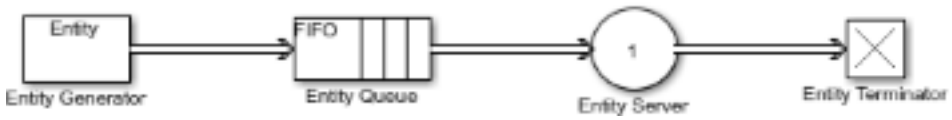
Assignment 2

Queueing in packet switching networks

ECE1150 - Introduction to Computer Networks
University of Pittsburgh
(100 points)

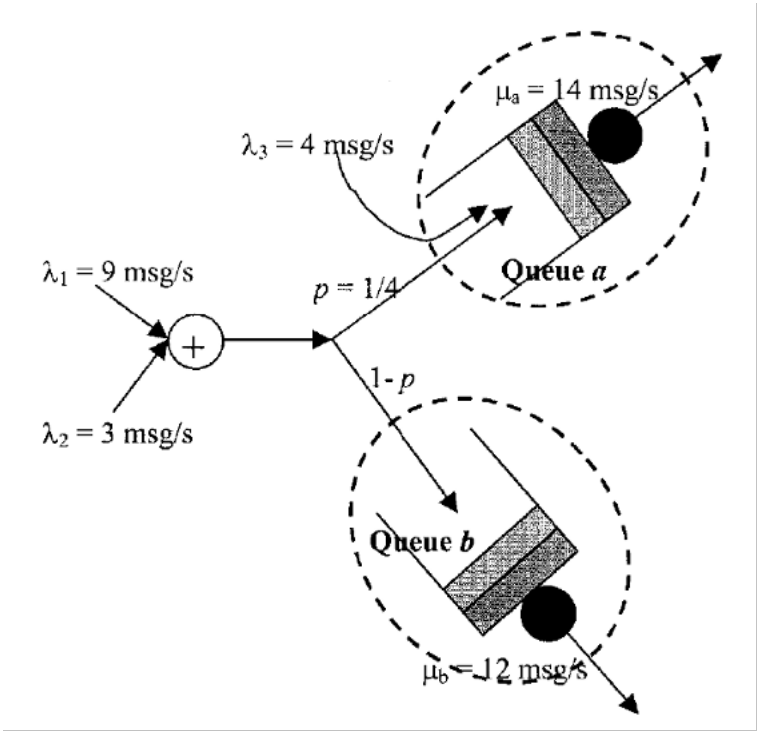
1. (24 points) Theorical and Simulink Simulation
   (a) (8 points) A single M/M/1 queue, with average arrival rate = 1 and average service rate = 1.5. Assume 10000 customers arriving to the queue. Interarrival and service time are exponentially distributed. Evaluate the average wait time and average service time analytically (using theoretical equations, e.g. Little theorem)
   (b) (8 points) Use SimEvents in Simulink to build the M/M/1 queue described above and verify your results with those you obtained in part a.

   In Simulink: You will need entity generator, queue, server and terminator to create simple model. Simple example model shown below.



   (c) (8 points) Simulate additional stable case and another unstable case for a queueing system. Plot the queue utilization and wait time showing impact of unstable queue. Comment of your results.

2. (24 points) Use SimEvents in Simulink to simulate the network shown in figure. Plot the service time and queuing delay at the output of each queue. Compare queuing delay with analytical results (you solved this analytically in lecture exercise, please put your solution again here.)



Note:

(a) (8 points) Blocks that may be needed for this question:
SimEvents –> Entity Generator
SimEvents –> Entity Queue
SimEvents –> Entity Server
SimEvents –> Entity Terminator
SimEvents –> Entity Input Switch
SimEvents –> Entity Output Switch
Simulink –> Commonly Used Blocks –> Scope
Simulink –> Commonly Used Blocks –> Sum
This is just a list of recommended blocks. You can also use other blocks as long as the overall goal is achieved.

(b) (8 points) The example of queuing system in official guide is a D/D/1 queue (D stands for deterministic), which is different from a M/M/1 queue. Please pay attention to the difference.

(c) (8 points) To generate independent random numbers, please make sure to use different random seeds or different generation approaches. Otherwise you will always get same sequence.
You can use the ready-to-go block within EXP_GEN.slx. To use this block, you first need to set the Time Source of Entity Generator & Server to be Signal Port and connect the block to the generator and server. Then set the mean value and seed by double-clicking on the block.

3. (12 points) Packets arrive to a queue with rate λ packets per second. The interarrival time is

At, which is exponentially distributed. Each packet is served, when service rate on average is μ packets per second. The service time is exponentially distributed with rate St.

(a) (8 points) In terms of λ and μ, what is the condition of stability of operation (buffer shouldn't overflow)

(b) (4 points) In terms of At and St, what is the condition of stability.

4. (20 points) Packets transmitted in LAN arrive at a router (modeled as M/M/1 queue). The packet arrival rate is modeled as Poisson process with rate L = 30 packets/second. The router's queue stores packets on a first come first serve (FIFO). The length of the packets is random. Packet length is exponentially distributed with average M=200 Bytes. It takes 125 microseconds to serve one byte.

   (a) (8 points) Is the service rate random? What is the service rate(if random then find the average service rate)?

   (b) (4 points) What is the average delay in queue(include service time)?

   (c) (4 points) What is the average waiting time for each packet until it gets served (not including service time)?

   (d) (4 points) Find the average number of packets in the queue

5. (10 points) What is the Internet protocol stack? State number and name of the layers and provide example function of each?

6. (10 points) Suppose that 28 users using a service. The traffic of each user is modeled as Poisson process, and each sends packets with average rate 36 packets/second. The service rate is 24 x 64 packets per second. What is the average delay in the queue.

Important! Submission instructions for Matlab /Simulink questions:
You need to copy to your submission file (word, or pdf) the Simulink models and the curves obtained from Simulink as a part of answering the questions. In addition to that, please also submit your Simulink file (.slx).