

Supermarket Queue Simulation Lab

Overview

In this lab, you will build a simulation of a supermarket checkout process to compare two different queue management policies:

1. **Separate Queues:** Each cash register has its own dedicated queue.
2. **Single Queue:** A single shared queue feeds all available cash registers.

The simulation models customers arriving at the supermarket. Each customer records the time they join the queue and the required service time once they begin checkout. The goal is to compute the average waiting time for customers under each policy.

Objectives

- **Learn Queue Data Structures:** Use queues to model real-world waiting lines.
- **Compare Policies:** Analyze which queue system minimizes waiting times.
- **Flexible Implementation:** The simulation can be implemented in either Python or Java.

Requirements

- **Customer Class:**
Models a customer with:
 - **Arrival Time:** The minute when the customer joins the queue.
 - **Service Time:** How many minutes the customer takes at the cash register.
- **Simulation Classes:** Two simulations that share common parameters:
 - **Arrival Probability:** Chance a customer arrives each minute.
 - **Number of Registers:** Total cash registers available.
 - **Total Minutes:** Duration of the simulation (in minutes).

Policy 1 – Separate Queues:

Each register has its own queue. When a customer arrives, they join the shortest queue. When a register becomes free, the first customer in its own queue is served.

Policy 2 – Single Queue:

A single shared queue is used. When any register is free, the next customer from this common queue goes to the available register.

Simulation Process (Common to Both Versions)

1. Initialization:

Set the simulation parameters and initialize registers and queues.

2. Minute-by-Minute Simulation:

For each simulated minute:

- **Customer Arrival:**

Use the arrival probability to decide if a new customer arrives. Generate a random service time (for example, between 1 and 5 minutes) for each arriving customer.

- **Queue Management:**

Depending on the policy:

- *Separate Queues:* Assign the customer to the register with the shortest queue.
- *Single Queue:* Add the customer to the common queue.

- **Processing Customers:**

For each register:

- If busy, decrement the remaining service time.
- If free, and if there is a waiting customer (from the register's own queue or the shared queue), remove the customer from the queue, record their waiting time (current minute minus arrival time), and start their service.

3. Results:

At the end of the simulation, calculate the average waiting time for all customers served.

Hand-in Instructions

- Include a comment at the top of each source file with the names of all students who worked on the project.
- Submit your final work as a zip file containing all project files.
- You may extend the simulation with additional realistic features (e.g., customers leaving if the line is too long, varying checkout times based on the number of items, etc.).