# EFFECTIVE ROUTE ANALYSIS FOR PETROL DELIVERY AND SYSTEM OPTIMIZATION USING ARENA SIMULATION

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# EFFECTIVE ROUTE ANALYSIS FOR PETROL DELIVERY AND SYSTEM OPTIMIZATION USING ARENA SIMULATION

**by**

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## LIST OF SYMBOLS

| | |
|---|---|
| A | Arc |
| A(*i*) | Arc permanent |
| $c_{ij}$ | Current Distance |
| *d(-)* | Shortest path distance |
| *d(i)* | Distance of shortest path |
| *d(j)* | Temporary distance |
| *d(u)* | Distance of shortest path |
| *d(v)* | Temporary distance |
| G | Graph |
| *i* | Shortest path length |
| *j* | Temporary node |
| K | Destination |
| m | Number of arcs |
| N | Nodes |
| *n* | Number of nodes |
| P | Path |
| *q* | Subpath |
| S | Starting node. |
| T | Shortest path tree |
| *t* | time |
| *u* | Shortest path length |
| *v* | Temporary node |
| V | Vertex |
| $x_{ijt}$ | Network from *i* to *j* is used in step *t* of the route |
| $\epsilon$ | Element |

| | |
|---|---|
| Σ | Subtotal |

## LIST OF ABBREVIATION

| | |
|---|---|
| QGIS | Quantum Geographical information system |
| RON | Research Octane Number |
| ATG | Automatic Tank Gauge |

**ANALISIS LALUAN PENGHANTARAN MINYAK YANG EFEKTIF DAN PENGOPTIMUMAN SISTEM MENGGUNAKAN SIMULASI ARENA**

## ABSTRAK

Minyak digali dan disimpan di kawasan depoh dan akan dihantar ke stesen minyak yang memerlukan. Kebiasaanya, depoh terletak jauh daripada stesen-stesen minyak. Oleh itu, salah satu masalah yang dipertimbangkan adalah perjalanan masa yang panjang menyebabkan stesen minyak kekurangan minyak dan seterusnya mengurangi keuntungan. Dalam kajian ini, depoh mempertimbangkan semula jalan alternatif untuk membandingkan keberkesanan dari segi kos dan jarak bagi lori tangki petrol ke sebuah stesen minyak bagi mencapai visi Pulau Pinang 2030 untuk menjadi sebuah negeri hijau dan pintar bersepadu yang akan memperkasakan negara, dengan mengurangkan tahap pelepasan karbon. Seterusnya, masalah lain yang berlaku dalam sistem pengurusan adalah dari segi masa menunggu dan waktu perkhidmatan bagi pelanggan yang terlalu lama. Simulasi diperlukan bagi menggambarkan situasi sebenar dan mengira prestasi di Stesen Minyak XYZ. Selain itu, simulasi tambahan perlu dilakukan untuk menentukan prestasi sekiranya kaunter pembayaran secara tunai ditambah. Oleh itu, kajian ini menerapkan Algoritma Dijkstra dan Teori Sistem Barisan dan Giliran untuk menyelesaikan masalah yang berlaku. Simulasi dilakukan dengan menggunakan Perisian QGIS dan hasilnya menunjukkan terdapat tiga laluan alternatif yang boleh digunakan untuk menghantar minyak ke Stesen Minyak XYZ. Laluan paling singkat adalah Laluan 1(laluan sedia ada) yang menggunakan jambatan pertama Pulau Pinang. Hasil Simulasi ARENA membantu memahami prestasi Stesen Minyak XYZ. Hasil kajian menunjukkan bahawa purata waktu menunggu pada waktu puncak lebih tinggi daripada jam biasa kerana kebarangkalian pelanggan membayar secara tunai lebih tinggi daripada

menggunakan kad dan hanya ada satu kaunter pembayaran tunai. Kajian ini juga dapat digunakan oleh stesen minyak atau industri yang berkaitan untuk meminimumkan jumlah kos dan memaksimumkan keuntungan. Terdapat beberapa cadangan kajian masa depan yang dapat diikuti iaitu kesan masa menunggu ketika terdapat lebih dari satu kaunter pembayaran di stesen minyak, pelanggan menggunakan aplikasi dalam talian untuk mengisi minyak kenderaan mereka dan meningkatkan pengumpulan data dengan mempertimbangkan masa yang lebih tepat dengan menggunakan minit dan saat.

**EFFECTIVE ROUTE ANALYSIS FOR PETROL DELIVERY AND SYSTEM OPTIMIZATION USING ARENA SIMULATION**

## ABSTRACT

Oil is extracted and stored in the depot and will be sent to the petrol station. Usually, depots are located far from petrol stations. Therefore, one of the problems that has been considered is the time travel that takes a long-time causing gas stations to run out of fuel and hence reduce profits. In that case, depot needs to reconsider alternative routes to compare the cost and distance effectiveness of petrol tankers to Petrol Station XYZ to achieve the vision of Penang 2030 to become an integrated green and smart state that will empower the country, by reducing carbon emissions. Next, another problem that occurs in the management system is in terms of waiting time and service time for customers which are too long. Simulations are needed to describe real situations and to calculate performance of Petrol Station XYZ. In addition, additional simulations need to be performed to determine performance if cash payment counters are added. Therefore, this study applying Dijkstra Algorithms and Queuing System to solve the problems. Simulations have been done using QGIS Software and the results show that there are three alternative routes that can be used to ship fuel to Petrol Station XYZ. The shortest route is Route 1 (existing route) which uses the first bridge of Penang. ARENA Simulation results help to understand the performance of Petrol Station XYZ. The results show that the average waiting time at peak hours is higher than normal hours because the probability of customers paying in cash is higher than using a card and there is only one cash payment counter. This study can also be used by gas stations or related industries to minimize

total costs and maximize profits. There are several future study suggestions that can be followed namely the effect of waiting time when there is more than one payment counter at the gas station, customers use online applications to refuel their vehicles and increase data collection by considering more precise timing, which include minutes and seconds.

# CHAPTER 1

# INTRODUCTION

## 1.1 General Introduction

A petrol station is a place or facility that sells motor vehicles fuels oils. As it is known today, the fuel service station is an institution of recent growth one which has gone through many different stages of its evolution (Beckman, 2011). Many people purchase petrol at gas stations daily. Companies that sell fuel will increase their profits by satisfying their consumers (Moazzami et al., 2013).

In Malaysia, there are many petrol stations scattering that sell fuel to their customers either in urban area or rural area. They provide a fuel in various types, which are RON 95, RON 97, RON 100 and Diesel. These fuels will be transferred through a tank lorry from the nearest fuel depot.

In 2017, the total number of petrol stations in Malaysia are 3700 stations. Comparatively, among other brands, Petronas had the most petrol stations across the country with 1065 stations because Petronas is the Malaysia's national oil company and a domestic product (Mohammed Asari, 2021). Then followed by Shell and Petron with number of petrol stations 950 and 570 stations, respectively. Figure 1.1 below shows the number of petrol stations across Malaysia in 2017, by brand (Mahamat, 2019).

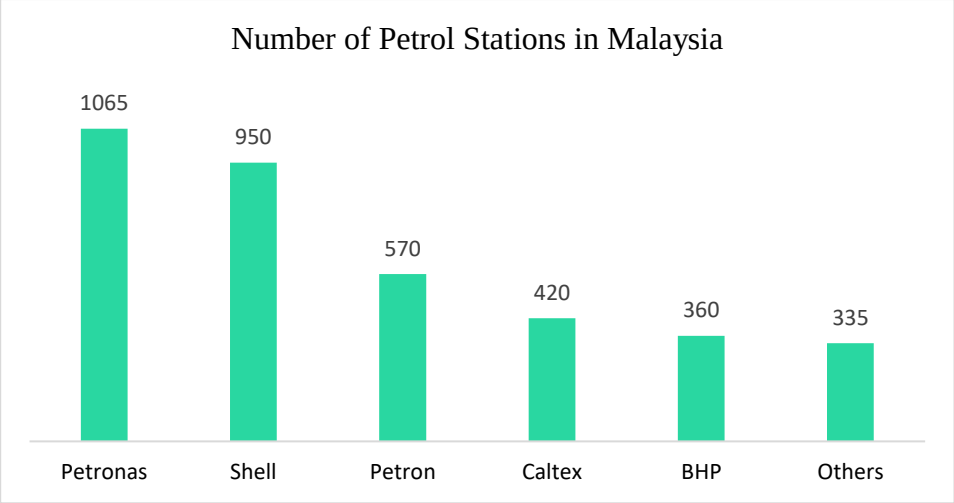


Figure 1.1 : Number of petrol station in Malaysia in 2017

In the island and mainland region of Penang, petrol stations can easily be found throughout the city. Figure 1.2 shows bar graph represented the number of petrol station in Penang (island) in year 2018. The highest number of petrol stations in Penang (island) is Shell and followed by Petronas (Mahamat, 2019). In this study, Petrol Station XYZ located in Penang (island) was selected.

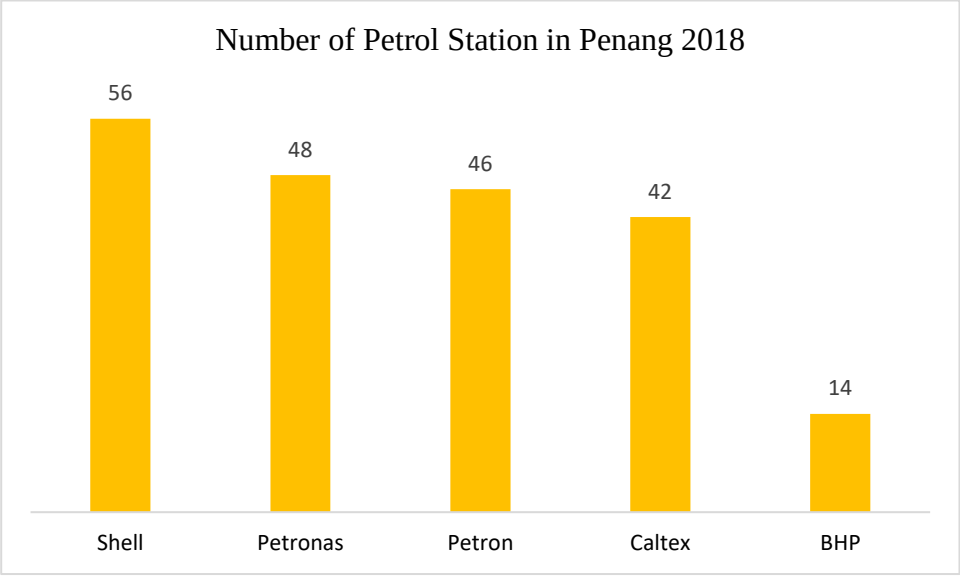


Figure 1.2 : Number of Petrol Station in Penang (island)

## 1.2 Problem Statement

In this research two main problems that need to be considered are which route that tank lorry will use to transfer the fuel and how to reduce the waiting time for customers at Petrol Station XYZ. Fuel will be stored in a depot located far from the Petrol Station XYZ. Hence, depot needs to reconsider the alternative routes that can be used by the lorry to compare the distances and time consumption. The nearest fuel depot is at Bukit Minyak (mainland) that will supply the fuel to this Petrol Station XYZ using a tank lorry. Figure 1.3 shows map location from depot to Petrol Station XYZ.


Figure 1.3 : Map location from depot to Petrol Station XYZ

Tank lorry uses the same route everyday which is first Penang Bridge and this route is often congested because most of road users will choose first Penang Bridge to enter the island. Hence, this will lead to a higher time consumption to transfer the fuel and it will make Penang 2030 vision difficult to achieve. The most important problem that exists any of pollution routing, vehicle routing or any type of routing is the distances and it is directly affect to carbon emission even a short distance. There are several algorithms that can be used to find the shortest distance for instance Bellman-Ford

Algorithm, Johnson's Algorithm, Dijkstra Algorithm and Viterbi Algorithm. In this study, Dijkstra Algorithm was used to find the shortest route at once achieves the fourth element of Penang 2030 vision by reducing the carbon emission.

There are five tanks at this petrol station, two tanks of RON 95, two tanks of RON 97 and one tank of Diesel. Each part of tank contains 27000 litres of fuels. In this petrol station there are 16 pumps which are 4 pumps (pumps 3,4,5,6) are specific for motorcyclist, and other 12 pumps are for cars and lorries driver. Table 1.1 shows types of petrol in every pump.

Table 1.1 : Types of petrol.

| Pump | RON 95 | RON 97 | Diesel |
|---|---|---|---|
| 1 | ✓ | ✓ | |
| 2 | ✓ | ✓ | |
| 3 | ✓ | | |
| 4 | ✓ | ✓ | |
| 5 | ✓ | ✓ | |
| 6 | ✓ | | |
| 7 | ✓ | ✓ | |
| 8 | ✓ | ✓ | |
| 9 | ✓ | ✓ | |
| 10 | ✓ | ✓ | |
| 11 | ✓ | | ✓ |
| 12 | ✓ | | ✓ |
| 13 | ✓ | | ✓ |
| 14 | ✓ | | ✓ |
| 15 | | | ✓ |
| 16 | | | ✓ |

Customers can decide either to pay with cash or use debit or credit card. Motorcyclist who wants to pay with cash, they can use pump 3, 4, 5 or 6 but if they want to pay use credit or debit card, they need to use pump 3 and pump 5 only. Whereas, customers who make the cash payment need to go to the counter. They can also do their shopping (if any) while refuelling their vehicles at the store. A cashier works at this

station, performs customers' payment for those who shop well as payments for the fuel. So, since the number of cars is always particularly high during peak hours, this will lead to queuing issues among customers.

The number of cars that came to refuel their car are the highest among other petrol station so it will lead to a long waiting time at this petrol station (Abdul Jabar, 2019). Data given by the manager of Petrol Station XYZ postulates that the average numbers of customers are 3038 customers per day. Hence, a real simulation needs to be developed to see real situation and forecast ways to reduce the waiting time based on the management limitations.

## 1.3 Objectives

To solve the issue raised from Section 1.2, the objectives are described as follows:

a) To compare the effectiveness route analysis for tank lorry from depot to Petrol Station XYZ using Dijkstra Algorithm.
b) To identify all the parameters characteristics such as customers' arriving, waiting, serving, and leaving time and number of servers during normal and peak hours.
c) To determine the performance of management at the petrol station using ARENA Simulation Software and forecast different scenarios such as adding more counter.

## 1.4 Scope and Limitation

There are some limitations to our project reach to meet all the objectives in 1.3. Firstly, all the possible routes from depot to the Petrol Station XYZ were defined and distance was considered. Existing routes and other possible routes will be compared and evaluated using network analysis tools in QGIS software. Tank lorry will supply fuel to Petrol Station XYZ directly from depot at Bukit Minyak without stopping anywhere else. In addition, Dijkstra Algorithm is used to solve the shortest path problem for a graph with non-negative edge costs and generate the shortest-path network.

Based on the result of interview conducted, Saturday and Tuesday are the most suitable pattern day for weekend and weekdays respectively for data collection. From the data given by petrol station's manager and 8.00 am to 10.00 am for normal hours and 2.00 pm to 4.00 pm for peak hours. Data for these two different scenarios were to see the pattern of arrival distribution and service distribution. Data were recorded at the Petrol Station XYZ for 10 pumps only and excluded motorcyclists and lorry drivers.

Simulation at Petrol Station XYZ also will be determined using ARENA Simulation Software. Tested and summarized the data obtained in a meaningful way to evaluate the related distribution of arrival and service time which is the inputs of the simulation model. The online application for refuelling was not implemented in this petrol station yet. So, it was not considered in this study.

## 1.5 Significant of Study

Based on the goal of these studies, the results can be used as the standard operating procedure of the petrol station or subsequently applied to other relevant industries. From the parameter characteristic, the petrol station will not have issue of lack of fuel and increase the satisfaction level towards the customers. The management performance will be more efficient when we understand the underlying issue such as the long queue for payment counter. Reducing fuel and time-consuming management costs will also minimise carbon emissions and keep the atmosphere cleaner. Another significant issue is no research is found about effective route analysis and system optimization at the petrol station in Penang. Therefore, this study also allows other similar industries to use simulation to make a prediction for various scenarios.

## 1.6 Summary

Fuel are natural substances , which are either extracted straight from the earth or produced by refining substances. Fuel is found far away or under the sea and they have to be transported through a pipeline or in a tanker. In this research there are two main problems that need to be considered, which are route that tank lorry used and how to reduce the waiting time of customers. Lorry will come every day to refuel this petrol station tanks and will use a route without considering the optimization of distance and time. Petrol Station XYZ is also identified as one of the busiest petrol stations in Penang. There are two types of payment methods which either to pay cash or using debit or credit card. Most of them pay cash and there is only one counter to serve the customers.

## 1.7 Organization of Thesis

This study consists of five chapters. Chapter 1 begins with an introduction to the petrol station. First, some clarity about Petrol Station XYZ and the issue raised. An overview of the literature review of previous research is given in Chapter 2. The literature starts with the Dijkstra Algorithm discussion and follows by queuing theory in different types of locations, such as airports, supermarkets, and banks, etc. We can see the gap between the previous researchers in this chapter.

Chapter 3 provides the methodology for this study. The methodological section provides the effective route analysis using Dijkstra Algorithm in QGIS Software, a detailed physical characteristic of server which are arrival time distribution, service time distribution and number of servers using ARENA Simulation. Chapter 4 contains some of the outcomes of the simulation and analysis discussion, which follows the approach, and the results were discussed to make this chapter complete. The conclusion of the outcome is presented in Chapter 5 with a recommendation for the future research.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter discuss all related research previous research. Section 2.2 will be discussed on what is related with petrol station. Section 2.3 is about previous research on Dijkstra Algorithm and Queuing Theory in various area such as bank, supermarket, hospital, and airport in section 2.4. This chapter will help to see the research gap from the previous research.

## 2.2 Petrol Station

Fuel is one of the most widely used sources of energy. According to Global Statistical Yearbook 2019, crude oil is the largest number of consumptions in World Energy with 32% and followed by coal 26%, gas 23%, biomass 10% and electricity 10% created by substances that are processed.

The petrol pump running physically in nowadays. It is an activity that basically requires more time and workers (Baqir & Motlak, 2021). Competitive advantage in this industry can be converted into three factors: petrol quality, service speed, and price. Since quality and price are similar in most markets, the most significant factor in customer satisfaction and revenue is speed of service and queue length (Conway & Briner, 2015)

Petrol station is the most important element for modern human life (Kang et al., 2020). The type of arrangement of petrol pumps, low space between two rows of fuel pumps, lack of adequate space for vehicles to maximise the usage of all pumps and eventually the type of internal pumps caused long queues at fuel stations in the country (Shojaie et al., 2012).

## 2.3 Dijkstra Algorithm

The shortest route needs to be determined to transfer the fuel from depot to petrol station. Dijkstra algorithm will be used to find the shortest route from one destination to other destination to minimize cost and maximize profit. Fahri et al. (2021) studied about the shortest route from a city to other city using the Dijkstra algorithm depending on the total distance travelled. Dijkstra's algorithm is one of the algorithms used to solve the shortest path and do not have a negative cost. This algorithm will find for a path with the minimum cost from one destination to another destination.

Dijkstra's algorithm solves a shortest-path problem on an undirected, nonnegative, weighted graph and calculates length of the shortest path from the source to each of the remaining vertices in the graph (Goldberg, 1989 and Ravindra et al. 1993). Dijkstra algorithm is applied to find the shortest route from Bandar Tun Razak to Berjaya Times Square and minimize the cost between these two destinations by using C programming . The shortest path is calculated by using C programming language in Dev C++ ( Syuhada et al., 2020).

Dijkstra's algorithm is an algorithm that used to be solution in determining the shortest path problem. It can also be used to find the shortest route between one tourist destination and all others. Hence, Dijkstra Algorithm is used to find the shortest path of the top ten tourist destinations in Bali. Dijkstra Algorithm successfully implemented by Java programming language (Fitriansyah et al., 2019).

Michal (2021) considers Dijkstra Algorithm of finding the route with the lowest cost to minimize an electric vehicle's energy usage. The implementation of the Dijkstra algorithm was developed in Java programming language. A simulation model of an electric vehicle was created, which allows the estimated energy consumption to be determined for the selected parts of the route. Alam & Faruq (2019) also studied on finding the shortest path for network using Dijkstra algorithm.

GIS and Dijkstra's Algorithm are used to calculate the shortest path. The system is implemented using GIS tools for people who rely on the public bus transportation requires to get the reliable bus information that can help them to reduce their waiting time at the bus stops (Khaing et al., 2018).

The use of Geographic Information Systems has increased considerably since the 80s and 90s (Rafael & Manuel, 2013). Dijkstra's Algorithm can be used to find the shortest path. This algorithm is not well suited for the shortest path search in large graphs (Rafael & Manuel, 2013). Norhafezah et al., (2018) state that using Dijkstra Algorithm will reduce time as cost of collection for solid waste.

Dijkstra's algorithm is the simplest path finding algorithm as compared to other contemporary algorithms because it reduces the amount of time and effort required to find the optimal or best path (Sivanandam et al., 2009). The shortest path source and destination matrix is computed by repeating the application of Dijkstra algorithm iteratively setting each node as source node and calculating the shortest paths to every other node of the network (Niska et al.,2006).

The basic idea of Dijkstra Algorithm is to explore the shortest path from the source point to the outside point gradually. The algorithm exists in many variants; Dijkstra's original variant found the shortest path between two nodes (Norhafezah et al., 2018). According to Table 2.1 below shows a summary of previous research on Dijkstra Algorithm to find the shortest route and there is no research that has been done in Penang, Malaysia

Table 2.1 :Dijkstra Algorithm

| | Researcher | Title | Field | GIS | Cost | Remarks |
|---|---|---|---|---|---|---|
| 1. | (Fahri et al., 2021) | Implementation of Dijkstra's Algorithm to Determine the Shortest Route in a City | Road | | ✓ | The problem of finding the shortest route can be solved by the Dijkstra algorithm. |
| 2. | (Syuhada et al., 2020) | Shortest Path from Bandar Tun Razak to Berjaya Times Square using Dijkstra Algorithm | Road | | ✓ | - |
| 3. | (Fitriansyah et al., 2019) | Dijkstra's Algorithm to Find Shortest Path of Tourist Destination in Bali | Road | | | Find shortest path of tourist destination in Bali and it successfully implemented using java programming language. |
| 4. | (Michal , 2021) | Selecting the route of an electric vehicle using the Dijkstra algorithm | Road | | ✓ | - |

| | Researcher | Title | Field | GIS | Cost | Remarks |
|---|---|---|---|---|---|---|
| 5 | (Alam & Faruq, 2019) | Finding Shortest Path for Road Network Using Dijkstra's Algorithm | Road | | | |
| 6. | (Khaing et al., 2018) | Using Dijkstra's Algorithm for Public Transportation System in Yangon Based on GIS | Public Transport | ✓ | | The shortest path from one destination to other destination was identified. |
| 7. | (Rafael & Manuel , 2013) | Algorithm for shortest path search in Geographic Information Systems by using reduced graphs | Road | ✓ | | |
| 8. | (Norhafezah et al., 2018) | Simulation of Municipal Solid Waste Route Optimization Dijkstra Algorithm | Road | | ✓ | Reduce time and cost of collection. |

| | Researcher | Title | Field | GIS | Cost | Remarks |
|---|---|---|---|---|---|---|
| 9. | (Niska et al.,2006) | Improved route planning and scheduling of waste collection and transport | Waste Collection Transport | ✓ | ✓ | Reduce cost compared with current situation |
| 10. | (Chipumuro et al.,2014) | Optimizing Routing of Residential Solid Waste Collection: Case Study of Chikova Residential Area in Zimbabwe | Waste Collection Transport | ✓ | ✓ | Total distance travelled was reduced. |

## 2.4 Queuing Theory

Queuing theory was first analyzed by a Danish engineer, mathematician and researcher named Agner Krarup Erlang in 1913 to solve telephone traffic problem (Vass and Szabo, 2015). Erlang's research through queuing theory began when he developed models to describe the Copenhagen telephone exchange (Kumar & Kumar Sharma, 2014). Some common examples of Queuing systems are bank-teller service, manufacturing systems, computer systems, communications systems, and maintenance systems.

A queuing system includes one or more servers which offer services of some type to arriving customers (Robert B. Cooper, 1981). The basic elements of queuing models depend on several factors such as arrival's distribution, service time distribution, queue discipline, queue size, calling population, and customers' behaviour which includes customers refusing to join in the waiting line (balking), leaving the line before being served (reneging), entering a line and then switched to another line to reduce their waiting time (jockeying), and gathering their things after paying at the checkout (Dharmawirya & Adi, 2012).

Queuing theory is a mathematical analysis of queue or waiting line (Sundarapandian, 2009). Queue exists because there is more demand for service than the facility for service available (Kembe et al., 2017). Queuing theory is an analysis observation of waiting time in system, serving time by the servers and length or

number of customers must wait in a queue. Queuing system are relatess to how an organization handles their inventory in order to meet customers need and satisfaction.

In a petrol station, a queueing model for a line can be developed by studying customer arrival and service behaviour, evaluating performance measures, and determining the optimum usage factor using a simulation approach. (Ohaneme et al., 2012). There are many problems can be solve by using queuing theory, one of them is reduces patient waiting time in healthcare industry (Mehandiratta, 2011). Waits in long queues is common and a part of life but it is not a good thing to practice in hospital where usually happened in Malaysia public hospitals. Long waiting queues shows the inefficiency in hospital services in many public hospital in Ghana and other developing countries (Afrane and Appah, 2016)

Queuing theory in a petrol station system with an emphasis on improving customer satisfaction by reducing waiting times through provision of enough servers and attendants (Akinnuli & Olugbade, 2014). Simulation is a mimic of the real life situation that occur, and it is the most effectively used as a stage in queuing analysis (Lade et al., 2013). Customers suffer in long waiting queues for hours waiting to being served (Mardiah and Basri, 2013).

Queuing theory is an analysis observation of waiting time in a system, serving time by the servers, and length or number of customers waiting in a queue (Anthony & Kembe, 2018). An excellent queuing model for proper appointment system is proposed as the quick fix to the problem of long waiting times in the system (Obulor

and Eke, 2016). Hobbs et al. (2000) added that consequently, customers become frustrated, and leave if they have other obligations. Queues occur when demand is more than services facilities or an inadequate number of service facilities. Servers will take more time to serve several customers so it will increase the waiting time. All the previous research was summarized in Table 2.2 below.

Table 2.2 : Queuing System

| | Researcher | Place | Single Channel | Multi Channel | No. of Queue | No. of Server | Peak Hours | Normal Hours | Reduce Time | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | (Jhala & Bhathawala, 2017) | Supermarket | ✓ | - | - | ✓ | - | - | ✓ | No priority in server and use questionnaire |
| 2 | (Larson & Sasanuma, 2010) | Parking | ✓ | - | ✓ | ✓ | - | - | - | - |
| 3 | (Oyatoye et al., 2011) | Port | - | ✓ | ✓ | ✓ | - | - | ✓ | |
| 4 | (Kumar & Kumar Sharma, 2014) | Petrol Station | - | ✓ | ✓ | ✓ | ✓ | - | ✓ | - |
| 5 | (Sheikh et al., 2013) | Bank | - | ✓ | ✓ | ✓ | - | - | ✓ | - |
| 6 | (Sagayaraj et al., 2015) | Petrol Station | ✓ | - | - | - | - | - | ✓ | Hiring New Worker |
| 7 | (Dehantoro et al., 2016) | Vehicle Service | - | ✓ | ✓ | ✓ | - | - | - | Reduce the lead time. |
| 8 | (Ademoh et al., 2014) | Airport | - | ✓ | ✓ | ✓ | - | - | ✓ | - |

| | Researcher | Place | Single Channel | Multi Channel | No. of Queue | No. of Server | Peak Hours | Normal Hours | Reduce Time | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 9 | (Ahsan et al., 2014) | Restaurant | - | ✓ | - | ✓ | - | - | ✓ | - |
| 10 | (Lartey, 2014) | Traffic Congestion | ✓ | - | ✓ | ✓ | ✓ | - | - | Improving the QoS performance. |
| 11 | (Yakubu & Najim, 2014) | ATM Service Optimization | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Not caused by insufficient ATMs but service unavailability |
| 12 | (Prasad & Badshah, 2014) | Railway Reservation System | ✓ | - | ✓ | ✓ | ✓ | - | - | Passengers need not to wait early morning to till 10.00 am for service. |
| 13 | (Yusuf et al., 2015) | Bank | - | - | ✓ | - | - | - | ✓ | - |
| 14 | (Bongkriwan & Tumewu, 2015) | Car Wash | - | ✓ | - | ✓ | ✓ | ✓ | - | Reduce the server |
| 15 | (Olu & Otonritse, 2015) | An Out-patient Clinic | ✓ | - | ✓ | ✓ | ✓ | ✓ | - | - |
| 16 | (Sharma & Bakul Barua, 2015) | Small Enterprise | ✓ | - | ✓ | ✓ | ✓ | - | - | Recommended that the store introduces another check-out counter |
| 17 | (Patel et al., 2012) | Railway Ticket | - | ✓ | ✓ | ✓ | ✓ | - | ✓ | Has enough no. of servers which is helpful during the peak hours. |

| | Researcher | Place | Single Channel | Multi Channel | No. of Queue | No. of Server | Peak Hours | Normal Hours | Reduce Time | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 18 | (Mala & Varma, 2016) | Traffic Congestion | ✓ | - | ✓ | - | ✓ | - | ✓ | Provide separate lanes for specific user. |
| 19 | (Furquan et al., 2015) | ATM Machine | ✓ | - | ✓ | ✓ | - | - | ✓ | Double server queuing model could be applied in this case. |
| 20 | (Kembe et al., 2017) | Petrol Station | - | ✓ | - | ✓ | ✓ | - | ✓ | - |
| 21 | (Priyangika & Cooray, 2016) | Checkout Operation in Supermarket | - | ✓ | ✓ | ✓ | ✓ | ✓ | - | Increasing number of servers not the solution to increase the efficiency of the service by each service unit. |
| 22 | (Boulton et al., 2016) | Stroke Unit Capacity | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | >12 beds would be required |
| 23 | (Obulor & Eke, 2016) | Hospital Appointment System | - | ✓ | ✓ | ✓ | - | - | ✓ | The appointment designed used. |
| 24 | (Mala & Varma, 2016) | Local Health Care Centre | ✓ | - | ✓ | ✓ | ✓ | - | - | Doctor may able to fix the no. of patients for a day |

## 2.5 ARENA Simulation

Petrol stations need to do some changes to increase the revenue and maintain their position in global marketplaces. Simulation modelling is a suitable technique for optimizing the management system. Simulation models also can be used to determine the changes in existing system without affecting it and simulation can evaluate the of a new system without building it (Betterton & Silver , 2012). Currently, many simulation softwares packages available to provide a user-friendly interface that help the efforts of building simulation models such as ProcessModel, ProModel, Arena and Simul8 (Alexander Kolker, 2008). ARENA Simulation Software is an efficient and useful tool that enables users to create animated simulation models that almost represent the system (Banks et al., 2014). Ghaled et al., (2015) states that a simulation is an experimental model that represents the real life.

## 2.6 Summary

From Table 2.1 and Table 2.2, as shown above are previous researchers do on finding shortest route using Dijkstra Algorithm and queuing system in many fields. All the variables were considered. However, only several of them have done their research at petrol station, and none of the previous research was done in Malaysia. There is very limited study on effective route analysis to refuel the fuel and queuing system in petrol stations. Dijkstra Algorithm will be used because there is no previous research on finding the shortest route using this algorithm and queuing system in this petrol station and is still new and there is a gap for the study. The simulation of the queuing system using ARENA software is also very limited. ARENA simulation software was used for this study. Currently, there is no study which shows the waiting line of customers served at the Petrol Station XYZ.

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

This chapter will discuss the methodology use, the purpose to use methodology to find the research gap. There are some methods that will be carried out using Dijkstra Algorithm, details physical characteristic of servers and optimisation of servers, customers and machines using ARENA Simulation. This chapter start with methodology flow of this research and followed by the method mentioned earlier.

## 3.2 Methodology Flow

This study start will an interview with the petrol station managers. Some questions were raised concerning the route and the petrol station itself. The Dijkstra Algorithm will be used to evaluate the shortest route from depot to the Petrol Station XYZ. Next, at this petrol station, data collection was carried out. To see the distribution, all parameter characteristics were recorded. Data about time and number of litres of fuel and number of cars also given by the managers.

Normal and peak hours for this study are identified from this data. Highest number of customers was choosen as peak hours and normal hours is choosing by lowest number of customers (Abdul Jabar, 2019). In order to optimise servers, customers and machines, all this data will be exported to ARENA Simulation and do a forecasting on adding more one counter.