CS 415 / CS 572 Modeling and Simulation of Systems

Assignment 2

Indian Institute of Technology (IIT) Goa

15th February 2022

Submission Instructions:

- Upload a report as a single **pdf** file. The report should be detailed enough to allow the TAs to assess whether you have completely and correctly solved a question (attach logs, plots, code snippets and simulation statistics for questions where necessary).
- Submit Python code for the indicated questions only as a single **.py** file per-question into the attached Google Form.
- Submissions in other formats (docx/ipynb etc) will not be considered. Marks may be deducted if your code shows lack of attention to proper coding conventions.
- Whenever a range of values is mentioned (for example, 10-20 minutes) assume that the random variable is *uniformly distributed* within this range, unless the distribution is explicitly specified.
- Use Python's Matplotlib library for generating your plots. The Python code you submit should include the functions for generating the final plots.
- You are not allowed to use Python libraries other than Matplotlib, Scipy, Math, Random, SimPy (which might require separate installation).
- This is an individual assignment. Suspected cases of copying/collusion will be reported to SSAC.

1 Assignment Frenzy

System Description

At midnight, 10 students staying in the IIT Goa hostel start working on a coding assignment that is due for submission the next morning at 7am. Although this is last-minute work, all students are ethical and work independently on their solutions. There is no copying/collusion.

Each student requires 4-5 hours' worth of effort to complete the assignment, so the task seems easily achievable. However, the students have old laptops with no battery backup and their work is hindered by frequent power cuts. A power cut occurs once every 1-2 hours and lasts for 10-15 minutes at a time. (To clarify, imagine the power cycles through the UP and DOWN states alternately. The UP state lasts for 1-2 hours and the DOWN state lasts for 10-15 minutes.)

Whenever a power cut occurs, all students stop their work and wait patiently for the power to come back up. After waiting for 5 minutes, a student may simply get bored and drift-off to sleep (with probability 0.4) or manage to stay awake and wait as long as it takes for the power to come back up (with probability 0.6). As soon as the power comes back up, the students that have not yet gone to sleep resume their work from the point where they left off. The students who slept off unfortunately wake up after 8am, when the submission deadline is already past.

Questions

1. **[Submit code]** Model this scenario using SimPy. Each simulation should cover the time from midnight until 7am. Run the simulation once to show a detailed activity log showing all instances when power went/came back, what each student was doing and how much work was remaining. At the end of every simulation run, a summary should be printed showing the total number of students that finished the assignment on time, the total number of power outages, the average time it took for a student to finish the work (across only the students that finished the work on time) etc.

2. Modify your code so that each simulation run lasts only as long as necessary. That is, either till 7am **or** until all students finish the assignment **or** until all students fall asleep, whichever occurs earlier.

3. Using 100 independent simulation runs, find out how many out of the ten students on average end up completing the assignment in time. Let us denote this quantity as N.

4. **[Submit code]** Let p be the probability of a student falling asleep after the first five minutes of a power failure (in the description above, we have assumed $p = 0.4$). Obtain a plot of how N varies with p as p ranges from 0 to 1.

5. **[Submit code]** To avoid falling asleep, some students consider having a cup of coffee from the night canteen every time a power failure occurs. Drinking a cup of coffee reduces the probability p to zero (only for that particular power failure instance). However, it takes almost 30 minutes to visit the canteen and have the coffee, considering that one typically encounters friends on the way.

   You can assume that students leave for the coffee break as soon as a power failure occurs. By the time they return, they find the power to be already back up (since the power down times typically last for only 10-15 mins).

   In the average case, for what value of p would you say that it is worth while to take a coffee break at every instance of power failure? To be specific, find out if N(with coffee breaks) is always better than N(without coffee breaks), whether this depends on the value of p, and for what value of p would you say that one approach is better than the other.

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