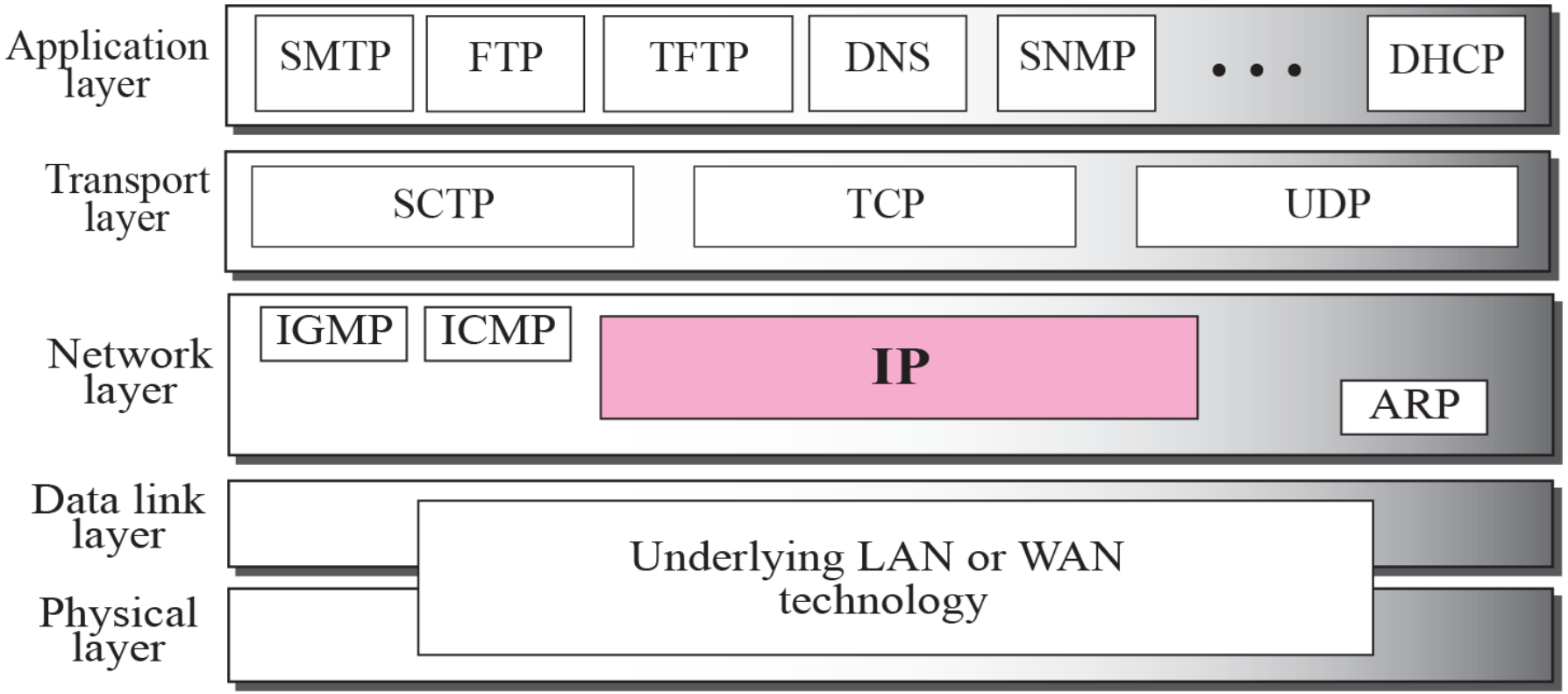
Internet Protocol Version4 (IPv4)

INTRODUCTION

The Internet Protocol (IP) is the transmission mechanism used by the TCP/IP protocols at the network layer.

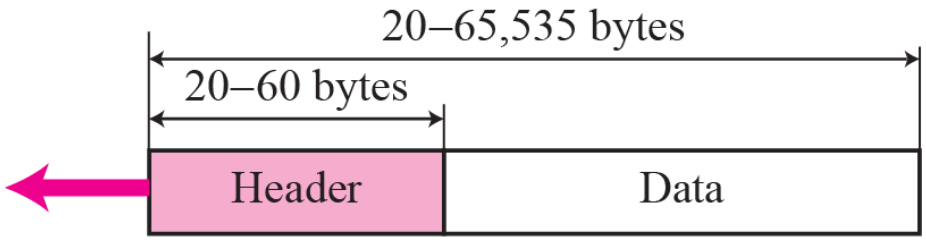
Figure 1 *Position of IP in TCP/IP protocol suite*



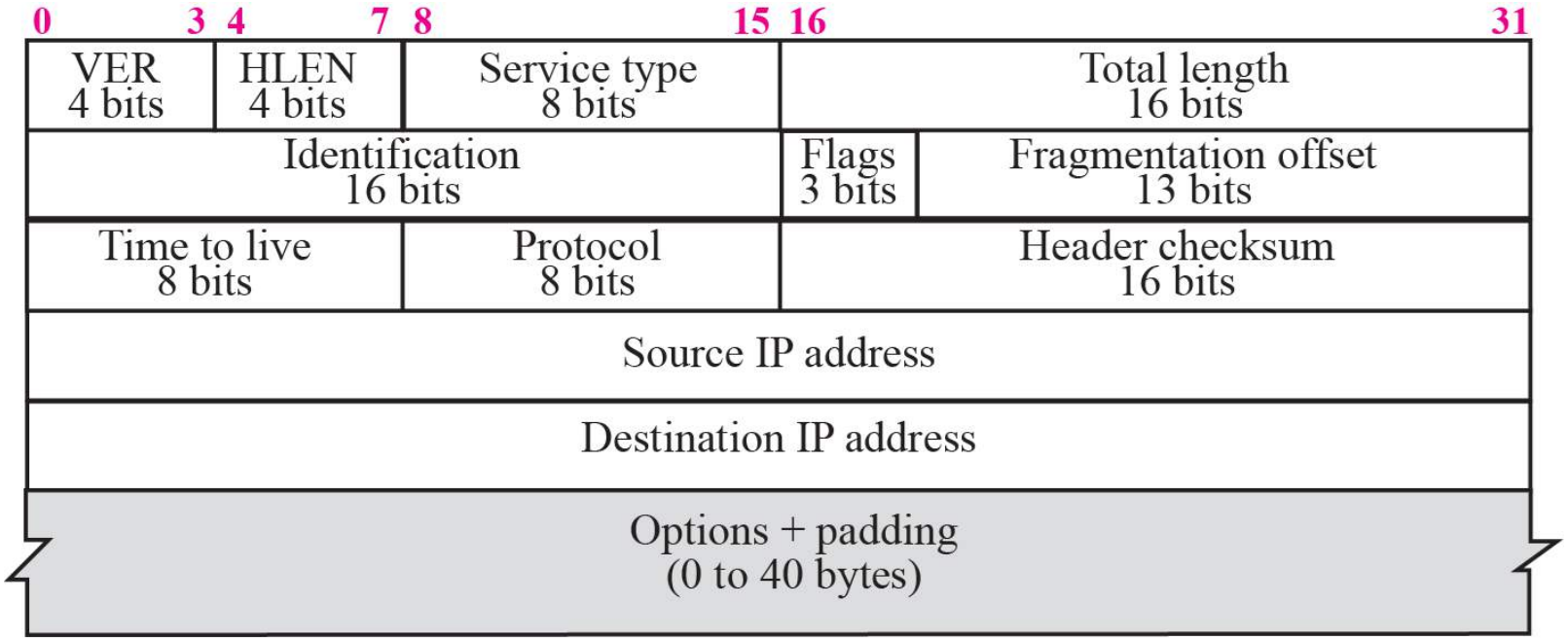
2 DATAGRAMS

Packets in the network (internet) layer are called *datagrams*. A datagram is a variable-length packet consisting of two parts: header and data. The header is 20 to 60 bytes in length and contains information essential to routing and delivery. It is customary in TCP/IP to show the header in 4-byte sections. A brief description of each field is in order.

Figure 2 ***IP datagram***



a. IP datagram



b. Header format

Note

The total length field defines the total length of the datagram including the header.

Example 1

An IP packet has arrived with the first 8 bits as shown:

```
01000010
```

The receiver discards the packet. Why?

Solution

There is an error in this packet. The 4 left-most bits (0100) show the version, which is correct. The next 4 bits (0010) show the wrong header length (2 × 4 = 8). The minimum number of bytes in the header must be 20. The packet has been corrupted in transmission.

Example 2

In an IP packet, the value of HLEN is 1000 in binary. How many bytes of options are being carried by this packet?

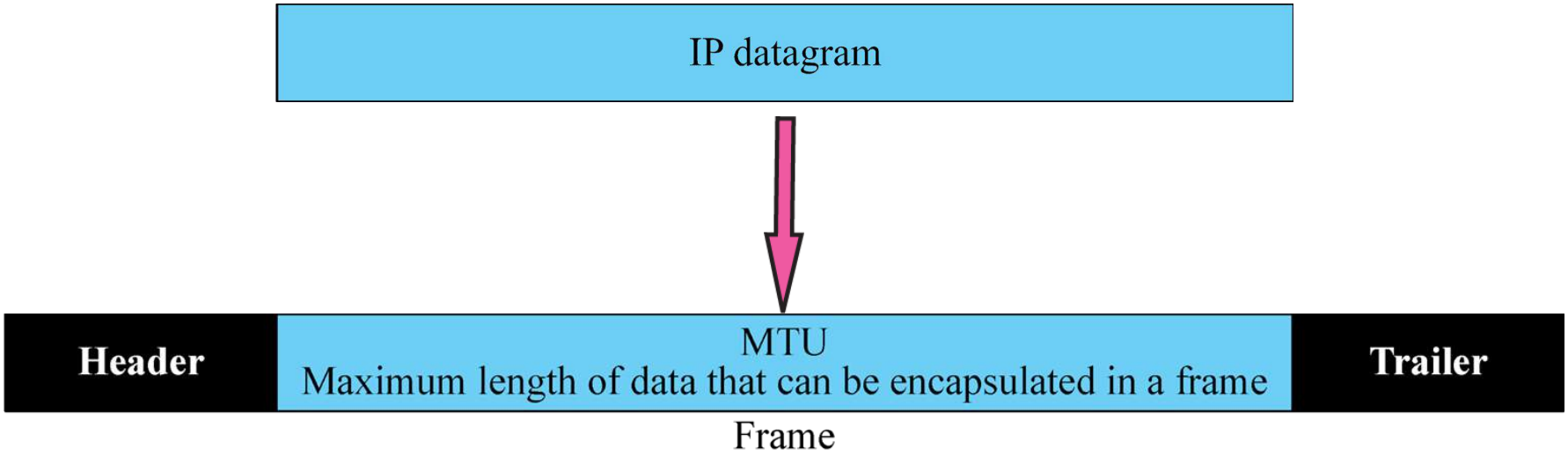
Solution

The HLEN value is 8, which means the total number of bytes in the header is 8 × 4 or 32 bytes. The first 20 bytes are the base header, the next 12 bytes are the options.

3 FRAGMENTATION

A datagram can travel through different networks. Each router decapsulates the IP datagram from the frame it receives, processes it, and then encapsulates it in another frame. The format and size of the received frame depend on the protocol used by the physical network through which the frame has just traveled. The format and size of the sent frame depend on the protocol used by the physical network through which the frame is going to travel.

Figure 6 *MTU*


IP datagram
Header
MTU
Maximum length of data that can be encapsulated in a frame
Trailer
Frame

Note

Only data in a datagram is fragmented.

Figure 7 ***Flags field***

D: Do not fragment
M: More fragments

Figure 8 *Fragmentation example*

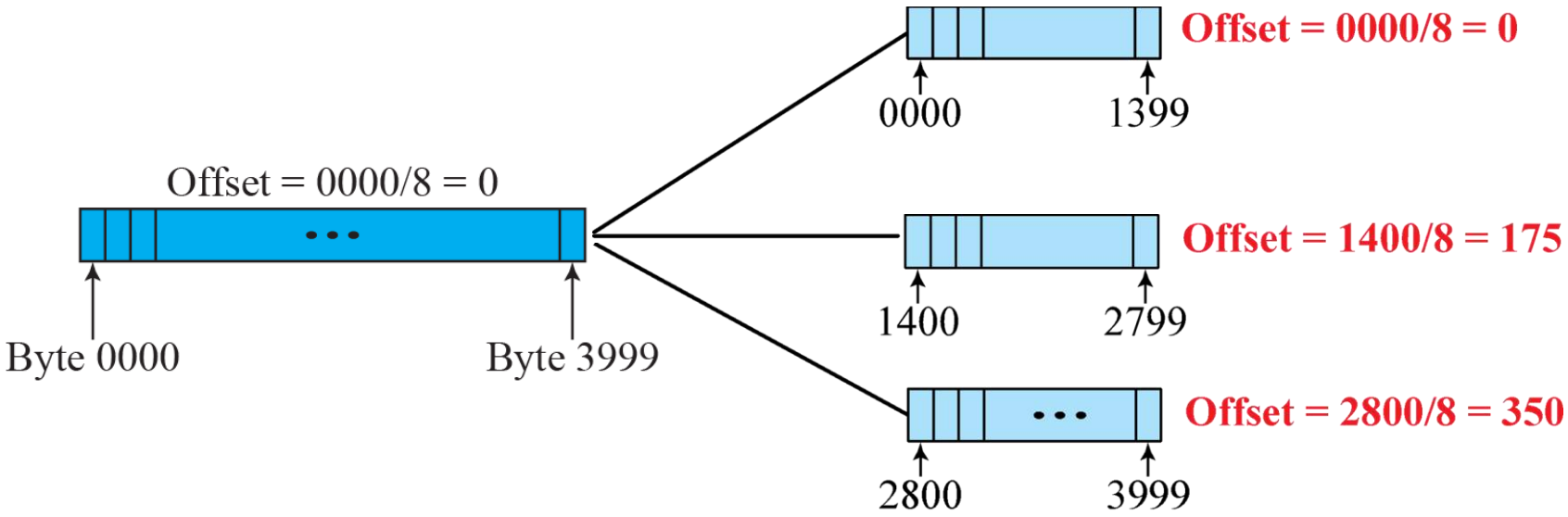
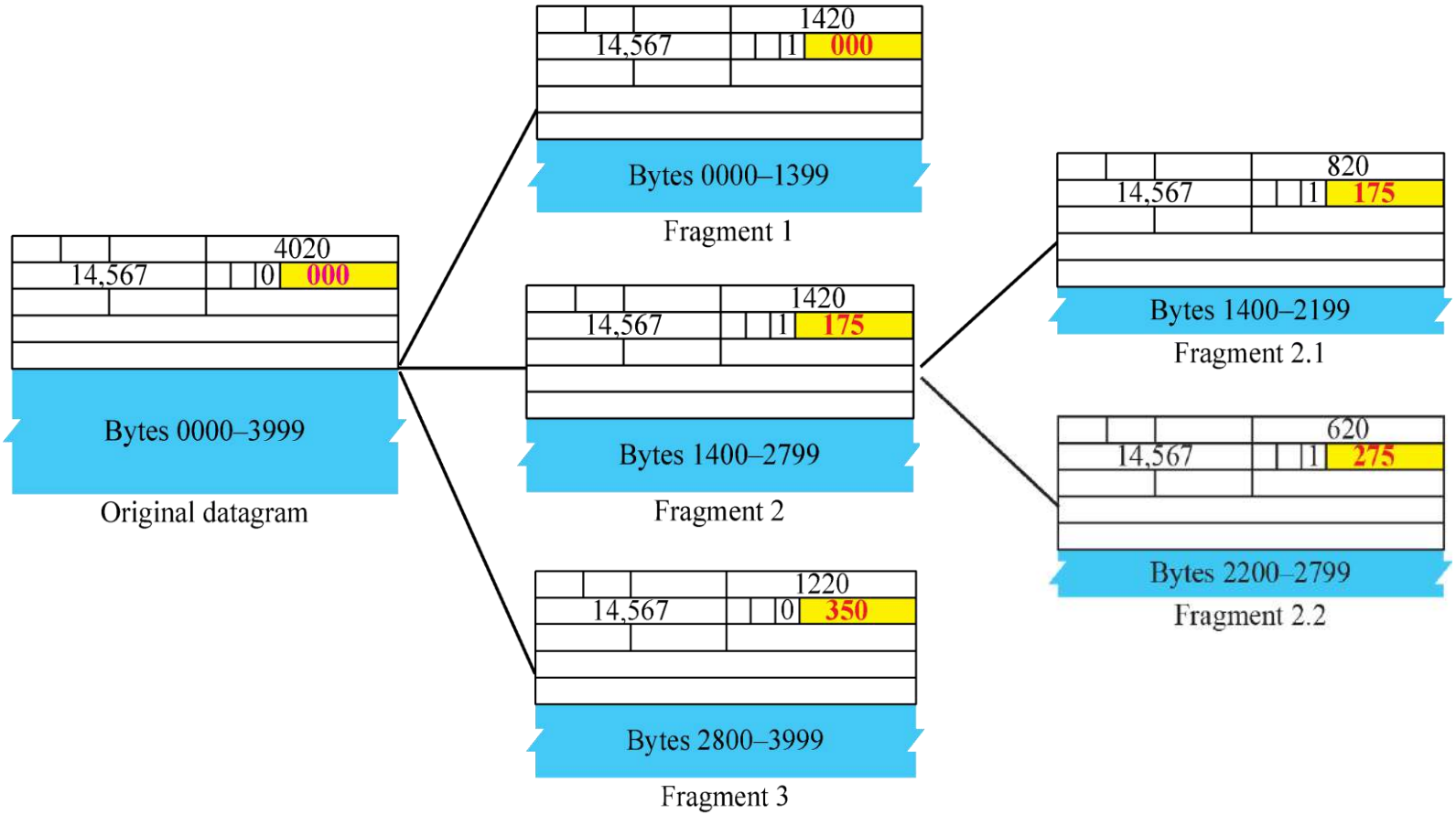


Figure 9 *Detailed fragmentation example*



Example 5

A packet has arrived with an M bit value of 0. Is this the first fragment, the last fragment, or a middle fragment? Do we know if the packet was fragmented?

Solution

If the M bit is 0, it means that there are no more fragments; the fragment is the last one. However, we cannot say if the original packet was fragmented or not. A nonfragmented packet is considered the last fragment.

Example 6

A packet has arrived with an M bit value of 1. Is this the first fragment, the last fragment, or a middle fragment? Do we know if the packet was fragmented?

Solution

If the M bit is 1, it means that there is at least one more fragment. This fragment can be the first one or a middle one, but not the last one. We don't know if it is the first one or a middle one; we need more information (the value of the fragmentation offset). See also the next example.

Example 7

A packet has arrived with an M bit value of 1 and a fragmentation offset value of zero. Is this the first fragment, the last fragment, or a middle fragment?

Solution

Because the M bit is 1, it is either the first fragment or a middle one. Because the offset value is 0, it is the first fragment.

Example 8

A packet has arrived in which the offset value is 100. What is the number of the first byte? Do we know the number of the last byte?

Solution

To find the number of the first byte, we multiply the offset value by 8. This means that the first byte number is 800. We cannot determine the number of the last byte unless we know the length of the data.

4 OPTIONS

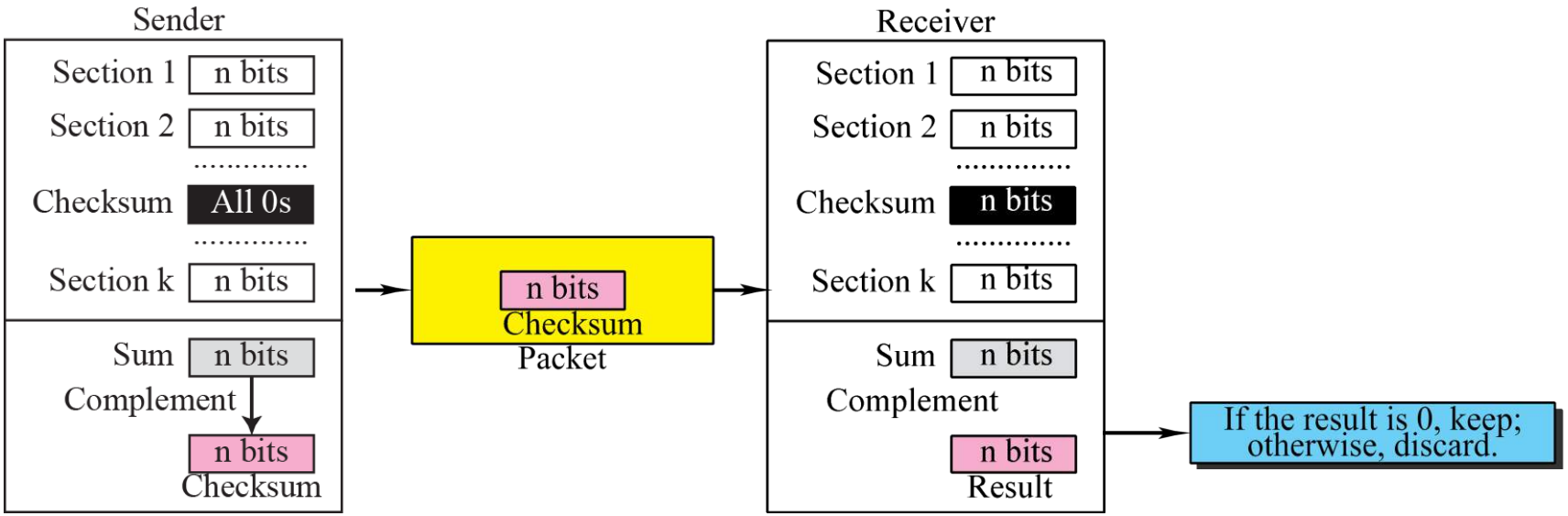
The header of the IP datagram is made of two parts: a fixed part and a variable part. The fixed part is 20 bytes long and was discussed in the previous section. The variable part comprises the options, which can be a maximum of 40 bytes.

Options, as the name implies, are not required for a datagram. They can be used for network testing and debugging. Although options are not a required part of the IP header, option processing is required.

5 CHECKSUM

The error detection method used by most TCP/IP protocols is called the checksum. The checksum protects against the corruption that may occur during the transmission of a packet. It is redundant information added to the packet. The checksum is calculated at the sender and the value obtained is sent with the packet. The receiver repeats the same calculation on the whole packet including the checksum. If the result is satisfactory (see below), the packet is accepted; otherwise, it is rejected.

Figure 12 *Checksum concept*



Note

Checksum in IP covers only the header, not the data.

Figure 13 *Example of checksum calculation at the sender*

4, 5, and 0	01000101	00000000
28	00000000	00011100
1	00000000	00000001
0 and 0	00000000	00000000
4 and 17	00000100	00010001
0	00000000	00000000
10.12	00001010	00001100
14.5	00001110	00000101
12.6	00001100	00000110
7.9	00000111	00001001
Sum	**01110100**	**01001110**
Checksum	**10001011**	**10110001**