LINKÖPING UNIVERSITY

Written Exam in
Internetworking
TSIN02

13th January 2024 14:00 - 18:00

Location:	T1, U7
Examiner:	Harald Nautsch
Teacher:	Harald Nautsch, 1361
Department:	ISY
Module:	TEN1
Number of problems:	11
Number of pages:	7 + formula collection
Permitted equipment:	Calculator with empty memory, TSIN02 formula collection, general English dictionaries without notes
Grades:	3 : 25-32 points 4 : 33-41 points 5 : 42-50 points
Other:	Answers should preferably be given in English. The teacher will visit around 16:00.

1 Link layer

a) Why is packet switching the more common choice for modern times?

(1 p)

b) As data transmission rates increase, it is often not efficient to keep simply increasing the speed of the components of the system. Why is that? What is often the preferred approach then?

(2 p)

c) Explain the main difference between forward error correction (FEC) and automatic repeat request (ARQ).

(1 p)

2 Transport and application layers

a) What is used in addition to the IP address in the socket layer for addressing?

(1 p)

b) Why is IPv4 a major bottleneck for deployment of the Internet of Things?

(2 p)

c) How does congestion control work in TCP?

(2 p)

3 **Optical networks**

a) Why is 1550 nm the preferred operational wavelength for optical communication systems?

(1 p)

b) Name the main advantage of using optical amplifiers instead of optical/electrical/optical converters.

(1 p)

c) What is a lightpath?

(1 p)

d) What is the main difference between an optical amplifier and a full regenerator?

(2 p)

4 **Network Economics**

a) Why is flat rate considered unfair?

(1 p)

b) Name one advantage for time dependent pricing for the telecom operator and one for the users.

(2 p)

5 **Data centers**

a) In the case of cloud networks, why is a simple inverted tree structure not scalable for growth? What should be used instead?

(2 p)

b) From the point of view of a company, name one advantage and one disadvantage of moving computing resources to the cloud.

(2 p)

6 Security

a) Name two differences between IP and IPsec.

(2 p)

b) What is cache poisoning?

(1 p)

c) What is a TCP SYN flood attack?

(1 p)

7 Optical networks

In the following tables, different commercial elements of an optical network are shown

Sources		
Laser A	$0.1mW$	1000 SEK
Laser B	$0.5mW$	2000 SEK
Laser C	$1mW$	3000 SEK
Receivers		
Photodetector A	Sensitivity $= -15dBm$	2000 SEK
Photodetector B	Sensitivity $= -20dBm$	3500 SEK
Photodetector C	Sensitivity $= -30dBm$	6000 SEK
Amplifiers		
Amplifier A	Gain $= 10dB$	1500 SEK
Amplifier B	Gain $= 20dB$	3000 SEK
Amplifier C	Gain $= 30dB$	5000 SEK

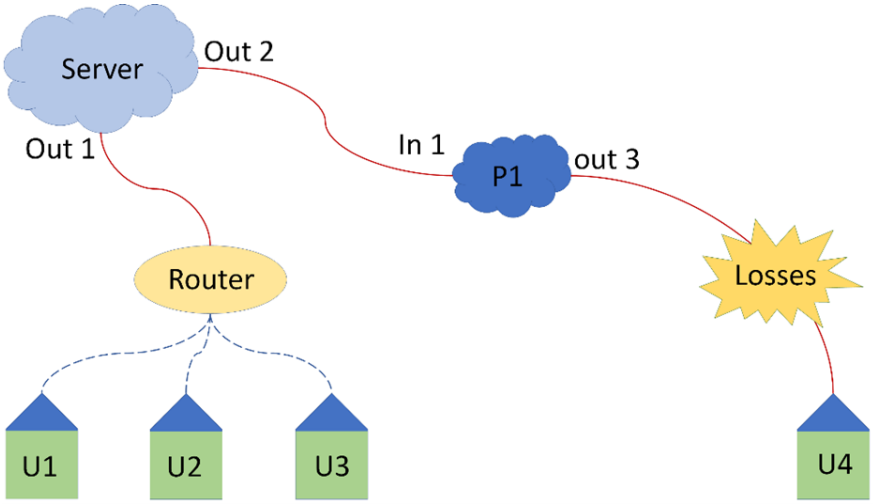
We will ignore the effects related to dispersion or other non-linear effects and we need the power for a correct analysis of the whole problem.

We want to build an optical link of 90 km with an optical fiber that has an attenuation coefficient $\alpha = 0.2\frac{dB}{km}$. Propose the necessary elements to make this network possible. The best design must consider the lowest monetary cost and must make sure that a proper connection is achieved (the receiver should receive the signal without any problems)

(5 p)

8 Optical Networks / Source Coding

We must design a network to provide telecommunication services to 4 clients as follows:



In order to support the amount of data, we will send it over a fiber optical link. We have devices capable of transforming optical signals into electrical signals (O/E) within the router. If more than $-5dBm$ of optical power is delivered to the router, it can be configured to provide IP addresses to clients, otherwise we lose packages. We have two optical fiber outputs from the server.

This router is connected to users "U1","U2", and "U3" through electrical connections (dashed blue lines). "Out 2" of the server is connected to a control point "P1", where the incoming power is analysed, and depending on its value, "P1" can apply amplification of $10dB$ to the signal to reach "U4" without problems. "U4" does not need a converter between electrical and optical signals. Optical fiber links are the standard telecommunications and operates at $1550nm$. From the server to the router we have $15km$ of fiber optics. On the other hand, we have $35km$ from the server "P1" and from "P1" to "U4" we have $20km$. The server sends the information at $0dBm$ of optical power at both outputs "Out 1" and "Out 2".

If point "P1" receives less than $-5dBm$ of optical power, then it decides to apply an amplification of $10dB$. The losses between "P1" and "U4" are $15dB$. Any other losses can be ignored. The attenuation constant of the optical fiber is $\alpha = 0.2\frac{dB}{km}$.

a) Given the above data, can the router work properly? Justify by calculations.

(1 p)

b) Suppose that the losses in the channel between "P1" and "U4" introduces a high bit error that can be modelled as Binary Symmetric Channel (BSC). The Bit error probability is equal to $p = 0.13$. Packets of 70 bytes are sent through this channel. Compute the obtainable efficiency if FEC is used over the link and compare it with the efficiency of using ARQ.

(3 p)

c) In order to understand the error in the channel you are tasked to investigate the signal strength that "U4" obtains. The Photodetector at location "U4" has a sensitivity of $P_s = -10dBm$. Is the amplifier activated and is the amplification enough at "P1" or does it have to be altered? In that case, how much must it be altered? Motivate answer with calculations!

(3 p)

9 Internetworking

An ISP is granted a block of addresses starting with 120.80.0.0 / 16. The ISP wants to distribute them to 250 customers as follows:

- 1st group has 150 large size businesses; each needs 256 addresses
- 2nd group has 100 medium size businesses; each needs 64 addresses

a) Design the sub-blocks and give the slash notation for each sub-block. (Find the first and the last IP addresses on each group)

(4 p)

b) Find out how many addresses after these allocations will be available.

(1 p)

10 **Internetworking**

A large number of consecutive IP addresses are available starting at 198.16.0.0. Suppose that two organizations A and B request 4200 and 1990 addresses respectively, and in that order. For that reason, you must design 2 subblocks. For each of these, give the first IP address assigned in that block, the last address assigned in that block and how many IP addresses will be available in each organization, after the allocations.

(4 p)

11 **Network Economics**

An ISP performs a network upgrade to meet the ever increasing data demand. The customers' price-demand curves before and after the upgrade are given by the functions:

$$D_{before}(p) = -\frac{1}{70}p + 5$$

$$D_{after}(p) = -\frac{1}{55}p + 10$$

We are using that the underlying utility functions are based on user polls where the users tell how much they are willing to pay for different amounts of data; that the utility functions are concave; that the derivative of the utility functions are invertible; and that the utility functions evaluated for 0 GB are 0.

a) The customers pay 50 SEK/GB flat rate before the service upgrade. Someone within the ISP suggests that the users should pay 350 SEK/GB flat rate after the upgrade to cover upgrade costs. Is it good or bad idea to upgrade with this new pricing scheme? Compare between before and after the upgrade. Motivate your answer.

(3 p)

b) What is the surplus if user based pricing is used instead after the upgrade?

(1 p)