# 4. Network Layer

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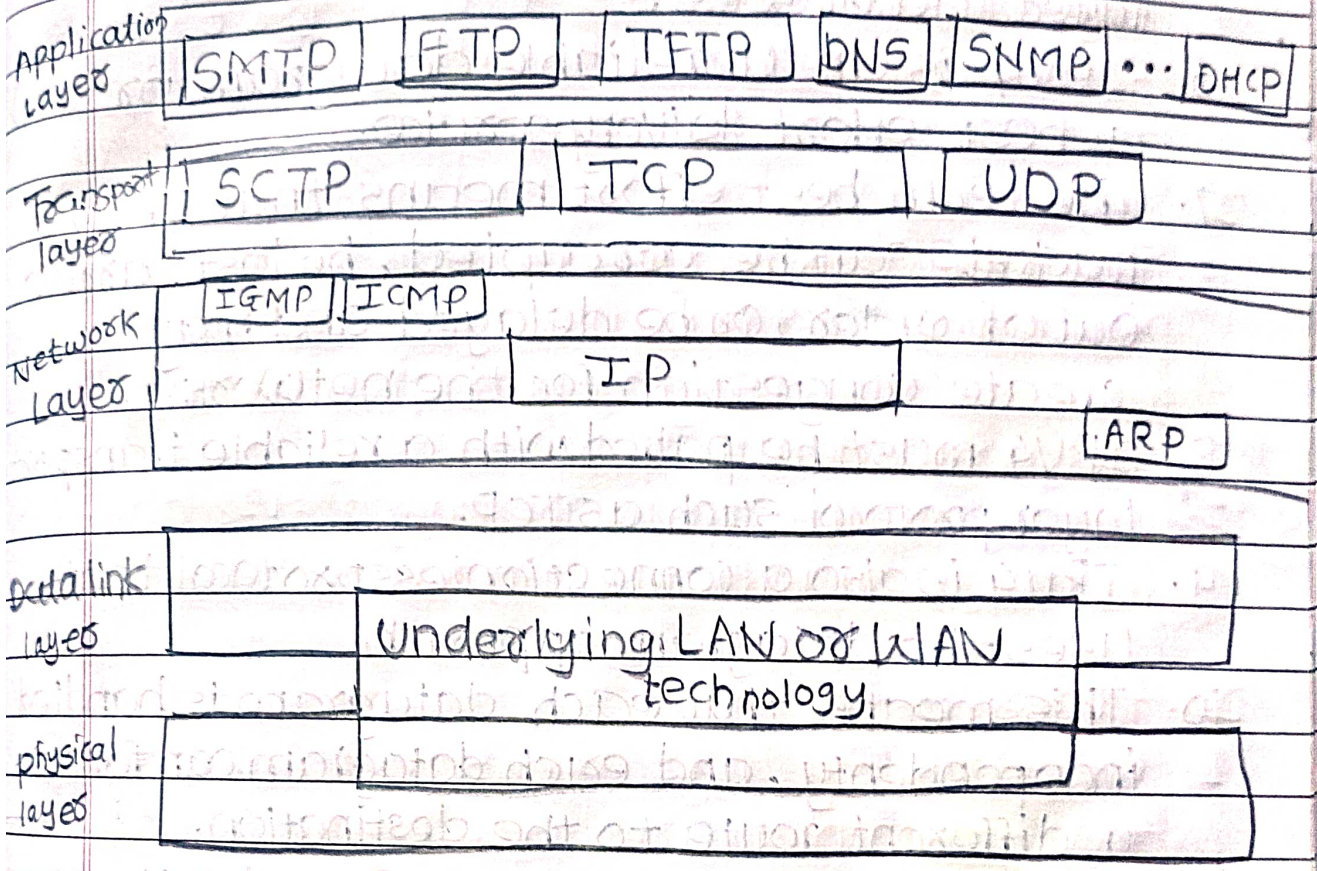
* Position of IP and other network-layer protocols in TCP/IP protocol suite




1. The network layer in version 4 can be thought of as one main protocol and three auxilary ones.
2. The main protocol, Internet protocol version 4 (IPv4), is responsible for packetizing, forwarding and delivery of a paket at the network layer.
3. The Internet Control Message Protocol V4 (ICMPv4) helps IPv4 to handle some errors that may occur in the network layer delivery.

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4. The Internet Group Management Protocol (IGMP) is used to help IPV4 multicasting.
5. The Address Resolution Protocol (ARP) is used to glue the network and data link layers in mapping network layer addresses to link layer addresses.
6. IPV4 is an unreliable datagram protocol a best effort delivery service.
7. The term best effort means that IPV4 packets can be corrupted, be lost, arrive out of order, or be delayed and may create congestion for the network.
8. IPV4 must be paired with a reliable transport layer protocol such as TCP.
9. IPV4 is also a connectionless protocol that uses the datagram approach.
10. This means that each datagram is handled independenty, and each datagram can follow a different route to the destination.
11. This implies that datagrams sent by the same source to the same destination could arrive out of order.

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## * IPV4 Addressing

1. The identifier used in the IP layer of the TCP/IP protocol suite to identify the connection of each device to the Internet is called the Internet address or IP address.
2. An IPV4 address is a 32-bit address that uniquely and universally defines the connection of a host or a router to the ~~routerto~~ Internet.
3. The IP address is the address of the connection, not the host or the router, because if the device is moved to another network, the IP address may be changed.
4. IPV4 addresses are unique in the sense that each address defines one, and only one, connection to the Internet.
5. If a device has two connections to the Internet via two network, it has two IPV4 addresses.
6. IPV4 addresses are universal in the sense that the addressing system must be accepted by any host that wants to be connected to the Internet.

## * Address space

1. A protocol like IPV4 that defines addresses has an address space.
2. A address space is the total number of addresses used by the protocol.
3. If a protocol uses b bits to define an address, the address space is $2^b$ because each bit can have different values (0 or 1).

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4. IPv4 uses 32 bit addresses, which means that the address space is $2^{32}$.

* Classful Addressing

1. The whole address space was divided into five classes (class A, B, C, D & E) this scheme is reffered to as classful addressing.

I. Class A:

1. The network length is 8 bit and host ID is 24 since the first bit which is 0, defines the class we can have only seven bits as the network identifier.

A
0-127

This means there are only $2^7 = 128$ networks in the world that can have a class A address.

II. Class B

1. Network length is 16 bits, but since the first two bits which are used for defined the class we can have 14 bit as the network identifier This means there are only $2^{14} = 16,384$ network in the world that can have class B address.

III Class C

The network length is 24 bits, but since three bits define the class, we can have only 21 bits as the network identifier.

This means there are $2^{21} = 2,097,152$ networks in the world that can have a class C address.

IV. Class D
Class D is not divided into prefix and suffix.
It is used for multicast address.

V. Class E
All addresses that start with 1111 in binary belong to class E.
As in class D, Class E is not divided into prefix and suffix and used as reserve.

| Class | Prefixes | First byte |
|---|---|---|
| A | n = 8 bits | 0 to 127 |
| B | n = 16 bits | 128 to 191 |
| C | n = 24 bits | 192 to 223 |
| D | Not applicable | 224 to 239 |
| E | —11— | 240 to 255 |

* Datagram Format:
1. IPV4 defines the format of a packet in which the data coming from the upper layer or other protocols are encapsulated
2. Packets used by the IP are called datagrams.
3. A datagram is a variable-length packet consisting of two part: header & payload (data)
4. The header is 20 to 60 bytes in length and contains information essential to routing and delivery.
5. It is customary in TCP/IP to show the header in 4-byte sections.

1. Version Number: The 4 bit version number (VER) field defines the version of the IPV4 protocol, which obviously has the value of 4.

2. Header length:

① The 4 bit header length (HLEN) field defines the total length of the datagram header in 4 byte words.

② The IPV4 datagram has a variable length header. When a device receives a datagram, it needs to know when the header stops and the data, which is encapsulated in the packet starts.

③ However, to make the value of the header length fit in a 4-bit header length, the total length of the header is calculated as 4 byte words.

④ The total length is divided by 4 and the value is inserted in the field.

⑤ The receiver needs to multiply the value of this field by 4 to find the total length.

3. Total length

1. This 16 bit field defines the total length of the IP datagram in bytes.
2. A 16 bit number can define a total length of up to 65535
3. To find the length of the data coming from the upper layer, subtract the header length from the total length.

4. The header length can be found by multiplying the value in the HLEN field by 4.

length of data = total length − (HLEN) × 4

5. Identification, flags and Fragmentation offset:
These 3 fields are related to the fragmentation of the IP datagram when the size of the datagram is larger than the underlying network can carry.

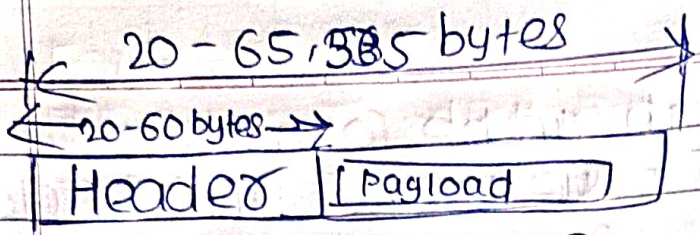
6. Time to live:
This may create extra traffic in the Internet.
The time to live (TTL) field ~~to~~ is used to control the maximum no. of hops (router) visited by the datagram.

~~8~~. Header checksum

7. Source and destination Address:
These 32 bit source and destination address fields define the IP address of the source and destination ~~address~~ respectively.

8. Options: A datagram header can have up to 40 bytes of options. Options can be used for network testing and debugging.

9. Payload: It is main reason to create ~~payload~~ datagram.
Payload is packet coming from other protocols that use the service of IP.




IP datagram

| 0 | 4 | 8 | 16 | 32 |
|---|---|---|---|---|
| VER (4 bits) | HLEN (4 bits) | Service Type (8 bits) | Total length (16 bits) | |
| Identification (16 bits) | | | Flags (3 bits) | Fragmentation offset (13 bits) |
| Time to live (8 bits) | | Protocol (8 bits) | Header checksum (16 bits) | |
| Source IP address (32 bits) | | | | |
| Destination IP address (32 bits) | | | | |
| options + padding (0 to 40 bytes) | | | | |

0 - Class A
1 0 B
1 1 0 C
1 1 1 0 D
1 1 1 1 0 E