Queuing Theory

Project : Queuing Model Simulation

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Goal

- Understand how to simulate queuing models on real-world scenarios and compare the corresponding results with the theoretical ones

- You will learn how to
  - simulate queuing models
  - calculate the theoretical results of queuing models
  - confirm the correctness of simulation based on the comparison between simulated and theoretical results

Tasks

- Simulating queuing modes modeled from two practical scenarios
- Obtaining the theoretical results of the queuing models
- Comparing the simulated and theoretical results for each scenario

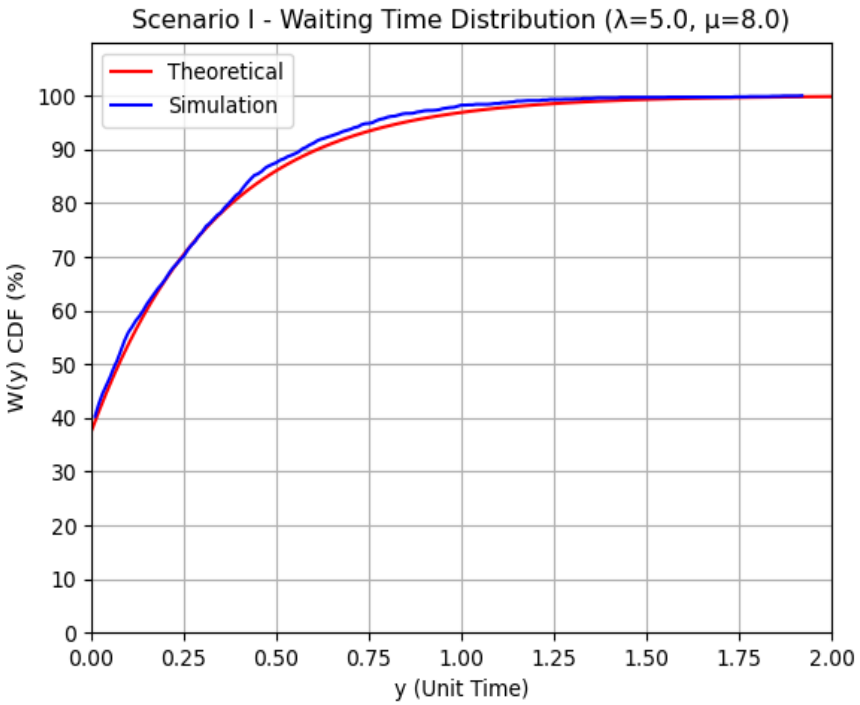
Scenario I

- Consider a network service with
  - 1 server, infinite queue size, and infinite number of packets
  - Packet arrivals in a Poisson process (λ)
  - Service times with an exponential distribution (μ)

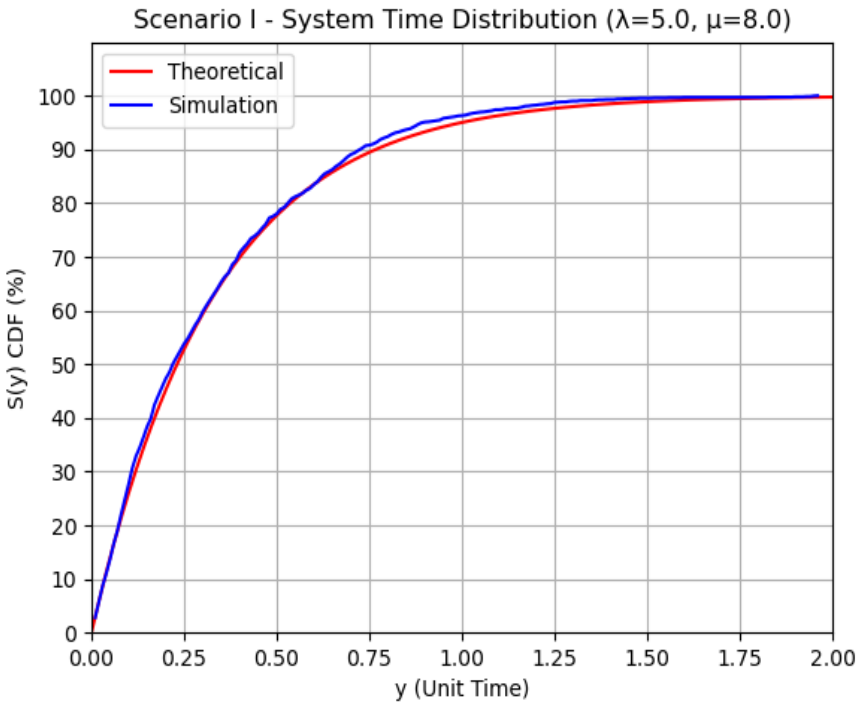
- What are its waiting and system time distributions?
  - Please draw CDF figures based on their theoretical results
  - Please draw CDF figures by simulating the network service
  - Compare the simulated and theoretical results by calculating their MSEs (Mean Square Errors)

Scenario I (cont.)

- Example Results



Mean Squared Error: 1.05



Mean Squared Error: 1.03

Scenario I (cont.)

- Consider the following two cases
  - Case I: $\lambda = 2$ packets/ms, $\mu = 10$ packets/ms
  - Case II: $\lambda = 8$ packets/ms, $\mu = 10$ packets/ms

Scenario II

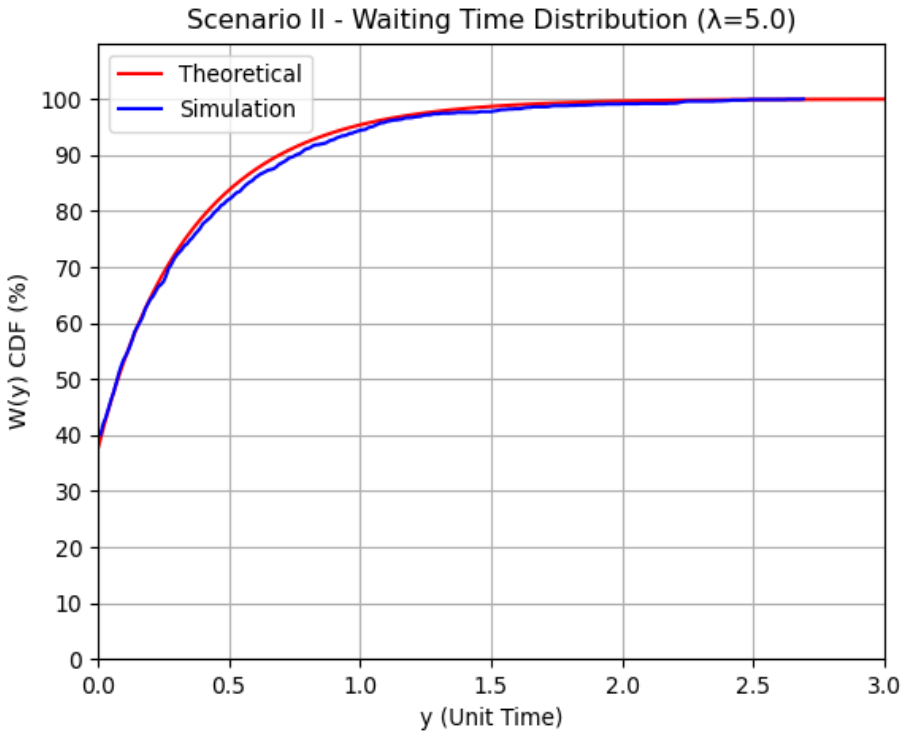
- Consider the service of a tiny bank branch with
  - 1 bank teller
    - Dealing with 2 different businesses, A and B
    - Handling A and B with average service times $\frac{1}{\lambda}$ and $\frac{1}{2\lambda}$, respectively
  - Infinite queue size and infinite number of customers
  - Packet arrivals in a Poisson process (λ)
  - Consider $\lambda = 10$ customers/sec

Scenario II (cont.)

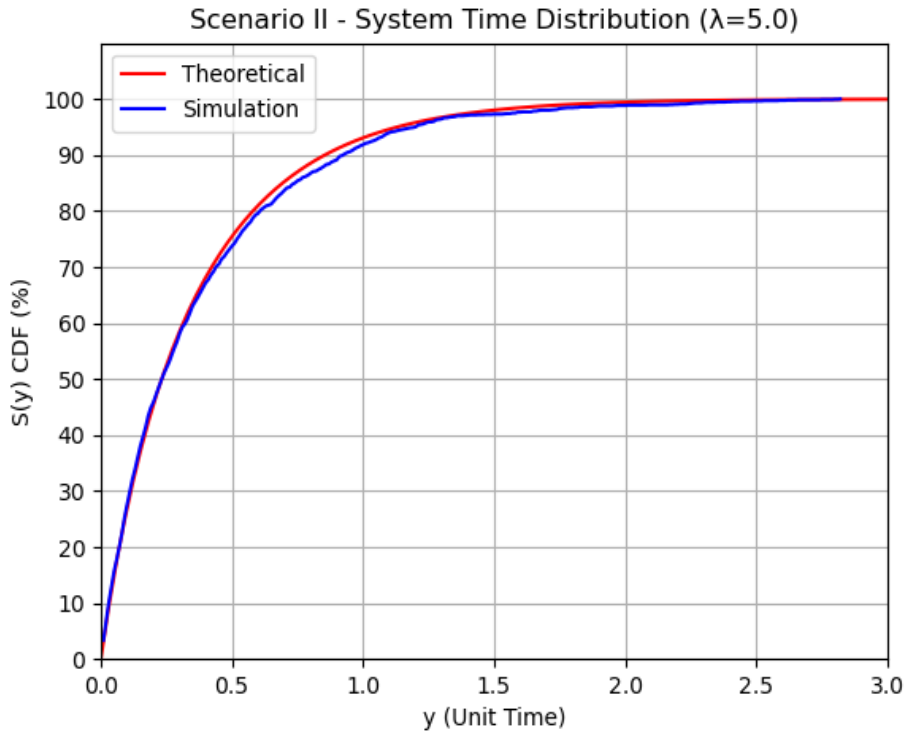
- What are its waiting and system time distributions?
  - Please draw CDF figures based on their theoretical results
  - Please draw CDF figures by simulating the network service
  - Compare the simulated and theoretical results by calculating their MSEs (Mean Square Errors)

Scenario II (cont.)

- Example Results



Mean Squared Error: 0.75



Mean Squared Error: 0.84

Scenario II (cont.)

- Consider the following two cases from history statistics
  - Case I: 50% of customers request service A, whereas 50% of customers do service B
  - Case II: 25% of customers request service A, whereas 75% of customers do service B

Project Report

- Item I: please describe how you get the theoretical distribution (30%)
  - Briefly explain the steps and the derivation detail is not needed
- Item II: please plot figures for two scenarios, each with two cases (40%)
  - Totally, there are 8 figures
- Item III: please compare simulation and theoretical results for each case (30%)
  - You can use MSEs to observe the difference between two distributions

Demo Video

- You should prepare a demo video, which includes
  - showing how you simulate each scenario (using one of two cases)
  - showing how you execute your program
  - showing how you plot the CDF figure
- Submission
  - giving the URL in a file, called demo_video.txt, for accessing your demo video

Project Submission

- Due date: 2024/1/2 11:55pm
- Submission rules
  - Put all your files into a directory and name it using your student ID(s)
  - Zip the directory and upload the zip file to E3
  - A sample of the zip file: 01212112.zip
    - scenario1.py
    - scenario2.py
    - report.pdf
    - demo_video.txt
    - ….

Hints

- You can leverage the P-K transform equation to get the theoretical distribution
- You can use any language for your programs
  - Python, MATLAB, etc.
  - All the third-party packages are all accepted
- You can use any kind of tool to draw the CDF figures
  - Including but not limited to Matplotlib for Python

Questions?