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

Exercise 8
31.3.2005

Problems 2–3 are homework exercises. Mark the problems you have solved in the beginning of the exercise class.

1. *Demo*
Consider the following simple teletraffic model:

   - Customers arrive according to a Poisson process with intensity λ.
   - Service times are IID and exponentially distributed with mean $1/\mu$.
   - There is one server ($n = 1$).
   - The number of waiting places is finite ($0 < m < \infty$).
   - Queueing discipline is FIFO.

   Let $X(t)$ denote the number of customers in the system at time t. According to Kendall's notation, what is this queueing model? Process $X(t)$ is a Markov process. Draw the state transition diagram of this Markov process. Under which conditions is the system stable (i.e. the equilibrium distribution exists)? Derive the equilibrium distribution, and, based on it, the probability p_L that an arriving customer is lost, and the probability p_W that an arriving customer has to wait.

2. *Homework exercise (1 point)*
Consider data traffic on a link between two routers (from router R1 to router R2) in a packet switched network. Traffic consists of packets arriving to the output buffer of router R1 with mean interarrival time t. Let L and C denote the mean packet length and the link speed, respectively. The buffer capacity is B packets. Consider this as an $M/M/1/B$ queueing model. Suppose that $t = 12\,\mu$s, $L = 1500$ bytes, $C = 1$ Gbps, and $B = 100$ packets. Determine the probability p_L that an arriving packet is lost, and the probability p_W that an arriving customer has to wait.

3. *Homework exercise (2 points)*
There are three physical link with separate routes between two routers. Occasionally these links get damaged. The operator has one repair team that takes care of these damages. If there are multiple links being broken down at the same time, the team repairs them one-by-one. The repairing time and the uptime are exponentially distributed with means $1/\mu$ and $1/\nu$, respectively. All repairing times and uptimes are independent of each other.

   (a) Let $X(t)$ denote the number of damaged links at time t. According to Kendall's notation, what is this queueing model? Process $X(t)$ is a Markov process. Draw the state transition diagram of this Markov process. Under which conditions is the system stable (i.e. the equilibrium distribution exists)? Derive the equilibrium distribution.

   (b) Suppose that $\mu = 1.0$ ja $\nu = 0.1$ (with the mean repairing time as the time unit). What is average number of damaged links? What is the probability that all links are out of operation at the same time? How long does this situation take on average?