

1. Consider a lossy queueing system (L1/27) with 2 parallel servers and 2 waiting places. The average interarrival time between two customers is 1 s, and the fraction of lost customers is $2/9$. In addition, it is known that the average waiting time (before service) is $6/7$ s, and the average service time is 2 s.
 - (a) What is the average number of waiting customers?
 - (b) What is the average number of customers in service?
 - (c) The customers departing from this system are directed to an infinite system (L1/25). What is the average number of customers in this latter system?

2. Consider elastic data traffic at the flow level (L2/29) on a link with speed 10 Mbps in an interval $[0, T]$, where $T = 16$ (time unit: second). The system is empty at time $t = 0$. New flows arrive at the following time instants: 1, 2, 5, 7, and 13. The sizes (in Mb) of these flows are: 20, 70, 30, 10, and 20. The link capacity is shared evenly (fairly) among all competing flows.
 - (a) Construct a figure that describes the flow arrival times, their total delays, and the number of flows in the system (that is, the traffic process) as a function of time $t \in [0, T]$.
 - (b) What is the average total delay of a flow?
 - (c) What is the average number of flows in the system?

3. Traffic measurements over Funet are available at

<http://www.csc.fi/funet/status/tools/wm>

Click the link between nodes `helsinki0-rtr` and `NORDUnet` to get access to the traffic measurements related to the link. All measurements are presented graphically. The two curves represent the two different directions of the link (`in` = from Stockholm to Helsinki and `out` = from Helsinki to Stockholm). A single point on the curve tells the average traffic at the corresponding time and with the resolution given. The default or raw resolution is 3 minutes. Find the curves from which you can estimate the following quantities:

- (a) The average traffic and time of the busiest and the lightest 3-minute periods on Tuesday, January 15, 2008 (both directions separately).
- (b) The average traffic and time of the busiest and the lightest 1-hour periods on Tuesday, January 15, 2008 (both directions separately).