Computer Networks and Distributed Systems

Solutions to Questionnaire about IP forwarding, addressing and numbering

Based on textbook "*Conceptual Computer Networks*" (WIP) by José María Foces Morán and José María Foces Vivancos

Context

- IP forwarding and IP fragmentation (Summary presentation: http://paloalto.unileon.es/cn/lect/CN-IP.pdf)
- Before working out the exercises about IP fragmentation, I recommend that you thoroughly review exercise no. 2 from the published solution to the Term No. exam(http://paloalto.unileon.es/cn/Q/CN-Ex1-2018-RefSOL.pdf) and review the exercises about IP fragmentation in questionnaire titled "STP and the intro to IP"
- When you can recall the concepts about encapsulation and MTU, etc. you can proceed to study the following exercises about IP fragmentation

1. Why is IP fragmentation necessary in IPv4?

   IP packets can have a maximum size of 65 Kbyte, in contrast, an Ethernet frame can have a max size of 1500 Bytes. This disparity in size between the network (IP) and the subnetwork (Ethernet) layers is solved by breaking down each IP packet into a series of fragments that can fit the Ethernet frame. IP packets contain a series of fields for controlling the fragmentation, so that the end receiver, when receiving a series of fragmented packets be able to restore the original IP packet.

   In IPv6, in principle, fragmentation is not necessary because transmitters, before starting the transmission of a flow of packets from some end host to some other determine the minimum MTU found (Path MTU).

2. Devise a simple example that illustrates IP fragmentation

   An IP router receives an IP packet P whose Destination IP indicates it should be forwarded onto Ethernet interface vni3. P's header is 20 Bytes and its payload is 280 bytes and the MTU (Maximum Transfer Size) of interface vni3 is 104 Bytes, therefore, P does not fit vni3's MTU, then the router has to fragment P into several IP fragments. Calculate the fragmentation scheme and the parameters of each of the resulting fragments.

   1. Each fragment has a 20 Byte IP header, therefore, the maximum payload size of each fragment is: Max size of fragment's payload = MTU – 20 = 104 – 20 = 84 Bytes

   2. Each fragment transports a piece of the P's payload, the position where each fragment's payload fits into the whole P's payload is marked by the fragment's Offset field. This field, however, represents the number of an 8-byte word, not the number of a *1-byte* word as we usually assume. Therefore, we must check whether the Max size of a fragment's payload calculated above is

divisible by 8:

84 bytes mod 8 = 4

Since the remainder is not 0, we adjust the Max size of each fragment's payload so that it is properly aligned on an 8-byte boundary:

Aligned Max size of fragment's payload = Max size of fragment's payload – 4 = 84 – 4 = 80 bytes

In summary: Each of the resulting fragments will have a **payload of a max size of 80 bytes**.

3. P's payload is 280 Bytes which we have to fragment into the following fragments:

   $N\ fragments = \frac{280\ Bytes}{80\ \frac{Bytes}{fragment}} = 3{,}5\ fragments$; A total of 3 full size fragments plus 1 partial sized fragment:

```
Fragment 0 = (Offset = 0; Payload size = 80 Bytes; MF flag = 1)

Fragment 1 = (Offset = 0 + 80/8; Payload size = 80 Bytes; MF flag = 1)
             (Offset = 10; Payload size = 80 Bytes; MF flag = 1)

Fragment 2 = (Offset = 10 + 80/8; Payload size = 80 Bytes; MF flag = 1)
             (Offset = 20; Payload size = 80 Bytes; MF flag = 1)

The preceding fragments contain a total number of bytes of 3·80 = 240, since the
total number of bytes contained in P's payload is 280, we have 280 – 240 bytes =
40 bytes remaining which we will include in the last fragment:

Fragment 3 = (Offset = 20 + 80/8; Payload size = 40 Bytes; MF flag = 0)
             (Offset = 30; Payload size = 40 Bytes; MF flag = 0)
```

3. Solve exercises no. 1 - 11 (Pages 10 and 11) from the following CN exam solutions document: http://paloalto.unileon.es/cn/notes/CN-ExRefSol2013.pdf

4. Solve exercise 15 (Page 13) from the CN exam solutions document mentioned right above.

5. Calculate whether IP 192.168.1.95 belongs to the IP block represented by network prefix 192.168.0.0/23

   1. The mask resulting from the CIDR prefix has a block of 23 bits 1:

      Mask = 255.255.254.0

   2. If the IP belongs to the IP block, then, the prefix resulting from (IP & Mask) should be equal to the prefix itself:

```
  192.168.  1. 95
& 255.255.254.  0
-----------------
  192.168.  0.  0
```

Check that the network prefix given is correct:

```
  192.168.  0.  0
& 255.255.254.  0
-----------------
  192.168.  0.  0
```

We conclude that the IP does belong to the IP block given, in other words, we might state that IP **matches the IP block with a length of 23 bits**.

6. Calculate whether IP 192.168.1.95 belongs to the IP block represented by network prefix 192.168.0.0/24

    1. The mask resulting from the CIDR prefix has a block of 24 bits 1:

       Mask = 255.255.255.0

    2. If the IP belongs to the IP block, then, the prefix resulting from (IP & Mask) should be equal to the prefix itself:

```
  192.168.  1. 95
& 255.255.255.  0
-----------------
  192.168.  1.  0
```

Check that the network prefix given is correct:

```
  192.168.  0.  0
& 255.255.255.  0
-----------------
  192.168.  0.  0
```

We conclude that the IP **does not** belong to the IP block given, in other words, the IP **didn't match** the prefix.