

Written Exam in
Internetworking
TSIN02

20th March 2025 8:00 - 12:00

Location:	TER3
Examiner:	Harald Nautsch
Teacher:	Harald Nautsch, 1361
Department:	ISY
Module:	TEN1
Number of problems:	11
Number of pages:	8 + 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 can be in English or Swedish. The teacher will visit around 10:00.

1 **Link layer**

- a) Why is a circuit switched network less efficient than a packet switched one?
(1 p)
- b) What is a MAC address?
(1 p)
- c) Communication protocols where the transmitter requires acknowledgement (ACK) packages from the receiver before sending new packages are limited in transmission rates when compared to protocols that do not use ACK packages. Explain why.
(1 p)
- d) Name two types of multiplexing. Why is multiplexing needed?
(2 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 one effect that causes dispersion on an optical signal after propagation over an optical fiber?
(1 p)
- c) What is the main difference between dB and dBm?
(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) It is common for large companies to have several data centers spread geographically across the world. Why is this done?
(1 p)

6 Security

- a) Describe what SSL/TSL is and when it should be used. (2 p)
- b) Why is DNSsec more secure than standard DNS? Why is it complex to implement in practice? (2 p)

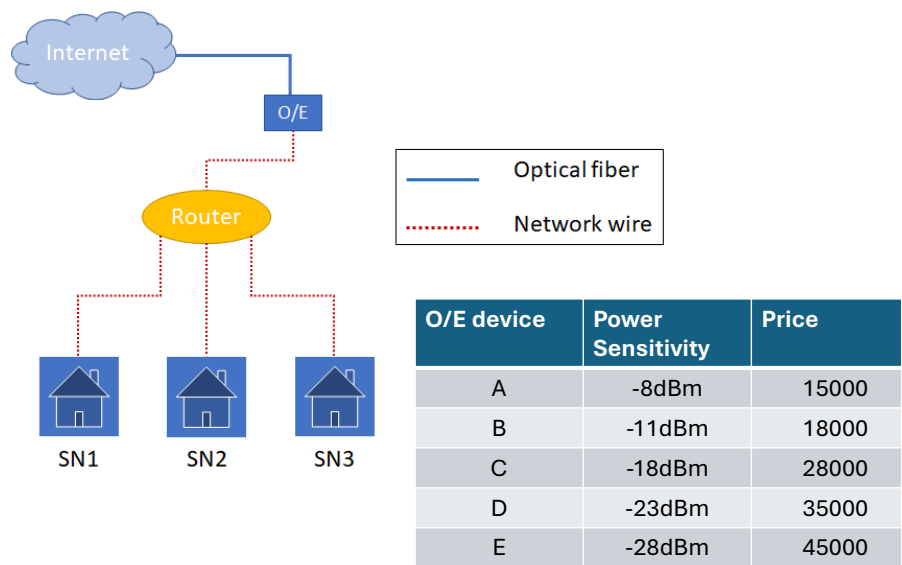
7 Internetworking

An ISP is granted a block of addresses starting with 120.60.0.0 / 16. The ISP wants to distribute them to 600 customers as follows:

- The first group has 50 large size businesses; each needs 512 addresses.
 - The second group has 200 small size businesses; each needs 32 addresses.
 - The third group has 350 Households; each needs 12 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 for the ISP. (1 p)
- c) One of the large sized business in the first group wants to internally divide their 512 addresses into 8 subblocks. Is this possible? If not, why? And if it is possible, what would those subblocks look like? (1 p)

8 Optical Networks

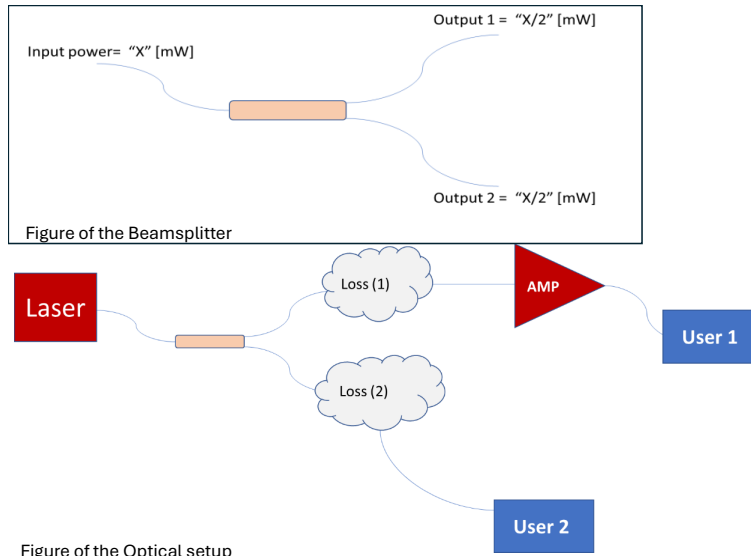
Suppose we supervise the design of a network where we must provide internet to 3 subnets connected by a router. All subnets belong to the same client. From our company we will send a large amount of data through fiber optics. We have a laser of 5 dBm that operates at 1550 nm ($\alpha = 0.2$ dB/km) and the optical fiber is 80 km long. The optical path also has an additional 7dB of losses. Before the Router, there is an optical/electrical converter (O/E) which can be considered as a photodetector. The following figure shows the network architecture.



As designers, we must choose a proper O/E given all conditions above. The table present 5 different options. Select from A, B, C, D or E the best option for your design. Any criteria you choose must be justified by calculation and any other explanation you consider relevant. (Hint: A good design is not always unique, but your design should consider being prepared for at least some downsides down the road, and you should also consider the lowest possible implementation cost to have a happy customer.)

(3 p)

9 Optical Networks



A beam splitter is an optical component able of splitting an incoming light beam into two different light beams. For our case, we will assume that both beams at the outputs have the same optical power and we will ignore any additional losses. The beam splitter is explained graphically in the top of the figure, X represents any power measured in milliwatts. We can place this component in an optical network to use a single laser for two different users. This optical setup is shown in the bottom of the figure. The laser is used to send optical information (a light beam) to the network. A beam splitter is placed to divide light and send information to two different users. Clouds represent all losses in each path: Loss (2) has a value of 9 dB and Loss (1) is unknown. AMP is an amplifier used to compensate losses and it has a gain of 4dB.

User 1 measures the power received and obtains a value of -17 dBm after the light travelled the network. We know that User 2 has half the power of User 1. We will ignore any other losses or non-linear effects. Now answer the following:

- a) What is the power received at User 2 in dBm and mW?

(2 p)

- b) Compute Loss (1).

(2 p)

- c) Compute the power of the laser in dBm.

(2 p)

10 Source/channel modelling

Consider coding for a network with packet losses with loss bursts following the Gilbert-Elliott process, i.e., the probability of a lost packet given that the previous packet was received $p_{l/r} = 0.07$, and the probability of a received packet given that the previous packet was lost $p_{r/l} = 0.31$. Assume that the probability density function (pdf) of the source is zero except in the interval $[0,1]$. Use uniform quantization with 14 reconstruction levels and assume that we operate in the high-rate regime. We do not use any means of protection against lost packets on the network. Assume that the MSE (Mean-Squared-Error) distortion is 1 if no packet arrives at the receiver.

- a) Draw a diagram of the Gilbert-Elliott process that describes this problem.

(2 p)

- b) What is the stationary channel loss probability?

(1 p)

- c) What is the stationary channel receive probability?

(1 p)

- d) What is the overall stationary mean MSE distortion considering the channel loss probability and the quantization distortion?

(1 p)

11 Network Economics

In order for the ISP to decide what the pricing of the service should, a survey was sent out to the users in order to see how much they use and what they would be happy to pay for. They come to the conclusion that they have two types of users (a heavy consumer and a light consumer) and their demand functions can be described as:

$$D_1(p) = -\frac{1}{15}p + 14$$

$$D_2(p) = -\frac{1}{35}p + 6$$

The ISP also decides that the customers should pay 45 SEK/GB. Assume that the underlying utility function (for both groups of customers) is concave; that the derivative of the utility function is invertible; and that the utility function evaluated for 0 GB is 0.

- a) Calculate the net utility for both types of customers using user-based pricing.

(2 p)

- b) Calculate the net utility for both types of customers using flat rate pricing.

(2 p)

- c) How should the ISP price their services in order to keep both of the user types happy? Motivate your answer!

(1 p)