International Journal of Eco-Innovation in Science and Engineering (IJEISE) Vol. 05 (1), 2024 (23-27)
https://ijeise.upnjatim.ac.id/ E-ISSN: 2721-8775

Article

Analysis of The Queue System in Self-Service Using The "ABC Supermarket" Queue Method

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Received: 30th April 2024; Revised: 27th May 2024; Accepted: 30th May 2024;
Available online: 30th May 2024; Published regularly: May and November

Abstract

A queuing system is a mathematical model used to analyze the phenomenon where entities wait to receive services from one or more service providers. In this system, arriving entities will queue if the service is not immediately available and will be served according to a specific order or priority when the service becomes available. ABC Supermarket is a store that is always busy with customers. Besides having low prices, ABC Supermarket also provides daily necessities. The purpose of this research is to determine whether the cashier queue system implemented at ABC Supermarket is effective or not. This research uses the queue system method. This research concludes that the queue system at ABC Supermarket with 6 cashiers has an average ρ value percentage of 41.67%, which falls into the ineffective category. The most effective number of cashiers is 3, with an average ρ value percentage of 83.33%, which falls into the effective category. The purpose of queuing system analysis is to optimize the performance of the queuing process by determining the optimal number of service providers required.

Keywords: Queue System, Optimization, FCFS, payment cashier.

1. Introduction

A queue is a waiting line for customers (units) who require services from one or more services (service facilities) [1];[2]. The mathematical study of waiting line events or phenomena is called queuing theory [3]. Waiting line incidents are caused by service needs exceeding the service capability (capacity) or service facilities, so customers who arrive cannot immediately get service, due to busy service activities [4].

The best service includes providing fast service so that customers are not left waiting for a long time [5];[6]. Ensuring prompt service demonstrates respect for the customer's time, enhances their overall experience, and can lead to increased satisfaction and loyalty. By minimizing wait times, businesses can show efficiency and care, creating a positive impression that encourages repeat patronage and positive word-of-mouth recommendations. The service here can take the form of improving the queuing system because in the many cases customers face, many complain about the long waiting time before processing their transactions [7];[8]. If long queues often arise, it will result in customer disappointment, and the level of trust in the service will decrease. Customers expect efficient and timely service, and prolonged wait times can lead to frustration and dissatisfaction. This negative experience can erode their confidence in the service provider, potentially driving them to

DOI:10.4186

seek alternatives. Consistently managing and minimizing wait times is crucial for maintaining customer trust and ensuring a positive reputation. Absolutely, efficiently managing and minimizing wait times is essential for preserving customer satisfaction and fostering a positive reputation. Long queues can lead to frustration and dissatisfaction among customers, potentially resulting in lost business and damage to the supermarket's reputation. Implementing strategies such as optimizing staffing levels, streamlining checkout processes, and utilizing technology like self-checkout systems can help minimize wait times and enhance the overall shopping experience for customers. Optimizing staffing levels ensures that there are enough employees available to assist customers efficiently during peak hours, reducing wait times. Streamlining checkout processes involves simplifying and speeding up the payment process, perhaps by using barcode scanners or contactless payment options. Additionally, implementing self-checkout systems allows customers to bypass traditional checkout lines, further reducing wait times and providing convenience. These strategies collectively enhance the overall shopping experience, leading to increased customer satisfaction and loyalty. Satisfied customers are more likely to return for future purchases and recommend the supermarket to others, fostering loyalty and driving business growth. Thus, focusing on enhancing the overall shopping experience can have a significant positive impact on customer satisfaction and loyalty.

A supermarket is a shopping center that provides daily necessities, especially food and drinks. One of the supermarkets that provides consumer materials to meet their daily needs is ABC Supermarket. The marketing activities carried out by ABC Supermarket are by providing various types of products from the company (as producer). ABC Supermarket has 6 cashiers which are open during peak hours or when consumers queue too long to get service. The large number of visitors at certain hours results in queues so that customers need time to wait until they are served and also the length of waiting time is influenced by the number of goods purchased by consumers. The high volume of visitors during peak hours leads to queues, causing customers to wait before being served. Additionally, the waiting time is affected by the number of items each customer purchases.

2. Material and Method

The research method used is a Queuing service method. Queuing system method is the mathematical study of waiting lines, or queues. It is used to model systems in which customers (which can be people, objects, or information) arrive at a service point, wait for service if it is not immediately available, and leave the system after being served. Queuing system method can be applied in various fields such as telecommunications, traffic engineering, computing, and business operations. In the service process to serve consumers, ABC Supermarket uses a multiple line queuing model, meaning there is more than one cashier and there is only one service stage that the customer must go through to complete the payment. The time required by customers is random, because the amount needed by each customer is different. The time required for each customer can indeed vary due to factors such as the number of items they need to purchase, the complexity of their shopping list, and individual shopping habits. This variability makes managing wait times more challenging but underscores the importance of implementing efficient strategies to minimize overall wait times and enhance the shopping experience for all customers, regardless of their individual needs. ABC Supermarket implements a first-come, first-served (FCFS) where customers who come first will be served first [9];[10];[11]. The First-Come, First-Served (FCFS) approach ensures that customers are served in the order they arrive, promoting fairness and predictability [12];[13];[14];[15]. By adhering to the principle that those who arrive first receive service first, businesses can manage customer expectations and reduce frustration. FCFS can help streamline operations, but it is crucial to manage it effectively to prevent long wait times and ensure that resources are allocated efficiently to meet customer demand [16];[17];[18]. By managing FCFS effectively and incorporating these strategies, organizations can improve their operational efficiency, reduce wait times, and ensure a more balanced allocation of resources to meet customer demand effectively [19];[20];[21]. The data obtained is the result of an interview with

DOI:10.4186

one of ABC Supermarket's employees. The purpose of this research is to determine the appropriate queuing system in order to optimize the number of cashiers at ABC supermarket.

3. Results and Discussion

ABC Supermarket employs 6 cashiers. The store operates from 8:00 AM to 8:00 PM (12 hours). During its operating hours, the store can serve 360 customers. On average, it takes a cashier 5 minutes to serve one customer.

3.1. Queue Analysis

Average arrival rate:
(λ) = 360 / 12 = 30 people/hour

Average service rate:
(μ) = 60 / 5 = 12 people/hour

Employee utilization rate:

$$P = \frac{\lambda}{s.\mu} = \frac{30}{6\,.12} = 0{,}4167$$

Average number of customers waiting to be served:

$$Po = \frac{1}{\left(\frac{\lambda:\mu}{n!}\right)n + \frac{\lambda:\mu}{s!\left(1-(\lambda:s\mu)\right)}}$$

$$= \frac{1}{1+\frac{(30:12)^1}{1!}+\frac{(30:12)^2}{2!}+\frac{(30:12)^3}{3!}+\frac{(30:12)^4}{4!}+\frac{(30:12)^5}{5!}+\frac{(30:12)^6}{6!\,(1-30:72)}}$$

$$= \frac{1}{12{,}2518} = 0{,}0816$$

Average queue length:

$$Lq = \frac{Po\left(\frac{\lambda}{\mu}\right)^6\left(\frac{\lambda}{\mu}\right)p}{s!\,(1-p)^2}$$

$$= \frac{(0{,}0816)(\frac{30}{12})^6(\frac{30}{12})}{6!\,(1-0{,}4167)^2}$$

$$= \frac{8{,}3014}{24{,}4944}$$

$$= 0{,}3389$$

Average number of customers in the system

$$L = Lq + \frac{\lambda}{\mu} = 0{,}3389 + 2{,}5 = 2{,}8389$$

Waiting time in the queue:

$$Wq = \frac{Lq}{\lambda} = \frac{0{,}3389}{30}$$
$$= 0{,}1129\ Hours$$
$$= 6{,}774\ minutes$$

Waiting time in the system:

$$W = Wq + \frac{1}{\mu}$$
$$= 0{,}1129 + 0{,}0833$$
$$= 0{,}1962\ hours = 11{,}772\ minutes$$

Probability of waiting:

$$P(w) = \frac{\lambda}{\mu}s\frac{Po}{s!\left(1-\left(\frac{\lambda}{\mu}\right)\right)}$$
$$= (2{,}4)\frac{0{,}0816}{6!\,(419{,}976)}$$
$$= 0{,}0474$$

The data indicates that the queue performance at ABC Supermarket shows that the Probability of an empty system or having no customers (Po) is approximately 8.16%, the time spent by customers in the queue (Ws) is around 11.772 minutes, the time customers spend waiting in the queue (Wq) is about 6.774 minutes, the number of customers waiting in the queue (Lq) is approximately 0.3389 customers, with the number of customers in the system (Ls) around 2-3 customers. The cashier utilization rate (ρ) is around 41.76%. The value of ρ is used as a reference in evaluating the effectiveness of cashier utilization. The average percentage of ρ value using 6 cashiers is around 41.76%. It appears that the use of 6 cashiers at ABC Supermarket is ineffective. Based on the queue performance calculations using 6 cashiers, the average service utilization rate (ρ) is 41.76%, which falls into the ineffective category. Analysis from this research indicates that the most effective number of cashiers is 3. If the supermarket desires to utilize the most effective number of cashiers, then employing 3 cashiers is optimal.

The characteristics of ABC Supermarket are the arrival at ABC Supermarket is independent, not influenced by previous or subsequent arrivals, in other words, arrivals are random. Service at ABC Supermarket is conducted by more than one cashier, and each cashier has one service channel. Typically, each cashier serves one customer before serving the next customer. This also follows a random arrival pattern. The system at ABC Supermarket does not have a limit on the number of customers that can be served, so its cashier service capacity is unlimited. The queue discipline implemented at

ABC Supermarket is the first come first served (FCFS) rule, meaning customers who arrive first will be served first.

4. Conclusions

The queue system performance at ABC Supermarket with 6 cashiers has an average service utilization rate (ϱ) of 41.76%, falling into the ineffective category. The most effective number of cashiers is 3, with an average ϱ value of 83.33%, considering the addition of employees serving within the cashier.

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