BAN – 403
Simulation of Business Processes
Spring 2023

Project 1 (100 points total)

The main report must be a pdf file named Assig1-BUS429.pdf, all the attachments must come in a zip file and have the prefix att-, for example, ”att-proj1.zip”.
You must deliver all the simulation and calculation files that you used to obtain any numerical result. Failing to do so will render those numerical results invalid, and they will be assessed as missing.
The main body of the report must be limited to a maximum of 5 pages, and it has to be self-contained, failing to comply will be penalized. Appendices may be used as support, but they should not be essential for the flow and understanding of the main body of the report.
For this project, the work must be entirely the result of the team credited with in the report. No collaboration is allowed between groups. Any use of generative AI must be acknowledged and explained. It is your responsibility to what extent it was use as a support and to what extent the solution is copied literally.

Montecarlo simulation: (20 Points)

Your task is to use Monte Carlo simulation to find the best investment proportions in five different assets you are considering for your portfolio. You may assume you have an arbitrary amount of money if that helps.
Select data for the daily close or adjusted close prices for 5 assets of your choice for the past 5 years, one source could be Yahoo finance. Simulate different portfolio compositions, compute the expected return, the expected variance, and use the Sharpe ratio to decide which portfolio composition is the best choice. This is a fairly common problem, and you will find plenty of references online. For your submission you must clearly document and explain the procedure you decided to implement, and explain the role of Monte Carlo simulation. Don't forget to cite any references used, including generative AI. The assessment will be based on how clear and precise is your report explaining your simulation, not only on the numerical result.

Queuing theory: (25 Points)

Use JaamSim to create a simulation of the process described in example 6.7 in the book ”Business Process Modeling, Simulation and Design”. This is an example of a $M/M/c/\infty/N$ queue. Your job is to compare the analytical approach with the simulation approach. We are particularly interested in the remark made just before the example 6.7 is presented, which says:
Remark: The $M/M/c/\infty/N$ model is based on the assumption that the time an individual job or customer spends in the calling population outside the queuing system is exponentially

distributed. However, it has been shown (see Bunday and Scraton, 1980) that the expressions for P_0 and P_n (and consequently, those for L, L_q, W, and W_q) also hold in more general situations. More precisely, the time that a job or customer spends outside the system is allowed to have any probability distribution as long as this distribution is the same for each job or customer and the average time is $1/\lambda$. Note that these situations fall outside the class of birth-and-death processes into a $G/M/c\infty/N$ model.
Use your Jaamsim simulation model to verify this remark with the data of example 6.7. You must do it at least with three general distributions for the interarrival times. You must clearly explain and justify your results, just numerical values without any explanation will be considered as an empty answer. Also, you must document your implementation in JaamSim.

General analytical models: (20 Points)

Consider a drive-through restaurant illustrated in class. The model presented in class is reproduced in Figure 1.

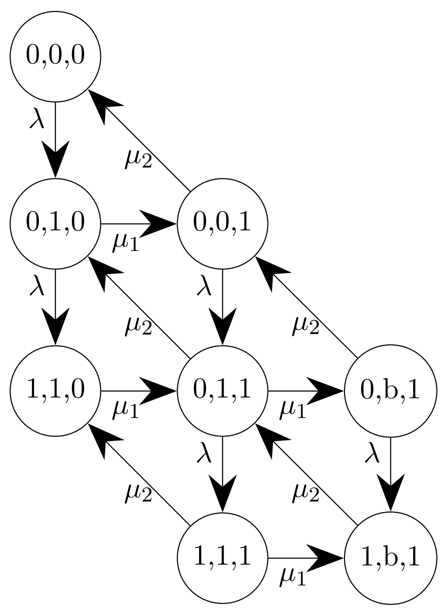

Figure 1: Transition diagram drive-through

After an extensive analysis of the data the following distributions were found reasonable:

- The service time at the microphone ordering the food follows an exponential distribution with a parameter $\mu_1 = 30\frac{orders}{hour}$
- The service time for food preparation and pay follows an exponential distributions with a parameter $\mu_2 = 40\frac{orders}{hour}$.
- The time between the arrival of two different clients follows an exponential distribution with a parameter $\lambda = 50\frac{clients}{hour}$.

The space at the drive-through only allows having 3 clients in the system. When all the space is used any arriving client has to leave immediately. The microphone station is a machine taking orders. Then, the orders are printed in the kitchen for the one employee working there to prepare them. When a client finishes ordering at the microphone it moves to the pickup window if there is space. If a previous customer is still waiting for an order when the client at the microphone finishes ordering, that client must stay at the microphone waiting to move to the pickup window. When a client receives the food it leaves the window immediately and any client behind can move immediately to the next step.

- (4/20 points) Compute the steady-state probabilities for the different states of this system using the balance of flow equations.
- (4/20 points) Using the steady state probabilities, compute the average number of clients in the system, the average rate of clients entering the drive-through, and the average time a client spends in the system.
- (4/20 points) Is this system stable? Justify your answer.
- (4/20 points) Build a simulation model with JaamSim and compare your analytical results with the simulation results. Are there any differences or do they match exactly? Explain your answer.
- (4/20 points) What happens if the food preparation time is not Exponential, but instead, it follows a normal distribution with the same mean. How does it compare with the previous model?

Airline Ticket Counter (Excersice 5, chapter 8, textbook) (35 Points)

At an airline ticket counter, the current practice is to allow queues to form before each ticket agent. Time between arrivals to the agents is exponentially distributed with a mean of 5 minutes. Customers join the shortest queue at the time of their arrival. The service time for the ticket agents is uniformly distributed between 2 and 10 minutes.

(a) Develop a JaamSim model to determine the minimum number of agents that will result in an average waiting time of 5 minutes or less.

(b) The airline has decided to change the procedure involved in processing customers by the ticket agents. A single line is formed, and customers are routed to the ticket agent who becomes free next. Modify the simulation model in Part (a) to simulate the process change. Determine the number of agents needed to achieve an average waiting time of 5 minutes or less.

(c) Compare the systems in Parts (a) and (b) in terms of the number of agents needed to achieve a maximum waiting time of 5 minutes.

(d) It has been found that a subset of the customers purchasing tickets is taking a long period of time. By separating ticket holders from non-ticket holders, management believes that improvements can be made in the processing of customers. The time needed to check in a person is uniformly distributed between 2 and 4 minutes. The time to purchase a ticket is uniformly distributed between 12 and 18 minutes. Assume that 15 percent of the customers will purchase tickets, and develop a model to simulate this situation. As before, the time between all arrivals is exponentially distributed with a mean of 5 minutes. Suggest staffing levels for both counters, assuming that the average waiting time should not exceed 5 minutes.