CUSTOMER QUEUING TIME IN RETAIL STORES: A CASE STUDY IN SM HYPERMARKET - SMDC JAZZ MALL

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Modeling and Simulation Theory (CSS142L)

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I. INTRODUCTION

a.) Background of the Study

Grocery stores are busy places where customers go through aisles stocked with various items, ranging from fresh products to household essentials. The process of these stores depends not just on having products available and priced competitively but also on efficiently managing customer queues. How queues are handled in grocery stores is essential for securing customer satisfaction and effectiveness.

Effective management of queues is vital because inefficient systems can result in long waiting times, leading to customer dissatisfaction. When lines move slowly or are disorganized, customers may feel their time is being wasted. Additionally, long queues discourage potential shoppers from entering the store, impacting the store's revenue and reputation.

From a processing perspective, inefficient queue systems can strain staffing resources. Employees may have to shift their focus from other important tasks to manage queues manually or handle customer complaints about delays. This can disrupt overall store processes and reduce staff productivity.

Therefore, optimizing queue systems in grocery stores is not just about reducing wait times but also about improving customer satisfaction and processing efficiency and eventually making a positive shopping experience that encourages customers to return and build loyalty.

b.) Objective of the Study

This study aims to enhance the efficiency of queue processing in grocery stores, reducing wait times and improving overall customer satisfaction.

c.) Scope of the Study

The scope of this study is limited to analyzing and simulating queuing dynamics at two specific grocery stores: Jazz Hypermarket and Shopwise. The focus will be on queue management at these stores during peak hours, precisely at 3 PM, from Sunday to Saturday. The study will assess the current queuing systems and propose potential improvements tailored to these specific conditions and locations.

d.) Significance of the Study

This study is important because it aims to tackle the critical issue of queue efficiency in grocery stores. The study aims to improve customer satisfaction, simplify operations, use staff resources more effectively, and ultimately create a better shopping experience by improving how queues are managed. This research is relevant now, focusing on improving service quality and competitiveness within the retail industry.

II. RELATED LITERATURE

2.1 Queueing model analysis of shopping malls in the COVID-19 pandemic era: a case study

Various studies have analyzed models and provided recommendations based on the specific circumstances of a grocery store. During the COVID-19 pandemic in Baghdad, Iraq, Aymen et al. proved that 10 unrestricted nodes within a network acting as the serving stations in a grocery store are proven effective in controlling the customer queue's traffic intensity. Furthermore, the created model yields significantly less average queue time than the service time for each customer, proving that the model effectively minimizes customer waiting times irrespective of the service times [1]. While this specific network of service stations might be effective, it is not guaranteed to yield its performance after the COVID-19 pandemic.

2.2 Application of Queuing Theory Analysis on GB Supermarket

Additionally, a study conducted by Rahaman et al. at the Grocery Bazaar (GB) supermarket at Akesan Lasu Igando, Lagos State, Nigeria analyzed the performance of the three servers assigned to the said store. Single Queueing Model (M/M/1) performed using variables such as Arrival Rate, Service Rate, Traffic Intensity, Average Time in the System, Average Time each Customer wait in the queue, Average Number of Customers waiting, Number of Customers in the System, Expected Average Total Time, Expected Number to be Served. On the other hand, Multi-Channel Queueing System (M/M/C) is performed using variables such as Service Rate, Traffic Intensity, Probability of having zero Customer in the System, Average expected Queue

Length, Average Number of Customers in the System, Expected Total Time, Waiting Time, Expected Number of Customers in the Queue, Probability of Queuing on the Arrival and Probability of not Queuing on the Arrival. The dataset is tested to inspect whether it follows a Poisson and exponential distribution [2]. The results indicated an optimized state of customer queuing due to its statistical validity, making the queueing model effective at any time on any day.

2.3 Bi-objective optimization of a queueing model with two-phase heterogeneous service

In the modern world, more technological advancements surfaced as a solution for the possible logistic limitations of the traditional cashier-customer model. As a solution, self-checkout systems are now being utilized in developed countries as they encounter more inventive technologies, making them more acclimatized to them [3]. The study, conducted at the follows an M/M/(1+c) queueing system with a two-phase heterogenous service system. The data for each customer follows a Poisson process to simulate the arrival of customers. Consequently, the queueing system is analyzed in a steady state and measures are gathered to assess the data. The researchers evaluated the results with a single-objective problem of minimizing cost function per unit time and applying a canonical particle swarm optimization algorithm to assess the data further. The study also utilized a bi-objective optimization model to formulate each customer's expected cost problem and waiting time [4]. The study aims to create a system that balances both operational costs and customer service quality to create a more productive grocery queueing system.

2.4 Society 5.0: a simulation optimization study of dynamic scheduling for a grocery store

Large-scale society-wide innovations are also proposed to improve queue times within grocery stores. Society 5.0 is a technology-based, human-centered society that utilizes cyber-physical systems and advanced technologies to enhance the quality of life. To leverage an enterprise's cost-effectiveness and customer satisfaction, dynamic scheduling is used to assess the required number of resources so that newly arrived customers' queue times are improved in real-time while keeping the resource and functional costs relatively low. The study, utilizing simulation tools such as Simio for simulation and OptQuest for assessing the required resources, concluded that dynamic scheduling effectively retains high customer satisfaction while keeping low resource costs for the benefit of the enterprise [5].

2.5 Making the Wait Worthwhile: Experiments on the Effect of Queueing on Consumption

Queueing times in grocery stores have a direct impact on product consumption. According to Ulku et. al (2019), longer waiting times increase customer consumption. This is due to the customers' behavior of weighing 'sunk costs' where the cost of time wasted waiting in a queue is the consumption of more goods. The study further emphasized that customers consume more to compensate for longer wait times. Furthermore, managerial initiatives to reduce customer wait times to improve customer satisfaction are also analyzed. The study discovered that wait times, while successfully alleviated by the given initiatives, reduce customer consumption [Link for the same research]. In conclusion, enterprises must recognize the inverse proportion of customer wait times and consumption to generate sustainable profit for the company while mediating customer satisfaction.

2.6 Queuing models with customers' impatience: a survey

Outside of the queueing system itself, various studies also consider the customer's reviews and grievances with an existing system. A study conducted by Sapana et al. (2023) took into account the queueing models and systems and the respective grievances that each of them yield among the customers. First, the queueing systems are emphasized in sequential order based on their respective customer impatience. Second, various queueing models are classified with customer's impatience. The information about specific features of the systems in mind is also illustrated in a tabular manner [5] to clarify the specific customer impatience with each queueing system. The study concluded that queueing models such as Single-Server, Single-Queue (M/M/1), Multiple-Server, Multiple-Queue (M/M/c), and Multiple-Server, Single-Queue yield their own customer grievances and impatience, highlighting the benefits and disadvantages of each model depending on the business requirements of an enterprise.

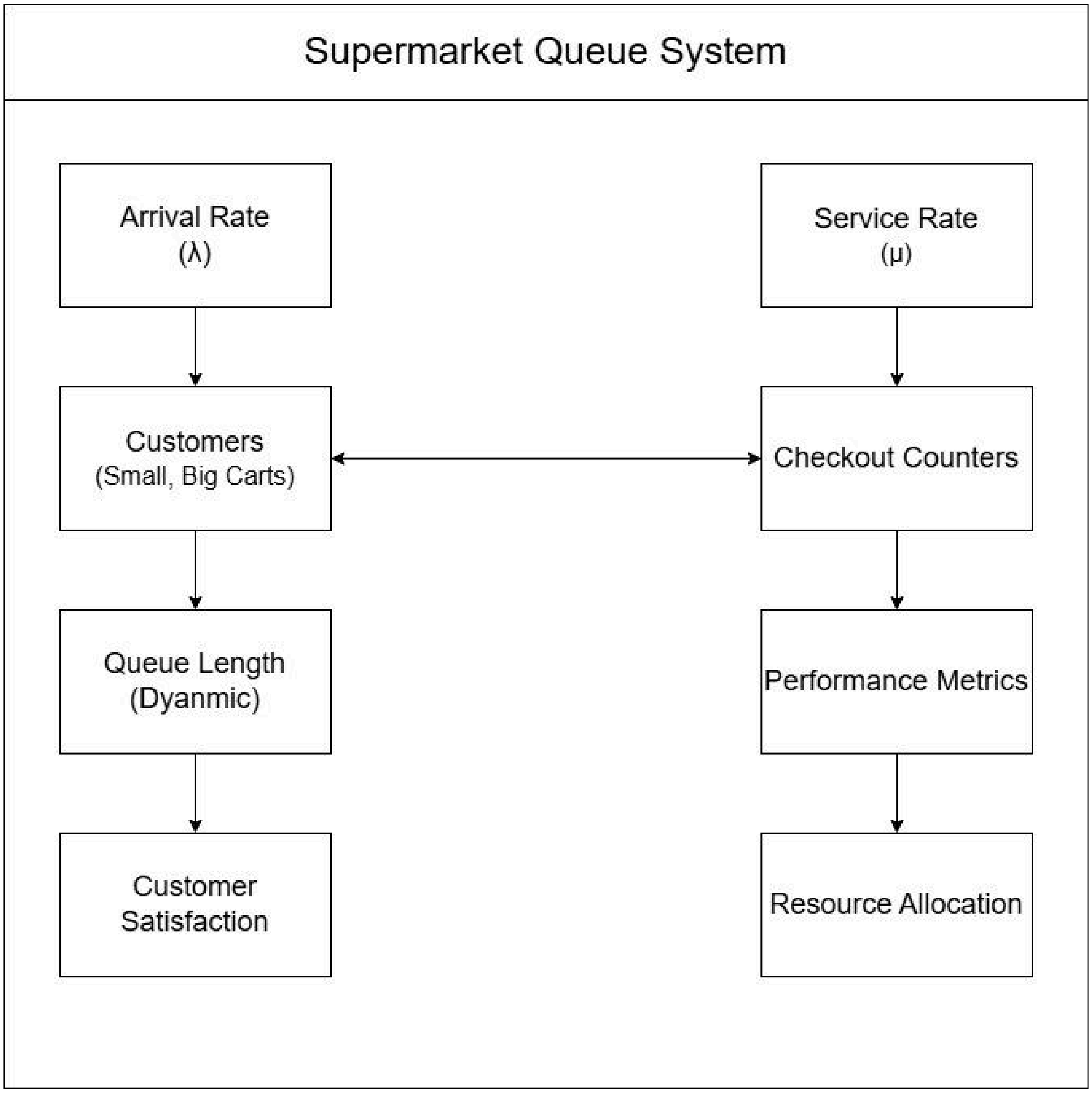
2.7 Breathing Down Your Neck!: The Impact of Queues on Customers Using a Retail Service

As a result of queueing grievances, the psychological impact also takes its toll on the people who use the retail service. Dahm et al. (2018) argue that significant queue times influence people's perception of retail service, making the phenomenon apply the social impact theory. Various social experiments are conducted to prove the existence of this phenomenon, and a proposal of solutions will be recommended. The study concluded that longer waiting times worsen the customer experience due to longer waiting times and the social pressure of the people being served at hand. The customer distress from the people at the queue is directly mediated by the social pressure that the customer at hand feels. In conclusion, various measures such as customer reassurance must be implemented to make the customer at hand feel less pressure to finish at an earlier time. Additionally, realigning the queue line to reduce the line of sight from the customer being served to the people waiting in the queue can alleviate their feelings of social pressure [6].

III. METHODOLOGY

3.1 Conceptual Framework

The diagram hypothesizes the relationships between different variables to be measured in data gathering. The variables are Arrival Rate, Service Rate, Customers, Service Counters, Queue Length, Performance Metrics, Customer Satisfaction, and Resource Allocation. Each lines signify a relationship between two variables - the variable within the origin of the line is a direct cause of the variable within the other end of the line.



1. Arrival Rate - represents the rate at which customers arrive at the grocery story. It dictates the number of customers inside the grocery store.
2. Service Rate - represents the rate at which servers finish serving each customer. It influences how quickly each customer is processed in the queue.
3. Customers - the customers and whether they hold small or big carts.
4. Service Counters - the points within the grocery store where customers can be readily served.
5. Queue Length - the concurrent length of the queue for each arriving customers. It is directly influenced by both the Arrival and Service Rates.

6. Performance Metrics - includes Average Waiting Time (AWT) and Average Turnaround Time (ATT), indicating the performance of the resulting queueing system.
7. Customer Satisfaction - directly influenced by the waiting time and service quality.
8. Resource Allocation - tradeoff of the number of service counters are available resources to balance customer satisfaction with resource availability.

3.2 Data Gathering

The researchers gathered six different data for each customer. Specifically, data is gathered for variables such as Arrival Time, Service Time through Service Start and End times, Wait Time, Service Time in minutes. Additionally, Queue Types of either Green or Big Carts are classified for each customer. The given data are observed and recorded in real-time inside the SM Jazz Hypermarket for 11 days straight starting from June 26, 2024 to maximize the data's scope. In the given days, the data is recorded from 1pm to 5pm as according to _____, it is the time range where most customers shop in grocery stores.

3.3 Set-up

In the event of data gathering, the researchers are positioned inside the SM Jazz Hypermarket to take note of customer arrival times. Each incoming customer's arrival time is recorded manually as soon as they enter the entrance door of the grocery. Their arrival times are recorded based on the time on a stopwatch.

Afterwards, wait times of the customers are recorded on a stopwatch as soon as they finished shopping and decided to go to the designated counters. In the event of being served by the cashier, their wait times finish and are recorded immediately. Consequently, the recording of their service times is initiated. The duration of the start and end of the cashier service based on the stopwatch recording will serve as their service time. At this point, it is visible from the researcher's point of view whether they are holding a green cart or big cart. This data is recorded on the 'Queue Type' variable.

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Different tools are utilized to measure and record in the data gathering. Stopwatch is used to take note of customer arrival times and their service start and end times. Additional two researchers utilized a laptop and notepad to make use of two different records in order to compare different values, making the gathered data as reliable as possible.

3.4 Rules in Data Gathering

Various rules are established to ensure consistency and reliability of the gathered data. For gathering times in the data, a standard of recording in the form of MM:SS is decided to ensure ease of recording and analysis. Additionally, for the computation of times based on recorded variables, the resultant must be in the decimal form of minutes. As an example,

$$Wait\ Time = Service\ End\ Time - Service\ Start\ Time$$

$$Wait\ Time = 15{:}43 - 12{:}32 = 3{:}11 = 3.1833\ minutes$$

This standard ensures that the time is uniformly recorded. It also ensures to create a standard in computation while also preventing confusion and possible errors for future data storage, mining, and analysis.

For the duration of data gathering, it is maintained that the data must be gathered consistently on the timeframe of 11 days and the hours 1 to 5pm to prevent unforeseen data biases. Furthermore, different shorthand notations are utilized to streamline data gathering. In the ‘Queue Type’ variable, ‘G’ served as the shorthand for Green Cart. On the other hand, ‘B’ served as the shorthand for Big Cart.

Rules are also established for the devices to be used in data gathering. Different stopwatches are utilized for each spot of the checkout counters to be able to record more than one customer at a time. Having multiple stopwatches gave the researchers an initiative for the possibility of malfunctioning devices.

3.5 Data Cleansing

IV. RESULTS AND DISCUSSION

Results

The study analyzes the impact of optimization on s service metrics, including Average Turnaround Time (ATAT), Average Waiting Time (AWT), customer arrival patterns, and service times by queue type. The results are illustrated through a series of bar plots and histograms that compare the performance of optimized and unoptimized systems.

Average Turnaround Time:

The bar plot *Figure 1.1* shows a clear distinction between the optimized and unoptimized systems. The *Optimized* system recorded an average turnaround time of approximately 11 minutes, whereas the *Unoptimized* system had a significantly higher average turnaround time of around 21 minutes. This stark contrast highlights the impact of optimization strategies on the efficiency of service delivery.

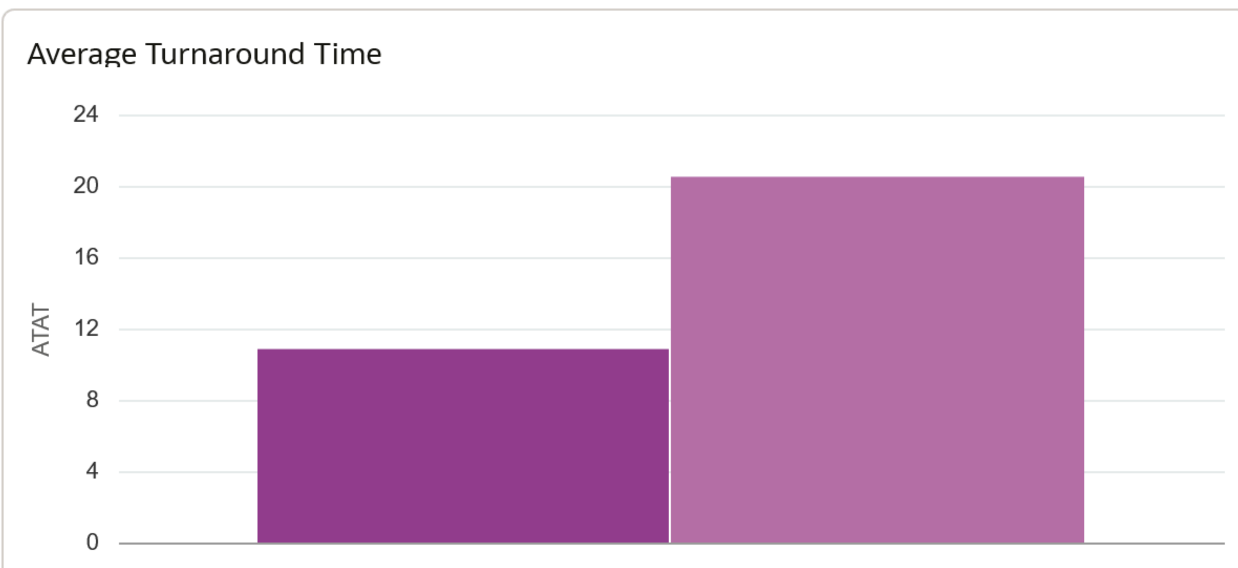

Figure 1.1 *Average Turnaround Time for Optimized and Unoptimized*

Average Waiting Time:

The bar plot *Figure 1.2* presents the average waiting times under both conditions. The *Optimized*" system recorded a significantly lower AWT of approximately 1.5

minutes, while the *Unoptimized* system exhibited a much higher AWT of around 10 minutes. This substantial reduction in waiting time in the optimized scenario highlights the effectiveness of the optimization strategies implemented.

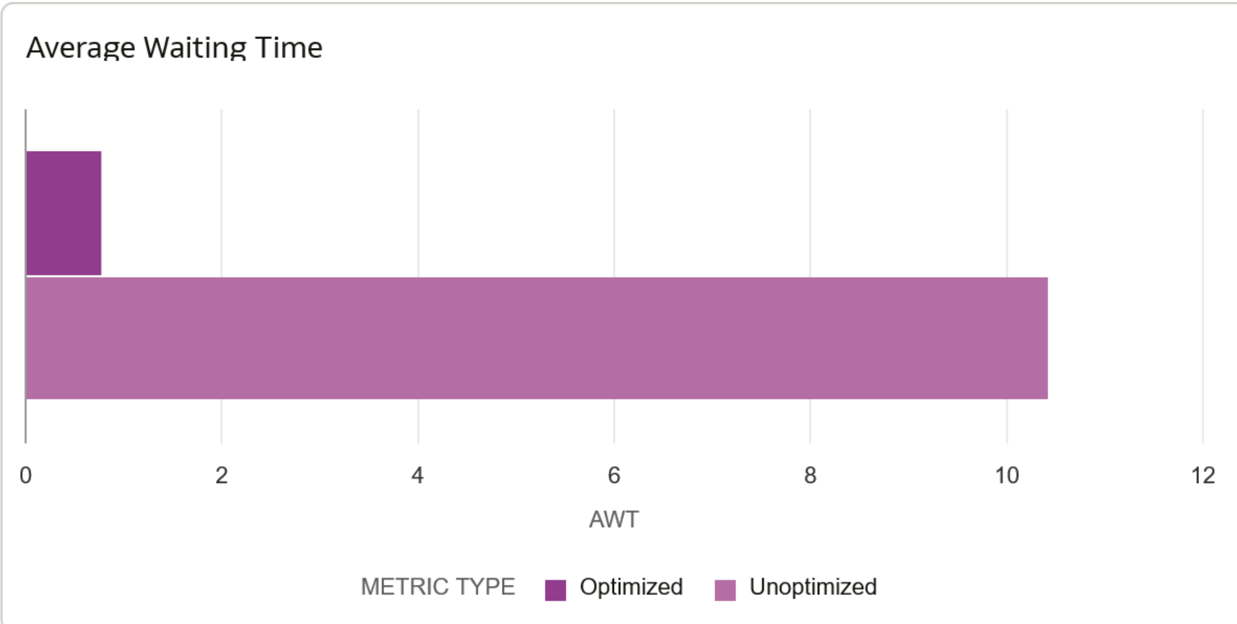

Figure 1.2 *Average Waiting Time for Optimized and Unoptimized*

Customer Arrival:

The histogram in Figure 1.3 shows the customer arrival classified under the date and time. As shown in the figure, the store's busy hours are between 1:00 PM and 3:00 PM, regardless of the day.

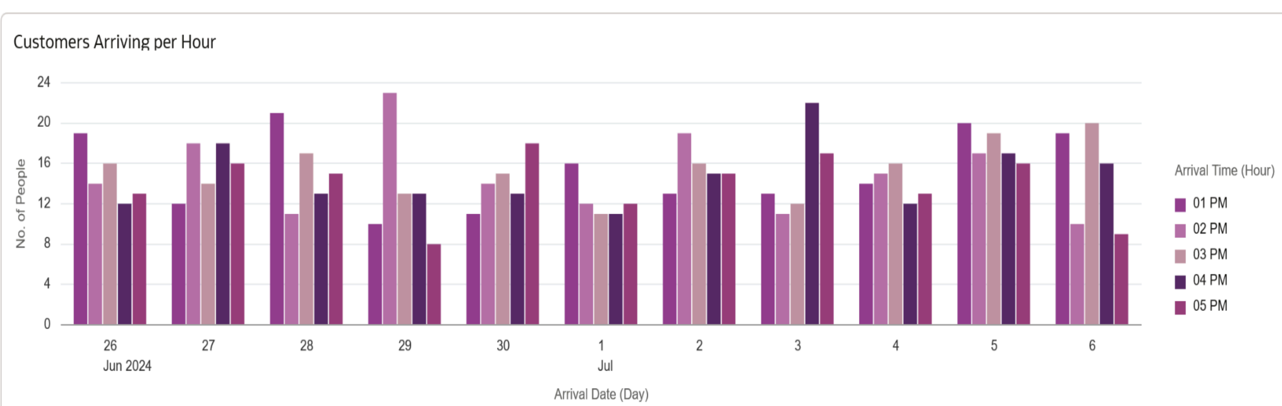

Figure 1.3 *Number of Customers Arriving Per Hour Over a Span of Several Days*

Average Turnaround Time by Queue Type:

Figure 1.4 provides insights into the Average Turnaround Time (ATAT) for different queue types, categorized into *Green Cart* and *Big Cart*. Both queue types exhibit a reduction in ATAT under optimized conditions compared to unoptimized ones. Specifically, the *Green Cart* queue shows an ATAT reduction from approximately 24 units in the unoptimized state to around 12 units in the optimized state. The *Big Cart* queue also shows a similar trend, indicating that optimization efforts are effective across different queue types.

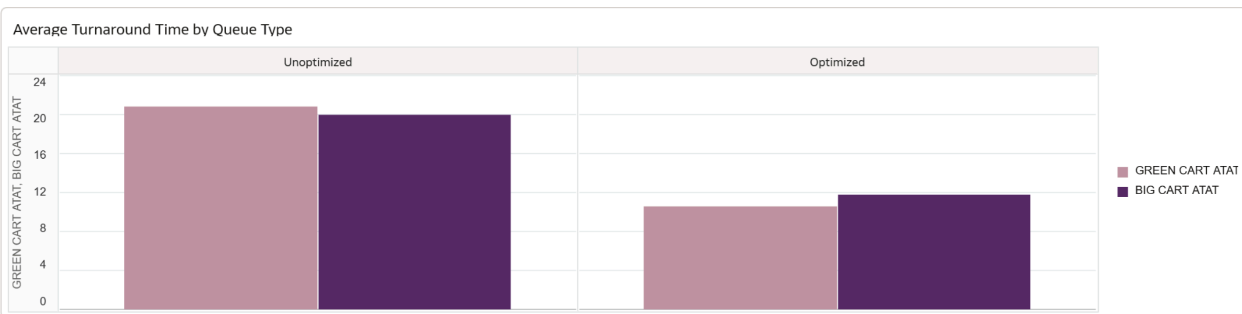

Figure 1.4 *Average Turnaround Time by Queue Type for Different Queue Types*

Average Waiting Time by Queue Type:

Figure 1.5 displays the Average Waiting Time (AWT) for different queue types under both unoptimized and optimized conditions. The unoptimized state shows significantly higher AWT for both *Green Cart* and *Big Cart* queues, with values around 10 units and 11 units, respectively. However, under optimized conditions, the AWT drops substantially, indicating improved efficiency and customer experience.

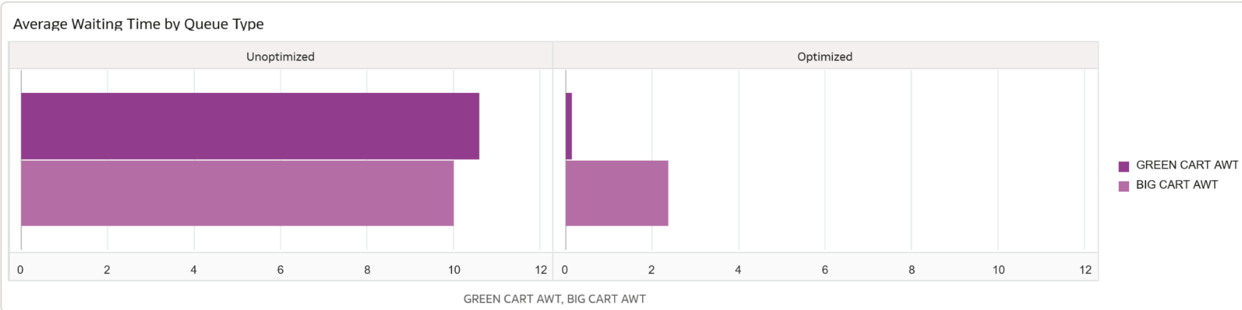

Figure 1.5 *Average Waiting Time for different Queue Types*

Service Time by Queue Type:

The graph illustrates service times for *Big Cart* and *Green Cart* queues between June 26th and July 6th, 2024. *Big Cart* consistently requires longer service times compared to *Green Cart*. Both queues experienced fluctuations in service times during the period, with peaks around June 27th and July 4th. Interestingly, service times for both queues converged towards the end of the period, with a slight decrease on July 6th. The reasons for these fluctuations are unclear without additional context, but potential factors include staffing levels, customer volume, or system efficiency.

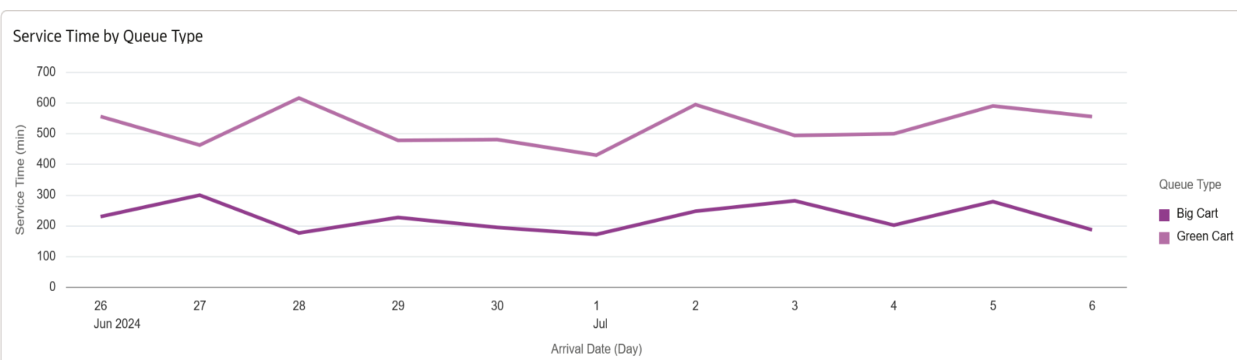

Figure 1.6 *Service Time of Cart A and Cart B*

Discussion

Summary of Findings

The analysis of queue dynamics at SM Jazz Hypermarket demonstrates the significant impact of optimization strategies on service efficiency. The key metrics of Average Turnaround Time (ATAT), Average Waiting Time (AWT), and Service Time reveal noticeable improvements under optimized conditions compared to unoptimized ones.

- **Average Turnaround Time (ATAT):** The optimized system significantly reduces ATAT across different queue types, particularly for Green Cart and Big Cart queues. This reduction suggests that the optimization strategies effectively streamline the overall service process, minimizing the time customers spend from arrival to service completion.
- **Average Waiting Time (AWT):** The optimized state substantially lowers AWT, indicating enhanced queue management and quicker customer service initiation. This improvement is critical in reducing customer frustration and enhancing their shopping experience.
- **Service Time:** Despite fluctuations in service times for both Green Cart and Big Cart queues, the overall trend shows convergence towards the end of the observation period. This convergence suggests that optimization efforts stabilize service times, leading to a more predictable and efficient checkout process.

Interpretation of Results

The fluctuations in service times observed in the study could be attributed to various factors such as changes in staffing levels, variations in customer volume, or differences in the efficiency of the checkout process. These factors need further investigation to understand their specific impacts on service efficiency.

Implications for Retail Management

The results of this study have several practical implications for retail management:

1. **Enhanced Customer Satisfaction:** By significantly reducing waiting times, optimized queue management systems can lead to higher customer satisfaction. Satisfied customers are more likely to return, thus increasing customer loyalty and potentially boosting store revenue.
2. **Operational Efficiency:** Streamlined queue management reduces the burden on staff, allowing them to focus on other critical tasks. This can enhance overall store productivity and operational efficiency.
3. **Data-Driven Decision Making:** The insights gained from this study can inform future decisions on staffing, resource allocation, and process improvements. Retail managers can use these findings to optimize their operations further and maintain a competitive edge in the market.

Limitations and Future Research

While the study provides valuable insights, it also has some limitations:

- **Limited Scope:** The study focuses on a specific period and set of conditions at SM Jazz Hypermarket. Future research could expand the scope to include different time periods, other stores, and varying customer demographics to generalize the findings.
- **External Factors:** The study does not account for external factors such as seasonal variations, promotional events, or economic conditions that could impact customer

behavior and queue dynamics. Including these factors in future studies could provide a more comprehensive understanding of queue management.

- **Technological Integration:** Future research could explore the integration of advanced technologies such as AI-driven queue management systems and self-checkout solutions to further enhance service efficiency and customer experience.

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