International Journal of Informatics, Economics, Management and Science
http://journal.stmikjayakarta.ac.id/index.php/ijiems
E-ISSN: 2809-8471 (online), **P-ISSN:** 2809-9281 (Print)
DOI: 10.52362/ijiems.v2i2.1181
Volume 2, Issue 2, August 2023, pp. 96-104

Application of the Monte Carlo Method in Modeling and Simulation of Service Queuing Systems at PT. Pos Indonesia Persero Binjai

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Received: May 20, 2023; **accepted** : July 15,2023 ; **Published** : August 4, 2023

Abstract: Queues are events that we often encounter in various places that provide services to the public, one of which is the Post Office. Service to customer satisfaction is a very important thing, so that improving the quality of customer service must always be done. A good queuing system will affect consumer behavior and satisfaction. PT. Pos Indonesia Persero Binjai is a service company where the purpose of PT. Pos Indonesia (Persero) itself is customer satisfaction oriented. The problems that occurred at PT. Pos Indonesia Persero Binjai caused long queues to build up in queues. To overcome these problems, it is necessary to improve the system such as applying the queuing model application by applying the queuing model method and Monte Carlo simulation. Monte Carlo is a probabilistic simulation method that generates random input to mimic the existing conditions of a problem by estimating the same distribution and in accordance with reality. So that with the improvement of the system, the application of the queuing model can be applied, directing customers to take queue numbers, and monitoring the queue card arrangement, adding tellers to serve customers, enlarging the waiting room so that customers are comfortable waiting and also determine the characteristics and performance measures of the queuing system in part of the payment counter and delivery of goods that will help PT. Pos Indonesia Binjai Company.

Keywords : Queuing, Monte Carlo, Simulation .

1. Introduction

Queues are events that we often encounter in various places that provide services to the community, including hospitals, banks, toll roads, post offices and others. Service to customer

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satisfaction is a very important thing, so that improving the quality of customer service must always be done. A good queuing system will affect consumer behavior and satisfaction. Queue is a state of waiting to get a turn. Generally a queue is formed if the number of customers to be served exceeds the available capacity, causing customers who come to be unable to be served immediately. In this case, customer satisfaction is the main priority. (Trisna, 2019).

PT. Pos Indonesia Persero Binjai is a service company where the purpose of PT. Pos Indonesia (Persero) itself is customer satisfaction oriented. Customers will feel dissatisfied if they have to wait a long time. PT. Pos Indonesia (Persero) Binjai already has a large workforce to serve customers by providing more than one counter to serve customers, but queue phenomena still occur.

The problems that occurred at PT. Pos Indonesia Persero Binjai The occurrence of long queues is caused by the buildup of queues where many customers do not take queue numbers when queuing, so that customers scramble to be at the front to be served and also the space to wait for the queue is limited, and the counter clerk (frontliner) to serve only has 3 tellers which causes queue occurs.

To overcome these problems, it is necessary to improve the system such as implementing a queuing model application, directing customers to take queue numbers, and monitoring queue card arrangements, adding tellers to serve customers, enlarging waiting rooms so that customers are comfortable waiting and also determining characteristics and dimensions. the performance of the queuing system at the payment counter and delivery of goods at PT. Pos Indonesia Binjai Company by applying the queue model method and Monte Carlo simulation.

In Winston's book, [9, p. 45, 2000] explained that not all problems in the real world can be solved analytically to achieve optimal results due to complexity, stochastic relationships and so on. Attempts to apply an analytical model to such a system usually require so many simplifying assumptions that solutions are less accurate or inadequate to implement. Simulation is a very powerful management science technique and is widely used for the analysis and study of complex systems.

2. Literature

This previous research is one of the references in conducting research so that it can enrich the theory used in reviewing the research conducted. In this study the authors take references from several writings.

One of the studies that has been carried out by (Mahessya 2017) which aims to analyze the customer service queue system that occurs at PT.Pos at the delivery counter. Which describes how the state of the queue that occurs and to find out whether the service provided to customers has been carried out optimally, even though the company already has several goods delivery counters.

Research by (Fajar Etri Lianti, 2020) which aims to find out the results of measuring system performance obtained from two methods, namely the analytical method and the Monte Carlo

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method compared to using field data. The results obtained indicate that the performance measurement produced by the Monte Carlo simulation method is more accurate than the analytical method.

Thus, companies often cannot meet market needs resulting in shortages due to the absence of a minimum stock of raw materials. From these problems a monte carlo simulation will be carried out, with modeling input in the form of production data and policies applied to determine the level of shortages. Then it was replicated 30 times, the result was an average shortage of 19.53 kg per day. For this reason, an alternative scenario is carried out by increasing the service level to 99% so that the reorder point becomes 1372 kg based on the calculation of the min-max method. The result is an average shortage per day of 6.06 kg per day. Other policy changes by reducing the number of orders for raw materials to 5% to 6935 kg. The result is an average shortage per day of 14.23 kg per day. So the best alternative to reduce the problem is the first alternative by increasing the service level to 99% so that the reorder point becomes 1372 kg and for further problems will be analyzed using a fishbone diagram. With a fishbone diagram, steps can be taken on potential factors that influence the problems that occur. (Waskito teak ferry, 2022) .

From the previous studies described above, the Monte Carlo method can be applied to determine more accurate performance measures. With this analysis, this research is used to apply the Monte Carlo method in simulating customer service queues.

3. Methods

3.1. Types of Research

A system is defined as a number of entities that can consist of humans, machines or other objects that have interactions, so that they can produce the same goal (Kelton 2007). The activity of imitating a system is called simulation, simulation is a method that focuses on imitating a system that is the object of its study.

Monte Carlo simulation is a sampling experiment that aims to estimate the type of distribution in an output variable, depending on several probabilistic variables that are input to a particular process. Monte Carlo simulations are often used to evaluate the expected impact of policy changes and the risks involved in a decision-making process (Evans & Olson, 2002).

3.2. Research Supporting Data

The data needed in this study consists of quantitative data and qualitative data. Quantitative data is collected by observing the arrival rate of customers, and data on customer service time at PT. Pos Indonesia (Persero) Binjai. Meanwhile, qualitative data was collected by interviewing customer satisfaction levels at PT. Pos Indonesia (Persero) Binjai.

3.3. Application of the Method

In carrying out a simulation using the Monte Carlo method, several random numbers are

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needed to determine the difference between the arrival time interval and the customer service time interval. Formation of random numbers is done by using the LCM (Linear Congruent Method).

From data collection in the field, the time of arrival, start of processing and completion of processing is obtained which can then be processed again to find the time in the queue and the time in the system as can be seen in the table below.

Table 1. Time in the Queue and Time in the System

No	AT	shh	SET	st	TI Q	TI S
1	7.55	8.00	8.05	5	0	5
2	8.06	8.06	8.11	5	0	5
3	8.12	8.12	8.17	5	0	5
4	8.22	8.22	8.27	5	0	5
5	8.25	8.27	8.32	5	2	7

Information :
AT : *Arrival Time* (arrival time)
SST : *Service Start Time* (start service)
SET : *Service End Time* (finished service)
TIQ : *Time In Queue* (time in queue)
TIS : *Time In System* (time in system)
ST : Service Time

3.4. Process Analysis

Queuing data process analysis at PT. Pos Indonesia Persero Binjai which will be processed using the *monte carlo method* as follows:

1. Input Data
   The data to be processed can be seen in the table below.

Table 2. Input data

Inputs	Time/person
Number of customers	30 people
Time of arrival	3-12 minutes
Service Time	2-5 minutes

2. intervals
   As for the interval in the queue process at PT. Pos Indonesia Persero Binjai as follows:

Table 3. Input of Arrival Difference Time Interval

Arrival Time	Probability	Cumulative	Random

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Interval	(Frequency)	Probability	Numbers
3	0.10	0 + 0.10 = 0.10	1 – 10
4	0.10	0.10 + 0.10 = 0.20	11–20
5	0.10	0.20 + 0.10 = 0.30	21–30
6	0.10	0.30 + 0.10 = 0.40	31–40
7	0.10	0.40 + 0.10 = 0.50	41–50
8	0.10	0.50 + 0.10 = 0.60	51–60
9	0.10	0.60 + 0.10 = 0.70	61–70
10	0.10	0.70 + 0.10 = 0.80	71–80
11	0.10	0.80 + 0.10 = 0.90	81–90
12	0.10	0.90 + 0.10 = 1.00	91–100

Input the service time interval at PT. Pos Indonesia Persero Binjai can be seen in the table below.

Table 4. Service Time Interval Input

Service Time Intervals	Probability (Frequency)	Cumulative Probability	Random Numbers
2	0.25	0 + 0.25 = 0.25	0 – 25
3	0.25	0.25 + 0.25 = 0.50	26 – 50
4	0.25	0.25 + 0.50 = 0.75	51–75
5	0.25	0.25 + 0.75 = 1.00	76 – 100

3. Generate random numbers.
   Drawing random numbers to get the IAT value using this simulation is as follows:

   The formula LCM = Xi+1= (a Xi+1 + C) mod M

   Information :
   a : Multiplication Constant
   Xi : The initial value specified
   C : Increase
   M : Fixed number

   Random Number Withdrawal for the difference in customer arrival time:
   a= 25 X0= 5 c= 7 m=100
   X1 = (25 x 5 + 7) mod 100
   = 132 mod 100
   = 32

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X2 = (25 x 32 + 7) mod 100
= 807 mod 100
= 7
X3 = (25 x 7 + 7) mod 100
= 182 mod 100
= 82
X4 = (25 x 82 + 7) mod 100
= 2057 mod 100
= 57
X5 = (25 x 57 + 7) mod 100
= 1432 mod 100
= 32

Still using the same formula, namely the following LCM formula for Random Number Drawing for the difference in customer service time:

a= 10 X0= 1 c=11 m=50

X1 = (10 x 1 + 11) mod 50
= 22 mod 50
= 22
X2 = (10 x 22 + 11) mod 50
= 231 mod 50
= 31
X3 = (10 x 31 + 11) mod 50
= 321 mod 50
= 21
X4 = (10 x 21 + 11) mod 50
= 221 mod 50
= 21
X5 = (10 x 21+ 11) mod 50
= 221 mod 50
= 21

4. Define graphs and random number intervals for each possibility.

Table 5. Random Numbers

Customer	Arrival Time		Service Time	
	Random Numbers	Intervals (Minutes)	Random Numbers	Intervals (Minutes)
1	32	6	22	3
2	7	3	31	4

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3	82	11	21	3
4	57	8	21	3
5	32	6	21	3

5. Make a simulation of the experimental circuit

After obtaining random numbers through the LCM (*Linear Congruent Method*) formula, illustrations are carried out using the monte carlo method simulation as shown in the following table:

Table 6. Illustration of the Monte Carlo Method Simulation

customers	RN	IAT	AT	shh	RN	st	SET	TI Q	TI S
1	32	6	8.06	8.06	22	3	8.09	0	3
2	7	3	8.09	8.09	31	4	8.12	4	8
3	82	11	8.20	8.20	21	3	8.23	3	6
4	57	8	8.28	8.28	21	3	8.31	3	6
5	32	6	8.34	8.34	21	3	8.37	3	6

4. Results And Discussion

Customer 1, arrival time is 08.06 because the arrival interval is 6 minutes and the Indonesian Post Office Perseo Binjai starts service at 08.00, can be served immediately at 08.06 because it is the first customer and there is no queue, transaction services occur for 3 minutes so the time to finish being served is (arrival time plus service time) at 08.09. For the time in queue 0 because it is the first customer and the time in the system is obtained from the service time plus the time in the queue for this first customer the time in the system is 3 minutes.

Customer 2, arrival time is 08.09 because the arrival time interval is 3 minutes from the first customer, and can be served immediately because the first customer has been served at 08.09, the transaction service time is 4 minutes based on random number intervals, so the finished time is served at 08.13 (08.09 plus 4 minutes), the waiting time for the 2nd customer is different from the first customer, namely the time after being served minus the service start time (08.12 minus 08.09) = 4 minutes, and the time in the system is the same as the first customer obtained from the service time plus the time in the queue at This second customer's time in the system is 6 minutes. This 2nd customer is the same as the next customer up to 30.

So the probability of a customer arriving at any time in the queue is about 3 minutes, the distance between the first customer and the next customer is because 88/30 = 2.93

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minutes and in the system is 6 minutes because 179/30 = 5.96.

The results of data processing using the queuing model using the *monte carlo method* at PT. Pos Indonesia Persero Binjai can be seen in the table below.

Table 7. Queue Service Phase Information for tellers

Information	Average customer waiting time in queue	88/ 30 = 2.93	**Minute**
	Average time customers are in the system	179 / 30 = 5.96	**Minute**

5. Conclusion

in this research, with this customer service queuing simulation can overcome the buildup of queues that occur at PT. Pos Indonesia using the Monte Carlo method. With this queue simulation system, it can calculate the probability of a customer arriving at any time in the queue, around 3 minutes, the distance between the first customer and the next customer is because 88/30 = 2.93 minutes and in the system is 6 minutes because 179/30 = 5.96. With the count of time per queue this will maximize the performance of the company's employees PT. Pos Indonesia to be faster in providing services to customers and to avoid the accumulation of queues that occur so that PT Pos Indonesia can provide satisfaction to customers for getting the right service.

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