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Vehicle Monitoring System with Geofencing Capability

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Abstract: Global Positioning System (GPS) is a technology used to determine the position of a specific object by using the concept of Global Navigation Satellite System (GNSS). The concept of geofencing is known as the technology that uses the GPS technology to design the boundary on a specific area where once the vehicle crosses the geofence area, it will trigger the system and send notifications either via email or SMS. One of the main purposes of GPS is to track the location of a device, object or vehicle and it can be displayed on the map. Currently, the technology of monitoring the location of the vehicle has not been implemented to a certain company. Therefore, this project presents the vehicle monitoring system with geofencing capability where the purpose of this project is to monitor the location of the vehicle especially for Universiti Tun Hussein Onn Malaysia (UTHM). Furthermore, this system provides a monitoring system on a real-time mode for the vehicle which also can be viewed on a smartphone. It also gives a notification once the vehicle is out of the geofence area. The component required for this system is Arduino Mega 2560 and FONA808 shield attached with GPS, GSM and Li-Po battery and the application needed to display the current location of the vehicle is Blynk App. Blynk App, will display information such as latitude, longitude and the map. The administrator of managing the vehicle is able to access the application via smartphone as long as there is internet connection. Practically, this system has been tested once the vehicle exits and enters the geofence area and the result shows the correct location of the vehicle together with email notifications.

Keywords: GPS, FONA808, GSM, geofencing, vehicle monitoring, Blynk App

1. Introduction

Many educational institutions in Malaysia have their vehicle to be used around campus. Most of the time, the vehicles are used to transport students and staff to attend various events around campus. Apart from that, staff are also provided with the university's vehicle to take care of business off-campus. However, these facilities are only available for students and staff of University Tun Hussein Onn Malaysia (UTHM). Therefore, this project aims to monitor the movement of university's vehicles by using the concept of geofencing. Geofencing is known as the boundary or the specific region in

**Corresponding author: hanif@uthm.edu.my* a geographical area [1]. The idea of this geofencing application is, once the vehicle enters or leaves the geofence boundary, it will send a notification via e-mail and Short Message Service (SMS) to the person in charge who handles the vehicles. Thus, the geographical boundaries are defined by using the Global Positioning System (GPS) [2]. This vehicle monitoring system uses an Arduino Mega 2560 and FONA808 breakout board which includes the Global System for Mobile Communication (GSM) and Global Positioning System (GPS) in the same board where it will monitor the current and initial positions of the vehicles. Therefore, once the car leaves the geofence boundary it will give notification through a mobile phone and will display the current location and position in real-time mode of the vehicle through a mobile application which is known as the Blynk App [3]. Through the application, all information such as latitude and longitude of the vehicle is stored in the Blynk App.

1.1 Problem Statement

Usually, the staff of Universiti Tun Hussein Onn Malaysia are able to utilize the university's vehicle to attend to work-related activities either in or off-campus. In other words, the person in charge has the authority to use the vehicle to go to any destination for job purpose. However, the university may have difficulties in monitoring the movement of the vehicle. Monitoring the vehicle should be done regularly to prevent staff from misusing the vehicle for their personal purpose. Nowadays, it becomes more challenging to monitor the vehicle because some of the university's vehicles still do not have the technology to track the movement of the car. This project will provide a solution by designing hardware where it can monitor the movement of the university's vehicle through the Blynk App on a smartphone.

2. Hardware and Software Configuration

2.1 System Design

The proposed system design consists of a hardware and software implementation part. As for the hardware part, it consists of components such as FONA808 shield attached with the GPS and GSM as well as Arduino Mega 2560. Meanwhile, for the software part, it used an IoT platform or also known as a cloud where the selected platform was Blynk App. In addition, this platform allows users to create and manages their own interfaces with widgets like button, displays, graph, maps and many more. This application can be accessed easily by installing it to the smartphone of the person in charge to monitor the vehicle's location.

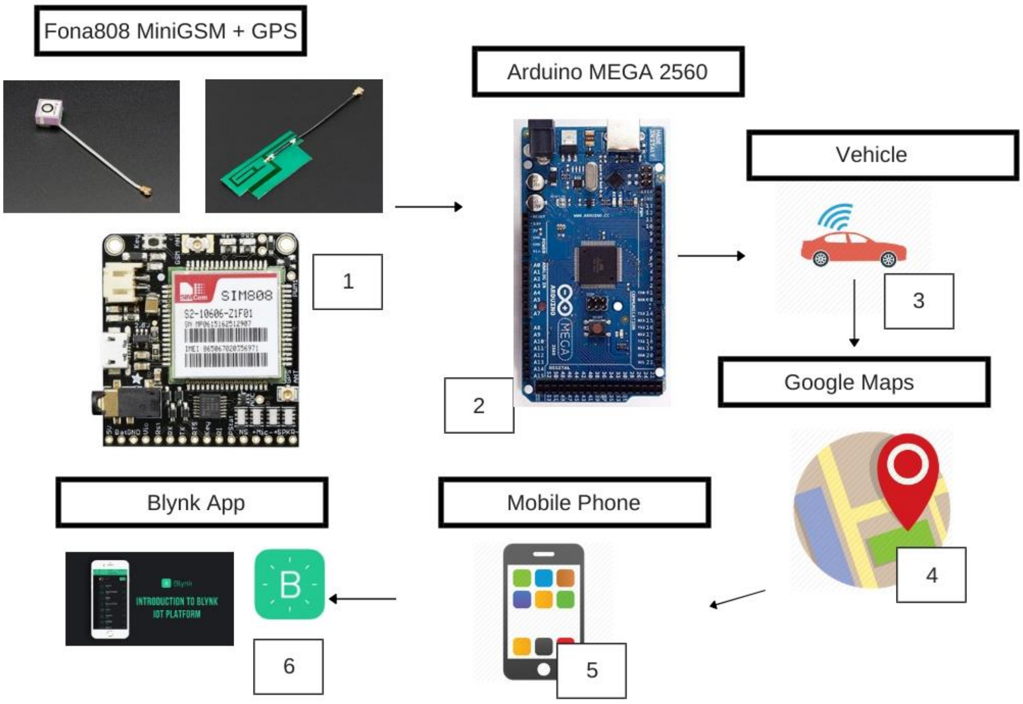


Fig. 1 - The project's workflow

Figure 1 shows the workflow of the project. First, the FONA808 MiniGSM and GPS is an all-in cellular module which contains a GSM antenna and GPS antenna. This module is used in this project to add a location-tracking and provide data and SMS for the system [4]. Secondly, the Arduino Mega 2560 microcontroller is used during the process of designing the circuit for the system and it will store the programming code which is transferred from the Arduino IDE software after the compilation of programming code is successful [5]. Thirdly, the vehicle is the main object that needs to be monitored and the monitoring system was installed inside the vehicle. Fourth, the web mapping used for this project is Google Maps [6] where its function is to display the current location including the latitude and longitude of the vehicle. Fifth, once the vehicle leaves the geofence boundary, the system will send a notification to the office or the person in charge through mobile phones. Finally, the Blynk App is used to display the current location including the latitude and longitude of the vehicle in a real-time mode as long as there is internet connection on the smartphone [7]. So, the data and information can be accessed by the admin from the office from time to time.

2.2 Circuit Design

In this project, there are only a few pins on the FONA808 shield that has been used. The selected pin was TX, RX, KEY, 5V and GND while the pins used from the Arduino Mega 2560 is 5V, GND, RX1 19 and TX1 18 as shown in Table 1. Besides, the GPS antenna, GSM antenna and Li-Po battery also attached to the FONA808 shield as shown in Figure 2. Furthermore, the communication protocol for this system has a baud rate which was 115200 b/s. It is because, the coding provided from the FONA808 library for GPS tracking was 115200 b/s. Overall, the system used 115200 b/s as the main default baud rate.

Table 1 - The hardware connection between Arduino Mega 2560 and FONA808

ARDUINO MEGA 2560	FONA808 SHIELD
GND	KEY
RX1 19	TX
TX1 18	RX
5V	5V
GND	GND

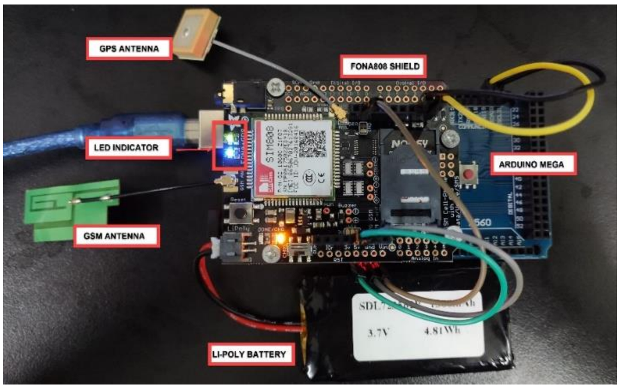


Fig. 2 - Project hardware connection

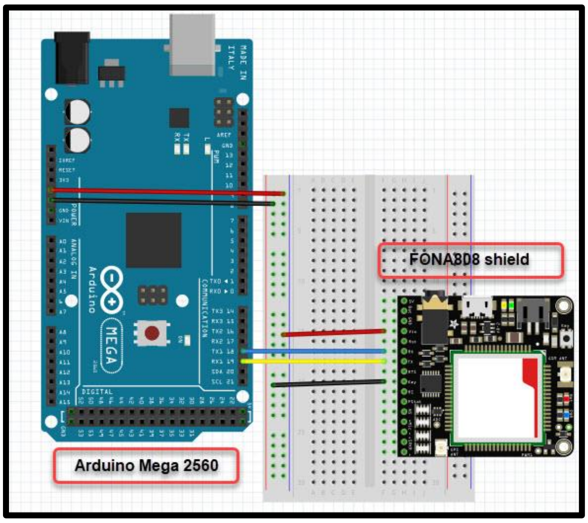


Fig. 3 - Project hardware connection

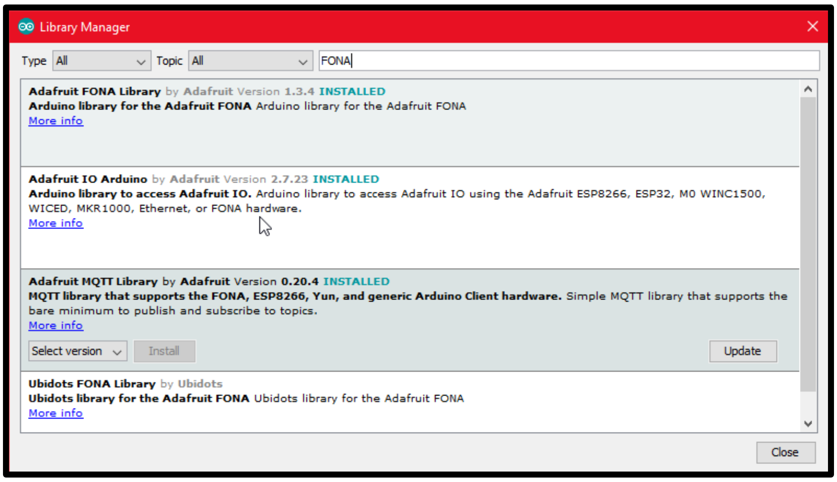
Moreover, the passive GPS antenna was used to provide detail location of the vehicle. This passive GPS antenna has a 1dBi gain and it has a smaller size which only has a 15mm x 15mm x 6.8mm and the length of the GPS includes the cable is 50mm. The design of the GPS antenna used a uFL connector on the cable makes it suitable for FONA808 shield which has the same type of connector.

Table 2 - Passive GPS antenna specifications

SPECIFICATIONS	DETAILS
Sensitivity	
1. Tracking	-165 dBm
2. Cold starts	-147 dBm
Time-To-First-Fix	
1. Cold starts	30s (typ.)
2. Hot starts	1s (typ.)
3. Warm starts	28s (typ.)
Accuracy	approx. 2.5 meters

2.3 Software Configurations

In this project, the hardware used to run the system which is the Arduino Mega 2560 and FONA808 shield. This module needs to be programmed via the Arduino Mega 2560 microcontroller to make it function and the additional library needs to be installed in the Arduino IDE software. Besides that, to install the additional library, the first step is to run the Arduino IDE software and from the software select Tools > Manage Libraries and the Library Manager will pop-up. After that, there are few libraries as shown in Figure 4 and Figure 5 are needed such as Adafruit FONA Library, Adafruit IO Arduino, Adafruit MQTT Library, Adafruit SleepyDog Library and Blynk. Thus, it is compulsory to install all the libraries needed so that the module can be programmed properly.



Library Manager

Type: All Topic: All FONA

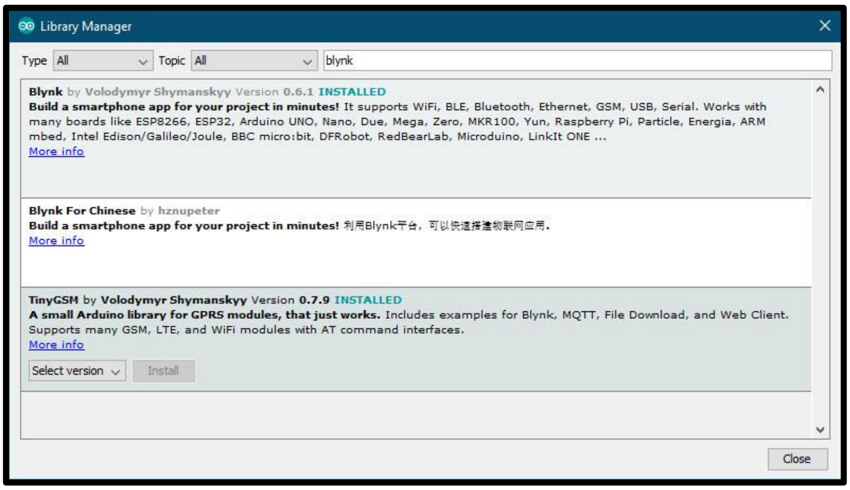
Adafruit FONA Library by Adafruit Version 1.3.4 INSTALLED
Arduino library for the Adafruit FONA Arduino library for the Adafruit FONA
More info

Adafruit IO Arduino by Adafruit Version 2.7.23 INSTALLED
Arduino library to access Adafruit IO. Arduino library to access Adafruit IO using the Adafruit ESP8266, ESP32, M0 WINC1500, WICED, MKR1000, Ethernet, or FONA hardware.
More info

Adafruit MQTT Library by **Adafruit** Version **0.20.4** INSTALLED
MQTT library that supports the FONA, ESP8266, Yun, and generic Arduino Client hardware. Simple MQTT library that supports the bare minimum to publish and subscribe to topics.
More info

Ubidots FONA Library by Ubidots
Ubidots library for the Adafruit FONA Ubidots library for the Adafruit FONA
More info

Fig. 4 - Libraries for the FONA808 shield



Library Manager

Type: All Topic: All blynk

Blynk by Volodymyr Shymanskyy Version 0.6.1 INSTALLED
Build a smartphone app for your project in minutes! It supports WiFi, BLE, Bluetooth, Ethernet, GSM, USB, Serial. Works with many boards like ESP8266, ESP32, Arduino UNO, Nano, Due, Mega, Zero, MKR100, Yun, Raspberry Pi, Particle, Energia, ARM mbed, Intel Edison/Galileo/Joule, BBC micro:bit, DFRobot, RedBearLab, Microduino, LinkIt ONE ...
More info

Blynk For Chinese by hznupeter
Build a smartphone app for your project in minutes! 利用Blynk平台，可以快速搭建物联网应用.
More info

TinyGSM by **Volodymyr Shymanskyy** Version **0.7.9** INSTALLED
A small Arduino library for GPRS modules, that just works. Includes examples for Blynk, MQTT, File Download, and Web Client. Supports many GSM, LTE, and WiFi modules with AT command interfaces.
More info

Fig. 5 - Library for Blynk

Figure 6 shows the flow on how to interface the Arduino Mega 2560 and FONA808 shield to the Blynk App. Firstly, the code for the Blynk App is typed by using the Arduino IDE software along with the token ID and the APN. After that, the code must be compiled to make sure to code does not contain any errors. Once the code successful, the code is uploaded to the microcontroller and the serial monitor is used to display the result of the code performance. Furthermore, when the serial monitor displays the microcontroller has been connected to the Blynk App, the user can open the Blynk App to make sure it is connected to the microcontroller. Meanwhile, if the microcontroller is not connected to the Blynk App, it is compulsory to check the program code and compile the code once again.

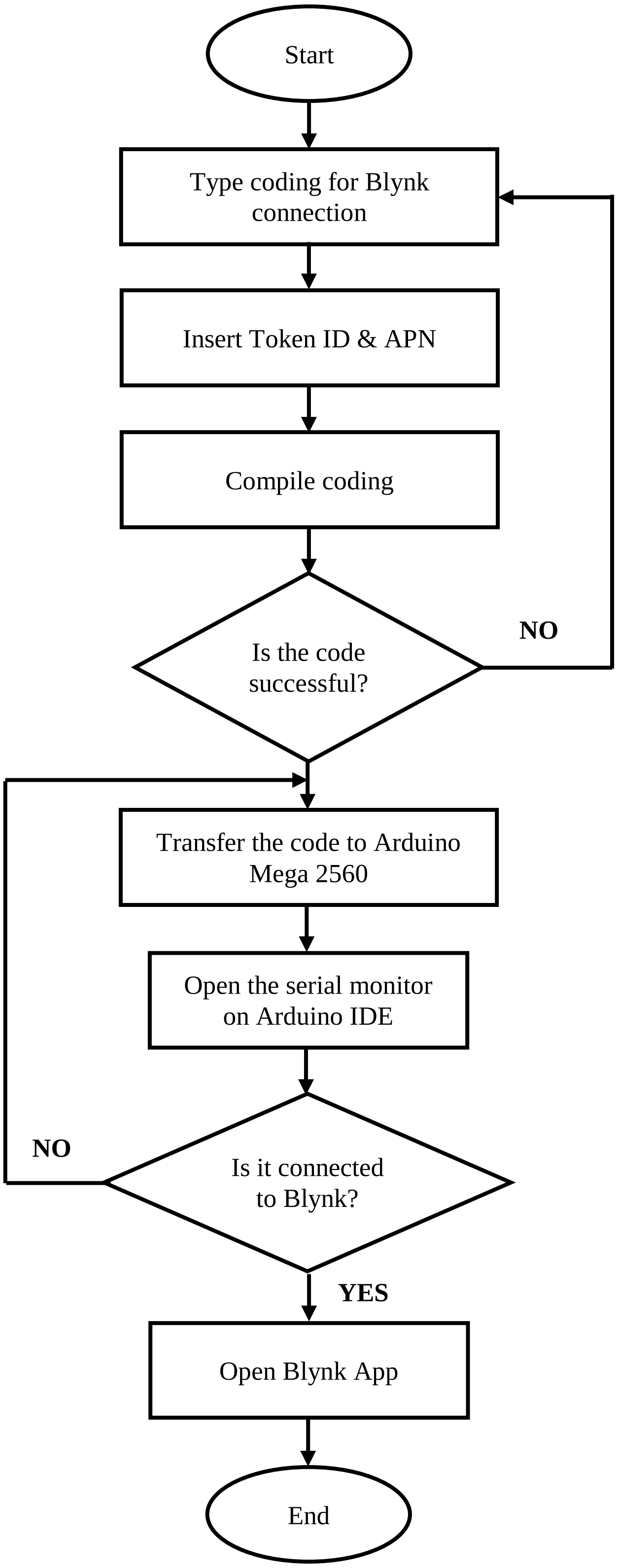

Start
Type coding for Blynk connection
Insert Token ID & APN
Compile coding
Is the code successful?
NO
Transfer the code to Arduino Mega 2560
Open the serial monitor on Arduino IDE
NO
Is it connected to Blynk?
YES
Open Blynk App
End

Fig. 6 - Flowchart of Blynk source code

2.4 Project Workflow

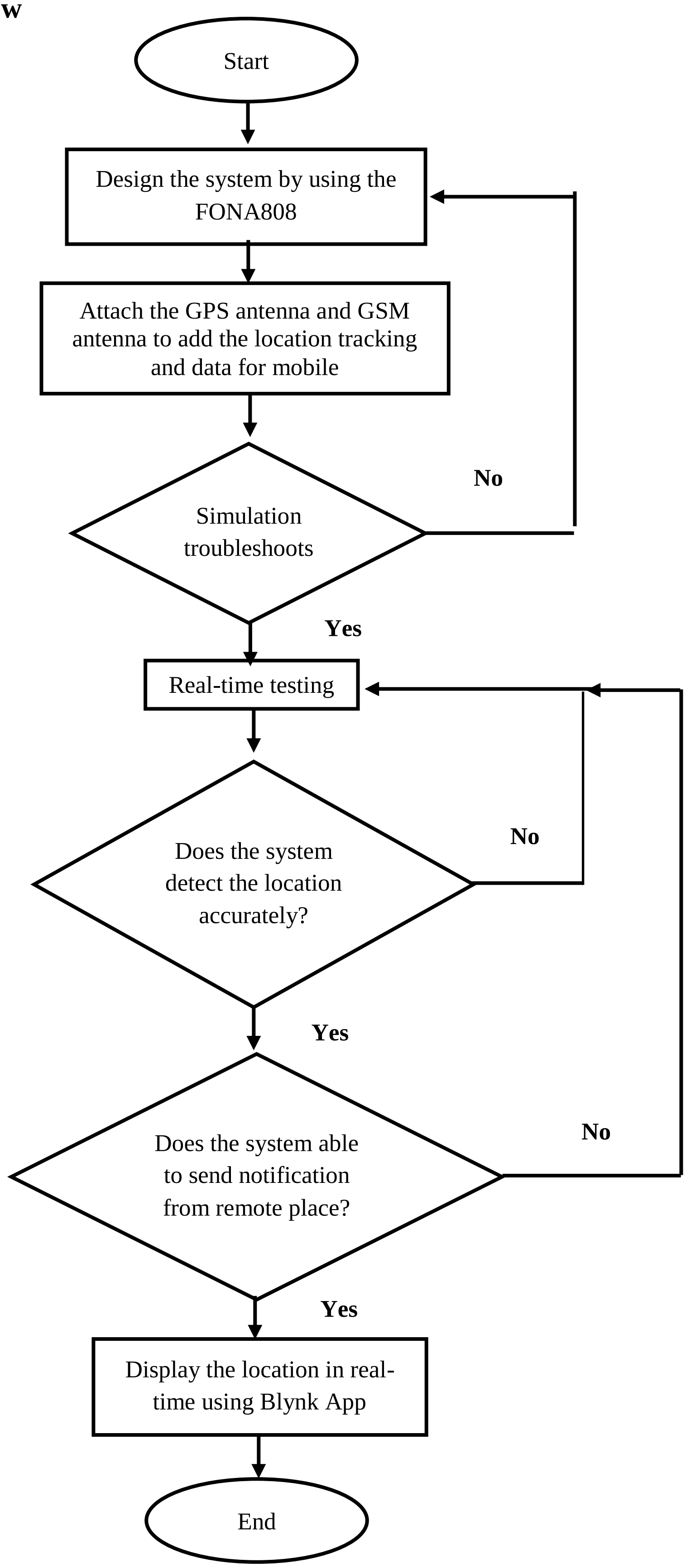

Start
Design the system by using the FONA808
Attach the GPS antenna and GSM antenna to add the location tracking and data for mobile
Simulation troubleshoots
No
Yes
Real-time testing
Does the system detect the location accurately?
No
Yes
Does the system able to send notification from remote place?
No
Yes
Display the location in real-time using Blynk App
End

Fig. 7 - The flowchart for design the project

Figure 7 shows the flowchart for the system design. Firstly, the system is designed by using the FONA808 shield with the GPS antenna and GSM antenna were attached to it. Next, if the simulation troubleshoots is not successful, it will return to the design system and if the simulation succeeds, it will direct to the real-time testing. After that, if the system is not able to detect the location and sends a notification for a remote place, it will go back to real-time testing and if it detects location accurately and sends a notification, the information is stored in the Blynk App. Thus, the Blynk App is an application on the smartphone where it has its own ability to develop a graphic interface for this project by using the widgets provided.

3. Result and Discussion

3.1 System Performance

The circuit designed between Arduino Mega 2560 and FONA808 shield is been tested by using the serial monitor on Arduino IDE to check either the system is able to obtain the data of latitude and longitude for the system. The purpose of this circuit design testing is to check the functionality of the system either it has a proper connection or not and it is also compulsory to compare the result obtained from serial monitor and real-time testing. Thus, during the testing, the software part which Arduino IDE must be included.

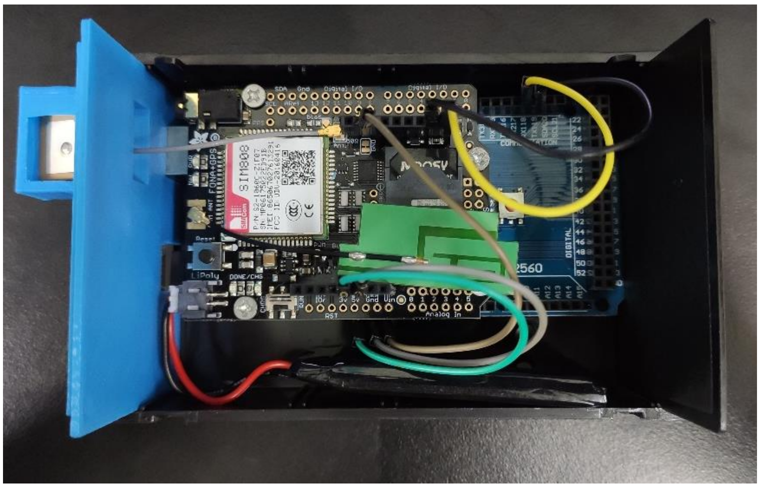


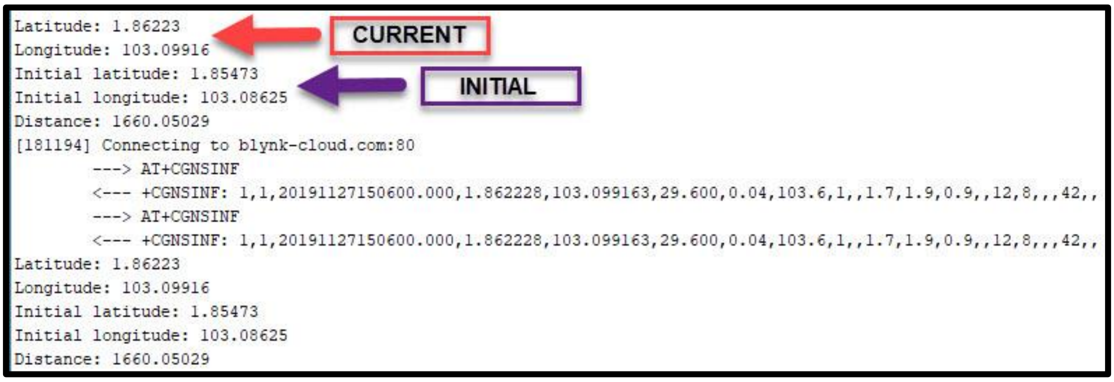
Fig. 8 - The prototype overview

Figure 8 shows the connection part between Arduino Mega 2560 and FONA808 shield. Besides, from the FONA808 shield, the yellow LED indicator shows the shield was turned on and running a program, meanwhile the blue LED indicator shows the network status where it has three different conditions as listed below:

Table 3 - FONA808 shield LED conditions

LED timing	LED conditions
64ms ON, 800ms OFF	The shield is currently running but has not made any connection to the network cellular.
64ms ON 3second OFF	The shield has made a connection to the network cellular so it can send and receive SMS and voice call.
64ms ON 300ms OFF	The GPRS data connection is activated.

Additionally, after the FONA808 has made a communication with the satellite, the network indicator will blink for 300ms and the GPS will receive a signal and the data will be transferred to the Arduino Mega 2560 microcontroller. Finally, the data of latitude and longitude will appear on the serial monitor as shown in Figure 9.

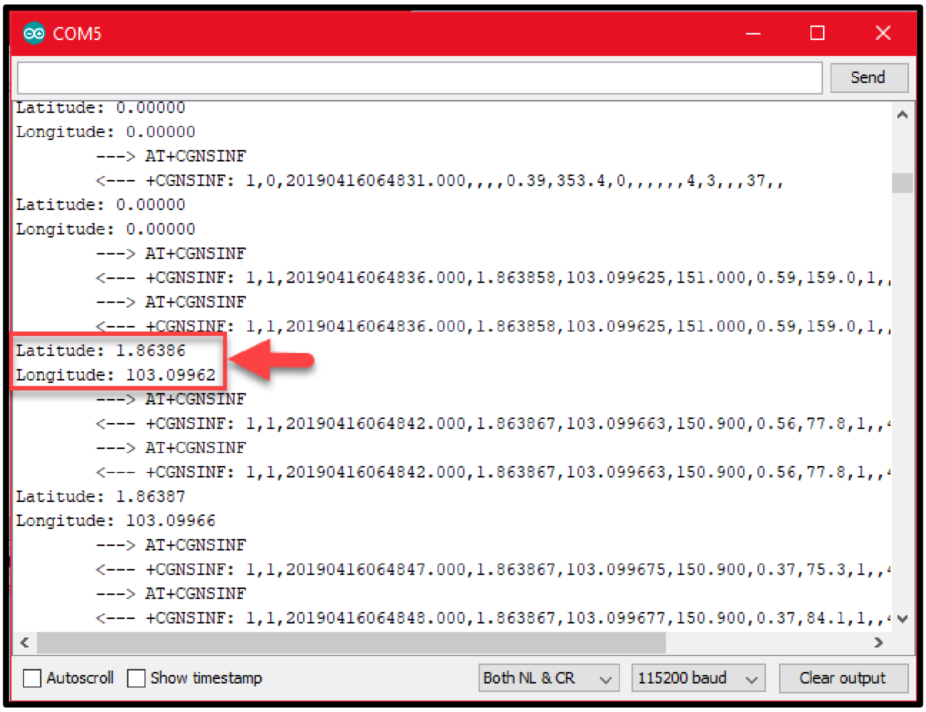


```
Latitude: 1.86223
Longitude: 103.09916
Initial latitude: 1.85473
Initial longitude: 103.08625
Distance: 1660.05029
[181194] Connecting to blynk-cloud.com:80
        ---> AT+CGNSINF
        <--- +CGNSINF: 1,1,20191127150600.000,1.862228,103.099163,29.600,0.04,103.6,1,,1.7,1.9,0.9,,12,8,,,42,,
        ---> AT+CGNSINF
        <--- +CGNSINF: 1,1,20191127150600.000,1.862228,103.099163,29.600,0.04,103.6,1,,1.7,1.9,0.9,,12,8,,,42,,
Latitude: 1.86223
Longitude: 103.09916
Initial latitude: 1.85473
Initial longitude: 103.08625
Distance: 1660.05029
```

Fig. 9 - Data obtained in serial monitor

3.2 Location detection

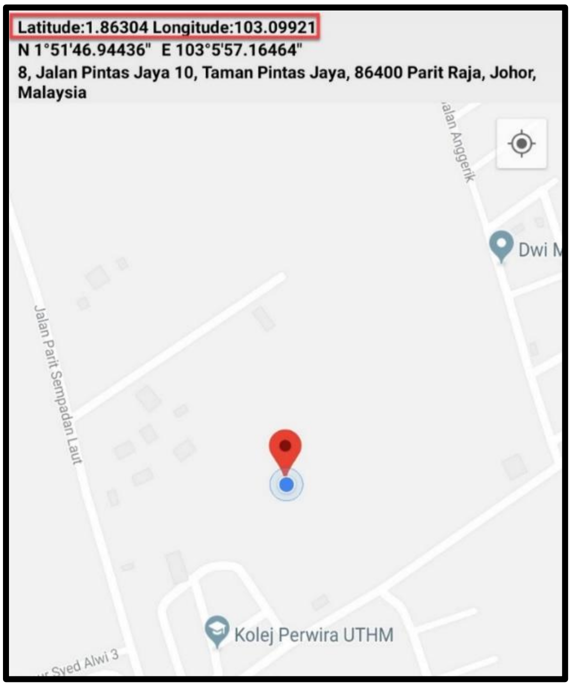
The circuit connection for the system between Arduino Mega 2560 and FONA808 shield which is attached to the GPS and GSM antenna were tested to make sure that the circuit connection is able to work efficiently. The serial monitor on the Arduino IDE shows current location of the devices is displayed. Based on Figure 10, it shows the latitude and the longitude location of the device. Hence, the signal on the serial monitor is displayed continuously when it has an active GPS receiver.



```
Latitude: 0.00000
Longitude: 0.00000
        ---> AT+CGNSINF
        <--- +CGNSINF: 1,0,20190416064831.000,,,,0.39,353.4,0,,,,,,4,3,,,37,,
Latitude: 0.00000
Longitude: 0.00000
        ---> AT+CGNSINF
        <--- +CGNSINF: 1,1,20190416064836.000,1.863858,103.099625,151.000,0.59,159.0,1,,
        ---> AT+CGNSINF
        <--- +CGNSINF: 1,1,20190416064836.000,1.863858,103.099625,151.000,0.59,159.0,1,,
Latitude: 1.86386
Longitude: 103.09962
        ---> AT+CGNSINF
        <--- +CGNSINF: 1,1,20190416064842.000,1.863867,103.099663,150.900,0.56,77.8,1,,
        ---> AT+CGNSINF
        <--- +CGNSINF: 1,1,20190416064842.000,1.863867,103.099663,150.900,0.56,77.8,1,,
Latitude: 1.86387
Longitude: 103.09966
        ---> AT+CGNSINF
        <--- +CGNSINF: 1,1,20190416064847.000,1.863867,103.099675,150.900,0.37,75.3,1,,
        ---> AT+CGNSINF
        <--- +CGNSINF: 1,1,20190416064848.000,1.863867,103.099677,150.900,0.37,84.1,1,,
```

Fig. 10 - The location of the device on the serial monitor

The result obtained for the longitude and latitude of the system device from the serial monitor by using the GPS antenna. Apart from that, to make sure the longitude and latitude of the location are correct, it can be proven by using the web mapping services which is Google Maps.



Latitude:1.86304 Longitude:103.09921

N 1°51'46.94436" E 103°5'57.16464"

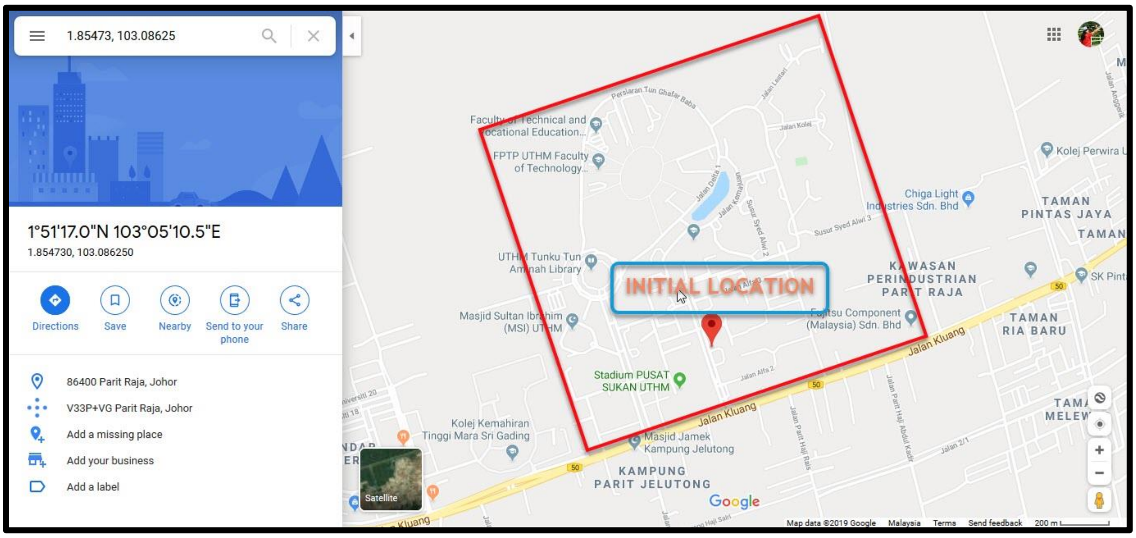
8, Jalan Pintas Jaya 10, Taman Pintas Jaya, 86400 Parit Raja, Johor, Malaysia

Fig. 11 - The location of the system device via mobile phone

Hence, the other method used to check the location of the system device is by using the application of GPS Coordinates via mobile phone. Figure 11 shows the location of the system device on the map of the GPS Coordinate application by running the application at the same time and besides the FONA808 shield. Thus, from both figures, it shows that the location of the system device in terms of latitude and longitude is almost the same which was (1.86304, 103.09921) respectively.

3.3 On-Site Results

The system was tested to examine the performance of the system in a real-time mode. Besides, during the testing, the system was connected to the USB adapter which connected to the cigarette lighter socket in the vehicle. Next, the hardware part especially the Arduino Mega 2560 and FONA808 shield were placed on the car dashboard to make sure the GPS antenna in the right position to get precise time synchronization with the satellite. The first point started near to Dewan Tunku Mahkota Ismail (DTMI), UTHM which has latitude (1.85473) and longitude (103.08625) which this location is in the geofence area as shown in Figure 12. Thus, from the first point, the vehicle will move around the geofence and proceed to the next location which is outside of the geofence area.



1.85473, 103.08625

1°51'17.0"N 103°05'10.5"E

1.854730, 103.086250

86400 Parit Raja, Johor

V33P+VG Parit Raja, Johor

Add a missing place

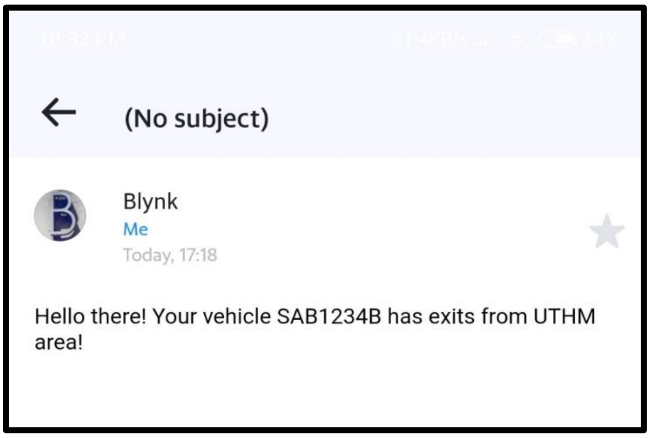
Add your business

Add a label

Directions
Save
Nearby
Send to your phone
Share
INITIAL LOCATION
Faculty of Technical and Vocational Education...
FPTP UTHM Faculty of Technology...
UTHM Tunku Tun Aminah Library
Masjid Sultan Ibrahim (MSI) UTHM
Stadium PUSAT SUKAN UTHM
Kolej Kemahiran Tinggi Mara Sri Gading
Masjid Jamek Kampung Jelutong
KAMPUNG PARIT JELUTONG
Chiga Light Industries Sdn. Bhd
KAWASAN PERINDUSTRIAN PARIT RAJA
Fujitsu Component (Malaysia) Sdn. Bhd
Kolej Perwira U
TAMAN PINTAS JAYA
TAMAN RIA BARU
TAMAN MELEW
SK Pint
Jalan Kluang
Satellite
Google
Map data ©2019 Google
Malaysia
Terms
Send feedback
200 m

Fig. 12 - Initial location for the geofencing

For the conditions, the vehicle moved out from the geofence area and headed towards Sri Gading for about 8.6km from the initial point. Once the vehicle is out of the geofence area, the system is triggered and the Blynk App send an email notification directly as shown in Figure 13. Furthermore, when the person-in-charge received the email notification, they can directly check the location of the vehicle on the Blynk App where the application displayed the current location of the vehicle as shown in Figure 14.

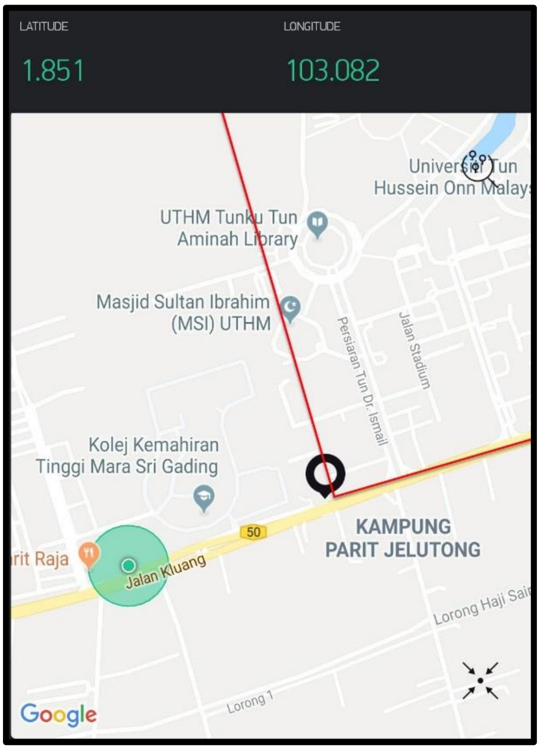


(No subject)

Blynk
Me
Today, 17:18

Hello there! Your vehicle SAB1234B has exits from UTHM area!

Fig. 13 - Email notification when the vehicle exits from UTHM area

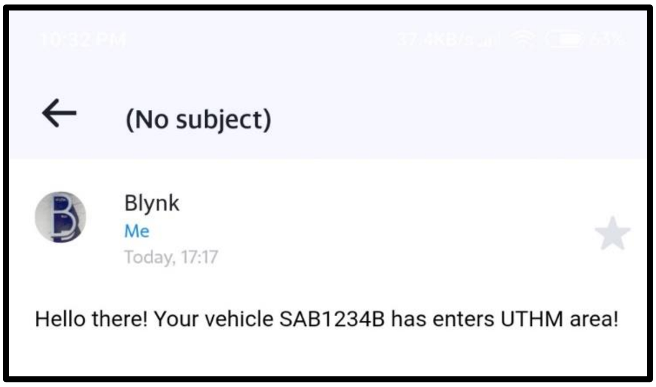


LATITUDE 1.851

LONGITUDE 103.082

Fig. 14 - The location of the system on the Blynk App

Next, the vehicle from Sri Gading moves towards the geofence area which is in UTHM area. Once the vehicle enters the geofence boundary, the system was triggered and the Blynk App sent an email notification directly as shown in Figure 15. Hence, when the person-in-charge received the email notification, they can directly check the location of the vehicle on the Blynk App where the application displayed the current location of the vehicle as shown in Figure 16.



(No subject)

Blynk
Me
Today, 17:17

Hello there! Your vehicle SAB1234B has enters UTHM area!

Fig. 15 - Email notification when the vehicle enters from UTHM area

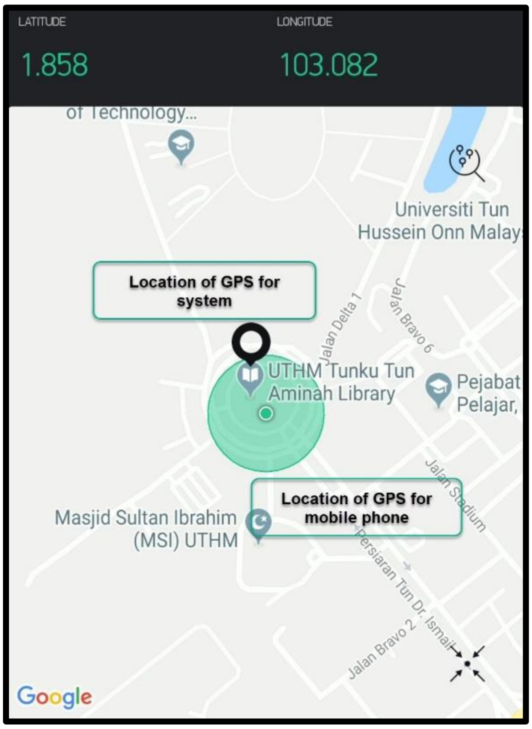

LATITUDE
1.858
LONGITUDE
103.082
of Technology...
Universiti Tun Hussein Onn Malay
Location of GPS for system
Jalan Delta 1
Jalan Bravo 6
UTHM Tunku Tun Aminah Library
Pejabat Pelajar,
Jalan Stadium
Location of GPS for mobile phone
Masjid Sultan Ibrahim (MSI) UTHM
Persiaran Tun Dr. Ismail
Jalan Bravo 2
Google

Fig. 16 - The location of the system on the Blynk App

4. Conclusion

As the project title stated, this project is focused on the Vehicle Monitoring System with Geofencing Capability. The Arduino IDE software was used to simulate the programming code and test the performance of the system by using the serial monitor provided in the Arduino IDE. Hence, the idea of making this project of the monitoring system is to monitor the movement of the vehicle especially in UTHM and the vehicle activities during working hour. Next, this monitoring system provides an accurate latitude and longitude location of the vehicle in the Blynk App where it is able to display the current location of the vehicle on the map widget in the Blynk App. Moreover, this system has been tested for months and the performance of this system produces an excellent result. The concept of geofencing has been implemented to this system where once the vehicle enters or exits the specific geofence area, a notification will be sent and it would be easier for the person-in-charge to check the current location of the vehicle by using the application of Blynk App which also part of the IoT platform that can be installed on the smartphone. Thus, the Vehicle Monitoring System with Geofencing Capability was built successfully.

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