Network basics

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What is a Network? A network is a group of connected devices that communicate and share data, resources, or services with each other.

Types of Networks

Network Type	Full Form	Range	Example
PAN	Personal Area Network	1 – 10 meters	Bluetooth, Smartwatch to Phone
LAN	Local Area Network	Up to 100 meters	Home Wi-Fi, Office Network
MAN	Metropolitan Area Network	Up to 50 km	City-wide Wi-Fi, Cable TV Networks
WAN	Wide Area Network	100 km to worldwide	The Internet, Bank Networks

Types of Data Transfer

- Fiber optic cable
- Copper cable
- Wireless (radio waves)

ISP (Internet Service Provider) gets a unique pool of IPs from **IANA (Internet Assigned Numbers Authority).**

Network Topologies

Topology	How to Achieve	Key Devices
Star	Connect all devices to a central switch/router	Switch, Router, Ethernet cables
Bus	Connect devices along a single backbone cable	Coaxial cable, T-connectors, Terminators
Ring	Connect each device to two others in a loop	Network Adapters, Fiber/Twisted pair cables
Mesh	Connect devices directly to multiple others	Routers, Switches, Wi-Fi Mesh Routers

Network Devices

Device	Function	Example Usage
Router	Connects different networks, assigns IPs	Home Wi-Fi, Internet backbone
Switch	Connects multiple devices in LAN using MAC addresses	Office LAN, Data centers
Hub	Broadcasts data to all devices	Small legacy networks
Modem	Converts digital to analog and vice versa	DSL, Fiber, and Cable internet
Repeater	Amplifies network signals	Extending Wi-Fi range
Access Point (AP)	Provides wireless network access	Office Wi-Fi, Public hotspots
Gateway	Connects different network protocols	VoIP systems, Enterprise network

Ports

- **Physical Port**
- **Logical Port** (software-based endpoint)

IPv4 vs IPv6

Feature	IPv4	IPv6
Bit Length	32 bits	128 bits
Address Space	4.3 billion	3.2 * 10^38
Format	Decimal	Hexadecimal

NIC (Network Interface Card) supports:
- Wired connections
- Wireless connections

Network Packets:
- **CRC (Cyclic Redundancy Check)** for error detection.
- **MAC address** included in the packet.
- **Frame Structure:** Destination MAC, Source MAC (6 bytes), Type (2 bytes), Data (46 - 1500 bytes), FCS (4 bytes, CRC for error checking).

IPv4 Address Classes

Class	First Octet Range	Default Subnet Mask	No. of Networks	No. of Hosts per Network
A	1 - 126	255.0.0.0	128	16,777,214
B	128 - 191	255.255.0.0	16,384	65,534
C	192 - 223	255.255.255.0	2,097,152	254
D	224 - 239	N/A (Multicast)	Multicast	Not for Host Assignment
E	240 - 255	N/A (Experimental)	Reserved	Not for Host Assignment

TCP/IP Model

- **Application Layer**: Application message
- **Transport Layer**: TCP segment or UDP datagram
- **Network Layer**: IP packet
- **Data Link Layer**: Ethernet frames
- **Physical Layer**: Hardware transmission

ARQ (Automatic Repeat Request) - Error detection & retransmission **ARP (Address Resolution Protocol)** - Retrieves MAC address from an IP

TCP vs UDP

TCP (Transmission Control Protocol)
- Reliable, connection-oriented
- 3-way handshake (SYN, SYN-ACK, ACK)
- Supports error correction

UDP (User Datagram Protocol)
- Unreliable, connectionless
- Used for real-time communication (VoIP, gaming, streaming)

Collision Avoidance in Ethernet

- **CSMA/CD (Carrier Sense Multiple Access with Collision Detection)** prevents data collision.
- **Ethernet speed**: 10 Gbps+

Comparison: Fiber Optic vs Copper Cable

Feature	Fiber Optic	Copper Cable (Ethernet)
Material	Glass or plastic fibers	Copper wires
Speed	Up to Tbps	Up to 10 Gbps
Distance	Up to 100 km	Few hundred meters
Security	More secure	Less secure

DHCP (Dynamic Host Configuration Protocol)
- **DORA Process** (Discover, Offer, Request, Acknowledge)
- Assigns:
    - IP Address
    - Subnet Mask
    - Default Gateway
    - DNS Server

Public vs Private IPs
- **Private IPs**: Used in local networks (e.g., 192.168.x.x, 10.x.x.x)
- **Public IPs**: Assigned by ISPs for internet communication

CIDR (Classless Inter-Domain Routing) notation:
- **/24** = 256 addresses
- **/16** = 65,536 addresses
- **/8** = 16,777,216 addresses

NAT (Network Address Translation)
Types:
- **Static NAT**: One private IP maps to one public IP
- **Dynamic NAT**: Uses a pool of public IPs
- **PAT (Port Address Translation)**: Maps multiple private IPs to one public IP with different ports

Encryption & Authentication
- **Symmetric Key Cryptography**: Uses one key (e.g., AES, DES)
- **Asymmetric Key Cryptography**: Uses public & private keys (e.g., RSA, Diffie-Hellman)

Digital Signature: Ensures integrity & authenticity using encryption & hashing.

HTTP vs HTTPS
- **HTTP (HyperText Transfer Protocol)**
    - Stateless protocol
    - Port: 80
- **HTTPS (HTTP Secure)**
    - Uses SSL/TLS encryption
    - Port: 443

HTTP Status Codes:
- **1xx** Informational
- **2xx** Success
- **3xx** Redirection
- **4xx** Client Error
- **5xx** Server Error

File Transfer Protocols

- **FTP**: File Transfer Protocol (TCP, Unsecured)
- **SFTP**: Secure FTP (Encrypted, TCP, Port 22)
- **TFTP**: Trivial FTP (Uses UDP, primarily for LAN)

Email Protocols

- **SMTP**: Sending emails between servers
- **POP3**: Retrieves emails but deletes them from the server
- **IMAP**: Retrieves emails while keeping them synced with the server

This document provides a comprehensive overview of network fundamentals, topologies, devices, protocols, and security measures.