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IJIEM (Indonesian Journal of Industrial Engineering & Management)

ISSN (Print) : 2614-7327 ISSN (Online) : 2745-9063

Optimization of Teller Services Using Queuing Theory at XYZ Bank

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ARTICLE INFORMATION

Article history:

Received: 7 July 2023
Revised: 25 July 2023
Accepted: 8 August 2023

Category: Research paper

Keywords:
Flexsim software
Multiple channel single phase
Queuing system
Teller services

DOI: 10.22441/ijiem.v4i3.21359

A B S T R A C T

Bank XYZ is one of the largest state-owned banks in Indonesia that provides various financial services. Currently Bank XYZ has 3 teller services only. This study aims to determine the use of customer queuing schemes currently used in XYZ bank teller services. The data processed is the arrival of customers who transact at the teller area of Bank XYZ. This study uses the Queuing Theory method with the M / M / S (Multiple Channel Single Phase) model and also uses FlexSim software. Then analyze with the addition of the number of tellers (services). Finally, a comparison is made between manual and software calculation methods. Based on the results of the data analysis, the optimal improvement in the application of the queuing system is to add 1 teller service to 4 teller services. The improvement in the performance of the queuing system is characterized by a reduction in the number of customers in line at peak hours 10.00 - 11.00 which initially amounted to 11 people reduced to 3 people and the average waiting time of customers in the queue from 10.08 minutes to 4.02 minutes. Therefore, optimal queuing system performance can be ensured by increasing the number of tellers to four.

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1. INTRODUCTION

XYZ Bank is a state-owned state-owned bank, which more than 50% of its shares are controlled by the State of Indonesia (Pasalbessy, 2021). With the existence of the bank, it can help the community's economy in the field of savings and loans and other bank services. The bank can be said to be good if the bank has been able to satisfy customers by providing customer service and comfort (Tiya, Bawono, & Chandra, 2022). One of the issues that a bank needs to pay attention to is queuing. With the existence of a fast, orderly, and safe queuing system. Will provide satisfaction to customers. One of the XYZ Banks that still has these problems is XYZ Bank Sidoarjo Branch which XYZ Bank Sidoarjo Branch only has 3 teller services. Teller services operate at 08.00 – 16.00 and break time at 12.00 – 13.00. The teller service can serve customer transaction activities such as cash deposits, fund withdrawals, pension withdrawals, and transfers. The number of customers per day who transact at the three tellers is approximately 250 to 300 customers. And also the mean time needed to serve a customer is about 4 minutes.

So there was a long queue for teller services at XYZ Bank Sidoarjo Branch. That's because each teller can serve as many as 90 to 100 customers and the serving time is 4 to 5 minutes. So customers will feel uncomfortable because they feel bored and time is wasted just to queue.

Based on the above problems, one method is used, namely the Queue Theory method. The queuing theory method is about queues or waiting lines that can be used to determine some characteristics and optimization in making decisions for a queuing system. This research is aimed at enhancing the services of XYZ Bank tellers. Sidoarjo Branch to customers with the queue theory method, so that the queue is not too long and customers feel happy comfortable and satisfied with the service

2. LITERATURE REVIEW

2.1 Optimization

Optimization is one branch of decision-making science that forgets the best results under the given circumstances (Yaduvanshi et al., 2019). The ultimate goal of All of these activities is to minimizing effort or maximize the desired profits (Raja, 2022). Since the effort required or desired utility can be expressed as a function of the variable decisions, optimization can be defined as the process of find out the conditions that produce the minimum or maximum value of a function. Optimization can be interpreted as an activity to get the minimum value of a function because to get the maximum value a function can perform by finding the minimum of negative functions of the same (Khasanah & Astuti, 2022). Therefore, the decision of the optimization problem is referred to as the optimal decision while (Ary, 2019): (i) Able to maximize or minimize the function of the goal, (ii) Able not to violate existing constraints or limitations.

2.2 Queueing

A queuing system consists of a customer, a server, and a set of rules that regulate customer entry. The science of queuing forms or often referred to as an imperative portion of operations and additionally a really important apparatus for operations managers. According to Heizer and Render in their book lines are individuals or products in a line holding up to be served (Maghfirah et al., 2019).

2.3 Queueing theory

The mathematical study of splitting or merging lines is called queue theory. Queue theory creates models that can be used to calculate queue lengths and wait times. (Koko et al., 2018). Queuing theory embodies the full scope of the model encompassing everything that can be seen in systems incorporating queuing characteristics (Adeyinka & Kareem, 2018). Thus, the main goal of this queuing theory is to discover a balance between the cost of service to waiting time (Parimala & Palaniammal, 2018).

2.4 Queuing Model

Common to all queueing systems, are 4 fundamental structure patterns for queues:

1. Single Channel Single-Phase
   This queueing system, in which only one service provider and a type of service are used, allows those already receiving services to withdraw from the queue as soon as possible.

Fig. 1. Single channel single-phase queuing models
Source: https://www.gramedia.com/literasi/teori-antrian/

2. Single Channel Multi-Phase
   This queuing system means that there are several different kinds of service offered by the queueing system, but one provider for each type of service.

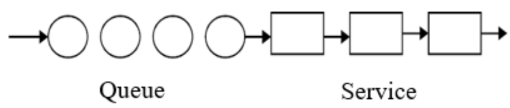

Fig. 2. Single channel multi-phase queuing models
Source: https://www.gramedia.com/literasi/teori-antrian/

3. Multi Channel Single-Phase
   This queuing system has one type of service, but multiple service providers.

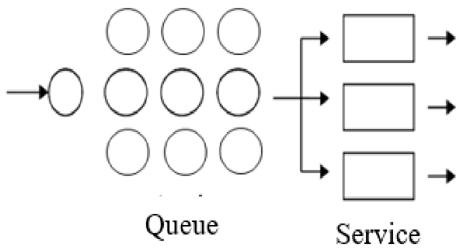

Fig. 3. Multi channel single-phase queuing models
Source: https://www.gramedia.com/literasi/teori-antrian/

4. Multi Channel Multi-Phase
   This queuing system has multiple types of services and multiple service providers for each type of service.

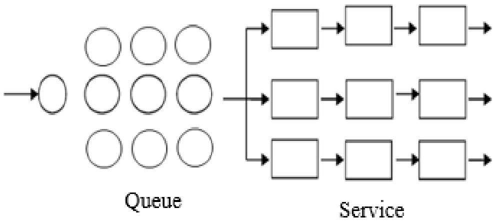

Fig. 4. Multi channel multi-phase queuing models
Source: https://www.gramedia.com/literasi/teori-antrian/

2.5 Queuing discipline

Queuing discipline is the concept of discussing the policy by which Customers are picked from a queue and served based on the order of arrival (Pradana, 2021). The division of queuing discipline is (Pertama et al., 2022): (i) First Come First Served (FCFS), the rule is that the person who receives the service first is the first customer. For example, a supermarket checkout line. (ii) Last Come First Served (LCFS) is a queue where those who come last are served first or first. For example, queuing in a pile of goods in a warehouse. (iii) Service In Random Order (SIRO), meaning that service or calls are based on random opportunities, no matter who arrives first. For example, lottery papers are taken randomly. (iv) Priority Service (PS), meaning that People with the highest priority take precedence over people with the lowest priority, even if they have already arrived in the waiting line.

2.6 FlexSim

FlexSim was developed by FlexSim Software Products, Inc and it is a discrete modeling & simulation software. This is a PC-based simulation software application for modeling, simulating, and visualizing business processes. Any FlexSim model can be rendered in 3D virtual reality animation. In addition, FlexSim allows modelers to perform model and submode programming functions directly in C++. And is the only simulation software that combines C ++ IDE and compiler in a graphical modeling environment (Tarigan & Brian, 2021).

3. RESEARCH METHOD

The place where this research was conducted was at XYZ Bank Sidoarjo Regency, East Java. For the time of conduct, this research will be carried out from June 5, 2023 to June 16, 2023. Here are the steps for solving this research problem as follows:

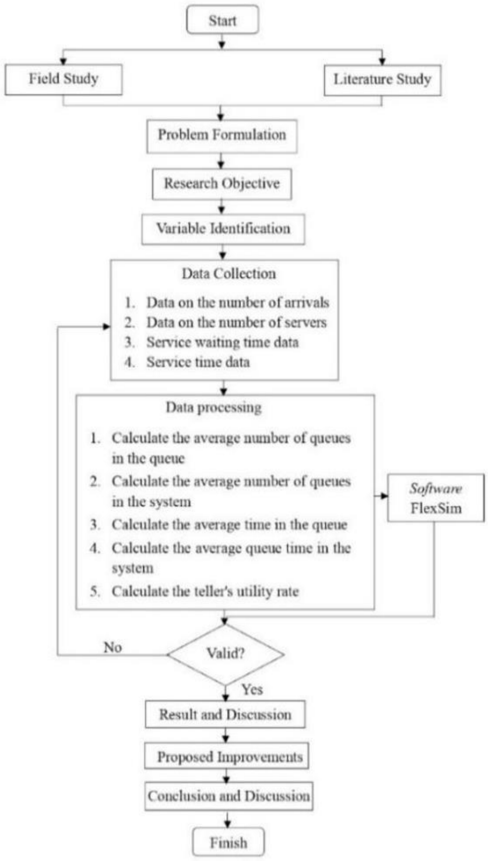

Fig. 5. Research method

4. RESULT AND DISCUSSION

The result section shows objectively the following is the arrival data of customers who transact at XYZ Bank teller services Sidoarjo Branch OfficeHere is the arrival data of customers who transact at XYZ Bank teller services Sidoarjo Branch Office. The following is the mean data of customer arrival rates and mean teller service levels.

Table 1. Mean customer arrival rate

Time	Customer Arrival	
	Customer Arrival in 10 Days	Mean Customer Arrival
08.00 – 09.00	347	35
09.00 – 10.00	498	50
10.00 – 11.00	469	47

Time	Customer Arrival	
	Customer Arrival in 10 Days	Mean Customer Arrival
11.00 – 12.00	408	41
13.00 – 14.00	427	43
14.00 – 15.00	340	34
15.00 – 16.00	192	19

(Source: processed data)

Table 2. Mean service level

Time	Mean Service Time (Min)	Service Level (People)
08.00 – 09.00 09.00 – 10.00 10.00 – 11.00 11.00 – 12.00 13.00 – 14.00 14.00 – 15.00 15.00 – 16.00	Mean Service Time is 4 minutes	15 Persons (obtained from 60 minutes/ meand service time)

(Source: processed data)

For example, the parameters of the queuing model are evaluated at 08.00 to 09.00

M = 3, λ = 35, μ = 15

- The probability of zero people on the system (P0).

  $$P0 = \frac{1}{\left[\sum_{n=0}^{m=1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right] + \frac{1}{M!}\left(\frac{\lambda}{\mu}\right)^M \frac{M\mu}{M\mu-\lambda}}$$

  $$= \frac{1}{\left[\frac{1}{0}\left(\frac{35}{15}\right)^0 + \frac{1}{1!}\left(\frac{35}{15}\right)^1\right] + \frac{1}{3!}\left(\frac{35}{15}\right)^3 \frac{3(15)}{3(15)-35}}$$

  = 0,032 Orang

- Mean number of customers in the system (L_s)

  $$L_s = \frac{\lambda\,\mu\left(\frac{\lambda}{\mu}\right)^M}{(M-1)!(M\mu-\lambda)^2}\,P0 + \frac{\lambda}{\mu}$$

  $$= \frac{35\,(15)\left(\frac{35}{15}\right)^3}{(3-1)!(3(15)-35)^2}\,0{,}032 + \frac{35}{15}$$

  = 2,549 people

- Mean time spent by customers awaiting or being served in the system (W_s)

  $W_s = \frac{Ls}{\lambda}$

  $= \frac{2{,}549}{35}$

  = 0,073 hours or 4,38 minutes

- The mean number of people or units waiting in the queue (L_q)

  $L_q = L_s - \frac{\lambda}{\mu}$

  $= 2{,}549 - \frac{35}{15}$

  = 0,216 people

- The average time customers and units spend waiting in the queue (W_q)

  $W_q = \frac{Lq}{\lambda}$

  $= \frac{0{,}216}{35}$

  = 0,006 hours or 0,36 minutes

- Teller utility level (*p*)

  $p = \frac{\lambda}{M\mu}$

  $= \frac{35}{3\,(15)}$

  = 0,778 or 77,8%

Description:

M : Number of open paths

λ : Average number of arrivals per unit time

μ :The number of persons per unit time served on each line

Based on the method, the results of the calculation of the queue system for the use of the M/M/s queue model with three tellers at the XYZ Bank Sidoarjo branch office are as follows:

Table 3. M/M/s model queuing system performance

Time	P0	L_s	W_s (Min)	L_q	W_q (Min)	*p* (%)
08.00 – 09.00	0,032	2,549	4,38	0,216	0,36	77,8%
09.00 – 10.00	-0,006	4,694	5,64	1,360	1,62	111,1%
10.00 – 11.00	-0,002	11,038	14,1	7,905	10,08	104,4%
11.00 – 12.00	0,009	4,402	6,42	1,669	2,46	91,1%
13.00 – 14.00	0,004	9,957	13,86	7,090	9,9	95,6%
14.00 – 15.00	0,038	2,438	4,32	0,171	0,3	75,6%
15.00 – 16.00	0,330	1,278	4,02	0,011	0,06	42,2%

From the table above it can be seen that: (a) Teller utilization rate or teller activity rate (*p*). The highest teller utilization rate or teller activity level is at 09.00 – 10.00 and 10.00 – 11.00 by 111,1% and 104,4%. (b) The average number of customers waiting in line (Lq). The average number of customers waiting for the longest line that occurred was in the time range 10.00 – 11.00 which queued was 7,905 people. Whilst the imply range of customers in the shortest queue happened in the term 15.00 – 16.00 as many as 0,011 human beings. (c) The average number of customers in the queuing system (Ls). The average wait time for customers in the longest system occurs in the period 10.00 – 11.00 where the number of customers is 11,038. Meanwhile, The average wait time for customers in the longest system occurs in the period 15.00 - 16.00 with 1,278 people. (d) The average amount of time a customer waited in line (Wq). The longest waiting time for customers is 10,08 minutes which was in the 10.00 – 11.00 period and the fastest time is for 0,06 minutes in 15.00 – 16.00 period. (e) Mean time spent by customers waiting or being served in the system (Ws). The longest time a customer spends on the system is 14,1 minutes at 10.00 to 11.00 period, while the fastest time is 4.02 minutes at 15.00 to 16.00 period.

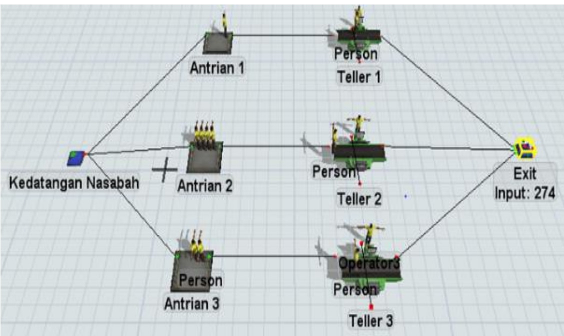

Fig. 6. Current flexSim software results
Source: FlexSim software

It can be visible inside the image above processing time of a customer transacting with a teller is 4 minutes and there are only 3 teller services, there are still remaining customers who are still waiting in line. The number of customers who have completed transactions at teller services amounts to 274 customers and customers who are still in the queue as many as 7 customers. In the results of running the Flexsim software, the queue with the current number of tellers shows that the queue at the current number of tellers shows that the queue at the XYZ Bank Sidoarjo Branch Office is still not optimal.

For example, the parameters of the queuing model are evaluated at 08.00 to 09.00 with improvement

M = 4, λ = 35, μ = 15

- The probability of zero people on the system (P0)

$$P0 = \frac{1}{\left[\sum_{n=0}^{m=1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right] + \frac{1}{M!}\left(\frac{\lambda}{\mu}\right)^M \frac{M\mu}{M\mu-\lambda}}$$

$$= \frac{1}{\left[\frac{1}{0}\left(\frac{35}{15}\right)^0 + \frac{1}{1!}\left(\frac{35}{15}\right)^1\right] + \frac{1}{4!}\left(\frac{35}{15}\right)^4 \frac{4(15)}{4(15)-35}}$$

= 0,026 people

- Mean number of customers in the system (L_s)

$$L_s = \frac{\lambda\,\mu\left(\frac{\lambda}{\mu}\right)^M}{(M-1)!(M\mu-\lambda)^2}\,P0 + \frac{\lambda}{\mu}$$

$$= \frac{35\,(15)\left(\frac{35}{15}\right)^4}{(4-1)!(4(15)-35)^2}\,0{,}026 + \frac{35}{15}$$

= 2,334 people

- Mean time spent by customers waiting or being served in the system (W_s)

$$W_s = \frac{Ls}{\lambda}$$

$$= \frac{2{,}334}{35}$$

= 0,067 hours atau 4,02 minutes

- The mean number of people or units waiting in the queue (L_q)

$$L_q = L_s - \frac{\lambda}{\mu}$$

$$= 2{,}334 - \frac{35}{15}$$

= 0,001 people

- The average time customers and units spend waiting in the queue (W_q)

$$W_q = \frac{Lq}{\lambda}$$

$$= \frac{0{,}001}{35}$$

= 0,00003 hours atau 0,002 minutes

- Teller utility level (*p*)

$$p = \frac{\lambda}{M\mu}$$

$$= \frac{35}{4\,(15)}$$

= 0,583 atau 58,3%

Based on the formula, the calculation of the queuing system is obtained if there is an addition of teller services to 4 teller services using the M/M/s model, which is as follows:

Table 4. Queuing system performance with 4 tellers

Time	P0	L_s	W_s (Min)	L_q	W_q (Min)	*p* (%)
08.00 – 09.00	0,026	2,334	4,02	0,001	0,002	58,3%
09.00 – 10.00	0,003	3,358	4,02	0,025	0,03	83,3%
10.00 – 11.00	0,004	3,144	4,02	0,011	0,012	78,3%
11.00 – 12.00	0,011	2,736	4,02	0,003	0,004	68,3%
13.00 – 14.00	0,008	2,871	4,02	0,004	0,006	71,7%
14.00 – 15.00	0,031	2,268	4,02	0,001	0,002	56,7%
15.00 – 16.00	0,317	1,267	4,02	0,0003	0,001	31,7%

From the table above it can be seen that: (a) Teller utilization rate or teller activity rate (p). The teller utilization rate or the level of teller activity is greatest after the addition of 1 teller occurs at 09.00 – 10.00 by 83,3% so that it has free time of 16,7%. (b) The average number of customers waiting in line (Lq). The average number of customers waiting for the longest line after the addition of 1 teller occurred in the period 09.00 – 10.00 where it was seen that the mean customer queuing was 0,025 people. While the average number of customers in the shortest queue occurs over a period of 15.00 – 16.00 as many as 0,0003 people. (c) The average number of customers in the queuing system (Ls).

The average wait time for customers in the longest system after the addition of 1 teller occurred in the period 09.00 – 10.00 where the number of customers was 3,358 people. While The average wait time for customers in the longest system in the period 15.00 – 16.00 as many as 1,267 people. (d) The average amount of time a customer waited in line (Wq). The longest time required by customers in the queue after adding 1 teller is for 0,03 minutes in the period 09.00 – 10.00 and the fastest time is for 0,001 minutes in the period 15.00 – 16.00. (e) Mean time spent by customers waiting or being served in the system (Ws). The amount of time spent by a customer on the system after adding 1 teller is 4,02 minutes in all periods.

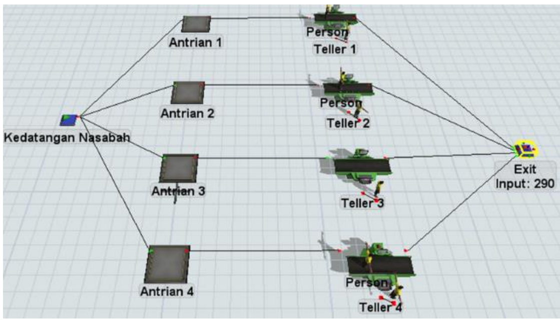

Fig. 7. FlexSim software results based improvement (Source: FlexSim Software)

In the results of running the Flexsim software, the queue with the addition of the number of tellers shows that the queue at the XYZ Bank Sidoarjo Branch Office is optimal. With the mean processing time for a customer to transact with a teller is 4 minutes and there is an addition of 1 teller to 4 teller services, there are no remaining customers who are still waiting in line. The number of customers who have completed transactions at teller services is even more, amounting to 290 customers.

5. CONCLUSION

Based totally on the outcomes and discussions of research conducted at XYZ Bank, can be concluded: (i) Based on the results of data processing and FlexSim software by adding one teller service to 4 teller services, The improvement in the queue system performance is characterized by a reduction in the number of customers within the line at peak hours 10.00 - 11.00 which initially amounted to 11,038 reduced to 3,144 people, and the mean customer waiting time in the queue from 10.08 minutes to 4.02 minutes, it contributed to improving the efficiency of the queueing system. (ii) In addition, the test results from FlexSim show that there's still a lack of optimal queue conditions for XYZ Bank teller service Sidoarjo branch office with only three services. The results of running the Flexsim software with an average service time of 4 minutes, there are still queues while working hours are over. Therefore, it is necessary to add one teller service to 4 teller services. With 4 teller services, there are no more remaining customers who are still waiting in line. This indicates that the queue for XYZ Bank Sidoarjo Branch Office is optimal.

Suggestions that can be given to Bank XYZ need to consider adding 1 teller service. With the addition of the number of tellers, the bank must reconsider in making decisions on cost issues so that the addition of teller services is maximized. By increasing the number of tellers, it will improve customer performance and satisfaction. Bank XYZ need provide a forum for customers to provide criticism and suggestions so that the company can further improve service quality.

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