TCP/IP Illustrated, Volume 1

The Protocols

W. Richard Stevens

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In Section 3.4 we'll extend our description of IP addresses to include subnetting, after describing IP routing. Figure 3.9 shows the special case IP addresses: host IDs and network IDs of all zero bits or all one bits.

1.5 The Domain Name System

Although the network interfaces on a host, and therefore the host itself, are known by IP addresses, humans work best using the *name* of a host. In the TCP/IP world the *Domain Name System* (DNS) is a distributed database that provides the mapping between IP addresses and hostnames. Chapter 14 looks into the DNS in detail.

For now we must be aware that any application can call a standard library function to look up the IP address (or addresses) corresponding to a given hostname. Similarly a function is provided to do the reverse lookup—given an IP address, look up the corresponding hostname.

Most applications that take a hostname as an argument also take an IP address. When we use the Telnet client in Chapter 4, for example, one time we specify a hostname and another time we specify an IP address.

1.6 Encapsulation

When an application sends data using TCP, the data is sent down the protocol stack, through each layer, until it is sent as a stream of bits across the network. Each layer adds information to the data by prepending headers (and sometimes adding trailer information) to the data that it receives. Figure 1.7 shows this process. The unit of data that TCP sends to IP is called a *TCP segment*. The unit of data that IP sends to the network interface is called an *IP datagram*. The stream of bits that flows across the Ethernet is called a *frame*.

The numbers at the bottom of the headers and trailer of the Ethernet frame in Figure 1.7 are the typical sizes of the headers in bytes. We'll have more to say about each of these headers in later sections.

A physical property of an Ethernet frame is that the size of its data must be between 46 and 1500 bytes. We'll encounter this minimum in Section 4.5 and we cover the maximum in Section 2.8.

All the Internet standards and most books on TCP/IP use the term *octet* instead of byte. The use of this cute, but baroque term is historical, since much of the early work on TCP/IP was done on systems such as the DEC-10, which did not use 8-bit bytes. Since almost every current computer system uses 8-bit bytes, we'll use the term *byte* in this text.

To be completely accurate in Figure 1.7 we should say that the unit of data passed between IP and the network interface is a *packet*. This packet can be either an IP datagram or a fragment of an IP datagram. We discuss fragmentation in detail in Section 11.5.

We could draw a nearly identical picture for UDP data. The only changes are that the unit of information that UDP passes to IP is called a *UDP datagram*, and the size of the UDP header is 8 bytes.

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3.2 IP Header

Figure 3.1 shows the format of an IP datagram. The normal size of the IP header is 20 bytes, unless options are present.

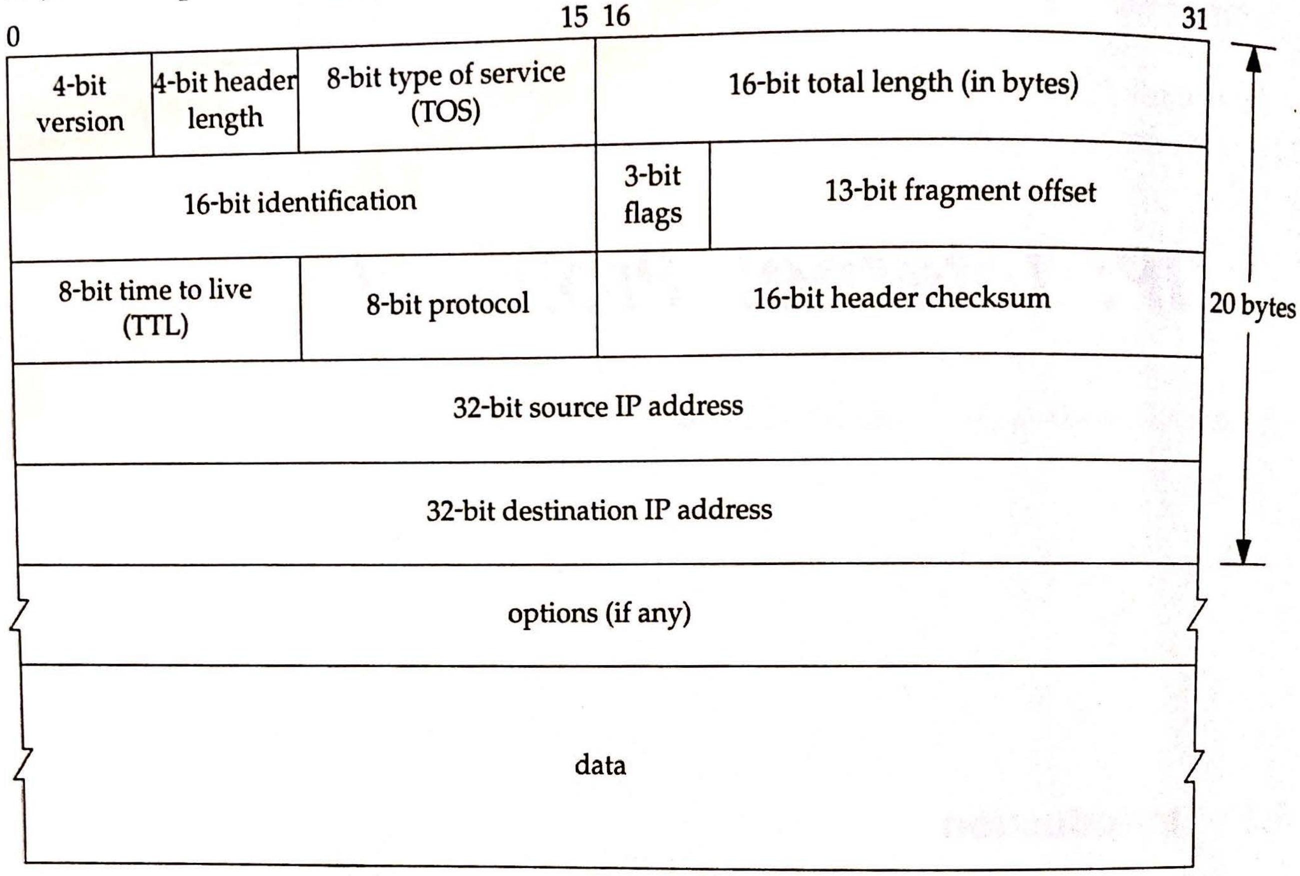

Figure 3.1 IP datagram, showing the fields in the IP header.

We will show the pictures of protocol headers in TCP/IP as in Figure 3.1. The most significant bit is numbered 0 at the left, and the least significant bit of a 32-bit value is numbered 31 on the right.

The 4 bytes in the 32-bit value are transmitted in the order: bits 0–7 first, then bits 8–15, then 16–23, and bits 24–31 last. This is called *big endian* byte ordering, which is the byte ordering required for all binary integers in the TCP/IP headers as they traverse a network. This is called the *network byte order*. Machines that store binary integers in other formats, such as the *little endian* format, must convert the header values into the network byte order before transmitting the data.

The current protocol *version* is 4, so IP is sometimes called IPv4. Section 3.10 discusses some proposals for a new version of IP.

The *header length* is the number of 32-bit words in the header, including any options. Since this is a 4-bit field, it limits the header to 60 bytes. In Chapter 8 we'll see that this limitation makes some of the options, such as the record route option, useless today. The normal value of this field (when no options are present) is 5.

The *type-of-service* field (TOS) is composed of a 3-bit precedence field (which is ignored today), 4 TOS bits, and an unused bit that must be 0. The 4 TOS bits are: minimize delay, maximize throughput, maximize reliability, and minimize monetary cost.

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