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Analysis and Simulation of a Queueing System in a Self-Service Seblak MSME using the FIFO Model

Hayati[1], Dio Ananda[2*]

[1,2]*Universitas Islam Negeri Sumatera Utara, Medan, Indonesia*
Hayati0701233155@uinsu.ac.id [1], dioanandaananda651@gmail.com [2]*

Abstract

Micro, Small, and Medium Enterprises (MSME) Seblak Buffet often experience long queues and inefficient waiting times, especially during peak hours, which negatively impact customer comfort and service quality. This study aims to analyze and analyze the business's queue system using the FIFO (First In First Out) model to improve service efficiency and fairness. Using a quantitative approach with M/M/1 modeling, on arrival times and following exponential distribution service, data were obtained from direct observation. The simulation results show that although FIFO maintains order, waiting times increase significantly during peak hours due to limited facilities. Therefore, this study recommends adding waiters or rearranging service flows during peak hours as an applicable solution to improve quality and customer satisfaction.

Keywords: *Queue system, FIFO, Modeling and simulation, Culinary MSME, M/M/1 model*

1. Introduction

Micro, Small, and Medium Enterprises (MSMEs) often experience a high rate of customer arrivals during business transactions [1], thus requiring an effective and efficient service system to provide comfort and maintain a good customer rating [2]. One real-life example of an MSME is a self-service seblak business, which often faces queue service conditions that are far from efficient, especially during peak hours. Customers have to wait too long before receiving service, making the transaction process ineffective and potentially causing discomfort. This problem indicates that the current service process is still not optimal in managing the queue flow properly. In this situation, several problems arise not only from the customers' side but also from the seller's side, such as queue accumulation, long waiting times, and customers who arrive earlier not always finishing their transactions faster than those who arrive later [3]. This not only disrupts operational smoothness but can also reduce customers' interest in returning for future transactions [4]. Therefore, an in-depth analysis is needed to evaluate the queue system currently implemented, so that inefficiencies can be identified and appropriate solutions can be determined. By finding solutions through the analysis, customer satisfaction and service convenience can be improved, while the seller's service process can become better and more structured [5]. Through modeling and simulation, queue conditions have become one of the methods widely used to analyze and improve service performance in various sectors [6], including culinary services, because they can provide an overview of the real conditions of a system without requiring direct changes to ongoing operations. Basically, a queue system processes interactions between customers arriving to obtain service and the available service facilities, using indicators such as queue length, waiting time, arrival rate, and service rate to assess system efficiency [7]. Therefore, in creating a more efficient queue system and providing a comfortable experience and good customer ratings, there is a service system model called FIFO (First In First Out) [8], which emphasizes that customers who arrive earlier will be served first. Its implementation is considered capable of creating a fairer system and reducing potential conflicts in service order. The FIFO model is also often used in MSME service simulations because of its simple structure and ease of implementation in real-world conditions [9]. This approach allows managers to identify bottlenecks, test alternative numbers of service staff, and evaluate the capacity of the existing system. Thus, queue modeling and simulation function not only as analytical tools but also as decision-making tools to improve efficiency and service quality for customers [10]. Based on this information, this research was conducted to analyze the queue system in the self-service seblak MSME by building and developing a simulation model using the FIFO (First In First Out) approach to evaluate and improve service efficiency. The results of this study are expected to provide recommendations for improving the queue system in order to minimize customer waiting time, reduce queue buildup, and support the improvement of service quality in the culinary MSME.

2. Problem

The self-service seblak MSME faces a major problem in the form of long customer queues and inefficient waiting times, especially during peak hours. The service system is still carried out manually without clear queue management, causing service order inconsistencies, so customers who arrive earlier are not always served first. This condition creates unfairness in service, reduces customer comfort, and has the potential to trigger dissatisfaction and decrease customers' interest in returning. In addition, the limited number of service staff and available service facilities are not proportional to the high customer arrival rate, resulting in suboptimal service system capacity. Until now, the self-service seblak MSME has also not implemented quantitative analysis and simulation of the queue system to evaluate service performance and determine appropriate solutions. Therefore, a structured study of queue system modeling and simulation is needed to identify sources of inefficiency and formulate improvement recommendations in order to enhance service quality and fairness for customers.

3. Method

3.1. Design

In solving the method and simulation described above, the FIFO (First In First Out) method is used, where customers who arrive first will be served first. Based on this method, the research is conducted using a quantitative approach that measures customer waiting times and arrival patterns within a more efficient service system. The study will be carried out using an experimental-simulative approach (queue modeling and simulation). FIFO modeling is applied under M/M/1 conditions, with Poisson arrivals (exponential interarrival times), exponential service times, and one server (service staff) [11].Customer arrivals are assumed to occur randomly based on the empirical distribution obtained from field observations, while service times are analyzed according to the server's ability to serve customers one by one. In this design, it is assumed that there are no customers who cancel the queue (balking) or leave the queue before being served (reneging), except in future model developments. Queue capacity is assumed to be unlimited so that system analysis can be carried out optimally. The main objective of this simulation experiment is to evaluate the performance of the current service system by measuring several indicators such as average waiting time (Wq), average queue length (Lq), server utilization rate (ρ), throughput, and the probability of queue occurrence [12], as well as comparing them with alternative scenarios that have the potential to improve service time efficiency.

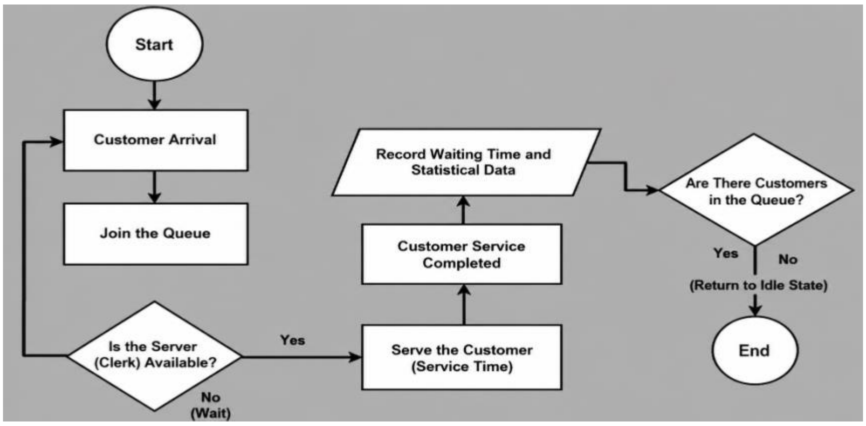

Fig. 1: Service Flow Design of the Seblak MSME

3.2. Algorithm or Systematic Research Steps

a. Field Data Collection

This research uses a quantitative method that produces a modeling system and experimental simulation through direct observation by measuring customer arrival times and customer service times to determine whether the queue system is efficient or not. This preliminary study was conducted to obtain the information needed to develop a system that meets user needs.

1. Observation

The researcher conducted observations at Seblak Sultan Prasmanan, located on Jl. Lapangan Golf. Observations were carried out on various activities related to the buying and selling process, including customer types, customer arrival times, customer service times, and customer completion times. In addition to observing operational activities, the researcher also observed and collected reviews from customers of Seblak Sultan Prasmanan.

2. Interarrival Time and Service Time Calculation Data

Based on the results of direct observations of customer arrival times, customer service times, and service completion times at Seblak Sultan Prasmanan, the following data were obtained:

Table 1: Customer Arrival Time and Service Time

HASIL OBSERVASI						
NO	**Nama**	**Arrival Time**	**Service Start**	**Service End**	**Interarrival time**	**Service Time**
1	Doni	13:20:43	13:23:10	13:45:07	0.00	21.95
2	Via	13:35:02	13:45:12	14:01:21	14.32	16.15
3	Angel	13:45:21	13:50:49	14:15:04	10.32	24.25
4	Kiky	14:20:23	14:23:45	14:45:53	35.03	22.13
5	Sina	14:41:15	14:49:21	14:59:10	20.87	9.82
6	Susi	14:59:21	15:21:12	15:30:03	18.10	8.85
7	Dewi	15:05:13	15:30:21	15:44:21	5.87	13.99
8	Naina	15:15:04	15:45:01	16:01:03	9.85	16.03
9	Edi	15:21:12	15:45:09	16:02:04	6.13	16.92
10	Surtika	15:43:33	16:02:23	16:21:08	22.35	18.75

Based on the data, the processed results are presented in tabular form and visualized through histograms to observe the distribution patterns of customer arrival times and service times, which will be used in the queue system modeling process. The histograms are shown below:

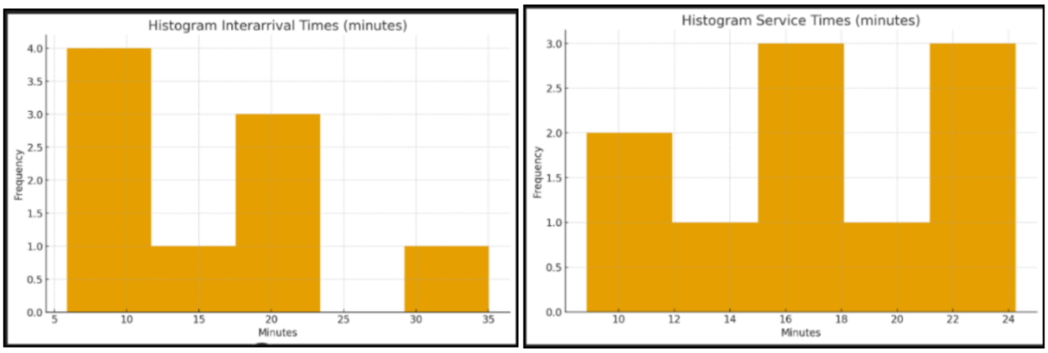

Fig. 2: Histogram interarrival and service times

Based on the histogram results, the interarrival time and service time data follow an exponential distribution, where most of the data are concentrated within shorter time intervals and gradually decrease as the time intervals become longer. Therefore, the queue modeling in this study assumes that both the arrival process and the service process follow an exponential distribution.

b. Design Workshop (Modeling)

After conducting observations and field data calculations, the resulting output began with diagram design for development purposes and continued through to the final database design for the system being developed. At this stage, three main activities were carried out, namely designing use case diagrams based on the needs analysis. For each use case diagram, an activity diagram was created to illustrate the flow of each use case in the system to be developed. Next, a database design was created using an Entity Relationship Diagram (ERD). Finally, an interface design was developed in accordance with the existing use cases, focusing not only on aesthetics but also on functionality. Continuous coordination with users was carried out to ensure that the resulting system met user requirements.

1. Use Case Diagram

Use case diagrams are used to map the core functional requirements that need to be developed so that the system can operate properly in accordance with the results of observations and data calculations [13]. There are three use cases representing the three main users of the system, namely the Customer, Seller, and Cashier, as shown in Figures 3, 4, and 5. The resulting use cases cover the queue process flow using the FIFO model.

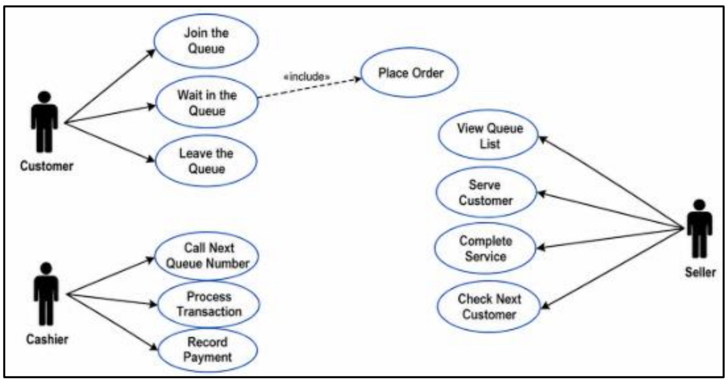

Fig. 3: FIFO Process Use Case Diagram

2. Activity Diagram

An Activity Diagram is needed to provide a more detailed explanation of each use case so that the overall system description becomes more complete [14]. This diagram helps developers build the system more easily because the flow of each use case is clearly illustrated from beginning to end. One example of an activity diagram is shown in Figure 5, which illustrates the queue process of the self-service seblak business using the FIFO model.

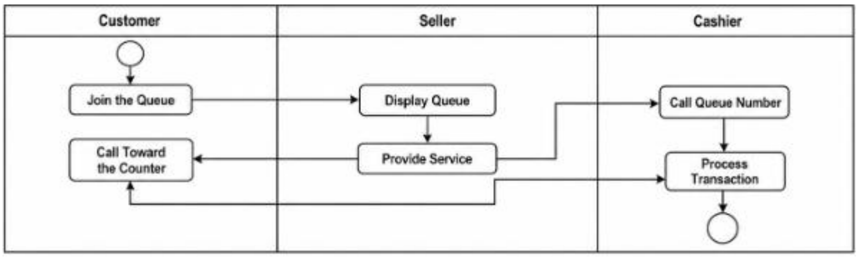

Fig. 4: FIFO Process Activity Diagram

3. Entity Relationship Diagram (ERD)

The creation of an Entity Relationship Diagram (ERD) was carried out to design how the data required by the system would be stored in a database [15]. The ERD was developed based on the use cases and other functional requirements expected to be included in the system.

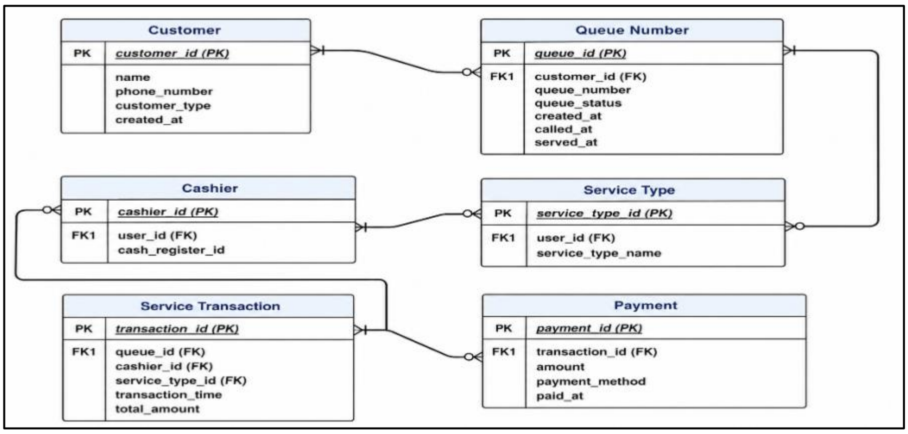

Fig. 5: Entity relationship diagram (ERD)

c. Implementation

The results of the complete design stage facilitate the implementation phase. At this stage, the system is executed partially to be introduced to the organization. Coding is carried out after all design processes have been completed. Several supporting software tools are used in the development process, including Visual Studio Code and SimPy (Python), which are used as code editors and simulation tools to implement a more flexible FIFO (First In First Out) model. Arena / Simul8 are used for GUI-based simulation and Monte Carlo analysis with Excel. For the user interface, the system is designed using the Bootstrap CSS framework and the jQuery JavaScript library, supported by Blade templating in Laravel. The database is designed and managed using MySQL Workbench with MySQL as the database management system. After the development process is completed, the FIFO-based queue management system will be implemented at Seblak Sultan Prasmanan.

4. Results and Discussion

4.1. Main Findings

After conducting a series of analyses and simulation modeling, several findings related to the service system of Seblak Prasmanan MSME were identified. The results indicate that customer arrivals are random in nature, with significant increases occurring during peak hours. The queueing system implemented follows the FIFO (First In First Out) principle, ensuring that service is provided fairly based on the order of customer arrivals. In addition, the simulation results show that customer waiting times tend to increase when the arrival rate approaches the service capacity of the staff. This indicates that limitations in service facilities and staff capacity are the main factors contributing to the formation of long queues. Nevertheless, the implementation of the FIFO model remains effective in maintaining order and fairness in the service process. Based on the FIFO-based system, customers are expected to receive more satisfactory service, which can contribute to positive ratings due to the speed and fairness of the service provided. Irregular customer arrival patterns can lead to service disruptions if the queue is not managed fairly, resulting in dissatisfaction and negative customer ratings because customers may experience excessive waiting times. Therefore, the FIFO model plays an important role in ensuring that service remains organized, efficient, and fair for all customers.Section headings.

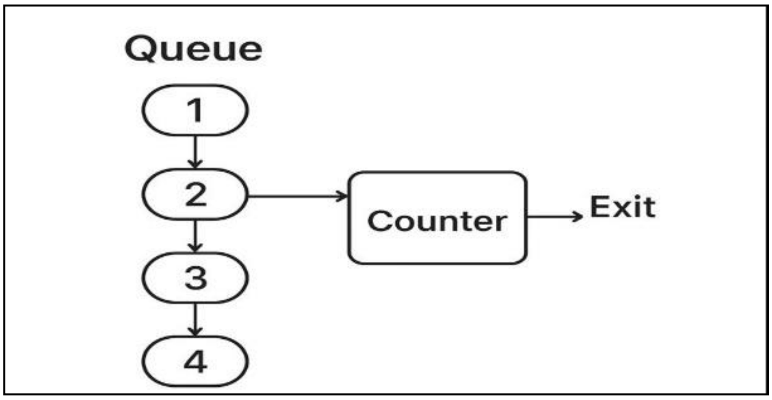

Fig. 6: Illustration of the FIFO Simulation Model for Self Service Seblak

Based on the simulation illustration of the FIFO model above, it can be observed that the FIFO queueing system is able to maintain service order and fairness, although during peak hours customer waiting times increase due to limited service facilities. However, with the implementation of the FIFO system, customers are likely to perceive the service as fair because they are served according to their arrival time, which can contribute to positive ratings for Seblak Sultan Prasmanan.

4.2. Interpretation

Based on Figures 2 and 3, it can be seen that a large number of customers arrive during peak hours, causing service quality to decrease and resulting in slightly longer waiting times. Through the implementation of the FIFO queueing system in the service process of Seblak Prasmanan MSME, the order of service is maintained consistently according to the sequence of customer arrivals. Therefore, the FIFO system is an appropriate approach to ensure fairness in service systems with random arrival characteristics. The increase in customer waiting time during peak hours can be interpreted as a consequence of customer arrival rates exceeding the service capacity of the staff. Thus, it can be concluded that the main issue does not lie in the queue discipline itself, but rather in the limitations of service facilities and staff capacity. The simulation results show that with a limited number of service staff, the FIFO queueing system is still able to maintain order, although it is not yet optimal in reducing customer waiting times during busy periods. The M/M/1 FIFO queueing model used in this study adequately represents the real service conditions of Seblak Prasmanan MSME, where the service process occurs sequentially and depends on a single main service facility. Therefore, the interpretation of these results suggests that improvements such as adding more staff during peak hours or reorganizing the service flow may help reduce customer waiting times and improve overall service performance.

4.3. Comparison with Previous Studies

There are several studies that have used the FIFO queueing model in service systems, both in the MSME sector and in public services. These studies generally aim to analyze service efficiency and customer waiting time. One of them is entitled *"Simulation of the FIFO Queueing Model to Optimize Service Request Handling at KUD CV. Rama Investama."* This research has similarities with previous studies in the use of the FIFO queueing model as a service discipline. In addition, a simulation approach was also used to analyze the performance of the queueing system, particularly in relation to customer waiting time and the level of staff workload, which can cause queues to become less organized. This research differs from previous studies in terms of the research object, namely Seblak Prasmanan MSME, which has buffet-style service characteristics and a manual queueing system. In contrast, the service system at KUD CV. Rama Investama already has relatively good technological support, although it still faces limitations in technological equipment that affect customer arrival handling and service efficiency. Therefore, the difference lies not only in the service environment but also in the operational characteristics of the queueing system being analyzed. The simulation findings are consistent with previous studies, which state that the FIFO model is capable of maintaining fairness in service delivery. However, this research shows that limitations in service facilities are the dominant factor contributing to increased waiting times, which differs from the service system at KUD CV. Rama Investama, where the emphasis is placed on the role of digital systems in queue management. Therefore, this simulation contributes by demonstrating the application and simulation of the FIFO queueing model in the context of small-scale culinary MSMEs, a setting that has not been widely discussed in previous studies.

5. Conclusion

This study concludes that optimal queue management and service quality are very important in creating a positive impression on customers of Seblak Sultan Prasmanan MSME, especially in the culinary business sector. The FIFO-based queue simulation model applied in this study provides an applicable solution to overcome the problem of inefficient waiting times. Through simulation using the Python programming language, various scenarios were tested to analyze arrival patterns, service duration, and average waiting times. The results show that the FIFO model is able to maintain fairness in service order and improve queue management performance, although waiting times may still increase during peak hours due to limited service capacity. This indicates that the effectiveness of the queueing system is influenced not only by the queue discipline itself but also by the availability of service resources. Based on the findings of this study, it is recommended to increase the number of service staff during peak hours so that all customers can be served more efficiently and receive better service experiences. By implementing the simulation results, Seblak Sultan Prasmanan can improve operational sustainability, increase productivity, and provide better service quality to customers, which may contribute to positive customer satisfaction and better ratings for the MSME.

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