Q2. 10 points, with 4 extra points

You have been asked to design and implement a M/M/1 and M/M/2 client-server queuing system. Your system will be the underlying software system for an operations research firm that sells software to model the performance of: (a) Banks with multiple tellers, and (b) Packet switching router.

Your report should discuss the usual components -- architecture, use cases, testing etc. Your report should also analyze some aspect of performance. (Interestingly, you could use performance analysis as a validation and debugging tool too!)

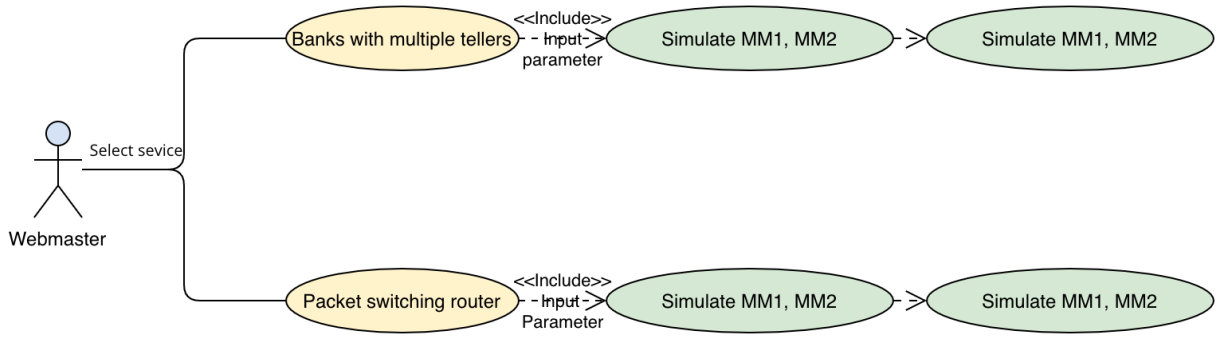
For extra credit: Design, Implement and discuss how you implemented reliability (e.g., defined number of packets are/were dropped) and resilience (e.g. operation under failure).

Solution:

M/M/1 and M/M/2 Queuing simulation system:
This system is designed for customers such as banks with multiple tellers or packet switching routers to analyze the queuing system with M/M/1 and M/M/2 queuing model.

Architecture:
The system consists with 2 parts, (a) Banks with multiple tellers, and (b) Packet switching router. For each part the system will simulate both M/M/1 and M/M/2 queuing model and print the result and plot. When the user launches the system, it will require user to select which service user would like to use. After that, system will ask user to input three parameters: arrival rate(min), service rate(min), and client numbers (bank's customer or packets).

Use case diagram:



Implementation:
Functional requirement:

- The system should output both M/M/1 and M/M/2 simulation results
- The system will plot customers wait time in plot

Non-functional requirement:

- The system cannot hang with large input (e.g. 1000 customers)

Software Testing:

Test case 1:

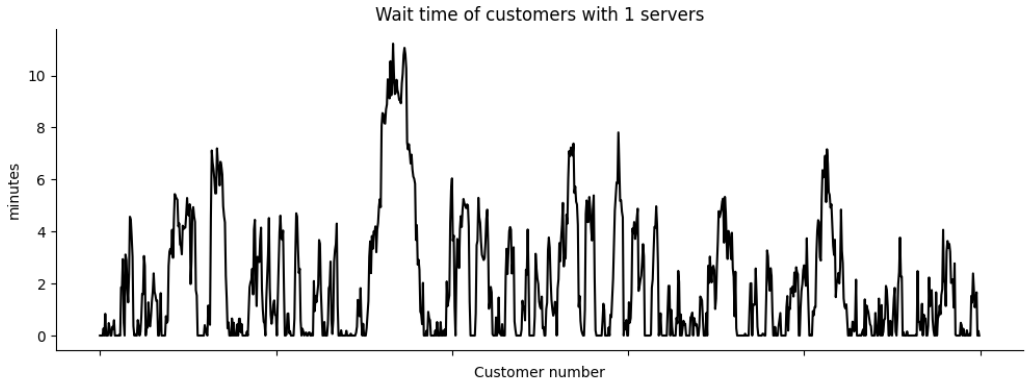
With following input condition

Please Select the service: 1.Banks 2.Packet switching router:1

Please enter the average customers per minute：1

Please enter the average number of people served per minute：1.5

Please enter the number of customers：1000



Output:

Servers : 1

Time Between Arrivals： 1.003540208760709

Service Time: (1/μ) 0.7107006852820134

Utilization (c): 0.7075900086805407

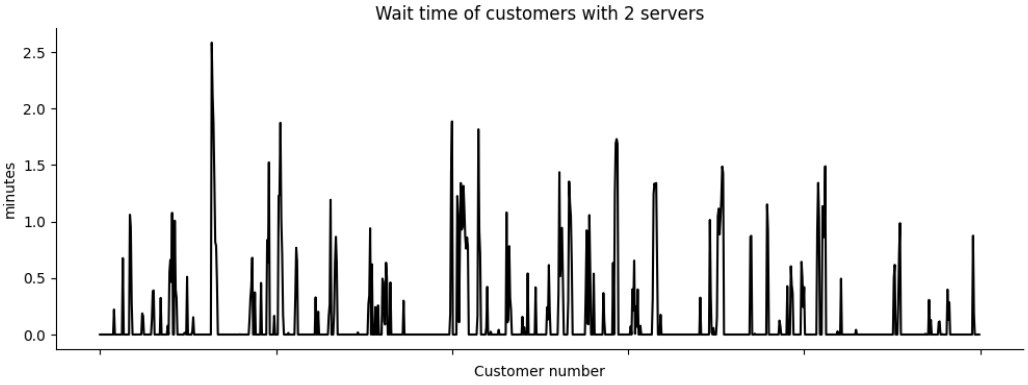
Expected wait time in line (minute): 1.9202734000000001

Expected time spent on the system (minute): 2.6309737999999996

Expected number of customers in line (Lq): 1.913119671611941

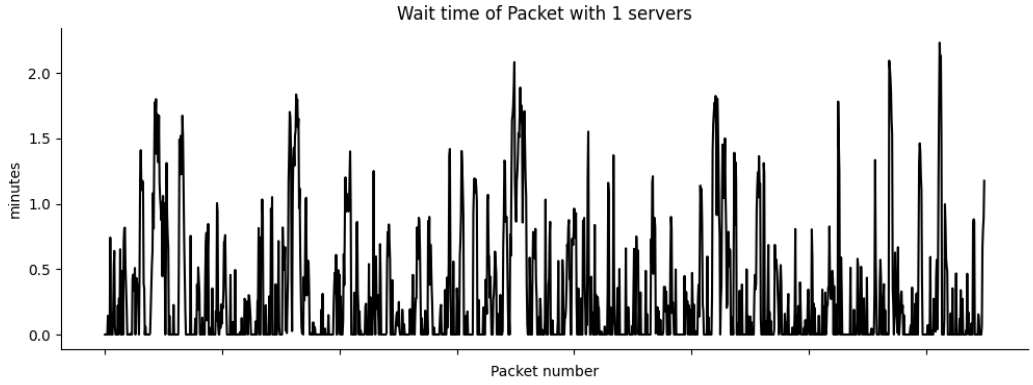
Expected number of clients in the system (Ls): 2.6207096802924816

Expected number of occupied servers : 0.7075900086805407

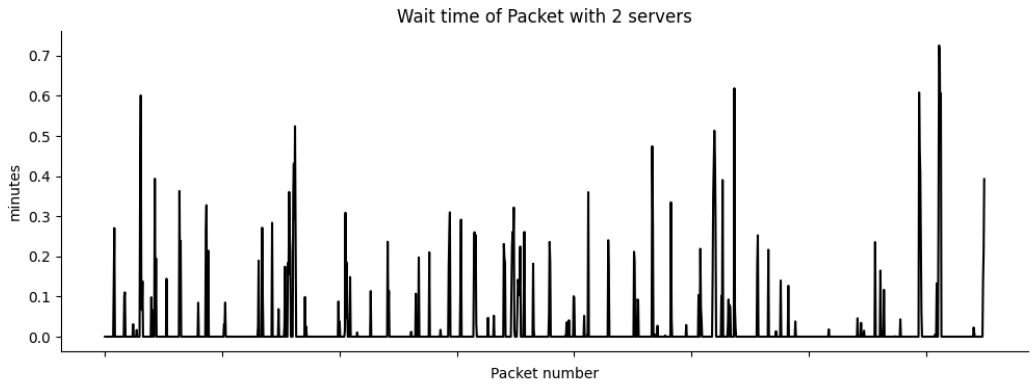


Output:
Servers : 2
Time Between Arrivals : 1.003540208760709
Service Time: (1/μ) 0.7107006852820134
Utilization (c): 0.3159774355924707
Expected wait time in line (minute): 0.1290735
Expected time spent on the system (minute): 0.8397739000000001
Expected number of customers in line (Lq): 0.2043748532727596
Expected number of clients in the system (Ls): 0.836329724457701
Expected number of occupied servers : 0.6319548711849414

Test case 2:
With following input condition:
Please Select the service: 1.Banks 2.Packet switching router2
Please enter the average packet per minute：2
Please enter the average number of packet departed per minute：4
Please enter the number of packets：1500



Output:
Servers : 1
Time Between Arrivals : 0.5158490058490683
Service Time: (1/μ) 0.258171044418318
Utilization (c): 0.49925293261216064
Expected wait time in line (minute): 0.30189906666666666
Expected time spent on the system (minute): 0.5600696666666667
Expected number of customers in line (Lq): 0.5842929097839182
Expected number of clients in the system (Ls): 1.083545842396078 9
Expected number of occupied servers : 0.49925293261216064



Output:

Servers : 2

Time Between Arrivals : 0.5158490058490683

Service Time: (1/μ) 0.258171044418318

Utilization (c): 0.23545164555896225

Expected wait time in line (minute): 0.020599866666666668

Expected time spent on the system (minute): 0.27877046666666666

Expected number of customers in line (Lq): 0.0690538266805398

Expected number of clients in the system (Ls): 0.5399571177984643

Expected number of occupied servers : 0.4709032911179245