HELSINKI UNIVERSITY OF TECHNOLOGY
Networking Laboratory
S-38.145 Introduction to Teletraffic Theory, Spring 2005

Examination
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1. Consider telephone traffic on a link in an interval $[0, T]$, where $T = 16$ (time unit: minute). The system is empty at time $t = 0$. New calls arrive at times

   - 1, 2, 5, 6, 7, 9, 12, and 13.

   The holding times of these calls (if they are not blocked) are, respectively,

   - 9, 2, 3, 1, 7, 2, 3, and 3.

   The capacity of the link is $n = 2$ channels.

   (a) Construct a figure that describes the call arrival times, channel-by-channel occupation, and the number of channels occupied as a function of time $t \in [0, T]$.
   (b) What is the ratio between the number of blocked calls and the total number of calls?
   (c) What is the ratio between the time the system is full and the total time?

2. Give the definition of the Erlang model, and write the call blocking probability as a function of the model parameters.

3. Consider the M/M/1/2 model with mean customer interarrival time of $1/\lambda$ time units and mean service time of $1/\mu$ time units. Let $X(t)$ denote the number of customers in the system at time t.

   (a) Draw the state transition diagram of Markov process $X(t)$.
   (b) Derive the equilibrium distribution of $X(t)$.
   (c) Assumed that $\lambda = \mu$, with which probability the service of an arriving customer is started immediately upon the arrival (without any wait)?

4. Consider elastic data traffic carried by a 10-Mbps link in a packet switched network. Use a pure sharing system model with a single server. New flows arrive according to a Poisson process at rate 9 flows per second, and the sizes of files to be transferred are independently and exponentially distributed with mean 1 Mbit. Let $X(t)$ denote the number of ongoing flows at time t.

   (a) What is the traffic load?
   (b) Derive the equilibrium distribution of $X(t)$.
   (c) What is the throughput of a flow?

5. Consider a connectionless packet switched network with three nodes connected in a tandem by two links: a $\rightarrow$ b $\rightarrow$ c. Both links have capacity of 100 Mbps. The following two routes are used in this network:

   - Route 1: a $\rightarrow$ b
   - Route 2: a $\rightarrow$ b $\rightarrow$ c

   For the two routes, new packets arrive with intensities $\lambda(1) = 3$ and $\lambda(2) = 5$ packets per ms, respectively. The mean packet length is 1250 bytes. Give the traffic load of each link. Assumed that the average link delays are $\bar{T}_1 = 0.5$ ms and $\bar{T}_2 = 0.2$ ms, what is the mean number of packets in the whole network?