LINKÖPING UNIVERSITY

Solutions to Written Exam in **Internetworking** **TSIN02**

20th March 2025

1 a) See the course literature.

b) See the course literature.

c) See the course literature.

d) See the course literature.

2 a) See the course literature.

b) See the course literature.

c) See the course literature.

3 a) See the course literature.

b) See the course literature.

c) See the course literature.

d) See the course literature.

4 a) See the course literature.

b) See the course literature.

5 a) See the course literature.

b) See the course literature.

6 a) See the course literature.

b) See the course literature.

7 a) For the first group:

$$512 \leq 2^N \Rightarrow N = 9$$

$$32 - 9 = 23$$

$$(512 - 1)_{dec.} = 0.0.1.255_{dot.dec.}$$

$$(50 \cdot 512 - 1)_{dec.} = 0.0.99.255_{dot.dec.}$$

First customer, Subnet: 120.60.0.0/23
First address: 120.60.0.0 Last address: 120.60.1.255

Second customer, Subnet: 120.60.2.0/23
First address: 120.60.2.0 Last address: 120.60.3.255

...

50th customer, Subnet: 120.60.98.0/23
First address: 120.60.98.0 Last address: 120.60.99.255

For the second group of businesses:

$$32 \leq 2^N \Rightarrow N = 5$$

$$32 - 5 = 27$$

$$(32 - 1)_{dec.} = 0.0.0.31_{dot.dec.}$$

$$(200 \cdot 32 - 1)_{dec.} = 0.0.24.255_{dot.dec.}$$

First customer, Subnet: 120.60.100.0/27
First address: 120.60.100.0 Last address: 120.60.100.31

Second customer, Subnet: 120.60.100.32/27
First Address: 120.60.100.32 Last Address: 120.60.100.63

...

200th customer, Subnet: 120.60.124.224/27
First address: 120.60.124.224 Last address: 120.60.124.255

For the third group of households:

$$12 \leq 2^N \Rightarrow 3.584\ldots \leq N \Rightarrow N = 4$$

$$32 - 4 = 28$$

$$(2^4 - 1)_{dec.} = 0.0.0.15_{dot.dec.}$$

$$(350 \cdot 16 - 1)_{dec.} = 0.0.21.223_{dot.dec.}$$

First customer, Subnet: 120.60.125.0/28
First address: 120.60.125.0 Last address: 120.60.125.15

Second customer, Subnet: 120.60.125.16/28
First Address: 120.60.125.16 Last Address: 120.60.125.31

...

350th customer, Subnet: 120.60.146.208/28
First address: 120.60.146.208 Last address: 120.60.146.223
The third group will get 16 adresses each instead of 12.

b) Addresses left after allocations:

$$2^{16} - 50 \cdot 512 - 200 \cdot 32 - 350 \cdot 16 = 27936$$

c) Yes! It is possible. For example, for the first business:

$$\frac{512}{8} = 64$$

Each subblock will get 64 adresses.

$$64 \leq 2^N \Rightarrow N = 6$$

$$32 - 6 = 26$$

$$(64 - 1)_{dec.} = 0.0.0.63_{dot.dec}$$

First Subblock, Subnet: 120.60.0.0/26
First adress: 120.60.0.0 Last adress: 120.60.0.63
Second Subblock, Subnet: 120.60.0.64/26
First adress: 120.60.0.64 Last adress: 120.60.0.127

...

Eigth Subblock, Subnet: 120.60.1.192/26
First adress: 120.60.1.192 Last adress: 120.60.1.255

8 $P_r = 5dBm - 0.2\frac{dB}{km} \cdot 80 - 7dB = -18dBm$

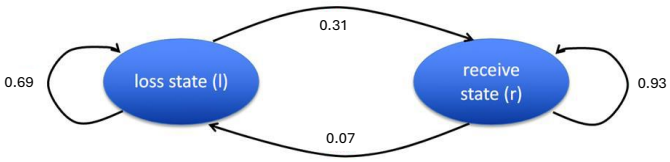
We could choose O/E device C, but this would not consider the future losses. Therefor, Opticon D is the cheapest and best option.

9 a) $P_{r2} = -17\text{dBm} - 3\text{dB} = -20\text{dBm} = 0.01\text{mW}$

b) $P_{r2} = P_{in2} - L_2 \Leftrightarrow P_{in2} = P_{r2} + L_2 = -20\text{dBm} + 9\text{dB} = -11\text{dBm}$
$P_{r1} = P_{in1} + L_1 + Amp \Leftrightarrow L_1 = P_{r1} - P_{in1} - Amp = 11\text{dBm} - 17\text{dBm} - 9\text{dB} = -15\text{dB}$

c) $P_{\text{laser}} = -11\text{dBm} + 3\text{dB} = -8\text{dBm}$

10 a)



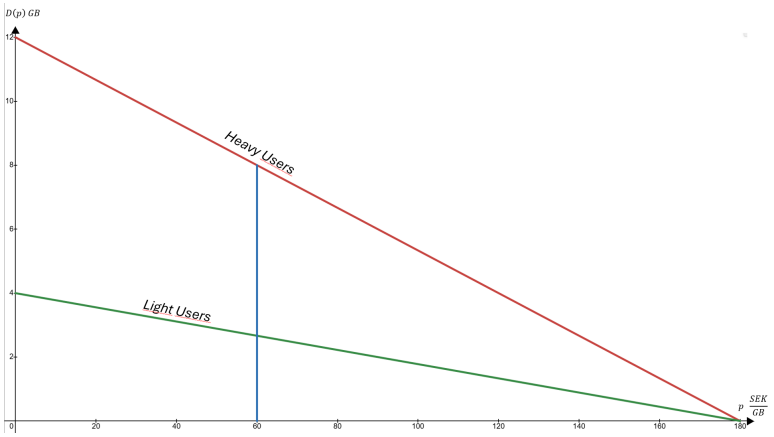
b)
$$P_l = \frac{p_{l/r}}{p_{l/r} + p_{r/l}} = \frac{0.07}{0.07 + 0.31} \approx 0.1842$$

c)
$$P_r = \frac{p_{r/l}}{p_{l/r} + p_{r/l}} = \frac{0.31}{0.07 + 0.31} \approx 0.8158$$

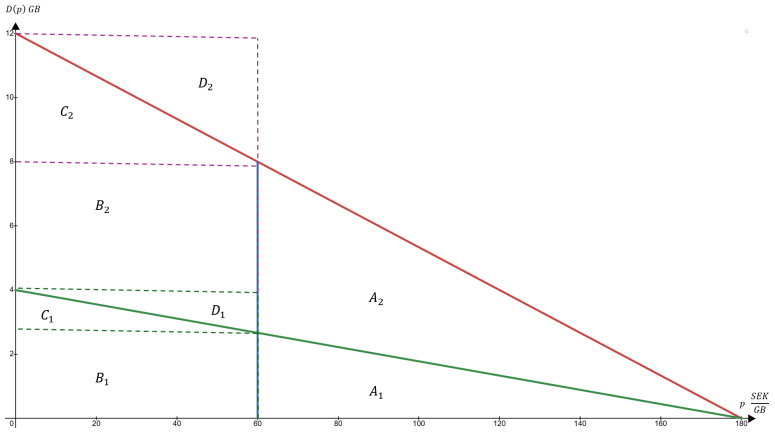
d)
$$D = P_l \cdot D_l + P_r \cdot D_r \approx 0.1842 \cdot 1 + 0.8158 \cdot \frac{(\frac{1}{14})^2}{12} \approx 0.185$$

11 a) (**NOTE**: The numbers in the figures are wrong at the moment, check back a later time for corrected figures.)

Drawing the demand functions for the users we get:



From this calculating $D_1(45) = 11$, $D_2(45) = \frac{33}{7} \approx 4.7143$. With this we get the graph with the different areas drawn in.



The net utility for usage based pricing for heavy users:

$$\begin{aligned}\text{Net utility} = \text{Utility - Cost} &= A_2 + B_2 - B_2 = A_2 \\ &= \frac{(210-45)\cdot 11}{2} = 907.50\text{SEK}\end{aligned}$$

And for light users:

$$\begin{aligned}\text{Net utility} = \text{Utility - Cost} &= A_1 + B_1 - B_1 = A_1 \\ &= \frac{(210-45)\cdot 33/7}{2} \approx 389\text{SEK}\end{aligned}$$

b) We assume that the price is set such that the heavy users will still pay 45 SEK/GB when using their maximum demand (14 GB), ie that the cost is $45 \cdot 14 = 630$ SEK.

For the net utility or surplus using flat rate, heavy users:

$$\begin{aligned}\text{Net utility} &= A_2 + B_2 + C_2 - (B_2 + C_2 + D_2) \\ &= \frac{210\cdot 14}{2} - 45\cdot 14 = 1470 - 630 = 840\text{SEK}\end{aligned}$$

And for the light users:

$$\begin{aligned}\text{Net utility} &= A_1 + B_1 + C_1 - (B_2 + C_2 + D_2) \\ &= \frac{210\cdot 6}{2} - 45\cdot 14 = 630 - 630 = 0\text{SEK}\end{aligned}$$

c) The ISP should use usage based pricing, because the surplus is positive for both kind of users if that is used.