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Research paper

Vehicle Service Locator Using GPS and Cloud Service on Android Platform

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Abstract

Location-based services are becoming a part of everyday life especially with the development of mobile communication, which include navigation systems, emergency services, tour planning or even finding the most convenient restaurant around. They have been playing an important role in providing necessary services efficiently with the use of Global Positioning System (GPS). When it comes to vehicle servicing, the problems faced by the users still remain especially in case of emergency breakdown mostly in finding the nearest services available. Consequently, this gives the encouragement to come out with a solution, which would help users ease their process of solving such problems. Vehicle Service Locator (VSL) allows user to locate the nearest tow trucks available, towing services and nearest vehicle service centers according to user's location data obtained via GPS and provides directions based on the user's current location.

Keywords: *vehicle services; vehicle towing; GPS; navigation; cloud services*

1. Introduction

Location-based services utilize user's geographic location from a mobile device to provide necessary services efficiently. In the future, the location-based services are expected to be a great help in differentiating one service provider from another [1]. Since the U.S. Government decided to make the Global Positioning System (GPS) to be freely available worldwide in the 1980s, many industries have taken up the opportunity to access data through GPS in order to enhance their products and services. Currently, GPS is commonly used in different industries varying from airlines, shipping companies, military and government industries and is widely used by the automotive industries, which have been integrating navigation system into cars.

This paper is motivated with the objective of solving the main problems faced by the users in finding the nearest tow trucks, towing services or the repair service centers. Currently, especially in Malaysia, there is no widely used application that leads users to locate or reach to the vehicle service providers. Moreover, apart from users, one of the most common problems faced by vehicle services providers is providing quality service to customer in a timely and efficient manner.

According to a research conducted, it is believed that the customers that are provided with up-to-date information from their towing companies feel more secure and content with their service [2]. It assists the users in getting the required service efficiently in accurate and timely manner, as well as the service providers by allowing the smooth functioning of the business. Vehicle Service Locator allows user to send request to the nearest tow trucks for the service and get the confirmation by the truck of the requested service with no delay. The application also allows the users to locate any vehicle services required through the list of service centers available, according to the problems encountered.

The major benefits of Vehicle Service Locator would include:

1. For users to locate the nearest tow trucks available and service centers based on the location,
2. Simplified and automated process of searching for nearest tow trucks, towing services and vehicle service centers in case of emergency breakdown, and
3. Improved efficiency of towing services and vehicle service centers by allowing users a direct access in a timely manner.

2. Literature Review

Location-based services are classified into two major categories, namely users request to determine their location and those that are triggered automatically once a certain condition is met, for example when a boundary is crossed [3]. Some of the most commonly discussed services include information services such as weather forecasts, navigation or routing services, e-commerce and transactions, tracking as well as for entertainment purposes. The existing similar applications to Vehicle Service Locator are mostly travel guide, tourism services or location search services.

2.1. Existing System Use

Openbay is an application based in United States where users can find and book car repairs, compare and schedule vehicle services

and get immediate pricing lists for maintenance and repair from local shops. Users are able to make bookings and payments for the

services via Openbay and receive rewards on completed service. Using Openbay, the users are assured that their needs will be fulfilled effectively and the application provides an online repair log to record the users' vehicle maintenance history. Openbay operates via website, as well as on both iOS and Android mobile operating systems [4].

Repair Pal is a vehicle repair and maintenance service application. Users will receive an estimation cost for the repair along with recommendations for proficient mechanics in the surrounding area. The application is able to track all the repairs and provide roadside assistance in case of any emergency breakdown. The application is available on both Android and iOS operating systems. The vehicle repair and maintenance information is synced and updated online at their official website, so that the users have an easy access to the information. Auto mechanics do not have the best reputation for trustworthiness. With Repair Pal, searching for mechanics and service centers is done efficiently just by selecting the type of vehicle and repair service needed as well as the cost estimation can be achieved [5].

GasBuddy mobile application is based in United States and it is one of the best ways to use in finding the cheapest and nearest gas station available based on users' location. It allows users to search by automatically detecting the location via GPS, as well as by typing in the physical address such as the city, state and zip code. GasBuddy's distinct features include reporting gas prices as well as having daily contests to keep the users community active. GasBuddy provides a real time gas prices so that consumers can have access to the information necessary to locate the lowest fuel prices available. It also allows users to provide the gas prices and by working together as a community, it assists everyone fulfilling their need effectively [6].

While comparing the existing location-based applications that are widely used and available on the market currently, it is acknowledged the different focuses of each application and the targeted users. It explains how they work and are used thus, it is helpful in providing more insight into how they are use and handful of example applications that users are using. Table I summarizes the characteristics of Openbay, RepairPal and GasBuddy as how they work in order to benefit customers. Overall, the comparison in Table 1 is to bring light to the current trends in the field to help in the development of this project.

Table 1: Comparison of Application Services

Openbay	RepairPal	GasBuddy
API is limited to reviews and ratings	API is limited to check-in data	API is not limited (Read and Write)
No specific mechanism for rewarding perspective	No specific mechanism for rewarding perspective	Game mechanics involve points and rewards
Available on iPhone, Android, Web-based platforms	Available on iPhone, Android and Web-based platforms	Available on iPhone, Android, Blackberry, Windows platforms

2.2. Available Cloud Services Platform

According to an article, most well known and commonly used platform to store and sync data is Firebase. Firebase offers client-side libraries for iOS, android, Java, all major JavaScript browser frameworks and Node.js. These libraries provide remarkable real-time data synchronization for clients. In Firebase, the data are allowed to be shared among the users. In order to restrict particular users from accessing the data, a server-side rules language is provided. The data can be stored as JavaScript Object Notation (JSON) and synced to all connected clients in real-time with Firebase NoSQL cloud database. The data is available even after the application goes offline. Users can also be authenticated using Facebook, Google, GitHub, Twitter, email and password or easily incorporate with the existing authentication system [7].

Meteor is the second platform, which is used to develop web and mobile apps. Meteor has magnificent data synchronization capabilities, which includes support for live enquiries. Moreover, Meteor allows developers to write code that can be run on both the client and the server-side. The Meteor platform consists of several tools and libraries which allows the developer to combine different components [8].

Amazon Web Services (AWS) presented Cognito that offers fast and easy authentication for users to store their data. Similar to Firebase, clients go directly to the database rather than through an application layer. In order to have a secure transmission, data sharing is not allowed among the users. As there is no shared server available, any additional data verification will have to be duplicated between different client types. Cloud Cruiser is a provider of financial management and analytics software for hybrid and multi-cloud computing environments. According to Cloud Cruiser, AWS is the senior member of the group and in the leading position. Furthermore, AWS has been around extremely longer than the others and establishing an early lead [9] [10].

In addition to Firebase, Meteor and AWS, Google Cloud Platform also has a lot of services with even more advanced technology than AWS. According to Srikanth Kakani, the CTO of Vdopia who have used both AWS and Google Cloud, many of its services are geared towards auto scaling, automatic traffic management and with low IT costs. Although Google's toolset is much smaller, they provide an efficient and quick delivery of those toolset. An advantage of Google is the overall I/O speed and the quick startup. Other than that, Google has a rapid growth in Big Data [11].

While all of these platforms provide different approaches to storing and accessing data, Firebase is probably a better fit for this project, Vehicle Service Locator (VSL), as it gives data that are more powerful storage with three core services: a real-time database, user authentication and hosting. In addition to the ease of building real-time applications, there is a lot of library support as well from open source community that would assist the developers in many ways. Thus, it is concluded that GPS will be used for location tracking, for android mobile application platform with Firebase framework in order to develop an application, which focuses on the search of tow truck, towing services and general vehicle maintenance and services centers. In Table 2 summarizes the features of the cloud services and its features.

Table 2: Comparison of Cloud Services

Cloud Database Platform	Features
Firebase	Provides both temporary and persistent disks (backed by Google Cloud) Free of charges
Meteor	One-line meteor deploy command Charges customers by the number of hours used
AWS Cognito	Provides temporary storage Charges customers by rounding up the number of hours used
Google Cloud	Provides both temporary storage and persistent disks charges for instances by rounding up the number of minutes used

2.3. The Revolution of Technology and Automotive

The present economies are drastically changing, provoked by advancement in developing markets, new technologies, supportability arrangements and changing customers inclinations around possession. Digitization, expanding mechanization and new plans of action have changed different businesses and vehicles will be part of it. Vehicles have been connected for many years, in ways that now it is seen as a routine. These connectivity can be divided into two categories, which are the embedded connectivity and leverage connectivity. Embedded connectivity is the infotainment system that is being built inside the vehicle, however, leverage connectivity any devices that is brought into the vehicle and act a display for the features. Nevertheless, car manufacturers always keeps themselves interfacing drivers and innovative system towards their goals of delivering the best than any other sectors [12].

2.4. Development

A mobile operating system offers the primary execution environment for applications on the phone much similar to a computer. This technology has enabled innovative and exciting mobile applications to be widely available from multimedia, social networking, gaming and even to be an assistance for daily activities. There are various mobile platforms available for locator apps that includes Android, iOS and Windows [13]. Among them, the most widely used ones are known to be Android and iOS [14]. As the most common platform, Android varies in some technical and business aspects from its competitors. In terms of technical advantage, unlike most of the competitors, Android is built upon an open-source platform, and most of the Android code is released under the open source Apache License [15]. As one of the Google's open source initiatives, Android follows a very simple procedure and developers will have more freedom to create the type of application or content they like.

Mobile applications, which implement a database, ensure that the users always have access to important information at any point of time in order to complete a task efficiently. In this application, Vehicle Service Locator, the database layer consists of the information regarding the vehicle services and repair shops and their availability. Furthermore, the application provides real time information regarding the current location of the user and the route to desired service center. Recently acquired by Google, Firebase provides client-side libraries for android, iOS, all major JavaScript browser frameworks, Node.js, and Java. Firebase allows data to be shared between users and to restrict how data can be accessed by particular users. It gives more powerful data storage with three core services: a real-time database, user authentication and hosting [16].

Taking the most widely used and available mobile features into consideration, the Vehicle Service Locator (VSL) is proposed to build on the android platform for both users and vehicle service providers to gain maximum benefits at the minimum cost. Vehicle Service Locator is implemented using GPS for location tracking, an android application platform with Firebase framework, which focuses on locating the tow truck, towing services and general vehicle maintenance and services centers. Besides, the development will be focused on delivering towards the connected car environment. In this case, the development is specific for an embedded or IoT use cases.

3. Proposed Work

For this purpose, android things is used as another form of platform. The proposed work is developed with two primary categories, which are based on their roles and functions provided in the application. The first category is the individual users, who are the primary users of the application. After signing up as individual users, they are given access to search the nearby tow trucks or service providers as well as access to request for service from the nearby tow trucks available. The second category is service providers who can sign up either as tow truck or service provider. The service providers who registered as Tow Truck are given access to accept or deny the request sent by individual users. The available tow trucks will be displayed to users under nearby tow truck and towing services functions. The service providers who are registered as services are given access to provide with the services available at the shops and it will be displayed to individual users under general maintenance and repair function according to the location sorted by nearest to furthest from user's location.

Vehicle Service Locator (VSL) consist of three main search functions for individual users, which are for nearest tow trucks, towing services and general vehicles maintenance and repair services. VSL is an application that provides location-based service for tow trucks, towing service centers and vehicle service centers with a user-friendly interface intended for individual users who are not familiar with latest technology and devices. The application provides users with the real-time information on the requested service which helps the towing services to in maintaining good communication with customers and allows the customers to stay informed of possible delays and appropriate arrival times upon request. Furthermore, VSL is developed in the context of connected car environment which focuses on the mobility cluster.

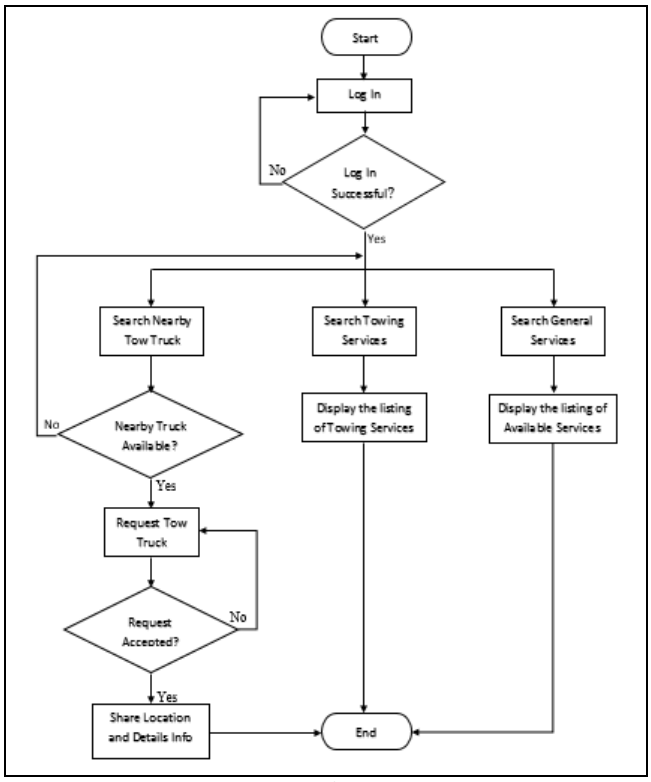

Fig. 1: Flowchart of VSL Application

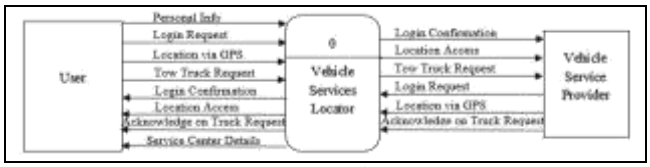

Fig. 2: Context Diagram of VSL Application

a)

b)

c)

Fig. 3: a) Main Page, b) Application Main Screen and c) Nearby Tow Truck Detail

4. Testing and Discussion

In order to ensure the developed application is capable to function accordingly and error-free, a series of testing is conducted on various areas. The testing process will also assist in ensuring the developed application meets the requirement as well as the project's objectives. Table 3 shows the test conducted for the application.

Table 3: Test Events and Results for Vehicle Service Locator

Event	Expected Result	Test 1	Test 2	Test 3	Comment
Registration and Login	User successfully registered and able to login to the application	X	✓	✓	User passwords were not hidden during test 1
Individual users - requesting for tow trucks	Nearby trucks are displayed and able to send request	✓	✓	✓	None
Service provider - receive notification for tow trucks request	Pushup notification for service providers upon user request	✓	✓	✓	None
Towing Services Function	Able to search the available service centers sorted by location nearest to furthest	X	X	✓	The search result was not sorted by location during test 1 and test 2
General Maintenance and Repair Search	Able to search the available service centers sorted by location nearest to furthest	X	✓	✓	The search result was not sorted by location during test 1 and test 2
User rating for nearby tow trucks requested and towing services	Users are able to rate on the skill of five after they receive the service or after service request	X	✓	✓	None
Logout button	Able to logout of the application	✓	✓	✓	None

For results, O indicates pass and X indicates failure or error during testing.

Apart from testing the different events on the application, database testing is also performed by using varieties of input and output values. The main reason of database testing is to ensure the data mapping. Similar to most of other applications widely used, Vehicle Service Locator also needs data to travel back and forth from the user interface to the backend database and vice versa. Fig 2 below is the JSON tree for this application, Vehicle Service Locator with two data nodes as Services referring to service providers or tow trucks and users referring to individual users.

Firebase real-time database is stored and synchronized with NoSQL database, where the data is synced to all connected application in real-time and the data remains available even if the application is offline. The data is stored in JavaScript Object Notation (JSON) format and it does not contain records or tables. If there is data added to JSON database tree, it becomes a node in the existing structure of the JSON database tree with an associated key. For an example, in VSL, the application is build where all the registered individual users and service providers will be able to share one real-time database instance and automatically receive the newest data.

Fig. 4: Firebase Database Interface

The database testing is followed by few more series to demonstrate the Firebase Real-time Database structure. The following figures are the test events showing how the data is added and stored with the associated key under the node specified in the JSON tree for each record of users registered through the front-end interface. The application interface illustrates the user face and the fields to enter data with following figure of the Firebase Real-time Database interface on the result after each node is added accordingly for each record entered.

Fig. 5: Firebase Test for Individual User

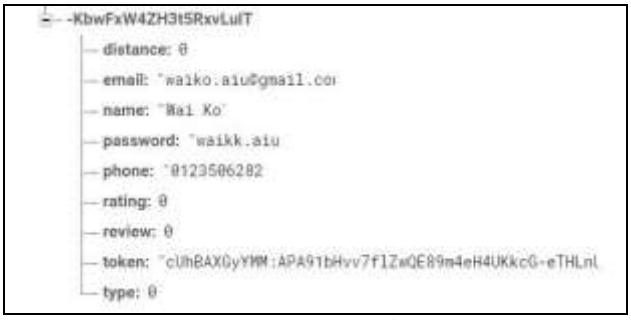

Fig. 6: Firebase Database Structure for Individual User

Fig. 7: Firebase Test for Tow Truck

Fig. 8: Firebase Database Structure for Tow Truck

Fig. 9: Firebase Test for General Service Providers

Fig. 10: Firebase Database Structure for General Service Providers

For the thorough evaluation of the developed application, Vehicle Service Locator, potential users were approached to use the application for feedback and performance evaluation. Thus, the result of the evaluation is the reviews based on the users' view on the effectiveness on the user interface design as well as the limitations faced by users' perspectives.

The application is shared with multiple users for testing and to seek their feedback and evaluations. Moreover, from that, the following list the suggestions on the performance of the Vehicle Service Locator for further improvement.

- Location to be recorded as keyed in rather than retrieving it from GPS upon registration
- Better and more interesting graphic user interface
- Notification should be sent automatically to the individual users and service providers once the request is accepted or rejected
- Built-in messenger between the users and service providers.

5. Conclusion

The proposed work is believed to be a benefit to targeted users and the connected car ecosystem. Having come from the original traditional way of having to contact service centers manually through calls or appointment, Vehicle Service Locator is much more rewarding for the long term with the development of today's technology. It is believed that the application either embedded or leveraged will assist users in fulfilling their needs and solving occasional problems with vehicles in an efficient and timely manner.

The key recommendations for future enhancement include:

- To record the user or service provider location as it is entered rather than retrieving it from GPS upon registration.
- To add search function where users are allowed to do the customized search for the services they want to acquire.
- To make the application more useful, the scope can be widen by including the other specific but required services related to vehicles, such as search function for car wash centers or providing the drivers with traffic information.

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