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Queue System Using Single Channel Single Phase for Gas Station Customers with an Arena Simulation Approach

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Abstract

The efficiency of the queuing system at a Public Fuel Filling Station (SPBU) is one of the crucial factors in maintaining smooth operations and increasing customer satisfaction. This study specifically analyzes the performance of the queuing system with a single channel single phase model at a gas station using a simulation approach assisted by Arena Simulation Software. The main focus of this study is to evaluate a number of performance indicators, such as average customer waiting time, queue length, server utilization rate, and service capacity that can be achieved under existing conditions and after the improvement scenario is implemented. Primary data was collected through direct observation in the field during peak hours, which were then processed and analyzed using probability distributions to model customer arrivals and service times. The simulation results show that the existing system has a very high server utilization rate, approaching 100%, indicating a potential risk of overload, although the average customer waiting time is relatively minimal. However, this performance can only be maintained under certain conditions and is at risk of decreasing significantly if there is a surge in customers beyond predictions. Simulation of the improvement scenario by significantly increasing the number of servers and operators succeeded in reducing the server utilization rate to the optimal level, shortening service time, and increasing the service capacity of the gas station. This proves that managerial intervention through the addition of service resources is a strategic step to increase operational efficiency.

Keywords: Queue system, single channel single phase, arena simulation, service efficiency, gas station.

1. Introduction

In the era of high mobility, the existence of Public Fuel Filling Stations (SPBU) plays an important role in meeting the fuel needs of the community (Royfando et al., 2024). One of the main challenges faced by SPBU is the ability to provide fast and efficient service amidst the increasing number of customers (Tjahjaningsih et al., 2021). Inability to manage queues can lead to long waiting times, decreased customer satisfaction, and decreased operational efficiency of SPBU.

The single channel single phase queuing system, where customers are served sequentially in one service channel, is a common approach applied at SPBU (Hasibuan et al., 2025). In this system, customers wait in one line until they get service. However, with this conventional approach, a more in-depth analysis is needed to determine whether efficiency can be improved, especially during peak hours.

This study aims to evaluate the queuing system at SPBU using simulation assisted by Promodel software. With this simulation, the best scenario can be identified to reduce customer waiting time, maximize service capacity, and increase operational efficiency of SPBU.

2. Literature Review

2.1. Queuing system theory

A queuing system is a method for analyzing how entities (for example, customers at a gas station) wait to be served by one or more servers. The single channel single phase model is a model where there is one queue line and one server to serve customers (Kamari and Trizula, 2022). According to queuing theory, variables such as arrival time, service time, and arrival rate greatly affect system performance. This model is widely applied in the retail and service sectors to improve operational efficiency and customer satisfaction.

2.2. Application of the single channel single phase model at gas stations

At gas stations, customers often experience long waiting times, especially during peak hours. The single channel single phase system allows monitoring and analysis of queue patterns. According to Smith (2005), queue analysis at gas stations helps managers understand how customer volume and service time affect capacity and operational efficiency, which ultimately impacts customer satisfaction.

2.3. Queuing System Theory

Queuing theory was first developed by Agner Krarup Erlang to analyze telecommunications systems. One of the basic formulas that is often used is Little's Law, namely:

$$L = \lambda \times W \quad (1)$$

Where:
- L: Average number of customers in the system.
- λ: Average arrival rate.
- W: Average waiting time in the system.

2.4. Queue simulation using arena

Arena is a widely used software for queuing system simulation and operational efficiency analysis. In queuing studies, Arena allows scenario modeling based on empirical data, such as customer arrival patterns and service times. This simulation can help in identifying optimal waiting times, server utilization, and service capacity.

2.5. Service efficiency and customer satisfaction

Customer satisfaction is influenced by the length of time they spend in the queue. The application of simulation to optimize the queuing system at gas stations is expected to reduce waiting times and increase customer satisfaction.

3. Methods

3.1. Research stages

The stages of research conducted can be seen in Figure 1.

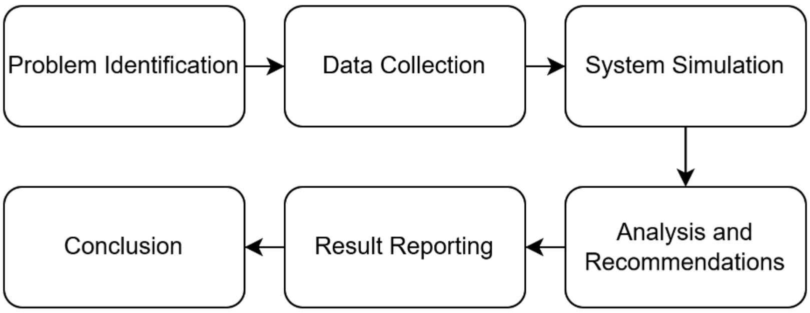


Figure 1: research Stages

3.2. Type of research

This research uses a quantitative approach. Quantitative methods are research methods based on the positivism paradigm, which are used to study certain populations or samples. Data collection is carried out using research instruments, while data analysis is quantitative or statistical to test the established hypotheses (Park et al., 2020; Zyoud et al., 2024)). The data used in this study are quantitative data, namely data that is processed statistically to calculate the number of optimal service lines and analyze the performance of service time facilities at the optimal level in the fuel filling process at gas stations. The data source in this study is primary data, namely the number of customer arrivals or individuals who use fuel filling facilities at gas stations. The data source for this study is primary data obtained through direct observation of the number of customer arrivals at gas stations.

3.3. Population and sample

Population is defined as a collection of elements or subjects with certain characteristics that are of concern to researchers to be analyzed and conclusions drawn (Casteel dan Bridier, 2021). In this study, the population in question is all service lines at the Jl. Raja H. Fisabilillah. The research sample consisted of customers who came and queued to refuel at the gas station

This study used a nonprobability sampling technique. This technique allows for subjective sample selection, where not all elements in the population have the same chance of being selected. Samples are selected based on chance or certain situations, so that not all elements of the population have the same chance of being included in the sample. Observations were conducted on April 29, with data collection in the afternoon session, namely 16:40 - 17:40, to represent customers queuing at that time

3.4. Queue system model

The service process at the gas station uses a Multiple Channel Query System queuing system, which means that there are several service lines and only one stage that customers must go through to complete the transaction (Zoraya Juanita and Maliki, 2020). Service time is random because each customer has different refueling needs. This system applies the first-come, first-served (FCFS) principle, where customers who arrive earlier will be served first (Wang and Liao, 2021). To analyze and optimize the performance of the service system, a queue formula is used that is in accordance with the Multiple Channel Query System model. This formula is used to calculate performance parameters such as average queue length, average waiting time, and utilization rate of service facilities.

a) The probability that there are 0 people in the system (no customers in the system).
b) The average number of customers in the system (Ls) is the average number of customers waiting to be served by the service facility and includes customers who are being served.

$$Ls = \frac{\mu(\frac{\lambda}{\mu})^M}{(M-1)!\,(M\mu-\lambda)^2} P_0 \tag{2}$$

c) The average queuing time in the system (Ws) is the average of the total time of customers waiting for service and the average time of the facility in completing the service.

$$W_s = \frac{L_s}{\lambda} \tag{3}$$

d) The average number of people or units waiting in the queue (Lq) is the number (amount) of service requests that come from customers waiting to be served.

$$L_q = L_s - \frac{\lambda}{\mu} \tag{4}$$

e) The average time spent by a customer or unit waiting in a queue (Wq) is the length of time required for customers to arrive and queue to receive service.

$$W_q = \frac{L_q}{\lambda} \tag{5}$$

3.5. Main Components in Simulation

a) Entity: Vehicles that come to the gas station to be serviced.
b) Server: Fuel pump that serves vehicles one by one.
c) Queue: Place where vehicles wait their turn to be serviced.
d) Service Time: Duration of service per vehicle, depending on fuel volume and operator efficiency.
e) Arrival Time: Pattern of vehicle arrivals, usually using a probability distribution (e.g. Poisson).
f) Simulation Output: Average waiting time, queue length, server utilization, and number of vehicles served.

3.5.1. Tables

All tables should be numbered with Arabic numerals. Headings should be placed above tables, left justified. Leave one line space between the heading and the table. Only horizontal lines should be used within a table, to distinguish the column headings from the body of the table, and immediately above and below the table. Tables must be embedded into the text and not supplied separately. The Table 1 below is an example which authors may find useful.

Table 1: An example of a table

An example of a column heading	Column A (*t*)	Column B (*T*)
And an entry	1	2
And another entry	3	4
And another entry	5	6

4. Results and Discussion

4.1. Location and focus of the research

This research was conducted at the Jl. Raja H. Fisabilillah gas station with a focus on two-wheeled vehicles that use premium and pertalite fuels. The refueling uses a single channel single phase queue model (Figure 2). The refueling process begins with the arrival of two-wheeled vehicles that enter the system, then wait for their turn to be served by the operator. After refueling is complete, the customer makes the payment and leaves the system.

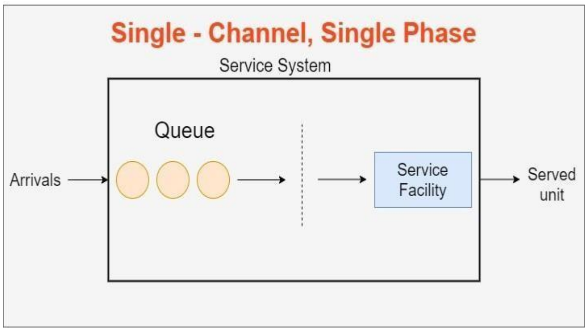


Figure 2: illustration of a queuing system

4.2. Time and data collection

The data used came from observations on March 29 to April 8, 2020, with a duration of 1–2 hours every day, starting at 16.40 to 18.40 WIB. This time was chosen because it is a busy hour with high queues and intensive service activities

Observations were made on the arrival time of two-wheeled vehicles, the start time of service and the end time. The data was then summarized into Ms. Excel to then find the difference in time between arrivals, process time and queue time as in Figure 3.

	Kendaraan	Waktu	Waktu Awal	Waktu.1	Waktu Antar Waktu Antar Waktu Waktu Waktu	Unnamed: 5	Unnamed: 6	Unnamed: 7	Unnamed: 8
0	Ke-	Kedatangan	Pelayanan	Selesai	Kedatangan	Kedatangan	Proses	Proses	Antrian
1	NaN	NaN	NaN	NaN	NaN	(Detik)	NaN	(Detik)	NaN
2	1	16:43:23	16:43:28	16:43:49	0:03:23	203	0:00:21	21	0:00:05
3	2	16:43:39	16:44:02	16:44:34	0:00:16	16	0:00:32	32	0:00:23
4	3	16:47:16	16:47:53	16:48:24	0:03:37	217	0:00:31	31	0:00:37
...	...	...	...	...	...	...	...	...	...
97	96	18:06:59	18:07:22	18:07:45	0:00:34	34	0:00:23	23	0:00:18
98	97	18:07:38	18:08:00	18:08:23	0:00:39	39	0:00:23	23	0:00:19
99	98	18:08:05	18:08:27	18:08:50	0:00:30	30	0:00:23	23	0:00:22
100	99	18:08:48	18:09:10	18:09:33	0:00:43	43	0:00:23	23	0:00:19
101	100	18:09:31	18:09:53	18:10:16	0:00:43	43	0:00:23	23	0:00:18

	Kendaraan	Waktu	Waktu Awal	Waktu.1	Waktu Antar Waktu Antar Waktu Waktu Waktu	Unnamed: 5	Unnamed: 6	Unnamed: 7	Unnamed: 8
0	Ke-	Kedatangan	Pelayanan	Selesai	Kedatangan	Kedatangan	Proses	Proses	Antrian
1	NaN	NaN	NaN	NaN	NaN	(Detik)	NaN	(Detik)	NaN
2	1	16:40:01	16:40:26	16:40:43	0:01:00	60	0:00:17	17	0:00:25
3	2	16:40:04	16:40:54	16:41:09	0:00:03	3	0:00:15	15	0:00:50
4	3	16:41:25	16:41:32	16:42:04	0:01:21	81	0:00:32	32	0:00:07
...	...	...	...	...	...	...	...	...	...
97	96	18:07:53	18:08:24	18:08:43	0:00:41	41	0:00:19	19	0:00:29
98	97	18:08:05	18:08:38	18:08:58	0:00:12	12	0:00:20	20	0:00:30
99	98	18:08:36	18:09:08	18:09:27	0:00:31	31	0:00:19	19	0:00:29
100	99	18:09:05	18:09:36	18:09:56	0:00:29	29	0:00:20	20	0:00:28
101	100	18:09:50	18:10:22	18:10:42	0:00:45	45	0:00:20	20	0:00:29

Figure 3: difference in time between arrivals

4.3. Data Processing with Input Analyzer

The observation data that has been summarized is then processed using Input Analyzer to determine the type of data distribution. Based on data processing using Input Analyzer using Arena software. There are several events that occur in the queue process in the creation of a simulation model (Figure 3), including:
1. Vehicle Arrival Process, which is described by the "Create" module.
2. Service Process, which is described by the "Process" module.
3. Server Leaving Process, which is described by the "Dispose" module.

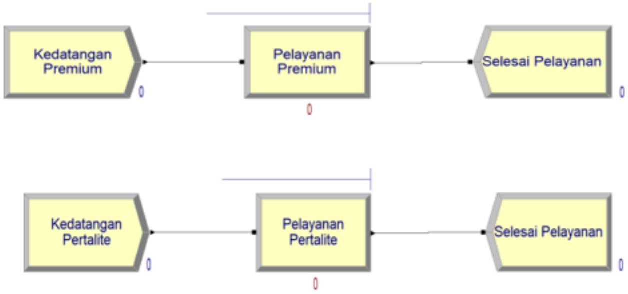


Figure 4: Queue event

In each Arena module and then a verification process is carried out to prove whether the model Next, data filling is carried out based on the simulation results, the value of the waiting time is also obtained at 0, both at premium and pertalite stations. This shows that the simulated model does not produce a queue. In addition to Entity and Queue, the server utility level can also be seen through the report results in the Resource section. Through this report, it can be seen that the instantaneous utilization and number busy values for both premium and pertalite are worth This shows that the server utility is very high, where the server is busy and working too much and maximally

This simulation aims to analyze the influence of various factors on the performance of the system being reviewed. System performance is measured through the server utility value, which represents the level of server busyness. Factors that are thought to influence the server utility value include the number of filling servers and the number of operators on the server. In this case, an alternative improvement is given to the system performance that aims to overcome the problems that occur in the system, namely the utility value of 1. Proposal After the simulation of the model is completed, a report will be obtained from the proposed improvement of the queue system. By adding the number of servers and the number of operators, so that there are 2 servers on premium and 2 servers on pertalite where each server has 2 operators, the utility output is obtained which is smaller than the previous system conditions. Queues at gas stations occur due to an imbalance between customer arrivals and the available service capacity. Some of the main causes of queues at gas stations can be summarized as follows:

a) Arrival Frequenc
   High Customers Customers arrive continuously with high intensity, especially during peak hours, thus exceeding the available service capacity
b) Variable Service Duration
   Service time per customer varies depending on the amount of fuel filled, payment method, or operator speed

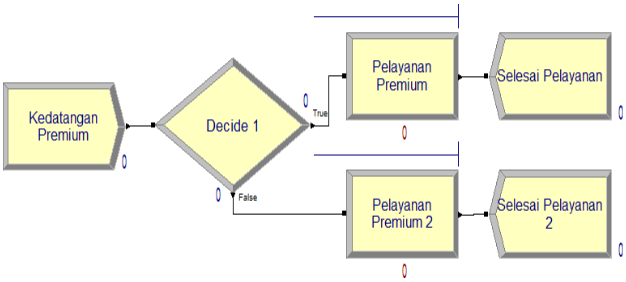


Figure 5: Queuing system

The queuing system, if simulated using Promodel software, is as shown in the following image:

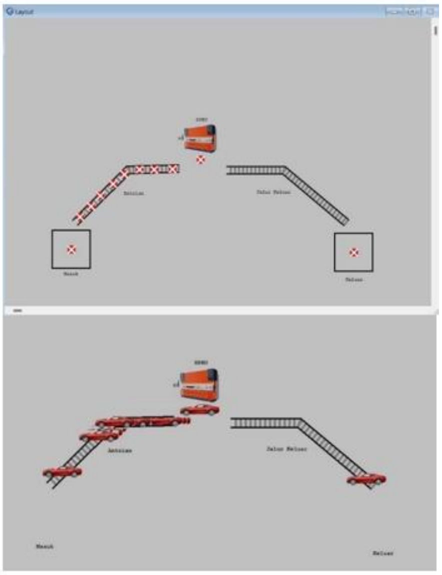


Figure 6: Queue simulation results using promodel

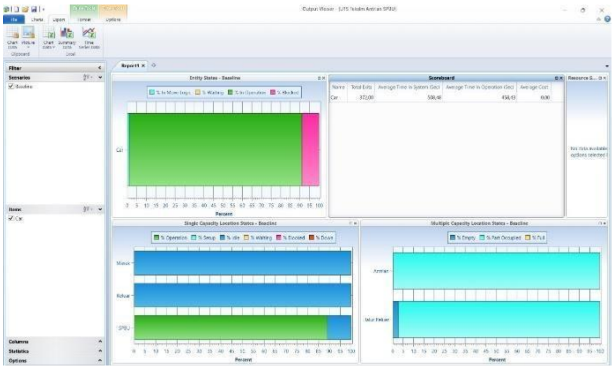


Figure 7: Arrival frequency 46 seconds and service frequency 43 seconds

Figure 8: Arrival frequency 42 seconds and service frequency 43 seconds

Figure 9: Premium gas station queue system in operation

The premium gas station queue system operates at a rate, 90.16% in operation dan 8.86% blocked


Scoreboard

Name	Total Exits	Average Time In System (Sec)	Average Time In Operation (Sec)	Average Cost
Car	372,00	508,48	458,43	0,00

Figure 10: Total testing time

With a total test time of 5 hours, 372 total exits were obtained, 508.48 (sec) average time in system, 458.43 (sec) average time in operation.

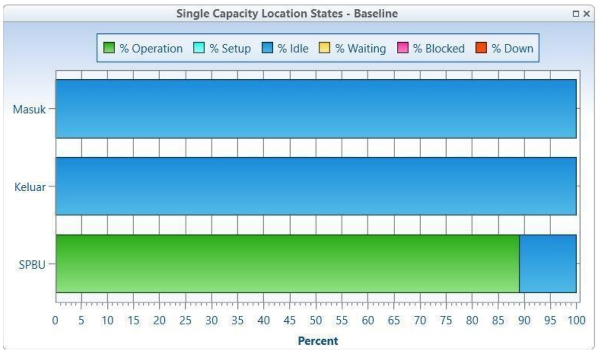


Figure 11: Capacity status

Capacity:

a. Entry and Exit have a capacity status of 100% idle.
b. Gas stations have a capacity status of 89.12% operation and 10.88% idle.

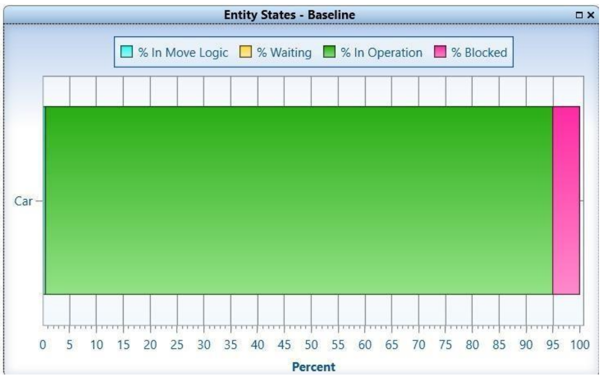
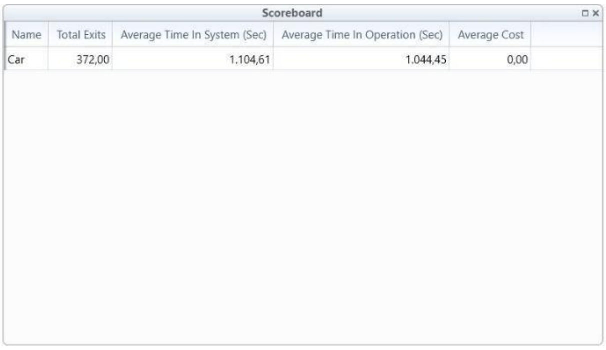


Figure 12: Gas station queuing system

The premium gas station queue system operates at a rate of 94.55% in operation and 8.86% blocked.



Scoreboard

Name	Total Exits	Average Time In System (Sec)	Average Time In Operation (Sec)	Average Cost
Car	372,00	1.104,61	1.044,45	0,00

Figure 13: Total testing time

With a total testing time of 5 hours, there were 372 total exits, 1,104.61 (sec) average time in system, and 1,044.45 (sec) average time in operation.

Figure 14: Capacity

Capacity:

a. Entering, has a capacity status of 76.68% idle and 23.32% blocked.
b. Exiting, has a capacity status of 100% idle.
c. Gas stations, have a capacity status of 89.14% operation and 10.86% idle.

4.4. Abstract model

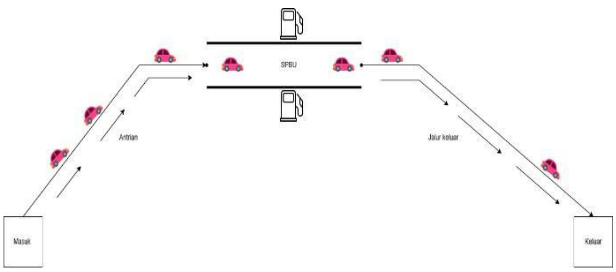


Figure 15: Abstract model

The abstract model describes a queuing system at a gas station consisting of an entrance lane, a vehicle queue, a service process, and an exit lane. Incoming vehicles enter through the entrance lane and form a queue before being served by the fuel pump (server). The service process takes place on two lanes, where each lane has one server that serves vehicles in turn (single channel single phase). After being served, vehicles exit through the exit lane. The length of the queue and waiting time are determined by the imbalance between the number of incoming vehicles and the available service capacity. The efficiency of this system can be improved by increasing the number of servers or speeding up the service process to reduce vehicle congestion and increase customer satisfaction.

5. Conclussion

This study analyzes the queuing system at gas stations using a single channel single phase model with Arena software simulation to improve service efficiency and reduce customer waiting time. The simulation results show that the current system has a very high server utilization rate, indicating that the server is working optimally but is at risk of overload, although the waiting time in several simulations is recorded as zero. To overcome this, it is recommended to increase the number of servers and operators for premium and pertalite services to two each, which has proven effective in reducing the server utilization rate to the optimal level. The implementation of this recommendation is expected to increase service capacity, speed up service time, and increase customer satisfaction, so that it can be a guide in optimizing gas station operational management.

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