

Analysis and Modeling of Queuing System Simulation in Payment Process at Minimarket (Case Study of Minimarket X Yogyakarta)

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ABSTRACT

Keywords: Antrian, Anylogic, Simulasi, Minimarket, Simulasi. This study aims to analyse the queue queuing system at Minimarket X to minimise the number of queues. The method in this writing uses a discrete event simulation method with the help of Analogic software. Simulation is used as a method to analyse problems that exist in the payment system at the Minimarket. At the same time, Analogic software is an illustration that can facilitate the queuing system to make it more transparent and accessible to understand. Observations conducted for 20 days show that the queuing system applied by Minimarket X is Multi-Channel – Single Phase and First Come, First Served (FCFS) or First In, First Out (FIFO) with four cashier officers (M/M/4). Each cashier is tasked with serving customers and processing purchased products by scanning them and packing each grocery. The average number of Minimarket visitors daily is 22 customers per hour with a queue length of 10 to 11 customers per hour, and the average waiting time for customers to be served is around 27 to 30 minutes. Using any logic software, the simulation obtained error results within 67 minutes and 43 seconds.



Introduction

Minimarket is a form of retail business with the concept of daily shopping in a practical, effective, and efficient way (Lope, 2023). The growth of the national retail industry encourages local retailers to develop the retail industry in their area (Hariyadi, 2016). Thus, minimarkets participate in enlivening the retail industry in Indonesia (Yosephine et al., 2022). Minimarket is a convenient shopping place where we can buy everything we need. The minimarket is a place to do the shopping process, replacing traditional markets. In the past, people often shopped at traditional markets or stalls close to where they lived, but because of the busyness and comfort provided, people preferred to shop at minimarkets (Lopez et al., 2023).

Minimarkets are usually managed with a modern and computerised system, making service and check prices easier. Shopping at a minimarket seems more practical, where we do it independently because information about the items we are looking for has been

provided in detail. Although it seems more practical and efficient, shopping at minimarkets also often has obstacles, namely in the form of payment processes that tend to be extended. So, the incident caused a long queue and led us to queue longer (Ramdani et al., 2021).

Today, queuing is an activity or event that we often encounter. The queue is one of the events where the number of service resources is not greater than the number of customers. In other words, the queue is an event caused by the absence of a balance between arrival patterns and the capacity how to serve customers (Lestari, 2021); in an era that is starting to develop, practical and modern causes many consumers who shop at minimarkets to want fast and precise service. However, the large number of customers who will be served in the queue causes customers who come not to be served immediately. In this case, customer satisfaction and loyalty are the main things (Azizi, 2022).

The same applies to Minimarket X, located in Bantul Regency, Yogyakarta. Minimarket X has ten branches in Yogyakarta. Minimarket X is also known as a comfortable shopping place, with relatively complete daily necessities and relatively cheap price offers. However, Minimarket X has a problem that often repeats in the form of a reasonably long payment queue. So, when the primary purpose of shopping at minimarkets is comfort, it becomes less comfortable because the queues are pretty long, especially on weekends, the beginning of the month, the end of the month, the afternoon, the evening and the approach of certain holiday celebrations.

Minimarket X usually operates every day from 08.30 WIB to 21.30 WIB. The data for this writing is taken from December 23, 2023, to January 11, 2024, for 20 days from 15.30 WIB to 17.30 WIB every day. Minimarket X generally serves many customers, so it experiences a long queue, and the time to be served in the queue is also quite long. Queues arise when an unbalanced condition exists between customers served and their servers (Lestari, 2021). The average number of Minimarket visitors daily is 22 customers per hour, with a queue length of 10 to 11 customers per hour, and the average waiting time for customers to be served is around 27 to 30 minutes.

The queuing system implemented by Minimarket X is Multi-Channel – Single Phase and First Come, First Served (FCFS) or First In, First Out (FIFO) with several cashier officers, as many as four people who are tasked with serving customers and processing the products purchased by scanning them and packing each grocery item. Because of the long queue, it raises the writer's curiosity about problems that often occur. So, in this study, a simulation will be carried out on the payment process at Minimarket X using a discrete event simulation model with the help of Analogic software. Simulation is used as a method to analyse problems that exist in the payment system at the Minimarket.

Discrete Event System (DES) concerns modelling a system that evolves by a representation whereby state variables change instantaneously at separate points in time (in more mathematical terms, it can be said that a system can change only at a quantifiable number of points in time.) With the help of Analogic software, the author thinks that it

can make a more transparent and easier-to-understand picture of the queuing system and make it easier for cashiers to minimise the number of queues during the payment process. The author also hopes this research can provide an understanding of minimarket X to improve the future queuing system in the payment process (Sopha & Sakti, 2021).

The previous research relevant to this study's problems can be seen in the following table.

Table 1
Previous Research

No	Researchers	Heading	Purpose	Conclusion
1	Murthy, Surasthya, Don Liquid (2018)	Simulation of Alfamart Pucangsawit Cashier Queue Model Enhancing <i>Arena Software</i>	Knowing the queue model of Alfamart Pucangsawit cashiers using <i>Arena software simulation</i> and making program simulations from the queuing system at Alfamart Pucangsawit cashiers	After modeling and using <i>Arena software</i> , the number of cashiers available is not qualified to reduce the length of queuing time at Alfamart Pucangsawit. Therefore, to maximise the number of consumers served, improvements can be made by increasing the number of cashiers to minimise waiting time.
2	Arafah, Wijayanti, and Runanto (2024)	Queuing System Analysis at Alfamart Ahmad Yani Purworejo	Obtain an overview and proof of the performance of the queuing system in the queue process of Alfamart Ahmad Yani Purworejo	The use of the queuing system at Alfamart Ahmad Yani is optimal by using <i>the Multiple Channel System</i> . This is evidenced by the data obtained showing that, on average, no people are waiting in the system.

Based on previous research described in the table above, it can be seen that there are differences between each title and the research the author examined (Sulistiyoningrum, 2018). The author's research compared the queue formula and the Anylogic application. In this method, the author sees the results of calculations, and the application produces the same or different results. As for the data analysis, the author reanalysed by adding 1 number of cashiers to compare with the number of cashiers in the field.

The goal of this study is for the author to represent the modelling of the queuing system in an analysed system. So that the specific objectives of this writing include the following:

1. Analyze efforts that can be applied in optimising customer service to reduce queues in the payment process at Minimarket X using queuing theory.
2. Identify the average time each customer needs in the payment process until each cashier serves it at Minimarket X.
3. Analyze the optimal number of cashiers to reduce long queues at Minimarket X's payment process.

Research Methods

Unit Analisis Data

The time referenced in this writing is rush hour, around afternoon to evening, on December 23, 2023. So, the object of research in this writing is visitors who decide to visit Minimarket X to look for their daily needs in Bantul, Yogyakarta.

Data Collection Methods

The data collection methods used by the authors in this study are:

1. Interview

Interviews are flexible tools for data collection, allowing the use of multi-sensory channels: verbal, nonverbal, seen, spoken, heard, and conducted online or offline, live or written interviews. The sequence of material that becomes interview material can be controlled but still provides room for spontaneity (Rahman, 2021).

2. Observation

One of the data collection methods widely used in qualitative research is planned observation, recording, analysis, and interpretation of behaviour, actions, or events/phenomena (Sekaran & Bougie, 2016).

3. Study Book

Data is collected by reading literature books, journals, the internet, magazines, and previous research related to the research (Ginting, 2019).

In addition, the author also made direct observations, but from a short distance, by measuring the arrival time of customers and the length of time they were queued until they were served at each cashier using a stopwatch. The data observed is in the form of the number of customer arrivals at each cashier, a specific time interval (arrival rate), and service time data (service time) per person.

Data Analysis Methods

Data analysis is an effort made by the author to collect data, process, and analyse it.

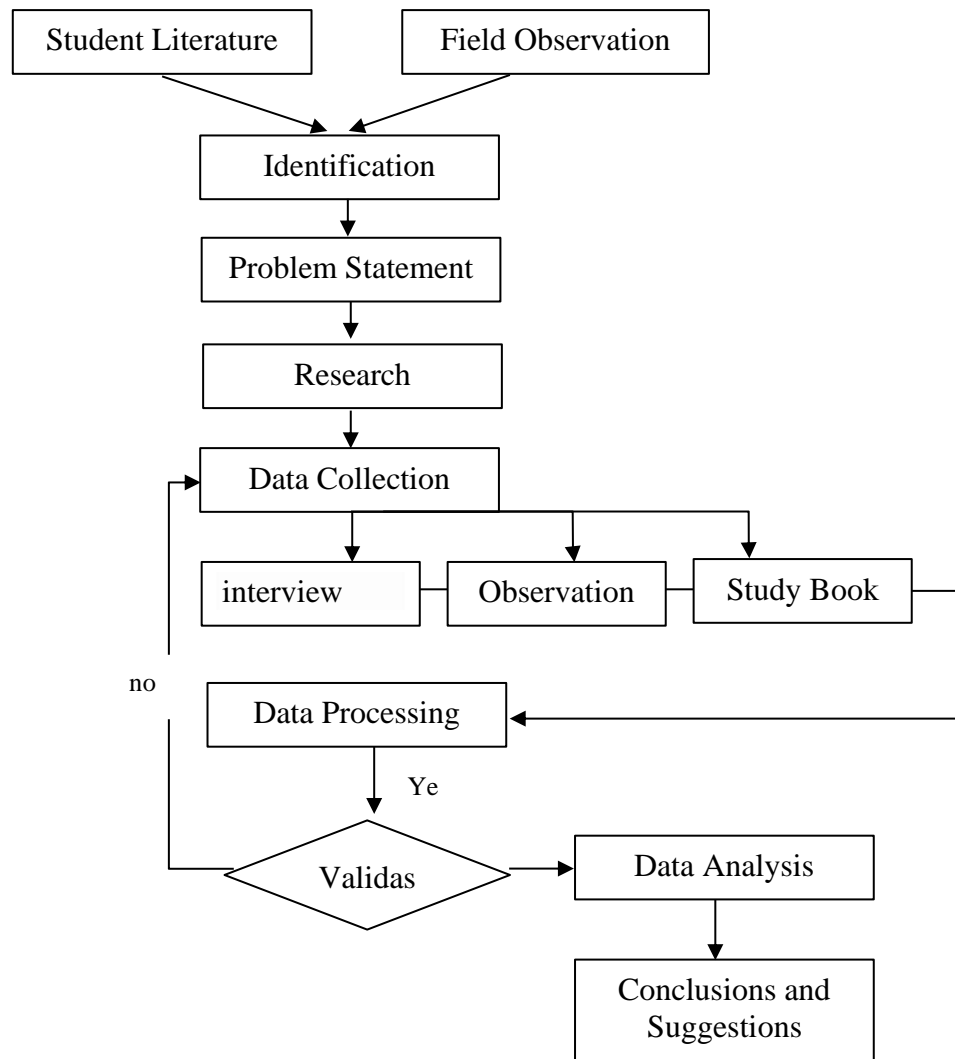


Figure 1 Research Flow

Results and Discussion

Data Processing Using Formulas

After the data collection, the author can obtain the number and average arrival of Time Union customers and the number and average Time Union customer service. The data is used for performance or queue performance. The queuing system at minimarket X is Multi-Channel—Single Phase, with the queue model used being (M/M/4) and First Come, First Served (FCFS) or First In, First Out (FIFO), so the data analysis carried out is as follows.

Average customer arrival rate in a unit of time

$$\lambda = \frac{\text{Total Kedatangan}}{\text{Waktu Pengamatan (Jam)}}$$

$$= \frac{44}{2}$$

$$= 22 \text{ orang/jam}$$

Based on the calculation results, the average customer arrival rate is 22 customers/hour.

Average customer service per unit of time (μ)

The average service time required to serve one customer is $\{(9,58 + 9,42 + 11,33 + 10,33): 4\} = 10,16$ atau ten menit.

$$\mu = \frac{\text{Jam Pengamatan}}{\text{Pelayanan Per Pelanggan}}$$

$$\mu = \frac{60 \text{ menit per jam}}{10 \text{ menit per pelanggan}}$$

$$\mu = 6 \text{ pelanggan/jam/perkasir}$$

Based on the calculation results, the average customer service in a unit of time is as many as six customers/hour or as many as 24 customers/hour for four cashiers.

City of service facilities (s = cash, i.e.) $\rho = \frac{\lambda}{s \cdot \mu} \rho = \frac{22}{4 \cdot 6} = \frac{22}{24} = \frac{11}{12}$

$$\rho = 0,92 = 92\%$$

Based on the calculation results, the level of water intensity or cashier busyness in serving customers is 0.92 or 92%.

The probability of certainty n customers in the system or P0 is equal to an empty cashier (P0)

$$oneP0 = 1 - \rho$$

$$oneP0 = 1 - 0,92$$

$$P0 = 0,08 = 8\%$$

Based on the calculation results, the time the cashier has to rest if the customer is not there or there are 0 customers (P0) is 0.08, or 8% of his busy time.

Average number of subscribers in the system (Ls)

$$Ls = \frac{\rho}{1-\rho}$$

$$= \frac{\frac{22}{24}}{1 - \frac{22}{24}}$$

$$= \frac{22}{24} \times \frac{24}{2}$$

$$= \frac{528}{48} = 11 \text{ orang/jam}$$

Based on the calculation results, the average number of customers in a system is 11 people/hour, so the system must be able to accommodate as many as 11 people/hour.

parent won the queue (Lq) $Lq = \frac{\lambda^2}{\mu(\mu-\lambda)} = \frac{22^2}{24(24-2)} = \frac{22^2}{24(2)}$

$$= \frac{484}{8} = 10,08 \text{ atau } 10 \text{ orang/jam}$$

Based on the calculation results, the average number of customers in the queue or customers waiting to be served and in the queue is ten people/hour.

Average customer time in a system (Ws)

$$n_e W_s = \frac{1}{\mu - \lambda} = \frac{1}{24 - 22} = \frac{1}{2} \text{ ,5 Jaau 30 Menit}$$

Based on the calculation results, the average time customers need to be in the system is 0.5 hours or 30 minutes.

Average time in queue (Wq)

$$W_q = \lambda / (\mu(\mu - \lambda))$$

$$= 22 / (24(24 - 22))$$

$$= 22 / 48$$

$$= 0,45 \text{ hours or } 27 \text{ minutes.}$$

Based on the calculation results, the average time needed for customers to be in the queue is 0.45 hours or 27 minutes.

Data Processing Using Anylogic Software

The processing results found for Multi-Channel - Single Phase simulation with four cashiers running for 120 minutes using Anylogic Software have the following results.

1. The simulation that was run resulted in an error caused by the large number of customers contained in the queue (queue overload), where the maximum capacity of the number of queues in one cashier is 12 customers.
2. The error results of the simulation or overload of the number of customers occurred within 67 minutes and 43 seconds.
3. The number of customers entered during that period was 77 customers.
4. There are 12 customers at each cashier who is queuing.
5. The number of customers being served by each cashier is one customer.
6. The number of customers who have finished being served and have left is 25 customers.

The results of the review can be seen in picture 2 below.

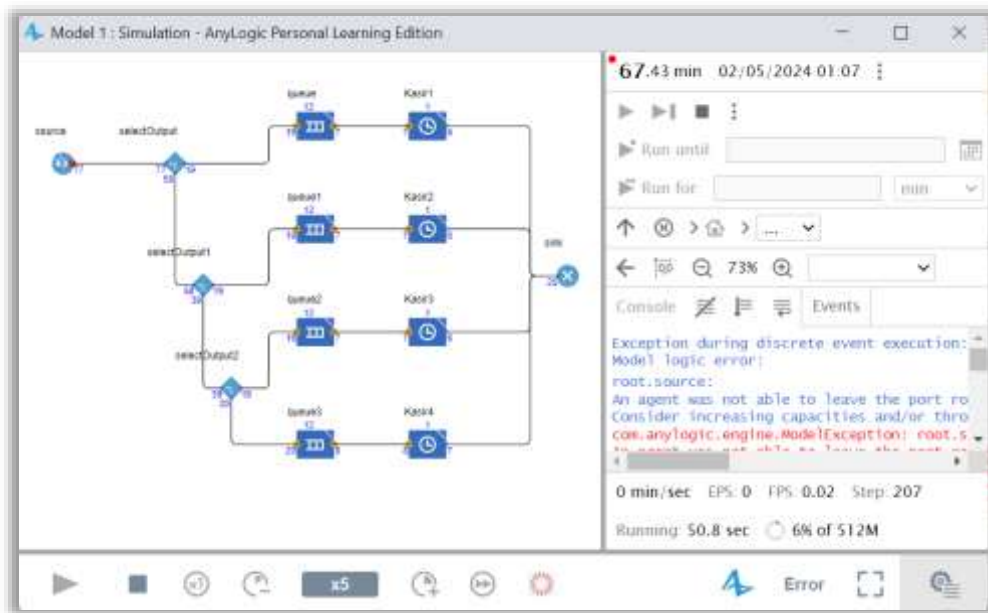


Figure 2 Simulation of Queue 4 Cashier Using Anylogic Software

Analysis of 5 Cashiers Using the Formula Average customer arrival rate in time units $\lambda=22$ people/hour

In this case, there is no difference in the number of customers who use 4 cashiers or five cashiers.

Average customer service per unit of time (μ)

$\mu=6$ Customer/Clock/Cashier

In this case, the average number of customers serviced in a unit of time is six for one cashier and 30 for five cashiers.

Level of service facility intensity (s = many servers or cashiers, ie 5)

$\rho=\lambda/(s.\mu)$

$\rho=22/(5*6)=22/30 = 11/15$

$\rho=0,73=73\%$

Based on the calculation results, the level of waiter intensity or cashier activity after adding one cashier to serving customers is 0.73 or 73%.

The probability of certainty n customers in the system or P0 is equal to an empty cashier (P0)

$P0=1-P$

$P0=1-0,73$

$P0=0,27=27\%$

Based on the calculation results, the time obtained after adding one cashier to the rest of the customers is unavailable, or 0 customers (P0) is 0.27 or 27% of the busy time.

Average number of subscribers in the system (Ls)

$Ls=\rho/(1-\rho)$

$= (11/15)/(1-11/15)$

$=11/15 \times 15/4$

$$=165/60$$

$$=2,75 \text{ orang/jam}$$

Based on the calculation results, a system's average number of customers is 2.75 people/hour.

The average number of customers in the queue (Lq)

$$Lq = \lambda^2 / (\mu(\mu - \lambda))$$

$$= 22^2 / (30(30 - 2))$$

$$= 22^2 / (24(2))$$

$$= 484 / 840$$

$$= 0,02 \text{ person/hour or } 1.6 \text{ person/minute}$$

Based on the calculation results, the average number of customers in the queue or customers waiting to be served and in the queue is 0.02 people/hour or 1.6 people/minute.

Average customer time in a system (Ws)

$$Ws = 1 / (\mu - \lambda)$$

$$= 1 / (30 - 22)$$

$$= 1/8$$

$$= 0,125 \text{ Hours or } 7.5 \text{ Minutes}$$

Based on the calculation results, the average time needed for customers to be in the system is 0.125 hours or 7.5 minutes.

Average time in queue (Wq)

$$W_q = \lambda / (\mu(\mu - \lambda))$$

$$= 22 / (30(30 - 2))$$

$$= 22 / 240$$

$$= 0,09 \text{ Hours or } 5,5 \text{ Menit}$$

Based on the calculation results, the average time needed for customers to be in the queue is 0.09 hours or 5.5 minutes.

The comparison between using four cashiers or adding one cashier to 5 cashiers can be seen in the following table to make it easier to see.

Table 2
Comparison of Calculations with 4 Cashiers and 5 Cashiers

	s = 4	s = 5
λ	22 Orang/Jam	22 Orang/Jam
μ	24 Orang/Jam	30 Orang/Jam
ρ	92%	73%
P_0	8%	27%
L_s	11 Orang/Jam	2,75 Appelsínugulur/sulta
L_q	10 Orang/Jam	0,02 Person/Hour or 1,6 Person/Hour
W_s	0.5 hours or 30 minutes	0.125 hours or 7.5 minutes
W_q	0.45 hours or 27 minutes	0.09 hours or 5.5 minutes

Based on Table 2, the results of adding one cashier have a significant impact on Minimarket X. Among them is the level of waiter intensity or cashier activity before adding cashiers, which reaches 92%. At the same time, after the addition of cashiers, the level of busyness of each cashier decreases by 19% to 73%. That way, the number of customers in the queue, the time of customers in the queue, and the time of customers in the system also seem significantly reduced by adding one cashier.

The calculation data on the average number of customers in the queue for four cashiers is 11 per hour, while there are 2.75 customers per hour with five cashiers. At the same time, the calculation results on the average customer time in a system for the use of four cashiers are 30 minutes and 7.5 minutes. In addition, the calculation results on the time it takes the average customer in the queue for four cashiers are 27 minutes and 5.5 minutes.

After calculating and comparing the 4 and 5 cashiers presented in the table above, it can be said that the addition of 1 cashier in Minimarket X can speed up the customer payment service process. In addition, using five cashiers can reduce the length of the queues and optimise the service process for customers. Thus, it is expected to maintain the sense of loyalty of customers who shop at Minimarket X.

Analysis of 5 Cashiers Using Anylogic Software

Data processing analysis by adding one cashier to 5 cashiers for Multi Channel-Single Phase simulation, which was run for 120 minutes using Anylogic Software, had the following results.

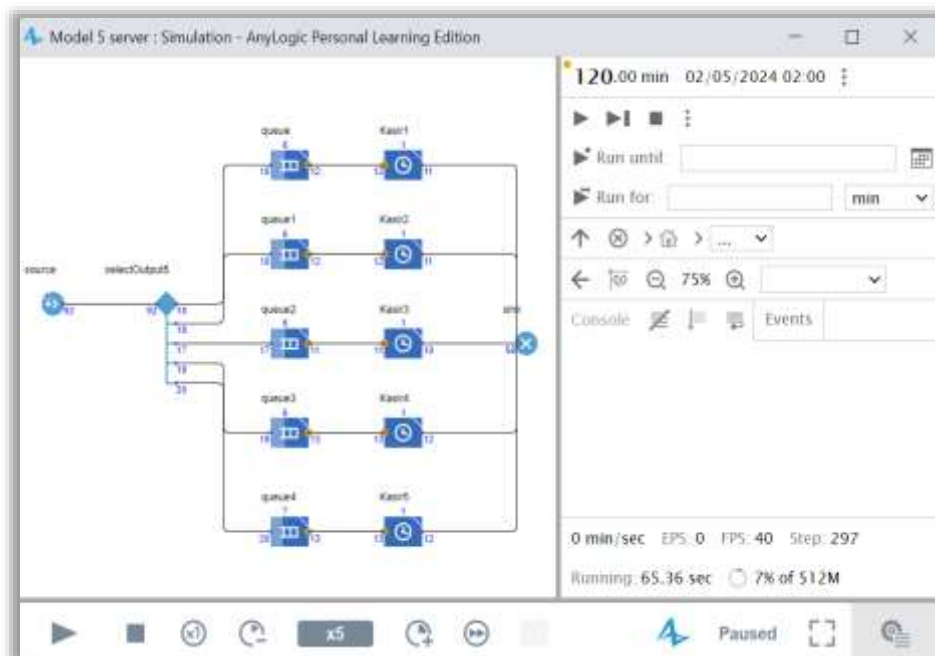


Figure 3 Simulation of Queue 5 Cashier Using Anylogic Software

Based on the picture above, the conclusions obtained are as follows.

1. The simulation results, which were run with five cashiers for 120 minutes, did not experience any problems or could be considered optimal.
2. The number of customers entered during this period was 92 customers.
3. The number of customers queuing at each cashier varies between the six lowest and the seven most customers.
4. The number of customers being served by each cashier is one customer.
5. The number of customers have finished being served and have left is 56 customers.
6. At each cashier, the number of queues long enough to meet the maximum of 12 customers was not increased.

Conclusion

Based on the results of research that the author has conducted from December 23, 2023, to January 11, 2024, with a case study at Minimarket X Yogyakarta, things that can be concluded are:

1. To reduce the queue length, the author conducted an analysis test of data obtained directly from the field and processed using a simulation calculation of the queuing system. The queuing system at minimarket X is in the form of a Multi-Channel - Single Phase with the queue model used (M/M/4) and First Come, First Served (FCFS) or First In, First Out (FIFO). In addition to processing data using formulas for simulation, the author also uses logic software to analyse problems in the payment system at Minimarket X.
2. The average number of customer service in a unit of time if using four cashiers is 24 customers/hour, while with five cashiers, as many as 30 customers/hour. The simulation results obtained using any logic software obtained error results for four cashiers within 67 minutes and 43 seconds, while the results for five cashiers that were run for 120 minutes did not find many problems, and there was no increase in the number of queues at each cashier.
3. Efforts that can be made in optimising service to customers and reducing the number of queues are to increase the number of cashiers from four to 5 cashiers. This is proven by the analysis carried out in the level of server intensity or the level of cashier activity before the addition of the cashier reaches 92%. At the same time, after the addition of the cashier, the level of busyness becomes 73%. The calculation data on the average number of customers in the queue for four cashiers is 11 per hour, while there are 2.75 customers per hour with five cashiers. At the same time, the calculation results on the average customer time in a system for the use of 4 cashiers is for 30 minutes and five cashiers, 7.5 minutes. In addition, the calculation results on the time it takes the average customer in the queue for four cashiers is 27 minutes and for five cashiers 5.5 minutes.

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