In the name of God

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CE 443: Computer Networks

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Homework 1

This is the solution sheet to HW1[1].

Part I

1. Let's assume that you are an ISP which has been assigned 8 Class B addresses (i.e. IP range from 128.16.0.0 to 128.23.0.0). You have 5 customers, each requiring 1K, 20K, 50K, 85K and 150K IP addresses. What address space would you assign to each customer? What percentage of this assigned IP range is wasted? What percentage of the total IP range available to the ISP is wasted?

   Solution:

   - 1K $\longrightarrow$ 1 class B $\longrightarrow$ 128.16.0.0 $\longrightarrow$ $wastage = 65536 - 1000 = 64536$
   - 20K $\longrightarrow$ 1 class B $\longrightarrow$ 128.17.0.0 $\longrightarrow$ $wastage = 65536 - 20000 = 45536$
   - 50K $\longrightarrow$ 1 class B $\longrightarrow$ 128.18.0.0 $\longrightarrow$ $wastage = 65536 - 50000 = 15536$
   - 85K $\longrightarrow$ 2 class B $\longrightarrow$ 128.19.0.0 to 128.20.0.0 $\longrightarrow$ $wastage = 2 \times 65536 - 85000 = 46072$
   - 150K $\longrightarrow$ 3 class B $\longrightarrow$ 128.21.0.0 to 128.23.0.0 $\longrightarrow$ $wastage = 3 \times 65536 - 150000 = 46608$

   Wastage in the assigned space $= \frac{(64536+45536+15536+46072+46608)}{8*65536} = 41.63\%$
   As all available IP range is assigned the total wastage over all blocks is 41.63% as well.

   Now assume that we are using CIDR blocks and the 126.16.0.0/13 block is assigned to the ISP. What blocks will you assign to each customer? What percentage of the assigned space is wasted? What percentage of the total /13 block is wasted?

   Solution:

   - 150K → 18 bits required → **126.000101**00.0.0[2][3] → 126.20.0.0/14 → $wastage = 262144 - 150000 = 112144$
   - 85K → 17 bits required → **126.0001001**0.0.0 → 126.18.0.0/15 → $wastage = 131072 - 85000 = 46072$
   - 50K → 16 bits required → **126.00010001**.0.0 → 126.17.0.0/16 → $wastage = 65536 - 50000 = 15536$
   - 20K → 15 bits required → **126.16.1**0000000.0 → 126.16.128.0/17 → $wastage = 32768 - 20000 = 12768$
   - 1K → 10 bits required → **126.16.011111**00.0 → 126.16.124.0/22 → $wastage = 1024 - 1000 = 24$

[1]Solutions are partially obtained from the HW submission by H. Eslami
[2]16 is 00010000 in binary.
[3]Network section of the address is highlighted in **Bold**.

Wastage in the assigned space = $\frac{(112144+46072+15536+12768+24)}{262144+131072+65536+32768+1024} = 37.87\%$
Total wastage over the /13 block = $\frac{(112144+46072+15536+12768+24)}{2^{19}} = 35.58\%$ **Corrected: divison should be over 2^{19} not 2^{13}**

2. We are trying to send out 1000 Bytes of data from node A to node D. We have the following topology: A—B—C—D. Assume that the link connecting A to B has a MTU of 520 Bytes, B to C has a MTU of 320 Bytes, and C to D has a MTU of 270 Bytes. Hence the initial packet payload sizes from A to B will be 500 Bytes. Also, assume that the IP header is 20 Bytes.

   - How many packets will be received by D? For each received packet provide the following information in each of the following fields: ID, Fragmentation bit, Fragmentation offset.

     Solution:

     Node A knows that the MTU on path A to B is 500 bytes (-20 for the IP header), so it splits the 1000 bytes into two 500 bytes packets and sends it on the link to B (there is no fragmentation here). The B to C link has a MTU of 300 bytes (-20 for the ip header), hence each 500 byte packet is fragmented in to two packets. Each fragmented packet needs to have size multiple of 8 bytes, **as the offset field increments in 8 bytes and not by bytes**, therefore the 500 byte packet is fragmented into packets of size 296, and 204.

     Finally, from C to D, the MTU is 250 bytes (-20 for ip header), this time only the 296 bytes packet is further fragmented to a 248 and 48 byte packet. Overall the following packets are received by D:

Packet	Payload(B)	ID	DF	MF	Offset
1	248	x	0	1	0
2	48	x	0	1	31
3	204	x	0	0	37
4	248	y	0	1	0
5	48	y	0	1	31
6	204	y	0	0	37

   - If we were able to find the minimum MTU of the path before sending out the data, how many and what sized packets would be received by D? How well would we utilize each link in the path? Compare each link utilization to the previous case in which we are unaware of the minimum MTU of the path.

     Solution:

     If A knew the min MTU in the path is only 250 (-20 IP header), then it would have created 4 packets each with size 250bytes. Hence link A to B would be $\frac{270}{520} = 52\%$ utilized, link B to C is $\frac{270}{320} = 84\%$, and link C to D is $\frac{270}{270} = 100\%$ utilized.

     In comparison, in the initial scenario, from link A to B we have 500 bytes of data transmitted, hence $\frac{520}{520} = 100\%$ utilization. From link B to C, we have two different sized packets, resulting in $\frac{316}{320} = 99\%$ and $\frac{204}{320} = 64\%$ for an average of 82% utilization. Finally from link C to D, we have three different packet sizes, hence $\frac{268}{270} = 99\%$, $\frac{68}{270} = 25\%$, and $\frac{224}{270} = 83\%$ utilization, resulting in an average utilization of 69%.

3. Assuming that there is no data compression, in each of the following cases calculate the bandwidth necessary for transmitting in real time:

   (a) Video at a resolution of 1024 x 768, 3 bytes/pixel, 25 frames/second.

   Solution: $1024 \times 768 \frac{pixels}{frame} \times 3 \frac{bytes}{pixels} \times 8 \frac{bit}{byte} \times 25 \frac{frame}{sec} = 471.8 Mbps$ **Corrected the incorrect calculaion**

   (b) 160 x 120 video, 1 byte/pixel, 12 frames/second.

   Solution: $160 \times 120 \frac{pixels}{frame} \times 1 \frac{bytes}{pixels} \times 8 \frac{bit}{byte} \times 12 \frac{frame}{sec} = 1.84 Mbps$

(c) CD-ROM music, assuming one CD holds 74 minutes' worth and takes 650 MB.

Solution: $\frac{650}{74}\frac{MB}{minutes} \times 2^{20}\frac{bytes}{MB} \times 8\frac{bit}{byte} \times \frac{1}{60}\frac{min}{sec} = 1.22Mbps$