
OPTIMIZATION OF THE QUEUE SYSTEM USING LINE BALANCING METHODS AND FLEXSIM SOFTWARE SIMULATION AT THE SIAGA MEDIKA BANYUMAS HOSPITAL

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ABSTRACT

Service is an important aspect for the service industry, including hospitals, one of the important aspects in a service is the queue. Siaga Medika Banyumas Hospital provides services with 3 doctors and there are 4 main services at Siaga Medika Banyumas Hospital, namely, registration, doctor services, payment and taking medicine. This research carries out queue simulations using flexsim and line balancing calculations. The results show that the line balancing calculation in the initial state has an average path efficiency of 64.90% with simulation results of 31 patients queuing. calculations after line balancing showed an average path efficiency of 87.17% with simulation results of 37 patients queuing. The alternative of adding 1 new doctor obtained an average path efficiency of 78.80% and made a difference in the number of queues for doctor services to 14 patients.

KEYWORDS

hospital, queue, line balancing, flexsim



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INTRODUCTION

Public services are the responsibility of the government and are carried out by government agencies, both at the central, regional and village levels. According to Ratminto and Winarsih (2012), service is an important aspect for an industry because it is the main factor that must be considered in service industry competition, including the hospital service industry.

One important aspect of a service is the queuing system, according to Ma'arif and Tanjung (2015), a queue is a waiting line situation where a number of physical units (migrants) are trying to receive services from limited facilities (service providers), so that entrants must wait some time in line to get your turn to be served. The waiting time in outpatient care according to the Ministry of Health Number 129/Menkes/SK/II/2008 is less or equal to 60 minutes (Ministry of Health, 2008). At Siaga Medika hospitals there are still many patients waiting an hour to an hour and a half. The reason for this long queue is due to the high frequency of patient arrivals and the limited number of doctors, which means

some patients have to wait. Where the patient arrival rate can reach 10 to 15 patients every hour.

One way to model this queuing system is to use flexsim software. FlexSim is a simulation to imitate or demonstrate various kinds of processes or facilities that exist in the real world on a 3D basis (Awandani, et al, 2019). The results of this flexsim simulation will later streamline work stations to minimize queues by using line balancing. Line balancing is a method of assigning a number of jobs to interconnected work stations in one production line so that there is the same station completion time at each work station (Prabowo, 2016).

Based on the above problems at the Siaga Medika Banyumas Hospital and the line balancing concept used to solve the problem, the aim of this research is to determine the efficiency of the queue system at the Siaga Medika Banyumas Hospital by applying the line balancing concept and simulating it using flexsim software.

RESEARCH METHOD

The Orthopedic Clinic at Siaga Medika Hospital has an average daily arrival rate of 87 patients with operational hours starting from 08.00 – 15.00 WIB. The data required is time processing data for each existing service, the existing queuing system is simulated first and then the path is balanced using line balancing.

A. Line Balancing

1. Define tasks, jobs, work sequences, and the time required to complete these tasks.
2. Create a precedent diagram/precedence diagram. The precedence diagram functions to illustrate the sequences of operations. The precedence diagram is used before proceeding to completion using the line balancing method.
3. Determine the cycle time or work cycle. Cycle time is the maximum time of each workstation.

$$C \geq t \max$$

4. Calculating the efficiency of the production line (Line efficiency). Line efficiency is the ratio of total work station time divided by cycles multiplied by the number of work stations or the total efficiency of work stations divided by the number of work stations.

$$w = \frac{Twc}{Tws}$$

5. Measuring the efficiency of the production path (Linei eifficieincy). Line efficiency is the ratio of the total time of a working station divided by the cycle times the number of working stations or the total efficiency of a working station divided by the number of working stations..

$$EL = \frac{\sum_{i=1}^k STi}{K.C}$$

6. Calculating free time balance/delay balance. Balance delay is a measure of the inefficiency of a production work station trajectory resulting from actual idle time caused by imperfect allocation between work stations.

$$BD = \frac{(K.C) - \sum_{i=1}^k STi}{K.C}$$

7. Determine the assignment of work elements to work stations

B. Simulation With Flexsim

After obtaining a more efficient system using line balancing calculations, the next step is to carry out a simulation using flexsim software

- a. Create a queue model according to the description of a real system using basic flexsim objects, namely source, processor, queue and sink.
- b. Determine the processing time, maximum capacity and others for each object and determine the processing time at each work station
- c. Determine distribution data for each workstation using the Expertfit tool.
- d. Enter distribution data into the simulation model as a time process for each work station.
- e. Then set the clock from the start of the process to the end and run the queuing system model by clicking the play/run button.

RESULT AND DISCUSSION

The results of the observations that have been compiled are data on service time, which is the length of service at the Registration, Doctor Queue, Doctor 1, Doctor 2, Doctor 3, Payment and Medicine Collection service facilities. The next stage is determining the distribution test for each data that has been collected from the observation results. In determining the type of distribution, the tools in the Flexsim software, namely expertfit.

Table 1. Distribution Data

Process	Distribution Data
Registration	loglaplace(251.027782, 87.459355, 2.032108, <stream>)
Doctor 1	johnsonbounded(73.107892, 4360.366117, 2.274577, 1.744751, <stream>)
Doctor 2	beta(477.063704, 2573.315490, 1.504589, 2.830019, <stream>)
Doctor 3	johnsonbounded(361.080585, 4865.763411, 1.696786, 1.034693, <stream>)
Payment	randomwalk(201.042932, 0.011950, 0.044938, <stream>)
Taking Medication	johnsonbounded(298.209190, 9731.078091, 1.256371, 0.673037, <stream>)

A. Intial State Queue System Simulation

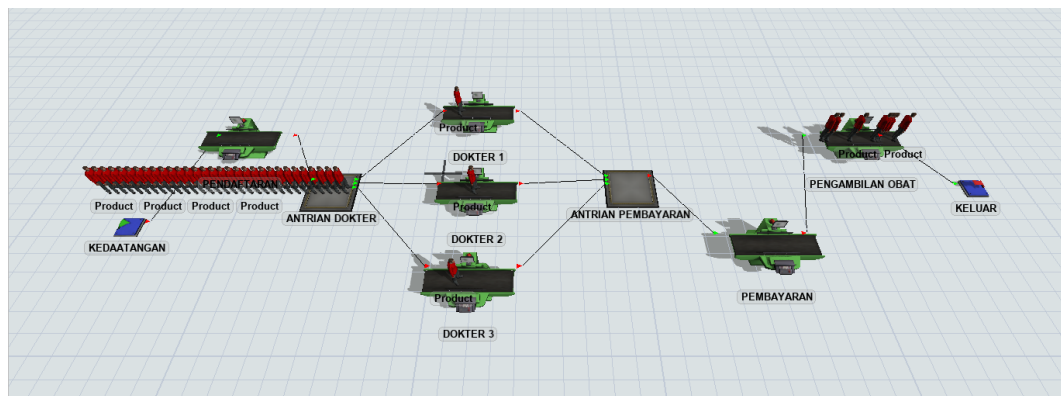


Figure 1. Description

Based on the simulation results with 87 arrivals, there was a buildup of 31 patients in the doctor's queue. So, it is necessary to streamline the queuing system by using line balancing to minimize existing queues.

Table 2. Process Time

Workstation	Process	Total Time (Minute)
1	Registration	33
	Doctor 1	20
2	Doctor 2	22
	Doctor 3	23
3	Payment	6
4	Taking Medication	38

Line efficiency (LE) of each medical service is calculated and the calculation results are obtained as follows:

a. Doctor 1

$$EL = \frac{\sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{97}{4 \times 38} \times 100\% = 63,81\%$$

Balance delay (BD) in this condition is calculated and the following calculation results are obtained:

$$BD = \frac{(K.C) - \sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{(4 \times 38) - 97}{4 \times 38} \times 100\% = 36,19\%$$

b. Doctor 2

$$EL = \frac{\sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{99}{4 \times 38} \times 100\% = 65,13\%$$

Balance delay (BD) in this condition is calculated and the following calculation results are obtained:

$$BD = \frac{(K.C) - \sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{(4 \times 38) - 99}{4 \times 38} \times 100\% = 34,87\%$$

c. Doctor 3

$$EL = \frac{\sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{100}{4 \times 38} \times 100\% = 65,78\%$$

Balance delay (BD) in this condition is calculated and the following calculation results are obtained:

$$BD = \frac{(K.C) - \sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{(4 \times 38) - 100}{4 \times 38} \times 100\% = 34,22\%$$

B. Line Balancing Calculations

a) Determining Cycle Time and minimize work station

The maximum time for taking medication is 38 minutes.

Because $C \geq t_{max}$

C = cycle time

t_{max} = greatest time of all work elements

$t_{max} = 38$ minutes

An efficient number of work stations can be applied to each doctor with the following equation:

$$\text{Doctor 1} = w = \frac{T_{wc}}{T_{ws}} = \frac{97}{38} = 2,5 \approx 3 \text{ Workstation}$$

$$\text{Doctor 2} = w = \frac{T_{wc}}{T_{ws}} = \frac{99}{38} = 2,6 \approx 3 \text{ Workstation}$$

$$\text{Doctor 3} = w = \frac{T_{wc}}{T_{ws}} = \frac{100}{38} = 2,6 \approx 3 \text{ Workstation}$$

Line efficiency (LE) of each doctor's service after line balancing is carried out and the following calculation results are obtained:

a. Dokter 1

$$EL = \frac{\sum_{i=1}^k ST_i}{K \cdot C} \times 100\% = \frac{97}{3 \times 38} \times 100\% = 86,08\%$$

Balance delay (BD) in this condition is calculated and the following calculation results are obtained:

$$BD = \frac{(K \cdot C) - \sum_{i=1}^k ST_i}{K \cdot C} \times 100\% = \frac{(3 \times 38) - 97}{3 \times 38} \times 100\% = 13,92\%$$

b. Dokter 2

$$EL = \frac{\sum_{i=1}^k ST_i}{K \cdot C} \times 100\% = \frac{99}{3 \times 38} \times 100\% = 86,84\%$$

Balance delay (BD) in this condition is calculated and the following calculation results are obtained:

$$BD = \frac{(K \cdot C) - \sum_{i=1}^k ST_i}{K \cdot C} \times 100\% = \frac{(3 \times 38) - 99}{3 \times 38} \times 100\% = 13,16\%$$

c. Dokter 3

$$EL = \frac{\sum_{i=1}^k ST_i}{K \cdot C} \times 100\% = \frac{100}{4 \times 38} \times 100\% = 88,59\%$$

Balance delay (BD) in this condition is calculated and the following calculation results are obtained:

$$BD = \frac{(K \cdot C) - \sum_{i=1}^k ST_i}{K \cdot C} \times 100\% = \frac{(4 \times 38) - 100}{4 \times 38} \times 100\% = 11,41\%$$

However, in this case, after the simulation was carried out and the Johnson bounded distribution data was obtained (327.304703, 5299.433833, 1.394690, 0.690418, <stream>), the doctor's queue increasingly piled up because the combination of payment and taking the medicine did not have much of an effect on the medicine queue.

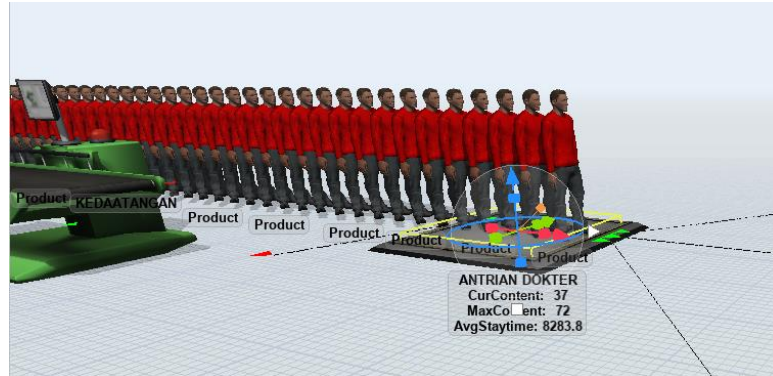


Figure 2. Simulation After Line Balancing

C. Alternative Additional 1 Doctor

Based on the simulation results in the doctor's queue, there are still many patients queuing, so a suggestion is given to add 1 doctor. The operating time for additional doctors is assumed to be the average service time of the 3 existing doctors and the operating time is $21.6 \approx 22$ minutes, and the efficiency obtained is as follows:

1) Dokter 1

$$EL = \frac{\sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{97}{3 \times 44} \times 100\% = 73,48\%$$

Balance delay (BD) in this condition is calculated and the following calculation results are obtained:

$$BD = \frac{(K.C) - \sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{(3 \times 44) - 97}{3 \times 44} \times 100\% = 26,52\%$$

2) Dokter 2

$$EL = \frac{\sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{99}{3 \times 44} \times 100\% = 75,00\%$$

Balance delay (BD) in this condition is calculated and the following calculation results are obtained:

$$BD = \frac{(K.C) - \sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{(3 \times 38) - 99}{3 \times 44} \times 100\% = 25,00\%$$

3) Dokter 3

$$EL = \frac{\sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{100}{3 \times 38} \times 100\% = 75,75\%$$

Balance delay (BD) in this condition is calculated and the following calculation results are obtained:

$$BD = \frac{(K.C) - \sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{(4 \times 38) - 100}{3 \times 38} \times 100\% = 24,25\%$$

4) Dokter 4

$$EL = \frac{\sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{99}{3 \times 42} \times 100\% = 75,00\%$$

Balance delay (BD) in this condition is calculated and the following calculation results are obtained:

$$BD = \frac{(K.C) - \sum_{i=1}^k ST_i}{K.C} \times 100\% = \frac{(3 \times 38) - 99}{3 \times 38} \times 100\% = 25,00\%$$

The next step is to create a queue model using 4 doctors and enter the results of the beta distribution test (558.163136, 2049.551595, 2.882818, 4.050814, <stream>) as the processing time for doctor 4. The following are the simulation results using 4 doctors:

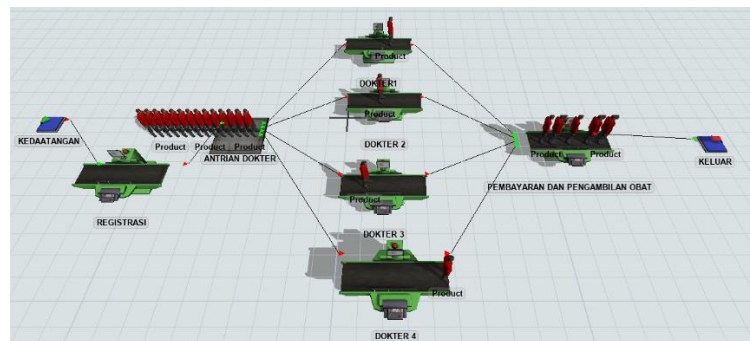


Figure 3. Simulation of Adding 1 Doctor

From the results of the simulation with 4 doctors, it can be seen that there was a reduction in the build-up in the doctor's queue, where in the initial simulation with 3 doctors it was seen that there was a build-up of 31 patients, whereas using 4 doctors could reduce the build-up by 17 patients, namely 14 patients queuing in the doctor's queue.

Table 3. Comparison

Queue System	Line Efficiency (%)	Balance Delay (%)
Initial Queuing System	64,90%	35,09%
After Line Balancing	87,17%	12,83
Adding 1 Doctor	74,80%	25,19

From the comparative analysis of the efficiency analysis of the recommendation route, the chosen alternative was the addition of doctors, because it was able to reduce the

queues in the doctor's queue and the route efficiency experienced an increase of 9.9%. This increase is quite significant and has an impact on the queuing system.

The results of this research are also supported by previous research conducted on the queuing system at a community health center with the result that the intensity of doctor's service had a busy level serving patients of 75% and caused patients to experience queues and required a waiting time of 6.42 minutes for patients to wait, thus requiring the addition of new doctors. at the health center (Wati, 2017)

CONCLUSION

The conclusions that are given by carrying out research are:

- a. Based on the initial balancing line calculations, it is known that the average path efficiency value is 64.90% and the balance time is 35.09, with the simulation results showing that there were predictions for 31 patients. If line balancing was carried out with station alignment, a path efficiency value of 87.17% and a balance of 12.83 were achieved, but the simulation results were shown to result in deviations for as many as 37 patients. The results were carried out by improving the queuing system by adding 1 doctor and achieving a path efficiency value of 78.80% and a balance of 25.19% with the simulation results being able to reduce the queue by 17 patients from the initial simulation results.
- b. From the comparative analysis of the efficiency analysis of the recommended route, the chosen alternative was the addition of doctors, because it was able to reduce queues in the queue of doctors and the route efficiency experienced an increase of 9.9%. This increase is quite significant and has an impact on the queuing system.

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