

IPv4 Datagram and Encapsulation

IP Datagram Overview

- At the **Network Layer**, packets are called **IP datagrams** (similar to Ethernet frames at the Data Link Layer).
- An **IP datagram** consists of two main parts:
 1. **Header** – Contains control information.
 2. **Payload** – Holds the actual data.

IPv4 Header Fields

The **IPv4 header** contains several important fields:

1. **Version (4 bits)** – Specifies the IP version (IPv4 or IPv6).
2. **Header Length (4 bits)** – Declares the total length of the header (usually **20 bytes** in IPv4).
3. **Service Type (8 bits)** – Used for **Quality of Service (QoS)**, prioritizing certain datagrams.
4. **Total Length (16 bits)** – Defines the **entire size** of the IP datagram (maximum **65,535 bytes**).
5. **Identification (16 bits)** – Groups fragmented packets together during transmission.
6. **Flags (3 bits) & Fragmentation Offset (13 bits)** –
 - Flags indicate whether a packet is **fragmented**.
 - Fragmentation offset helps reassemble packets correctly.
7. **Time to Live (TTL) (8 bits)** – Controls how long a datagram can exist before being discarded (decreases at each router hop).
8. **Protocol (8 bits)** – Indicates the **transport layer protocol** used (e.g., TCP or UDP).
9. **Header Checksum (16 bits)** – Ensures the **integrity** of the IP header.
10. **Source & Destination IP Addresses (32 bits each)** – Specify the sender and receiver of the datagram.
11. **IP Options (Variable length, optional)** – Used for testing or specific routing requirements.
12. **Padding** – Ensures the header has a correct size.

Encapsulation Process

- The **IP datagram** itself is encapsulated within an **Ethernet frame** as its payload.
- The **IP datagram's payload** contains a **TCP or UDP packet**, forming a layered structure.
- This layered approach ensures proper communication between different network layers.