Internet Protocol Tutorial Sample Solutions

Question 1

An IPv4 datagram with no header options and with 2000 bytes/octets of message data (i.e. the data after the header) is to be transmitted from a host on a network A to its destination on a network D via one of two different networks, B and C. The maximum transmission units (MTU) of networks A and D are both 3000 bytes/octets, those of B and C are 704 and 1500 bytes/octets, respectively.

a) Calculate the number and size of fragments, and their fragment offset values, when the datagram follows the route over B to reach its final destination.
b) Calculate the number and size of fragments, and their fragment offset values, when the datagram follows the route over C to reach its final destination.
c) Explain briefly what happens if the route followed is through B then C. Similarly, explain what occurs if the datagram passes through C then B. What is the number of fragments in each case?

Sample Solution

No fragmentation occurs for transmission through networks A or D.

a) In the ABD route, the datagram is fragmented on entering network B. A fragment in network B can have maximum size 704 including header, 684 (704 - 20) excluding header (an IP header with no options is 20 bytes long), 680 (lowest multiple of 8 below 684) for each fragment data aside from last. The number of fragments is therefore 3 (2000/680), with sizes in bytes/octets and offsets in 8-byte words as follows.
   - Fragment data size = 680, datagram size = 700 (680 + 20), offset = 0
   - Fragment data size = 680, datagram size = 700 (680 + 20), offset = 85 (680 / 8)
   - Fragment data size = 640 (2000 - (2 x 680)), datagram size = 660 (640 + 20), offset = 170 (1360 / 8).

   Other multiples of 8 are acceptable.

b) In the ACD route, the datagram is fragmented on entering network C. A fragment in network C can have maximum size 1500 including header, 1480 (1500 - 20) excluding header (an IP header with no options is 20 bytes long), 1480 (lowest multiple of 8 below 1480) for each fragment data aside from last. The number of fragments is therefore 2 (2000 / 1480), with sizes in bytes/octets and offsets in 8-byte words as follows.
   - Fragment data size = 1480, datagram size = 1500 (1480 + 20), offset = 0
   - Fragment data size = 520 (2000 - 1480), datagram size = 540 (520 + 20), offset = 185 (1480 / 8).
   - Other multiples of 8 are acceptable.

c) Along the ABCD route, fragmentation is required over B only (as is done in Question (a)), since MTU of C network is larger than that of B. The number of fragments will be 3. However, along the ACBD route, fragmentation is required over C and then again over B.

This, however, does not change the number of fragments (3 when in B). 4 fragments can also be argued along the latter route: split into 2 in C, then largest needs to split into 3 in B.

Question 2

The one's complement sum of all 16 bit words of an IPv4 header, except the first, is 11001010 01011001 (binary). Given that the first two bytes are 69 and 128 (decimal), calculate the final IP header checksum in binary (show your working).

Explain what the checksum is used for.

Sample Solution

Add the first two bytes to the rest. 1 is carried, so add this to the sum. Take the one's complement of the result.

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  01000101 10000000    (69, 128)
  11001010 01011001    (rest of header sum)
1 00001111 11011001    (sum of header, 1 carried)
                   1   (add the 1)
  00001111 11011010    (final one's complement sum)
  11110000 00100101    (checksum = one's complement of above sum)
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The IP header checksum is used to check that the IP header has been transmitted without corruption. It is re-calculated by the receiver and compared.