Aalto University School of Electrical Engineering
Department of Communications and Networking
S-38.3141 Teletraffic Theory, Spring 2011

Examination
24.5.2011
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1. Consider a linear network with two links $j = 1, 2$. The long route $r = 0$ uses both links, while the short routes $r = 1, 2$ use a single link (r). Traffic consists of ordinary telephone calls that are IID and exponentially distributed with mean $1/\mu$. New calls of class r (using route r) arrive according to an independent Poisson process with intensity λ_r. Let B_r denote the end-to-end blocking probability for class r. Assume now that $C_1 = C_2 = 2$. By applying the Reduced Load Approximation method, give a system of equations from which an approximative value for B_0 can be solved (as a function of $a_0 = \lambda_0/\mu$, $a_1 = \lambda_1/\mu$, and $a_2 = \lambda_2/\mu$).

2. Consider a closed queueing network with three customers and two nodes. The routing probabilities are $q_{11} = q_{12} = q_{21} = q_{22} = 1/2$. The service times in both nodes are independent and exponentially distributed with mean 1 min.

   (a) What is the mean number of customers in node 1?

   (b) What is the mean sojourn time of a customer in node 1?

   (c) What is the average customer flow through node 1 (in customers/min)?

3. Consider a linear network with three links $j = 1, 2, 3$. The long route $r = 0$ uses all links, while the short routes $r = 1, 2, 3$ use a single link (r). Let $n_r > 0$ denote the number of flows on route r. Assume that $n_0 = 2$, $n_1 = 1$, $n_2 = 2$, and $n_3 = 3$. All links have capacity $C = 10$ Mbps, and all flows have the same access rate $s = 10$ Mbps. By applying the filling algorithm, determine the maxmin fair bandwidth shares (x_0, x_1, x_2, x_3) for the flows on different routes.

4. Consider a base station in a cellular system utilizing channel-aware scheduling for the downlink transmissions consisting of elastic flows with mean size of $E[X] = 100$ Mbit. New flows arrive according to a Poisson process with mean interarrival time of $1/\lambda = 10$ s. Given that there are n flows in the system at time t, the average rate at which the flows are served is assumed to be $c(n) = nr$, where $r = 1$ Mbit/s. Use the PS queue with state-dependent service rate to model the system.

   (a) What is the probability $P\{N = 0\}$ that the system is empty?

   (b) What is the mean number of flows $E[N]$ in the system?

   (c) What is the mean delay $E[T]$ of a flow?

5. Consider a linear network with three links $j = 1, 2, 3$. The long route $r = 0$ uses all links (in the order $1 \to 2 \to 3$), while the short routes $r = 1, 2, 3$ use a single link (r). Let $n_r > 0$ denote the number of flows on route r. Assume that $n_0 = 2$, $n_1 = 1$, $n_2 = 2$, and $n_3 = 3$. All links have capacity $C = 10$ Mbps, and all flows have the same access rate $a = 10$ Mbps. Determine the bandwidth shares $(\varphi_0, \varphi_1, \varphi_2, \varphi_3)$ for the flows on different routes "in the jungle" (without any end-to-end congestion control scheme) when the buffer management in the network nodes is tail dropping.