The OSI Model – Network Layer (Layer 3)

- **Purpose:**
  - Enables connectivity between end devices on **different networks** (beyond a LAN).
  - Provides **logical addressing** (IP addresses) and selects paths from **source to destination**.
- **Devices at Layer 3:**
  - **Routers:** Operate at this layer and separate different networks.

Routing

- **Switches (Layer 2):**
  - Connect devices within the same LAN but do **not separate networks.**
- **Routers (Layer 3):**
  - Connect multiple LANs and split networks, assigning each LAN a **unique IP network address.**
  - Example:
    - **Network 1:** 192.168.1.0/24 (Subnet Mask: 255.255.255.0).
    - **Network 2:** 192.168.2.0/24.
- **Router Interface IPs:**

  v
  - Each interface on a router connects to a specific LAN and has its own IP address:
    - **G0/0 (LAN1):** 192.168.1.254/24.
    - **G0/1 (LAN2):** 192.168.2.254/24.
- **Broadcast Behavior:**

  - A broadcast stays within its LAN and does not cross a router.

IPv4 Addressing and Headers

- **IPv4 Address Format:**

  - **32-bit binary number** split into 4 octets.
  - Represented in **dotted decimal format** (e.g., 192.168.1.254).
- **Binary Conversion Example:**

  - IP: 192.168.1.254.
  - Binary: `11000000.10101000.00000001.11111110`.
  - Each octet corresponds to 8 bits (values: 128, 64, 32, 16, 8, 4, 2, 1).
- **Field Details in IPv4 Header:**

  - Contains **source IP address** and **destination IP address.**

Decimal to Binary Conversion

1. Example: **221**
    - Subtract the value of each binary slot from the decimal number:
        - 221 - 128 = 93 → **1** in the 128 slot.
        - 93 - 64 = 29 → **1** in the 64 slot.
        - 29 - 32 is not possible → **0** in the 32 slot.
        - Continue: 11011101.
2. Example: **127**
    - Result: `01111111`.

IPv4 Address Components

- **Network Portion and Host Portion:**
    - Represented by the **prefix length** (e.g., `/24`).
    - `/24` means the first 24 bits are the **network portion.**
        - Example: `192.168.1.0/24` → Network: `192.168.1`, Host: last octet.

IPv4 Address Classes

Class	First octet	First octet numeric range
A	0xxxxxxx	0-127
B	10xxxxxx	128-191
C	110xxxxx	192-223
D	1110xxxx	224-239
E	1111xxxx	240-255

- **Classes:** Determine the structure of the network portion.
    - **Class A:**
        - Range: 0-126 (127 is reserved for loopback: used to test the ‘network stack’ (think OSI, TCP/IP model) on the local device).
        - Network Prefix: `/8`.
        - Netmask: `255.0.0.0`.
    - **Class B:**
        - Range: 128-191.
        - Network Prefix: `/16`.
        - Netmask: `255.255.0.0`.
    - **Class C:**
        - Range: 192-223.
        - Network Prefix: `/24`.
        - Netmask: `255.255.255.0`.
    - **Class D:** Reserved for **multicast addresses.**
    - **Class E:** Reserved for **experimental purposes.**

Network Address and Broadcast Address

- **Network Address:**
    - Host portion = all **0s.**
    - Example: `192.168.1.0/24`.
    - Identifies the network itself and **cannot** be assigned to hosts.
- **Broadcast Address:**
    - Host portion = all **1s.**
    - Example: `192.168.1.255`.
    - Used to send packets to **all devices** in the network.
- **Usable Host Addresses:**
    - Range: **1 to 254** in a `/24` subnet.
    - Two addresses (network and broadcast) are reserved.

Class	Leading bits	Size of *network number* bit field	Size of *rest* bit field	Number of networks	Addresses per network
Class A	0	8	24	128 (2^7)	16,777,216 (2^{24})
Class B	10	16	16	16,384 (2^{14})	65,536 (2^{16})
Class C	110	24	8	2,097,152 (2^{21})	~~256 (2^8)~~ 254

Examples of Binary to IPv4 Conversion

1. **Binary:** `10011010010011100110111100100000`
    - Octets: `154.78.111.32`.
    - Prefix: `/16` → Network: `154.78`, Host: `111.32`.
2. **Binary:** `00001100100000001111101100010111`
    - Octets: `12.128.251.23`.
    - Prefix: `/8` → Network: `12`, Host: `128.251.23`.

Key Notes

- **Prefix Length:** Determines the size of the network portion.
- **Netmask:** Defines the boundary between the network and host portions.
    - Example: `/24` → Netmask: `255.255.255.0`.
- **Subnetting:** Dividing an IP range into smaller sub-networks to improve efficiency and security.