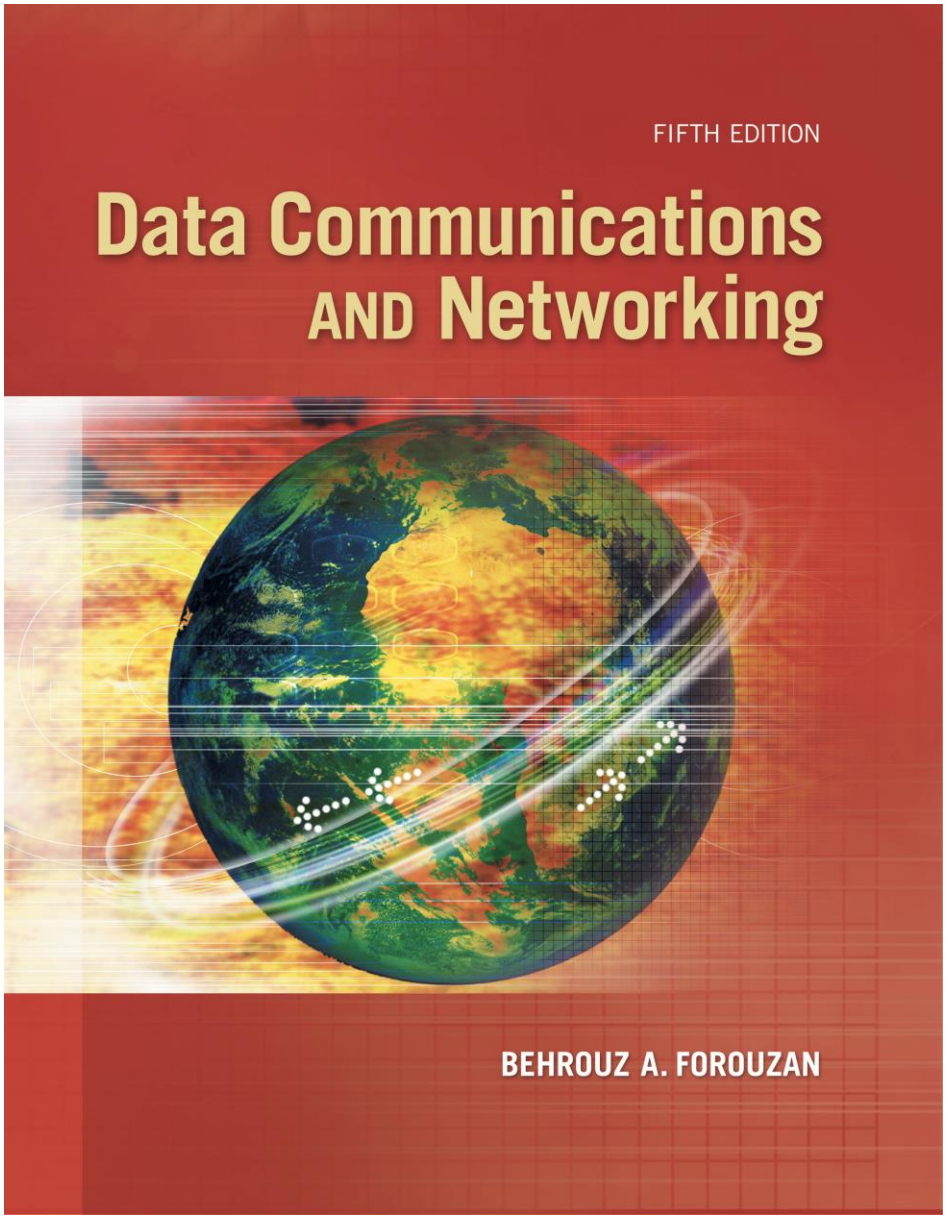
Chapter 19

Network Layer Protocols

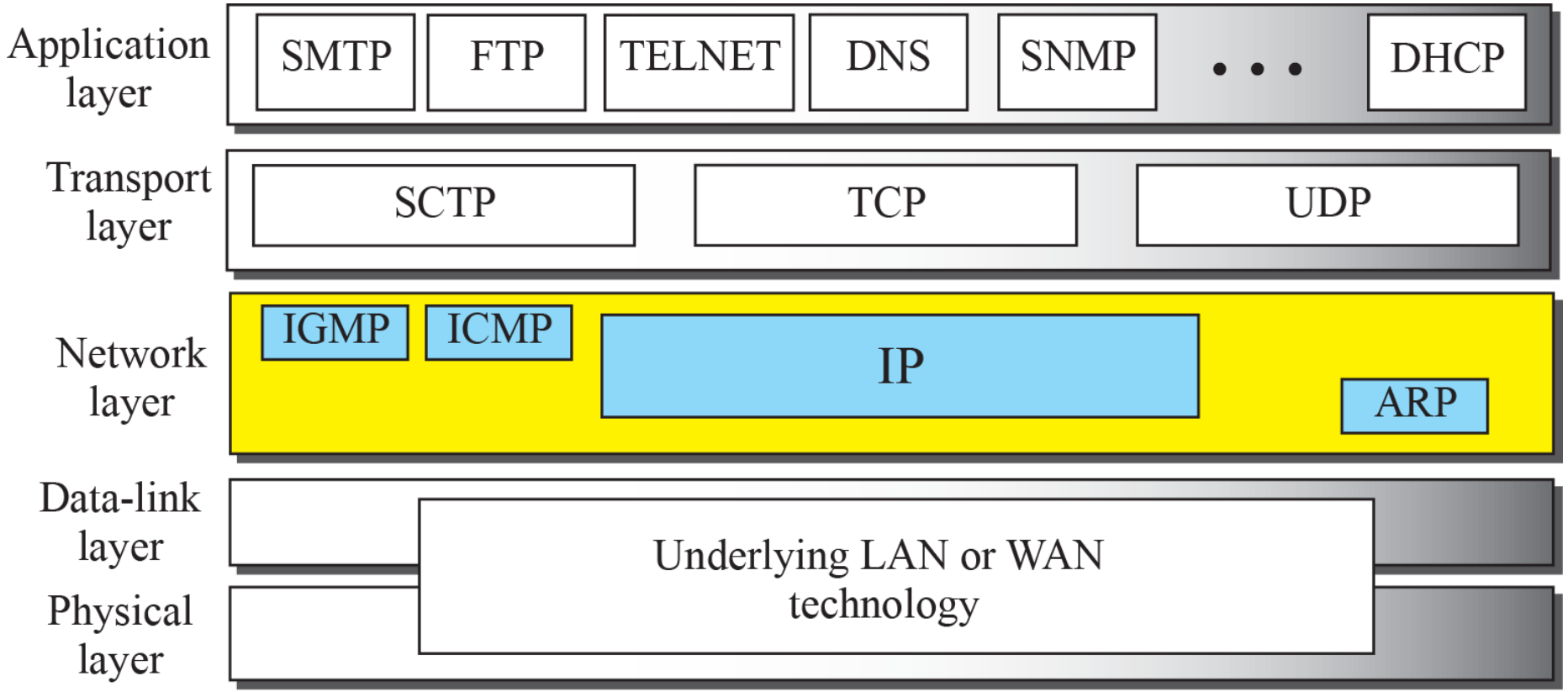


19.1 NETWORK-LAYER PROTOCOLS

The network layer in version 4 can be thought of as one main protocol and three auxiliary ones.

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

Figure 19.1: ***Position of IP and other network-layer protocols in TCP/IP protocol suite***



19.19.1 Datagram Format

Packets used by the IP are called datagrams. Figure 19.2 shows the IPv4 datagram format. A datagram is a variable-length packet consisting of two parts: header and payload (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..

Figure 19.2: *IP datagram*

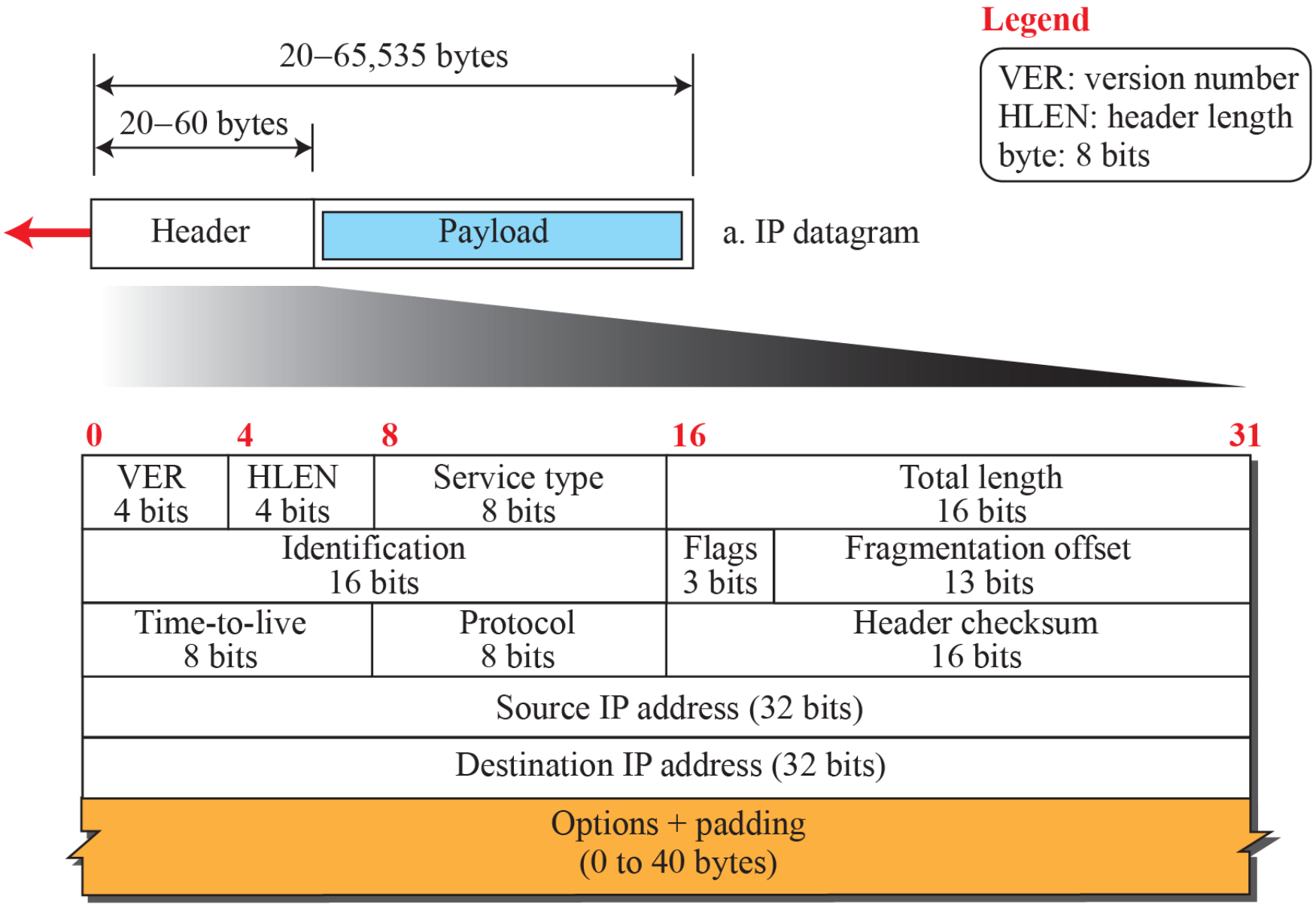
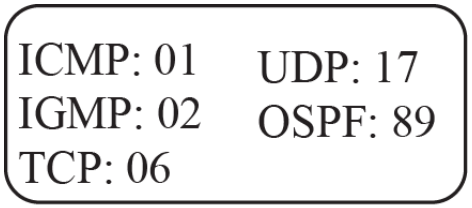
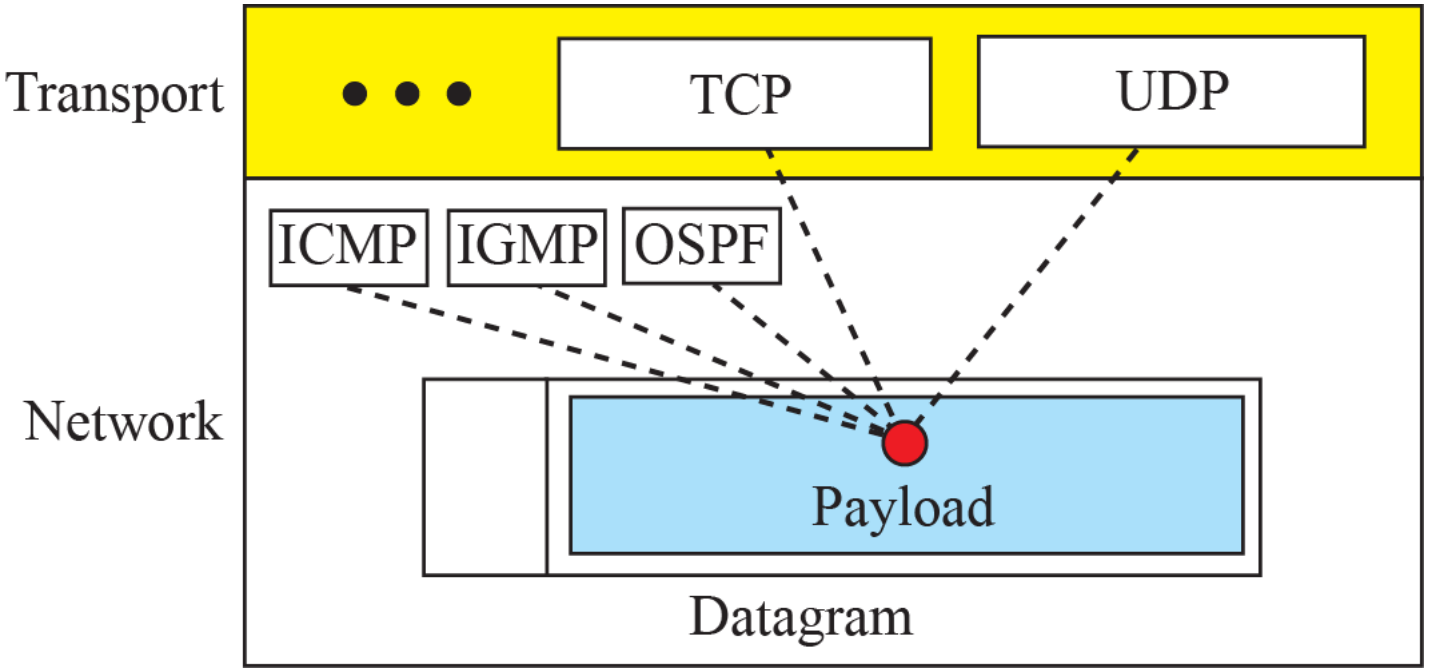


Figure 19.3: ***Multiplexing and demultiplexing using the value of the protocol field***



Some protocol values



19.2 ICMPv4

IPv4

- *has no error-reporting or error-correcting mechanism.*
- *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.

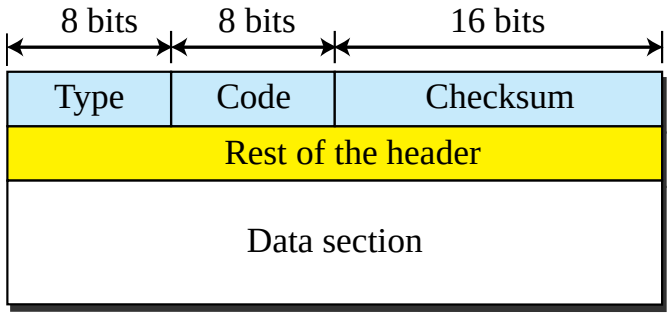
19.2.1 MESSAGES

ICMP messages are divided into two broad categories: error-reporting messages and query messages.

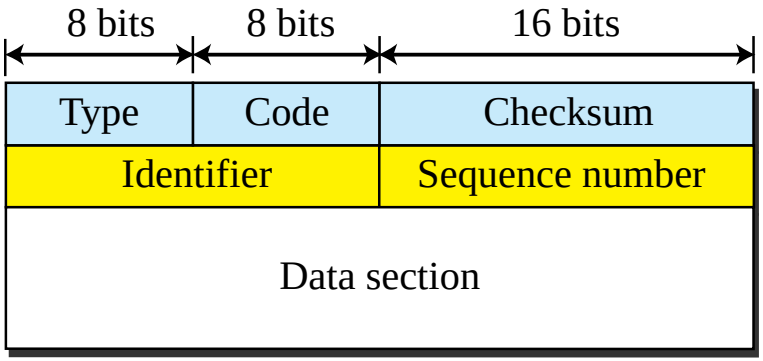
Error-reporting messages report problems that a router or a host (destination) may encounter when it processes an IP packet.

Query messages, which occur in pairs, help a host or a network manager get specific information from a router or another host. For example, nodes can discover their neighbors. Also, hosts can discover and learn about routers on their network and routers can help a node redirect its messages.

Figure 19.8: General format of ICMP messages



Error-reporting messages



Query messages

Type and code values

Error-reporting messages

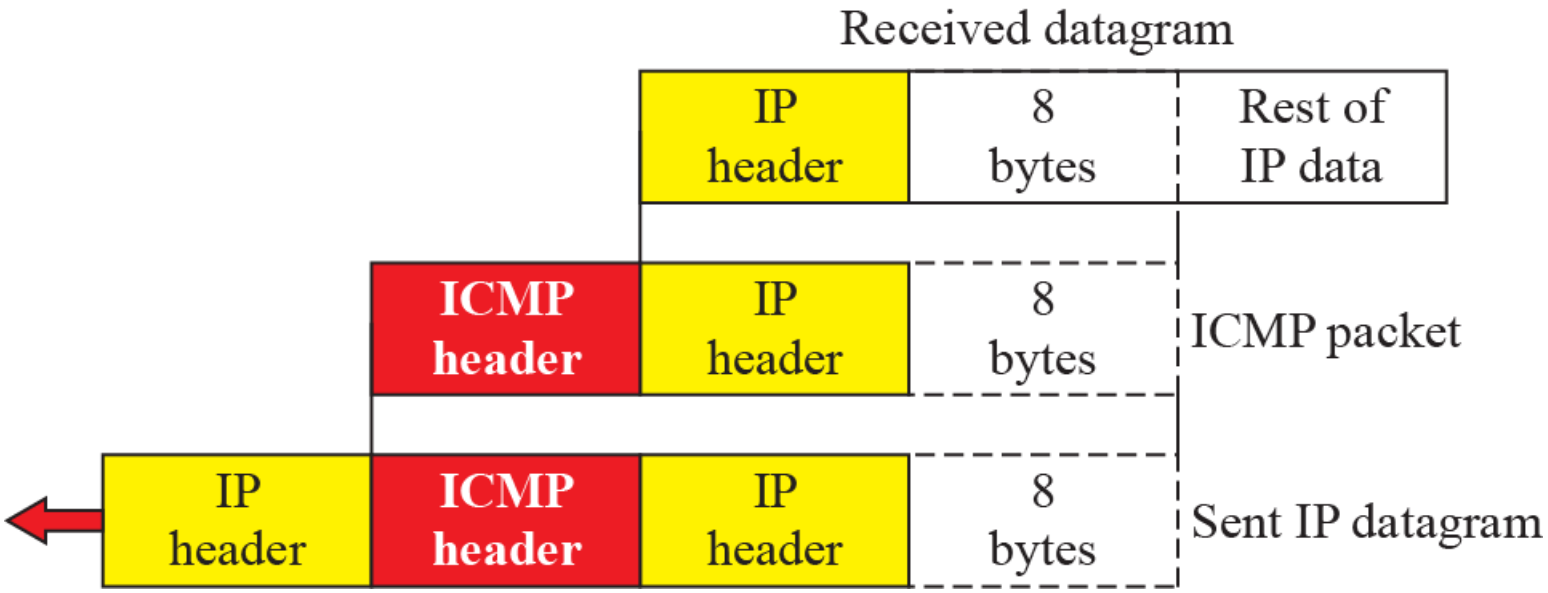
03: Destination unreachable (codes 0 to 15)
04: Source quench (only code 0)
05: Redirection (codes 0 to 3)
11: Time exceeded (codes 0 and 1)
12: Parameter problem (codes 0 and 1)

Query messages

08 and 00: Echo request and reply (only code 0)
13 and 14: Timestamp request and reply (only code 0)

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

Figure 19.9: ***Contents of data field for the error messages***



19.2.2 Debugging Tools

There are several tools that can be used in the Internet for debugging. We can determine the viability of a host or router. We can trace the route of a packet.

We introduce two tools that use ICMP for debugging:

- *ping*
- *traceroute.*

Example 19.11

The following shows how we send a ping message to the auniversity.edu site. We set the identifier field in the echo request and reply message and start the sequence number from 0; this number is incremented by one each time a new message is sent. Note that ping can calculate the round-trip time. It inserts the sending time in the data section of the message. When the packet arrives, it subtracts the arrival time from the departure time to get the round-trip time (*rtt*).

```
$ ping auniversity.edu
PING auniversity.edu (152.181.8.3)  56 (84)  bytes of data.
64 bytes from auniversity.edu (152.181.8.3): icmp_seq=0    ttl=62    time=1.91 ms
```

Example 19.11(continued)

```
64 bytes from auniversity.edu (152.181.8.3): icmp_seq=1    ttl=62    time=2.04 ms
64 bytes from auniversity.edu (152.181.8.3): icmp_seq=2    ttl=62    time=1.90 ms
64 bytes from auniversity.edu (152.181.8.3): icmp_seq=3    ttl=62    time=1.97 ms
64 bytes from auniversity.edu (152.181.8.3): icmp_seq=4    ttl=62    time=1.93 ms
64 bytes from auniversity.edu (152.181.8.3): icmp_seq=5    ttl=62    time=2.00 ms
--- auniversity.edu statistics ---
6 packets transmitted, 6 received, 0% packet loss
rtt min/avg/max = 1.90/1.95/2.04 ms
```

```
C:\Users\ankit>tracert google.com

Tracing route to google.com [172.217.167.206]
over a maximum of 30 hops:

  1     1 ms    <1 ms    <1 ms  MYGROUP [192.168.1.1]
  2     8 ms     7 ms     5 ms  abts-north-dynamic-255.159.162.122.airtelbroadband.in [122.162.159.255]
  3     6 ms     8 ms     5 ms  nsg-corporate-073.5.180.122.airtel.in [122.180.5.73]
  4     5 ms     9 ms    12 ms  116.119.109.0
  5    11 ms    11 ms    11 ms  142.250.161.56
  6    12 ms     7 ms     8 ms  142.251.66.169
  7     9 ms     8 ms     8 ms  209.85.252.65
  8     9 ms     8 ms     8 ms  del03s18-in-f14.1e100.net [172.217.167.206]

Trace complete.
```

```
C:\Users\ankit>tracert du.ac.in

Tracing route to du.ac.in [3.33.160.68]
over a maximum of 30 hops:

  1     1 ms     1 ms    <1 ms  MYGROUP [192.168.1.1]
  2     5 ms     5 ms     7 ms  abts-north-dynamic-255.159.162.122.airtelbroadband.in [122.162.159.255]
  3    19 ms     7 ms     5 ms  nsg-corporate-073.5.180.122.airtel.in [122.180.5.73]
  4     7 ms     4 ms     5 ms  116.119.109.10
  5    56 ms    10 ms     8 ms  99.83.64.168
  6   801 ms   998 ms   996 ms  150.222.217.148
  7   154 ms   245 ms   487 ms  150.222.217.153
  8     *        *        *     Request timed out.
  9   181 ms  1056 ms  1009 ms  150.222.244.247
 10     *        *        *     Request timed out.
 11   685 ms  1017 ms  1017 ms  52.93.116.80
 12   461 ms   991 ms  1023 ms  aeae1abfd9923c77d.awsglobalaccelerator.com [3.33.160.68]

Trace complete.
```

Figure 19.10: ***Example of traceroute program***