HELSINKI UNIVERSITY OF TECHNOLOGY
Networking Laboratory
S-38.145 Introduction to Teletraffic Theory

Examination
13.5.2003
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Write on each paper
- S-38.145 Introduction to Teletraffic Theory, Examination 13.5.2003
- your student identification number, your last name, your first names
- signature

1. Explain briefly the following terms/concepts:
   (a) Birth-death process
   (b) Cell switching
   (c) Statistical Multiplexing
   (d) Random number generator
   (e) Confidence interval
   (f) Token bucket

2. The Erlang formula was originally used in the modelling of a link between two telephone exchanges.
   a) What assumptions are made on the traffic (call arrivals and holding times) in the model? What is Kendall's notation for the model? (3p)
   c) The traffic between the two exchanges consists of calls which arrive with the average interarrival time of 3 minutes. The average call holding time is 3 minutes. Using the Erlang model, determine the required number of channels in the link so that the blocking is less than 3%. (3p)

3. a) Consider the time and call blocking probabilities in a loss system. When are the two quantities equal and when are they not? Explain why and give examples for both cases. (3p)
   b) Consider a system consisting of a routing processor and a buffer. In the system, one packet can be processed at a time and others have to wait in the buffer. If there are, on average, $\bar{N}$ packets in the system and the average number of packets waiting for service in the buffer is $\bar{N}_W$, what is the traffic load ρ of the system? (3p)
   Hint: For example, you may use Little's formula.

4. Assume that information is transferred using fixed size packets. If the size N of the packet is the length of an ATM cell, it is $N = 48+5$ bytes long, where one byte is 8 bits. If ATM and virtual connections are used for information transfer we can approximate the extra time needed for setting up the connection to be equal to 1 second. If IP datagrams are used to transfer the information, there is no need for connection set up, but for the fixed size packet size, the required packet header is longer. Assume that the IP header is 20 bytes long and that the total length (including the header) of an IP packet is $N = 53$ bytes.
   Which of the two methods is faster, if the transferred message has a size of 5 Mbits and the connection speed is 2 Mbps, and it is assumed the the total time consists only of the set up delay and data transfer?

5. Consider a queueing system with one server and infinite number of waiting places. Customers arrive according to a Poisson process with intensity λ. The service times are independent and exponentially distributed with expected value $1/\mu$. However, not all customers are accepted into the system. When the system is in state n the customer gets into the system with probability $1/(n+1)$, and is thus rejected with probability $n/(n+1)$. Denote the number of customers in the system , i.e. the state of the systemm at time t by $X(t)$. The process $X(t)$ is Markov process.
   a) Draw the state transition diagram of $X(t)$. (2p)
   b) Under what conditions is the system stable, i.e. there exists an equilibrium distribution? Derive the equilibrium distribution (when it exits) for the process $X(t)$. (4p)
   Hint: Random selection. If a random selection is made from a Poisson process with intensity λ such that each arrival is selected with probability p, independently of the others, the resulting process is a Poisson process with intensity $p\lambda$.