Simulation Analysis of Cashier Service Queue System at a Supermarket

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Abstract

XYZ Supermarket is a retail business unit that sells all the necessities of daily life such as groceries, beverages, household products, and so on. With the various needs provided by XYZ supermarket, this makes the supermarket always filled with customers, causing a long queue at the cashier. To improve efficient service, it is necessary to build a queue simulation with the aimof reducing waiting time and work in progress on the cashier system. This research was conducted by using the Arena Version 14.0 application and using a discrete simulation method, namely a simulation method that discusses a model system that is always evolves due to the representation of changes in variables under certain conditions at certain times. This research results in two improvement scenarios, for the first scenario, namely adding two additional servers and adding two operators on the server and for the second scenario, adding one additional operator to the two servers. The average waiting time on the first repair is 0.2454 minutes and the average work in progress is 7.43. Then for the second improvement, the average waiting time is 0.055 minutes and the average work in progress is 2.77. Therefore, it is recommended for XYZ supermarket to add one operator to both cashiers to speed up service to be more efficient.

Keywords
Supermarket Queues, Waiting Time, Worker Utilization, Arena

1. Introduction

One of the queues that often occurs is a queue at a shopping center or supermarket, this queue usually occurs while waiting to make a purchase payment at the cashier. In this case, visitors often spend quite a long time and are inefficient. In this study, the simulation method is used to provide a solution for the supermarket in determining the number of cashiers. XYZ Supermarket is a retail business unit that sells all the necessities of daily life such as groceries, beverages, household products, and so on. With the various needs provided by XYZ supermarket, this makes the supermarket always fulfilled by customers, causing a long queue at the cashier.

To improve efficient service, it is necessary to do queue simulation with the aim of reducing waiting time and work in progress on the cashier system. This research was conducted by using the Arena Version 14.0 application and using a discrete simulation method, namely a simulation method that discusses a systemmodel that is always evolving due to the representation of changes in variables under certain conditions at certain times. This research was conducted at the XYZ supermarket in the city of Bekasi, West Java province. At the supermarket, it was found that there was a queue in the process. In shopping, starting from the customer arriving and having to check the shopping bag, if you bring a product fromoutside it must be marked first so that the queue that occurs at the cashier systemthere are several things that cause the service to take a long time.

These activities include calculating the number of similar products and then scanning the barcode, moving shopping items from the trolley to the cashier desk, arranging groceries into shopping bags such as heavy items placed under and so on, also the payment process takes a long time, sometimes customers need time to prepare their cash and cashiers prepare their change if they use a credit card or debit card it also takes time to process. There are several emergency conditions that can also hinder the queuing process at the cashier, such as the item to be scanned with a barcode has a problemso it must be replaced with another similar product first.

1.1 Simulation Purpose

This study aims to increase the effectiveness and efficiency of the queuing systemby reducing the waiting time in the XYZ supermarket queuing system by proposing two scenarios for improving the queuing system. We will first test these two improvements on the Arena software to get the value of utilization, waiting time and productivity.

This research resulted in two improvement scenarios, for the first scenario, namely adding two additional servers and adding one operator to each of these additional servers and for the second scenario, adding an additional operator on both servers. Before applying it directly to a real system, it's a good idea to simulate the systemon the Arena software and see which improvements have the most significant impact on reducing queues from XYZ supermarket. More improvements are made to the cashier system because it is the cashier system that generates the most queues for customers.

1.2 Scopes of Problem

This research is focused on the discussion with some scopes of the problemas follows:

a. This research was conducted at XYZ supermarket and focused on the queuing system in the payment or cashier section.
b. This study only covers the arrival, service, a queue of visitors at the cashier, and the performance of the existing cashier system.
c. The research was conducted using Arena 14.0 software to simulate the queuing system which will be an improvement.
d. The study looked at the utility factor of cashier work and customer arrivals and exits at XYZ supermarket.
e. This research is not calculated for changing work shifts / changing hours of rest.

1.3 Assumption

In the process of making this big task report, the following assumptions are used:

a. The arrival of customers is the same throughout the working time, there is no busy time and free time.
b. The simulation systemthat we designed works for 12 hours, from 08.00 to 20.00.
c. In deciding to queue at the cashier 1 or 2, the chances of entering the customer queue are the same, namely 47.5%.

2. Literature Review

According to Heizer and Render (2005), there are three components in a queuing system, namely:

a. The arrival or input of the arrival systemhas characteristics such as population size, behavior and a statistical distribution.
b. Discipline queue or queue itself. Queue characteristics include whether the number of queues is limited or unlimited in length and the material or people in it.

c. Service Facilities its characteristics include the design and distribution of service time statistics.

Queuing discipline shows the decision guidelines used to select individuals who enter the queue to be served first. According to Heizer and Render (2005), there are several forms of service discipline used, namely:

a. FCFS (First Come First Served) or FIFO (First in First Out) meaning, first to come (to), first to be served (out). For example, the queue at the cashier at the supermarket.
b. LCFS (Last Come First Served) or LIFO (Last in First Out) means, the last to arrive first to leave. For example, the queuing systemin the elevator for the same floor.

2.1 Entity

The entities contained in the XYZ supermarket cashier queuing systemmodeling are the supermarket customers who make payments at the cashier from all types of purchases ranging frombasic materials, supporting needs, electronic goods, and so on.

2.2 Activity/Relationship

The systemstarts with customers who come to the supermarket to check their groceries, if the customer brings other products fromoutside, it must be marked first or deposited in the goods storage after that the customer can enter the supermarket to shop. When the customer has finished shopping, the customer enters the payment queue or the cashier, these activities include product counting which is then scanned with the barcode, moving groceries fromthe trolley to the cashier desk, arranging groceries into shopping bags such as heavy items placed under and etc.

Also in the payment process that takes a long time, sometimes customers need time to prepare their cash and provide their change, if they use a credit card or debit card it also takes time for the process. There are several emergency conditions that can also hinder the queuing process at the cashier, such as the itemto be scanned with a barcode has a problemso it must be replaced with another product first.

2.3 Resource

In shopping checks, there is one clerk and for the initial model there are only two cashier servers where each cashier server is handled by one cashier. One cashier starts by sorting the same product to be scanned, then scans the barcode to enter the items that have been purchased for the customer, after that also processes the customer's payment.

3. Study Methodology

Observation methods and literature study in the research were used to collect data. The Observation method is one method that is carried out by directing to the place that is used as the object of research, namely at the cashier at the XYZ supermarket in the city of Bekasi, West Java province to obtain the required data. The data is data on the number of customer arrivals and cashier service time. The process of data collection was carried out for 2 hours 30 minutes at 08.00-11.30 WIB. The literature study is carried out by studying various theories that have a relationship with their research and as a supporter of researchers using reference books, journals, and websites related to theories about queues.

3.1 Structural Data

At this stage explain the structure and flow of the supermarket data, which contains all the processes available in it so that it can be a reference for observation to analyze fromthe queue system.

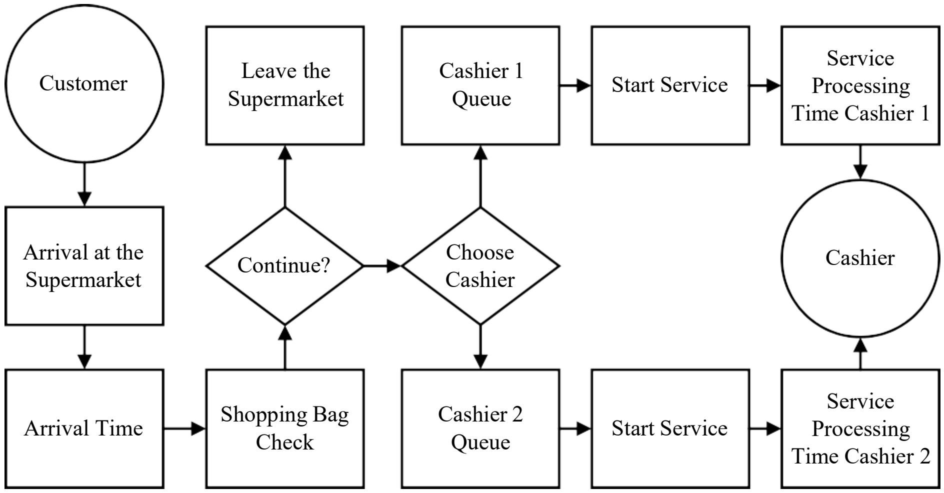

Figure 1. Structure data of XYZ Supermarket Model

3.2 Operational Data

In addition, the phase for measuring performance is carried out by converting the relationships between entities into a model that converts structural data into operational data. Therefore, operational data is related to strategic operations between entities. This study categorizes the relationship strategy between customers and cashier operators using the First Come First Served (FCFS) service discipline method where customers arrive early at the cashier systemand wil be served first.

3.3 Numerical Data

Table 1. Numerical data of XYZ Supermarket Model

Operation	Resource	Expression	Time (Minutes)	Item
Arrival	Customer	BETA	0.5 + 5 * (1.11, 1.15)	
Choose Server	Customer			47.5% Cashier 1 47.5% Cashier 2
Cashier Service 1	Cashier	BETA	0.5 + 10 * (0.795, 0.94)	
Cashier Service 2	Cashier	BETA	1.5 + 9 * (1.02, 0.852)	

4. Performance Measurement

Performance measurement is carried out to assess the attributes that have been obtained through arena software modeling which represents thecustomer and cashier relationship. Performance measurement is gained through several steps including actual system model, verification and validation, experimentation result and analysis, and proposed improvement scenario.

4.1 Actual System Model

The cashier queue systemat XYZ supermarket is then made a simulation model using the Arena Simulation software with the layout results as follows:

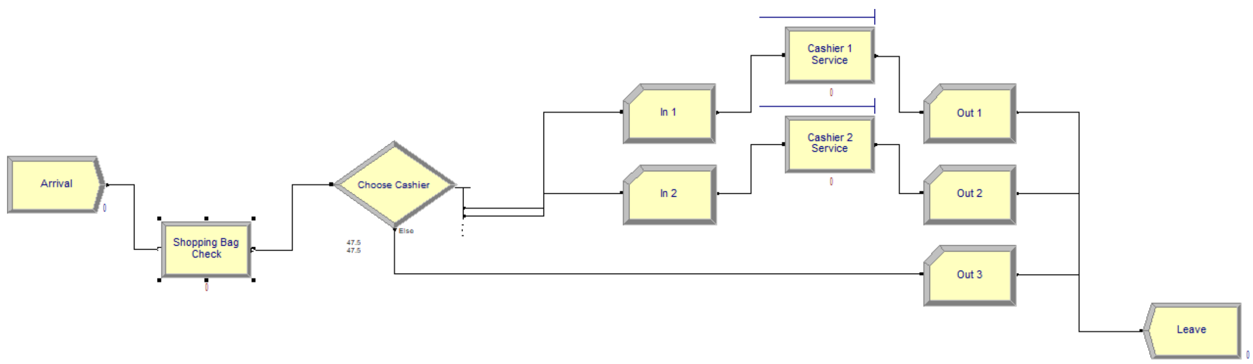

Figure 2. XYZ supermarket actual system model

In the supermarket cashier queuesystem, several events occur in the queue, including:

a. The customer arrival process is described using the “Create” module.
b. The shopping bag check process and the service process at both cashiers are described using the “Process” module.
c. Decision-making to choose a service at one of the cashiers in the systemor to leave the systemis described using the “Decide” module.
d. The process of leaving the supermarket queuing systemis described using the “Dispose” module.
e. To more easily find out how many entities enter and exit the system, the "Record" module is used before and after entering the cashier's service and also after selecting the cashier for the entity that immediately leaves the system.

4.2 Verification and Validation

Model verification is a way to prove whether the simulation model created is correct and can run or not. The model that has been made is considered correct and can be run if it has gone through the check model function on the run menu and after that, a notification appears as below.

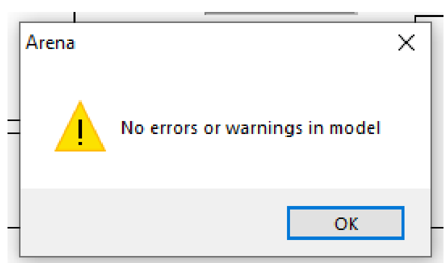

Figure 3. Verification of XYZ supermarket actual system model

Model validation aims to determine the suitability of the simulation results with the symptoms or processes that are imitated. A model can be said to be valid when it does not have a significant difference with the real system that is observed both from its characteristics and from its behavior. The simulation is run with the provision of 1 time of replication in one work shift for 12 hours with a length of time of replication for 12 hours. After the simulation is complete, a report is obtained fromthe systemmodel that has been run.

4.3 Experimentation Result and Analysis

After the simulation was run for 12 hours, based on the report, the average systemprocess results were 5.31 minutes and the maximum system processing time was 10.5 minutes, the system waiting time was 16.56 minutes and the system waiting time was maximum of 47.5 minutes, and the number of system exits was 239 from 247 entities that entered the system.

The actual system modeling of the cashier queue, the two cashiers each have one operator who performs cashier services. Based on the report, the average waiting time for cashier 1 service is 17.10 minutes with a maximum value of 44.17 minutes, and the average waiting time for cashier service 2 is 10.10 minutes with a maximum value of 37.10 minutes. Average operator utilization the average at cashier 1 is 93.19% and the average operator utility level at cashier 2 is 84.07%.

4.4 Proposed Improvement Scenario

Improvement are needed to make the systemruns optimally, because the results after running the simulation in a fairly high level of waiting time and utilization.

a. Improvement Scenario 1

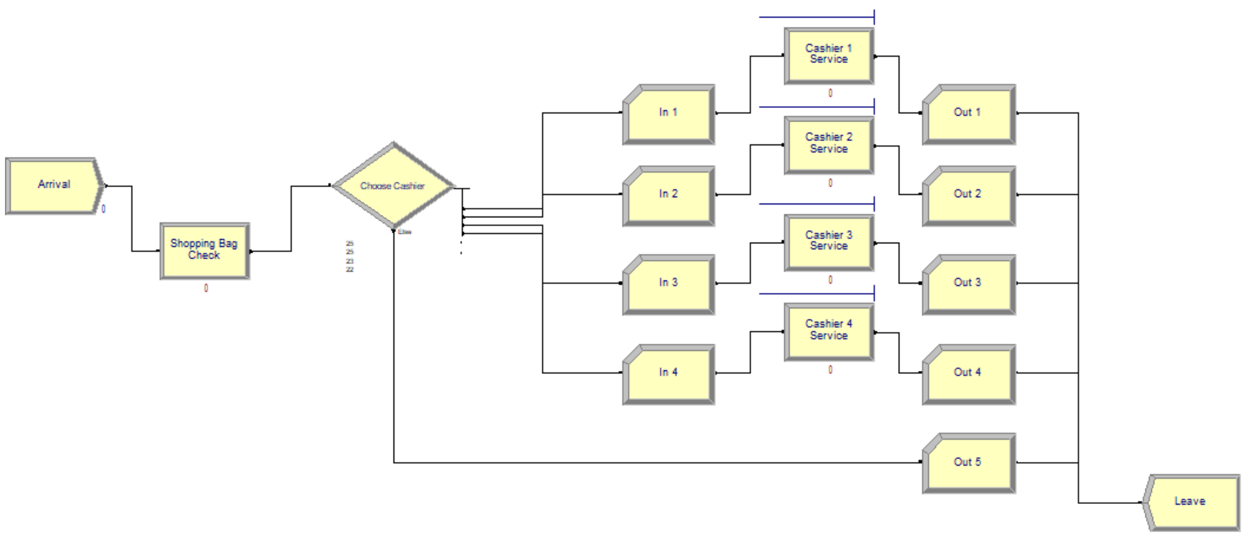

Figure 4. Improvement scenario model simulation 1

The above is a modeling of the first improvement system for the cashier queue at XYZ supermarket using Arena Simulation software. In this first improvement scenario, there are the addition of two additional servers and the addition of two additional operators on the second server. Based on the results of the report, after the simulation was run for 12 hours, the average system processing time was 0.12 minutes and the maximum systemprocessing time was 0.6 minutes, the systemaverage waiting time was 0.24 minutes and the system maximum waiting time was 1.76 minutes, and the number of exiting the systemwas 229 out of 238 entities that entered the system.

In the first improvement scenario of the cashier queue, the four cashiers each have one operator who performs cashier services. Based on the results of the report, the average waiting time for cashier service 1 is 0.03 minutes with a maximum value of 0.17 minutes, for cashier service 2 is 0.04 minutes with a maximum value of 0.30 minutes, for cashier service 3 is 0.54 minutes with a maximum value of 1.70 minutes, and for cashier service 4 it is 0.12 minutes with a maximum value of 0.63 minutes. The average operator utilization rate at cashier 1 is 46.86%, at cashier 2 is 52.03%, at cashier 3 is 84.24%, and at cashier 4 is 56.61%.

b. Improvement Scenario 2

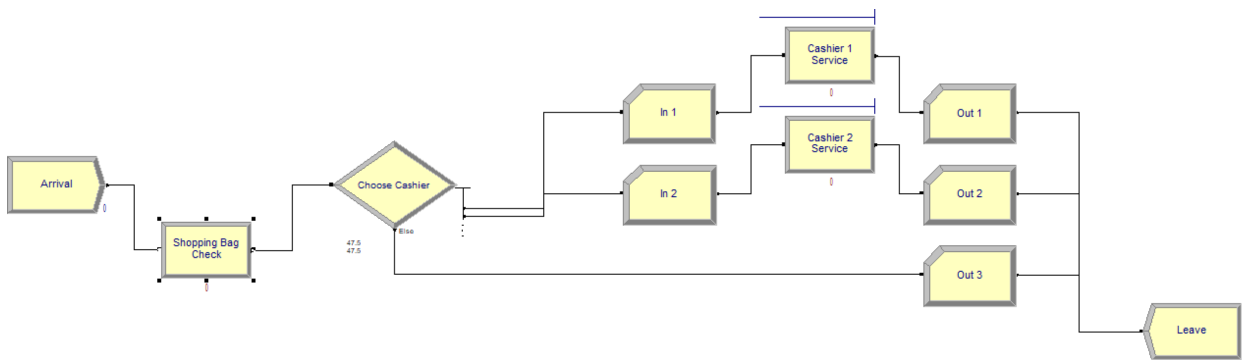

Figure 5. Improvement scenario model simulation 2

The above is a scenario modeling system for repairing the two cashier queues at XYZ supermarket using Arena Simulation software. In this second improvement scenario, there is the addition of one additional operator on each server that serves as a packer of goods. Based on the results of the report, after the simulation was run for 12 hours, the average system processing time was 0.08 minutes and the maximum system processing time was 0.17 minutes, the system average waiting time was 0.05 minutes and the system maximum waiting time was 0.21 minutes, and the number of exiting the systemwas 236 of the 238 entities that entered the system.

In the scenario of improvement the two cashier queues, the two cashiers each have two operators who perform cashier services. Based on the results of the report, the average waiting time for cashier service 1 is 0.0053 minutes with a maximum value of 0.09 minutes, and the average waiting time for cas hier service 2 is 0.0058 minutes with a maximum value of 0.15 minutes. The average operator utilization rate at cashier 1 is 55.26%, at cashier 2 is 56.54%, packer 1 is 26.26%, and packer 2 is 29.91%.

4.4 Comparison of Actual and Proposed Improvement System

After simulating the three models and the results have been released, then a comparison of the level of utilization, waiting time, and productivity is carried out.

a. Utilization Rate Comparison

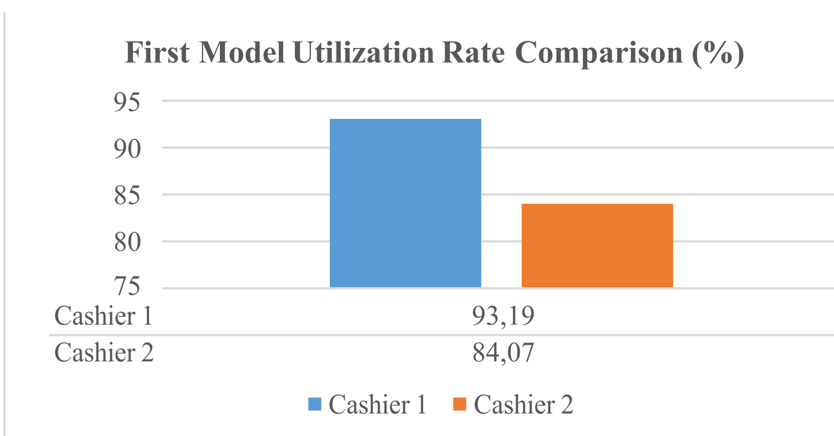

Figure 6. First model utilization rate comparison chart

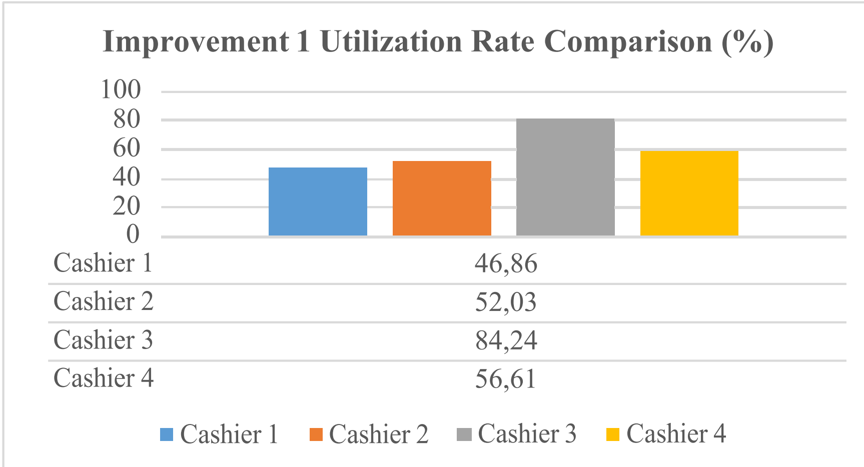

Figure 7. Improvement 1 utilization rate comparison chart

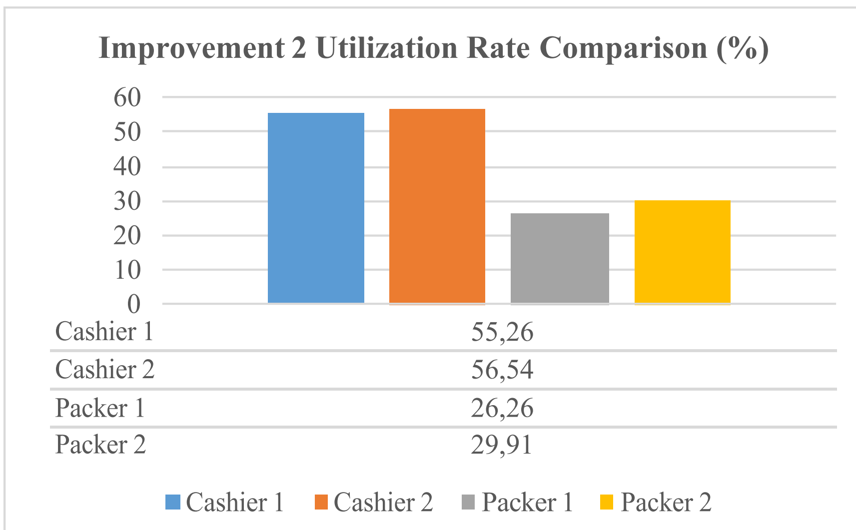

Figure 8. Improvement 2 utilization rate comparison chart

Based on the comparison graph of the utilization level above, it shows that in the first improvement after the systemwas added to 4 cashier servers, the utilization of cashier 1 and cashier 2 decreased. However, there is still a fairly dense queue at cashier 3 so that the utilization of cashier 3 can be said to be high. In the second improvement by not adding a server but by adding one operator to the two cashier servers who served as packaging, the results obtained were evenly distributed between cashier 1 and cashier 2. In the second improvement, the utilization value of cashier 1 and cashier 2 also decreased compared to the utilization in the initial model.

b. Waiting Time Comparison

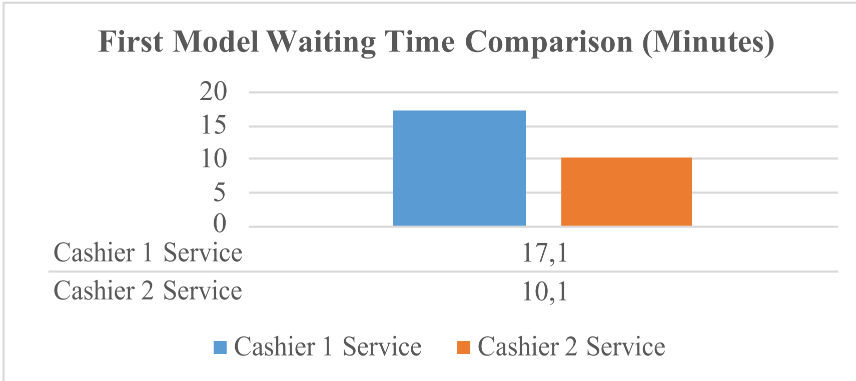

Figure 9. First model waiting time comparison chart

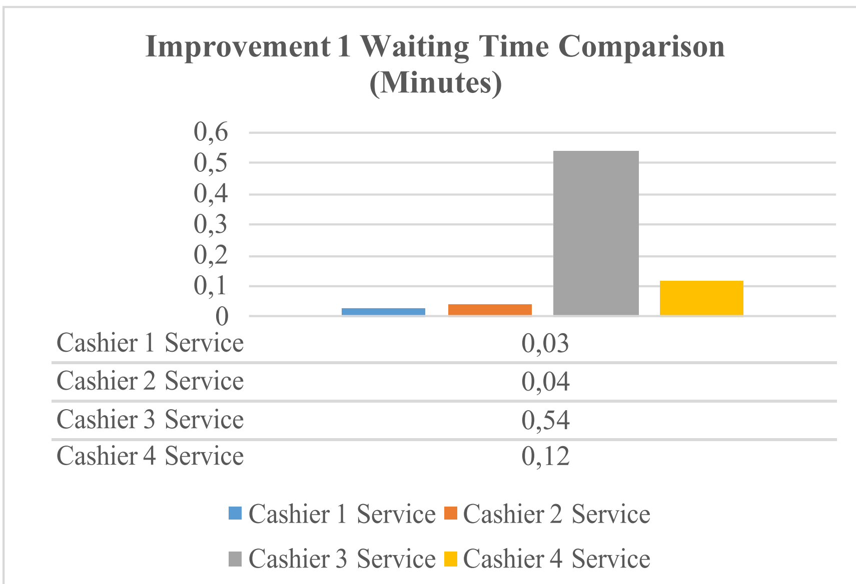

Figure 10. Improvement 1 waiting time comparison chart

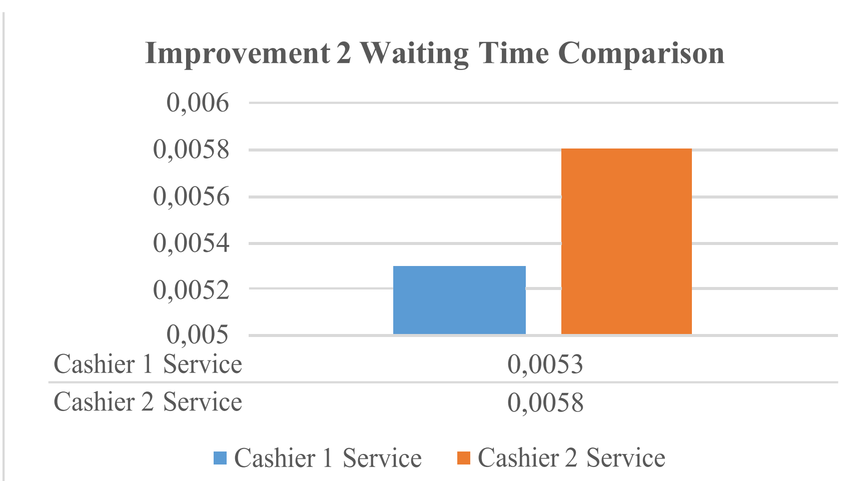

Figure 11. Improvement 2 waiting time comparison chart

Based on the waiting time comparison chart above, shows that in both scenarios the improvement has decreasing the average waiting time of the systemcompared to the initial model. The second improvement scenario has a lower average systemwaiting time than the first improvement scenario, which is 0.05 minutes.

c. Productivity Rate Comparison

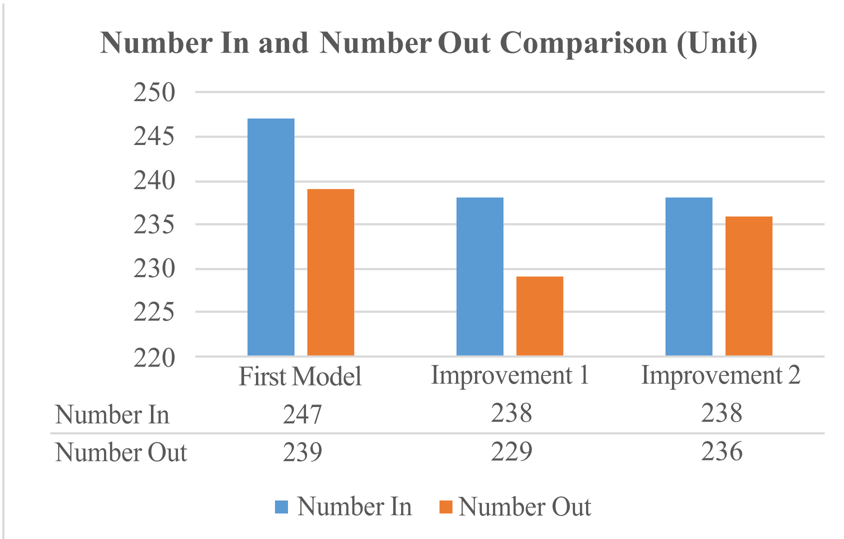

Figure 12. Number in and number out comparison chart

Based on the comparison chart of number in and number out above, it shows that in the initial model the number out produced was 239, in the first improvement scenario the number out produced was 229 which decreased fromthe initial model but with a decreased number in, and in the scenario the second improvement number out resulted in 236 which increased fromthe first improvement scenario.

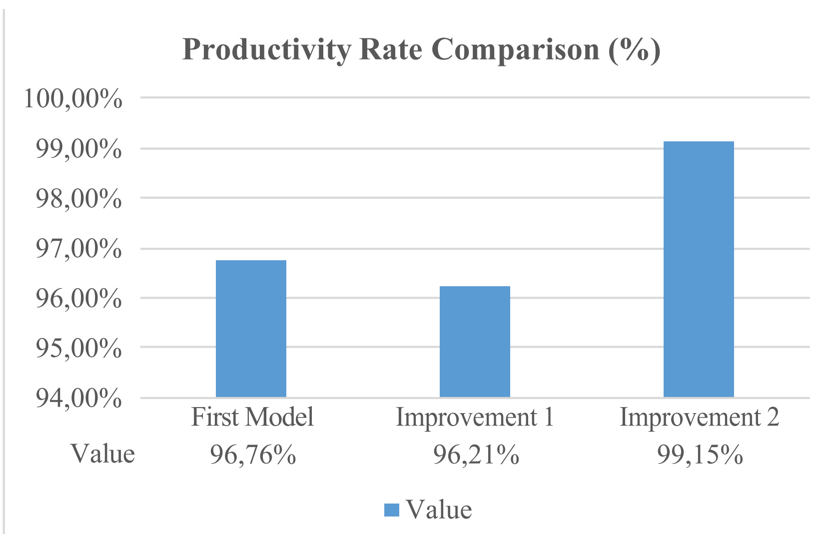

Figure 13. Productivity rate comparison chart

Based on the comparison graph of productivity levels above, it shows that in the first improvement scenario, the lowest productivity level is 96.21%. Meanwhile, the highest productivity level is in the second improvement scenario, which is 99.15%.

5. Conclusion and Suggestion

After the simulation using the Arena software, it is found that the simulation of the second improvement scenario model has better results compared to the initial model simulation and the first improvement scenario simulation. Based on the level of utilization of the simulation system, the second improvement scenario experienced a decrease in utility compared to the initial simulation model and the first improvement scenario simulation, which means that in the second improvement scenario, the cashier server experienced a decrease in queue density because it had completed faster service. Based on the waiting time, the second improvement scenario also has a lower average systemwaiting time compared to the initial model and the first improvement scenario, because the second scenario waiting time is only 0.05 minutes. Judging from the productivity level, the second improvement scenario has a value of 99.15% greater than the productivity of the initial model or the first improvement scenario.

Therefore, the simulation of the second improvement scenario is the most optimal simulation so that it can be chosen to be applied to the XYZ supermarket cashier queue system namely by adding one additional operator to the two servers that serve as packaging. Then our suggestions for further research can be to observe more deeply related to the problems in this research and can also examine whether the proposals selected in this study can be applied or not.

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