LINKÖPING UNIVERSITY

Solutions to Written Exam in
Internetworking
TSIN02

13th January 2024

1
a) See the course literature.
b) See the course literature.
c) 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.

c) See the course literature.

7 We consider a simple design (source, optical fiber and photodetector). In the first instance, we consider a link without amplifiers to reduce monetary cost.

$$P_s \leq P_{in} - \alpha \cdot l \Rightarrow \alpha \cdot l \leq P_{in} - P_s$$

Calculating $\alpha \cdot l = 18dB$, and we see that with different types of lasers and photodetectors we get:

$P_{in} - P_s$	Laser A	Laser B	Laser C
Photodetector A	5	12	15
Photodetector B	10	17	20
Photodetector C	20	27	30

We see that the green marked values in the table fulfills the condition. The cheapest option is using Laser C and Photodetector B. This can also be motivated that a more sensitive photodetector could introduce more noise in the signal. So can also an Amplifier. One can though also motivate using Laser B and Photodetector C to plan for the future, degrading fiber or other unforseen circumstances that gives more losses in the channel.

8

a)

$$P_{router} = P_{out1} - \alpha \cdot l$$

$$P_{router} = 0dBm - 15km \cdot 0.2\frac{dB}{km}$$

$$P_{router} = -3dBm$$

Since $P_{router} \geq -5dBm$ then the router can work properly.

b) For FEC:

$$h(p) = -p\log_2(p) - (1-p)\log_2(1-p)$$

$$h(0.13) \approx 0.5574$$

Capacity for this channel $C = 1 - h(p) \approx 0.4426$

For ARQ:

$$P = 1 - (1-p)^N$$

$$P = 1 - (1-0.13)^{70} \approx 0.99994161 \approx 1$$

Capacity for this channel: $C = 1 - P \approx 0$

Clearly, FEC is best for this channel.

c)

$$P_{in1} = P_{out2} - \alpha \cdot l_{ServertoP1}$$
$$P_{in1} = 0dBm - 0.2\frac{dB}{km} \cdot 35km$$
$$P_{in1} = -7dBm$$

This means that "P1" activates and amplify the signal. This gives us that:

$$P_s \leq -7dBm + 10dB - 15dB - 0.2\frac{dB}{km} \cdot 20 = -16dBm$$
$$-10dBm \nleq -16dBm$$

Which means that the amplification needs to be altered with $6dB$. The new amplification at "P1" will be $16dB$.

9 a) For the first group:

$$256 \leq 2^N \Rightarrow N = 8$$

$$32 - 8 = 24$$
$$(256 - 1)_{dec.} = 0.0.0.255_{dot.dec.}$$
$$(150 \cdot 256 - 1)_{dec.} = 0.0.149.255_{dot.dec.}$$

First customer, subnet: 120.80.0.0/24

First address 120.80.0.0, last address 120.80.0.255

Second customer, subnet: 120.80.1.0/24

First address 120.80.1.0, last address 120.80.1.255

...

150th customer, subnet: 120.80.149.0/24

First address 120.80.149.0, last address 120.80.149.255

For the second group of businesses:

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

$$32 - 6 = 26$$
$$(64 - 1)_{dec.} = 0.0.0.63_{dot.dec.}$$
$$(100 \cdot 64 - 1)_{dec.} = 0.0.2.127_{dot.dec.}$$

First customer, subnet: 120.80.150.0/26

First address 120.80.150.0, last address 120.80.150.63

Second customer, subnet: 120.80.150.64/26

First address 120.80.150.64, last address 120.80.150.127

...

100th customer, subnet: 120.80.174.192/26

First address 120.80.174.192, last address 120.80.174.255

b) Addresses left after allocations:

$$2^{16} - 64 * 100 - 150 * 256 = 20736$$

10 For organisation A:

$$4200 \leq 2^N \Rightarrow N \geq \log_2(4200) = 12.0361736126 \Rightarrow N = 13$$

$$32 - 13 = 19$$

$$(2^{13} - 1)_{dec.} = 0.0.31.255_{dot.dec.}$$

This gives us the subnet: 198.16.0.0/19 First address: 198.16.0.0 Last address: 198.16.31.255 addresses left: $2^{13} - 4200 = 3992$
For Organisation B:

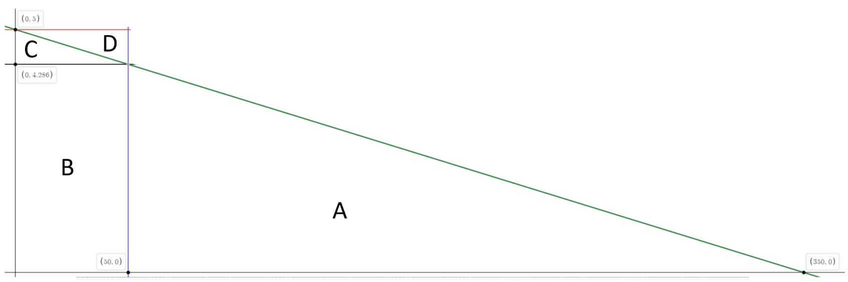
$$1990 \leq 2^N \Rightarrow N \geq \log_2(1990) = 10.9585527154 \Rightarrow N = 11$$

$$32 - 11 = 21$$

$$(2^{11} - 1)_{dec.} = 0.0.7.255_{dot.dec.}$$

This gives us the subnet: 198.16.32.0/21 First address: 198.16.32.0 Last address: 198.16.39.255 addresses left: $2^{11} - 1990 = 58$

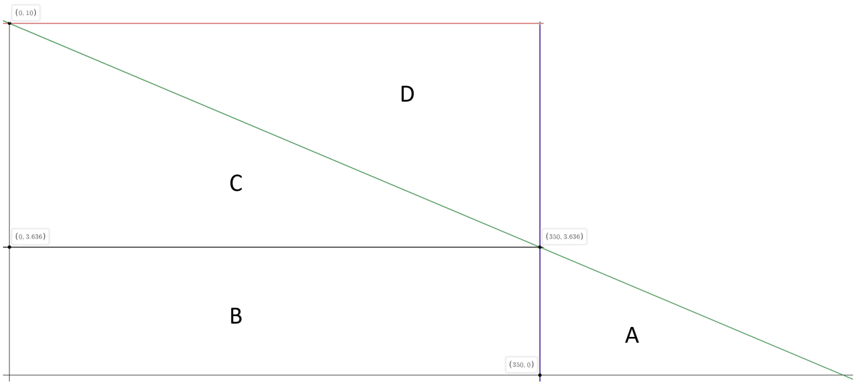
11 a) Demand function before the upgrade:



To investigate if the price setting after the upgrade is a good idea we need to compare with the price before the upgrade. The Surplus for flat rate can be calculated as:

$$
\begin{aligned}
Surplus &= Utility - Cost = A + B + C - (B + C + D) \\
&= \frac{350 \cdot 5}{2} - 50 \cdot 5 = 625 \text{ SEK}
\end{aligned}
$$

Demand function after upgrade:



After the upgrade,using flat rate and the suggested pricing, the surplus will be:

$$
\begin{aligned}
Surplus &= Utility - Cost = A + B + C - (B + C + D) \\
&= \frac{550 \cdot 10}{2} - 350 \cdot 10 = -750 \text{ SEK}
\end{aligned}
$$

Before the upgrade the people where happy, since the surplus was positive. But after the upgrade, with the suggested pricing, they will be unhappy since the surplus is negative.

b) Using graph in figure 3 to calculate the Surplus after the upgrade using Usage based pricing. This gives us:

$$
\begin{aligned}
Surplus &= Utility - Cost = A + B - B = A \\
&= \frac{(550 - 350) \cdot 3.636}{2} = 363.6 \text{ SEK}
\end{aligned}
$$

If we assume that the suggestion is coming from an investigation of what customers are willing to pay, then we can say that they would be happy with the User based pricing instead of the flat rate pricing. This is since the Surplus is positive in the Usage based pricing and not in the flat rate. But one can question if this is a good model since the surplus always will be positive in user based pricing.