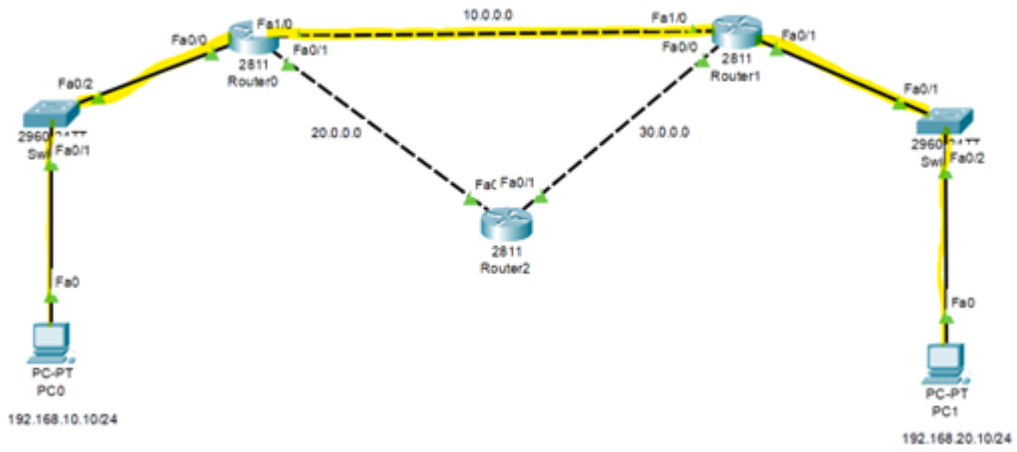
OSPF Network Structure:

- **Areas**: OSPF networks are divided into areas to improve scalability. Area 0 (the backbone area) is the core of the OSPF network, and all other areas connect to it.
- **LSA (Link-State Advertisement)**: Routers exchange LSAs to share information about their link-state and network topology.
- **DR and BDR**: In multi-access networks (e.g., Ethernet), OSPF elects a Designated Router (DR) and a Backup Designated Router (BDR) to reduce the number of OSPF adjacencies and simplify the network.

Advantages of OSPF:

- **Scalability**: OSPF is suitable for large and complex networks due to its hierarchical design.
- **Efficiency**: The use of areas and DR/BDR reduces routing overhead.
- **Quick Convergence**: OSPF quickly adapts to network changes, minimizing downtime.
- **Security**: OSPF supports authentication to ensure the integrity of routing information.

Configuring OSPF:



Syntax: **#network <network-range> <wildcard> <area> 0**

Subnet Mask	Wildcard mask
255.0.0.0	0.255.255.255
255.255.0.0	0.0.255.255
255.255.255.0	0.0.0.255

Configuring Router R0:

```
Router>en
Router>enable
Router#conf
Router#configure ter
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#router ospf 1
Router(config-router)#network 192.168.10.0 0.0.0.255 area 0
Router(config-router)#network 10.0.0.0 0.255.255.255 area 0
Router(config-router)#network 20.0.0.0 0.255.255.255 area 0
Router(config-router)#exit
Router(config)#exit
Router#
%SYS-5-CONFIG_I: Configured from console by console

Router#wr
Building configuration...
[OK]
Router#
```

Configuring Router R1:

```
Router>en
Router>enable
Router#conf
Router#configure ter
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#router ospf 2
Router(config-router)#network 10.0.0.0 0.255.255.255 area 0
Router(config-router)#network
00:22:00: %OSPF-5-ADJCHG: Process 2, Nbr 192.168.10.1 on FastEthernet1/0 from LOADING to
FULL, Loading Don
% Incomplete command.
Router(config-router)#network 30.0.0.0 0.0.0.255 area 0
Router(config-router)#network 192.168.20.0 0.0.0.255 area 0
Router(config-router)#exit
Router(config)#exit
Router#
%SYS-5-CONFIG_I: Configured from console by console

Router#wr
Building configuration...
[OK]
Router#
```

Configuring Router R2:

```
Router>en
Router>enable
Router#conf
Router#configure ter
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#router ospf 3
```

```
Router(config-router)#network 30.0.0.0 0.255.255.255 area 0
Router(config-router)#network 20.0.0.0 0.255.255.255 area 0
Router(config-router)#exit
Router(config)#exit
Router#
%SYS-5-CONFIG_I: Configured from console by console

Router#wr
Building configuration...
[OK]
Router#
```

25. Dynamic Routing - EIGRP

Monday, January 13, 2025 10:35 AM

Enhanced Interior Gateway Routing Protocol (EIGRP) is an advanced distance-vector routing protocol developed by Cisco. It combines the best features of distance vector and link-state protocols, making it efficient and scalable for large networks.

Here's a detailed look at EIGRP:

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.
2. **DUAL Algorithm**: EIGRP uses the Diffusing Update Algorithm (DUAL) to ensure loop-free and efficient route calculations.
3. **VLSM Support**: EIGRP supports Variable Length Subnet Masking (VLSM) for efficient IP address utilization.
4. **Rapid Convergence**: EIGRP quickly converges by using route updates that only include changes in the network topology, not the entire routing table.
5. **Multicast and Unicast**: EIGRP uses multicast updates to reduce unnecessary traffic but can also send unicast updates for reliability.
6. **Load Balancing**: EIGRP supports unequal-cost load balancing, allowing it to utilize multiple paths with different metrics efficiently.

EIGRP Metrics:

EIGRP uses a composite metric based on several factors, including:

- **Bandwidth**: The lowest bandwidth along the path.
- **Delay**: The cumulative delay along the path.
- **Load**: The load on the link.
- **Reliability**: The reliability of the link.
- **MTU**: The maximum transmission unit size (though MTU is not used in metric calculations by default).

Advantages of EIGRP:

- **Efficiency**: EIGRP uses incremental updates, reducing bandwidth usage compared to protocols that send full routing tables.
- **Scalability**: It's well-suited for large enterprise networks.
- **Flexibility**: Supports various network topologies and can integrate with other routing protocols.
- **Resiliency**: Provides rapid convergence and route redundancy.

Syntax:

```
Router(config)# router eigrp [autonomous-system-number]
Router(config-router)# network [network-address] [wildcard-mask]
Router(config-router)# exit
Router(config)# exit
```

Configuring EIGRP:

Steps:

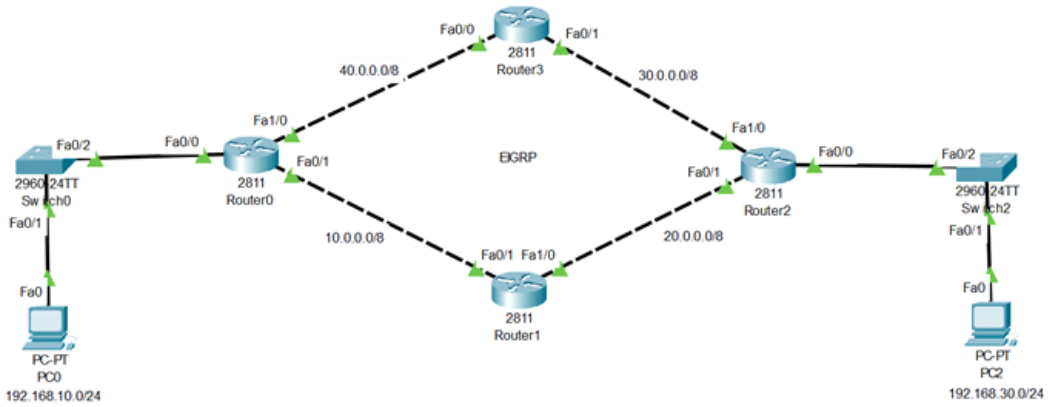
1. Becoming neighbor.
2. Exchange routing info.

3. Choose best route.

Condition to become neighbor

- Autonomous System number (AS) must be same.
- Subnet must be same.
- Authentication.

Here, only directly connected networks.



Configuring Router R0:

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R0
R0(config)#
R0(config)#router eigrp 30
R0(config-router)#network 192.168.10.0 0.0.0.255
R0(config-router)#network 40.0.0.0 0.255.255.255
R0(config-router)#network 10.0.0.0 0.255.255.255
R0(config-router)#exit
R0(config)#^Z
R0#
%SYS-5-CONFIG_I: Configured from console by console

R0#wr
Building configuration...
[OK]
R0#
```

Configuring Router R1:

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R1
R1(config)#router eigrp 30
R1(config-router)#network 40.0.0.0 0.255.255.255
R1(config-router)#network 30.0.0.0 0.255.255.255
R1(config-router)#exit
R1(config)#^Z
R1#
%SYS-5-CONFIG_I: Configured from console by console

R1#wr
Building configuration...
[OK]
R1#
R1#
```

Configuring Router R2:

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R2
R2(config)#
R2(config)#router eigrp 30
R2(config-router)#network 30.0.0.0 0.255.255.255
R2(config-router)#
%DUAL-5-NBRCHANGE: IP-EIGRP 30: Neighbor 30.0.0.1 (FastEthernet1/0) is up: new adjacency

R2(config-router)#network 20.0.0.0 0.255.255.255
R2(config-router)#network 192.168.30.0 0.0.0.255
R2(config-router)#exit
R2(config)#
R2(config)#^Z
R2#
%SYS-5-CONFIG_I: Configured from console by console

R2#wr
R2#write
Building configuration...
[OK]
R2#
```

Configuring Router R3:

```
Router>enable
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#hostname R3
R3(config)#
R3(config)#
R3(config)#router eigrp 30
R3(config-router)#network 40.0.0.0 0.255.255.255
R3(config-router)#
%DUAL-5-NBRCHANGE: IP-EIGRP 30: Neighbor 40.0.0.1 (FastEthernet0/0) is up: new adjacency

R3(config-router)#network 30.0.0.0 0.255.255.255
R3(config-router)#exit
R3(config)#^Z
R3#
%SYS-5-CONFIG_I: Configured from console by console

R3#wr
R3#write
Building configuration...
[OK]
R3#
```

26. Access Control List (ACLs)

Monday, January 13, 2025 10:40 AM

Access Control Lists (ACLs) are used in networking to filter traffic and provide security for network devices. They can control both inbound and outbound traffic based on a set of criteria, such as IP addresses, protocols, and port numbers.

Types of ACLs

1. **Standard ACLs**
2. **Extended ACLs**
3. **Named ACLs**

1. Standard ACLs

Standard ACLs filter traffic solely based on the source IP address. They are simple but not as flexible as extended ACLs because they cannot filter traffic based on other criteria like destination IP address, protocol type, or port number.

- **Number Range**: 1-99 and 1300-1999
- **Syntax**:

  Router(config)# access-list [access-list-number] permit|deny [source-IP-address] [wildcard-mask]

  Router(config)# interface [interface-type] [interface-number]

  Router(config-if)# ip access-group [access-list-number] in|out

  Router(config-if)# exit

2. Extended ACLs

Extended ACLs provide more granular control compared to standard ACLs. They can filter traffic based on both source and destination IP addresses, protocol type (e.g., TCP, UDP, ICMP), and port numbers.

- **Number Range**: 100-199 and 2000-2699
- **Syntax**:

  Router(config)# access-list [access-list-number] permit|deny [protocol] [source-IP-address] [source-wildcard-mask] [destination-IP-address] [destination-wildcard-mask] [operator] [port-number]

  Router(config)# interface [interface-type] [interface-number]

  Router(config-if)# ip access-group [access-list-number] in|out

  Router(config-if)# exit

3. Named ACLs

Named ACLs are a more flexible way of defining ACLs. Instead of using a numbered ACL, you can assign a descriptive name, making it easier to manage and understand.

- **Syntax**:
  Router(config)# ip access-list standard|extended [ACL-name]

  Router(config-std-nacl)# permit|deny [source-IP-address] [wildcard-mask] (for standard ACL)

  Router(config-ext-nacl)# permit|deny [protocol] [source-IP-address] [source-wildcard-mask] [destination-IP-address] [destination-wildcard-mask] [operator] [port-number] (for extended ACL)

  Router(config)# interface [interface-type] [interface-number]

  Router(config-if)# ip access-group [ACL-name] in|out

  Router(config-if)# exit

Summary

- **Standard ACLs**: Simple, filters by source IP address only.
- **Extended ACLs**: More granular, filters by source and destination IP, protocol, and port.
- **Named ACLs**: More flexible, easier to manage using descriptive names.

27. Internet Protocol V6

Monday, January 13, 2025 10:47 AM

- **IPv6** (Internet Protocol version 6) is the most recent version of the Internet Protocol (IP) designed to replace IPv4.
- It was developed to address the limitations of IPv4, primarily the exhaustion of IP addresses. Here's an in-depth look at IPv6:

Key Features of IPv6:

1. **Larger Address Space**: IPv6 uses 128-bit addresses, allowing for approximately 3.4 x 10 ^38 unique addresses, compared to IPv4's 32-bit addresses (about 4.3 billion addresses).
2. **Simplified Header**: IPv6 has a simplified and more efficient header structure, reducing the processing burden on routers.
3. **Improved Security**: IPv6 was designed with security in mind, incorporating IPsec (IP Security) as a mandatory feature.
4. **Auto-Configuration**: IPv6 supports both stateful (DHCPv6) and stateless (SLAAC) auto-configuration mechanisms.
5. **No NAT Required**: With the vast address space of IPv6, Network Address Translation (NAT) is no longer necessary, simplifying network design.
6. **Improved Multicast and Anycast**: IPv6 enhances multicast (efficient delivery of packets to multiple destinations) and introduces anycast (packets delivered to the nearest member of a group).

IPv6 Address Structure:

- An IPv6 address is represented as eight groups of four hexadecimal digits, separated by colons, e.g., 2001:0db8:85a3:0000:0000:8a2e:0370:7334.
- Leading zeros in each group can be omitted, and a sequence of consecutive zeros can be compressed using :: (only once in an address), e.g., 2001:db8:85a3::8a2e:370:7334.

Types of IPv6 Addresses:

1. **Unicast**: A single unique address for one-to-one communication.
    - **Global Unicast**: Globally routable addresses (similar to public IPv4 addresses).
    - **Link-Local**: Used for communication within a single network segment (automatically configured, prefix fe80::/10).
2. **Multicast**: One-to-many communication, where packets are delivered to all interfaces in a multicast group (prefix ff00::/8).
3. **Anycast**: One-to-nearest communication, where packets are delivered to the nearest member of a group of interfaces sharing the same address.

Transition Mechanisms:

To ensure a smooth transition from IPv4 to IPv6, several mechanisms are used:

1. **Dual Stack**: Devices run both IPv4 and IPv6 simultaneously, allowing for gradual migration.
2. **Tunneling**: IPv6 packets are encapsulated within IPv4 packets to traverse IPv4 networks.
    - **6to4**: A transition mechanism that allows IPv6 packets to be transmitted over an IPv4 network.
    - **Teredo**: A tunnelling protocol that enables IPv6 connectivity for devices behind IPv4 NATs.

3. **Translation**: Techniques like NAT64 translate IPv6 packets to IPv4 packets and vice versa.

Benefits of IPv6:

- **Scalability**: Vast address space supports the growing number of internet-connected devices.
- **Simplicity**: Simplified header and no need for NAT streamline network operations.
- **Security**: Built-in IPsec ensures secure communication.
- **Efficiency**: Improved routing efficiency and multicast support optimize network performance.