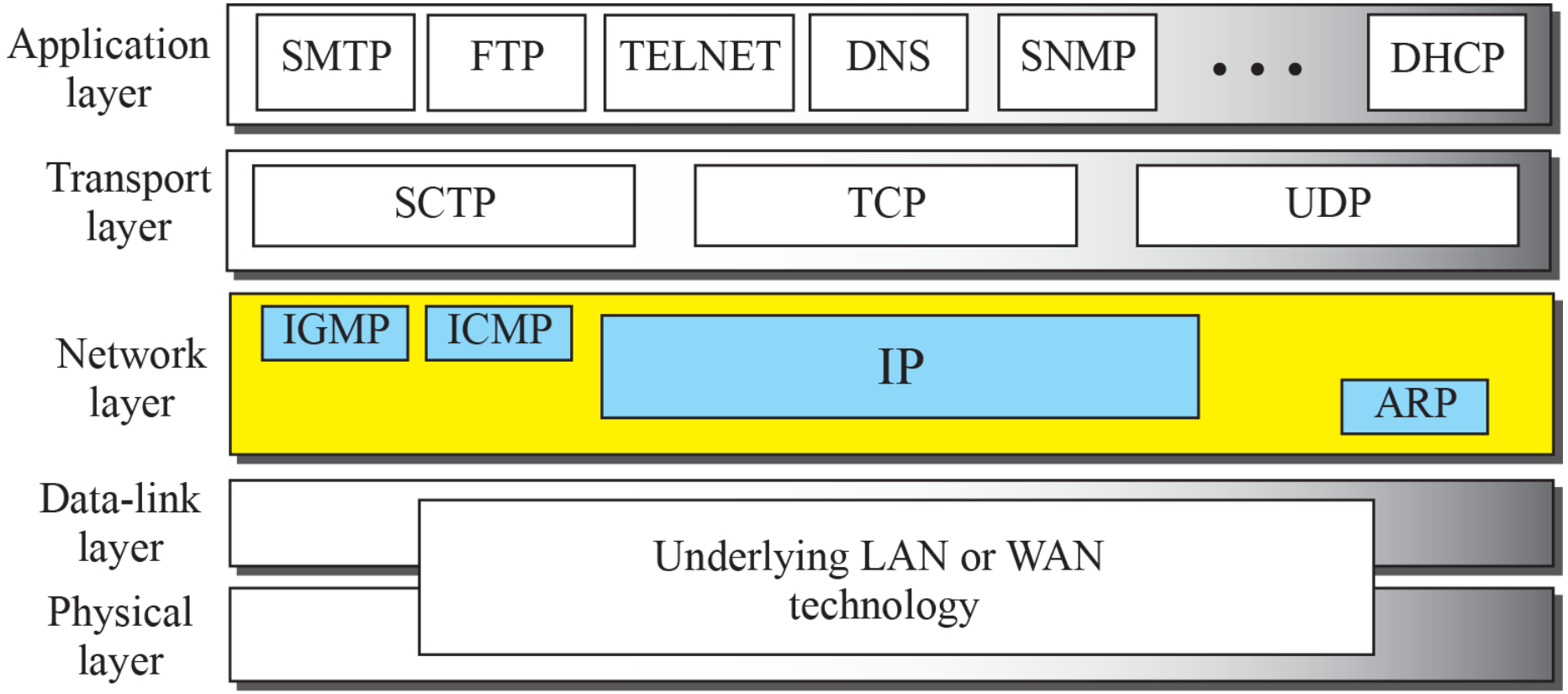
Chapter 19

Network Layer Protocols

NETWORK-LAYER PROTOCOLS

- *IPv4 is responsible for packetizing, forwarding, and delivery of a packet.*
- *ICMPv4 helps IPv4 to handle some errors that may occur in delivery.*
- *IGMP is used to help IPv4 in multicasting.*
- *ARP is used in address mapping.*

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



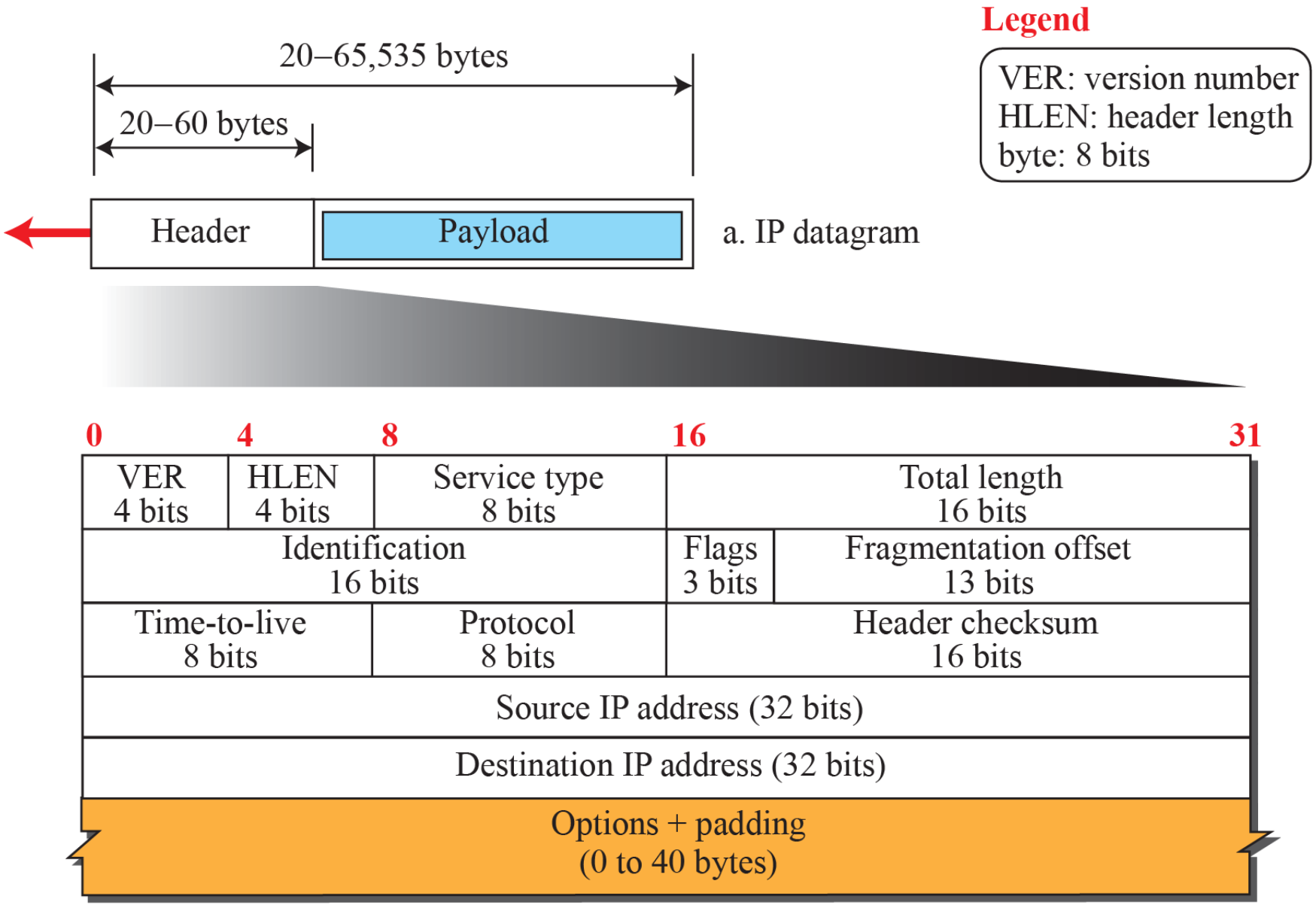
Datagram Format

A datagram is a variable-length packet consisting of two parts:

- *Header*
- *payload (data)*

The header is 20 to 60 bytes in length and contains information essential to routing and delivery.

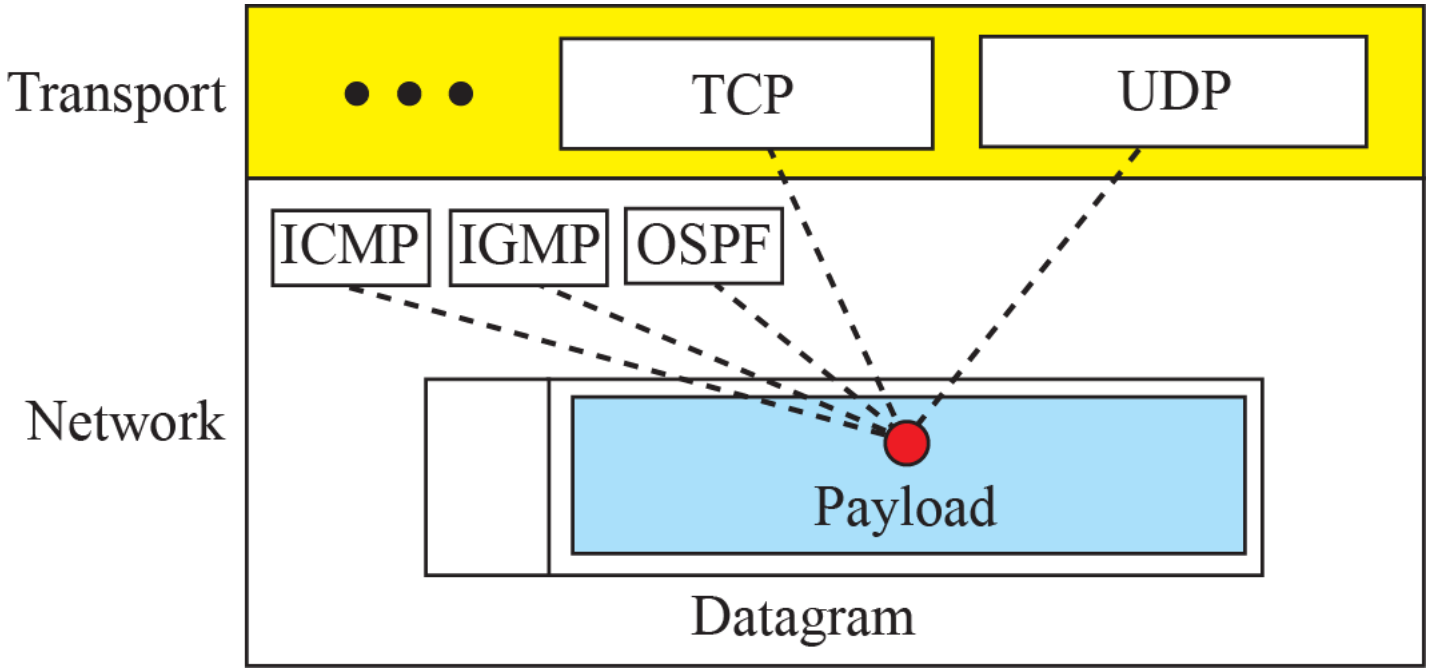
IP datagram


Legend
VER: version number
HLEN: header length
byte: 8 bits
20–65,535 bytes
20–60 bytes
Header
Payload
a. IP datagram
0
4
8
16
31
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)
b. Header format

Multiplexing and demultiplexing using the value of the protocol field

ICMP: 01
IGMP: 02
TCP: 06
UDP: 17
OSPF: 89

Some protocol values



Example 19.1

An IPv4 packet has arrived with the first 8 bits as $(01000010)_2$ The receiver discards the packet. Why?.

Solution

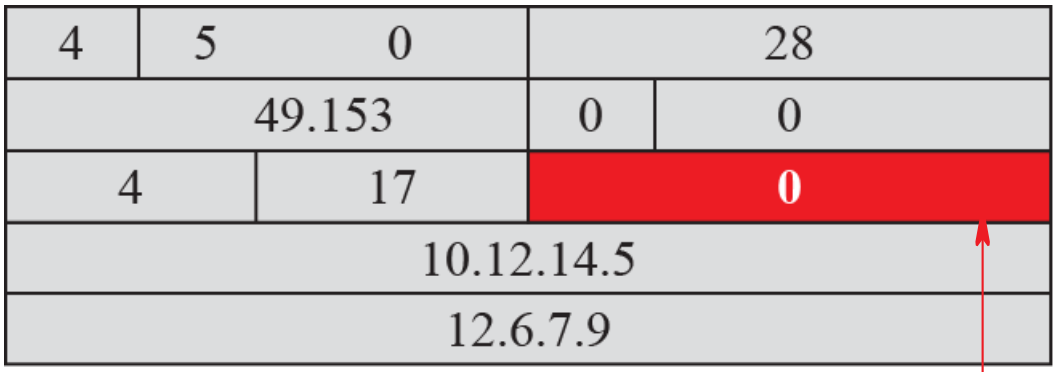
There is an error in this packet. The 4 leftmost bits $(0100)_2$ show the version, which is correct. The next 4 bits $(0010)_2$ show an invalid header length ($2 \times 4 = 8$). The minimum number of bytes in the header must be 20. The packet has been corrupted in transmission.

Example 19.2

In an IPv4 packet, the value of HLEN is $(1000)_2$. 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.

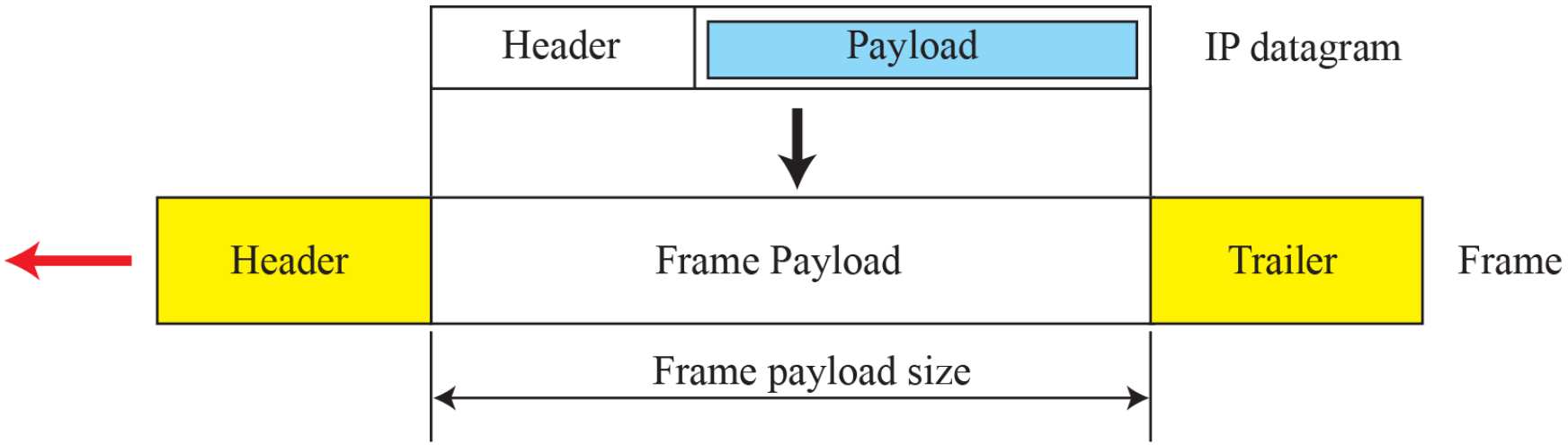


4, 5, and 0	→	4	5	0	0
28	→	0	0	1	C
1	→	C	0	0	1
0 and 0	→	0	0	0	0
4 and 17	→	0	4	1	1
0	→	0	0	0	0
10.12	→	0	A	0	C
14.5	→	0	E	0	5
12.6	→	0	C	0	6
7.9	→	0	7	0	9
Sum	→	1 3	4	4	E
Wrapped sum	→	3	4	4	F
Checksum	→	**C**	**B**	**B**	**0**

Fragmentation

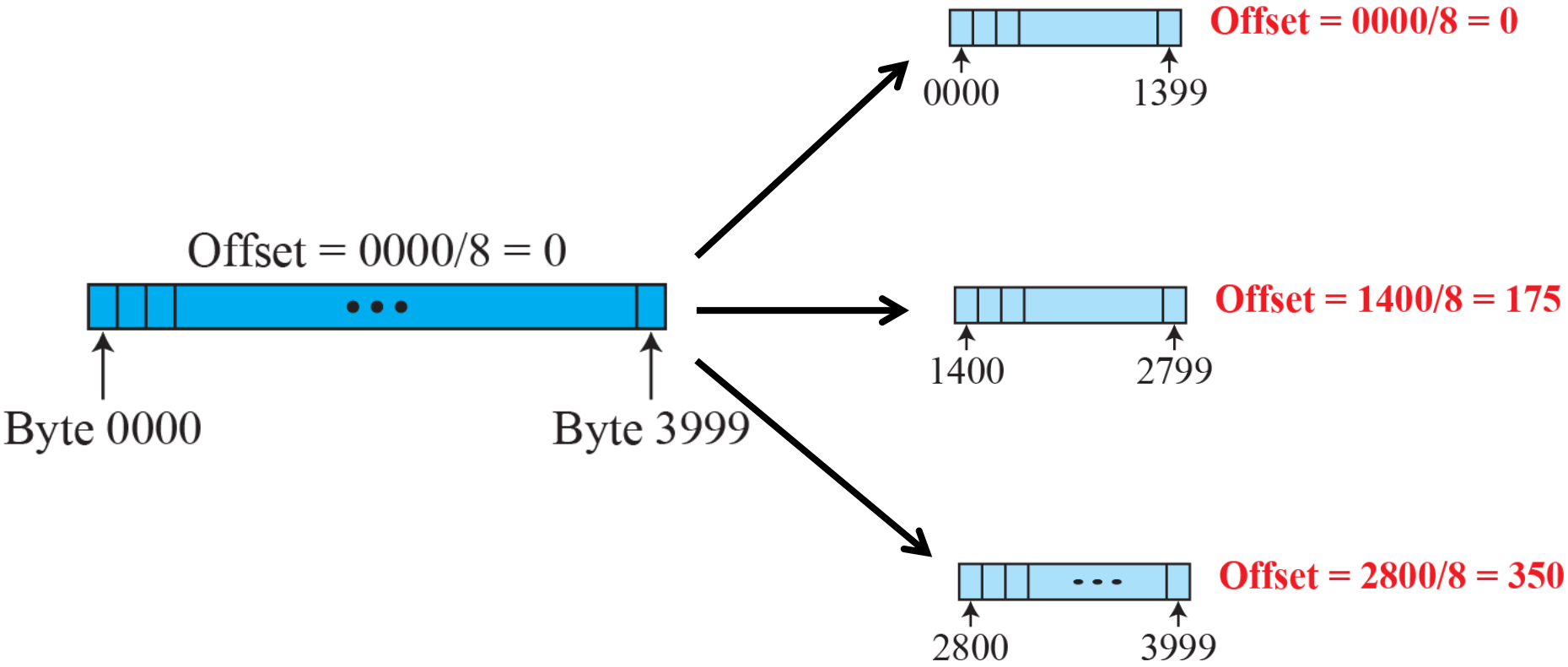
The format and size of the sent frame depend on the protocol used by the physical network through which the frame is going to travel. For example, if a router connects a LAN to a WAN, it receives a frame in the LAN format and sends a frame in the WAN format.

Maximum transfer unit (MTU)

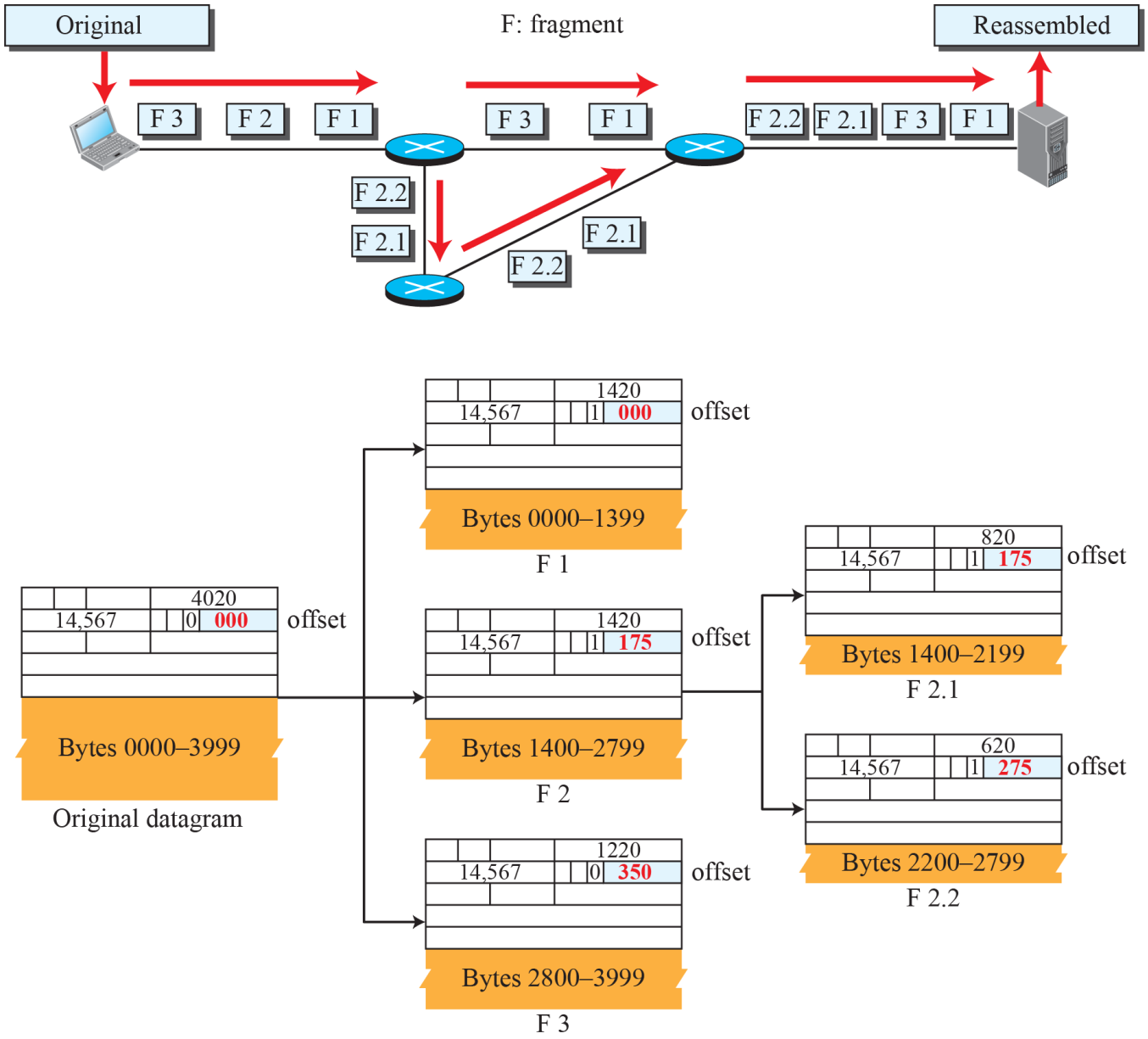


MTU: Maximum size of frame payload

Fragmentation example



Detailed fragmentation example



ICMPv4

- The IPv4 has no error-reporting or error-correcting mechanism.

- The IP protocol also lacks a mechanism for host and management queries.

- The Internet Control Message Protocol version 4 (ICMPv4) has been designed to compensate for the above two deficiencies.

MESSAGES

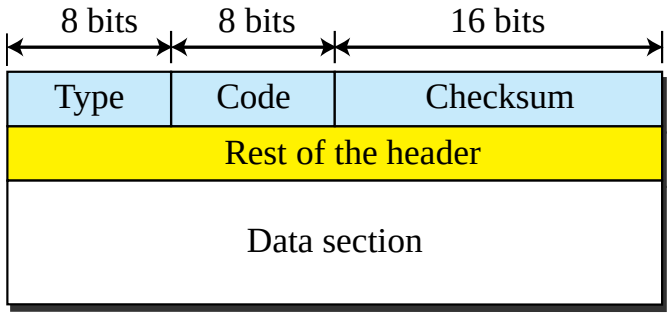
- error-reporting messages

  report problems that a router or a host (destination) may encounter when it processes an IP packet.

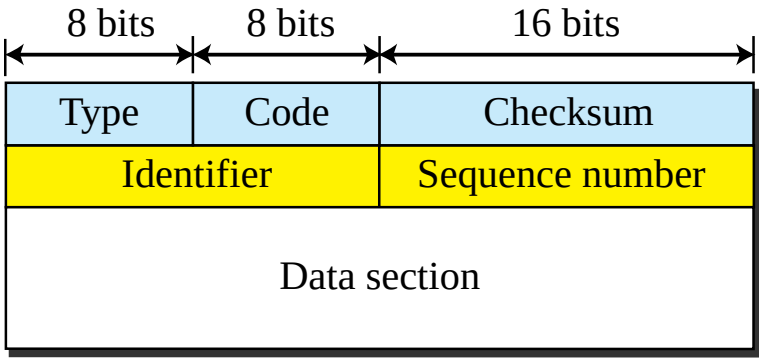
- query messages

  help a host or a network manager get specific information from a router or another host.

General format of ICMP messages



Error-reporting messages



Query messages

Type and code values

Error-reporting messages	**Query messages**
03: Destination unreachable (codes 0 to 15)	08 and 00: Echo request and reply (only code 0)
04: Source quench (only code 0)	13 and 14: Timestamp request and reply (only code 0)
05: Redirection (codes 0 to 3)	
11: Time exceeded (codes 0 and 1)	
12: Parameter problem (codes 0 and 1)	

Note: See the book website for more explanation about the code values.

Contents of data field for the error messages