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Computer Networks Cheat Sheet

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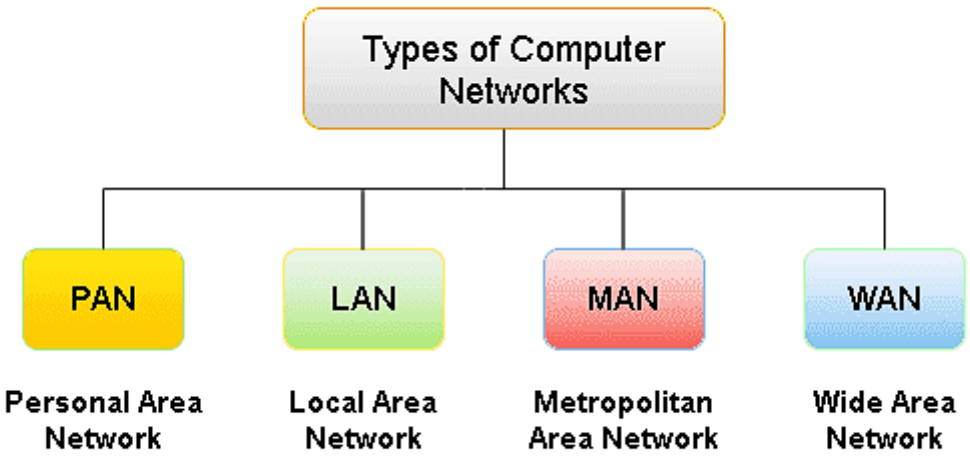
What is Computer Networking?

Computer networking is the process of connecting multiple devices to communicate and share resources, such as data, applications, and hardware, using wired or wireless technologies.

Types of computer networks:

PAN: Connects personal devices like phones, laptops, and smartwatches using Bluetooth or USB.
LAN: Connects devices in a small area like a home, office, or school using cables or Wi-Fi.

MAN: Links multiple LANs within a city or campus for better connectivity.
WAN: Covers large areas like cities or countries, connecting



Network Architectures

Client-Server Model

Description: Centralized system where clients request resources from a server (e.g., web browsing, email).

Advantages:

Efficient resource management, Higher security, Easy to update/maintain.

Disadvantages:

Single point of failure, Scalability issues, Higher setup cost.

Peer-to-Peer (P2P) Model

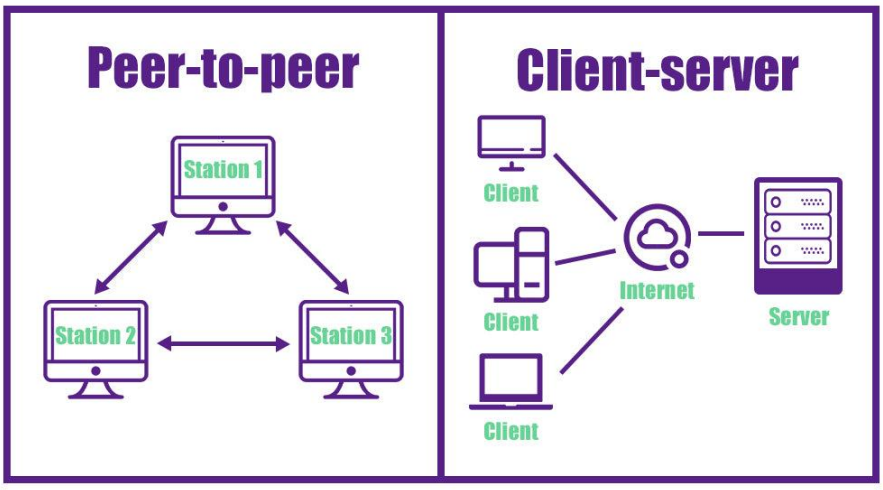
Description:

Decentralized network where devices share resources directly (e.g., file sharing, blockchain).

Advantages:

No single point of failure, Scalable, Cost-effective.

Disadvantages:



Socket Programming

A way of connecting two nodes on a network to communicate. One socket (server) listens on a port, while the other socket (client) connects to it

Socket Types

-TCP Socket (Stream Socket): Provides reliable, connection-based communication (i.e., TCP protocol).

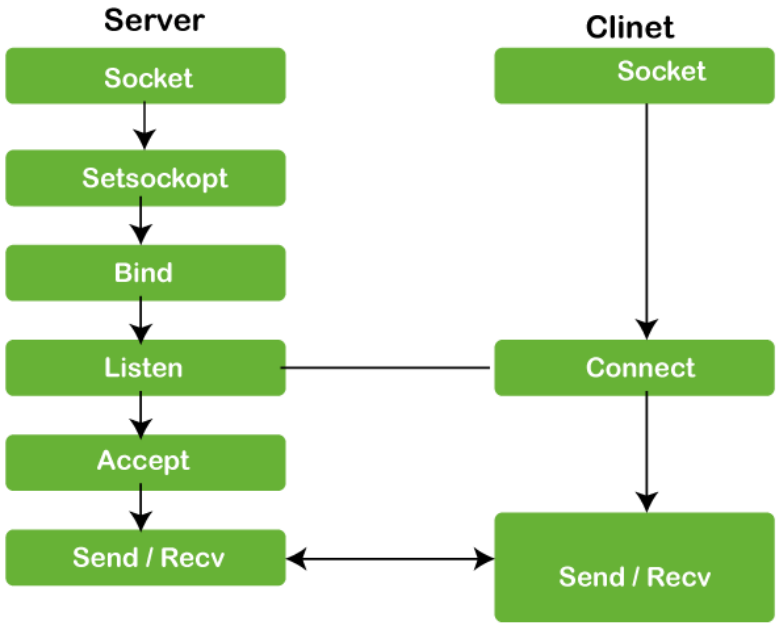
-UDP Socket (Datagram Socket): Provides connectionless communication, faster but unreliable (i.e., UDP protocol).

Server Stages

Socket Creation – socket (domain, type, protocol) creates a socket.
Set Socket Options – setsockopt() enables reuse of address/port.
Bind – bind() assigns an IP and port to the socket.
Listen – listen() makes the socket wait for client connections.
Accept – accept() establishes a connection with the client.

Client Stages

Socket Creation – Same as server.
Connect – connect() connects the client to the server.



Network Topologies

Bus: All devices share a single cable; simple but can have collisions.

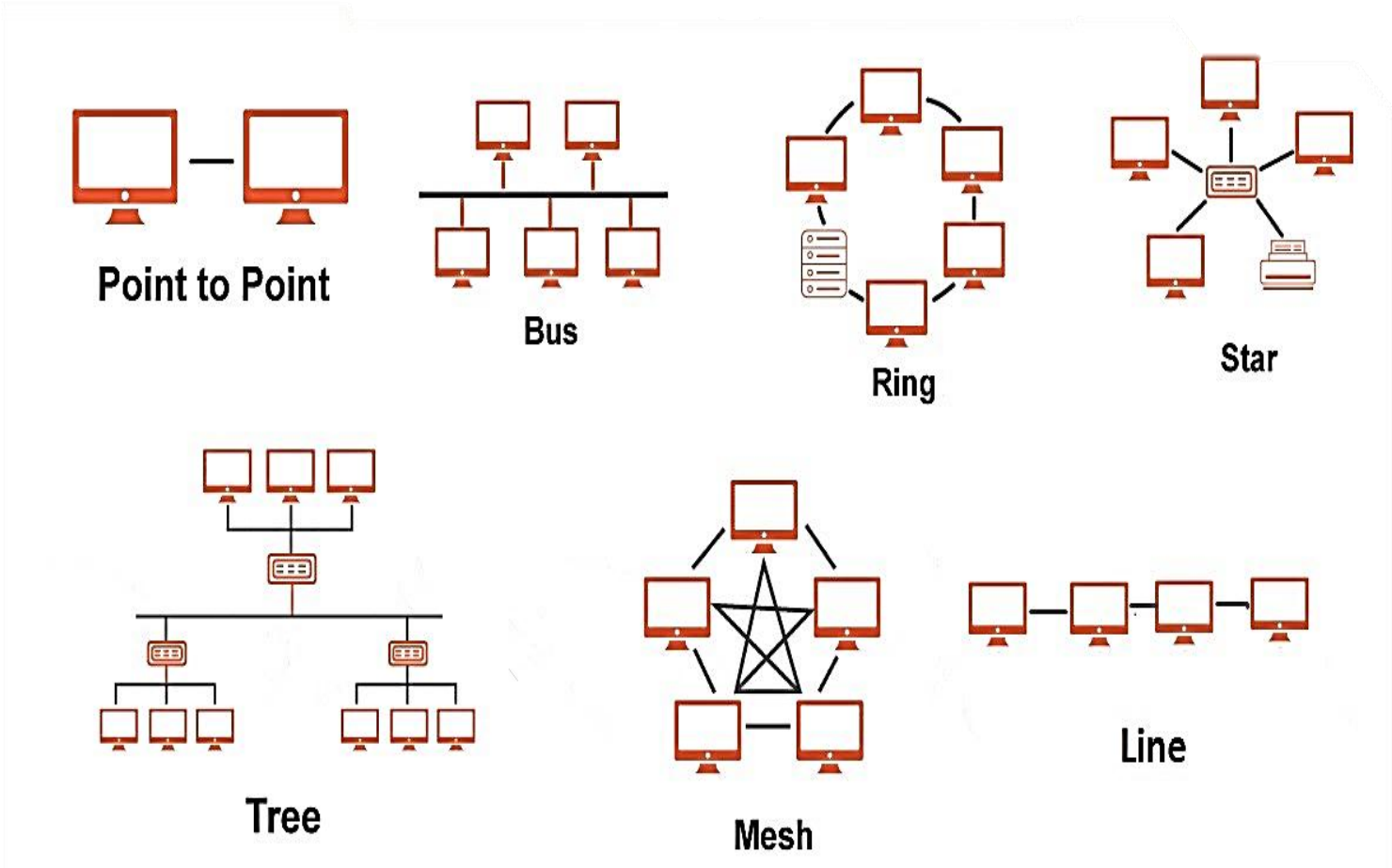
Star: Devices connect to a central hub; reliable but hub failure affects all.

Ring: Devices form a loop; efficient but a single failure can break the network.

Mesh: Every device connects to others; highly reliable but expensive.

Tree: A hierarchical structure with a root node and branches; scalable but complex.

Point-to-Point: Direct connection between two devices; simple and fast but limited.



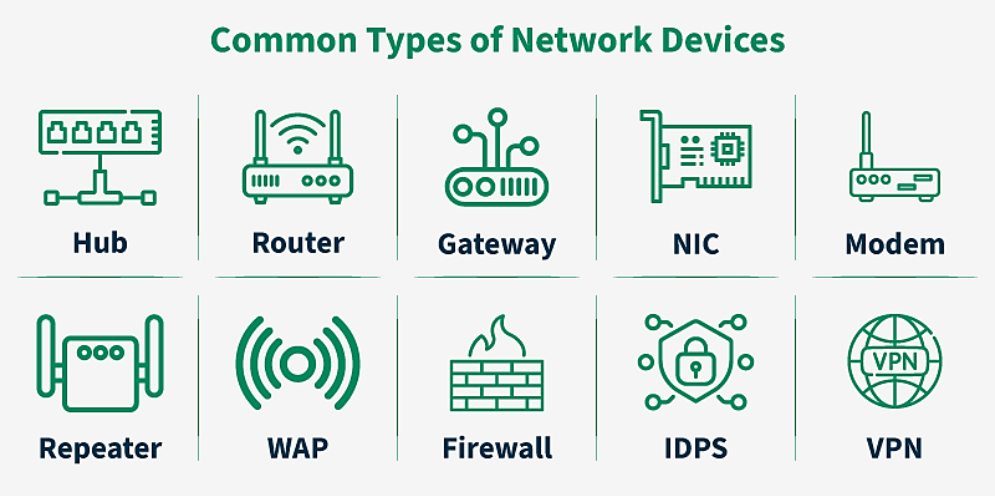
Network Devices

Router: Connects different networks and directs data between them.

Switch: Manages data flow within a network by forwarding data to specific devices.

Modem: Converts digital and analog signals for internet access.

Firewall: Protects the network from unauthorized access and cyber threats.



Network Layers & Concepts

Encapsulation & Decapsulation – Wrapping/unwrapping data in layers during transmission.

Flow Control & Congestion Control – Managing traffic to prevent overload.

Quality of Service (QoS) – Prioritizing network traffic for performance optimization.

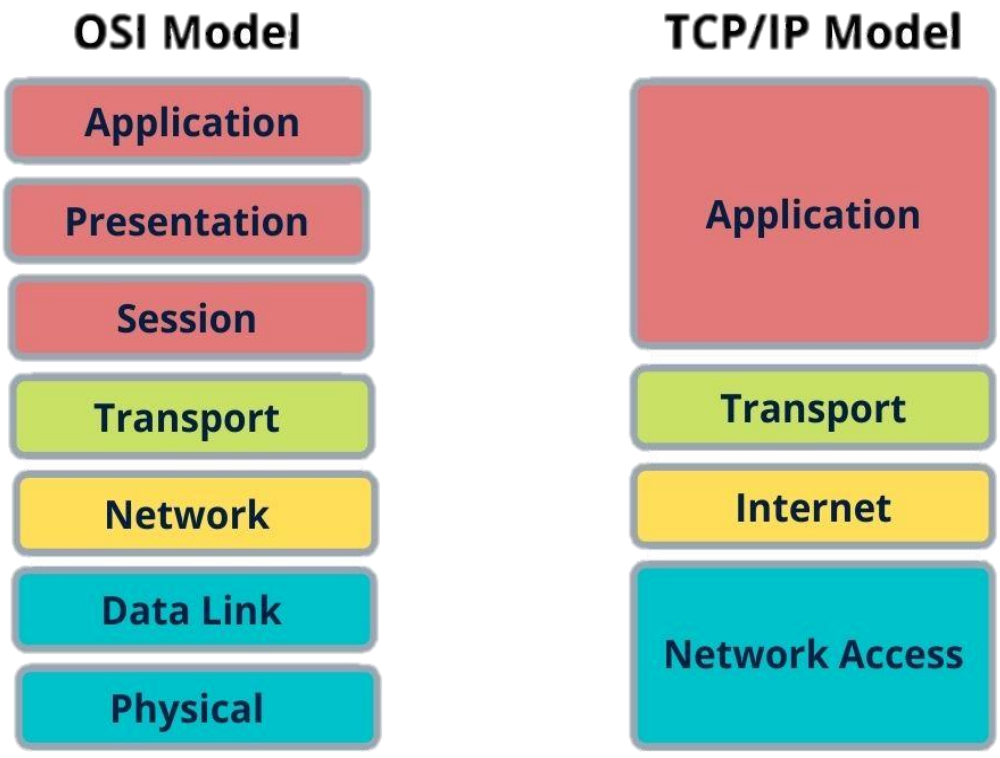
OSI Model & TCP/IP Model

7-Layer OSI Model:

1. Physical: Transmits raw data (cables, signals).
2. Data Link: Manages MAC addresses, error detection.
3. Network: Handles IP addressing and routing.
4. Transport: Ensures reliable data transfer (TCP, UDP).
5. Session: Manages connections between applications.
6. Presentation: Encrypts, compresses, and formats data.
7. Application: Provides services like HTTP, FTP, and email.

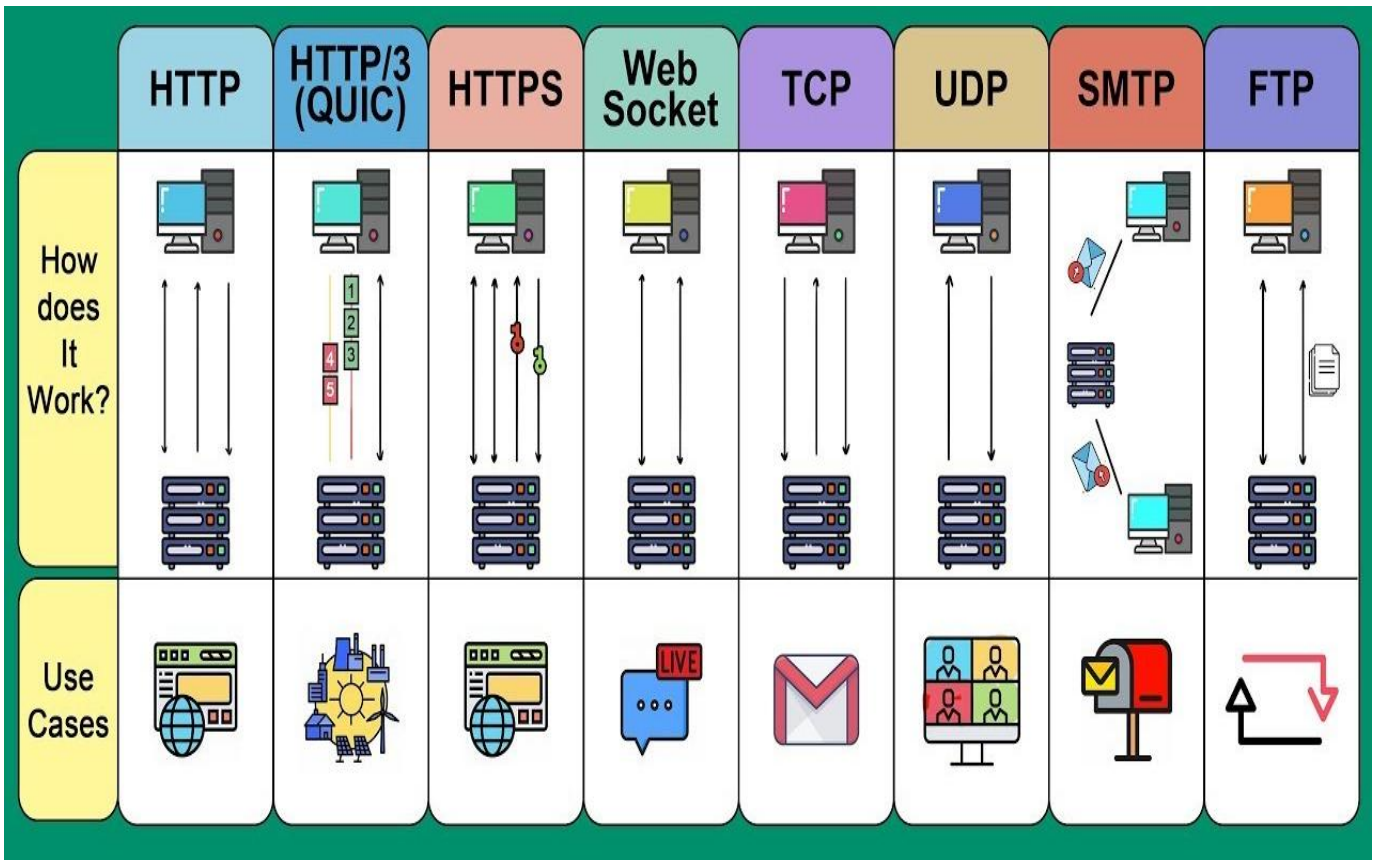
4-Layer TCP/IP Model:

1. Network Access: Handles physical connections and data transmission.
2. Internet: Manages IP addressing and routing.
3. Transport: Ensures end-to-end communication (TCP, UDP).
4. Application: Supports user applications like web browsing and email.



Networking Protocols

TCP/IP – Ensures reliable data transmission over networks.
HTTP/HTTPS – Used for web browsing; HTTPS is secure.
FTP – Transfers files between computers.
SMTP/POP3/IMAP – Email protocols for sending and receiving messages.
DNS – Translates domain names (e.g., google.com) into IP addresses.
ICMP – Handles error reporting and diagnostics.
ARP & RARP – Resolves IP addresses to MAC addresses and vice versa.
DHCP – Assigns IP addresses dynamically to devices.
BGP – Essential for routing between ISPs on the internet.



IEEE Networking Standards

IEEE Standard	Technology	Description
IEEE 802.3	Ethernet (Wired LAN)	Defines Ethernet networking standards, including Fast Ethernet (100 Mbps) and Gigabit Ethernet (1 Gbps, 10 Gbps).
IEEE 802.11	Wi-Fi (Wireless LAN - WLAN)	Covers wireless networking standards like Wi-Fi 4 (802.11n), Wi-Fi 5 (802.11ac), and Wi-Fi 6 (802.11ax).
IEEE 802.15	Bluetooth & WPAN	Short-range wireless communication for Bluetooth, Zigbee, and Wireless Personal Area Networks (WPANs).
IEEE 802.16	WiMAX (Broadband Wireless)	Provides long-range broadband wireless access, used in rural areas for high-speed internet.
IEEE 802.1X	Network Security	Authentication protocol for securing wired and wireless networks (e.g., enterprise Wi-Fi security).

Network Redundancy & Fault Tolerance

Load Balancing: Distributes network traffic to prevent overload.

Failover Mechanisms: Ensures backup systems take over in case of failure.

Redundant Links: Multiple network paths to prevent disconnection.

RAID for Network Storage: Protects data with redundant disk configurations.

Network Security

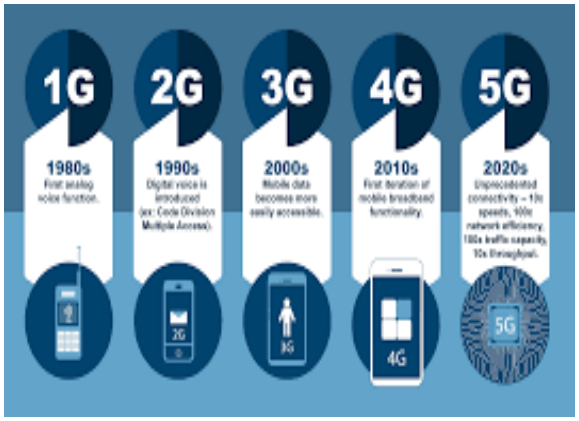
Firewalls – Filter incoming and outgoing traffic to protect networks.
VPNs – Encrypt internet connections for secure remote access.
Intrusion Detection Systems (IDS) – Monitor network traffic for suspicious activity.
MAC Filtering – Restricts network access based on device MAC addresses.
Public Key Infrastructure (PKI) – Manages digital certificates and encryption for secure communication.
Zero Trust Security – Requires strict identity verification for every access request.
MITM (Man-in-the-Middle) Attacks – Unauthorized interception of network communication.

Wireless Networks

Wi-Fi (802.11) – Standard for wireless local area networks (WLANs).
Bluetooth – Short-range wireless communication for devices.
Ad Hoc Networks – Temporary peer-to-peer wireless connections.
Mesh Wi-Fi Networks – Multiple routers working together for wider coverage.
NFC (Near Field Communication) – Enables contactless payments and data transfers.
LoRa (Long Range) – Low-power, long-range wireless communication for IoT.

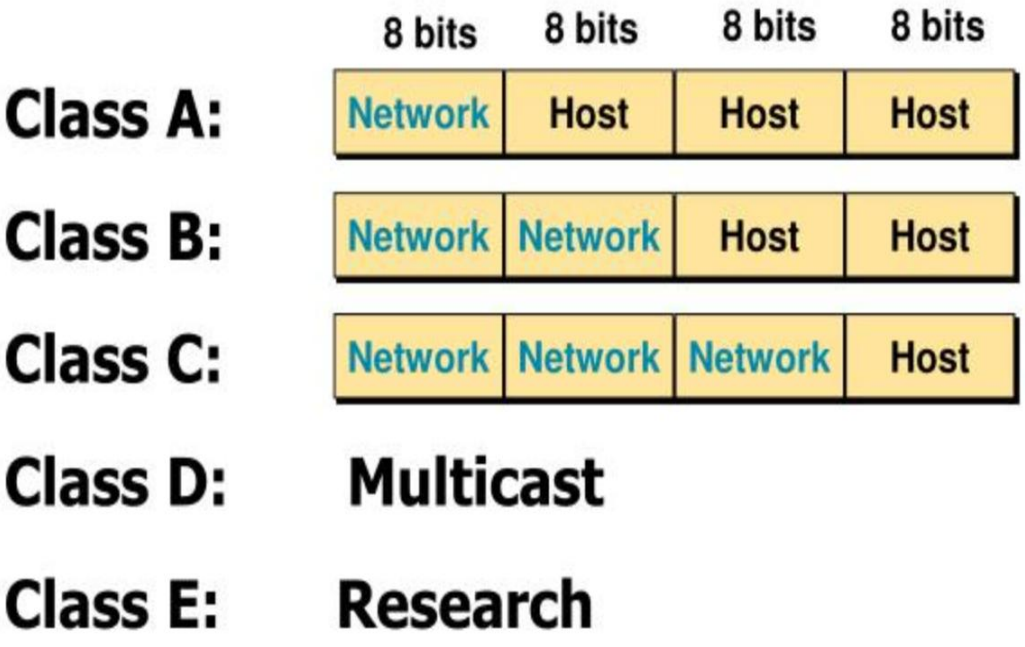
Mobile Networks

3G – First mobile broadband, enabling basic internet browsing.
4G LTE – High-speed mobile internet with improved reliability.
5G – Ultra-fast speeds, low latency, and massive device connectivity.
6G (Future) – Expected to bring AI-driven networking and terabit speeds.



Subnet Masking

Subnet masking is a way to separate the network part and the device (host) part of an IP address. It uses a special number called a subnet mask, and does a simple comparison (AND operation) to find which part of the IP belongs to the network. This helps routers know where to send data.



Network Troubleshooting Tools

Ping: Checks connectivity between devices.

Traceroute: Identifies the route packets take to reach a destination.

Netstat: Displays active network connections.

Nslookup: Resolves domain names to IP addresses.

Wireshark: Captures and analyzes network traffic.

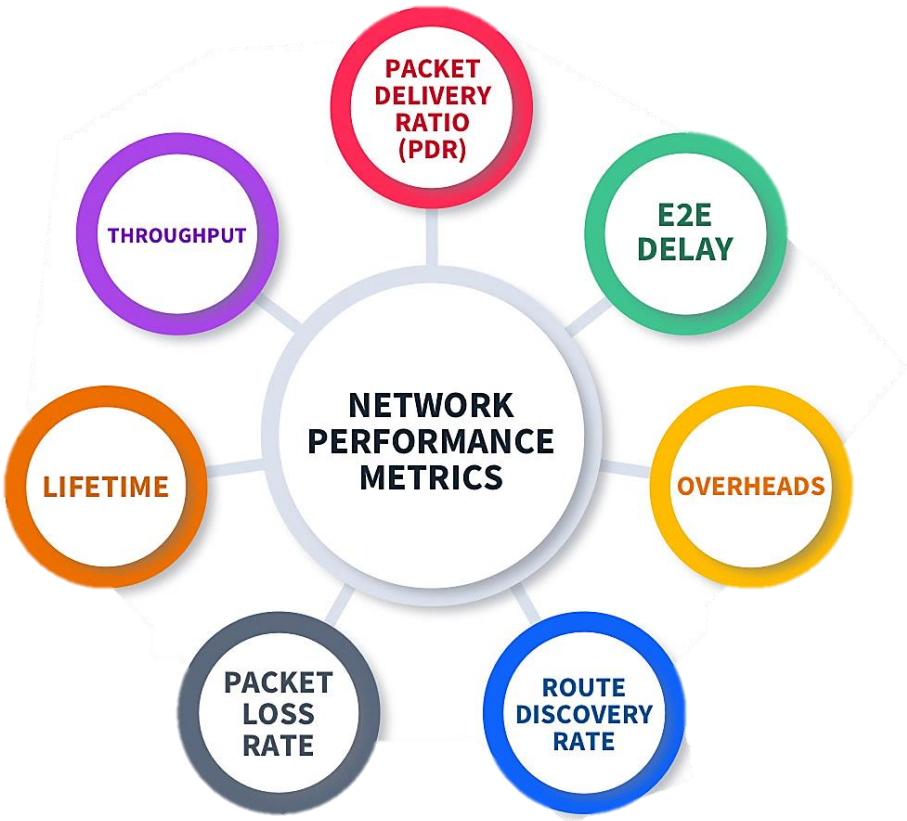
Network Performance Metrics

Bandwidth: Maximum data transfer rate of a network.

Latency: Delay in data transmission.

Throughput: Actual data transfer rate in real conditions.

Packet Loss: Data packets lost during transmission.



Networking Delays

The time taken for a data packet to travel from source to destination is known as Networking delay.

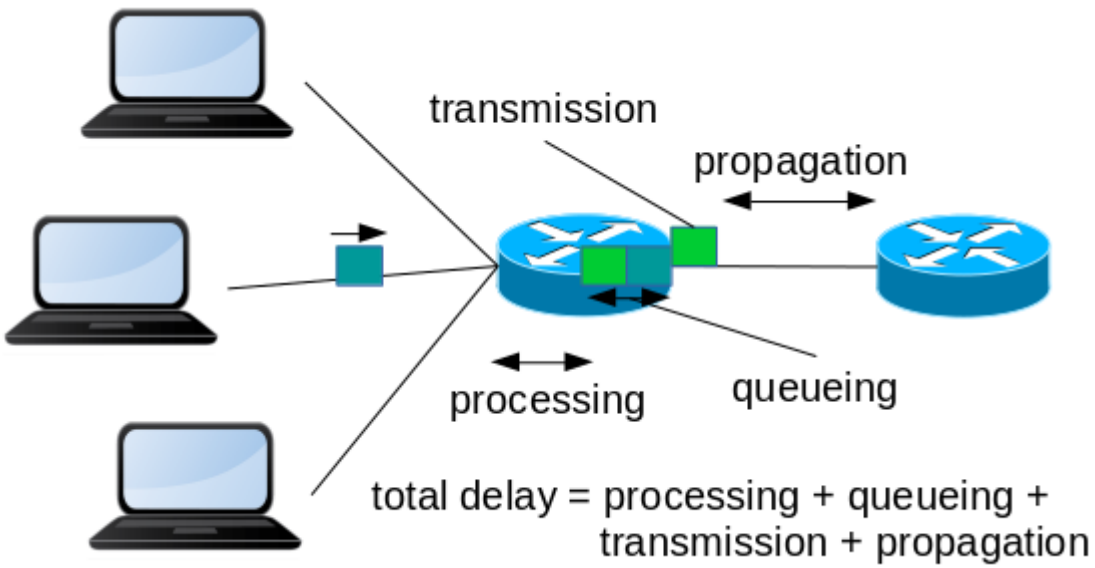
Types of Network Delays

Latency – Total time taken for a packet to reach its destination.

1. **Propagation Delay** – Time for a signal to travel through the medium.
    - Formula: Propagation Delay = Distance / Speed of Signal
2. **Transmission Delay** – Time taken to push all bits into the link.
    - Formula: Transmission Delay = Packet Size / Bandwidth
3. **Processing Delay** – Time routers/switches take to process packets.
4. **Queuing Delay** – Time a packet waits in a queue before processing.

Ways to Reduce Network Delays

Use faster transmission media (fiber optics over copper cables), Optimize routing algorithms, Increase bandwidth, Reduce congestion using load balancing and QoS techniques.

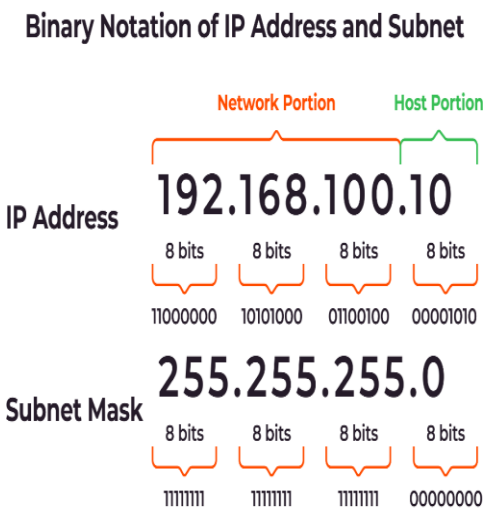


IP Addressing & Subnetting

IPv4 (32-bit) & IPv6 (128-bit): IPv6 offers more addresses and better security.

Private vs. Public IPs: Private IPs are for local networks; public IPs are globally unique.

Subnet Mask & CIDR: Defines network size (e.g., 255.255.255.0 or /24 for 256 addresses).

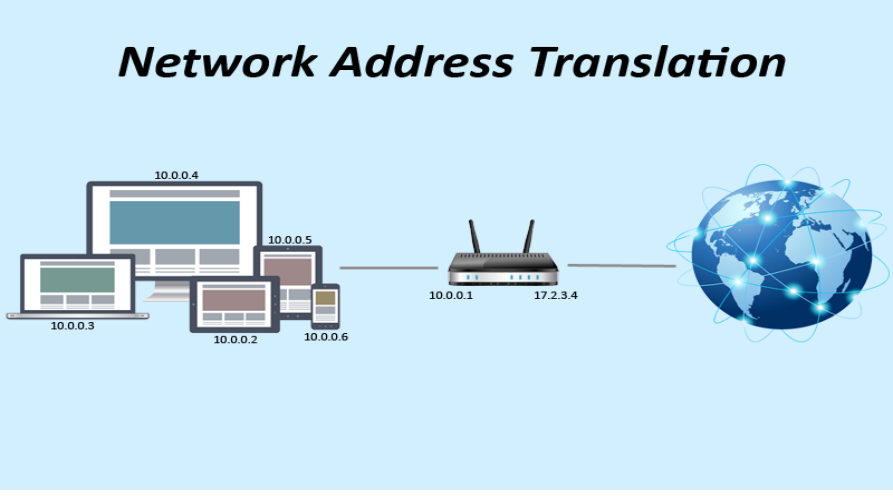


Network Address Translation (NAT)

NAT is critical for understanding how devices share public IPs, especially with IPv4 exhaustion. It ties into your "IP Addressing & Subnetting" section.

Network Address Translation (NAT)

- Purpose: Maps private IPs to public IPs for internet access.
- Types: Static (1-to-1), Dynamic (pool), PAT (port-based, many-to-1).
- Example: 192.168.1.10: port → 203.0.113.5: port.
- Pros: Saves IPv4 addresses; Cons: Can complicate peer-to-peer apps.



Multiplexing & Demultiplexing in Networking

Multiplexer (MUX) – Combines multiple data streams into **one signal** for efficient transmission over a single communication channel.
Demultiplexer (DEMUX) – Splits a single incoming signal into **multiple data streams** at the receiver's end.
Types of Multiplexing:

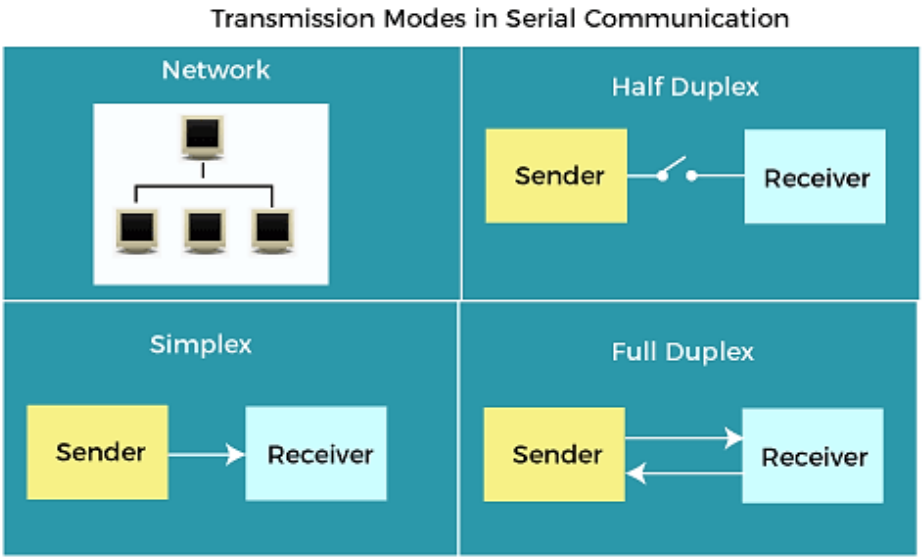
- **FDM (Frequency Division Multiplexing)** – Assigns different frequency bands to multiple signals (e.g., radio, TV broadcasting).
- **TDM (Time Division Multiplexing)** – Divides transmission time into slots for multiple signals (e.g., telephone networks).
- **WDM (Wavelength Division Multiplexing)** – Used in fiber optics to transmit multiple light signals at different wavelengths.

Data Transmission Modes

Simplex: One-way communication (e.g., radio broadcasting).

Half-Duplex: Two-way communication, but only one direction at a time (e.g., walkie-talkies).

Full-Duplex: Simultaneous two-way communication (e.g., phone calls).



Cloud & Modern Networking

Cloud Computing: Internet-based computing services (AWS, Azure, GCP).

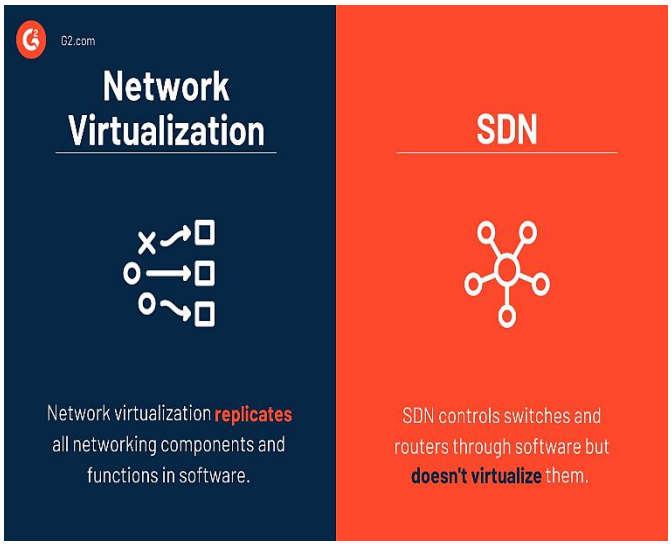
SDN (Software-Defined Networking): Centralized network control for flexibility.

Edge Computing & IoT: Processes data closer to devices for faster responses.

Network Virtualization & SDN

Virtual LAN (VLAN): Logically separates network traffic to improve security and efficiency.

Software-Defined Networking (SDN): Centralized network control for better management and flexibility.



References:

GOOGLE & CHATGPT.

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