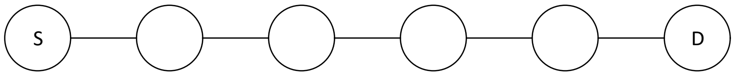
ASSIGNMENT I

QUEUES AND DELAYS

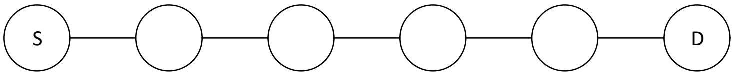
This assignment is to be done by a group of two students. The students are encouraged to prepare the assignment before the class considering the indicated parameter values. In the classroom, the professor will indicate the specific parameters to be used by each group, so the students should make themselves ready to easily adapt their calculations and software to the new parameters.

1. Message transmission across a number of hops greater than one becomes more efficient if the message is broken in several fragments, each sent in a different packet, as long as the overhead is not too high.
    a. Consider a network with linear topology, spanning d hops from sender to receiver. Deduce the expressions for (1) transmission delay, and (2) optimal number of message fragments n, as a function of d, message size l_m, overhead length h, and data rate R. **Justify.**
    b. Calculate the transmission delay and check the optimal number of fragments for a network with 5 hops from sender to receiver, $l_m = 3200$ byte, $h = 100\ byte$, and $R = 1000000$ byte/s. Repeat the calculation for 10 hops.
    c. Compare the result obtained in b) with that obtained without fragmentation.



2. Consider a single M/M/1/K queue, with $K = 15$ and $\lambda = 1000$ packet/s. The average packet size is equal to 20 byte, maximum packet size is 60 byte and the data rate is $R = 200000$ bit/s.
    a. Calculate the expected throughput, expected blocking probability, average waiting time (queue and system) and maximum waiting time (queue and system). Compare with simulation results using OMNET++ (set the simulation time to 2000s). Explain the differences.
    b. Change the simulated queueing model to D/M/1/K, keeping the same parameters. Compare the analytical and simulation results. Explain the differences.
    c. Repeat the calculations and simulations in a) for $K = 5$. Compare the results. Explain the differences.

3. Consider a network with linear topology and 5 hops from sender to receiver. At each node, queuing parameters are the same as the default in Exercise 2. Calculate the expected blocking probability, average waiting time in the system and maximum waiting time in the system. Explain the differences between the analytical and simulation results.



4. Consider a single priority queue. Three different applications A1, A2 and A3 run concurrently, sharing the network capacity. The applications are prioritized such that $p(A1) > p(A2) > p(A3)$. Each priority has its own queue, each with buffer size equal to 5. Packet arrival rates are $\lambda_0 = \lambda_1 = \lambda_2 = 500$ packet/s. Average/maximum packet sizes are as follows: $l(A1) = 20/60$ byte, $\lambda(A2) = 20/100$ byte and $\lambda(A3) = 20/200$ byte. Other parameters are the same as the default in Exercise 3. Simulate the system.
    a. Simulate system and obtain the throughput, blocking probability, average waiting time (queue and system), as well as the maximum waiting time in the system of the different applications. Explain the differences.
    b. Calculate the same performance metrics. Compare with simulation results. Explain the differences.