Aalto University School of Electrical Engineering
Department of Communications and Networking
ELEC-C7210 Modeling and analysis of communication networks, Autumn 2015

Examination
21.10.2015
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Please answer to all five (5) questions

1. Buses arrive at a bus stop according to a Poisson process with an average interarrival time of 30 minutes. You arrive at the bus stop at a random time. Thus, you don't know when the previous bus left, nor when the next bus will arrive.

   (a) Let T denote the time until the arrival of the next bus. Specify the distribution and the mean value of the random variable T?

   (b) What is the probability that at least one bus arrives during a 1-hour interval following your arrival?

2. Consider the M/M/3/3 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 the Markov process $X(t)$.

   (b) Derive the equilibrium distribution of $X(t)$. Are there any stability conditions?

   (c) Assume that $\lambda = \mu$. What is the probability that an arriving customer is blocked from the system?

3. 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 4 flows per second, and the sizes of files to be transferred are independently and exponentially distributed with mean 2 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?

4. Consider a Markov process with state space $S = \{0, 1, 2, 3\}$ and the following state transition rate matrix

$$Q = \begin{pmatrix} - & 1 & 0 & 0 \\ 0 & - & 1 & 0 \\ 1 & \mu & - & 0 \\ 0 & 1 & 1 & - \end{pmatrix}.$$

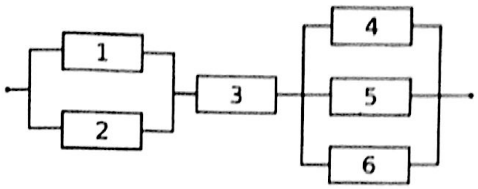
   a) Draw the state transition diagram of the process. Is this process irreducible?

   b) Write and solve the global balance equations (GBE).

   c) Assume that the system is started from the state 3 at time 0. What is the relationship between this initial distribution and the equilibrium distribution you solved in b-part?

Last question on the other side of the paper

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



(b) What is the availability of the above system? Availability of component 3 is 1. For the rest of the components, the MDT is 1 [time unit]. However, MTTF of components 1 and 2 is 2 [time units] and for components 4, 5 and 6 it is 4 [time units].