EE555, Spring 2020
Mini-Project, 10 Points (2+2+2+2+2)
Due: February 25

This mini-project is a programming project. All submissions must be in an **Excel form with embedded Macros** (any language will do. Best and easiest is to use Visual Basic)). Your user Interface has to be **VERY** user friendly!!!! A digital box will be created for your submissions in the Extra Credit Assignment Folder of our web site. A **single Excel Attachment** (Sheet 1, Part 1, Sheet 2, Part 2, Sheet 3, Part 3, Sheet 4: Part 4 and Sheet 5, Part 5)). **All questions on this mini project MUST be addressed to me ONLY**. Group of 2's can work on this project. After submission, each group is required to visit me in my office (after the deadline) to demonstrate with arbitrary chosen test cases. I have 4 DEN students. You can form 2 groups or you can work individually. Let me know your preference and I will put you in touch with others.

Part 1:
It is desired to design an Erlang B calculator for the M/M/c/c "lost calls queuing model" that we discussed on Friday session. The input parameters are the average arrival rate (λ) in packets/min, the average service rate (μ) in packets/min and the probability of blocking, P_B. **The output parameter should be the number of servers "c" required to satisfy the P_B requirement. Remember that the number of servers has to be an integer. So if the answer from your "calculation is not an integer, you need to take the "next" higher integer.**

Part 2:
It is desired to design an Erlang C calculator for the M/M/c "delayed calls queuing model" that we discussed on Friday session. The input parameters are the average arrival rate (λ) in packets/min, the average service rate (μ) in packets/min. In addition, you are given the following two "input constraints":

a. The probability that an arriving Packet will find all servers busy (i.e. P (W > 0)) should not exceed ε where ε is an input parameter.

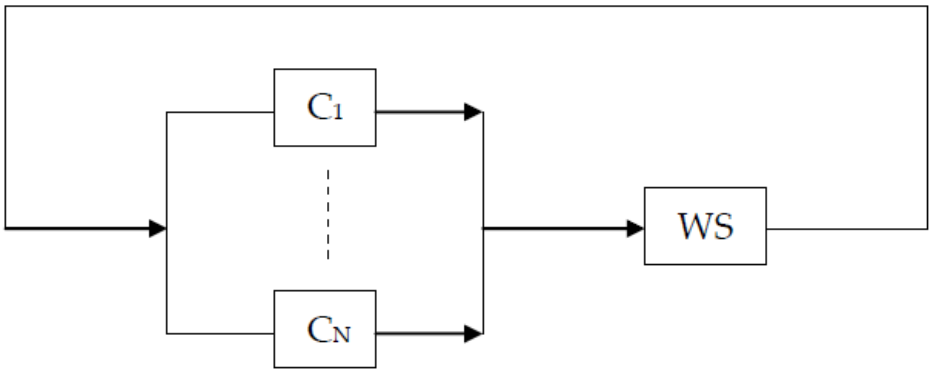
b. Given that an arriving packet must wait, the average waiting time should not exceed α minutes where α is an input parameter. Hint: This is conditional expectations. Review EE503)

The outputs of your calculator should be the number of servers required to satisfy the above requirements/constraints. In addition, your calculator should enable me to

find the following averages: The average number of busy servers and the average number of packets in the system (both waiting and being served

Part 3:

You have a cyclic system with a web server serving N clients (N is an input parameter). Each client can be in two states. In the first state, the client is "preparing a request for service". In the second state, the client has generated the request that is either waiting in the Queue or being served. Each source spends an exponentially distributed amount of time α preparing each server request (α is an input parameter). The server, serves one client at a time with an exponentially distributed service rate of μ requests/sec (μ is an input parameter). **What percentage of the time is the web server busy? What is the throughput of the system? What is the average time spent in the system for each request? What proportion of the time that each client spends waiting for the completion of his request?**



Part 4:

Suppose we have a single server. Packets arrive according to a Poisson Process with an average arriving rate of λ packets/sec (an input Parameter). The capacity of the system is K (an input parameter). The time required to serve each packet is an exponentially distributed with mean service time of $1/\mu$ (μ which is the average service rate is an input parameter. If there are n packets in the system, the probability that an arriving packet will "balk" (Balk means refuse to enter) is n/K for n = 0, 1, 2, 3, … K (So for example if n = 0, the probability that an arriving packet will balk from entering the system is 0. If n = 1, the probability that an arriving packet will balk from entering the system is 1/K and so on.).. **It is desired to calculate the server utilization and the average number of Packets in the system (Both output parameters)**

Part 5:

Suppose we have a system with two servers, S_1 and S_2. S_1 is faster than S_2. Both servers provide exponential service with average service rates of μ_1 and μ_2 respectively (Both input parameters and of $\mu_1 > \mu_2$). Packets arrive according to a Poisson Process with an average arrival rate of λ (input parameter). Server S_1 has infinite buffer. Server S_2 has no buffer. Define the state of the system as (n_1, n_2) where n_1 is the number of packets in the first system (Both waiting and being served) and n_2 is the number of packets being served by the second server for example (3, 1) means there are 1 packet being served by S_1 and two packets waiting for s1 and one packet being served by S_2. Another example (0, 1) means S_1 is idle and one packet is being served by S_2 and so on (Note that state (2, 0) is NOT a possible state). Arriving packets that see the system is empty will join the faster Server. **It is desired to find (i.e. output parameters), the probability that is the system is idle and the system utilization.**

Hint: In all of the above questions you need to sketch (on paper) the state rate transition diagram like we did in the discussion session #2 and get the steady state probabilities (PMF)