The analysis of queue model on a motorcycle parking area

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Abstract. This research aims to determine the queue model on a motorcycle parking area at Jember University and its performance measures. The data collection method in this research uses the observation method. Data taken are the number of arrivals, the number of departures, and service time. To get arrival distribution and service time distribution use mathematical calculation and Kolmogorov-Smirnov Test with SPSS Statistics. After arrival distribution and service time distribution are known, then using Kendall Notation rule to get queue model. Formula derivation and POM-QM for Windows are used to obtain performance measurement values in the queue model. After getting the data needed through observation, then analysed data to determine the value of arrival rate and service rate, then the data is reanalysed to find out the data obtained has been steady-state. This research is known that steady-state, so that distribution test can be done, with the result that the arrival distribution was Poisson distribution and the service time distribution was Exponential distribution. In modelling the queue Kendall Notation is required. It’s used to clarify how the queue system reviewed works and is modelled. Based on the results of data analysis in this research, the queue model obtained was (M/M/1):(FIFO/∞/∞).

1. Introduction

Service as a system, every business representing a system consisting of two main components: service operations (1) and service delivery (2) [1]. Queue is a phenomenon faced by customers in service provider companies. Problems related to queuing mechanism [2,3] are waiting time and queue length. Especially the problem of time, waiting is a tedious thing if waiting in line for a long time. Besides being boring, waiting is a waste of time and tiring. Meanwhile, for the problem of the length of the queue related to the capacity of the place to queue [4]. The motivation for the research of this queuing model comes out of situations seen in capacitated inventory situations where in the customers coordinate their orders so as to minimize the ordering costs [5,6]. The investigation of queuing models with impatient customers is very helpful and imperative as such systems often arise in many real life problem[7,8]. The research was conducted in the motorcycle parking area of Faculty of Teacher Training and Education Jember University. This research aims to determine the queuing model and size of performance of parking area. The queue system is the arrival of customers to get services, waiting to be served if the service facility (server) is still busy, getting service and then leaving the system after being served [9]. On the exit path of the parking area, there is an exit guard that on duty to check Vehicle registration certificate motorcycle registration that will exit the parking area. On the way out the parking area also often queues happen. Queues usually occur when changed hours between courses, because there are so many students who will pass the exit of the parking area.
and have to do the Vehicle registration certificate motorcycle checking stage on the exit line of the parking area.

In the queue system there are three characteristic components, namely: (a) arrival characteristics or system input; (b) queue characteristics; (c) service characteristics. The following is a description of the three characteristics of the queue system. Arrival characteristics include population size, arrival behaviour, and arrival patterns. Queue characteristics include, First In First Out (FIFO), which is the first customer to come, first served, Last In First Out (LIFO), namely the customer queue system that comes last, first-served, Service in Random Order (SIRO) which is a call based on opportunity random, no matter who comes first, and Shortest Operation Times (SOT), which is a service system that requires the shortest service time to get the first service. Service characteristics include service system design and service time distribution [10]. In the structure of the queuing model, there are 4 dominant factors, namely, system boundaries, inputs, processes, and outputs [4]. Yechiali and Naor [11] provided that where the M/M/1 queue was analyzed in the steady-state regime when the rates of arrival and service are subject to Poisson alternations.

Opportunities that are often referred to as probabilities can be seen as a way of expressing a measure of uncertainty or the possibility of an event occurring or not happening. To reveal uncertainty or certainty, systematic modelling is needed which is theoretically expressed by distribution. The probability value of an event in an experiment is spread between 0 and 1 between 0% and 100%. If the probability/https://doi.org/10.1088/1742-6596/1490/1/012008

1. Power Distribution: The probability distribution of Poisson X random variables, which states the number of successes that occur in a given time interval or region is expressed by t, given by:

\[ f(x) = \frac{e^{-\lambda x} \lambda^x}{x!}, \quad x = 0, 1, 2, \ldots \text{ and } \lambda > 0. \] (1)

2. Exponential Distribution, random variable X is said to be exponentially distributed with the \( \beta \) parameter if it is based on Gamma spark plugs with parameters \( \alpha = 1 \text{ dan } \beta \).

\[ f(x) = \frac{1}{\beta} e^{-x/\beta}, \quad 0 \leq x \leq \infty \text{ untuk } \beta > 0 \] (2)

An example of a problem that requires the function of exponential density is the theory of reliability. For example the length of time until damage to parts [12]. The distribution match test is used to match or test whether observational data sets follow a certain distribution, by comparing the frequency of observations with the expected frequency of a hypothesis. The test used in this study is the one-sample Kolmogorov-Smirnov test. This test determines a point where both distributions are expected and the distribution of observations has the biggest difference. By looking at the sampling distribution, whether a large difference is observed might occur if these observations also have a random sample of theoretical distributions.

The hypothesis for the Kolmogorov-Smirnov test is:

\[ H_0 = \text{data follows the specified distribution} \]

\[ H_1 = \text{data does not follow the specified distribution} \]

With test criteria:

If the Asymp Sign value (2-tailed) > 0.05 then \( H_0 \) is accepted

If the Asymp Sign value (2-tailed) <0.05 then \( H_0 \) is rejected.

D.G. Kendall introduces the notation for queuing models with parallel systems and this notation provides an overview of 3 basic characteristics, namely: arrival distribution, departure distribution, and the number of channels. Lee gives notation for the other two characters: service discipline and the maximum allowable amount in the system. So that identifies several types of queue systems used Kendall and Lee notations, and complete notation is indicated in \((a/b/c) ; (d/e/f)\), where \( a \) is the arrival distribution, \( b \) is the service distribution, \( c \) is the number of services, \( d \) is the service rule, \( e \) is the maximum allowable number in the queue system, and \( f \) is the size of the calling source [13]. This research aims to determine the queuing to find arrival distribution and service distribution, so required software SPSS Statistics. The SPSS statistics software used is SPSS statistics version 17.0. Various
queue models can be used in the Operations Management field. By optimizing the service system, it can be determined the service time, the number of queue channels, and the right number of services using queue models. The M/M/1 queue is the most well-known queueing system modelling [14-16], whose customers arrive according to a Poisson process, and the service times are exponentially distributed. Its generalizations are often employed to describe more complex systems.

Queue Model [17,18] (M/M/1): (GD/∞/∞), many numbers of arrivals and departures are Poisson distributions with the arrival rate \( \lambda \) and service level \( \mu \) (time of each arrival is an Exponential distribution with an average of \( \frac{1}{\lambda} \) and service time is an exponential distribution with an average of \( \frac{1}{\mu} \)), service facilities 1, capacity queue (service system) there is no limit and unlimited input source size [19]. Queue model (M/M/1): (GD/∞/∞) has a measure of performance, namely the probability of no service \( (P_0) \), utility level \( (U) \), average number of objects in the system \( (L_s) \), average number - the object in the queue \( (L_q) \), the average waiting time experienced by objects in the system \( (W_s) \), and the average waiting time experienced by the object in the queue \( (W_q) \) as in Table 1. The results of performance measures in the queueing model can be obtained from software. The software used in calculating performance measures in the queuing model in this research is POM-QM for Windows 5.

| Measure of performance                  | Formula                                      |
|----------------------------------------|----------------------------------------------|
| The probability of no service \( (P_0) \) | \((1 - \rho)\)                               |
| Utility level \( (U) \)                | \(\frac{\rho}{\mu}\)                        |
| Average number of objects in the system \( (L_s) \), | \(\frac{1}{1 - \rho}\)                      |
| Average number - the object in the queue \( (L_q) \) | \(\frac{\rho^2}{1 - \rho}\)                |
| The average waiting time experienced by objects in the system \( (W_s) \) | \(\frac{\mu(1 - \rho)}{\mu(1 - \rho)}\) |
| The average waiting time experienced by the object in the queue \( (W_q) \) | \(\frac{1}{\mu(1 - \rho)}\)                |

2. Research method

The type of research used in this study is quantitative research. In this research, procedure is needed which is a stage that is carried out until data is obtained to be completed until conclusions are found that are in accordance with the research objectives. The purpose of this study was to determine the queuing model applied to the motorcycle parking area in the faculty of teacher training and education at Jember University and to measure the performance of the model and to find out whether the application of the model was effective. The research method in this research is introduction activities, making research instruments (interview guidelines, observation sheets, questionnaire guidelines, and validation sheets), instrument validation test (validated instruments are interview guidelines and questionnaire guidelines and if they are not valid so revisions are made until they are valid). If valid then can do interviews and fill out the questionnaire and then can make observations. The next step is to analyze the results of observations to determine the arrival rate and the rate of service. To get the queuing model, so need arrival distribution and service distribution. So, it is needed a distribution match test to determine the arrival distribution and service distribution, distribution match test use software SPPS Statistics and use Mathematical calculation. Then analyzing queuing system includes arrival characteristics namely population size, arrival behaviour, arrival patterns, queuing characteristics, and service characteristics namely service system design and service patterns, thus from three characteristics will forming a queuing model structure. After finding a suitable distribution for the arrival distribution and service distribution and after analyzing the queuing system, the next
Step is to determine the queuing model based on the Kendall notation rules. Having found a queuing model then calculate the performance measure in the queuing model with formula derivation and use software POM-QM for Windows. The conclusions are to know about queuing model in the motorcycle parking area, performance measure in the queuing model, and to know how effective that model with use queuing model simulation with add 1 waiting line.

Figure 1. Flowchart of Research Procedures

3. Results and discussion
The research was conducted for a month with an effective lecture that is from Monday until Friday on the 1st until 31st of the March, 2019. Service in the exit lane of the parking area of building 3 FKIP UNEJ there was only one exit used, and there was only 1 service facility. There is no limit regarding the size of the queue, the queue is calculated when at least 2 objects are queued to get service [4]. Based on the results of the study, the queue occurred in Table 2.

Table 2. Queue Schedule that occurs in the Parking Area

| Time       | Monday | Tuesday | Wednesday | Thursday | Friday |
|------------|--------|---------|-----------|----------|--------|
| 08.30 – 09.00 | √      | -       | -         | √        | √      |
| 10.20 – 10.50 | √      | √       | √         | -        | √      |
| 12.10 – 12.40 | -      | -       | √         | -        | -      |
| 14.00 – 14.30 | √      | √       | -         | √        | √      |

Based on the results of the research it was found that the arrival rate value was smaller than the service level, the calculation result was \( \rho < 1 \), so that the queuing system applied to the parking area of students' building 3 FKIP UNEJ was concluded to be stable. The structure of the queuing model applied to the parking area can be seen in Figure 2.
The queuing system that is applied to the parking area in queuing theory is commonly known as Single Channel - Single Phase because there is only 1 queue path and only 1 service stage is available (Figure 2). The queuing rules that are applied to the exit lane of the parking area are the first to queue who will get the first service too, in theory Queues are known as FIFO (First In First Out). Many object queues, time for queues, number of service facilities and length of service affect the size of the model in the queue model.

Figure 2. Queue System Structure Model in the Parking Area

Distribution test is to determine the arrival distribution and time distribution of services applied to the parking area using the Kendall Notation rule. Then, looking for the queue model that is applied to the parking area. The Kolmogorov-Smirnov test was used to obtain the suitability of distribution with the expected distribution of all visits at the exit of the parking area. queues, number of service facilities and length of service affect the size of the model in the queue model.

1. Arrival Distribution Test
   To get a conclusion whether the expected distribution is in accordance with the distribution of observations, then hypothesis testing is done against the output of the results of processing SPSS 17.0 with a hypothesis for the Kolmogorov-Smirnov test as follows:
   \[ H_0 = F_0(x) = S_N(x) \], the arrival population is Poisson distribution
   \[ H_1 = F_0(x) \neq S_N(x) \], the visiting population is not Poisson distribution
   Decision making is based on probability values (Asymp. Sig. (2 tailed)) with a value of \( \alpha = 0.01 \).
   If the probability value is > 0.05 then \( H_0 \) is accepted, conversely if the probability value is < 0.05 then \( H_0 \) is rejected. The arrival distribution test results can be seen in Table 3.

2. Service Distribution Test
   Similar to the arrival distribution test, to get conclusions about the distribution of services that are expected to be in accordance with the distribution of observation, then hypothesis testing is done on the results of SPSS 17.0 processing with a hypothesis for the Kolmogorov-Smirnov test as follows:
   \[ H_0 = F_0(x) = S_N(x) \], the population is exponentially distributed
   \[ H_1 = F_0(x) \neq S_N(x) \], the visiting population is not exponentially distributed
   Decision making is based on probability values (Asymp. Sig. (2 tailed)) with a value of \( \alpha = 0.01 \).
   If the probability value is > 0.05 then \( H_0 \) is accepted, conversely if the probability value is < 0.05 then \( H_0 \) is rejected. The test results of service time distribution can be seen in Table 3.

Table 3. Arrival Distribution Test and Service Distribution Test

| Day  | Time  | Arrival Distribution Test | Service Distribution Test |
|------|-------|---------------------------|---------------------------|
|      |       |                           |                           |
In modelling of a queue, Kendall Notation is needed. The Kendall notation is used to clarify how the queue system reviewed works and is modelled. Kendall notation is shown in \((a/b/c) : (d/e/f)\). Based on the results of the Distribution test of one Kolmogorov-Smirnov sample regarding Arrival Distribution and Service Distribution, the results of observations, the results of interviews, were obtained: \(a\) = Poisson Distribution (M), \(b\) = Exponential Distribution (M), \(c\) = one (1), \(d\) = First In First Out (FIFO), \(e\) = unlimited (\(\infty\)), and \(f\) = unlimited (\(\infty\)). Based on the results of the study found that the queuing model in the parking area is \((M/M/1) : (FIFO/\infty/\infty)\), or can be seen in Table 5. From the calculation of the average arrival rate (\(\lambda\)) and the average level of service time (\(\mu\)) can be calculated the effectiveness of the service queue system in the parking area of the student building 3 of FKIP UNEJ. Parking area service system performance measurements in the queue model \((M/M/1) : (FIFO/\infty/\infty)\) using the POM-QM application for Windows 5. The performance size to be searched is \(P_0\) (in percent), \(U\) (in percent), \(L_s\) (in motorbikes), \(L_q\) (in motorbikes), \(W_s\) (in minutes), and \(W_q\) (in minutes), can be seen in Table 4.

### Table 4. Queue Model and Performance Size in the Queue Model

| Day     | Time       | Queue Model                  | Result |
|---------|------------|------------------------------|--------|
| Monday  | 08.30 – 09.00 | \((M/M/1) : (FIFO/\infty/\infty)\) | 19     |
|         | 10.20 – 10.50   | \((M/M/1) : (FIFO/\infty/\infty)\) | 60     |
|         | 14.00 – 14.30   | \((M/M/1) : (FIFO/\infty/\infty)\) | 19     |
|         | 10.20 – 10.50   | \((M/M/1) : (FIFO/\infty/\infty)\) | 13     |
| Tuesday | 14.00 – 14.30   | \((M/M/1) : (FIFO/\infty/\infty)\) | 4     |
|         | 10.20 – 10.50   | \((M/M/1) : (FIFO/\infty/\infty)\) | 17     |
|         | 12.10 – 12.40   | \((M/M/1) : (FIFO/\infty/\infty)\) | 57     |
|         | 14.00 – 14.30   | \((M/M/1) : (FIFO/\infty/\infty)\) | 12     |
| Wednesday | 12.10 – 12.40 | \((M/M/1) : (FIFO/\infty/\infty)\) | 31     |
|         | 14.00 – 14.30   | \((M/M/1) : (FIFO/\infty/\infty)\) | 27     |
|         | 08.30 – 09.00   | \((M/M/1) : (FIFO/\infty/\infty)\) | 14     |
|         | 10.20 – 10.50   | \((M/M/1) : (FIFO/\infty/\infty)\) | 34     |
|         | 14.00 – 14.30   | \((M/M/1) : (FIFO/\infty/\infty)\) | 22     |

The largest number of arrivals and arrival rates is Thursday 2:00 - 02:30 p.m. Therefore, Thursday 2:00 - 2:30 p.m is used as a sample to test the model with 2 exits. Arrival distribution, service distribution, queue rules, call rules, and queue limits also remain the same as on 1 exit lane.
of the arrival rate on Thursday at 2:00 - 2:30 p.m is 11 people/minute. If you add one more waiting line, the arrival rate will change to half of the previous one, which is 5.5 people/minute. Based on the Table 4, it is found that the value of $P_0$ is 82% so that this can be interpreted that the service is not busy and parking attendants are unemployed. The value of $L_s$ and $L_q$ is only 1, so this causes no queues on the exit line of the parking area. Furthermore, the $W_q$ value obtained 1 second, so it can be concluded that there will be no queue in the exit area of the parking area and $W_s$ value is 5 seconds. Calculation of total costs in the queue system ($T_C$) requires $C_w$ (the cost of waiting for each time unit), $C_o$ (operational costs per unit of time), $L_s$, and many channels ($c$), as follows:

$$T_C = C_w \cdot L_s + C_o \cdot c$$

From the results of interviews obtained, car park area guards work from 7:00 a.m. - 4:00 p.m. and payment for each parking area guard is Rp. 700,000 / month. For 1 lane exit of the parking area: $T_C = $ Rp. 1,300 per 30 minutes and for 2 lines out of the parking area: $T_C = $ Rp. 500,200 per 30 minutes. If you add 1 exit, the parking area guard will increase, so the total cost in the queue system will increase.

4. Conclusion and suggestion

From the results of the analysis and calculation of the results of research in the pathway out of the motorcycle parking area of student building 3 Faculty of Teacher Training and Education Jember University on Monday to Friday it can be concluded that $\lambda < \mu$ so that the queue system is in a steady-state condition. In the Distribution test of one Kolmogorov-Smirnov sample on the Arrival Distribution test and the Service Time Distribution test, it was obtained that the Arrival Time Distribution was Poisson distribution (in the Queue Theory symbolized by M) and Exponential Distribution of Services (in the Queue Theory symbolized by M). There is 1 service line and 1 service stage (Single Chanel - Single Phase) with the queue rule, if the first object is queuing then the object gets the first service as well or in the Queue Theory known as First In First Out (FIFO). So, based on the Kendall Notation rule the queuing model is applied to the parking area after the student motorbike building 3 FKIP UNEJ with (M/M/1) : (FIFO/$c/\infty$).

Based on the calculation of performance measures of the service system in the queuing model are as follows: the percentage of unemployed servants is less than 50%, namely on Monday (08.30 - 09.00 a.m. & 02.00 - 02.30 p.m.), Tuesday (10.20 - 10.50 a.m. & 02.00 - 02.30 p.m), Wednesday (10.20 - 10.50 a.m. & 02.00 - 02.30 p.m), Thursday (08.30 - 09.00 a.m. & 02.00 - 02.30 p.m), and Friday (08.30 - 09.00 a.m., 10.20 - 10.50 a.m. & 02.00 - 02.30 p.m) and the percentage of unemployed servants is more than 50%, namely on Monday 10.20 - 10.50 a.m. and Wednesday 12.10 - 12.40 p.m., the greater the percentage of servants unemployed, the smaller the level of utilization and use of the server, the average number of objects that are in the system and in the queue of more than 5 motors is on Tuesday 10.20 - 10.50 a.m., Wednesday at 02:00 - 02:30 p.m, and Friday 8:30 a.m. to 9:00 a.m., and for the average number of objects in the system and in a queue less than or equal to 5 motors are other days and hours, and, the average waiting time experienced by objects in the system and in the queue is less than 1 minute, with the results of the questionnaire stating 246 out of 261 respondents are able to queue for less than or equal to 1 minute.

From the simulation results by adding 1 more exit lane so that it becomes 2 lanes out of the parking area, it can be concluded that with 1 lane out of the parking area that has been applied it is stated that 1 lane out of the parking area has been effective in terms of cost and service as well as in the queue, if 2 lines out of the parking area are applied then from the calculations obtained need additional costs for parking area guards and additional costs for additional lanes but are more effective in terms of queuing.

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