Lesson 6: Data Communication & Networking

1. Physical Layer Concepts

Data Communication Model

- Sender → Message → Medium → Receiver → Protocol

Signals & Properties

- **Types:** Analog (continuous) vs. Digital (discrete).
- **Properties:** Amplitude, Frequency (f), Wavelength (λ), Propagation Speed (c). Relationship: $c = f * \lambda$.
- **Signal Impairment:** Attenuation (loss of strength), Distortion (shape change), Noise (interference).

Transmission & Encoding

- **Media:** Guided (Twisted Pair, Coax, Fiber Optic) vs. Unguided (Radio waves, Microwaves).
- **Modulation:** Modifying a carrier wave to encode data (AM, FM, PM, ASK, FSK, PSK).
- **Synchronization:** Aligning sender/receiver clocks. **Manchester Encoding** aids this.
- **PSTN & Modems:** Analog phone network. A **Modem** converts digital signals to analog for PSTN, and vice-versa.

2. Data Link Layer Concepts

LAN Topologies & Hardware

- **Topologies:** Bus, Star, Ring, Mesh.
- **Hardware:** Hub (Broadcasts), Switch (Intelligent forwarding), Bridge (Connects similar LANs).

Media Access Control (MAC)

- **MAC Address:** 48-bit unique hardware address.
- **Frame (Data Unit):** Contains source & destination MAC addresses for the *next hop*.
- **Access Protocols:** Manage shared media access. Evolution: ALOHA → Ethernet (CSMA/CD).
- **Error Control:** Parity Check (detects single-bit errors).

3. IP Addressing

IPv4 Address Classes

Class	1st Octet Range	Default Mask	Format
A	1-126	255.0.0.0 (/8)	N.H.H.H
B	128-191	255.255.0.0 (/16)	N.N.H.H
C	192-223	255.255.255.0 (/24)	N.N.N.H

Default IPv4 Classes (Classful Addressing)

N=Network, H=Host. Private IP Ranges: 10.x.x.x, 172.16-31.x.x, 192.168.x.x

Subnetting Example

Subnetting 192.168.1.0/24 to get 4 subnets

1. **Goal:** Need 4 subnets. To get 4 (2^2) subnets, we must borrow **2 bits** from the host portion.
2. **Old Mask:** /24 is ...00000000
3. **New Mask:** Borrow 2 bits. New mask is /26. ...11000000 which is **255.255.255.192**.
4. **Block Size:** $256 - 192 = 64$. Each subnet will have 64 addresses.
5. **The Subnets:**
   - **Subnet 1:** 192.168.1.0 - 192.168.1.63 (Usable: .1 to .62)
   - **Subnet 2:** 192.168.1.64 - 192.168.1.127 (Usable: .65 to .126)
   - **Subnet 3:** 192.168.1.128 - 192.168.1.191 (Usable: .129 to .190)
   - **Subnet 4:** 192.168.1.192 - 192.168.1.255 (Usable: .193 to .254)

4. Transport Layer

- **Ports & Multiplexing:** Port numbers identify specific applications, allowing multiple apps to use the network simultaneously.
- **Protocols:**

TCP vs. UDP

- **UDP (User Datagram):** Connectionless, fast, no delivery guarantee. *Use: DNS, VoIP, Gaming.*
- **TCP (Transmission Control):** Connection-oriented, reliable, ordered delivery. Slower. *Use: Web (HTTP), Email (SMTP).*

5. Application, Security & Models

Reference Models & Data Units

OSI vs. TCP/IP Layers & Data Units

OSI Layer	TCP/IP Layer	Data Unit
App/Pres/Sess	Application	Data
Transport	Transport	Segment
Network	Internet	Packet
Data Link	Network Access	Frame
Physical		Bit

Application Layer Services

- **Client-Server Model:** A client requests services/resources from a central server.
- **DHCP:** Automatically assigns IP addresses.
- **DNS:** Hierarchical system that translates domain names to IP addresses.
- **NAT/Proxy:** Allows devices with private IPs to share a single public IP.

Network Security

- **Encryption:** Symmetric (one key) vs. Asymmetric (public/private keys).
- **Digital Signature:** Ensures authenticity & integrity.
- **Threats:** Viruses, Trojans, Malware, Phishing.
- **Protection:** Firewalls, Antivirus software.