Vehicle Tracking Application Based on Real Time Traffic

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***Abstract*—Vehicle tracking application is very important to track the movement of vehicles such as bus, train and taxi. One of the issues in vehicle tracking system is the accuracy of estimation time. With the help of technology, it is possible for the vehicle operators to provide accurate estimated time of arrival to the users. This paper aims to improve the accuracy of vehicle estimated time so that users can expect the arrival of the vehicle. An application is proposed in this paper and it uses Global Positioning System (GPS) on Android smartphone to determine the location of a vehicle and the coordinates is stored in Firebase Real-time Database which optimized for syncing of data in real-time. Furthermore, Google distance matrix Application Programming Interface (API) is used to calculate the estimated arrival time of the vehicle. Distance matrix API is able to return time of travel between two points, based on recommended route and traffic information. The prototype of application went through several stages of software testing and evaluation. Based on the users feedback the system is better in terms of estimating the arrival time.**

***Index Terms*—Arrival time estimation, distance matrix API, Firebase real-time database, real-time tracking**

I. Introduction

Public transport such as bus, train and taxi not only bring convenience to the users but also offers social benefits like reduce traffic congestion, improve air quality, and eliminate parking issues [1]. Generally, schedule of such service can be retrieved on the official website of the service providers. Nonetheless, information included in the timetable provided are usually limited to details like departure time, stops and routes, which is insufficient to the users. Real-time location sharing systems have increased the efficiency of many services especially in the logistics industry. Real-time location tracking has become very common to people nowadays. One of main driving factor for the growth in the usage of real-time tracking is the reduction in cost of global positioning system (GPS)-enabled device. GPS is a satellite navigational system which originally designed for navigation [2]. GPS can also be used to collect information such as the longitude and latitude of an object, speed and time [3]. GPS based vehicle tracking and monitoring system can be implemented to minimize the waiting time of users for the vehicles [4].

One of the main reasons public transport services did not receive positive feedback from people is the high variability in the arrival time of vehicle [1]. People are reluctant to use public transport services if they have to wait for a long period of time [5]. Travel time of the vehicle is affected by several factors and it brings a lot of inconvenience to the users. Therefore, information like accurate prediction of vehicle arrival time is important to the users [6]. However, information provided by most of the service operators are static and limited such as the schedule and operating hours [6]. As technology advances, it possible for the service operator to provide accurate estimation of arrival time to the user with the help of technology. One of the main reasons public transport services did not receive positive feedback from people is the high variability in the arrival time of the vehicle.

According to the survey done by Malaysian Communications and Multimedia Commission (MCMC), the penetration rate of smartphone in Malaysia has rose from 68.7% in 2016 to 75.9% in 2017 [7] and this number is expected to grow larger in 2018. Besides, smartphone users who used their smartphone to access to the Internet increased by 26% since 2012 [7]. The usage and adoption of mobile application rises as the users of smartphone continue to grow. Most of the applications today make good use of the Internet connectivity. These Internet-enabled applications are designed to solve our daily problems [8]. For example, if someone unfamiliar with certain area, he or she can use a navigation application to arrive at the destination without any hassle. As of 2nd quarter 2018, market of mobile operating system mainly occupied by Android which stands at 88% and iOS which has market share of 11.9% [9]. Mobile application able to access to and interact with the data or

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hardware of the device such as geography location, storage and camera. Smartphones provide a very good platform to deploy vehicle tracking system as smartphones are GPS-enabled and can be connected to the Internet easily using cellular data network. In this paper, a prototype Android-based mobile application is proposed. Location of the vehicle is tracked using GPS technology and arrival time of shuttle is estimated using data provided by Google distance matrix application programming interface (API).

II. Literature Review

A vehicle tracking system that utilizes the technology of short message service (SMS) has been proposed by researcher [10]. A special device is installed in the vehicle that is to be tracked. The device will collect GPS data of the vehicle and send the data to the server by using SMS service. In this system, there is a server that will handle the message sent from the device mounted on vehicle and also the request from the users. Server will read the message and retrieve the GPS coordinates comprised in the message. The coordinates are then stored in a database and technique called location mapping is used to get the name of location for the coordinates [10]. This location name will be sent to the user when user send request to the server. The advantage of the system is that it does not require subscription to cellular data network to transmit data as it uses SMS technology.

There are several vehicle tracking systems have been developed using combination of GSM (global system for mobile communication) and GPS technology. For example, an anti-theft tracking system that allows vehicle owner to track their vehicle [11]. In this system, the tracker device that consists of GSM modem and GPS receiver will constantly monitor the vehicle and only return the location of vehicle when requested. Therefore, there is no need of a central server in this system. When user requests the location of vehicle, the request is sent to the modem instead of a server. The user will receive a message that contains the longitude and latitude of the vehicle. Other than the system mentioned, a web-based GPS-GPRS vehicle tracking system has been developed to serve enterprises that have large number of vehicles [12]. The system consists three different parts which are the tracking device mounted to the vehicle, a web-based application used to view the location, and a central server that receives and transmits data [12]. GPS coordinates of the vehicle is retrieved at certain interval and sent to the central server by using General Packet Radio Service (GPRS). Then, user will be able to view the location on the web application that has a Google maps embedded in it. Google maps is a mapping service that developed and provided by Google and it can be embedded into a third-party website by using Google maps API [13].

Another a GPS-based location tracking system for personal use through the implementation of Android device is developed [2]. Android smartphone is used as a tracker device because the tracking target is the user of system. Therefore, it is more suitable to use Android smartphone instead of a special device. The system utilizes the GPS location service features in smartphone to monitor the location of user. The GPS data will send to an Apache server through Internet and save in a database. This system can be used a safety tool for the user [2]. When a user is lost, he/she can use the application to find a way back as the system will track the visited path by user. One of the benefits of this system is that it does not require any special device or a dedicated GPS receiver. However, this system might not suitable for vehicle tracking system that require to monitor a large amount of vehicle as usage of smartphone as tracker device for each vehicle will be costly, unless the application is installed on the smartphone of driver. Public transport tracking with implementation of Firebase Real-time Database is also developed [14]. This system consists of a driver side application and a user side application. The driver side application will be installed on a smartphone mounted to vehicle that is used as the tracker device. This application will send the location to the firebase real-time database on a predetermined interval through Internet. User able to track the location of the vehicle by sending request to the database. Once the request is received, connection will be established between the application and the real-time database. The user-side application does not need to continuously request for the location data because the real time feature of the database will synchronize the data across the users [14]. Cost is an important factor when designing a real-time location tracking system. A research has been conducted to reduce the cost of vehicle tracking system. In this research, researchers used a GM862 module that has GPS and GPRS integrated as tracking device [15]. The GPS receiver will calculate the location and send it to a monitoring server through GPRS connection.

Accurate estimation of arrival time is important to reduce the waiting time of user. Over the years, many researches have been done to develop a model or system that able to predict the arrival time or duration spent on road accurately. A real-time estimation of arrival time of vehicle based on historical data has been proposed [16]. The arrival time is estimated by calculating the arrival time of vehicle at the stop before and historical data about the arrival time. First, the data is collected over a period of four months and then the data is analyzed. The data collected includes the speed of the vehicle, coordinates of vehicle, timestamp. The model takes average speed based on location and average speed based on time slot into considerations while producing the prediction for arrival time. The relationship between speed, time, and location is analyzed and used in the calculation of prediction [16]. Historical data-based model can be accurate provided that the sample size is large. If the sample size is small, the accuracy of prediction will be affected by factors like weather conditions and road conditions. Accurate estimation of travel time of vehicle is essential component in predicting the arrival time. An effective model based on GPS and radio frequency identification (RFID) data is developed to predict the real-time travel time of vehicle. [17] As technology advances, automatic

vehicle locator (AVL) has been widely used in public transport across the world. In this model, AVL collected real-time vehicle location data and RFID data is used as the input for short-term prediction [17]. RFID data is simulated by data collected manually. After deployment, RFID data is expected to be collected automatically through RFID devices. This model able to produce a more accurate prediction than the model that based on AVL collected data only as it takes various conditions into consideration. Additionally, a statistical model is proposed to estimate travel time based on low frequency GPS probe vehicle data [18]. The model consists two different layers, which are the network model and observation model. Network model takes the travel time between two adjacent intersections and delay at the intersections into consideration. Low frequency vehicle trace is used by observation model to provide method to estimate parameters of network model. Maximum likelihood estimation is used over the data collected in this model.

Another system is developed to automate process of obtaining travel time matrix form multiple origins to multiple destinations by implementing Google maps API [19]. By using Google maps API, preparation for data such as the transportation network data and vehicle trajectory data is minimized. Google maps API will take the coordinates of an origin and a destination as input and return estimated travel time. The system developed will takes a set of origins and a set of destinations and retrieve the travel time between each origin and destination by calling Google maps API. Travel time obtained through Google maps API uses a more updated road data and it takes difference between peak hours and off-peak hours into consideration [19]. Information like the location of vehicle and estimated arrival time is important for users to plan their journey better. A system that predicts the arrival time based on the current moving speed of the vehicle and historical data of average velocity on the same day and time of day [20]. The system is divided into a GPS based system and a prediction system. GPS based system will retrieve the real time speed of the vehicle, while average velocity based on historical data is calculated by the prediction system. Attributes like road segment, volume of traffic, number of intersections are considered when using historical data. Calculation of distance between two points also plays an important part in the estimation of arrival time. In this paper, Haversine formula is used to calculate the distance between a pair of longitude and latitude as it is more accurate [21]. However, this model proposed might only suitable for area where the traffic conditions are relatively consistent and do not fluctuate greatly. Besides, a huge amount of historical data might be needed to provide a more accurate prediction [22], [23].

III. Methodology

Rapid Application Development (RAD) as shown in Fig. 1 will be used as the methodology of this project. RAD approach emphasizes on reducing planning phase and maximizing the development of prototype [24]-[30]. This makes RAD method suitable for software development that proceeds in a rapid pace as it able to deliver the final product in shorter time. Therefore, RAD is an ideal methodology for this project as the duration allowed for this project is relatively short and prototype is vital part of the project. Rapid application development model divides into four phases which are requirements planning, user design, construction and cutover. For this project, since the product will not be launched, so the cutover phase will be replaced by a report writing phase as the final phase of the development progress.

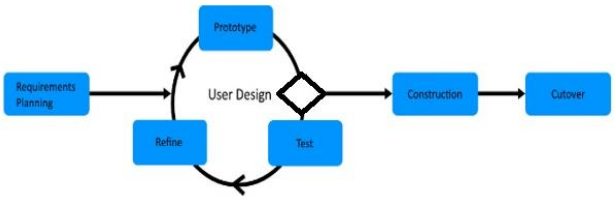

Fig. 1. Rapid Application Development methodology.

A. Requirements Planning

This phase is equivalent to the system planning and analysis phases of software development life cycle (SDLC). At this phase, research is carried out to identify the current problem and decide on the project title. After the title of the project is determined then, a proposal will be constructed.

B. User Design

The development of the system will be started at this phase. Models or prototypes that represent the functions and features of the system will be developed. The prototypes constructed will be tested. Then, the prototype will be refined based on the comments and feedbacks. The sources of the comments are coming from potential users. The potential users are people that uses vehicle to move from one place to another place. To ensure the authenticity and validity of the comments we will involve an expert from transportation to review the comments and feedbacks. After iterations of testing and refining, a finalized prototype should be delivered. The methods of testing and refining are following the normal software development methodology when the vehicle tracking application is being develop there are many errors in coding the application. Therefore, we need to test and refine the application to make sure all the functions are working perfectly as desired.

C. Construction

In this phase, the prototypes developed in the user design phase will be combined and turned into a final working model. This development should be completed in a short time as most of the changes happened in the user design phase. The coding of the system is done using Android Studio. Once the system is approved, the application will undergo different testing, including unit and system testing to make sure that the application is bug-free, and all the functions are working as expected.

D. Report Writing

Report writing will be the last phase of this project. In this phase, a complete report will be drafted. Modifications will be done based on the suggestions from the supervisor. The report should include everything about the project including introduction, information gathering, analysis, evaluation and conclusion. At the end of this project, a finalized report and the source code for the application will be submitted.

IV. Design and Development

This section will discuss about the design and implementation of the system. The prototype for the system is developed using Android Studio.

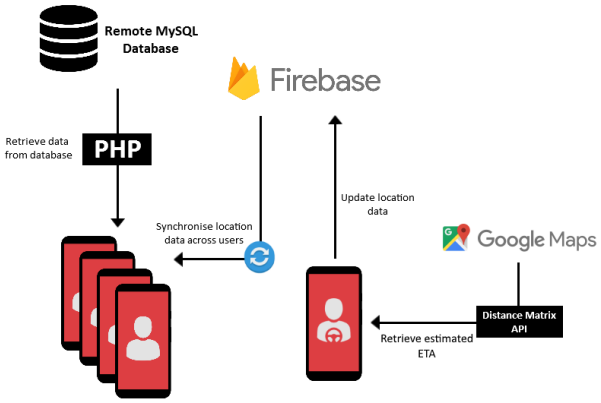

Fig. 2. System architecture of vehicle tracking application.

A. Overall System Architecture

The system architecture of vehicle tracking system is showed in Fig. 2. The system utilizes the Internet connectivity and built-in GPS features of Android smartphone. The system can be divided into driver side application and user side application. Driver side application will be installed on an Android smartphone which will be mounted to a vehicle. Once the application started, the GPS coordinates of the device will be retrieved with one second interval. One second interval is based on the feedback from potential users that most likely will use the application. Users do not specify one second interval, but they just want the application to start fast. The system analyst interprets one second interval is fast. The updated longitude and latitude of the device is then recorded in a firebase realtime database through the cellular data network. Location data of the vehicle will be synchronized across the users. After the vehicle driver chose the next vehicle stop that vehicle is travelling to, the application will calculate the estimated arrival time of vehicle at the next vehicle stop based on current traffic conditions by passing the coordinates of vehicle and the coordinates of destination to Distance Matrix API. Vehicle user need to install the user side application on their Android smartphone. This application features a Google maps that will display the real-time location of vehicles. Each location of vehicle is represented by a marker with the identification number of the vehicle. The map will also show location of all vehicle stops. The next arrival time at each vehicle stop is also displayed to the user. Other than that, user also able to retrieve data such as schedule and notice from a remote MySQL database through PHP script on the server. Feedback submitted from user will also be saved in this database. The reason this database is used is because these data are structured data and they are more suitable to be stored in a database with schema. Firebase is a NoSQL, schema-less database and it is more suitable for unstructured and real time data. The performance of the application is optimized with the implementation of two different.

B. User Interface Design for Driver Side Application

The application will detect whether the location service (GPS) of the device is enabled. If it is not enabled, the application will request the driver to turn on the location service by navigating to the settings page. Once it is enabled, driver will be navigated to the main page as shown in Fig. 3. In the main page, driver can choose the ID of vehicle from a drop-down menu and turn on the "start service" toggle button to start retrieving GPS coordinates of the device. Then, the location of the device will be automatically displayed on the Google maps. Driver can choose the next vehicle stop the vehicle is travelling by pressing the destination button. If the driver turns off the "start service" toggle button, the coordinates of the device will be removed from the database.

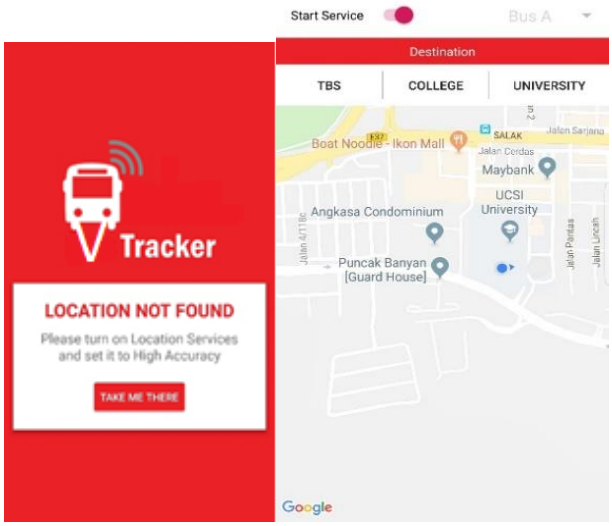

Fig. 3. Driver side application user interface.

C. User Interface Design for User Side Application

Fig. 4 shows the homepage where the notice or news about the vehicle service retrieved from a remote MySQL database and displayed to the users in a list. Every notice or news consists of the date for which the notice or news is posted so user will know whether it is an up to date information.

A message that indicate that the vehicle service is not available will be displayed at the center to notify user if there is no vehicle location recorded in the database. Once the message is prompted, user will not be able to interact with map. If the vehicle service is available at that moment, the real-time location of vehicle in service will be displayed on a Google maps as shown in Fig. 5. The next arrival time of vehicle at each vehicle stop is also displayed on the top of the map. User can click on the traffic light button to check the traffic conditions.

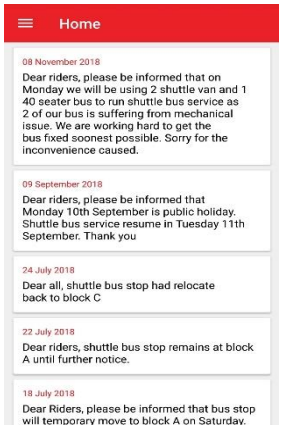

Fig. 4. Homepage for user side application.

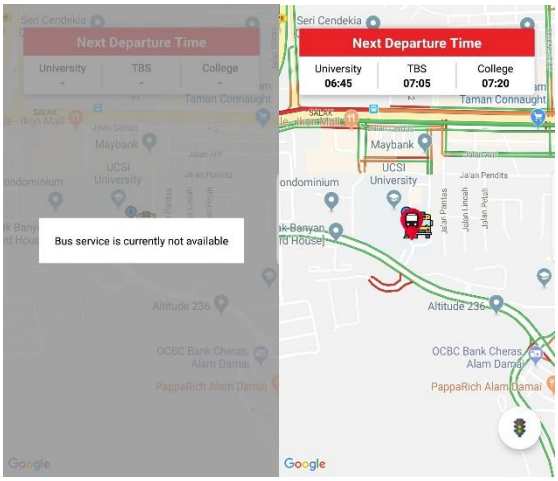

Fig. 5. Vehicle tracking page for user side application.

Fig. 6. Schedule page for user side application.

Fig. 6 shows the schedule page where user can check the preset timetable for the vehicle service. User can check the schedule for a vehicle stop by choosing it at the bottom navigation bar. The timetable is grouped into weekdays and Saturday.

Fig. 7 shows the feedback page where user can submit feedback by pressing the blue floating button. User needs to provide first name and last name before submitting. If the text field for first name, last name and content of feedback is empty an error message will be prompted under the text field. Email address is optional when submitting the feedback. User can only submit feedback with maximum 250 characters.

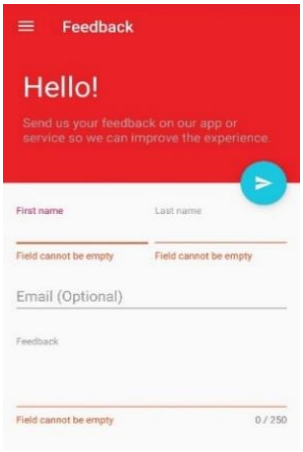

Fig. 7. Feedback page for user side application.

V. Conclusion

In this paper, an Android application that allow users to track the real time location of the vehicle and view the departure time of vehicle is developed and tested. The application is divided into two versions, which are driver side application and user side application. Driver side application is used to retrieve GPS coordinates of vehicle as well as to calculate the arrival time of vehicle at the next stop. User side application will be able to get the real-time location of vehicle and the arrival time of the next vehicle by querying database. Since most of the processing and calculation will be done by driver side application, user side application will be cheap to use in terms of resources used. However, one of the limitations of the application is that both driver and user need to be connected to the Internet to use the application. The prototype developed in this paper went through four-level software test to make sure the application works as expected. Furthermore, the system is also evaluated by interviewing students after they tested the prototype to determine whether the system has achieved its objectives. Based on the responses, the system is concluded to have fulfilled the objectives of the paper.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Dr. Abdul Samad leaded the conducted research and wrote the paper, while Dr. Abdurrahman Jalil edited the paper according to the template given. Mohd Helmy developed the application and analyzed the results. All authors had reviewed and approved the final version of the paper.

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