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COMSC 76 Queue Project - Self-Checkout Report

Introduction:

This report documents the implementation and comparison of three distinct models for self-checkout stations in a grocery store. The objective was to assess the efficiency and performance of each model under similar conditions. The model is built off of suggestions from the Queue.java file and parameters from the sample report posted under the assignment description where our group then designed and implemented our following simulation of the 3 different proposed checkout line models for the COMSC 76 project.

Description:

1. One Line for Customers, Multiple Checkout Stations (Model 1):
 - In this model, customers form a single line, and there are multiple checkout stations.
 - Customers are served on a first-come, first-served basis.
2. Multiple Lines for Customers, Least Customers Per Line (Model 2):
 - Customers have the option to choose from multiple lines, each with its own checkout station.
 - Customers select the line with the fewest number of customers ahead.
3. Multiple Lines for Customers, Random Line Selection (Model 3):
 - Similar to Model 2, but customers randomly select a line to join.

Parameters:

The Customer class defines several key parameters and calculates the checkout time:

- Each customer has a random number of items to check out, ranging from 10 to 40.
- It takes 5 seconds to scan each item.
- Payment time varies randomly between 20 to 40 seconds and is defined in the getDuration() method of the customer class

The CheckoutStation class tracks when stations are free, busy, and current customer using the station:

- The startCheckout() method monitors the customer at the station, checkout duration, and marks if the station is busy, and update() is used to mark the station as not busy when the customer is done.
- isFree() is used to mark open stations.

The Simulation class is used to keep track of customers served, wait times, and queue lengths for the simulated checkout stations.

- The methods runModelOneLine(), runModelLeastCustomers(), and runModelRandomLine() are used to simulate the different models.

The Checkout class sets the simulation duration, customer arrival rate, and number of stations and runs the simulation.

- We followed the use of 5 stations, 7200 seconds (e.g. 2 hours) for total duration, and 30 seconds for customer arrival rate.

Methodology:

- Each model was simulated for a duration of two hours, with a simulated clock ticking for units representing seconds ran.
- A common set of randomly generated customers was used for all models to ensure a fair comparison.
- Performance metrics such as total customers served, remaining customers in line, maximum line length, and average customer waiting time were recorded for each model.

Simulation Results

Model	Customers Served	Line 1 Length	Line 2 Length	Line 3 Length	Line 4 Length	Line 5 Length	Max Queue Length	Avg Customer Wait Time
Model 1	229	0	0	0	0	0	12	2 min 26 sec
Model 2	235	2	1	1	0	1	2	2 min 11 sec
Model 3	220	7	2	6	1	4	13	7 min 18 sec

From the results given we have inferred that **Model 2** is the best under these particular parameters, where customers have the option to choose from multiple lines with corresponding checkout stations as it has the fastest average customer wait time, lowest queue length, and

serves the most amount of people in a two hour time frame. It is important to note that although repeated runs of the program yield similar results, Model 1 and 2 tend to fluctuate between each other as the optimal model due to randomness among the various simulations. Further statistical testing could be done such as through bootstrapping, ANOVA, or monte carlo simulations to determine whether or not the difference in average customer wait time is statistically significant between model 1 or 2. It is clear however that models 1 and 2 are superior to model 3 under the conditions of our designed simulation.

Appendix

Program Output:

```
Running CheckoutOneLine:
Model 1: One line for customers, 5 stations
Total elapsed time: 120 min 0 sec
Customers served: 229
Length of line 1: 0
Length of line 2: 0
Length of line 3: 0
Length of line 4: 0
Length of line 5: 0
Maximum queue length: 12
Average customer waiting time: 2 min 26 sec

Running CheckoutLeastCustomers:
Model 2: Least customers per line, 5 stations
Total elapsed time: 120 min 0 sec
Customers served: 235
Length of line 1: 2
Length of line 2: 1
Length of line 3: 1
Length of line 4: 0
Length of line 5: 1
Maximum queue length: 2
Average customer waiting time: 2 min 11 sec

Running CheckoutRandomLine:
Model 3: Random line for customers, 5 stations
Total elapsed time: 120 min 0 sec
Customers served: 220
Length of line 1: 7
Length of line 2: 2
Length of line 3: 6
Length of line 4: 1
Length of line 5: 4
Maximum queue length: 13
Average customer waiting time: 7 min 18 sec
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