SMART PUBLIC TRANSPORT SYSTEM WITH ROUTE OPTIMIZATION

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SMART PUBLIC TRANSPORT SYSTEM WITH ROUTE OPTIMIZATION

by

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This thesis is dedicated to everyone in the field of robotics with the internet of things research who embarks the journey of expanding the collection of knowledge and transcendent passion for continuous improvement in the internet of things.

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ABSTRACT

Nowadays, transportation is a necessity for urban area citizen. The most common travelling means for them are public transports such as bus. In public bus transportation system, there is a flaw of lack of real time information to the passengers. Buses are often delayed in urban area due to the traffic condition during peak hour. The delay and long waiting period are inefficient and time wasting for the travelers. The experience of the travelers can be improved if real time information of the bus system such as current location, estimate time arrival to the designated station and traffic condition are provided with easier access for the passengers. With the provided information, travelers will be able to find alternate choices for buses depending of the circumstances. A smart transportation system has been proposed where travelers able to obtain real time information of the buses with mobile phone application. In this present scenario, a Global Positioning System (GPS) based system is designed to identify the location of the bus and send it to a database store at Firebase Realtime Database via wireless network. The Google Maps API is used to get the optimized route and display on the map in the Smartphone application. Thus, users will be able to continuously monitor a moving vehicle on demand using the Smartphone application and determine the estimated distance and time for the vehicle to arrive at a given destination.

SISTEM PENGANGKUTAN AWAM PINTAR DENGAN PENGOPTIMUMAN LALUAN

ABSTRAK

Pada masa kini, pengangkutan adalah keperluan untuk warga bandar. Cara perjalanan yang paling biasa bagi mereka adalah pengangkutan awam seperti bas. Dalam sistem pengangkutan bas awam, terdapat kekurangan maklumat masa sebenar kepada para penumpang. Bas sering ditangguhkan di kawasan bandar disebabkan oleh keadaan lalu lintas pada waktu puncak. Masa tangguh dan menunggu lama tidak cekap dan membuang masa untuk pelancong. Pengalaman para pelancong dapat ditingkatkan jika maklumat masa nyata sistem bas seperti lokasi saat ini, perkiraan waktu ketibaan ke stesen yang ditetapkan dan kondisi lalu lintas disediakan dengan akses yang lebih mudah bagi para penumpang. Dengan maklumat yang disediakan, pengguna akan dapat mencari pilihan alternatif untuk bas bergantung kepada keadaan. Sistem pengangkutan pintar telah dicadangkan di mana pelancong dapat memperoleh maklumat masa sebenar bas dengan aplikasi telefon bimbit. Dalam senario ini, sistem berasaskan Sistem Penentudukan Global (GPS) direka untuk mengenal pasti lokasi bas dan menghantarnya ke kedai pangkalan data di Firebase Realtime Database melalui rangkaian tanpa wayar. API Peta Google digunakan untuk mendapatkan laluan yang dioptimumkan dan paparan di peta dalam aplikasi telefon pintar. Oleh itu, pengguna akan dapat memantau secara berterusan kenderaan yang bergerak mengikut permintaan menggunakan aplikasi Smartphone dan menentukan jarak dan masa yang dianggarkan untuk kenderaan itu tiba di destinasi tertentu.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Public transportation is one of the core components to support the growth sustainability of a city center. In Malaysia context, public transportation services in Klang Valley has been a major transportation system because of the rapid socio-economic development taking place in this area. In fact, the reduction of the dependence of motor vehicles is one of the key elements in the management of the urban environment [1]. According from a survey by students from Institute for Social Science Studies, University Putra Malaysia, among 445 youth respondents in Klang Valley, 99.1% of them use public transport and 66.8% of them agree that public transportation is important [1]. From Public Bus Level Of Service Performance In Peninsular Malaysia: Correlation Analyses On Level Of Service (Los) And Passengers' Satisfaction Level published in Planning Malaysia Journal, among 1130 respondents from Peninsular Malaysia, 60.4% of respondents are dissatisfied with current public bus service [2].The main important elements that influence customer satisfaction with public transportations are safety (34.3%) followed by accessibility (19.7%), reliability (17.3%), fares, communication and experience [3].

Public transit whether it is buses, trains, or ferries can be particularly frustrating for passengers. Although public transit is typically cheaper and greener than traveling by a private vehicle, public transit may not be as comfortable, convenient, or as quick as a private vehicle, passengers will have to plan their schedules around the public transit timetables, and unforeseen circumstances may disrupt public transit operations. However, public transit is starting to become more comfortable, districts are offering more benefits for passengers such as internet access. Further, Internet of Things (IoT) technology is now becoming more commonplace in public transit too. Smart connected public transportation systems will offer many benefits to passengers. This technology will further improve the passenger’s experience on public transit by offering real time vehicle tracking, notifications in the event of an unexpected events, and personalized travel news to passengers [4].

Before the IoT technology has introduce to transportation system, the user can only know the fixed route of the bus and time arrival of the bus. This result in lack of real-time information as there will be traffic condition on the route and caused the bus to delay. As excessive long waiting often discourages the travelers and makes them reluctant to take buses.

The aim of the project is to provide a platform for public bus riders to optimize their travel using real-time tracking system. With the advancements in technology, automated vehicle tracking systems (VTS) have become very prominent. The implementation details of a VTS that can display the vehicle position on Google maps, is presented in this paper. In this system, a Global Positioning System (GPS) module controlled by a Raspberry Pi 3 microcontroller will be used to transmit the real-time position to a cloud database, Firebase Realtime database using wireless network with built-in WIFI module at Raspberry Pi 3. The GPS module and the Raspberry Pi 3 microcontroller are placed inside a vehicle. The vehicle position is updated every 60 s as the vehicle is moving and will display on Android app. The system will show an optimized route to a destination for user without trapping in a serious traffic congestion. Thus, this system can increase efficiency, accessibility, and reliability.

1.2 Problem Statement

Vehicle tracking systems are used around the world in many fields such as vehicle position tracking systems, vehicle anti-theft tracking systems, fleet management systems, and intelligent transportation systems (ITS).

A real time vehicle tracking system proposed by Pradip V Mistary and R H Chile [5] based on ARM7 GPS and GSM technology to allow user to track their vehicle remotely through the mobile network. Their proposed system presents the raw data of the location of vehicle which are latitude and longitude in a Graphical User Interface (GUI) developed by using MATLAB and then show the location on Google Earth. Their system tracked the vehicle in a fixed period and show on the Google Earth after the vehicle has stopped. This system is not efficient as it presents the data in offline mode or known as non-real-time system.

Another system proposed by Vincent T.F. Chow, et al. which is Utilizing Real-Time Travel Information, Mobile Applications and Wearable Devices for Smart Public Transportation [6]. This system can retrieve the required data automatically, reporting real-time public transportation information and providing users with personalized recommendations for using public transits. However, there is a limitation of this approach is that the user may be unable to catch the bus even if the walking time is less than the ETA. There are multiple sources of uncertainty related to this issue. First, the intended vehicle may arrive earlier than expected due to the inaccuracy of ETA provided by the public transportation service provider. Second, GPS may not be accurate enough to locate the user (especially in the area surrounded by tall buildings). Third, the user may slow down / stop when walking to the suggested bus stop (e.g., due to traffic lights). This limitation can be overcome with a route optimization system for the user to have an alternative path to reach the bus station.

P. Jyothi and G. Harish had proposed a similar project as real time vehicle monitoring, tracking and controlling system [7]. The proposed system would place inside the vehicle whose position is to be determined on the web page and monitored at real time. If the driver drives the vehicle on the wrong path, then the alert message will be sent from the proposed system to the vehicle's owner mobile and speakers alert driven using driver. If the vehicle's speed goes beyond the specified value of the speed, then also the warning message will be sent from system to the owner mobile. Their system provides an important role in a smart transportation system, however, the system lack of the functionality to visualize the data better for the user such as real time location shown in map at a mobile application or website.

In summary, the current proposed intelligent transportation systems have their own limitations such as present data in offline mode and unable to display an optimized route.

1.3 Objectives

Based on above mentioned problem, the objectives of this project are:

1. To develop a smart public transport solution with real-time tracking system.
2. To develop a route optimization system with IoT.

1.4 Project Scope

A Smart Transportation System with Route Optimization is proposed to track the bus location and able to suggest an alternative path and present the data on map with mobile application. In this project, the vehicle tracking system will implement in a vehicle instead of bus to proof the functionality and accuracy of GPS module and to show the ability of Android application to display the real-time location of vehicle as well as optimized route to a destination or waypoints. In this project, we will focus on the development of Firebase Realtime database instead of the server development. Route optimization is designed with Google Map API which provides several parameters that comes together with the data of traffic condition. The implementation of Google Map API will be focused in this project rather than the collection of traffic condition data of several geological area.

1.5 Thesis Outline

This thesis consists of five chapters which to describe and explain the project in detail.

Chapter 1 will start a brief explanation on the research background, followed by problem statement, research objectives and finally the research scope.

Chapter 2 presents the literature review about this project. The previous work of vehicle tracking system, IoT architecture and route optimization are studied and explained in detail in this chapter. The advantages and disadvantages of the previous work will be discussed also.

Chapter 3 focuses on the methodology to develop system for vehicle tracking system and Internet of Things architecture. It includes the development of data acquisition from GPS module, Internet of Things protocol, database development, and data visualization on mobile application with Android.

Chapter 4 presents the results and discussions for this project. This chapter shows result of testing the accuracy of GPS, latency of Firebase Realtime database, real-time vehicle tracking system, and testing the Android application to show the optimize route.

Finally, Chapter 5 presents the conclusion of this project. Summary of the project implementation is included. The limitation of Internet of Thing and Raspberry Pi 3 is commented and provide suggestion for future improvement or development.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter covers the study, analysis and interpretation of previous work, relevant fundamental theories and concept about this project. Besides that, drawbacks and advantages of previous works will be discussed in this chapter. Section 2.2 discusses the existing smart transportation system with vehicle tracking system and Internet of Things architecture. Section 2.3 discuss the study of route optimization and previous work done.

2.2 Smart Transportation System

With the advent of Internet of Things, transportation system in the world has approaching the direction of smart or intelligent. Shiv. H. Sutar, et al. proposed Integration of Smart Phone and IoT for development of Smart Public Transportation System [8]. They suggested that Hardware approaches to Intelligent Transportation System are too dependent on the quality of the sensors and the micro controllers used. Moreover, flexibility of such approaches is also less along with the complexity involved in the bundling together of the various components into a single hardware framework. They propose a simple Android and IoT based approach which can provide dynamic bus tracking information to the bus-stops as well as the commuters in an efficient manner.

An Internet-of-Things Enabled Connected Navigation System for Urban Bus Riders has been proposed by Marcus Handte, et al. [9]. They show how the idea of the IoT can be applied to improve the experience of public bus usage and present the Urban Bus Navigator (UBN), a personalized bus navigation system with the ability to seamlessly interconnect bus passengers with the real-world public bus infrastructure. In their system, they implement Crowd-aware route recommendation collects and predicts crowd levels on bus journeys to suggest better and less crowded routes to bus riders. They also provide an IoT-based distributed software and hardware system that connects bus riders' mobile devices with bus vehicles using short-range WiFi communication.

A smart city contains various domains such as waste management, transportation system etc. This paper discusses about existing smart transportation and smart city architectures and compare them with respect to various parameters. Comparison can help in building robust and generic software architecture for transportation domain of smart city. Pooja Parmar has proposed a Study and Comparison of Transportation System Architectures for Smart City [10]. He found that the main concept of the smart transportation is to get the right information at the right place and on right device to make the transport related decision in a bold manner and to facilitate the citizens need in more quick and fast means [11]. In his research, he discussed various architectures for smart transportation. These architectures are addressing various functions like parking, traffic, traffic data communication, shared vehicles, navigation, energy management etc.

Table 2. 1 Comparison between Smart Transportation Architectures [10]

	Aim	**Principle**	**Challengers Addressed**	**Functionality**
Transportation architecture for multi-station shared vehicle	Provide efficient, user-friendly and manageable shared multi-station vehicle system to the user	Client-server architecture	Design and modify the system	Vehicle usage
Efficient Graph-Oriented Smart Transportation using Internet of Things generated Big Data	To provide real-time provision of services and infrastructure.	Cloud computing/Big data	Managing, storing, processing, and analyzing the data for intelligent decision.	Navigation
A Cloud-Based Intelligent Car Parking Services For Smart Cities	To find, allocate, reserve, and provide the 'best' car parking lot for each individual user/driver.	Cloud computing	To Store and manage data and notify user as he come within the predefined range	Parking
Transportation - Cyber Physical System(TCPS)	Tight conjoining of and coordination between cyber and physical resources	SOA	Connect the cyber and physical components	General transportation

Transportation system architecture for traffic jam based on SOA	To reuse the architectural styles and patterns, which express a fundamental structural organization of software systems and its behavior.	SOA	Measure cohesion for each distinct service.	Traffic jam
Designing a Smart City Internet of Things Platform with Microservice Architecture	To build robust architectures that are highly available, scale on demand, and evolve over time.	SOA	Scalability, evolvability, and maintainability of large-scale distributed systems	Energy management

In summary of all the proposed solution above, it is clear that Smart Transportation System is a combination of vehicle tracking system with Internet of Things Architecture.

2.2.1 Vehicle Tracking System

Vehicle tracking systems were first implemented for the shipping industry because people wanted to know where each vehicle was at any given time. These days, however, with technology growing at a fast pace, automated vehicle tracking system is being used in a variety of ways to track and display vehicle locations in real-time. Normally a vehicle tracking system involve the use of GPS module. SeokJu Lee, et al. proposed a Design and Implementation of Vehicle Tracking System Using

GPS/GSM/GPRS Technology and Smartphone Application [12]. Their system able to track the exact location of a moving or stationary vehicle in real-time. In the system of vehicle tracking normally include a server to store the database and an application to display the vehicle location on Google Maps. They used GPRS and GSM to transmit the data from GPS module to a microcontroller then into the server that store the database. On the other end, the web interface written in PHP is implemented to directly connect to a database. A vehicle's geographic coordinates and a vehicle’s unique ID obtained from an in-vehicle device are recorded in a database table. And a Smartphone application has been created to display a vehicle location on Google maps.

Similar system has done by Prashant A. Shinde, et al. with their Real Time Vehicle Monitoring and Tracking System based on Embedded Linux board and Android Application [13]. They extracted and separated the data from the GPS module which output the NMEA message structure of $GNRMC into coordinates and speed of the vehicle. Their system shows the tracking position of the vehicle on webpage developed by using HTML, and PHP.

There are several platforms that can be used for vehicle tracking system. Dhiraj Sunehra proposed a Real Time Vehicle Tracking on Google Maps using Raspberry Pi Web Server [14]. An Arduino is used to read and send the GPS values to the web server which in this project, Raspberry Pi will act as a server for testing environment or for storing files. A WIFI router is used to access the internet for Raspberry Pi. Extra Putty is used to communicate with the server. PHP is used to write the web programs to display the vehicle position on Google maps.

Vehicle Tracking System is a system where it needs to provide exact and efficient information to users. This is a well-known fact that the information can be generated through related and valid data. The need is to handle the received data carefully so that the users could get relevant and exact information. Rajeev Kumar and Harish Kumar has done a research on the Availability and handling of data received through GPS device: In tracking a vehicle [15]. By using a Vehicle Tracking System, the raw data can be extracted through devices mounted on vehicles, analyzed and formatted for making further conclusions related with tracking. They proposed a solution to modify the information fetched by GPS device and initial format of raw data according user demand and usage.

2.2.2 Internet of Things Architecture

The Internet of Things (IoT) refers to the network of objects, devices, machines, vehicles, buildings, and other physical systems with embedded sensing, computing, and communication capabilities, that sense and share real-time information about the physical world. When connecting the IoT to the Cloud, vast amounts of data collected from multiple locations can be processed and analyzed to create meaningful information for the end users. At the same time, the intrinsic limitations of lightweight mobile devices (e.g., battery life, processing power, storage capacity) can be alleviated by taking advantage of the extensive resources in the Cloud. Marc Barcelo et al. has done a research on IoT-Cloud Service Optimization in Next Generation Smart Environments [16]. Their work shows that the main advantages of IoT-Cloud are:

- Low Latency.
- High Reliability.
- Reduced Operational Cost.
- High Flexibility
- Location Awareness and Mobility Support

- Scalability

IoT-Cloud networks hence emerge as an ideal platform for the implementation of IoT services in the context of a wide range of smart environments, such as smart grids, smart mobility, smart buildings, and smart cities. In smart mobility services, the analysis of data collected at the edge of the network can significantly increase responsiveness to sudden events, such as vehicle collisions, improving the efficiency and safety of transportation networks. In smart buildings, while centralized cloud resources can be used for complex data analysis, edge cloud nodes are ideally suited for low-latency real-time physical system control and actuation [16].

In order to choose a Cloud platform for IoT system, a comparison of existing Cloud platform has been made. Lindita Nebiu Hyseni and Afërdita Ibrahimi compares the cloud computing platforms provided by Amazon and Google [17]. Their result is as shown as below.

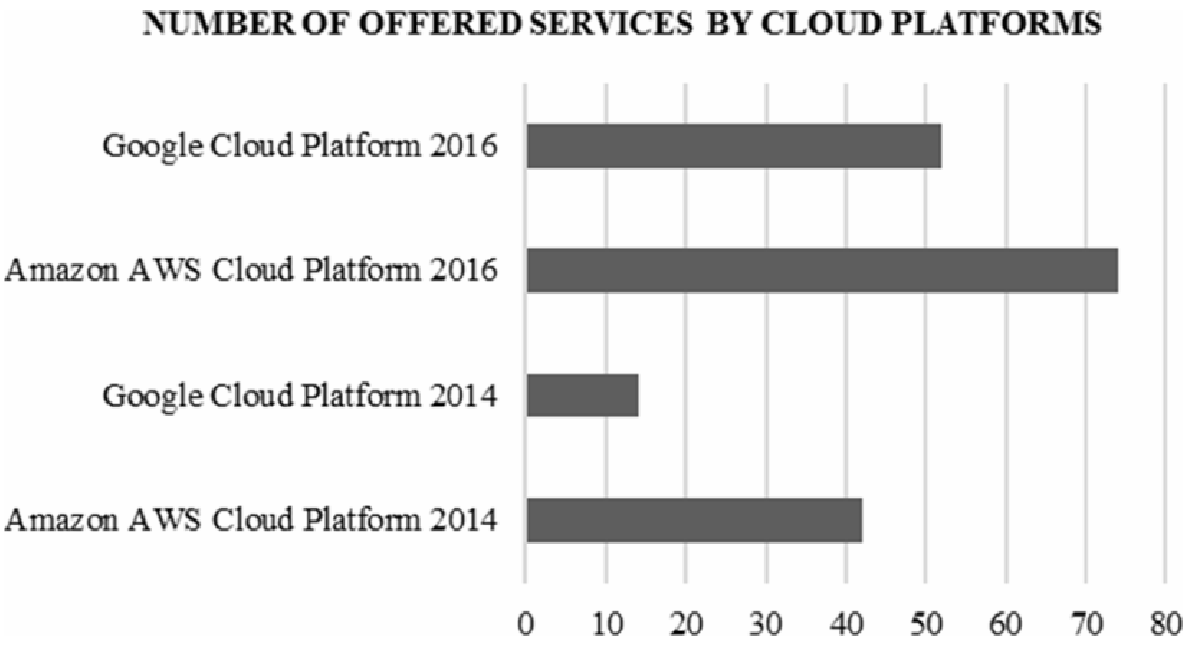

Figure 2. 1 Comparison of Amazon and Google Cloud Platform [17]

Their result shows that Amazon provides more services than Google, but Google has a better pricing as it is scalable depends on the user system.

Robayet Nasim, et al. proposed a solution of Mobile Publish/Subscribe System for Intelligent Transport Systems over a Cloud Environment [18]. In order to implement IoT in transportation system, the application need to process a large amount of real time data. However, deploying such applications in a large-scale environment requires scalable and flexible communication models in order to link the information among providers and consumers. They suggested Publish/Subscribe (Pub/Sub) systems which is perfectly suitable for developing large-scale applications within Smart Transportation System.

2.3 Study of Route Optimization

Vehicle Route Optimization (VRO) is one of most important topic now-a-days. Vehicle Routing Problem (VRP) is to find a path in a group of cities such that the length of path of all cities connected is minimized. There are several algorithms to solve the problem. Sri Suryani Prasetiyowati, et al. made a research on route optimization system based on passenger occupancy prediction [19]. Their system consists of several steps such as select a route, make a path from the crowded points, calculate the length of path by using Google Maps API, generate points for the locations in path and display the points on Google Map. They use Kriging Method to predict the occupancy of passenger.

Koh Song Sang, et al. has done a Study of Group Route Optimization for IoT Enabled Urban Transportation Network. Instead of optimizing the routing path for individual drivers, they study how to develop a new method to provide new routing method based on vehicles' similarities in a specific urban's transportation environment. They proposed the algorithm which affect by the traffic data such as road condition, weather condition and number of vehicle on the route. Another feature is highlighted to justify the traffic condition which is average waiting time of vehicles to determine the presents of traffic congestion situation [20].

Ying Zhu from Georgia State University introduced her experience of using Google Chart Tools and Google Maps in a data visualization. Google Maps API is a set of JavaScript classes that let users customize and embed Google Maps in their webpages. For example, users can place markers on Google Maps to visualize data points associated with geolocations. Users can also create customized directions.

Users can make spatial queries when combining Google Maps API with Google Fusion Tables. That is, through Google Maps API, users can submit a geolocation and radius to a Fusion Table. The table will then return all the data points in that region, which can be displayed on the map [22].

2.4 Summary

From all the researchers review on the vehicle tracking system, Internet of Things, and route optimization, there are a lot of researches on vehicle tracking system. A smartphone application is best to visualize the location of a vehicle. However, the vehicle tracking need to be in real-time. Internet of Things architecture will be implemented in the system. From the research, Google Cloud Platform provide the best service for Internet of Things architecture. With Google Cloud Platform, the vehicle tracking system can obtained location information and displayed on the smartphone application in real-time. For route optimization feature, Google Maps API is utilized to create an optimized route. Google Cloud Platform provide the API services that are needed to implement route optimization with Google Maps API.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will explain and highlight the overall project development process in detail. The overall project development process will be divided into 4 stages which are real-time tracking, data import and export, database development, route optimization, Android app development, testing and evaluation. This project consists of both software and hardware implementation. Software part is the development of Internet of Things architecture which includes database development, route optimization and Android app development. For the hardware part, it shows the communication between GPS module and Raspberry Pi 3. This chapter describes the overview of project implementation which explains the overview of all the stages.

3.2 Project requirement

3.2.1 Hardware

Throughout the project, a microcomputer/ microcontroller with Wi-Fi module is used to allow the controller to connect with cloud server via wireless network. Raspberry Pi 3 is used as the interface to receive data from GPS module and send it to Google cloud server via wireless network. Raspberry Pi 3 is a microcomputer with built-in Wi-Fi module. Besides, a Debian distribution of Linux OS is used in Raspberry Pi to ease the process of development. Raspberry Pi 3 consist of GPIO pin which allows us to interface the GPS module using serial communication. Figure 3.1 shows the GPIO pin of Raspberry Pi 3.

		Physical Pins			
GPIO#	2nd func	pin#	pin#	2nd func	GPIO#
N/A	+3V3	1	2	+5V	N/A
GPIO2	SDA1 (I2C)	3	4	+5V	N/A
GPIO3	SCL1 (I2C)	5	6	GND	N/A
GPIO4	GCLK	7	8	TXD0 (UART)	GPIO14
N/A	GND	9	10	RXD0 (UART)	GPIO15
GPIO17	GEN0	11	12	GEN1	GPIO18
GPIO27	GEN2	13	14	GND	N/A
GPIO22	GEN3	15	16	GEN4	GPIO23
N/A	+3V3	17	18	GEN5	GPIO24
GPIO10	MOSI (SPI)	19	20	GND	N/A
GPIO9	MISO (SPI)	21	22	GEN6	GPIO25
GPIO11	SCLK (SPI)	23	24	CE0_N (SPI)	GPIO8
N/A	GND	25	26	CE1_N (SPI)	GPIO7
EEPROM	ID_SD	27	28	ID_SC	EEPROM
GPIO5	N/A	29	30	GND	N/A
GPIO6	N/A	31	32	-	GPIO12
GPIO13	N/A	33	34	GND	N/A
GPIO19	N/A	35	36	N/A	GPIO16
GPIO26	N/A	37	38	N/A	GPIO20
N/A	GND	39	40	N/A	GPIO21

Figure 3. 1 GPIO of Raspberry Pi 3

SKM 53 GPS module is used to obtain the coordinate of the vehicle. Power for SKM 53 GPS module is supply from 5V of UART pin. UART communication is used to interface this GPS module to microcontroller. This SKM53 Series is embedded with GPS antenna which enables high performance navigation in the most stringent applications and solid fix even in harsh GPS visibility environments. Figure 3.2 shows the SKM 53 GPS module used in this project.

Figure 3. 2 SKM 53 GPS Module

Android phone is used in this project as data visualization management tool. Location of vehicle will be shown in Google Map that is included in the mobile application. A Xiaomi 10000mah portable power-bank is used as the power source for the Raspberry Pi 3 board.

3.2.2 Software

In this project, Raspbian Jessie OS is used as the Operating system for Raspberry Pi 3. Raspbian Jessie is built-in with SSH which allows PuTTY terminal to use SSH remote access Raspberry Pi to program the GPIO pin. Putty is used to initiate Raspberry Pi GUI and view on another computer. PuTTY is a software tool used to remote access Raspberry Pi board, by entering the IP address of the board. It supports several network protocols, Secure Copy (SCP), Secure Shell (SSH), Telnet, rlogin, and raw socket connection. In this project, SSH is used to connect the Raspberry Pi 3 board to a personal laptop. The laptop and Raspberry Pi must connect to the same wireless network and the IP address of Raspberry Pi 3 is needed to initialize in PuTTY to enter the terminal of Raspberry Pi 3 board. Python libraries are used to allow interfacing with GPIO pin and remotely connect Firebase Realtime Database. Android Studio is used to develop mobile application. Android Studio is the official integrated development environment for Google's Android operating system.

3.3 Internet of Things Architecture

The Internet of Things architecture of this system consists of three-layer high level architecture. This architecture consists of three layers which are Perception Layer, Network Layer, and Application layer. Perception Layer is based on the sensing technology in this project, GPS module. Raspberry Pi 3 as microcontroller takes part in this layer with the role of parsing the GPS information to get the required information only which are more convenient for network transmission with minimum data size. Network Layer is serves as a back-end tool that responsible to transmit data to application layer through wireless network with Hypertext Transfer Protocol (HTTP). To store the data transmitted, a cloud-hosted database, Firebase Realtime database is used in this layer. Application layer act as a front-end of the IoT architecture, used the data stored by the previous layer and apply the information to develop an Android Application. Figure 3.3 shows the IoT architecture of this system with three layers.

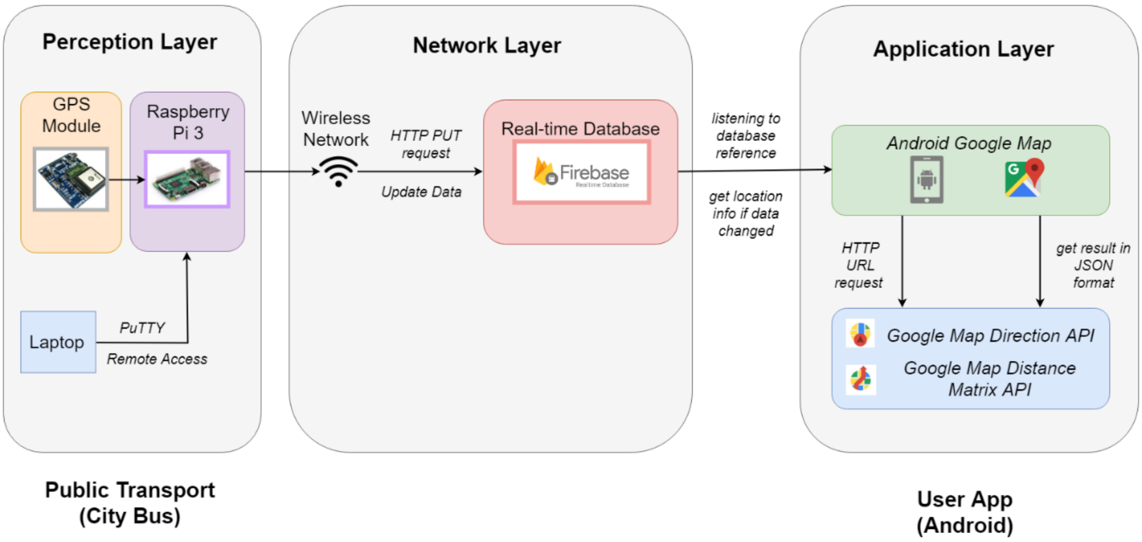

Figure 3. 3 System IoT Architecture

3.3.1 Internet of Things Protocol

Hypertext Transfer Protocol (HTTP) is used to enable communications between clients and servers with request-response protocol. In this project, Firebase Realtime database has its own cloud server and Raspberry Pi 3 and smartphone with Android application are the clients that request response from the Firebase server. In this project, Raspberry Pi 3 used HTTP PUT request method to upload and replace the data in Firebase Realtime Database. The difference between PUT request method and POST request method is that PUT does not have side effect whether it called once or several times. However, POST request method may have additional effects such as passing an order several times.

In this project, the Internet Service Provider used is a personal data hotspot. The personal data hotspot is used to ensure the stability of the network throughout the experiment process of the vehicle tracking system.

3.3.2 Firebase Realtime Database

The Firebase Realtime Database is a NoSQL database with a cloud server that supported by Google Cloud Platform. Data is stored as JSON format and synchronized in real-time to every connected client such as Android application. The Android application is a cross-platform application from Firebase and able to access the Firebase Realtime Database instance and automatically receive the updates with the newest data.

A NoSQL database provides a service to store and retrieve data that its data structure is different from other than the tabular data structure used in relational databases such as MySQL that uses table structure to store the data.

JavaScript Object Notation (JSON) is an independent data exchange format which is minimal and readable format for structuring data. JSON supports all the basic data types such as numbers, strings, arrays, and Boolean values.

To create a Firebase Realtime Database, a Google Cloud Platform account is registered with 1 US dollar which is approximately RM 3.97 for trial version with 300-dollar credit in the Google Cloud Platform for the usage of trial services. In this project, a Firebase Realtime Database is created, and a database path is generated. Figure 3.4 shows the interface of the Firebase Realtime Database and the database path generated.

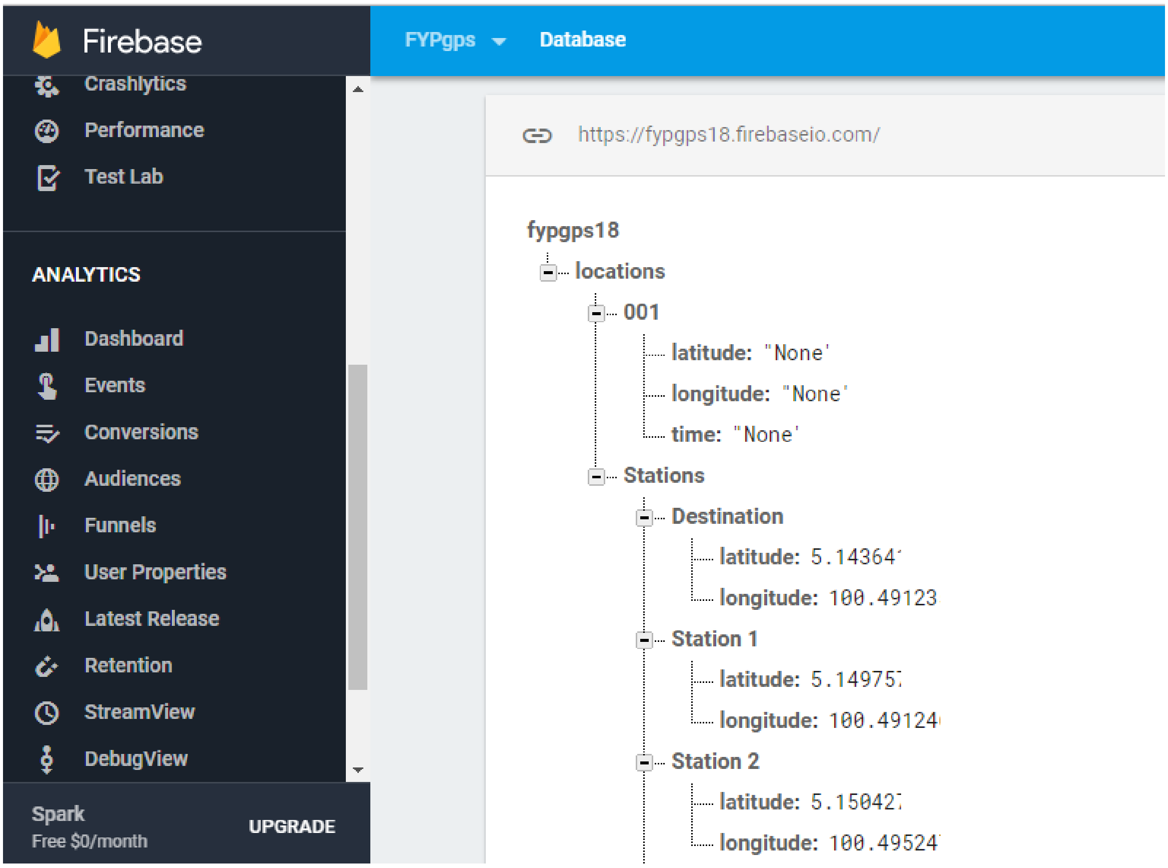

Figure 3. 4 Firebase Realtime Database Interface

3.4 Remote Access Raspberry Pi 3

Secure Socket Shell (SSH), is utilized to remote access Raspberry Pi 3 with a laptop. SSH is a network protocol that allow user to remote access a computer with a secure network. PuTTY software is installed on laptop to utilized SSH method. For SSH to work, both laptop and the remote access target, Raspberry Pi 3 are connected to the same wireless local network which is a personal mobile hotspot.

The IP address of Raspberry Pi 3 is specified in PuTTY configuration to start the remote access session as shown in Figure 3.5. The administrator login is required to access the Raspberry Pi 3 terminal. Figure 3.6 shows the terminal of PuTTY remote accessing Raspberry Pi 3. Python code is developed by using PuTTY remote access terminal through this project.

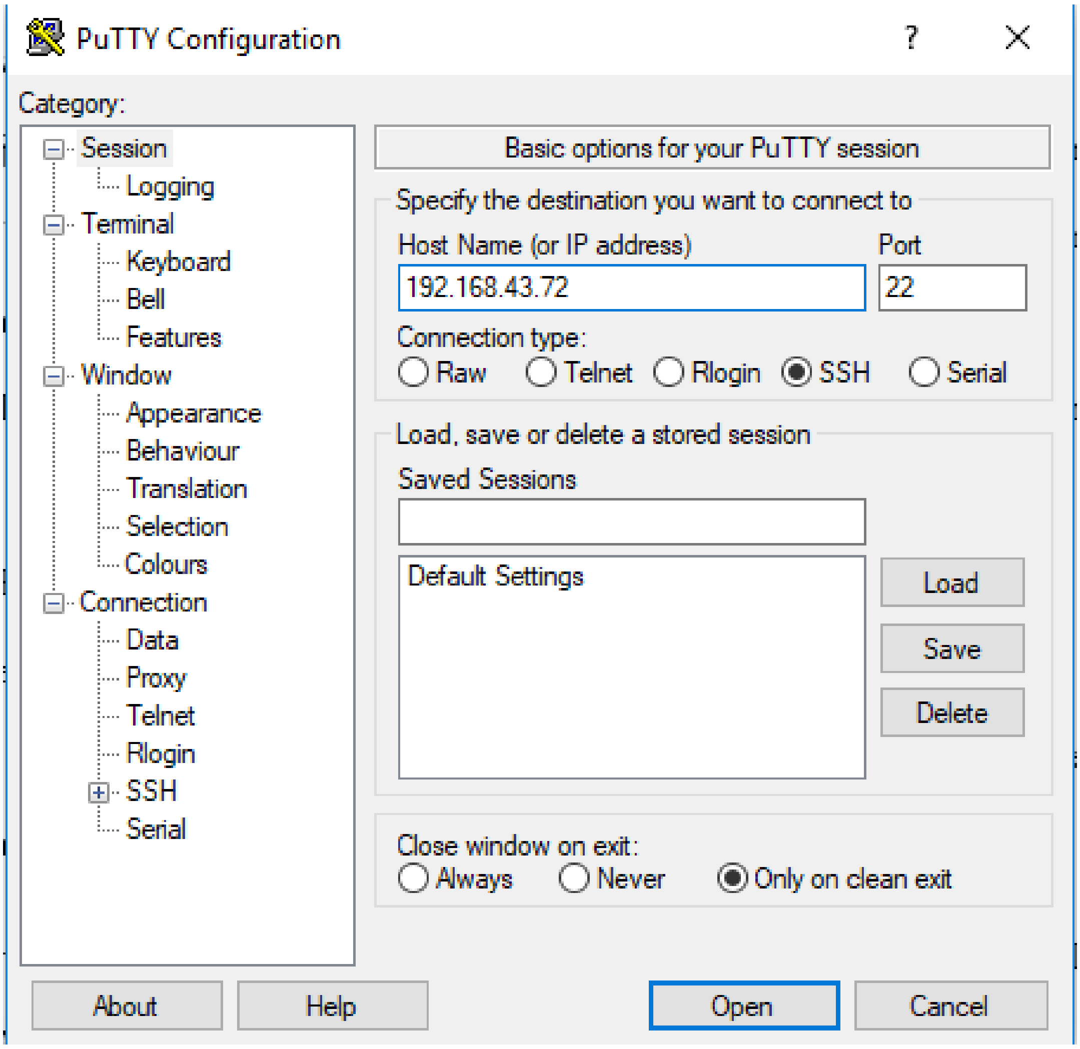

Figure 3. 5 PuTTY configuration