INTELLIGENT COMPLEMENTARY RIDE SHARING SYSTEM

G.L.S.R. Gunawardena

IT16011380

Degree of Bachelor of Science in Information Technology

Specializing in Information Technology

Department of Information Technology

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Dissertation submitted in partial fulfilment of the requirements for the Special Honors Degree of Bachelor of Science in Information Technology Specializing in Information Technology

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DECLARATION

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(Dr. Janaka Wijekoon)

ABSTRACT

Traffic congestion has become a major concern due to the large number of vehicles entering in to the urban areas. As reasons for traffic congestion, most of people use private cars instead of public vehicles. The key reason is that the level of comfortability in public transportation is not matching with passengers' expectation. Personal vehicles are underutilized since only one or two people travel at once. The proposed system is a new rideshare platform to professionals, which was "Plus Go" to minimize the nonconformist traffic congestion in urban areas. The ride sharing has brought so many positive aspects for the society including as reducing travel cost, reducing traffic congestion, and minimizing environmental pollution. Reduce travel cost is one of significant benefit which is provided by "Plus Go." Two types of fare calculations are used in "Plus Go," such as estimated fare and actual fare calculation. To calculate the estimated fare, it considered the fuel consumption for the vehicle which you selected for the ride using the "Multiple linear regression" algorithm. OBD II (On-board diagnostics) Adapter used to get the real-time fuel consumption of the vehicle and that a data is essential for the calculation of the actual fare.

Keywords— Ride-sharing, Machine Learning, Multiple Linear Regression, Dynamic Fare Calculation, OBD II

ACKNOWLEDGEMENT

I would like to extend my sincere gratitude to Dr.Janaka Wijekoon for the constant guidance throughout the project as the supervisor, Dr.Dharshana Kasthurirathna for giving constant feedback on the project application, and everyone who provided their sensitive data to be used in the training and testing purposes of the developed application.

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FC	**Fare Calculation**
OBD	**On-board diagnostics**
API	**Application Programming Interface**
RAM	**Random Access Memory**
GPS	**Global Positioning System**

LIST OF APPENDICES

1. INTRODUCTION

1.1 Introduction

According to the statistics of the Department of motor vehicles, in 2015, Over 500000 vehicles arrived in Colombo, and more than 1.8 million people arrived in rush hours [1]. Private vehicles are the highest portion of the number of vehicles, which entered the Colombo area. One possible way to reduce this number of vehicles is to travel by public transportation. Public transportation is the best and optimum solution to reduce traffic in the urban area because of public transportation can carry more people at once. As an average bus can take 33.6 persons at once nevertheless during single-car usually carries only 1.87 persons; which proves that most of the people travel almost alone. Professionals use private vehicles instead of public transportation due to concern about comfortability because public vehicles comfortability level does not match with peoples' expectations. That can consider as one of the reasons which impacts to the traffic congestion. According to the transport authority's observation, lost incurred daily as a result of traffic congestion is over Rs.500 million.

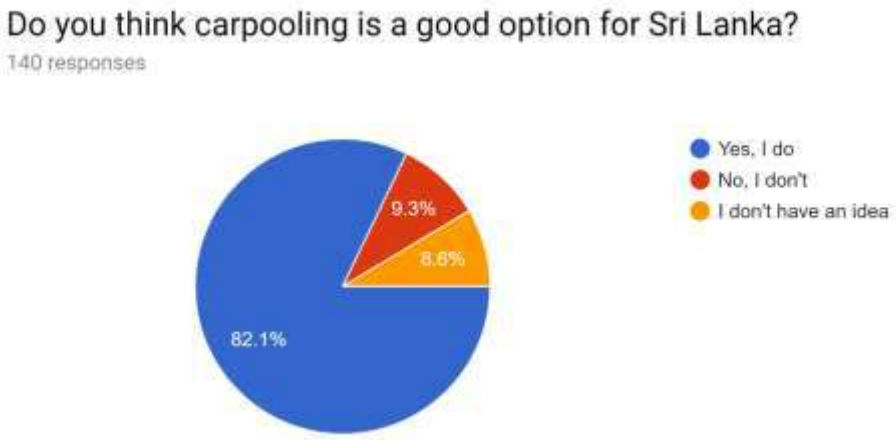
According to the Report of World Population Prospects 2017 in the United Nations, by 2030, the Sri Lankan population forecast will be around 21,474,701 [2]. Hence, the demand for private transportation has also increased over the last few years [2]. Therefore, huge traffic has occurred in urban areas, especially in Colombo area.When the statics on number of trips the users have during the rush hours, based on western province statistics, "CoMTrans" incurred that 10.0 million trips were recorded in the year 2012.They predicted that total trips in 2035 will be 17.8 million, whereas trips in Sri Lanka expects 1.8 times high. [3]. The survey identified different types of trips were used by the Sri Lankans such as from home to work, from work to home, from home to school, from school to home, home to other, from other to home and from non-home-based trip. from Non-home-based trip highly participate in the past few years as well as such trips will be increased in future as [4] summarized. Therefore, the speed of vehicles on the road will effectively be reduced to 10 Kmph-1 during peak hours of morning by 2035. Moreover,

as per [4], it was identified that Sri Lanka experienced 471 billion economic loss last several years because of the traffic congestions [4].

After an in-depth study of the context introduced ridesharing concept to professionals as a Mobile application that can able to minimize traffic congestion in urban areas, using that application can reduce the number of underutilized vehicles and increase the ratio of people who travelled in a single car. After filtering out the similar direction, time, professionalism and a group of people travelling according to their needs, suitable vehicles will be suggested.

1.2 Background Literature

To confirm the above hypothesis, it have done survey using 150 professionals. From the survey results, it identified 82.1% of professionals' responses are positive, while 9.3% thought that carpooling is the not suitable mechanism for Sri Lanka and rest of them had no idea about this carpooling context.

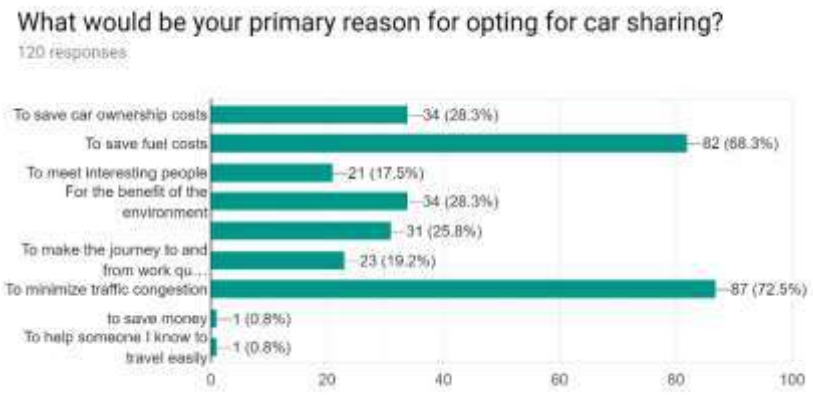


Considered the responses from the question of "What would be your reason for opting car sharing?" among those options, two options were highlighted clearly. Those were "To

minimize traffic congestions" and "To save fuel costs" their responses percentage were respectively 72.5% and 68.3%.

Figure 1.2.2 Reasons for opting Ridesharing

Besides, we conducted another survey to get the vehicle details along with fuel



consumption of the vehicles in the urban areas that collected from this survey [5], using that data we predicted the fuel consumption according to the vehicle condition. That result used to predict the fare calculation passenger before requested to the ride.

The fare calculation is considered the business logic of this system. In a previous study done by Zoepf, Chen, Adu, and Pozo (2018), the fare has to be calculated according to the vehicle type along with a minimum cost. Furthermore based on time and distance added to the cost as dynamic factors. The driver has to bear all expenses associated with vehicle operation including depreciation, insurance, maintenance, repairs, and fuel which varies from the driver to driver, or from vehicle to vehicle [6]. From the study of Santos and Xavier (2013), riders can decide how much the passenger is willing to pay for the trip. Then the system computes the cost based on the current fuel price and fuel consumption for the ride. Next, the system suggests a driver according to the willingness to pay the amount [7]. According to a study of Riquelme, Banerjee, and Johari, they
identified two methodology for pricing .those methodologies are called as static and dynamic price. The static pricing method assigns a fixed price for all drivers who are on

the platform. Hence, the price does not change based on instantaneously available service capacity. These parameters slightly different across of the day (Even most taxicab services price evenings differently from daytime hours). Importance of static price is not affecting to the instantaneous state, but it will only react to the course changes. They have derived an equation for dynamic pricing where their equation enters the list of available drivers, base price, distance and time and as the result, the dynamic price is given [8]. Considering the above literature regarding the cost calculation, there is no proper way to calculate the cost for a single passenger. In our proposed solution, we will be using multiple linear regression method to predict the fuel consumption, which results in estimating the cost for the ride. From the study of Aleksandar, Silvana and Valentina (2015), they have proved Mean Absolute Percentage Error (MAPE) of using Multiple Linear regression in their study is 3.0730601 using a trained set of data. From that we have identified error percentage of using regression model in critical analysis is comparatively lower than other regression models and we'll be using it for our fare calculation procedure to produce an accurate result [9].

1.3 Research Gap

During the period of observed the existing product in the similar domain found several existing ridesharing application in the Sri Lanka market [10,11,12]. Some of them failed due not to fulfil customer needs and requirements. We were able to identify the existing application features and shortcomings that data using for the improvement of our proposed system. Features of existing products and brand-new features are combined with our proposed system that will more productive for society. Society can get the maximum benefit from the FC component due to introduce new features that discussed below table.

Features	**UDIO**	**Carpooling.lk**	**RideShare.lk**	**Proposed Solution**

The system will decide the estimated cost before joining the trip.	✓	✗	✗	✓
Vehicle fuel cost calculated according to the condition of the vehicle. (Engine Capacity, Manufacture year, Registered year, mileage etc.) [4]	✗	✗	✗	✓
Passengers can get off in any place where is the between source and destination because the price will calculate passenger travel distance	✗	✗	✗	✓

1.4 Research Problem

According to the statistics from the Road Development Authority, there is the number of private vehicles entering the Colombo Municipal Council (CMC) is increasing over the past three decades[14]. Due to that reason, traffic congestions are increasing as well as the numbers of accidents are increasing. As a result of the traffic congestion, people are getting delay to reach their destinations, increased fuel wastage and monetary losses. That impacted the whole development process; hence, the government has been lost over Rs.500 million daily [13].

To reduce traffic congestion, people need public transportation instead of the private vehicle because of the huge number of crowd travel at once. There are some issues in Public Transportation, such as not comfortable because it is overcrowded, too expensive if we get on air-conditioned buses and so on[14]. Therefore, we thought of introducing a ride-sharing app, which could become a solution to traffic congestion. The basic idea

behind that was to combine professionals who are travelling to work by their private vehicles. Ability to reduce the number of vehicles using the ride-sharing application because of one vehicle carries several people together.

1.5 Research Objectives

1.5.1 Main Objectives

The main objective of this research is to develop an effective solution to minimize the traffic congestion during office hours in urban areas. Because of that, we thought of introducing a ride-sharing app for the working people (office staff) which will help to minimize the traffic congestion. Ride sharing service has become a convenient and felicitous transportation system to everyone in everywhere at any time. Apart from reducing the traffic congestion, there are some other tremendous positive impact on our proposed solution. Some of them are building the network among professionals with similar social status, which will help to reduce the stress and improve the productivity while travelling as a passenger, minimize the environment pollution and fuel consumption cost and help to save the car ownership cost and ensure the security of passengers too.

1.5.2 Specific Objectives

The Specific objective of fare calculation is to give reasonable cost to both drivers and passengers. While the ride with passenger meet the several segments. If new passenger joins the trip or passenger end up the trip, new segment will be created. Each Segment calculate fare for the passenger that calculation depends on cost for fuel consumption within the segment, the number of current passengers, and the current price of the fuel in Sri Lanka. Used OBD II adapter to get fuel consumption of the vehicle. Equation (2) Calculate the fare for the Segment. Final fare calculated using the addition of segment's fare which passenger has been travelled.

1.5.2.1 Operations

Both driver and passenger are interacting with the FC component. After passenger requested the trip, driver able to handle the all the part of the until the trip ended.

- Passenger should choose a preferred driver from the suggested list
- user can view the past trip history application used as a passenger
- user can view the past trip history application used as a driver
- The system should calculate estimated fare
- Passenger should request to the driver for the ride
- Passenger can cancel the request trip
- The driver should acknowledge the passenger request
- Driver should start the trip
- Driver should end the trip
- Passenger can decide to get off before destination
- The system should calculate fare of the trip

2. RESEARCH METHODOLOGY

2.1 Methodology

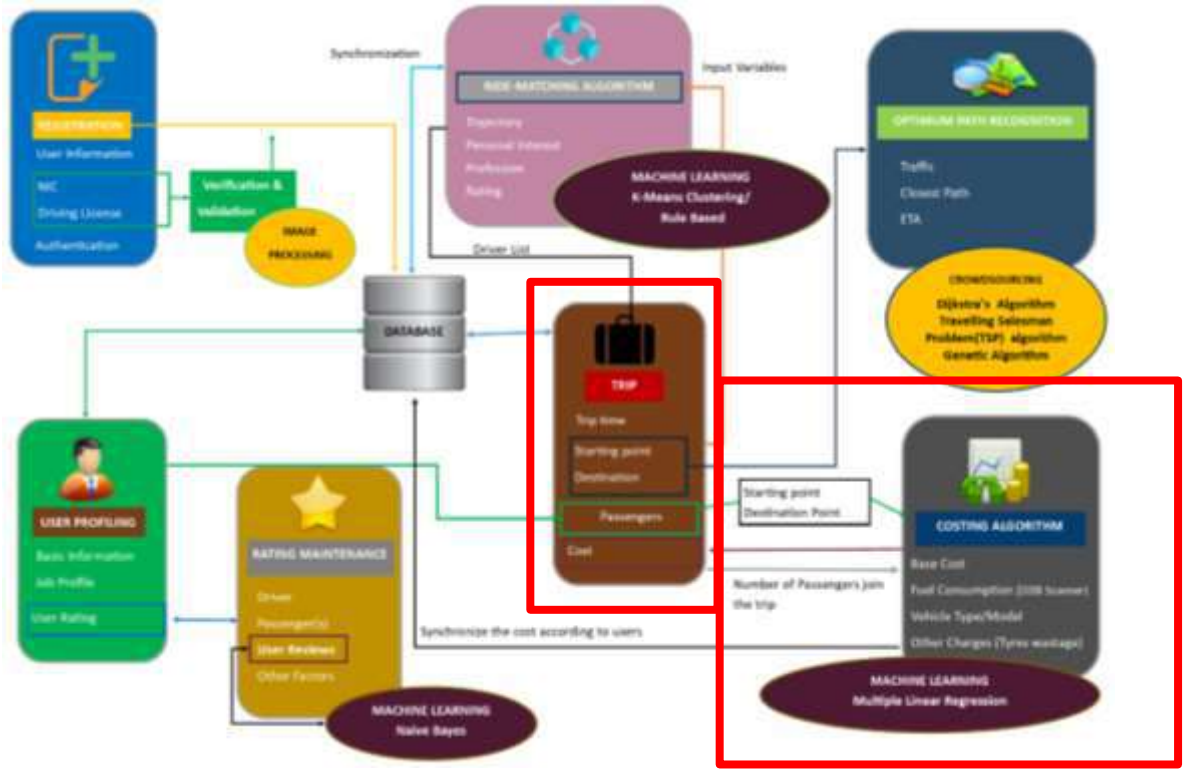


Figure 3.1 - Overall System Diagram In the user

Fare calculation plays a vital role in distributing fare among the passengers. There were two types of fare calculations. First one was estimated fare calculation which is predicted before starting the ride, and the other one is the actual fare calculated using the statistics collected, and it will be notified to passengers via a push-up notification at
the end of the riding session. Fuel consumption varies from vehicle to vehicle. So, the project surveyed to collect information about the cars which were travelling within the Colombo area. Statistics like manufacturer year, engine capacity were collected during the survey.

Fuel type, engine power (kW), transmission type, travelled mileage and average fuel consumption. Afterwards a multiple linear regression model is created to predict the fuel consumption according to the vehicle condition. Number of kilometers get according to the starting point and destination of the passenger using Google distance matrix API.
It is identified that it is reasonable to use the following properties for an estimated fare calculation: (i) the price of a liter of fuel in Sri Lanka market(c); (ii) distance(d); (iii) number of passenger/s joined with the ride(p); (iv) fuel consumption(n) in km/l. Equation (1) is derived as a result of the study to calculate the estimated fare of a user.

$$Estimated\ fare\ Calculation = \frac{\left(\frac{c}{n}\right) * d}{p}$$

Equation 1: Estimated fare Calculation

Need to share some important notice both drivers and passengers. So, it was decided to push notification better than text messaging or call mechanism. After in-depth studied, we choose firebase cloud messaging (FCM) Service. Essential to follow several steps to achieve this target.

I) User authenticates to a firebase app

After the user authenticates returned in the information of users as a callback function to the client device.

```
W/BiChannelGoogleApi: [FirebaseAuth: ] getGoogleApiForMethod() returned Gms: com.google.firebase.auth.api.internal.zzal@20ff8cc
D/FirebaseAuth: Notifying id token listeners about user ( Fl4Z9n4DubRpPEi6qgYaivDLqGj2 ).
    Notifying auth state listeners about user ( Fl4Z9n4DubRpPEi6qgYaivDLqGj2 ).
D/FirebaseApp: Notifying auth state listeners.
    Notified 1 auth state listeners.
```

The returned callback contains the user id (UID), which is the unique id across all providers, and it never changes for a specific authenticated user.

II) Generate device registration tokenDevice registration token is essential to send push notifications as well as that token should be saved on firebase real-time database if user authentication success because of that data save under the user UID which generated in

the authentication process. That generated token should save under the userId in MySQL database because we need to send notification from device to another device (From passenger to driver / From driver to passenger).

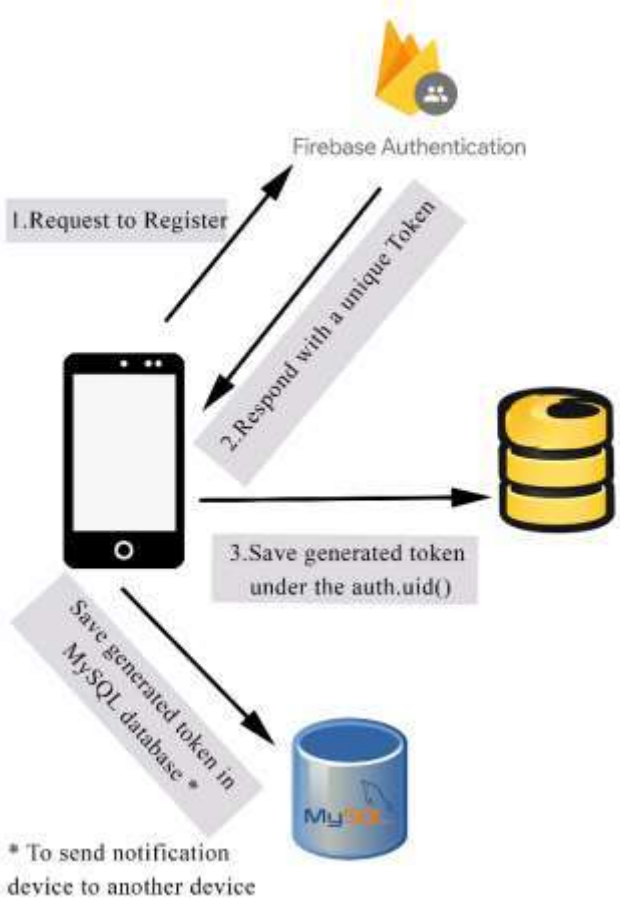
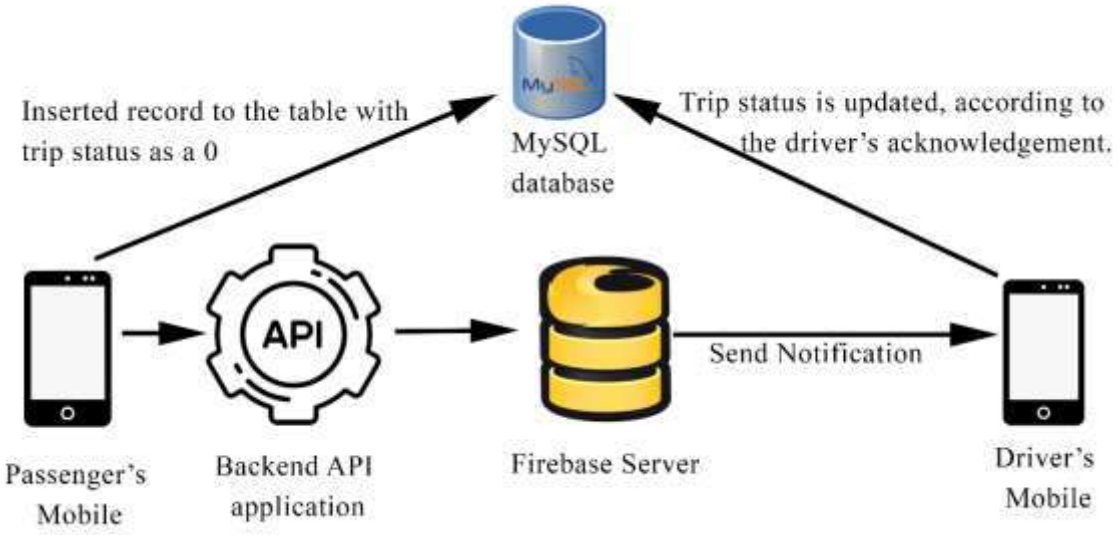


Figure 2.1.4 -Client app registration [15]

Figure 1 Device token save along with user authenticate email

Initially, developed REST API using NodeJS to send notification alone with device token. Unable to send notification without the same network, due to service running on the localhost. To broke that limitation, we deployed our REST API in firebase, after that firebase notification service works on ideally without any disturbances.

The trip requested process as follow,



The static pricing methods assign a fixed price for all the users who are on the platform, and it's obviously not fair depending on the distance and time they travel. Therefore, introduced new fare equation to calculate the fare of the ride. Equation (2) calculates for each segment created throughout the ride. If new passenger joins the trip or passenger end up the trip, new segment will be created. Segment denotes i_n ($n \in Z+$), segment i_1 start fuel consumption is f_{i-1} , as well as segment i_1 end fuel consumption is f_i .

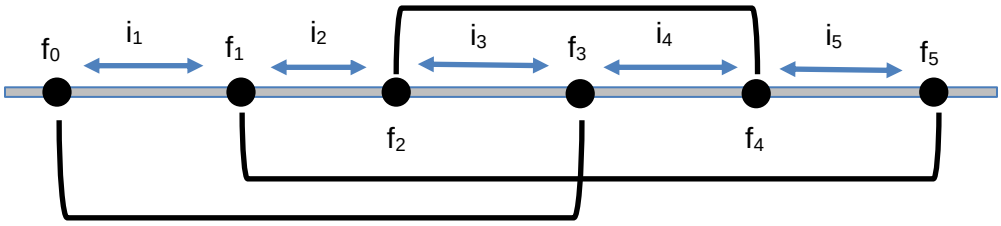


Figure 2.1.7 - Graphical representation how segment divide

Inputs of the equation are the cost for fuel consumption within the segment (f), the number of current passengers (p), and the current price of the fuel in Sri Lanka (price).

$$C\ i\ (Total\ fare\ for\ the\ i\ th\ segment) = \frac{f * price}{\sum p}$$

With the fare of one segment is calculated, we add all the segments together to find out the total fare of the ride using (3).

$$\text{Total Fare of the Ride} = \sum_{i=Start\ point}^{end\ point} (C\ i)$$

Real-time fuel consumption gets from the OBD II Scanner that device based on ELM327 microcontroller, which has a low power CMOS design and RS232 serial interface. Based on the terminal type, it includes an RS232 to Bluetooth, USB or WIFI converter module inside the adaptor. In the mobile phone applicable only Bluetooth and Wi-Fi among of them Bluetooth is better because since it was less expensive and typically has a lower power consumption [16].

The overall overview of the fare calculation component that can able to get clear idea from the following Use case diagram.

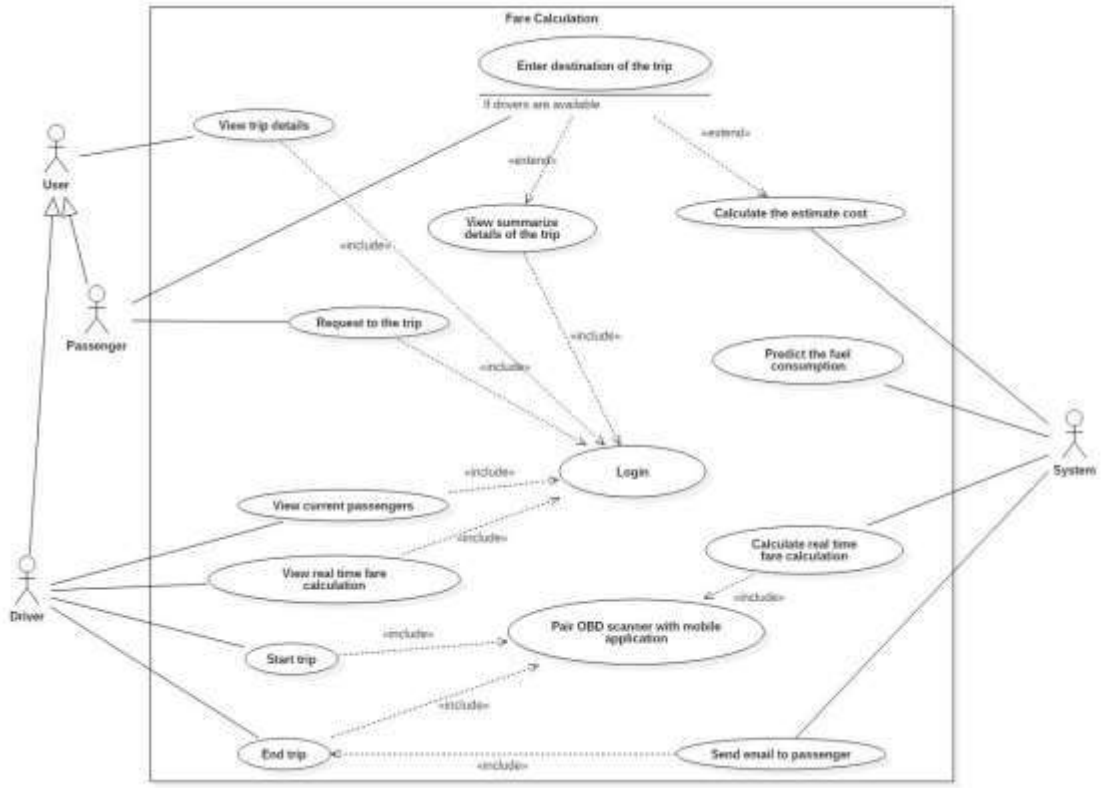


Figure 2.1.8 - Use Case of FC

2.2 Commercialization aspects of the product

“Plus Go” aims to reduce the number of vehicles in the urban areas because of vast numbers of the vehicles enter the urban areas daily basis. So, the business perspective of the “Plus Go”, that was high potential an application because it is representing a considerable problem in Sri Lanka. “Plus Go” specialized for the professionals who daily travel into the Colombo area. When Professionals as passenger requested to the ride, suggested same or higher professionals as drivers. Result of the “Plus Go” minimize traffic congestion in urban areas, save fuel cost of vehicles owner, and environment-friendly.

Initial Phase, “Plus Go” covers only Colombo area afterwards, we decided to expand it in all over the country after the promotion campaign. Our application is free to download and use. We would charge only 10% of the total fare spend by a particular user as our

revenue. Currently, all the services in the application are free, and we will be introducing new value-added services in the future for a small monthly subscription fee. After successfully the beta testing we hope to release it officially.

Currently our application support only android platform, so we will plane to develop for IOS platform. we will plan to introduce new promotion codes, locality schemas as well as an insurance plan to more interactive to the users in our application

2.3 Testing & Implementation

2.3.1 Implementation

2.3.1.1 Hardware Interfaces

To use this "+Go" product user need to properly plug into OBD adapter into the vehicle's OBD port before starting the trip and also user needs to have proper Internet facility. In addition to that, the GPS module will be used for the identification of the current location of the passenger when estimating the fare for the journey.

2.3.1.2 Software Interfaces

The main software interfaces used in the FC component are,

Android Studio	For the development of mobile application
Genymotion Emulator	Emulating purposes
MySQL	Cloud Database Management
Firebase	User authentication purpose Real time database To send notification using firebase cloud Messaging Service
Python	To implement the backend algorithms

Express js	For Development of web API
Distance matrix API	Identify the distance of two Geo Locations

Table 2.1.4.1: Software Interfaces

2.3.1.3 Communication Interfaces

Internet connection is an essential thing for the communication between the mobile app and web server. As well as, Bluetooth facility will use for the between mobile and OBD Scanner.

2.3.1.4 Memory Constraints

- Android version should be 6.0 or higher
- 1 GB RAM
- 100 MB Memory space

2.3.2 Testing

Testing plays a significant role in any application because it depends on the success of the application. Bugs are one of the attributes in the measure the quality, and if bugs are high, it seems app is not ready to release the outsiders. Need to identify the bugs in initial phase otherwise time-consuming, cost-effective. Therefore, we used the V model in the testing phase, where each component after the completion is tested individually before the integration. It can identify the bugs before the unit testing that was more effective that can avoid conflict in the integration process. After completing the whole system, application release to the alpha testing. As the Mobile application, front end, and backend need to be testing together that can get maximum outcome.

Table 2.3.2.1 Test Case 01

Test Case ID	TC01
Test Case Description	To calculate estimate fare calculation
Pre-Condition	Need to be a registered user
Test Procedure	● Provide starting point and destination ● Select the driver from suggested driver list
Test Input	● Start point: Kelaniya ● Destination: Kadawatha ● Current passenger: 1 ● Price of liter of fuel: Rs.136.00 ● Vehicle Information ○ Manufacture year :2017 ○ Registered Year :2018 no of cylinders :3 ○ Fuel type: petrol – Hybrid ○ Engine capacity: 658 cc Engine Power: 38 kW ○ Mileage 7233
Expected Output	Rs.30.28
Actual Output	Rs.30.28

Table 2.3.2.2 Test Case 02

Test Case ID	TC02
Test Case Description	Request to the ride
Pre-Condition	Need to be a registered user
Test Procedure	● Provide the destination ● Click search driver ● Click on the relevant driver ● Click on the “Join a Ride” button
Test Input	● Driver’s device token: X ● Passenger’s device token : Y ● Passenger Name: Jude ● passengerId: U1558711443502 ● driverId: U1558711443513 ● tripId: O1558711443513 ● Start point: Kelaniya ● Destination: Kadawatha
Expected Output	Display Message as “Your request message has been sent”
Actual Output	Success Message

Table 2.3.2.3 Test Case 03

Test Case ID	TC03
Test Case Description	Accept of the trip
Pre-Condition	● Need to be a registered user ● Passenger need to request to the trip ● OBD II device pair with driver's mobile
Test Procedure	● Driver provide the response for the request
Test Input	● Passenger's device token : Y
Expected Output	Driver's mobile redirect to the driver dashboard Passenger received the notification as "Driver will arrive soon. Please wait until knocks at your place"
Actual Output	Received the notification the system as expected

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Predict the fuel consumption of the vehicle

Collected dataset divided into two parts in the multiple linear regression such as trainee dataset and test dataset. Trainee dataset reserved 80% of the whole dataset to trained the linear model and rest of dataset apply for the trained model. After the model, compare the predicted value and actual value. After the comparison model accuracy is 92.08%. Other accuracy measurements as follow,

Correlation coefficient	0.8232
Mean absolute error	0.726
Root mean squared error	1.198
Relative absolute error	50.1178 %
Root relative squared error	65.5605 %

Table 3.1.1.1 Other accuracy Measurements in Multiple linear regression model

3.1.2 System Interfaces

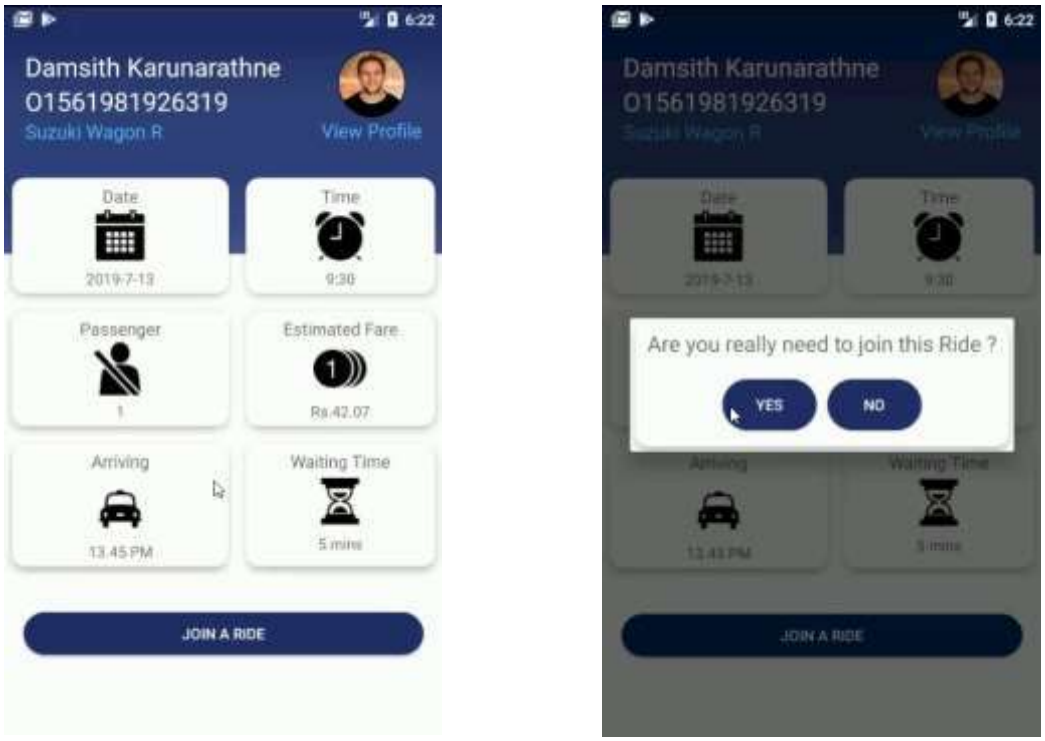


Figure 3.1.4.1 -Trip summary details and request to the ride

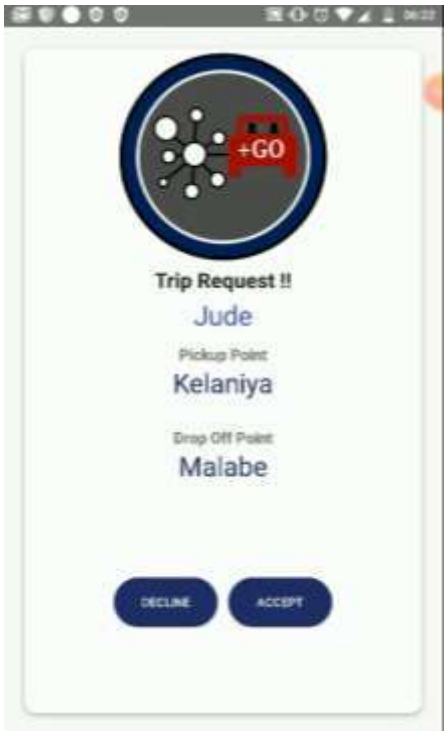
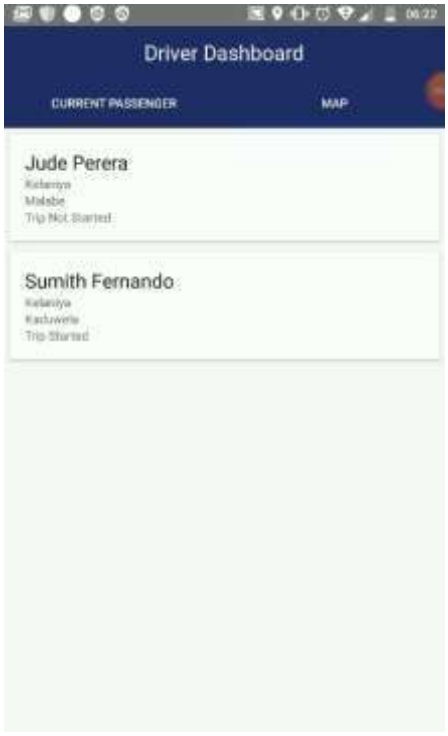


Figure 3.1.4.2 -Trip Requested Notification to the driver


Ride Confirmation
Driver will arriving soon. Please Wait until knocks at your plac
Suzuki Wagon R
View Profile
Date
2019-7-13
Time
9:30
Passenger
1
Estimated Fare
Rs.42.07
Arriving
13.45 PM
Waiting Time
5 mins
PLEASE WAIT FOR THE DRIVER RESPONSE
CANCEL A RIDE


Driver Dashboard
CURRENT PASSENGER
MAP
Jude Perera
Kelaniya
Malabe
Trip Not Started
Sumith Fernando
Kelaniya
Kaduwela
Trip Started


+GO
Trip Information
Jude Perera
Source
Kelaniya
Destination
Malabe
Status
Trip Not Started
START TRIP


+GO
Are you sure to start the trip?
YES
NO
START TRIP

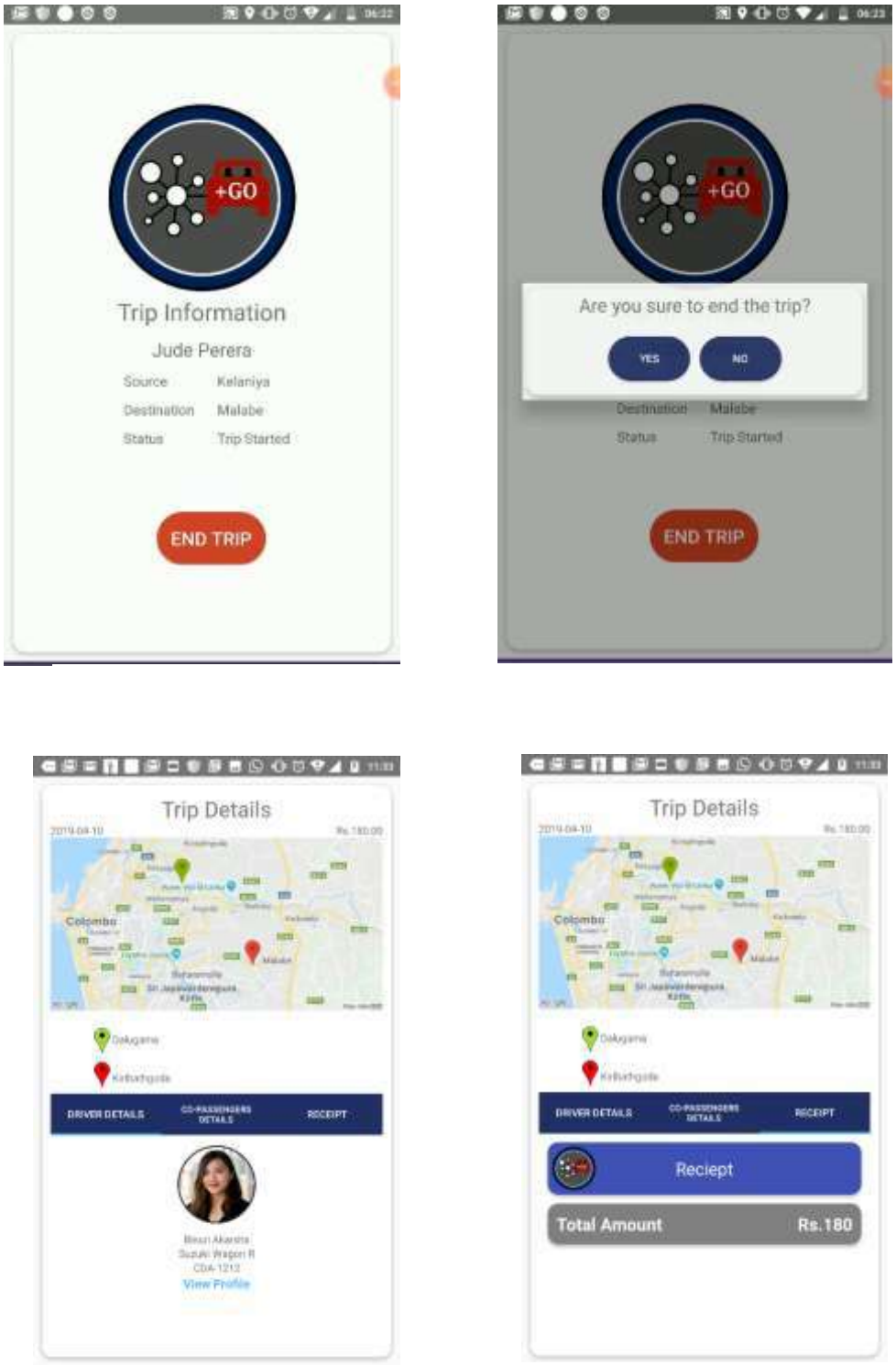


Figure 3.1.4.7 -Trip history details when you selected trip as a passenger

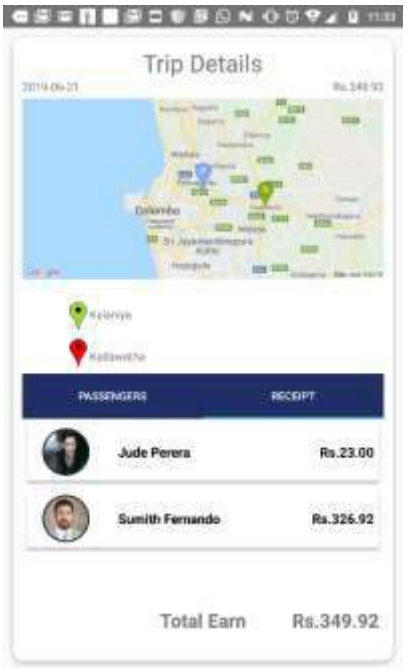


Figure 3.1.4.8 – trip history details when selected a trip as a driver

3.2 Research Findings

As our survey, we confirmed that traffic congestion is the most annoying thing in urban areas. As a result of that condition, the country gains more negative things. As a solution, we came up with “Plus Go” with Ridesharing concept that can minimize traffic congestion up to a considerable level not only that, reduce air pollution due to minimizing the CO2 emission. That is the one kind of investment for the future.

In fare, calculation component describes the, how to divide reasonable fare calculation under the ridesharing concept. It may be price comparatively lower than other taxi services in Sri Lanka because of that people interest and try to get experience with service.

“Plus Go” is an android based mobile application as well as it uses python web services; therefore, less amount of processing power needs to mobile phone. Therefore, the consumption of the battery of the mobile phone is very low.

To read the fuel consumption of the vehicle, used OBD II ELM 327 adapter. In the mobile phone supports only Bluetooth and Wi-Fi among them, we choose Bluetooth adapter because since it was less expensive and typically has a lower power consumption as well as we can get a high amount of accuracy level from OBD reader.

3.3 Discussion

The Primary objective of FC is to give a reasonable cost to both drivers and passengers. For those two types of fare calculation in different places. First one is the predicted fuel consumption that consumption display after selected the driver for the ride. That estimated need to some of the vehicle information (model year, registration year, engine capacity, fuel type, number of cylinders, engine power, mileage), no of current passengers, distance to the destination and current price of a liter of fuel. After surveyed vehicle information to predict fuel consumption according to the vehicle conditions. Initially surveyed with

less number of features but it was not a success due to not enough variable with variations with fuel consumption.

OBD II ELM 327 Bluetooth adapter used to calculate the actual cost for the passenger. Initially, planned to read mileage and Instant fuel consumption (L/100km) from the OBD, but that was not a success after testing several vehicles. After, found an alternative solution for it. Idling fuel consumption, and Driving fuel consumption use instead of mileage, and instant fuel consumption.

Vehicle	**Mileage**	**Instant Fuel Consumption(L/100km)**	**Idling Fuel consumption**	**Driving fuel consumption**
Alto LXI	✗	✗	✗	✗
Toyota VIOS	✓	✓	✓	✓
Suzuki Wagon- R	not supported for few vehicles	Supported some of vehicle value not acceptable	✓	✓
Toyota Allion	✓	✓	✓	✓
Toyota Vitz	Supported	✓	✓	✓

	some of vehicles not supported			
Ssangyong kyron	✓	✓	✓	✓

Table 3.3.1 Comparison the features with OBD II using different vehicles

4. CONCLUSION

As our survey, we confirmed that traffic congestion is the most annoying thing in urban areas. We identified and confirmed that traffic congestion is the root cause for several negative effects in the country as well as the environment. In order to become a proper solution to this issue , we extended the concept of ride sharing as an Intelligent Complementary Ride Sharing System; which was enriched with several machine learning and image processing techniques and has proven that the results are produced with more distinguished accuracy in the context of ride-sharing.

In fare calculation component, dynamic fare is calculated according to the factors mentioned throughout this document. This calculated fare is comparatively lower than other taxi services in Sri Lanka. Due to that, people interest and try to get experience with service.

To read the fuel consumption of the vehicle, used OBD II ELM 327 adapter. In the mobile phone supports only Bluetooth and Wi-Fi among them, we choose Bluetooth adapter because since it was less expensive and typically has a lower power consumption as well as we can get a high amount of accuracy level from OBD reader.

Finally, it is important to emphasize the fact that “Intelligent Complementary Ride Sharing System” which is also known with the application name “+Go” can become a unique and effective solution to reduce traffic congestion in Sri Lanka.

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6. APPENDICES

Appendix A: Survey to collect fuel consumption details