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Research.

ANALYSIS OF COMMUTER LINE TICKET PURCHASE QUEUING SYSTEM IN BOGOR STATION

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***Abstract**. Queue is a situation that happen to people, goods, and components that need to wait to get a service. The good quality of service will satisfy the customers and decrease the queue line. Queue often happens in a station especially in weekdays. A long queue line happens in the station is one of the problems that need to be solved. Instead of manual ticket purchasing that served by the operator, today PT KAI Commuter Line also serve ticket purchasing using THB machine. The purpose of this study is to compare the performance of queuing model that happen in Bogor station locket and to determine if the queuing model is efficient by comparing the service standard, between the manual and the one that used THB machine. The method used in this research was descriptive method by using queuing theory calculation. The model of locket queuing using THB machine in Bogor Station is Multi Channel-Multi Phase, in ticket purchasing using THB machine. Besides, in the operator locket service, the queuing model is Single Channel-Single Phase. Both s ticket purchasing service use First In First Out (FIFO) disciple. The maximum amount of the queue line and the source of customers' arrival are infinite. Based on the value of system performance can be concluded that queuing system and the service given already great and effective (based on the performance measure and probability or passengers'' chances), passengers who are waiting to buy tickets, either manual or using machine less than 1, or assumed 1 person. From the observation, the use of THB machine decrease the queue line, but need to be socialized because passengers does not know how to use THB machine to buy ticket independently.*

Keywords: queue, queuing model, commuter line ticket purchasing, Bogor station

INTRODUCTION

The phenomena of queue problem, especially in Indonesia become the main problem that often happen daily. The phenomena of waiting is the direct result of random public service operation tools. Generally, the customers' arrival and the repairing time are unknown before, because if we know those things before, the tools operation can be scheduled to omit the needs of waiting (Taha, 1996) and Kakiay (2004). One of the places that cannot be separated from queuing problem is in a train station. Many people use train service to go to another places. A train is faster than a bus. This make people prefer to use a train than a bus.

Considering the rhythm of life in Jabodetabek (Jakarta Bogor Depok Tangerang Bekasi) that require faster yet cheaper transportation service, train, in this case Commuter Line that managed by PT KAI Commuter Line, chosen by the people. By August 2017, the average amount of KRL users each day touch 993.804 users in weekdays, and the highest users in a day is 1.065.552 (www.krl.co.id).

In Bogor Station, the average amount of Commuter Line passengers in weekdays is 90 thousand to 100 thousand people. In the weekends on Saturday and Sunday, the amount decreasing to 80 thousand people. The amount of Commuter Line trips that arrive and depart from Bogor Station is 350-360 trips each day to Jakarta Kota, Jatinegara, and Depok (Interview Antara with Head of Bogor Station / Sugiharto on April 2017-

https://megapolitan.antaranews.com https://megapolitan.antaranews.com). From the data, every day Bogor Station is always crowd by tickets' purchasers. This condition can be seen in the ticket service lockets either Manual Ticket Purchasing Locket (with the service of the operator of PT KAI) that use Daily-Paid Ticket and Multi Trips Card, or THB machine locket. The service delivery to the customers should be fast and responsive so that the customers do not need to waste their time in the queue line.

The time of service that the customers get might be different one to another based on the speed of the service operator and also the amount of the service facilities provided. The ability and the amount of the operator also give impacts toward the continuity of ticketing services. Because the passengers' arrival and the service time are unpredictable (random), the service operation cannot be scheduled before.

To solve that problem, the queuing theory approach is used by determining the model and measurement of the queuing performance system in Manual Ticket Purchasing Locket both Daily-Paid Ticket and Multi Trip Card and also THB machine in Bogor Station so they can improve the station service.

The purposes of this research are:

1. To determine the suitable model to illustrate the condition in Commuter Line Ticket Purchasing Locket (THB machine and manual).
2. To compare the queuing performance system in Commuter Line Ticket Purchasing Locket (THB machine and manual).

LITERATURE REVIEW

Queuing Theory

Kakiay (2004) said that the purpose of queuing theory is to investigate the activity in service facility in a random condition in a queuing system happen. The basic purpose of queue models is to minimize the total of two costs, direct service facility provider cost and indirect cost that followed because customers need to wait to be serviced. If a system has more than optimal facility service required, means that they need more capital investment, but id the amount of service facility is less than the optimal amount, it means that the service is delay.

Factors that influence the queue line and services (Kakiay, 2004) are:

1. Arrival Distribution
   a. Single arrivals
   b. Bulk arrivals
   Both components should be noticed in the design of service system.
2. Service Time Distribution
   a. Single service
   b. Bulk service
3. Service facility
   a. Series form, in a line or circular.
   b. Parallel form, in several series and parallel line.
   c. Station circuit form, can be designed series with more than one service in each station. This form also can be done in parallel form with different stations.
4. Service Disciple
   Service disciple divided into 4 forms:
   a. FCFS (first come first service)
   b. LCFS (last come first service)
   c. SIRO (service in random order)
   d. Priority service, means that the service only given to special customers (VIP customers)
5. Queuing Measurement
   a. Infinite queue

b. Finite queue

6. Calling Source

In a service facility, the calling source can be machine or human. If some machine do not work well, the calling source will decreasing and cannot serve the customers.

Kendal Notation

Kakiay (2004) mentioned that the combination form of arrival process with service is known as standart:

(a/b/c) : (d/e/f)

The symbol a, b, c, d, e and f are the basic components from queue line model, with:
a = arrival distribution
b = service time departure
c = the amount of parallel service (c= 2,3 ,…, ∞)
d = service disciple, like FCFC, FIFO, LCFS, SIRO, or PR
e = the maximum amount of system allowed (queue and system)
f = the amount of customers who enter the system as sources

Poisson Distribution

Gross and Harris (1998) said that if the arrival frequency of a variable random following the Poisson distribution, the inter arrival time following Exponential distribution.

Evidence:

f (t) = density probability function inter arrival interval time t successive events , t ≥ 0.

F (t) = cumulative function t.

If T is a random variable that stated the time interval successively, then:

$\mathrm{P}\{T \geq t\} = \mathrm{P}$ P {no arrival in t time} = $P_0(t) = e^{-\lambda t}$

Then, F(t) as a cumulative distribution function from T, obtained:

$$F(t) = \mathrm{P}\{T \leq t\} = 1 - e^{-\lambda t}$$

So the density function:

$$f(t) = \frac{dF(t)}{dt} = \lambda e^{-\lambda t}$$ for λ> 0, 0 < t < ∞

If the successive time arrival interval follows the exponential distribution with the average of $1/\lambda$ then the amount of events in a period in a time must be Poisson distribution with the average of arrival λ.

Model (M/M/c):(GD/∞/∞)

In this model, the customers of PT KAI Commuter Line in Bogor Station arrive with constant rate λ and maximum n ticket purchaser served at the same time. Rate of service per service is μ, then the average of effective arrival rate: . where the effective arrival rate is not depend on the arrival frequency in the system (Taha, 1996).

Gross and Harris (1998) stated that if $r=\lambda/\mu$ and $\rho=r/c=\lambda/c\mu$ □ service probability when there is no ticket purchaser is:

$$P_0 = \left\{ \sum_{m=0}^{c-1} \frac{(c\rho)^m}{m!} + \frac{(c\rho)^c}{c!\,(1-\rho)} \right\}^{-1}$$

The probability for *n* ticket purchaser is:

$$P_n = \frac{P_0}{c!\,c^{n-c}} \left(\frac{\lambda}{\mu}\right)^n = \frac{\lambda^n}{c!\,c^{n-c}\,\mu^n} P_0$$

Thus, the measurement of performance system for model (M/M/c) : (GD/∞/∞) can be stated as:

1. Ticket purchaser frequency estimated in a queue line

$$L_q = \left(\frac{r^c \rho}{c!(1-\rho)^2} \right) P_0$$

2. Ticket purchaser frequency estimated in a system

$$L_s = L_q + r$$

$$L_s = \left(\frac{r^c \rho}{c!(1-\rho)^2} \right) P_0 + r$$

3. Waiting time estimated in the rule

$$W_q = \frac{L_q}{\lambda} = \left(\frac{r^c}{c!(c\mu)(1-\rho)^2} \right) P_0$$

4. Waiting time estimated in the system

$$W_s = \frac{1}{\mu} + W_q$$

Model (M/G/1):(GD/∞/∞)

Model (M/G/1):(GD/∞/∞) or The Pollaczek-Khintchine (P–K) is a formula that obtained in single service situation that meet the three assumption below:

1. Poisson arrival with the arrival average λ
2. General time service distribution with average service expectation $E[t]=\frac{1}{\mu}$ and variant var[t].
3. Steady state situation with $\rho = \lambda E\{t\} < 1$ or

$$\rho = \frac{\lambda}{\mu} < 1$$

$$\text{With } E[t] = \frac{1}{\mu} \text{ and } \rho = \frac{\lambda}{\mu}, \text{ so : } L_s = \rho + \frac{\rho^2 + \lambda^2 \operatorname{var}(t)}{2(1-\rho)}$$

The equation above is known of P-K formula :
L_s = ticket purchaser frequency in system
λ = the average of ticket purchaser arrival
E[t] = time service expected

RESEARCH METHOD

The data used in this research is primer data that have been taken from the observation conducted in Bogor Station. The research was conducted in weekdays, from Monday to Friday, October 23rd – 27th 2017 at 07.00-10.00 (the data was taken for 5 days). The data taken were arrival frequency, arrival time interval, service frequency, and service time. The assumption is the arrival process and the service in the same day and considered to represent the population in the other days.

The analysis steps that been used to reach the purpose of the study can be stated below:

1. Decide the theme to discuss, and then decide the place and the method of the research.
2. Do the research directly in the place that already decide previously. The data taken were arrival frequency, ticket purchaser arrival time interval, service frequency, and ticket purchaser service time in time that researcher choose (the researcher choose in hour).
3. Determine the queuing model that suitable to the data.
4. Determine the measurement of performance system, the amount of ticket purchasing in queue line (Lq), the amount of ticket purchaser in system (Ls), waiting time in queue (Wq), and the waiting time in system (Ws).
5. All the result data of the research processed using Software QM for Windows version 5.2.
6. Create the discussion of the result from the performance service measurement obtained and determine the new model.
7. Conclude the ticket service system in Bogor Station.

RESULT AND DISCUSSION

Queuing System Model

From the result of steady-state analysis, performance service measurement, and the matching test of arrival distribution and ticket purchaser service obtained that the queuing system model in ticketing service in Bogor is:

Table 1 Queuing System Model

Manual queuing ticket purchasing Single, single, 1 line, FIFO, infinite	Model (M/G/1):(GD/ ∞/∞) or well known as *The Pollaczek-Khintchine* (P–K)
THB machine ticket purchasing Multiple, 12 lines, 12 lines FIFO, infinite	Model (M/M/c):(GD/∞/∞)

Source: Observation Result, 2017

Performance System Measurement

THB machine ticket purchasing/ Independent

Below is the result of the processed data from the research using software QM for Windows version 5.2 for ticket purchasing using THB machine/ Independent. The amount of the machines are 12 pieces, considered as 12 queue lines, passengers in and out independently, with FIFO service system.

Table 2 Result of Data Processed using QM for Windows Parameter Ticket with THB

QM for Windows - [Data] Results

simulasi dulu solution

Parameter	Value		Parameter	Value	Minutes	Seconds
M/M/1 (exponential service times)			Average server utilization	,02		
Arrival rate(lambda)	5		Average number in the queue(Lq)	,08		
Service rate(mu)	20		Average number in the system(L)	,33		
Number of servers	12		Average time in the queue(Wq)	,02	1	60
			Average time in the system(W)	,07	4	240

Source : Data Primer Proceed, 2017

Annotation:
Ls : ticket purchaser frequency estimated in system
Lq : ticket purchaser frequency estimated in queue line
Ws : waiting time estimated in system
Wq : waiting time estimated in queue line
P0 : probability of the amount service when there is no purchaser arrive

From the table above can be seen that:

Average frequency of ticket purchaser estimated in queue line / Lq is 0.08 or assumed as 1 person, the average frequency of ticket purchaser estimated in system / Ls is 0.33 or assumed as 1 person.

The waiting time average estimated in system / Wq is 1 minute and 60 seconds, the waiting time estimated in queue line / Ws is 4 minutes and 240 seconds.

From the data that obtained in 5 weekdays, the value of ρ , as mentioned in the table is 0.02 or 2%. The value of usability level is less than one, it means that the average of arrival rate of ticket purchaser is no more that the average rate of service so that this condition meet the steady state condition.

Table 3 Ticket Probability using THB

simulasi dulu solution

k	Prob (num in sys = k)	Prob (num in sys <= k)	Prob (num in sys >k)
0	,98	,98	,02
1	,02	1	0
2	0	1	0
3	0	1	0

Source : Data primer proceed, 2017

In the probability table above can be seen that when k=0, the probability there is no passanger in waiting system to purchase ticket is 0.02 (Prob column (num is sys)).

THB Machine Ticket Purchasing / Independent

Below is the processing result of the research using software QM for Windows version 5.2 for ticket purchasing using THB machine/independent. The amount of the machine is 12 pieces, considered as 12 queue lines, the passengers in an out independently, using FIFO service system.

Table 4 result of data proceed QM for Windows Parameter Ticket Manually

QM for Windows - [Data] Results

Perbandingan Solution

Parameter	Value		Parameter	Value	Minutes	Seconds
M/M/s			Average server utilization	,04		
Arrival rate(lambda)	10		Average number in the queue(Lq)	0		
Service rate(mu)	20		Average number in the system(L)	,5		
Number of servers	12		Average time in the queue(Wq)	0	0	0
			Average time in the system(W)	,05	3	180

Source: Data Primer proceed, 2017

The data above showed that:

The average frequency of ticket purchaser estimated in queue line / Lq is 0 or assumed that there is no purchaser queuing in the line, the average frequency ticket purchaser estimated in system / Ls is 0.5 or assumed as 1 person.

The average of waiting time estimated in system / Wq is 0 minute, the average of waiting time estimated in queue line / Ws is 3 minutes and 180 seconds.

From the data obtained in 5 weekdays, the value of ρ is gained, as stated in the table as 0.04 or 4%. The value of usability level is less than one, it means that the average arrival ticket purchaser is not more that the average rate of the service, so that this condition meet the steady state condition.

Table 5 ticket probability manually

Perbandingan Solution

k	Prob (num in sys = k)	Prob (num in sys <= k)	Prob (num in sys >k)
0	,61	,61	,39
1	,3	,91	,09
2	,08	,99	,01
3	,01	1	,0
4	,0	1	0
5	0	1	0
6	0	1	0

Source: Data Primer proceed, 2017

From the probability table above, can be seen that when k=0, the probability is there is no passenger in the system who is waiting for ticket purchasing as 0.39 (Prob column (num is sys)).

The recapitulation of the two ticket purchasing performance services can be seen in Table 6 below:

Table 6
Recapitulation of ticket purchasing performance services using THB machine and manually

Service Type	Utility	Lq	Ls	Wq	Ws	Probability
Ticket Purchasing using THB Machine	0,02	0,08	0,33	0,02	0,07	0,02
Ticket Purchasing Manually	0,39	0	0,5	0	0,05	0,04

Source: Data Primer Proceed, 2017

From the table 6 above, can be seen that the measurement of performance system is already great, strengthen by the probability and passengers' chance to wait for the ticket purchasing, either using machine or manually is less than 1, or assumed 1 person. Generally, the queuing and service system given in Bogor Station is good and effective.

From the observation, the use of ticket purchasing using THB machine decrease the queue line. Based on the informal interview that the researcher conducted to 10 passengers queuing in the manual ticketing locket, they have to queue manually because they do not know how to buy ticket using THB machine. According to the researcher's observation, there is no operator stand by around the THB machine to tell the customers how to use the THB machine. In this case, PT KAI Commuter Line, especially in Bogor Station should do the socialization or give guidance to the passengers in using THB machine to purchase ticket.

CONCLUSION AND SUGGESTION

Based on the result and the analysis of the research data in Bogor Station:

1. Queuing model in ticket purchasing using THB model is Model (M/G/1):(GD/ ∞/∞) or known as *The Pollaczek-Khintchine* (P–K), single, single, 1 line, FIFO, infinite. Besides, the queuing model in ticket purchasing manually is Model (M/M/c):(GD/∞/∞), multiple, 12 lines, 12 lines, FIFO, infinite.
2. Based on the measurement of the performance system ca be concluded that the queuing system and service given are good and effective (seen from performance measurement and probability or passengers' chance), passengers who wait to purchase ticket, either manually or using machine is less than 1, or assumed 1 person.

Suggestions based on the research is from the observation conducted, the use of ticketing service using THB machine decrease the length of the queue line, but need to be socialized over again because many passengers have no idea how to use THB machine to purchase ticket independently.

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