CSE3001
SOFTWARE ENGINEERING

FLEET MANAGEMENT SYSTEM

J COMPONENT PROJECT REPORT

Submitted by

RUCHICA SINHA 18BCE2016
SHRAVANI SHETE 18BCE2125

in partial fulfillment for the award of the degree of

B. Tech in
Computer Science and Engineering

School of Computer Science and Engineering

May 2020

Table of Contents

SOFTWARE REQUIREMENT DOCUMENTATION

1. Aim 5

2. Scope 5

3. Purpose 5

4. Perspective 6

5. User Characteristics 6

    5.1 Administrators and authorized personals Module 7

    5.2 User Module 7

    5.3 Tracking Module 7

    5.4 Help Module 7

    5.5 Health Module 7

6. Software Requirements 8

7. Hardware Requirements 8

8. Functional Requirements 9

9. Non-Functional Requirements 10

10. ER Diagram 11

SOFTWARE DESIGN DOCUMENTATION

1. Introduction 12

2. Design Considerations..... 13

2.1 Assumptions and Dependencies 13

2.2 Goals and Guidelines 13

3. Architectural Strategies 14

4. System Architecture 14

5. Policies and Tactics 15

6. Detailed System Design..... 16

6.1 Website Design.....17

6.2 Gantt Chart 18

6.3 Use Case Diagram 18

6.4 Sequence Diagram 21

6.5 Collaboration Diagram 23

6.6 Class Diagram 25

IMPLEMENTATION

1. Login/ Signup 26

2. Dashboard 27

3. Driver 28

4. Vehicles 29

5. Booking 30

6. Booking Continued 31

7. Repair 32

8. Report 33

9. Database 34

    9.1 Site Administration 34

    9.2 Users 35

    9.3 Booking 36

    9.4 Driver 36

    9.5 Repair..... 37

    9.6 Vehicles 37

10. App Designs 38

    10.1 Login page…….. 39

    10.2 Home page…… 40

    10.3 View Admins and their details……. 41

    10.4 View users…… 42

10.5 Active bookings …….. 44

10.6 Spare parts availability……. 45

10.7 Driver Details……. 46

10.8 RoadSide assistance…… 47

10.9 Admin help……. 49

10.10 Alert section……. 51

11. Glossary 51

SOFTWARE REQUIREMENT SPECIFICATION

1. AIM

We aim to define a model for the efficient fleet management and service maintenance of the vehicles, spare parts inventory, and supplier's records management. We hope to successfully complete the project with the cooperation of our group members. By doing this project we hope to obtain valuable knowledge for the foreseeable future.

2. SCOPE

The fleet management system is used for monitoring different kinds of motor vehicles such as cars, vans, trucks, aircraft, ships as well as rail cars. It has numerous applications such as vehicle maintenance, vehicle tracking, and diagnostics, improving driver performance, speed control, repair, routing, employees, location, drivers, and fuel management.

Fleet management is a complex and largely data-driven process that requires involvement in every part of a company's fleet. A successful fleet management program will track, analyze, and work to optimize every aspect of the fleet, which encompasses hiring and training drivers, acquiring vehicles, tracking the fleet, regulating maintenance and safety protocols, mitigating risk, and preparing for all operation situations.

3. PURPOSE

The objective of Fleet Management in business is to ensure the work vehicles of business are operating smoothly, are constantly seeking ways to improve performance, are able to keep operating costs at a minimum, and maintain compliance with government regulations. Fleet Management System is the range of functions that allows transportation companies in business to minimize the risk related to improving efficiency, proven return on investment, productivity in business and reducing the overall cost.
It is a modular-based system that has been developed for the group of transportation or large companies using fleets/vehicles with the sole intention of operating the business in a timely manner and reliable way.

Fleet management includes a range of functions like tracking valuable assets; automating the fleet reports, Management of vehicles and security & control of the fleet.
Using dedicated software for managing fleet brings multiple benefits to the table:

- automates tasks (e.g. proper routing)
- streamlines associated processes (e.g. Vehicle maintenance)
- provides real-time insights for better management of both drivers and vehicles
- connects vehicles
- ensures smart transportation
- enhances driver safety
- guarantees consistent fleet performance
- reduces costs

4. PERSPECTIVE

The super users of the system are the 'ADMIN' and the 'MANAGERS' of the different departments allocated by the admin. The admin may be the owner of the transportation organization or the manager of the transportation department of a particular manufacturing company. If any other vehicle is added to the fleet which already exists for the organization/department the details of the vehicle are added. The details include whether it is a new one or taken out of any loan/lease. Any employee is newly appointed or the existing employee is taken off both the details are maintained including their personal details and professional details. The details of the maintenance that are being performed such as repairs/services and to be performed are also maintained.

The maintenance to be performed can also be scheduled for each type of vehicle. The details of the parts/inventory used for the vehicles are maintained. The reorder level and the reorder quantity are predefined for each particular type of part. The Vendors or suppliers of the vehicles, parts and performs the maintenance required for the vehicles. The particulars of the various vendors are maintained in this system. Examples of large business fleets include Rental car/truck companies, Moving companies, Taxi companies, Delivery companies, Long haul semi-truck companies.

5. USER CHARACTERISTICS

1. Administrators and authorized personals Module
2. User Module
3. Tracking Module

4. Help Module
5. Health Module

Administrators and authorized personals Module

A list of authorized personnel will be granted permission to access the management side of the fleet. No one can register as admin after the accounts are created until the code is altered to ensure security. The admin account has all the privileges, to check about any particular vehicle (fleet) or customer, to block any account, to update the status about health and generate alerts, to calculate the payment, making changes into accounts of users, maintain a list of all the customers and the spare part inventory status, etc.

User Module

After the user has registered and logged in, then the features provided can be used by the user. If the user is a customer then he can see all the available fleet could be taken on rent. There are two users that are present here in this system. One is admin but the other is a user. This user has all the privileges but it cannot register itself on this system as the admin needs to verify the registering user. After the admin verifies the user only when he is eligible to use the system.

Tracking Module

Vehicle tracking systems are commonly used by fleet operators for fleet management functions such as fleet tracking, routing, dispatching, on-board information, and security. Some vehicle tracking systems are bundled with or interface with fleet management software. Along with commercial fleet operators, urban transit agencies use the technology for a number of purposes, including monitoring schedule adherence of buses in service, triggering automatic changes of buses' destination sign displays once the vehicle approaches the bus terminus (or other set location along a bus route such as a particular bus stop along the route), and triggering pre-recorded (or even synthetic speech) bus stop, route (and its destination) or service announcements for passengers.

Help Module

This module gives the customers/ users the privilege to contact nearby towing, roadside assistance, and car health check-up (according to the parameters mentioned earlier) facilities, in case of any emergency situation. In this case, the customers are made aware of the nearby service stations.

Health Module

Our fleet car safety module includes workplace health and safety videos on topics including braking, vehicle speed, distractions for drivers, drug and alcohol awareness, manual handling, pre-operational checks, and more.

6. SOFTWARE REQUIREMENTS:

Frontend - HTML, CSS, Javascript, Python3
Backend - Django
Database - Sqlite3
Processor - Ubuntu as an operating system.

Database: Obtaining databases from,The merchants who have sold the vehicles to the fleet, the data from the spare parts inventory, the list of managers and authorized personals who will be granted the permission and list of customers who are currently using the fleet for required work.

Mapping Systems: This is the main software component of the Fleet management system. This whole system is dependent on the web mapping of the data or information that the GPS devices provide. Google maps could be used as the tool which displays geographical information on a map which is the most accepted form as digital data.

7. HARDWARE REQUIREMENTS:

Mobile Phones: Any Mobile phone with the driver with GPS enabled in it can be used for the real time tracking of the vehicle and the driver. This provides us with the location access to any of the fleet.

GPS Device: Connectivity to GSM/GPRS models fixed on the vehicles. Live GPS tracking devices are ideal for most vehicle tracking needs. With live GPS tracking systems in the fleet, you can have access to real-time data about vehicle location, use, driving speed, etc. This can be used to track driving habits, route vehicles more effectively, keep tabs on equipment that is at high risk of theft or emergency situation.

Web browser: Internet Explorer 5.0 and above.

Socket connection: One of the main software components of the Fleet management system is a socket communication server. It is a central server component that communicates with the tracking units. Socket connection is capable of communicating with multiple clients units using multiple threads as it establishes TCP/IP socket connection with the remote hardware units. When the fleet GPS is connected, the server will authenticate the connection and proceed to receive information from the device.

8. FUNCTIONAL REQUIREMENTS

MANAGING VEHICLES:

We will provide you all the information regarding the fleet/vehicles in the web portal's dashboard-like vehicles insurance details, vehicle renewable reminders and Maintenance/service reminders for vehicles, etc. Our system provides automated reports for every penny you spent on the vehicle and each expense you are going to do in the meantime. We provide a vehicle orders bar where you can manage orders and get previous order details.

GPS TRACKING:

The tracking unit collects the location information with the help of the GPS (Global Positioning System) device which we used in our system as hardware. Global Positioning System can be used for providing the route to the fleet. GPS formats collect information into the system-specific packet format and send it to the server via socket connection server. Global Positioning System tracking system uses the Global Navigation Satellite System (GNSS) network. This network incorporates a range of satellites that use microwave signals that are transmitted to GPS devices to give information on location, vehicle speed, time and direction by which we can manage Real time tracking of the fleet which includes vehicle tracking, driver detail and asset details and Fleet scheduling management for on-time deliveries and customer services.

SPEED TRACKING:

Driving with excessive speed is one of the main factors in fatal road accidents. Driving at a safe speed can help save lives. Fleet managers have an interest in keeping their drivers on the road and out of the troubles, and they also want to ensure that their fleet is operating in an efficient and timely manner. Speed tracking and reporting is a principal feature in the Fleet Management System. In terms of reporting, our systems will report all offenses to base in real time (even have the capacity to set an SMS alert)

GEOFENCE:

Geofence is described as the circular areas which are defined around a particular location. It is set by the client in the Fleet Management system by being able to define the radius of the area. The GPS location of the center of the circle and the radius define a Geo-fence. If a vehicles GPS location is within the Geofence, then they are in safe area and if any vehicle go outside the area of geofence the client is notified by a text or email alert and the event is recorded

AUTOMATE THE FLEET REPORT:

We surely provide the automated report on each transaction or order. We provide automated reports of the previous orders of the fleet which you can check at any time or download the file.

9. NON-FUNCTIONAL REQUIREMENTS:

Server: We can use any server for this management system but we prefer these two servers to be precise that we will be working on:

NGINX Server – Nginx is an open-source web server that can handle a website with a huge amount of traffic. It is a high-performance web server developed with an intention to handle websites with a large number of users. Its specialty is that it can run on a minimal amount of resources and handle a large number of requests.

Digital Ocean Server – Digital ocean server or 'droplets' is a cloud server that is designed to store and server a massive amount of data while making it easy and cost-effective. Digital ocean server uses KVM as a hypervisor and can be created in various sizes. It helps in build deploy and scale cloud application faster and more efficient

Database: We will be using any of these two databases for storing the data we collected from the tracking devices of the fleet:

PostGIS/PostgreSQL
Django Administrator
MySQL

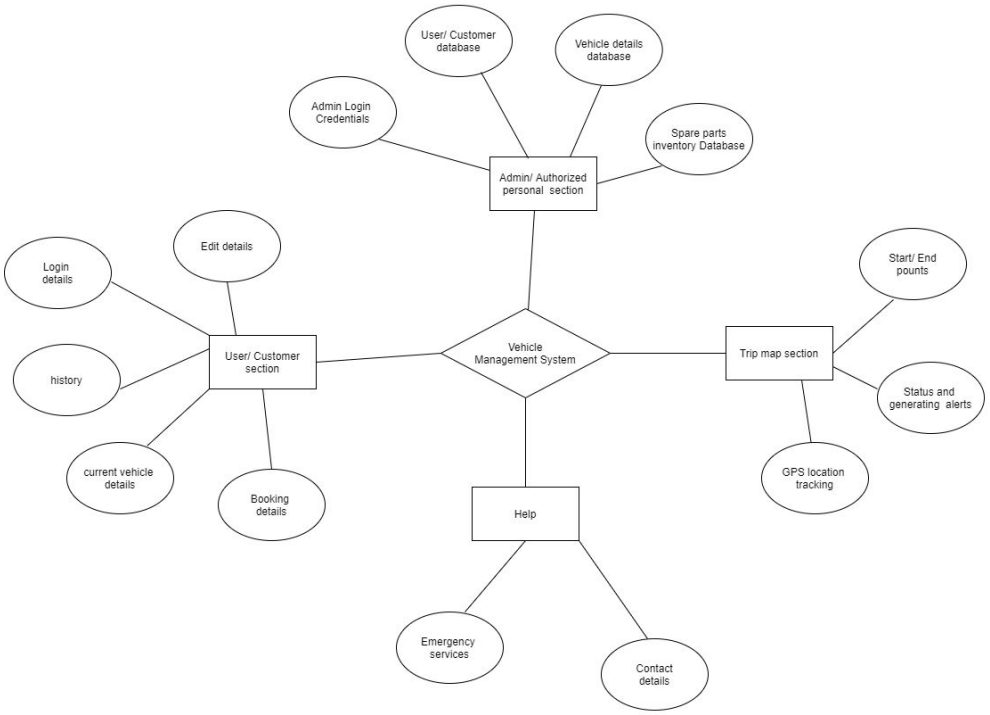
Mapping Systems: This is the main software component of the Fleet management system. This whole system is dependent on the web mapping of the data or information that the GPS devices provide. For mapping the data we can use any of these two Mapping systems.

Google Maps: Google Maps is the tool that is used to display geographical information on a map which is in a widely accepted standard format for digital maps.

OSM (Open Street Map): OSM is the software that creates and distributes the open-source graphics data of the world. OSM has no restrictions of the technical or legal type. It allows free access to its map images and underlying map data. Here we can show our tracking data in real time.

E-R Diagram

Fleet management system



Text

SOFTWARE DESIGN DOCUMENTATION

1. INTRODUCTION

This will serve as "objective evidence" that the designers and/or implementers are following through on their commitment to implement the functionality described in the requirements specification. It will be able to adequately serve as training material for new project members, imparting to them enough information and understanding about the project implementation, so that they are able to understand what is being said in design meetings, and won't feel as if they are drowning when they are first asked to create or modify source code.

2. DESIGN CONSIDERATIONS

3.1 **Assumptions and Dependencies**

For the program to run, the software called XAMPP is used XAMPP is a free and open-source cross-platform web server solution stack package developed by Apache Friends, consisting mainly of the Apache HTTP Server, MariaDB database, and interpreters for scripts written in the PHP and Perl programming languages
Any operating system will work if it supports XAMPP
There end users are expected to have basic computer knowledge

3.2 **Goals and Guidelines**

The following design principles were used while making the project

• Open/Closed Principle (OCP)
This principle states that software entities (classes, modules, functions, etc.) should be open for extension but closed for modification. The "closed" part of the rule states that once a module has been developed and tested, the code should only be changed to correct bugs. The "open" part says that you should be able to extend existing code in order to introduce new functionality.

• Interface Segregation Principle (ISP)

This principle states that Clients should not be forced to depend upon interfaces that they don't use. This means the number of members in the interface that is visible to the dependent class should be minimized.

• The KISS principle ("Keep it simple stupid)
This principle states that try to keep each small piece of software simple and unnecessary complexity should be avoided. This helps us to write easy maintainable code.

• DRY (Don't Repeat Yourself)
This principle states that each small pieces of knowledge (code) may only occur exactly once in the entire system. This helps us to write scalable, maintainable and reusable Code.

• Single Responsibility Principle (SRP)
This principle states that there should never be more than one reason for a class to change. This means that you should design your classes in such a way that each class should have a single purpose.

3. ARCHITECTURAL STRATEGIES

The strategies adopted during the development process are:

- Relational - Indexing
- Ability to store user history
- User habits to store for analysis
- Minimalistic interface
- Intuitive process flow
- Easy to read results
- Future extension to support web based application

- Modules used in this project are:
  Administrators and authorized personals Module
  User Module
  Tracking Module
  Help Module
  Health Module
  Alert section to display emergency situation of any fleet

- Software Requirements of this project are:
    - **Web application**
      Frontend - HTML, CSS, Javascript, Python3
      Backend - Django
      Database - Sqlite3
      Processor - Ubuntu as an operating system.
    - **Mobile application**
      Frontend - Flutter, Android studio
      Backend - Dart
      Database - SQFlite Plugin
      Map services - **google_maps_flutter**: ^0.5.11
      Processor - Android/ IOs as an operating system.

- Hardware Requirements of this project are:
  Mobile Phones
  GPS Device
  Continuous internet connection while using the application
  Web browser
  Socket connection

4. SYSTEM ARCHITECTURE

User Table

Unique ID	Name	Address	Phone	Login Details

Admin Table

Unique ID	Name	Department	Phone	Login Details

Vehicles Details Table

Vehicle No.	Health Criteria Details	Last Service Date	Currently in use yes/ no

Active Bookings

Fleet Id	Admin incharge	Starting Point	Ending Point

Spare Parts in the Inventory

Parts Name	Availability

Service Centers

Location	Name of Center	Contact Details

5. POLICIES AND TACTICS

To implement software design, we used a variety of strategies that help us define the respective tasks and assist them with the designing process. Here are a few of these strategies we used for designing accurately as well as bug free software products.

Structured Design: This is a conceptualisation of problems into several well organised elements of solutions. It is mainly concerned about the solution design. The biggest advantage of structured design is that it gives a better understanding of how the problem is being solved. Structured design also makes it simpler for the designer to concentrate on the problem more accurately. Additionally, a well-structured design follows some rules for communication among multiple modules, like cohesion and coupling, where cohesion is the grouping of all functionally related elements and coupling is the communication between different modules. In short, a well-structured design has high cohesion and low coupling arrangement.

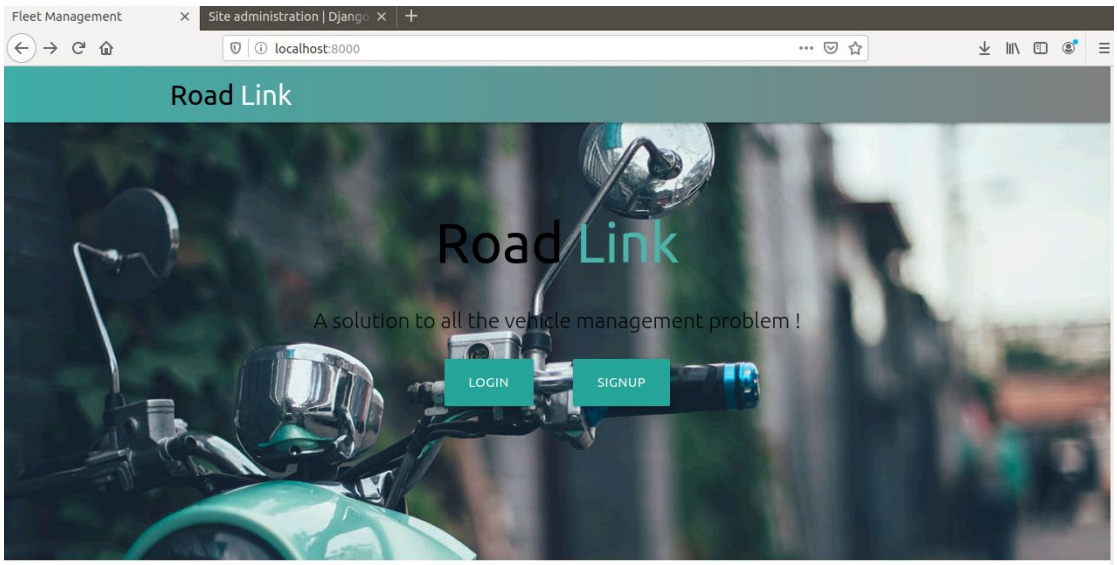
Function-Oriented Design: This is one of the classical methods of software design, where decomposition centres on identifying the major software function and then elaborating and refining them in a top-down manner. In Function oriented design, the system consists of many smaller sub-systems known as functions. These functions can perform significant tasks in the system. Also, in this the system is considered as the top view of all

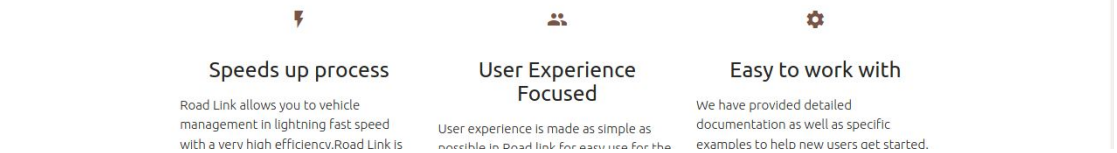
functions. Furthermore, function-oriented design inherits some qualities and properties of Structured Design, where divide and conquer methodology is used. This type of design works well where the system state does not matter, and the program or function works on input rather than on state.

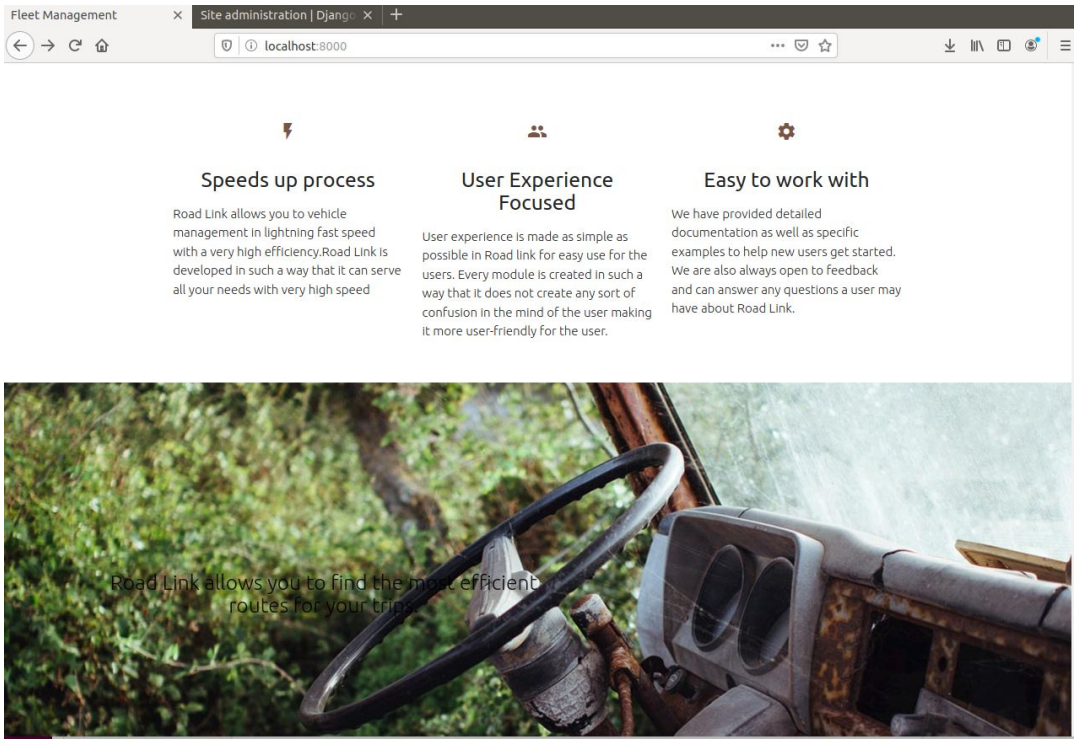
Object-Oriented Design: Object oriented design works with around the entities and characteristics rather than with the function involved in the software system. The whole concept of software solution revolves around the engaged entities.

6. DETAILED SYSTEM DESIGN

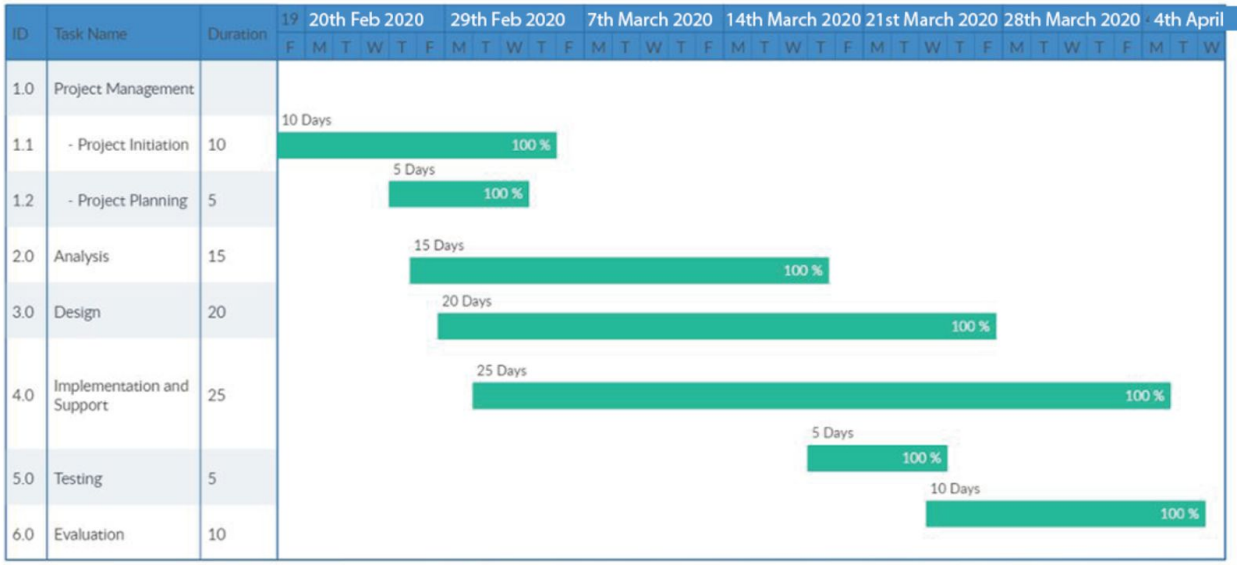
Website Designs


Fleet Management
Site administration | Django
localhost:8000
Road Link
Road Link
A solution to all the vehicle management problem !
LOGIN
SIGNUP

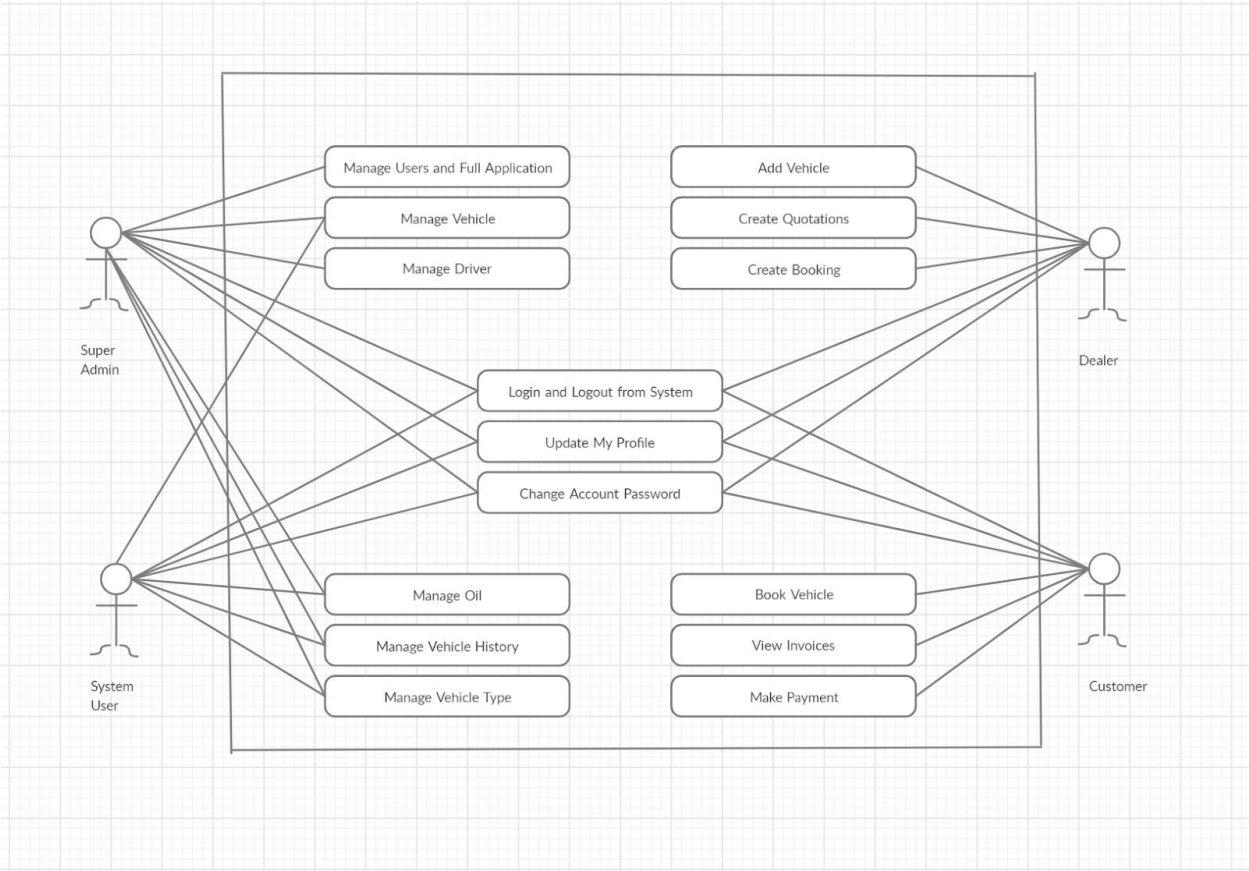

Speeds up process
Road Link allows you to vehicle management in lightning fast speed with a very high efficiency.Road Link is
User Experience Focused
User experience is made as simple as
Easy to work with
We have provided detailed documentation as well as specific examples to help new users get started.

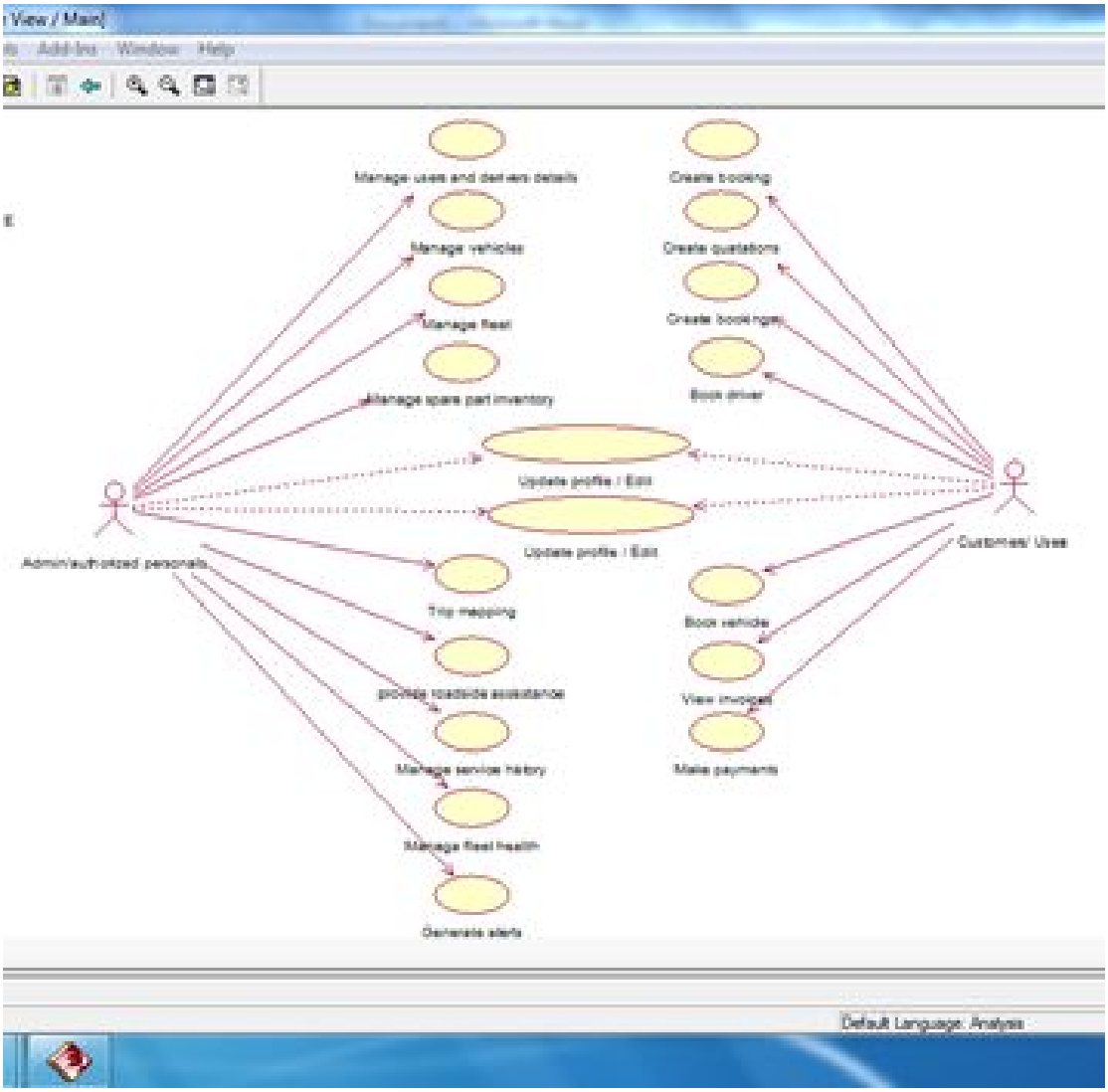

Fleet Management
Site administration | Django
localhost:8000
Speeds up process
Road Link allows you to vehicle management in lightning fast speed with a very high efficiency.Road Link is developed in such a way that it can serve all your needs with very high speed
User Experience Focused
User experience is made as simple as possible in Road link for easy use for the users. Every module is created in such a way that it does not create any sort of confusion in the mind of the user making it more user-friendly for the user.
Easy to work with
We have provided detailed documentation as well as specific examples to help new users get started. We are also always open to feedback and can answer any questions a user may have about Road Link.
Road Link allows you to find the most efficient routes for your trips

Gantt Chart:

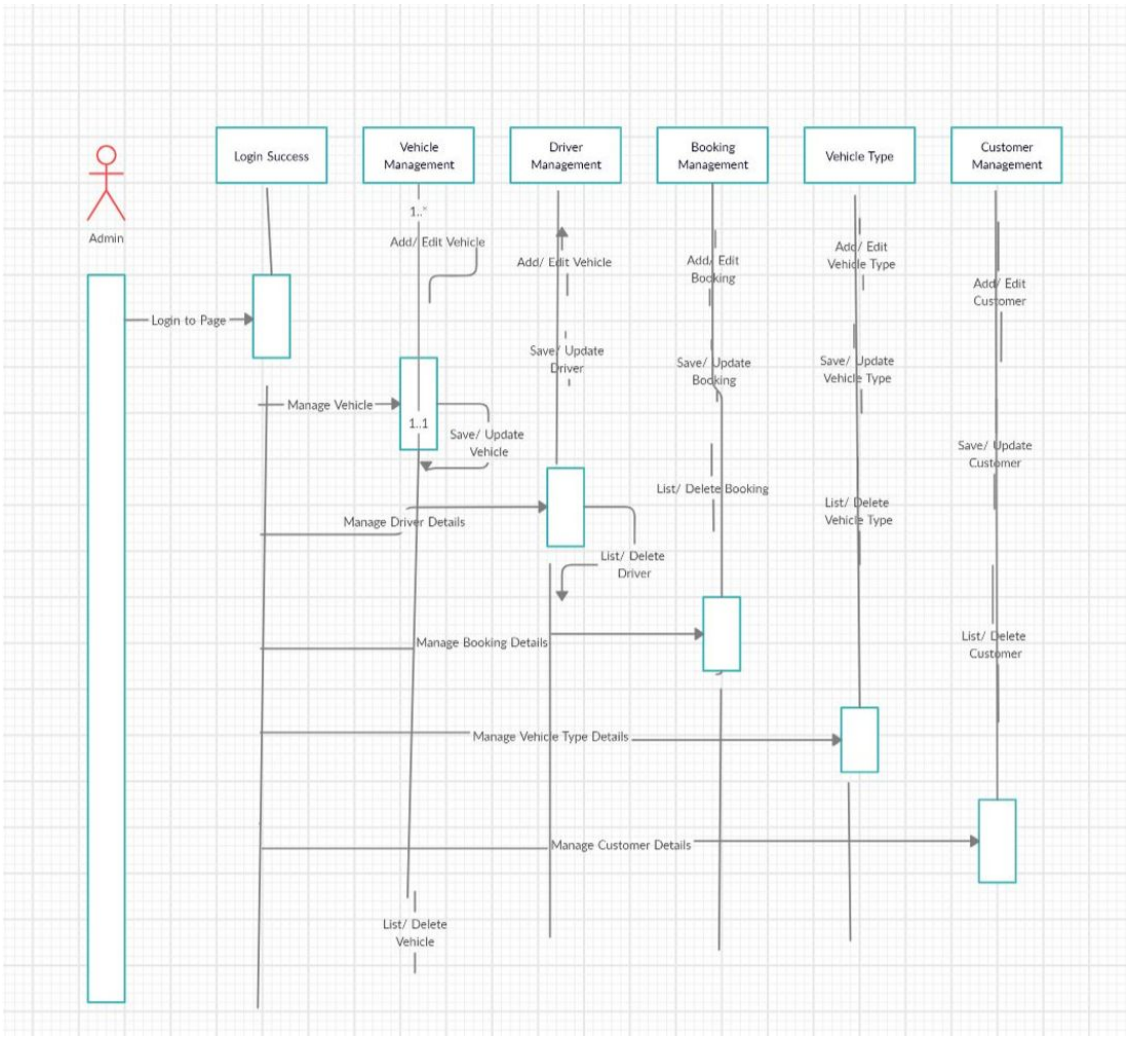


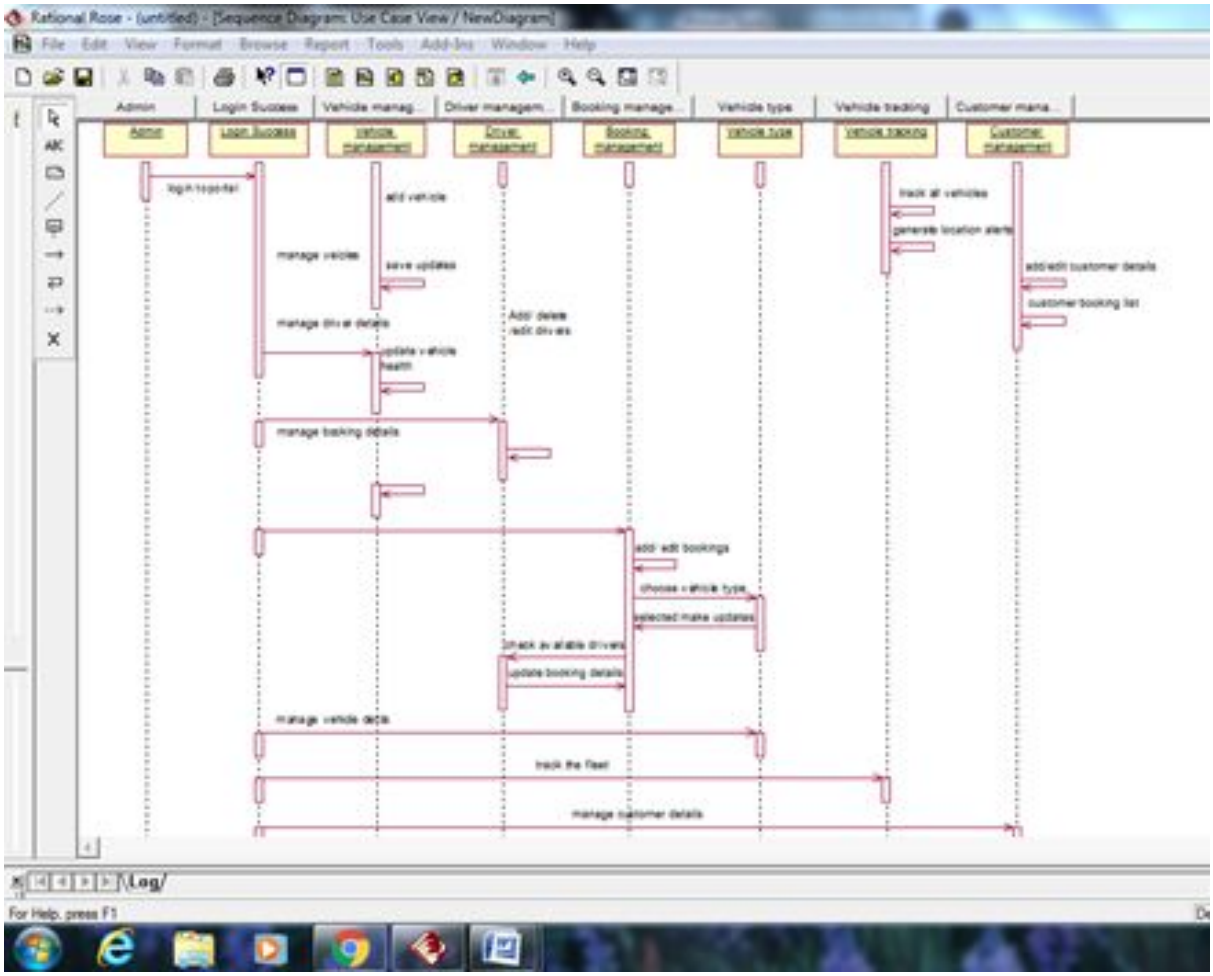
Use Case Diagram:



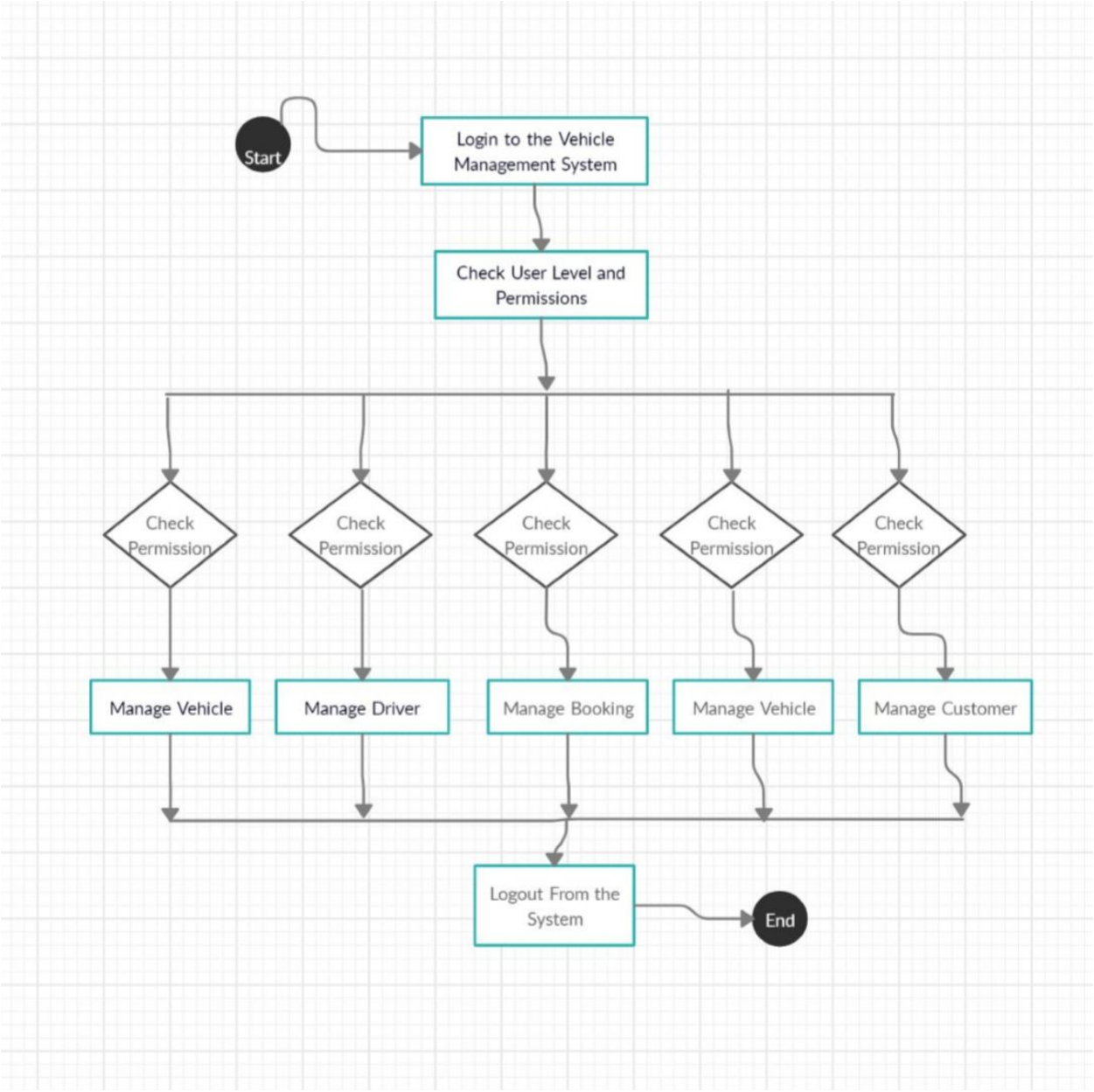

View / Main
Add-Ins
Window
Help
Manage vehicles
Manage fleet
Manage spare part inventory
Create booking
Create quotations
Book driver
Update profile / Edit
Update profile / Edit
Admin/authorized personals
Customer/ User
Trip mapping
Book vehicle
Manage service history
Make payments
Manage fleet health
Generate alerts
Default Language: Analysis

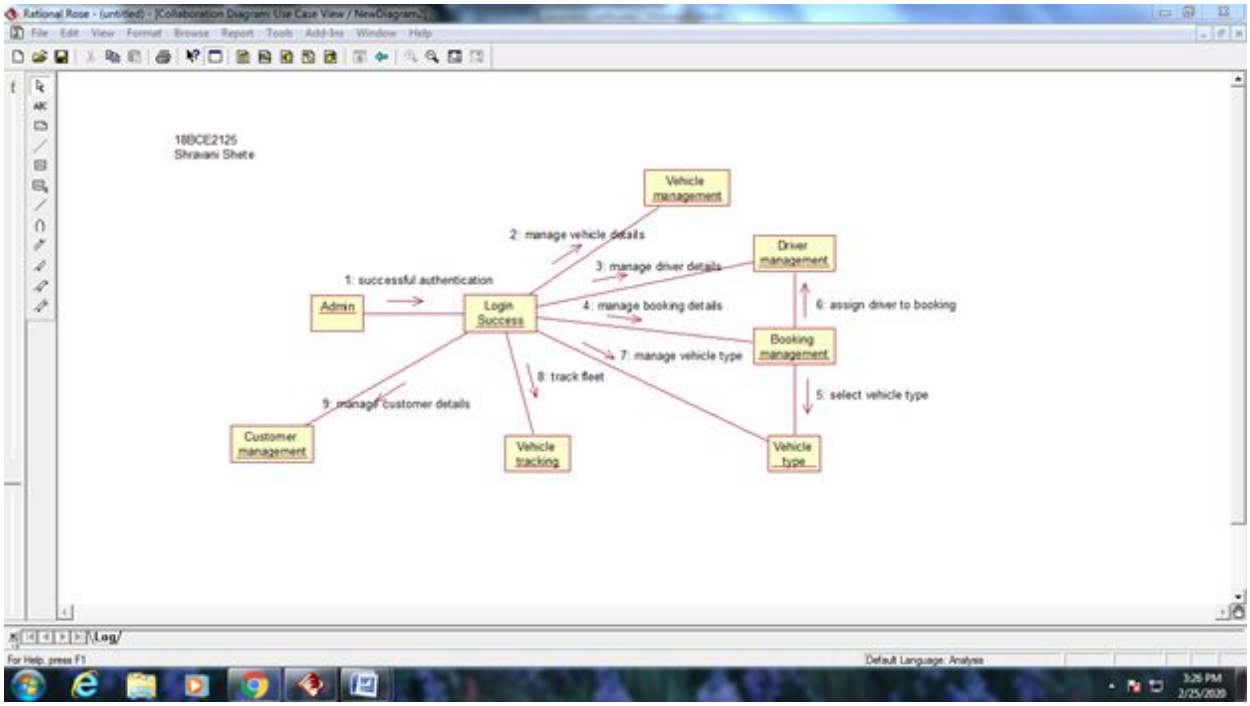
Sequence Diagram:



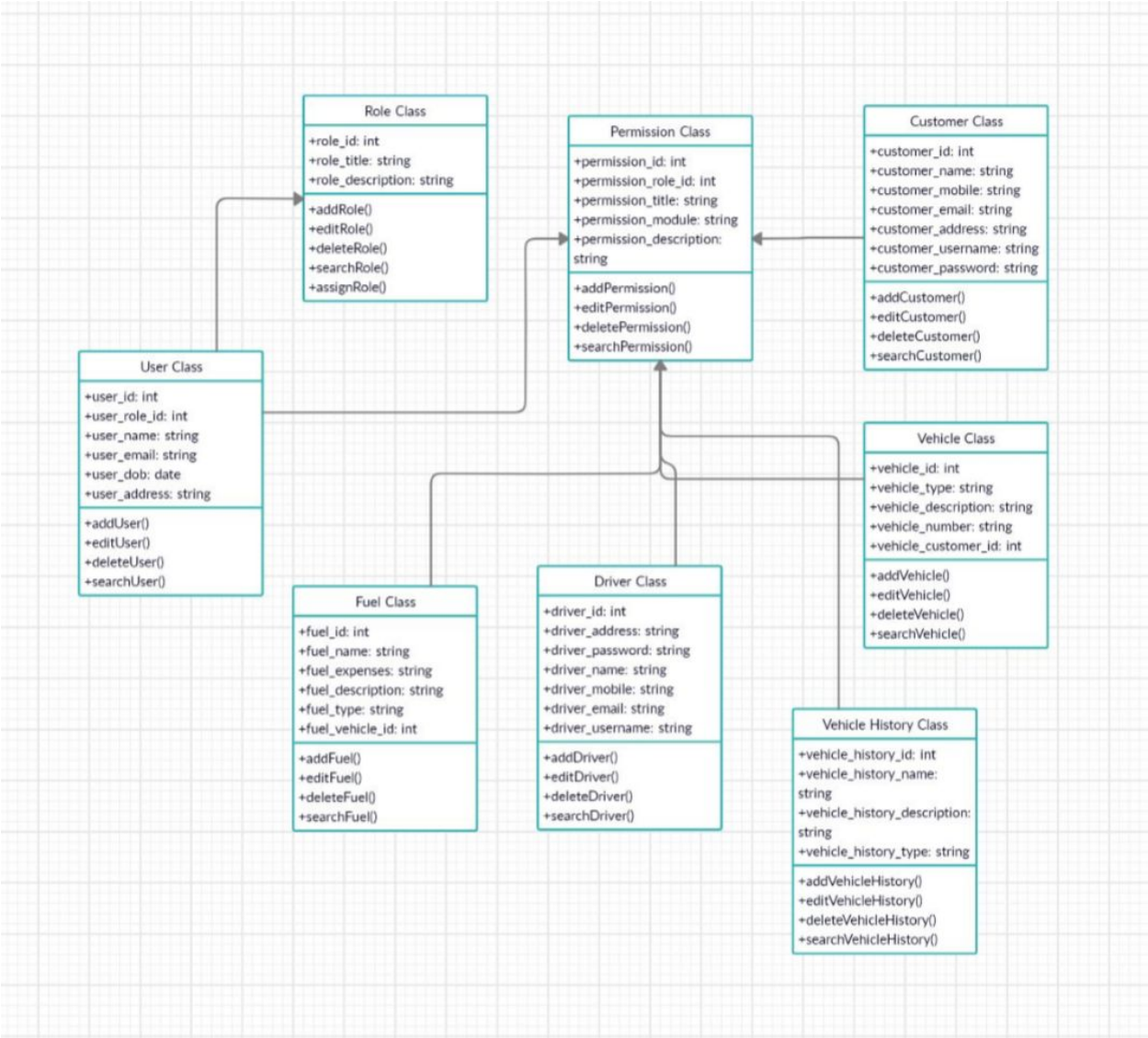

Rational Rose - (untitled) - [Sequence Diagram: Use Case View / NewDiagram]
File Edit View Format Browse Report Tools Add-Ins Window Help
Admin
Login Success
Vehicle manag...
Driver managem...
Booking manage...
Vehicle type
Vehicle tracking
Customer mana...
login to portal
add vehicle
manage vehicle
save updates
manage driver details
update vehicle health
Add/ delete /edit drivers
track all vehicles
generate location alerts
add/edit customer details
customer booking list
manage booking details
add/ edit bookings
choose vehicle type
selected make updates
update booking details
manage vehicle details
track the fleet
manage customer details
Log/
For Help, press F1

Collaboration Diagram:




18BCE2125
Shravani Shete
Vehicle management
2: manage vehicle details
Driver management
3: manage driver details
1: successful authentication
Admin
Login Success
4: manage booking details
6: assign driver to booking
Booking management
7: manage vehicle type
8: track fleet
5: select vehicle type
9: manage customer details
Customer management
Vehicle tracking
Vehicle type

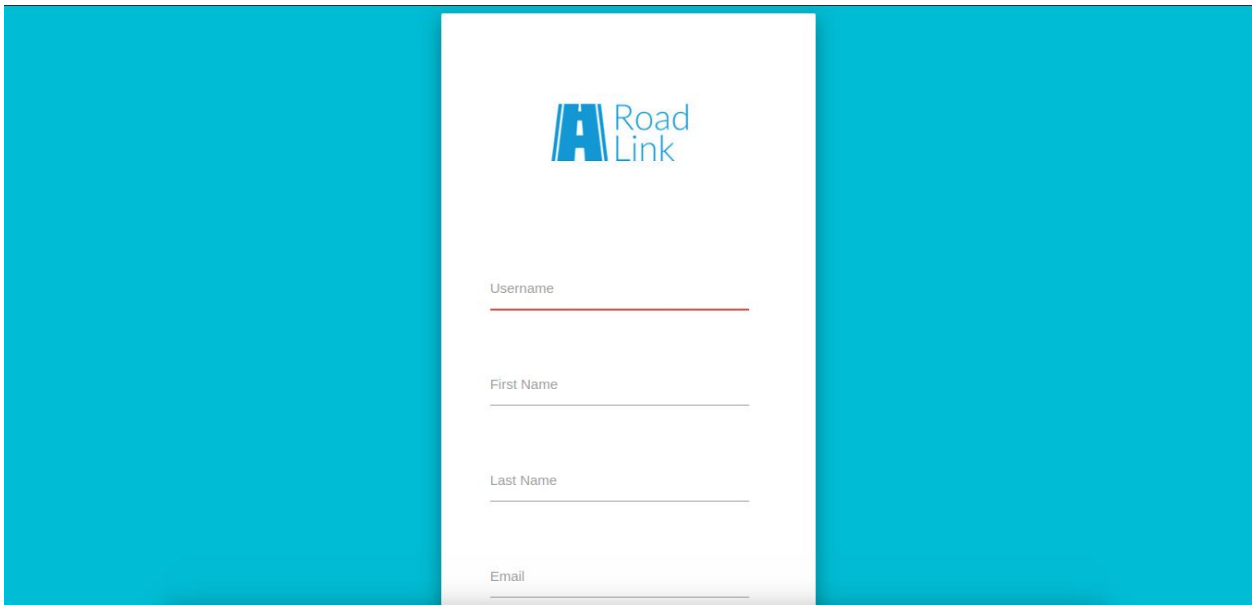
Class Diagram:

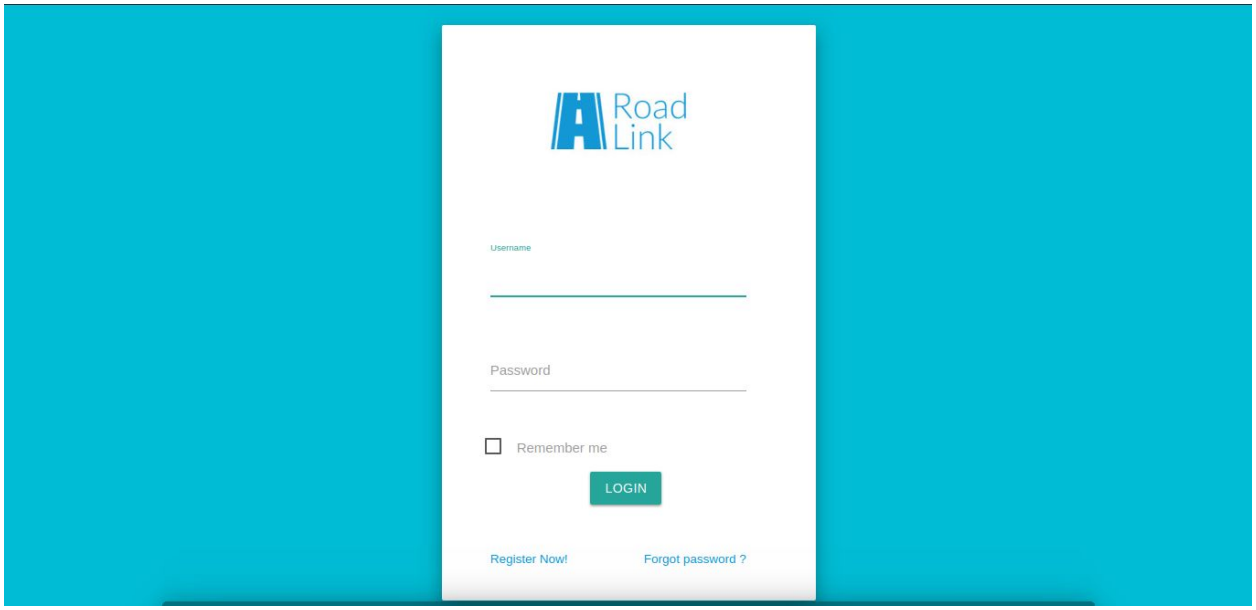


IMPLEMENTATION

1. **Login/Signup**

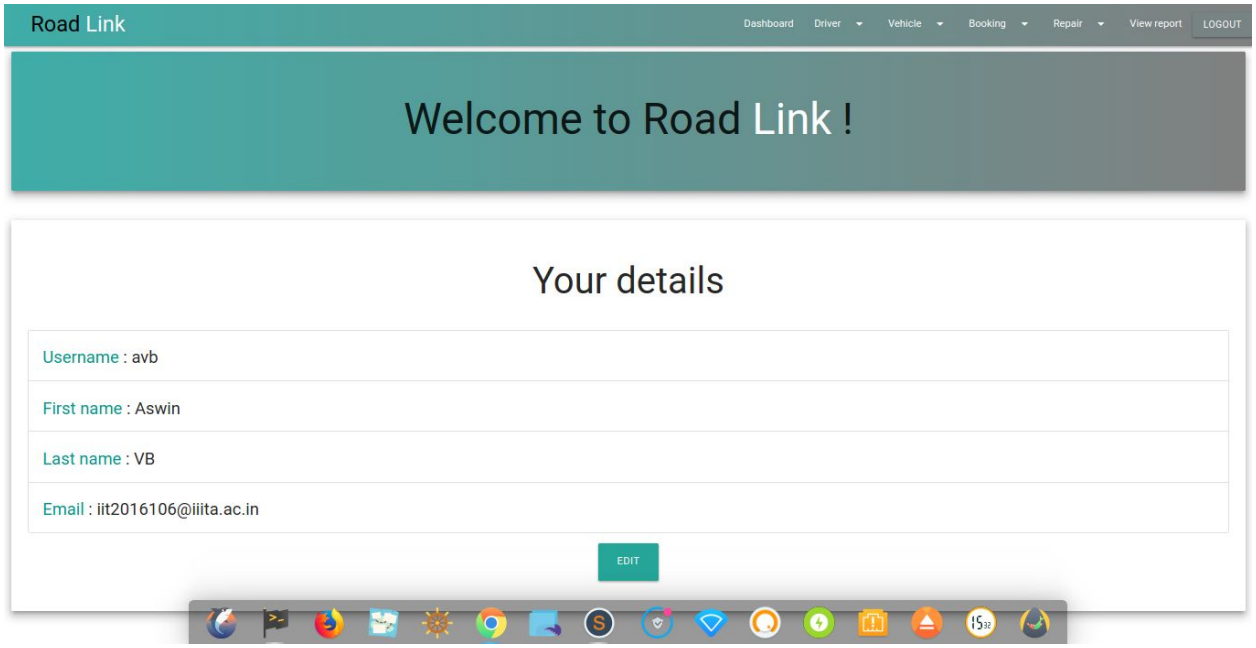
   Users can sign up/login to the portal with these pages. It takes in necessary fields required for the user details.





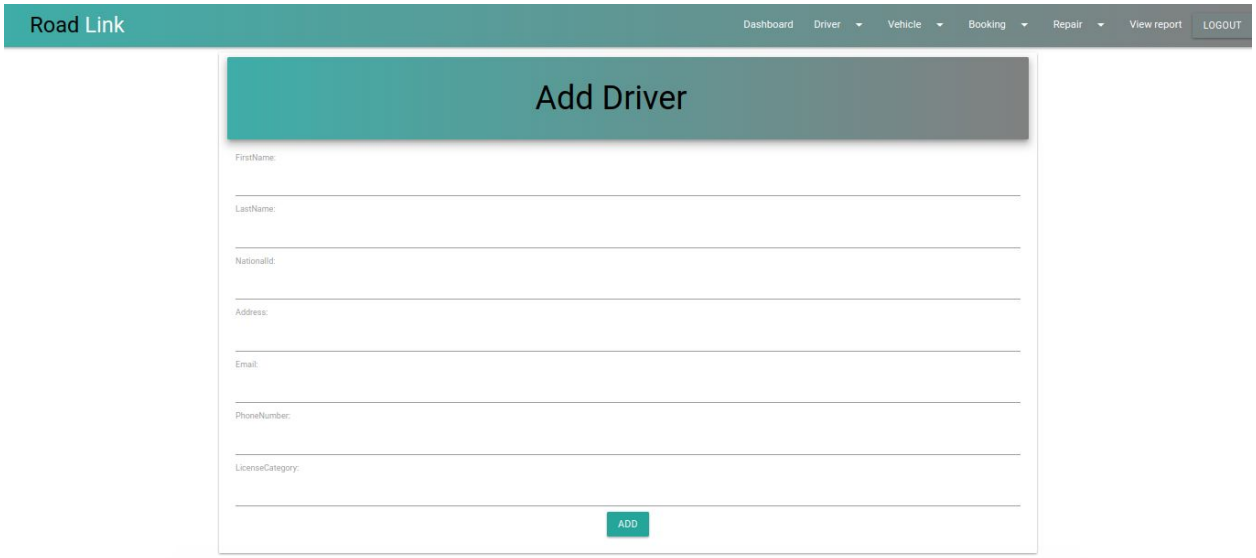
2. Dashboard

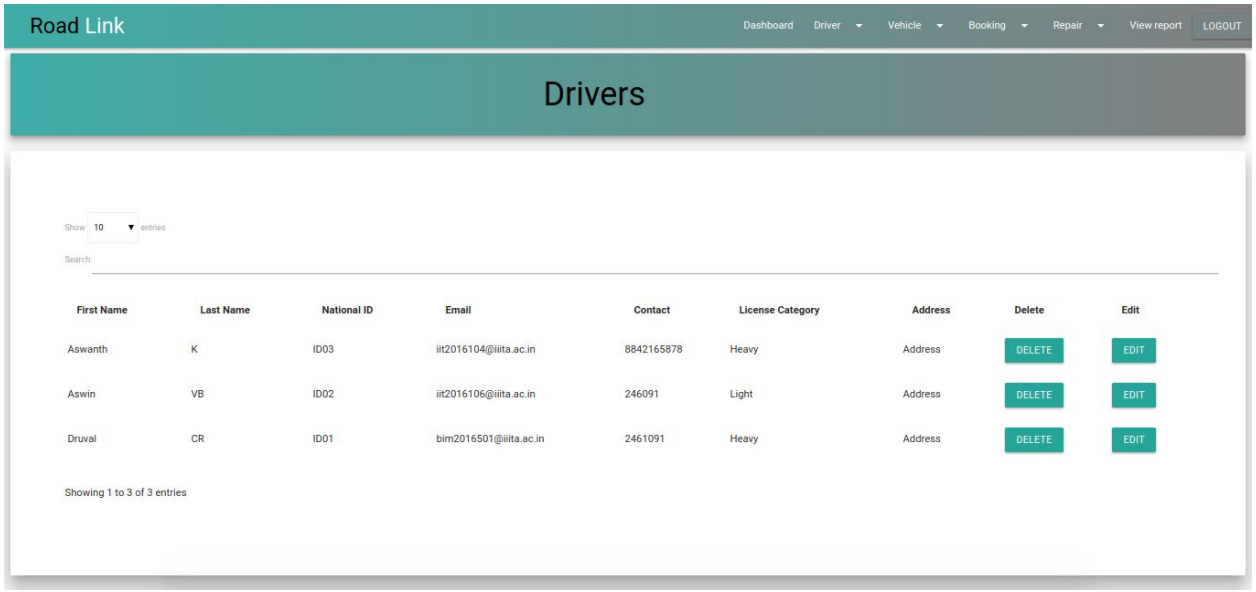
This is the dashboard in which you can view your details is shown and the user can edit the details.



3. Driver

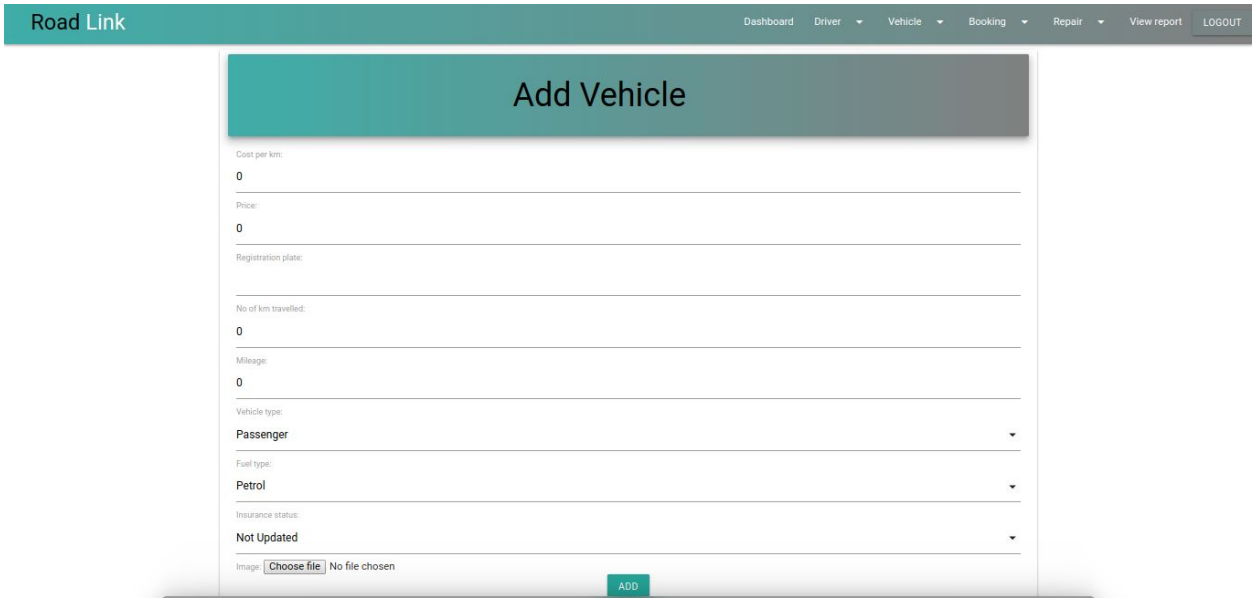
The Driver Section has two pages , one is to add a driver and the other is to view the list of drivers available.This section is only visible for the users which have admin access. The Driver list has the features to search and sort list according to the fields.

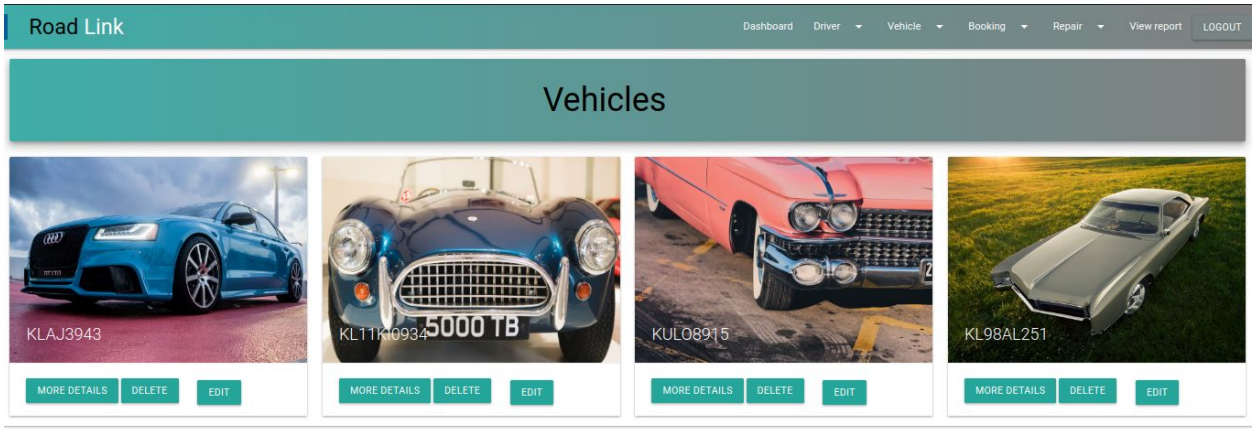

Road Link
Dashboard
Driver
Vehicle
Booking
Repair
View report
LOGOUT
Add Driver
FirstName:
LastName:
NationalId:
Address:
Email:
PhoneNumber:
LicenseCategory:
ADD


Road Link
Dashboard
Driver
Vehicle
Booking
Repair
View report
LOGOUT
Drivers
Show 10 entries
Search:
First Name
Last Name
National ID
Email
Contact
License Category
Address
Delete
Edit
Aswanth K ID03 iit2016104@iiita.ac.in 8842165878 Heavy Address DELETE EDIT
Aswin VB ID02 iit2016106@iiita.ac.in 246091 Light Address DELETE EDIT
Druval CR ID01 bim2016501@iiita.ac.in 2461091 Heavy Address DELETE EDIT
Showing 1 to 3 of 3 entries

4. Vehicles

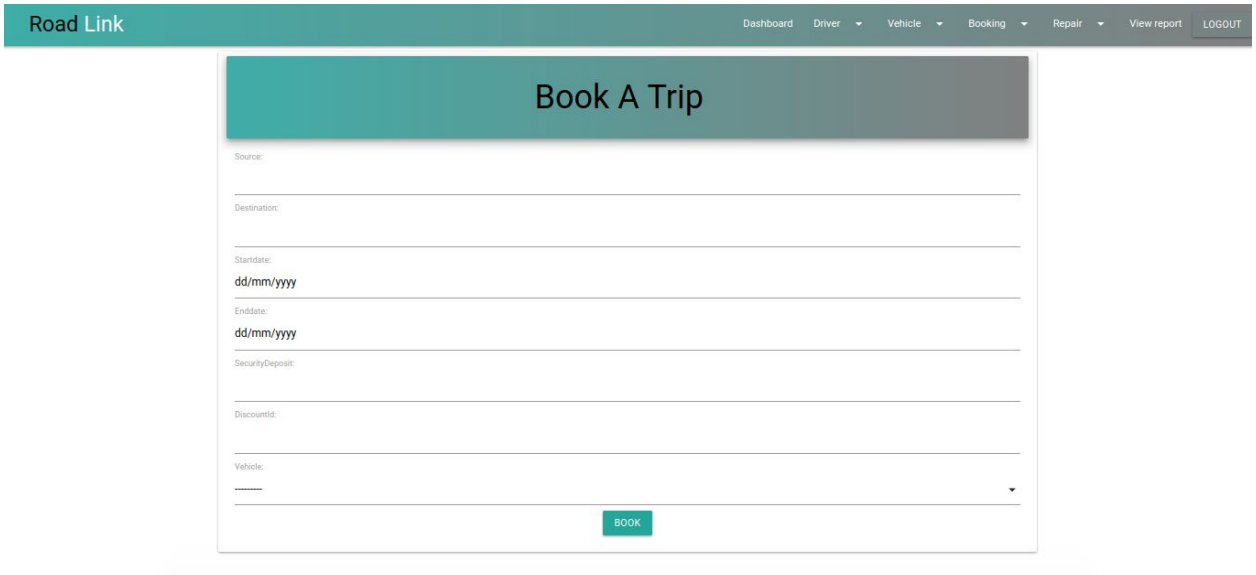
In this section there are two pages one is to add vehicles and the other to list the vehicles owned by the user. In the vehicle list page the user can view individual details , edit the details and delete the vehicle.

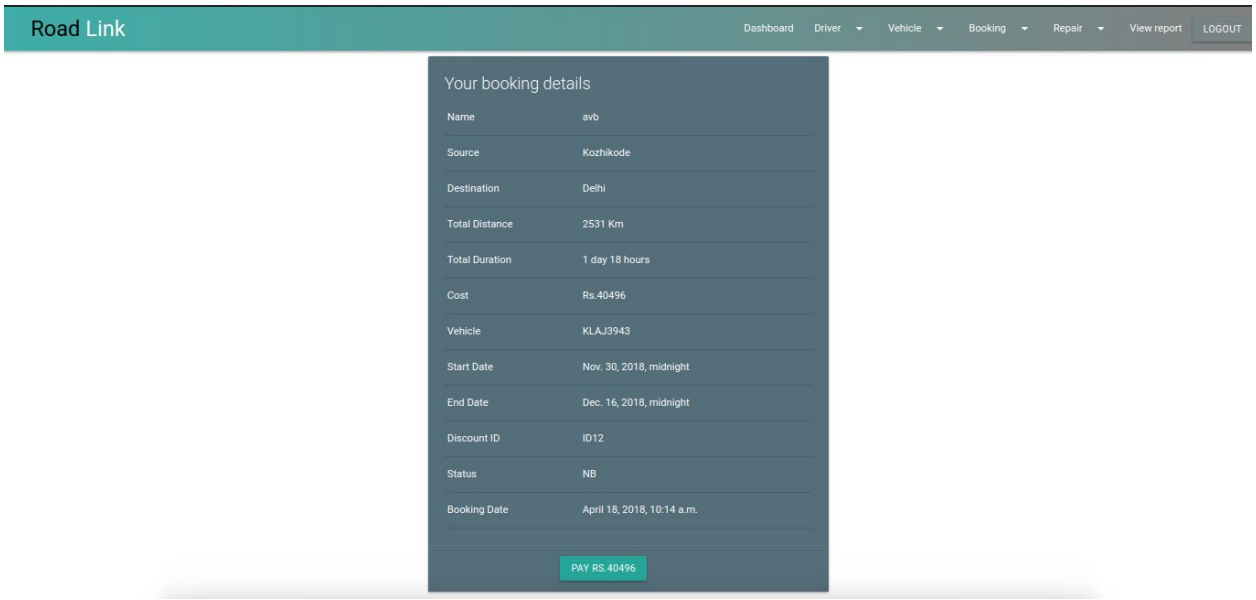




5. Booking

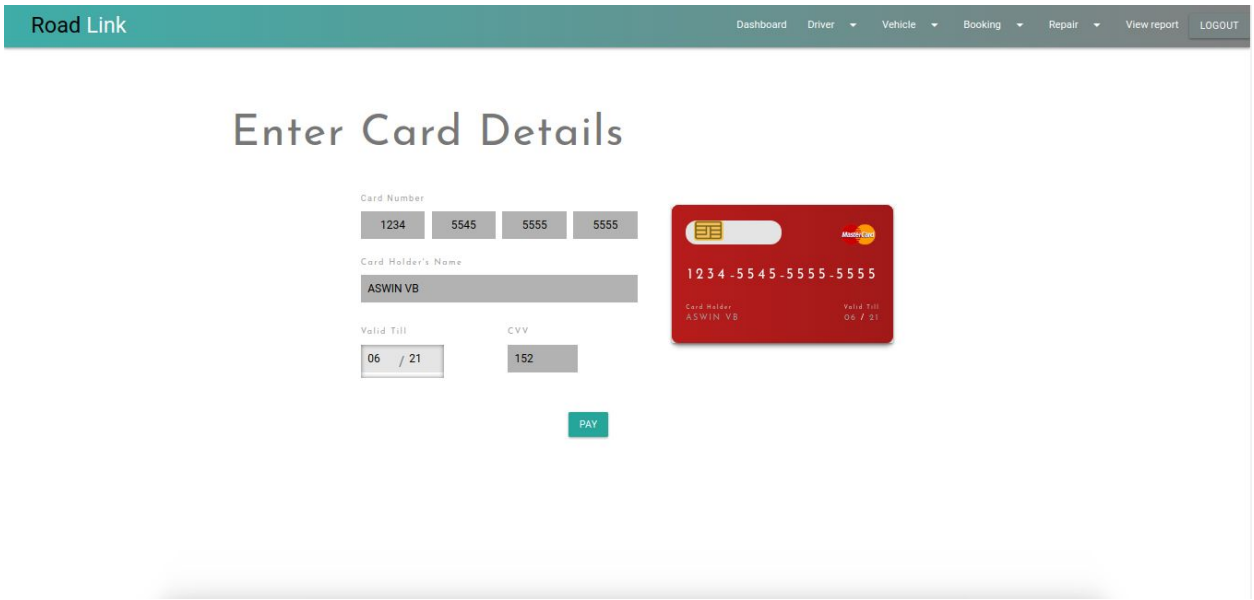
Booking section has four pages, one is the form to book a trip the second one is the success page where the booking details including the distance,cost,duration is displayed using google maps api. In the success page you have an option to pay which will take you into the payment page.

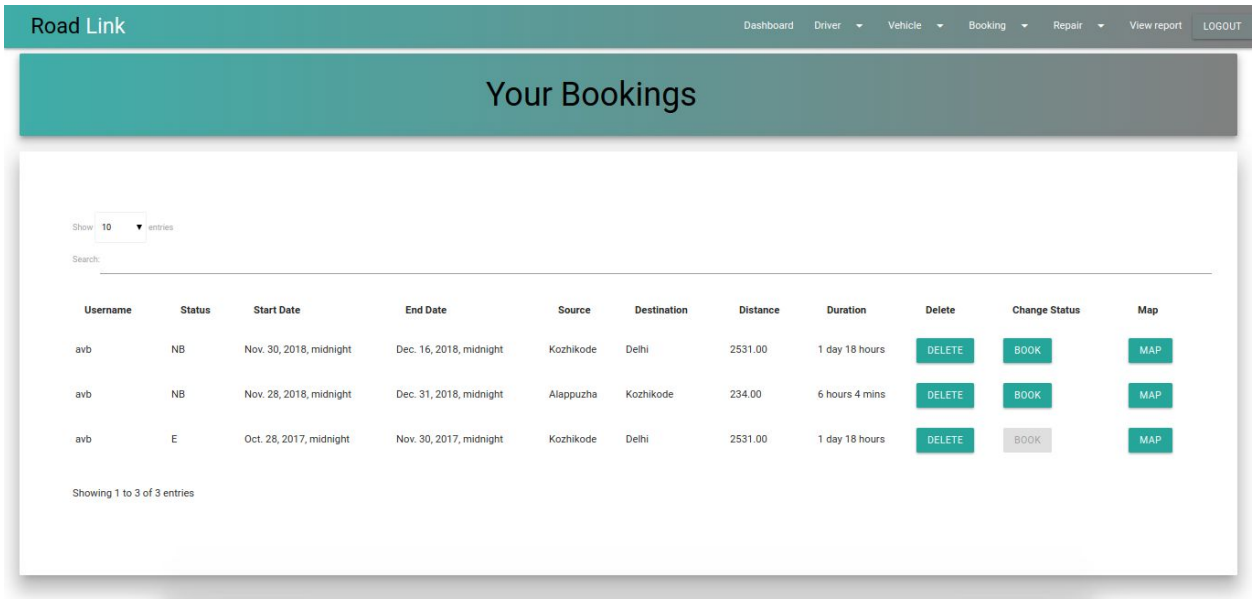




6. Booking - continued

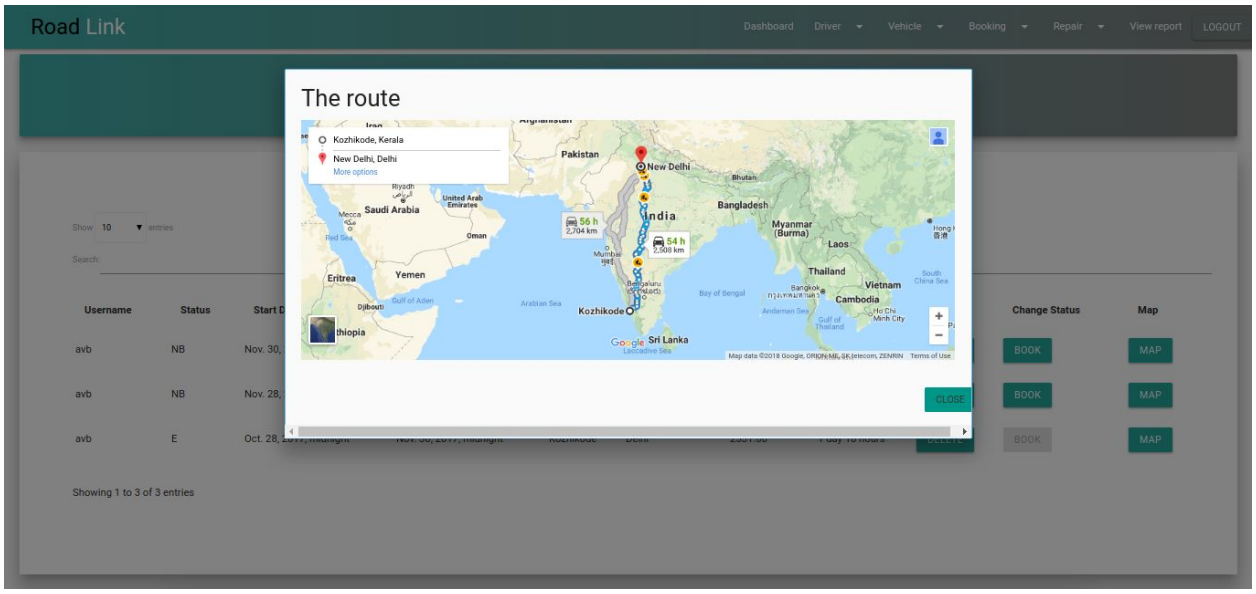
Payment page lets you enter the card details to pay. There is a page to display all the bookings made by the user wherein the user can search for the bookings. The admin will have another option which is to confirm the booking and a driver will be allotted and a mail will be sent to the user saying the mail is confirmed.





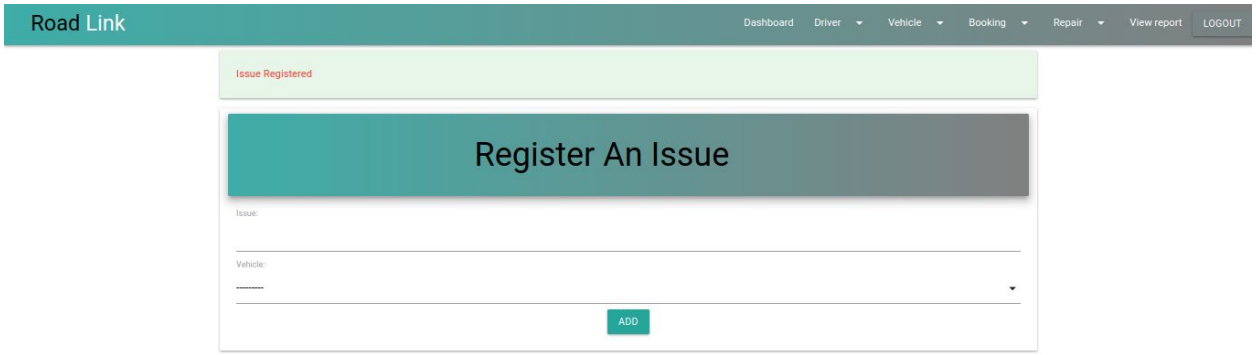
7. Booking - continued

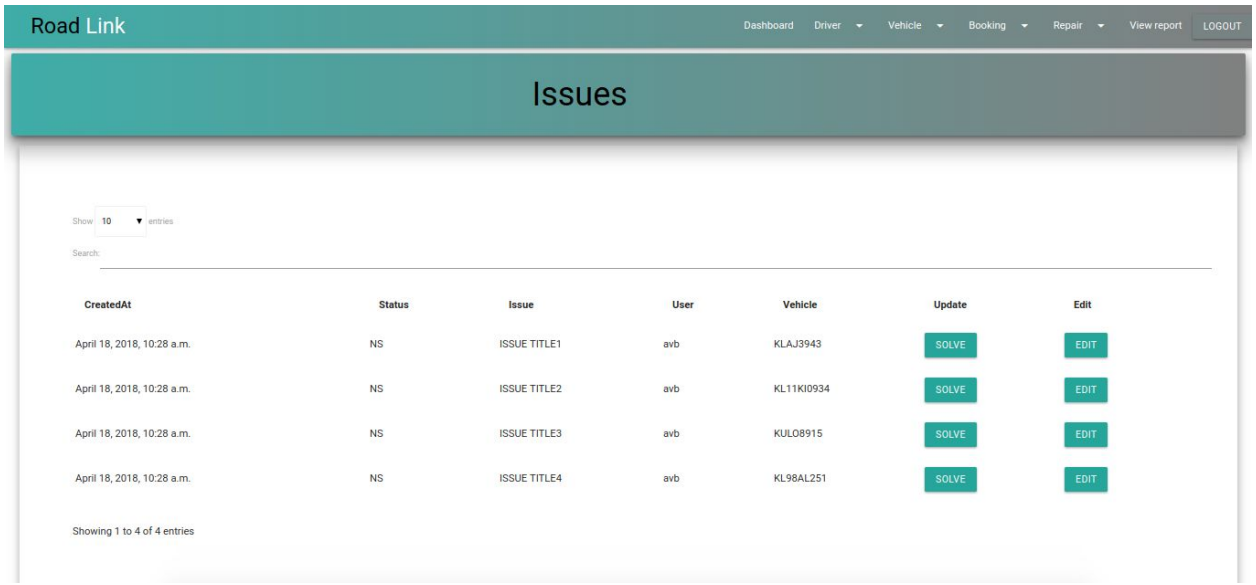
The map option in the booking list page displays the route using google maps api.When the admin confirms the booking a confirmation mail will be send to the user.



8. Repair

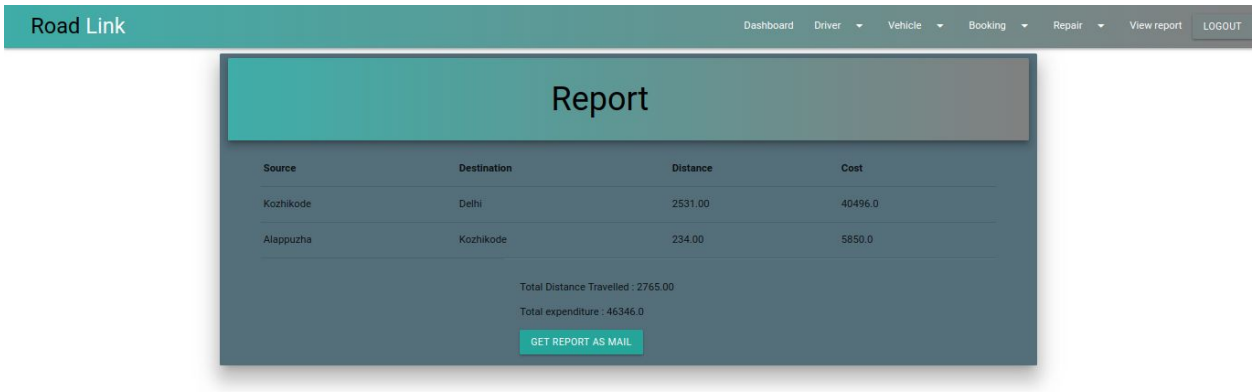
The repair section has two pages , one for reporting the issue and another page to show the issues made by the user . In the issues page the admin has an option to solve the issue made by all the users.





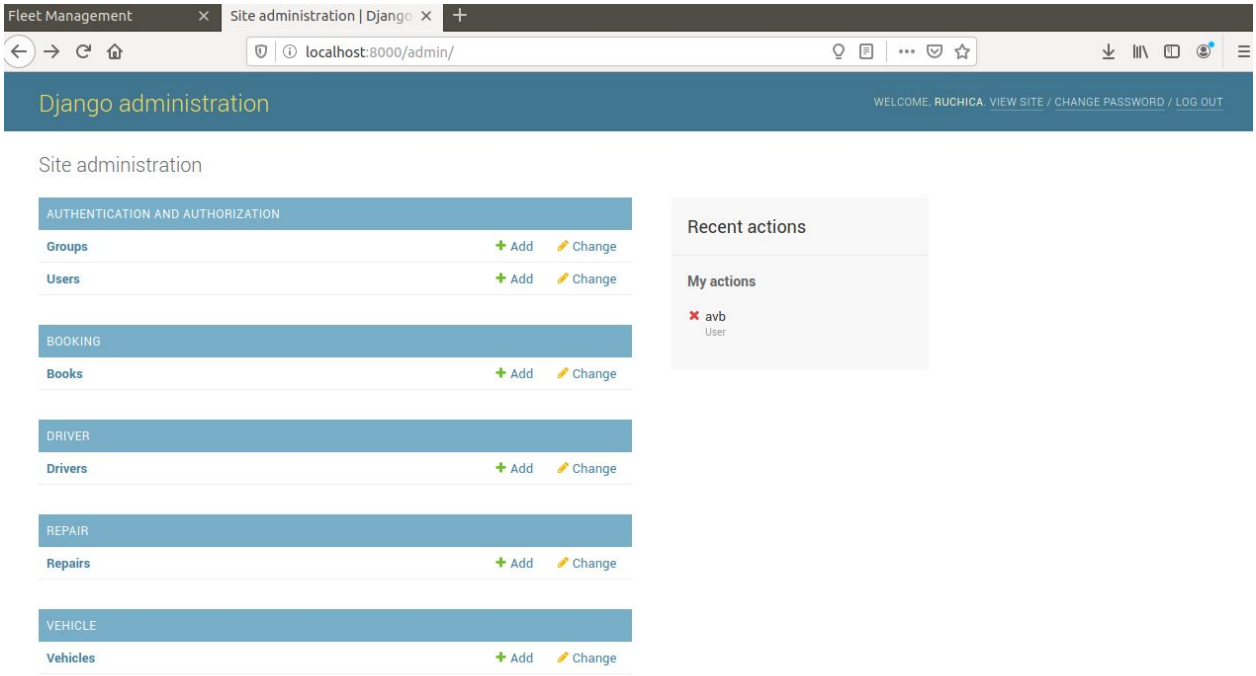
9. Report

Each user can have a report of the trips that he has made. There is an option to mail the user about the report for further use.

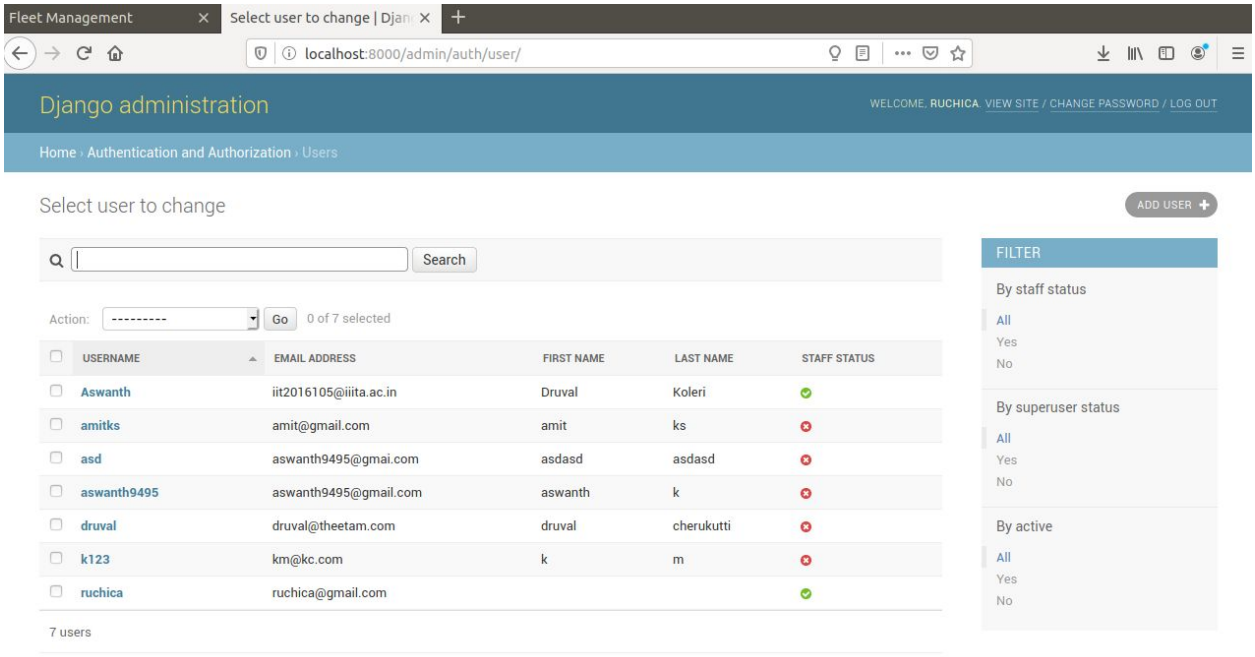


10. Database

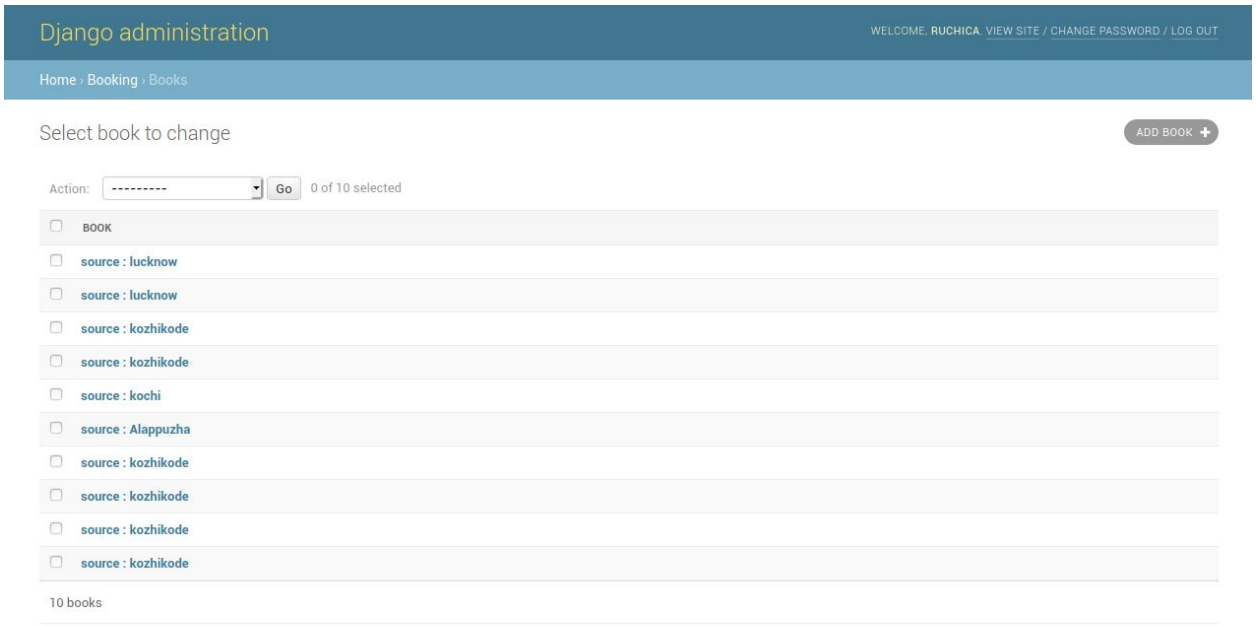
Site Administration


Fleet Management
Site administration | Django
localhost:8000/admin/
Django administration
WELCOME, RUCHICA. VIEW SITE / CHANGE PASSWORD / LOG OUT
Site administration
AUTHENTICATION AND AUTHORIZATION
Groups + Add Change
Users + Add Change
BOOKING
Books + Add Change
DRIVER
Drivers + Add Change
REPAIR
Repairs + Add Change
VEHICLE
Vehicles + Add Change
Recent actions
My actions
avb
User

Users


Fleet Management
Select user to change | Djan
localhost:8000/admin/auth/user/
Django administration
WELCOME, RUCHICA. VIEW SITE / CHANGE PASSWORD / LOG OUT
Home › Authentication and Authorization › Users
Select user to change
ADD USER
Search
Action: ---------
Go
0 of 7 selected
USERNAME
EMAIL ADDRESS
FIRST NAME
LAST NAME
STAFF STATUS
Aswanth iit2016105@iiita.ac.in Druval Koleri
amitks amit@gmail.com amit ks
asd aswanth9495@gmai.com asdasd asdasd
aswanth9495 aswanth9495@gmail.com aswanth k
druval druval@theetam.com druval cherukutti
k123 km@kc.com k m
ruchica ruchica@gmail.com
7 users
FILTER
By staff status
All
Yes
No
By superuser status
All
Yes
No
By active
All
Yes
No

Booking



Driver

Repair

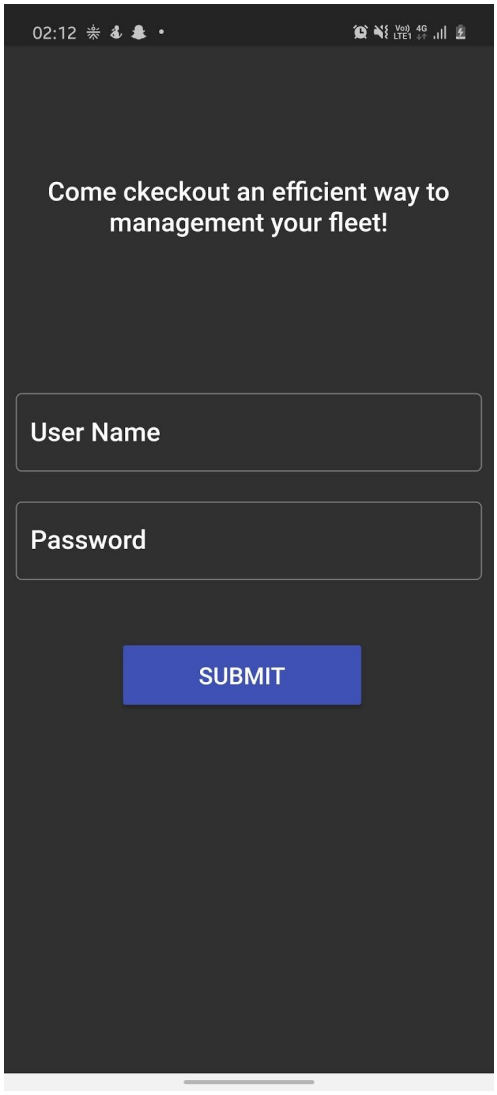
Vehicles

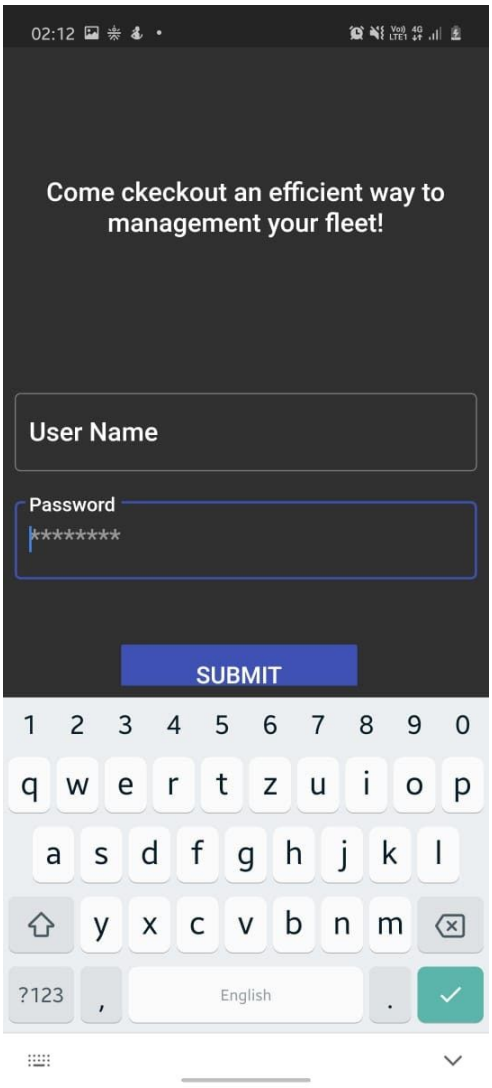
APP DESIGNS

Admin side

1.Login Page

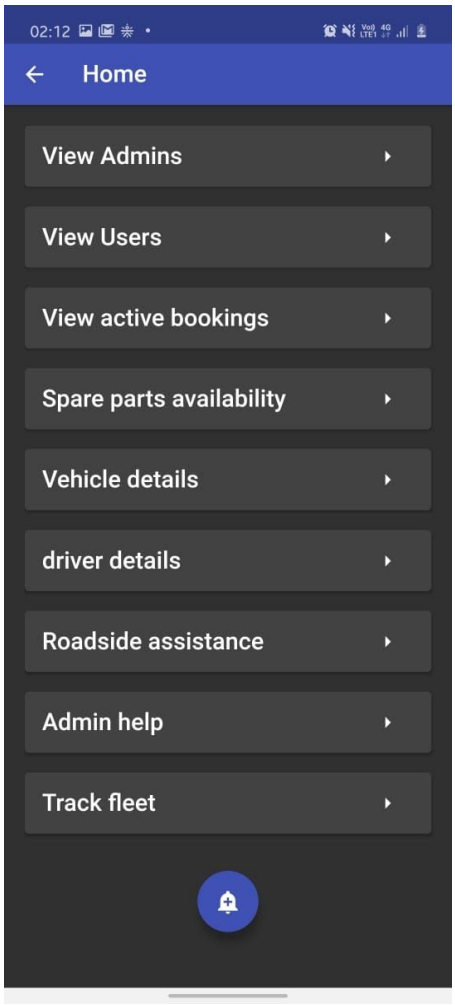
The admin logs into the application using the **admin ID and password** provided to him by the management team.

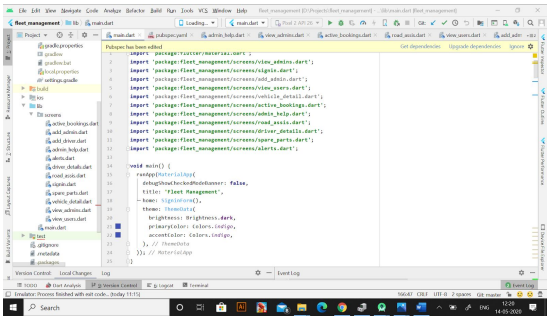


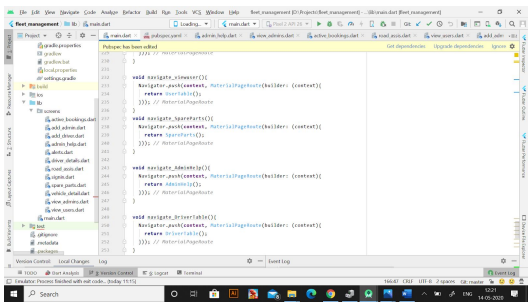


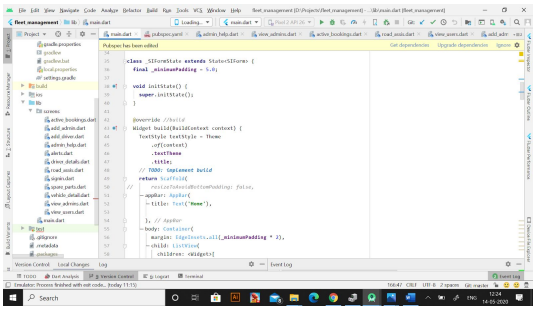
2.Home Page

This displays the list of operations that can be performed by the authorised admins. They can click on their desired option (fleet health, alerts, tracking, driver details etc.) that takes them to view the respective information.









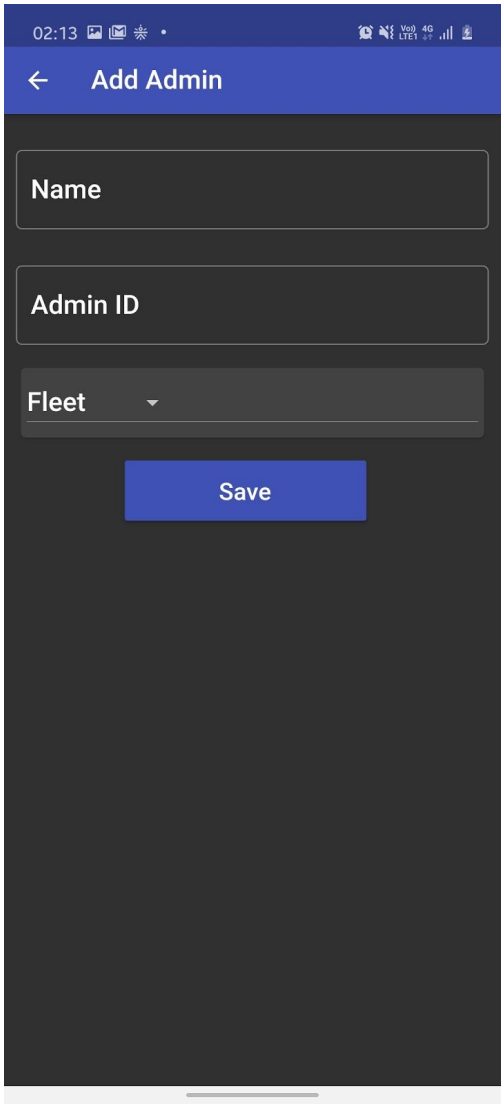
3. View Admins and their details

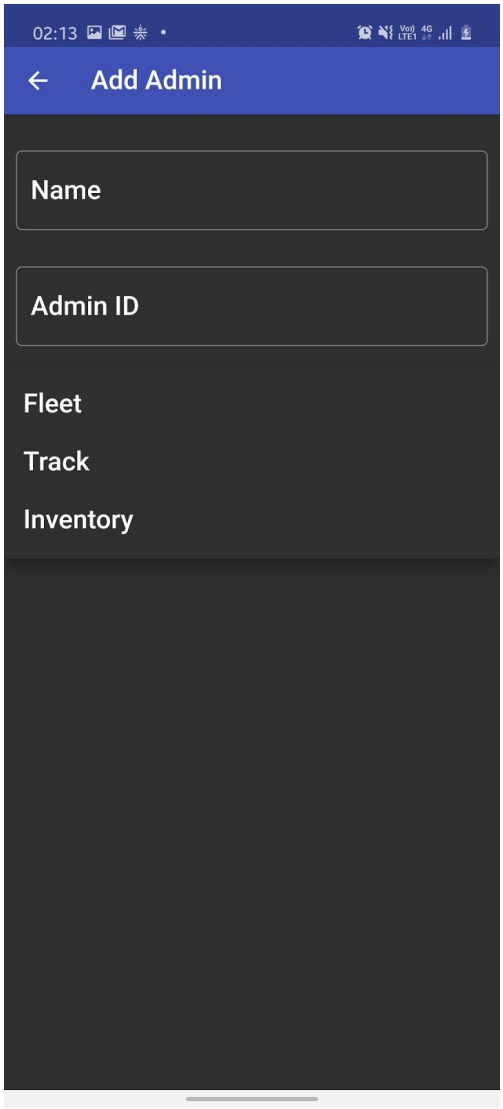
Admins are identified using an unique Admin ID and the department they work in.

3a. Add Admins

To access the Add admin section click on the **add floating button** displayed on the bottom right corner of the above screen(view admins)

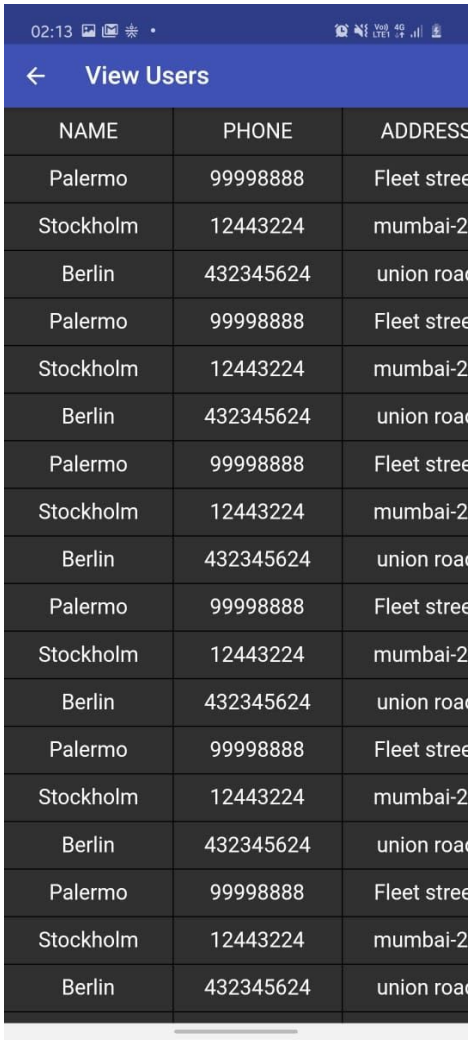
New admins can be added by filling the necessary details listed below. This will automatically add the new users to the Database with existing admins





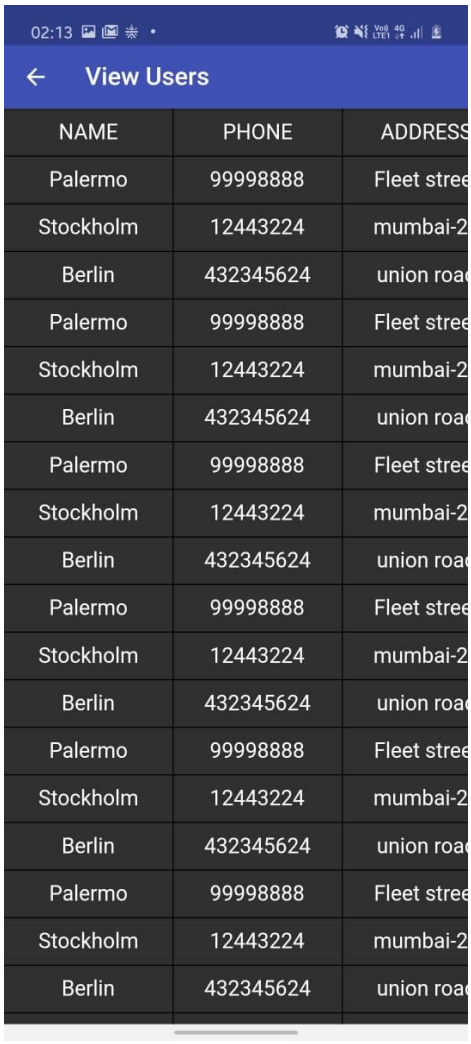
4.View Users

Displays a list of users/customers that book the fleet.



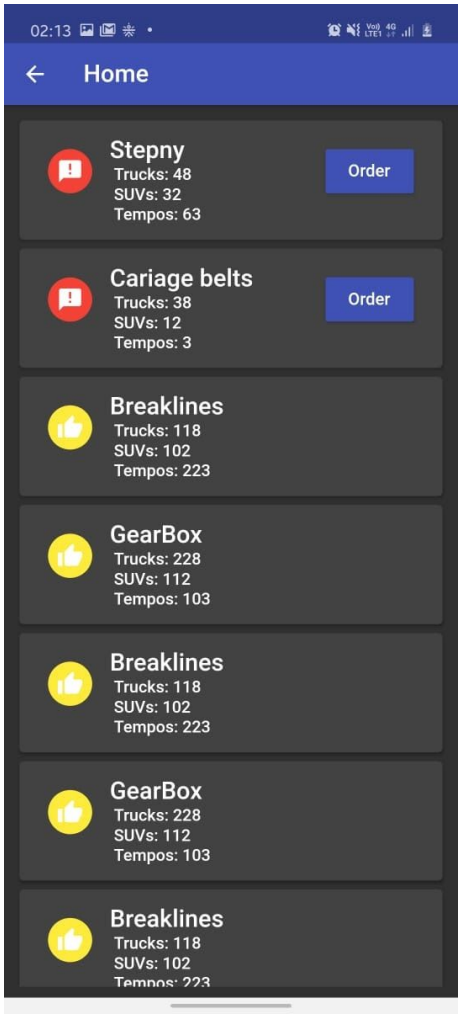
5.View active bookings

Displays the list of fleets that are currently engaged and shows the admin under which they are assigned.



6. Spare parts availability

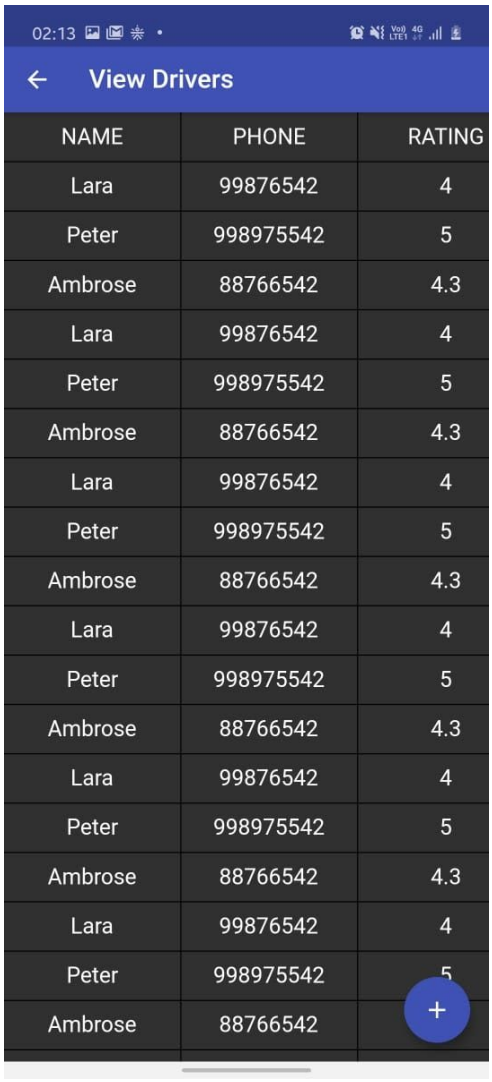
The spare parts inventory is the location at which the spare parts for the fleets are stored to ensure their availability at all time this virtual repository stores the count of each part and generates alerts fill the count falls below 100.



By clicking on the order button we allow you to order spare parts from registered forums.

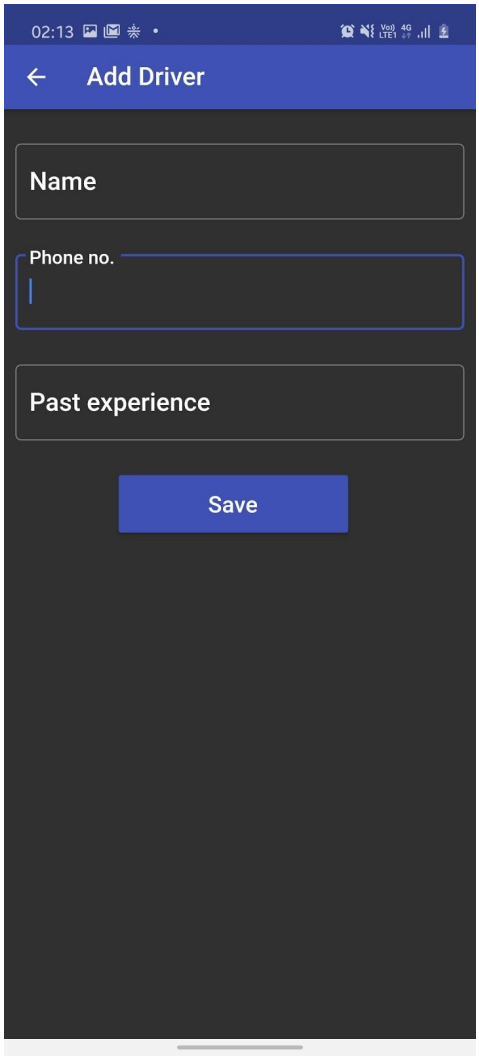
7. Driver Details

The drivers registered with our platform are showcased here. After every fleet is completed the customer/users can rate the driver's performance(ratings column).



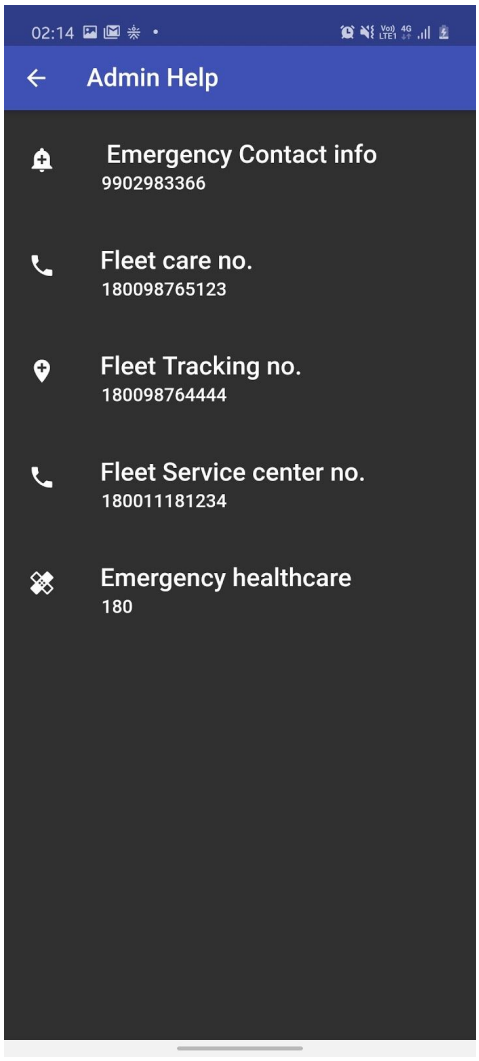
7a. Add Drivers

A new driver can be added by the admin by clicking the **add driver floating button** in the bottom right corner of the screen.



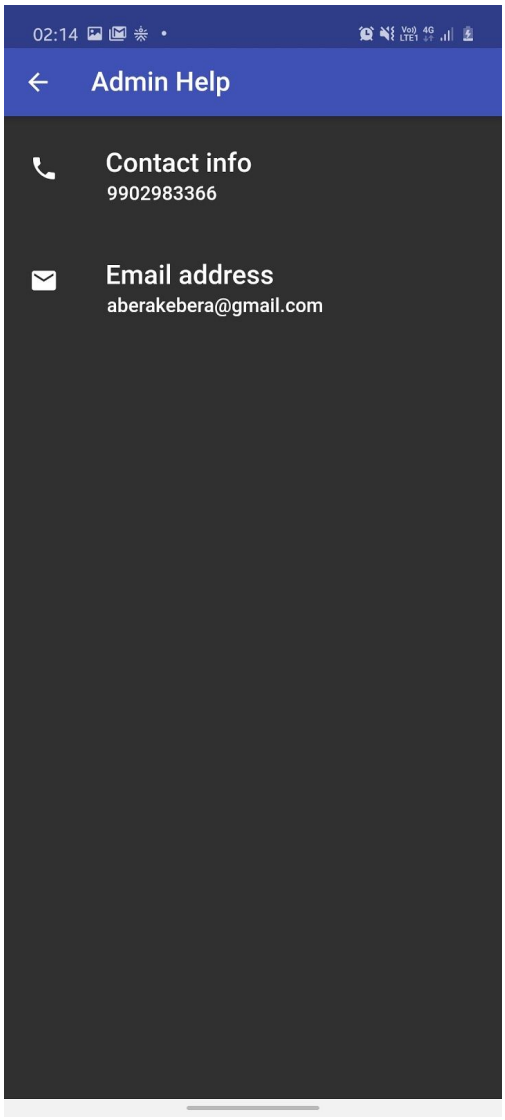
8. RoadSide Assistance

The fleet can avail this feature provided on our application in case it encounters an emergency during its course of service.



9. Admin Help

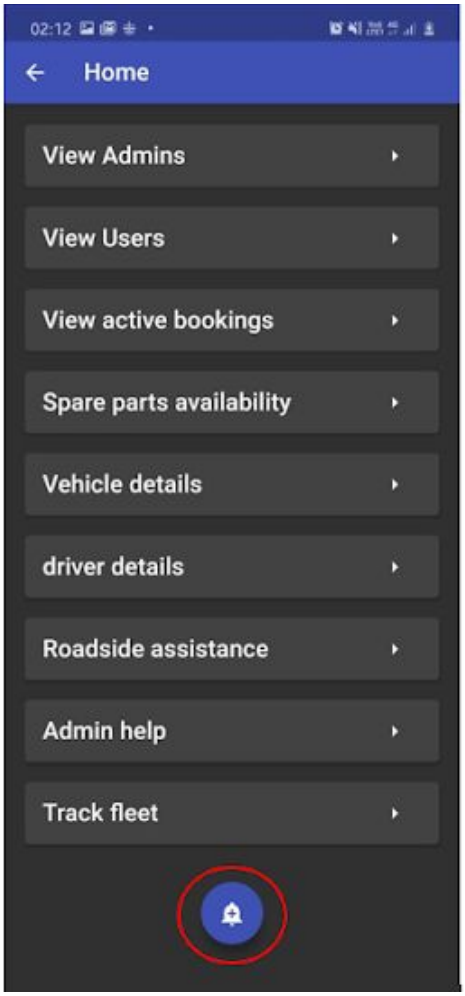
The admin can contact the below services in case of any inconvenience caused on the portal.

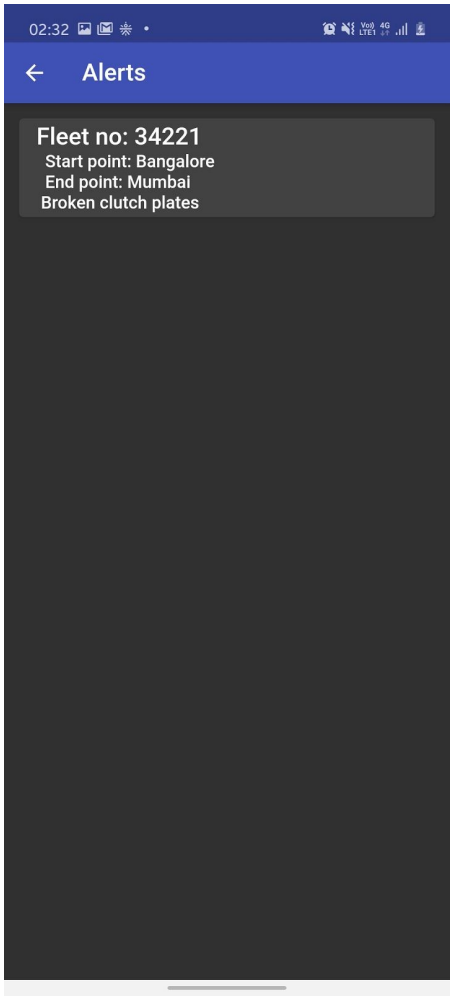


9. Alerts section

In case any fleet in an emergency situation an alert will be thrown to the admin side so the needful can be done.

Here it displays the Fleet ID, tour details and the reason for generating the alerts.





10. Track Fleet

This will display a particular fleet (selected by their respective Fleet ID's).

We have implemented this using google cloud API's and Mapbox, although still under construction.

11. **GLOSSARY**

Entity: An entity, in context to software engineering is an object which is a component of data. A group or collection of entities that are similar to each other can be defined as an entity set. The property of each attribute of the entity can be defined as needed.

Relationship: A relationship, in context to programming is defined as the relation between two entities. Relationships are also designed in order to reduce redundancy of data in the database, this will result in minimizing storage required and faster processing.

DB – Database: A database is used to collect all the information/data required in a systematic manner such that it can be accessed easily. This also makes sure that the data is properly managed, updated and deleted. The database for a particular project will contain all the relevant data required by the project or end users. A database also ensures that data can be stored safe and secure in one place while being easily accessible.

DBMS – Database Management System: Database Management System is a software tool that is used for storing and retrieving users' data. It includes all the features to manipulate the data in the database.

RDBMS – Relational Database Management System: An RDBMS is a subset of a DBMS and is specifically used for relational data.

E-R – Entity-Relationship Model: This is a high level data model that is used to conceptualize the elements or entities in the program. It used to portray the entity and the relationships that exist between these entities for a particular system.

****