***MODELLING AND SIMULATIONS***

***PROJECT 3950***

***GROCERY STORE - QUEUING MODEL***

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# Introduction

On entering any grocery store one is sure to see at least one line. At peak operating hours, one is guaranteed to observe a line at each available cashier. At Massy Stores, St. Augustine six (6) cashiers were observed, five (5) regular cashiers and the express lane.

# Objective

The project seeks to analyse a grocery’s queuing system, create a simulation and recommend applicable improvements

# Methodology

The following data was recorded for each customer in each line at the grocery store:

* Arrival Time – the time at which the customer joined the queue
* Service Start Time – the time at which the cashier started servicing the customer
* Service End Time – the time at which the cashier finished servicing the customer
* Drop Time – the time at which the customer left the queue to join another
* Number of Items –the number of items processed by the cashier for the customer being serviced.
* Payment Method – whether the customer paid via a card, credit or debit, or cash.

While the grocery has multiple lines, each line is served by a single, designated cashier. This gives a ‘multiple single queue with a single server’ scenario. Each queue is considered individually based on its’ observed unique characteristics. The following examination of the queuing process uses values from the first observed queue.

Once a customer has finished browsing and acquired the items they wish to purchase they join a line. The time taken for customers to join the line varies with each pair of customers. However, using the arrival time of consecutive customers it is observed that a customer arrives, on average, every 1.08 minutes. This is the interarrival rate. The arrival rate, lambda , is  , 1 customer per minute.

From this data, a comparison is then made to a simulation generated using Python. This simulation varies the amount of servers that is available to accommodate the customers of the grocery.

The goal of this project, is to identify the ideal amount of express lanes and general lanes for the grocery, Massy Stores.

Given the data captured for each customer, a customer class was created, allowing the devised simulation to access the individual characteristics of each customer.

class Customer:

def \_\_init\_\_(self,arrival\_time,service\_start\_time,service\_time):

                      self.arrival\_time=arrival\_time

                      self.service\_start\_time=service\_start\_time

                      self.service\_time=service\_time

self.service\_end\_time=self.service\_start\_time+self.service\_time

                    self.wait=self.service\_start\_time-self.arrival\_time

Within Customer, wait represents the length of time the customer was in the queue and service\_time represents the time taken for the cashier to complete processing the customer’s goods.

These variables depend on primarily on the customers within the grocery and the cashier. The customer’s select the queue they wish to join, thereby increasing its length. Factors affecting the customer’s selection of a line include:

* Number of items in their cart.
* Number of customers in the queue.
* Number of items in the carts of customer already in the line.
* Perceived service rate of the cashier.

These factors will in turn affect the customer’s wait time and the service rate. It is expected that as the number of items increases the service time will increase, thus decreasing the service rate.

The choice of which line among the available lines for express lane or general lane, in the Python simulation, was done using random uniform distribution. This was because it is assumed that the customer will attempt to go to the line that is the least long. Therefore, over time, the lines will all take around the same length of time no matter the choice. Therefore, a random choice of which line to enter was made for a simpler simulation that is still effective.

# Implementation

A comparative approach was taken when assessing the grocery’s system. A Simulation was created of the observed grocery and compared to a created grocery. Assuming customers arrived at the queues exponentially, the following are used to compare the operations of the cashiers:

* Number of Customers Serviced
* Mean Service Time
* Mean Wait Time
* Mean Time in the System
* Utilization
* Length of the Queue

The average of the above criteria for all lanes, excluding the express lane, which is done separately, is obtained and the compared to the modelled grocery.

The associated costs are calculated using the Utilization and the Length of the Queue. The two costs considered are:

1. The cost of an idle cashier.
2. The cost of waiting for the customer.

Reasoning that a customer isn’t paid to wait, and can lose money by waiting, in the case of persons who use their lunch break to purchase items and exceed the allotted time, the cost of waiting is set higher than the cost of an idle cashier.

# Analysis

MASSY STORES accommodates seventeen (17) cashiers, including the Express Lane, however, seventeen cashiers were not present during the data collection, only six (6). The number of cashiers, along with the associated total cost was simulated and compared to that of the observations.

Using the output, the total cost to the actual grocery $1426.00 is much higher than that obtained in the simulation, $864.56. In both cases the express lane was found to be very costly. The express lane, designated to accommodate faster checkout, can process more customers in a timely manner than the other general lanes. This is reflected in the differences in the Mean Service Time.

# Conclusion/ Recommendation

It was observed that when the cashier had completed servicing a customer, at times, the next customer would be required to wait as the customer or cashier assisted in bagging the customer’s items, to make space available for the next customer’s items. This can be avoided by introducing a bagging wheel. This allows the attendant, or cashier where there is no attendant, to place the scanned items into bags before the service is completed.

To increase the efficiency of the servers in the grocery, two things must be considered. These two things are; the speed of the cashiers and the number of cashiers. For this project, it was assumed that quality cashiers were hired, where their performance cannot be improved. Our own judgement proved that they were quite efficient in cashing. Therefore, to improve the performance and reduce the waiting time of the customer, the number of express lanes and general lanes needed were simulated.

From this, we came to the conclusion, that the number of servers currently utilized in Massy Stores is ineffective to address the arrival rate of the customers. We believe Massy Stores should reduce/increase the number of servers/cashiers available for general/express lanes.