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Analysis of Queue System to Improve the Quality of Service in Gra PARI Telkomsel Banda Aceh

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Abstract: The problem of queue is how to balance the waiting costs and preventing cost of the queue to gain maximum profit. Queuing analysis can be done by knowing arrival distribution, service time distribution, queue discipline, and queuing model. The purpose of the paper is to calculate the optimal number of servers so users do not wait too long in line, know the queue model in accordance with queuing conditions, and improve the efficiency and performance of servers. In processing data, we are using analysis of distribution and M/G/s queuing method. The result of queuing system performance based on analysis and calculation shows that the queue model is (M/ G/ 8) :(FIFO/∞/∞). The average time the customer waits in the queue is 17.17 minutes and the average service time per customer is 14.39 minutes. Customer is served for 14.39 minutes but before being served it must wait for 17.17 minutes. This condition indicates that waiting time is more than serving time. The system utility level at Gra PARI Banda Aceh is 95.5%, it indicates that utility is so high that it should be repaired to optimize the utility. The waiting time in the queue is 17.17 minutes, the waiting time in the system is 31.66 minutes, and the queue length in the system is 17 people. This will make the bottleneck of customers who will queue before being served. Based on the analysis of the new design, it is known that the addition of 1 server from 8 to 9 servers is the most optimal solution. The addition of 1 server can reduce the system utility up to 84.9% and waiting time in the queue is 2.91 minutes, waiting time in the system 17.4 minutes, and the queue length in the system 9 people. Cost analysis also shows the solution can reduce the cost of queue, so the optimal model has been found in this study. Therefore, optimal queuing conditions can help companies to improve service quality.

Key Words: Queuing system, Queuing model, M/G/8, FIFO, Service quality

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INTRODUCTION

The queuing theory is the people or goods in line waiting to be served or how the company can determine the best time and facilities to serve customers efficiently. The long waiting queues of the customer to get a service shift wasted a lot of time (Hillier, 2012; Kuo & Chen, 2015). Although the company has invested a lot of costs to overcome queuing problems, but not many companies apply the queuing model to calculate the optimal number of servers.

The high number of queues is also indicated by the number of customers who stood waiting for the queue because the seating provided is already full of other customers. Such a scene almost happens every day and its peak point in the afternoon. Even many customers who come eventually have to cancel their visit when they see the high queue. Since this problem has been happening almost daily and is no longer a seasonal phenomenon, it should be resolved soon. The high queue can cause bad experience and this condition can cause switching of customers. The disadvantage for customers is the presence of other activities that will be sacrificed to keep waiting to be served. For company itself will incur losses in the potential customers who will subscribe but cancel because they do not want to wait. So the research question is how to determine the optimal queuing model to improve the quality of service.

Optimization of service system can be determined from the service time, the number of queue channels, and the number of appropriate services by using queuing models (Gross & Harris, 1998). The steady-state size of the service system performance can be obtained from the number of arrivals and service time by calculating the probability of the service system. Kakiay (2004) When using queuing models, many articles use assumptions in the invention of the distribution of arrivals and services, but

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in this study the distributions are identified with statistical models. Therefore, queuing conditions that use the right model can help the company to apply the optimal queue system, so the quality of service can be maintained. As for the problems in this research, they are as follows:

1. What is the optimal number of servers for a good queuing system
2. How to model a better queue to reduce the queue
3. How to improve the efficiency and performance of servers

THEORETICAL REVIEW

The waiting situation is a part of the circumstances that occur in a series of operational activities that are random in a service facility. Customers come to the place at random, irregular time and can not be served immediately so they have to wait long enough. By studying queuing theory, service providers can work to serve without having to wait in a long queue. Kakiay (2004) The distribution of the queue length just before an arrival epoch equals the distribution of the queue length just after a departure epoch. The constraint for this result to be valid is that, with probability one, arrivals, and service completions, occur individually, i.e., not in batches. Boon, Boxma, Kella, and Miyazawa (2017) Service system optimizing can specify the service time, number of queue channels, and the appropriate number of services using queuing models. There are some common models most often used by the company by adjusting the situation and conditions. Single or paralel channel model with arrival distribution is poisson and service time distribution is exponential (M/M/1 or M/M/S, single or paralel channel model with arrival distribution is poisson and service time distribution is constant (M/D/1 or M/D/S), single or parallel channel model with arrival distribution is poisson and service time distribution is general (M/G/1 or M/G/S), single or paralel channel model with arrival distribution is general and service time distribution is General (G/G/1 or G/G/S) (Endang & Risal, 2017; Gross & Harris, 1998).

The art of applied queueing theory is to construct a model that is simple enough so that it yields mathematical analysis, yet contains sufficient detail so that its performance measures reflect the behavior of the real system (Sztrik, 2010). The stationary queue length and virtual waiting time (unfinished workload) have time dependent distributions (Davis & Vollmann, 1990; Xiong, Murdoch, & Stanford, 2015).

Terminology and notation used in this queue calculation are as follows: Pn = probability n customers in system, N = number of customers in the system, Ls = expected number of customers in the system, Lq = expected number of customers in the queue, Ws = waiting time of customers in the system, Wq = waiting time of customers in the queue, λn = The mean arrival rate of new customers in systems, μn = The mean service rate for overall systems. In service systems, it may be the case that two types of customers must be served: one with high holding cost and the other with correspondingly lower cost (Cao & Xie, 2016). Total cost formulated by $TC = Ec(Ci) \times Ev(Cw)$. Expected number of customers in the queue is $Lq = \lambda\ (Wq)$. Waiting time of customers in the system is $W_s = W_q + 1/\mu$ and waiting time of customers in the queue is (Gross & Harris, 1998; Kakiay, 2004)

$$Wq = \frac{\lambda^n \mu^{-2} (\frac{1}{\mu})^{s-1}}{2(s-1)!(s-\frac{\lambda}{\mu})^2 \left[\sum_{n=0}^{s-1} \frac{(\frac{\lambda}{\mu})^n}{n!} + \frac{(\frac{\lambda}{\mu})^n}{(s-1)!(s-\frac{\lambda}{\mu})} \right]} \tag{1}$$

The amount of time customers must spend waiting can significantly influence their satisfaction. Even if the product quality differs, there is a significant weight that is attached to the serving time and this can determine where the customer chooses to get the service. There are costs associated with waiting for the service although they are difficult to measure (Xiao, Zang, & Zhang, 2003).

EMPIRICAL REVIEW

Bonga (2013) compared efficiency levels for the single server model and concluded that improving the rate of serving customers improves customer satisfaction. A comparison with multi-server queuing model was done and the single server model was not found better. Hence a switch from single server to multi server model was encouraged. However, the study recognizes a cost and benefit analysis to be done since the cost side was not evaluated by the study. Toshiba, Sanjay and Anil (2013) converted the M/M/Z/: FCFS model into M/M/1/: FCFS to know which one is more efficient, a line or more lines. Takine (2016) considers a special class of continuous-time Markov chains of level-dependent M/G/1-type, where block matrices representing downward jumps in the infinitesimal generator are nonsingular. Lopatatzidis, De Bock, De Cooman, De Vuyst, and Walraevens (2016) study the robustness of performance predictions of discrete-time finite-capacity queues by applying the framework of imprecise probabilities.

RESEARCH METHODS

1. Arrival and service time distribution is analyzed with statistical method using software easy fit. The distribution type and queue discipline will be used to determine the queuing model.
2. The queuing model used in this research is the M/G/s model.
3. The best model and optimal count of server are determined by simulation technique which is the shortest waiting time in the queue and the lowest queuing cost.

RESULTS AND DISCUSSION

Arrival and service time distribution

Analysis of arrival time and service time distribution is done to determine the queue model according to the distribution pattern (Render & Stair, 2006). Testing the distribution of customer arrival frequency data is done to determine the trend pattern distribution data. The distribution test is performed on arrival frequency data every 15 minutes for 8 hours. Since the arrival frequency data is nominal data, the test is performed for discrete distribution. Based on goodness of fit result from distribution test, where after doing analysis that arrival frequency data have critical value received poisson distributed. Testing the distribution of customer service time data is done to determine the trend pattern distribution data. The distribution test is performed on the inter-arrival time data which has been sorted and made in minutes. Since service time data are ratio data, then the test is done for continuous distribution. Based on the result of goodness of fit from distribution test, where it was shown that service time data have critical values received distributed Lognormal. The distribution test is done statistically and assisted by easyfit software.

Arrival time distribution has a Poisson Distribution, shown in Figure 1 and service time distribution has a Lognormal Distribution, shown in Figure 2.

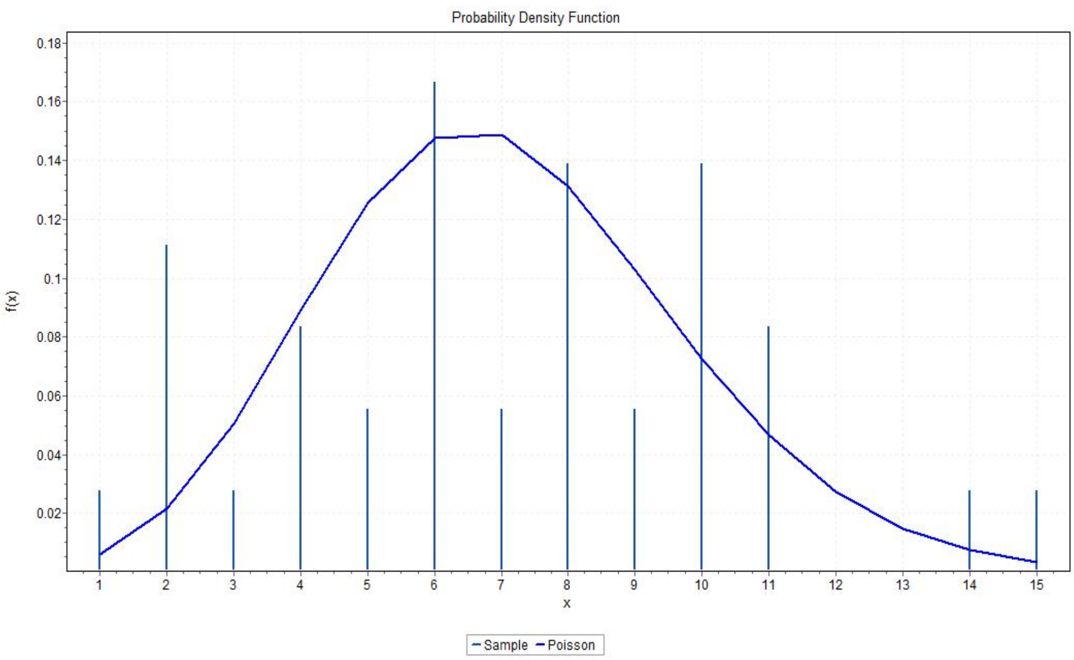

Figure 1. Probability density function of arrival time distribution

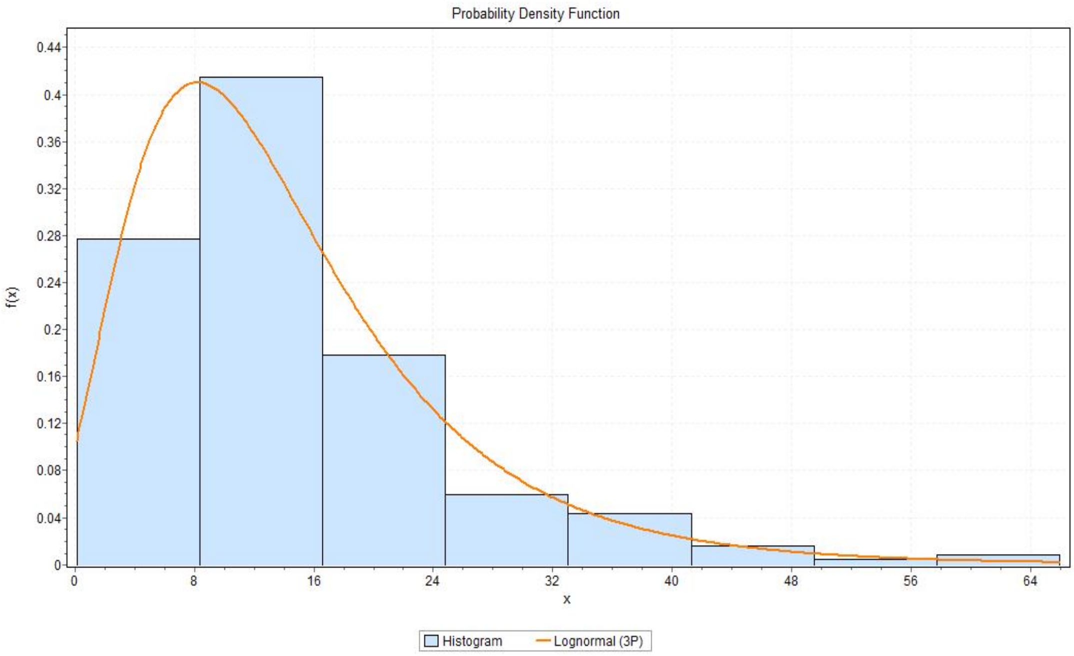

Figure 2. Probability density function of service time distribution

Determine the queue model

Based on the results of the distribution test of both the arrival frequency distribution and the distribution of service time, it can be said that the queue system in GraPARI Banda Aceh follows the model (M/G/8) :(FIFO/∞/∞). The model is a distribution model with arrival frequency distributed Poisson, distribution of arrival time and service of general distribution (Lognormal) and number of servants operating is 8 servers with FIFO queue discipline (first come first served).

Queue system performance and utilization

Queue model formulation and calculations are shown below:

1. The mean arrival rate (λ).

$\lambda = 0.527$ customer per minute.

2. The mean service rate for overall systems (μ).

$\mu = 0.069$ customer per minute.

3. Probability of exactly n customers in the system (ρ).

$\rho = \frac{\lambda}{s\mu} = \frac{0.527}{8\times 0.069} = 0.995$

4. Waiting time of customers in the queue (Wq).

$$Wq = \frac{0.527^8 (0.069)^{-2} (\frac{0.527}{0.069})^{8-1}}{2(8-1)!(8-\frac{0.527}{0.069})^2 \left[\frac{(\frac{0.527}{0.069})^0}{0!}+\frac{(\frac{0.527}{0.069})^1}{1!}+\frac{(\frac{0.527}{0.069})^2}{2!}+....+\frac{(\frac{0.527}{0.069})^8}{(8-1)!(8-\frac{0.527}{0.069})}\right]} = 17.17 \text{ minute}$$

5. Waiting time of customers in the system (Ws)

$Ws = Wq + 1 / \mu = 17.17 + \frac{1}{0.069} = 31.66$ minute

6. Expected number of customers in the queue (Lq).

$Ls = \lambda\ (Ws) = 0.527\ (34.49) = 18.17 \approx 18$ customers.

7. Expected number of customers in the system (Ls).

Lq $= \lambda\ (Wq) = 0.527\ (17.7) = 9.05 \approx 9$ customers.

8. Cost Analysis of Queue

$TC = Ec(Ci) \times Ev(Cw) = 0.36$ (Rp 5.500.000) $\times 17.17$ (Rp 208 x 5.483) = Rp 21.569.810

Improvement of the queue system performance

The average time the customer waits in the queue is 17.17 minutes and the average service time per customer is 14.39 minutes. Customer is served for 14.39 minutes but before being served it must wait for 17.17 minutes. This condition indicates that waiting time is more than serving time. The system utility level at GraPARI Banda Aceh is 95.5%. It indicates that utility is so high that it should be repaired to optimize the utility. The waiting time in the queue is 17.17 minutes, the waiting time in the system is 31.66 minutes and the queue length in the system is 17 people. This will make the bottleneck of customers who will queue before being served. The simulation of the improving count of servers is shown in the Table 1 below. Customer perception through questionnaire shows that 66% were not satisfied with queuing conditions, 29% felt normal and 5% were satisfied. In case of count of customer in system, there are 84% who felt that the number of customers in GraPARI Banda Aceh was overwhelming, 15% felt normal and 1% felt slightly. The customer income has shown that 46% have income below IDR 2.5 million.

Customer perceptions also show that the number of customers in GraPARI Banda Aceh is overwhelming and is not satisfied with the condition of the queuing system. This will certainly be a bad impact on customers as well as on Telkomsel itself. There are also customers who often cancel visits because of the high queue that occurrs. It is certainly very unfortunate considering many of the customers who do not have a flexible time to be able to come back. It will be a factor that will affect customers switch to another competitor.

Cost analysis also shows that the total cost incurred due to the queue condition is very large which is about 21.50 million rupiah per month. The fee comes from fees by customers or by Telkomsel. The total cost has not been added to the loss due to psychological factors that dampen the spirit of the customers as they spend a lot of time waiting. Based on the analysis, it must be improved from the queuing system. Repairs can be done by adding or reducing the number of servers. This is due to impossible restrictions on the number of customers who will come to Gra PARI. After performing analysis for queuing conditions in the old system, the design of a new system will be done with the consideration of the addition or reduction of the number of servers. The results of the calculation of queue parameters for the queue system are as follows.

Table 1: Performance comparison of number of servers count of server

Parameter	7	8	9	10	11
λ	0.527	0.527	0.527	0.527	0.527
μ	0.069	0.069	0.069	0.069	0.069
s	7	8	9	10	11
P	109.1%	95.5%	84.9%	76.4%	69.4%
Wq	-14.68	17.17	2.91	1.02	0.42
Ws	-0.19	31.66	17.40	15.51	14.91
Lq	-7.74	9.05	1.53	0.54	0.22
Ls	0	17	9	8	8
Queuing cost	20,250,211	21,569,810	10,810,203	14,157,934	18,968,002
Result	Not steady state	Steady state	Steady state	Steady state	Steady state

Discussion

The art of applied queueing theory is to construct a model that is simple enough so that it yields mathematical analysis. Sztrik (2010) Optimization of service system can be determined from the service time, the number of queue channels, and the number of appropriate services by using queuing models (Gross & Harris, 1998). When using queuing models, many articles use assumptions in the invention of the distribution of arrivals and services (Lopatatzidis et al., 2016), but in this study the distributions are identified with statistical models. Therefore, queuing conditions that use the right model can help the company to apply the optimal queue system, so the quality of service can be maintained. The steady state size of the service system performance can be obtained from the number of arrivals and service times by calculating the probability of the service system.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The performance of the queuing system indicates that the customer is served for 14.39 minutes but before being served it must wait for 17.17 minutes. The condition shows that there is longer waiting time in the queue compared to the time served. The research found that the most optimal number of servers to reduce the queue is by adding 1 server to a total of 9 servers in customer service of GraPARI Banda Aceh. Increasing the number of these servers can help reduce the costs caused by the queue. Better queue model for queuing system in GraPARI Banda Aceh is (M/G/9): (FIFO/∞/∞). The performance and quality of service can be improved by increasing the number of servers to 9 and all servers working normally and performing services in accordance with the predefined standards. It is shown when the addition of servers from 10 and 11 resulted in increasing costs compared to 9 servers. Server reduction to 7 servers is not recommended, as the reduction leads to non steady state of p conditions (conditions where the system can no longer serve existing customers).

Recommendations

Looking at the research results, suggestions that can be given are as because of the many distribution patterns of arrival time and service time, it is necessary to have further research on queue analysis with lognormal distribution and the others without using general distribution formulation. Due to the very limited computerized applications that can accommodate the calculations for the queue model that the service time is generalized, it is necessary to develop computer applications that accommodate all types of distribution so that it can be compared to the results of manual calculations by computer simulation. Due to the vastness of queuing applications in the telecommunication business, especially Telkomsel, it can be developed as a queue application with priority system, provision of online queue booking application, and an online customer service performance appraisal system as well as provision of additional facilities in queue.

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— This article does not have any appendix. —