BDA450 W23 Assignment 2

Due date: March 7th, 11:59pm

This is an INDIVIDUAL assignment. The work that you complete and submit must be your own, not the work of others, nor the work of a team. It is permissible to discuss the assignment in general terms, discuss general approaches to problems, help someone to understand a concept or give them a bit of advice if they have a problem, etc. However, you are not permitted to 'work together', nor to give/receive solutions (whether partial or complete) to/from other students.

Clear indicators that you are violating the rules include (but are not limited to):

- Looking at someone else's work and using that to come up with your own submission
- Sharing/sending/receiving/copying files to/from other students
- Using cut-and-paste or copy-and-paste (if both the source and destination are not your own creations)
- Etc.

If you are unclear at all about what is permissible, please ask your professor.

Submit your work in MySeneca. Include both your code, and the required output.
Late submissions <u>will not be accepted</u>.

Scenario

You work in the management group for a hospital. Managing the ambulance service is an important part of your group's work: if you have insufficient ambulances, people with emergencies might have to wait a very long time, while if you have too many ambulances, you are wasting extraordinary amounts of money. To aid in the planning process, your institution wishes to use simulation. You will build a simulation that explores the relationships between the number of emergencies, the number of ambulances, and the resulting costs and waiting times.

You have a fixed pool of ambulances, each staffed with two paramedics. Emergency calls are placed by phone to the 911 call centre; there is no limit on how many calls can be placed at a time. When a call comes in, the next available ambulance drives to the site of the emergency. Some time is spent assessing the patient, caring for them, and then loading them into the ambulance; the ambulance then returns to the hospital. After returning, the ambulance takes the next available bay, and unloads the patient. After finishing unloading, the ambulance is available to handle the next emergency.

You will use SimPy to develop a discrete event simulation. This simulation can be built using the tools, methods, and constructs we have covered in class—you will not need to invent any novel methods to solve this problem.

Specifics:

- You will run your simulation for 8 hours, simulating the afternoon/evening shift.
- We won't consider navigating routes on a street map; instead, we will simplify the situation by basing travel times on linear distance between the hospital and the patient's location. To account for this unrealistically direct routing, assume that drivers drive at a constant speed of 55 km/h. (Note that that most other measures in the simulation are denominated in minutes!)
- Your hospital covers a small city that is approximately circular in shape, and is located near the middle of that circle. The radius of the city (in km) is a parameter to the simulation. Every point within the circular region is equally likely to be the location of an emergency. Thus, to determine the linear distance to a random customer, you can use the function[1]:

  distance = city_radius * sqrt(random())

  where random() is a uniform random generator over the interval [0, 1] (such as the random() function in Python's random module.)
- When a call comes in for an emergency, if an ambulance is available, they leave the hospital immediately. Otherwise, ambulances each handle the next emergency when they become available.
- When an ambulance arrives at an emergency, it takes a random amount of time before they have the patient loaded into the ambulance. This time is approximately normal, with a mean of 11 minutes and a standard deviation of 2.5 minutes.
- When the ambulance arrives back at the hospital, there are only a fixed number of loading bays available to unload the patient. (The number of bays is a parameter to the simulation.) If there are no bays available, the ambulance (and the patient) must wait until one becomes available. Once a bay is available, it takes 5 minutes to unload.
- Immediately after the patient is unloaded, the ambulance becomes available to handle subsequent emergencies.
- It costs approximately $265/hour for an ambulance.

(Please define all constants (e.g., mean time to load a patient) using named variables at the top of your program, rather than simply using numerical constants directly embedded within your functions.)

The number of ambulances, the emergency rate (in average minutes between emergencies), the radius of the town, and the number of bays should be parameters to your simulation.

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[1] Distance formula based on work presented in https://stackoverflow.com/questions/5837572/generate-a-random-point-within-a-circle-uniformly/50746409#50746409

Hint: In this case, it is best to model the patients/emergencies as the processes (rather than ambulances).

Required

For each of the following, your simulation should calculate useful summary statistics (e.g., mean, standard deviation, etc.) and produce a useful histogram:

- Time from the emergency call to an ambulance becoming available
- Time from the emergency call to the ambulance reaching the patient
- Time waiting for a bay to unload the patient
- Time from the emergency call to the patient having been unloaded at the hospital

You also need to report the average utilization of the ambulances, and the cost incurred for the period (single values, no distribution/summary stats required).

You must submit both your output (in PDF format, or test/image files), as well as your code (in .py or Jupyter notebook).

Part A

Submit your code, as well as your output for a simulation run with 5 ambulances, an emergency rate of 7 minutes (average) between emergencies, a city radius of 12 km, and 3 bays.

Part B

Using appropriate simulation approaches, answer the following questions:

- For the parameter values given above, suppose that you need to report the 90th percentile total wait time (i.e., 90% of patients wait less than this time, from calling until ultimately being unloaded). (Ideally, this would be an average over many simulation runs, but for this assignment, you can determine it from a single run.)
- If you want 90% of your patients to have total wait times of 35 minutes or less, and with all other parameters the same as above, how many ambulances do you need?