MAASTRICHT UNIVERSITY, DEPARTMENT OF ADVANCED COMPUTING SCIENCES
SIMULATION AND STATISTICAL ANALYSIS (KEN2530)

Bonus Assignment
Dividing ambulances over a region

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SETTING

Given is an ambulance service at a hospital, which has to cover seven regions in total. Every region has five ambulances and is shaped as hexagon which fits precisely inside a circle with diameter 10, has an ambulance waiting dock placed at its center and the hospital is located in the middle region, thus the hospital is a waiting dock as well. This is also indicated in Figure 1.

The ambulances are responsible for picking up all patients throughout all seven regions and bringing them to the hospital in the central region. After dropping off a patient at the hospital, the ambulance either drives back to the waiting dock it is assigned to, or it directly drives on to another patient that needs to be picked up in its region.

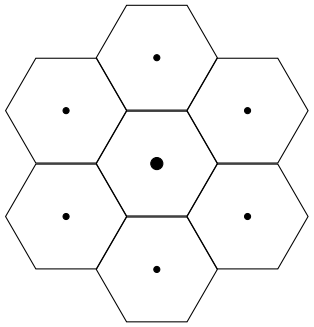

Figure 1: The seven regions with the hospital located at the center of the middle region, indicated by the largest dot. The smaller dots indicate the regional waiting docks.

Patients arrive with three different priority levels ($A1$, $A2$, and B). Patients with priority level $A1$ have priority and should be picked up within 15-minutes after the arrival of the patient in at least 98% of the cases. Priority level $A2$ is given to patients that need to be picked up, but who are not in a life-threatening situation. Finally, priority level B is given to scheduled pick-ups of patients. Due to this nature, patients of priority level B should be served before $A2$ patients but after $A1$ patients.

Ambulance crews can be scheduled in 4 or in 8 hour blocks and shifts start at whole hours, where the night shift always is 23:00-07:00, and crews cannot start a shift within this timeframe, nor end a shift between 02:00-07:00. You can assume that there is an infinite pool of ambulance crews that you can use.

Patients of each priority level arrive according to a time-varying Poisson process, with rate

$$\lambda(t) = 3 - 2 \cdot \sin\left(\frac{5(\pi + t)}{6\pi}\right), \tag{1}$$

in which time is measured in hours.

The time it takes to bring a patient to the hospital (regardless of the patient priority level) is defined as the driving time in minutes (measured by the Manhattan distance between the location

of the call locations and the location of the ambulances) and the processing time of the patient at the scene. Assume that this processing time (in minutes) follows an Erlang-3 distribution with parameter $\lambda = 1$.
The locations at which patients need to be picked up are chosen uniform at random in their region of origin.

GOAL

Implement this setting in java, using the engine provided and modifying it where necessary, but don't start making large modifications and optimizations. The output measures of interest are the fraction of patients for which the 15-minute response time for $A1$ patients is met, the mean waiting time of patients of priority level $A1$, $A2$ and B. Provide a 95% confidence interval for all reported measures. Ensure that you can do proper statistics, thus ensuring that all assumptions of such confidence interval are satisfied. The statistical analysis can be performed in MATLAB. Make a schedule on for the ambulance crews over the day, that should be cost effective (to some degree).

WHAT YOU MUST PRODUCE

- A Java project that can run the complete simulation.
- A MATLAB/Java software bundle that does the data analysis on collected data (could be combined with previous).
- A report (max 5 pages) showing, visualizing and discussing the results and drawing conclusions, describing your model and describing your choices. Those page numbers are a maximum since we don't know how many pictures you want to include.
- A clip in mp4 format (h.264) with narrations of maximal 5 minutes where you take us through your code, demo your product and tell us what nice features are in there. There are open source tools available for that, e.g., OBS studio.
- In the report/clip be sure to highlight.
  - What your model is.
  - How many ambulances you need and where they are placed.
  - The confidence intervals.
  - How you found the performance guarantees.
- You are allowed to work in groups of 4 to 8 students. If you work in a group of 4, then this does not change the grading rubrics compared to a group of 8. So teaming up has clear benefits. Obviously, you are allowed to collaborate within your group, but not with other groups.

WHAT YOU SHOULD **NOT** BE DOING IS

- Using add-on libraries to do things.
  - You can use the built-in random number generator, but for generating random variates other than $U(0,1)$ or $N(0,1)$, you must demonstrate that you master techniques for generating random variates.

  - For tests that we discussed in class: use your own code. If you want to do fancier stuff e.g. the Wilcoxon rank sum test or signed rank test, you can use the MATLAB functions for that even though they are in toolboxes. You are also free to use the `tinv` function to find values from the t-distribution.

- Using an alternative engine.
- Using MATLAB toolboxes, unless explicitly allowed.
- Copying code from the internet. That's plagiarism.
- Having others write code. That's plagiarism.
- List personal information in your code like name, student number. Your code will be off-site plagiarism checked.
- Waste time making a GUI.
- Make the clip fit in 5 minutes by increasing the speed.

WHAT YOU SHOULD BE DOING IS

- Start early; We cannot stress this enough!
- Exploit the fact that you learn things during the labs
- Contribute homogeneously to the project group
- Use the project to show that you master the course material
- Motivate the choices in your report

TIMELINE FOR THE BONUS ASSIGNMENT

- Before 7/11/2022 11:00h: Register your group by per group sending us an email with as subject "with as subject "SSA bonus group registration", all group members in the CC and listing the group composition. Failure to to this before the deadline means that you cannot participate in the bonus project.
- Before 12/12/2022 10:30h: hand in all deliverables through Canvas.

EXTERNAL PACKAGES THAT YOU MAY USE

- `https://github.com/bastibe/Violinplot-Matlab`

FREQUENTLY ASKED QUESTIONS

- Can I use Python instead of Java? ANSWER: No, you cannot use Python.