Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF REAL-TIME VEHICLE IDENTITY DATABASE AT TOLL GATE USING RFID TECHNOLOGY

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Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours

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DEVELOPMENT OF REAL-TIME VEHICLE IDENTITY DATABASE AT TOLL GATE USING RFID TECHNOLOGY

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A project report submitted
in partial fulfillment of the requirements for the degree of
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Faculty of Electrical and Electronic Engineering Technology
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2021

DECLARATION

I declare that this project report entitled "Development of Real-time Vehicle Identity Database at Toll Gate using RFID Technology" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : 6/2/2022

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology (Industrial Automation & Robotics) with Honours.

Signature : 

Supervisor Name : TS. SULAIMAN BIN SABIKAN

Date : 6/2/2022

DEDICATION

To my beloved mother, Krishna Vaini, and sister, Sri Suganyaa, thanks a lot for making the project possible. Without those financial and moral support provided by you, it would not be possible to complete this.

ABSTRACT

The role of RFID technology in real-life applications are making positive impacts on the application's efficiency. A much faster and accurate data can be acquired and stored if associated with database system in real-time. The volume of vehicles on road in Malaysia increasing tremendously every year and yet there is not any effective database system has been developed to record the information of the vehicles passing the toll gates. The current Automatic Number Plate Recognition (ANPR) using integrated camera system facing difficulties in succession rate due to various in features of vehicle number plate. This causes a difficulty in developing a real-time database on vehicles' information accessing toll gates. The objective of this project is to develop a RFID detection system with a real-time database on vehicles' information accessing toll gates, set up a data presentation dashboard as a user interface and to analyze the traffic data from the developed databases. This project used a small single-board computer to process tag's serial number from microcontroller and store it in database in real-time. A microcontroller has been used to connect the RFID scanner. High Frequency (HF) RFID passive tag and reader used for detection. Node-RED acts as a platform to virtually connect the microcontroller, databases, and other string messages output. The databases have been added as data source in Grafana which acts as data visualization platform. Three presentation panels have been created that display the information of the vehicles' information passing the toll gate, traffic volume and bar chart of vehicle type volume. As a solution, an RFID-based real-time database on vehicles' information accessing toll gates with a functional user interface has been developed.

ABSTRAK

Peranan teknologi RFID dalam aplikasi kehidupan sebenar memberi kesan positif terhadap kecekapan aplikasi. Data yang lebih pantas dan tepat boleh diperoleh dan disimpan jika dikaitkan dengan sistem pangkalan data dalam masa nyata. Jumlah kenderaan di jalan raya di Malaysia meningkat dengan pesat setiap tahun namun tiada sistem pangkalan data yang berkesan telah dibangunkan untuk merekodkan maklumat kenderaan yang melalui pintu tol. Pengecaman Plat Nombor Automatik (ANPR) semasa menggunakan sistem kamera bersepadu menghadapi kesukaran dalam kadar penggantian disebabkan oleh pelbagai ciri plat nombor kenderaan. Ini menyebabkan kesukaran untuk membangunkan pangkalan data masa nyata mengenai maklumat kenderaan yang mengakses pintu tol. Objektif projek ini adalah untuk membangunkan sistem pengesanan RFID dengan pangkalan data masa nyata mengenai maklumat kenderaan yang mengakses pintu tol, menyediakan papan pemuka pembentangan data sebagai antara muka pengguna dan menganalisis data trafik daripada pangkalan data yang dibangunkan. Projek ini menggunakan komputer papan tunggal kecil untuk memproses nombor siri tag daripada mikro pengawal dan menyimpannya dalam pangkalan data dalam masa nyata. Mikro pengawal telah digunakan untuk menyambungkan pengimbas RFID. Tag pasif RFID Frekuensi Tinggi (HF) dan pembaca digunakan untuk pengesanan. Node-RED bertindak sebagai platform untuk menyambung secara maya mikro pengawal, pangkalan data dan output mesej rentetan lain. Pangkalan data telah ditambah sebagai sumber data dalam Grafana yang bertindak sebagai platform visualisasi data. Tiga panel pembentangan telah diwujudkan yang memaparkan maklumat maklumat kenderaan yang melepasi pintu tol, isipadu trafik dan carta bar isipadu jenis kenderaan. Kesimpulannya, penyelidik membangunkan pangkalan data masa nyata berasaskan RFID mengenai maklumat kenderaan yang mengakses pintu tol dengan antara muka pengguna yang berfungsi.

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My highest appreciation goes to my parents and family members for their love and prayer during the period of my study.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

LIST OF ABBREVIATIONS

RFID	-	Radio Frequency Identification
VIT	-	Vehicle Identity Tag
TEV	-	Toll Entry Vehicle
VIR	-	Vehicle Identity Record
NPs	-	Number Plates
SQL	-	Structured Query Language
RFID	-	Radio Frequency Identification
VIT	-	Vehicle Identity Tag

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Project Background

Millions of vehicles are passing through toll gates every day yet there is not any effective database system has been developed to record the information of the vehicles passing the toll gates. A database is an organized collection of structured information or data stored electronically in a computer system. Automatic Number Plate Recognition (ANPR) using integrated camera system were developed as a solution for this. The first ANPR system was invented in 1976 in the UK [1][2]. The system then gained the attention after the improvement of digital camera and the increase in computational capacity over the last decades. This system works with the help of camera capturing images of number plates (NPs) of vehicle and then process the images through special algorithm to extract the alphanumeric from the plate.

However, the challenges begin when the images captured needs to have a high resolution as low-resolution images can result in different output than actual. In real-time application there are possibilities for the image captured gets blurred due to the speed of vehicle movement and environmental factor[3]. An improved optical character recognition (OCR) based ANPR using features trained neural network were proposed by having a three stages of image processing which is Number Plate Localization (NPL), character segmentation and OCR matching [4]. The improved system still achieved 96.9% succession rate under normal circumstances.

More studies were caried out on modifying the algorithm patterns for a better capture and process the image to extract the alphanumeric from the NPs accurately. ANPR system using You Only Look Once (YOLO) detector were also proposed but it is still has some future works to be done in terms of achieving more accurate detection in different scenarios such as inclined number plates and optimizing the speed of the detection stages [5]. However, the current ANPR system facing difficulties in succession rate to recognize the number plate due to various in features of vehicle NPs such as area and aspect ratio of the number plate, background color, foreground color, shape, number of lines, font face/ size of characters, spacing between characters. Moreover, the environmental factor becomes a challenge for this system as the images were capture under various environmental condition such as varying lighting and weather conditions, varying pollution level and wind turbulences [6]. There are articles mentioned ANPR system been a costly technology available only for a limited range of systems[7]. Even though many studies are working on modifying the algorithms, augmentation, and camera technology yet none achieved a satisfying accuracy result for wide range of implementation. In the recent years, research about RFID technology were increased and started to implement on toll collection system and smart parking system yet develop a database system for vehicle using the RFID technology.

This project is about developing a database system with Radio Frequency Identification Technology (RFID) and Vehicle Identity Tag (VIT) .With the implementation of RFID technology, the detection can be done more effectively [8]. When the reader detects the tag, the single-board computer, Raspberry Pi refers to the Vehicle Identity Record (VIR) database through Internet of Things (IoT) based on the unique VIT serial number detected to acquire the information. It is then transmitting the information to store in a new database called Toll Entry Vehicle (TEV) database which stores the information of vehicles passed by the toll gate.

1.2 Problem Statement

A real-time database on vehicle passing toll gates is an important record to be recorded as it serves number of purposes such as a method of cataloguing the movement of traffic, prevent crimes and helps in police investigation. However, the current Automatic Number Plate Recognition (ANPR) using integrated camera system facing difficulties due to many aspects such as the NPs are various in features such as area and aspect ratio of the number plate, background color, foreground color, shape, number of lines, font face/ size of characters, spacing between characters. Moreover, the current RFID technology are yet used in developing database system for vehicles on road. The system to create a real-time database of vehicles accessing the toll gates yet developed due to the current vehicle identity detection system is still not ready to operate in big scale due to the challenges mentioned above. Moreover, there is also no user interface has been developed to access the real-time database to be used by the relevant traffic department authorities or government authorities such as the police department for investigation purpose and monitor the traffic activity at toll gate. Therefore, the project proposes a system that develop a database on vehicles' information passing toll gates and design data visualization panels as a user interface.

1.3 Project Objective

The objective of the project are as follows:

i) To develop a vehicle identity detection system using Vehicle Identity Tag (VIT) and RFID technology at toll gate.

ii) To develop a real-time database on vehicle passing through toll gates via internet communication.

iii) To develop a user interface to monitor the system

iv) To analyze the traffic data from developed databases.

1.4 Scope of Project

By narrowing the needs for this project, a few guidelines are proposed to ensure that this project will achieve the stated objectives. The scope of this project are as follows:

i) Raspberry Pi 4 acts as a single-board computer to this project.

ii) NodeMCU ESP32 acts as a microcontroller to this project.

iii) Develop the user interface in Grafana and present the necessary data acquired from the NodeMCU ESP32 and databases.

iv) Develop the database system with the implementation of password security feature as added security in SQL database server.

v) Develop the RFID detection system using Mifare RC 522 High Frequency (HF) RFID reader and tag.

vi) Integrate RFID detection system with Vehicle Identity Record (VIR) and Toll Entry Vehicle (TEV) databases.

vii) The databases and data presentation panels are accessible by localhost device only.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In today's world, vehicle production increases tremendously every year as the demand for its usage become vital in human's life. The number of vehicles on road increases but there is not any system has been developed to create a database about the information of the vehicles on road especially at toll gates. Database is an organized collection of structured information or data stored electronically in a computer system for example storing the information of the vehicle such as vehicle number, car type & color, expiry date of road tax and owner information in a server system. Therefore, this project helps to develop a system to create a database on vehicles passing the toll gates with the help of RFID technology. This system will help the government authorities to monitor the vehicle passing toll gates which also helps in police investigation.

2.2 Radio Frequency Identification (RFID) Technology

RFID technology is an automatic technology and aids machines or computers to identify object, record metadata or control individual through radio waves signal. Over the last decades, RFID becomes so popular among many sectors of industries due to its wide range of usage in many scales. The system consists of tag which also known as transmitters/responders and readers. The RFID reader will communicate with the RFID tag through radio wave signal enables data transfer. Figure 2.1 shows how RFID reader and tag communicates. As shown in Figure 2.1, RFID technology has a wide range of frequency band spectrum such as Low Frequency (LF), High Frequency (HF) and Ultra-High

Frequency (UHF). This promises wholesale changes across a broad spectrum of business activities and aims to cut cost on the traditional bar code system [9].

The basic premise behind the RFID system is marked with tags. These tags contain transponders messages readable by specialized RFID readers. Most RFID tags can store with a Unique Identification Number (UIN), for example, a customer number or product Stock-Keeping Unit (SKU) code. Further, they read and retrieve information through the customer's ID number from the database. RFID tags can also contain editable memory, which can update the information from a Central Database; transfer those updates to RFID trackers which can read from any location. This information can be automatically encrypted at any speed of the tag movement. By accessing and decoding that available information, complete information about the vehicle can be retrieved. Figure 2.1 shows how RFID system works while Figure 2.2 shows the radio frequency band spectrum ranges.

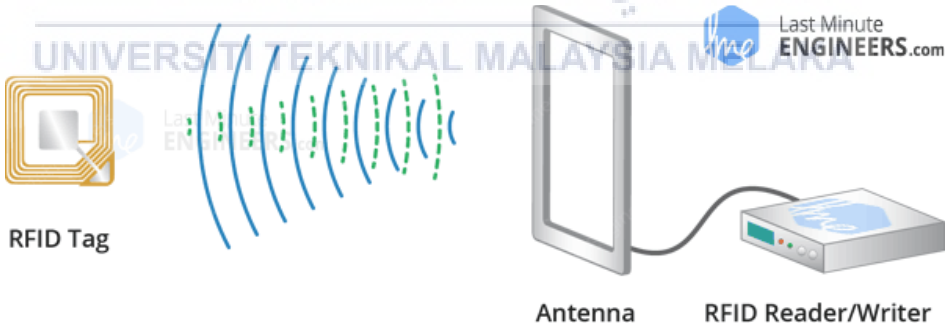


Figure 2.1 How RFID Communicates

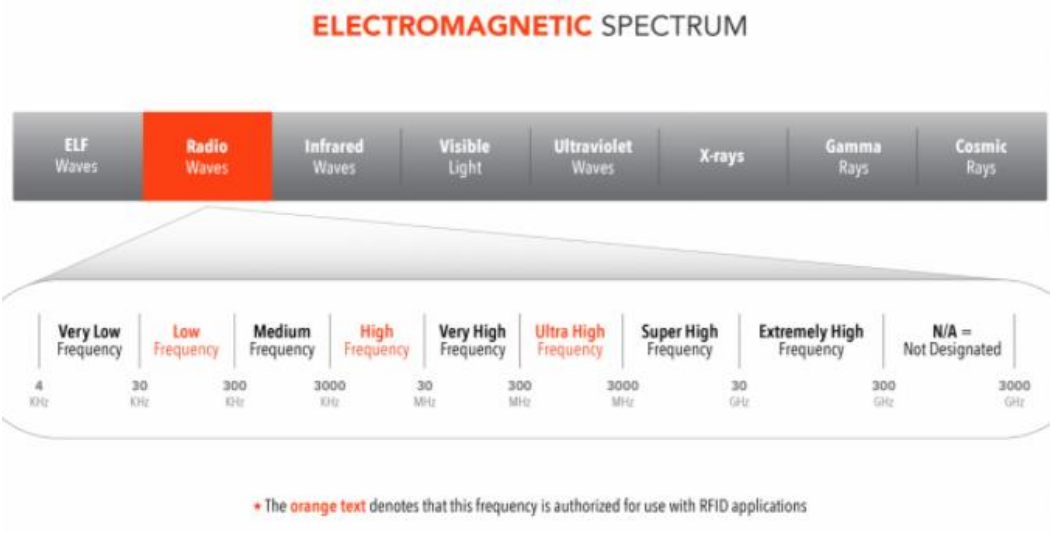


Figure 2.2 Frequency Band Spectrum of RFID

In [10] stated a brief information about RFID technology in terms of advantage, disadvantage, components and types of tags.

RFID tag consists of two main component which is a silicon chip that contains the information and another one is an antenna which receive and transmit signals. RFID tag can be categorized into two which is active tags and passive tags.

Table 2.1 Active and Passive Tag

ACTIVE TAG	PASSIVE TAG
Has its own power supply with an internal battery	It has no internal power source

Types of Active Tag

- Transponders (433MHz)
- Beacons (915MHz)

Types of Passive Tag

- Low Frequency Tag
- High Frequency Tag
- Ultra-High Frequency Tag

Table 2.2 Frequency range of passive tags

Low Frequency	High Frequency	Ultra-High Frequency
125kHz – 134kHz frequency range	Approximately 13.56MHz	300MHz to 3GHz frequency range
0-10cm of short read range	About 1 meter read range	3-5 meter read range

Table 2.1 shows the description of active and passive tag while Table 2.2 shows the frequency range of the types of passive tag.

Like many other technologies, RFID technology system also encountering a new set of challenges in providing security and privacy for users or organizations against possible threats. Privacy becomes one of the concern of users when their information are stored electronically such as in chip and tag. [11] defined the consumer privacy as 'control over information disclosure and the environment in which a consumer transaction occurs'. [12] delivers a complete review of RFID related security threats and basic solutions for it. According to [12], security threats of RFID can be split into two main categories which is:

i) Privacy Violation – Attackers tries to steal the information from the objects by eavesdropping to the communication between the object and the reader.

ii) Security Violation – an adversary counterfeits the behaviors of a tag or reader by making undesirable communications

Physical RFID threats are those threats use physical means attacking the RFID system. It can be categorized into several category:

i) Disable tags – Attackers may temporarily or permanently disable the tag by taking advantage of the wireless nature of RFID system. Besides that, the attacker can also erase the memory of the tag by sending 'kill command'.

ii) Tag modification – usage of RFID tags which allows to erase/write memory enable the attacker to modify or delete the valuable data from the memory of the tag.

iii) Cloning Tags – Every RFID tag comes with an unique set of number. The attacker clones or imitates the tags after skimming the tag's information. The cloning is not a difficult task for an attacker if the unique number of the tag is exposed by the attacker.

iv) Reverse Engineering and Physical Exploration – Tamper resistant mechanism is one of an added security feature for an RFID tag but however adding the security feature costs higher. Low-cost RFID tags which have not equipped with the feature enables attacker to duplicate the tag with reverse engineering. This is not same as tag cloning as this does not require physical exploration of the tag.

RFID channel threats refers to attacks targeting the less secure channel between a reader and a tag. Air is the medium for the RFID technology which is also known as wireless communication between the reader and the tag. Figure 2.3 shows how eavesdropping works. This kind of threats are categorized into several category:

i) Eavesdropping – happens when the channel is overheard secretly by an attacker to acquire information. RFID technology which uses Ultra High Frequency (UHF) bandwidth spectrum which enables a longer range of

communication between a ta and reader becomes less difficult for an attacker to attempt it.

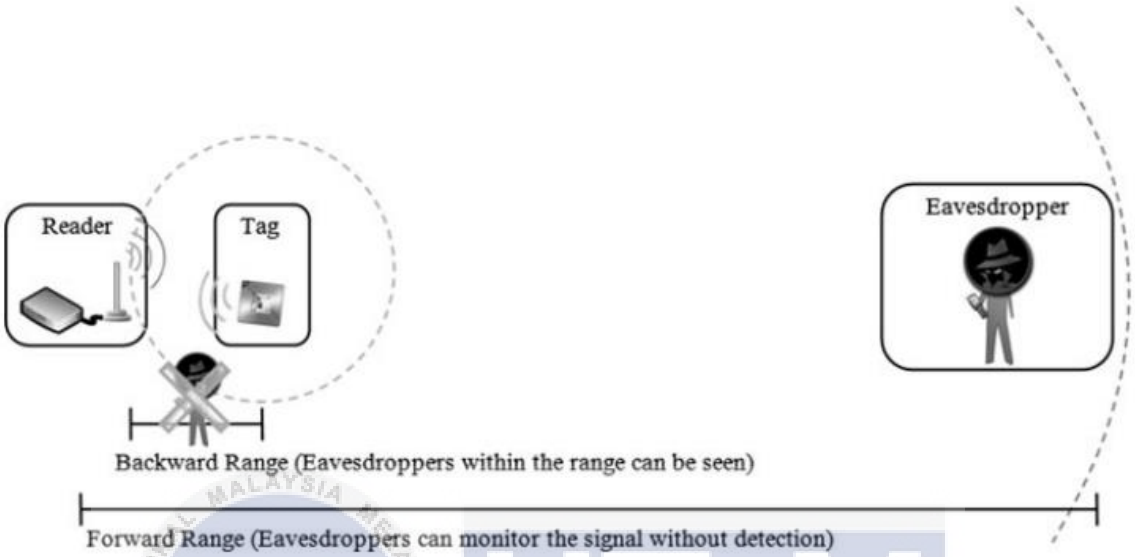


Figure 2.3 Eavesdropping Security Threat

ii) Snooping – defined as illegal reading of a device's identity and data.

iii) Replay attack – a malicious node replays that information which is overheard through the communication between the reader and the tag. Stamp program, a one-time password, using random number in authentication protocol are some of the ways to overcome this kind of attacks. In [13] proposed a number of solution to overcome replay attacks such as David's Digital Library RFID protocol and distributed RFID interrogator.

iv) Relay attack – Also known as man-in-the-middle attack where an attacker set up an illegal device in between the communication range of the reader and the tag. The illegal device will intercept the information and pass it to another end device whether the attacker gets the information.

Table 2.3 Difference between Eavesdropping and Snooping

Eavesdropping	Snooping
Attackers collect information that is shared between a legitimate reader and legitimate tag	Attackers collect the information without the owner's knowledge by an unauthorized reader

Table 2.3 shows the differences between eavesdropping and snooping attack. In above mentioned number of possible ways of threats and attacks that could break the privacy in RFID technology. However, there are also several ways to tackle the threats and attacks through some of the solutions which has been studied and proven through research. Those are:

i) Killing tags – It is a method to use to kill the tag after using it. By this way, the tags are no longer functional and cannot be re-activated anymore.

ii) Sleeping tags – In the method, the reader will send a 'sleep' command to the tag which put the tag in inactive mode temporarily. Unlike killing method, using this method the tag can still be activated again.

iii) Faraday Cage – This cage is designed and made of conducting materials which prevent penetration of any signal inside the cage. This method was inspired by the characteristics of electromagnetic which was introduced in [14].

iv) Proxy Privacy Devices – privacy enforcing devices can be added to the RFID systems like RFID Guardian proposed in [15]. It is a platform that provides a centralized RFID security policies like auditing, efficient key management, access controls and acts as mediator. This is more likely an RFID firewall.

2.3 Database System

Any collection of electronic records that can be processed to produce useful information is referred to as a database. To perform various data-processing operations, the data can be accessed, modified, managed, controlled, and organized. The data is typically indexed across rows, columns, and tables to facilitate workload processing and data querying. Database Management Systems (DBMS) are the technological solutions used to optimize and manage data storage and retrieval from databases.

Types of databases:

i) Object-oriented

ii) Relational

iii) Distributed

iv) Hierarchical

v) Network

In [16] proposed that by making few changes to a parallel or distributed relational database system, it can be competitive platform for the modern data management system known as scalar linear algebra. A total of 4 set different sets of experiments were carried out.

i) First experiment - Contrast the efficiency of SimSQL with the new linear algebra types with that of several other platforms.

ii) Second experiment – A couple of relatively complex machine learning computations and demonstrate how adding matrix and vector types to the relational model can greatly speed up the underlying machine learning computations.

iii) Third Experiment - Run several examples with and without the query optimizer knowing about the matrix and vector size information to

demonstrate the importance of incorporating the templated dimensionality information into the optimizer.

iv) Forth Experiment - Use the block matrix multiply to demonstrate the runtime benefit of our non-random partitioning.

The researcher acquired the result as the tuple-based and matrix-based implementation is less when linear algebra objects were used for building more complicated machine learning computations. The researcher also stated that the proposed system does not automatically support chunking or blocking large matrices. Hence, these limitations can be solved in future work.

According to [17], the researcher stated that Relational Database Management System (RDBMS) faces a decrease in performance when handling a large amount of data. As a solution, the researcher proposed an alternative solution called NoSQL. A hybrid model of MySQL and MongoDB was compared with RDBMS on the performance when being used in web application. Figure 2.4 show the design of MySQL for hybrid database

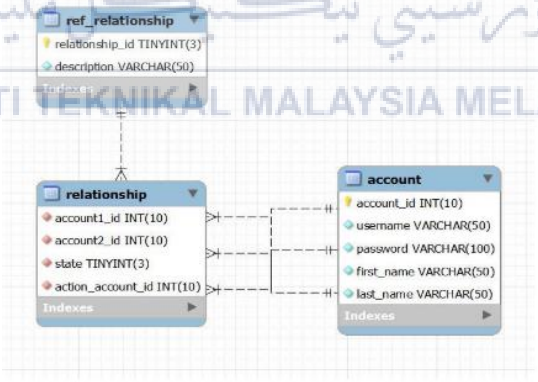


Figure 2.4 MySQL design for hybrid database

Table 2.4 The three chat datasets for experiments

Datasets	Size
First Dataset	100,000 data
Second Dataset	500,000 data
Third Dataset	1,000,000 data

Table 2.5 Summary of average response time

Database Model	Average Read Response Time (s)		
	First Dataset	Second Dataset	Third Dataset
MySQL Database	0.0205	0.5589	2.2938
Hybrid Database	0.0226	0.0311	0.0430
Response speed-up:	-0.0021	0.5278	2.2508

The researcher implemented a social medial website equipped with feature such as chatting between users to evaluate the performance of different database models. The size of the data in the datasets are shown in the table in Table 2.4 while the result of the average time taken of response for database model shown at Table 2.5.

The average read response time for MySQL website is 0.0205 second and for website that use hybrid database is 0.0226 second. The difference between them is only 0.0021 second, where MySQL is a little bit faster than MongoDB. The researcher concluded the result from the evaluation. Table 2.6 shows the performance of the MySQL and hybrid model.

Table 2.6 The performance of the models

MySQL	Hybrid Model of MongoDB and MySQL
Improves the web application performance	Improves the web application performance
MySQL write procedure is more consistent	Relatively better write time than MySQL
Handle more sensitive data and maintaining data consistency	Use less disk space than MySQL

As IoT applications spread throughout smart city appliances, industry, and agriculture, the amount of data stored in IoT databases grows as well. In [18], the researcher carried out a comparative study on the performance of open source databases such as MySQL, MongoDB and PostgreSQL. The evaluation process included 3 experimental scenarios: -

i. Select queries experimentation on IoT data
ii. Insert queries experimentation on IoT data
iii. Aggregation functions experimentation on IoT data

In the first experiment, a fixed number of records are returned to compare query execution times in MySQL, PostgreSQL, and MongoDB. Up to 500.000 (500K) records were returned in the IoT database during the total execution time. Figure 2.5 shows the performance chart of the models.

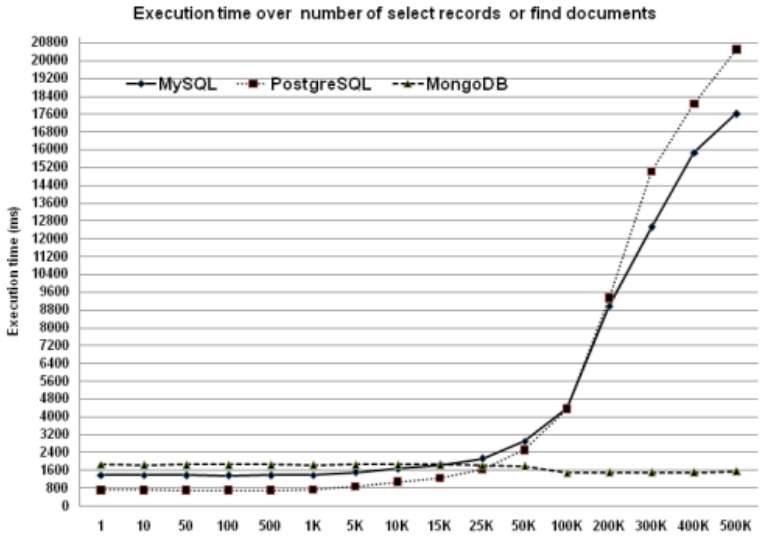


Figure 2.5 Total time execution in IoT databases over number of records

Experiment 2 was carried out by performing several insert queries within a transaction. Then, the total transaction execution time was measured. Figure 2.6 shows the evaluation of insert queries execution time in IoT database

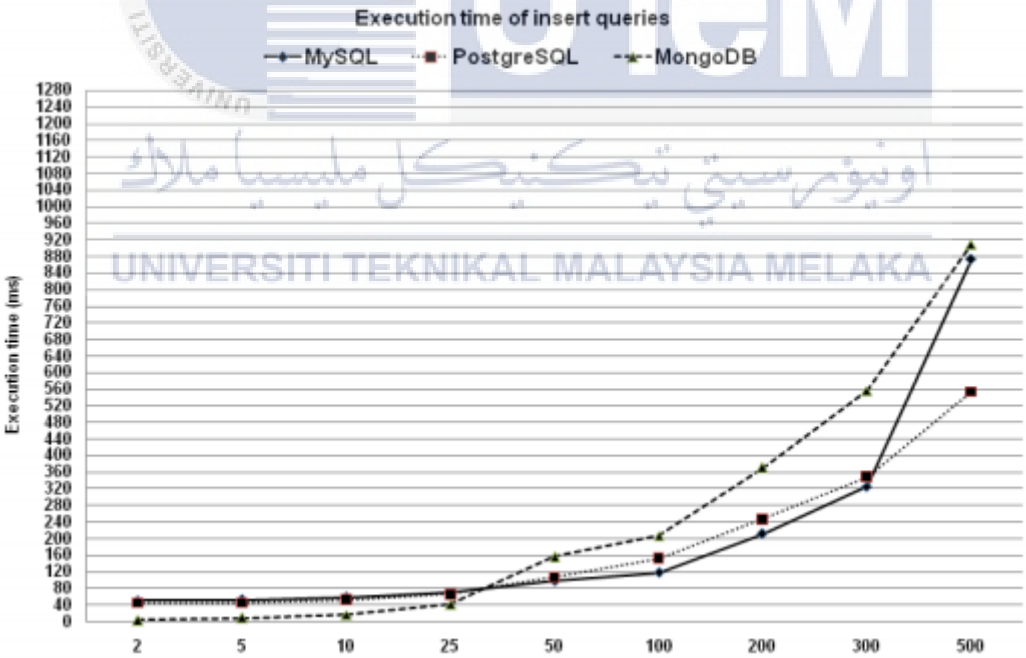


Figure 2.6 Evaluation of Insert Queries execution time in IoT database

In a nutshell, the researcher stated for small number of selected records PostgreSQL outperforms MySQL and MongoDB. MongoDB performs better when comes to big number

of selected record while MySQL outperforms better than PostgreSQL but not better than MongoDB.

2.4 Review of Previous Related Research Work

A vehicle identity database can be developed by having the vehicle's information. Every vehicle has its own uniqueness which is the number plate. By recognizing the content in the number plate, the information can be acquired to create the database. To identify the number plate recognition and make it an automated system, integrated camera technology were first developed in UK [1]. Throughout decades, the camera system was then modified many times in the attempt to reach a complete success rate of Number Plates (NPs) recognition meanwhile RFID technology also were progressing its potential over the recent decades.

According to [19], most of the technique for camera system that has been proposed before were worked but under restricted conditions such as limited vehicle speed, fixed illumination, designated routes, and stationary backgrounds[20] . This aim of this research is to reduce the restrictions, so the proposed technique consists of two main modules: a license plate locating module and a license number identification module. However, when the camera viewing angle increases, the success rate decreases as well until it results in 98.8% of succession rate.

A robust and efficient ANPR system based on You Only Look Once (YOLO) object detector was proposed in [5]. This system possesses a trained Convolutional Neural Networks (CNNs) so that it can work efficiently under different conditions such as variations in camera, lighting, and background. The camera was fixed on a car viewing the road to capture the Number Plates (NPs) on the front to check its efficiency. Figure 2.7 shows how the ANPR system works in real life situation.

Figure 2.7 Sample of images taken under different background and lighting

The datasets were collected and closely analyzed by the researcher. The researcher stated that it has successfully able to get the results accurately for 144 out of 150 vehicles which has a succession rate of 96%. However, there were no results were taken under different aspects such as variation in number plate design. This is important because in [6], the researcher mentioned that various in area and aspect ratio of the license plate is one of the challenges faced by the ANPR camera system recently.

In [8] proposed a system based on Ultra-High Frequency (UHF) band RFID technology to develop a vehicle's database entering/leaving road gates like residential area guard house entrance or toll gates. RFID technology is gradually matured which makes implementation process much easier. This system does not only record the data but also determines whether the gate to be open or not which acts as a payment gateway. It also stated that using UHF band long distance sensing ability promotes the speed of identification which is also stated in [21]. This system also works together with the camera technology as if the

validation checking is passed, an image will be taken and saves it in the guest list for record purpose. The proposed system could not only reduce cost of manpower but also promote the security as well.

According to [22], the manual toll collection system, Radio Frequency (RF) Tags, Barcodes and Number plate recognition have disadvantages that lead to some errors in the corresponding system. This paper presents a brief review of toll collection systems which includes RF tags, Barcodes, Automatic Number Plate Recognition (ANPR) using camera technology. The systems mentioned are recognizing the car in different ways such as the RF tags system using radio waves and ANPR system using camera to capture images and compute.

Table 2.5 Disadvantages of the system

Radio Frequency Tags	**ANPR**	**Barcode**
RF tags cannot be implemented on all vehicle as it gets expensive in costing wise	ANPR is an automatic system which possess significant error possibilities like false prediction of number plate	Optical systems proved to have poor reading reliability in inclement weather environment and in rainy seasons especially when vehicles are dirty
Expensive than barcode	Image processing requires relatively more time and hence multiple readings have slow rate and hence reliability decreases.	Limited in detection range
Materials like metal & liquid can affect the signal	The system is unable to identify plates due to dirty or damaged license plates,	Have no read/write capabilities

	the presence of bumper stickers and similar text on a vehicle, and reduction of visibility caused by rain and fog	
	Low reliability because of the complexity involved in image processing.	

Table 2.5 shows the disadvantages of Radio Frequency Tags, ANPR and Barcode system. The table helps to identify the limitation of the system

Besides that, in [23] proposed employee attendance management system using RFID technology which is integrated with database system. In this system, ID card of all the employee were replaced by an RFID card which holds the information of the employee. The unique number stored in the memory of the card will be used to identify the employee. When the reader scans the RFID card, the system will first check the unique number of the card into the database which is connected to the computer to check whether the number has been registered into the system or not. If the tag number is found in the database, then the system will save the employee details including the employee id, name, and time of the attendance into the backend database. This backend database can be used to monitor the attendance activity of an employee. If the card unique number is not in the database, the system will ask the user to contact the administrator to record the tag number. If the ID has been scanned before then the system will reject the card and notify the user that the card has been successfully scanned. In conclusion, the researcher stated that this system offers an easy way in recapitulation of employee attendance data for payroll purpose, existence of database helps in monitoring the employees log in time activity and absence activity. Thus, it makes

the performance evaluation process of the employee much easier and valid. Figure 2.8 shows an overview working principle of the system.

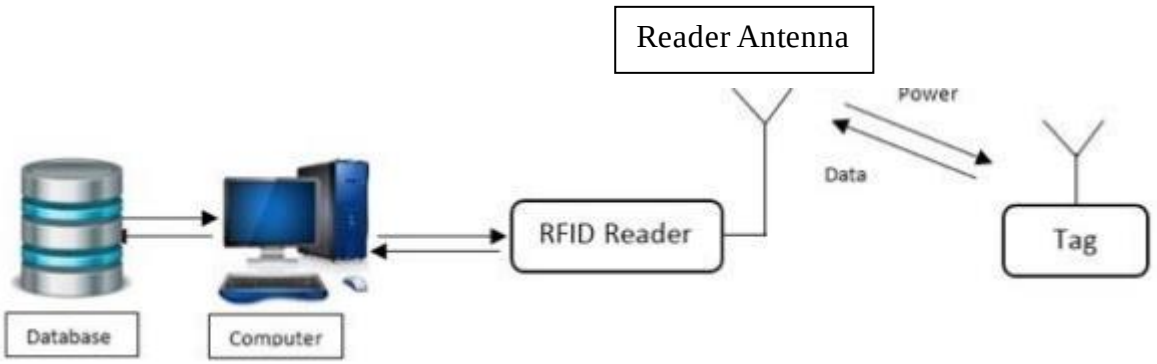


Figure 2.8 An overview working principle of the RFID system

In [24] Proposed a research work on analysis and simulation of RFID system using Ultra High Frequency bandwidth spectrum for vehicle detection. One of the analysis parts was carried out on how the vehicle's movement speed affects the detection succession rate. It stated that the system performance for detection is satisfactory for the vehicles moving with an average speed of 100 km/h and the success rate diminish for vehicles moving faster than 100 km/h. One of the ways to solve is by using better antennas with higher gains. Other than that, optimize the tags query procedures by setting repeated 'Read' commands several times.

A system to control the vehicle's emission level and control the traffic using RFID technology was proposed in [25] . Semi-passive RFID tags were attached to all the vehicles and RFID readers were placed at traffic signals, toll gates and parking slots. The reader reads all the tag of vehicles that crossing the system and able to alert the concerned departments of the problematic vehicles. The RFID tag on the vehicle holds the vehicle's information. Besides that, traditional traffic gives a uniform time for all directions for the vehicles to pass but this system may cause high traffic congestion due to different density of vehicles in

directions. As a solution for this problem, the researcher designed the proposed system in a way where the system provides more time and gives priority to the direction with more vehicles. The density of vehicles is detected by the RFID system where the system able to count the number of vehicles in a particular direction through the communication between the RFID reader and tag on the vehicles. The researcher also stated implementation of RFID technology on traffic system is very crucial as the number of vehicles on road increases tremendously throughout the year but a system to monitor this is still in beginning stage at most of the countries.

Furthermore, in [26] proposed RFID technology-based system to eliminate the problems faced at toll gates such as incorrect toll collection due to human error and longer processing time in manual toll collection system. Moreover, the researcher is also intended to introduce identification system for vehicles to find stolen vehicles and vehicles with criminal record. The user must create an account through a mobile application where the details are collected. Each time a vehicle reaches the toll gate, the RFID reader detect the tag and acts as a payment gateway for the toll collection system. The system also alerts the concerned department if the vehicle has any criminal record such as hit and run case. The researcher also stated that usage Automated Number Plate Recognition (ANPR) system using integrated camera technology at toll gates requires high installation cost.

A new platform called PCIV (an RFID-based intelligent platform for vehicular control) to monitor road traffic in public transportation system was proposed in [27]. A roadside unit (RSU) which is a RFID reader were placed at roads to detect RFID tags in vehicles. A software system was designed to process, store, and present the information acquired by the RSUs. The experimental setups were carried out at a university campus and a medium-size city in Colombia.

Table 2.7 The result acquired in University Campus and City

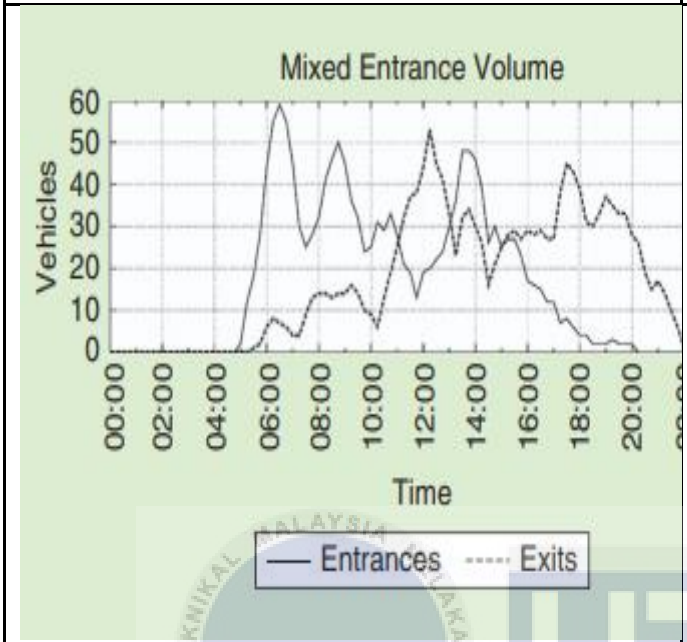
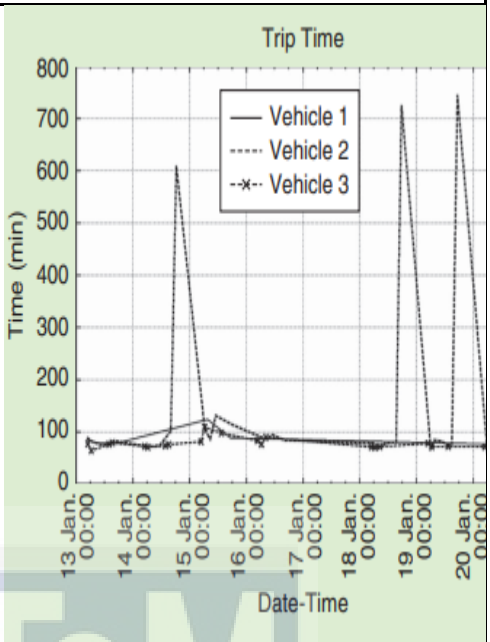
University Campus	City
	
It can be observed a high volume at the entrance between 7.00 a.m. and 9.00 a.m. which is the class starting time.	An example of trip duration taken by three different public transport

Table 2.7 shows the result acquired in university campus and city. The researcher stated it is much better to use RFID technology than GPS because RFID presents a cheaper cost about 1 dollar while a GPS monitoring system cost hundreds of dollars per vehicle.

A news article stated PLUS Malaysia Bhd is integrating RFID into all of its highway, with at least one lane per plaza by early 2022 [28]. This article shows that Malaysia is about to adapt the RFID technology on toll gate system at highway. The system will be using the RFID technology for a better payment gateway system at tolls. Besides that, it is also stated that the ANPR system will work with Toll Validation Centre to seamlessly process customers' payments however the AI in the validation system was still being enhanced, and in circumstances where the number plate was illegible due to corrosion, grime, or the use of non-standardized, stylized number plates, human workers would assist.

2.5 Summary

The purpose this literature review was to view the composition in the past studies related to the project. All the research was clearly defined and justified with its proper content on abstract, introduction, methodology and finding results. The reviewed research papers helped in understanding the technology better to design the project appropriately. In a nutshell, the previous work-related research papers proposing two main technology which is ANPR camera system and RFID technology.

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter contains a detailed overview of the vehicle identity database development system that will be implemented at toll gates. This project is divided into two sections: hardware and software implementation. The development of this project involves a several number of components. This chapter will give an overall overview on how this project is approached in building the system. Throughout this chapter, the progress of this project is detailed and demonstrated. The instrument that was used for data collection is also described and the procedures that were followed to carry out this study are included. Next, it also discusses the methods used to analyze the data.

3.2 Research Methodology Flowchart

Flowcharts are used to design and document the system's simple processes. In this part, the flowchart representing the process of design and development of the project to the designated output. The flowchart plays a vital role as it helps to understand the flow of the project and the processes that has been done. Figure 3.1 shows an overview of the research methodology flowchart.

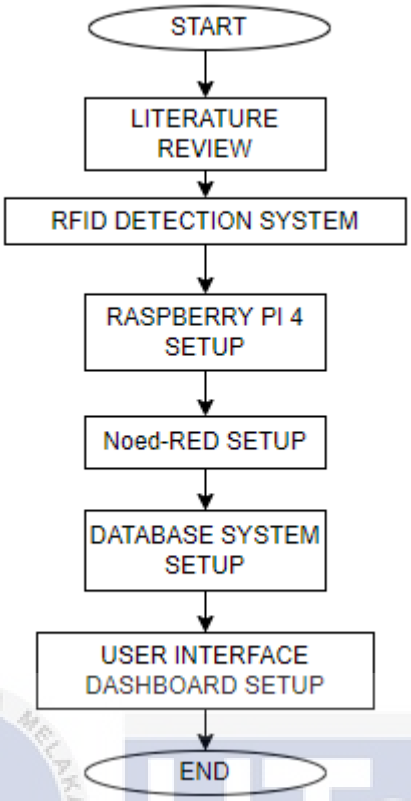


Figure 3.1 Research methodology flowchart

The flowchart shows an overview of the process takes place from the beginning until the end of the project. The total work has been segregated into 5 milestones. Each milestone had completed before stepping on the next consecutive milestone as the previous milestone becomes a prerequisite for the work.

3.3 Milestone 1: Development of RFID Detection System Hardware

The objective of this milestone is to develop the RFID detection system by using ESP32 device and Mifare RC522 High frequency RFID scanner. Figure 3.2 shows the flowchart of Milestone 1. The flowchart explains the process and expected result for Milestone 1.

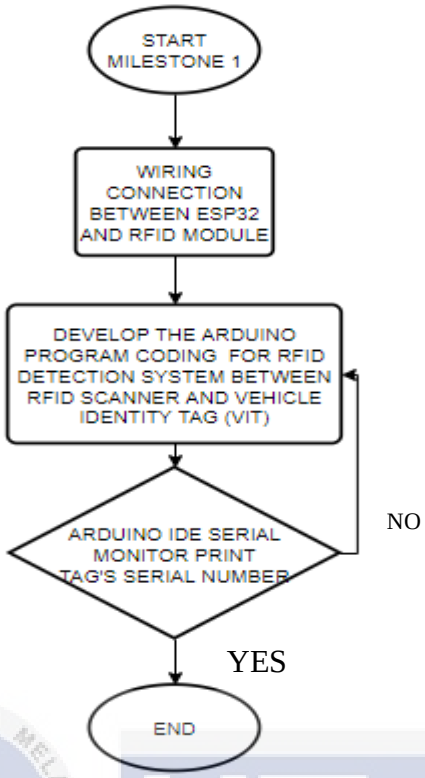


Figure 3.2 Milestone 1 flowchart

The project begins with developing the RFID detection system hardware between the scanner and the tag which involves wiring work between the modules and building the Arduino coding program for the desired output.

Figure 3.3 shows the wiring connection between the NodeMCU ESP32 and RFID RC 522 module. RC522 High frequency RFID module was selected for the demonstration purpose. A 5-Volt supply been given to power up the ESP32. Then, the Arduino program coding were developed to set up the RFID detection system at the initial stage.

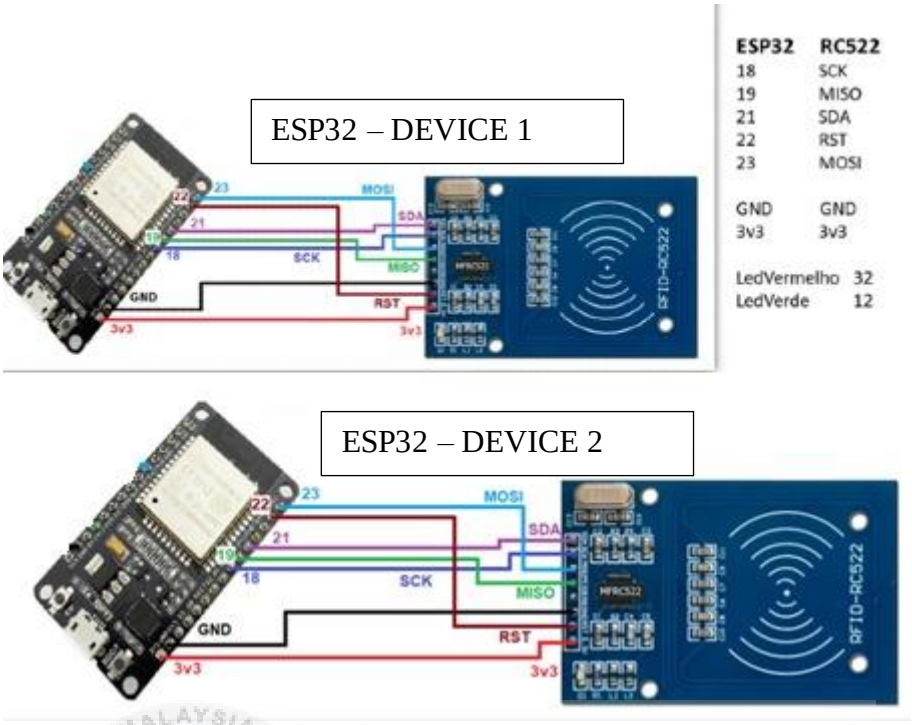


Figure 3.3 Wiring connection between two ESP32 device and two RFID module

Figure 3.4 shows the coding has been developed for the RFID detection system. The coding development process include downloads of vital library files and ESP32 module file. Serial monitor tab in Arduino IDE has been used as an output screen to verify the succession of the detection.


```
#define LED 12
#define LED1 32
/* Read RFID Tag with RC522 RFID Reader
 *  Made by miliohm.com
 */

#include <SPI.h>
#include <MFRC522.h>
constexpr uint8_t RST_PIN = 22;     // Configurable, see typical pin layout above
constexpr uint8_t SS_PIN = 21;     // Configurable, see typical pin layout above
MFRC522 rfid(SS_PIN, RST_PIN); // Instance of the class
MFRC522::MIFARE_Key key;
String tag;
void setup() {
  Serial.begin(9600);
  SPI.begin(); // Init SPI bus
  rfid.PCD_Init(); // Init MFRC522
   pinMode(LED,OUTPUT);
   pinMode(LED1,OUTPUT);
rfid.PCD_DumpVersionToSerial();
     rfid.PCD_Init();
  Serial.println("Approach your reader card...");
  Serial.println();
}
void loop() {
```

Figure 3.4 Arduino coding for RFID detection system

3.3.1 Microcontroller

A microcontroller is a need in most of embedded applications that need both processing functionality and agile, responsive interaction with digital signal, analog signal, and electromechanical components. Figure 3.5 shows the NodeMCU ESP32.

Figure 3.5 NodeMCU ESP32

Microcontroller is basically an integrated circuit device used for controlling input and outputs based on the program that has been programmed. Although there are a few microcontrollers are there in the market currently, there are several reasons behind the choose of NODEMCU ESP32 for this project. This project was designed to use a microcontroller to control the inputs, outputs and establish a Wi-Fi connection between the centralized server to transmit and receive data. For such condition, Arduino Mega and ESP8266 microcontroller is not the best option for such application. This is because Arduino Mega does not has consist of Wi-Fi module to establish an internet connection unless a Wi-Fi module added separately to Arduino Mega microcontroller. By adding Wi-Fi module to Arduino Mega, it will get costlier, bigger in size and usage of additional ports for the wiring connection.

Besides that, ESP8266 has a built in Wi-Fi module but unlike Arduino Mega it has less I/O pins which results in shortage of pin for usage. This also will limit the project's

expanding capability in future such as shortage of pins to use when adding inputs and outputs. NodeMCU ESP32 is the best option for this project because it has built in Wi-Fi with 36 General Purpose Input Output (GPIOs).

Table 3.1 Comparison table between Arduino, ESP 8266 and ESP 32

Microcontrollers	Arduino Mega	ESP8266	ESP32
Bluetooth	No	Yes	Yes
GPIO	54	17	36
Analog to Digital Converter (ADC)		1	18
Wi-Fi	No	Yes	Yes
Touch Sensor	No	No	Yes
Temperature Sensor	No	No	Yes
Frequency	16MHz	80MHz	160MHz
PWM	15	8	16
Price Estimation	RM42.80	RM25.00	RM30.00

Table 3.1 shows a comparison table between the Arduino, ESP 8266 and ESP 32.

3.3.2 Mifare RC-522 RFID Module & Tag

Mifare RC-522 RFID module is a high frequency module which is uses in smaller range detection. As the proposed system is a prototype, RC-522 low frequency was used as a substitute for the Ultra-High Frequency RFID module for demonstration purpose. It has an operating voltage of 3.3V and it can only read data from passive tags that operate on 13.56MHz. Figure 3.6 shows RC-522 RFID module and passive tag.

Figure 3.6 RC-522 RFID module and passive tag

The size of the module is like a standard bank card size that can fit into shape of small box. The price is typically cheap which rm RM7.00. Besides that, the RFID tag that comes together is a passive tag which does not has its own power supply. It gets the supply from the radio-wave frequency which bring near the RFID scanner. RFID scanner generates its own radio-wave frequency.

3.4 Milestone 2: Raspberry Pi 4 Setup

The purpose of this milestone is to setup the Raspberry Pi 4 because it acts as a single-board computer in this project. Besides that, Wi-Fi connection setup for ESP32 are one of the objective in this milestone. Figure 3.7 shows the flowchart of Milestone 2. The flowchart explains the process and expected result for Milestone 2.

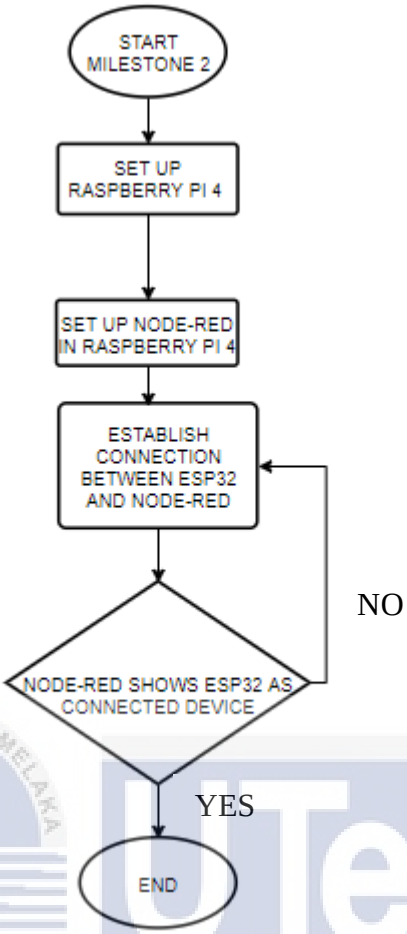


Figure 3.7 Process flowchart of Milestone 2

Milestone 2 starts with the task to set up Raspberry Pi 4 (RPi 4). A 32GB memory card was inserted in computer and downloaded Raspberry Operation System into the memory card. Then, the memory card has been inserted into the Raspberry Pi 4 and gave 5V/4.5A supply to power on it. Figure 3.8 shows the downloading process of Raspberry Pi operating server. The project was designed to set up the RPi 4 without connecting it with mouse and monitor. The setup of RPi 4 was done through Wi-Fi connection.

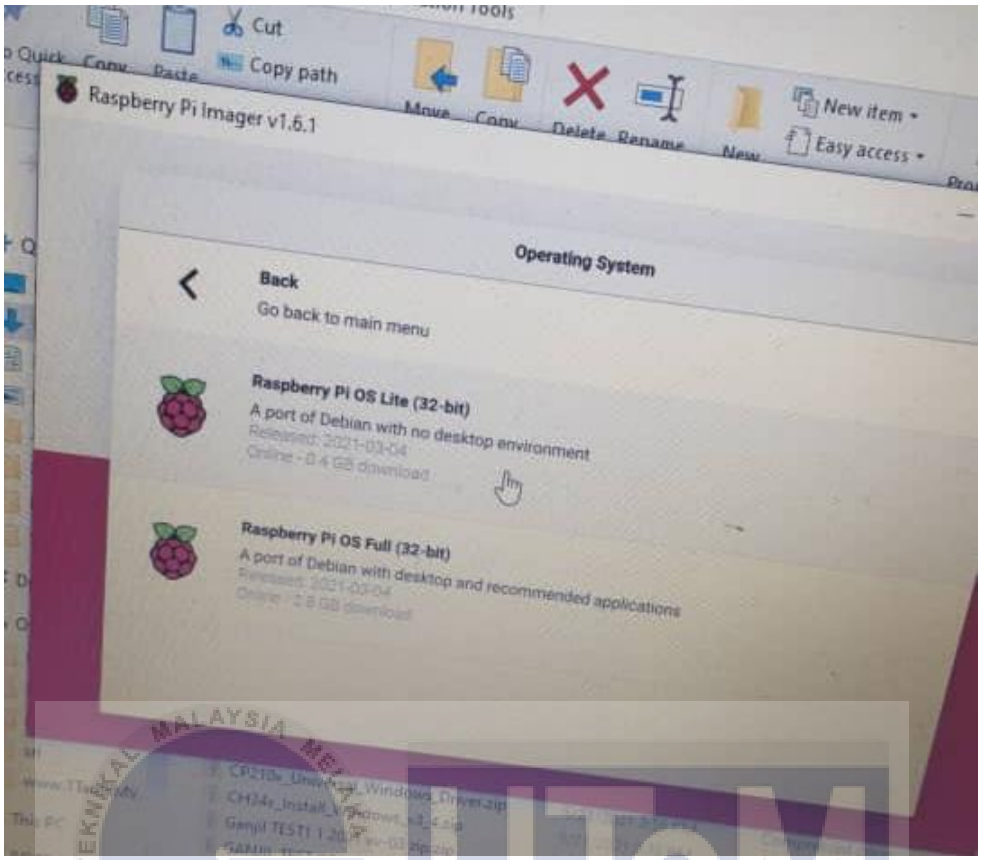


Figure 3.8 Downloading of Raspberry Pi OS

Procedure to connect RPi 4 through Wi-Fi without connecting it with mouse and keyboard:

1) Created an empty text file and rename it as 'ssh' and remove the '.txt' at behind. Figure 3.9 shows a sample file of 'ssh'

Figure 3.9 SSH file

2) Created a text file and write the Wi-Fi SSID and password as the Figure 3.10 shows below

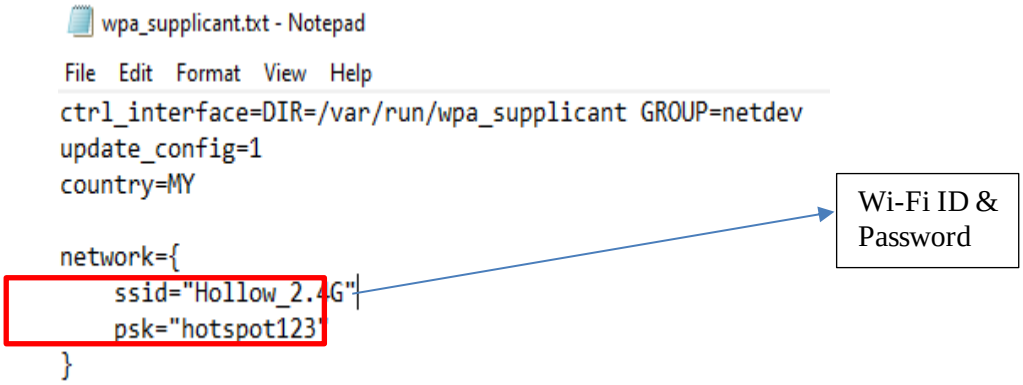


Figure 3.10 Details and format for wpa.supplicant.conf file

3) Renamed the file as "wpa_supplicant.conf"

4) Both files were then saved into the memory card before inserting into the RPi 4.

5) Download PuttyTv software application on computer and enter the IP address of the RPi 4 to connect with it through Wi-Fi.

The RPi 4 were then configured through some specific line to commands in PuttyTv to update, upgrade, install Node-RED and MQTT broker, establish automatic connection between RPi 4 and Node-RED whenever turned on. Figure 3.11 shows some sample of execution codes in RPi 4 for the tasks.

```
-- Install Mosquitto MQTT:
sudo apt install -y mosquitto mosquitto-clients
-- Run Mosquitto MQTT at boot:
sudo systemctl enable mosquitto.service
-- Check Mosquitto is installed:
mosquitto -v

-- install node-red:
bash <(curl -sL https://raw.githubusercontent.com/node-red/linux-installers/master/deb/update-nodejs-and-nodered)
-- Run node-red at boot:
sudo systemctl enable nodered.service
```

Figure 3.11 Commands lines used in Raspberry Pi 4 set up

Once the RPi 4 was successfully set up. The Arduino coding program was then improvised to establish a connection between ESP32 and Node-RED. A few more libraries related with Wi-Fi tools were added and IP address of RPi 4 was included in the Arduino coding as MQTT broker for the ESP32 to know to which network it should connect. SSID and password of Wi-Fi were also included in the coding to establish a Wi-Fi to the ESP32 device. Figure 3.12 shows line of commands in Arduino IDE to establish connection to Node-RED.

Figure 3.12 Line of commands in Arduino to establish connection

A mobile application named 'Fing' has been used to check the devices connected to the Wi-Fi. Fing App is a free network toolkit and scanner for iOS and Android that discover all the devices within the network. By using this application, the connection of the devices was confirmed easily. After the devices were connected successfully, the Node-RED was configured to make the ESP32 device as a client to the Node-RED so that ESP32 able to send the data from the input to Node-RED.

3.4.1 Single-board Computer

A single-board computer (SBC) is a complete computer built on a single circuit board, with microprocessor, memory, inputs and outputs. Single-board computers are commonly made as demonstration or development systems, for educational systems, or for use as embedded computer controllers. Figure 3.13 shows Raspberry Pi 4.

Figure 3.13 Raspberry Pi 4

The proposed project has a part where it must perform task like read and write database. For such application, a database server is needed to store and organize database and provide access to authorized users. Structured Query Language (SQL) is one of the most popular database servers which is supported and easily installed in Raspberry Pi.

Besides that, the project needs the write and read database tasks to be perform at faster rate because there are thousands of cars with Vehicle Identity Tag (VIT) will be scanned at toll gates every day. For such high volume, if there is a delay in the read and write database process, the system's efficiency will drop. On the other hand, the microprocessor

also needs to receive and transmit data to the microcontroller. As a solution, Raspberry Pi with 4GB RAM has been used for better system performance speed.

Furthermore, Raspberry Pi has built in Wi-Fi module which enables it to connect with internet. With such feature, the project was designed to establish wireless connection between ESP32 and Raspberry Pi to exchange data. Thus, there will be fewer wiring connections which results in cost saving and make the troubleshoot procedure less difficult. By making the troubleshoot process easier, the problem can be rectified faster and resume the operation at toll lane. Raspberry Pi has a lot of expanding capability. Thus, it can allow many new implementations in future such as cooperating with camera technology.

3.5 Milestone 3: Node-RED Setup

Milestone 3 consists of the work of Node-RED setup where it acts as a platform to virtually connect the microcontroller, databases, and other string messages output. A bunch of configuration works include in this milestone. Figure 3.14 shows the process flowchart of milestone 3.

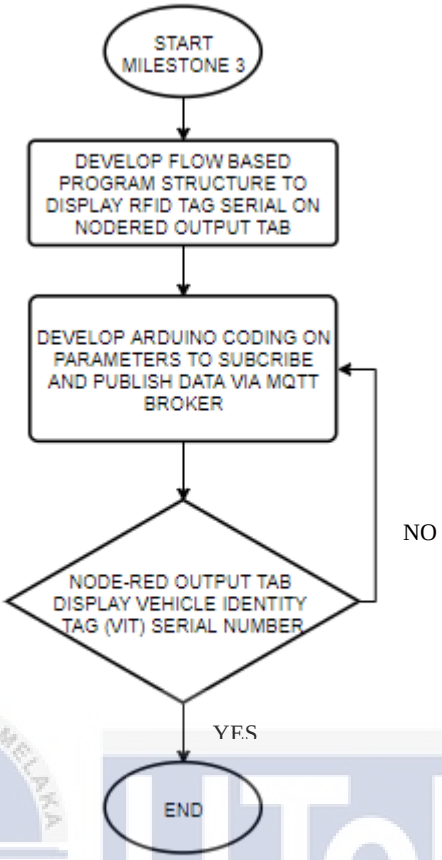


Figure 3.14 Process flowchart of Milestone 3

A flow-based program was then developed in Node-RED. A simple flow-based program was developed at the initial stage to display the serial number of Vehicle Identity Tag (VIT) on the output tab on Node-RED. A ‘mqtt in’ node was taken and configured. An identity was given to the node as ‘growShed/rfid’ to represent the output from the ESP32. Figure 3.15 shows the configuration of ‘mqtt in’ node.

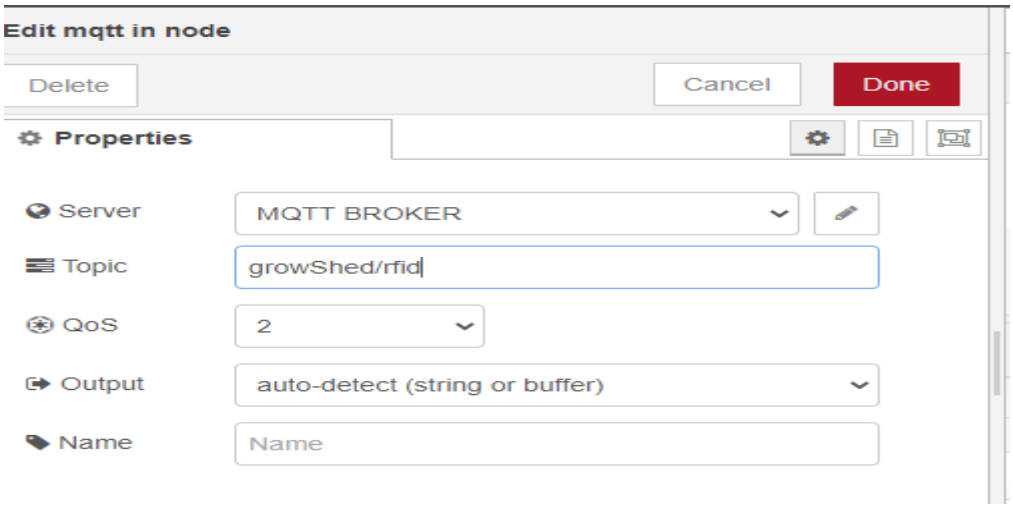


Figure 3.15 Configured settings of MQTT in node

The mqtt node was then connect to a 'msg.payload' node which function as displaying the output in terms of character or numbers. Once the flow-based was developed. The 'Deploy' button was clicked to make the program in execution mode. Arduino coding was then improvised to send the specific data to Node-RED. The output that needed to be displayed on Node-RED was declared in the coding. Figure 3.16 shows the flow-based program between mqtt node and function node. Figure 3.17 shows the basic coding of Arduino to transmit data to Node-RED.

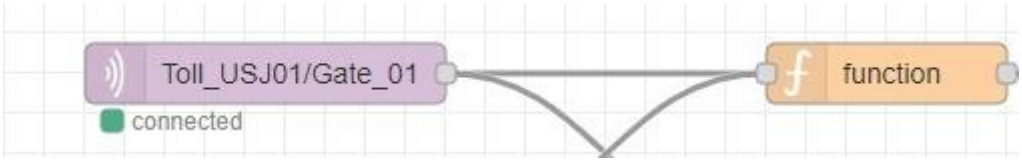


Figure 3.16 Simple RFID flow-based program

```
sketch_jun07a §
 *  Made by miliohm.com
 */

#define mqttTempl "growShed/templ"

  client.setServer(mqtt_server, 1883);
  client.connect("growTentController");

  if ( ! rfid.PICC_IsNewCardPresent())
    return;
  if (rfid.PICC_ReadCardSerial()) {
    for (byte i = 0; i < 4; i++) {
      tag += rfid.uid.uidByte[i];
      delay(50);
    }
    Serial.println(tag);

    rfid.PICC_HaltA();
    rfid.PCD_StopCryptol();

      client.publish(mqttTempl, String(tag).c_str(),true);
      tag = "";

    }
```

Figure 3.17 Arduino coding executed to send data to Node-RED

Once both Node-RED and ESP32 program had successfully uploaded. The Vehicle Identity Tag (VIT) was scanned on the RFID module and the serial number of the tag successfully displayed at the 'debug' tab on the Node-RED. This had confirmed the flow of data transmission is as expected. Figure 3.18 shows the data flow from RFID to Node-RED.

RFID module → ESP32 → Node-RED

Figure 3.18 The flow of data transmission

3.5.1 Node-RED

Node-RED is a flow-based development tool for visual programming which has been developed for wiring together hardware devices. Many projects demand the use of programming language coding to set up the operation flow. However, coding-based programs has cons such as difficulty in troubleshoot, hard to understand and hard to implement new ideas. As a solution for this problem, the project was designed to use Node-RED as the base platform to connect the ESP32, Raspberry Pi and SQL database server. In Node-RED the usage of program coding can be minimized a lot which enables the troubleshooting to be done easier. However, there is also a way to program the flow sequence in Node-RED using Node.Js.

3.6 Milestone 4: Database System Setup

The objective of this milestone is to develop the database system to store the information of the vehicles in real-time. The developed databases function as the memory in this proposed project. Figure 3.19 shows the process flowchart of milestone 4.

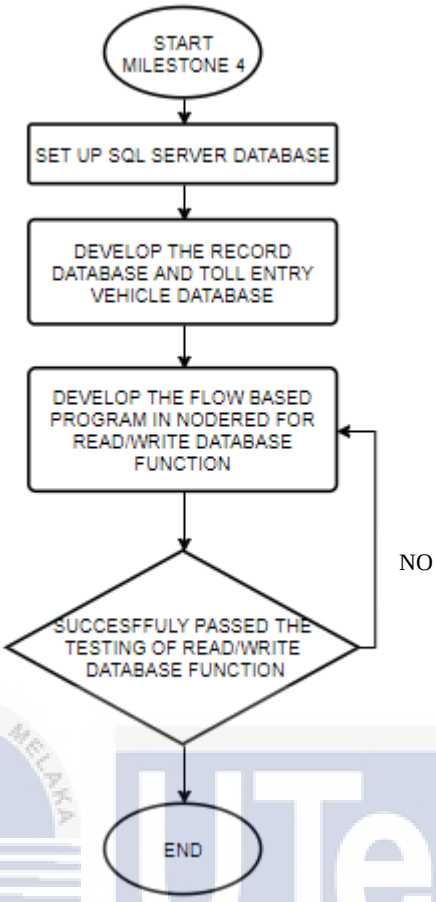


Figure 3.19 Process flowchart of Milestone 4

A database server is needed to build databases. The SQL server database was set up. Two databases were needed to create which is Vehicle Identity Record database and Toll Entry Vehicle (TEV) database. The databases were linked to Node-RED. The Vehicle Identity Record holds the information of the tag's serial number. Then, the flow-based program was modified for Node-RED to read and write database. The serial number received at Node-RED was searched within the Vehicle Identity Record to acquire the information. This information was then written at TEV database. Several tags were scanned to observe the output and the result was as expected.

Database system creation is the main objective in the milestone, so SQL database has been downloaded at the beginning. TablePlus, a database management tool has been

used to configure the SQL more easily rather than usage of codes which is complicating. Two databases have been created which is:

i. Vehicle Identity Record (VIR) Database – stores the information of the vehicle

ii. Toll Entry Vehicle Database – stores the information of the vehicle that passes the toll gate

Four samples of vehicle identity have been inserted into the Vehicle Identity Record (VIR) database. Figure 3.20 shows the identity information that stored on 4 samples of vehicle in VIR Database. The information of a vehicle includes:

i. Created date & time of the tag

ii. Vehicle Identity Tag (VIT) serial number

iii. Vehicle plate number

iv. Vehicle model

v. Vehicle color

vi. Vehicle owner name

vii. Vehicle owner's IC number

viii. Road tax expiry date

ix. Vehicle body type

x. Ownership Status

xi. Engine Number

xii. Chassis Number

Created_On	RFIDTag	Vehicle_Number	Vehicle_Model	Vehicle_Color	Owner_Name	Identity_Number
2021-12-22 06:55:08	4386507054	WKK 1726	PERODUA MYVI 1.3 EZi (AUTO)	BLUE	CHITRA A/P KAMAL	970201102221
2021-12-22 06:55:08	1152364827054	JKK 5226	PROTON WIRA 1.5 GL (M)	BLUE	ANDREW GEORGE	900120143325
2021-12-22 07:13:05	8312113127054	BFN 576	HONDA ELYSION	WHITE	ALI BIN ABU	890224106665
2021-12-22 07:13:05	2012201961787054	JDK 5521	NISSAN / CABSTAR BF 22 HUX	GREY	YUVA A/P SAMY	700104143321

Identity_Number	Expiry_date	Vehicle_Body_Type	Ownership_Status	Engine_Number	Chasis_Number
970201102221	2022-04-01	CAR	PERSENDIRIAN	52WVC10338	1HGBH41JXMN1...
900120143325	2022-06-11	BUS	SYARIKAT	43WTC10343	23HFREH41JXM...
890224106665	2022-05-01	VAN	PERSENDIRIAN	101RTC25641	68HNJ41JXMN3...
700104143321	2022-07-15	LORRY	SYARIKAT	25KKM63524	99PPDREH41FH...

Figure 3.20 Four samples of vehicle identity

Toll Entry Vehicle (TEV) database only stores the information:

i) Date and time of the Vehicle Identity Tag (VIT) scanned

ii) Name of the tollgate the VIT been scanned

iii) VIT serial number

Once successfully the databases have been created, the flow-based program in Node-RED has been developed to connect the databases into the system. By this, read/write function on database was developed. Figure 3.21 shows the flow-based program in Node-RED between RFID system and database system.

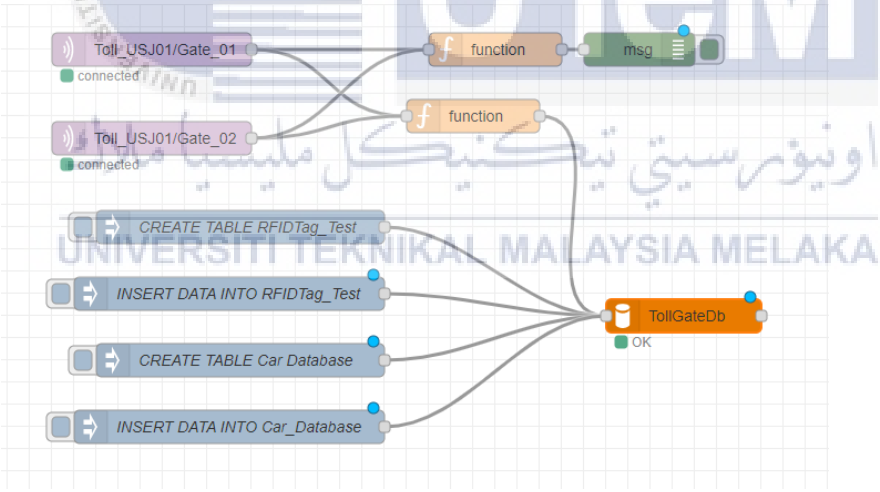


Figure 3.21 Flow-based program of RFID system integrating with database

The orange color node in the Figure 3.21 above represents SQL database system which is already installed. Configurations such as IP address setup, port number, username, password, and database name have been done for the node to connect to the desired database. Figure 3.22 shows the configuration on the node.

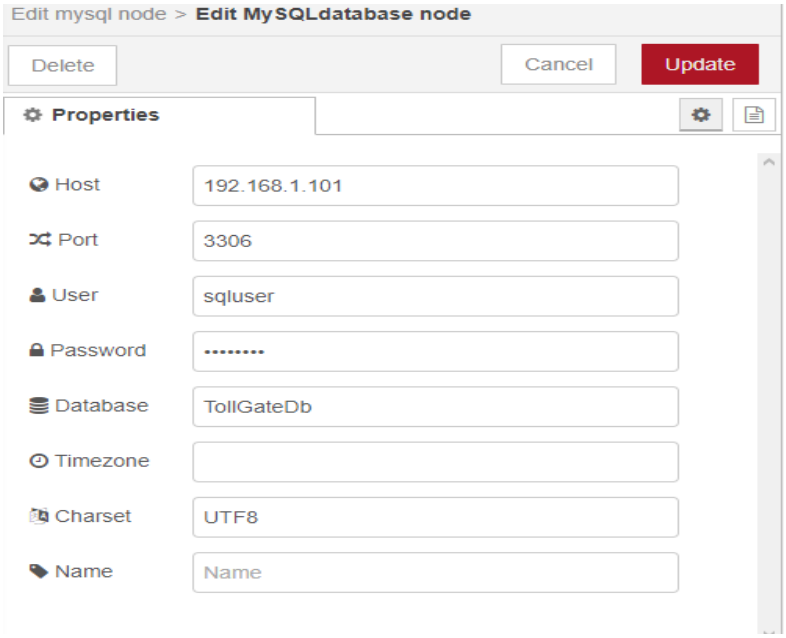


Figure 3.22 Configuration on SQL database node

3.6.1 Database Server

The main objective of the project is to create a database of the vehicles passing through the toll gates. A database is an organized collection of structured information, or data, typically stored electronically in a computer system. A database server is needed to set up a database. Database servers are used to store and maintain databases on the server, as well as to give authorized users access to the data. This type of server stores data in a central area that can be backed up on a regular basis. It also allows users to access data from anywhere on the network. After due consideration, Structured Query Language (SQL) server has been finalized to be used as the database server for the project. SQL is a sophisticated programming language that extends the capability of a typical database language. It is simple to understand and use, and it can handle large amount of data by integrating with programming languages. As huge amount of data will be generated, collected, and stored every day in the database, it is very important to use proper skill set to fetch useful data. There are number of advantages in SQL server such as: -

i) Easy to install

ii) Enhanced performance – has built-in transparent data compression and encryption features

iii) Highly secure – uses advanced encryption algorithms that make cracking the security layers very impossible.

iv) Perform backups regularly

v) Use monitoring tools – helps to find performance issues device issues and application issues

3.6.2 Database Management Tool

Database system usually needs the use of coding for configuration which is not user friendly. To make the database system to be managed easily, TablePlus software application has been used. TablePlus is a modern native software with a simple user interface that allows developers to manage several databases at the same time in a very efficient and secure manner. Most popular databases are supported by TablePlus, including MySQL, Postgres, SQL Server, SQLite, Microsoft SQL Server, Redis, Redshift, Oracle, and many others. With the use of TablePlus, user can easily configure the database thus eliminating the needs of coding on this.

3.7 Milestone 5: User Interface Dashboard Setup

Milestone 5 is completely on developing the user interface to monitor the system and analyze the data. Data visualization is an important segment in this project as the data presentations designed to be more efficient and accurate to meet users' expectation. Figure 3.23 shows the process flowchart of milestone 5.

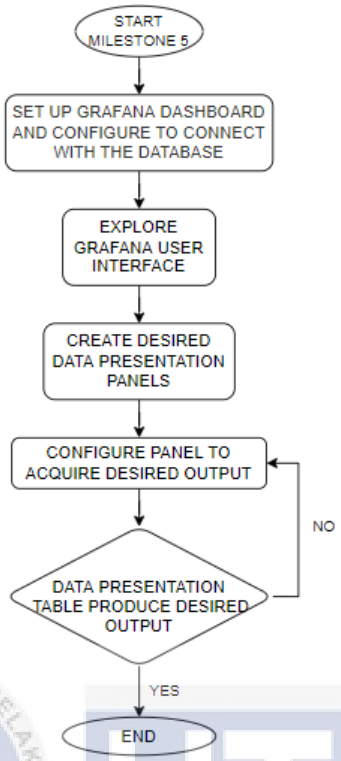


Figure 3.23 Process flowchart of Milestone 5

This milestone is where the data visualization/user interface has been built. At the beginning, Grafana, the data visualization platform has been configured. A Grafana dashboard has been created and connected remotely through network with the database which made the dashboard has the accessibility to the TEV and VIR database according to the local host port number (:3306). Figure 3.24 shows the configuration setup to connect Grafana with database.

Figure 3.24 Grafana configuration to connect with MySQL database

Once the Grafana dashboard has been created, exploration process in the dashboard has been done. Exploring the dashboard is very important as it shows the number of ways of presenting the data such as:

i) Time series

ii) Table form

iii) Bar chart

iv) Stat

v) Gauge

vi) Pie chart

vii) Logs

After exploring the dashboard, data presentation panels have been created by clicking 'Add Panel' at the top. Three data presentation panels have been created which is:

i) Toll Entry Vehicle panel

ii) Traffic volume panel

iii) Vehicle type volume bar chart

3.7.1 Toll Entry Vehicle Panel

The settings have been configured to make the panel accessible to both TEV and VIR database. Figure 3.25 shows the configuration of the TEV data presentation panel. The 'A' refers to TEV database while 'B' refers to VIR database. Only 8 out of 12 information from VIR database has been presented on this panel for a simpler and efficient data presentation table while the toll identity address and Vehicle Identity Tag (VIT) tag number has been presented from the TEV database.

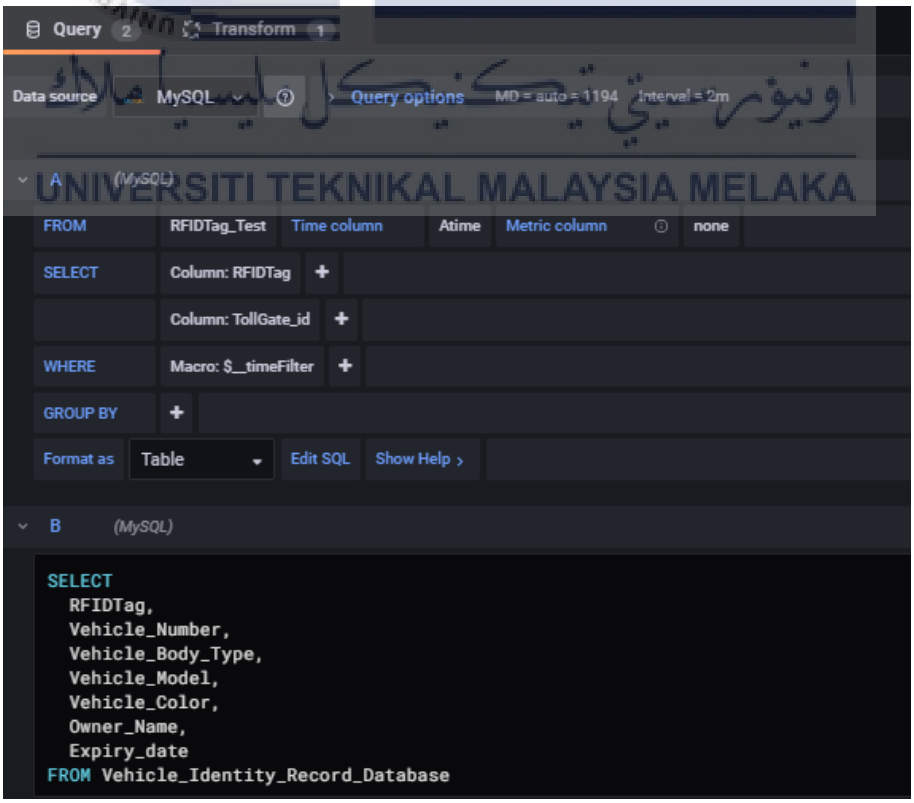


Figure 3.25 Configuration of TEV data presentation panel

A ‘Merge’ transformation has been used to allow the presentation panel to communicate with both databases. Figure 3.26 shows how the TEV data presentation table works in general to acquire the desired output. Besides that, ‘column filter’ option has been enabled which acts as a search engine in the selected column.

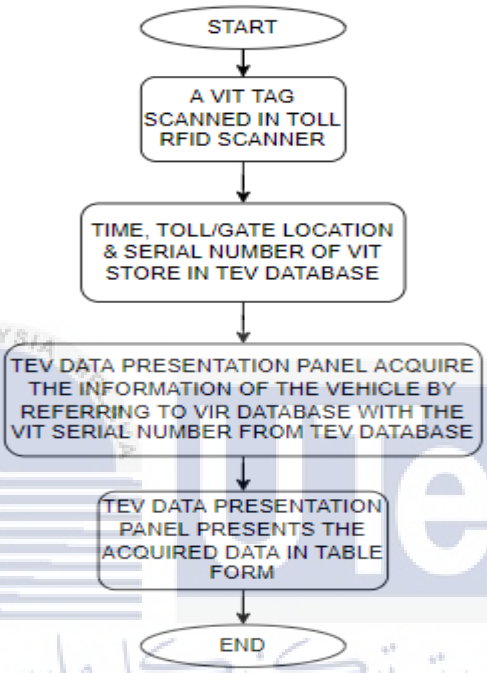


Figure 3.26 TEV data presentation panel working principle

3.7.2 Traffic Volume Panel

This panel has been created to present the vehicle volume according to time series. The database accessibility has been configured in the panel as same as done for the TEV data presentation panel. The time and number of vehicles are the two variables needed in this panel, so the panel visualization format was set in time series. The Vehicle Identity Tag (TAG) column was used as a counter to determine the number of vehicles.

Besides that, an interval function has been added to the panel. Interval function counts the total amount of vehicle for a particular volume active period according to the duration of the search period. For an example, if the panel was set to show the chart of traffic volume for 7 days, each bar in the chart represents the total number of vehicles passed in a duration of 30 minutes. The color, width of the bar, alignment, point size, and legend value were then configured for the desired output. Figure 3.27 shows the edit mode of the mentioned panel.

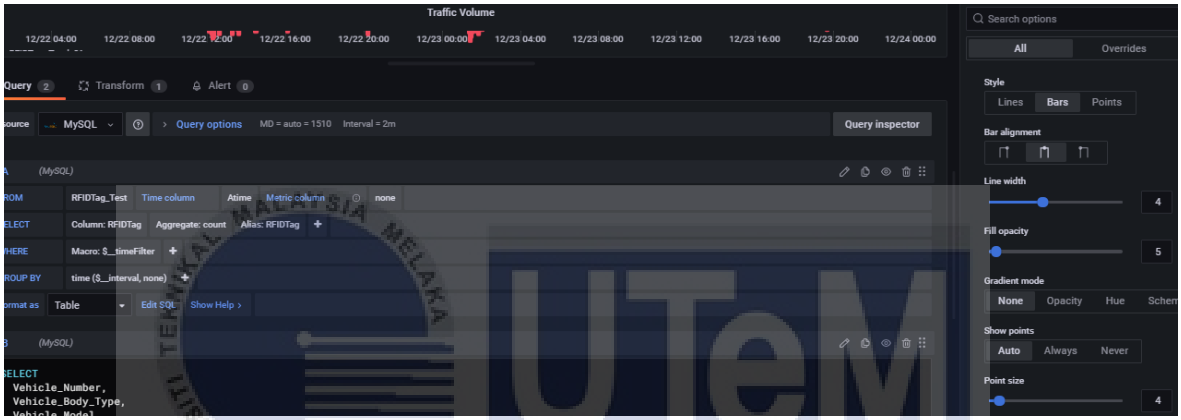


Figure 3.27 Configuration mode of Traffic Volume panel

3.7.3 Vehicle Type Volume Bar Chart Panel

This panel has been created to present the volume of vehicle type such as car, bus, lorry and others in desired period. This panel configured the same way as done for the first panel, but the data visualization format was set at bar chart format. Additionally, a 'group by' transformation has been used. This transformation works as grouping a particular set of data. The vehicle body type data has been grouped and VITs has been counted to differentiate the type of vehicles and acquire their total number respectively. The bar width, line width, fill opacity and bar orientation has been configured to acquired desired output. Figure 3.28 shows the edit mode of the mentioned panel.

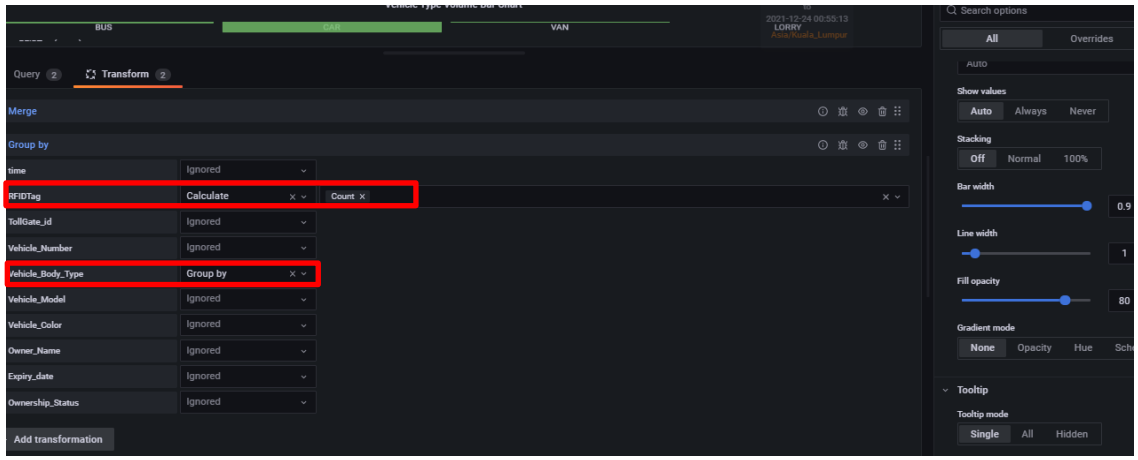


Figure 3.28 Configuration mode of vehicle type volume bar chart panel

3.7.4 Data Presentation/visualization Platform

Data visualization is one of the most important parts in a project because that is what going to show the output of the project to the user. To show the output in a most attractive way, Grafana has been chose to present the data to the user. Grafana is a web-based analytics and interactive visualization program that runs on a variety of platforms. When connected to supported data sources, it produces web-based charts, graphs, and alerts. Grafana has a lot of functions which enable the project has a vast range of capability to adapt to future implementation. By this, the user will be able to add more data presentation panel or also modify the existing data presentation panel easily.

3.8 Experimental Design

Once all the milestones were done. The experimental design process took place. In this testing phase, the project undergone a series of tests such as: -

a) Scan several tags in both RFID scanner simultaneously.

b) Test of longer run period for the system

c) Test for user interface command sequence

The results from the test were strongly observed and analyzed to determine the efficiency of the system. All dissatisfied result was troubleshooted for the error caused by and further improvised as a solution to get expected result.

3.9 Summary

This chapter has outlined and justified the research methodology implemented in this dissertation and its validity. Because of the nature of the research, the author opted for the qualitative strategy, bound by interpretivist approach. This chapter briefly explained the whole process and procedures that has been carried out for the completion of the project.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Overview

This chapter presents the results and discussions of the project. Previous research papers related with the scope of this project were reviewed by the researcher to demonstrate the applicability of the proposed system. As proposed system intended to work in a big scale, a lot more focus had on the response and output result to ensure the efficiency of the system is at optimum level.

4.2 Result of RFID Detection System Hardware

The Figure 4.1 shows the ESP32 connected RFID module using jumper cables

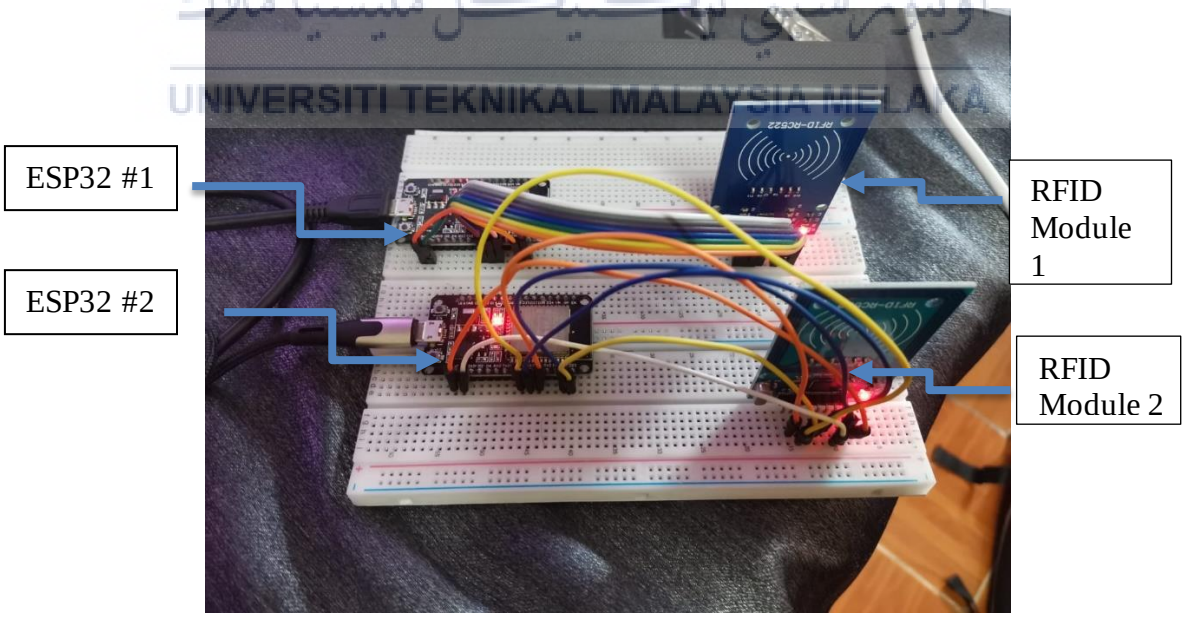


Figure 4.1 Wiring connection between ESP 32 and RFID module

The Arduino program were started to develop according to the wiring pin connection to acquire the output from the RFID which is the serial number of the RFID tag. The wiring connection were the same for both ESP32 device. Arduino's serial monitor tab (COM3 and COM6) were used to see the output result. Figure 4.2 shows the serial monitor tab of Arduino displaying the tag's serial number.

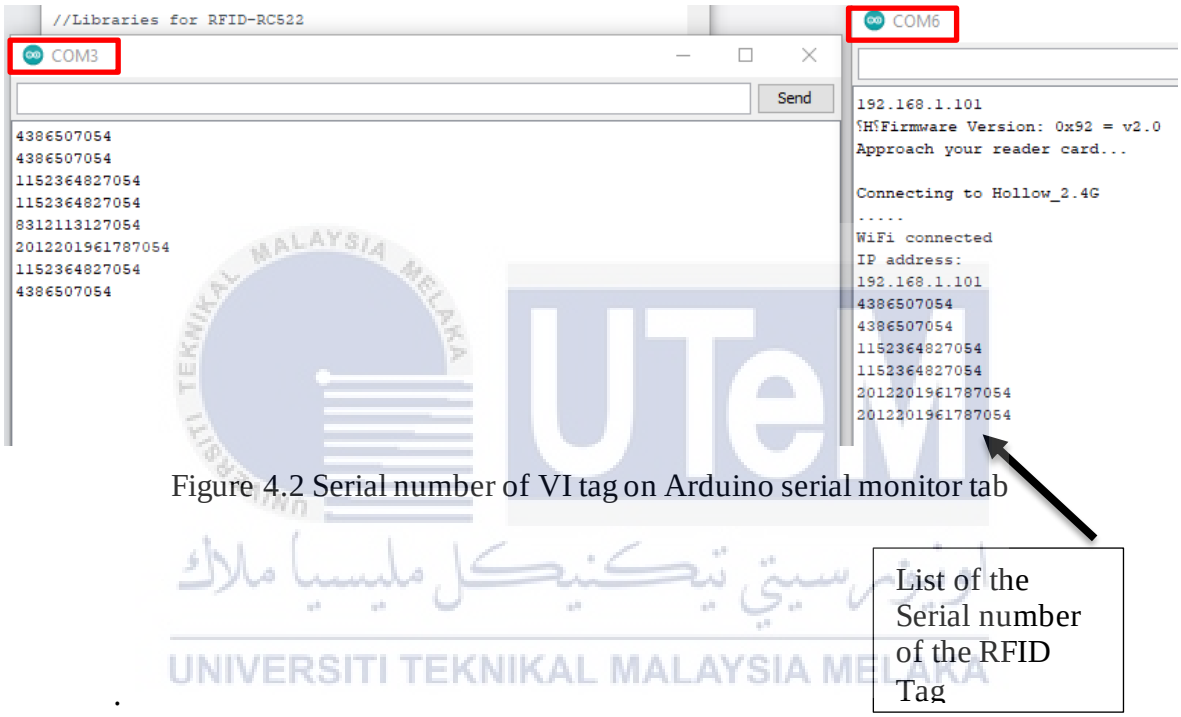


Figure 4.2 Serial number of VI tag on Arduino serial monitor tab

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4.3 Result of Raspberry Pi 4 Setup

Figure 4.3 shows the image of Raspberry Pi 4 is operating with a supply of 5V/5A output charger using type-C cable.

Figure 4.3 Raspberry Pi 4 operating

The Figure 4.4 shows what the PuttyTv software display after the RPi 4 successfully connected with the Wi-Fi. The commands to update, upgrade and install software will be typed here for execution in RPi 4.

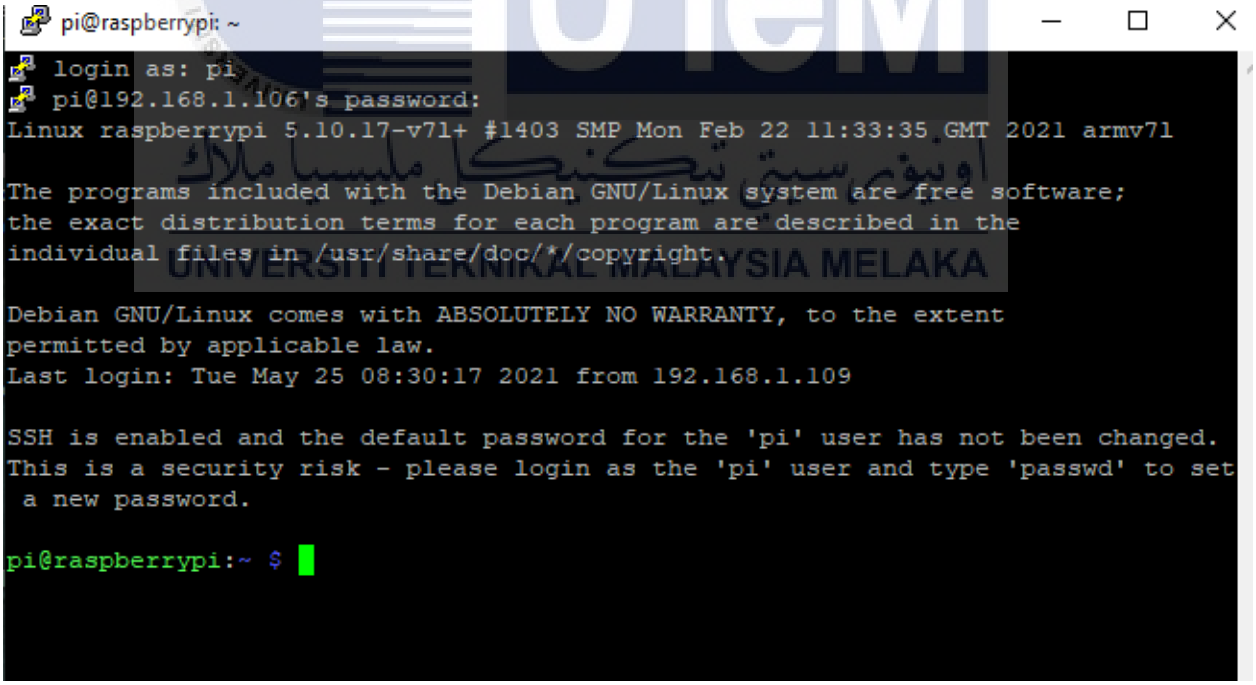

Figure 4.4 Interface of PuttyTv connect with RPi 4

Figure 4.5 shows the Fing mobile application showing the devices that are connection to the Wi-Fi. Fing App is a free network toolkit and scanner for iOS and Android that discover all the devices within the network.

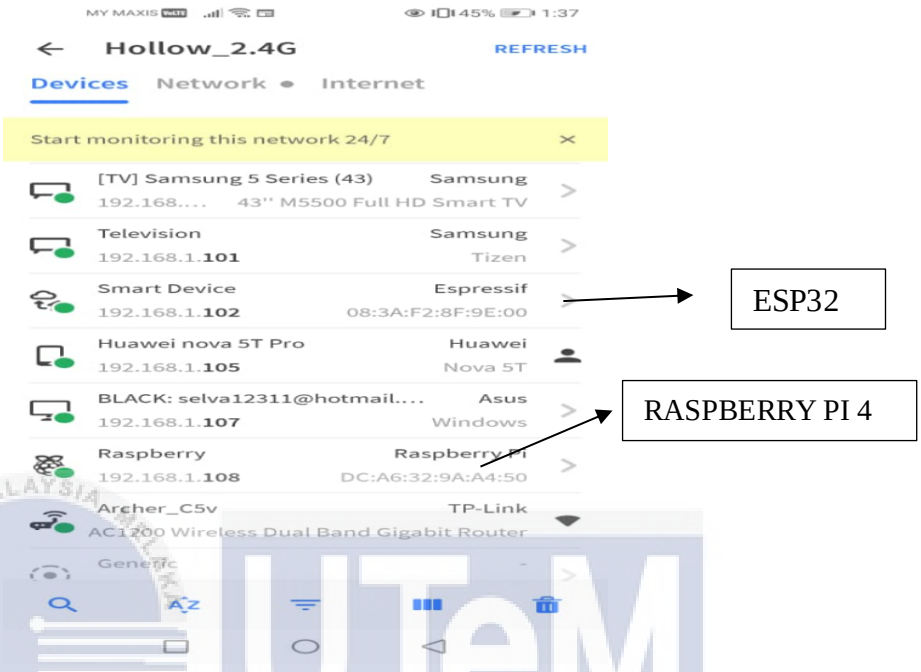

Figure 4.5 Display devices connected to the Wi-Fi in Fing mobile application

The Fing mobile application shows the device connected to the same Wi-Fi the phone connected. By using this, it is easy to check whether both ESP32 and RPi 4 connected to the Wi-Fi or not.

4.4 Result of Node-RED Setup

The 'connected' text below the 'mqtt in' node shows that the ESP32 is in connection with the node in the Node-RED. Figure 4.6 shows the flow-based program in Node-RED.

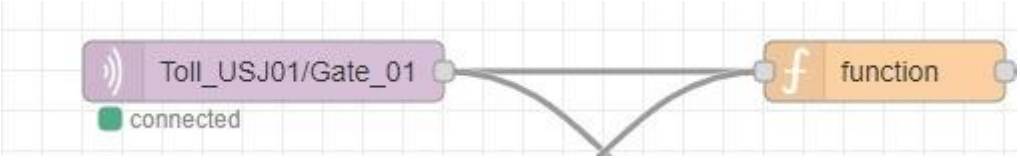

Figure 4.6 Node-RED flow-based program successfully deployed

In milestone 1, the serial number was printed in the Arduino IDE serial monitor tab. The project was further developed until connecting it with the Node-RED system via Wi-Fi. The flow-based program that has been developed to display the tag's serial number was successful in milestone 3. Figure 4.7 shows the output tab of Node-RED displaying the tag's serial number.

Figure 4.7 Display of VIT serial number on Node-RED output tab

4.5 Result of Database System Setup

Database setup was the objective of this milestone. The MySQL database was installed in Docker Desktop for ease-of-use purpose. The MySQL can be start/stop by just clicking at the button provided. Figure 4.8 shows the user interface of Docker Desktop to activate or de-activate the MySQL database.

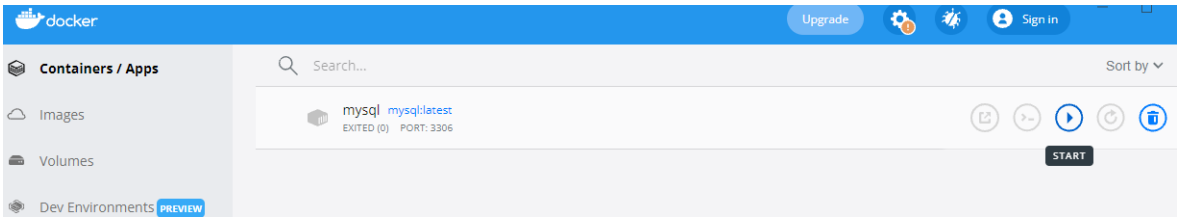

Figure 4.8 MySQL database in Docker Desktop

TablePlus were used to make a user-friendly environment on configuring MySQL. Figure 4.9 shows the user interface of TablePlus application.

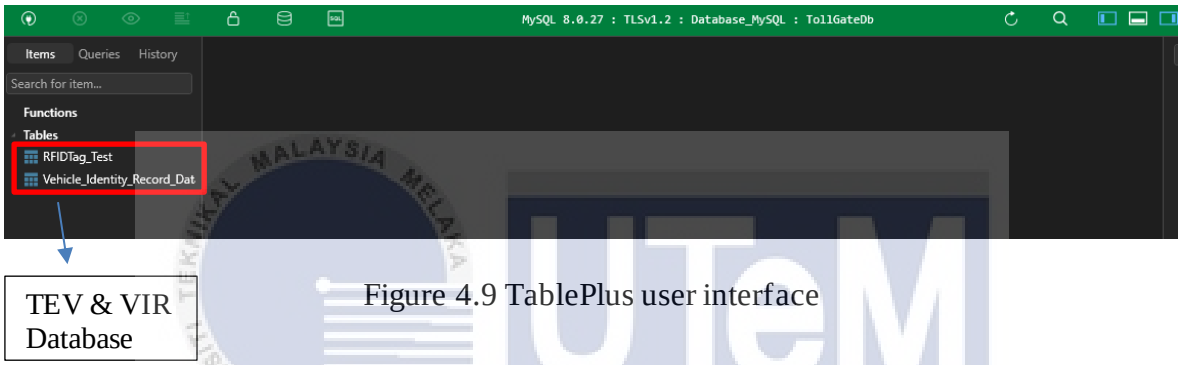

Figure 4.9 TablePlus user interface

The flow-based program in Node-RED was setup and configured to connect the MySQL database. The database was successfully connected after configuring the port number, IP address, username, password, and database name. Figure 4.10 shows the database system successfully connected to the Node-RED.

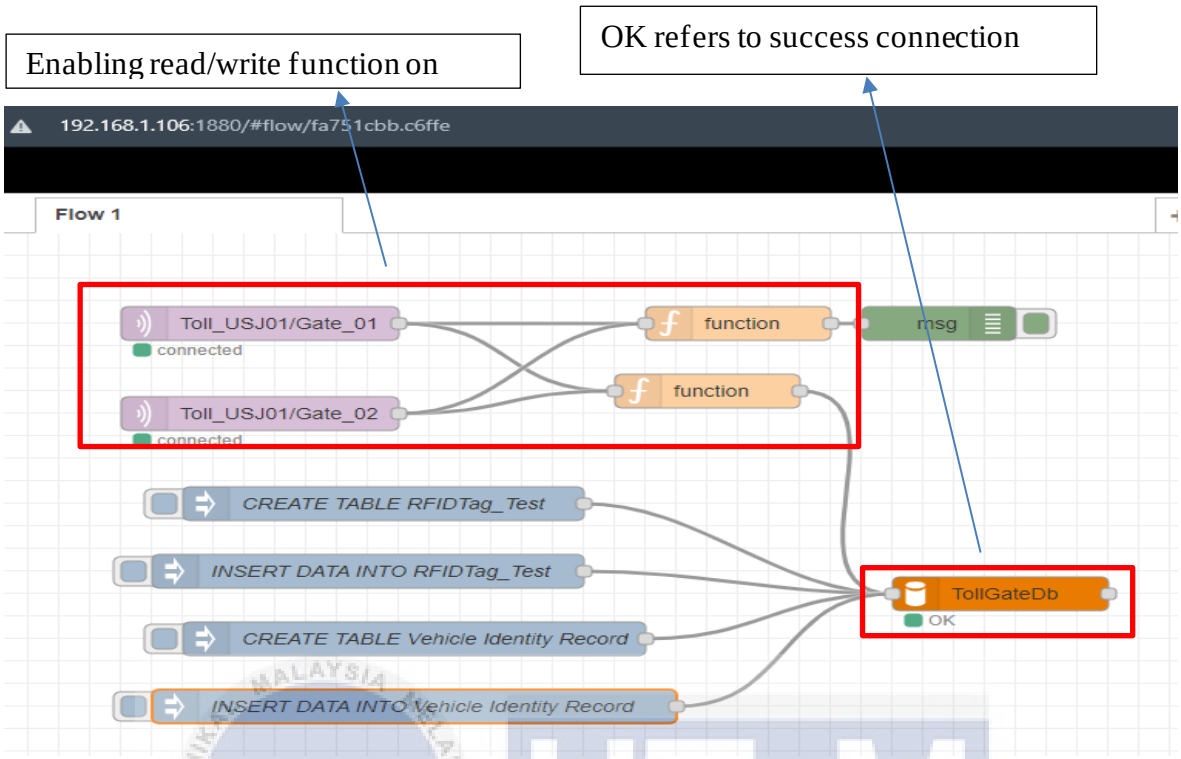

Figure 4.10 MySQL database connection success

The sample VITs were tested by scanning in the RFID scanner. The output was as expected as it printed the time, VIT serial number, toll location and gate number on the TEV database. Figure 4.11 shows the output on TEV database after the VITs been scanned on the RFID scanner.

p_Id ↓	Atime	TollGate_id	RFIDTag
695	2021-12-23 11:42:12	Toll_USJ01/Gate_01	4386507054
694	2021-12-22 18:02:57	Toll_USJ01/Gate_01	8312113127054
693	2021-12-22 17:50:52	Toll_USJ01/Gate_01	8312113127054
692	2021-12-22 17:50:44	Toll_USJ01/Gate_01	1152364827054
691	2021-12-22 17:50:43	Toll_USJ01/Gate_01	1152364827054

Figure 4.11 Output on TEV database

4.6 Result of User Interface Dashboard Setup

The Grafana dashboard was successfully connected to the database by adding at 'data source' under configuration option. Figure 4.12 shows the MySQL database has

connected the database in its data source which enable Grafana dashboard to access the TEV and VIR databases.

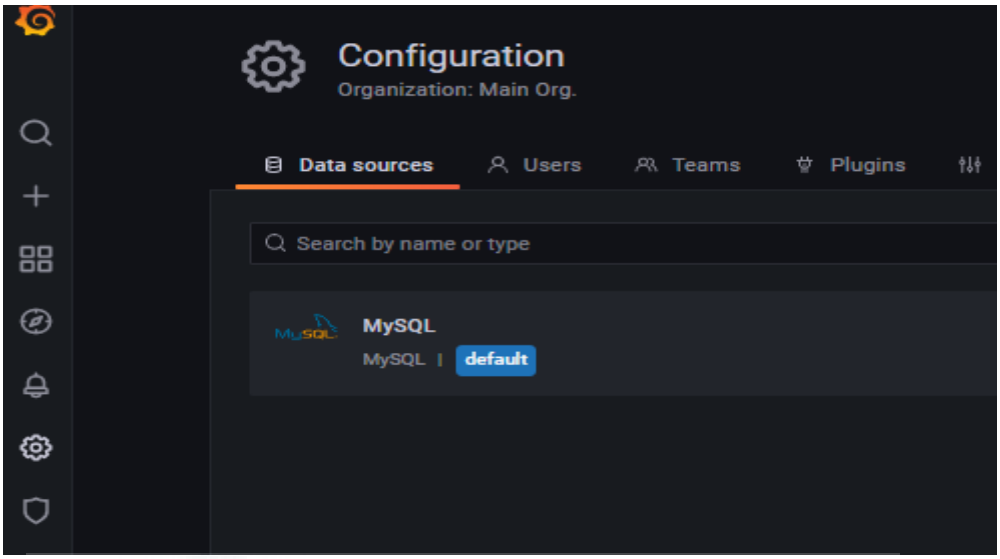

Figure 4.12 Connection success between Grafana and MySQL

4.6.1 Toll Entry Vehicle Panel Output

The sample VITs were scanned on Gate 1 RFID scanner to produce the output based on Gate 1. Figure 4.13 shows the TEV panel output for the respective Gate 1.

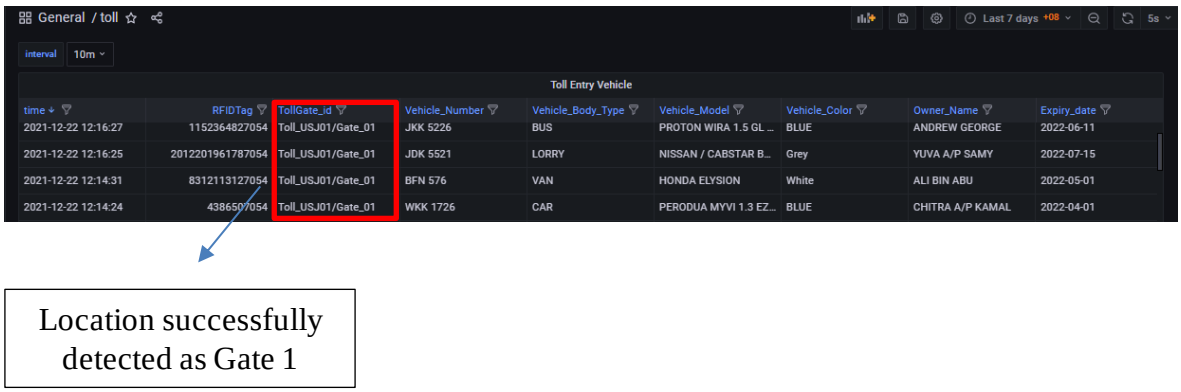

Figure 4.13 TEV panel output on Gate 1 scanner

The sample VITs were scanned on Gate 2 RFID scanner to produce the output based on Gate 1. Figure 4.14 shows the TEV panel output for the respective Gate 2.

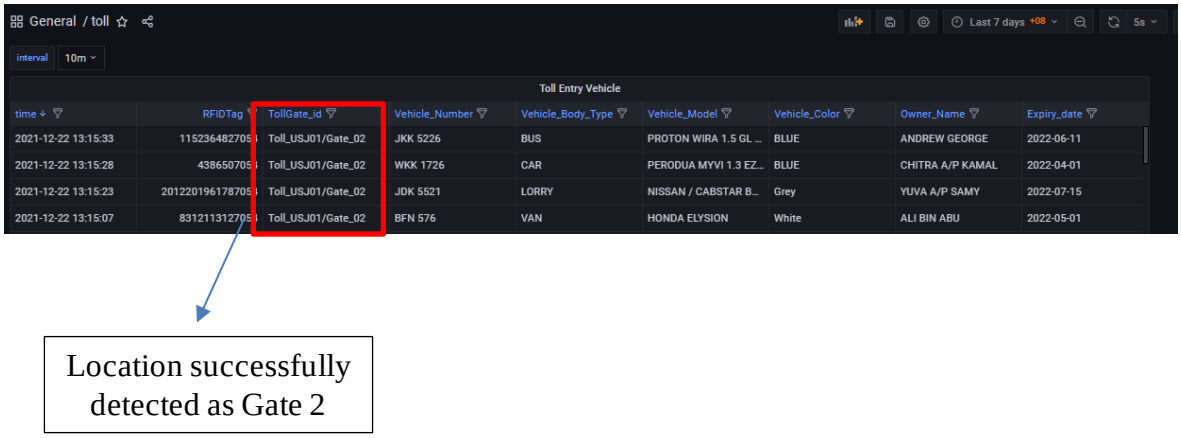

Figure 4.14 TEV panel output on Gate 2 scanner

The sample VITs were scanned on both Gate 1 and Gate 2 RFID scanner simultaneously to produce the output based on both gates. Figure 4.15 shows the TEV panel output for both gates.

Figure 4.15 TEV panel output on Gate 1 & Gate 2 scanner

4.6.1.1 TEV Panel Filtration

The 'column filter' built-in option has been enabled to filter the column with alphanumeric input. For example, Figure 4.16 shows how the user interface looks when the

filter image beside the column title is clicked. The filter column displays the number of vehicle plate number variation available.

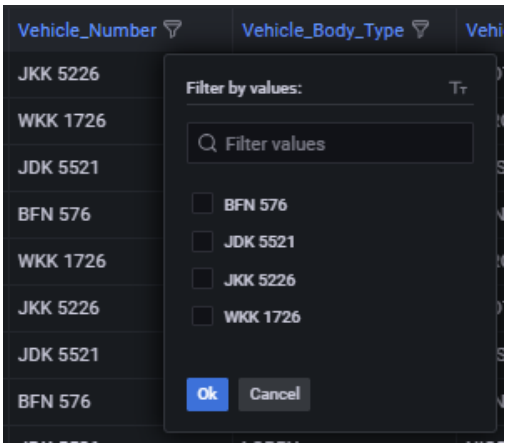

Figure 4.16 TEV panel vehicle number filtration option

When a random set of number of '26' is given as input, it automatically filtered and showed all the vehicle plate numbers that consist of number '26'. Figure 4.17 shows how the filtration column automatically filters based on the given input.

Figure 4.17 Filtration column automatically filters the given input

When both 'JKK 5226' and 'WKK 1726' is marked and clicked 'Ok'. The 'Vehicle_Number' column gone through the filtration process and showed both set of

vehicle numbers only in the column according to time. Figure 4.18 shows the output of the 'Vehicle_Number' column filtration.

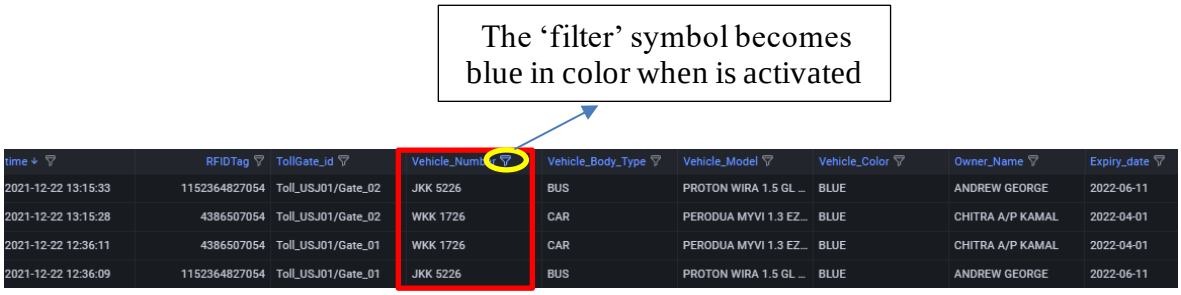

Figure 4.18 Output of the 'Vehicle_Number' column filtration

Furthermore, another filtration has been conducted by filtering for 'bus' as a double filtration in the 'Vehicle_Body_Type' column. Figure 4.19 shows the additional filtration been configured in the 'Vehicle_Body_Type'.

Figure 4.19 Additional filtration configuration

The output acquired was as expected as it filtered the vehicle with number '26' number and 'BUS' body type. Figure 4.20 shows the output acquired from the double filtration.

time	RFIDTag	TollGate_id	Vehicle_Number	Vehicle_Body_Type	Vehicle_Model	Vehicle_Color	Owner_Name	Expiry_date
2021-12-22 13:15:33	1152364827054	Toll_USJ01/Gate_02	JKK 5226	BUS	PROTON WIRA 1.5 GL ...	BLUE	ANDREW GEORGE	2022-06-11
2021-12-22 12:36:09	1152364827054	Toll_USJ01/Gate_01	JKK 5226	BUS	PROTON WIRA 1.5 GL ...	BLUE	ANDREW GEORGE	2022-06-11

Figure 4.20 Output of double filtration

4.6.2 Traffic Volume Panel Output

This panel has been created to present the vehicle volume according to time series for a particular desired period. A period of 7 days and 2 days range has been selected to produce the output. Figure 4.21 and Figure 4.22 shows the traffic volume based on the desired period respectively. A configuration has been made to display the total number of vehicles at the left bottom of the panel.

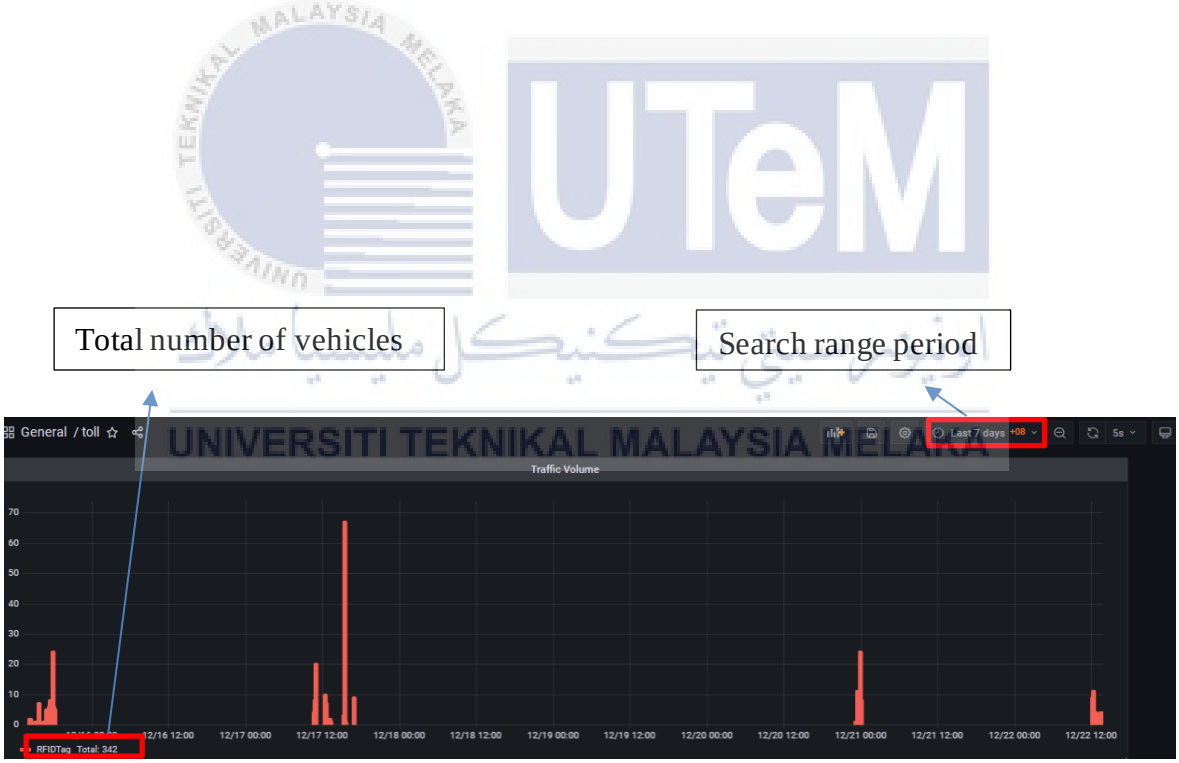

Figure 4.21 Traffic volume of past 7 days

Figure 4.22 Traffic volume of past 2 days

Besides that, there is an option called as 'annotation' which a note can be written on the reading panel for reference purposes. A vertical blue dashed line appeared on the place the annotation was written. Figure 4.23 shows an example of annotation has been made on the panel.

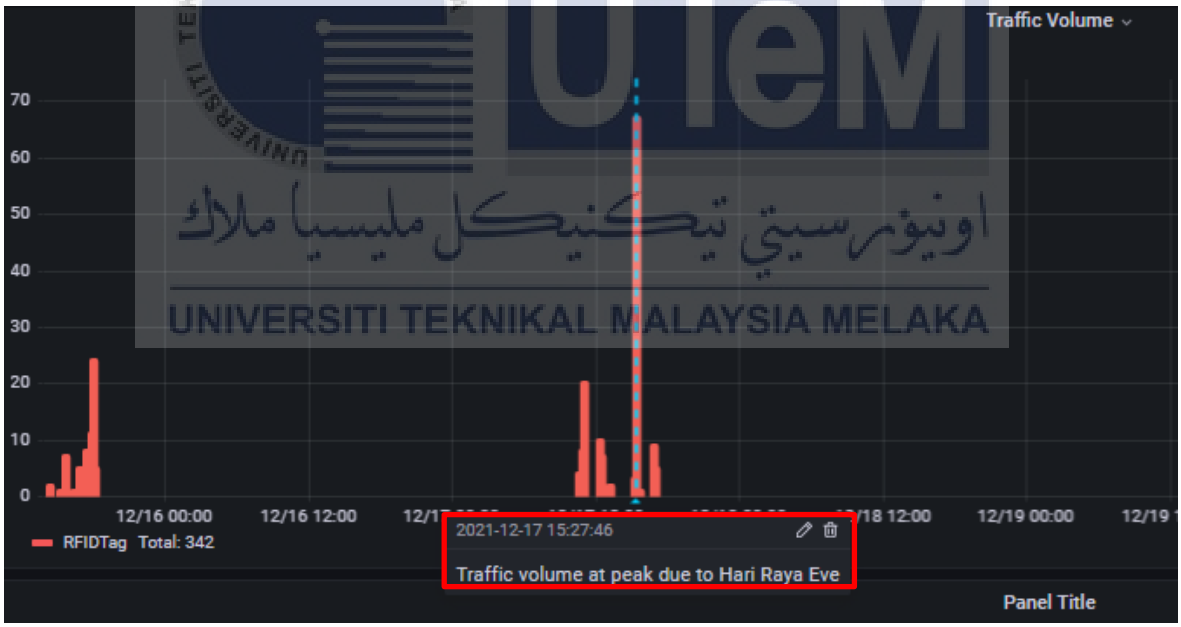

Figure 4.23 Annotation on Traffic Volume panel

4.6.3 Vehicle Type Volume Bar Chart Output

This panel present the volume of vehicle type such as car, bus, lorry and others in desired period. A period of 7 days has been selected to produce the output. The output is in

a bar chart form and each bar represents a vehicle body type. Above all the bars in the bar chart, the total number of the respect vehicle type has been displayed. Figure 4.2 4 shows the vehicle type volume bar chart for 7 days' time range.

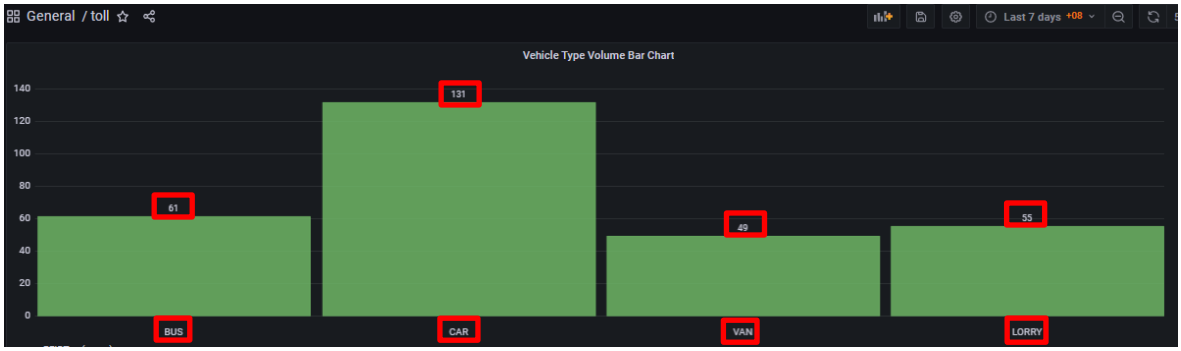

Figure 4.24 Vehicle type volume bar chart for 7 days period

4.7 Discussion

The idea of using RFID technology is the first step towards barrier-free highway experience in Malaysia however the adoption of RFID technology was only focused on using them as a toll payment gateway and to implement Multi-Lane Free-Flow (MLFF) by end of 2026 . In line with Malaysia's MLFF plan, the implementation of MLFF eliminates the requirement of toll lane thus the vehicles' movement on road are uninterruptable by toll payment method.

Although this is a good progression but the absence of a system to collect the information of vehicles on highway at toll payment area are like a lack of utilization of the RFID technology's potential. The proposed project was initiated to utilize the RFID technology as it has the great potential for mass adoption. Some limitations are unavoidable as there is still room for improvement through future works. Recent articles shows that Malaysian citizens are unhappy with RFID system as there are reports of users being double

charged and toll gantries unable to read their tags being as common. It is also important to understand that Malaysia is still in the amateur stage on this adoption and further improvising is essential for efficiency.

In real world application, the maintenance and troubleshoot process should be convenient enough to act if any fault has been triggered. The usage of Wi-Fi as a medium to connect the microcontroller and Raspberry Pi 4 eliminates the need of cable thus resulting in easier maintenance and troubleshooting process. The Node-RED which acts as a platform to virtually connect microcontroller, database and other necessary string message outputs eliminates the use of coding thus reducing connection complexity and avoid wire usage.

As for the outputs acquired, the presentation panels are well designed in a way where it is efficient and has the capacity to adapt to future development. For instance, if the user wishes to add more presentation panel for other data analysis, the panel can be easily built and do not require any coding language to configure. Furthermore, a bunch of built-in features are available in Grafana platform which would come in handy for further expansion and development. Figure 4.25 shows the working flow of the proposed system.

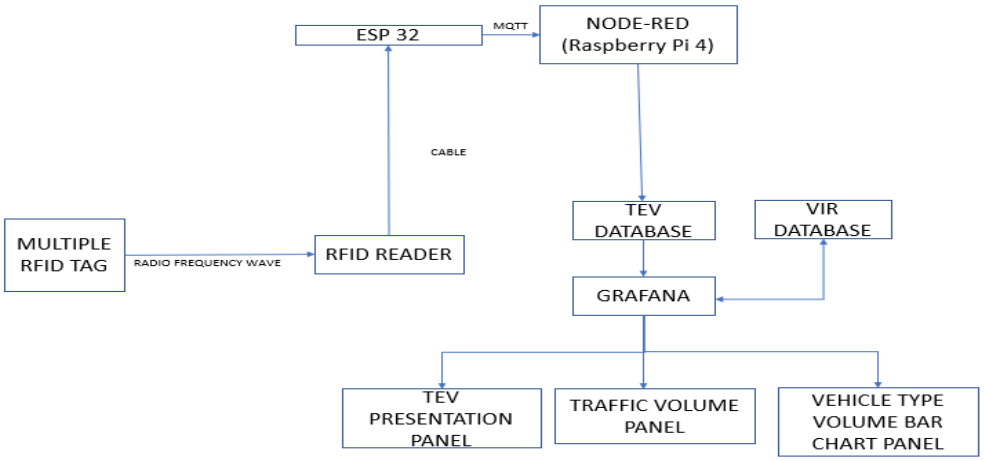

Figure 4.25 Working flow block diagram

The outputs acquired will be very useful for the relevant traffic department authorities or government authorities such as the police department for investigation purpose and monitor the traffic activity at toll gate. By this, a more efficient investigation can be carried out. The traffic data acquired from the proposed project such as the traffic volume and vehicle type volume bar chart will greatly contribute to the relevant traffic authorities for data analysis. The data can be analyzed for a better Highway Traffic Management System (HTMS). HTMS ensures road safety ensure road safety and smooth transportation for drivers and road operators by providing information of traffic. Besides that, a digital identity is given to all vehicles by implementing this proposed project where this identity can be utilized for other upcoming developments like smart parking system and smart traffic management system.

4.8 Summary

The whole chapter delivered the outcome of the milestone targets as previously planned in methodology. The results acquired from each milestone were as expected. The results acquired were further analyzed to ensure the result produced was accurate and provide in optimum response time.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This thesis presents a system to develop a database on vehicles' identity passing toll gates in real-time. The need of the database is crucial as the number of vehicles on road increases tremendously every year. The growth in the number causing complication in cataloguing the movement of traffic which becomes an obstacle for better Highway Traffic Management System (HTMS). With the help of real-time developed database,

The system proposed was design and developed with the help of much proven related research. By using the Wi-Fi technology connection as a medium to transfer data causes less wire to be used which results in convenience in troubleshooting and maintenance. Grafana which acts as a data visualization platform in this project has a great capacity to adapt to any future development. The results acquired was as expected and greatly improvised with the features has in Grafana. The presentation panels designed in a way where user can view the data easily in chart. The panel's visualization was designed to look in an attractive way.

5.2 Future Works

There is always a room for improvement. The proposed system can be further improvised in areas such as:

i) Adjust the view range and power range of RFID scanner to scan VIT from more than one lane.

ii) It can be also developed by cooperating with the ANPR camera technology in toll gates to acquire image evidence proof as a part of data in database.

iii) The implementation of added security to the system are highly welcomed to eradicate security threats.

iv) The project design does not currently used as a payment gateway system as the sole purpose of this project is just to create a real-time database. In future, this system can be work together with the payment gateway system.

5.3 Project Potential of Commercialization

This project has potential to earn people's attention if commercialize in market because:

i) RFID is a mature technology has potential and ability for mass adoption

ii) This is the only system that provides such toll traffic data as in the output and vehicles' information database in real-time .

iii) Functional user interface which has great capacity for further expansion and development.

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APPENDICES

Appendix A Arduino Coding on RFID Detection System

```
#include <WiFi.h>
#define LED 12
#define lamp 32
const char* ssid = "Hollow_2.4G";         // Wifi Name and password
const char* password = "hotspot123";
//Libraries for RFID-RC522
#include <SPI.h>
#include <MFRC522.h>

//Libraries for MQTT
#include <PubSubClient.h>


constexpr uint8_t RST_PIN = 22;
constexpr uint8_t SS_PIN = 21;
MFRC522::MIFARE_Key key;
MFRC522 rfid = MFRC522(SS_PIN, RST_PIN);
String tag;

//MQTT Setup Start
#include <PubSubClient.h>

WiFiClient espClient;
PubSubClient client(espClient);
#define mqttTemp1 "Toll_USJ01/Gate_01"
//MQTT Setup End
/////



//IPAddress local_IP(192, 168, 1, 144);
//IPAddress gateway(192, 168, 1, 254);
//IPAddress subnet(255, 255, 255, 0);
//IPAddress primaryDNS(8, 8, 8, 8); // this is optional
//IPAddress secondaryDNS(8, 8, 4, 4); // this is optional


// Change the variable to your Raspberry Pi IP address, so it connects to your MQTT
broker
#define mqtt_server "192.168.1.108"
////

long now = millis();
```

```
long lastMeasure = 0;

// Don't change the function below. This functions connects your ESP8266 to your router
void setup_wifi() {
  delay(10);
  // We start by connecting to a WiFi network
  Serial.println();
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.print("WiFi connected - ESP IP address: ");
  Serial.println(WiFi.localIP());
}

// This functions is executed when some device publishes a message to a topic that your
ESP8266 is subscribed to
// Change the function below to add logic to your program, so when a device publishes a
message to a topic that
// your ESP8266 is subscribed you can actually do something
void callback(String topic, byte* message, unsigned int length) {
  Serial.print("Message arrived on topic: ");
  Serial.print(topic);
  Serial.print(". Message: ");
  String messageTemp;

  for (int i = 0; i < length; i++) {
    Serial.print((char)message[i]);
    messageTemp += (char)message[i];
  }
  Serial.println();

  // Feel free to add more if statements to control more GPIOs with MQTT

  // If a message is received on the topic room/lamp, you check if the message is either on
or off. Turns the lamp GPIO according to the message
  if (topic == "room/lamp") {
    Serial.print("Changing Room lamp to ");
    if (messageTemp == "on") {
      digitalWrite(lamp, HIGH);
      Serial.print("On");
    }
    else if (messageTemp == "off") {
      digitalWrite(lamp, LOW);
      Serial.print("Off");
    }
```

```
  }
  Serial.println();
}

// This functions reconnects your ESP8266 to your MQTT broker
// Change the function below if you want to subscribe to more topics with your ESP8266
void reconnect() {
  // Loop until we're reconnected
  while (!client.connected()) {
    Serial.println("Attempting MQTT connection...");

    if (client.connect("ESP8266Client")) {
      Serial.println("connected");
      // Subscribe or resubscribe to a topic
      // You can subscribe to more topics (to control more LEDs in this example)
      client.subscribe("room/lamp");
    } else {
      Serial.print("failed, rc=");
      Serial.print(client.state());
      Serial.println(" try again in 5 seconds");
      // Wait 5 seconds before retrying
      delay(5000);
    }

  }
}
```



```
void setup() {
  Serial.begin(9600);
  Serial.println();

  SPI.begin(); // Init SPI bus
  rfid.PCD_Init(); // Init MFRC522
  pinMode(LED, OUTPUT);
  pinMode(lamp, OUTPUT);
  rfid.PCD_DumpVersionToSerial();
  rfid.PCD_Init();
  Serial.println("Approach your reader card...");
  Serial.println();

  // begin Wifi connect
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.mode(WIFI_STA);
  WiFi.disconnect();
  delay(2000);
  WiFi.begin(ssid, password);
```

```
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());
  //end Wifi connect
  setup_wifi();

  client.setCallback(callback);
  client.setServer(mqtt_server, 1883);
  client.connect("growTentController");



  unsigned status;


}

void loop()
{

  digitalWrite(LED, HIGH);
  if (!client.connected()) {
    reconnect();
  }
  if (!client.loop())

    client.connect("ESP8266Client");

  if ( ! rfid.PICC_IsNewCardPresent())
    return;
  if (rfid.PICC_ReadCardSerial()) {
    for (byte i = 0; i < 6; i++) {
      tag += rfid.uid.uidByte[i];
      delay(50);
    }
    Serial.println(tag);

    rfid.PICC_HaltA();
    rfid.PCD_StopCrypto1();

    client.publish(mqttTemp1, String(tag).c_str(), true);
    tag = "";

  }
```

```
}
```

Appendix B Specification of RC-522 RFID Scanner

Specification:

- Operating Current :13-26mA/DC 3.3V
- Idle Current :10-13mA/DC 3.3V
- Sleep Current:: less than 80uA
- Peak Current: less than 30mA
- Operating Frequency: 13.56MHz
- Supported card types: mifare1 S50, mifare1 S70, mifare UltraLight, mifare Pro, mifare Desfire and mifare Classic
- Environmental Operating Temperature: -20-80 degrees Celsius
- Environmental Storage Temperature: -40-85 degrees Celsius
- Relative humidity: relative humidity 5% -95%
- Data transfer rate: maximum 10Mbit/s
- Size: RFID-RC522 Module:3.9 x 6 cm The Standard S50 Blank Card :8.5 x 5.4 cm
- Diameter of S50 special-shaped card: 3.1(max)