Simulation Mini-Projects

Academic year 2024/2025 Nuno Lau/Amaro Sousa

1. A service facility consists of two type A servers and one type B server. Assume that customers arrive at the facility with interarrival times that are IID exponential random variables with a mean of 1 minute. Upon arrival, a customer is determined to be either a type 1 customer or a type 2 customer, with respective probabilities of 0.8 and 0.2. A type 1 customer can be served by any server but will choose a type A server if one is available. Service times for type 1 customers are IID exponential random variables with a mean of 0.8 minute, regardless of the type of server. Type 1 customers who find all servers busy join a single FIFO queue for type 1 customers. A type 2 customer requires service from both a type A server and a type B server simultaneously. Service times for type 2 customers are uniformly distributed between 0.5 and 0.7 minute. Type 2 customers who arrive to find both type A servers busy or the type B server busy join a single FIFO queue for type 2 customers. Upon completion of service of any customer, preference is given to a type 2 customer if one is present and if both a type A and the type B server are then idle. Otherwise, preference is given to a type 1 customer.

   1.1. Simulate the facility for exactly 1000 minutes and estimate the expected average delay in queue and the expected time average number in queue for each type of customer. Also estimate the expected proportion of time that each server spends on each type of customer.

   1.2. Check which one is better in reducing the maximum of the average delay in queue for both types of costumers:

      1.2.1. One more server of type A.

      1.2.2. One more server of type B.

2. Consider the adapted Lotka-Volterra model for the evolution of predator-prey populations. The evolution is traced by keeping track of the following metrics:

   - *x(t)*: which represents the number of preys.
   - *y(t)*: which represents the number of predators.

   The differential equations that govern this model are the following:

$$\frac{dx(t)}{dt} = \alpha.x(t) - \beta.x(t).y(t)$$

$$\frac{dy(t)}{dt} = \delta.x(t).y(t) - \gamma.y(t)$$

   2.1. Write a simulation program that can trace the evolution of x*(t)*, and *y(t)*, using the Forward Euler method, when given the values of *x(0)*, *y(0)*, α, β, δ, γ, Δt and t_{final}. Initial values and parameters can be specified in the command line or in a file.

2.2. Write a simulation program that can trace the evolution of $x(t)$, and $y(t)$, using the Runge Kutta method, when given the values of $x(0)$, $y(0)$, α, β, δ, γ, Δt and t_{final}. Initial values and parameters can be specified in the command line or in a file.

2.3. Compare the precision of the previous approaches.

Delivery

You should deliver:

- The source code of all simulation programs;
- A report that presents: a) the answers to the questions raised in this document; b) the strategy followed for the resolution of the various implementation tasks; c) the experiments and results used to validate the solution.

Due dates

Materials (delivery using elearning platform): July 8, 2025

Bibliography

[1] "Simulation Modeling & Analysis", 5^{th} edition, Averill M. Law, McGraw-Hill