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Intelligent Shuttle Management and Routing Algorithm

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Abstract. Nowadays, most of the big Universities and campuses have Shuttle cabs running in them to cater the transportational needs of the students and faculties. While some shuttle services ask for a meagre sum to be paid for the usage, no digital payment system is onboard these vehicles to go truly cashless. Even more troublesome is the fact that sometimes during the day, some of these cabs run with bare number of passengers, which can result in unwanted budget loss to the shuttle operator. The main purpose of this paper is to create a system with two types of applications: A web portal and an Android app, to digitize the Shuttle cab industry. This system can be used for digital cashless payment feature, tracking passengers, tracking cabs and more importantly, manage the number of shuttle cabs in every route to maximize profit. This project is built upon an ASP.NET website connected to a cloud service along with an Android app that tracks and reads the passengers ID using an attached barcode reader along with the current GPS coordinates, and sends these data to the cloud for processing using the phone's internet connectivity.

1. Introduction

Shuttle services are basically any kind of method used to transport people back and forth from one point to another. Usually all shuttle services would have specific designated pick-up and drop-off points. Shuttle services could be run between these stops at regular intervals or at certain times of the day. While some companies / organizations have this shuttle service free of cost for the users, sometimes there could be a nominal charge for using the service. Services like this help people save time by saving them a long walk between various points of interest in a big campus / university. Shuttle services also help in increasing public safety as it reduces the amount of people walking through the campus roads before or after a big event.

As the campuses become bigger and bigger, larger number of shuttle cabs are needed for the smooth and easy transportational needs of the users. As the number of shuttle cabs increases, management of these cabs become difficult; especially in case of tracking passenger usage and income made per cab. These data solely rely upon the drivers who drive these cabs or by the conductor inside these cabs. The administrator has no other way to know for sure.

To tackle this problem of managing a big shuttle fleet, this paper proposes a Global Positioning System (GPS) based solution where the cabs can be constantly monitored by the administrator and the students and faculties can find where the nearest cabs are. This proposed system also can be used to manage the budget of the users as it will log all the activities of the passengers, while using the cab. This system is cost effective as it does not need any costly equipment to make this system working. The driver's Android phone connected to a barcode scanner would make half the system. The data from the phone would be sent to a server from which users can view the various data.

This paper has been categorized into the following: Section 2 discusses the current shuttle management methods and their limitations. Section 3 talks about the related works about cab tracking. The proposed system and algorithm is explained in Sections 4 and 5 followed by the implementation result in Section 6. Section 7 highlights the results. Conclusion and future works are shown in Section 8.

2. Existing Cab Management methods and their limitations

2.1 No Tracking of Users

The administrator of the cab service have no idea of who all are using the service and how often each user use the service. The admin also won't have any idea about the number of passengers in each cab at a specific time of the day.

2.2 No Budget Management System

Usually shuttle cabs won't have any tickets or receipts for its transactional proof. The money collected by the driver or the cab conductor is the only way where the admin gets to know about the income the cab provider makes. Forms of forgery about the number of passengers boarded or the amount made during the trip can be manipulated here.

2.3 No Scheduling of Cabs

As the drivers won't always know when the peak time is and where is the cab mostly needed to the passengers, most of the times these cabs run with less than sufficient passengers to make any profit. This software helps in routing each and every cab depending on the current needs of the users.

2.4 Users have no idea whether the cab is full or not

Users of the cab service have no idea whether the arriving cab is already full or empty. Only when the cab has reached in front of the user does the user get to know about the status inside the cab. This could be irritant to the user who is in a rush to get to his / her destination fast.

2.5. Routing for multiple Routes

Usually no accurate route allotting model is being used to run the cabs. Certain number of cabs are allotted in each route by default based on no criteria. This program helps in determining which route has the most passenger traffic and helps in allotting cabs to the route with more number of users, from the route where there is less traffic.

3. Related Works

While references [1] and [2] proposes great systems to track vehicle positions in real time, there are limitations where it could be deployed for shuttle services in large campuses or universities. As shuttle services are not being paid for the distance they run or the amount of time for the journey, this system does not need a separate variable for time or distance for its calculations [3]. Here the price tag for users are also mostly constant. Hence this system needed a new algorithm where time, cost or distance is not considered and yet these cabs could be managed efficiently maximizing profit and usability to both the administrator and the users.

4. Proposed Systems

The proposed Intelligent Shuttle Management and Routing program consists of mainly 3 parts.

1. The Web Portal
2. Android App
3. Cloud Server

Along with these three components, the Intelligent Shuttle Management and Routing Algorithm (ISMARA) is used to manage and route the cabs through the various routes depending on the passenger demands. This paper is mainly about the proposal of this algorithm.

The schematic diagram of the entire system is as follow:

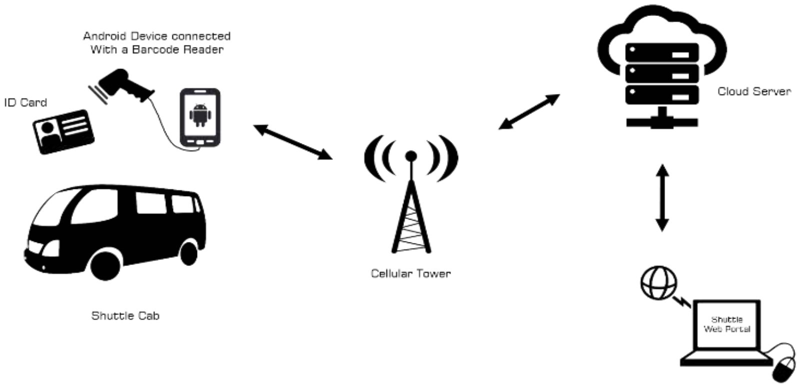


Fig. 1. Schematic diagram of the proposed system

4.1 The Web Portal

The web portal is the biggest part of this project. This part handles most of the modules this project need. The various modules which the Web Portal handles is as follow:

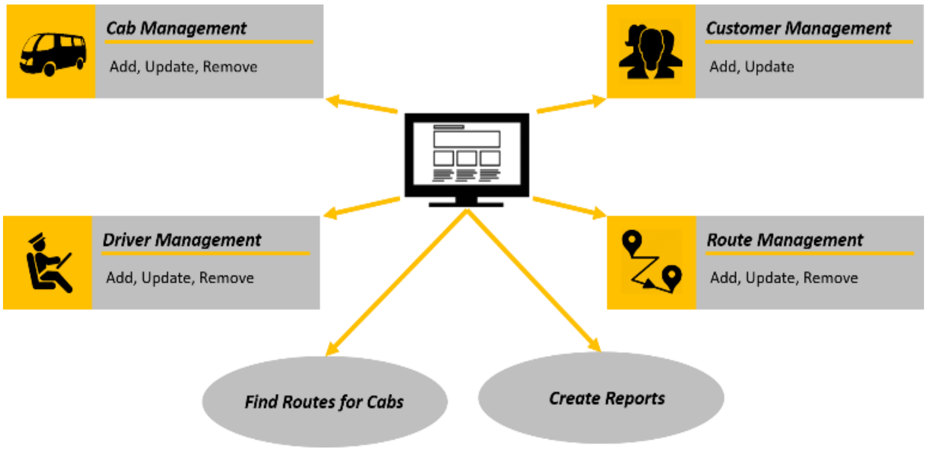


Fig. 2. Module diagram of the web portal

4.1.1 Cab Management

This module deals about all things related to the cab. This involves the admin adding and updating the cab details such as its Registration number, seating capacity, current serviceable status, etc. Based on these data, the cab will be selected for the route to travel.

4.1.2 Driver Management

Driver Management module deals with the driver details. Here the admin gets to add or update driver details like his personal info, login ID and password, see his active hours, etc

4.1.3 Route Management

This module deals with the route info. The admin can add or update any existing routes. Route info stored includes the route source and destination, route name and the geofence location latitude and longitude for the android phone to track the route progress.

4.1.4 Customer Management

This is a basic module that tracks and stores the passenger details of the cab. It records the number and times each and every passenger has used the system and calculates the total amount he or she has to pay to the cab service provider. Only a registered user can log in to the app to view their history. Non registered users are also added to the database using their ID registration number that is scanned during the cab usage, but they can't login to the app without creating an account.

The Web Portal is made using ASP.NET (C#) as front end with MySQL as the Back End Data Centre. The website is made with HTML 5 standards and Responsive design so that it could be accessed using any Internet enabled device; not just the desktop computer. The main two users of the system is the Administrator and the user. The Administrator can log in and see the various reports like total income, daily reports, view the customers who used the shuttle service, add or update cabs, add or update routes, add or update drivers, etc.

The Passengers can log in using their registration number and see the total they have spent using the cab, number of times they have travelled as well as other statistics like view the date in which they travelled the most and the hour span where they use the cabs the most. They can also view the nearest cab and where it is heading as well as the passenger numbers inside so that they can get the cab fast without any wait.

4.2The Android App

The various modules which the Android app deals with are the following:

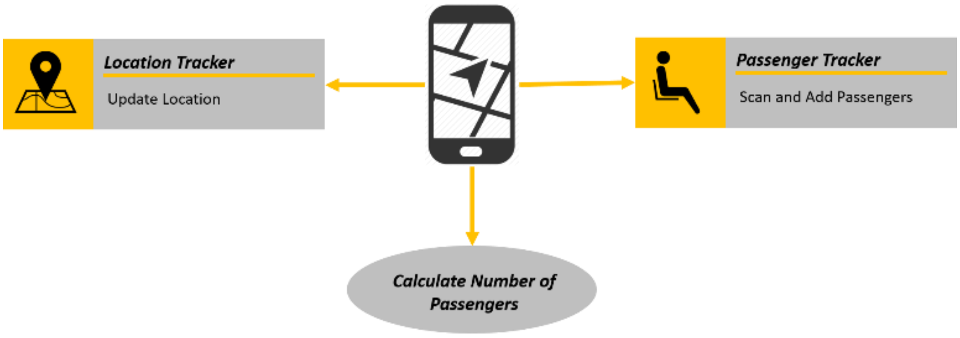


Fig. 3. Module diagram of the android App

4.2.1 Location Tracker

This module is one of the important part of the Android app. This module deals with sending the current accurate geo-location data to the cloud server at periodical intervals. This module also sends location data whenever a passenger comes aboard the cab to find the denser passenger usage points in the map.

4.2.2 Passenger Tracker

This is comparatively a simple module where the sole duty of this module is to read the Registration ID of the passenger from their ID Cards and send it to the cloud server for customer usage processing.

Along with this, this module also deals with sending the total passenger statistics inside the shuttle cab to the cloud server so that passengers waiting for the cab could view whether the cab is full or not from their mobile device.

The Android app is developed using Android Studio, with support to be used with any Android Device. Depending on the screen size, the app will change its look to accommodate the screen.

The main functionality of the Android App is to act like a Location tracker and a passenger tracker [4]. When the Admin logs in to the app, he will be made to select the cab for the day which he will be driving. Then the app shows the map view which shows the route in which the cab should take, along with the stops where there have been high passenger demands in the past 5 minutes. All this is calculated when the cab reaches its destination geofence marker and sent to the drivers android phone. When a passenger gets in, using the attached barcode reader to the mobile, the driver scans the passengers ID card, which gets transmitted to the cloud along with the current location of the cab.

4.3 The Cloud Server

The third part in this project is the Cloud Server which holds all the data sent by the Drivers Android App and provides data statistics and views to the Web Portal users and the android app customers. Data is stored in a MySQL Database [5] hosted in the cloud. The Cloud server also does an important functionality. When a cab has reached its destination marker, the app will trigger a function which gets executed in the cloud which determines the route that has large passenger demands and allots the cab to that route [6]. The cloud also sends the data like where the most passenger demand locations were in the past five minutes, using HTTP responses [7].

5. Proposed Algorithm

The proposed ISMARA Algorithm consists mainly of 4 steps which are comparatively easy to implement. The four steps are the following:
Let the number of Routes be R, total number of cabs be C, cabs running currently in a particular route be C*, and the number of passengers be P. The minimum number of passengers needed for making profit must be defined.

Step 1: Start dispersing 1 cab each to R routes.

$$C^*_{\text{(Route i)}} = 1 \quad (1)$$

Step 2: Calculate the average P value along each of the R routes.

$$\text{Avg. } P_{(i)} = P_{(\text{Cab } 1)} + P_{(\text{Cab } 2)} + \ldots + P_{(\text{Cab } C^*)} / C^* \quad (2)$$

Step 3: Calculate the Cab Index value by dividing the average P value with C* of that particular route.

$$\text{Cab Index Value } R_{(i)} = \text{Avg. } P_{(i)} / C^* \quad (3)$$

If the Cab Index value is greater than 1.2 (the minimum passenger to cab ratio defined by the admin), add
one more cab to that route.

$$C^*_{\text{(Route i)}} = C^* + 1 \quad (4)$$

Else if the Cab Index value is less than or equal to 1.2, subtract one cab from that particular route.

$$C^*_{\text{(Route i)}} = C^* - 1 \quad (5)$$

Step 4: Repeat Step 3 till the shuttle cab servicing time is over.

If everything goes right, and another cab is needed in that route, the cab driver of the least used route or a currently inactive cab will be notified about the demand needs via the app. If the cab number is too much for the passenger demands, the app will notify which all cabs are to stop servicing to maximize profit and minimize wastage of fuel.

6. Implementation

For implementing this system, we have used the Samsung Galaxy Note 4 Android Version 6.0.1 Marshmallow as the Drivers Screen connected to a Handheld 32 bit Decoder Barcode Scanner to scan the passengers ID card. The phone is placed on a mobile stand attached to the vehicles windshield. The data from the Drivers Android phone is sent to the cloud server registered by us with MySQL database support in it included. For the web portal, any Internet enabled device is usable; here we use a Windows 10 PC with the browser being Mozilla Firefox.

As it can be seen from the Figure 4, the admin gets to see many statistics on his landing page after signing in. The admin can then add or update driver details, add or update cabs, add or update routes or even track the various cabs running.

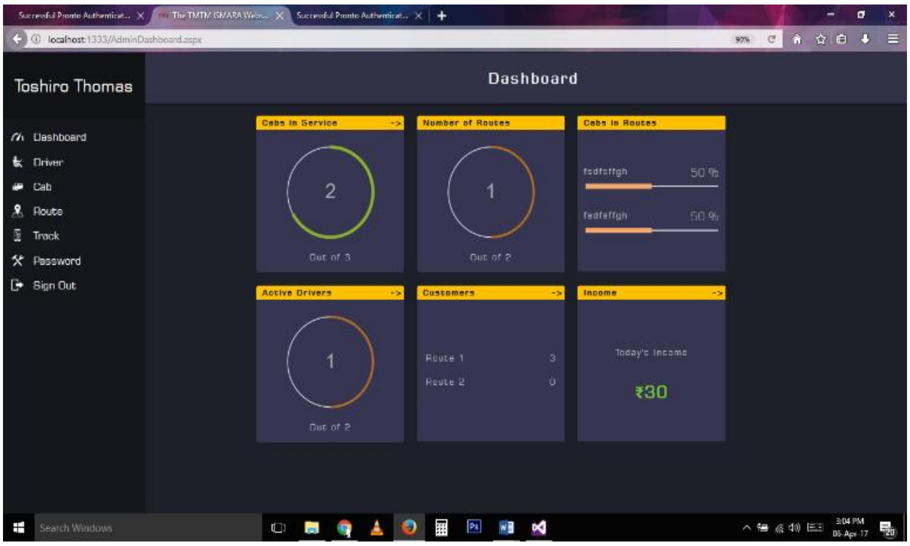


Fig. 4. The web portal admin dashboard

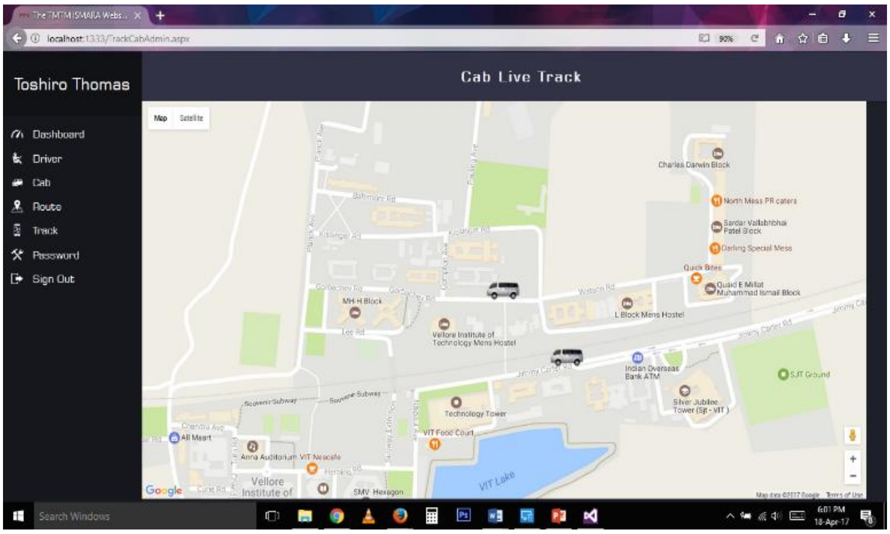
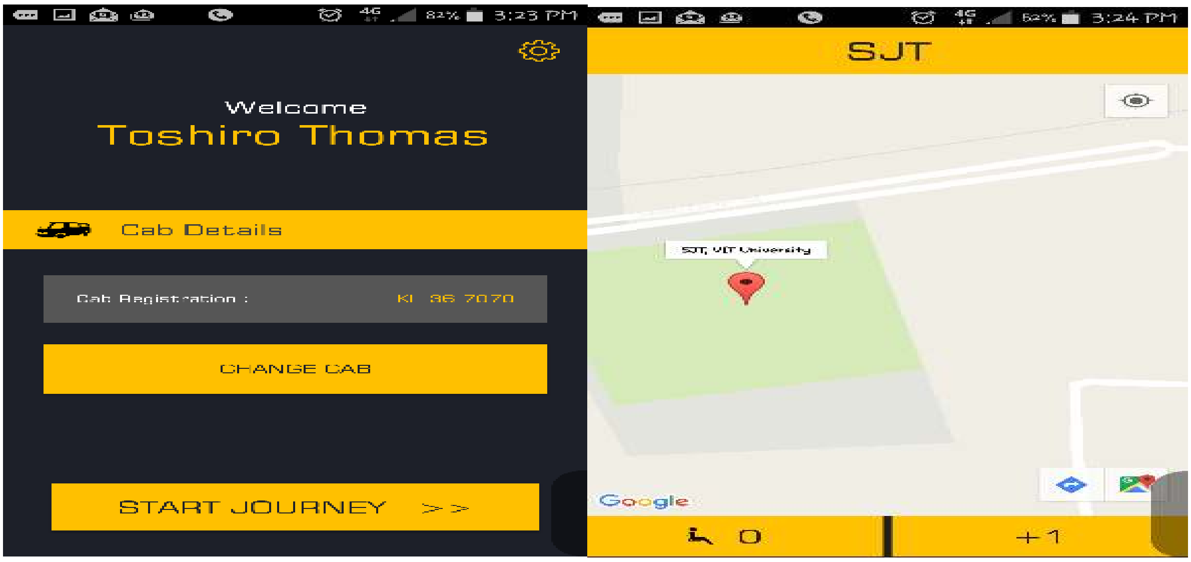


Fig. 5. The web portal live track

The above seen Cab Live Track feature is available to both the Administrator and the customers. The customers can use this feature to find the nearest cab available to them.



Cab Registration : KL 36 7070

Fig. 6. The driver's app screens

The driver gets to know the next route to take and the current passenger number inside his cab, all from one screen. This app tracks the cab movement and sends the GPS coordinates periodically to the cloud server, as well as the Registration ID of the passenger who comes aboard. In cases where the passenger does not have an ID card when boarding, the app is still made to accommodate such changes where the Driver can manually enter the '+1' button to add a passenger and collect the money personally by the Driver.

7. Findings

To get the final results, we had to test the app. For this we used the VIT University, Vellore campus to do so. The cabs, routes and coordinates of the routes where inputted and made to test. The program started by sending off one cab each to all routes and depending on the passenger demands, the cabs where increased. When the cab reached the destination, the Geofence triggered and notified that the trip was over and the server gave the cab the next route to take. It also showed the cab statistics of that trip in the Drivers screen. The system performed as it was supposed to do.

8. Conclusion and Future Works

This project was made using various technologies like the Android OS phone, Barcode reader, Cloud server and Website portal. All the needed aspects of this project which had to be taken care during the project development was seen into and implemented. Till some future technologies like identifying people faster or sending data to the cloud server faster and more efficiently, or identifying the current location with less power and more precision, could be implemented with cheaper costs, this project will satisfy the current Shuttle cab needs in most of the large campuses or universities.

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