Institut supérieur d'informatique et de mathématiques de Monastir

Niveau: L2INFO
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Année Universitaire : 2023/2024

TP2: Carthage Road Trip

Due: _______, November __, 2023 (12:00pm)

Learning objectives:

The purpose of this assignment is to learn about trace-driven simulation, random variate generation, statistics, and correlation.

Background:

The year 2023 has been a special one for Tunisia, marking the 66th anniversary of the republic. As part of the celebration, the Government of Tunisia has granted free entry to all national museums and monuments in 2023. One consequence of this decree has been a 30% increase in the number of tourists visiting Tunis. This is a good thing in terms of tourism revenue, but a bad thing in terms of the congestion (and queueing delay!) to see some of our favourite tourist sites in Tunis and Carthage.

On the highway from Sousse to Tunis, there is a museum entry gate/booth, at which a driver can obtain a free museum pass if they do not already have one. (In fact, there are four such booths in parallel, but we will be modelling only one such booth, since its statistical behaviour should be representative of the others.) Cars arrive at random according to a Poisson arrival process, with a mean arrival rate of lambda cars per minute. Cars spend some time waiting in the queue until they get to the booth at the front. Once they are at the booth, they obtain their museum pass, and possibly some maps, plus answers to any other questions that they may have about Tunis. This "service time" may vary for each driver.

Your task is to build a trace-driven discrete-event simulation model of this system in order to understand the impacts of an increased arrival rate on the expected queueing delay to enter the museum. You will also study the sensitivity to correlations (if any) in the service times and/or arrival times in the system.

Technical Requirements:

In this assignment, you will implement a trace-driven simulation (in python using Simpy) to evaluate the average queueing delay for the museum entry process, under a variety of workload assumptions. All of your simulation runs should be for 10,000 cars. In all of these experiments, you can assume that the vehicle arrivals follow a Poisson arrival process, with a mean rate of lambda cars per minute. You will vary lambda from 0.5 to 0.65 in steps of 0.05 (i.e., you will have 4 different trace files to use for arrival times when doing your trace-driven simulations). You will also have four different trace files for your service times (see below).

The specific workload models to consider for the service times are the following:

- Deterministic: The service time for each car/driver when they get to the front is always exactly 1.5 minutes.
- Exponential: The service time for each car/driver is exponentially distributed and independent, with a mean of 1.5 minutes.

- Hyper-exponential: For half (50%) of the drivers, the service time is exponentially distributed and independent, with a mean of 1.0 minutes, while for the other half, the service time is exponentially distributed and independent, with a mean of 2.0 minutes.
- Correlated Exponential: The service time for each car/driver is exponentially distributed, with a mean of 1.5 minutes, but with a small positive correlation (about 0.2) between successive service times.

When you are finished, please submit your solution in electronic form to your TA. Your submission should include the source code for your simulation program, a brief user manual describing how to compile and use your simulator, and a description of the results generated using your program. Please remember that assignments are to be done individually, and submitted to your TA on or before the stated deadline. The penalty for late submissions is 4 marks per day (or portion thereof) beyond the deadline.

Grading Rubric

The grading scheme for the assignment is as follows:

- **8 marks** for the design and implementation of a proper trace-driven discrete-event simulator (i.e., main simulation loop, state variables, data structures, input file handling, random number generation, statistical output, etc)
- **4 marks** for correct implementation of models to generate (and store as files) the service time models indicated above (1 mark each, total of 4)
- **6 marks** for a table of simulation results estimating the mean and standard deviation of queueing delay, as a function of lambda, for each of the four service time models. Supplement your tabular results with a few sentences summarizing the main observations from your results.
- **2 marks** for a clear and concise user manual (at most 1 page) that describes how to compile, configure, and use your simulation program. Make sure to clarify where and how the testing was done (e.g., home, university, office), what works, and what does not. Be honest!

Up to **2 bonus marks** will be awarded for additional simulation experiments that add a small positive correlation to the arrival process (without changing the mean arrival rate), which clearly show whether the queueing delay is more sensitive, equally sensitive, or less sensitive to correlation in the arrival process than correlation in the service time process. (For this bonus work, it suffices to use only the iid Exponential service time model and the lambda=0.5 assumption.)