Exam in
TSIN02 Internetworking, TEN1

Department of Electrical Engineering (ISY), Linköping University

Exam date: January 18, 2014, 14:00–18:00

Course responsible Daniel Persson, tel.: 281351, the exam rooms will be visited twice during the exam, at about 15.00 and 17.00 o'clock.

Material Calculator with empty memory, TSIN02 collection of formulas, & language dictionary to/from English.

Grading You can get 50 points in total. For grade three (3) you need 20 points, for grade four (4) you need 30 points, and for grade five (5) you need 40 points. An erroneous answer, unclear, incomplete or badly motivated solutions give point reductions down to a minimum of 0 points. No fractional points are awarded.

Exam returns The exams are returned 2014-02-18 at 12.40-13.00 in Daniel's office, Building B, entrance B29, top floor, corridor A. After that, the exams can be picked up at the Student's Office of the Dept. of EE. (ISY), Building B, Corridor D between Entrances B27 and B29.

Solutions The exam solutions will be available on the TSIN02 exam web page (www.commsys.isy.liu.se/en/student/kurser/tentor?TSIN02) within five working days after the exam.

Result announcement The exams are normally corrected within 10 working days after the exam and the results are reported to Ladok by the Ladok administrator at ISY within 2 days after that. Then, an email with the exam result is automatically sent from Ladok to each student who is registered on the course.

PLEASE NOTE THAT THE PROBLEMS ARE NOT NECESSARILY IN ORDER OF DIFFICULTY. IT IS OFTEN POSSIBLE TO CONTINUE SOLVING (b), EVEN IF ONE DOES NOT FIND AN ANSWER TO (a) ETC. Good luck!

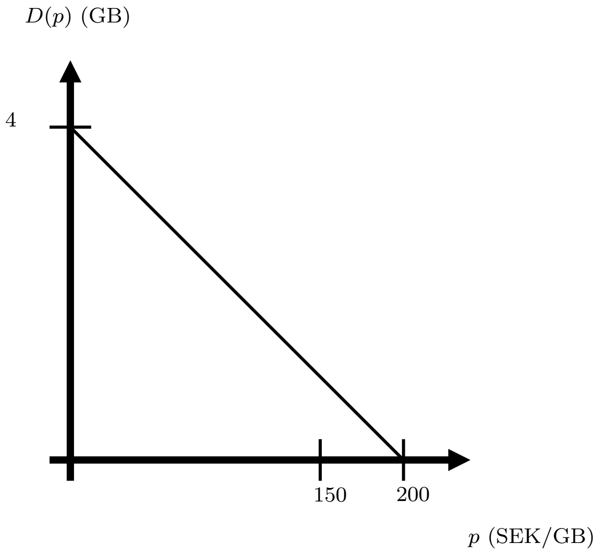

Figure 1: Demand $D(p)$ as a function of price p in Problem 3.

1. **Mobile IP:** Describe Mobile IP: Why is it used? Describe a setup with communication between two entities! Describe a problem with Mobile IP! Do not use more than 1 A4-page with "normal" handwriting letter size! If the text is longer than this, point reductions will apply.

(8 p)

2. **IPv4:** An ISP sells IP addresses and related services to two big customers. The ISP has acquired a continuous block of network addresses starting at 173.75.17.30. Allocate a subnet containing 131072 addresses as close as possible to 173.75.17.30! Subdivide this subnet into 2 equally big subnets. Give the first and last addresses of the three subnets in dotted decimal notation, as well as the subnet masks!

(8 p)

3. **Usage-based and flat rate pricing:** An ISP performs a network upgrade to meet the ever increasing data demand. It decides that the customers will pay $k = 150$ SEK/GB. The customers' price-demand curve is shown in Fig. 1. We are using that the underlying utility function is based on a user poll where the users tell how much they are willing to pay for different amounts of data; that the utility function is concave; that the derivative of the utility function is invertible; and that the utility function evaluated for 0 GB is 0.

   a) What is the net utility measured in SEK for a customer under usage-based pricing?
   b) What is the net utility measured in SEK for a customer under flat rate?
   c) Interpret the results! Especially comment on the difference in net utility in (a) and (b)!

(9 p)

4. **Clouds:** You have started a data center provider company. In one part of a server hall, you have 1000 helper (H) servers that run helper functions to be called by the 1000 main computational servers (M). You must connect these two groups of computers - good connectivity is important! You choose to connect the M- and H-servers through a Clos network with the M-servers on one side, and the H-servers on the other side.

   The Clos network has 2×3-type input switches, which means that the output switches are 3×2-type switches.

   a) How many middle switches do you need?
   b) How many connectors on each side do the middle switches have?
   c) Is your Clos network non-blocking or rearrangeably non-blocking? Motivate your answer!
   d) We know that big switches are expensive. Replace each middle switch with a group af smaller switches! Choose a Clos network for this task, and maintain the non-blocking or rearrangeably non-blocking property above. Describe the used switch types, i.e., the number of input and output connectors, for each Clos network switch.

   (9 p)

5. **Fairness-efficiency tradeoff:** Some flows use more physical links than others. This means that if all flows get the same throughput on all links, and the same price per communicated GB, some flows are less profitable than others. An ISP will now install functionality in the routers to divide resources on the links among flows, and you are in charge of the task. You start by trying out the following toy example shown in Fig. 2 (it can be shown that the involved problems are convex. These problems can thus be solved with huge amounts of flows even on a single computer, i.e., the toy example can easily be extended to a more realistic scenario). We denote the rate in Gbps allocated to session i by x_i.

   a) The throughput limit for each link is 1 Gbps. Formulate the optimization of the generalized fairness measure $F_{\beta,\lambda}(\mathbf{x})$ subject to all constraints for the network in Fig. 2.
   b) Choosing $\beta = \frac{1}{2}$, we solve the above optimization problem for different values of $\frac{1}{\lambda}$ and obtain Fig. 3, which shows the optimal rate for each session for different value of $\frac{1}{\lambda}$. Comment on the effect of $\frac{1}{\lambda}$ on the rate allocation to different flows!

   (8 p)

6. **Source coding for packet networks:** The Linköping Police will use a new system for real-time tracking of cars breaking the speed limit, and your company will deliver the system. Cameras take grayscale photos of the cars and submit them on the Internet to a central car tracking server.

   To make the system real-time, yet robust, you will employ error concealment. You interleave the data in two packets by putting every odd pixel in packet 1, and every even pixel in packet 2. Thousands of pixels are put in packet 1 and 2, and you thereafter continue to put odd pixels in packet 3 and even pixels in packet 4,

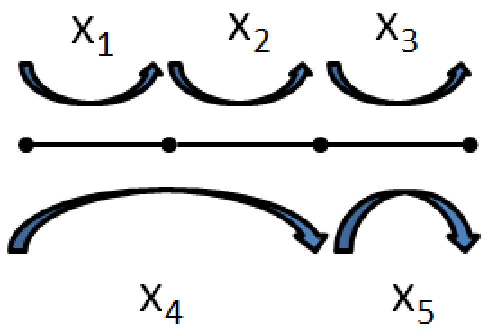

Figure 2: Network used in Problem 5.

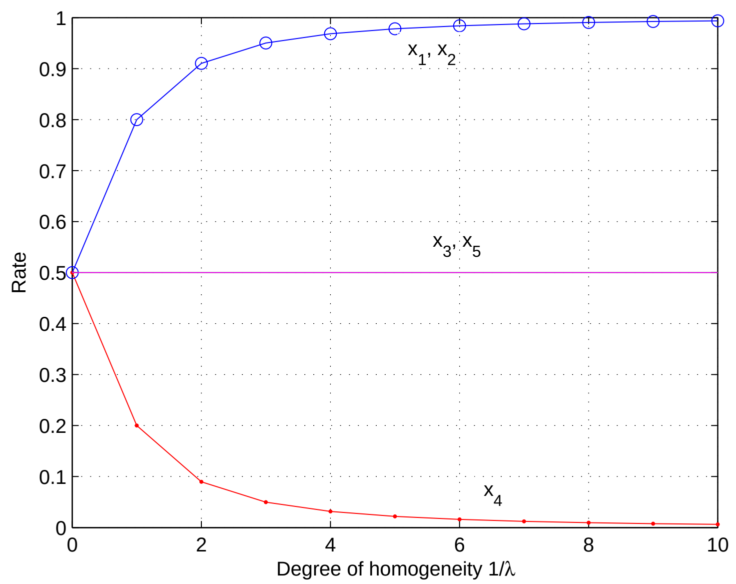

Figure 3: Optimal rate allocation for Problem 5.

and so on. We assume no quantization distortion, and that a single packet is lost. We assume quantization distortion to be neglectible, and model the image as an auto-regressive process

$$x_n = ax_{n-1} + u_n$$

where u_n is a zero-mean Gaussian variable with variance 1, and $a = 0.7$. What is the error concealment MSE with and without interleaving if we use prediction from the most recent pixel in the packet before the lost packet?

(8 p)