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Implementation Kolmogorov-Smirnov Method on Queue System Simulation

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Abstract

Long queue always happen as main problem in re-registration of new students who passed the NewRegistration Student (NRS). The long queue makes the queuing system crowded and cannot be controlled properly. This research is aimed in knowing the model, process simulation model and how to use the method of Kolmogorov-Smirnov of system for re-registration of new students. The method is suitable on how to solve long queue system with new model and simulation. The proposed method is implemented in Senior High School in Padang, West Sumatera, Indonesia. The result of this research shows that after we divided queuing post 1 into two sub-posts namely post 1a and 1b on the first day and we note that average long applicants waiting at post 1a and 1b are smaller i.e. 2.3 minutes and 2.8 seconds as previously for 15 minutes. Furthermore, we divided queuing post 2 into 2 sub-posts namely post 2a and 2b on first day note that average long applicants wait at post 1a and 1b are smaller i.e. 0.2 minutes and 0.2 minutes as previously for 32 minutes. It can be concluded that the solution to the registration posts can make an average registration time waiting to be smaller.

Keywords: Modeling; Simulation; Shortest; Queue System; Kolmogorov-Smirnov method.

1. Introduction

The following is a guide to writing research paper in The process of New Registration Student (NRS) On-Line performed during 6 days. That system sorting and selecting appropriate against students who register based on the results of Final School Score (FSS) of students and also a selection of the school was chosen by the students. After the students is stated received in that school, the students are required to re-register at that school. Re-registration process conducted at the school where the students were accepted with supplement the terms set by each school. State High School (SHS) 4 Padang is one of the high schools are public schools that are in the city of Padang is one of the organizers of NRS On-Line. The SHS 4 Padang also holds re-register for the students who are accepted at SHS 4 Padang. The SHS 4 Padang set several conditions which should be met by students who re-register. Requirements to re-register them are as follows:

- Submit the proof of registration of NRS On-Line in the form of a print-out NRS on-line
- Pay for the construction fee of schools and Emotional Spiritual Quotient (ESQ) training
- Pay for the school uniform including uniform white and gray, scout, batik, religion clothes and sports
- Select the size of the clothes that have been ordered

To simplify and speed up the re-registration process in SHS 4 Padang, the schools provide 4 post. The first

post is used to receive the proof of registration of NRS On-Line in the form of a print-out NRS on-line, The second post is used to serve the construction fee of schools and ESQ training, The third post is used to serving the school uniform including uniform white and gray, scout, batik, religion clothes and sports, and the fourth post is used to select the size of the clothes that have been ordered. Every student must do the registration by sequence with complete terms on post one then continued to post two and then post three and the last post four without any post that check is by passed. The re-registration of new students of SHS 4 Padang in 2013 was serving the student for 280 students. Re-Registration process opened for 4 days starting from 09.00 am until 15:00 am. On any post registration placed 1 person officer re-registration that will serve students. Because of the time to register is very short and the officer of registration is limited and many students perform re-registration then definitely would happen long enough queue in registration process restarted. One of the ways can to resolve the problem of these queues is to create models that can describe the real system of new student re-registration. By trying a variety of models and simulate each model so the school could find out the weaknesses of the system so that it can take the most appropriate actions that the queue happens to be minimal possible. Based on real conditions, the situation that has happened so far and wishes the author to seek a way out of the problem then the writers will conduct research under the title Modeling and Simulation of Shortest Queue System with Kolmogorov-Smirnov Method [1,2].

Based on the issues raised in the background above, the formulation of the problem in this research are: First, how to make a proper model for the system of new re-registration student, second how to simulate the model that corresponds to the real system at new student re-registration queue and third how to use the method of Kolmogorov-Smirnov to simulate queueing system at new students re-registration. In summary, the contributions of this work are given as follow:

- a. Firstly, this research proposed a model that is created by using a computer that represents the real system queuing symbol.
- b. Secondly, the model proposed and simulation on the study carried out using the computer used Pro-model software 7.5.
- c. Thirdly, the method used in this simulation is the Kolmogorov-Smirnov method.
- d. Finally, the modeling and simulation on the study specifically on the system queues the new student re-registration NR Son-line at SHS 4 Padang.

This paper is organized as follows: Literature review of this paper is discussed in section 2. Methodology used in this paper discussed in section 3. The result and discussion of research of this paper are discussed in section 4. Finally the conclusions of his paper are given in Section 5.

2 Research Method

In general, queueing phenomena occur when some kind of customers, desiring to receive some kind of service, compete for the use of a service facility (containing one or multiple servers) able to deliver the required service. Most queueing models assume that a service facility delivers exactly one type of service and that all customers requiring this type of service are accommodated in one common queue. If more than one service is needed, multiple different service facilities can be provided, i.e., one service facility for each type of service, and individual separate queues are formed in front of these service facilities. In all such models, customers are only hindered by customers that require exactly the same kind of service i.e. that compete for the same resources [1]. Appointment delay is the time elapsed from the moment a customer requests an appointment until the actual appointment time scheduled for that customer. Service delay is the time elapsed from the time a customer arrives at the service facility (the appointment time if he is punctual) until the time when he is actually served. Service providers prefer to keep appointment intervals short in order to minimize the server idle time. However, short appointment intervals tend to cause congestion in the waiting room, which results in long direct waiting times. On the

other hand, if appointments are scheduled sparsely, customers may encounter long indirect delays. One of the main problems associated with long indirect delays is that they typically lead to high no-show rates [2]. Queueing models for servers with interruptions have been previously studied. However, all those works have considered a server with a time-invariant service rate and server interruption rate. Two-class preemptive queueing models have been proposed for OSA networks where the CR server interruptions are modelled as the busy periods of the preemptive primary traffic. With this approach, the server is considered time-invariant with a constant service rate and interruption rate. Furthermore, it is not straightforward to use those models to study OSA networks with generally distributed operating and interruption periods [3]. A more elementary solution of the Shortest Queuing problem was obtained by Adan, Wessels and Zijm, first for the symmetric case and later for the asymmetric case. They obtained in both cases the solution as an infinite mixture of geometric distributions as described [4].

The appropriate mixture is chosen so that all the boundary conditions are satisfied for the forward Kolmogorov equation for this Markov chain. The basic method used in and is called the compensation approach, which is surveyed more thoroughly in and has been used also on many other models [4]. Modeling such a process can help answering the question of how a system should be designed, in which requests arrive at random time points. If the system is busy, then the requests queue up, therefore, if the queue gets too long, the users might experience bad delays or request drops, if the buffers are not big enough. From a capacity planner point of view, it is important to know how build up a system that can handle requests that arrive at random and are unpredictable, except in a probability sense [5]. There are some other aspects that are necessary for business process simulation. The simulation requires a more detailed business process analysis, investigation in the duration of activities and incoming workflow, which is not described in the standard business process model. It is necessary to investigate the duration of the activity and to explore a workflow. Activities of programmatically submitted simulation models need to be represented as processes with certain parameters, resources, attributes, and relationships. It must contain all relevant information about the activities because simulation is a representation of the mathematical calculations to a certain level. It requires the simulation engine and tool or software code, which can use this engine in order to simulate the model [6]. The Kolmogorov-Smirnov test (hereafter the KS test) is a much used goodness-of-fit test. In particular, it is often employed to test normality, also in climate research. Normality tests are important for at least two reasons. First, nonlinearity and interacting physical

processes usually lead to non-Gaussian distributions, and the generating mechanism of the processes can therefore be better understood by examining the distribution of selected variables. For instance, Burgers and Stephenson (1999) test for the normality of the amplitude of the El Niño–Southern Oscillation (ENSO) using moment estimates of skewness and kurtosis. Such moments can be used to diagnose nonlinear processes and to provide powerful tools for validating models [7]. A second reason for implementing normality tests is that many statistical procedures require or are optimal under the assumption of normality, and it is therefore of interest to know whether or not this assumption is fulfilled. A recent example of such a use of a normality test is given in Sanders and Lea (2005) in their study of hurricane activity. Of course it may also be of interest to test for the presence of other specific distributions, as in Mohy montet *al.* [9] who has studied extreme value distributions [7]. The Kolmogorov–Smirnov test (K–S test) is a nonparametric test which can be modified to test goodness of fit. A Pareto distributed random variable can be transformed to an exponential distributed variable. The specific case of testing for an exponential distribution using the K–S test has been thoroughly investigated also when the parameter is unknown and estimated. The basic concept of Kolmogorov Smirnov test for normality is to compare the distribution of the data with a normal distribution of fixed. The normal distribution is the raw data that has been transformed into the shape of a Z-Score and is assumed to be normal. So in fact a test of Kolmogorov Smirnov test is the difference between the tested data normality with normal raw data, as in a regular, if different from the test of significance below

0.05 means there is a significant difference, and if the above 0.05 significant threshold does not occur a significant difference [8]. Many data analysis methods depend on the assumption that data were sampled from a normal distribution or at least from a distribution that is sufficiently close to a normal distribution. For example, one often tests normality of residuals after fitting a linear model to the data in order to ensure that the normality assumption of the model is satisfied. Such an assumption is of great importance because, in many cases, it determines the method that ought to be used to estimate the unknown parameters of a model and also dictates the test procedures that analysts may apply [9].

There are several tests available to determine whether a sample comes from a normally distributed population. Those theory-driven tests include the Kolmogorov–Smirnov test [10,11], Anderson–Darling test [12,13], Cramer–von Mises test [14,15], Shapiro–Wilk test [16,17], Shapiro–Francia test [18,19]. The first three tests are based on the empirical cumulative distribution. The Shapiro–

Francia test is specifically designed for testing normality and is a modification of the more general Shapiro–Wilk test. There are also tests that exploit the shape of the distribution of the data. For example, the widely available Jarque–Bera test [20,21] is based on skewness and kurtosis of the data. Similar research has been done previously only reveals how the simulation was done and how the model is created. While in this study revealed how to manipulate data so that a known frequency distribution of data and the simulation method using the Kolmogorov–Smirnov. With this method, we can use some data to simulate with the result that the shortest queueing of a model queueing system [22].

These steps include research from the beginning up to the end of the study. Research on the framework, namely:

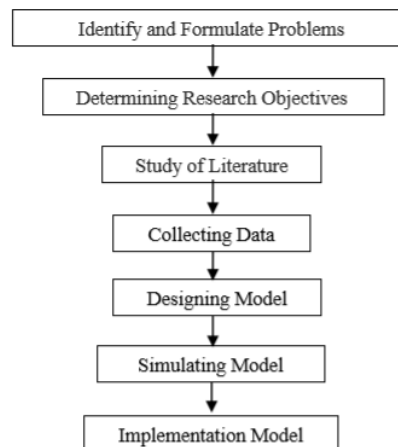


Figure. 1 Framework of Research

In Figure 1, there are seven steps that are performed in this research. First step in this research is to identify, formulate and limit problems. We identify the problem that appear in the queueing system in order to this research is really discussed real problem in system. Then we formulate the problem into three formulations in order to research can find conceptual conclusion after that we give limitation the problem in order to research is not going out of the problem. Second step is determining research objectives. We determine research object so that it can be useful to many people. Third step is study of literature so that the research based on theoretical background. Fourth step is collecting the data that will be process into simulation. Fifth step is designing the model so that the system can be simulated with computer. Sixth step is simulating the model. We simulate the model so that chose the best model from several alternative models. Seventh step is implementation the model, we implementation the best model in real system. The technique is used in collecting data in this study was

observational data and interview techniques (See Table 1).

Table. 1 Data Collection Form

Queue	Service Open	Service	Departure	Service	Service Finish	Service Closed
1	09.00	-	-	-	-	15.00
2	09.00	-	-	-	-	15.00
....	09.00	-	-	-	-	15.00
n	09.00	-	-	-	-	15.00

The data is collected from all students. The data collection form is filled by four people who were sitting on post 1, post 2, post 3 and post 4 after that they wrote the data in that form at time 09:00 until 15:00 for four days. The four people are the independent volunteers of this research. On column 1 there is data of queue number, column 2 is data of service open time, column 3 is data of service officer,

column 4 is departure time, column 5 is service long, column 6 is service finish time and column 7 is service closed time. The model describes the actual shape of objects/tools, systems are emulated and referenced. The model referred to in this research is a model of queuing system new students re-registration passed NRS on-line at SHS 4 Padang.



Figure. 2 Model of Re-Registration of SHS 4 Padang Who's Passed NRS On-Line

In Figure 2, we can see there are four posts in the real student re-registration process. The four posts are post 1, post 2, post 3, and post 4. The process is done on each post varies depending on the post without bypassed. Before post 1 the student should take queuing if the registrant is too many than the

student should waiting for long time and then go to queuing post 2, post queuing 3 and queuing post 4. The waiting time depends on the number of registrant at same time and service time each student. The process is done on each post varies depending on the post without bypassed. Before post 1 the student should take queuing if the registrant is too many than the

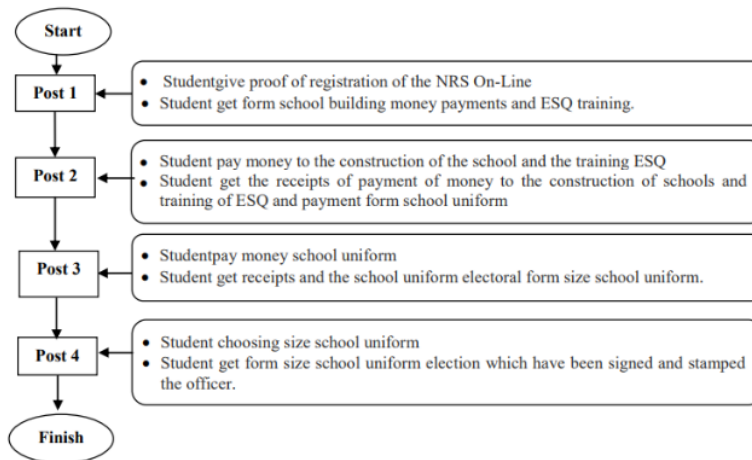


Figure. 3 Flowchart of Each Post Process

From Figure 3, the process on each post is different depending on its function. Those processes are:

Post 1:

In post 1, student should give proof of registration of the NRS On-Line and then the student get form money payments of school building and ESQ training. After that the student go to the next post namely post 2 with bringing that form.

Post 2:

In post 2, Student should pay money payments of school building and ESQ training than student get the receipts of money payments of school building and ESQ training than the student get form money payment of school uniform. After that the student go to the next post namely post 3 with bringing that form.

Post 3:

In post 3, student should pay money payment of school uniform than student get receipts and the school uniform electoral form size school uniform. After that the student go to the nextpost namely post 4 with bringing that form.

Post 4:

In post 4, student should choosing size school uniform than student get form size school uniform which have been signed and stamped by the officer.

The data that has been collected is processed with the Kolmogorov-Smirnov method, if the data is normally distributed or not. When distributed normally then the data can be simulated. Simulation means trying to operate the model has been designed so that the model can be computerized describes conditions in the real system in field. In this study the simulation does is

against the model queue new student re-registration pass on-line at PSB SHS 4 Padang. The software which used to simulate the model is namely Pro-model 7.5. With using this software the simulation can be seen in animation form and we can use the data has been collect into Pro-model 7.5.

3. Result and Discussion

Information sources of interview in this study is Headmaster of SHS 4 Padang namely Mr. Yunisra. This interview used the question as 20 questions. Graph of data distribution has been collected on first dayavailable in Figure 4 as follow:

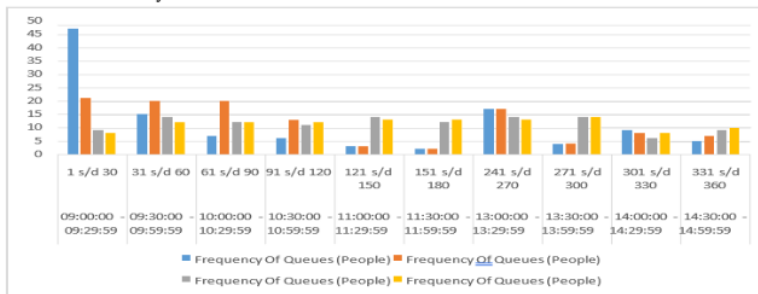


Figure. 4 Graph of data distribution on the first day

According to Figure 4 above we can see that queueing frequency on post 1 is biggest than other posts at time 09:00:00 – 09:29:59 where a queueing frequency on post 2 is biggest than other posts at time 09:30:00 – 09:59:59, and 10:00:00 – 10:29:59. Queueing frequency on post 3 is

biggest than other posts at time 11:00:00 – 11:29:59 whereas queueing frequency on post 4 is biggest than other posts at time 14:30:00 – 14:59:59. The total number of applicant is 115 students. Graph of data distribution has been collected on second day available in Figure 5 as follow :



Figure. 5 Graph of data distribution on the second day

According to Figure 5 above we can see that queueing frequency on post 1 is biggest than other posts at time 09:00:00 – 09:29:59 and time 13:00:00 – 13:29:59 whereas queueing frequency on post 2 is biggest than other posts at time 09:30:00 – 09:59:59, and 10:00:00 – 10:29:59. Queueing frequency

on post 3 is never bigger than other posts whereas queueing frequency on post 4 is biggest than other posts at time 10:30:00 – 10:59:59. The total number of applicant is 82 students. Graph of data distribution has been collected on third day available in Figure 6 as follow:

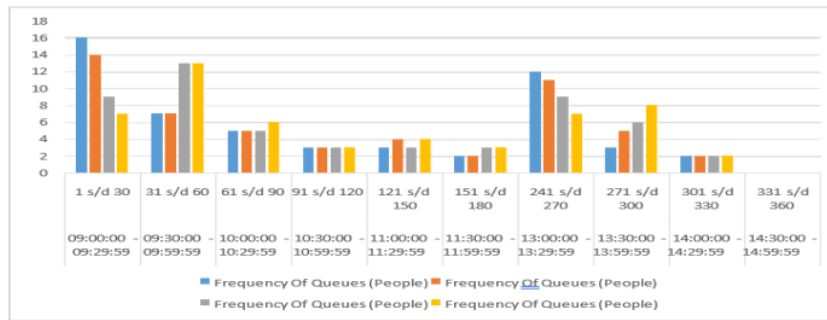


Figure. 6 Graph of data distribution on the third day

According to Figure 6 above we can see that queuing frequency on post 1 is biggest than other posts at time 09:00:00 – 09:29:59 and time 13:00:00 – 13:29:59 whereas queuing frequency on post 2 is biggest than other posts at time 09:30:00 – 09:59:59, 09:30:00 – 10:59:59, and 13:00:00 – 13:29:59. Queueing frequency on post 3 is never bigger than other posts whereas queuing frequency on post 4 is biggest than other posts at time 10:30:00 – 10:59:59. The total number of applicant is 53 students. Graph of data distribution has been collected on fourth day available in Figure 7 as follow:

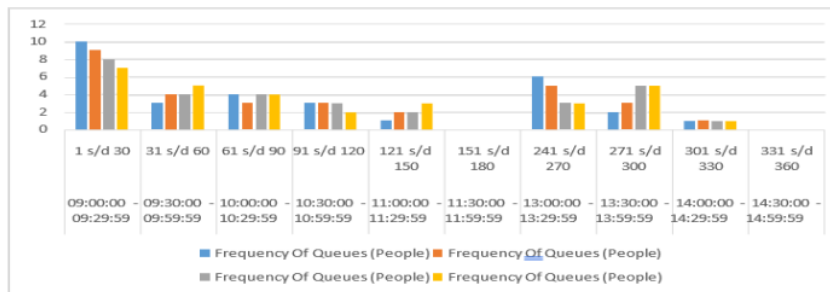


Figure. 7 Graph of data distribution on the fourth day

According to Figure 7 above we can see that queuing frequency on post 1 is biggest than other posts at time 09:00:00 – 09:29:59 and time 13:00:00 – 13:29:59 whereas queuing frequency on post 2 is biggest than other posts at time 09:00:00 – 09:29:59 and 13:00:00 – 13:29:59. Queueing frequency on post 3 and post 4 is never bigger than other posts. The total number of applicant is 30 students. Based on the above distribution data above, we can conclude that:

- On the first day the total of applicants is very much, they are 115 people with crowded and largest registration queue occurs at post 1. In the next post 2 while queuing at post 3 and post 4 is not too long.
- On the second day the total of applicants is less than first day, they are 82 people with crowded the largest registration queue occurs at post 1 in the next post 2 while queuing at post 3 and post 4 is not too long.
- On the third day of the number of applicants is less than first and second day 53 people with crowded the largest registration queue occurs at post 1 while queuing at post 2, post 3 and post 4 is not to long.

- On the fourth day of the number of applicants is less than another day 30 people with no crowded queue occurs.

Data that has been collected on the distribution of data then tested with the Kolmogorov-Smirnov method in order to know is the distributin data normally or not. The Kolmogorov-Smirnov method have 12 steps to calculate the data result. The steps of Kolmogorov-Smirnov methods are:

- Determine the Hypothesis which will be test. The hypothesis which will be test are: H_0 = Data is normally distributed H_1 = Data is unnormally distributed
- Determine the measurement significant value (α). The measurement significant value is usually used to is 5 % or 0.05. $\alpha = 0.0$
- Calculate the number of data (n) wich will be test. In this research the data wich will be tes 33 e 280 data wich gotten by the total of data on first day, second day, third day and fourth day at registration. The details of this caculation are follows.

- $n = \text{Data on first day} + \text{Data on second day} + \text{Data on third day} + \text{Data on fourth day}$
 $n = 115 + 82 + 53 + 30$
 $n = 280$
- Calculate the average (mean) of the data which will be test.
 - Calculate the standard deviation (SD) of the data which will be test.
 - Sort the data by ascending then filled into Kolmogorov-Smirnov.
 - Calculate the value of Z score of each raw.
 - Calculate the value of Ft of each raw data which will be test than filled into table 2. To calculate the value of Ft.
 - Calculate the value of Fs of each raw which will be test.
 - Calculate the absolute value of each raw which will be test.
 - Complete all of raw of each cell data.
 - Calculate the statistic test.

Simulation models queue undertaken is simulated against 280 applicants are divided into 4 different simulation of Queuing on the first day, second day, third day and fourth day. Because many of the participants are included in the registration queue then simulated in this chapter are performed on the first day in the post registration 1 to 5 samples during registration just opened at 09.00.00 – 09.30.00. The simulation of real queuing system available in the Table 3 as follow:

Table. 3 Simulation of queue on first day post 1

Applicant	Arrival Hour Applicants	Arrival of Applicants	Service Start	Service Long	Service Finish	Applicants Waiting Time	Officer Status	Officer Waste Time
1	9:01:00	1.0	1.0	1.0	2.0	0.0	Busy	0.0
2	9:01:00	1.0	2.0	1.0	3.0	1.0	Busy	0.0
3	9:01:00	1.0	3.0	1.5	4.5	2.0	Busy	0.0
4	9:01:00	1.0	4.5	1.0	5.5	3.5	Busy	0.0
5	9:01:00	1.0	5.5	2.0	7.5	4.5	Busy	0.0
until	...	...	...	...	...	...	...	...
115	14:50:00	350.0	350.0	1.0	351.0	0.0	Closed	0.0
Summing ($\sum xi$)		12985.0	14768.5	163.5	14932.0	1783.5	-	186.5
Average (xi)		112.9	128.4	1.4	129.8	15.5	-	1.6
Standard Deviation		122.2	111.9	0.5	111.9	14.8	-	6.4

Base on Table 3 above, we can see that average of applicant waiting time is 15.5 minutes and average officer waste time is 1.6 minutes whereas the number of applicants is 115 students because of it the officer status on post 1 is busy from open serving until closed serving. The simulation of real queuing system available in the Table 4 as follow:

Table. 5 Simulation of queue on the first day of post 3

Applicant	Arrival Hour Applicants	Arrival of Applicants	Service Start	Service Long	Service Finish	Applicant Waiting Time	Officer Status	Officer Waste Time
1	9:06:00	6.0	6.0	3.0	9.0	0.29	Busy	0.0
2	9:08:00	8.0	9.0	2.0	11.0	1.0	Busy	0.0
3	9:11:00	11.0	11.0	3.0	14.0	0.0	Busy	0.0
4	9:14:00	14.0	14.0	3.0	17.0	0.0	Busy	0.0
5	9:17:00	17.0	17.0	3.0	20.0	0.0	Busy	0.0
until	...	...	...	...	...	...	...	...
115	14:55:00	355.0	355.0	2.0	357.0	0.0	Closed	0.0
Summing ($\sum xi$)		19289.0	19587.5	274.0	19861.5	239.0	-	77.0
Average (xi)		167.7	170.3	2.40	172.7	2.1	-	0.7
Standard Deviation		106.2	106.5	0.40	106.4	1.5	-	5.6

Base on Table 5 above, we can see that average of applicant waiting time is 2.1 minutes and average officer waste time is 0.7 minutes whereas the number of applicants is 115 students because of it the officer status on post 1 is busy from open serving until closed serving. The simulation of real queuing system available in the Table 6 as follow:

Table. 6 Simulation of queue on first day of post 4

Applicant	Arrival Hour Applicants	Arrival of Applicants	Service Start	Service Long	Service Finish	Applicants Waiting Time	Officer Status	Officer Waste Time
1	9:10:00	10.0	10.0	1.0	11.0	0.0	No Job	1.0
2	9:12:00	12.0	12.0	2.0	14.0	0.0	No Job	1.0
3	9:15:00	15.0	15.0	1.5	16.5	0.0	No Job	1.5
4	9:18:00	18.0	18.0	1.0	19.0	0.0	No Job	2.0
5	9:21:00	21.0	21.0	2.0	23.0	0.0	No Job	0.0
until	...	...	...	...	...	...	...	...
115	14:58:00	358.0	358.0	2.0	360.0	0.0	Closed	0.0
Total		20035.0	20044.0	198.0	20242.0	7.5	-	152.0
Average (xi)		174.2	174.3	1.7	176.0	0.1	-	1.3
Standard Deviation		106.6	106.6	0.6	106.7	0.2	-	5.6

Base on Table 6 above, we can see that average of applicant waiting time is 0.1 minutes and average officer waste time is 1.3 minutes whereas the number of applicants is 115 students because of it the officer status on post 1 is no job from open serving until closed serving. According to the data of simulation of re-registration on first day, we know that has been long queue and each applicant has to waiting for a long

time on the post 1 and post 2. Because of that condition, we should suggest a new model for the re-registration system. We has suggest 3 models and simulate each of them. One of the three model is the best model with short queue and minimum time waiting applicant. The best model than three suggest model available in Figure 8 below:

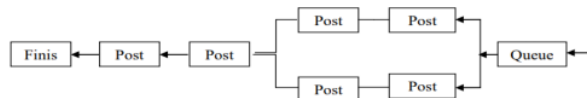


Figure. 8 The design of the best suggestion model

Base on the picture above, we can see that the post re-registration has divided into six posts. Atfirst Post 1 only one post then it is divided into two sub-posts i.e. post 1a and post 1b. In addition atfirst post 2 ⁴¹ by one post then it is divided into two sub-posts i.e. post 2a and post 2b while post 3 and post 4 are not changed. After we simulated the best suggest model

above the queuing long and average applicant waiting is smallest than the other models. The suggestion model about has been implementation into software namely Pro-model version 7.5. The suggested model and real model are given in Figure 9 as follow:

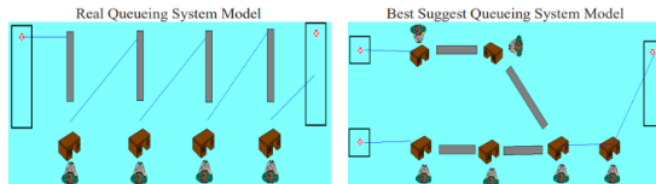


Figure. 9 Comparison of real model system with best suggest model system

4. Conclusion

²⁷ This paper has discussed modeling and simulation of shortest queue system with Kolmogorov- Smirnov method. The following conclusions have been drawn: (1) After we divided post 1 into two posts namely post 1a and 1b on first day note that average long applicants wait at post 1a and 1b are smaller i.e. 2.3 minutes and 2.8 seconds previously for 15 minutes.

(2) After we divided post 2 into 2 posts namely post 2a and 2b on first day note that average long applicants wait at post 1a and 1b ⁴² smaller 0.2 minutes and 0.2 minutes previously for 32 minutes. (3) With the results of the simulation is done it can be concluded that the breakdown of the post registration may make the average time waiting for the registration to become smaller.

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