

Introduction to Computer Networks

(Source: A.S.Tanenbaum: Computer Networks, 3rd. edition)

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exist. These are constructed from high-bandwidth lines and fast routers. Attached to the backbones are regional (midlevel) networks, and attached to these regional networks are the LANs at many universities, companies, and Internet service providers (Fig. 5-44).

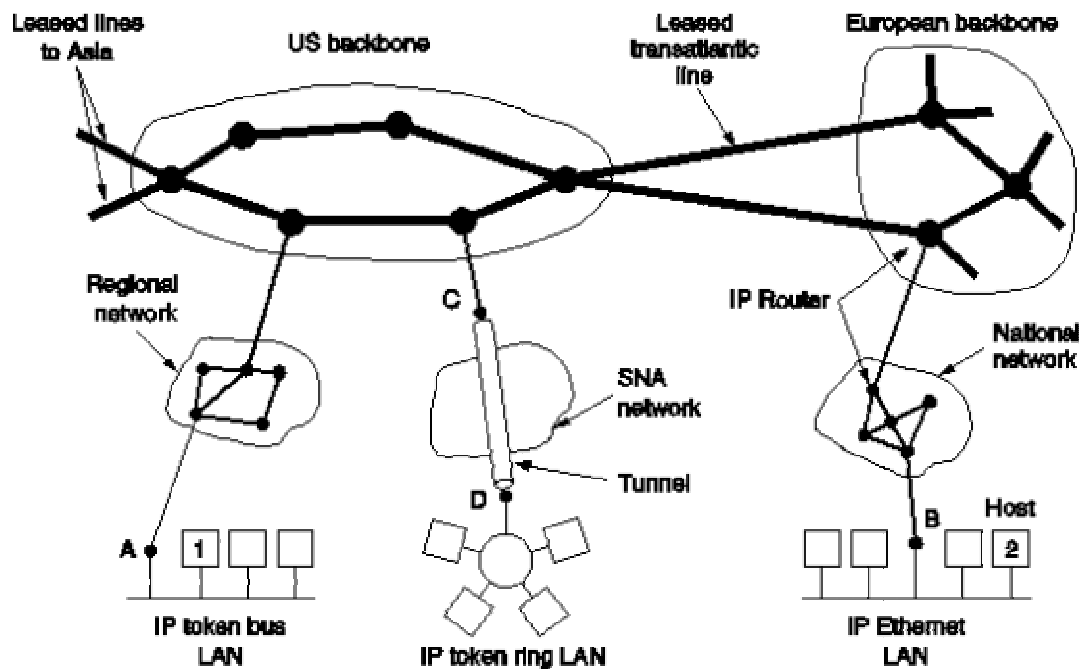


Fig. 5-44. The Internet is an interconnected collection of many networks.

The glue that holds the Internet together is the network layer protocol, *IP* (Internet Protocol).

Communication in the Internet works as follows: The transport layer takes data streams and break them up into datagrams usually around 1500 bytes long (in theory, they can be up to 64 Kbytes). Each datagram is transmitted through the Internet, possibly being fragmented into smaller units. When all pieces finally get to the destination machine, they are reassembled by the network layer into the original datagram. This datagram is then handed to the transport layer, which inserts it into the receiving process' input stream.

3.2.1. The IP Protocol

An IP datagram consists of a header part and a text part. The header has a 20 byte fixed part and a variable length optional part (Fig. 5-45). It is transmitted from left to right, with the high-order field of the Version field going first (big endian order).

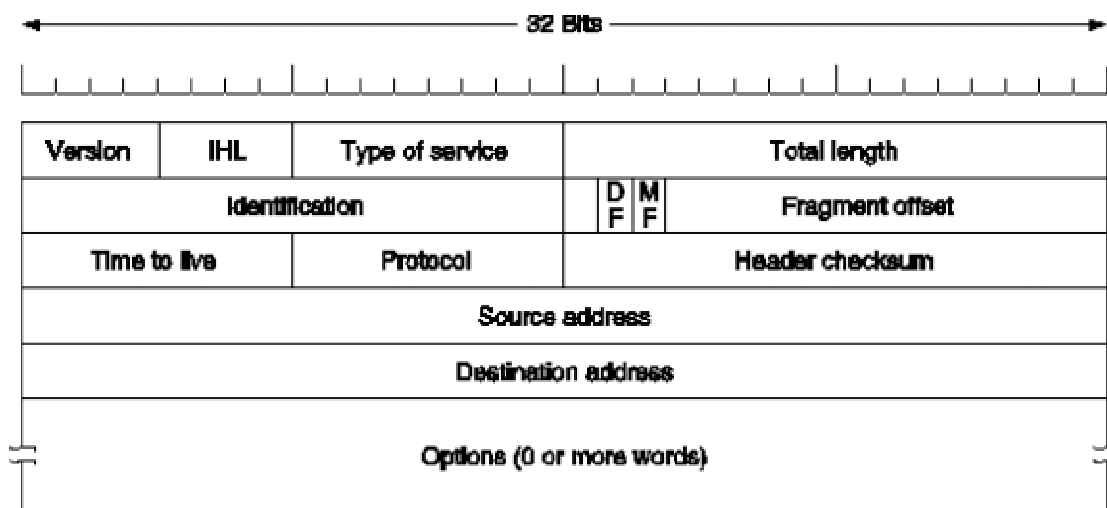


Fig. 5-45. The IP (Internet Protocol) header.

Meanings of single fields in the IP header:

- Version - version of the protocol the datagram belongs to.
- IHL - length of the header in 32-bit words. The minimum value is 5, the maximum value is 15.
- Type of service - type of service the host wants from a subnet. In practice, current routers ignore this field.
- Total length - the total length of the datagram (65535 bytes maximum).
- Identification - allows the destination host to determine which datagram a newly arrived fragment belongs to. All the fragments of a datagram contain the same Identification value.
- DF - stands for Don't fragment. It is an order to the router not to fragment the datagram because the destination is incapable of putting the pieces back together again (all machines are required to accept fragments of 576 bytes or less).
- MF - stands for More Fragments. All fragments except the last one have this bit set.
- Fragment offset - tells where in the current datagram this fragment belongs. All fragments except the last one in a datagram must be a multiple of 8 bytes, the elementary fragment unit.
- Time to live - a counter used to limit packet lifetimes. In practice, it just counts hops. It must be decremented on each hop. When it hits zero, the packet is discarded and a warning packet is sent back to the source host.
- Protocol - the identification of the protocol the datagram belongs to.
- Header checksum - verifies the header only. It is recomputed at each hop.
- Source address, destination address - indicate the network number and host number.
- Options - provides an escape to allow subsequent versions of the protocol to include information not present in the original design, to permit experiments to try out new ideas. This field is variable length. Each option begins with a 1-byte code identifying the option. Currently five options are defined, but not all routers support them. E.g., Record route option tells the routers along the path to append their IP address to the option field. This allows system managers to track down bugs in the routing algorithms.

Option	Description
Security	Specifies how secret the datagram is
Strict source routing	Gives the complete path to be followed
Loose source routing	Gives a list of routers not to be missed
Record route	Makes each router append its IP address
Timestamp	Makes each router append its address and timestamp

Fig. 5-46. IP options.

3.2.2. IP Addresses

Every host and router on the Internet has an *IP address*, which encodes its network number (prefix part of the address) and host number (suffix part of the address). The combination is unique.

All IP addresses are 32 bits long. The format of IP address is in Fig. 5-47. Those machines connected to multiple networks have a different IP address on each network.

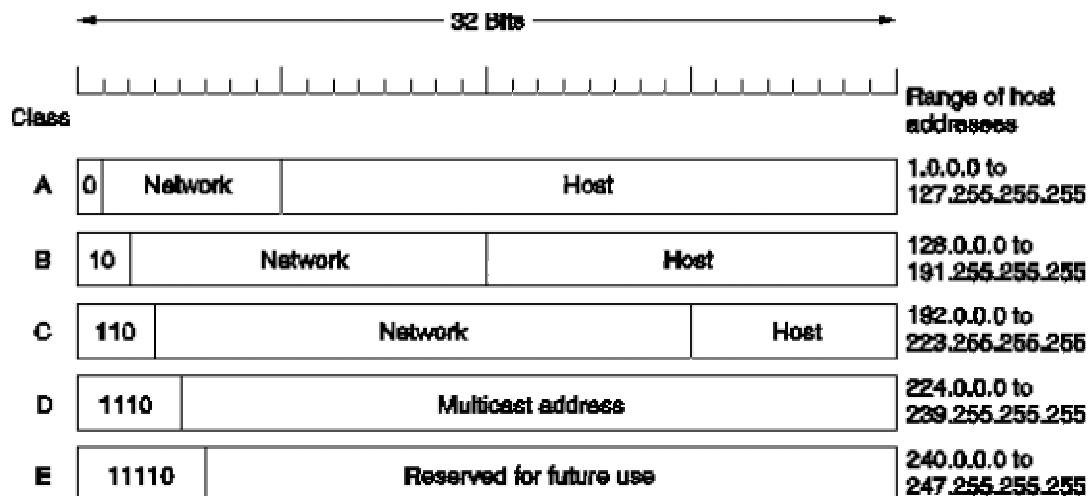


Fig. 5-47. IP address formats.

IP addresses can be divided into 5 classes. There are 3 primary classes, A, B, and C, used for host addresses. Class D is used for multicasting which allows delivery to a set of computers. Class E is reserved for future use. The first four bits of an address determine the class to which the address belongs.

The *class A* format allows for up to 126 networks with 16 million hosts each.

The *class B* format allows for up to 16382 networks with 64 K hosts each.

The *class C* format allows for up to 2 million networks with 254 hosts each.

Network numbers on the top level are assigned by the NIC (Network Information Center). For single organizations, the network number are assigned by Internet service providers.