Aalto University
School of Science and Engineering
Department of Communications and Networking
S-38.1146 Introduction to Performance Analysis, Spring 2010

**Examination**
3.9.2010
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**Please answer to all five (5) questions**

1. Consider a pure loss system with 10 servers. The average service time is 5 min. It is also known that the average number of customers in the system is 8.0 and an arriving customer is lost with probability of 20%. Determine the total arrival rate of new customers (including both those who enter the system and those who are lost)?

2. Consider the M/M/1/2/2 model where the mean idle time of a customer is $1/\nu$ time units and the mean service time is $1/\mu$ time units. Let $X(t)$ denote the number of customers in the system at time $t$.

   (a) Draw the state transition diagram of the Markov process $X(t)$.

   (b) Derive the equilibrium distribution of $X(t)$.

   (c) Assumed that $\nu = \mu$, determine the time blocking probability and the call blocking probability.

3. You arrive at a bus stop where buses pass by according to a Poisson process with average interarrival time of 12 minutes. Let $T$ denote the time until the arrival of the next bus.

   (a) You arrive at the bus stop at a random time instant. What is the distribution of the random variable $T$?

   (b) You arrive at the bus stop just after the departure of the previous bus. What is the distribution of the random variable $T$ in this case? What is the expected waiting time?

   (c) You arrive at the bus stop at a random time instant. Let $X$ denote the number of buses that arrive during the next 4 minutes after your arrival. What is the distribution of the random variable $X$?

4. Consider a packet switched trunk network with three nodes connected to each other as a tandem by two link pairs: a — b — c. The capacity of each separate (one-way) link is 100 Mbps. The following six routes are used in this network:

   - Route 1: a $\rightarrow$ b
   - Route 2: b $\rightarrow$ c
   - Route 3: a $\rightarrow$ b $\rightarrow$ c
   - Route 4: b $\rightarrow$ a
   - Route 5: c $\rightarrow$ b
   - Route 6: c $\rightarrow$ b $\rightarrow$ a

   For each route, new packets arrive according to an independent Poisson process with intensities $\lambda(1) = \lambda(2) = 5$, $\lambda(3) = 15$, $\lambda(4) = \lambda(5) = 1$, $\lambda(6) = 3$ packets/ms. The packet lengths are independently and exponentially distributed with mean 500 bytes.

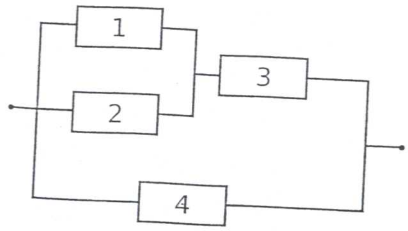
   (a) Draw a picture describing this queueing network model.

   (b) Compute the traffic loads for each link.

   (c) Compute the mean end-to-end packet delays for the routes 3 and 6.

**Last question on the other side of the paper**

5. (a) Determine the structure function $\phi(\mathrm{x})$ of the structure of independent components in the reliability block diagram below.




(b) If the components in above diagram are repairable, what is the availability of the above system? The availability of each of the components 1 and 2 is 2/3, the availability of component 3 is 1 and the availability of component 4 is 1/2?

(c) Tell briefly in words what is **availability**? (That is, give some definiton of availability)