DESIGN AND ANALYSIS OF LOCATION TRACKING SYSTEM USING 4G COMMUNICATION FOR EMERGENCY VEHICLE.

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DESIGN AND ANALYSIS OF LOCATION TRACKING SYSTEM USING 4G COMMUNICATION FOR EMERGENCY VEHICLE.

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

Faculty of Electronic and Computer Engineering
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DECLARATION

I declare that this report entitled "Design and analysis of location tracking system using 4G communication for emergency vehicle" is the result of my own work except for quotes as cited in the references.

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Date : 29 June 2020…………………

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : ……………………………………

Supervisor Name : Fakrulradzi Bin Idris……………

Date : 29 June 2020…………………

DEDICATION

All praise and thanks to ALLAH's will, the Lord of the worlds, and greetings to the great visit of Prophet Muhammad S.A.W, his family, friends and those who fight to uphold Islam all over the world. Special thanks to my father, Ab Jalil Bin Talib and loving Ainon Bt Md Said, beloved siblings and friends for helping me to finish this Final Year Project. Also, to my gracious supervisor, Dr Fakrulradzi Bin Idris for supervises teaching me. May your help be blessed by ALLAH S.W.T.

ABSTRACT

Emergency Facilities such as fire stations have very poorly managed time response records. In fire stations they manage all their records on physical paper or files, they do not have any computer system through which they can trace the location of all their vehicle and coordinate their fire truck. This tracking system uses the SIM7600X 4G HAT module and an Arduino Nano that then views data on an Internet of Things (IoT) dashboard. The system is a real time tracking system, which will continuously monitor a moving vehicle and report the status of the vehicle on demand. The SIM7600X 4G HAT module has a Global Positioning System (GPS) modem that uses satellite technology for its navigation system, and will continuously give data such as coordinates, speed, distance travelled and others. The SIM7600X 4G HAT module also have a Global System for Mobile Communications (GSM) modem that inter-networks to the Internet and provide cellular network for sending data into the IoT Dashboard. The IoT dashboard that this system uses is called the ThingsBoard. This system will be installed inside the emergency vehicle. When the emergency vehicle departs from the base station, the time response will start counting and the base station can start to monitor the real time movement of the vehicle and also its speed. All the recorded data will be store in the ThingsBoard database.

ABSTRAK

Pada masa kini, Agensi kecemasan seperti Bomba tidak mempunyai system yang boleh merekod masa tindak balas dengan automatic. Di balai bomba, mereka menguruskan semua catatan masa di atas kertas, bermaksud mereka tidak mempunyai sistem yang boleh menjejak lokasi semua kenderaan. Sistem penjejakan ini menggunakan modul SIM7600X 4G HAT dan Arduino Nano dan melihat data di papan pemuka Internet benda. Sistem ini adalah pengesanan masa nyata, yang akan terus memantau kenderaan bergerak dan melaporkan status kenderaan. Modul SIM7600X 4G HAT mempunyai modem Sistem Penentudududukan Global yang menggunakan teknologi satelit untuk sistem navigasinya dan akan secara berterusan memberikan data seperti koordinat, kelajuan, jarak perjalanan dan lain-lain. Ia juga mempunyai modem sistem global untuk komunikasi antara rangkaian dengan Internet yang menyediakan rangkaian selular untuk menghantar data ke dalam papan pemuka Internet benda. Papan pemuka Internet benda yang digunakan adalah aplikasi ThingsBoard dan ia akan dipasang di dalam kenderaan kecemasan. Apabila berlepas dari stesen pangkalan, tindak balas masa akan mula dikira dan stesen pangkalan dapat mula memantau pergerakan masa sebenar kenderaan dan juga kelajuannya. Semua data yang direkodkan akan disimpan di pangkalan data ThingsBoard.

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LIST OF SYMBOLS AND ABBREVIATIONS

GPS	:	Global Positioning System
RSSI	:	Received signal strength indicator
IoT	:	Internet of Things
GNSS	:	Global Navigation Satellite System
GSM	:	Global System for Mobile Communications
QoS	:	Quality of Signal
IP	:	Internet Protocol
GPRS	:	General Packet Radio Service
TCP	:	Transmission Control Protocol
PHP	:	Hypertext Preprocessor
MQTT	:	Message Queuing Telemetry Transport
CoAP	:	Constrained Application Protocol
HTPP	:	HyperText Transfer Protocol

CHAPTER 1

INTRODUCTION

This chapter provides an overview of the project where an explanation of the project goals and problem statement will be provided. The scope of the project will be presented in this chapter to indicate the range of work covered and not covered by the project. The methodology part also contains a brief explanation of the project flow to help understand the methods used to complete the project and what happens during the development of the project.

1.1 Objective

This Project is set out to:

a) Design a tracking system that monitors the movement of emergency vehicle using a Global Positioning System (GPS) module.

b) Implement real time mapping to record time and positions of emergency vehicle.

c) To analyze response time, speed and Received Signal Strength Indicator (RSSI) for different routes.

1.2 Background

The basic philosophy of emergency response facilities such as the fire department is to act and reduce the loss of life and property damage as quickly as possible in an emergency. The quality of emergency response refers to measuring the pace of squads in response to emergencies and the time that was needed for the squads to reach the incident location from their fire station.

In a study of initial emergency response performance of fire fighters in Malaysia, it noted that by measuring the time taken per meter for each response and later averaged based on the frequency of cases from a sample set of fire stations, an overall average for initial emergency response time weighted of 3.71 seconds per meter was recorded. The study also shows that apparently the average initial emergency response of fire fighter squads in Malaysia is better than that reported in previous studies by other emergency responders [1].

From *Buku Pelan Integriti Bomba*, it states that all dispatched operation unit in a fire station needs to follow the key performance indicator (KPI) to ensures arrival at the scene of the incident fast, safe and in a secure time frame. Because the key performance indicator (KPI) has set the time of arrival at the site of the incident (time of response) in the area of service in compliance with the time limit [2].

For emergency calls, one minute might mean the difference between life and death. To make sure they arrive punctually and to the exact location is important for them. The idea of this project comes from the emergency vehicles such as ambulances or fire engines, which has very poor management on their time response records. It is because all the records are recorded manually which does not look good in an engineering perspective. Plus, in the base station they cannot trace the location of all their vehicle and cannot coordinate the fire truck efficiently. Therefore, this project is about to design a Tracking System for emergency vehicle that allows the vehicle's location to be displayed against a map backdrop in real time system using 4G communication module and Global Navigation Satellite System (GNSS) positioning module. Moreover, this system will have a database of the time response of the vehicle for when the emergency vehicle has departed and arrived at the location of the scene. In this system, the base station can also monitor the speed of the vehicle. So, the system can be divided into three parts: tracking the location of vehicle, time response of the vehicle and speed of the vehicle.

By using an electronic map, it will help the user in the fire station to view an emergency vehicle's location. The Google Map or connected server helps the fire base station to monitor the targeted vehicle. Therefore, it will save plenty of time for the user in the base station, rather than wasting time by calling the driver to know the emergency vehicle's location as it is now much easier when it can be monitored online.

1.3 Problem Statement

In today technological level, emergency facilities such as fire station is not able to effectively monitor the location of their fire truck once there depart for duty. Normally the fire fighter in charge would report their time arrival to the headquarters once they arrived at the scene. But due to how the informer is an individual, this means that the info can be falsified. In fire stations, they manage all their time response manually. This mean they do not have any automated system to generate the time. Therefore, this project aims to digitalize the process of monitoring the location of the emergency vehicle and the time of its journey while simultaneously record all the data into a single database.

1.4 Scope of Work

This project will consist of three main components to develop the Vehicle tracking system; monitor the movement of emergency vehicle using GPS module, implement real time system from map interfaces and record time response into database. This project integrates hardware and software that help tracks and locates the vehicle. This project consists of 3 major hardware circuit to develop the final system: GSM modem SIM7600E-H 4G, the GPS Antenna and the microcontroller Arduino Nano. The vehicle unit incorporates the hardware part inside the vehicle that is to be track.

The concept is mainly based on modem that receives signals from a satellite with the use of a GPS antenna. In this project, Arduino Nano is used as a microcontroller. Arduino Nano is interfaced serially to SIM7600E-H 4G module and GPS receiver. The GPS receiver will continuously give the data of latitude and longitude that is the location of the vehicle. The baud rate for the SIM7600E-H 4G module is 300bps ~ 4Mbps (default: 115200bps) and the auto bauding baud rate: 9600bps ~ 115200bps

[3]. Baud rate is the rate at which information was transferred in a communication channel. The operating voltage is 5V/3.3V.

To explain simply, the tracking system can track and display vehicles via digital mapping. The software will use the exact location of each point and save it into the database so that it can later be used and displayed on a screen by using real maps in the ThingsBoard. ThingsBoard is a free open source IoT platform for IoT projects for data collection, device management, processing and visualization for IoT projects. The time response and speed of the fire truck will be recorded once they depart from the base station and arrive at the location scene. Lastly all the data will be stored at the ThingsBoard's database

CHAPTER 2

LITERATURE REVIEW

This section will cover literature review about previous researchers on topic related to the project. Also, theories about the core subject on this project such as GPS Global Positioning System (GPS), generation of Global System for Mobile Communications (GSM) and what is tracking system.

2.1 GPS for Tracking System

A global positioning system (GPS) is a radio wave receiver. It is used to give the three-dimensional coordinates (x, y, z, or latitude, longitude, and height) to provide coordinates that gives the exact position of an element in a certain space [4]. It has been developed to be used as a surveillance tool by the United States for their government and army. Specifically, the GPS was created by Dr. Ivan and the United States Department of Defense as a collaborative work to construct a global positioning system, primarily used for mapping purposes. It was created specifically for militarily [5]. It helps army troops stay organized and find their own way back to base or to their targets. It is because the creation of GPS can also help the army detect their enemy positions and other threats. However, today's GPS is used by millions of people to navigate on their basis life. Plus, GPS also immensely useful in mapping driving or walking directions.

Architecture of GPS includes the GPS receiver and community of user. The GPS receivers transforms the Singular Values (SV) signals to the estimation of time, velocity, and location. There are four satellites that are used in estimation of the four dimensions of X position, Y position, Z position and the Time. This allows the GPS receivers to be used in time distribution, navigation, research, and positioning purposes. However, the primary function of GPS is for navigation in three dimensions. The Figure 2.1 below shows the receiver represents the user community while the control component represents the GPS receivers [6].

From the GPS we can produce a tracking system. As we know a Tracking System is used to monitor objects or persons on a journey and can provide a timely sequence of location data for further processing. Tracking system is divided into two type; active and passive. The passive is passive device that stores GPS speed, location, heading and sometimes a trigger event such as key on or off, the door that can be open or closed. Passive trackers store data on your device and then download it to your computer. As a result, Passive GPS tracker can only identify issues after they have occurred. While the active device will collect the data transmit by the real-time via cellular or satellite networks to your computer or data center to be evaluated. This project can be classified as an active tracking system. It is because this system is using a cellular data that can transmit the real-time data into the device through the IoT dashboard. The user will be able to track a vehicle in real-time.

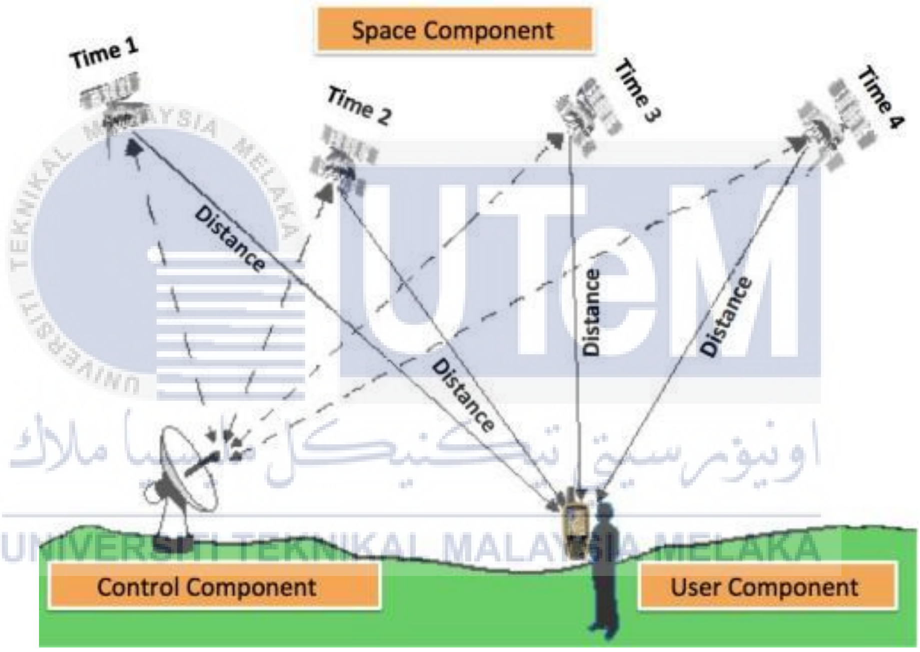

Figure 2.1: Diagram of user component and GPS receiver (control component) [6]**.**

A Communication Systems can either be Wired or Wireless while using either Guided or Unguided medium for communication. In wired Communication, the medium for physical paths that can be used for data transfer includes Co-axial cables, Optical Fiber Links and Twisted Pair Cables. This kind of mediums are classified as Guided mediums where the mediums essentially guides the signals to be propagated from one point to another.

On the other hand, Wireless Communication does not require any physical tool, but instead spreads the signal via the space around it. And because the characteristic of space that only allows signal transmission without any guidance, the medium used in Wireless Communication is classified as Unguided Medium .Even though in wireless communication there are no use of any cables, the signal's reception and signal's transmission are achieved through the use of the Antenna. The way that Antennas accomplishes this is by converting electrical signals into radio signals in the form of electromagnetic (EM) waves, the antenna can also do the vise-versa and convert radio signal that the antenna receive into electrical signals. The electromagnetic waves that the antenna transmit propagates through space. Therefore, the transmission of the antenna consists of the use of a transmitter and receiver electronic devices simultaneously.

The three components of the basic wireless communication system includes: the transmitter, the channel and the receiver. The Figure 2.2 below shows the block diagram of wireless communication system.

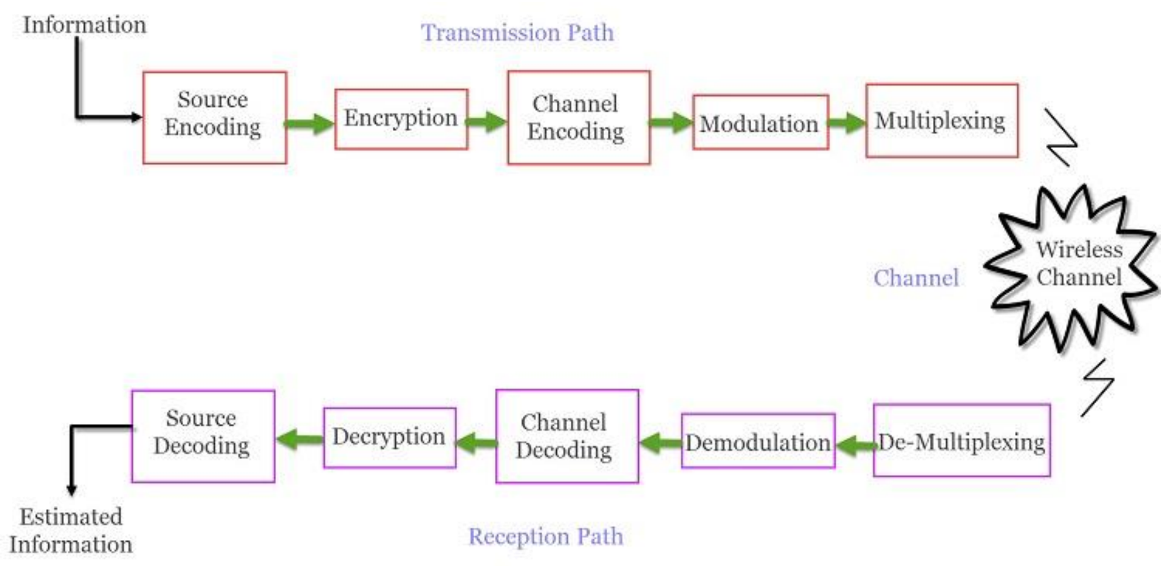

Figure 2.2: Block diagram of Wireless Communication System

2.1.1 First, second and third Wireless Generations

The first generations of wireless cellular technology is known as 1G, also known as analog technology, it enables voice-only calls. But the device that uses 1G had a lot of short comings. Not only does the device had a short battery life and poor voice quality, but it also only provided minimal protection and were very prone to disconnecting during calls. These short comings are due to the 1G's highest speed which is 2.4 Kbps and that the first generations era of phones were very heavy [7]. Even though the first model were used by corporate and executive, it was still weighing about 3-4 kg. Making it unsuitable for personal use, plus taking into consideration that the devices at the time would be extremely expensive to buy. Figure 2.3 show the example of first generations.

Figure 2.3: The first mobile phone.

For 2G mobile communication system, is the next step of generation after 1G. This generations started in 1980's and finish in 1990's was completely for voice transmission. The digital signal and speed up until 64 kbps, it manage to delivers operations like SMS MMS [7]. In 2G system, the GSM technology was introduced. GSM is a global system for mobile communication that uses digital modulation to increase the quality of voice. But when it comes to data service, 2G had difficulties. Therefore, 3G was the next system after 2G system. 3G system was released in 2000. The objective of the system is to achieve high speed data by using 14 Mbps of data. It also provided data services, Global Roaming and access to television and video. 3G offered faster communication compare to the 1G or 2G system. The system is based on wide band wireless network fulfilling the international mobile telecommunications[8] . From Figure 2.4 shown the simple explanation from first to third generation.

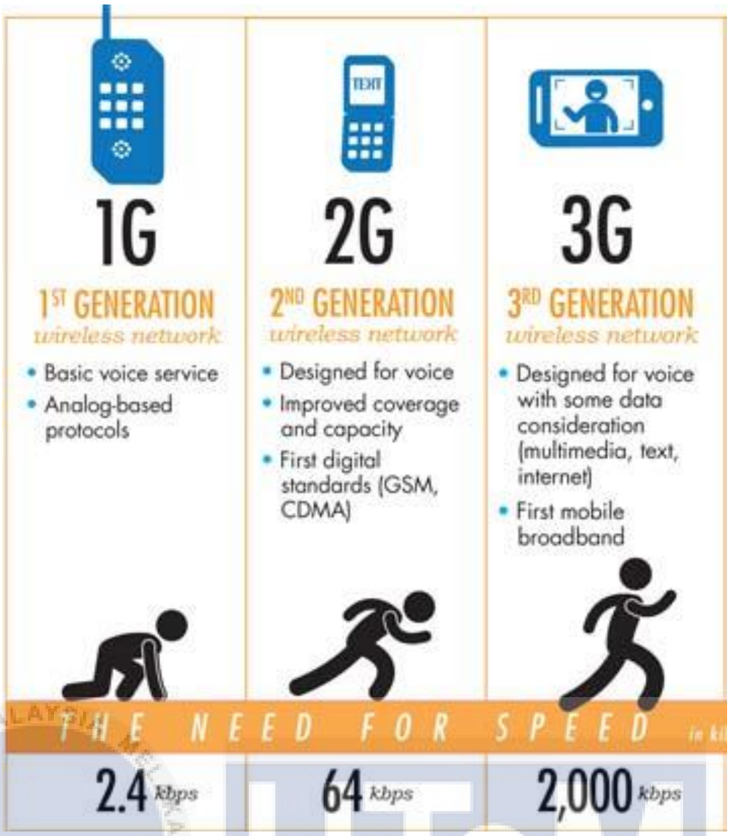

Figure 2.4: Simple explanation of 1G , 2G and 3G system.

2.1.2 4G Wireless Generations

A 4G network, also commonly known as a Long Term Evolution (LTE) system, provides almost similar features with the 3G network but with additional services such as Multi-Media Newspaper to watch television shows that are more clear and also the ability to send data much faster than previous generations. 4G was initially developed with consideration to match future application's Quality of Service (QoS) and rate requirements. Such as its potential use in Video messaging, High Definition Television (HDTV) content, Multimedia Messaging Service (MMS), Mobile Television, Digital Video Broadcasting (DVB), limited voice and data services, wireless broadband connectivity, and other bandwidth related services. From the above definition 4G communication system, it better than the 3G system, it is because

4G offers more convenient multimedia communication services based in the future where 4G system would replace the 3G system is an inevitable trend in communication systems development [9] .

4G communication system can be divide into access layer, carrier layer and the service control layer 3 layers. The access layer allows users to use a number of terminals via different forms of access to this system, this aspect would be revolutionary. Next the carrier layer offers Quality of Service (QoS) monitoring, security protection, address translation and other features, and the IP protocol interface between the access layer interface would be open. The control layer allows the business management, loading and also can be open interface between it and load-bearing layer in order to provide a new third party business applications [10] .

2.2 GSM Module and GPRS Module

The Global System for Mobile Communications (GSM) is a very popular mobile communication modem used throughout the globe ever since its concept was first introduced in 1970 at Bell Laboratories. GSM is an open and digital wireless technology that the frequency bands for the transmission of mobile voice and mobile data run at 850MHz, 900MHz, 1800MHz and 1900MHz [11]. The GSM network was developed for social activities such as a digital system that uses a multiple access time division (TDMA) technique, it operates as a channel access method for shared-medium networks. The way the GSM accomplishes this is by digitizing and reducing data before it sends the data down in its particular time slot through a channel of two different streams of client data.

The Base Station Subsystem (BSS) give the connectivity to the Mobile Stations (MS) and to the Network Subsystem (NSS). After that Network Subsystem (NN) via the BSS or subscribers in the Public Switched Telephone Network (PSTN) will transmit user signals to other mobile devices. Plus, it also supplies user data. The performance of NSS and BSS will be monitored by the Operation & Maintenance Subsystem (OMS). Other than that, it will also remotely debugs when having any problems or faults in the networking elements. Interface elements to data networking, the Short Message Service (SMS) or the Voice Mail System will be added to complete the GSM system architecture. The Figure 2.5 provide simple image of architecture of GSM.

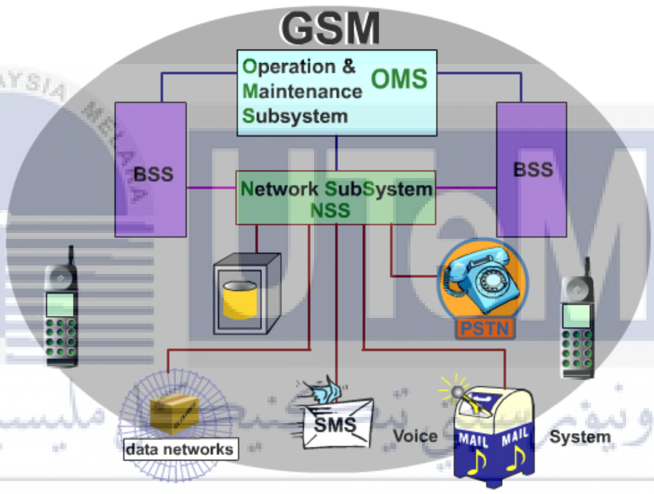

Figure 2.5:Architecture of GSM

General Packet Radio Service (GPRS) is a packet-oriented mobile data service on the Global Mobile Communications (GSM) network for the 2G and 3G wireless communication networks. The GPRS was an upgraded system from the basic GSM features. It provided mobile handset obtained more data speed than GSM. It allowed data to be sent and received across mobile telephone networks. It also supported internet protocol (IP) and Point to point protocol (PPP). In this mode PPP is often not supported for mobile phone operators, but if the mobile device was used as a modem to the connected computer, PPP is used to tunnel IP to the phone. When TCP/IP is used, each phone can have one or more IP address allocated. GPRS will store and forward the IP packets to the phone. Figure 2.5 show the architecture of GPRS.

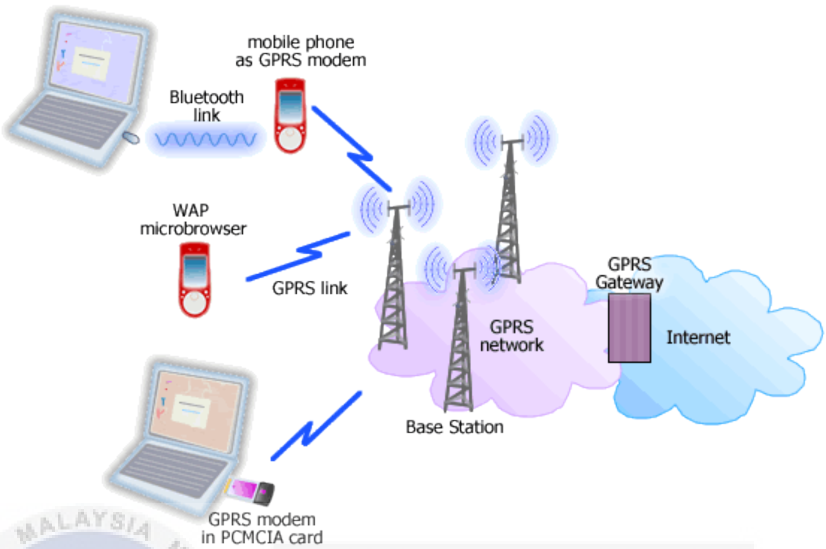

Figure 2.6:Architecture of GPRS

2.3 Previous Research

Salman Almishari, Nor Ababtein, Prajna Dash and Kshirasagar Naik have proposed a GPS-based tracking system as one of the IoT applications for tracking systems. The system made sure for efficient transportation for real-time tracking. The system is made up of three major parts: the tracking unit, Cloud and Android applications. The tracking unit exists inside of the vehicle and transmits the necessary information to the cloud, such as the temperature and current position of the vehicle, through identifying the vehicle's coordinates, where the location is shown on the map to provide real-time tracking [12].

As we know there are several ways to track the vehicle such as track using user's mobile phone. Because most smartphones are equipped with GPS modules and can be easily loaded with mobile application tracking programs. In many cases, the use of smart phones as position detection sensors is more feasible than other commercially available devices. People who drive the vehicle can use their cell phone to make the monitoring easier and cheap but based on Fatima Nadhim Ameen, Ziad Saeed Mohammed and Abdulrahman Ikram Sddiq that integrated An Economic Tracking Scheme for GPS-GSM Based Moving Object Tracking System said that there are more ease of configuration and alteration in mobile devices compared to dedicated consumer hardware monitoring devices [13]. In developing countries and many regions of the world, the coverage area, availability and efficiency of the Internet is lower than that of GSM systems. To make sure that this system is widely implemented, the GPS-GSM-based tracking systems are more reliable.

Ni Ni San Hlaing, Ma Naing and San San Naing has designed GPS and GSM Based Vehicle Tracking System [14] . In this project the GSM module used to send and receive messages from a different GSM number. When the car owner needs to know the location of the vehicle, they must first send a keyword message. At the time, the GSM device was functioning to give a mobile phone number back to the owner. In this project, the GPS module also contains a message containing the latitude and longitude of the vehicle. After that, the owner needs to copy the coordinates and paste on google map. From this process, it can be concluded that there will be a delay on the process to get the real location from the google map. Therefore, in this system it will try to neglect the delay by automatically giving the real time location of the vehicle.

When referring to P.Jyothi ‘s project, his project is design with GPS / GSM SIM900A unit, which contains all two aspects, namely GPS and GSM [15]. The GPS for the current location of the car and the GSM was used to transmit a warning message to the mobile owner of the vehicle. The proposed system would be installed inside a vehicle. In this project the system displayed the coordinate using LPC2148 Board.

Therefore, it cannot display the real time map to client, it only sent the coordinate using SMS to center. The Figure 2.7 is shows the diagram of the system.

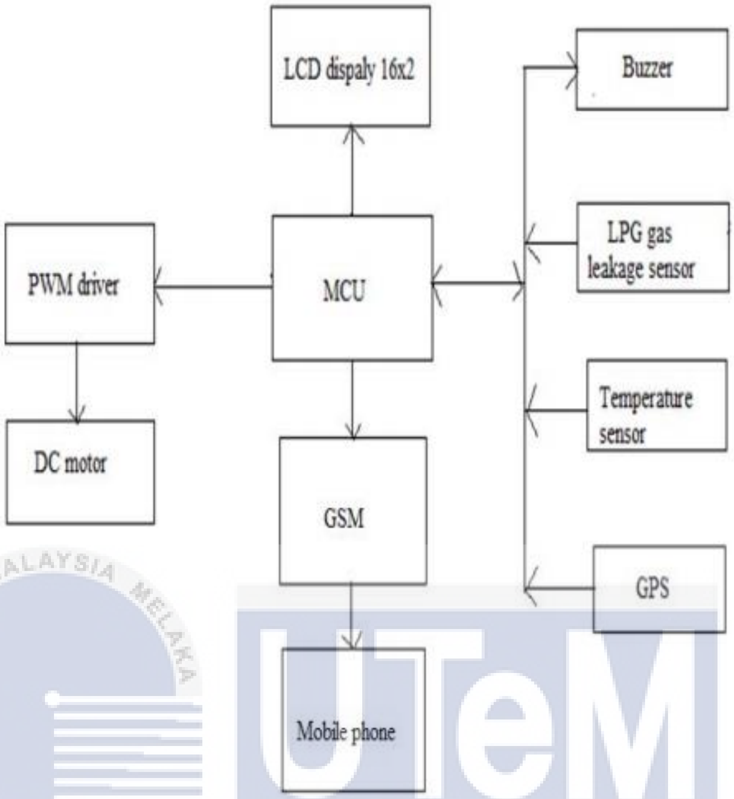

Figure 2.7: Diagram of the project [15]

In 2015 Prashant A. Shinde created a project named Advanced Vehicle Monitoring and Tracking System based on Raspberry Pi [16]. The project used Raspberry pi which was located inside of the vehicle and the GPS sim908 module. Vehicle tracking and monitoring system has been proposed and implemented for the purpose of securing it. The location of the school cars is tracked between two different locations, A and B for the purpose of providing a safe environment for transportation. The proposed system is based on the advantages of the Raspberry Pi, which supports the latest technology as an extension on the Linux system. By using this system, information and data are stored and used for tracking and monitoring purposes at the real time. It can be concluded that by using Raspberry Pi will give a lot of advantages to the system. The Figure below showing the block diagram of the system.

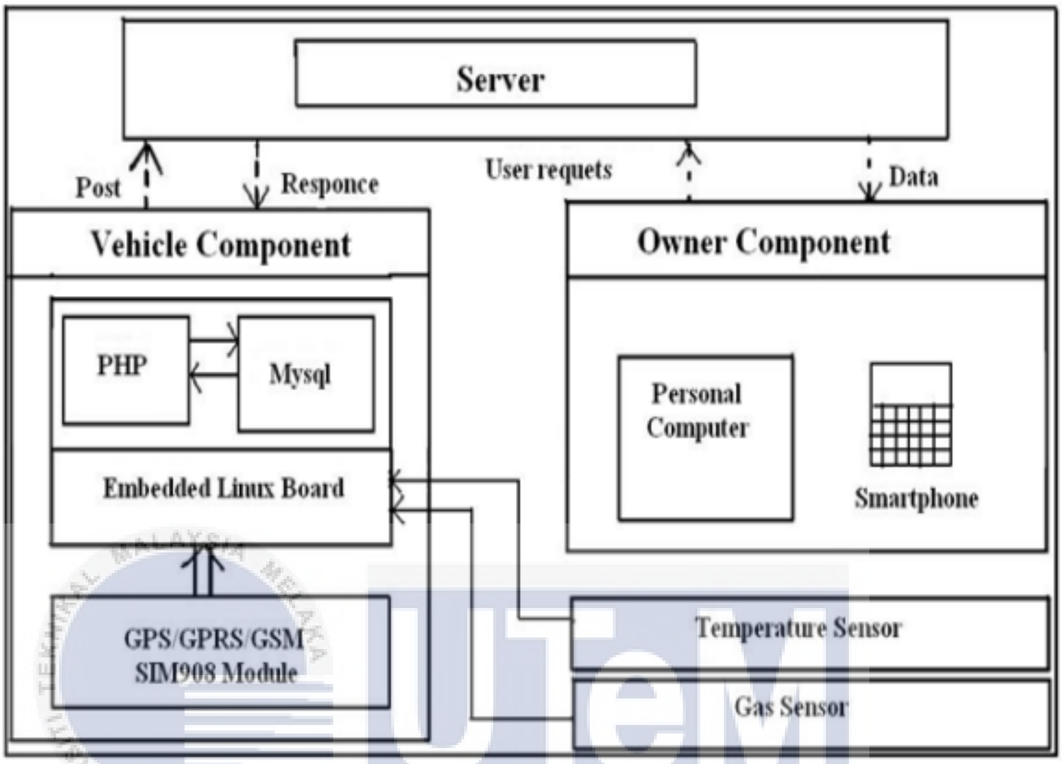

Figure 2.8: Diagram of the system [16]

Next in Pradip V Mistary and R H Chile project, the project is using Global Positioning System (GPS), the Global Mobile Communication System (GSM) modem and microcontroller are incorporated with the goal of allowing users to locate their vehicles quickly and conveniently [17]. This system provides the user with the facility to remotely monitor their vehicle through a mobile network. It also describes the implementation of the hardware model vehicle tracking systems and the GUI software to show the actual location of the vehicle. But this system need to improve by connecting the GSM modem to the MATLAB GUI, so there is no need for the operator to manually set these readings and make the system more stable.

In next research by Lee, Seokju Tewolde and Girma Kwon Jaerock developed and tested a vehicle tracking system to track the exact location of a moving or stationary vehicle in real time. This paper represented the development and implementation of vehicle tracking system. The vehicle tracking system uses an in-vehicle computer, a database and a smartphone application. In this function, the in-vehicle system consists of a microcontroller and a GPS / GSM / GPRS unit to obtain information on the location of the vehicle and send it to the database via the GSM / GPRS network. On the other hand, the web interface written in PHP is used to connect directly to the server. The geographical coordinates of the vehicle and the unique ID of the vehicle obtained from the in-vehicle computer are registered in the database table as shown on Figure 2.8. Plus, a Smartphone application has been developed to view the location of the vehicle on Google maps. The device was able to experimentally demonstrate its success in monitoring the position of the vehicle from anywhere at any time. In addition, this system implementation is low-cost focused on easily accessible off - the-shelf digital modules. Plus, this system developed a database that store time and the coordinate of the vehicle. In conclusion the system is more systematic because the database implemented time period that programmed based on the vehicle's movement [18].

ID	VehicleID	Time	Latitude	Longitude
36	2013	2013-10-10 07:28:18	43.01491	-83.71395
37	2013	2013-10-10 07:28:27	43.01459	-83.71360
38	2013	2013-10-10 07:28:36	43.01462	-83.71347
39	2013	2013-10-10 07:28:44	43.01433	-83.71321
40	2013	2013-10-10 07:28:52	43.01376	-83.71273
41	2013	2013-10-10 07:29:02	43.01353	-83.71255
42	2013	2013-10-10 07:29:11	43.01351	-83.71253

Figure 2.9 : A real vehicle’s location information with time period [18] .

CHAPTER 3

METHODOLOGY

This chapter clearly explains the methods used to complete this task. This outlines how well this plan was carried out to accomplish the goals of the company. This chapter also includes the explanation of the entire project methodology and the development of the prototype stage by stage in detail. In addition, all component is used to create the model are explained in detail on their functionality and working theory. The steps of how each component is implemented in a prototype are also covered in this chapter.

3.1 Planning of project

To make sure the project is finish on time, a project planning is made to make sure the project is in the progress and flow smoothly according to schedule. Planning of project is usually implemented at first stage of the project plus the help from Gannt Chart. Gantt chart helps researcher to schedule and keep in track for project completion. The Gantt Chart is a timeframe which is used as a project management method to illustrate how the process is going to operate. It can see the individual tasks, duration, and the sequence of project. It will help to view the overall timeline for the project and the expected completion date.

3.2 Hardware

The core function of this system is to construct a system for emergency vehicle so that the emergency vehicle such as Fire Truck can archive their time response. Because in Fire and Rescue Department of Malaysia 2016 Report state that want to improve emergency response times across the country. Fire Truck managed to get to their location within 10 minutes only for time response but only 60% of emergency calls answered by the fire station that were handled. This amount can be raised to 80 percent in the near term by the department if they had improvement in their whole system [19].

In this section, the hardware components used for the project are discussed in detail. The brain of the project is Arduino Nano as a microcontroller. Initially, this system works on getting geo coordinates latitude and longitude and used the GPS module to capture the position and the speed of the vehicles. The GSM module part is for cellular networking.

3.2.1 Arduino Nano

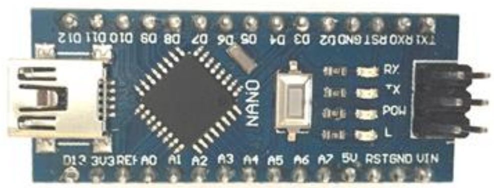

Figure 3.1:Arduino Nano

Arduino is the open-source microcontroller system that is widely used to build an electronics project such as simple or complex project. It also named as programmable integrated board. By use sensors and inputs it will give interaction with big range of output. For example, having some LEDs, Motor control or displays. There as many as 30 type of processor that Arduino have such as Arduino Nano, Arduino Uno, Arduino Mega and many more. In this project Arduino Nano was used. Arduino Nano is as shown on Figure 3.1. It is because Arduino nano is more breadboard friendly compare to others type of Arduino. Moreover, it very easy to handle the connections between hardware.

There are several ways to power this Nano. For example is by USB Jack, the step is easy by connecting the cable to mini USB jack to computer or at phone charger [20]. From that it will give the power requiring to enable the board. More than that it can be supplied by using Pin. By using the pin, an unregulated 6-12V can be supplied to the Arduino. The regulator's board will regulate it to +5V. Next for pins on Nano Board have about 14 optical pins and 8 analog pins. There a several function on Arduino Nano as the description of each pin of Arduino Nano configuration and its functions presented in Figure 3.2.

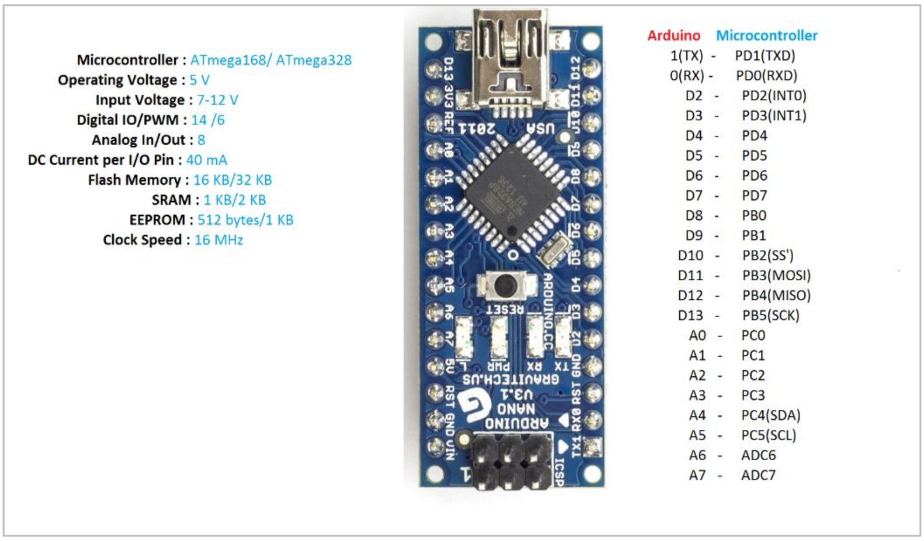

Figure 3.2 : Pin description of Arduino Nano and its function[20]

3.2.2 SIM7600E-H 4G Module

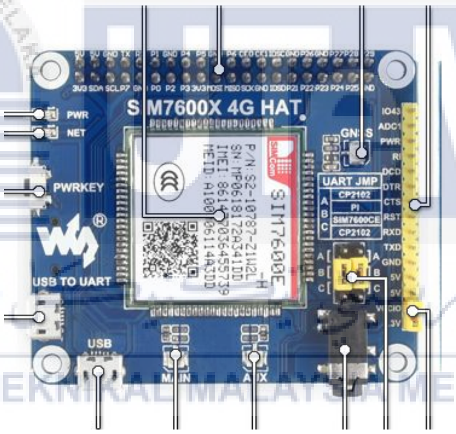

Figure 3.3:Front view of SIM7600X 4G HAT

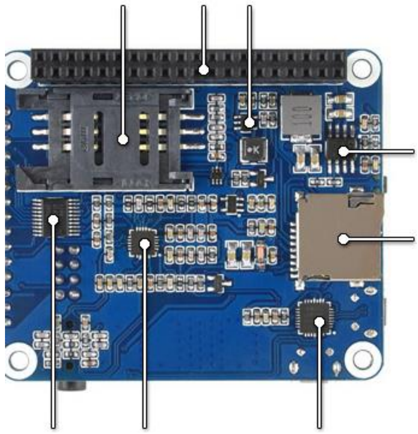

Figure 3.4:Back view of SIM7600X 4G HAT

On the Figure 3.3 and Figure 3.4 is front and back side of SIM7600E-H 4 G HAT. This is a 2G, 3G and 4G communication and GNSS positioning module that allows downlink data transfer from LTE CAT4 up to 150Mbps and has relatively low power consumption. Simply put, this component supports cellular communication including SMS and internet data as well as GNSS integrated positioning sensor. It's called the GSM module occasionally. To surf the Internet, it can link this 4G module to a computer or add it to Raspberry Pi to allow functions such as 4G high-speed connectivity, wireless communication, telephone calls, sending text messages, global positioning, etc [3].

3.2.3 Global Positioning System (GPS) Antenna.

This GPS antenna that show on Figure 3.5 draws about 10mA and will give an additional 28 dB of gain. The length of the cable is about 5 meters, therefore it can be placed wherever as needed because the GPS Antenna needs to have a clear, unobstructed sky view and must be put on top of a vehicle to receive the best microwave signals that need to communicate with satellites. The frequency range operated around 1575.42±1.023 MHz. For the voltage range is about 2.5V- 5.5V and for current range is about 6.6 mA - 16.6 mA. The GPS signals can be extremely weak, its need high demands on take the antenna. It can be said that the choice of antenna is very important role in GPS performance. The procedure of this GPS antenna works is when it receiving the GPS signal, the lower frequency will be convert then sent down to the cable. Next, when the GPS receiver is an up converter, it will be converting the signal back to the original frequency and lastly delivering it to the GPS receiver.

Figure 3.5:GPS Antenna

3.2.4 Global System for Mobile Communications (GSM) Antenna.

The GSM communications are dependent on GSM antennas. The GSM antenna show on figure 3.6. The antenna will be allowing the communications signals either need to be sending or receiving. The antenna that have be used in this system give operation at both GSM Quad Band Frequencies with +2dBi gain. This antenna also operating in Quad Band 890/960 and 1710/1880 MHz Frequencies.

Figure 3.6:GSM Antenna

3.3 Software Component

3.3.1 Arduino IDE

Arduino IDE is an open-source program that provide programming languages for this system. It is to ensure the communication between microcontroller with SIM7600E-H 4G module or any other hardware. For receiving data from satellite and sending data into database, Arduino Nano microcontroller and SIM7600E-H module used a code programmed by using Arduino IDE software. The function of Arduino IDE is used to compile the code into the microcontroller. The program C- is used for programming language [21]. The coding primarily consists of two parts-void setup() known as program preparation, only takes place once; another aspect of it is void loop() known as program execution.

3.3.2 ThingsBoard.io

ThingsBoard.io is an open-source for server-side platform that provide user to monitoring and controling Internet of Things (IoT)'s devices. It used for data collection, editing, display and system management tool. ThingsBoard.io supports standard MQTT, CoAP and HTTP IoT protocols. It helps the user to sign, control and monitor different devices. It also provides a server-side framework API for sending command to devices and back to vice versa. ThingsBoard.io supports HyperSQL DataBase, PostgreSQL and Cassandra databases on the storage and visualization data [22]. It offers users personalized dashboards with several configurable widgets to track data in real time. Figure 3.7 shown front page of the ThingsBoard.io website.

Figure 3.7:ThingsBoard.io website.

3.4 Project Flowchart

Flowchart was designed with the purpose of showing workflow or process in step-by-step boxes according to its order. Each box is connected with arrows as it shows the solution of any problems regarding the project from inside the boxes. There are five steps that gives a major impact to the development of the project, which research, design, development, testing and analysis. The general workflow of the project is shown in the flowchart as in Figure 3.8.

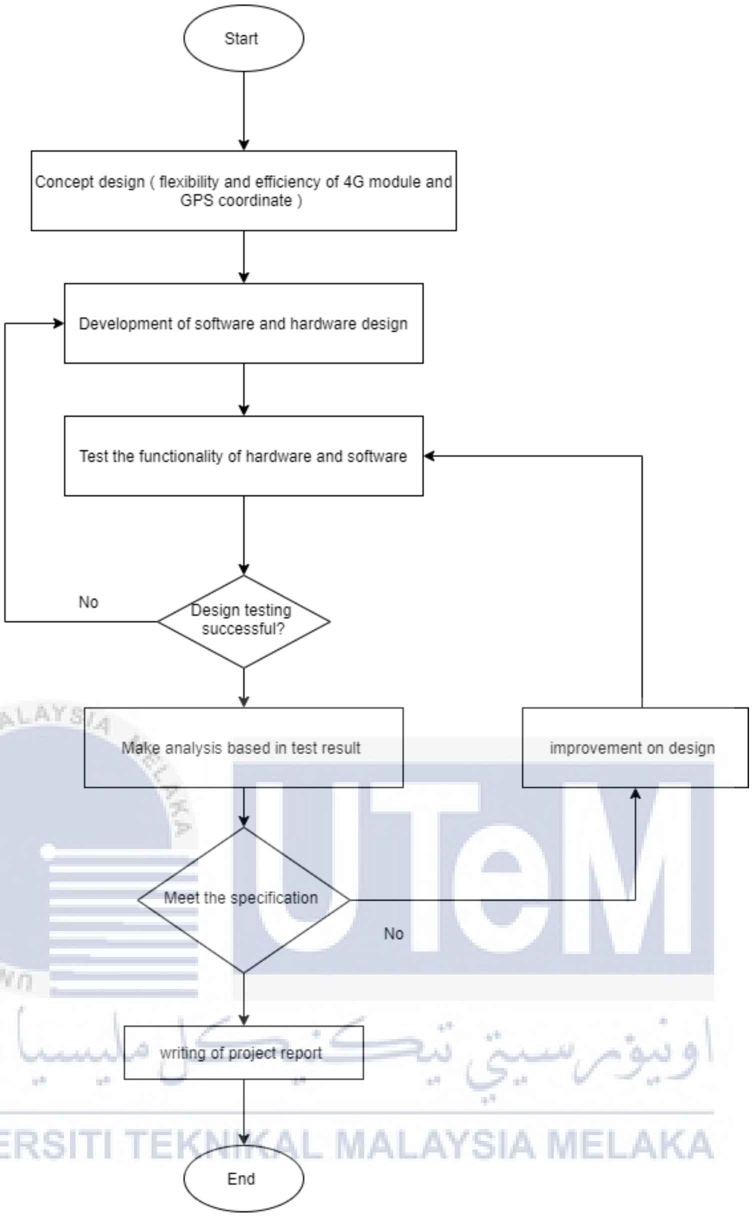

Figure 3.8 : Flowchart of the project

The main purpose of this project development is to obtain implement real time mapping to record time and positions of emergency vehicle using Arduino Nano, SIM7600X 4G HAT and IoT.

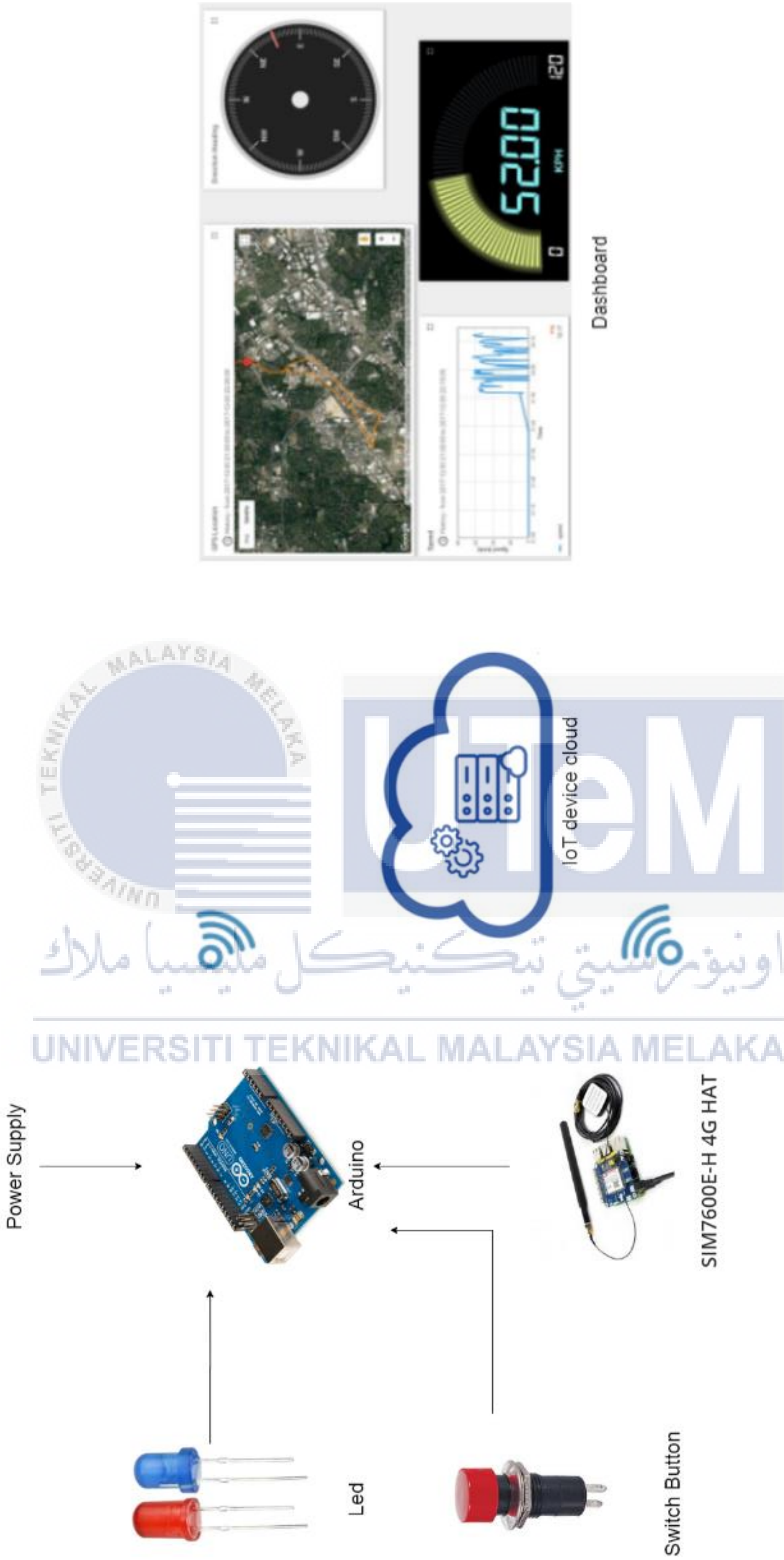

Figure 3.9 : Architecture of the project

The diagram above shows the architecture of this project. The vehicle tracking system is installed inside the vehicle that want to be traced. The system will connect inside at vehicle to get power supply and get connected with internet via SIM7600E-H 4G module hardware. First when the emergency vehicle is moving from the base station the timer will start counting. When the vehicle arrived at the scene location, the timer will stop counting. The timer will record and store at the database. As it will name as time response. At the same time, user at the base station can monitor the real time location and the speed of the moving vehicle so that the driver cannot give the wrong information to the station.

3.4.1 Hardware System Design and Development

The layout of the project's hardware starts with the designing of circuit through schematic diagram. Each component used were arranged in the schematic diagram and then applied physically and accordingly to the main breadboard. The connections are made based on the manual and datasheet of each components. As the setup was completed, a simple test was run. By using Fritzing software, the connection made between the Arduino Nano with SIM7600E-H 4G Module, GPS Antenna, GSM Antenna, Led and Switch were simulated. Several designs were made beforehand and each was tested before choosing a permanent design [23] . The Fritzing simulation can be seen as electronic design automation tools as in Figure 3.10 below which is the PCB view of the main circuit.

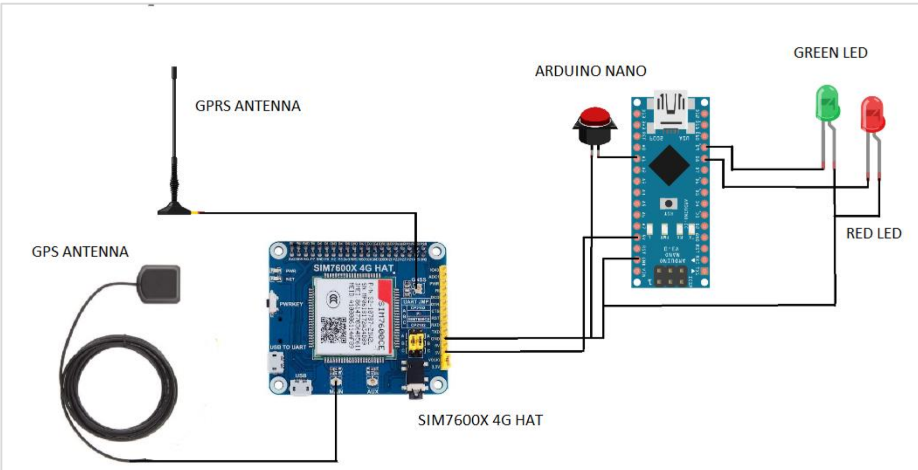

Figure 3.10: Electronic design automation tools.

3.4.1.1 Configuration of between Hardware

The SIM7600E-H 4G Module hardware is the core part of this project. It is because the SIM7600E-H 4G module is needed to be set to incorporate specific GPS and GSM system. GPS gives the vehicle location coordinates; GSM transmits these data to the server. Connecting the Arduino Nano with the SIM7600E-H 4G Module, the pins need to be exactly connected as the instruction on the datasheet. It cannot be easily moved around and edited later in the coding as other components do since this module uses serial communication. In any case, the communication between Arduino Nano and GSM module is serial. The serial pins of Arduino is Rx and Tx. Tx and Rx are abbreviations for Transmit and Receive, respectively. In this project Tx pin of 4G module to Rx pin of Arduino and Rx pin of 4G module to Tx pin of Arduino. The connection between two hardware is shown in Table 3.1.

Table 3.1: Pin Connection between Arduino Nano with SIM7600E-H 4G Module

Arduino Nano	SIM7600E-H 4G Module
5V	5V
GND	GND
2	TXD
5	PWD
3	RXD

Next is the configuration between Arduino Nano with Switch button and LED. The function of Switch Button is for the time response. When the vehicle starts to depart the user can press the button and timer will start counting. After that, the red LED will switch on. The function of Green LED is to notify the user when the system finish initializing the GPS system and GPRS system. It can be said that Green LED will turn on after all the system is ready to use. The components used in this system that already organized with numbers listed in Table 3.2, complete hardware design and development of this system shown in Figures 3.11.

Table 3.2: : Component Numbering for Hardware System Design and Development

Numbering	Component
1.	Green LED
2.	Red LED
3.	GPS Antenna
4.	GSM/GPRS Antenna
5.	Arduino Nano

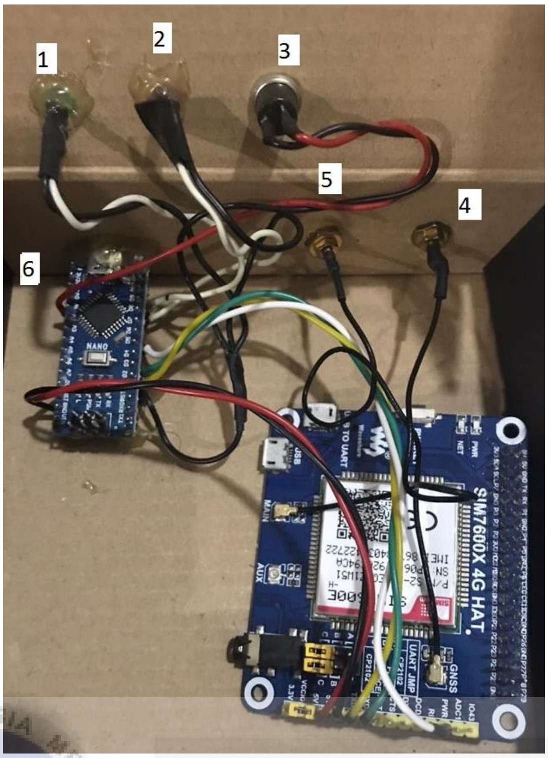

Figure 3.11: Complete Numbering and Arrangement of Hardware Design

3.4.2 Software system design and development

This project required two different parts that needed to be to develop. The first one is connecting the Arduino Nano to the SIM7600E-H 4G Module and to get serial communication between both hardware. Next is to get the internet connection between Simcard network from SIM7600E-H 4G Module. The last part is to develop and design a simple dashboard on ThingsBoard with the purpose of displaying the result and this has to work well together with SIM6700E 4G module. The Figure 3.12 show flow chart on how the system algorithm is given below.

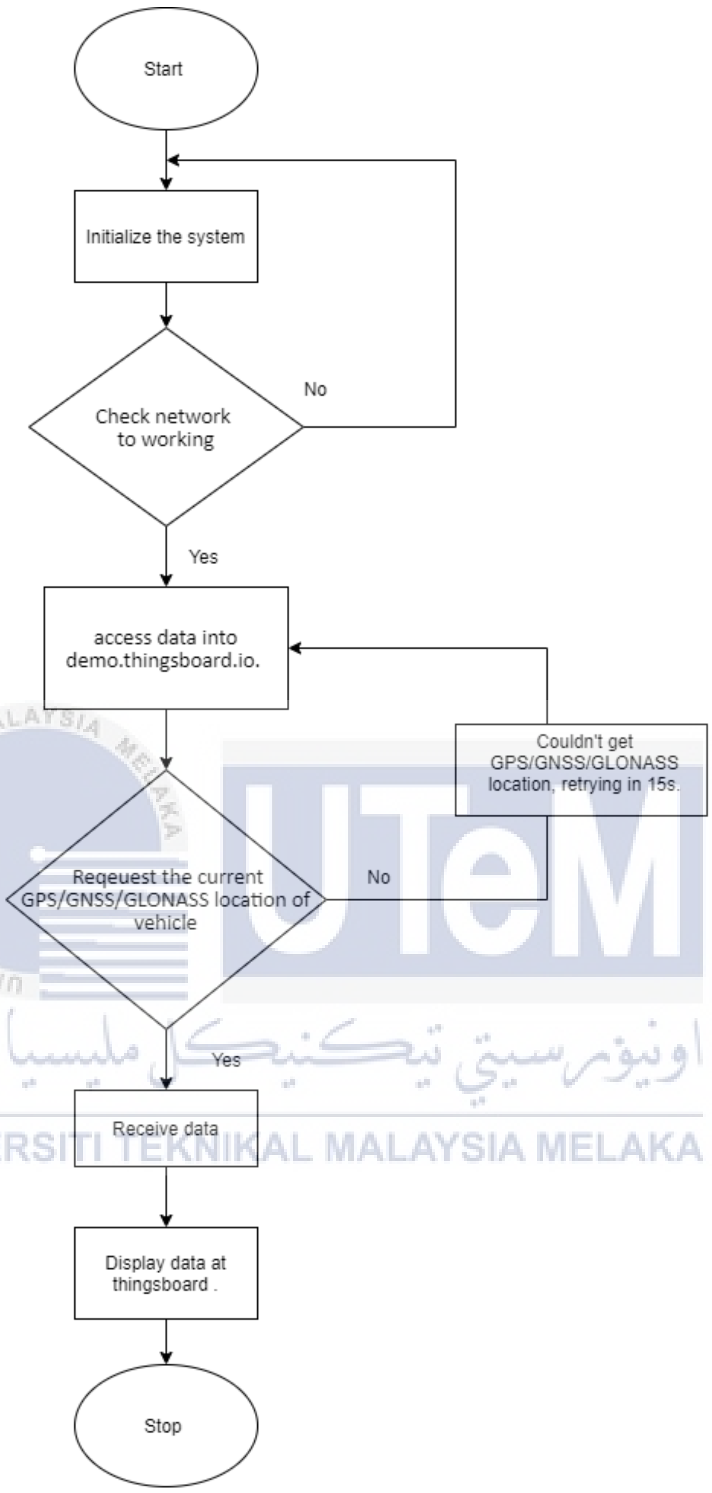

Figure 3.12: The system algorithm

3.4.2.1 Coding Development on Arduino IDE

The coding development on this project is all about connecting SIM7600E-H 4G Module with Arduino nano microcontroller for sending location data via internet protocol on ThingsBoard software. Some libraries such as TinyGsmClient.h, SoftwareSerial.h and ThingsBoard.h need to be installed on Arduino IDE. Declaration of libraries and pins is show on Figure 3.13.

```
#define TINY_GSM_MODEM_SIM7600 //Use SIM7600

//Use this Library
#include <TinyGsmClient.h>
#include <SoftwareSerial.h>
#include "ThingsBoard.h"

//Arduino Pin used
#define GSM_PWR 5 //Pin 5 Arduino connect to GSM Power pin
#define LED_Red 8
#define LED_Green 9
#define Btn_Pin A1
```

Figure 3.13: Declaration libraries and pins.

The SIM7600E-H 4G module with GPS antenna and GSM antenna will connect with Arduino Nano. When it receives the power supply, the module will send the AT command. If the response of corresponding AT command is answering OK, then it check the response of SIM card and whole network status for confirmation of registration. The coding on Figure 3.14 below is about connecting GSM Antenna and GPS Antenna.

```
//GSM use 9600 baud rate
serialGsm.begin(9600);
delay(2000);

//Check if GSM already turn on.
if(!sendATcommand("AT","OK",1000)) //if off, turn GSM on
{
    Serial.println("Turn On GSM");
    digitalWrite(GSM_PWR,LOW);
    delay(1500);
    digitalWrite(GSM_PWR,HIGH);
    delay(1000);
}
pinMode(GSM_PWR, INPUT_PULLUP);

Serial.println(F("\nInitializing modem..."));
modem.restart();

String modemInfo = modem.getModemInfo();
Serial.print(F("Modem: "));
Serial.println(modemInfo);

modem.enableGPS();//turn on GPS
delay(15000L);
// Unlock your SIM card with a PIN
//modem.simUnlock("1234");
Serial.println("Initialize Complete");
```

Figure 3.14: Coding connecting GSM Antenna and GPS Antenna.

```
// Connect to the ThingsBoard
if (!tb.connected())
{
    Serial.print("Connecting to: ");
    Serial.print(THINGSBOARD_SERVER);
    Serial.print(" with token ");
    Serial.println(TOKEN);
    if (!tb.connect(THINGSBOARD_SERVER, TOKEN))
    {
        Serial.println("Failed to connect");
        return;
    }
    Serial.print("Connection OK. ");
}
```


Figure 3.15: Coding for internet protocol.

Next is about the development coding on for internet protocol as show on Figure 3.15. To create connection between internet protocol, first need to define Token from Thingboard server. Access token is device credentials that are used in order to connect to the ThingsBoard server by applications that are running on the device. Lastly to send all data and display the result to ThingsBoard 'tb.sendTelementryFLoat ' is used.

3.4.2.2 Dashboard ThingsBoard Development

To create a dashboard on ThingsBoard the first thing to do is to create an account. When open the live demo home screen, this a screen where can manage all the devices, edit dashboard and many more. The core part on this development is the manage Credentials. On this manage credentials will give the access token as show on Figure 3.16 and Figure 3.17, this is essentially the device ID and is analogous to the device ID used for posting data to ThingsBoard.

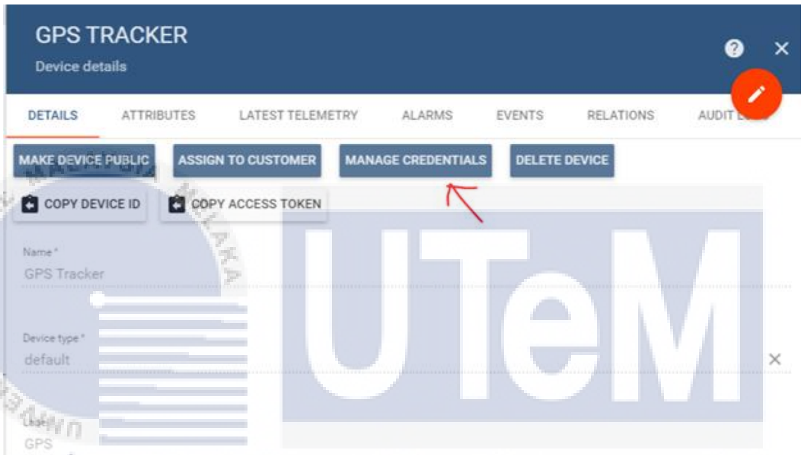

Figure 3.16: Manage credentials on ThingsBoard

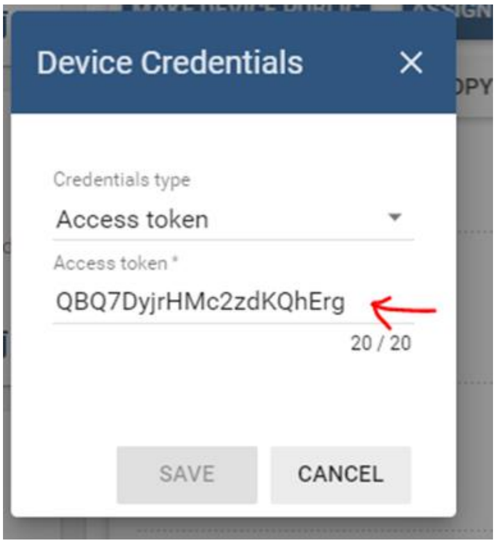

Figure 3.17: Manage the Access Token on ThingsBoard

The data from Arduino to ThingsBoard can be sent after the access token is paste on ThingsBoard declaration on Arduino coding. Next is to put the widget on dashboard. The maps, speed and time response widget will be used on this system. Figure 3.18 shows the complete dashboard after settings all the widget.

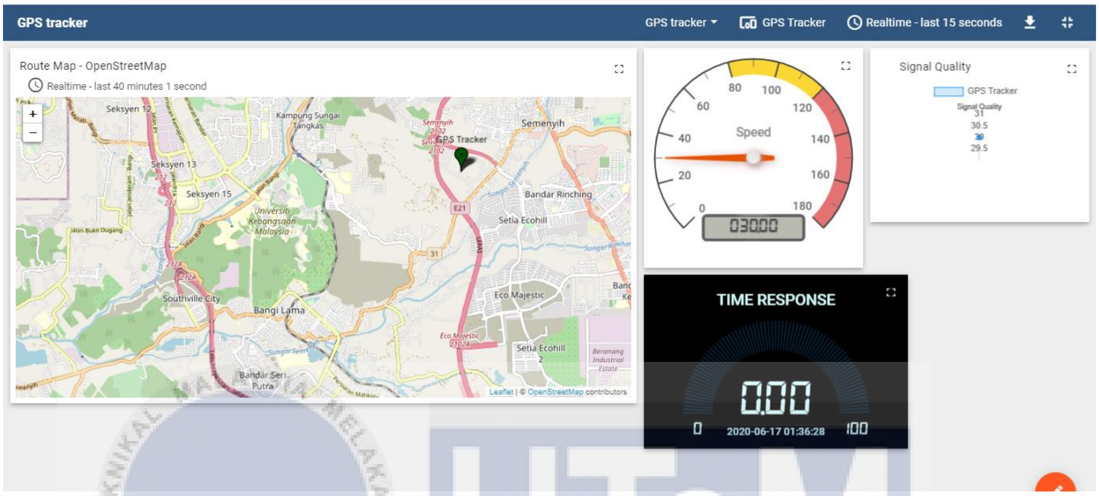

Figure 3.18: Full dashboard on ThingsBoard

CHAPTER 4

RESULTS AND DISCUSSION

This chapter will provide all the results obtained from this project. Also, this chapter covers the analysis of vehicle tracking system from the ThingsBoard software platform. A simple test analysis event was conducted by choosing same destination but two different routes to be used. The two different routes will be analysed based on speed, time respond and the signal strength. Lastly, the analysis was conducted with another route but the data is taken per day. All the data analytic was view in graphically to evaluate the performance of the system.

4.1 Data Analysis time response of route fireman arrived at destination.

To ensure this project is highly efficient, a simple test event was conducted by choosing two different routes. The total distance between two different routes is same between starting point and the end point. In these different routes the time response and speed was being compared.

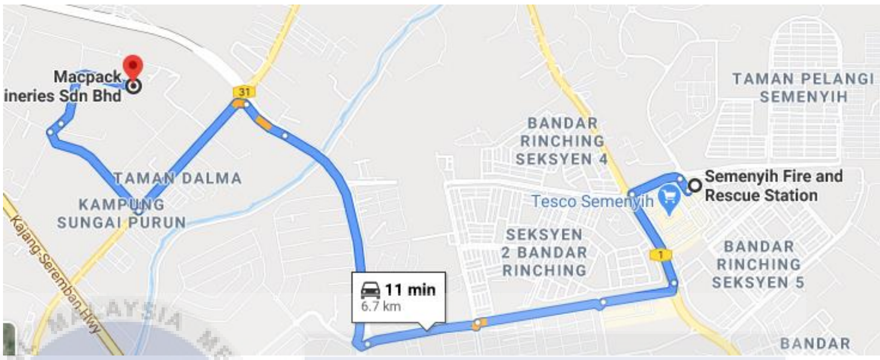

Figure 4.1: Route A

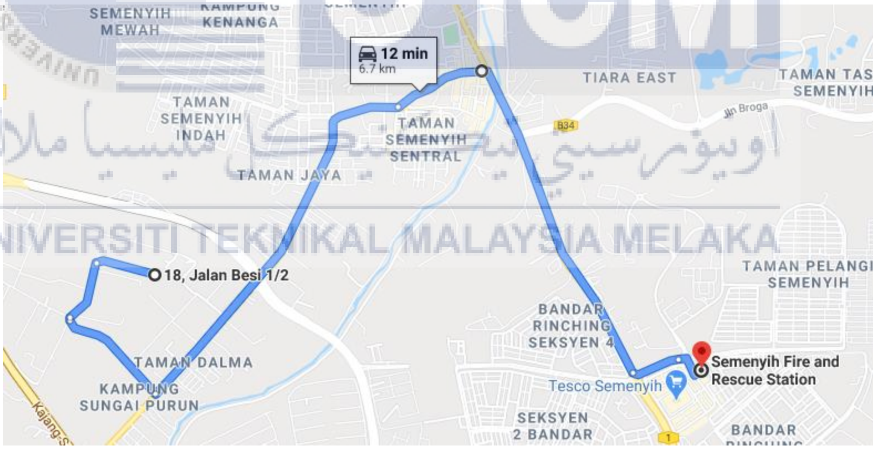

Figure 4.2: Route B

Figure 4.1 and Figure 4.2 show the expected time on google. The Route Are named as Route A and Route B. Both of the time response were different even though the total distance was the same. After the experiment was conducted by using this system, it achieved a more accurate recorded time response, the routes traveled and the speed taken by the vehicle. All the data was recorded on the ThingsBoard. Figure 4.3 and Figure 4.4 shows the mapped results in ThingsBoard for Route A and Route B.

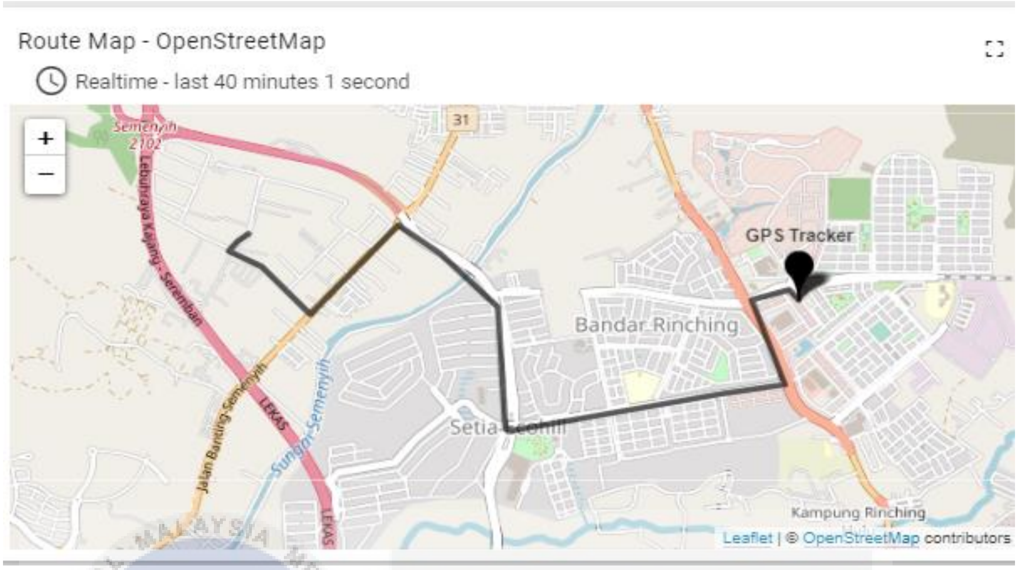

Figure 4.3: Result for Route A

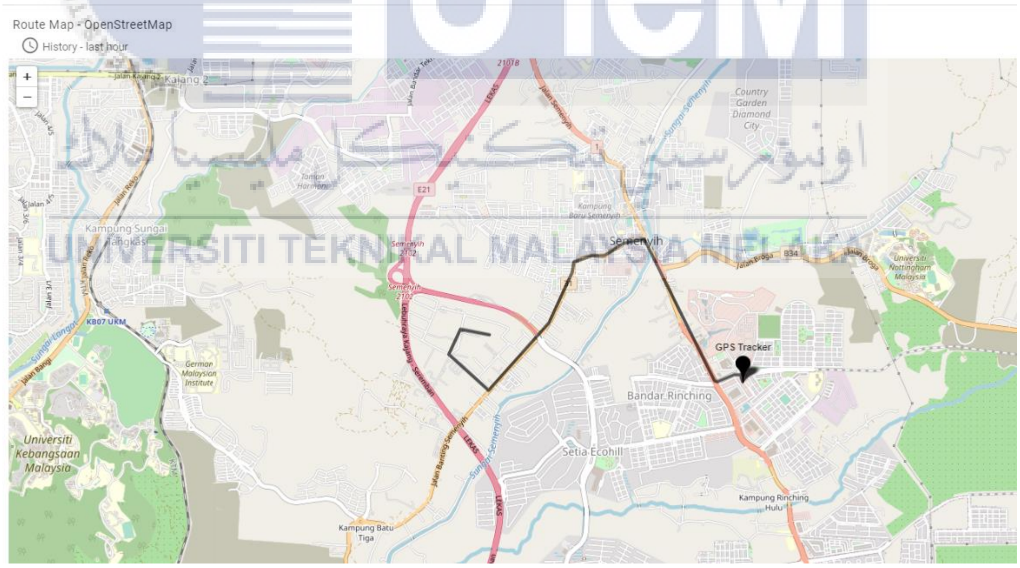

Figure 4.4: Result for Route B

From ThingsBoard the real time moving vehicle will be shown throughout the map. It can be viewed from several platform such on a computer or mobile device. The routes travel began from Semenyih Fire and Rescue station to Macpack Machineries factory. The total distance is same which is 6.7 km. After the test was conducted, the comparison was made between routes. The core different between two routes was time response for each route. Table 4.1 below shows the time response between two routes.

Table 4.1: Time Response for both routes.

Routes	Time Response (minute)
Route A	
Route B	

Although the distance is the same it had different result between time response on Route A and Route B. The difference is by two minutes, but a two minutes difference is crucial on an emergency case. Because the time response for the Emergency scenario is relate to their key performance indicator (KPI) of emergency time response for their team. A team's KPI can be the reason whether or not a life would be safe during the emergency.

From the test conducted there are several factors that might affect the time response. One of the effects is the speed of both routes taken towards their destination. Below shows the result of the two different routes.

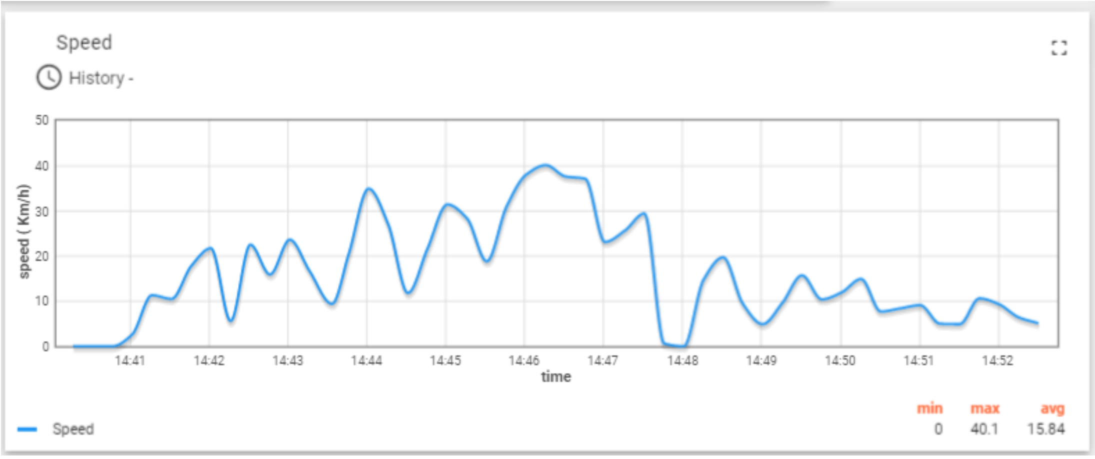

Figure 4.5: The graph of speed for Route A.

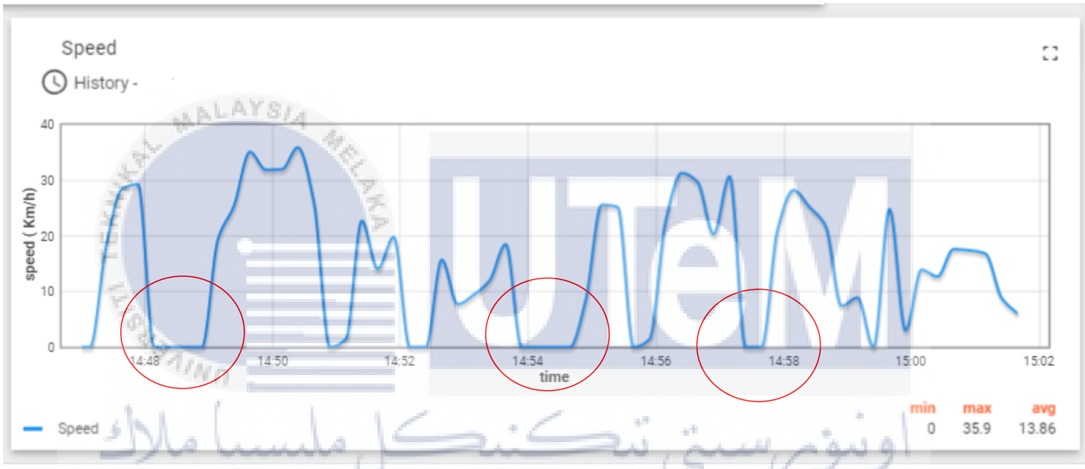

Figure 4.6: The graph speed for Route B

From Route A the minimum speed was 0 Km/h and the maximum speed was 40.1 km/h. The total average of the speed was 15.84 km/h. While from Route B the minimum speed was 0 km/h and maximum speed is 35.9km/h. The total average of the speed was 13.86 km/h. The different between both routes was 1.98 km/h. From the data collected Route A have been observed to have a higher total average speed when compared to Route B. Therefore, it can be concluded that the average speed will influencing time response for each route. Plus, from the speed graph, it shows the fluctuating pattern on both routes. In the speed graph for Route B the vehicle can be observed stopping multiple times more than Route A (as indicated by the red circles in Figure 4.6), due to there being more traffic lights on Route B rather than Route A.

4.2 Factor that effect the Time response and Speed between two routes.

The total distance for Route A and Route B is same which is 6.7 km. It from Semenyih Fire and Rescue station to Macpack Machineries factory Semenyih. After the test conduct the result on time response is different and it shows the two different speed taken by the vehicle. The speed for Route B is higher compared to Route A from the average calculation speed.

There was a several factors can influence the time of the run and speed taken such as traffic lights, number of cars on the road and the road condition. For the traffic light, the way that a traffic lights works will put a lot of randomness in the time for a run. The longer timer for traffic light will affect the numbers of cars on the road. From observation the total traffic light on Route A is 4 while Route B have 8 traffic light. Total traffic light on Route A is doubled for Route B. It can be seen that from the graph in Figure 4.6 the amount of stopping time for Route B is higher compared to Route A. This prove that the number of traffic light affects the total average speed and automatically influence the time response.

The more traffic light present of the route the greater the number of cars will be on the roads. It can also be a cause of increase run time. The more cars are there on the road, the longer it will take for the emergency vehicle to maneuverer to get past them. Figure 4.7 below show example of traffic light that causes long queues of cars.

Figure 4.7: Example image of traffic light with que of car.

4.3 Analysis of the communication modem Received Signal Strength Indicator (RSSI) on both routes.

RSSI is the term Radio-Frequency (RF) and also stands for Received Signal Strength Indicator. It is for measuring the range-based the present of power received by the radio signal, which estimates the distance based on the signal strength received by the sensor node. Plus, it for obtain the communication modem Received Signal Strength Indicator (RSSI) which determines the received power in the GPRS Antenna.

Checking the signal strength of the operator using a modem is by using command the programme code 'AT + CSQ'. This is the Signal to Noise Ratio measurement that is used to ascertain the relative quality of the receiving the cellular signal. It is because there are not having ways for RSSI measurement. Therefore, all manufacturers report CSQ between 0 and 31. The scaling is unique to each cellular module model. To converting the CSQ value to a Received Signal Strength Indicator (RSSI) value, it must be assumed the noiseless environment. The 'AT+CSQ' commands returns signal strength [24]. The returned value range is 0 and -30. The returned values map to received signal strength indicator (RSSI) is measured in dBm.

For example, 0 in CSQ value, while in RSSI is -11dBm. Table 4.2 below show value of RSSI, CSQ and condition of the signal.

Table 4.2 Value of RSSI , CSQ and condition of the signal

CSQ	RSSI (dBm)	Signal Condition
2 until 9	-109 until 95	Marginal
10 until 14	-93 until -85	OK
15 until19	-83 until 75	Good
20 until 30	-75 until 53	Excellent.
99	0	not present or not measurable

For this system we try to measure the RSSI for Route A and Route B to compare the signal strength. The result is sending to ThingsBoard database. As shown on Figure 4.8 and 4.9 is example result on serial network on Arduino IDE and result signal quality on ThingsBoard.

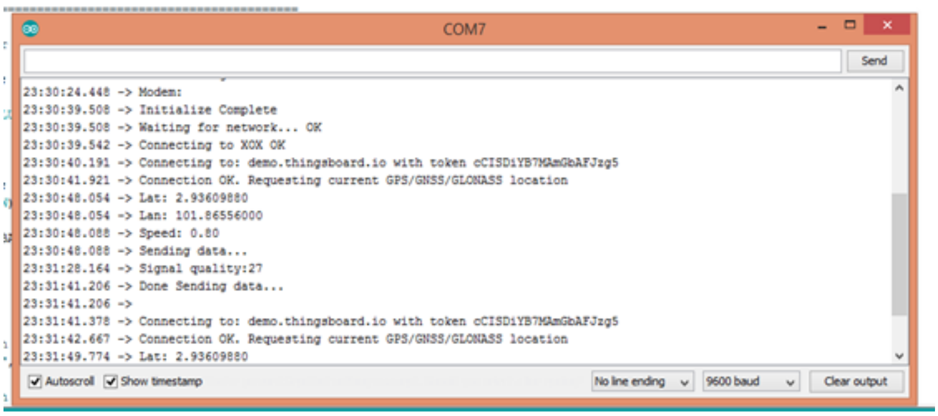

Figure 4.8: Result on serial network.

New Timeseries table

Realtime - last 7 days

Timestamp ↓	Signal Quality
2020-06-16 13:01:42	27
2020-06-16 13:01:11	27
2020-06-16 13:00:41	27
2020-06-16 12:48:39	27
2020-06-16 12:48:09	30
2020-06-16 12:47:38	30
2020-06-16 12:47:08	30
2020-06-16 12:46:37	23
2020-06-16 12:46:06	23
2020-06-16 12:45:35	23

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Figure 4.9: Result Signal Quality on ThingsBoard for Route A

Timeseries table

Realtime - last 30 minutes

Timestamp ↓	Signal Quality
2020-06-11 15:13:08	27
2020-06-11 15:12:37	27
2020-06-11 15:12:06	27
2020-06-11 15:11:35	27
2020-06-11 15:11:05	20
2020-06-11 15:10:34	20
2020-06-11 15:10:03	20
2020-06-11 15:09:33	20

Items per page: 10 1 – 10 of 17

Figure 4.10: Result Signal Quality on ThingsBoard for Route B

After the RSSI test is conduct, the minimum and maximum value signal strength for Route A is 23 and 30. While the minimum and maximum value for signal strength for Route B is 20 and 29. Both of the signal strength for Route A and Route B is lay on excellent condition.

4.4 Analysis of time and speed on Route C

Another test was conducted by using another route. The routes were from Semenyih Fire and Rescue station to RTG factory. The total distance is about 3.2 km and the time expected by google map is 7 min. The Figure 4.11 show the expected result in google map.

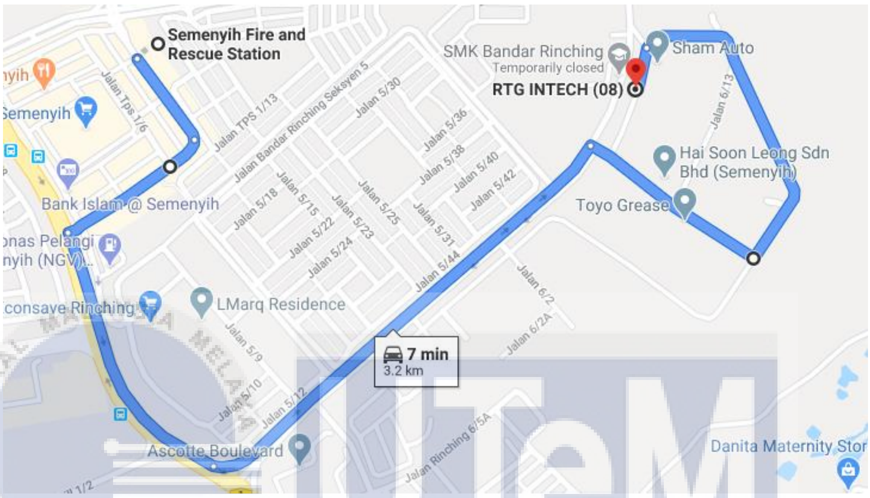

Figure 4.11: Expected time on google for Route C

In this part of analysis, the test is conduct on the same day but various of time. The test is conduct during morning, afternoon, evening and night. The time response and speed were being compared. The table below show the time response and average of speed.

Table 4.3: The Comparison between time conduct with time response and average speed

Time conduct	Time response	Average Speed (km/h)
Morning (9.57 am – 10.03 am)	5 min 10 sec	15.18
Afternoon (15.42pm -15.50 pm)	8 min 03 sec	10.22
Evening (18.37 pm – 18.48 pm)	9 min 08sec	10.37
Night (21.09 pm – 21.15 pm)	6 min 49 sec	15.15

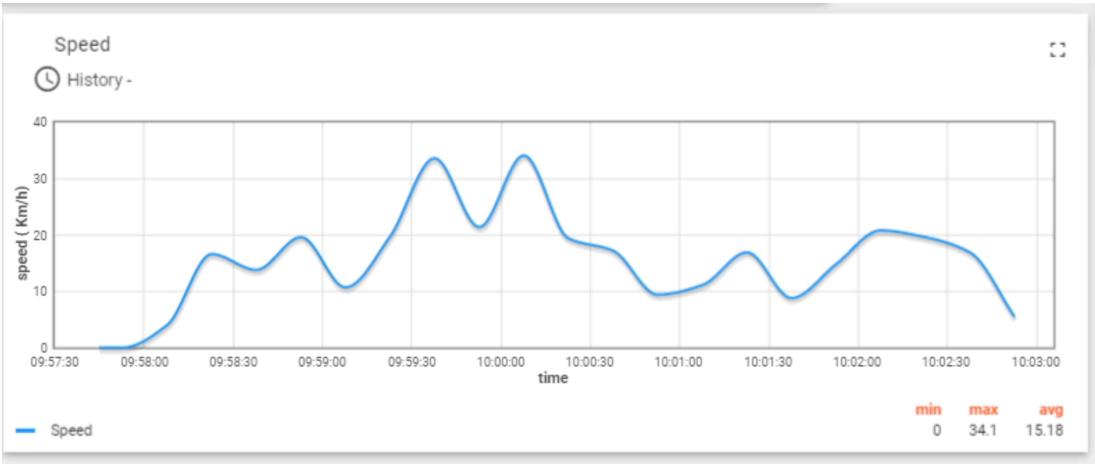

Figure 4.12: Speed taken in the morning

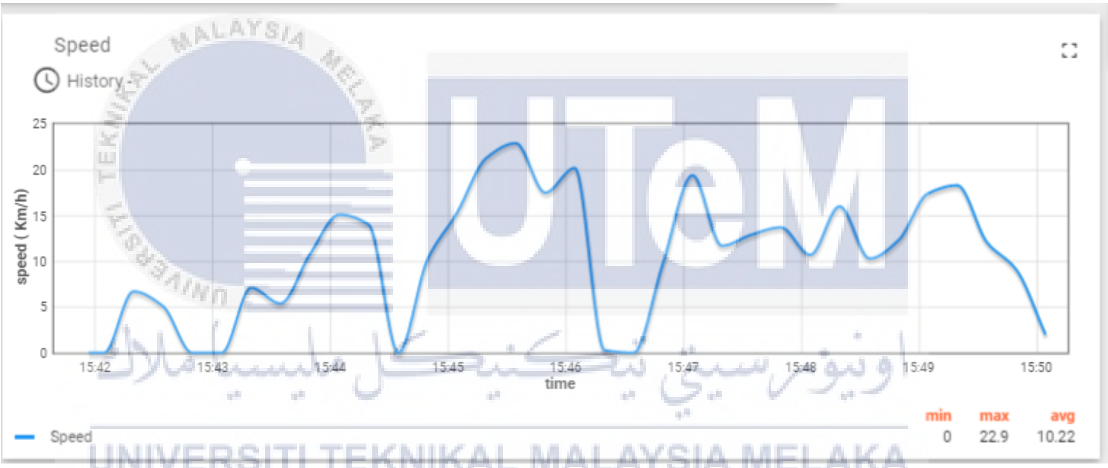

Figure 4.13: Speed taken in the afternoon

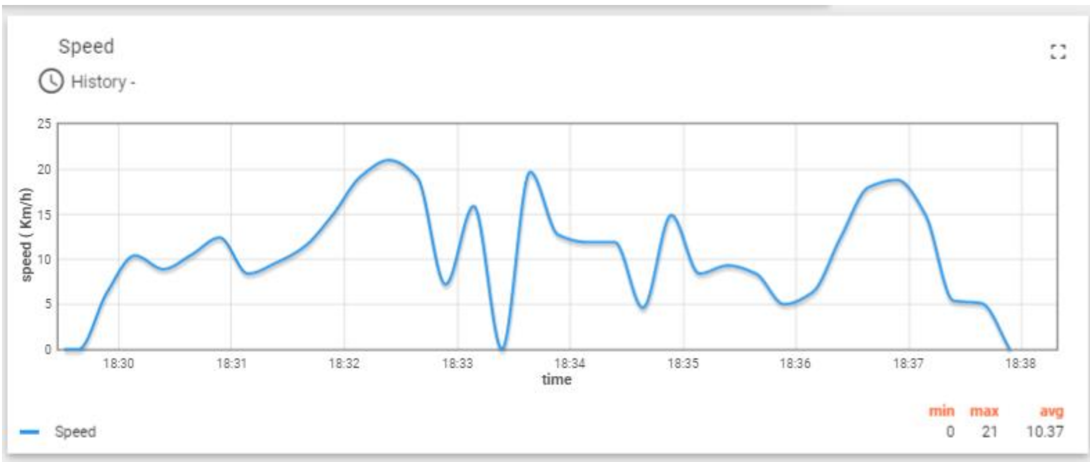

Figure 4.14: Speed taken in the evening

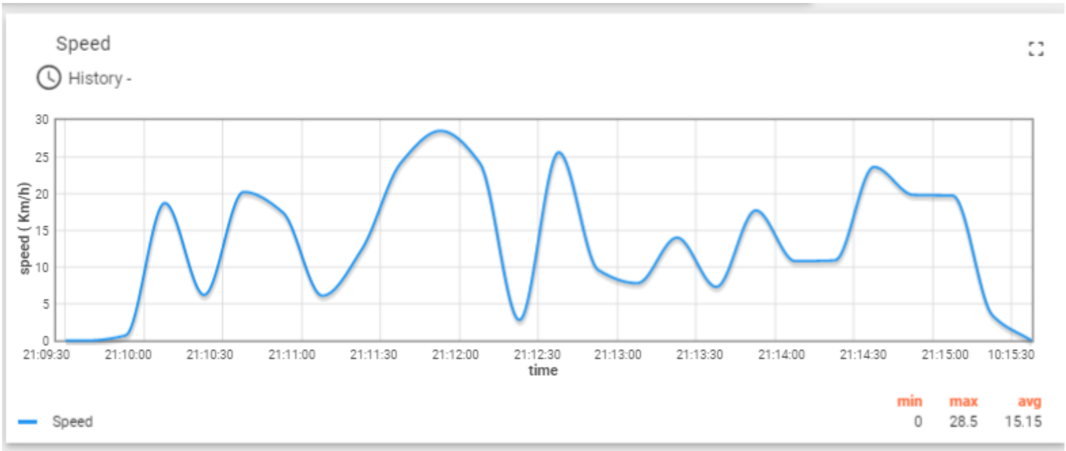

Figure 4.15: Speed taken in the night

From the table 4.3 show the comparison result between speed and time response in different time of the day. In the morning on 9.57 a.m. to 10.03 a.m. the time response acquired five minutes and ten second and for the vehicle to arrive to the location with the average speed of 15.18 km/h. While in the afternoon (15.42pm -15.50 pm), the time response was eight minute and three second with the average speed 10.22 km/h. During the evening (18.37 pm – 18.48 pm), the response time is eight minute and eight second while the average speed achieved at 10.37km/h. Lastly during the night around 21.09 p.m. to 21.15 p.m., the vehicle's achieved an average speed of 15.15 km/h resulting in a response time of 6 minutes 49 second. From the results taken, it can be seen that the time response during morning and night achieved faster result compared to the afternoon and evening. It is because the average speed taken during the morning and night is higher compared to the afternoon and evening. The higher average speed during the morning and night was possible due to the lack of vehicle on the main road, resulting in less traffic and a smoother journey.

From Figure 4.14 until Figure 4.15 show the graph result for speed taken by different time throughout the day. It can be seen that the graphs fluctuate throughout the drive, it is because of the several factors that affects the speed of the vehicle. Namely other cars slowing down, traffic light, bad road condition and speed bumps.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

This chapter provides conclusion of the overall project including discussion on the achievement of the objective and the overall working of the prototype. At the end of this chapter, a future recommendation is given to further improve on this project.

5.1 Conclusion

In this thesis, a vehicle tracking system that is flexible, customizable, and accurate was developed. The tracking system uses the SIM67000 4G module, an Arduino Nano and view the data on IoT dashboards. The Arduino Nano is the brain of the system and the SIM7600E-H 4G module is to enable data transmission over GPRS network, while the GPS provide the location data. Whenever GPS receives a new data it is updated in the ThingsBoard and hence able to see the real time location on the maps Using this system the base station can monitor the real position of the vehicle, the time response between distance completed by it and the speed vehicle use. This project also programed to send the signal quality data through ThingsBoard. To get a better idea how the signal is behaving and whether it gets affected by other factors it's a good idea to monitor the signal strength. Implementation of GPS tracker in emergency vehicle can certainly bring revolutionary change in Emergency Facilities. This project also can increase the Key performance indicator (KPI) for their team. Therefore, if this project can be commercial it may be help on others sector such as transportation or delivery purpose.

5.2 Recommendations.

There are several recommendations are listed to improve the designed and development of this tracking system. Firstly, the system can add several sensors on time response to further optimize and automate the system flow. Therefore, the delay time can be reduced. Next is by creating a personalized database such as MySQL for private use. When there is a private database for storage, the data received will be stored more securely compared to using ThingsBoard. Lastly this system can add new functionality such as detecting traffic light when going through a route. It will help base station to detect which routes is faster to take than compared to other routes.

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