Evaluation on Application of Queuing Theory On Payment System in the Supermarket “Saga” Padang Pariaman West Sumatra

Sonny Koeswara¹, Muhammad Kholil², Zetra Pratama³, Hendri⁴

¹Sonnykoeswara78@gmail.com, ²m.kholil2009@gmail.com,
³zetra.pratama@gmail.com, ⁴hendriabubakar@mercubuana.ac.id

Universitas Mercu Buana

Abstract. facilities is less than the number of people who need the services. This phenomenon is the result of customer arrival and service time are not balanced. In this case, we use queuing modeling to assist management in determining the optimal number of supermarket’s cashiers at Saga swalayan Padang Pariaman. The problem to be reduced are at the crowded time and at the deserted time during office hour of the supermarket to provide optimal performance in service. In this research, we used multiple lines queuing system (M/M/S) for analyzing. The calculation was done manually and using the software “Quantitative for Windows” with waiting lines module. The result of the research revealed that the performances of the existing queuing system was not optimal due to the usage of the payment facility and the cashier skill are still low.

Keyword : Queue, Cashiers, Safety state, the optimization, (M/M/S)

1. Introduction

One of the operation activities in a supermarket is the payment systems. Each payment transaction will be served by the cashier where in a certain circumstances the customer must queue to get the service, so that adequate service facilities are needed to provide quality services to the customers.

Customers assess the operational quality of a Supermarket is on the basis of the length of time waiting and speed of the cashier in providing services. If the queue is too long, the satisfaction of the customers who need services will not be fulfilled and can affect the image of the company. Furthermore, it will affect the number of the customers who make transactions and profits to be obtained by the company.

This Queuing problem becomes one of competitiveness factors of the retail industries. If the service delivered is good then customers will be interested in conducting transactions in the supermarket. In the service sector, customer satisfaction is so important that improving the quality of service is critical for the retail company.

To improve the quality of service in payment point, the management is required to design a queue system and the optimal numbers of cashiers. If the number of the cashiers is no adequate, it will result in increasing of the customer queuing time to get the service and vice versa if too many cashiers will
cause the low level of cashiers usability, which means there is idle time at the cashier thus increasing the company’s operating cost.

An understanding of queuing theory becomes indispensable in making decisions about the most appropriate queuing model to support the smooth operation of the company.

2. Research Purposes
The purpose of the study are:

1. To find out the optimal number of cashier at the Supermarket Saga in Padang Pariaman West Sumatra
2. To find out the performance of payment system in self service mode at the Supermarket Saga in Padang Pariaman West Sumatra.

3. Research Method
This research is a descriptive quantitative research that explains how the application of queue theory on Supermarket payment system in Supermarket Saga Padang Pariaman, West Sumatra based on the result of calculation of queue formula for model multiple disciplines (M/M/S).

The study was conducted in February 2018 with data taking for 15 days at random. Based on the preliminary discussions with the management, then this research is done on payment facility or supermarket cashier at Supermarket Saga, Padang Pariaman, with the condition of three conditions in hours, normal condition (10.00 – 12.00), deserted condition (14.00 – 16.00) and crowded conditions (18.00 – 20.00).

Description of troubleshooting steps in this research are as follows:

1. Start means starting research by making preparations related to research
2. Collecting data needed to be processed
3. Analyze the data that has been collected using multiple path models
4. Analyze the optimal service level
5. Analyze the development of service performance
6. Drawing conclusions and suggestions from the research result obtained

Data Collections
This observation was conducted for 15 days randomly divided in to three sessions that is, February 06 – 10, 2018, February 18 – 22, 2018 and March 01 – 05, 2018
- Research at normal conditions at 10.00 – 12.00 a.m
- Research at deserted time of 14.00 – 16.00 pm
- Research at crowded conditions at 18.00 – 20.00 a.m

| Table 1. Data “ Customers Arrival” |
| No | Day   | Date       | Working day on Supermarket | Arrival (Amount/Days) |
|----|-------|------------|-----------------------------|-----------------------|
|    |       |            | 10.00-12.00 | 14.00-16.00 | 18.00-20.00 |            |
| 1  | Fryday | 06/02/2018 | 169          | 84           | 349         | 602        |
| 2  | Saturday | 07/02/2018 | 179          | 88           | 369         | 636        |
| 3  | Sunday | 08/02/2018 | 171          | 95           | 361         | 627        |
| 4  | Monday | 09/02/2018 | 181          | 72           | 329         | 582        |
| 5  | Tuesday | 10/02/2018 | 186          | 68           | 348         | 602        |
| 6  | Wendesday | 18/02/2018 | 143          | 52           | 266         | 461        |
| 7  | Thursdya | 19/02/2018 | 138          | 67           | 271         | 476        |
| 8  | Friday | 20/02/2018 | 138          | 82           | 263         | 483        |
Table 2. Service Average per hours

| Evaluation          | Amount | Arrival | Work | μ     |
|---------------------|--------|---------|------|-------|
| 10.00 – 11.00       | 1186   | 79      | 7 hours | 80    |
| 11.00 – 12.00       | 1232   | 82      | 7 hours | 80    |
| 14.00 – 15.00       | 556    | 37      | 7 hours | 80    |
| 15.00 – 16.00       | 632    | 42      | 7 hours | 80    |
| 18.00 – 19.00       | 1450   | 97      | 7 hours | 80    |
| 19.00 – 20.00       | 1627   | 117     | 7 hours | 80    |

Table 3. Arrival Average Customers

| Conditions | Period/Hours | Amount | Amount | Arrival |
|------------|-------------|--------|--------|---------|
| Normal     | 10.00 – 11.00 | 1186   | 2418   | 81      |
|            | 11.00 – 12.00 | 1232   |        |         |
| Deserted   | 14.00 – 15.00 | 556    | 1188   | 40      |
|            | 15.00 – 16.00 | 632    |        |         |
| Crowded    | 18.00 – 19.00 | 1450   | 4829   | 108     |
|            | 19.00 – 20.00 | 1752   |        |         |

4. Data Processing

After conducting data collection, the data is processed through several stages. In the payment process to serve customers we used multiple path queue models where more than one counter but only one stage of service that the customer must go through to complete the payment. Therefore, to optimize the payment process we can use the queuing formula model (M/M/S), as follows:

a. The probability that there are 0 people in the system (no customer in the system)

\[ P_0 = \frac{1}{\sum_{n=0}^{M} \frac{\lambda^n}{n!} + \frac{\lambda}{M!} M \mu M \mu - \lambda} \]

M = Number of open lines
\( \lambda \) = average arrival amount per time unit
\( \mu \) = The average number served per unit of time on each path
n = the number of customers
b. The average number of requests in the system

\[ L_s = \frac{\lambda \mu (\frac{\lambda}{\mu})^M}{(M-1)(M\mu - \lambda)} \left( P_0 + \frac{\lambda}{\mu} \right) \]

\[ M = \text{Number of open lines} \]
\[ \lambda = \text{average arrival amount per time unit} \]
\[ \mu = \text{the average number served per unit of time on each path} \]
\[ P_0 = \text{probability there are 0 people in the system} \]

c. \[ W_s = \frac{L_s}{\lambda} \]
\[ L_s = \text{average number of customer in the system} \]
\[ W_s = \frac{L_s}{\lambda} \]
\[ L_s = \text{average number of customer in the system} \]
\[ \lambda = \text{average arrival amount per time units} \]

d. The number of people or average units waiting in the queue
\[ L_q = L_s - \frac{\lambda}{\mu} \]
\[ L_s = \text{average number a customers in the system} \]
\[ \lambda = \text{average arrival amount per time unit} \]
\[ \mu = \text{the average number served per unit of time on each path} \]

e. The Average time spent by customer or unit to wait in queue
\[ W_q = \frac{L_q}{\lambda} \]
\[ L_q = \text{the average number of units waiting in the queue} \]
\[ \lambda = \text{average arrival amount per time unit} \]

5. The Result of the Research

At Supermarket Saga Swalayan Padang Pariaman there are 7 cashiers on the line, in fact, on average only 4 cashiers are open to serve the customers. At a certain moment, there are still customers queuing on the system because of the difference in service time provided although the type of service required the same. The following shows the results of queuing system analysis using multiple path queue (M/M/S) model. This calculation is to find the value of Po, ρ, Ls, Ws, Lq and Wq manually and by using software Quantitative method for Window module waiting line. So that the result can be calculated as follows:

1. In a normal condition, (10.00 – 12.00 hours), probability there are 0 people in the system of 0.3628 or 36.28%
2. In a deserted condition (14.00 – 16.00 hours) probability there are 0 people in the system 0.6065 or 60.65%
3. In a crowded condition at (18.00 – 20.00 hours) the probability of 0 people in the system that is 0.2577 or 25.77%

The probability that there are 0 people in the highest system occurs in deserted condition which means that the possibility of no costumer need service is 60.65% while in crowded condition there is probability that there 0 people in the lowest system which mean highest arrival rate cashier’s busyness level (ρ)

The average level of service usability of the cashier under normal condition at 10.00 – 12.00 am of 0.2531 or 25.31%. While the average usability level of cashier service in deserted condition at 14.00 – 16.00 pm amounted to 0.1250 or 12.50%, and average usage level of cashier service in crowded condition at 18.00 – 20.00 pm equal to 0.3375 or 33.75%.
The level of usability of the cashier service is still low that is below 1 or 100% which means the level of customer arrivals is still low in supermarket.

The average number of queues in the queue (Lq), the average number of customers queuing at normal time (10.00 – 12.00 am), as much as 0.0072, while the average number of customers in the queue in the deserted condition (14.00 – 16.00 pm) as much as 0.0003, and the average number of customers in queue at crowded condition (18.00 – 20.00 pm) as much as 0.0274

- The Average number of customers in the system (Ls), the average number of customer waiting in the system under normal condition, as much as 1.0197 people, in the deserted condition, as much as 0.5003 people and in crowded condition, as much as 1.3774 people.
- Average time spent by a customer to wait in queue (Wq). The average time customers spent waiting in the queue, under normal condition, is 0.0053 minutes, while in deserted condition, the average time customers spend waiting in the queue is 0.0004 minutes, and in the crowded condition, the average time customers spend waiting in the queue is 0.0152 minutes
- The average time spent by a customer in the system (Ws), under normal condition is 0.7553 minutes or 45.3204 seconds, where as in deserted condition, the average time customers spend to wait in the system is 0.7504 minutes or 45.0232 seconds, and in crowded condition, the average time customers spend to wait is 0.7652 minutes or 45.9142 seconds.

6. Conclusion
The conclusion can be obtained from the queue application implemented at Supermarket Saga Padang Pariaman as follows:

1. Supermarket Saga Padang Pariaman, has a 7 cashiers but on average 4 cashiers operate, because it is adjusted to the number of queues that occur in the system. The queuing structure model used by Supermarket Saga is multichannel single phase and service customers with the first come first serve (FCFS) queue discipline where first come customer will be served first. The results of data processing obtained that the number of optimal cashier in a deserted condition is 2 cashiers, in normal conditions are 3 cashiers and in crowded condition as many as 4 cashiers
2. Service system performance on Supermarket Saga, less optimal because the usage of payment facilities or cashier are still low. The reduction of the cashier in a deserted condition into 2 cashiers, in normal condition into 3 cashiers and the addition of the cashiers resulted Supermarket Saga Padang Pariaman more optimal in serving customers. Under normal conditions, 3 cashiers led to the average level of cashier’s use or cashier’s business increased to 33.75% than with 4 cashiers by 25.31% and in deserted condition with the use of 2 cashiers.

7. Suggestion
Based on the result of the research, the suggestions are intended for the company policy in order to achieve optimal cashier number and service system performance at optimum level, among others:

1. For the company, reduce the number of cashiers in order to be employed in other parts of the work, so that no time idle at the cashier. Make a grocery or wholesale cashier so it does not cause other customers to wait in line long enough
2. For the next researcher, selecting a research object that has a very high customer arrival rate and the company has an unbalanced number of cashiers with the arrival rate of its customer so it
really need an improvement in its queuing system. The research time is conducted for a month or more so that the data obtained can represent all transactions that occur within the company.

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