A STUDY OF QUEUING TIME IN WAITING LINE OF SUPERMARKET AT CASHIER COUNTER BY USING SIMULATION

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NUR ATIRAH BINTI ABIT (PC12029)

Thesis submitted in fulfillment of the requirement for the award of the degree in Bachelor of Industrial Technology Management with Honors

Faculty of Industrial Management
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2015

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Industrial Technology Management with Honors.

Signature:
Name of Supervisor:
Position:
Date:

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotation and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature:
Name:
ID Number:
Date:

DEDICATION

This thesis is dedicated this thesis to my parents and friends, who support and assistance me while completing this thesis.

I would like to dedicate this thesis to my supervisors, Mr. Hasahudin Bin Hassan, who gives me a lot of advice, suggestion and additional knowledge throughout my study.

Finally, I want to dedicate this study to Tunas Manja Sdn. Bhd. as well because willing to share information and experience in their business.

ACKNOWLEDGEMENTS

I am grateful and would like to express my sincere gratitude to my supervisor Mr. Hasahudin Bin Hassan for his germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research possible. He has always impressed me with his professional in which it relates to this study. I appreciate his advices during the time of carry out this thesis. His advices me that this study's objective is not only for fulfill the final year project but also for the future use which may relate to my career.

My sincere thanks to all my course mates who share their knowledge and helping me in writing and conducting my study. There are many obstacles I faced during this study, but I manage to keep this on until I manage to finish the study. It is because of the support given by a precious friend in UMP.

I acknowledge my sincere indebtedness and gratitude to my parent for the love, patience, and sacrifice throughout my life. It is hard to express out all my appreciation for their devotion, faith and support in my ability to succeed my goals.

ABSTRACT

This study focuses on queuing time in waiting line in relationship to the customer satisfaction. This study was conducted to the operational activity on cashier counter at one on the supermarket in Kuantan. This study applied simulation approach by using Arena Software to develop and simulate actual process at cashier counter. This study took one year duration to be completed. It is the quantitative study in which the performance is measured by the utilization for the whole system at cashier counter. By using simulation model on cashier counter, this is significant improvement on queuing time in waiting line by 30% on the normal duration (Recording 1 min 90 sec).

Keywords: Queuing time, Simulation, ARENA software, Waiting Line design, Cashier Counter, Utilization

ABSTRAK

Kajian ini memberi tumpuan kepada masa menunggu dalam barisan sejajr dalam hubungan untuk kepuasan pelanggan. Kajian ini dijalankan untuk aktiviti operasi di kaunter juruwang di satu pasaraya di Kuantan. Kajian ini menggunakan pendekatan simulasi dengan menggunakan perisian Arena untuk memajukan dan meransang proses sebenar di kaunter juruwang. Kajian ini mengambil tempoh satu tahun untuk dilengkapkan. Ia adalah kajian kuantitatif di mana prestasi diukur dengan penggunaan untuk seluruh system di kaunter juruwang. Dengan menggunakan model simulasi di kaunter juruwang, ini adalah peningkatan yang ketara pada masa menunggu dalam barisan iaitu masa menunggu 30% pada tempoh normal (rakaman 1 min 90 s).

Kata kunci: Beratur masa, Simulasi, ARENA perisian, Reka bentuk barisan menunggu, Kaunter juruwang, Penggunaan

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LIST OF SYMBOLS

$\boldsymbol{\lambda}$ = mean arrival rate of customer

μ = mean of service rate

p = rate of utilization

s = the number of server in system

n = the number of customer

L = average number of customer in the system

L_Q = average number of customer in the line

W_Q = average time customer wait in line

P_n = probability that n customer in the system given time

P_0 = probability of no customer in system

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

As developing countries and the increasing of population of society, the system management in our country is in need of improvement in terms of all aspects including of supermarket system, banking system, hospitalization system and so on. From day to day, billions of people would be demand for a service that had been provided. They would be flooded to the placed to make their daily matters such as making a loan or open an account book at bank, buying goods at the supermarket, getting treatment in a hospital or clinic and for people work at port they are waiting their container to be served and waiting line occur. Some of them had been faced to wait for a long time before they would be served. All these situations need a system so everything works smoothly. The system called as simulation. Simulation is a method of problem solving that is indispensable to solve real-world problems and it is used to describe and analyze the behavior of a system (Banks 1999) [2].

Consumers today are more constrained by the time than ever before. The services providers should be understand that consumers put their time to wait and in term of their perspective it is just as futile wait for services delivery. Furthermore, the customer waiting in line to get their services probably would be lost of customer (Sheu, McHaney et al. 2003) [12]. Figure 1.1 shows waiting cost and service level trade-off.

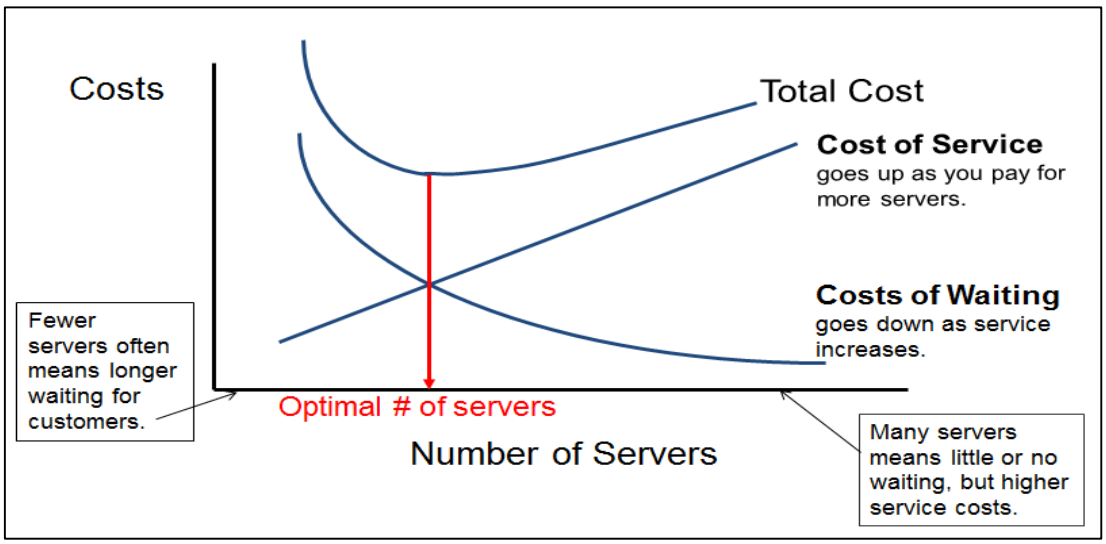


Figure 1.1: Waiting cost and service level trade-off

The source of customer service population divided into two categories such finite and infinite. The finite customer population means the numbers of customers already in the system may effected when the number of new customers arrived. The rates at which people generate new customers do not affect the number of the customers waiting in line called infinite.

In this situation, the cooperation between services provider and the customer are needed. For this situation should be considered as waiting line situation. Therefore, one problem at the counter services which is affected to the cost is Waiting Line Problem. Each customer has a variety of action when they are waiting in line such balk, renege and jockey. Balking occurs when at the first views of customer to long line; they do not enter the waiting line. Reneging occurs when customer enter the waiting line but leaves before they had been served. Jockeying occurs when customer in waiting line change to another line hoping that ways could be reduce their waiting time.

The designing of model of waiting line is not easier thing. It is was designed to be more better management in service process instead of lowering the customer waiting time for satisfaction of customer (Sheu, McHaney et al. 2003) [12]. Basically, the service process occurs such as where the customer enter the service system forming a

waiting line, the customer take an order and wait for their needed. In service-based customer convenience must visit the service facilities so that the service will be provided (Sheu, McHaney et al. 2003) [12]. Figure 1.2 shows the design of waiting line model.

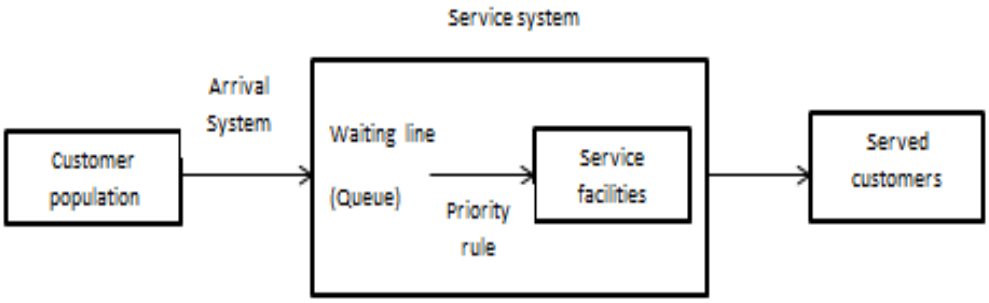


Figure 1.2: Design of waiting line model

Furthermore, the design of 1 to 4 offers different design structure in terms of the waiting line is designed and the way in which the process is a great service (Sheu, McHaney et al. 2003). Example of service process shows at Figure 1.3.1 until Figure 1.3.4.

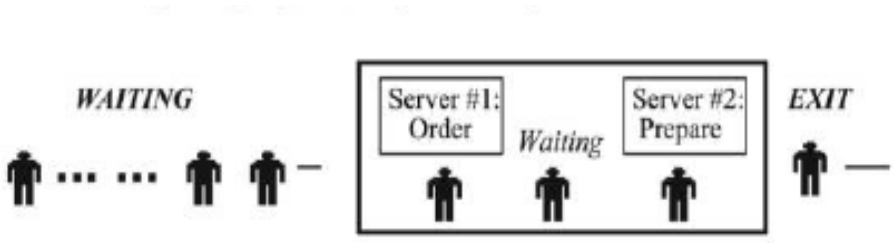


Figure 1.3.1: Design Multi-stage, Single-queue, Single-server System

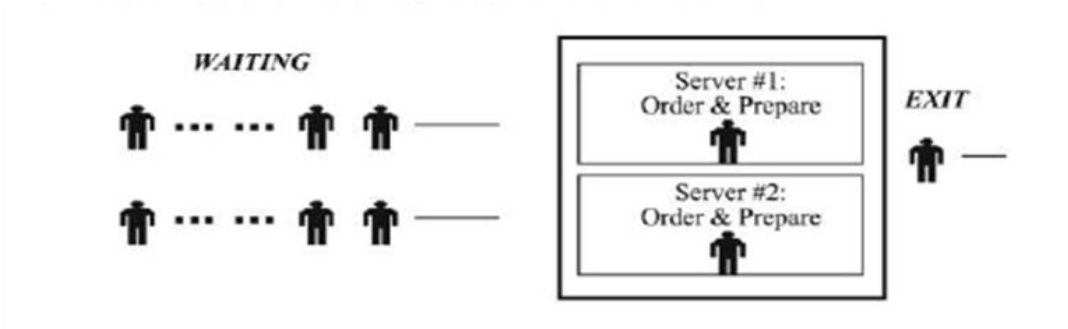


Figure 1.3.2: Design Single-stage, Multiple-queue, Multiple-server System

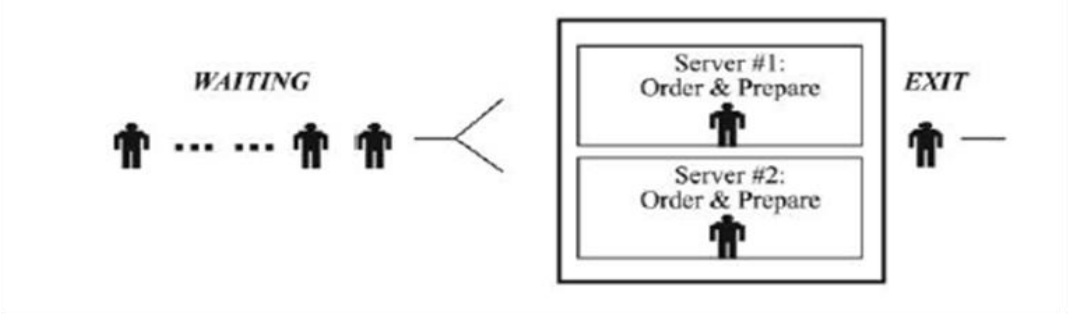
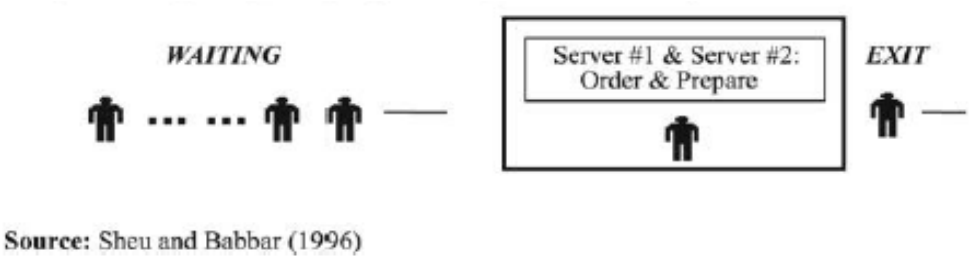


Figure 1.3.3: Design Single-stage, Single-queue, Multiple-server System



Source: Sheu and Babbar (1996)

Figure 1.3.4: Design Single-stage, Single-queue, and Single-team-server System

Figure 1.3: the different structure waiting line

With the changes that occur in the design, the waiting time of customer was identified. The service processing from cashier counter, is the problem of waste time on customer service which is a set of tasks of a job and in such a way to lower idle time between customer service, meet the best ways of waiting line that influence the waiting time of customer instead of to satisfy the customer.

1.2 PROBLEM STATEMENT

Generally, the problems of this study are focusing on waiting time on customers. The main problem occurs under this study are:

a) The queuing and idle time among of cashier counter that influence of waiting time of customer such as a lot of customer or inefficiency server.
b) The queuing and idle time given high cost for the company.

1.3 OBJECTIVE OF THE STUDY

The objective of this study is to enhance the satisfaction of the customer through reducing the queue and idle time among of cashier counter at waiting line. The objective of the study is:

a) To determine better path of model used for waiting line of customer that be served
b) To develop the simulation model to reduce the queueing time at operation service of supermarket.

1.4 METHODOLOGY

In order to solve the waiting time of customers, the mathematical method of service operation has been used. Many of mathematical method's methodology explored and founded.

In these fields, the mathematical method of service operations usually used to solve problem of waiting time of customer for service industry area. It is going on all over the world of service operation unless if the manager of company minimizing the queuing and idle time among cashier counter toward customer. Therefore, the mathematical method can help to achieve the objective of this study.

This mathematical method can use within a spreadsheet format. The spreadsheet format are provided to estimate the coefficient of variance and standard deviation of queuing and idle time among of service serve that influence customer waiting in line (Zhao, Hou et al. 2014) [13].

In other hand, the optimization model also can be used to solve this problem. Optimization model including of changing in it is maximum and minimum objective function, variable, parameter or may be changing for it is constraint to minimize the queuing and idle time between the cashier counter and customer (Zhao, Hou et al. 2014) [13]. The optimization method to optimize the customer waiting affected the real cost among service industry area. Besides, this method also to optimize the number of cashier counter if some specific value placed on the time of customers (Ittig 2002) [5].

The best optimization method had been used usually linear programming (LP) which is decision making on the variable linearly depending of the objective function. In this study, the linear programming (LP) the best ways for solving problem at service industry area.

1.5 SIGNIFICANT OF STUDY

The main target of this study is to obtain customer satisfy by reducing the waiting time of customer that occur at service operation. Furthermore, it is would help to enhance the efficiency of cashier counter toward waiting time of customer. Moreover, this studies also to determine either the queuing and idle time influent to cost of the company.

1.6 SCOPE OF STUDY

This study would be done at Tunas Manja Sdn. Bhd. This has a supermarket within one floors of a building at Taman Tas, Gambang. Business activity of Tunas Manja was retailing and wholesale. The data collection would be collected from one of the staff of operation department at Tunas Manja Sdn. Bhd. The model of this study

would be applied to waiting time of customer while paid their items. Besides, it is also helps to gain customer satisfaction based on how efficiency of cashier counter works.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The waiting process in operation industry consists of many counters at the cashier counter that influence of waiting or queuing time problem. This problem has been addressed from many researchers within different methods are developed in order to minimize the queuing time of customer waiting in line. Among of researcher used commonly methods such as linear programming, queuing theory, spreadsheet format and simulation, etc. In this chapter, it is related literature review regarding of research from researcher had been done. This chapter contains three parts which are the first part reviews the problem background of waiting line. Second part reviews the detailed of methodology are used in this study and the last part is the model that would be used to minimize the queuing and idle time within customer waiting in line.

2.2 PROBLEM BACKGROUND

This study focuses on waiting line problem of the cashier counter operation. More detailed explanation of the problems encountered such the queuing and idle time will be made in the next section. The waiting line under study focuses on the problem that called waiting and queuing time in the waiting in line by customer. The customer's perception about the quality of the service is very important in business for any organization. The waiting line consists of many customers queuing in cashier counter for paying off their expenses, and at each counter is certain operation service are performed regarding idle time. The waiting line problem occurs when one or two counters are facing many of customer wait in line and waste much their time to get their

service to be served. This problem causes to queuing and idle time at waiting line system.

On the other hand, in order to solve the waiting line problem, the detailed of cycle time on each server taken, the kind or type of expenses of customer buy, and queuing time at each counter has to be considered. The idle time has been considered as between the cycle time of cashier counter and the queuing time of the customer. The sum of time for all operational services of this cashier counter should not exceed the cycle time given. Besides, the number of customers waiting would be minimized if only if the number of cycle time of cashier counter is minimized too.

2.3 METHODOLOGY OF MODELLING

There are many models that were used to solve the waiting line problem such as simulation, modelling, linear programming (LP), and queuing theory. The objective of all these models is to obtain perfect waiting line system. Furthermore, all of the models listed to achieve high satisfaction among customer through reducing the idle time as possible. The system also can be defined as a group of objects that are joined together a few regular interaction or interdependent with each other towards some objective or achievement. The good system provides a good strategy to help implement the best feasible solution. Models of system have been classified into two which is a mathematical model or physical model as follows Figure 2.3.

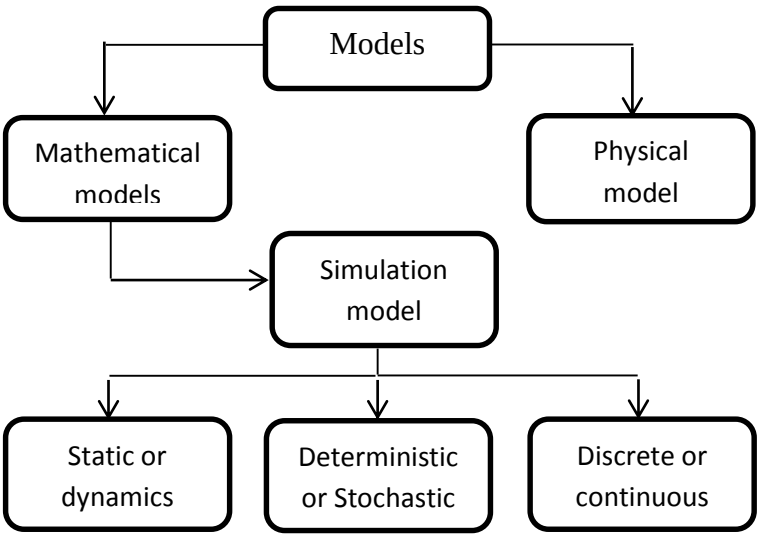


Figure 2.3: Classification of models system

1. Physical model:

Queuing theory: This theory occurred when the customer may arrive one by one or in batch. The example of batch arrivals is university student where queuing in line to pay some bus fares before boarding.

2. Mathematical model:

Linear programming (LP): LP problem defined as the problem of minimizing and maximizing a linear function and constraint based on the decision of problem either linear equalities or inequalities. LP is commonly or optimal decision making tool in this case study. The main problem faced by all managers is how to provide for limited time between activities.

3. Simulation model: Simulation models are powerful technique for solving variety of problem in the world and it is imitation of operation of a real world tool system over time (Banks 1999) [2]. Simulation models can be done using manually or computer systems and among of researcher used a simulation models in experimental techniques. The basic idea of simulation models are, simulation models would be given some equation throughout means and the time dependent behaviour has been determine. Besides, there are two ways that simulation model could be used such as:

Analysis tool: The analysis tool for prediction of effect change that may occur through the existing system.

Design tool: The design tool for predict the performance of the new system under a set a circumstances which vary.

The simulation model also has entities, attributes, variable, resources, queues, events, simulation clock and starting and stopping (Kelton, Sadowski et al. 2012) [6].

4. Static or dynamic model: The static or Monte Carlo simulation is a types of simulation that computing the result by repetitive random sampling with the statistical analysis (Bortz, Kalos et al. 1975) [3] or the changing of a system only at particular times. For dynamic model, the system is always changing over time. For example, the researcher has done a simulation about time of customer arrived at supermarket from 10 A.M to 10 P.M.

5. Deterministic or Stochastic model: Deterministic and Stochastic is a mathematical model in which the right decision was determined by the known relationship between events with no changing of any room. The output produce should be as same as input. Different with the stochastic which is there are the input have more than one of variable and output follows the input getting.

6. Discrete or continuous model: This modelling concept means when the event or operation occur only one of the variable would be a change in discrete point in the time. Along this event, this modelling would be capture and solve the problem occur at that time (Banks 1999).

2.3.1 ADVANTAGES OF SIMULATION MODEL

The advantages of simulation models are followed: (Banks 1999) [2]

- To choose correctly

  - The simulation model would be greatly helped manage in resolving the problems faced, especially if the manager wants to make a decision that could affect profit and loss of organization

- Time expansion and compression

  - It is allowed the company to move faster or slow down the situation, meanwhile the investigation of that problem can be done. For example, one of the managers at Supermarket Company wants to reduce the waiting of customer in line when the peak hour achieved. So, before peak hour arrived managers can spend two hours for examining all events that occurred during one minute of activity simulation.

- Understands "What if"

  - Once the simulation develops, it is would be provided a convenient experimental laboratory to perform "what if" and sensitivity analysis.

- Ability to gain insight

  - Once the organization or company had been through of developing a valid simulation model, the managers may be impossible to attain through another technique, policies, and production procedure or may be make some modification in the model and seeing the effected change in software within real system.

2.4 RESEACHER FINDING

Through the resources that have been reviewed by researchers found, most of the problems that occurred in the operating system are queuing problem, waiting time problem and idle time between cashier counter and customer.

2.4.1 Waiting time problem

Morabito and Lima (2004) [8] conducted research about analysis of congestion of customer in the Brazilian Supermarket Association (ABRAS). Through their study

found that many customers regularly come to the supermarket based on customer experience themselves such as they know about the layout of the supermarket, the arrangement of product of shelves and the most important to the customer is less congested time periods. They are suggested simple Markovian model for minimizing the waiting time of customer considered also customer behaviour while the customer waits to be served

Adan and Resing (2015) [1] studied about the effect in term of cost based on waiting time. They are more pay attention to analytical method and applying of queuing model in their case study. The outcome that they get from their case study is queuing model very useful tool for design all of systems such as capacities, layout and control system.

Kar (1996) [11] are discussed about the checkout counters at Bangsar supermarket. This supermarket is facing problem to plan and manage their checkout services. So, he wants to propose through queuing system theory by mathematical and operation scientists. Besides, the mean queuing length at checkout has been calculated. He also used the SAS simulation studio may be would be helping the business run smoothly and helps the business to manage their decision making process.

2.4.2 Queuing problem

Nafees and Liang (2006) [9], they used queuing theory to analysis the quality of service for operation checkout at ICA supermarket. The problem that they want overcome are occurring congestion at the checkout operation unit when the customer start coming. So within this problem, they are trying to detect or eliminate the different variable based on service and time for improving the quality of services.

Tripathi (2013) [10], she proposed a simulation of queuing models of sales checkout service performance. The problem that she faced in her research is the customer has to wait long in a queue between 8.9 minutes compared the customer queue with two servers which is 7.2 minutes per weekday. By simulation of queuing model,

the problem has been solved by multiple server queuing models. She got average time number of customer queue in line for two servers is 21.3 minutes compared to one server is 28.9 minutes. Hence, she has been minimizing the queue time by minimizing 7.6 minutes per weekday.

2.5 SUMMARY

In this chapter has been reviewed about simulation model and waiting line problem in service operating system. This problem has been highlighted in two problems are waiting, an idle time problem and queuing problem. Hence, all of the problem would analyse and solve the problem in this case study. Furthermore, the previous study and work from the researcher has been proved with successful results with the different method of solving problems based on waiting; idle time and queuing time. The objective of this case study is to enhance the efficiency of cashier counter or counter service by using the ordinary methods researchers used it in the past.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

It is can be said as the number of experiments conducted on the model simulation is one of the artificial realities to determine the actual behavior in the real environment. Equivalent to situations where a simulation of reality in physical form, or another researcher called was analog simulation. For a complex and complicated problem, analog simulation may not be practical, and real experimentation with the system may not be uneconomical in decision making especially in terms of management. Such complex systems are formulated in a mathematical model that has been developed through the computer program because the problem should be resolved through the use of sophisticated electronic computer called as simulation system.

This chapter would be discussing the methodology of the research. There consist of four section that be discussed. The researching design is the first section. Second section in this chapter would be mention of description of process of waiting line. The third section is the method collection of data that be used and once the data has been collected, the mathematical method would formulate based on the problem had been faced. Besides, mathematical method that chooses in case problem is solved by computer software as evidence.

3.2 RESEARGHING DESIGN

The Arena simulation is also one part of simulation system that used for waiting line and queueing time problem to solve. Simulation Arena, Linear Programming (LP),

Decision Model, Queuing Theory also can be categories in operation research (OR). OR can be defined as a method for analyzing all problems to be solved and decide which will be useful in the management of the organization. In OR, the problem would be divided into basic components and then solved in steps prescribed by mathematical analysis. Besides, the conceptual model which is simulation method, analysis of network, theory of queuing and mathematical logic has been used in OR. In my study I would using the computer simulation called Arena Simulation. The Figure 3.1 shown as seven step to conduct Simulation (Law 2003) [7].

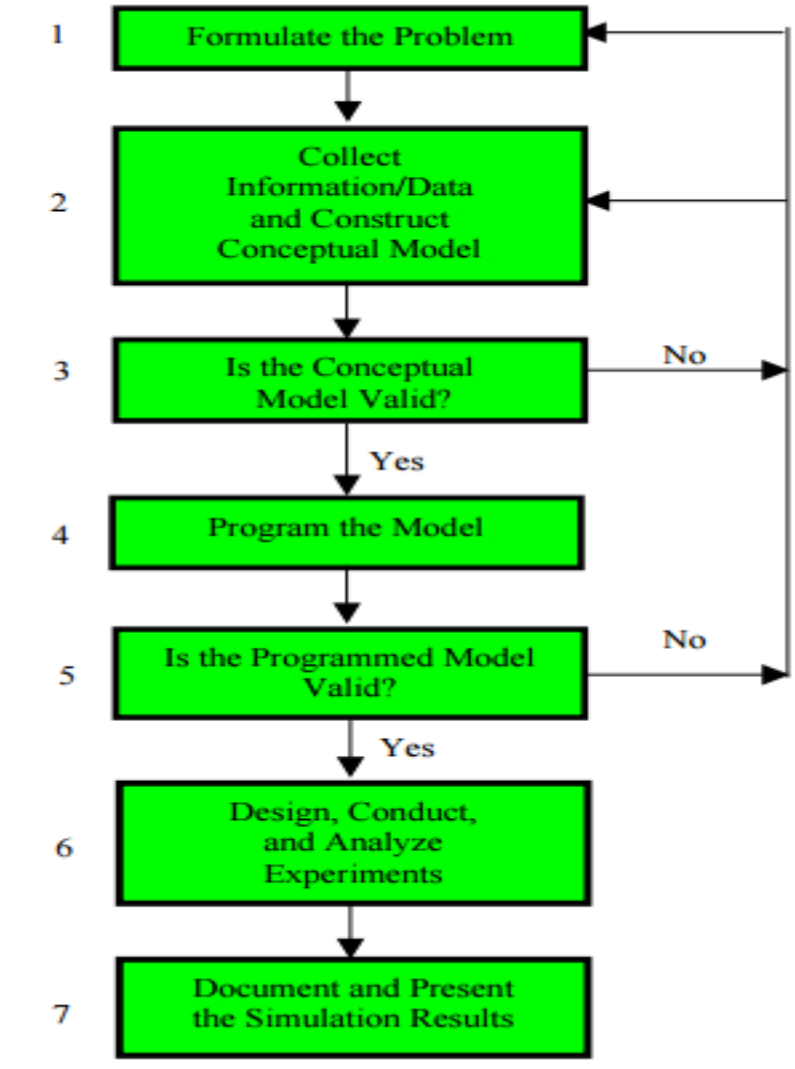


Figure 3.2: Seven Step Approach of Simulation by Averill M. Law (2003)

In steps 1, formulate the problem through reformulate the problem and better understand obtained. This is because sometimes the problem there is not the same as a real problem. Step 2, collect information/data and construct conceptual model by gathering data and information on operating system or system structure of a case study. Step 3, is the conceptual model valid? In this step asked whether the structure path of a conceptual model that performs is valid or not before continuing to the next step. Step 4 is programmed model. The conceptual model also called as commercial simulation-software product. It is divided into two types of commercial simulation-software product which is an application oriented (SIMPROCESS, Flexsim, and Pro-Model) and general purpose (Arena, Extend, and SLX). In step 5 are asking whether the performance measure from the simulation model from existing and actual system is reliable or not. Step 6, design, conduct, and analysis experiment which is focusing on all aspects seem as the simulation run length, the number of independent model replication and length of the warm up period. The last step, document and present the simulation result through documentation of model or structure, the computer programming description and the result of a case study.

3.3 DESCRIPTION THE PROCESS AT THE WAITING LINE

Tunas Manja Sdn. Bhd. is a business company that related to retailing and wholesaling. The product from this company includes of food line (drink, beverage, chocolates, etc.), household, soft-line (fabrics and textile) and hard- line (hardware, electrical, etc.). The Tunas Manja Sdn. Bhd. has categories as convenient shop based on the capacity of product they have. The categories of Tunas Manja in this case are it is a convenient supermarket because of they have their own wholesales that could be kept store the all of the product.

It is consists of eight cashier counter with always congested by customer arrived and customer waits in line for paid their item. The process for waiting line in all over supermarket usually is the same which is arriving different customer, choose and select product, customer waiting in line and queue time started, paying item at cashier counter and customer exit from supermarket shown in Figure 3.3.1 and the proposed model that build in ARENA simulation software in Figure 3.3.2.

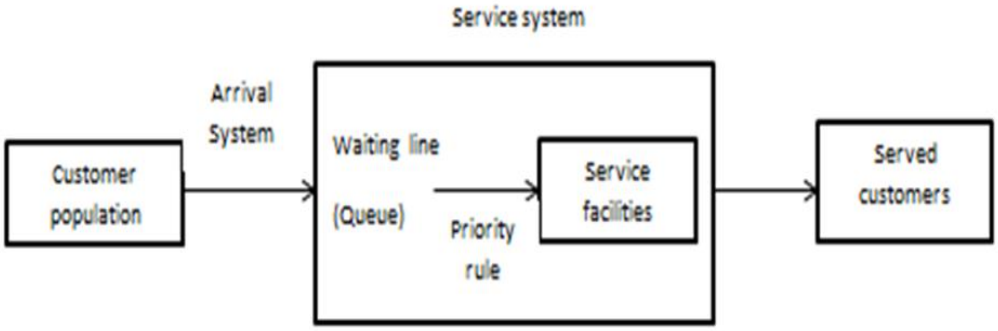


Figure 3.3.1: Process flow of wait in line

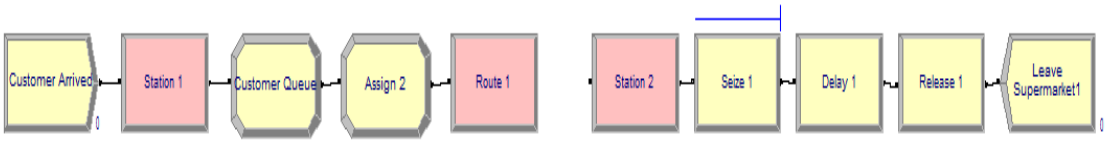


Figure 3.3.2: Constructed model of Waiting Line in counter service in ARENA

3.4 METHOD OF DATA COLLECTION

The accuracy in collecting data is very important in the commandment in this case study. Data collection is the processing of gathering and measure information based on interest variable, systematic fashion establishment, hypothesis testing and, outcome evaluation. On the other hand, the systematic fashion would be used while data had been collected to get the validation of results. The systematic fashion divided into three fashions such as observation, historical data, and interview.

3.4.1 Observation

The systematic observation is a way of collecting data by watching behaviour, event, or condition in their natural situation. This method would be help in understanding what is going on into the operating system or situation.

3.4.2 Historical Data

In this method, the data would be getting through other sources such as the annual report and the background of the problems of the company in more detailed.

3.4.3 Interview

The systematic interview method is the method of formal and informal conservation for two people. So, this is one way to collect the data through an interview session with the manager and staff of the company itself. It I could help to get more accurate information based on their experiences themselves.

3.5 WAITING LINE METHOD

The waiting line method is one important solution in the simulation model. Many problems in industry, especially operation used the simulation model in solving their problem. There are many assumptions to be simplified. In this case study, some of performance difficult to obtain by analytically such as increasing of waiting times and increasing of customer are queuing in the line. The cost waiting line system that should be considered is the service cost and the waiting cost. Logically, there are some steps to solve the waiting line problem.

Modelling: Firstly, be careful when collecting the data. Collect all relevant data to be included in the calculation of the number of customers who have given service or the number of customers who not already given services, number of customers are waiting in line and etc. The transformation of quantitative description of problem into mathematical method called as modelling. The correct data would be given a best result.

Solving: When the data have been collected and modelling, the solution would appear in computer software that could be used in this problem.

3.6 MEASUREMENT OF WAITING LINE MODEL

One of the objectives of the study is to develop a simulation of waiting line model to solve the problem. The aim of the model is to reduce the waiting line and queue or idle time between counter service and customers. The characterizations of waiting line system operation as are following (Harrington, 2000):

- The probability number of customers in the system
- The average number of customers in the line
- The average number of customers in the system
- The average time of customer waits in the waiting line
- The average time a customer wait in the system
- The probability of customer that arrived to wait for their service
- The rate of utilization system

To find the best waiting line model, the measurement with different model would be selected such single – server waiting line and multiple – server model.

3.6.1 Single – server waiting line model

In this model involving of single –server, single – line, and single – phase system. The characteristic of the waiting line operation could be calculated as follows:

$$\lambda = mean\ arrival\ rate\ of\ customer \quad ----------(3.1)$$

$$\mu = mean\ service\ rate \quad ----------(3.2)$$

$$p = \frac{\lambda}{\mu} = rate\ of\ utilization\ system \quad ----------(3.3)$$

$$L = \frac{\lambda}{\mu - \lambda} = the\ average\ number\ of\ customer\ in\ the\ system \quad -----(3.4)$$

$$L_Q = pL = the\ average\ number\ of\ customer\ in\ the\ line \quad ------ (3.5)$$

$W = \frac{1}{\mu - \lambda} = the\ average\ time\ a\ customer\ wait\ in\ system - - - - - - - (3.6)$

$W_Q = pW = the\ average\ time\ customer\ wait\ in\ waiting\ line \quad - - - - (3.7)$

$P_n = (1-p)p^n$

$the\ probability\ that\ n\ customers\ are\ in\ service\ system\ at\ given\ time - (3.8)$

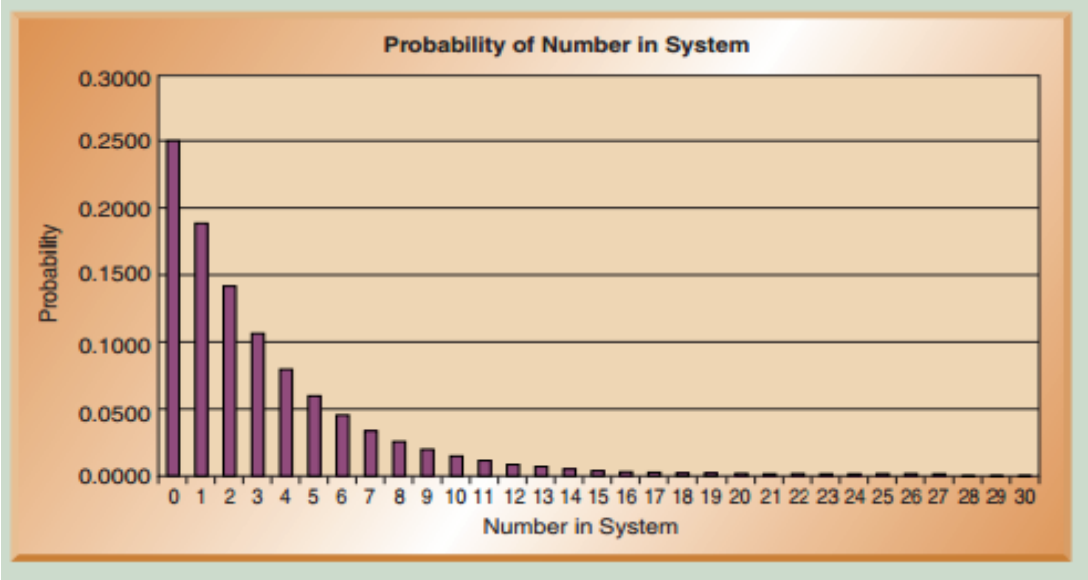
$\mu > \lambda$, waiting line grows in infinite smaller

$\mu \leq \lambda$, waiting line grows in infinite larger

The calculation followed the some assumption when the model are made such (1) customer of behaviour (jockeying, balking, and reneging), (2) the Poisson distribution are that describing of customer arrival by mean arrival rate of customer (λ) or average time between customer arrive based on exponential distribution ($1/\lambda$), (3) the Poisson distribution that describing of mean service rate (μ) or average service time for one customer based on exponential distribution ($1/\mu$), (4) subscribe to the principle of waiting line first-come, first- served. Example of solution as following:

	A	B	C
1	**Queuing Analysis: Single Server**		
2			
3	**Inputs**		
4	Time unit	hour	
5	Arrival Rate (lambda)	15	customers/hour
6	Service Rate (mu)	20	customers/hour
7			
8	**Intermediate Calculations**		
9	Average time between arrivals	0.066667	hour
10	Average service time	0.05	hour
11			
12	**Performance Measures**		
13	Rho (average server utilization)	**0.75**	
14	P0 (probability the system is empty)	**0.25**	
15	L (average number in the system)	**3**	customers
16	Lq (average number waiting in the queue)	**2.25**	customers
17	W (average time in the system)	**0.2**	hour
18	Wq (average time in the queue)	**0.15**	hour
19			
20	**Probability of a specific number of customers in the system**		
21	Number	2	
22	Probability	**0.140625**	

(a)



(b)

Figure 3.6.1 (a and b): Example of spreadsheet and probability single – server.

3.6.2 Multiple – server waiting line model

In this model, the availability to forming of single line had been served by first server higher. The characteristic of waiting line operating could be calculated as follows:

$s = the\ number\ of\ server\ in\ system$ ––––––––––––––––––– (3.9)

$p = \frac{\lambda}{s\mu} = rate\ of\ utilization\ system$ ––––––––––––––––––– (3.10)

$P_0 = \sum_{n=0}^{s-1} \frac{(\lambda/\mu)^n}{n!} + \frac{(\lambda/\mu)^s}{s!}\left(\frac{1}{1-P}\right)$ ––––––––––––––––––––= –(3.11)

$probability\ of\ no\ customer\ in\ system$

$L_Q = \frac{P_0(\lambda/\mu)^s p}{s!(1-p)^2} = the\ average\ number\ of\ customer\ wait\ in\ line$ –––– (3.12)

$W_Q = \frac{L_Q}{\lambda} = the\ average\ time\ customer\ wait\ in\ line$ ––––––––––(3.13)

$W = W_Q + \frac{1}{\mu} = the\ average\ time\ spent\ in\ system$ ––––––––––– (3.14)

$L = \lambda W = the\ average\ number\ of\ customer\ in\ service\ system$ –––– (3.15)

$$P_n = \begin{cases} \frac{(\lambda/\mu)^n}{n!} P_0 & for\ n \le s \\ \frac{(\lambda/\mu)^n}{s!s^{n-s}} P_0 & for\ n > s \end{cases}$$ ––––––––––––––––––––(3.16)

$probability\ that\ n\ customer\ in\ the\ system\ given\ time$

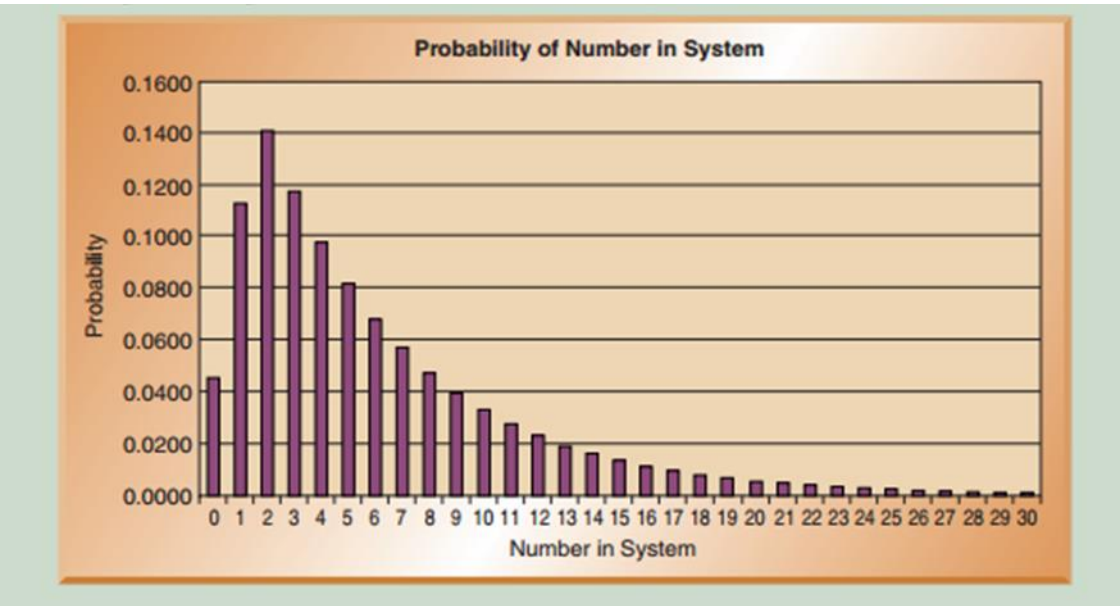
$s\mu > \lambda, waiting\ line\ grows\ infinite\ smaller$

$s\mu \leq \lambda, waiting\ line\ grows\ infinite\ larger$

The calculation followed some assumption when the model is made such as $s =$ exponential distribution of service time for each server or mean of service time is $1/\mu$. The example of solution as follows:

	A	B	C	D	E	F	G	H
1	**Queuing Analysis: Multiple Servers**							
2								
3	**Inputs**				**Working Calculations, mainly for P0 Calculation**			
4	Time unit	hour						
5	Arrival Rate (lambda)	45	customers/hour		lambda/mu	2.5		
6	Service Rate per Server (mu)	18	customers/hour		s!	6		
7	Number of Servers (s)	3	servers					
8					**n**	**(λ/μ)^n**	**n!**	**Sum**
9	**Intermediate Calculations**				0	1	1	1
10	Average time between arrivals	0.022222	hour		1	2.5	1	3.5
11	Average service time per server	0.055556	hour		2	6.25	2	6.625
12	Combined service rate (s*mu)	54	customers/hour		3	15.625	6	9.22916667
13					4	39.0625	24	10.8567708
14	**Performance Measures**				5	97.65625	120	11.6705729
15	Rho (average server utilization)	0.833333			6	244.14063	720	12.0096571
16	P0 (probability the system is empty)	0.044944			7	610.35156	5040	12.1307586
17	L (average number in the system)	6.011236	customers		8	1525.8789	40320	12.1686028
18	Lq (average number waiting in the queue)	3.511236	customers		9	3814.6973	362880	12.1791151
19	W (average time in the system)	0.133583	hour		10	9536.7432	3628800	12.1817432
20	Wq (average time in the queue)	0.078027	hour		11	23841.858	39916800	12.1823405
21					12	59604.645	479001600	12.1824649
22	**Probability of a specific number of customers in the system**				13	149011.61	6.227E+09	12.1824888
23	Number	5			14	372529.03	8.718E+10	12.1824931
24	Probability	0.081279			15	931322.57	1.308E+12	12.1824938
25					16	2328306.4	2.092E+13	12.1824939
26					17	5820766.1	3.557E+14	12.182494
27					18	14551915	6.402E+15	12.182494
108					99	2.489E+39	9.33E+155	12.182494
109					100	6.223E+39	9.33E+157	12.182494

(a)



(b)

Figure 3.6.2 (a and b): Example spreadsheet and probability multiple – server

3.6.3 Calculation of waiting line cost

Total Cost (TC) = Waiting Cost + Service Cost

$$= (c_w L) + (c_s k) \quad ----------- (3.17)$$

$k =$ Number of channels $\quad c_w =$ Waiting Cost

$c_s =$Service Cost

3.7 SUMMARY

For the whole this chapter are describe the framework of the model for achieving the objective by using of waiting line model under operation research (OR). This chapter also proposed the how to formulate the simulation of waiting line model. Furthermore, by using this model the waiting line and queue or idle time between cashier counter and customer had been solved. In other hand, the satisfaction of the customer would be achieved as long as the efficiency of server performance at a high level.

CHAPTER FOUR

DATA COLLECTION AND ANALYSIS

4.1 INTRODUCTION

In this chapter, there would be detailed and explanations of the results and findings, which based on the method described in Chapter Three. Data analysis is a very important step to support the study. The data collection method had been discussed in the previous chapter as well. In this study, the data are gathered from the supermarket Tunas Manja Sdn. Bhd. in Gambang, Pahang. Tunas Manja in Gambang is one of supermarket that sells groceries, baby items, bath items and so on.

The selected waiting line, Tunas Manja Waiting Line, is studied in one of the issue occurred at that company. The disadvantage of Tunas Manja, the problem is always repetitive time to another time because of they does not use the simulation technology to carry out the problem. In my study, I would suggest new technology to this company to solve the problem by carrying out some data that had been collected and the information would be used in computer simulation to reflect the actual situation.

Besides, computer simulation can provide an assessment of the operations in this study. The actual waiting line modelling in computer simulation can be varied as what we wish. But, the understanding is needed on advanced models and identify where the problem are lies.

In the case of this study, the Arena simulation software will be used to form a model and would run the simulation programme. This simulation would help in testing, reviewing and demonstrating of waiting line to achieve the objective.

4.2 DATA COLLECTION AT WAITING LINE

Queuing time is the processing time of customer wait their turn to be served. Solve the queuing time in waiting line is main objective the study. The queuing time is studied in the entire cashier counter at the Tunas Manja supermarket in the unit of minutes. Table 4.2.1 and Table 4.2.2 below show that the data had been collected at eight cashier counters with different phenomenon.

Time	No. of Counter	No. of Worker	No. of Customer	Customer Queue Time (min)	Customer Served Time (min)
10.00 am	1	3	18	20.00	24.30
	2	3	14	17.30	25.53
	3	3	9	20.39	25.13
until	4	3	7	6.36	12.11
	5	3	10	13.09	17.24
	6	3	8	2.16	10.28
	7	2	6	0.00	8.28
5.00 pm	8	2	5	0.59	2.04
	Total	22	77	80.29	125.31

Table 4.2.1: Pattern of customer waited before get a salary

Time	No. of Counter	No. of Worker	No. of Customer	Customer Queue Time (min)	Customer Served Time (min)
10.00 am	1	3	18	33.08	40.38
	2	3	15	35.28	43.38
	3	3	17	34.30	43.34
until	4	3	16	27.40	38.38
	5	3	14	13.26	36.31
	6	3	16	24.03	35.39
	7	2	11	15.27	24.06
5.00 pm	8	2	14	18.09	27.14
	Total	22	121	200.71	288.38

Table 4.2.2: Pattern of customer waited after get a salary

The table above refers to the time it takes for customers buying commodities in supermarkets. The time taken by the customer to wait at the cashier counter has been recorded according to the same days (Sunday) and hours (10.00 am until 4.05 pm) but a different phenomenon which is month of community get a salary and month of community getting salary not yet. The number of customers arrived at for each cashier counter is not same because of the layout of supermarket which is customer mostly arrived at counter 1,2,3 and 4 compared to another counter because of it is close to the wet ingredients (fish, meat, chicken, vegetable) and spices (soy sauce, black pepper sauce).

The types of facilities provided for customers while buying influence the queuing time and the length of the waiting line. The facilities provided for customer

easier carry their items while shopping is there have small trolley, big trolley and basket. In other hand, certain of customer do not use the facilities because not much of the items they want to buy. Therefore, the sum of items that be scanning by cashier at counter and customer wait before they be served is the factors which effect the waiting line process.

4.3 DATA ANALYSIS AT WAITING LINE

In the analysis of this data, what involved when data had been collected is the number of counters have, the length of waiting line in the system, the time taken when the customer are queued, the time taken when the customers are getting the service.

The result in whole of study is focusing more to the how much customer could be served in one hour and the waiting time of customer while they in payment process at the counter. From the data that had been collected at Table 4.2.2, we can see the time taken for customer queue and the time taken for customer served have the highest total compared to Table 4.2.1. So, this study would be more focusing too busy day which is the waiting line problem are occurred with every time additional customer come into the system. The Table 4.3 shows the Waiting Line in busy day result for single-channel system at the cashier counter of Tunas Manja by POM Software to get a more accurate result. But, it is could be calculated by applying the equations stated in chapter 3.

Waiting Lines Results

Waiting Line in Busy Day Solution

Parameter	Value	Parameter	Value	Seconds	Seconds * 60
Single-channel System		Average server utilization	.67		
Arrival rate(lambda)	18	Average number in the queue(Lq)	1.33		
Service rate(mu)	27	Average number in the system(Ls)	2		
Number of servers	1	Average time in the queue(Wq)	.07	4.44	266.67
		Average time in the system(Ws)	.11	6.67	400

Table 4.3: Result of Waiting Line in Busy Day

From the table, the Tunas Manja Sdn. Bhd. used a single-channel system which is the basic process starting the customer arrived with different entity type (big trolley, small trolley, basket and non-basket) in each counter before checkout from supermarket.

4.3.1 Development of Model

In the process of developing new models, the waiting line of customers for each cashier counter are varied. It is including of the behavior of customers while customer waits before they had been served at cashier counter. All of the process involved in cahier counter starting with customer wait in line until they finished making payments for the items they buy are varying in their time constraint. In developing of Waiting Line model by Arena Simulation involved of CREATE module, PROCESS module, SEIZE module, DELAY module and DISPOSE module.

The function of CREATE module which giving the new entities for the model. The entities refer to the customer. To determine the existence of entities that needed by providing four pieces information such as the time arrives for first batch, number of entities arrived in batches, the inter-arrival time between batches and the total number of batches that want to create. The arrival of customers is the name that been used to assign in module. The arrival of customer occurred randomly and the time between arrivals (the inter-arrival intervals) follow the behavior throughout exponential probability distribution with value of mean is 15 minute.

Next, when the entity enter the SEIZE module it is would waits in a queue until all the resources (cashier counter) available. The type of resource usage should be specified.

Furthermore, DELAY module occurred when the entity delay in a specified amount of time. When the entity arrived at the DELAY module, the time would be resulted through time delay expression.

The PROCESS and DISPOSE module are important to represent the flow of entities through the system. The PROCESS and DISPOSE module must be connected so that the flow of entities could be run in system. At the end of simulating process, the result for the model would be published.

Arena simulation is developed to represent the current waiting line in reality. While the process, the animation viewing simulation flow entities is clearly visible unless the modeler quick advances the entire process. It is conceivable to add a few pictures to be inserted in the waiting line with some attractive picture like man/lady and machines as the resources and the routes of passing the entities starting with one counter then onto the next.

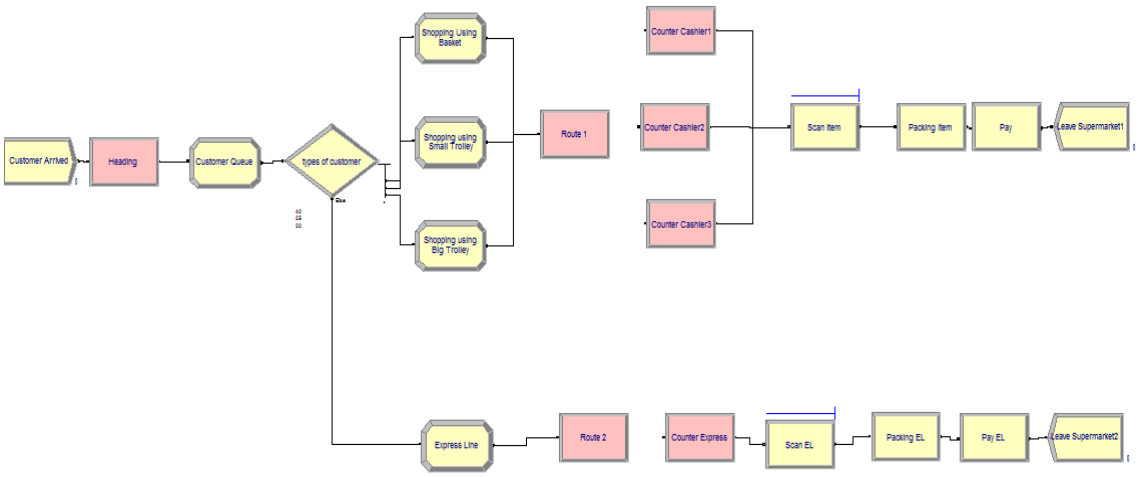


Figure 4.3.1: Constructed New Model of Waiting Line in ARENA

From the figure above, the new pattern of model for Tunas Manja has been developed to solve the waiting line problem. The model is started with arrival of customer1, customer2, customer3 and customer4 to cashier counter after all of them pick up the items they want to buy at shelves of goods. Each customer brings with different type of entity as follows:

1. Customer 1 - bring all items using the big trolley
2. Customer 2 - bring all items using the basket
3. Customer 3 – bring all items using small trolley
4. Customer 4 – bring all items in non-basket

Then, the customer with different entity is involved in the waiting line and the queuing time of customer waits in the system will be automatically calculated during the simulation. For this development model, the model used is Single channel- Single queue with Multiple-counter system which means the cashier counter that available automatically the customer will be there. In fully time 2 worker at cashier counter would be there for effectively system. The role of 2 worker for each cashier counter are one of them would be scan the items and make transaction between customers and another would be packaging the items. Lastly, the process the end with the customer leaves the supermarket.

4.3.2 Output of Arena Simulation Model

After conceptual model are developed in Arena Simulation, the new result of the Arena simulation produced as shows at Table 4.3.1.

Model: Single-channel, Single Queue, Multiple counter systems
Arrival rate (lambda) = 18 customer per hour
Service rate (mu) = 31 customers per hour
Number of server = 2

Parameter	Value
Average server utilization	0.78
Average number in queue (Lq)	1.45
Average number in the system (Ls)	2.05
Average time in the queue (Wq)	0.09
Average time in the system (Ws)	0.18

Table 4.3.1: Result for new model of Waiting Line using ARENA

The Table 4.3.1. shows the result for a new model of Waiting Line using ARENA Simulation. It is shows the positive result for the company to solve problems in their supermarket. When the design of waiting line changes into one line but with two cashier counters, it is more effective and efficient.

From the result, server utilization is increasing about 0.11% compared the actual scenario. Server utilization or cashier counter utilization refers to the percentage of time during which the cashier counter is busy processing jobs during a simulation. Server utilization can be estimated by dividing the amount of time where that cashier counter is busy during simulation with the amount of time covered in the simulation. It is can concluded that if the value of server utilization become higher, it is more effective in the system. Thus it has helped increase the average number of customers who will queue in the system is 1.45 compared the eldest result. The differences between two of the Lq is 0.12 per minutes.

The queuing time before applying the Arena Simulation was 4.44 minutes. After applying the model, the queuing time is 2.54 minutes. The model helps to reduce 1.90 minutes of queuing time either the customer bring different types of entity.

Furthermore, the average time of customer involved in the system are reducing to 0.04 minutes which is Ws actual scenario is 0.11 minutes and the Ws computer simulation is 0.07 minutes. It is shows that all the people movement in the system in right track without facing for a long time to wait before had been served.

4.4 VERIFICATION AND VALIDATION OF DATA

The Verification and Validation of computer simulation models is directly amid the improvement of a simulation model with a definitive objective of delivering an exact and trustworthy model. Arena Simulation models are progressive being utilized to take care of issues and to help in choice making decision. The developers and users of these models, the chiefs utilizing data got from the consequences of these models and the people influenced by choices based on such model are rightly worries with whether a model and its outcomes are "correct". This concern is tended to through verified and valid of the simulation model.

Moreover, the verification and validation of simulation model begin after functional details have been recorded. The verification and validation of simulation model starts after functional specifications have been documented and initial model development has been completed. Verification and validation is an iterative process that takes place throughout the development of a model and starting model improvement has been finished. Verification and validation is an iterative process that happens all through the improvement of model.

Validation is a programmed computer to guarantee that the information entered is sensible and reasonable. It is not check the precision of information. The validation also could be viewed as input-output transformation which is consists of comparison of the output in the real system with the output in the computer simulation. Data that had been collected in the real system much but not least same with computer system in order to perform the test.

Verification is the conformation process of conceptual model that wants to apply to the real system either it is suitable or not in the new system that wants to implement. In this study, the verification would be done with introduce the new model of Arena simulation that has been developed to the company either this model are suitable and could give advantage to their company especially to solved their Waiting Line problem in cashier counter.

4.5 SUMMARY

These chapters' presents the data collected from Tunas Manja Sdn. Bhd. and analyze these data before and after applying the model. By applying the model, goals of this study are accomplished that Waiting Line Problem at the cashier counter is solved. The model reduces 1.90 minutes per customer either different entity type. As the result, the Waiting Line efficiency enhanced.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter completes up the framework of the essential disclosures from the work done in this research. The discussion starts with a general overview of the research issues. In with these issues of Waiting Line framework at Tunas Manja Sdn. Bhd., the ARENA simulation was made in this study. Besides, the model experimentally would be carry out through "what –if" analysis which is to see how the changes made of model affected in output of the whole waiting line system. In other hand, the contribution and recommendation provide in this chapter as well.

5.2 OVERVIEW OF THE RESEARCH PROBLEM

The Waiting Line could be occurring in a variety of situations in this world. The Waiting Line is the process where someone would be involved in a system to get a service before leaving the system. Waiting Line problem has been founded some of researchers, the reducing queuing time in waiting line is important for the customer satisfaction. Moreover, the time queues of customers to pay their items at the counter to be a big deal in this study. The problem caused the unsatisfying customer for waiting for a long time before they get pay their items at cashier counter especially many of customer come to shopping at certain times. Therefore, this problem would decrease the profit of the company by reducing effective working time.

This study attempts to improve efficiency through the Waiting Line through Arena Simulation approaches. The approach developed a model by using computer

simulation to how the changes of arrival customer affected the queuing time in waiting line model. The target of developing the new model for the company is to reduce the time of customer wait for a long time before had been served before leave the supermarket.

The Arena Simulation has been developed in this study to solve the Waiting Line problem and to obtain an optimum solution. Therefore, the achieving of objective is: (1) To determine better path of the model used for waiting line of customer that be served. (2) To develop the simulation model to reduce the queuing time at operation service of the supermarket.

The Arena Simulation model reduces 1.90 minutes of queuing time through single-server multiple channel design. In other hand, with the reduction of the queuing time in the waiting line could give the satisfaction to customers of the services rendered. Thus, the achievement of the Waiting Line problem is summarized as below:

i. The queuing time of customer in the waiting line before had been served are solved.
ii. Unable to find a solution in search of more accessible path model for more effective and could give more satisfaction for customers.
iii. Helped the company to solve the problem in getting a best optimum solution of the Waiting Line Problem throughout the Arena simulation.

5.3 CONTRIBUTION OF THE STUDY

The contribution of this study is as follows:

- Arena simulation was a capable computer system to acquire the solution of the problem.
- The study helps the company
- Developed the Arena simulation for Waiting Line model to solve the queuing time in the operation system.

- The study offers the company some assistance with enhancing the effectiveness of the waiting line in the system.
- The study helps the management to effectively apply the model to solve the queuing time problem of customer in the system.

5.4 RECOMMENDATION

In the business world, the effectiveness and efficiency in the system is a key to success in any business. But, the difficulty that had been facing is to identify the actual problem in the organization. With introducing of the simulation method to the industry hopefully it is could help in any problem occurred.

The simulation also one of tool analysis that not costly to the company. Hence, this simulation could assist an user to making quicker and reliable decision. The result also could be changing in anytime as what we want to change in the operation system.

Besides, at the point when adjustment is connected on the created model, it enables the simulation keeps running as what has been set in the time setup. In other word, we could programme the simulation like what we want to simulate such as setting the customer arrival time, number of counter, design of path of waiting line and etc. Hence, it has the capacity run the models in month or even a year in simulate the software to turn out with the future yield.

There are many of positive impact that Tunas Manja Sdn. Bhd. could get from the improvement of waiting line of customer in cashier counter. First, earning reputation and loyalty which is it may be can attract more customer for coming the supermarket. With new technology that Tunas Manja has such Arena simulation enable to provide high satisfaction of customer especially in terms of services. Next, the profitability of company would be highly because of the highly of coming of customer to the supermarket.

Furthermore, simulation software can go far for further study with different perspective in terms of cost of organization, layout of factory, warehouse and logistic

area. It is very helpful for increasing of national economies by introducing this simulation software among local service industry such as Giant supermarket and developed Arena simulation for international service industry such as Tesco hypermarket. So that, the new knowledge process and sharing information could be shared together between other expertise.

5.5 SUGGESTION

In this study, there has some suggestion that may provide a little improvement for the company.

a) Determine an acceptable waiting time for the customer
b) Segmentation of customer
c) Keep employees not serving the customers out of sight
d) Try to divert the customer's attention when waiting in line of system
e) Train the servers to be friendly
f) Take a long-term perspective toward getting rid of the queues
g) Encourage the customers to come during the peak time

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APPENDIX A

DATA COLLECTION ON WEEKEND (BEFORE SALARY)

Time	No. of Counter	No. of customer	Cust. Queue (min)	Type of Entity	Cust. Served (min)
10.00 am		1	-	BT	5.15
	C1	1	5.15	B	0.38
10.15 am		1	0.38	B	0.34
10.20 am		1	-	BT	0.45
		1	-	ST	4.12
	C2	1	-	ST	2.0
		1	2.0	B	0.42
10.30 am		1	0.42	B	0.34
10.35 am		1	-	BT	5.25
	C3	1	5.25	BT	4.50
10.45 am		1	4.50	ST	2.23
10.50 am	C4	1	-	B	2.33
10.00 am					
11.05 am		1	-	B	1.50
	C5	1	-	NB	0.25
11.15 am		1	0.25	NB	0.34
11.20 am	C6	1	-	NB	0.24

11.35 am		1	-	B	1.24
11.40 am	C7	1	-	BT	4.50
11.50 am					
11.55 am	C8	1	-	NB	0.24
12.05 pm		1	0.24	NB	0.45
12.10 pm		1	-	B	1.56
		1	1.56	B	1.03
		1	1.03	B	0.53
		1	-	NB	0.24
		1	-	ST	3.1
	C1	1	3.1	NB	0.32
		1	0.32	NB	0.41
		1	-	ST	3.52
		1	3.52	B	1.23
		1	1.51	ST	2.38
12.20 pm		1	2.38	NB	0.58
12.25 pm		1	-	ST	2.51
		1	2.51	BT	4.45
		1	4.45	ST	2.42
		1	2.42	NB	0.31
	C2	1	0.31	ST	2.23
		1	2.23	ST	2.56

		1	2.56	NB	0.46
12.35 pm		1	-	NB	0.21
12.40 pm	C3	1	-	B	0.15
		1	0.15	B	0.43
		1	0.43	BT	3.57
		1	3.57	BT	4.00
		1	4.00	NB	0.36
		1	0.36	NB	0.27
		1	0.27	NB	0.48
		1	0.48	ST	2.58
12.50 pm		1	2.58	NB	0.10
12.55 pm	C4	1	-	-	0.34
		1	0.34	ST	2.52
		1	2.52	ST	3.10
		1	3.10	ST	3.15
1.05 pm		1	-	NB	0.25
1.10 pm	C5	1	-	NB	1.02
		1	1.02	BT	5.05
		1	5.05	ST	3.45
		1	3.45	B	2.10
		1	-	NB	0.51
		1	0.51	B	2.41

1.20 pm		1	2.41	NB	0.22
1.25 pm		1	-	NB	0.29
	C6	1	-	NB	0.31
		1	-	B	1.47
1.35 pm		1	-	NB	0.28
1.40 pm		1	-	NB	0.44
		1	0.44	NB	0.32
		1	-	B	1.51
	C7	1	-	B	1.32
		1	1.32	BT	4.05
1.50 pm		1	-	ST	2.01
1.55 pm		1	-	NB	0.29
	C8	1	-	NB	0.35
2.05 pm		1	0.35	NB	0.31
2.10 pm		1	-	B	1.05
	C1	1	1.05	B	0.58
		1	-	NB	0.33
2.20 pm		1	-	NB	0.37
2.25 pm	C2	1	-	ST	3.05
2.35 pm					
2.40 pm	C3	1	-	ST	2.45
2.50 pm					

2.55 pm 3.05 pm	C4	1	-	NB	0.42
3.10 pm 3.20 pm	C5	-	-	-	-
3.25 pm 3.35 pm	C6	-	-	-	-
3.40 pm 3.50 pm	C7	1	-	B	2.03
3.55 pm 4.00 pm	C8	-	-	-	-

KEYS: BT =Big Trolley

ST =Small Trolley

B =Basket

NB =Non Basket

APPENDIX B

DATA COLLECTION ON WEEKEND (AFTER SALARY)

Time	No. of Counter	No. of customer	Cust. Queue (min)	Type of Entity	Cust. Served (min)
10.00 am		1	-	B	0.48
		1	-	ST	2.52
	C1	1	-	ST	2.41
		1	-	B	1.21
10.15 am		1	1.21	NB	0.31
10.20 am		1	-	ST	3.01
		1	3.01	B	2.23
	C2	1	2.23	B	1.51
		1	1.51	B	5.43
10.30 am		1	5.43	BT	4.32
10.35 am		1	-	NB	0.42
		1	0.42	B	1.33
		1	1.33	NB	0.28
	C3	1	0.28	ST	3.05
		1	3.05	B	1.47
		1	2.47	BT	4.02
10.45 am		1	4.02	ST	2.27

10.50 am		1	-	B	2.22
		1	2.22	BT	3.57
		1	3.57	BT	4.27
	C4	1	4.27	B	2.02
		1	2.02	ST	2.58
10.00 am		1	-	ST	3.02
11.05 am		1	-	NB	0.41
		1	0.41	ST	3.21
	C5	1	-	BT	4.56
11.15 am		1	4.56	NB	0.38
11.20 am		1	-	BT	5.21
		1	5.21	B	1.59
		1	1.59	NB	0.32
	C6	1	0.32	ST	3.15
		1	-	B	2.05
11.35 am		1	2.05	NB	0.42
11.40 am		1	-	NB	0.36
		1	0.36	BT	4.08
	C7	1	4.08	ST	3.24
		1	3.24	B	2.12
11.50 am		1	2.12	NB	0.43
11.55 am		1	-	B	2.50

		1	2.50	B	2.42
	C8	1	2.42	NB	0.38
		1	0.38	BT	5.13
		1	5.13	B	2.51
12.05 pm		1	-	NB	0.38
12.10 pm		1	-	ST	4.38
		1	4.38	B	2.31
		1	2.51	BT	4.58
	C1	1	4.58	B	2.05
		1	2.05	ST	4.21
12.20 pm		1	4.21	NB	0.42
12.25 pm		1	-	BT	4.59
		1	4.59	BT	4.45
		1	4.45	B	2.13
		1	2.13	B	2.42
	C2	1	2.42	ST	3.33
		1			
		1			
12.35 pm		1			
12.40 pm	C3	1	-	B	2.41
		1	2.41	ST	3.31
		1	3.31	BT	5.03

		1	5.03	BT	4.58
12.50 pm		1	4.58	B	1.57
12.55 pm		1	-	NB	0.29
	C4	1	0.29	B	1.30
		1	1.30	BT	4.44
1.05 pm		1	4.44	ST	2.53
1.10 pm		1	-	B	1.43
		1	-	NB	0.28
	C5	1	0.28	ST	3.09
		1	-	B	2.15
1.20 pm		1	2.15	B	1.58
1.25 pm		1	-	BT	4.03
	C6	1	4.03	ST	3.31
		1	-	NB	0.36
1.35 pm		1	-	NB	0.21
1.40 pm		1	-	B	1.52
	C7	1	1.52	NB	0.45
1.50 pm		1	-	BT	5.02
1.55 pm		1	-	NB	0.48
		1	0.48	B	2.22
	C8	1	-	ST	2.49
2.05 pm		1	-	B	1.38

2.10 pm		1	-	NB	0.42
		1	0.42	B	1.20
		1	1.20	B	1.41
	C1	1	1.41	ST	2.58
		1	2.58	BT	4.38
		1	4.38	BT	4.15
2.20 pm		1	4.15	NB	0.36
2.25 pm	C2	1	-	BT	3.58
		1	3.58	BT	4.05
		1	4.05	B	1.08
		1	1.08	NB	0.40
2.35 pm		1	0.40	NB	0.45
2.40 pm	C3	1	-	B	2.28
		1	2.28	B	1.59
		1	1.59	ST	3.24
		1	3.24	NB	0.29
2.50 pm		1	0.29	BT	5.00
2.55 pm		1	-	NB	0.38
		1	0.38	ST	2.29
		1	2.29	BT	4.48
	C4	1	4.48	B	1.33
		1	1.33	NB	0.41

3.05 pm		1	0.41	B	2.05
3.10 pm	C5	1	-	ST	3.08
		1	3.08	BT/B	10.21
		1	-	B	2.10
		1	-	B	1.58
3.20 pm		1	1.58	ST	2.25
3.25 pm	C6	1	-	NB	0.51
		1	0.51	NB	3.21
		1	3.21	NB	0.33
		1	0.33	NB	0.36
		1	0.36	BT	6.02
3.35 pm		1	6.02	ST	3.11
3.40 pm	C7	1	-	B	2.26
		1	-	ST	5.15
3.50 pm		1	3.15	NB	0.21
3.55 pm	C8	1	-	BT	5.12
		1	5.12	B	1.32
		1	1.32	NB	0.34
4.05 pm		1	0.34	NB	0.46

KEYS: BT =Big Trolley

ST =Small Trolley

B =Basket

NB =Non Basket