CHAPTER 20

Network Layer: Internet Protocol

Solutions to Odd-Numbered Review Questions and Exercises

Review Questions

1. The delivery of a frame in the data link layer is ***node-to-node.*** The delivery of a packet at the network layer is ***host-to-host***.

3. Each data link layer protocol has a limit on the size of the packet it can carry. When a datagram is encapsulated in a frame, the total size of the datagram must be less than this limit. Otherwise, the datagram must be ***fragmented***. IPv4 allows fragmentation at the host and any router; IPv6 allows fragmentation only at the host.

5. ***Options*** can be used for network testing and debugging. We mentioned six options: no-operation, end-of-option, record-route, strict-source-route, loose-source-route, and timestamp. A ***no-operation*** option is a 1-byte option used as a filler between options. An ***end-of-option*** option is a 1-byte option used for padding at the end of the option field. A ***record-route*** option is used to record the Internet routers that handle the datagram. A ***strict-source-route*** option is used by the source to predetermine a route for the datagram. A ***loose-source-route*** option is similar to the strict source route, but it is less rigid. Each router in the list must be visited, but the datagram can visit other routers as well. A ***timestamp*** option is used to record the time of datagram processing by a router.

7. In IPv4, priority is handled by a field called ***service type*** (in the early interpretation) or ***differential services*** (in the latest interpretation). In the former interpretation, the three leftmost bits of this field define the priority or precedence; in the latter interpretation, the four leftmost bits of this field define the priority. In IPv6, the four-bit ***priority*** field handles two categories of traffic: *congestion-controlled* and *noncongestion-controlled*.

9. The ***checksum*** is eliminated in IPv6 because it is provided by upper-layer protocols; it is therefore not needed at this level.

Exercises

11. If no fragmentation occurs at the router, then the only field to change in the base header is the ***time to live*** field. If any of the multiple-byte options are present, then there will be changes in the option headers as well (to record the route and/or timestamp). If fragmentation does occur, the ***total length*** field will change to reflect the total length of each datagram. The ***more*** fragment bit of the flags field and the fragmentation ***offset*** field may also change to reflect the fragmentation. If options are present and fragmentation occurs, the ***header length*** field of the base header may also change to reflect whether or not the option was included in the fragments.

13.

Advantages of a large MTU:

- Good for transferring large amounts of data over long distances
- No fragmentation necessary; faster delivery and no reassembly
- Fewer lost datagrams
- More efficient (less overhead)

Advantages of a small MTU:

- Good for transferring time-sensitive data such as audio or video
- Better suited for multiplexing

15. The value of the header length field of an IP packet can never be less than 5 because every IP datagram must have at least a base header that has a fixed size of 20 bytes. The value of HLEN field, when multiplied by 4, gives the number of bytes contained in the header. Therefore the minimum value of this field is 5. This field has a value of exactly 5 when there are no options included in the header.

17. If the size of the option field is 20 bytes, then the total length of the header is 40 bytes (20 byte base header plus 20 bytes of options). The HLEN field will be the total number of bytes in the header divided by 4, in this case ten (1010 in binary).

19. Since there is no option information, the header length is 20, which means that the value of HLEN field is **5** or **0101** in binary. The value of total length is 1024 + 20 or **1044** (**00000100 00010100** in binary).

21. If the M (*more*) bit is zero, this means that the datagram is either the last fragment or the it is not fragmented at all. Since the *offset* is 0, it cannot be the last fragment of a fragmented datagram. ***The datagram is not fragmented***.

23. Let us first find the value of header fields before answering the questions:

    VER = 0x4 = **4**
    HLEN =0x5 = 5 $\rightarrow 5 \times 4 =$ **20**
    Service =0x00 = **0**
    Total Length = 0x0054 = **84**
    Identification = 0x0003 = **3**
    Flags and Fragmentation = 0x0000 $\rightarrow$ D = **0** M= **0** offset = **0**
    Time to live = 0x20 = **32**
    Protocol = 0x06 = **6**

Checksum = 0x5850
Source Address: 0x7C4E0302 = **124.78.3.2**
Destination Address: 0xB40E0F02 = **180.14.15.2**

We can then answer the questions:

a. If we calculate the checksum, we get 0x0000. ***The packet is not corrupted***.
b. Since the length of the header is 20 bytes, ***there are no options.***
c. Since *M* = 0 and *offset* = 0, ***the packet is not fragmented.***
d. The total length is 84. ***Data size is 64 bytes (84 –20)***.
e. Since the value of *time to live* = 32, ***the packet may visit up to 32 more routers***.
f. ***The identification number of the packet is 3***.
g. ***The type of service is normal***.