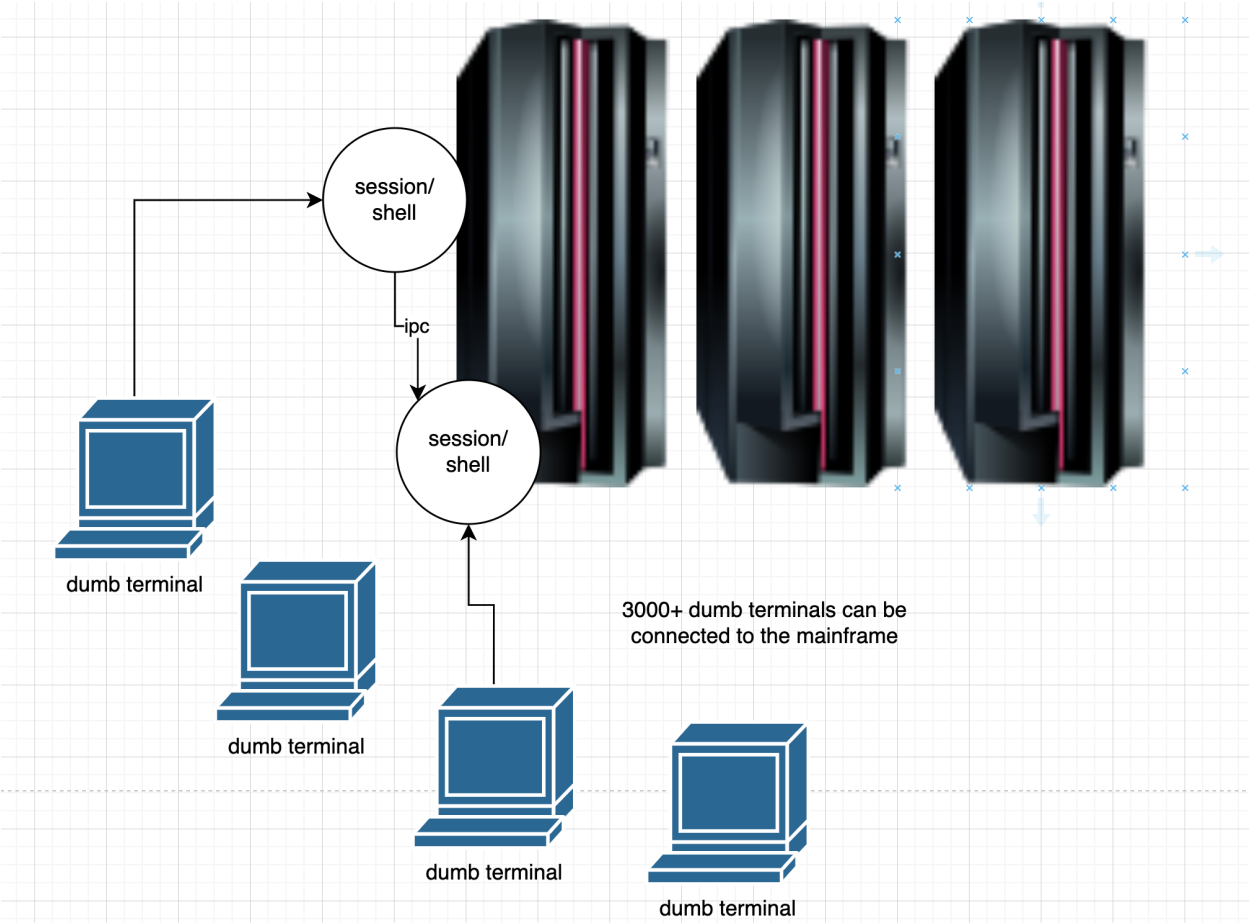
Network fundamentals

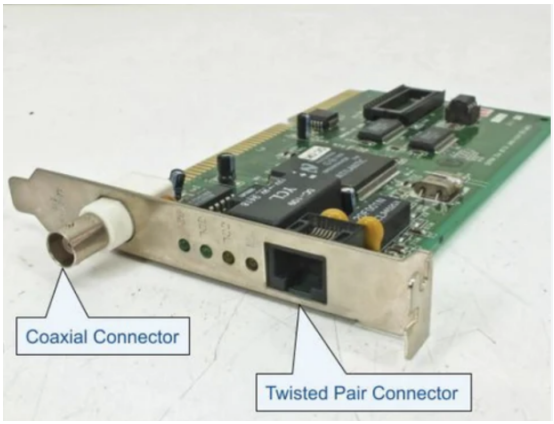


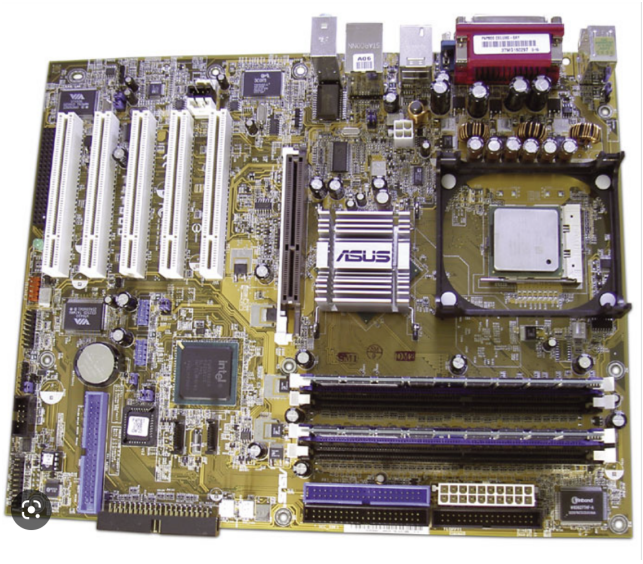
Components involved in computer network

1. NIC (network interface card)
2. Hub
3. Switch/ bridge
4. Modem
5. Router
6. Cables
7. Connectors
    a. T junction
    b. Caps

Network interface cards

- Hardware device to be installed on a motherboard of a PC
- Allows a network cable to be connected to your PC
- Most modern computer's motherboard already has an integrated NIC
- It has a socket for a network cable called RJ45
- In most modern laptops, we don't have this at all, instead we depend on wireless network interface card

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Hub

- As the name suggests, it is the central piece of equipment in a computer network
- Has multiple (5 to 8) rj45 sockets, using which you may connect multiple computers and printers, making it a computer network
- When a computer wants to send a message to another computer, this acts like a receiver of the message, which then broadcasts the message to all the computers. The one which is the intended recipient, will only receive the message.

Switch

- similar to a hub, but with much better performance and more number of connection possibilities
- Unlike the hub, it does not broadcast the message to all the computers, but forwards the message to the intended recipient directly

Modem (Modulator + Demodulator)

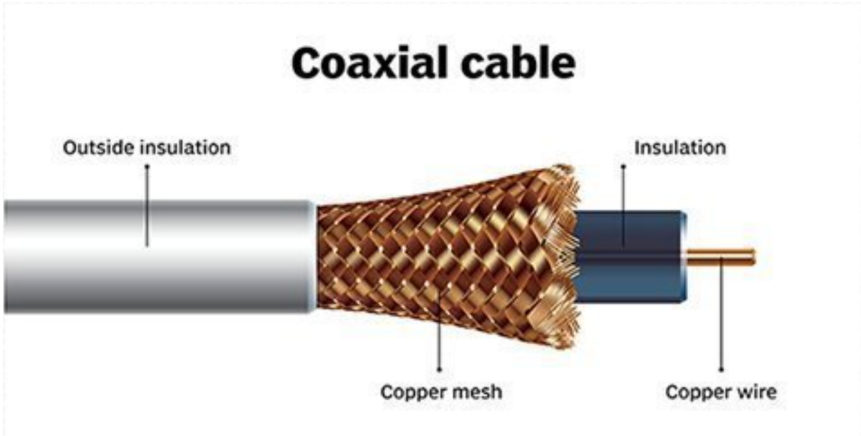
- A device that was used for getting an external internet connection via the telephone line
- Used AM/FM band to carry the internet signals
- Special software was used on the PC to switch ON/OFF the internet connection.

Router

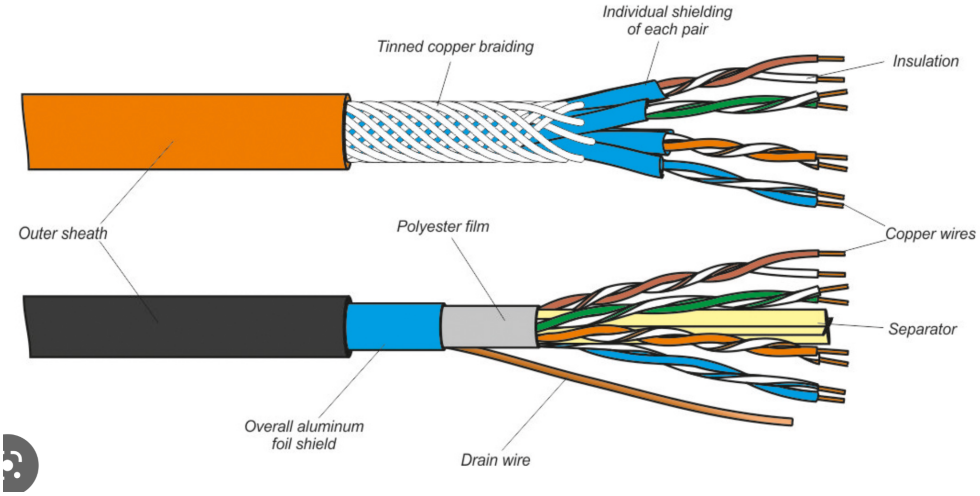
- Replacement for Modem
- Use this for a local network of computers or receiving internet connection from an external source.
- Mostly every home network has one.
- Different types of connection media are available
    - Regular high speed internet cable
    - Optic fiber cable

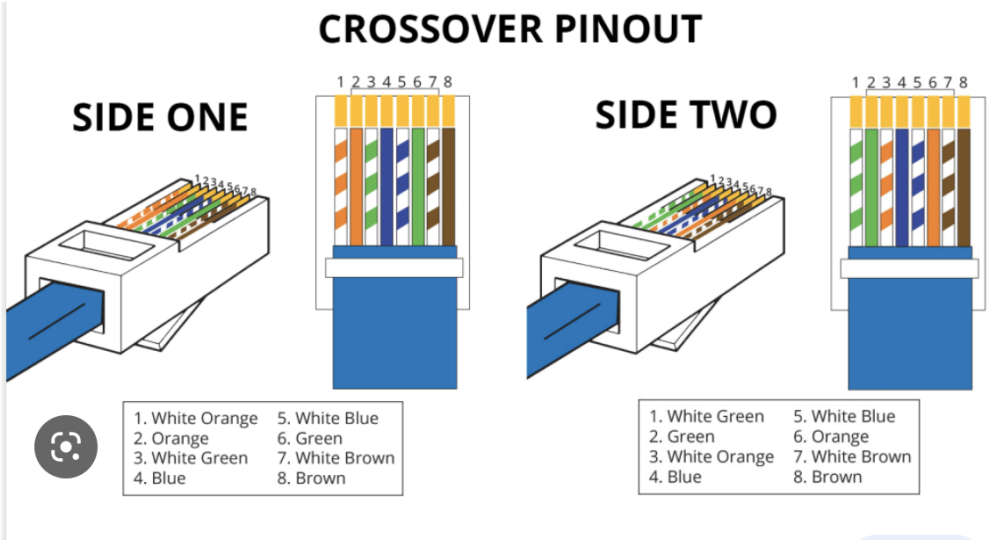
Cables

- One of the most important components of a computer network
- Primary medium of transmission
- Specialized cables are used
    - Coaxial cable
    - Twisted pair cable
    - Fiber optic cable

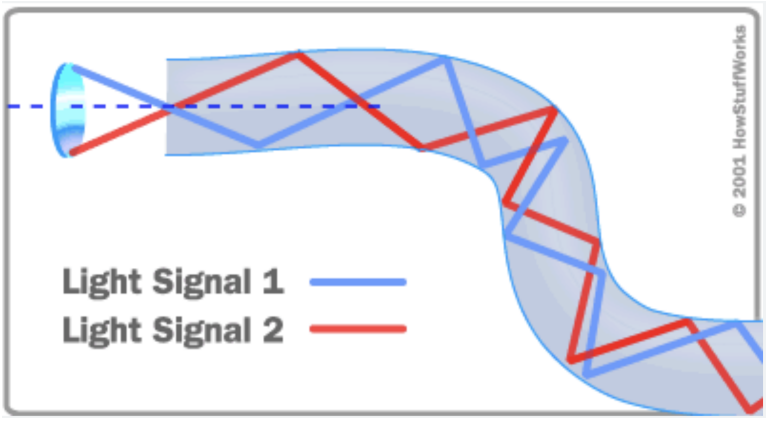


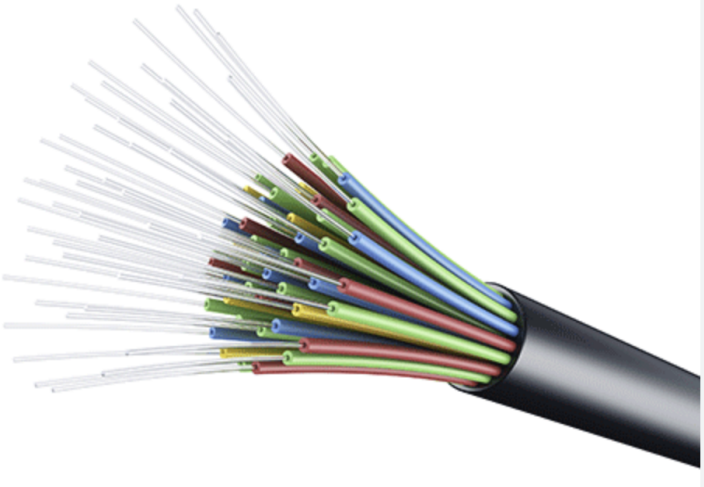
Twisted pair cable





Optic fiber working principle





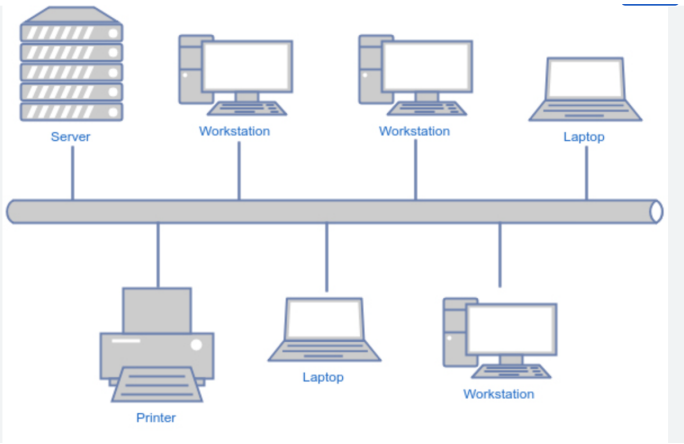
How does the internet work?
https://www.youtube.com/watch?v=TNQsmPf24go

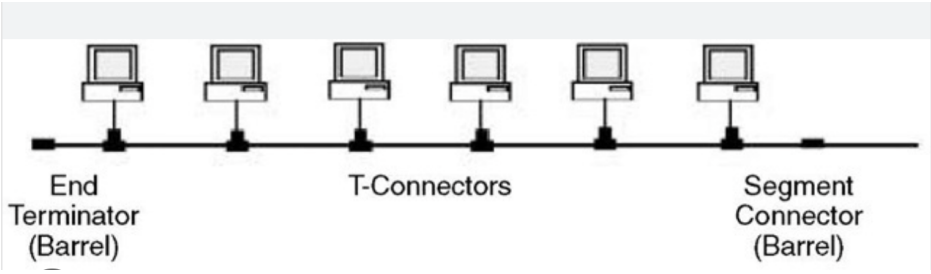
Network topologies

- Defines the structure or architecture of the network
- How to put all the components together so that a network exists
- Based on the geometric representation of all the nodes (computers and other devices like printers)
    - Bus
    - Ring
    - Star
    - Tree
    - Mesh
    - Hybrid

Bus topology

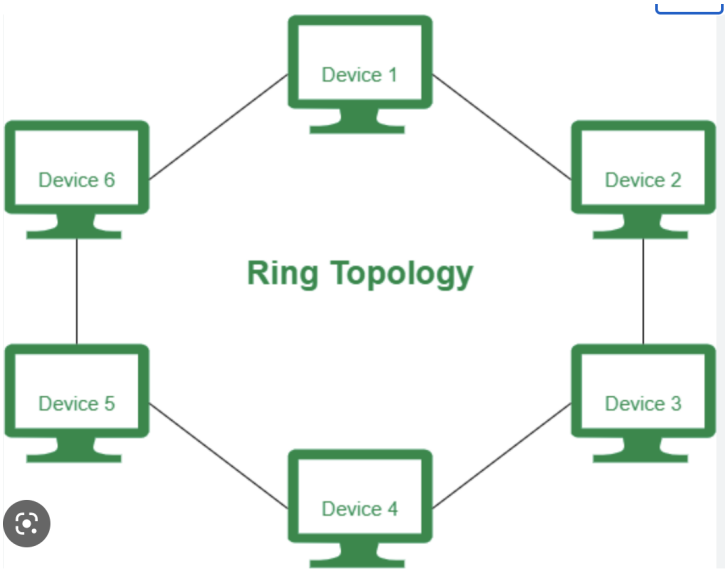
- Uses coaxial cable with T-Connectors, barrels and Terminators
- No computer is designated as server
- You can share files with each other
- Advantages:
    - Low cost
        - no hub/switch required
        - coaxial cable is less expensive than twisted pair cable, which also require RJ45 plugs, crimping tool, sockets etc
    - Simple to use/ setup/ install
    - Failure in one node will not impact other nodes
- Disadvantages:
    - Limited for small number of nodes
    - Extensive cabling may disrupt the entire network
    - Troubleshooting is difficult
    - Low performance
    - signal interference is high due to close proximity of other cables and EMF
    - Attenuation - loss of signal due to the length of the cable





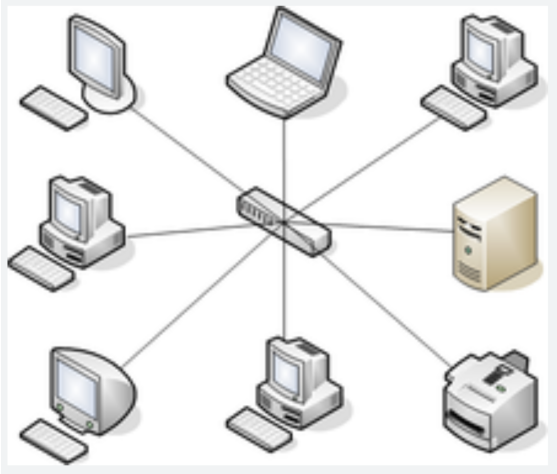
Ring topology

- Similar to bus topology, except that there are no terminators, and the two endpoints are connected to each other, forming a circle
- Advantages:
    - all of that of bus topology
    - many hardware/software tools for network monitoring is available
    - reliable
- Disadvantages
    - all of that of bus topology



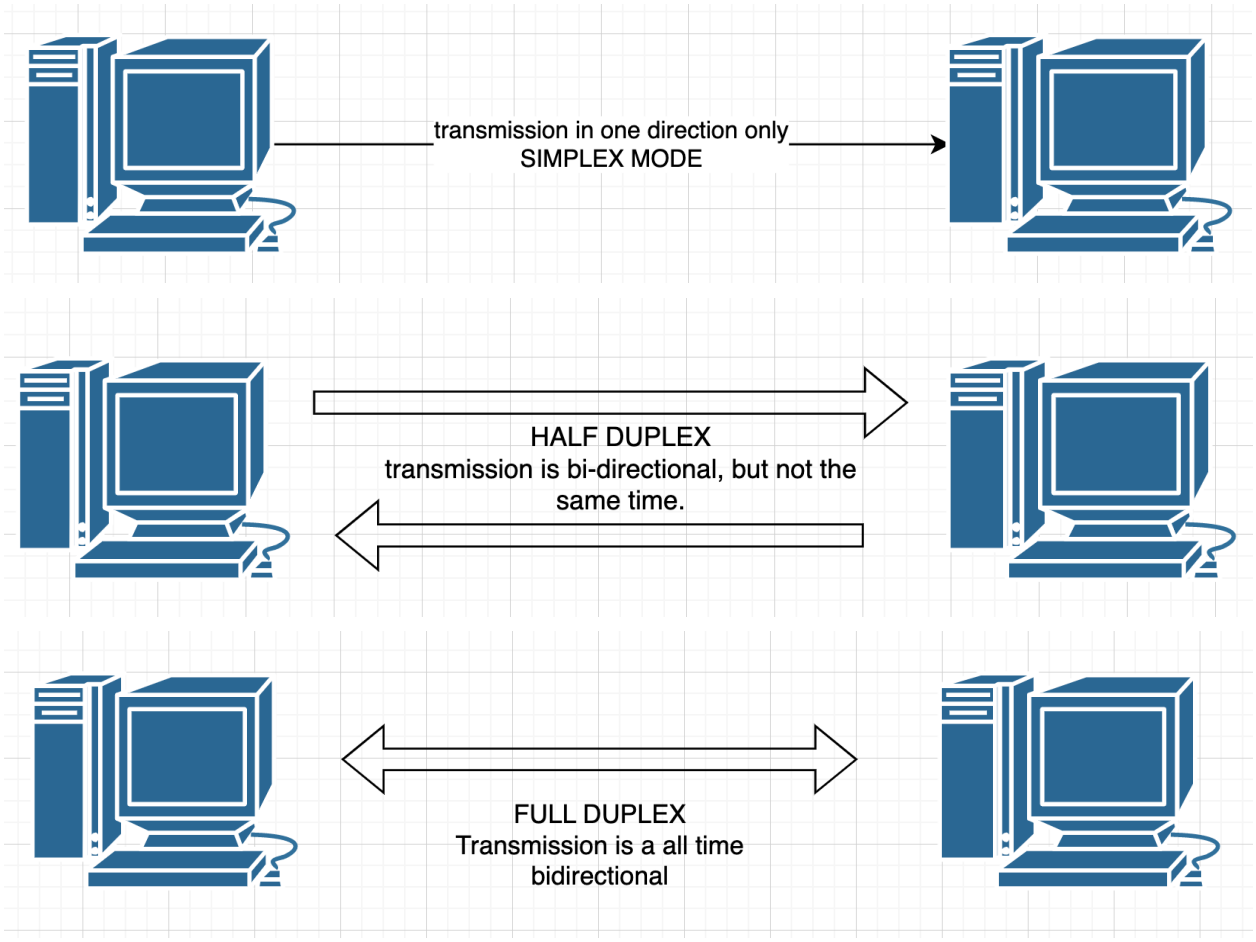
Star topology

- Uses twisted pair cable along with a hub or a switch (or a router today)
- Hub is the central piece of hardware that connects all the nodes
- Advantages:
    - Better performance than that of bus/ ring topology
        - just by using the twisted pair cable alone
    - More control over the network (betters software)
    - Limited failure (due to the cabling efficiency)
    - Adding/ removing nodes to the network does not affect other nodes
    - Data speed up to 100 Mbps
- Disadvantages:
    - Single point of failure (hub)
    - Cost is high
        - cable
        - sockets/ plugs/ tools
        - hub/ switch



Modes of transmission

1. It's the way in which data is transmitted from one node to another node in the network
2. A.k.a communication mode
3. Transmission media (such as cable) provide a direction of communication, and hence the transmission mode is a directional mode
4. Based on the direction, the transmission mode is divided into:
    a. Simpex mode
    b. Half duplex mode
    c. Full duplex mode



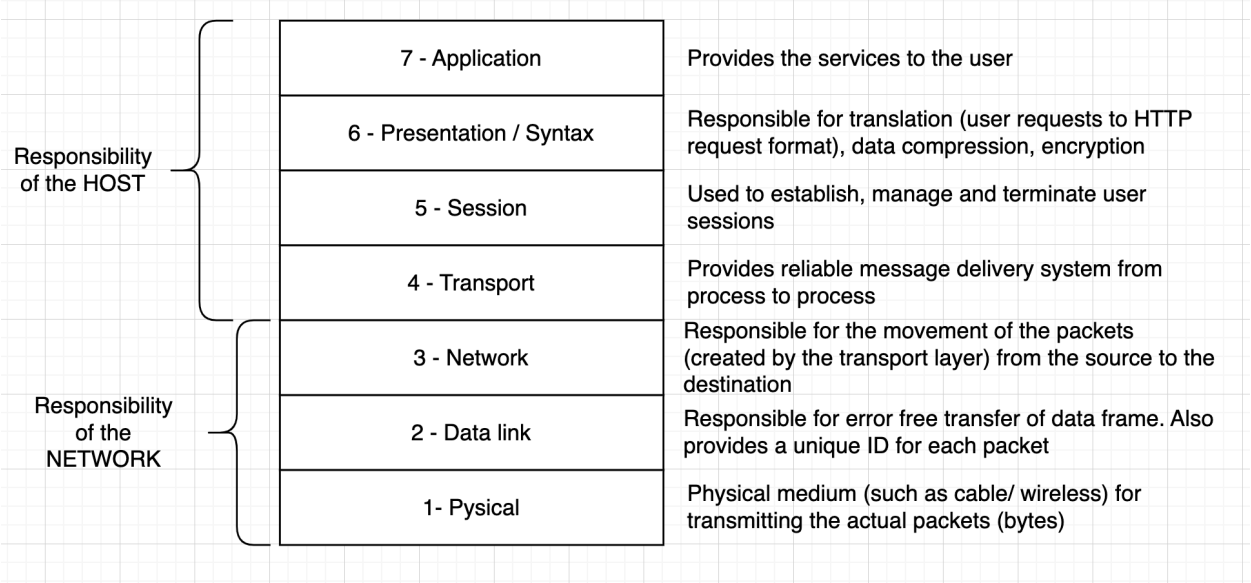
Types of computer networks

(based on size and geographical distribution)

1. LAN - Local area network
2. PAN - Personal area network
3. MAN - Metropolitan area network
4. WAN - Wide area network
5. VWAN - Very Wide area network

The OSI Reference model

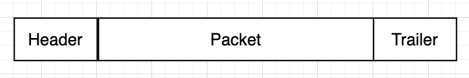
- Open System Interconnectivity model
- Standardized by ISO



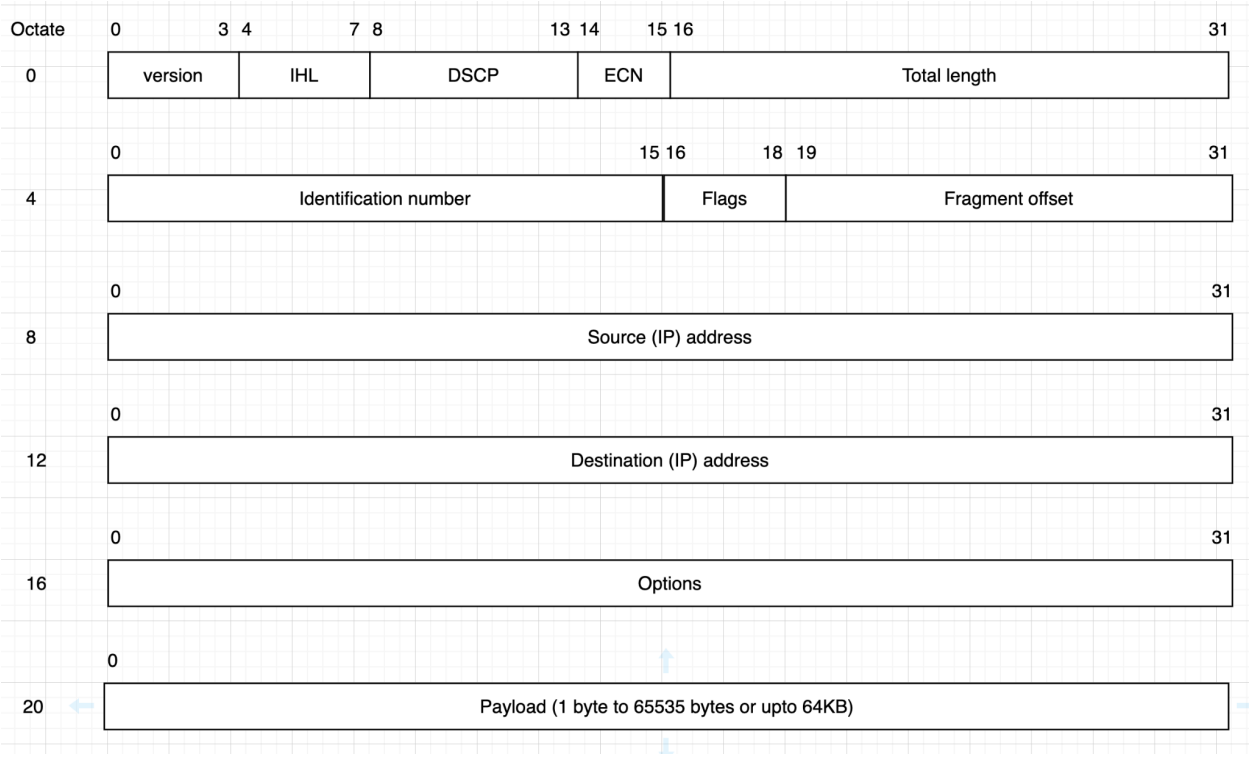
	Example implementations
7 - Application	Web browsers, MS-Teams, Zoom, MS-Outlook, WhatsApp, Telegram
6 - Presentation / Syntax	HTTP, SMTP, ...
5 - Session	
4 - Transport	TCP or UDP
3 - Network	Router / IP ARP
2 - Data link	NIC / MAC
1- Pysical	Cables

Data frame created by Data Link Layer

- When receiving a message from the network:
    - While the DLL gets a packet from the physical layer, it adds a “header” and a “trailer” to the same, making it a data-frame. This is what is given to the Network layer.
- When sending a message to the network
    - The DLL strips off the header and the trailer from the data-frame and sends only the packet over the network.



Structure of an IPv4 packet

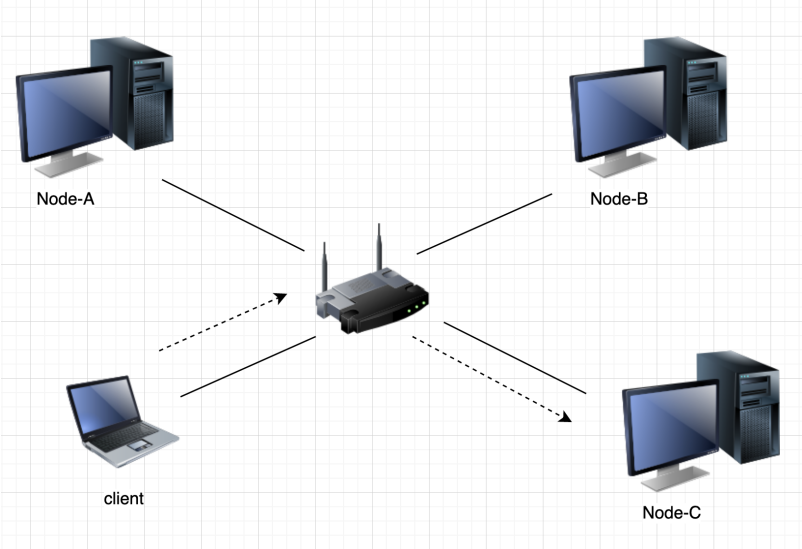


- VERSION - IP version used (IPv4 → 4)
- IHL → Internet Header Length
- DSCP → Differentiated Service Code Point (Type of service)
- ECN → Explicit Congestion Notification (Any possible traffic congestion seen en-route)

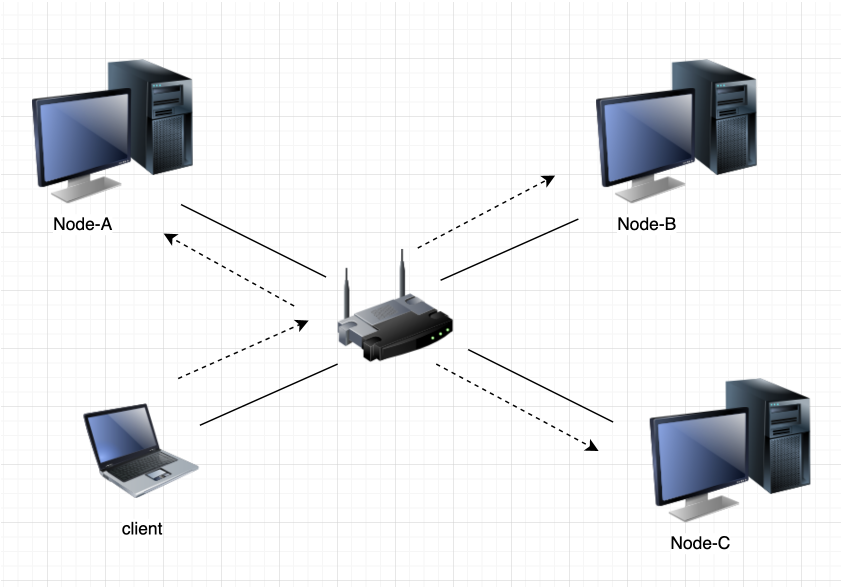
IPv4 Addressing

3 types of addressing modes

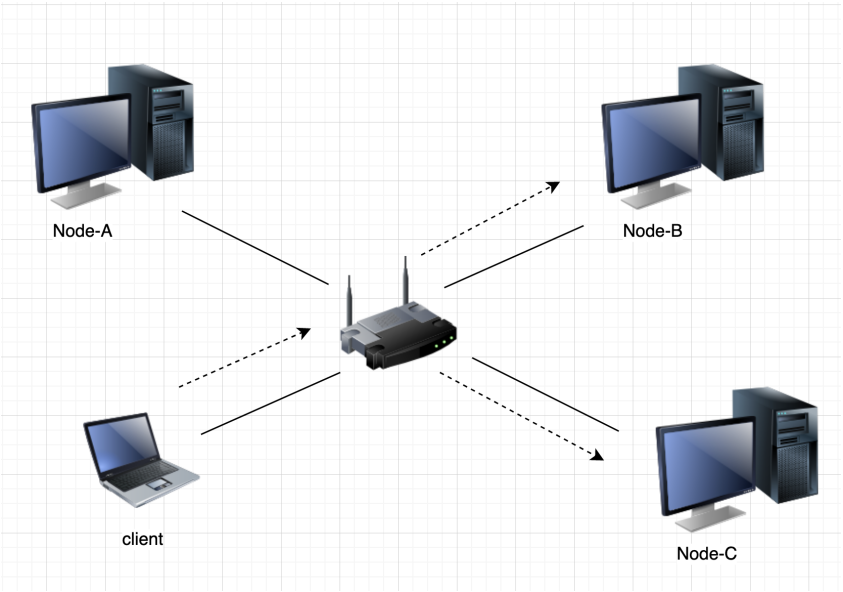
- Unicast addressing mode
    a. Data is sent to only one destined node
    b. Destination address field (in the IP header) contains 32-bit address of the destination
    c. Clients send data to the targeted server



- Broadcast addressing mode
    - The packet is addressed to all the hosts of the network segment
    - The destination address field in the IP header contains a special broadcast address (255.255.255.255)
    - When the node sees the packet on the network, it is supposed to process the same

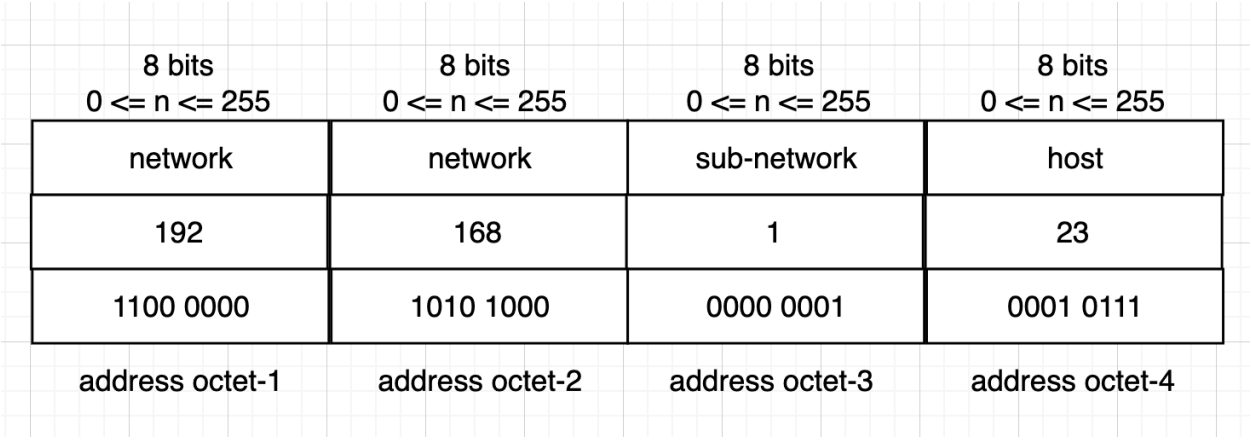


- Multicast addressing mode
    - Combination of unicast and broadcast modes
    - Neither destined for single node or all the nodes
    - Messages sent by a client may be processed by one more more nodes
    - The IP header has a special address (224.x.x.x) as the destination address



Hierarchical Addressing Scheme

- The address field (in the IP header) contains 4 bytes, each of which represents networks and hosts



8 bits 0 <= n <= 255	8 bits 0 <= n <= 255	8 bits 0 <= n <= 255	8 bits 0 <= n <= 255
network	network	sub-network	host
192	168	1	23
1100 0000	1010 1000	0000 0001	0001 0111
address octet-1	address octet-2	address octet-3	address octet-4

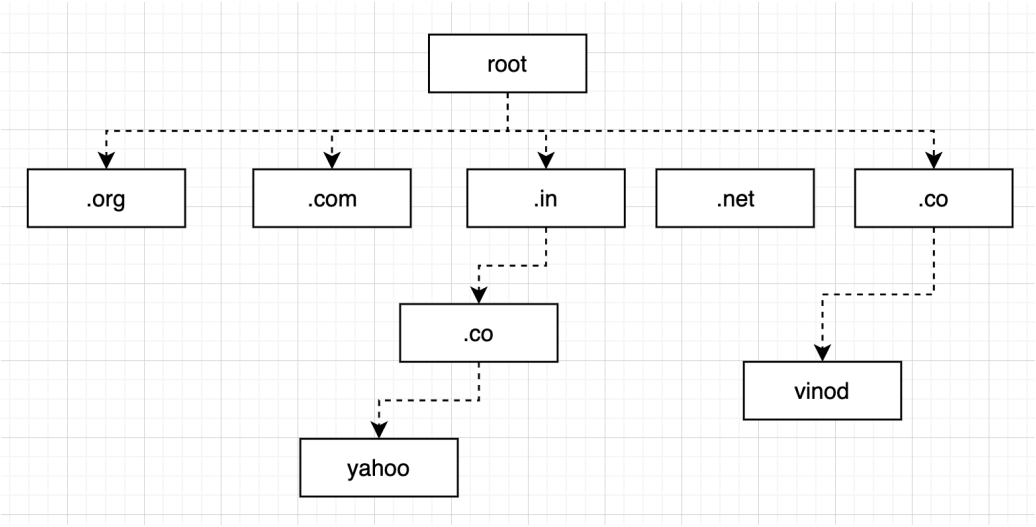
IPv4 Address classes

Categorized into 5 classes

- Class A
    - 1st bit in the 1st octet is always 0, which means we have only 7 bits for representing a number
    - 1.x.x.x to 126.x.x.x
    - The default subnet mask is 255.0.0.0
    - The maximum number of networks possible is 126
    - Address format for this class is 0#######.########.########.########
- Class B
    - 1st two bits of the 1st octet are always equal to “10”
    - 128.x.x.x to 191.x.x.x
    - Address format for this class is 10######.########.########.########
    - Can represent up to 16384 networks and 65534 hosts
- Class C
    - 1st 3 bits of the 1st octet = “110”
    - 192.x.x.x to 223.x.x.x
    - Address format for this class is 110#####.########.########.########
    - Up to 2^21 (20,97,152) networks and 254 hosts in each network (53,26,76,608)
- Class D
    - (self learning)
- Class E
    - (self learning)

Application protocols

1. DNS
    a. Domain name system
    b. It is a directory service that provides a mapping between the name of the host and the network IP address
    c. TLD (Top level domain) registrars
        i. .com → commercial
        ii. .info → informational
        iii. .org → organizational
        iv. .edu → educational
        v. .biz → business
        vi. .dev → programming/tools/etc
        vii. .ai → artificial intelligence



2. FTP (File transfer protocol)
3. Telnet (Terminal Network)
4. SMTP (Simple mail transfer protocol)
5. POP3 (Post office protocol)
6. SNMP (Simple network management protocol)
7. HTTP (HyperText Transfer Protocol)