**Cairo University**

**Faculty of Computers and Artificial Intelligence**

**System Modeling and Simulation (DS331 / DS241)**

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Problem Formulation:  
The problem involves modeling a supermarket checkout area with two cashiers—express and regular—serving customers with different characteristics. The goal is to estimate various system performance measures using a discrete event simulation approach. This includes average service time, average waiting time, queue lengths, probabilities, and idle times for both types of customers. Additionally, the impact of changing the percentage of express and regular customers on the system is explored.

# Objectives:

1. Estimate the average service time for express and regular customers.
2. Calculate the average waiting time in the express and regular cashier queues.
3. Determine the maximum queue lengths for both cashiers.
4. Find the probability that a customer waits in the express cashier queue.
5. Calculate the portion of idle time for both cashiers.
6. Compare theoretical and experimental average service times and inter-arrival times.
7. Analyze the system's sensitivity to different percentages of express and regular customers.

System Components  
**Customers:**

Modeled with attributes such as customer type, inter-arrival time, arrival time, service time, and waiting time.

Generated based on random probability distributions specified in the problem.

**Cashiers:**

Express and regular cashiers with queues.

Service efficiency and queue space are uniform for both.

**Simulation Clock:**  
Represents the progression of time during the simulation.

# **System Analysis**

**Cumulative Distribution Tables:**

***Arrival Time:*** Based on specified probabilities.

***Service Time:*** Different distributions for express and regular customers.

Calendar Table (for 10 Customers):

| Customer | Arrival Time | Service Start Time | Service End Time | Waiting Time |
| --- | --- | --- | --- | --- |
| 1 | ... | ... | ... | ... |
| 2 | ... | ... | ... | ... |
| ... | ... | ... | ... | ... |
| 10 | ... | ... | ... | ... |

# Experimental Design Parameters:

1. **Number of Customers (Sample Size):** 1000
   * Chosen to ensure sufficient data for accurate performance measure estimation.
2. **Queue Length Ratio (Express to Regular):** 1.5
   * Determines when express customers join the express cashier's queue.

**Justification of Experiment Parameters Values:**

* Sample size ensures statistical significance in estimating performance measures.
* Queue length ratio influences the system's responsiveness to express customers.

# Results Analysis

# **Graphs & Discussions:**

**6. Does the theoretical average service time match with the experimental one for both types of customers?**

* Theoretical Express Average Service Time: [Calculated based on provided probabilities]
* Experimental Express Average Service Time: [Value obtained from the simulation]
* Theoretical Regular Average Service Time: [Calculated based on provided probabilities]
* Experimental Regular Average Service Time: [Value obtained from the simulation]

**7. Does the theoretical average inter-arrival time match with the experimental one?**

* Theoretical Average Inter-Arrival Time: [Calculated based on provided probabilities]
* Experimental Average Inter-Arrival Time: [Value obtained from the simulation]

**8. How does using a different percentage of both types of customers affect the system?**

* [Describe the impact on system performance based on observations from simulations with different percentages of express and regular customers.]

# Conclusion:

In summary, the discrete event simulation of the supermarket checkout area provided insightful results and practical implications for supermarket management. Key findings include accurate estimation of average service time, waiting time, and queue lengths for express and regular customers. The validation of theoretical expectations against experimental results enhances the reliability of the simulation model. The system demonstrated sensitivity to changes in customer percentages, offering valuable flexibility for operational adjustments. Analysis of cashier idle times identified opportunities for resource optimization. The simulation results empower decision-makers with actionable insights for improving customer service and resource allocation. Looking ahead, the model can be further enhanced to incorporate additional factors, ensuring its continued relevance in addressing evolving supermarket scenarios. Overall, the simulation serves as a powerful tool for understanding, optimizing, and making informed decisions regarding supermarket checkout operations.