



EASY RIDE - Secure Carpooling Mobile Application for Travellers

By

KOGILAN A/L KRISHNANSAMY

TP038521

UC3F1906IT(ISS)

A project submitted in partial fulfilment of the requirements of Asia Pacific University of Technology and Innovation for the degree of

B.Sc. (Hons) Information Technology specialism in Information System Security

Supervised by: MR. AMAD ARSHAD

2nd Marker: DR. CHANDRA REKA A/P RAMACHANDRAN

March-2020

Acknowledgement

The completion of this final year project could not be possible without the participation and support of so many people whose names may not be enumerated. Their contributions are sincerely appreciated and gratefully acknowledged.

First and foremost, I would like to express my sincere gratitude and indebtedness to my academic supervisor, Mr Amad Arshad for his constructive guidance, patience and enthusiasm. He explained every single step of this report evidently and helped me to comprehend the requirements in the easiest way. Moreover, I would like to thank Dr Chandra Reka, my second marker who has provided me with some fascinating ideas on how to enhance the overall report and the system.

Furthermore, I would like to thank Mr Dhason Padmakumar for providing me with the opportunity to carry out my final year project at Asia Pacific University. Every knowledge that has been conveyed was very helpful and made it easier for me to conduct detailed researches pertaining to my proposed topic.

On the other hand, my honourable gratitude towards the respondents who have allocated their precious time in contributing their insights by participating in my primary research. Their valuable inputs and opinions helped me to understand the overall requirements of my target market. Moreover, I would like to show my outmost gratitude to my parents for their unfailing support and continuous encouragement which helped me to endeavour and overcome all the obstacles during the completion of this report.

Table of Contents

Acknowledgement	1
1 Introduction to the Study	15
1.1 Background to the project	15
1.2 Problem Context	17
1.3 Rationale.....	19
1.4 Potential Benefits.....	19
1.4.1 Tangible Benefits.....	19
1.4.2 Intangible Benefits.....	19
1.5 Target Users.....	20
1.6 Scope and Objectives	20
1.6.1 Aims	20
1.6.2 Objectives.....	20
1.6.3 Deliverables.....	21
1.6.4 Nature of Challenges.....	22
1.7 Overview of the Final Year Report.....	23
1.8 Project Plan.....	24
2 Literature Review	27
2.1 Introduction	27
2.2 Domain Research	28
2.2.1 Transportation Problems in Malaysia	28
2.2.2 Peoples' Perspective towards Ride Hailing Services.....	34
2.2.3 The Future of Transportation.....	38
2.3 Similar Systems	39
2.4 Critical Analysis	43
2.5 Summary	43
3 Technical Research.....	44

3.1	Application chosen.....	44
3.2	Programming Language chosen	46
3.2.1	Front-End	46
3.2.2	Back-End	48
3.3	Interactive Development Environment (IDE) chosen.....	50
3.4	Libraries or Tools Chosen	52
3.5	Database Management System chosen	54
3.6	Operating System chosen	56
3.7	Web Server chosen	57
3.8	Additional Services	58
3.8.1	Proguard	58
3.9	Summary	59
4	System Development Methodology	60
4.1	Introduction	60
4.2	Compare and Contrast.....	61
4.3	Chosen Methodology with Justification (XP Programming)	68
4.4	Characteristics of XP Programming	69
4.5	Phases of XP Programming	71
5	Research Methods	76
5.1	Introduction	76
5.2	Design	78
5.2.1	Questionnaire.....	78
5.2.2	Interview.....	89
5.3	Summary	94
6	Requirement Validation.....	95
6.1	Analysis of data collected.....	95
6.1.1	Analysis of data collected through questionnaire.....	96

6.1.2	Analysis of data collected through interview	117
6.2	Summary	122
7	System Architecture	123
7.1	Introduction	123
7.2	Abstract Architecture	124
7.2.1	System Design	124
7.2.1.1	System Architectural Design.....	125
7.2.1.2	Use Case Diagram	127
7.2.1.3	Use Case Specifications	128
7.2.1.4	Activity Diagram	141
7.2.1.5	Class Diagram	155
7.2.2	Database Design	156
7.2.2.1	Entity Relationship Diagram.....	156
7.2.2.2	Database Table Structure	157
7.2.3	Interface Design (Storyboard)	172
7.2.3.1	Sign in Activity.....	172
7.2.3.2	Sign Up Activity.....	173
7.2.3.3	Verifications Activity (Passenger).....	174
7.2.3.4	Find a Ride Activity (Passenger).....	175
7.2.3.5	Search Journeys Activity (Passenger).....	176
7.2.3.6	View Available Rides Activity (Passenger).....	177
7.2.3.7	View Ride Details Activity (Passenger)	178
7.2.3.8	View Journey Information and Make Payment Activity (Passenger)	179
7.2.3.9	Make Payment Activity (Passenger).....	180
7.2.3.10	Cancel Journey Activity (Passenger)	181
7.2.3.11	Add a Card Activity (Passenger)	182
7.2.3.12	Delete a Card Activity (Passenger).....	183

7.2.3.13	Feedback Activity	184
7.2.3.14	Manage Profile Activity	185
7.2.3.15	Manage Journeys Activity (Passenger and Driver)	186
7.2.3.16	Register a New Car Activity (Driver).....	187
7.2.3.17	Manage Cars Activity (Driver).....	188
7.2.3.18	Add Path Activity (Driver).....	189
7.2.3.19	Manage Paths Activity (Driver)	190
7.2.3.20	Complete Journey Activity (Driver)	191
7.2.3.21	Verify or Accept Journeys Activity (Driver)	192
8	Project Plan	193
8.1	Details of the release plan	193
8.1.1	Version 1.0 of Easy Ride Carpooling Mobile Application	193
8.1.2	Version 2.0 of Easy Ride Carpooling Mobile Application	194
8.1.3	Version 3.0 of Easy Ride Carpooling Mobile Application	195
8.2	Test Plan.....	196
8.2.1	Test Plan for Unit Testing	196
8.2.1.1	Login Test Plan.....	196
8.2.1.2	Sign Up Test Plan	198
8.2.1.3	Feedback Test Plan	201
8.2.1.4	Find a Ride Test Plan	201
8.2.1.5	Manage Journeys (Passengers) Test Plan	203
8.2.1.6	Manage Profile (Passengers) Test Plan.....	205
8.2.1.7	Manage Paths (Driver) Test Plan.....	208
8.2.1.8	Manage Cars (Driver) Test Plan.....	211
8.2.1.9	Manage Journeys (Drivers) Test Plan.....	212
8.2.2	Test Plan for User Acceptance Testing.....	215
9	Implementation	216

9.1	Screenshots	216
9.1.1	Splash Screen.....	216
9.1.2	Sign-in Activity	217
9.1.3	Sign Up Activity	218
9.1.4	Feedback Activity	219
9.1.5	Find a Ride Activity (Passenger).....	220
9.1.6	Show Current Location Activity (Passenger).....	221
9.1.7	'Select Date and Time' Activity (Passenger)	222
9.1.8	Choose Pickup Location and Drop off Location with Autocomplete for Address Activity (Passenger)	223
9.1.9	Show Available Rides and Book a Ride Activities (Passenger)	224
9.1.10	Cancel Journey Activity (Passenger)	225
9.1.11	Manage Journeys Activity (Passenger).....	226
9.1.12	Current Journey Details Activity (Passenger)	227
9.1.13	Make Payment	228
9.1.14	Completed Journey Activity (Passenger).....	229
9.1.15	Manage Profile Activity (Passenger)	230
9.1.16	Manage Verifications Activity (Passenger)	231
9.1.17	Email Verification Activity (Passenger)	232
9.1.18	Phone Verification Activity (Passenger).....	233
9.1.19	Driving License Verification Activity (Passenger)	234
9.1.20	Identification Card Verification (Passenger).....	235
9.1.21	Manage Cards Activity (Passenger).....	236
9.1.22	Manage Paths Activity (Driver).....	237
9.1.23	Choose Start Location and End Location with Autocomplete for Address Activity (Driver).....	238
9.1.24	Enter Path Name and Choose Car Activity (Driver)	239
9.1.25	Create Waypoints / Pickup Points Activity (Driver)	240

9.1.26	Manage Journeys Activity (Driver)	241
9.1.27	Approve or Reject Activity (Driver).....	242
9.1.28	Complete Journey Activity (Driver)	243
9.1.29	Manage Cars Activity (Driver).....	244
9.2	Sample Codes	245
9.2.1	Front End (Android)	245
9.2.1.1	Implementation of RX Java.....	245
9.2.1.2	Car Adapter Class	246
9.2.1.3	API calls.....	246
9.2.1.4	Logo Fade in Animation	247
9.2.1.5	OkHttpClient Implementation.....	248
9.2.1.6	Show Card Method	248
9.2.1.7	Implementation of MicroBlink SDK	249
9.2.1.8	Car Model Class	250
9.2.1.9	Implementation of Google Maps	251
9.2.1.10	Fingerprint Authentication for Payment	251
9.2.2	Back End (Node.js).....	252
9.2.2.1	Configuration of routes	252
9.2.2.2	Password Hashing using Bcrypt	253
9.2.2.3	Integration of JSON Web Token (JWT)	254
9.2.2.4	Configuration of Mongoose and MongoDB	255
9.2.2.5	Email Verification.....	256
9.2.2.6	Phone Verification	257
9.2.2.7	Upload Image to S3	257
9.2.2.8	Calculate price based on the distance	258
9.2.2.9	Credit Card Tokenization.....	259
10	System Validation	260

10.1	Unit Testing.....	260
10.1.1	Login	260
10.1.2	Sign Up.....	262
10.1.3	Feedback.....	265
10.1.4	Find a Ride	266
10.1.5	Manage Journeys (Passengers).....	267
10.1.6	Manage Profile (Passengers)	269
10.1.7	Manage Paths (Driver)	273
10.1.8	Manage Cars (Driver)	276
10.1.9	Manage Journeys (Drivers)	278
10.2	User Acceptance Testing	280
10.3	Summary	291
11	Conclusion and Reflection.....	292
11.1	Critical Evaluation.....	292
11.2	Conclusion	294
12	References.....	295
13	Appendices.....	306
13.1	Project Investigations Feedback and Learning Contract Form.....	306
13.2	Log Sheet (8 Log Sheets).....	307
13.3	FYP Poster	308
13.4	First Two Pages of Turnitin Report.....	309
13.5	Project Proposal Form	311
13.6	Project Specification Form	315
13.7	Ethics Form.....	328
13.8	Gantt Chart.....	333

List of Tables

Table 1: Project Plan	26
Table 2 Advantages and Disadvantages of GrabCar	39
Table 3: Advantages and Disadvantages of SOCAR.....	40
Table 4: Advantages and Disadvantages of Ryde	41
Table 5: Comparison between Web, Native and Hybrid Applications (Saccomani, 2019)....	45
Table 6: : Comparisons of Front-End Programming Languages (Android Authority, 2019). 47	
Table 7: Comparisons between Python, Node.js and Ruby on Rails (Zakhar Yung, 2018) ...	49
Table 8: Chosen IDE for Front End.....	50
Table 9: Chosen IDE for Back-End	51
Table 10 : Tools and Libraries.....	53
Table 11: Comparison between MySQL, PostgreSQL and MongoDB (DB-Engines, 2019) .	55
Table 12 Advantages and Disadvantages of Waterfall Model	61
Table 13: Advantages and Disadvantages of XP Programming.....	63
Table 14: Advantages and Disadvantages of Spiral.....	65
Table 15: General Comparisons between Waterfall, Extreme Programming and Spiral.....	67
Table 16: Users Table Structure	159
Table 17: Cars Table Structure	160
Table 18: Feedback Table Structure	161
Table 19: Journeys Table Structure	163
Table 20: Waypoints Table Structure	165
Table 21: Paths Table Structure.....	167
Table 22: Credit Cards Table Structure.....	168
Table 23: Earnings Table Structure	170
Table 24: Payment Table Structure.....	171
Table 25: Login Component (Test Plan).....	197

Table 26: Sign Up Component (Test Plan)	200
Table 27: Feedback Component (Test Plan)	201
Table 28: Find a Ride Component (Test Plan)	203
Table 29: Manage Journeys Component - Passenger (Test Plan)	204
Table 30 : Manage Profile Component(Test Plan)	208
Table 31: Manage Paths Component - Driver (Test Plan)	210
Table 32: Manage Cars Component - Drivers (Test Plan).....	212
Table 33: Manage Journeys Component - Drivers (Test Plan)	214
Table 34: Login Unit Testing	261
Table 35: Sign Up Unit Testing.....	264
Table 36: Feedback Unit Testing.....	265
Table 37: Find a Ride Unit Testing.....	267
Table 38: Manage Journeys (Passengers) Unit Testing	269
Table 39: Manage Profile (Passengers) Unit Testing	273
Table 40: Manage Paths (Driver) Unit Testing	276
Table 41: Manage Cars (Driver) Unit Testing.....	277
Table 42: Manage Journeys (Drivers) Unit Testing.....	279

Table of Figures

Figure 1: Transport Statistics of Malaysia in 2017 (The Ministry of Transport Malaysia, 2017)	29
Figure 2: The statistics of public complaints. Source: (Lebuhraya Lembaga Malaysia, 2019)	29
Figure 3 : Share of transport cost in household income. Source: (Oxford Economics, 2019)	32
Figure 4: The number and length of toll highways. Source (Lebuhraya Lembaga Malaysia, 2019)	33
Figure 5: Revolution of ride hailing (Anon., 2016)	35
Figure 7: Architecture of Elastic Beanstalk (AWS, 2019).....	57
Figure 8 : Extreme Programming Methodology (Tatvasoft.com, 2015).....	68
Figure 9: Workflow of release plan diagram (Wells, 1999).....	71
Figure 10: Workflow of iteration planning (Wells, 1999)	72
Figure 11 : Unit Test Life Cycle (Tutorials Point, 2018).....	75
Figure 12: : System Architectural Design of Easy Ride	125
Figure 13: Use Case Diagram of Easy Ride	127
Figure 14: Login Activity Diagram	141
Figure 15: User Registration Activity Diagram.....	142
Figure 16: Send Feedback Activity Diagram	143
Figure 17: Find a Ride Activity Diagram.....	144
Figure 18: Manage Journeys Activity Diagram.....	145
Figure 19: Make Payment Activity Diagram	146
Figure 20: Verify License Activity Diagram.....	147
Figure 21: Manage Cards Activity Diagram	148
Figure 22: Verify Phone Number Activity Diagram	149
Figure 23: Verify Email Address Activity Diagram.....	150
Figure 24: Manage Paths Activity Diagram.....	151

Figure 25: Manage Cars Activity Diagram	152
Figure 26: Manage Journeys Activity Diagram.....	153
Figure 27: Create Rides Activity Diagram.....	154
Figure 28 : Class Diagram of Easy Ride	155
Figure 29: Entity Relationship Diagram of Easy Ride.....	156
Figure 30: Interface for Sign in Page.....	172
Figure 31: Interface for Sign Up Page	173
Figure 32: Interface for Verifications Page	174
Figure 33: Interface for Find a Ride Page	175
Figure 34: Interface for Search Journeys Page	176
Figure 35: Interface for View Available Rides Page	177
Figure 36: Interface for View Ride Details Page.....	178
Figure 37: Interface for View Journey Information Page	179
Figure 38: Interface for Make Payment Page	180
Figure 39: Interface for Cancel Journey Page	181
Figure 40: Interface for Add a Card Page	182
Figure 41: Interface for Delete a Card Page	183
Figure 42: Interface for Feedback Page	184
Figure 43: Interface for Manage Profile Page	185
Figure 44: Interface for Manage Journeys Page	186
Figure 45: Interface for Register a New Car Page	187
Figure 46: Interface for Manage Cars Page.....	188
Figure 47: Interface for Add Path Page.....	189
Figure 48: Interface for Manage Paths Page	190
Figure 49 :Interface for Complete Journey Page	191
Figure 50: Interface for Verify or Accept Journeys Page	192

Figure 51: Splash Screen.....	216
Figure 52: Sign In Activity.....	217
Figure 53: Sign Up Activity	218
Figure 54: Feedback Activity	219
Figure 55: Find a Ride Activity	220
Figure 56: Show Current Location Activity (Passengers).....	221
Figure 57: Select Date and Time Activity	222
Figure 58: Choose Pickup Location and Dropoff Location Activity (Passenger)	223
Figure 59: Show Available Rides Activity (Passenger).....	224
Figure 60: Cancel Journey Activity (Passenger)	225
Figure 61: Manage Journeys Activity (Passenger)	226
Figure 62: Current Journey Details Activity (Passenger)	227
Figure 63: Make Payment Activity (Passenger)	228
Figure 64: Completed Journey Activity (Passenger)	229
Figure 65: Manage Profile Activity (Passenger)	230
Figure 66: Manage Verifications Activity (Passenger).....	231
Figure 67: Email Verification Activity (Passenger)	232
Figure 68: Phone Number Verification Activity (Passenger)	233
Figure 69: Driving License Verification Activity (Passenger).....	234
Figure 70: Identification Card Verification (Passenger)	235
Figure 71: Manage Cards Activity (Passenger).....	236
Figure 72: Manage Paths Activity (Driver).....	237
Figure 73: Choose Start Location and End Location (Driver)	238
Figure 74: Enter Path Name and Choose Car Activity (Driver).....	239
Figure 75: Create Waypoints / Pickup Points Activity (Driver).....	240
Figure 76: Manage Journeys Activity (Driver)	241

Figure 77: Approve or Reject Activity (Driver)	242
Figure 78: Complete Journey Activity (Driver)	243
Figure 79: Manage Cars Activity (Driver)	244
Figure 80: Code Snippet for RX Java	245
Figure 81: Code Snippet for Car Adapter Class	246
Figure 82: Code Snippet for API calls	246
Figure 83: Code Snippet for Fade In Animation	247
Figure 84: Code Snippet for OkHTTP Client Implementation	248
Figure 85: Code Snippet for Show Card Method	248
Figure 86: Code Snippet of MicroBlink SDK	249
Figure 87: Code Snippet for Car Model Class	250
Figure 88: Code Snippet for Google Maps Implementation	251
Figure 89: Code Snippet for Fingerprint Authentication	251
Figure 90: Code Snippet for Route Configurations	252
Figure 91: Code Snippet for Password Hashing using Bcrypt	253
Figure 92: Code Snippet for Integration of JSON Web Token	254
Figure 93: Code Snippet for the Mongoose and MongoDB configurations	255
Figure 94: Code Snippet for Email Verification.....	256
Figure 95: Code Snippet for Phone Verification	257
Figure 96 : Code Snippet for Uploading Image to S3.....	257
Figure 97: Code Snippet for Calculating Price.....	258
Figure 98: Code Snippet for Credit Card Tokenization	259

1 Introduction to the Study

1.1 Background to the project

When one thinks about sharing rides, one's mind will definitely steer towards the word 'carpool'. Carpool can be elucidated as an arrangement between two or more individuals to make a planned journey in a single car, typically to the same destination where each person takes turn to drive the others. In certain carpool scenarios, there will be only one car owner who drives other passengers to the desired destination (Rideshare, 2018). Carpooling is an economically efficient and rational approach. This is because it can significantly reduce a person's overall travelling cost which includes tolls and fuel expenses. The more the passengers in the carpool, the less the travelling expenses will be. On the other hand, carpooling is also considered to be an environmentally friendly approach as sharing journey mitigates traffic congestion on the roads, greenhouse gas emissions and the need for additional parking bays.

According to the research carried out by Environment Canada (2018), air pollution caused by vehicles is severely linked to various health-related issues such as skin allergies, respiratory diseases and asthma. Hence, by practicing carpool, these health problems can be gradually alleviated. In addition to that, travelling alone causes stress and makes the overall journey boring and tedious. Through carpooling, the travellers can make new acquaintances and turn a loneliness journey into a cheerful one. Despite the fact that carpooling reaps huge benefits to both drivers and passengers, some people are still deeply sceptical and tentative about carpooling. They are overwhelmed with a lot of questions such as:

- Where to find a travelling companion who travels to the same location?
- Will the travelling schedule of the driver clash with the passengers?
- How safe it is to travel with a complete stranger via carpooling?
- Is it convenient in practicing carpooling?
- How to split the travelling expenses among the driver and passengers?
- Is there any digital platform that promotes carpooling?
- If there is a digital platform for carpooling, how secure is the passengers' information?
- Is the information of the registered passengers safe and confidential?

Considering all these questions, it should be clear now that there is a lack of a reliable platform which promotes the concept of carpooling among individuals. Therefore, in order to overcome this problem, a **secure carpooling platform for travellers (Easy Ride)** will be developed in this project in which travellers who do not possess a car can look for someone nearby who owns a car and travels to the same location. This platform will be designed and developed as a mobile application to bring greater convenience to the users. The target audience of this project are Malaysian especially those who live in urban cities such as Kuala Lumpur and Petaling Jaya where they have to go through tremendous traffic nearly every day. Since security risks remain a primary concern in carpooling, this project will be carried out by placing huge emphasis on mitigating the possible vulnerabilities by implementing some robust security features. With that, this project intends to deliver a reliable and efficient carpooling environment in which customers no longer have to worry about their safety.

1.2 Problem Context

It is undeniably true that the number of vehicles on road is increasing tremendously from day to day. Based on the article published by Paulton in 2017, vehicle registrations in Malaysia has already hit a staggering number of 28.2 million units. As the number of vehicles on road increases, the rate of traffic congestion also increases. When the vast majority of people use private automotive vehicles and seek to drive during rush hours, the roads get severely snarled-up; leading to various problems. People who stuck in heavy traffic may be late for work, causing them to waste their valuable time and becomes less productive (Nptcel, 2018). From a different view, when the world is overpopulated with motorized vehicles, the environment is also getting severely affected due to the carbon and greenhouse gas emissions. This relatively contributes to global warming and climate changes.

Most of the people tend to neglect the use of public transportation and decide to own a vehicle without thinking about the expenses. The overall cost of private transportation is comparatively high, and the automotive owners are forced to spend a lot of money to cover the toll, car maintenance and fuel expenses. Moreover, nearly all the vehicles moving in traffic are single occupancy which means there are no other passengers in the vehicle except for the driver. Carpooling seems to be a reasonable and coherent way to overcome these problems (Ali, 2018). However, people tend to give a doubtful and anxious look when they are recommended with this approach. This is mainly because of the unfamiliarity of fellow companions. In a few carpool events, passengers are forced to travel with a complete stranger which may create a little inconvenience and discomfort. The entire journey would be odd as some passengers develop a queer feeling within themselves, thinking that the stranger will threaten or cause harm to them. The situation will get even worse if the strangers are reluctant to share any of their personal information or reveal too much about themselves.

Although there are several carpooling platforms available via online, data privacy remains a huge concern among the travellers. According to a survey by McAfee, 40% of people feel that their personal information stored in an organisation's database is not safe and widely exposed to various threats (Medium Corporation, 2019). In conjunction, it is terrifying to know that even huge corporations such as Facebook and Panera Bread have experienced data breaches that put millions of personal data of their clients into the hands of cyber perpetrators (Medium Corporation, 2019). This will eventually lead to various privacy, integrity and confidentiality issues. In December 2017, Singapore government fined Grab with a total amount of \$16,000

for unintentionally leaking customers' data via email marketing campaigns which expose the mobile numbers and names of their customers. Grab stated that the incident occurred due to the incorrect assembly of database tables that store customers' personal information. Later, the breach was immediately reported to Singapore's Personal Data Protection Commission (PDPC) for further interrogations and investigations. Grab apologised for the breach and promptly implemented severe data validations to perform checks and mask the phone numbers in the respective marketing campaigns (The Drum, 2019)

Taking all these problems into consideration, it can be deduced that security is one of the major issues which obstruct certain travellers to practice carpooling in their daily lives. Henceforth, all the mentioned primary problems here can be overcome with the presence of a digitalised platform which offers secure and reliable carpooling services.

1.3 Rationale

The proposed mobile application brings huge advantages to the community and environment by creating an efficient carpooling ecosystem. Connecting people and creating a strong culture of sustainability will be the primary purpose of this application as it serves a path for people to reach out and connect with more travellers. Besides fostering social networks, this application is defined to be cost-effective as it helps the drivers and passengers to share the overall travel expenses. Apart from that, the implementation of this application will definitely offer convenience and hassle-free solution to those who stay in places which provide limited public transportation facilities. If deployed and managed well, this application can be considered as a strong alternative for public transportation. Furthermore, this application is also aimed to maintain and protect users' data integrity through the integration of various security features. Data privacy and confidentiality will be no longer an issue as the application will be developed in a way to handle potential threats and vulnerabilities. The proposed application will be reinforced with various security features such as Bcrypt Hashing, Fingerprint Authentication and tamper detection technologies in order to prevent vulnerabilities and maintain users' data integrity. When considering the outcome of the application, there are two types of benefits:

1.4 Potential Benefits

1.4.1 Tangible Benefits

- ❖ Establishes a wide social network of car owners and passengers
- ❖ Keeps track of all carpooling activities in an organised way
- ❖ Maintains the validity and integrity of users' data
- ❖ Reduces overall traffic congestion in the road
- ❖ Saves commuter's time, money and travelling costs

1.4.2 Intangible Benefits

- ❖ Encourages a digitalized way of carpooling
- ❖ Allows travellers to have a joyful journey without being struck with loneliness or boredom
- ❖ Creates satisfaction among vehicle owners who would be helping the passengers to commute
- ❖ Fosters a safe and reliable travelling experience as all the users' information are verified and validated upon registration

- ❖ Promotes a greener environment by reducing the number of single-occupancy cars in the road

1.5 Target Users

Target users can be defined as a group of individuals who share common characteristics and show mutual interests to a particular service or product. The target users of the proposed carpooling mobile application are Malaysian travellers who are facing difficulties in travelling. The system provides a better alternative for those who rely on public transportations to travel to other places. At the same time, the system also focuses on car owners who are willing to offer carpooling services via the platform.

1.6 Scope and Objectives

1.6.1 Aims

The aim of this project is to develop a secure and reliable mobile application that promotes the practice of carpooling in Malaysia by allowing car owners to share journeys with passengers who travel along the same way. This system is hoped to establish a social connection and foster a better relationship between car owners and passengers by satisfying their travelling needs.

1.6.2 Objectives

- ❖ To analyse and provide solutions for the current transportation problems in Malaysia
- ❖ To find out the perspectives and expectations of targeted users towards the practice of digitalized carpooling
- ❖ To integrate intuitive and fascinating carpooling functions in the system
- ❖ To implement various security features in order to protect the system from vulnerabilities and unauthorised intrusions.
- ❖ To evaluate whether the needs and expectations of the users are met upon system deployment

1.6.3 Deliverables

In short, Easy Ride is a secure mobile application which promotes carpooling among vehicle owners and passengers who travel to the same location. Some fundamental features have been included into the application to enhance the overall efficiency and user-friendliness.

Core Features

- ❖ As soon as the users start the application, they will be prompted to the login page in which they have to input their respective username and password.
- ❖ If they do not own an account, they will be directed to the registration page which requires them to create a new account.
- ❖ Once they log into the application, they will see an option either to offer a car ride or search for a particular ride.
- ❖ If the user wants to offer a car ride, the user is required to upload a picture of his identification card and driving license for security purposes. After the system verifies the user's credentials, he or she is able to offer a car ride by inputting the starting point, destination, time and overall travel expenses.
- ❖ If the user wishes to search for a particular journey which fulfils his or her travel needs, he or she needs to input all the requested information and click 'search'. If the journey matches the requirements of the user, he or she can book a ride with the car owner at the agreed time.
- ❖ This platform also offers reliable payment services which allow passengers to make payments for each and every successful ride.

Special Features

Since security is one of the main concerns in this project, various security features will be implemented throughout the application to secure users' data such as:

- ❖ JSON Web Token will be used to define a compact and self-contained way for securely transmitting information between the client device and server.
- ❖ This system also aims to provide one-way road to security by hashing passwords through the implementation of Bcrypt Hashing.
- ❖ Code obfuscation will be done with the use of JavaGuard library to make the source code difficult for the potential hackers to understand.

Enhanced Features

- ❖ Google Maps will be integrated in this application to provide real-time navigation features to the users.
- ❖ Fingerprint authentication will be implemented in the system with the use of built-in Android library to make the payment processes secure and reliable.

1.6.4 Nature of Challenges

Since the proposed application is intended to provide seamless carpooling experience to the users, all the pre-defined challenges need to be analysed and addressed in an effective manner. One of the leading challenges would be to understand and perceive the requirements of the targeted users. This issue can be solved by choosing the correct and most-suitable data gathering techniques which clearly outline what the user expects from the proposed application. On the other hand, creating trust and assurance among users would be another primary challenge because the application requires the users to deal with strangers. Proper verifications need to be done upon registration to authenticate and validate the credentials given by the new users. This approach will definitely instil trust and belief among people that the application is reliable and safe to use.

Furthermore, as the application requests and stores some of the personal information of the users, securing their information from potential threats would be the biggest challenge in this project. Implementing strong security features such as Tokenization, Bcrypt Hashing, Code Obfuscation and Session Handling are highly recommended to prevent any sort of cyber exploitation. Besides that, a secondary database is required to make the application to be highly available in the event of system failover. Apart from that, since the application would be newly introduced to the market, there is a high tendency for the users to face some difficulties when using the application for the first time. Henceforth, clear instructions and 24/7 support should be given to the customers to ensure that they comprehend all the functionalities and workflow of the system.

1.7 Overview of the Final Year Report

The final year report comprises a total of eleven chapters, all of which relates to a detailed research associated with the proposed system which is **Easy Ride - Secure Carpooling Mobile Application for Travellers**. Chapter One incorporates the introduction to the study which clearly elaborates the project background, problem context, project rationale, potential benefits, target users, scope, nature of challenges and a Gantt Chart that depicts the overall planning and workflow of this project. The second chapter provides the reader with a secondary research that is conducted using literature from relevant journals, websites, articles and other sources. The findings of the secondary research mainly describe the domain factors that drive for the need of a digitalised carpooling mobile application in Malaysia. Moreover, the research also explains the characteristics and functionalities of the systems that are similar to the proposed one. Chapter Three evidently explains the technical resources that are required for the development of the proposed system. This chapter contains detailed information about the chosen programming language, Interactive Development Environment (IDE), libraries, database management system, operating system, web server and web browser. The fourth chapter contains a comprehensive research on how the proposed system will be developed in accordance to the chosen system development methodology. The fifth chapter clearly elucidates the data gathering techniques that are performed by the researcher to obtain some in-depth insights and requirements of the targeted end-users. Interview and questionnaire are chosen to be the most appropriate data gathering techniques for this proposed project. Chapter Six includes detailed analysis of data collected through questionnaire and interview which helps the researcher to ensure the system requirements are aligned with the customer needs. Chapter Seven specifies the system architecture of the project which includes the use case diagram, activity diagram and database designs. This chapter provides a brief overview about the workflow, structure and relationship between the components of the system. The seventh chapter clearly explains the release plans of the system together with the test plans for unit testing and user acceptance testing. Chapter Nine highlights the overall implementation of the system with the help of system screenshots and code snippets. Chapter Ten includes the system validation in which the results of unit testing and user acceptance testing are included. These results are necessary in order to understand whether all the user requirements are met. The final chapter of this report provides a general conclusion and the reflections gained by the researcher throughout the completion of this report.

1.8 Project Plan

Final Year Project				
Semester 1				
Task Name	Duration	Start Date	End Date	Status
Project Proposal Form	8 days	21 th June 2019	28 th June 2019	Done
Project Specifications Form	46 days	29 th June 2019	12 th August 2019	Done
Chapter 1: Introduction to the Study	7 days	13th August 2019	19th August 2019	
1.1 Background to the Project	1 day	13 th August 2019	13 th August 2019	Done
1.2 Problem Statement	1 day	14 th August 2019	14 th August 2019	Done
1.3 Rationale	1 day	15 th August 2019	15 th August 2019	Done
1.4 Potential Benefits	1 day	16 th August 2019	16 th August 2019	Done
1.5 Target Users	1 day	17 th August 2019	17 th August 2019	Done
1.6 Scope and Objectives	1 day	18 th August 2019	18 th August 2019	Done
1.7 Overview of the Report	1 day	19 th August 2019	19 th August 2019	Done
Chapter 2: Literature Review	14 days	20th August 2019	2nd September 2019	
2.1 Introduction	3 days	20 th August 2019	22 nd August 2019	Done
2.2 Domain Research	7 days	23 rd August 2019	29 th August 2019	Done
2.3 Similar Systems	2 days	30 th August 2019	31 st August 2019	Done
2.4 Summary	2 days	1 st September 2019	2 nd September 2019	Done
Chapter 3: Technical Research	6 days	3rd September 2019	8th September 2019	Done
3.1 Programming Language	1 day	3 rd September 2019	3 rd September 2019	Done

3.2 Interactive Development Environment	1 day	4 th September 2019	4 th September 2019	Done
3.3 Libraries / Tools	1 day	5 th September 2019	5 th September 2019	Done
3.4 Database Management System	1 day	6 th September 2019	6 th September 2019	Done
3.5 Operating System	1 day	7 th September 2019	7 th September 2019	Done
3.6 Web Server	1 day	8 th September 2019	8 th September 2019	Done
Chapter 4: System Development Methodology	8 days	9th September 2019	16th September 2019	Done
Chapter 5: Research Methods	13 days	17th September 2019	29th September 2019	Done
5.2 Introduction	3 days	17 th September 2019	19 th September 2019	Done
5.3 Design	7 days	20 th September 2019	26 th September 2019	Done
5.4 Summary	3 days	27 th September 2019	29 th September 2019	Done
Chapter 6: Requirements Validation	11 days	30th September 2019	10th October 2019	Done
6.1 Analysis of Data	9 days	30 th September 2019	8 th October 2019	Done
6.2 Summary	2 days	9 th October 2019	10 th October 2019	Done
Semester 2				
Chapter 7: System Architecture	21 days	21st October 2019	10th November 2019	Done
System and Database Designs	12 days	21 st October 2019	1 st November 2019	Done
Interface Designs	9 days	2 nd November 2019	10 th November 2019	Done
Chapter 9: Implementation	82 days	11th November 2019	1st February 2019	Done
Development of User Interface	17 days	11 th November 2019	27 th November 2019	Done

Backend Development	35 days	28 th November 2019	1 st January 2020	Done
Database integration	30 days	2 nd January 2020	1 st February 2020	Done
Chapter 10: System Validation	17 days	2nd February 2020	18th February 2020	Done
Unit Testing	6 days	2 nd February 2020	7 th February 2020	Done
Integration Testing	6 days	8 th February 2020	13 th February 2020	Done
User Acceptance Testing	5 days	14 th February 2020	18 th February 2020	Done
Chapter 11: Conclusion and Reflection	1 day	19th February 2020	19th February 2020	Done
FYP Presentation	1 day	11th March 2020	11th March 2020	Done

Table 1: Project Plan

2 Literature Review

2.1 Introduction

The influence of digitalization has opened pathways for new ideas and opportunities to reduce cost and different ideas by opening up new business models (Baron, 2017). The transformation of digital ecosystem has been a key reason for the birth of digital urbanization. This urbanization has been creating significant challenges to the people and government in terms of resources, infrastructures and also energy. According to United Nations in 2014, an estimation of 54 percent of the world's population was residing in urban areas. But by 2050, a total of 66 percent of the world population is estimated to start living in urban areas all over the world (Mukti and Prambudia, 2018). Hence, as the amount of population is seen to increase at urban areas, the problem of mobility in urban areas has seen to be rising as well. This is supported by World Bank Group (2014) where it is stated that the annual passenger traffic on roads will exceed 50 percent higher when compared to 2015.

However here in Malaysia, urban mobility might be a major problem to the country soon. As a solution, a consolidative idea was born in efforts to reduce traffic congestion which would be E-hailing services. Statistics reveal a massive 80 percent of Malaysians prefer E-hailing services such as Grab and Uber due to comfortability of commute and also direct point A to point B travel business model compared to public transport which cannot facilitate passengers to specific places. When surveyed, spending money on a reliable and a satisfying commute is preferred by most of the Malaysians (Hsien, 2018). E-hailing services can be described as a service that matches passengers with a preferred vehicle which can provide service to transport them from preferred point A to point B locations directly. Services such as these require streamflow of transport network which is usually provided by established ridesharing companies. The concept of ridesharing can be said to be the birth of digitalization where passengers can look for their perfect trip to a place with regulated pricing.

2.2 Domain Research

2.2.1 Transportation Problems in Malaysia

Massive Traffic Congestion

The typical routine in Malaysia is driven by the interaction of traffic, drivers and streets. Traffic flows vary with time and place; mostly throughout the day as it fluctuates with peaks in the morning and in the evening. Many places may have very high volume of traffic due to active economic activities, for example in the main business district of major cities. But other places, including leisure roads, may have to account for heavy traffic only on weekends and holidays. The design and construction of such an installation require proper planning and appropriate engineering judgment, which are not predictable. Congestion occurs when the traffic number is much higher than that of existing road installations (the capacity). The Level of Service (LoS) of such facilities deteriorates when the amount of traffic reaches the capacity of the existing facilities. Because of changes in their convenience, i.e. reduced speed, longer travel time or longer time at road intersections, the users of the affected highway would experience lower LoS. All these made them lose valuable time that could have been used for other useful and more successful enterprises.

Commuting in traffics in the capital of Malaysia has been getting worse from year to year. The traffic rise in the statistics despite the efforts of speed-up lanes and the use of smart toll systems such as Touch and Go and Smart Tag (Mustapha and Nik Hashim, 2016). The government has introduced alternative public transport models such as Rapid commuter bus and train systems to overcome traffic in Kuala Lumpur. On the other side, a yearly budget is being allocated just for public transportation as an agenda to further ease traffic congestion in the capital state. As a new update, Times (2019) has stated that the government has introduced a new electric bus system in Kuala Lumpur and has allocated a budget of 450 million ringgits. Despite these efforts, the problem of traffic around Klang Valley, in general, has been impacting other major cities around Malaysia (Ministry of Transport Malaysia, 2017).

JADUAL 1.13: PURATA TRAFIK HARIAN (ADT) DI 63 LOKASI, SEMENANJUNG MALAYSIA, 2008-2017 Table 1.13: Average Daily Traffic (ADT) at 63 Locations, Peninsular Malaysia, 2008-2017													
BIL No	STESEN Station	KM	LOKASI Location	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
PERAK													
1	AR 101	106.6	Ipoh-Tanjung Malim (Slim River Toll house)	13,854	15,038	15,322	14,039	14,431	15,328	16,501	16,736	15,187	14,913
2	AR 204	78.9	Ipoh-Lumut	21,138	23,920	22,389	23,758	25,283	25,942	23,834	26,494	25,939	27,384
3	AR 301	35.9	Ipoh-Kampar	23,050	23,659	31,022	30,311	27,497	28,520	27,126	30,592	24,654	29,911
4	AR 303	5.6	Ipoh-Gopeng	71,205	79,513	84,135	73,487	85,819	77,195	78,210	78,136	77,483	87,006
5	AR 501	30.4	Ipoh-Kuala Kangsar (500m North of Sg. Siput Town)	18,036	19,086	19,426	22,500	19,251	20,478	18,578	19,895	19,933	20,443
6	AR 601	79.7	Ipoh-Batu Hamper-Changkat Jering	16,091	16,752	14,128	11,726	19,410	20,588	19,881	20,664	21,327	19,058
7	AR 603	82.1	Ipoh-Changkat Jering-Semangkol	10,034	7,076	10,270	18,644	12,586	12,938	12,531	12,949	13,919	9,227
8	AR 703	106.3	Ipoh-Teluk Intan-Simpang Empat	24,244	25,159	25,365	25,004	28,465	25,489	25,865	27,249	33,024	26,218
9	AR 801	96.6	Ipoh-Kuala Kangsar-Gerik	2,509	2,715	1,724	3,110	3,562	3,487	2,828	3,139	3,017	2,798
10	AR 803	2.4	Lebuh Raya Timur-Barat	2,945	3,078	3,337	3,148	3,944	3,796	3,636	3,293	3,818	3,923
SELANGOR													
11	BR 102	3.5	Klang-Port Klang (Jalan Watson)	47,817	46,690	52,901	53,983	57,835	56,513	52,563	49,706	47,667	47,521
12	BR 106	-	300m From The Federal Highway's Junction-North Klang Straits Bypass	129,408	122,468	141,121	135,678	140,780	143,223	136,424	131,348	128,988	101,893
13	BR 203	48.3	Klang-Merb-Batu Laut	6,711	7,023	7,101	6,852	7,128	7,777	7,741	7,890	7,999	5,903
14	BR 405	45.1	Kuala Lumpur-Kepong-Kuils Selangor	19,991	20,938	22,822	23,003	23,648	21,278	22,618	21,611	22,277	21,568
15	BR 501	72.1	Klang-Sabek Bernam	17,977	19,773	20,466	21,743	23,370	22,174	22,443	20,838	24,554	21,642
16	BR 604	21.7	Kuala Lumpur-Kajang	57,288	58,929	56,609	57,591	53,689	59,023	54,222	48,737	48,199	46,607
17	BR 701	58.6	Kuala Lumpur-Kuala Kubu Baru Junction (South of Junction)	12,307	13,209	18,293	13,430	13,320	15,082	15,022	15,538	16,063	13,476
18	BR 902	19.0	Kuala Lumpur-Karak Highway	137,870	150,213	129,345	144,334	151,486	147,449	144,308	129,579	138,711	153,545
PAHANG													
19	CR 102	67.0	Kuala Lumpur-Kuantan (along KL-Karak Highway)	20,703	22,224	28,109	27,653	28,470	26,509	28,300	30,436	31,036	1,833
20	CR 403	233.0	Kuantan-Maran	23,395	26,064	28,248	29,142	31,136	31,416	31,876	29,856	30,231	33,247
21	CR 410	32.5	Kuantan-Kemaman	20,260	22,249	22,079	23,278	22,911	21,601	22,995	20,827	24,850	30,052
22	CR 503	282.0	Kuala Lumpur-Kuala Lipis- Kampung Padang Tuanku-Kota Bharu	6,609	6,159	6,253	7,053	7,513	6,985	7,319	8,063	8,757	8,302
23	CR 603	3.0	Pekan-Nenas	5,746	7,783	8,650	9,761	10,319	11,563	11,535	10,741	11,620	11,606
24	CR 801	115.0	Kuantan-Karak	11,567	11,614	11,771	11,597	13,281	13,328	15,673	14,874	15,730	16,731
25	CR 805	189.0	Kuantan-Maran	6,587	6,761	6,980	8,049	7,088	6,952	6,714	6,369	6,841	6,915
26	CR 902	-	Kuantan-Segamat (400m. Bkt. Ibam-Rompin Junction North Bound)	7,316	11,634	8,102	8,427	9,545	8,763	9,314	9,985	10,514	10,416

SUMBER: KEMENTERIAN KERJA RAYA
Source: Ministry of Works

Figure 1: Transport Statistics of Malaysia in 2017 (The Ministry of Transport Malaysia, 2017)

The Open Traffic program collected by Ali (2018) is about 2 million data samples relevant to the speed metric. The analysis shows that the average traffic speed during weekdays is more than expected and during weekends relatively less. His study observed that on weekends, the average speed falls between 44-49 km/h, the speed is also at the slowest on Fridays as the Muslims offer the prayers in large numbers and in the congregation. The other main reason for the low speed is that most of the people are going to their hometown after the day has been called. In relation to that, the illustration below shows the statistics of public complaints from 2017 to 2018 on the road and safety issue.

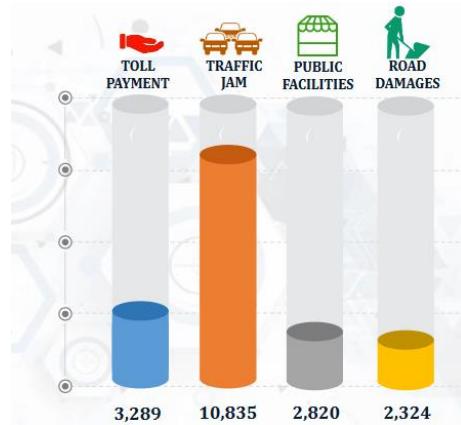


Figure 2:The statistics of public complaints. Source: (Lebuhraya Lembaga Malaysia, 2019)

Based on the figure above, the highest complaint registered from the year 2017 to 2018 is traffic jam. This clearly indicates that traffic jam is affecting Malaysian psychological behaviour. Approximately 10,835 complains were registered at the highest, complaints launched for toll payment was at 3,289, public facilities at 2,820 and road damages at 2,324 which is not even 50 % from the complains made on the traffic jam in Malaysia during 2017 till 2018. 38% of FDR roads in Malaysia, many of which have radial links to town centres, are rated as service E or F, which means they are moderate or highly congested, according to the Department of Highway Planning (HPU). This statement is strongly supported by Verghis (2019) who claimed that the traffic congestion in Malaysia costs more than 1.1 % of the national GDP annually or over RM 3,100 per resident. Len (2019) mentioned that the demand for vehicles on the road at the time of each working day can surpass the capability of the road network resulting in mobility problems for a large number of people travelling in mostly private vehicles during the same time period. Ismail (2018) predicted that the next quality assessment of the junction will be carried out by including the expected increase in traffic and potential peak hour traffic volumes from other intersections. The junction performance is measured by the saturation level and vehicle queues.

Greenhouse Gas Emissions from Cars

A number of research studies found that carpooling would reduce emissions of greenhouse gases (GHG). Bharadwaj (2017) reports which were based on a model simulation claimed that individual passengers minimize the emission of GHGs by about 4% to 5%. from a personal travel plan. An estimated 7.2 million tons of GHGs in each year can be saved in Malaysia, if every 100 cars are added with additional passengers (Shahidat, 2014). The study also estimates that Malaysia can save 68.0 million tons, with one passenger added on 10 vehicles annually in Malaysia (Lokman, 2017). The SMART2020 study also focuses on the possibility of lowering carbon dioxide emissions by 70 million to 190 million tonnes, by the use of information technology and communications technology (ICT) such as app-based carpooling to improve road efficiencies (Global e-Sustainability Initiative, 2019).

With increasing motorisation and growing reliance on private modes, oil and diesel consumption has increased rapidly. The transport industry currently consumes approximately 36 per cent of domestic electricity. It has also proven to be a big carbon dioxide (CO₂) emitter and accounts for other air pollution gasses. Shahidad (2014) stated that Malaysia has recorded 42.43 million tonnes, which accounts for 22.9 percent of Malaysia's overall CO₂ emissions. There are expectations for an increase in the number of registered motor vehicles which will eventually increase CO₂ emissions further in future years. The rise of CO₂ emissions from the Malaysian transport sector is the reason why the emissions of CO₂ have risen from around 15 million tons at the beginning of the 1990s to 42.43 million tons in 2012. According to estimates, the transport sector wants to reduce CO₂ by 9.17 million tons by the year 2020, so that its emissions are reduced by 40%. Ismail (2015) also supported that higher motorization is causing a lot of problems in Malaysia with regards to road congestion, high pollution level, high non-renewable energy consumption, threats to quality of life and high traffic accidents. The potentially sustainable transport option, which will lead to an increased customer satisfaction, should become the public transport network. Besides keeping riders in public bus transportation with high-quality services, different alternatives can be considered to satisfy their travel demands. The operational variable is highly related to client satisfaction. In order to improve customer satisfaction, greater attention is needed. The crucial factor in achieving higher satisfaction is frequency, cost, timeliness and travel time.

One of the most adverse effects of emissions from vehicles is that they have a negative impact on air quality, global warming and citizen's health. In Malaysia, it has been reported that the emissions of CO₂ from road transport were around 60,000 tonnes in 2007. An effective strategy was found to promote public transport, based on the parametric analysis which showed that it could reduce consumption of fuel by approximately 1000 tonnes and decrease CO₂ emissions by about 7% (Abdelfatah, 2015). Then Shahee (2018) and Dahalan (2015) said that low-income households and minority families are typically subjected to an excessive highway and vehicle emissions. According to a conference done by Yahaya (2019) on sustainable transportation system in Malaysia, around 4% of Malaysians which is approximately 11.3 million people are living within 500 feet of the main road. This research indicates that there is a higher risk for certain communities to get exposed to air pollution from traffic due to residential proximity to highway systems.

As identified by Minhans (2013), air pollution can also lead to environmental costs, noise pollution, vibrations and other adverse effects. Greenhouse gas emissions include the emissions of carbon monoxide (CO), particulate matter (PM10), nitrogen oxides (NOX), and sulphur oxides (SOX) directly into the atmosphere. The sum of contaminants was estimated to be high based on the traffic volume for the predicted years. Air pollution from outdoors is one of the ten leading causes of high-income countries' deaths (World Health Organisation Malaysia, 2019). Carpooling can, therefore, act as one of the key mitigation measures for reducing greenhouse gas emissions from traffic to these areas.

High Transportation Costs

Carpooling provides Malaysians with several financial and fiscal incentive as identified in the research of Koting (2017). This is supported by (Masirin, 2019)'s article that claimed that carpooling is a cost-effective strategy to alleviate traffic and minimize additional road and public transit capacities, facilitating growth in transportation resources and personal performance. His study found that casual carpooling can significantly reduce energy consumption for 15 commuters, which means that the same number of passengers can use express bus services at a lower cost. The figure below shows the bar graph for share of transport cost in accordance of household income.

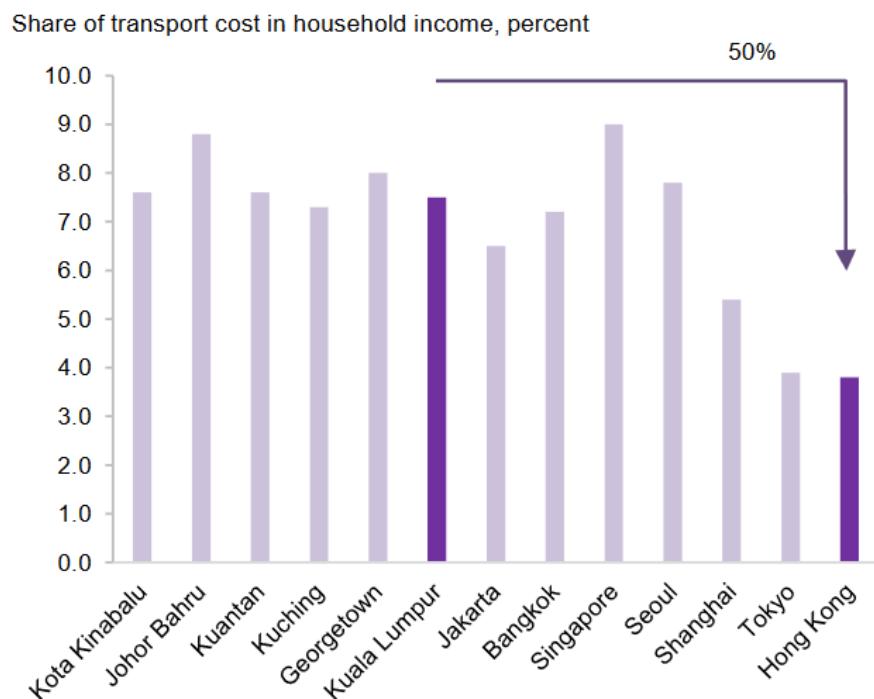


Figure 3 : Share of transport cost in household income. Source: (Oxford Economics, 2019)

According to the survey conducted by Oxford Economics (2019), transit costs are relatively high in Malaysia compared to other cities from Eastern Asia. Their research shows that the overall transport costs in Kuala Lumpur is 10% higher, which is 59% more than that in Hong Kong and Tokyo, and the share of household transport costs in Kuala Lumpur is 50% more than in Hong Kong and Tokyo. Thanking Mahirah's study for her analysis on congested road pricing which ascertained that the preference for fast roads that peaks at the highest tolls will normally be distributed. With regard to the determinants of WTP on reducing travel times, the organisation was found to be ready to pay for faster transport for women, the cohorts of the medium age and higher income and higher education.

Shukri (2013) asserted that cost of maintenance and operating of a vehicle is increasing. Wahab(2017) added that some general car workshops appear to mislead customers by asking them the wrong issues or problems, so that additional costs are charged for the service. Consumers often believe that some mechanics have coerced them to substitute some of their vehicle parts that have been considered defective or unusable, even though that is not the case (Bungga, 2017). There are also concerns about misbehaviour and failures to treat customers with good behaviour or disrespectful actions (Sinar Harian, 2017). The figure below shows number and length of toll highways based on the last 5 years of Malaysian plan.

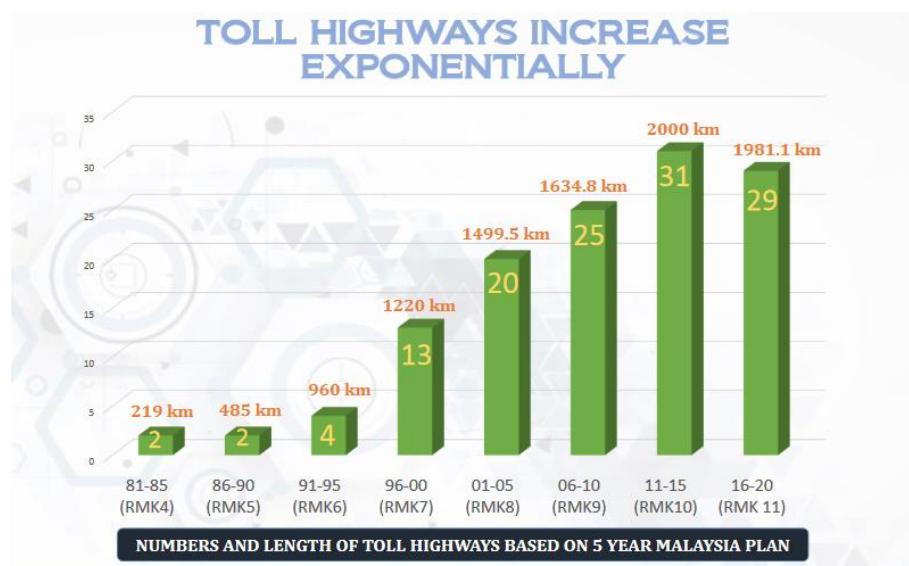


Figure 4: The number and length of toll highways. Source (Lebuhraya Lembaga Malaysia, 2019)

According to (Lebuhraya Lembaga Malaysia, 2019)'s statistical report above, it is clearly illustrated that the number and length of toll highways dramatically increased in the past five years. The increase in toll highways relatively increase the cost of toll payment which is a huge load on the citizen's shoulder besides their vehicle maintenance cost, oil price, time and energy.

Talking about the oil price, Department of Statistics Malaysia (2019) released a report on consumer price index which stated that approximately 550 gallons of fuel is used by the average passenger car each year. Ariffin (2013) argued that the most effective strategy for reducing energy use is to implement policies for carpools in addition to driving prohibition. Another study by Shaheed (2018) said that a potential fuel saving plan can be projected in Malaysia by reducing the usage of 0.80 billion gallons of fuel per year if an extra passenger is added in 100 passenger vehicles. It also reports the possible annual fuel savings in Malaysia of 7.54 to 7.74 billion gallons if every 10 cars adds one additional passenger. Another study by Susilawati (2018) supported that carpools could save 33 million gallons of gasoline a week, with one additional passenger driving an average commuting vehicle. Regional carpools can also have a significant effect on fuel savings.

2.2.2 Peoples' Perspective towards Ride Hailing Services

Ride-hailing has been transforming as a major service in most parts of the world. But historically, ride hailing was implemented during 1640's. The demand for transportation from point A to B have been officially recorded when in 1635, hackney Carriage Act was the first legislation to be passed to control horse-drawn carriages in England (Bellis, 2019). Thanks to technology and inventions, the ride hailing platform started to evolve gradually by introduction of cars during 1897 and the first ever known taxi service is called as Daimler Victoria. From there, ride hailing platform was given a revival by the introduction of yellow taxis or also known as cabs which became the main identity of taxis worldwide. But the fact is evolution of ride hailing as a service did not stop there. Humans are always capable to perform modifications on almost everything in order to make life easier.

The current idea of ride hailing as a service is when a customer hires a car or a driver to bring them from point A to preferred point B. Taxi's in general do provide this service in most of the countries. However, in Malaysia, most taxis recently have not been in the best shape when comparing with other ride hailing platforms. Taxis in Malaysia have been operating since 1966 as a partial government service, while generating economy to the country. Taxis still operate in major cities like Kuala Lumpur, Petaling Jaya, Penang, Johore Bahru, Kedah Kuala Terengganu and more. But in recent lights it can be said that taxi services have gone down due to several reasons.

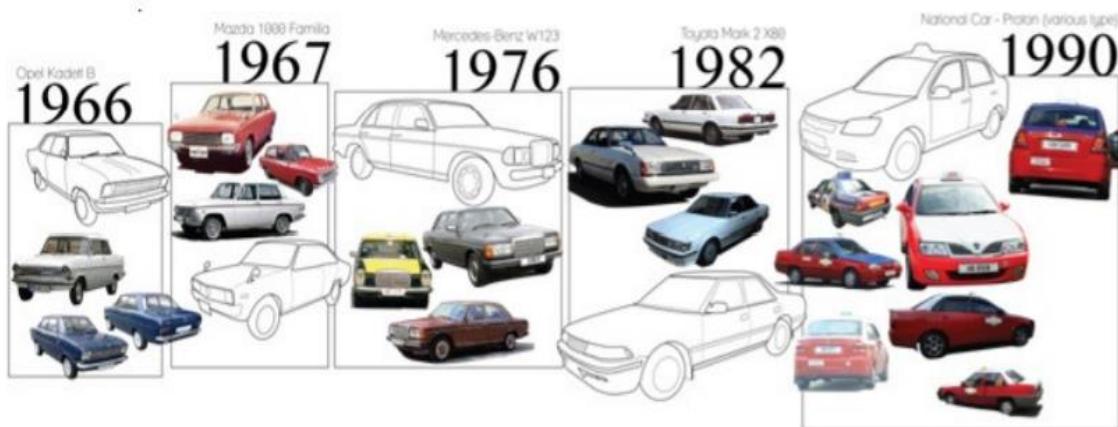


Figure 5: Revolution of ride hailing (Anon., 2016)

Taxi Services

The reputation of taxi services in Malaysia has been marred in general due to not just one but many reasons. Even though, strict regulations have been set up by the government to control taxi drivers all over the places, they still get away with practices like not using the taxi meter given by the company. This creates a scenario that appears to have regulations but without accountability. Customers regularly get cheated on with high fares set by the taxi drivers even before the ride. Only after an agreement of fixed fare, the customers are treated and brought to their destination (LEESAN, 2018). This automatically creates dissatisfaction and distrust between daily travellers; thus they avoid using taxis by relying more on government provided train systems and also buses. Moreover, many taxi drivers have a record of being rude and unpleasant to customers regardless of locals or foreigners. In 2015, Malaysia was in the top spot as the country with worst taxi drivers followed by Paris and Bangkok. Due to lack of monitoring, the taxi drivers are mostly dishonest and non-presentable adding that they keep their vehicles in a bad shape. So, from here, it is clear now that the reputation of taxi services

has been damaged by the drivers that Malaysians nowadays prefer other types of ride hailing services.

Lack of security and monitoring

As the cost of living is seen to be rising in most of the cities, the amount of crime rates will increase similarly. The rate of kidnaps in city averagely increases 3.6% per 1000 people every 5 years. This is relatable because without proper monitoring, perpetrators can disguise as taxi drivers at regular taxi stands and fish for victims. Not just that, licensed taxi drivers can be also violent and aggressive at times at customers. For an example, two years before, 2 siblings disguised as cab drivers and picked up victims to offer them rides. The victims were then threatened and assaulted, asking for their bank cards and PIN's (Nsubunga, 2019). This incident happened because the victim was unable to verify if the siblings were actually cab drivers or not. Limitations such as this could lead to more than kidnapping such rape and murder. Hence, lack of simple security and monitoring could further push away customers from choosing taxi services as cases such as this will question the reliability of these services.

Hence, newly developed transportation networking system could be able to solve issues and focus more on providing better rides. Looking for a ride has been made much easier by calling up the car or taxi through phone calls or virtually make bookings through an application. This means there would be no more long waits at a fixed point to hail a taxi. Furthermore, this service is not compulsorily provided only by taxis' or cabs but by regular citizens who own a car. Therefore, a new entity was introduced under ride hailing services which is e-ride hailing.

E-hailing services are rapidly changing the transportation structure in major cities. People are seen to rely more on e-hailing rides comprising both taxi and regular citizens as drivers compared to conventional taxi drivers. This inclusively leads to a major drop in taxi services, ending up in a clash between both the services in Malaysia. According to Lau (2019), taxi drivers all across Malaysia planned to hold up a rally to make a protest against the current transport minister, Anthony Loke Siew Fook. Apparently taxi drivers in Malaysia demanded for equal treatment as same as other e-hailing drivers. On the other hand, Ferrarse (2019) has stated on his research that most e-hailing ride service users have said that taxi drivers in Malaysia have more bad reputation and are unreliable compared to new e-hailing ride service providers such as grab and uber. His survey has showed that e-hailing ride always provide competitive and at times cheaper compared to taxi rides which tends to fleece money by any means. Moreover, convenience is proven in e-hailing services where the customers can just

book rides using a mobile phone and the ride arrives exactly at the spot that they have marked as a meet-up point. Hence, it has become clear that people prefer e-hailing services compared to traditional hailing services due to the convenience and also proper and cheaper pricing. In the near future, technologically advanced transportation network systems might be implemented with the motive of simplifying and economically viable.

Limitations in the current e-hailing services

There are several e-hailing services in the marketplace to provide enhanced travelling experiences to the users such as SOCAR and GrabCar. GrabCar is specialized in providing ride-hailing transports services whereas SOCAR offers a car-sharing platform in which customers can rent a car for a specific duration. However, there are several limitations in both of the applications. Despite providing a wide range of services such as logistics, food delivery and e-wallet, GrabCar still lacks a systematic carpooling platform which allows car owners to share journeys with passengers. GrabCar introduced GrabHitch in 2017 as an attempt to provide carpooling experience to the users but it did not go well due to poor design and implementation (Grab, 2018). In the application, car owners are not restricted to any regulations and they can cancel a ride anytime without informing the passengers. And sometimes, one of the passengers would be not be informed by the driver that an additional passenger would join the ride. This may create a little inconvenience and discomfort for the passengers (Grab, 2018). With all these problems, GrabHitch was eventually removed from GrabCar mobile application. On the other hand, SOCAR only offers car rental services, opting out other significant options such as ride-hailing and carpooling. Due to the unavailability of other services, SOCAR can only capture the attention of a smaller number of audience. To summarise, all the limitations of GrabCar and SOCAR should be studied and analysed meticulously to develop a more customer-oriented carpooling mobile application which focuses on usability and user-friendliness.

2.2.3 The Future of Transportation

The future of transportation ecosystem will evolve into something new that it might include services like carsharing and also shared micro mobility. This is because a transformative effect is needed and can be achieved by having access to mobility in the future and by converging shared mobility, electrification and also automation. According to Mire (2019), this type of evolution will benefit both service provider and customers in terms of overall reduced cost, tend to be more efficient, human driven and convenient. On the other hand, Reina (2019) has supported the previous statement by describing the involvement of electronic vehicles (EV) which provides a pollution free solution when it comes to transporting people and goods around the globe. With technological advancements, it might be possible to even integrate secure systems with EV's, creating a fully automated vehicle without human intervention.

2.3 Similar Systems

1) GrabCar

Grab is a transportation network-based organization that is also known as GrabTaxi and MyTeksi founded by Anthony Tan in 2012. The organization began as a taxi-booking application that aims to assist drivers and rider by providing bookings for vehicles such as cars, bicycles and shuttle buses (Ho, 2018). To boost the organization's growth and to establish a unique standing in the market, Grab innovates and creates a lot of unique services for users such as GrabPay and GrabFood. Fundamentally, the Grab application allocates taxis and cars to nearest passengers via location-sharing system. The organization recently added useful feature into the application which allows users to cancel booking before driver is assigned to them. Moreover, users are also able to alter destinations while they are in transit with the use of the application (Philstar.com, 2019). Grab application can be downloaded for free and is compatible for both Android and iOS. The following table briefly exhibits the core advantages and disadvantages of GrabCar application in terms of user experience and usability.

Advantages	Disadvantages
Cheaper	Slower Response time-
Many vehicle options	No further reply to questions
Secure Credit Card Payment	Occasional unavailability of drivers especially late night or during peak hours
Helps with Language Barrier	Fare rate varies according to time and occasion
Greater consistency	Not available in suburban areas (For example: Kelantan and West Malaysia)
Free Rides at certain times (During promotion period)	-

Table 2 Advantages and Disadvantages of GrabCar

2) SOCAR

On the other hand, SOCAR Malaysia is a portable vehicle sharing system founded by Leon Foong. SOCAR technology company enables customers to make momentary rental bookings and share the vehicles with others. The strategy of this technology is to ensure convenience for individuals as well as reducing impact to environment by allowing larger quantity of drivers to share cars. The application platform permits customers to book and rent vehicle according to hour, day or week that has 100 pick-up points in Kuala Lumpur. The SOCAR zones for customers to pick-up cars are shopping malls, LRT or MRT stations and car is unlocked by customers using the application in their mobile. To add on flexibility, the SOCAR vehicle can be provided to customers at desired pick-up points and drop-off location according to their preferences (Chan, 2018). SOCAR application is compatible for both iOS and Android that is free of download in App Store and Play Store. The following table clearly explains the advantages and limitations that can be found in SOCAR mobile application.

Advantages	Disadvantages
Cheaper than Grab (charged on per hour rate, days or months)	There have been several bugs on the applications
Can drive to multiple destinations back and forth	Poor customer service at times
No hassle as of waiting for a grab driver	No proper or reliable back-up system in case of an emergency.
Can have an experience on being in a luxury car through renting	Only available in highly populated areas
Absolutely no paperwork required to rent the car	-
Environmental-friendly, Number of cars on the road can be greatly reduced if a lot of people start going for car sharing opportunities like SOCAR.	-

Table 3: Advantages and Disadvantages of SOCAR

3) RYDE

Ryde is a carpool application, which was founded by a Singaporean named Terence Zou in 2015. It was initially established in Singapore as the most popular carpool mobile app before launching in Malaysia on 2019. The app's main objective is to create a community that favours carpooling as the preferred mode of transportation which may save costs and maintain the eco-friendly environment (Tan, 2019). The app started off with RydePOOL which provides carpooling service. Later in 2018, Ryde introduced RydeX in Singapore that offered a service which was similar to what Grab was offering; thus, people were comparing between the two services to choose from (Dayangku, 2019). To avoid competing against Grab which happened to be the ride-hailing giant in Malaysia, Ryde has decided to only launch RydePOOL and RydePET (carpooling with pet-friendly support) services for now. Unlike the regular e-hailing services where the driver has no initial intention to travel to the customer's drop-off point, RydePOOL works as a carpooling service where the driver has already planned for a trip along the drop-off point of the Ryde app user.

Advantages	Disadvantages
Cheaper than ride-hailing due to splitting of cost (e.g. fuel, toll, car depreciation cost, etc.)	Some passengers may feel uncomfortable to travel with another passenger
Able to select the number of passengers manually while booking	Slower response times during off-peak hours
Ability to book in advance (from 3 minutes to 7 days)	Only available in Klang Valley for now
Ability to set the usual departing time from home or work to ease the process of searching for a commute	Less number of drivers as it is still new to the Malaysian market
No commission taken from the drivers	-
Ability to send private request to favourite drivers from past trips	-

Table 4: Advantages and Disadvantages of RYDE

Adoption from Similar Systems

Since Grab and SOCAR are running successfully in the market, a lot of beneficial features can be adopted from those applications during the development of the proposed carpooling system. Grab application incorporates a messaging feature called GrabChat in which templated messages can be translated automatically. For instance, if a message is sent in Myanmar Language, the application instantly translates the message to English based on users' preferences, leaving no space for language barriers. Taking this into consideration, Easy Ride should be developed with the integration of language translation functions to reduce language barriers among Malaysians. Moreover, design ideas for the proposed carpooling application can be derived from RYDE as it integrates clean and user-friendly interfaces with less images. Moreover, in RYDE, the users are required to upload a picture of themselves, holding their Identification Card during the registration process. This provides more secure and reliable authentication platform within the application. Therefore, the proposed carpooling application should also be developed in a way it can verify users' Identification Card for registration purposes. On the other hand, there is a unique thing about SOCAR which might captivate the attention of all the travellers. Users are not required to have a key to drive the car as all the fundamental functions are integrated within the application itself, providing users with seamless experience. This fascinating feature can be considered for the proposed carpooling application after analysing the possible security threats.

2.4 Critical Analysis

Although every transportation-based application has different objectives to meet, an ordinary consumer would expect to perform various actions all within the same app without having to install or switch between different applications. For example, a consumer who prefers to use both ride-hailing service and vehicle rental booking service depending on convenience has to have both the applications installed in their mobile device, which may consume a noticeable amount of storage. Although this may just be one of the first-world problems, such small inconvenience may affect the lives of other people in terms of productivity and efficiency. By integrating all types of transportation services into a single application, it is possible to make significant changes in everyone's daily lives. For instance, consumer to choose between different services can be quicker, managing the overall business can be easier, benefit of minimized monopoly for consumers and more as such.

2.5 Summary

In a nutshell, a comprehensive research was conducted using literature from relevant journals in order to gain some in-depth insights on the domain factors that drive for the need of a digitalized carpooling mobile application. Findings from previous researchers have helped to comprehend the current transportation problems in Malaysia. This discussion evidently highlighted the factors that cause dissatisfaction and frustration among Malaysians in the aspect of transportation and travelling. Moreover, a research on the similar systems is conducted to provide some information on the functionalities and features of the system. These comparisons also help the researcher to understand how the systems capture the attention and fulfil the requirements of end-users. Moreover, this literature review also helps the researcher to understand what are the elements that need to be avoided during the development phase in order to maintain customer satisfaction.

3 Technical Research

3.1 Application chosen

Mobile applications come in different types and diversities to accommodate different needs and requirements of the users. Three different types of mobile application are chosen and further compared as shown in the table below.

Web Application	Native Application	Hybrid Application
Can be accessed from a web browser over the Internet	Specifically developed for a single platform.	Are built with the use of web technologies such as CSS, JavaScript and HTML.
Most of the web applications are developed with the use of HTML5, CSS3 and JavaScript	Native IOS applications are usually developed with Objective-C or Swift while native Android applications are developed with Java or Kotlin.	Native plugins are needed to use the native features of the user's device such as microphone and camera
There is a wide range of templates and framework for developing web applications such as Angular and React	Capable of communicating with all the features of user's device such as camera, microphone and image storage	Hybrid applications can be developed for any platform with the use of only one repository or codebase.
Limited access to the device's native hardware.	Considered to be the most reliable and fastest platform for better user experience	Provides users with the same and consistent experience even though if the user wishes to use another device.
Incurs tremendous costs of support and maintenance among different mobile platforms.	Developing a native application is quite intense because the developers have to build and support different codebase for different platforms.	Entirely relies on various dependencies and frameworks such as Ionic and Cordova.

The quality standards of web applications are not controlled by any specific regulatory authority.	Comprises its own development tools and software development kits.	Can be scaled to a new platform with very minimal efforts.
--	--	--

Table 5: Comparison between Web, Native and Hybrid Applications (Saccomani, 2019)

Chosen Application with Justification

After evaluating the core compatibilities and characteristics, the researcher has decided to develop a native carpooling mobile application. This is because applications that are written in native code are much more fast and powerful than the applications that are written in HTML and JavaScript. Native applications can easily access the native features of the device without the need of dealing with plugin complexities. Moreover, native applications come with its own set of development tools and software development kits which make the overall development process more efficient and systematic. Unlike hybrid applications which have to be dependent on several open source platforms and libraries, native applications can be developed independently without any platform restrictions. The native application was chosen to be developed for Android instead of iOS as the survey done by the developer proves that majority of the people are using Android-based mobile devices; hence, it will be easier to make improvements based on feedbacks gained from many users. However, developing a native application for iOS devices would be taken into consideration for future enhancements. Moreover, since this carpooling mobile application needs the support from third party libraries such as RxJava and Retrofit, it requires a unique codebase which provides high-quality usability and performance (Clear Bridge Mobile, 2019). Other than that, if the proposed system is built as a native application, it can be tested and deployed quicker compared to web and hybrid applications. These strong justifications have made the researcher to develop the carpooling system as a native application.

3.2 Programming Language chosen

3.2.1 Front-End

Since the proposed carpooling mobile application will be developed as an android application, the feasible and suggested front-end languages are Java, Kotlin and C++. These three languages are further compared and evaluated as shown in the table below.

Java	Kotlin	C++
It is said to be the official and the most popular language of Android development.	Considered to be a modern programming language with static supports	Multi-paradigm, compiled and general-purpose
Object-oriented programming language	Interoperable with Java. This means it provides Kotlin developers with full access over Java frameworks, resources and libraries	Robust, systematic and general-purpose programming language that derived from C
Multi-threading capabilities are integrated in Java which means multiple processes can be run simultaneously	There are some familiar syntax and object-oriented concepts integrated in Kotlin. Therefore, developers can learn this language within a short period of time	Helps the processes to directly interact with the internal components of a device
It is considered to be robust, fast and reliable	Kotlin executes via the Java Virtual Machine	It is classified as a statically typed platform, thus, there is no assumption made on the type of data. This significantly helps the compiler to recognize the errors and bugs before the program executes.

Very limited security threats as the scope of the language is within Java Virtual Machine	. Helps the developers to create a more streamlined system	Comprises effective algorithms which can be widely utilized by developers.
Abundant online resources and it is supported by a huge community	Supports lambda functions recursions, higher-order functions and extended generics.	-

Table 6: : Comparisons of Front-End Programming Languages (Android Authority, 2019)

Chosen Front-End Language with Justification

After much deliberations and considerations, Java is chosen to be the most suitable front-end programming language to develop the proposed carpooling mobile application. This is because Java is a portable programming language which incorporates object-oriented paradigms to make the overall application more structured and organised. Moreover, Java comprises a wide variety of classes and frameworks for I/O operations, memory management and networking. The developer can leverage all these frameworks and optimize the functions of the proposed carpooling mobile application. On the other hand, due to the fact that Java operates within a Virtual Machine, there is no necessity to recompile the application for every phone, thus security can be preserved. Java should be chosen for this project because it offers a greater flexibility and scalability (Quora, 2017). The developer can make use of the built-in Java components to scale the application based on the changing user requirements and needs. With strong performance and enhanced features, Java can provide a stable and reliable medium for the application to run while delivering extensive benefits.

3.2.2 Back-End

Back-end programming language provides a significant support to developers to create algorithms and logical components of an application. Three different back-end programming languages are chosen and further evaluated as shown in the table below

Python	Node.js	Ruby on Rails
Famous programming language widely used for server-side web development and scripting.	Cross-platform and open-source environment for JavaScript	Framework that supports server-side web and mobile applications
Can be run on multifarious platforms such as Windows, Linux and Mac	Offers a group of asynchronous I/O primitives via its standardized library	Extracts and facilitates all the similar repetitive functionalities and tasks.
Allows developers to write codes with relatively fewer lines compared to other programming languages.	Provides flexibility for the developer to manage thousands of concurrent connections with only one server	Encompasses a group of conventions which hasten the development phase. Therefore, the developers are not required to spend time on configurations.
Extensively used to manage big data and execute convoluted mathematics.	Node.js provides robust technology stack. This means that developers that have trained in frontend JavaScript can start programming the server side through Node.js with minimum effort.	Places greater emphasis on the application design and a logical structure is presented within the application. The application can be easily exposed as an Application Programming Interface.
Can serve the functions of both procedural and object-oriented concepts.	Node.js is capable of adding, deleting, modifying data in the database.	Suitable for Rapid Application Development (RAD) methodology as it makes it easier to adapt to changes.

Comprises dictionary data structures that serve improved process control capabilities.	Provides a memory efficient environment through a single-threaded programming.	Contains effective testing frameworks to prevent bugs and errors.
--	--	---

Table 7: Comparisons between Python, Node.js and Ruby on Rails (Zakhar Yung, 2018)

Chosen Back-End Language with Justifications

After evaluating the advantages and key features, Node.js has been chosen to be the most compatible back-end programming language for the proposed carpooling mobile application. Node.js provides a full stack JavaScript development for event-based back-end application. This means it supports enhanced productivity and performance, code sharing and delivers a set of free development tools. Since Node.js is primarily made for applications with I/O access, it is very much suitable for the proposed system which requires frequent reading and writing operations. Being the simplest application framework, it emphasizes on the preferences of developers without the need of having a learning curve. In addition, it also provides a robust routed API which allows the development of REST API and routes for simple applications (Monterail, 2018). Moreover, Node.js includes a package manager called NPM in which the developer can explore hundreds of useful tools which can broaden the ecosystem of Node.js. Besides that, Node.js is regularly updated with security patches and optimization features which can support the modern JavaScript capabilities.

3.3 Interactive Development Environment (IDE) chosen

Integrated Development Environment (IDE) can be elucidated as a software suite that encompasses primary tools needed to develop a software. Since the proposed application is segregated into front-end and back-end development, two different IDEs are used throughout the project. Android Studio is used to develop the Front-End whereas Visual Studio Code is used to develop the Back-End.

Interactive Development Environment	Explanation
Front-End	
Android Studio	Android Studio offers an effective and fully integrated medium to develop applications that run on Android devices. It incorporates a sophisticated visual layout editor in which the developer can design complex layouts for the proposed application. Moreover, Android Studio also comprises an APK analyser that helps the developer to shrink the overall size of the Android application by analysing the internal DEX files and manifest files. Besides that, there is an enhanced emulator which allows the developer to execute the applications in a simulation-based environment which includes distinct configurations. On the other hand, Android Studio also provides an intelligent code editor for developers to write code in a much more systematic and productive manner. Being supported by Gradle, different build variants can be generated in Android Studio to provide support to different Android devices. There are built-in profiling tools that display the statistics of the application's CPU, network activities and memory (Android Studio, 2019).

Table 8: Chosen IDE for Front End

Back-End	
Visual Studio Code	Visual Studio Code can be described as a robust and lightweight source code editor that can run on Linux, MacOS and Windows. It incorporates built-in support for Node.js, TypeScript and JavaScript and even provides support for other languages such as C++, C#, Java and Python. Other than that, Visual Studio Code comes with IntelliSense that offers code modification features such as automatic code completion with the reference of variable types and parameter information. The written code can be debugged directly with the use of break points and interactive console. It provides built-in version control features such as staging file, making commits and reviewing past codes. Moreover, Visual Studio Code is extensively customizable in which the developers are able to include new languages, debuggers and themes based on their preferences and needs. These extensions are executed as distinct processes to maintain the optimization and processing speed (Visual Studio Code, 2019).

Table 9: Chosen IDE for Back-End

3.4 Libraries or Tools Chosen

As explained in the table below, there are several libraries and tools have been proposed for the development of the system.

Tools/ Libraries	Justifications
RxJava	RxJava is a robust implementation of Java VM that includes Reactive Extensions (a complete library for creating asynchronous and event-based functions with the use of observable sequences). It comes with a strong programming dimension to maintain a proper sequence of data and events (Akarnkd, 2016). RxJava made the operations of filtering and retrieving information from database a lot easier with Observables. This library also provides a strong compatibility to use method references and lambda expressions (Luis Pereira, 2016).
Retrofit	Retrofit can be described as a REST Client which particularly servers for Android and Java based applications. With the use of Retrofit, developers are able to extract and save structured data such as JSON via a REST webservice. Retrofit makes use of HTTP clients such as OkHTTP to create and send HTTP requests. Moreover, it provides a strong support for data serialization in which the developers can configure what type of converters to be used. (Quora, 2017)

GoldFinger	<p>Goldfinger is an Android library that integrates and simplifies fingerprint authentication features. Besides supporting encryption and decryption, this library provides simple but powerful user verification via fingerprint scanning. This library includes two different methods. The first method is to examine if the user's device contains fingerprint hardware whereas the second method is to identify if the user has already enrolled his fingerprint into the device. However, Goldfinger does not store supports the functions or extensions of RX (Orxy, 2018).</p>
Google Maps	<p>Google Maps library will be used in the proposed carpooling mobile application for location tracking and navigation purposes. This library handles a lot of functions such as displaying map to users, downloading requested data and responding to map gestures. On the other hand, the developer can also make use of API calls to append markers and polygons to a standard map. These objects allow users to interact with the map while providing information about locations (Google Maps Platform, 2019).</p>

Table 10 : Tools and Libraries

3.5 Database Management System chosen

Database Management System (DBMS) can be elucidated as a software package that is designed to define, alter, extract and manage data in a database (Techopedia, 2019). Three different DBMS are chosen and further evaluated as shown in the table below.

Attributes	MongoDB	MySQL	PostgreSQL
Specification	Represents data as a collection of JSON document where MongoDB is considered as a NoSQL database.	Data in MySQL is represented in tables and rows.	It is considered as relational database management system. PostgreSQL is available in multiple languages
Uniqueness	<u>High Availability</u> With high availability, data can be recovered easily in the event of failure	<u>Low Maintenance</u> Only low-level maintenance is required to support the operations of MySQL	<u>Strong third-party support</u> PostgreSQL has advanced features where it can be used as a third-party tool for designing and managing the utilities of the system.
Differences	Developer is not required to refine the schema in order to use MongoDB	It requires the developers to define the tables and column before storing data in MySQL.	It can be considered as an active tool to improve the existing features of the system
Main Points	- Collection - Field - Document	-Table -Column -Row	- Table - Row - Column
Scaling	Horizontal	Vertical	Vertical

Key Features	<ul style="list-style-type: none"> -Embedded with data models support -Rich in query language support -Embedded with various storage engine support 	<ul style="list-style-type: none"> - Triggers -Replication support - SSL support -Unicode support 	<ul style="list-style-type: none"> - Triggers -Stored produces -Roles
Website	Mongodb.com	Mysql.com	Postgresql.org
Access methods	Supports all standards	Supports all standards	Supports all standards
Advantages	<ul style="list-style-type: none"> - MongoDB provides a fast reading speed - Ease on implementing environmental setup - Flexible database sharing 	<ul style="list-style-type: none"> -Easier utilization -Secure -Scalable and powerful 	<ul style="list-style-type: none"> - It is an open source of SQL standard compliant RDBMS - It is a strong third-party source - Extensible
Disadvantages	<ul style="list-style-type: none"> - Memory limitation - Limited data size 	<ul style="list-style-type: none"> - Reliability issues -Stagnated development 	<ul style="list-style-type: none"> - Less popularity - Weak performance - Poor hosting capabilities

Table 11: Comparison between MySQL, PostgreSQL and MongoDB (DB-Engines, 2019)

Chosen DBMS with Justifications

After extensive evaluations and comparisons, MongoDB has been chosen as the most suitable database management system for the proposed system. MongoDB is comparatively easier to use as it comprises less convoluted functions and tools. On the other hand, MongoDB is a NoSQL database which means it supports scalable model with huge transactions. In addition, MongoDB also helps the developer to create the proposed application faster, manage different types of data types, and handle information efficiently. Due to the fact that the documents of MongoDB can be mapped directly to latest object-oriented programming languages, software development is made easier. Besides that, MongoDB is so flexible as it can enlarge the database scheme based on the business requirements (MongoDB, 2019).

3.6 Operating System chosen

The chosen operating system for the proposed carpooling mobile application is Android. Android is a Linux-based operating system which was designed and developed by Open Handset Alliance (OHA) (Techopedia, 2019). It brings tremendous hardware and software capabilities which helps the developers to effectively build applications. There are no supports for the GNU libraries, and it does not emphasize on the native X Windows system. The Linux kernel serves as an abstraction between the hardware and software in the phone. With the use of android operating system, the core services such as security, memory management and network stack can be effectively integrated and managed. Software developers who want to create applications for the Android OS can download the. Android Software Development Kit (SDK) which comes with an interpreter, an emulator and libraries. Below are the some of the basic features that can be found in an Android device.

- ❖ Optimized 2D and 3D graphics, multimedia and GSM connectivity
- ❖ Bluetooth
- ❖ EDGE
- ❖ Wi-Fi
- ❖ SQLite
- ❖ Camera
- ❖ GPS
- ❖ Compass
- ❖ Accelerometer

3.7 Web Server chosen

Elastic Beanstalk has been chosen as the most suitable web server for the proposed application. Elastic Beanstalk is a compute service introduced by AWS targeting the developers to reduce their workload in managing and deploying applications which are uploaded by users to the AWS cloud. Elastic Beanstalk is able to deliver and handle the configuration for users while enabling developers to upload the application to the AWS cloud. The application that is delivered to users will be provided along with additional services such as auto-scaling, health monitoring, load balancing, and capacity provisioning. A creation of a local application would be required before using the Elastic Beanstalk, which can be developed using any platform (e.g. Node.js, PHP, Python, etc.). Once that is done, Elastic Beanstalk will be required in which an application should be created with an environment being able to allow users to upload their local application. Implementing Elastic Beanstalk for developing an application would be cost effective as there will be no cost involved separately for the service as users are only required to pay for the resources that are being used to run the application such as using Amazon S3 for storage purposes. At the same time, the overall cost may vary according to the size of the S3 bucket, number of EC2 instances and database instances configurations (Intellipaat, 2019). Moreover, due to the involvement of auto-scaling together with Elastic Beanstalk, it can automatically scale accordingly to the application's traffic intensity. Furthermore, Elastic Beanstalk also provides the flexibility to customize the configurations of services which have used for the application. For instance, users can configure the type of EC2 instance that is optimal for their application. In fact, users are able to change the settings accordingly if they choose to manually control certain services.

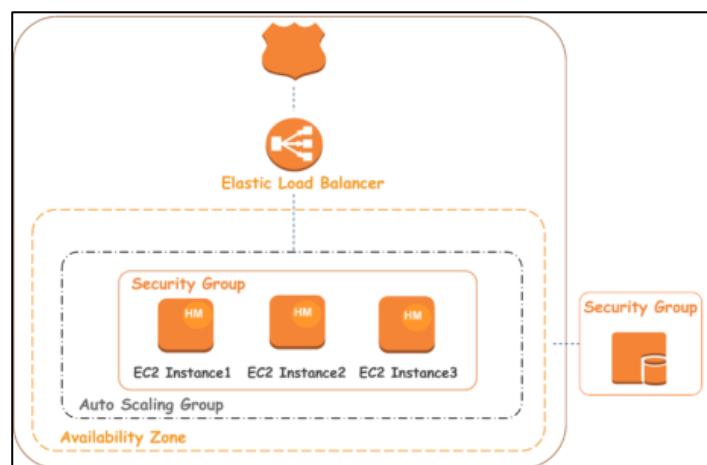


Figure 6: Architecture of Elastic Beanstalk (AWS, 2019)

3.8 Additional Services

3.8.1 Proguard

Proguard is an Android built-in service which helps to shrink, optimize and obfuscate Java class files. This service is used to identify and eliminate unutilised classes, objects, parameters and attributes. Moreover, this service is also used to analyse and optimize the bytecode of the methods used in the application. Generally, android applications can be easily reverse engineered by malicious users in the attempt of tampering the source code. In order to prevent this, Proguard can be used to rename the fields, objects and classes with obscure and meaningless names. This makes more difficult for malicious users to tamper the source code while making the codebase smaller and more organized (Performatix, 2019).

3.9 Summary

In a nutshell, a comprehensive research has been done to choose the most suitable technical resources for the overall development of the proposed application. The chosen programming languages, IDE, tools and libraries, DBMS, operating system and web server will enable the developer to have a better understanding on the complete workflow and the functions of the system. Moreover, this research also helps the developer to grasp some in-depth technical knowledge on the chosen tools and techniques before they can start developing the proposed application. Strong and constructive justifications are given for all the choices made in order to clarify why they are required for this project. It is undeniably true that choosing the right tools and platform is very significant for any project as it will enhance the efficiency and productivity of the developer.

4 System Development Methodology

4.1 Introduction

Before starting any software development project, the developer must first identify the most suitable system development methodology that can be used in the development cycle of the project. A system development methodology refers to a framework which is used in order to structure, plan, manage, control, execute and deploy a complete and functional information system (Cms.gov, 2005). Over the years, a wide variety of different system development methodology frameworks have been created to adapt and accommodate the various types of project specifications and requirements found in the various types of software development projects. Each variation of system development methodologies bares their own distinct strengths and weaknesses. For the developer to be able to best determine which of the system development methodologies are most suitable for the project some facts need to be taken into consideration. Factors such as the size of the organisation, the budget of the project and duration of the project needs to be analysed and considered when choosing the most suitable system development methodology framework. This is because each of the available methodologies are best suited to specific kinds of projects based on their technical, organisational, project and team requirements. The project team should evaluate, analyse and consider the benefits and drawbacks of each system development methodology to determine the most suitable methodology to be used for the project. For this project there are three different system development methodologies that have been compared among each other to determine the most suitable to be used for the development cycle of the project. The three development methodologies that are identified and explained in this chapter are waterfall model, Extreme Programming (XP) and Spiral Model.

4.2 Compare and Contrast

1) Waterfall Model

Waterfall Model methodology also known as Linear Sequential Life Cycle Model is one of the most traditional and commonly used types of system development methodology for software development projects (Guru99.com, n.d.). This methodology's life cycle model is usually considered to be a classic style of software development methodologies. The main concept behind this methodology is that the software development process of the waterfall model is a linear sequential flow. This means that, any phase in the development process can only begin when the earlier phase of the development process has been completed and there is no overlapping of phases in this methodology. Each phase must be completed before a new phase can begin. This methodology is best suited for software development projects which have a long development time and have a defined set of requirements (Tatvasoft.com, 2015). The table below shows the advantages and disadvantages of the waterfall model.

Advantages	Disadvantages
Less convoluted and convenient to use	This methodology is not recommended if the project requirements are not comprehensible,
Phases are completed one at a time which allows an efficient workflow	Unidirectional.
It suits for smaller projects where requirements are well understood.	Difficult in assessing risk management
Deliverables can be easily identified and understood.	Difficult in accommodating to changes once the process begins

Table 12 Advantages and Disadvantages of Waterfall Model

2) Extreme Programming

Extreme Programming or also known as XP is an agile software development methodology which was developed in the aims of producing better and improved quality software together with a better quality of life for the development team (Agile Alliance, 2018). Extreme programming is a software which was developed with the ability to adapt to the changing client requirements (Powell-Morse, 2017). This framework comprises effective programming or coding approaches which are usually most suitable to be used in large and complex software development projects. Since extreme programming is an agile software development methodology, agile principles play a key role in how this methodology is used. The programmers in the project team who are using extreme programming methodology for their software project are advised to focus more on process repetitions and requirement changes. Extreme programming methodology was developed in order to provide an iterative and small frequent release which is done throughout the project life cycle. This is done in order to allow both the team members of the project team and clients to be able to examine and scrutinize the progress of the project throughout the entire software development life cycle (Airbrake.io, 2018). By doing so, it allows the project team to be able to show the clients on what are the current progresses in the project, and it helps the client to be able to examine and have a better understanding on what is going on in the project. One of the main benefits of extreme programming methodology is that it is able to implement a conducive environment which increases the productivity and efficiency of the project team members with the aims of achieving the project's goals. Based on various studies that have been done on extreme programming methodology framework it is proven that XP is one of the most successful agile methodologies to be used in many different projects and corporations yielding great end results. The following table briefly describes the advantages and disadvantages of XP Programming.

Advantages	Disadvantages
Enhanced teamwork	Pair programming may cause duplications of source code and eventually leads to data redundancy
Assessing risks in a better way	Does not own a set of measurement plans
Encourages robust and simple source code	Absence of quality assurance for coding
Easy to accommodate changes	More code-centric than design.
Facilitates team's responsibility	High possibility for UI /UX issues.

Table 13: Advantages and Disadvantages of XP Programming

3) Spiral Model

Spiral Model is an agile software development methodology which incorporates a combination of linear and iterative framework. The spiral model is a sophisticated model which was created with the aim of focusing on earlier identification and reduction of project risk (Tatvasoft.com, 2015). The spiral model involves identifying, estimating and monitoring the technical feasibility and risk management of a project without overrunning the estimated project costing. There are four major phases in this spiral model. The first phase in this spiral model is evaluate alternative, identify, resolve risk. In this phase the project team will first start on a small scale exploring, identifying and analysing the risk which are associated and found in the project. Once that is done the team will then come out with resolutions in order to resolve the risk that were identified in the project. Once all the risk of the project has been identified then the second phase is development and validation phase. In this phase, the development process has begun and development for the project such as simulations, product design, requirements validations are all done in this phase. Once a functional part of the system is developed and completed the project team will then test and verify if the software is up to the standards of the client. The client will also help to test and verify the functionality of the software in this phase as well. Once everything has passed and been verified by both the project team and the clients then the project team will move into the next phase which is planning for the next phase. For this phase the project team will then gather the requirements and create a new development plan for the next phase. The deliverables of this phase are things such as a development plan, integration and testing plan etc. Finally, once all the 3 phases are done then the last phase is the determine objectives, alternatives and constraints. For this last phase the developed software is then reviewed in comparison with the objectives set for the project. The review process is done by both the project team and the client in order to determine if the developed software meets the required objectives. Table below clearly explains the core advantages and disadvantages of Spiral Model.

Advantages	Disadvantages
Highly recommended for large and risk-driven projects	The overall cost will be comparatively higher.
Earlier detection of errors	Experts are required to assess the risks and general assumptions of the project.
The overall expenditures of the project can be assessed frequently	A small mistake in any protocol can result in various repercussions
Allows the developers to implement prototype in any stage of the software development	Preparing the documentation can be tedious

Table 14: Advantages and Disadvantages of Spiral

After meticulously analysing the disadvantages and advantages of each methodology, the researcher has compared the core characteristics and attributes of the methodologies as shown in the table below.

Attributes/ Characteristics	Chosen Methodologies		
	Waterfall Model	Extreme Programming	Spiral
General Explanation	A classic approach that places huge emphasis on sequential development	Intended to enhance the program value and responsiveness to changing customer requirements.	A risk-driven framework for software projects.
Stages Involved	<ul style="list-style-type: none"> • Requirements Specification • Analysis • System Design • Implementation • Testing and Maintenance 	<ul style="list-style-type: none"> • Release Plan • Iteration Plan • Acceptance Test • Stand up Meeting • Pair Negotiation • Unit Test • Pair Programming • Code 	<ul style="list-style-type: none"> • Determine objectives • Identify risks • Development and test • Plan the next iteration
Cost	Relatively costs less compared to agile methodologies	Initial cost is low, but it may increase according to the changing requirements	Depends on the size of the projects
Speed of the Project	Comparatively slow	Very fast	Moderate

Necessity of documentations	A complete documentation is required before the initiation of the project.	Does not give much importance to documentations	Controlled documentation based on each phase. Objectives of the phases, solutions and prototype designs will be included in the documentation
Efficiency	Less efficient because it is difficult to be implemented for large projects	Efficient for small projects that focus on implementation	Efficient in managing risks and devising prototypes

Table 15: General Comparisons between Waterfall, Extreme Programming and Spiral

4.3 Chosen Methodology with Justification (XP Programming)

Based on the research that has been done above on all the different software development methodologies and after much considerations and deliberations, the developer has decided to choose **XP Programming** as the framework to develop the proposed carpooling mobile application. Due to the fact that the overall project duration is only three months and no budget is involved, the developer has proposed XP for the project development. Another reason that the developer has chosen to use XP programming is because of its versatility and ease of use. Although Waterfall and spiral models bring their own advantages, the team feels that XP's benefits highly fit the specification of this overall project. The following diagram briefly illustrates the workflow of XP Programming framework.

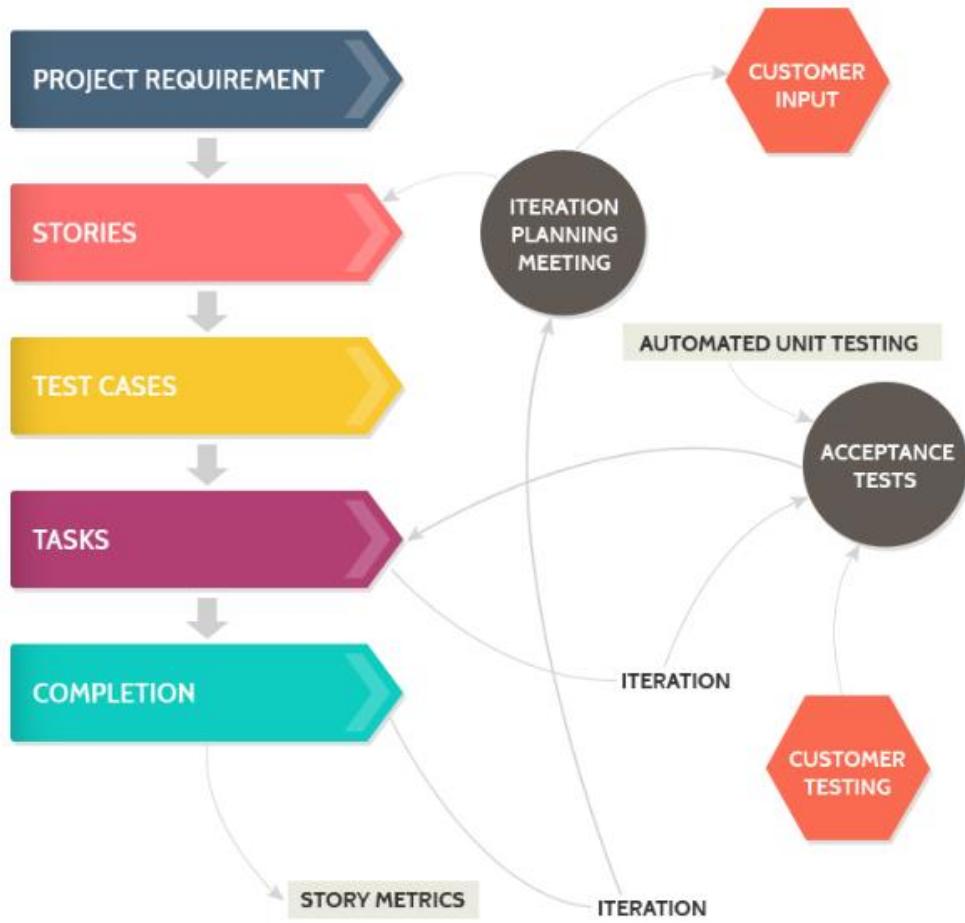


Figure 7 : Extreme Programming Methodology (Tatvasoft.com, 2015)

4.4 Characteristics of XP Programming

According to Don Wells, the fundamental values of XP come in five different diversities which are communication, simplicity, feedback, courage and respect. All the mentioned values have been further explained below.

1) Communication

It is undeniably true that all sort of software development frameworks completely relies on a communication aspect. In XP, communication needs to be constantly done among the development team and customers in order to fully comprehend the changing requirements and hasten the development process. XP stresses the importance of face-to-face communication and general meetings which can be a great platform to gather fascinating ideas for the project (Agile Alliance, 2018).

2) Simplicity

XP emphasises on the word ‘efficiency’ which means getting the most output with the least input. Instead of focusing all aspects, XP programmers only deal with the necessary things which the program requires. Besides saving a lot time, this approach can keep the design of the system as simple as possible so that it is easier to maintain and revise (Agile Alliance, 2018).

3) Feedback

Through constant “releases” in short development cycles, the developer will receive multiple feedbacks from customers on how to further refine and improve the system. With the feedbacks, the developer can identify the areas for improvement and devise new enhancements for the system (Agile Alliance, 2018).

4) Courage

Courage is the most fundamental aspect of Extreme Programming. This is because XP programmers have to be transparent and should disclose the progress and project estimations to the customers from time to time. On the other hand, pointless excuses should be completely avoided in this methodology because the customer wants the program to be deployed within the promised time frame. XP programmers have to be fearless in adapting to drastic changes throughout the development phase (Agile Alliance, 2018).

5) Respect

Establishing a positive relationship between team members is a must when it comes to XP methodology. All the members in the software development team should respect each other and foster a mutual understanding, so that a coordinated working environment can be achieved. Teamwork and brainstorming sessions are highly emphasised in this framework to identify and gather ideas on enthralling designs and solutions (Agile Alliance, 2018).

4.5 Phases of XP Programming

1) Planning

Release Planning

In general, the main purpose of having a release plan is to outline the *user stories*¹ that will be implemented for each system release. Release plan comprises a set of rules that permits everyone who is involved in the project to contribute their own ideas and make decisions. Since programmers play a prominent role in the development of Easy Ride, they are privileged to suggest some components which can be implemented. Distinct iterations must be analysed in advance before each iteration begins. The release planning of the proposed system can be categorised into four basic attributes which are resources, quality, scope and time. No one is authorised to govern any of the four attributes. If by any chance someone makes an amendment in one of those attributes, others will be affected too (Wells, 1999). The following diagram briefly illustrates the basic workflow of release plan diagram.

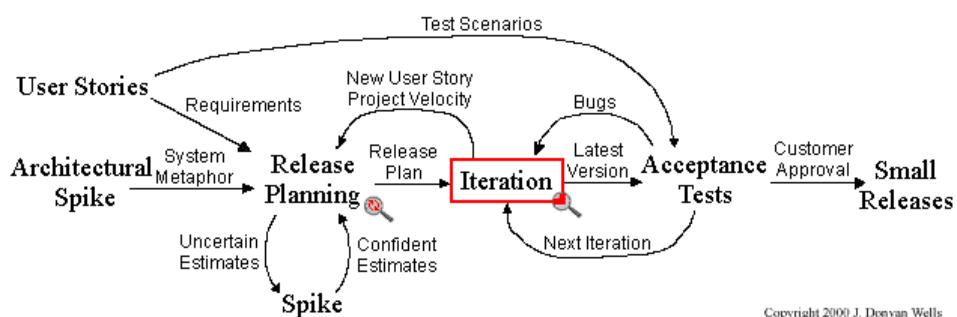


Figure 8: Workflow of release plan diagram (Wells, 1999)

¹ Tool in agile software development to capture a description of a software feature from an end-user perspective

Iteration Planning

The objective of having an iterative planning is to create iterative schemes for the project tasks. Customers have the rights to choose the user stories from the sequence of release plans. The chosen user stories are divided into distinct tasks which will be then executed accordingly by the programming team. If a programming task is difficult, the system developers of Easy Ride should estimate and propose a longer time for the respective task. The primary goal of conducting this meeting is to evaluate and stabilize the list of user stories that the developer is going to deliver in the near future (Bright Hub, 2018). The following diagram briefly describes the workflow of iteration planning.

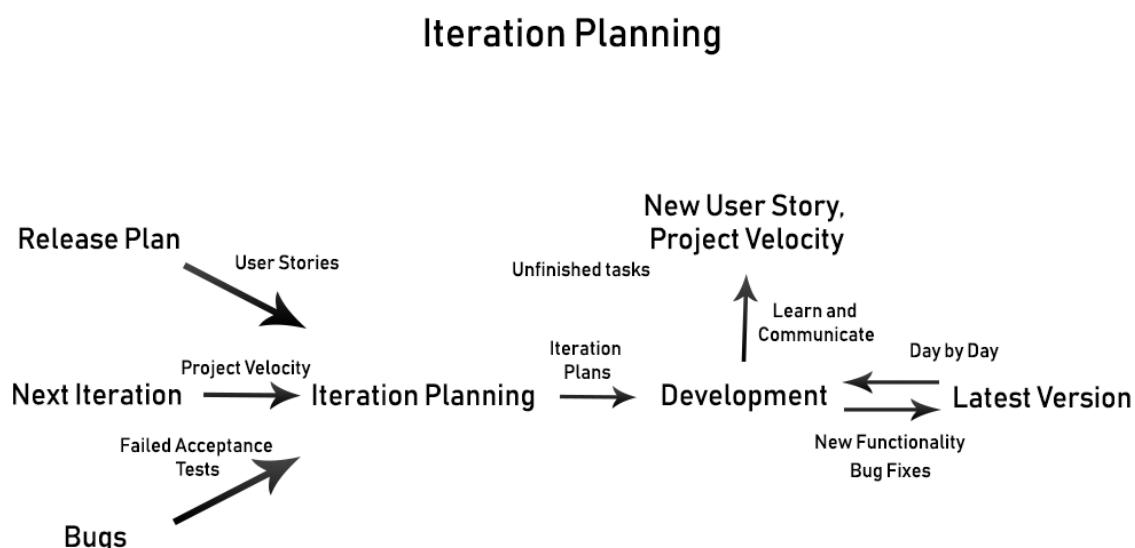


Figure 9: Workflow of iteration planning (Wells, 1999)

Stand-Up Meeting

The main purpose of having a stand-up meeting is to allow an effective communication flow among the entire team. Throughout the meeting, everyone involved in the project of Easy Ride can express their personal opinions and ideas on how to ameliorate the quality of the project.

The main questions that will be addressed during the stand-up meeting are:

- What have the team done since the last stand-up meeting?
- What will the team do before the next stand-up meeting?
- What are the problems that the team is currently facing?

In order to deliver an efficient system before the promised timeframe, the developer of Easy Ride should organise stand-up meetings regularly and share fascinating ideas.

2) Designing

An iteration of Extreme Programming begins with designing. Without a functional design, the developers will not be able to understand the mutual relationship between the data and system functionalities. Therefore, relevant logical and physical designs should be presented earlier before the actual implementation takes place. A good design helps the programmers to avoid dependencies which means changing one part of a program will not impact the other parts of the program. The following are some of the principles and guidelines that the developer should follow during the designing phase (Bright Hub, 2016).

- Avoid convoluted designs
- Place more importance on simplicity
- Use good naming convention for the entities and attributes
- Implement clear design patterns
- Make full use of object-oriented technology and explore potential solutions for a specific problem.

3) Implementation

This is where the actual implementation comes in. Programmers start to write code based on the user stories collected from release and iteration planning. A small change in the source code can bring a greater repercussion to the entire system, thus, high level of attention is required during this phase. It is undeniably true that a complete source code defines a complete program. Once the developer completes the coding without any error, a fully functional system can be deployed for the use of customers.

4) Testing

Acceptance Testing

Acceptance Testing can be defined as a testing technique used to decide whether or not the software meets the requirement specifications (Tutorialspoint, 2018). In other words, acceptance testing is carried out to test and evaluate each user story during the development phase. A user story can only be considered as complete if it passes acceptance test without any error. End-users of Easy Ride system are accountable to revise the validity of the acceptance tests and highlight the mistakes to the developers for further amendments. For instance, if a particular function of Easy Ride does not align with the end-user needs, the administrative staff should quickly report to the developer before he or she proceeds with further implementations.

Unit Testing

Unit testing can be classified as one of the most fundamental phases in Extreme Programming. In unit testing, all the individual components of a system are tested and verified for bugs and runtime errors. Generally, XP programmers practice test-driven development (TDD) which needs an intensive style of unit testing (SearchSoftwareQuality, 2018). Developer of Easy Ride should place a greater emphasis on unit testing and verify every single component of the system in order to eliminate unintentional errors. The following diagram briefly describes the processes within unit test.

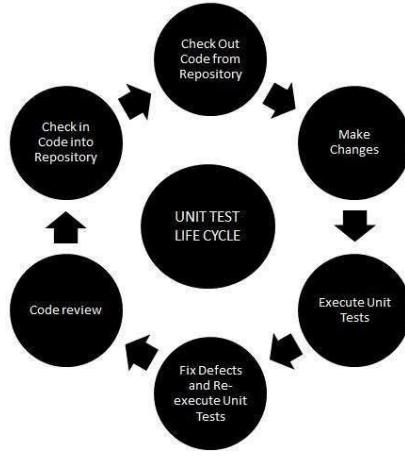


Figure 10 : Unit Test Life Cycle (Tutorials Point, 2018)

5) Listening

Listening and obtaining customer feedback is one of the fundamental mechanisms of Extreme Programming. After the program has been deployed, the developer is accountable to get feedback from both the project manager and end-users. The basis of feedback is the customer acceptance tests. If the customers are not satisfied with a particular function, their feedback will become the basis of new requirements and the process of design, implementation, test and listen repeats. In contrast, if the customers are satisfied with the function, the iteration ends there and the design for the new iteration starts. Taking this into consideration, the developer of Easy Ride should constantly ask for customer feedback and immediately make relevant changes if required.

5 Research Methods

5.1 Introduction

In conjunction with the secondary research carried out through literature review, a more in-depth and comprehensive primary research will be conducted to gather and analyse information from a range of different sources. Primarily, questionnaires and interviews have been chosen as the main data gathering methods to further refine the study.

In this project, questionnaires act as a medium in obtaining thorough insights and information on the proposed system from a pre-defined group of respondents. Due to the fact that the targeted respondents predominantly consist of working adults and students who are most probably busy with their own tasks and responsibilities, survey can be carried out by sending them questionnaires which is considered quick and more effective in terms of scalability. As questionnaires are flexible and allow a wider range of distributions via online, it is highly expected to receive immense and rapid response from both the respondents. On the other hand, conducting questionnaires are relatively cost-effective compared to other data gathering techniques such as focus groups and observation which incur unnecessary costs. With the aid of free online survey tools such as Google Forms and Survey Planet, questionnaire can be created and disseminated to the targeted respondents effortlessly without spending money (Explorable, 2017).

Apart from being inexpensive and flexible, the results gathered from the questionnaire would be easier to analyse as they mainly incorporate quantitative data rather than qualitative data. There are multifarious built-in features in online survey tools which enable the researcher to periodically analyse and visualise the results without a scientific research or manual interpretations. Furthermore, questionnaires are designed to maintain the respondents' anonymity. Since some respondents may not want to disclose their personal information when answering the questions, survey can be conducted as it allows for complete invisibility and a more private communication. This concealment brings the respondents to ease and encourage them to answer truthfully without having the fear that their personal information will be revealed to a third party. Moreover, survey can also be classified as a medium to gather and scrutinise user perspectives, preferences and expectations on a particular field of domain. Therefore, surveys are designed in a more standardized way, so that the respondents can be acquainted themselves with the questions. For instance, most of the surveys include Likert

scales which often use a rating from ‘strongly agree’ to ‘strongly disagree’, encouraging the respondents to understand the questions and provide close-ended responses.

On the other hand, interviews are described as qualitative data collection methods that are used to gain highly personalized data. They are conducted to obtain information from a relatively smaller group of respondents on a wider range of topics (University of Twente, 2018). The primary benefit of conducting interviews is to extract a full analysis and explanation of a specific research subject. Thus, it enables the researcher to gain some rigorous insights on the context of the subject without restricting its scope. Interviewers are able to observe the body language and face expressions of the interviewees and determine if they are excited or uncomfortable with certain types of questions. Even though one tries to falsify the answers during an interview, the interviewers can discern the validity of those answers. Moreover, the interviewers possess a greater control over the flow and scope of the interviews which allows them to conduct the interviews in a more structured and consistent manner (Madziwa, 2016). Despite the fact that conducting interviews require a lot of time in terms of gathering and analysing information, it allows the interviewers to have a better interpretation on the feedbacks and opinions given by the interviewees.

These robust justifications have made the researcher to choose questionnaire and interview as the best data gathering techniques to obtain some deep insights from both the respondents.

5.2 Design

A set of questionnaires with multiple questions required to gather information for the proposed system have been created. The questionnaire basically comprises multiple choices questions in order to facilitate the respondents to answer the questions without any difficulties. Minimal to no jargons have been used in the listed questions so that the respondents would not face any difficulties in understanding the question clearly and answer it accurately. Moreover, each question consists of their own objectives where these questions are being asked to help the researcher to understand the current scenario properly as well as the user requirement of the proposed system. Besides that, one set of interview question has been created by the researcher consisting several questions that are required for gathering relevant information. These interview questions were written up in order to prevent the interview from being dragged on for a longer period of time. In addition to that, most of the designed questions are straightforward and simple so that the interview does not become more time consuming.

5.2.1 Questionnaire

Proper planning on every single detail such as the sample size, targeted population, location and duration are extremely prominent to be considered and fixed upon carrying out any project. Based on the discussion, it was decided that the population for this questionnaire would be young adults who are more enthusiastic towards travelling in Malaysia. In addition to that, the targeted sample size to be collected for completing the analysis would be 110 respondents. A total of two weeks would be allocated to distribute the questionnaires. The questionnaires would be created as an online-based questionnaire in which Google Forms would be used to prepare it. Respondents would be asked to answer the prepared questionnaire through smart devices such as Smartphone or iPad given by the researcher rather than attempting to get responds in person. Beforehand, the respondents would be given a brief and concise explanation on the purpose of the questionnaire so that the respondents would have a better understanding on the importance of this data gathering, in hope that they would respond the questions with utmost honesty. Upon completion of data gathering, the results gained will be analysed using the Google Form tool where further evaluations will be done later.

Easy Ride - Secure Carpooling Mobile Application for Travellers

Dear respondents,

This survey is conducted as my final year research project, which shall be submitted as part of fulfillment of the Bachelor of Science (Honors) in Information Technology specialism in Information Systems Security from Asia Pacific University of Technology and Innovation.

The main objective of this survey is to gain an in-depth knowledge about users' perspective towards developing a secure mobile application which promotes the practice of carpooling among travellers in Malaysia. This system is aimed to establish a reliable and convenient platform for travellers to share journeys to their desired destinations.

Kindly answer all of the questions honestly and accurately as possible. All responses to this survey will be held in strictest of confidential and will be used for academic purposes only. The findings from this survey will be reported only in aggregated level and anonymity of individuals is guaranteed.

The survey will take less than 5 minutes. Your kind participation is very much appreciated. Should you have any queries regarding this questionnaire, do not hesitate to email me at
TP038521@mail.apu.edu.my.

Thank you for your cooperation and support.

Prepared by,
Kogilan Krishnansamy

NEXT

Easy Ride - Secure Carpooling Mobile Application for Travellers

* Required

Demographic Profile

Gender *

- Male
- Female

Age *

- 20 and below
- 21-25
- 26-35
- 36-45
- 46-55

Employment Status *

- Student
- Self-Employed
- Freelancer
- Employee
- Employer
- Other: _____

Mobile Operating System *

- Android
- iOS
- Other: _____

BACK

NEXT

Never submit passwords through Google Forms.

Respondents' Travelling Experience

What is your primary mode of transportation? *

Car

Bus / Train

Walk

Cycle

Other: _____

What are the factor(s) you would consider in travelling? *

Cost

Time

Ease

Other: _____

What is your average travel expenses per week to office or other places ? *

Less than RM100

RM100 to RM300

RM300 to RM500

More than RM500

Have you ever felt bored when travelling alone? *

Yes

No

How often do you encounter traffic congestion when travelling?

*

- 0-1 day in a week
- 2-3 days in a week
- 4-6 days in a week
- Everyday

Have you ever been late for a meeting or an event because of traffic congestion? *

- Yes
- No

Please rate how strongly you agree or disagree each of the following factors that lead to traffic congestion? *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
High number of cars on the road	<input type="radio"/>				
Sudden accidents	<input type="radio"/>				
Police roadblocks	<input type="radio"/>				
Reckless drivers who do not follow the traffic rules	<input type="radio"/>				

BACK

NEXT

Never submit passwords through Google Forms.

Respondents' Carpooling Experience

Have you ever involved in carpooling? *

- Yes
 - No

If you answered 'yes' for the previous question, how would you rate your carpooling experience?



Would you be interested to offer a ride to someone if he or she is willing to share the transportation costs? *

- Yes
 - No

On a scale of 1 to 5, how much do you agree or disagree that the practice of carpooling can reduce traffic congestion? *



On a scale of 1 to 5, how much do you agree or disagree that the practice of carpooling can reduce environmental pollution? *



BACK

NEXT

Never submit passwords through Google Forms.

Introduction to The Application

Do you think a seamless carpooling application to travel would be beneficial to you ? *

- Yes
- No
- Maybe

Personal Safety

From a security perspective, do you think that the car owners must be thoroughly verified before they can offer a ride to a passenger via the mobile application ? *

- Yes
- No
- Maybe

If you answered yes for the previous question, what type of verification method should be implemented in the application?

- Identification Card and License Verification
- Face Verification
- Car Plate Number Verification
- All the above

Payment

What do you think the most suitable pricing system for a shared journey via the mobile application? *

A fixed cost decided by the car owner

A cost per kilometer

Other: _____

What is your preferred payment method for the carpooling? *

Cash

Online Payment

Other: _____

Other Recommendations

Kindly suggest other recommendations that can be implemented in the proposed carpooling mobile application in order to serve the community better. *

Your answer

Thank you for participating in this survey.

[BACK](#)

[SUBMIT](#)

The Objectives of Questions

No	Questions	Objectives
Demographic Profile		
1	Gender	To determine the gender of the respondents.
2	Age	To determine the age of the respondents.
3	Employment Status	To determine the profession or position of the respondents.
4	Mobile Operating System	To determine the type of mobile operating system that is mostly used by the respondents.
Respondents' Travelling Experience		
5	What is your primary mode of transportation?	To find out how the respondents travel to other places in Malaysia.
6	What are the factor(s) you would consider in travelling?	To find out what are the factors that are being emphasized by respondents when travelling.
7	What are your average travel expenses per week to office or other places?	To find out the weekly costs that are spent by respondents for travelling purposes.
8	Have you ever felt bored when travelling alone?	To investigate the perception of respondents towards travelling alone.
9	How often do you encounter traffic congestion when travelling?	To find out how frequently the respondents experience traffic congestion when travelling to other places.
10	Please rate how strongly you agree or disagree each of the following factors that lead to traffic congestion?	To gather some information on how strongly the respondents agree or disagree on the mentioned factors that contribute to traffic congestion.
Respondents' Carpooling Experience		
11	Have you ever involved in carpooling?	To determine whether the respondents have travelled via carpooling before.

12	If you answered 'yes' for the previous question, how would you rate your carpooling experience?	To find out the level of respondents' interest towards carpooling.
13	Would you be interested to offer a ride to someone if he or she is willing to share the transportation costs?	To identify the respondents' perspective on offering ride to strangers with the agreement of sharing transportation costs.
14	On a scale of 1 to 5, how much do you agree or disagree that the practice of carpooling can reduce traffic congestion?	To gain some insights on the perception of respondents whether traffic congestion can be mitigated with the practice of carpooling.
15	On a scale of 1 to 5, how much do you agree or disagree that the practice of carpooling can reduce environmental pollution?	To gain some insights on the perception of respondents whether environmental pollution can be mitigated with the practice of carpooling.
Introduction to the Application		
16	Do you think a seamless carpooling application to travel would be beneficial to you?	To find out whether the respondents are interested towards a digitalized carpooling mobile application.
	Personal Safety	
17	From a security perspective, do you think that the car owners must be thoroughly verified before they can offer a ride to a passenger via the mobile application?	To find out whether the respondents would like to see a verification process in the proposed mobile application.
18	If you answered yes for the previous question, what type of verification method should be implemented in the application?	To determine the respondents' preferred verification method in the proposed mobile application.
	Payment	
19	What do you think the most suitable pricing system for a shared journey via the mobile application?	To determine the users' perception on how the overall travelling costs must be calculated within the application.

20	What is your preferred payment method for the carpooling?	To find out what type of payment method that the respondents would like to see in the proposed application.
Other Recommendations		
21	Kindly suggest other recommendations that can be implemented in the proposed carpooling mobile application in order to serve the community better.	To understand and analyse the suggestions that are recommended by the respondents which can be considered for implementation.

5.2.2 Interview

The target sample required for this data gathering would be a maximum of two security specialists. Initial contacts would be made by the researcher to those security specialists will be by emailing the interview questions to their general email. A brief and concise introduction on the purpose of the research would be properly explained to the respondents in order to provide a sense of trust where the option for the mode if interview is provided to the interviewee to choose from according to their convenience. Therefore, one set of interview questions were designed with 8 prominent questions for the respondents to answer while conducting the interview. Besides that, these questions would help the researcher to collect data on the possible threats and attacks that might be placed on a mobile application as well as the vulnerabilities that should be patched or prevented upon development. The entire interview process has a purpose of helping the researcher fully understand the security concerns of developing a mobile application. Hence, upon data collection, self-analysis would be conducted to scrutinise and evaluate the answers provided by the interviewees.

Interview (for security features)

Name of Interviewee:

Date and Time of Interview:

Location:

Position:

The main purpose of this interview session is to obtain some of your valuable insights on the security features that can be implemented in the proposed carpooling mobile application.

- 1) What are the common vulnerabilities and threats that can be found in mobile applications that are available in the market?

- 2) How important it is to protect customers' data from the reach of cyber criminals?

- 3) How to ensure that the users who registered in the system are trustworthy and legitimate?

- 4) Is two-factor authentication sufficient to secure the login and registration processes in the proposed system?

- 5) What type of encryption or hashing algorithm that can be used to cipher the data stored in the database?

- 6) What other security measures that can be considered during the development of the proposed system?

- 7) Since Amazon Web Services are planned to be used, is there any specific service that can be used to protect the application from unauthorised intrusion?

- 8) Is there any additional feature that can be implemented in the system to enhance user experience?

The Objectives of Interview Questions

No	Questions	Objectives
1	What are the common vulnerabilities and threats that can be found in mobile applications that are available in the market?	To find out the common cyberattacks that are currently threatening the mobile applications in the market and to find out what are the underlying factors behind these cyberattacks.
2	How important it is to protect customers' data from the reach of cyber criminals?	To determine why customers' data is so important for an organisation and why it needs to be protected.
3	How to ensure that the users who registered in the system are trustworthy and legitimate?	To find out what are the possible security measures that can be considered for the authentication of registered users.
4	Is two-factor authentication sufficient to secure the login and registration processes in the proposed system?	To have an in-depth understanding on interviewees' perception towards the reliability of two-factor authentication for the proposed system.
5	What type of encryption or hashing algorithm that can be used to cipher the data stored in the database?	To investigate and analyse the most feasible encryption or hashing algorithm for the proposed system.
6	What other security measures that can be considered during the development of the proposed system?	To obtain some strong suggestions from the interviewee on additional security features that can be proposed for the system.
7	Since Amazon Web Services are planned to be used, is there any specific service that can be used to protect the application from unauthorised intrusion?	To find out if there is any specific Amazon Web Services that can be used in the system development.

8	Is there any additional feature that can be implemented in the system to enhance user experience?	To understand and analyse the suggestions that are recommended by the interviewees which can be considered for implementation.
---	---	--

5.3 Summary

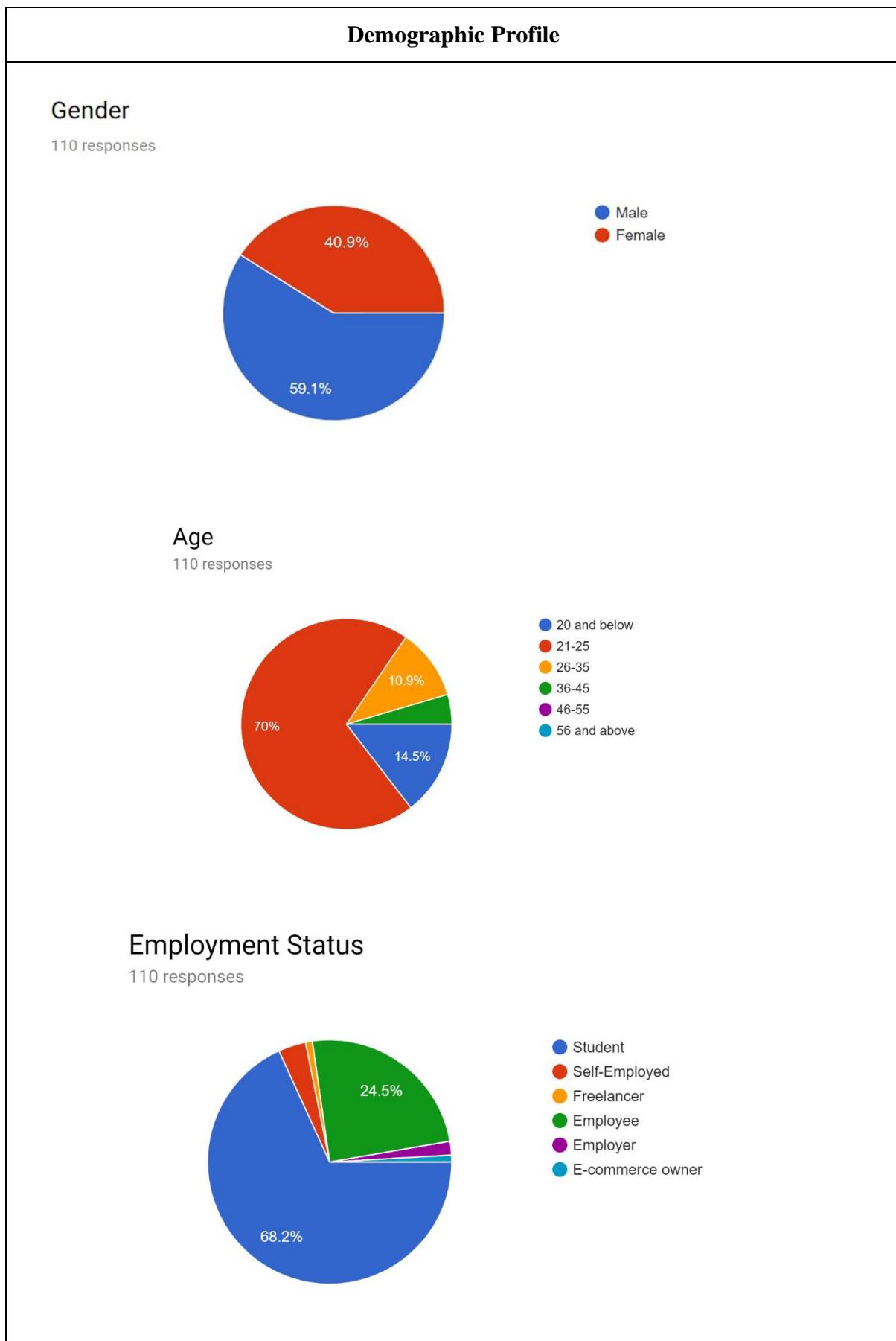
Taking into account the accessibility, ease, quality and cost-effectiveness of the instruments, the researcher has selected the questionnaire and interview techniques for data collection to perform the analysis successfully. Google Forms is used to build a questionnaire in which it allows the researcher to include both the information sheet, the consent form and the actual questionnaire in the same framework. The questionnaire was intended to be answered by 110 participants who are traveling in Malaysia through a mode of transportation. In addition to that, interview questions were designed in an attempt for the researcher to gather answers from up to two security specialist representatives available in Malaysia. The interview questions are all the about possible vulnerabilities and risks to be found in a mobile application, two-factor authentication, hashing algorithm, and the security countermeasures to be taken to prevent cyber-attacks on the proposed mobile application. Finally, before any data collection activities were carried out, the questions within the questionnaire and interview must be reviewed and approved by the supervisor of the researcher.

6 Requirement Validation

6.1 Analysis of data collected

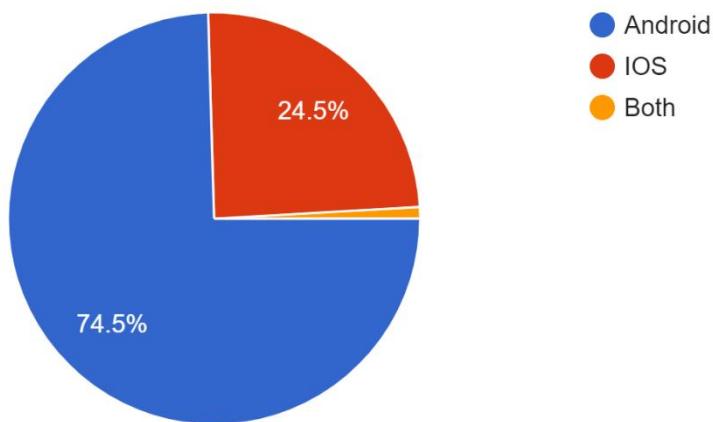
As mentioned earlier, an organised set of questionnaires was created and distributed to the target participants in order to obtain some sincere responses which can further refine the research. Upon successful distribution of questionnaires, the researcher has managed to collect responses from a total of 110 respondents within few days. After performing the initial study, it can be deduced that different respondents demonstrate different views towards the questions being asked. With the use of a survey management tool (Google Forms), the results of each question are effectively gathered and represented in graphical formats for an easier comprehension. The questionnaire results are generalized and further evaluated to understand the respondents' perception towards the proposed carpooling mobile application. On the other hand, the researcher has encountered some difficulties in disseminating the survey to individuals who are older than 45 years old. This problem was tackled by personally approaching few elderly people to obtain their insights on the proposed application. Moreover, the researcher has conducted interview with two security specialists to get some insights on the security features that can be implemented in the application. Both security specialists have provided detailed clarifications for the questions being asked and this makes the overall technical research much easier. The following section briefly discusses the analysis for the results gathered from the questionnaire and interview.

6.1.1 Analysis of data collected through questionnaire



Mobile Operating System

110 responses



Analysis for Section A

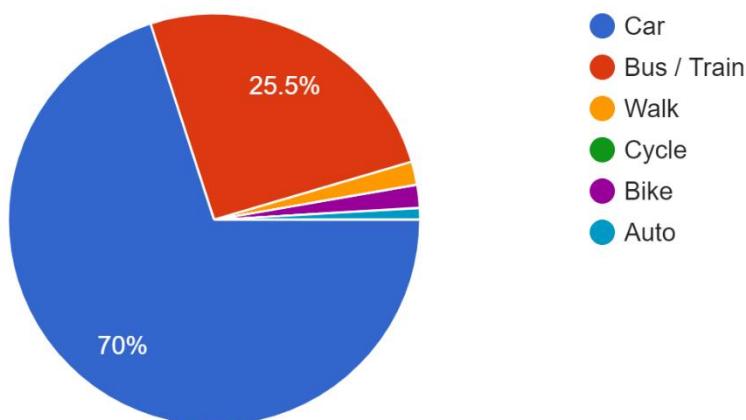
Approximately 85% of the respondents fall under the age of 25 and it clearly indicates that the respondents are predominantly youths. Young adults are particularly chosen as the target audience for this survey because they are more enthusiastic about travelling compared to elderly people. On the other hand, in the pie chart that is used to determine the employment status of respondents, students occupy the major proportion with almost 70% followed by employees with 24.5%. Students are required to attend classes in their respective educational institutions; thus, they have to travel almost every day. On the other hand, working adults have to visit their offices on a regular basis to accomplish their respective tasks. According to the pie chart which identifies the gender of the respondents, males are seen to be dominating than females. However, these results will not have huge impact in the overall research. Moreover, three-quarters of the respondents have stated that they are using mobile phones with Android

Operating System. With this, a generalization can be made to strongly justify that there are more Android users than IOS users in Malaysia. Therefore, it is strongly suggested for the developer to consider developing Android-based mobile application in order to reach a larger audience.

Respondents' Travelling Experience

What is your primary mode of transportation?

110 responses

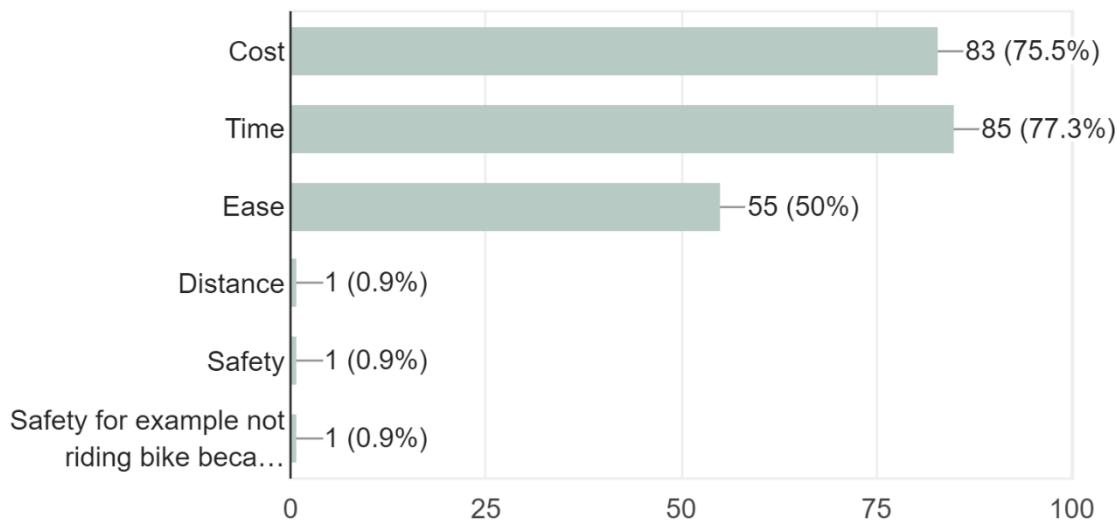


Analysis

According to the pie chart above, exactly 70% of the respondents have chosen car as their primary mode of transportation. It can be deduced that the respondents place greater importance on comfort and safety when it comes to transportation. This is because cars provide relatively comfortable environment for short journeys compared to other transportation modes. On the other hand, a smaller fraction of respondents have stated that they primarily use public transportation such as buses and trains for travelling. It can be assumed that these respondents either do not own a car or think public transportation serves their needs better.

What are the factor(s) you would consider in travelling?

110 responses

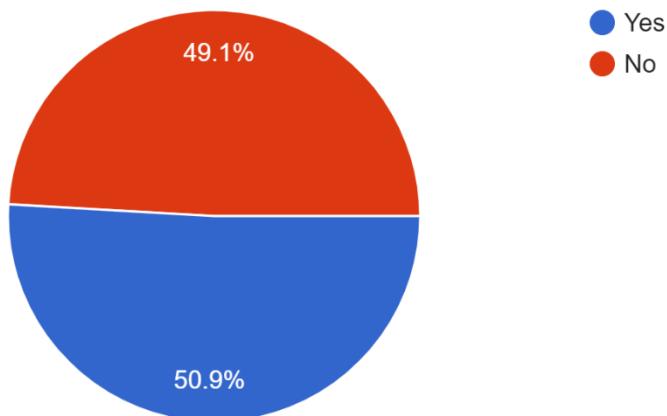


Analysis

The bar chart above evidently shows that the top factor that influences respondents' travel experience is cost. Individuals seek for cost-effective ways of travelling as they are not willing to spend too much money. On the other hand, time is also considered as one of the factors that affect the travel experience of respondents. They would like to reach their respective destinations within a short period of time. Moreover, exactly half of the respondents choose 'ease' as one of the factors that they would consider in travelling. The respondents wish to travel to other places effortlessly without any hindrance. Therefore, it is highly recommended for the developer to give importance to all the mentioned factors when designing the proposed application.

Have you ever felt bored when travelling alone?

110 responses

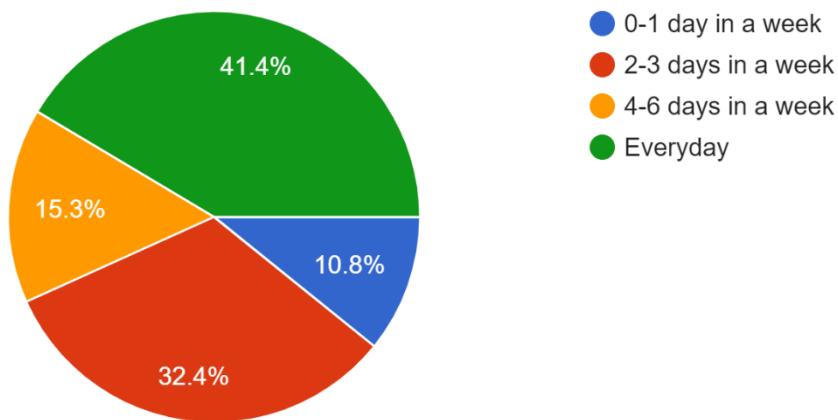


Analysis

Based on the gathered responses, about 50% of the respondents felt bored during their travelling period and almost 50% of the other respondents do not feel bored during the travel. This shows a mix of reactions and perspectives from different types of people when it comes to travelling alone.

How often do you encounter traffic congestion when travelling?

110 responses

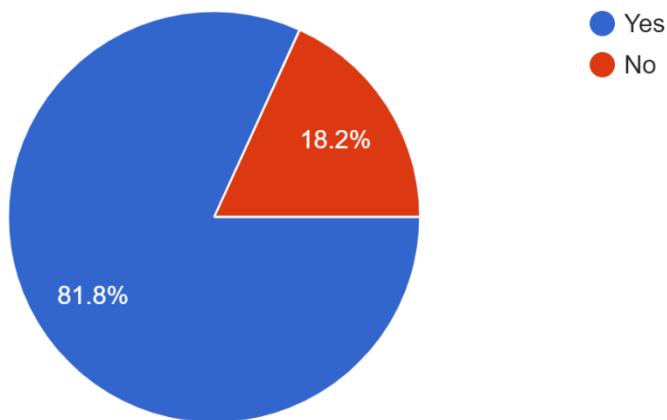


Analysis

The responses gained from distributing the questionnaires have shown that majority of the respondents encounter traffic congestion when travelling. 41.4% of respondents have said that they get stuck in traffic congestions every day. This shows that traffic congestions have impacted many people out there in the country.

Have you ever been late for a meeting or an event because of traffic congestion?

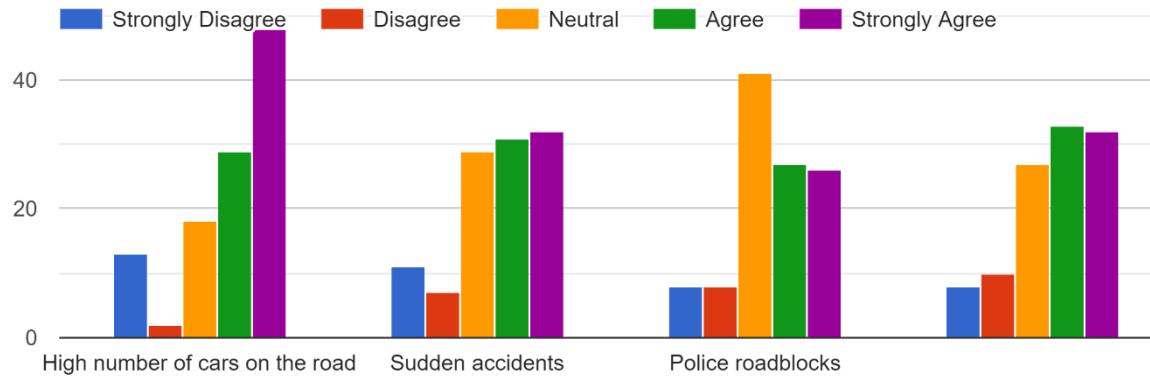
110 responses



Analysis

Based on the result of the responses shown above, it can be seen that majority of the respondents have been late for a meeting or an event due to traffic congestion. This has proven that people are getting affected from traffic congestions and a serious workaround or solution should be implemented in order to avoid such circumstances from occurring again in their daily life.

Please rate how strongly you agree or disagree each of the following factors that lead to traffic congestion?



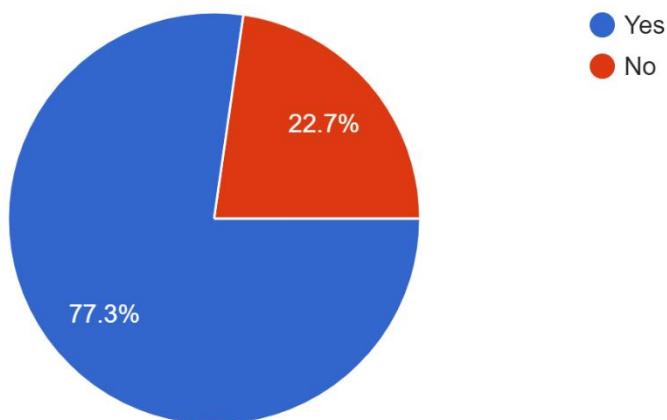
Analysis

Based on the given factors, most of the respondents have strongly agreed that high number of cars on the road are the main factor that leads to traffic congestions. Since this is being the primary factor towards traffic congestion, an impulsive solution could be produced through the introduction of the proposed mobile application as it leads towards reducing the number of cars on the road through carpooling. Hence, a proper response from the community could be expected towards the launch of the proposed application.

Respondents' Carpooling Experience

Have you ever involved in carpooling?

110 responses

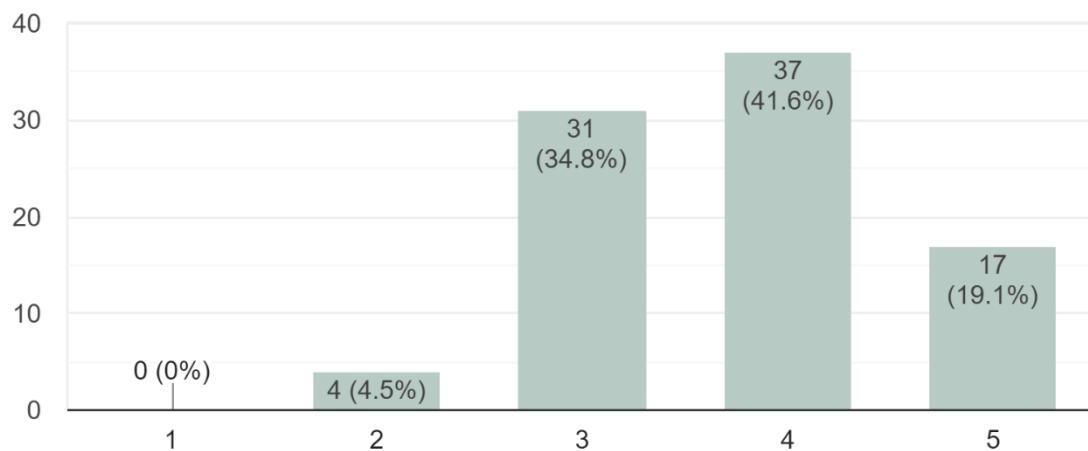


Analysis

Based on the results shown above, it can be seen that many respondents have been involved in carpooling before. Almost 80% of respondents have said "Yes" for this question where the researcher will be able to conclude that most people are aware of the carpooling concept and a proper solution would be needed to further enhance it.

If you answered 'yes' for the previous question, how would you rate your carpooling experience?

89 responses

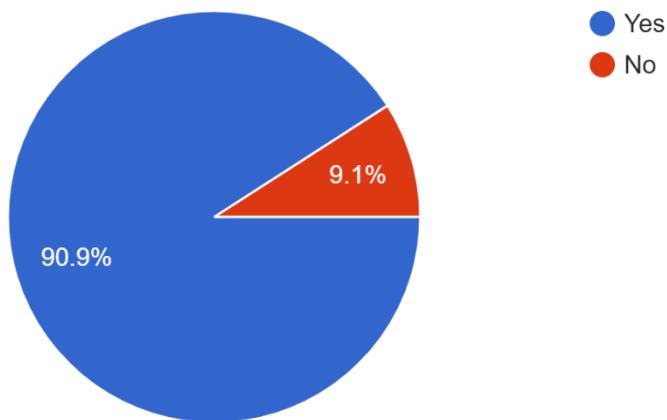


Analysis

Based on the responses given from the previous question, the researcher has gathered 89 responses from 110 respondents for this question where the respondents have been asked on their carpooling experience. 31 respondents have given a rating of 3 on their overall carpooling experience and 37 respondents have given a rating of 4 on their overall carpooling experience. This shows that the respondents have mixed experiences on carpooling which would definitely need to be refined in order to boost up their carpooling experience.

Would you be interested to offer a ride to someone if he or she is willing to share the transportation costs?

110 responses

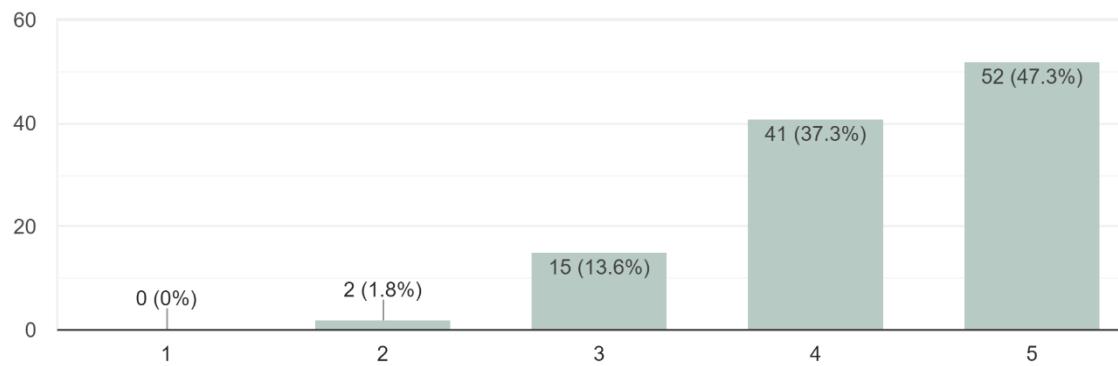


Analysis

Majority of the respondents have responded “Yes” for this question where the respondents are willing to offer a ride to someone if they are willing to share the transportation costs. This shows that the proposed idea would work well among the community as it mainly focuses on carpooling while sharing the overall expenses of a certain ride. In addition to that, this also shows that people are comfortable on providing ride to a total stranger.

On a scale of 1 to 5, how much do you agree or disagree that the practice of carpooling can reduce traffic congestion?

110 responses

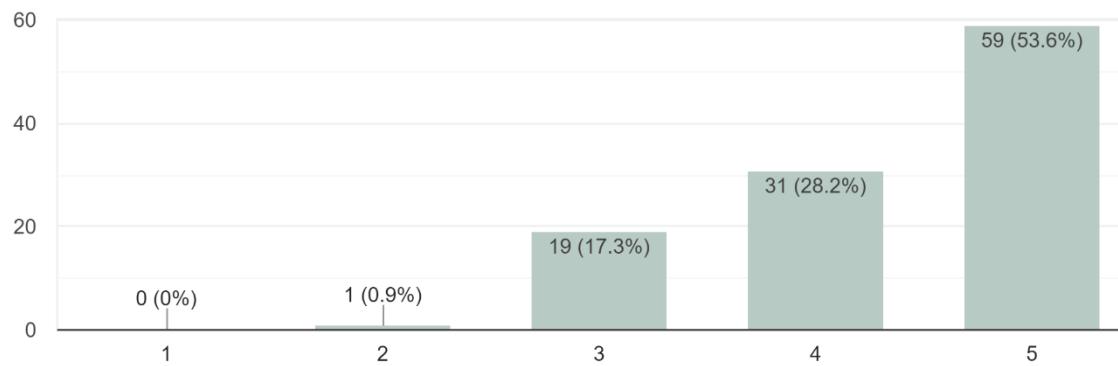


Analysis

Based on the responses gathered, most of the respondents have agreed that the practice of carpooling can help to reduce traffic congestions. This is because traffic congestion occurs mainly due to excessive number of cars being used by the travellers to a specific area. Hence, bringing in the concept of carpooling could reduce the number of cars used to travel to a specific place which in return would result in the decrease of traffic congestions.

On a scale of 1 to 5, how much do you agree or disagree that the practice of carpooling can reduce environmental pollution?

110 responses



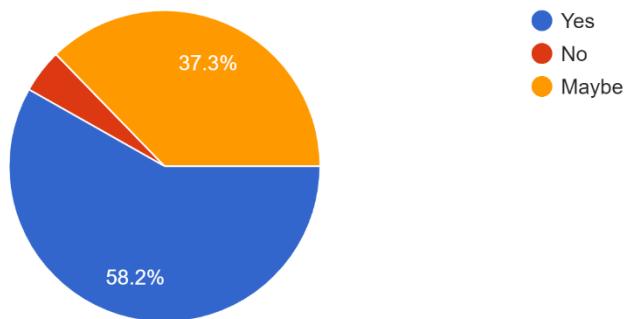
Analysis

Responses above shows that majority of the respondents agree that the practice of carpooling could reduce environmental pollution. Since environmental pollution has caused huge problems in a country like Malaysia, it is wise to come up with a solution which could contribute towards preventing or reducing environmental pollution which was mainly caused by the usage of motorized vehicles.

Introduction to The Application

Do you think a seamless carpooling application to travel would be beneficial to you ?

110 responses



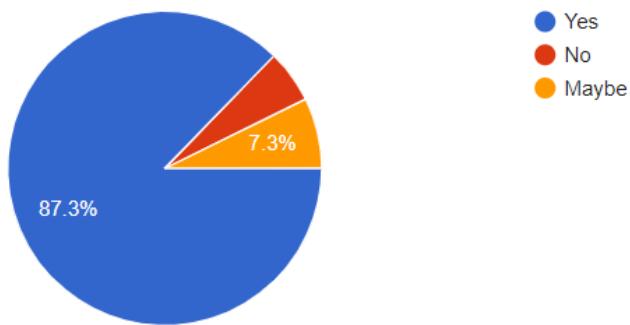
Analysis

Based on the pie chart above, about 60% of respondents have said that they would consider using a carpooling mobile application to travel. About 38% of respondents have responded "Maybe" for this question. This could be due to their past unpleasant experience towards carpooling which might need to be improvised to serve the community better. Hence, it could be said that developing this application will meet the demand of the consumers that are interested in carpooling.

Personal Safety

From a security perspective, do you think that the car owners must be thoroughly verified before they can offer a ride to a passenger via the mobile application ?

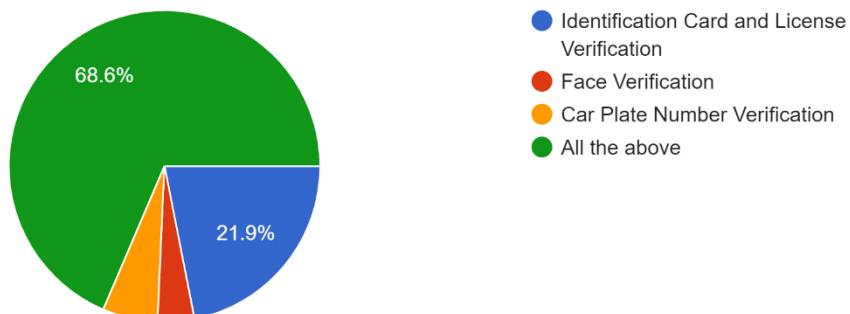
110 responses



Analysis	Based on the collected responses, it can be seen that most of the respondents would require the car owners to be verified before they could offer a ride to the passenger via the mobile application. Therefore, safety countermeasures are highly required to be implemented in the development of the mobile application in order to gain more trust from the consumers towards using the mobile application.
----------	---

If you answered yes for the previous question, what type of verification method should be implemented in the application?

105 responses



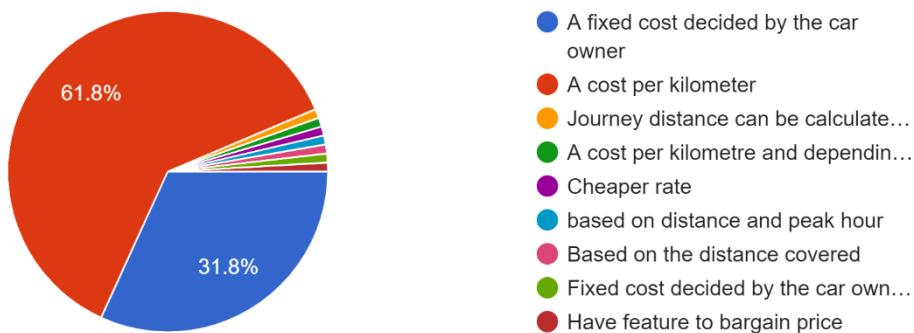
Analysis

Based on the results shown above, it can be seen that most of the respondents would prefer multiple verification such as identification card and licence verification, face verification and car plate verification for the car owners before offering a ride to the passengers. This shows that people are very much concerned on their safety while travelling with an unknown person.

Payment

What do you think the most suitable pricing system for a shared journey via the mobile application?

110 responses

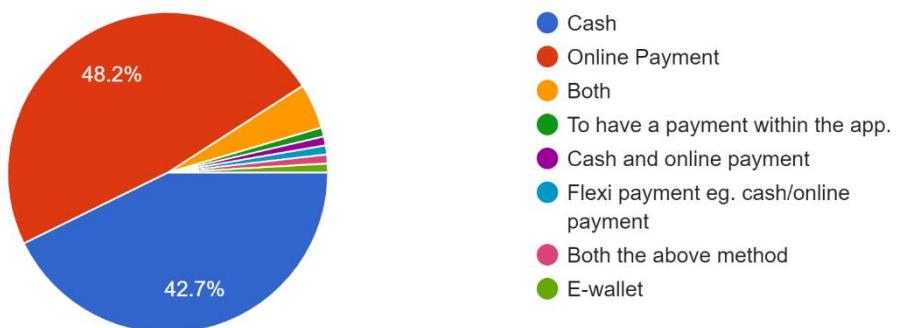


Analysis

Highest respondents of 61.8 % would prefer to charge the cost per kilometre for a shared journey via the mobile application. While 31.8 % of the respondents answered that they would pay a fixed cost decided by the car owner and other respondents have multiple suggestions like cheaper rate, distance and peak hour based, distance covered, price bargaining features and other relevant responses.

What is your preferred payment method for the carpooling?

110 responses



Analysis

Based on the results from the given questionnaires, some respondents prefer cash payment whereas some respondents prefer online payment. Hence, including both type of payments within the mobile application would serve the community better. This would definitely invoke interest from people who prefers different types of payment methods.

The following are some of the suggestions provided by the respondents which can further enhance proposed carpooling mobile application in terms or reliability and consistency.

- 1) Create the app with a feature where user can name and request for pickup from an unregistered place on the map
- 2) Fingerprint authentication for payment
- 3) Arrival time, distance, driver contact details and cancellation policy
- 4) Earn rewards to motivate users
- 5) It would be better with face verification, license identification and identification card.
Users would feel more secured
- 6) Only accept if both passengers accept
- 7) Security purposes must be taken into consideration
- 8) Chat features to let them the passengers negotiate the price
- 9) System specialised for ladies
- 10) Prevention of exorbitant charges. This being said then, the application has to have a system that would ideally say the average charge and the carpooling driver can play around with as well to prevent it from being too cheap or too expensive.
- 11) The application must activate user's live location for safety purpose and to avoid kidnapping
- 12) Maybe do a background check on the driver before he gets to drive for the carpooling service
- 13) Details of all passengers must be shown
- 14) The passengers should get to know who their companions are during the carpooling ride are to ensure the safety of them and others travelling with them throughout their journey
- 15) The cars involved in carpooling system to be equipped with dash cam and before every ride, the app should prompt for consent for recording if required
- 16) A tracking system must be integrated
- 17) Minimize detour ratio for passenger
- 18) Option to choose only female drivers/passengers for safety purposes
- 19) Rewarding system
- 20) GPS live tracking for enhanced safety
- 21) Pre-payment car pooling

22) A reservation feature that could allow future bookings for carpools
23) A safety verification of the driver and the passenger
24) The duration to reach the destination
25) Do consider the experience of the drive and background screening
26) Girls and guys that don't recognize each other should not carpool together after a certain time (Late nights). For safety purposes.
27) User friendly GUI
28) Do booking for carpooling before a day to avoid consequences on that specific day
29) Limit the radius/time of the driver allowed to pick up the passengers in order to provide a fast service which will not annoy the passengers by making them travel for a longer time before reaching to their respective destination.
30) Should have less update and shouldn't consume more space in mobile
31) Allow passengers to vote for songs played in car
32) Once the trip starts, a timer on the app keeps track of the trip distance and automatically pays the driver when the trip ends.
33) Easy to use.
34) A safety control button in the application
35) Higher security, emergency button in case of any emergency
36) You may use biometric identification for this application. For example, the user might update their personal information or bank account information in the app therefore, implementation of biometric identification will be more secured.
37) More priorities should be given on the payment method
38) Provides features such as sharing of driver's detail and current location to family or friends to ensure the safety of the passenger in case anything bad happens.
39) More payment method
40) Stop between route options to do some work done.
41) User friendly interface to be easily accessed by all age generations
42) Have a tracking system for location that can be shared to family for safety purposes
43) Security for the safety of people in the car
44) Better algorithm for matching the driver and the passenger
45) Thorough background check on the driver to make sure he has no prior history of crime
46) Allow advance booking/schedule

Introduce benefit plans: Discount will be given based on number of carpooling days or collaborate with other companies to provide vouchers
47) All the details of the driver must be submitted to the police so if there's any problem the police can use the details to detect that person.
48) An emergency button that directly dials to the close person or 911
49) -Favourite ride group feature (Assume that a user only prefers to go with a specific car owner by forming his/her own carpooling group members) Selection of route to be used(Assume that the system have saved the previous route that have been used to go to a specific location; maybe there might be several routes have been used to reach the same location; user able to select the route preference based on the safety and shortest time factors)
50) Able to negotiate the price
51) It would be better if it could work as a social site so the car poolers and passengers can know each other better and get along easily.
52) The option of choosing carpool gender for security and personal purposes. For example, female car owners can opt for only female riders, or female riders can only opt for female car owner and vice versa.

6.1.2 Analysis of data collected through interview

Interview 1

Name of Interviewee: Alhusna binti Osman

Date and Time of Interview: 1st October 2019

Location: Petronas ICT Sdn Bhd

Position: Security Operations Manager

The main purpose of this interview session is to obtain some of your valuable insights on the security features that can be implemented in the proposed carpooling mobile application.

1) What are the common vulnerabilities and threats that can be found in mobile applications that are available in the market?

- Lack of Transport Layer Protection
- Weak Authentication and Authorisation Methods
- Less emphasis on binary protections enable malicious hackers to reverse engineer the application code
- Poor encryption can lead to broken cryptography

2) How important it is to protect customers' data from the reach of cyber criminals?

Customers' data is considered as an important asset for an organisation. Cyber perpetrators constantly attempt to steal or modify organisations' data to fulfil their own needs. Therefore, adequate data protection needs to be implemented in the proposed application in order to prevent any cyber intrusion and to build trust among the customers.

3) How to ensure that the users who registered in the system are trustworthy and legitimate?

As mentioned in your questionnaire, verification processes must be integrated into the application. The personal entities of the registered drivers must be thoroughly verified by administrator before allowing them to offer ride to passengers.

- 4) Is two-factor authentication sufficient to secure the login and registration processes in the proposed system?

Yes. It is sufficient because it provides an extra layer of protection to verify the user credentials before they can access the system.

- 5) What type of encryption or hashing algorithm that can be used to cipher the data stored in the database?

Bcrypt Hashing can be used because it helps to create a platform for password security that supports high computation power.

- 6) What other security measures that can be considered during the development of the proposed system?

- Facial recognition feature can be considered for real-time verification of registered users

- 7) Since Amazon Web Services are planned to be used, is there any specific service that can be used to protect the application from unauthorised intrusion?

- AWS WAF can be used as a web application firewall to protect the back-end services from any sort of exploitation.

- 8) Is there any additional feature that can be implemented in the system to enhance user experience?

Limit the radius/time of the driver allowed to pick up the passengers in order to provide a fast service which will not annoy the passengers by making them travel for a longer time before reaching to their respective destination.

Analysis

Based on the interview done with the Security Operations Manager of Petronas ICT Sdn Bhd, it was learned that security has become one of the major concerns by the organization and they do not take this issue with a grain of salt. The company has gone to an extent where they have researched the common vulnerabilities found in mobile applications in detail. This shows their determination in studying further about the security vulnerabilities, that they could work on to prevent the system in their organization from being attacked. Moreover, the suggestion to include Bcrypt Hashing was taken into consideration to be implemented into this application, with the logical supporting statement that the interviewee gave along with it.

Interview 2

Name of Interviewee: Sarveen Kumaran

Date and Time of Interview: 2nd October 2019

Location: Nimbus Cloud Sdn Bhd

Position: Security Analyst

The main purpose of this interview session is to obtain some of your valuable insights on the security features that can be implemented in the proposed carpooling mobile application.

- 1) What are the common vulnerabilities and threats that can be found in mobile applications that are available in the market?

Client-Side Injection. Injections like SQL and JavaScript code can be easily be injected if there is no input validation. Improper Session Handling. If the session is actively stored in the phone, in some circumstances the session can be easily stolen or hijacked.

- 2) How important it is to protect customers' data from the reach of cyber criminals?

It is the most crucial aspect that should be always considered in order to gain the trust from the users.

- 3) How to ensure that the users who registered in the system are trustworthy and legitimate?

By verifying and validating duplicate information of a user. Ensure the user to register using their active mobile number and also their identification number.

- 4) Is two-factor authentication sufficient to secure the login and registration processes in the proposed system?

Yes. It is good enough.

- 5) What type of encryption or hashing algorithm that can be used to cipher the data stored in the database?

AES-256 for encryption with certification protection. The certificate can be protected using a private key. SHA-512 for hashing to add on extra bits to the data.

- 6) What other security measures that can be considered during the development of the proposed system?

Applying stored procedures from database side. Tokenisation in client-server architecture. Lock the account in a few numbers of failed login attempts. Block bot requests to filter DDos attacks.

- 7) Since Amazon Web Services are planned to be used, is there any specific service that can be used to protect the application from unauthorised intrusion?

Apply private subnets for database and EC2s. Use load balancer in order to avoid direct contact with the servers. Enable Advanced AWS Shield to stop advance DDOS attacks. Enable auto-scaling policy in order to ensure availability.

- 8) Is there any additional feature that can be implemented in the system to enhance user experience?

Optimize the size of the front end by utilizing all the functions and programs in the server side. Have a simple and organised interface for the novice users. Enable voice control to use the application for the disabled.

Analysis

According to the interview done with one of the security analysts in Nimbus Cloud Sdn Bhd, it has been learned that he emphasizes more on database security threats that should be aware of and features that should be implemented into the system. The interviewee has critically analysed and thought carefully about the potential vulnerabilities and threats for mobile application as he has mentioned about session hijacking threat which many people may not be aware of. The suggestions given for the implementation of additional features are constructive and logical. For example, enabling voice control for disableds to use the application may not seem like a unique feature, yet it is a logical solution for the disableds and a feature that has to be made compulsory for every mobile application.

6.2 Summary

By conducting both the interview and questionnaire, various data and ideas have been collected which have helped tremendously to develop the application. In this evolving technological era, almost every system is transforming into virtual components; let it be a computer, personal assistant, or even cash. However, there are people who still against adapting to the change due to safety concerns of using such applications to make payments or using a service which involves them physically. Such a problem would be difficult to resolve as long as there are people who resist to change and stepping out of the comfort zone. Due to safety concerns among citizens, the establishment of such ride-sharing platform is still slow in this country. Thus, citizens have to be educated with current technologies along with its vulnerabilities and threats to make sure that they are aware of an application's capability in providing a secured service. In summation, the results obtained from both data gathering methods have assisted the researcher to enhance the idea further and implement additional security features into the application.

7 System Architecture

7.1 Introduction

As mentioned earlier, Easy Ride is a mobile application that incorporates several fascinating features to fulfil the carpooling needs and requirements of Malaysian travellers. In this section, all the relevant features and business login of this application are deliberately explained for reader's comprehension.

In general, the system works similar to an e-hailing application in which the passenger can search and book a ride by entering the starting point, destination and the time. Google Maps has been integrated in the application to provide a visual representation of all the available journeys to the passengers. As soon as they book a ride, the passengers have to wait for a confirmation from drivers. The drivers have the privilege to either accept or decline the requested journeys based on their availability. Throughout the system, the passengers are able to track and manage all of their upcoming, current and past journeys. Moreover, the system also allows a registered passenger to become a driver by verifying his or her email address, phone number, identification card and driving license. Through the configuration of Amazon SES, the system sends a confirmation email to the respective passenger in order to validate his or her email address. Moreover, Nexmo API has been integrated to send a four-digit pin to the passenger's mobile phone in order to validate his or her mobile number. On the other hand, BlinkID SDK has also been incorporated in which the passenger is required to scan and verify his or her identification card and license on both sides. Once all the mentioned information is verified by the application, the system permits the passenger to become a driver.

The drivers are able to add and manage their cars in the system by providing the requested information. They can create journeys and add waypoints from which they would like to pick up and drop passengers throughout their journeys. Similar to passengers, the drivers are also able to track their upcoming, current and past journeys within the application. Besides that, payment processes have also been included in the system where passengers are capable to make payments to their respective drivers after each journey. Since payment processes require huge emphasis on security, biometric authentication has been included where the passengers are required to authenticate their fingerprint before making any payment. Moreover, both drivers and passengers are able to send feedback or contact the administrator within the application if they face any issues or need more clarification.

To summarise, the developer has implemented all the mentioned features to provide a seamless carpooling experience to both the drivers and passengers. Since confidential information and payment processes are involved in this application, a greater focus has been given to security features in order to gain trust of the registered users.

7.2 Abstract Architecture

7.2.1 System Design

System design can be elucidated as a structured process of designing the components of a system such as the interfaces, architecture, entities and modules. The following list provides a brief overview of all the components in a system design.

- Architecture – highlights the relationship, structure and general functionalities of a system.
- Modules – highlights the tasks and activities that are presented within a system.
- Interfaces – Intermediary for information exchange and how the details will be displayed on the screen.
- Entities – highlights a group of attributes and their corresponding behaviour.

The main objective of system design is to provide an in-depth information about the elements in a system which help to create consistent architectural framework and entities. Moreover, system design is also crucial to understand how well the system components communicate with each other to accomplish certain pre-defined requirements. The design characteristics are meticulously analysed and assessed to identify the most suitable design options for the respective system (Odhiambo, 2018). All the object-oriented UML design representations of Easy Rude such as the use case diagram, activity diagram and class diagram are included in this chapter. Moreover, this chapter also includes a system architectural design which gives a general overview of how the entire application is deployed with the use of AWS services.

7.2.1.1 System Architectural Design

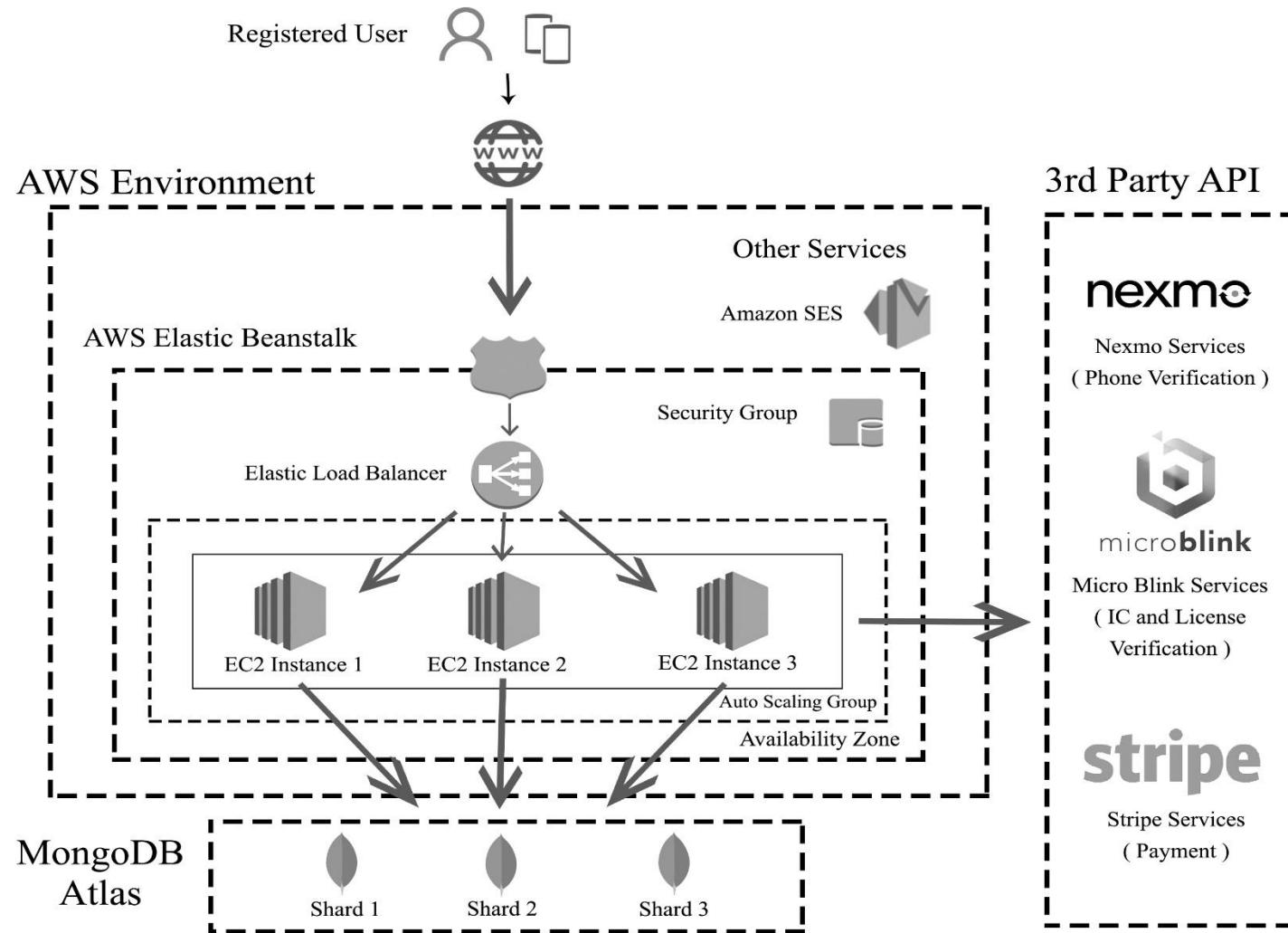


Figure 11: System Architectural Design of Easy Ride

Diagram above clearly illustrates the system architecture that has been used to implement and deploy the back-end application of Easy Ride. As mentioned earlier in the section of ‘technical research’, the back-end application of Easy Ride has been developed with the aid of Node.js web application framework.

As can be seen in the above diagram, the back-end application is hosted in AWS Elastic Beanstalk which is an orchestration service that manages a set of AWS services such as EC2 instances, CloudWatch, Simple Notification Service (SNS), S3 and Elastic Load Balancer (AWS, 2019). All the API calls will be sent to the Elastic Beanstalk in which the Elastic Load Balancer transmits the requests to the active EC2 instances. The back-end application hosted in the EC2 instances process the requests and send the response back to the users. On the other hand, an Auto Scaling Group has been implemented to scale out the number of instances horizontally in the event of high traffic spikes. Moreover, Security Groups have been configured in Elastic Beanstalk in order to restrict unwanted or unauthorised traffic into the application. Apart from that, Amazon SES has been used within the architecture in order to send email notifications to the registered users. Besides that, MongoDB from MongoDB Atlas is used as the primary database for Easy Ride application. In MongoDB, all the records are stored in collections which contains a set of different documents. Three different shards are implemented as a replica set within the MongoDB in order to provide high availability and redundancy for all the records.

Besides that, several third-party APIs have been integrated within the architecture. For instance, Stripe is used to handle payments processes within the application whereas Nexmo is used to verify the phone number of registered users. Moreover, MicroBlink is used in the application to capture and verify the license and IC of registered drivers.

All the services shown in the architecture are effectively implemented in the system in order to achieve the desired functionalities and requirements.

7.2.1.2 Use Case Diagram

Use case diagram can be elucidated as a behavioural diagram which graphically represents the functionalities of a system by using use cases and actors as the core components (SmartDraw, 2020). The following image briefly demonstrates the use case diagram of Easy Ride mobile application.

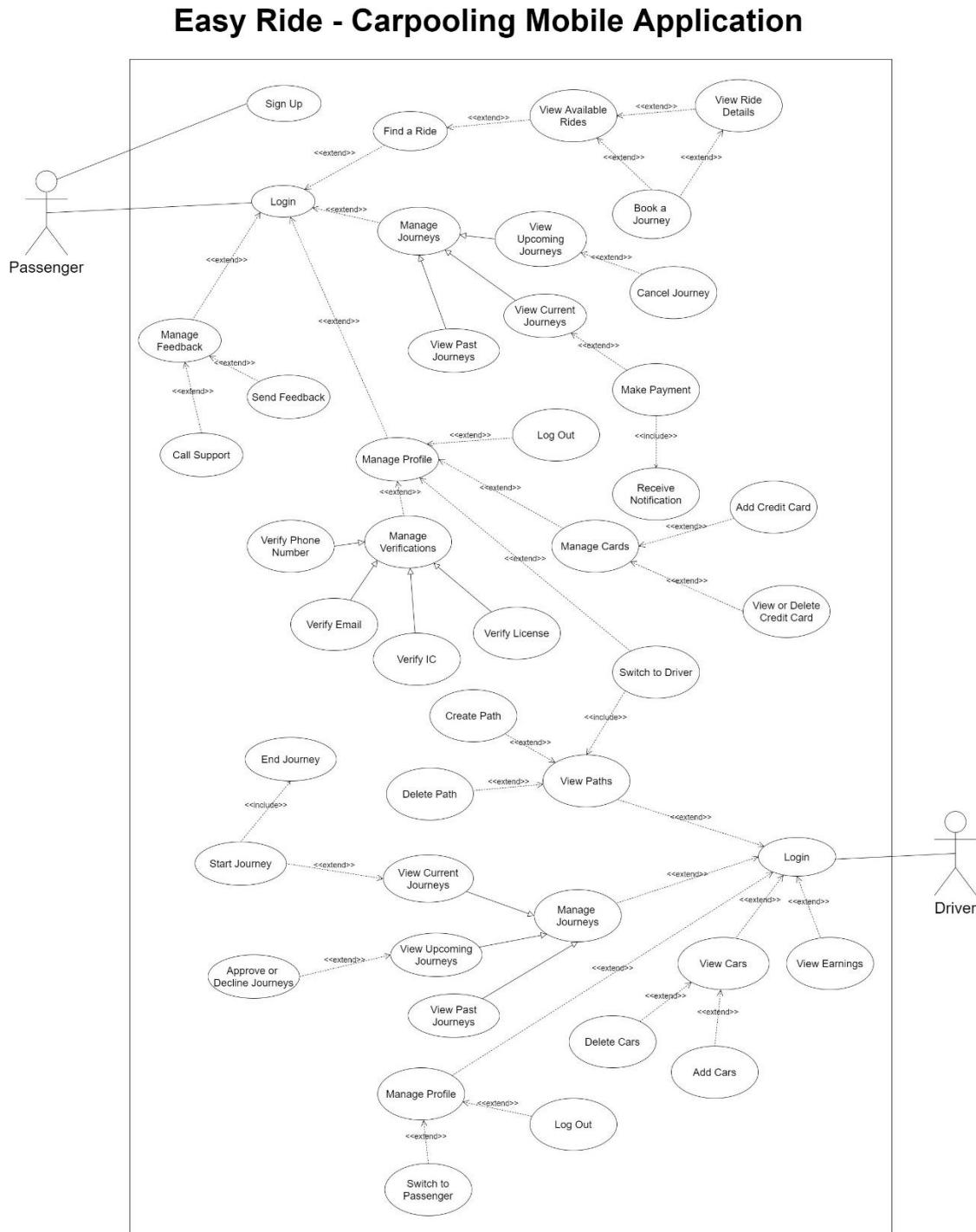


Figure 12: Use Case Diagram of Easy Ride

Since the use case diagram is huge, I have included it in the softcopy for your reference

7.2.1.3 Use Case Specifications

Sign up Specifications

Use Case ID	1.0
Use Case Name	Sign Up
Description	To register a new passenger
Actor	New User
Dependency	-
Priority	Critical

Login Specifications

Use Case ID	2.0
Use Case Name	Login
Description	Log into the system by providing credentials
Actor	Passenger
Dependency	-
Priority	Critical

Find a Ride Specifications

Use Case ID	3.0
Use Case Name	Find a Ride
Description	To find a ride by providing the starting point, destination and time
Actor	Passenger
Dependency	Login
Priority	Medium

View Available Rides Specifications

Use Case ID	4.0
Use Case Name	View Available Rides
Description	To view all the available rides based on passenger's inputs
Actor	Passenger
Dependency	Find a Ride
Priority	Medium

View Ride Details Specifications

Use Case ID	5.0
Use Case Name	View Ride Details
Description	View the detailed description of individual rides
Actor	Passenger
Dependency	View Available Rides / Book a Journey
Priority	Medium

Book a Journey Specifications

Use Case ID	6.0
Use Case Name	Book a Journey
Description	To book a specific journey and send notification to the respective driver
Actor	Passenger
Dependency	View Available Rides
Priority	Medium

Manage Journeys Specifications

Use Case ID	7.0
Use Case Name	Manage Journeys
Description	To manage all the booked journeys
Actor	Passenger/Driver
Dependency	Login
Priority	Medium

View Upcoming Journeys Specifications

Use Case ID	8.0
Use Case Name	View Upcoming Journeys
Description	To view all the details of pre-booked journeys
Actor	Driver / Passenger
Dependency	Manage Journeys
Priority	Medium

Cancel Journeys Specifications

Use Case ID	9.0
Use Case Name	Cancel Journey
Description	To cancel a booked journey
Actor	Passenger
Dependency	View Upcoming Journeys
Priority	Medium

View Past Journeys Specifications

Use Case ID	10.0
Use Case Name	View Past Journeys
Description	To view all the details of past journeys
Actor	Driver / Passenger
Dependency	Manage Journeys
Priority	Medium

View Current Journeys Specifications

Use Case ID	11.0
Use Case Name	View Current Journeys
Description	To view all the details of the current journeys
Actor	Driver / Passenger
Dependency	Manage Journeys
Priority	Medium

Make Payment Specifications

Use Case ID	12.0
Use Case Name	Make Payment
Description	To make payment after each and every successful journey
Actor	Passenger
Dependency	View Current Journey
Priority	Critical

Receive Notification Specifications

Use Case ID	13.0
Use Case Name	Receive Notification
Description	To receive notification upon successful payment
Actor	Passenger
Dependency	Make Payment
Priority	Critical

Manage Feedback Specifications

Use Case ID	14.0
Use Case Name	Manage Feedback
Description	To manage all the feedback functionalities
Actor	Passenger
Dependency	Login
Priority	Medium

Call Support Specifications

Use Case ID	15.0
Use Case Name	Call Support
Description	To call the administrators of the system
Actor	Passenger
Dependency	Manage Feedback
Priority	Medium

Send Feedback Specifications

Use Case ID	16.0
Use Case Name	Send Feedback
Description	To send feedback to the administrator regarding the system
Actor	Passenger
Dependency	Manage Feedback
Priority	Medium

Manage Profile Specifications

Use Case ID	17.0
Use Case Name	Manage Profile
Description	To manage the user's profile
Actor	Passenger / Actor
Dependency	Login
Priority	Medium

Log Out Specifications

Use Case ID	18.0
Use Case Name	Log Out
Description	To log out of the application
Actor	Passenger / Driver
Dependency	Manage Profile
Priority	Critical

Manage Verifications Specifications

Use Case ID	19.0
Use Case Name	Manage Verifications
Description	To manage all the verification processes in order to become a driver
Actor	Passenger
Dependency	Manage Profile
Priority	Critical

Verify Phone Number Specifications

Use Case ID	20.0
Use Case Name	Verify Phone Number
Description	To verify passenger's phone number with Nexmo API
Actor	Passenger
Dependency	Manage Verifications
Priority	Critical

Verify Email Specifications

Use Case ID	21.0
Use Case Name	Verify Email
Description	To verify the email address of the passenger
Actor	Passenger
Dependency	Manage Verifications
Priority	Critical

Verify License Specifications

Use Case ID	22.0
Use Case Name	Verify License
Description	To verify the license of passenger with MicroBlink SDK
Actor	Passenger
Dependency	Manage Verifications
Priority	Critical

Verify IC Specifications

Use Case ID	23.0
Use Case Name	Verify IC
Description	To verify the identification card of passenger with MicroBlink SDK
Actor	Passenger
Dependency	Manage Verifications
Priority	Critical

Manage Cards Specifications

Use Case ID	24.0
Use Case Name	Manage Cards
Description	To manage the credit card of the passenger
Actor	Passenger
Dependency	Manage Profile
Priority	Medium

Add Credit Card Specifications

Use Case ID	25.0
Use Case Name	Add Credit Card
Description	To add a new credit card of the passenger
Actor	Passenger
Dependency	Manage Cards
Priority	Critical

View or Delete Credit Card Specifications

Use Case ID	26.0
Use Case Name	View or Delete Credit Card
Description	To view or delete unused credit card from the system
Actor	Passenger
Dependency	Manage Cards
Priority	Critical

Switch to Driver Specifications

Use Case ID	27.0
Use Case Name	Switch to Driver
Description	To become a driver and use driver's functionalities
Actor	Passenger
Dependency	Manage Profile
Priority	Medium

View Paths Specifications

Use Case ID	28.0
Use Case Name	View Paths
Description	To view all the paths created by the respective driver
Actor	Driver
Dependency	Login
Priority	Medium

Create Path Specifications

Use Case ID	29.0
Use Case Name	Create Path
Description	To create a path by inputting the starting point, destination, time and waypoints
Actor	Driver
Dependency	View Path
Priority	Medium

Delete Path Specifications

Use Case ID	30.0
Use Case Name	Delete Path
Description	To delete a path which is previously created
Actor	Driver
Dependency	View Path
Priority	Medium

View Earnings Specifications

Use Case ID	31.0
Use Case Name	View Earnings
Description	To view the overall earnings from the offered rides
Actor	Driver
Dependency	View Path
Priority	Medium

View Cars Specifications

Use Case ID	32.0
Use Case Name	View Cards
Description	To view all the cards that are added
Actor	Driver
Dependency	Login
Priority	Medium

Add Cars Specifications

Use Case ID	33.0
Use Case Name	Add Cars
Description	To add a new car into the system
Actor	Driver
Dependency	View cars
Priority	Mediums

Delete Cars Specifications

Use Case ID	34.0
Use Case Name	Delete Cars
Description	To delete a car that has been previously added
Actor	Driver
Dependency	View Cars
Priority	Medium

Start Journey Specifications

Use Case ID	35.0
Use Case Name	Start Journey
Description	To start an approved journey when the time arrives
Actor	Driver
Dependency	View Current Journeys
Priority	Critical

End Journey Specifications

Use Case ID	36.0
Use Case Name	End Journey
Description	To end a journey after the passenger reaches the destination
Actor	Driver
Dependency	Start Journey
Priority	Medium

Approve or Decline Journey Specifications

Use Case ID	37.0
Use Case Name	Approve or Decline Journeys
Description	To approve or decline a requested journey
Actor	Driver
Dependency	View Upcoming Journeys
Priority	Critical

Switch to Passenger

Use Case ID	38.0
Use Case Name	Switch to Passenger
Description	To switch to passenger's role and use passenger's functionalities
Actor	Driver
Dependency	Manage Profile
Priority	Medium

7.2.1.4 Activity Diagram

7.2.1.4.1 Login Activity

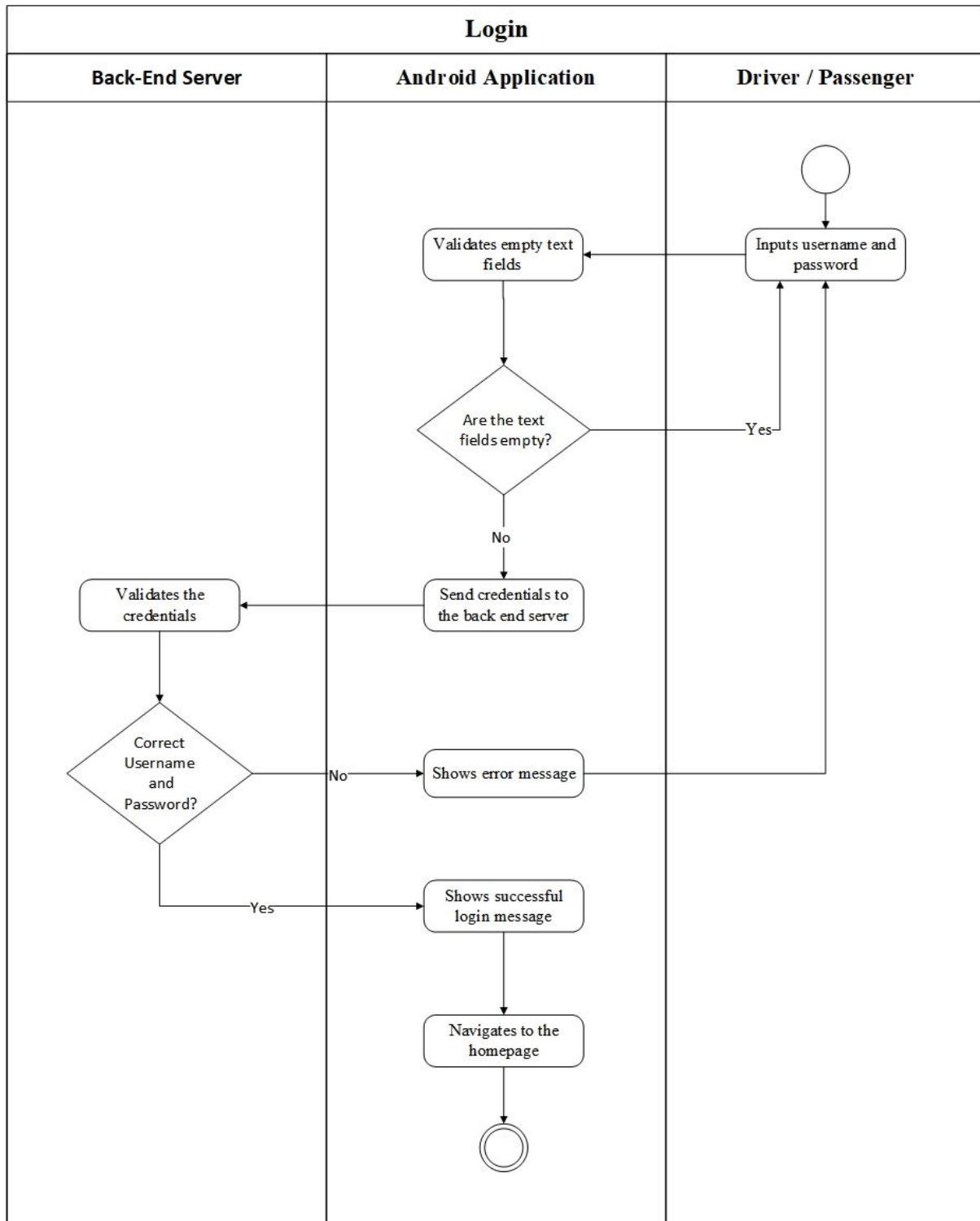


Figure 13: Login Activity Diagram

7.2.1.4.2 User Registration Activity

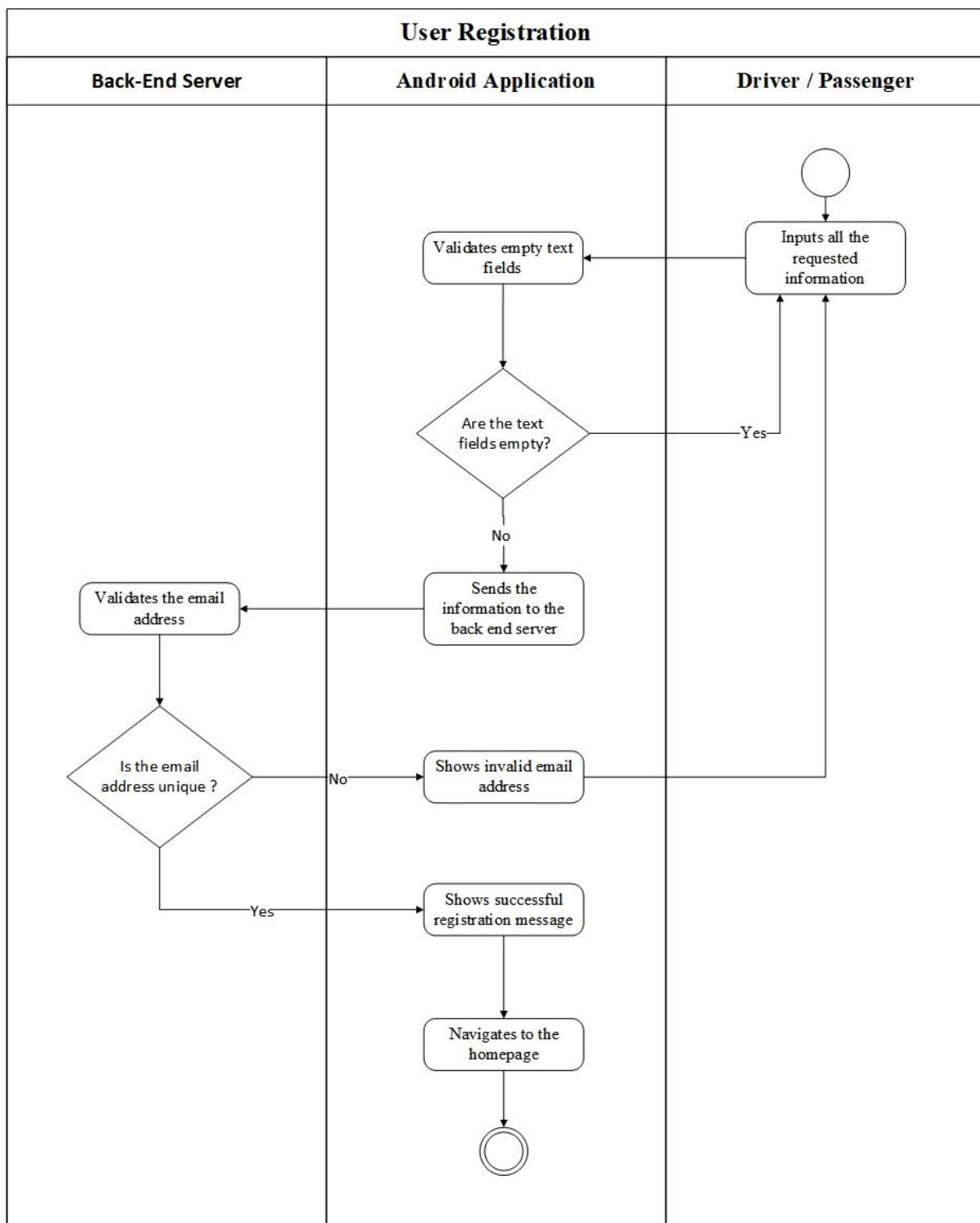


Figure 14: User Registration Activity Diagram

7.2.1.4.3 Send Feedback (Passengers) Activity

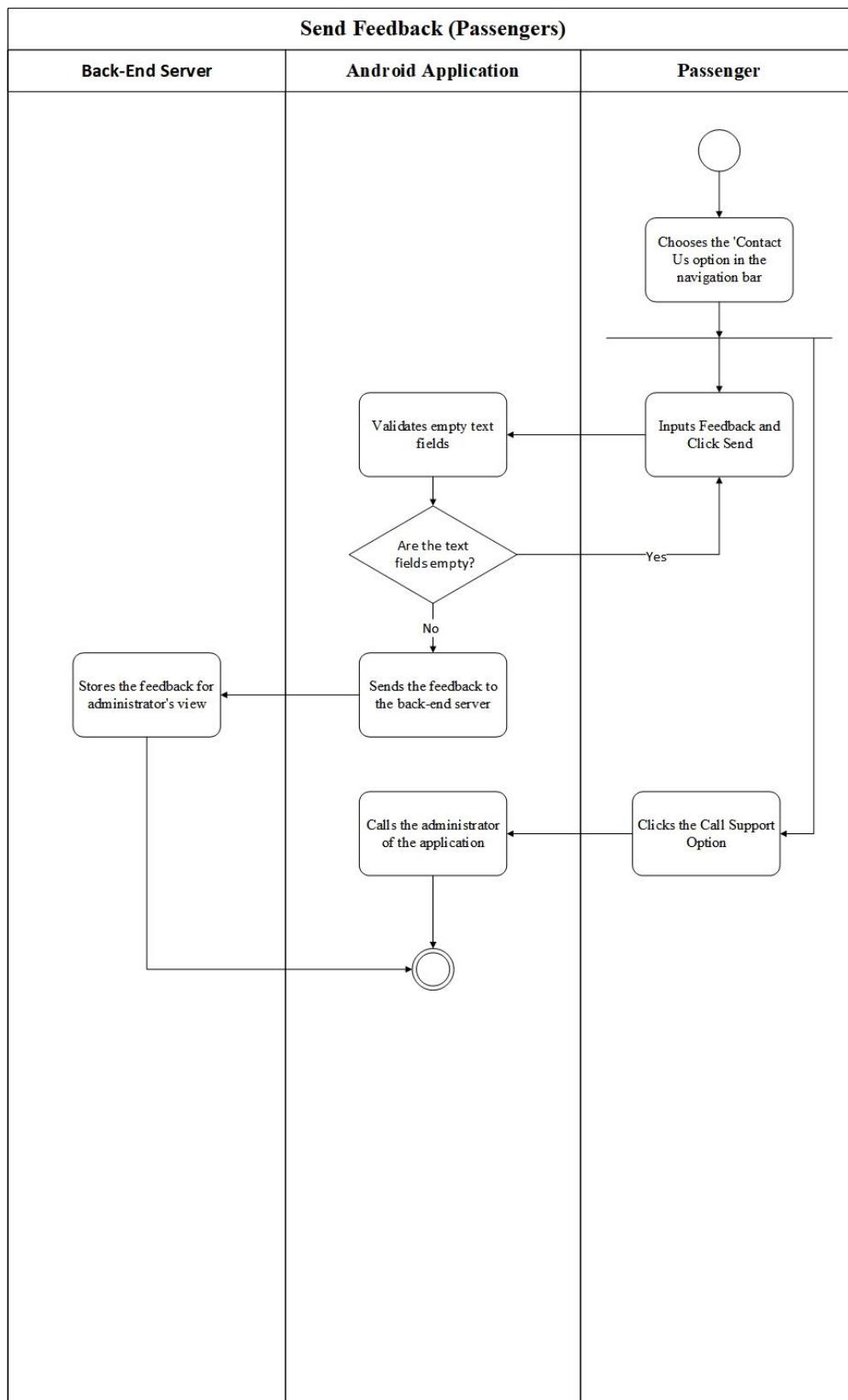


Figure 15: Send Feedback Activity Diagram

7.2.1.4.4 Find a Ride (Passengers) Activity

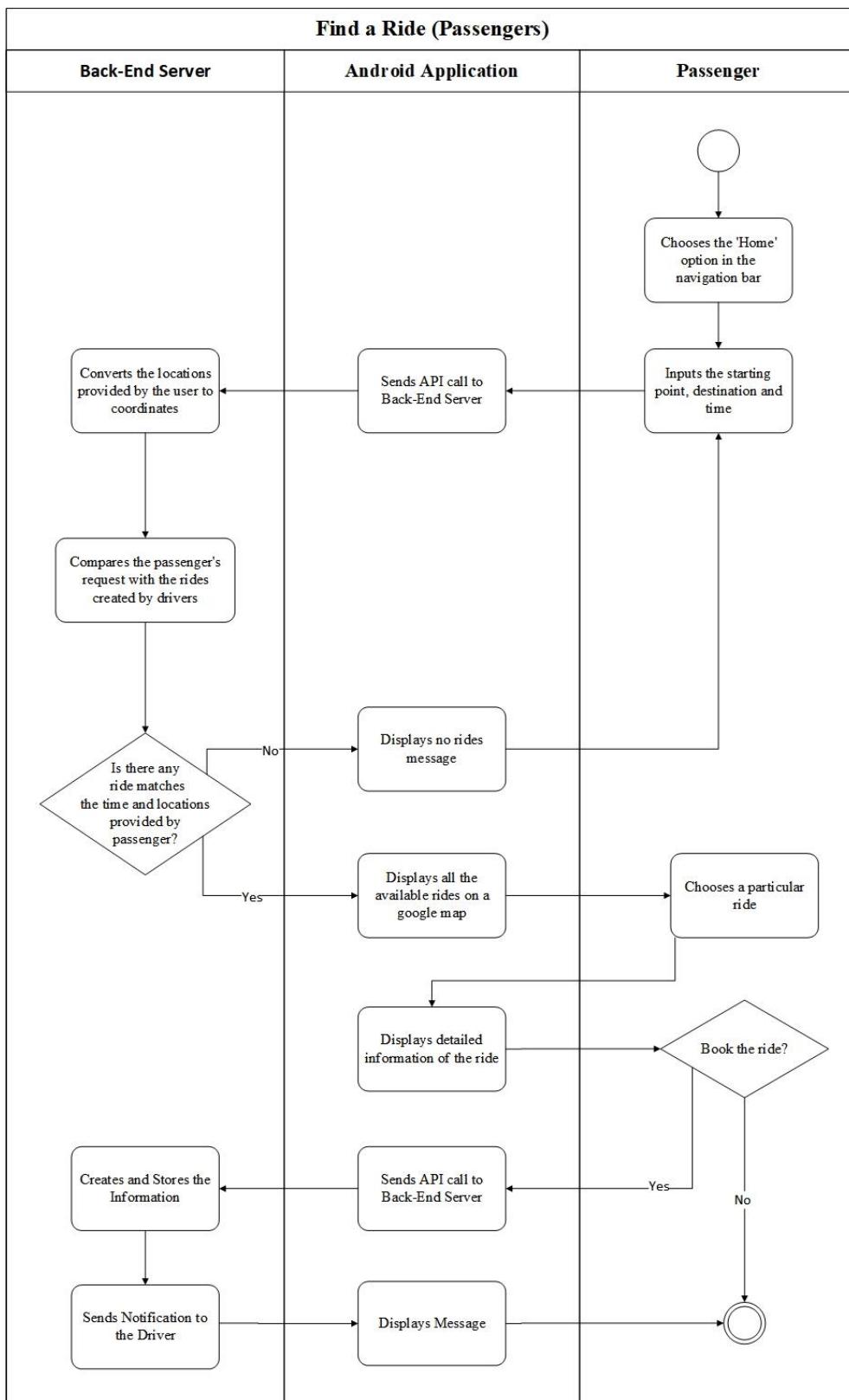


Figure 16: Find a Ride Activity Diagram

7.2.1.4.5 Manage Journeys (Passengers) Activity

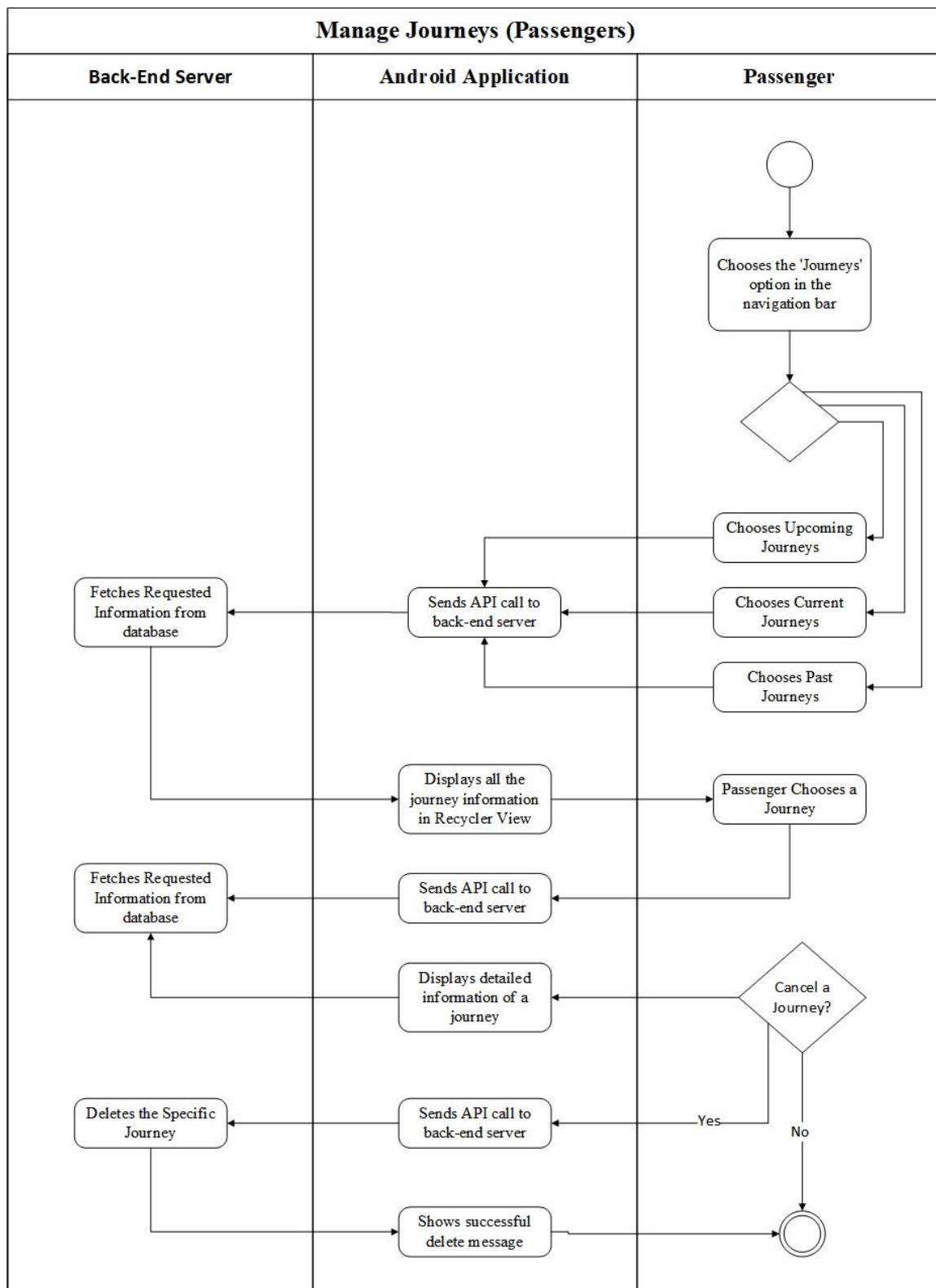


Figure 17: Manage Journeys Activity Diagram

7.2.1.4.6 Make Payment (Passenger) Activity

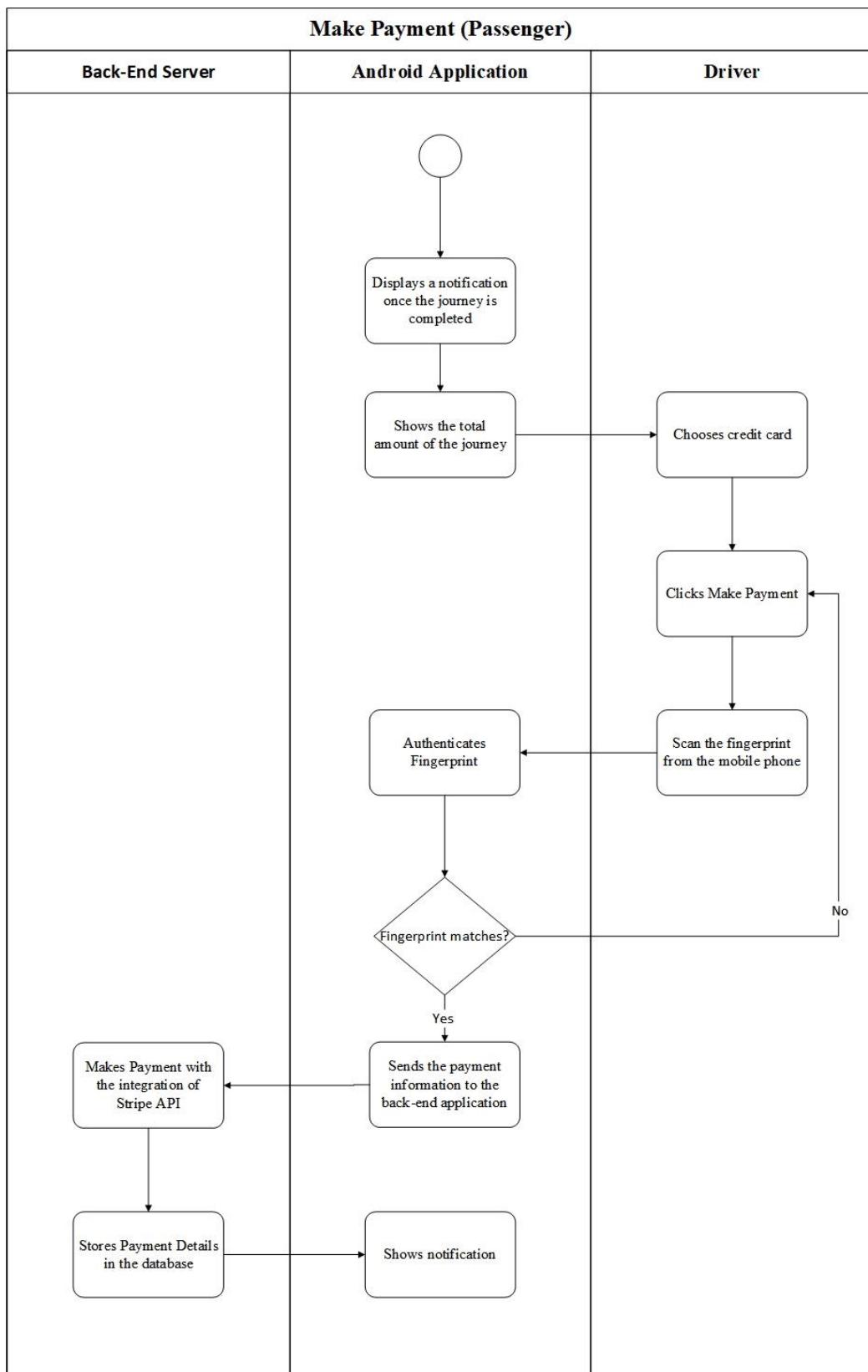


Figure 18: Make Payment Activity Diagram

7.2.1.4.7 Verify License (Passengers) Activity

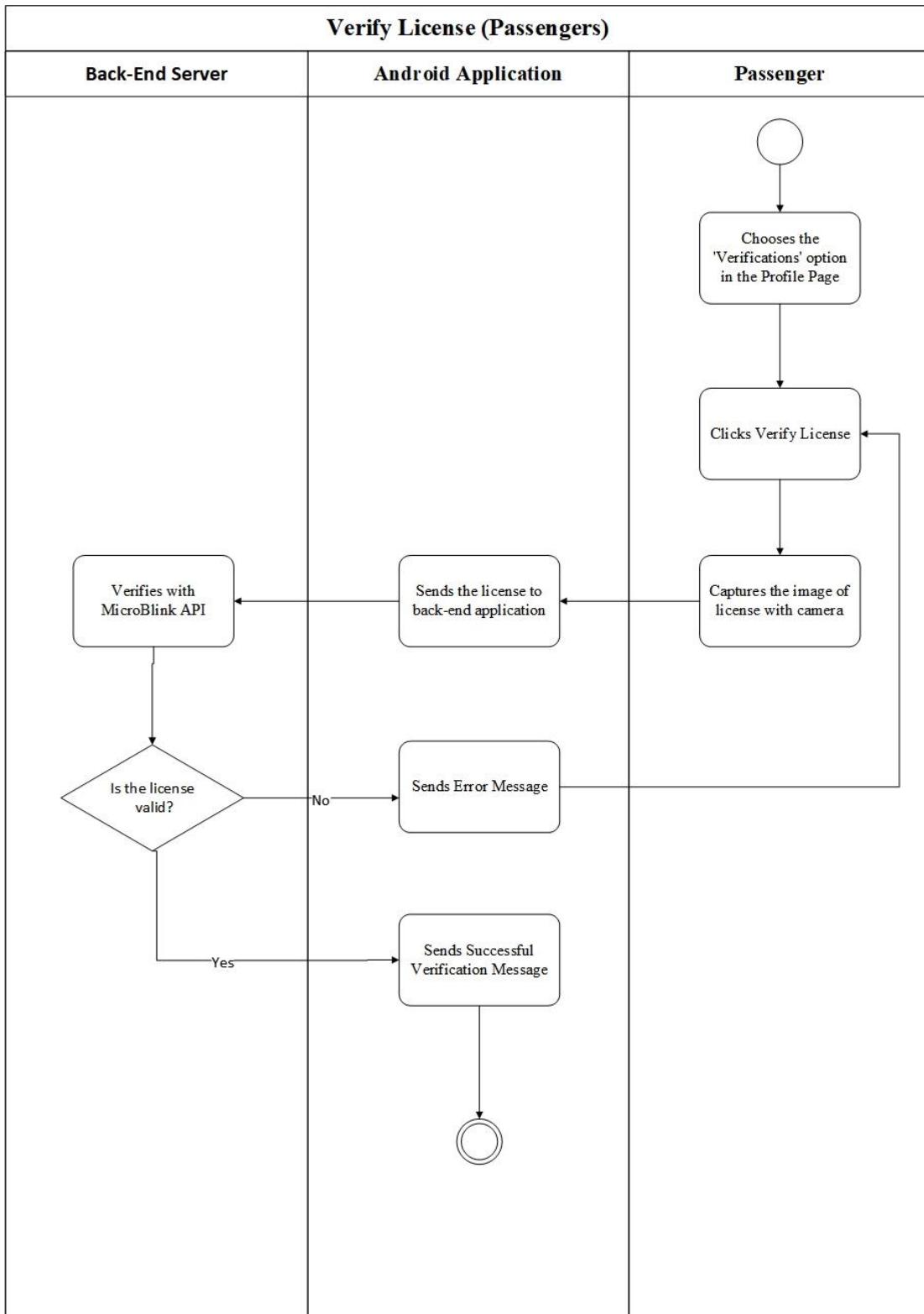


Figure 19: Verify License Activity Diagram

7.2.1.4.8 Manage Cards (Passenger) Activity

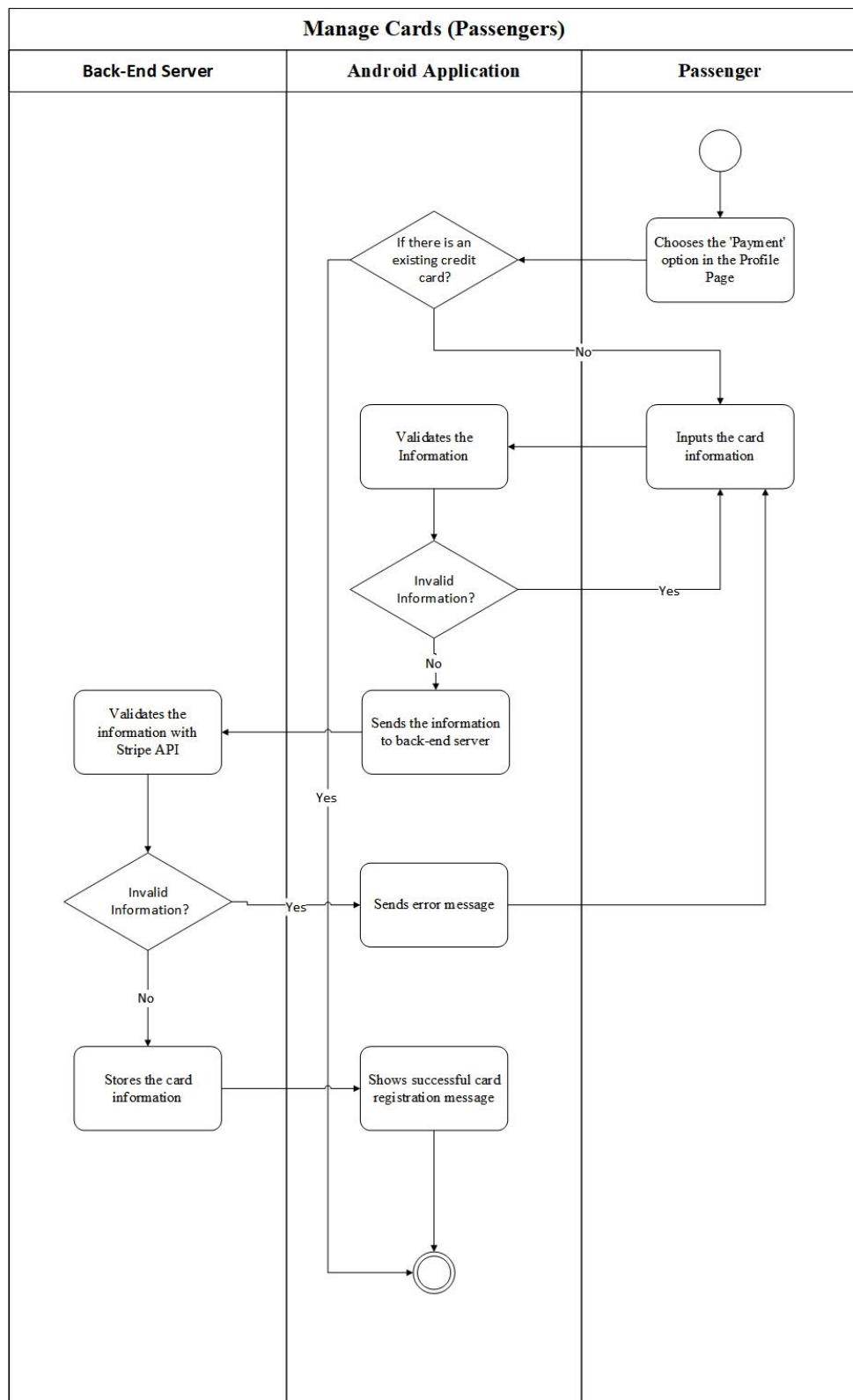


Figure 20: Manage Cards Activity Diagram

7.2.1.4.9 Verify Phone Number (Passengers) Activity

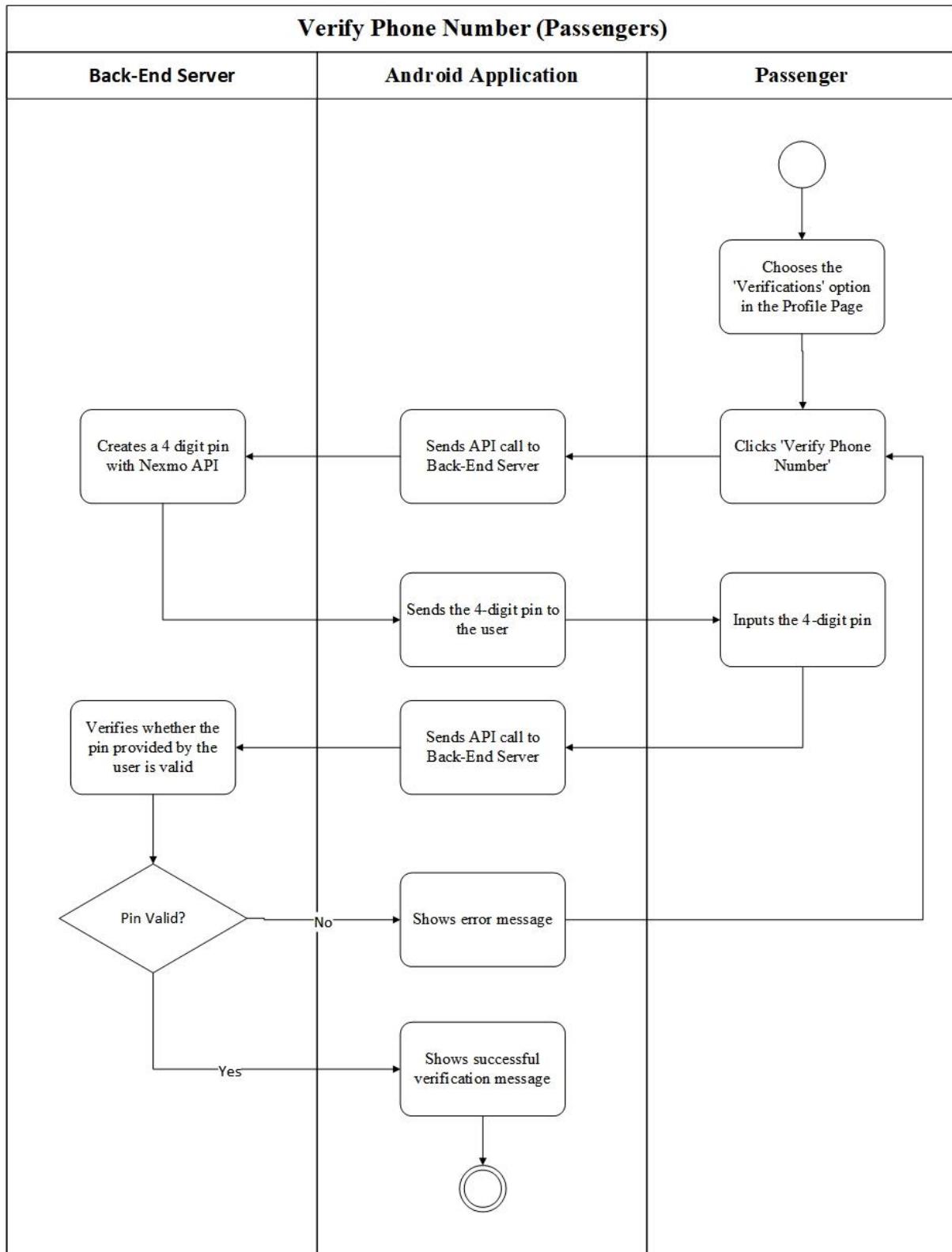


Figure 21: Verify Phone Number Activity Diagram

7.2.1.4.10 Verify Email Address (Passengers) Activity

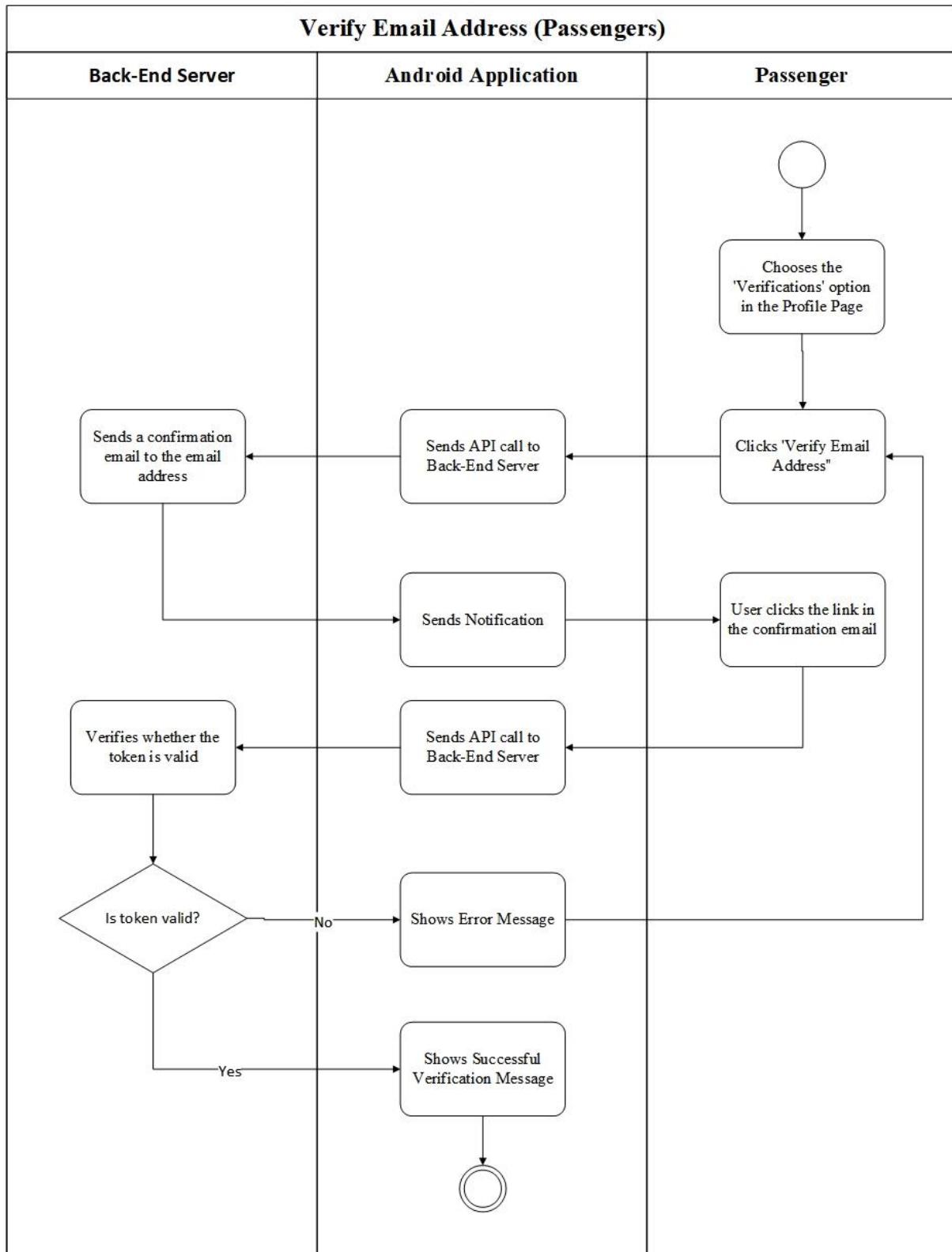


Figure 22: Verify Email Address Activity Diagram

7.2.1.4.11 Manage Paths (Drivers) Activity

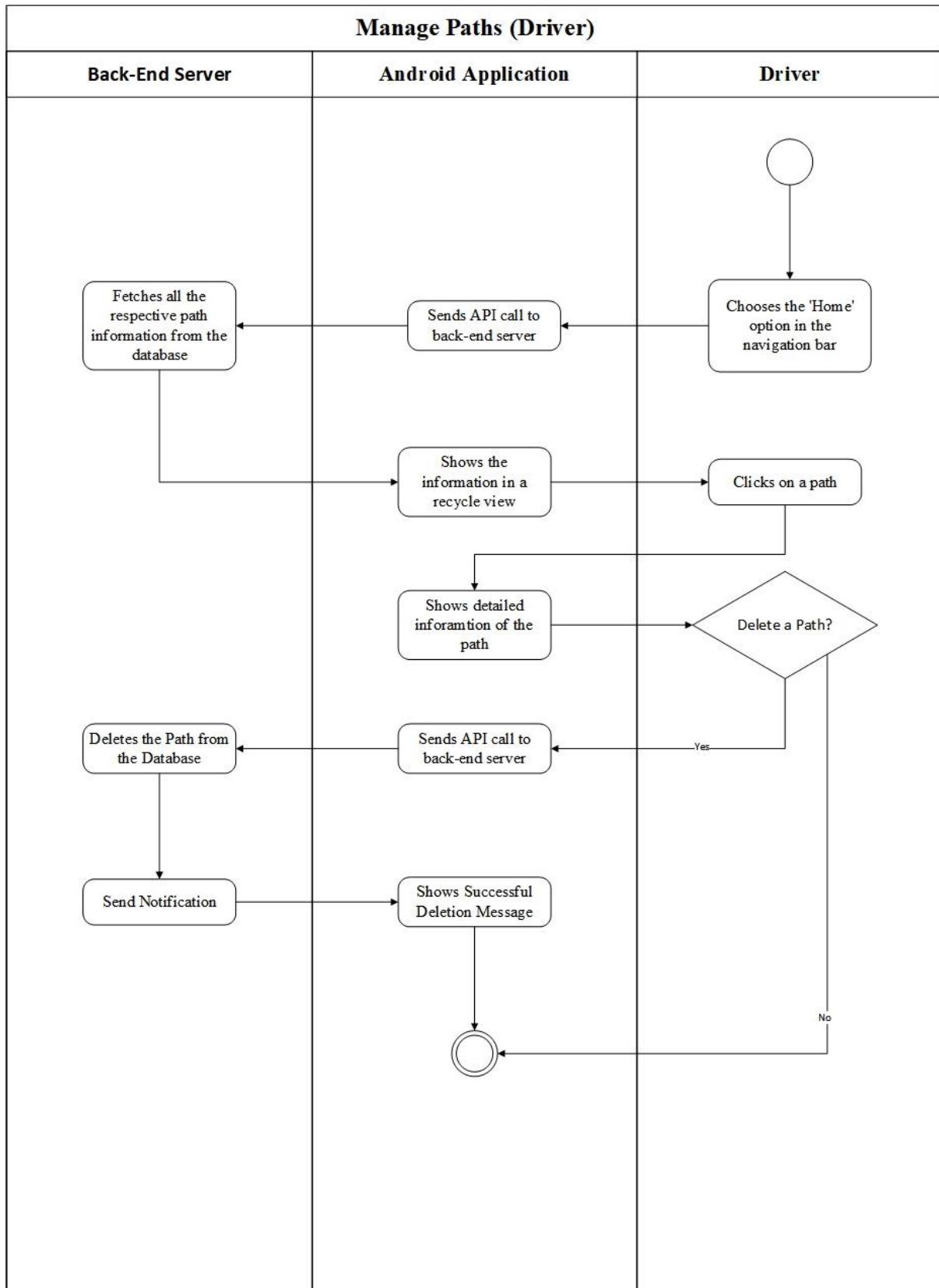


Figure 23: Manage Paths Activity Diagram

7.2.1.4.12 Manage Cars (Drivers) Activity

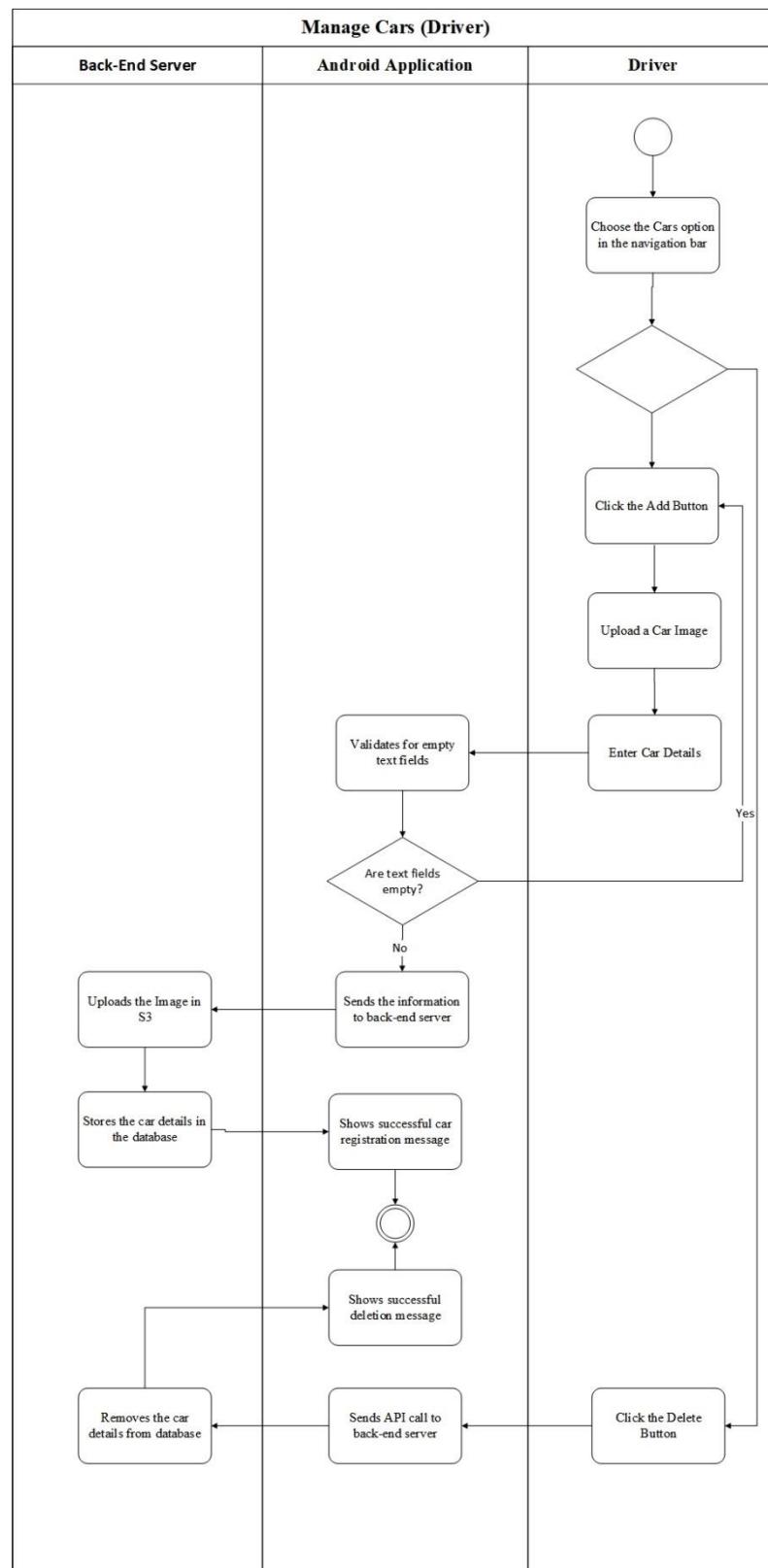


Figure 24: Manage Cars Activity Diagram

7.2.1.4.13 Manage Journeys (Drivers) Activity

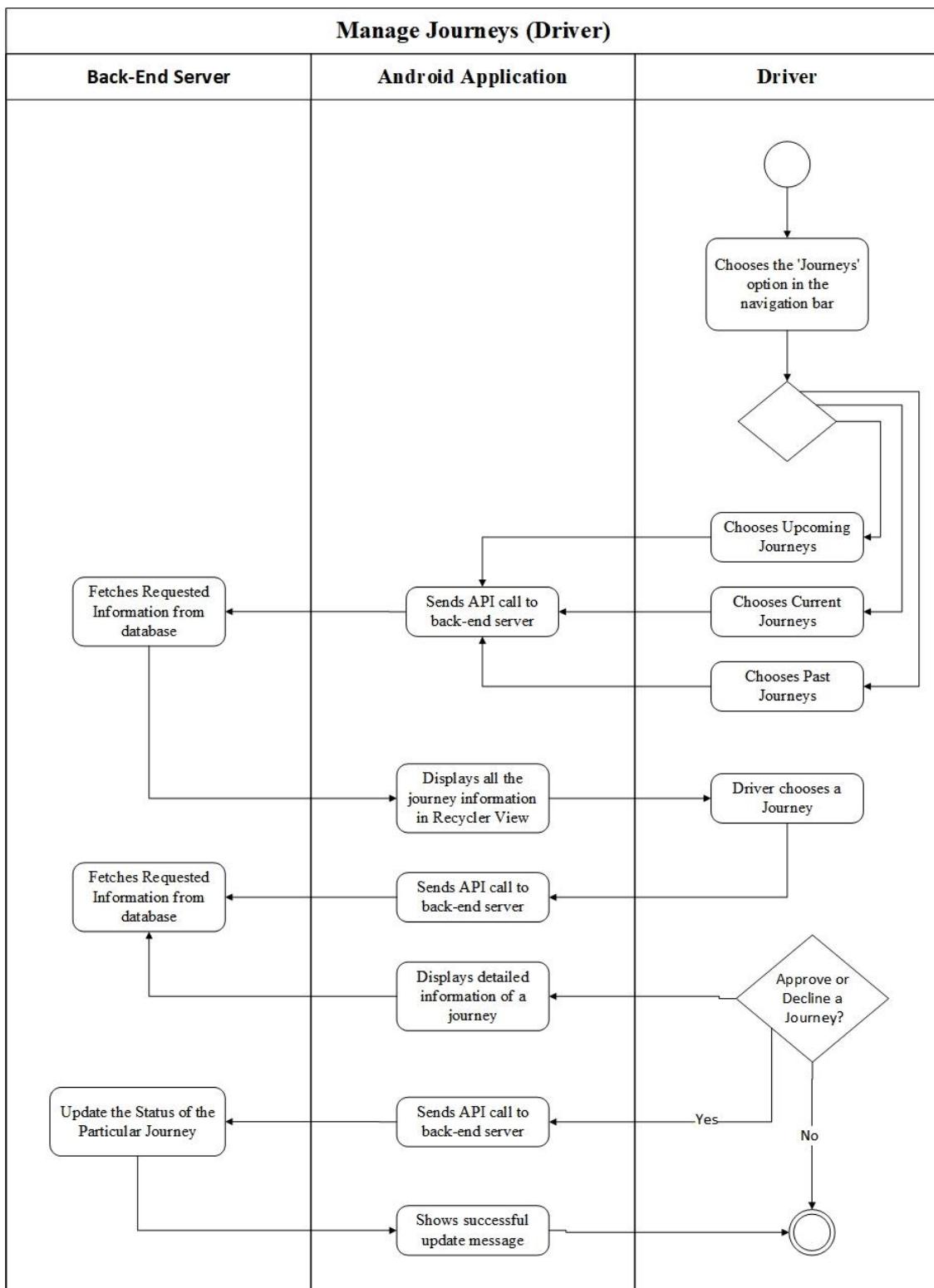


Figure 25: Manage Journeys Activity Diagram

7.2.1.4.14 Create Rides (Drivers) Activity

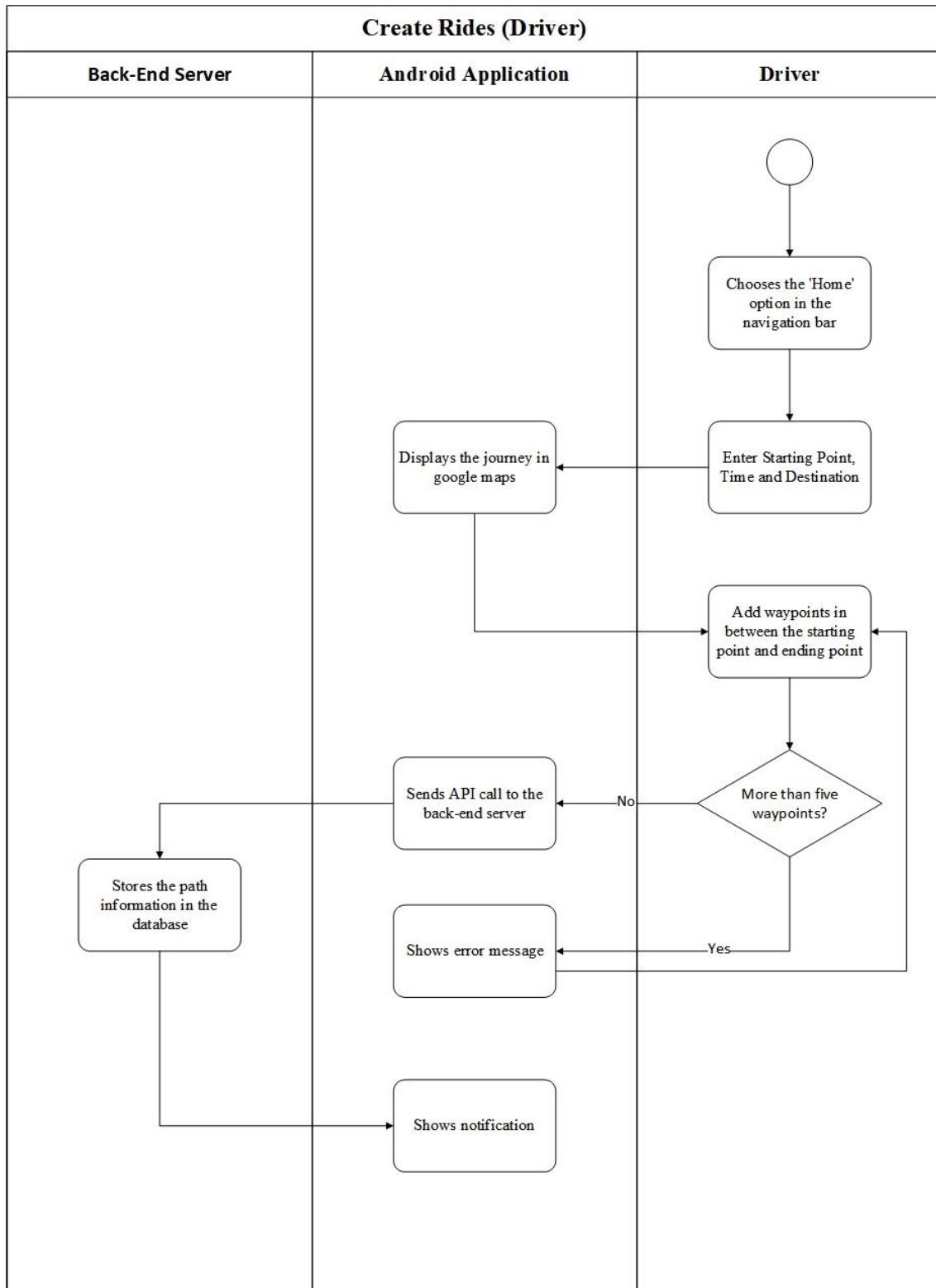


Figure 26: Create Rides Activity Diagram

7.2.1.5 Class Diagram

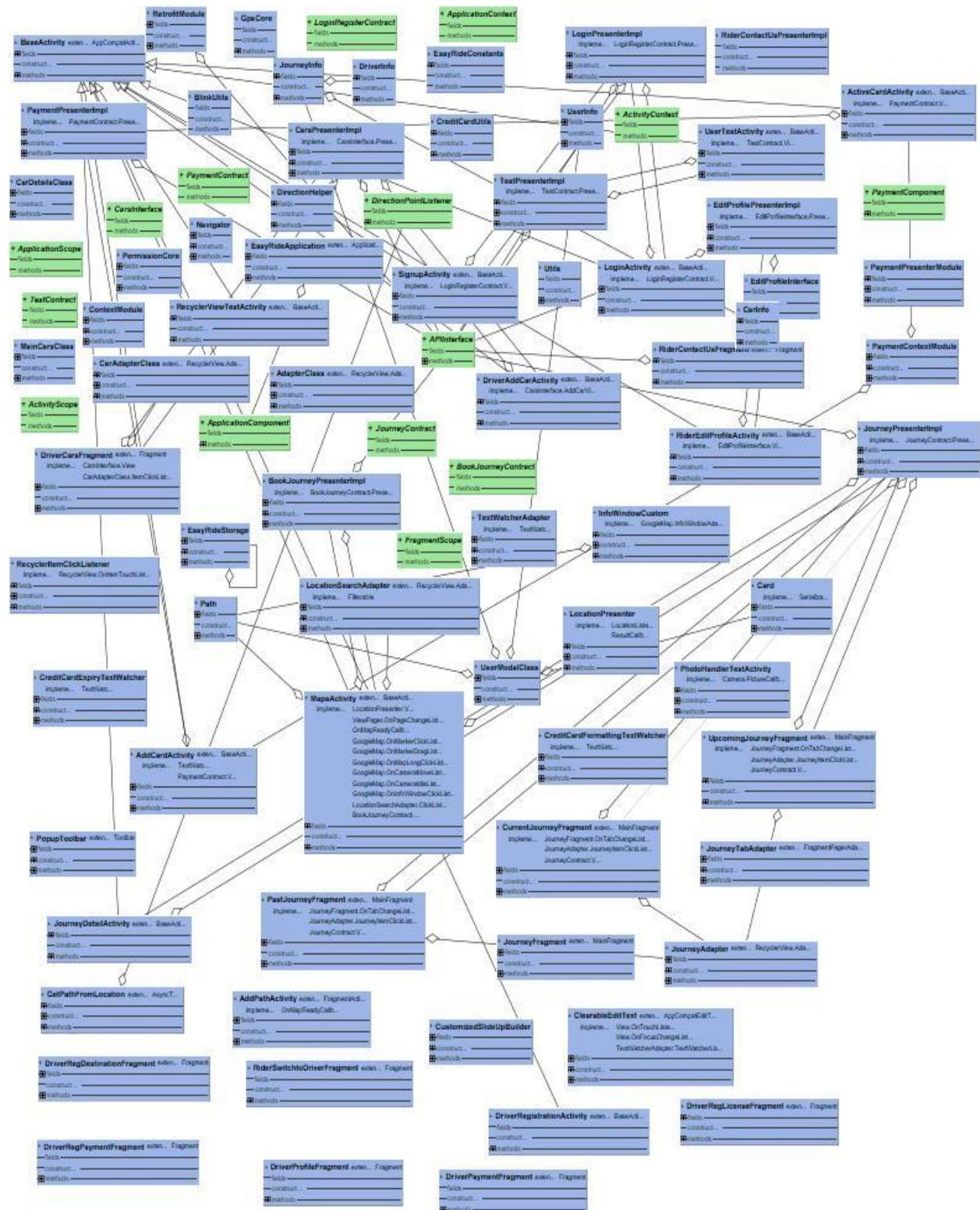


Figure 27 : Class Diagram of Easy Ride

Since the class diagram is huge, I have included it in the softcopy for your reference

7.2.2 Database Design

7.2.2.1 Entity Relationship Diagram

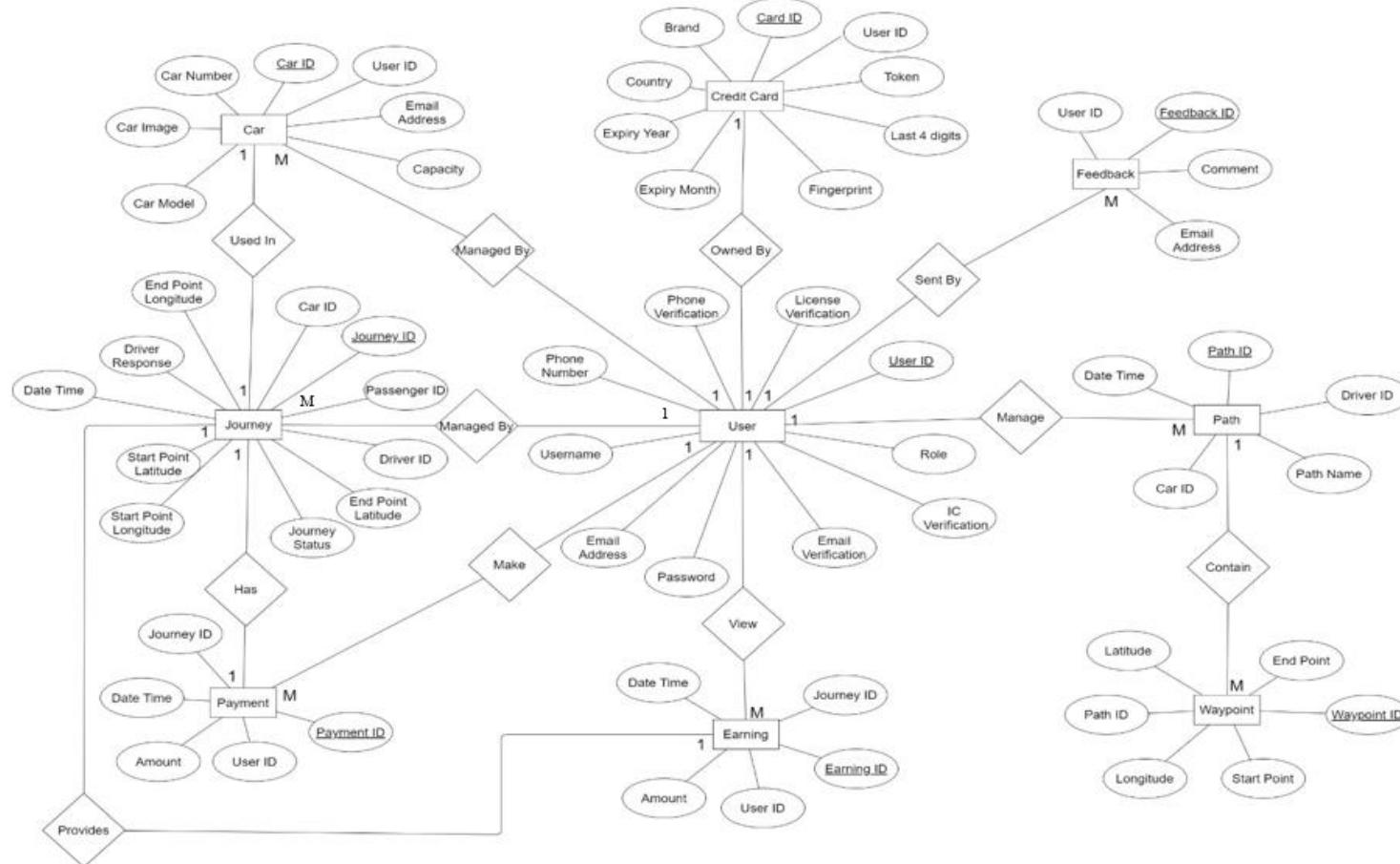


Figure 28: Entity Relationship Diagram of Easy Ride

Since the ERD diagram is huge, I have included it in the softcopy for your reference

7.2.2.2 Database Table Structure

According to David Meador, a typical database table structure contains detailed information of the tables stored in the database (Medor, 2018)..

The main advantage of data table structure is that it delivers a well-structured and clear information of the database and redundancy of duplicate columns can be identified. The following clearly demonstrates the table structure of different entities within the database.

Users Table

Table Name	users
Description	To store the information of users who have registered with Easy Ride
Primary Key	_id

Attribute Name	Description	Data Type	Format	PK or FK	Required	Foreign Key Reference Table
_id	Unique identification number of registered users	oid	-	PK	Yes	-
username	The username of registered user	string	-	-	Yes	-
password	The password created by user to access the system	string	-	-	Yes	-

email	The email address of users	string	-	-	Yes	-
phone	The phone number of users	integer	-	-	Yes	-
emailverification	To indicate whether the email address of the user is verified	boolean	-	-	Yes	-
phoneneverification	To indicate whether the phone number of the user is verified	boolean	-	-	Yes	-
icverification	To indicate whether the IC of the user is verified	boolean	-	-	Yes	-
licenseverification	To indicate whether the license of the user is verified	boolean	-	-	Yes	-

approle	The role of the registered user (Passenger / Driver)	string	-	-	Yes	-
---------	--	--------	---	---	-----	---

Table 16: Users Table Structure

Cars Table

Table Name	cars
Description	To store the information of cars added by the drivers
Primary Key	_id

Attribute Name	Description	Data Type	Format	PK or FK	Required	Foreign Key Reference Table
_id	Unique identification number of the cars added by users	oid	-	PK	Yes	-
emailaddress	To specify the email address of the car owner	string	-	-	Yes	-

carnumber	The plate number of the cars	string	-	-	Yes	-
carmodel	The brand of the cars	string	-	-	Yes	-
carimage	The URL of the car image which was uploaded in S3	string	-	-	Yes	-
capacity	The capacity of the cars	integer	-	-	Yes	-
userid	The identification of the car owners	oid	-	FK	Yes	users

Table 17: Cars Table Structure

Feedbacks Table

Table Name	feedbacks
Description	To store the feedbacks provided by the users
Primary Key	_id

Attribute Name	Description	Data Type	Format	PK or FK	Required	Foreign Key Reference Table
_id	Unique identification number of each feedback	oid	-	PK	Yes	-
userId	The identification number of users who sent the feedback	oid	-	FK	Yes	users
email	The email address of the users	string	-	-	Yes	-
comment	The feedback provided by users	string	-	-	Yes	-

Table 18: Feedback Table Structure

Journeys Table

Table Name	journeys
Description	To store the journeys that are booked by passengers
Primary Key	_id

Attribute Name	Description	Data Type	Format	PK or FK	Required	Foreign Key Reference Table
_id	Unique identification number of the journeys	oid	-	PK	Yes	-
dateTime	The date and time of the journey	string	yyyy-mm-dd HH:MM:SS	-	Yes	-
carId	The identification number of cars that are used in the journey	oid	-	FK	Yes	cars
driverResponse	The response from the driver (Approved/ Declined)	string	-	-	Yes	-

userId	The unique identification number of the passenger	oid	-	FK	Yes	users
driverId	The unique identification of the driver	oid	-	FK	Yes	users
journeyStatus	The status of the journey (Accepted/ Started/ Pending)/	string	-	-	Yes	-
startPointLat	The latitude of the starting point	string	-	-	Yes	-
startPointLong	The longitude of the starting point	string	-	-	Yes	-
endPointLat	The latitude of the ending point	string	-	-	Yes	-
endPointLong	The longitude of the ending point	string	-	-	Yes	-

Table 19: Journeys Table Structure

Waypoints Table

Table Name	waypoints
Description	To store the waypoints that are associated with the path
Primary Key	_id

Attribute Name	Description	Data Type	Format	PK or FK	Required	Foreign Key Reference Table
_id	Unique identification number of the waypoints	oid	-	PK	Yes	-
pathId	The unique identification number of paths that contains these waypoints	oid	-	FK	Yes	paths
latitude	The latitude of waypoint	string	-	-	Yes	-
longitude	The longitude of waypoint	string	-	-	Yes	-

isStart	To indicate whether this is the starting point of a path	boolean	-	-	Yes	-
isEnd	To indicate whether this is the ending point of a path	boolean	-	-	Yes	-

Table 20: Waypoints Table Structure

Paths Table

Table Name	paths
Description	To store the paths that are created by the driver
Primary Key	_id

Attribute Name	Description	Data Type	Format	PK or FK	Required	Foreign Key Reference Table
_id	Unique identification number of path that is created by a driver	oid	-	PK	Yes	-
dateTime	The date and time of the specified path	string	yyyy-mm-dd HH:MM:SS	-	Yes	-
driverId	The identification number of drivers who create the path	string	-	FK	Yes	users
pathName	The name of the path	string	-	-	Yes	-

carId	The identification number of the car that will be used in the path	string	-	FK	Yes	cars
-------	--	--------	---	----	-----	------

Table 21: Paths Table Structure

Credit Cards Table

Table Name	creditcards
Description	To store the credit card details of the passengers
Primary Key	_id

Attribute Name	Description	Data Type	Format	PK or FK	Required	Foreign Key Reference Table
_id	Unique identification number of credit card added by the passenger	oid	-	PK	Yes	-
user_id	The identification number of user	string	-	FK	Yes	users

	who added the credit card					
brand	The type of credit card	string	-	-	Yes	-
country	The place where the credit card is registered	string	-	-	Yes	-
exp_month	The expiry month of the credit card	integer	00	-	Yes	-
exp_year	The expiry year of the credit card	integer	0000	-	Yes	-
fingerprint	The fingerprint associated with the credit card	string	-	-	Yes	-
token	The token used to validate the credit card	string	-	-	Yes	-
last4	The last four digits of the credit card	integer	0000	-	Yes	-

Table 22: Credit Cards Table Structure

Earnings Table

Table Name	earnings
Description	To store the earning details of drivers
Primary Key	_id

Attribute Name	Description	Data Type	Format	PK or FK	Required	Foreign Key Reference Table
_id	Unique identification number of each earning record	oid	-	PK	Yes	-
userId	The identification number of drivers who earned the amount	string	-	FK	Yes	users
amount	The overall amount earned by the drivers for a journey	float	0.00	-	Yes	-

dateTime	The date and time when the payment is made	string	yyyy-mm-dd HH:MM:SS	-	Yes	-
journeyId	The unique identification number of the journey	string	-	FK	Yes	journeys

Table 23: Earnings Table Structure

Payment Table

Table Name	payment
Description	To store the payment details of all the completed journeys
Primary Key	_id

Attribute Name	Description	Data Type	Format	PK or FK	Required	Foreign Key Reference Table
_id	Unique identification number of the payment records	oid	-	PK	Yes	-

dateTime	The date and time when the payment is made	string	yyyy-mm-dd HH:MM:SS	-	Yes	-
journeyId	The identification number of the journey	string	-	-	Yes	-
amount	The amount that has been paid by the passengers upon the completion of the journey	string	0.00	-	Yes	-
userId	The unique identification number of the passengers	string	-	FK	Yes	users

Table 24: Payment Table Structure

7.2.3 Interface Design (Storyboard)

7.2.3.1 Sign in Activity



Figure 29: Interface for Sign in Page

7.2.3.2 Sign Up Activity



Figure 30: Interface for Sign Up Page

7.2.3.3 Verifications Activity (Passenger)

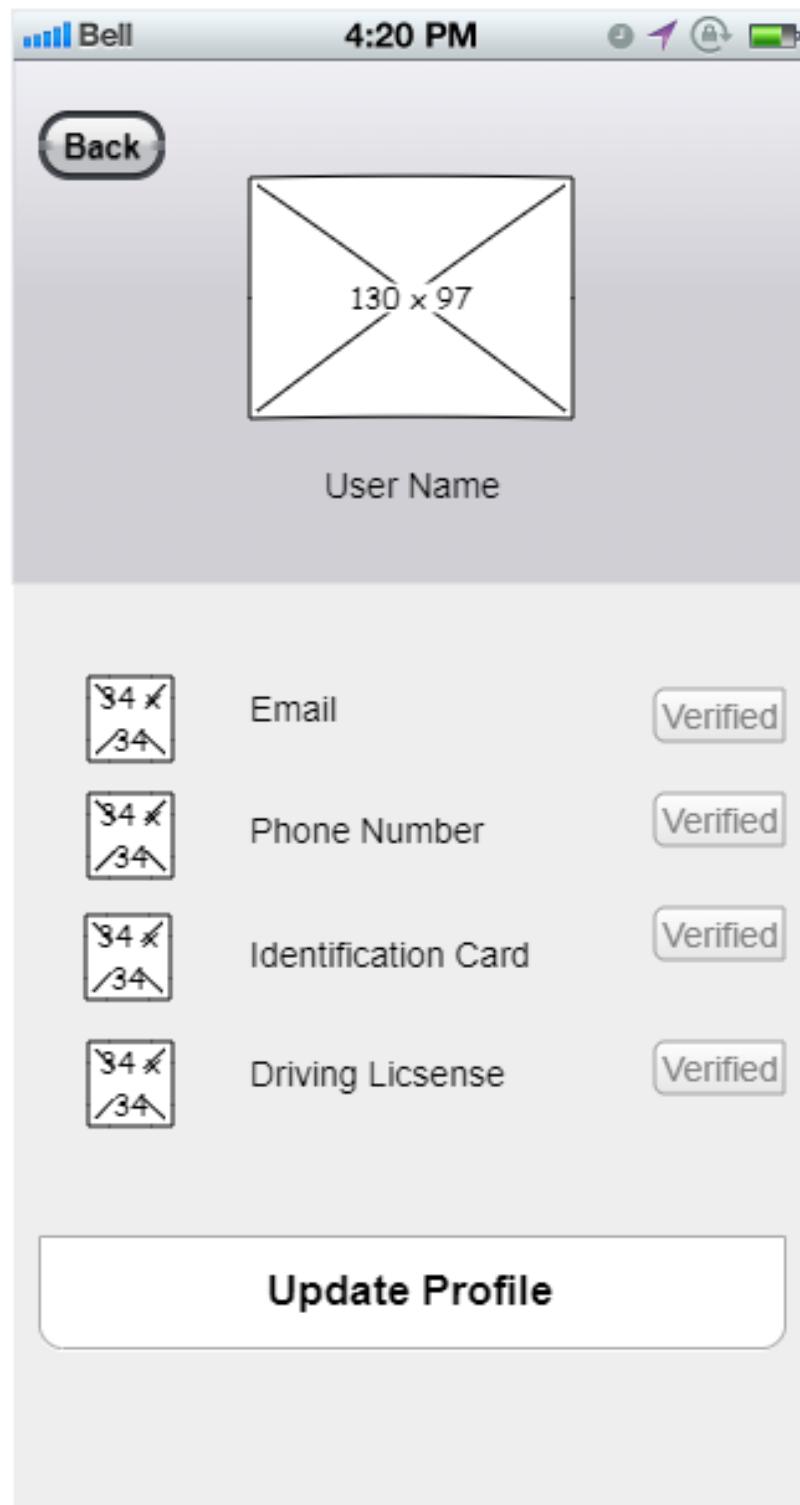


Figure 31: Interface for Verifications Page

7.2.3.4 Find a Ride Activity (Passenger)

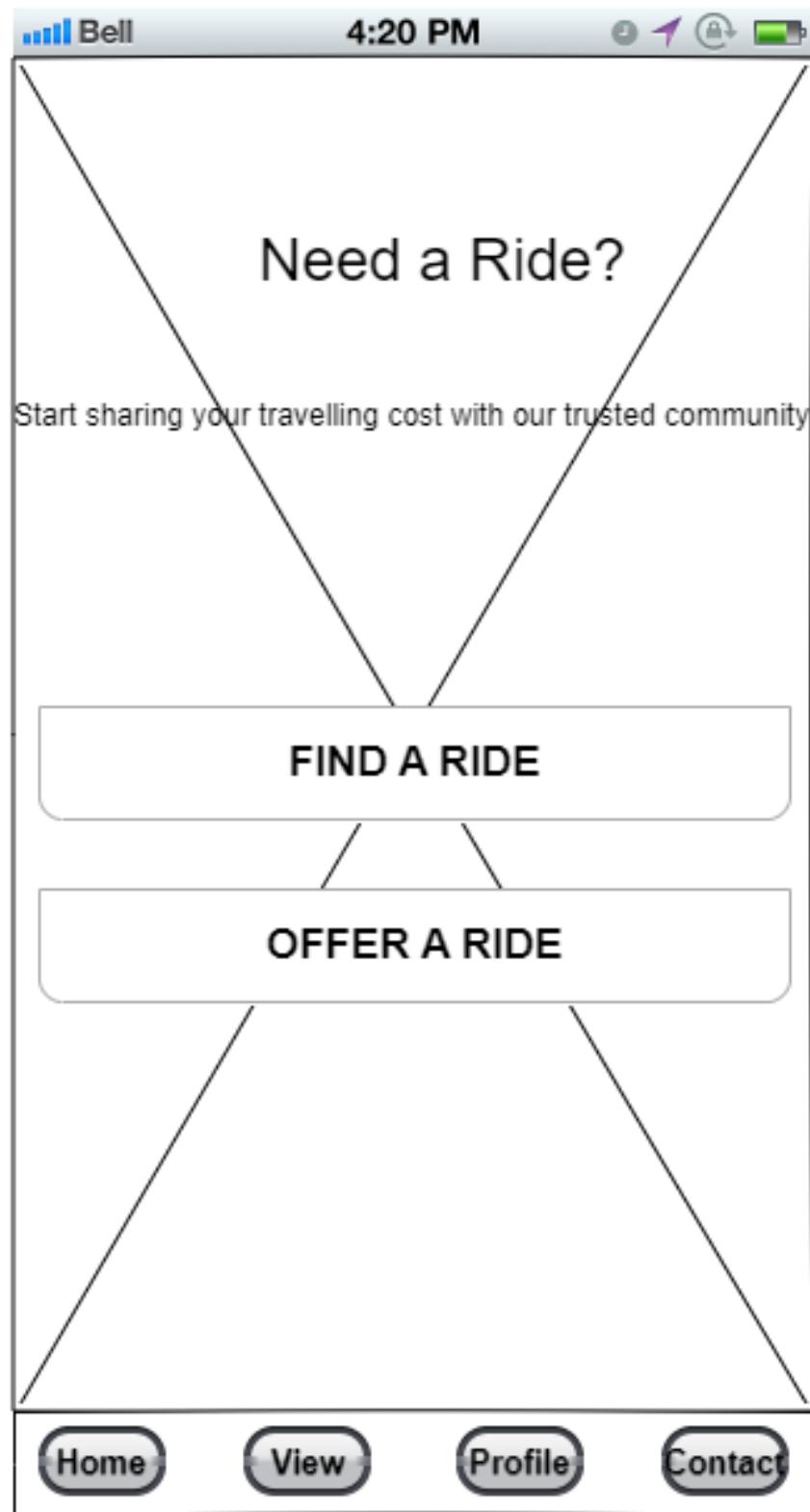


Figure 32: Interface for Find a Ride Page

7.2.3.5 Search Journeys Activity (Passenger)

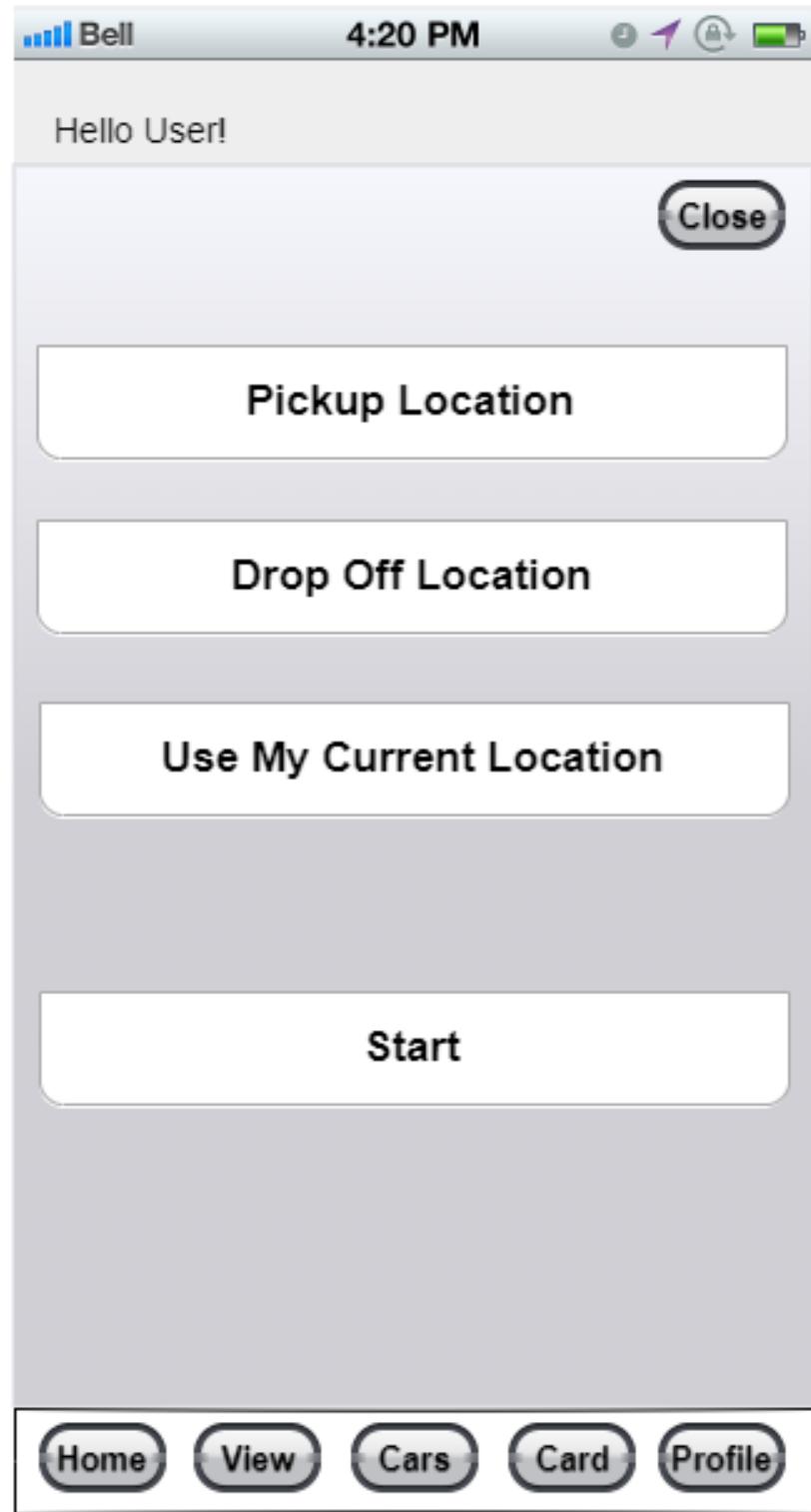


Figure 33: Interface for Search Journeys Page

7.2.3.6 View Available Rides Activity (Passenger)

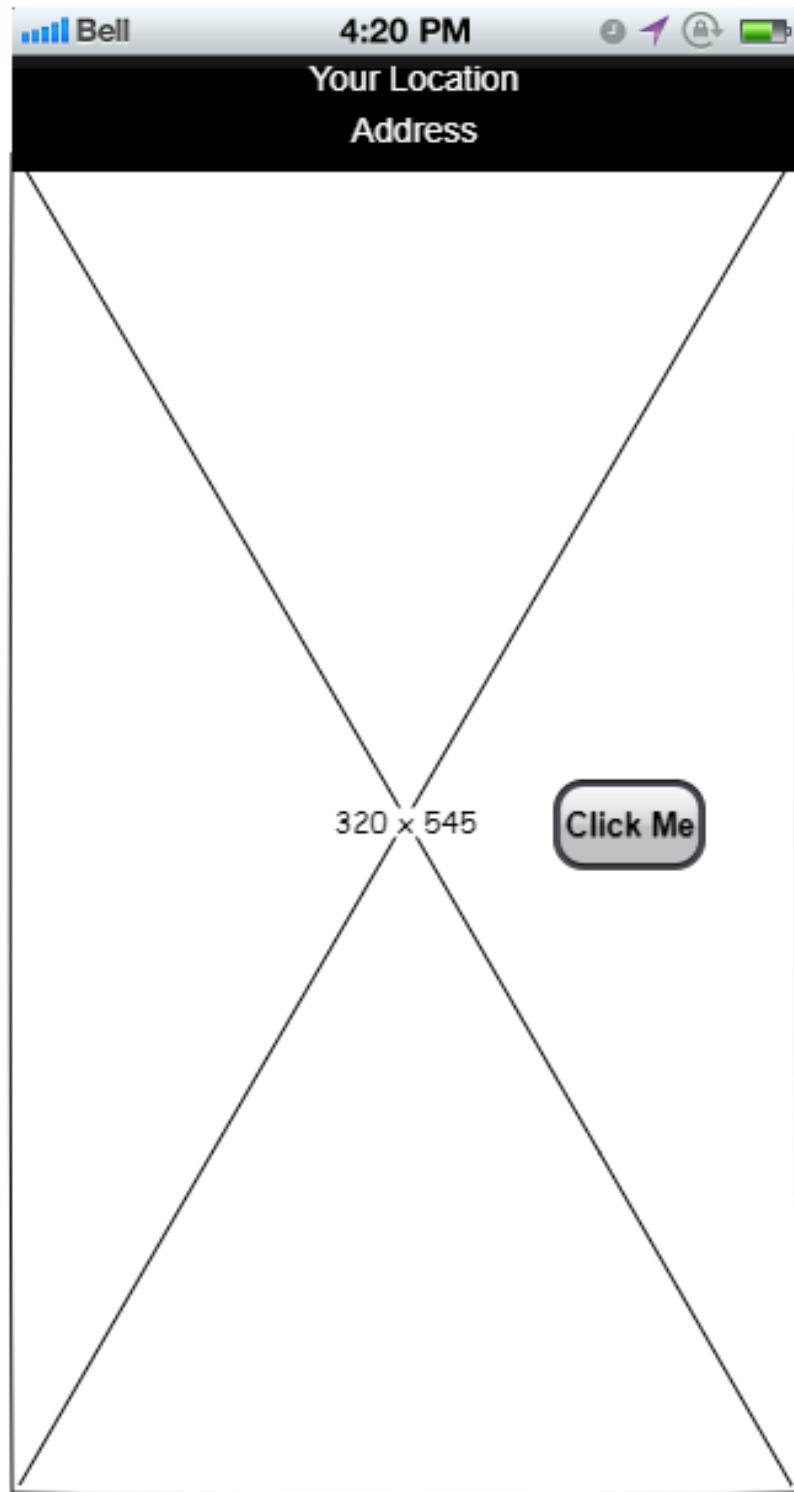


Figure 34: Interface for View Available Rides Page

7.2.3.7 View Ride Details Activity (Passenger)

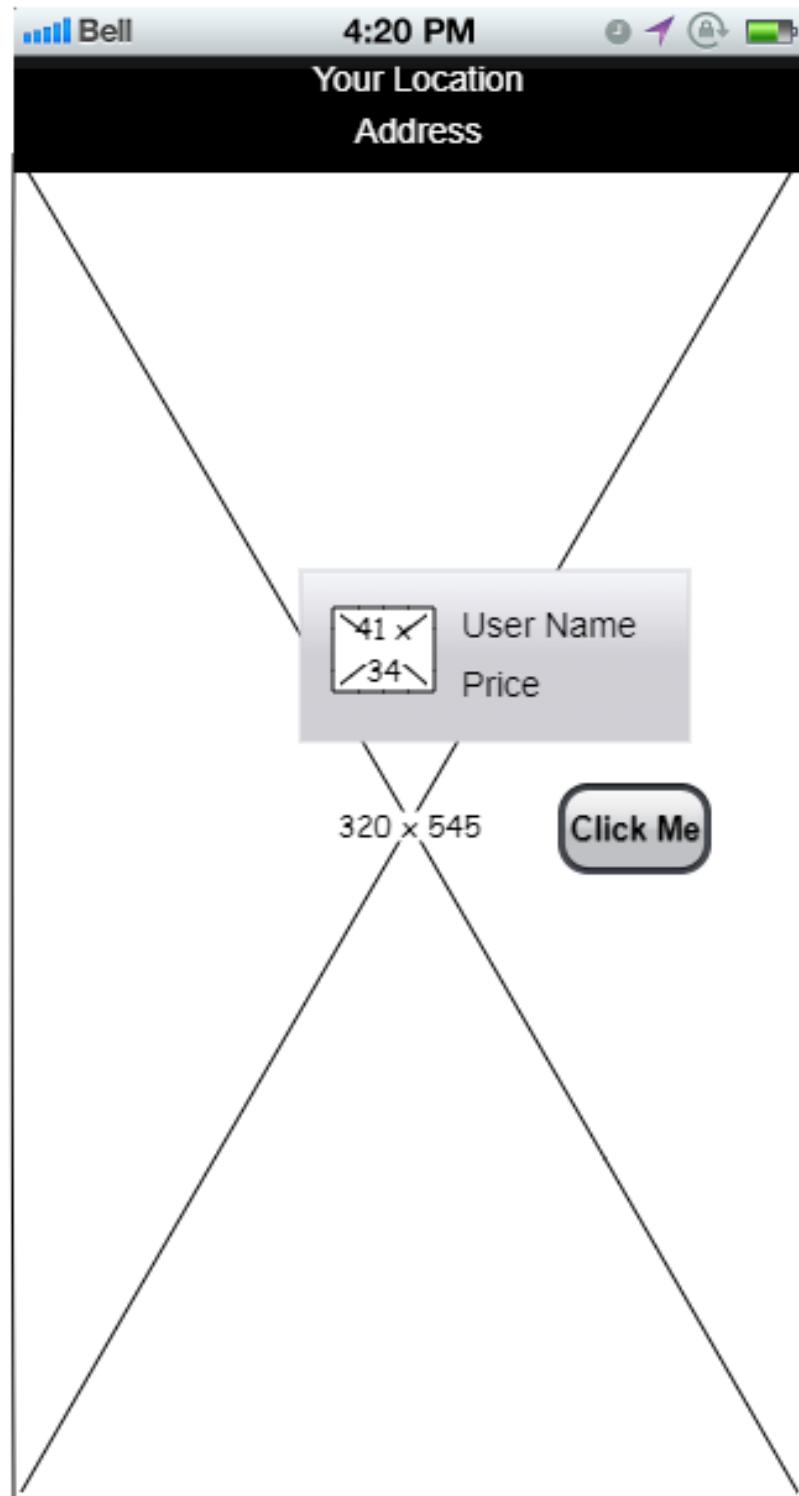


Figure 35: Interface for View Ride Details Page

7.2.3.8 View Journey Information and Make Payment Activity (Passenger)

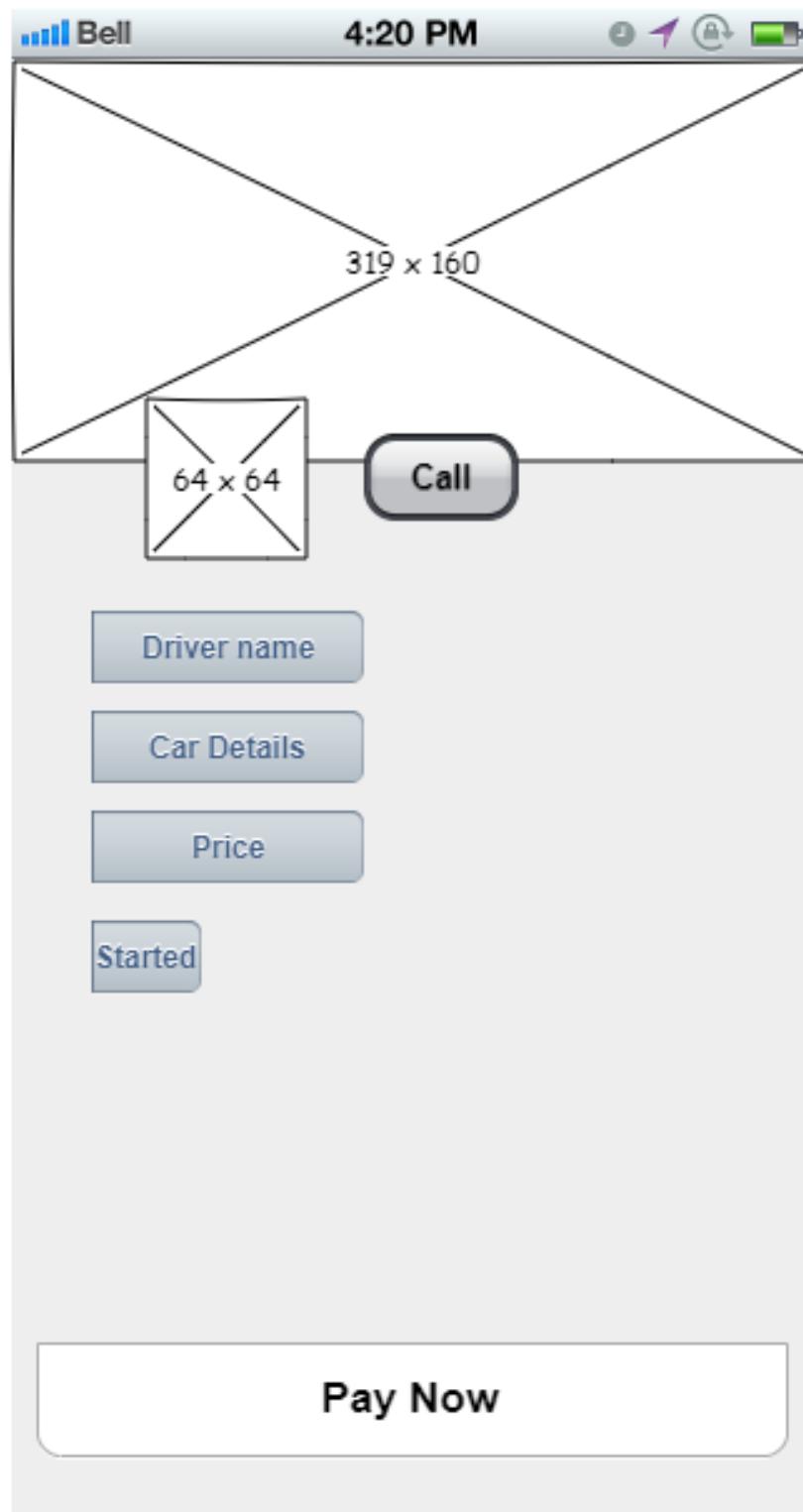


Figure 36: Interface for View Journey Information Page

7.2.3.9 Make Payment Activity (Passenger)

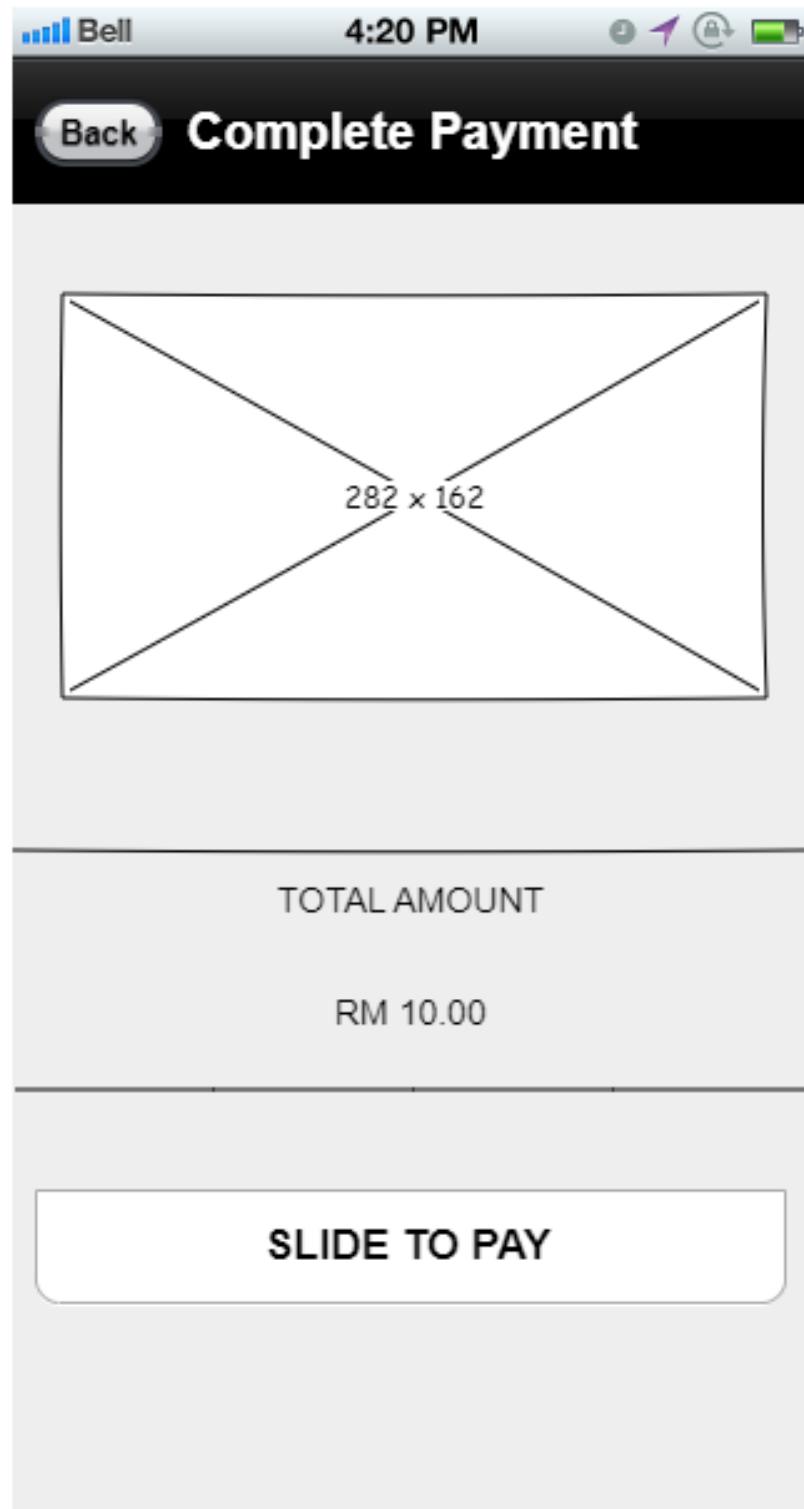


Figure 37: Interface for Make Payment Page

7.2.3.10 Cancel Journey Activity (Passenger)

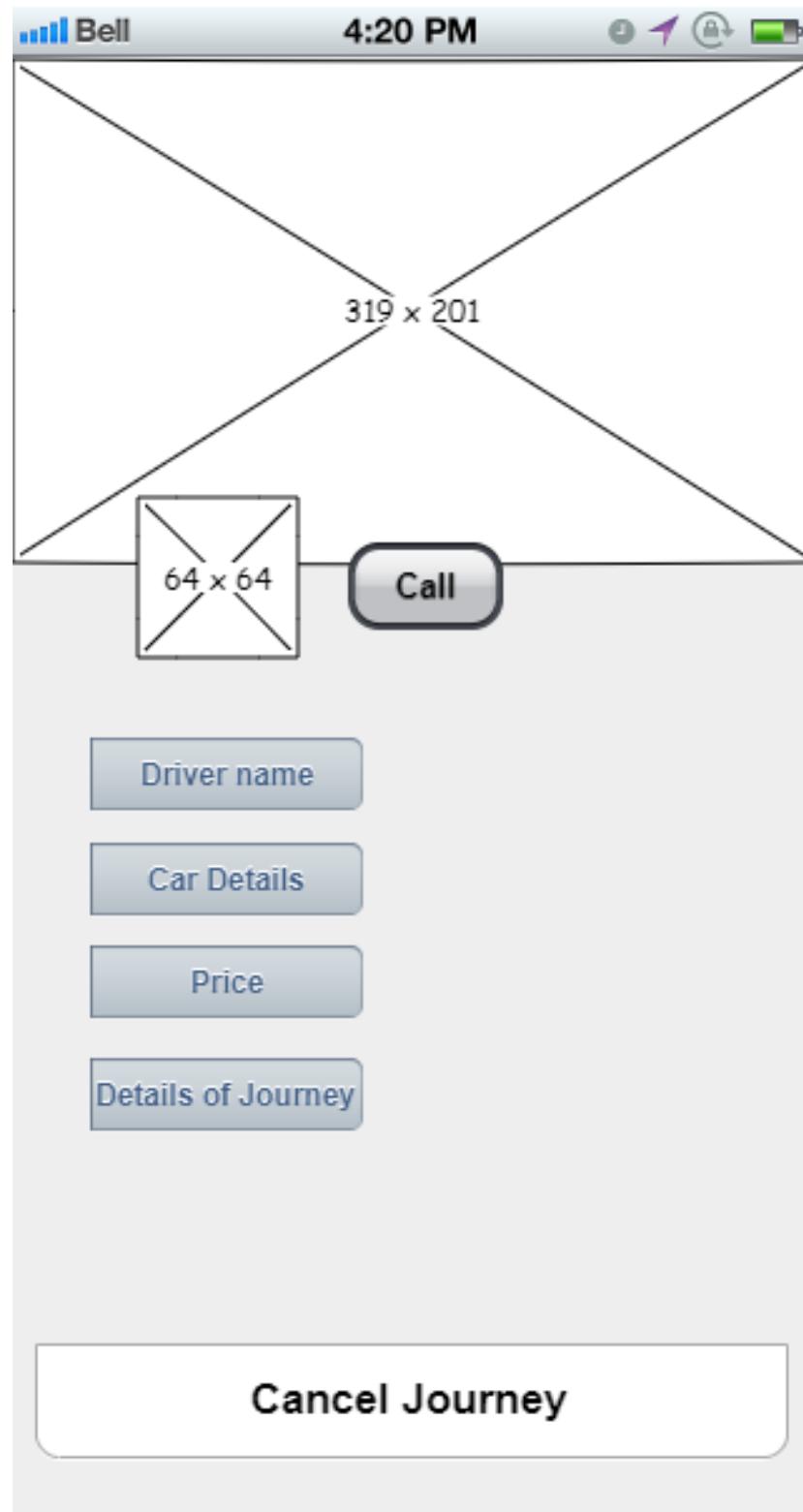


Figure 38: Interface for Cancel Journey Page

7.2.3.11 Add a Card Activity (Passenger)

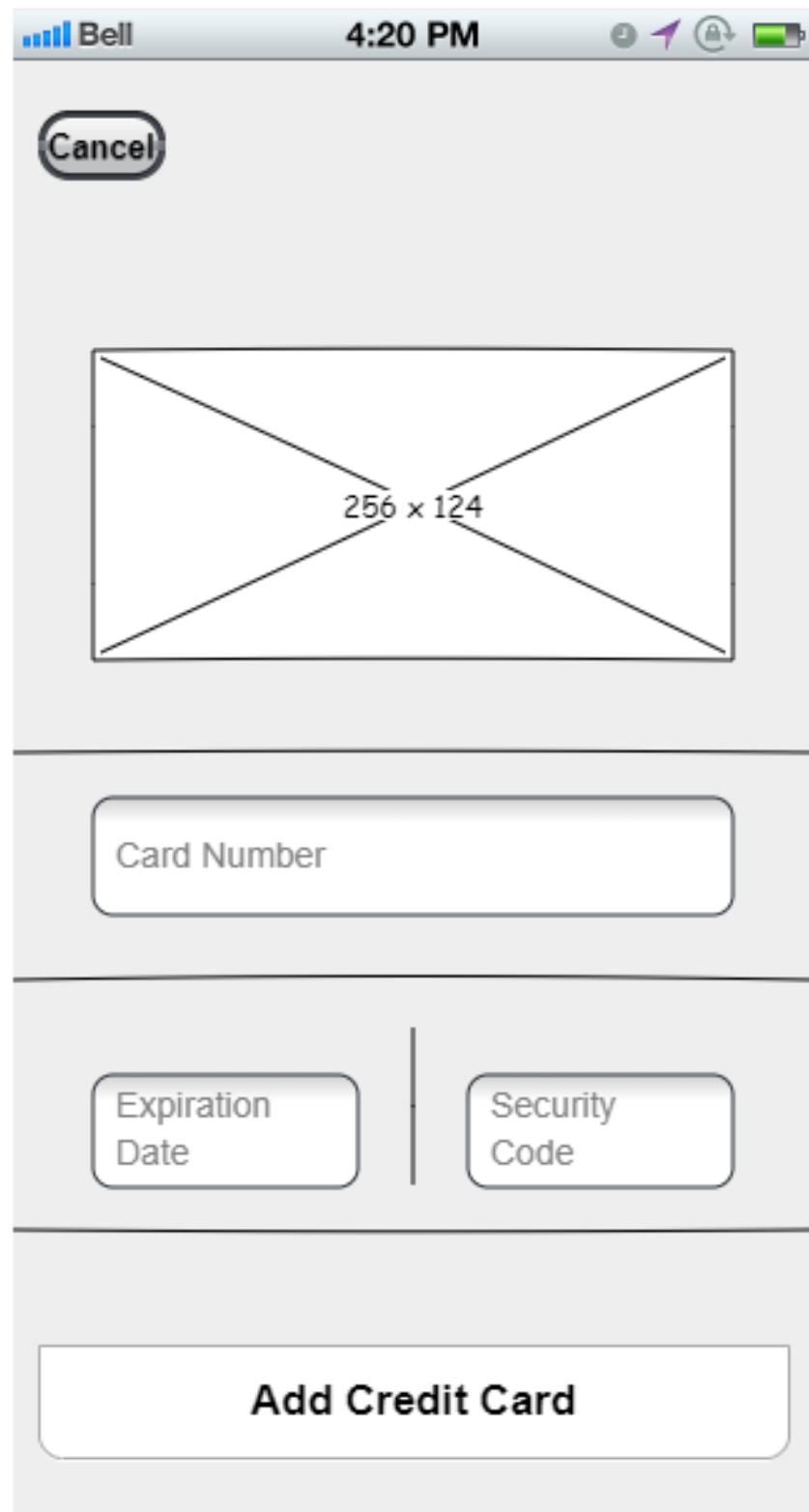


Figure 39: Interface for Add a Card Page

7.2.3.12 Delete a Card Activity (Passenger)

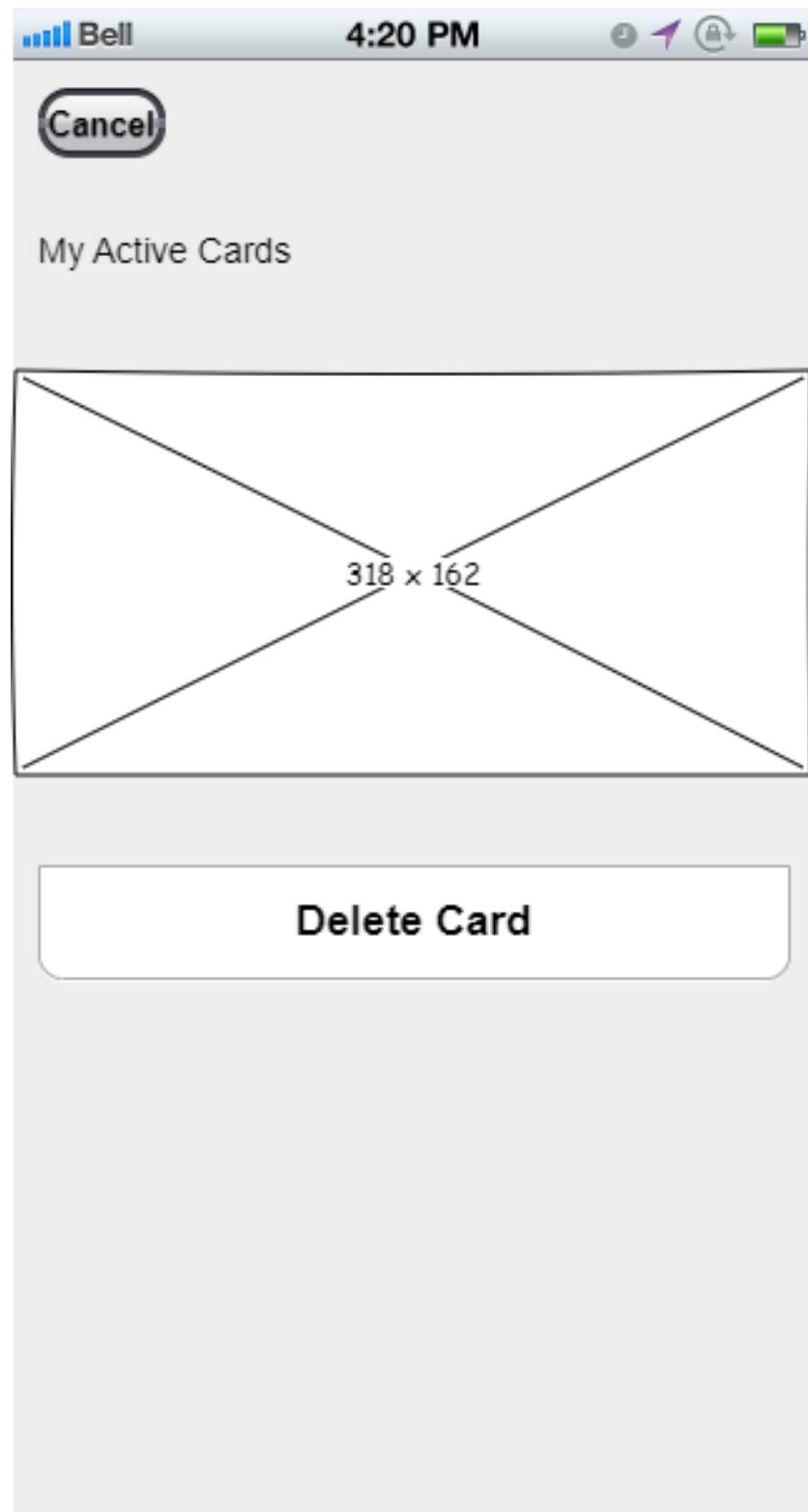


Figure 40: Interface for Delete a Card Page

7.2.3.13 Feedback Activity

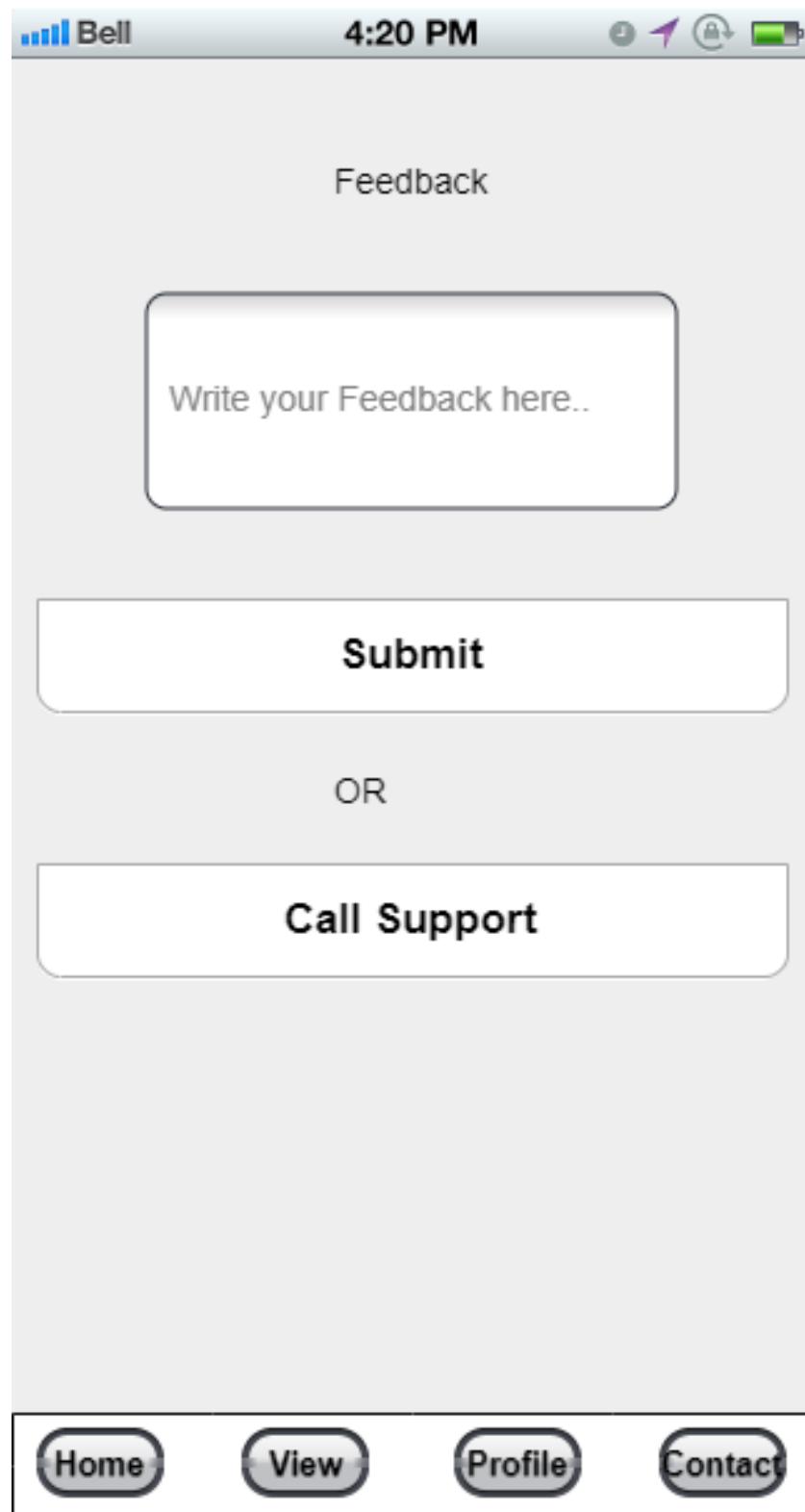


Figure 41: Interface for Feedback Page

7.2.3.14 Manage Profile Activity

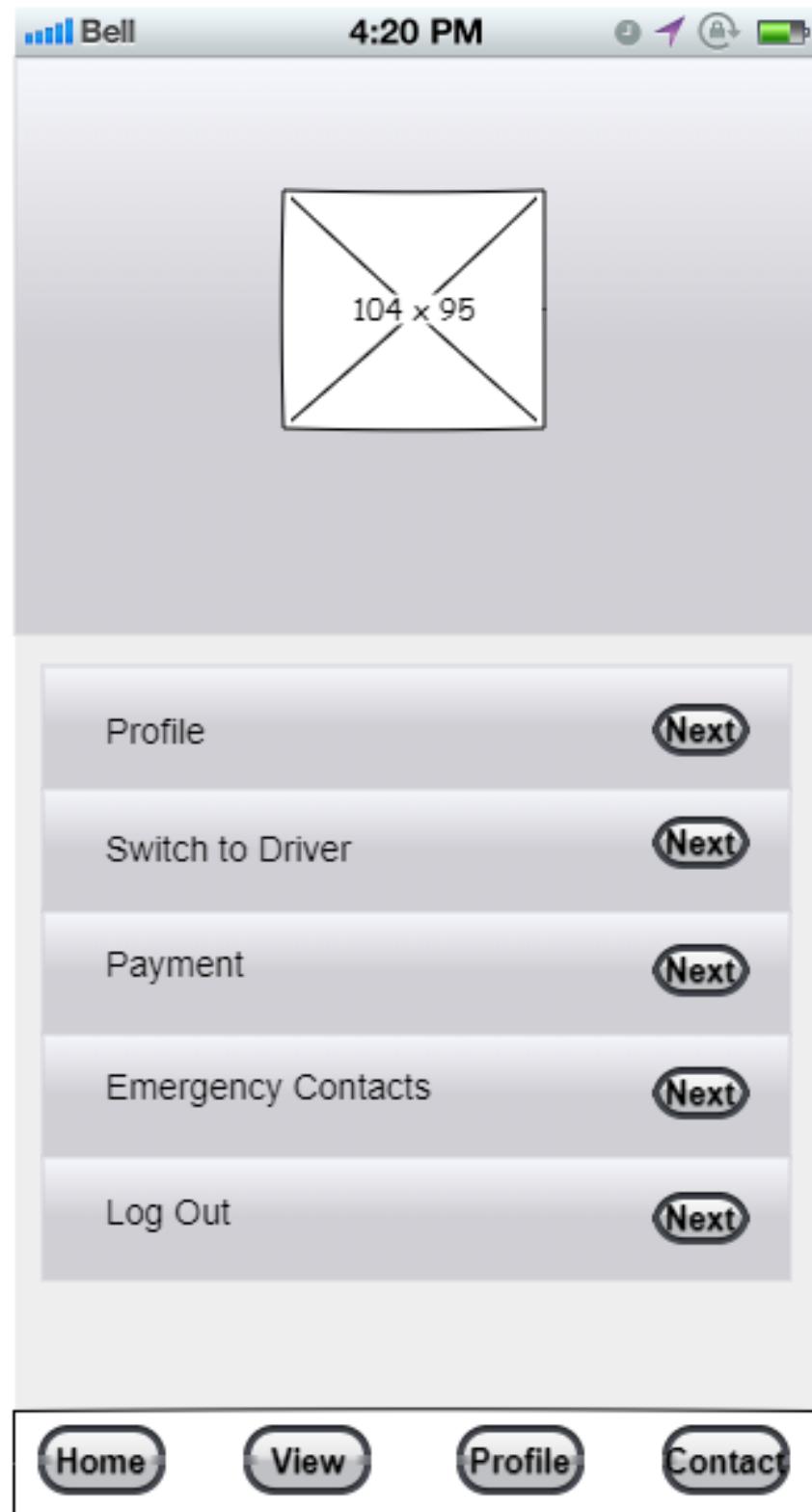


Figure 42: Interface for Manage Profile Page

7.2.3.15 Manage Journeys Activity (Passenger and Driver)

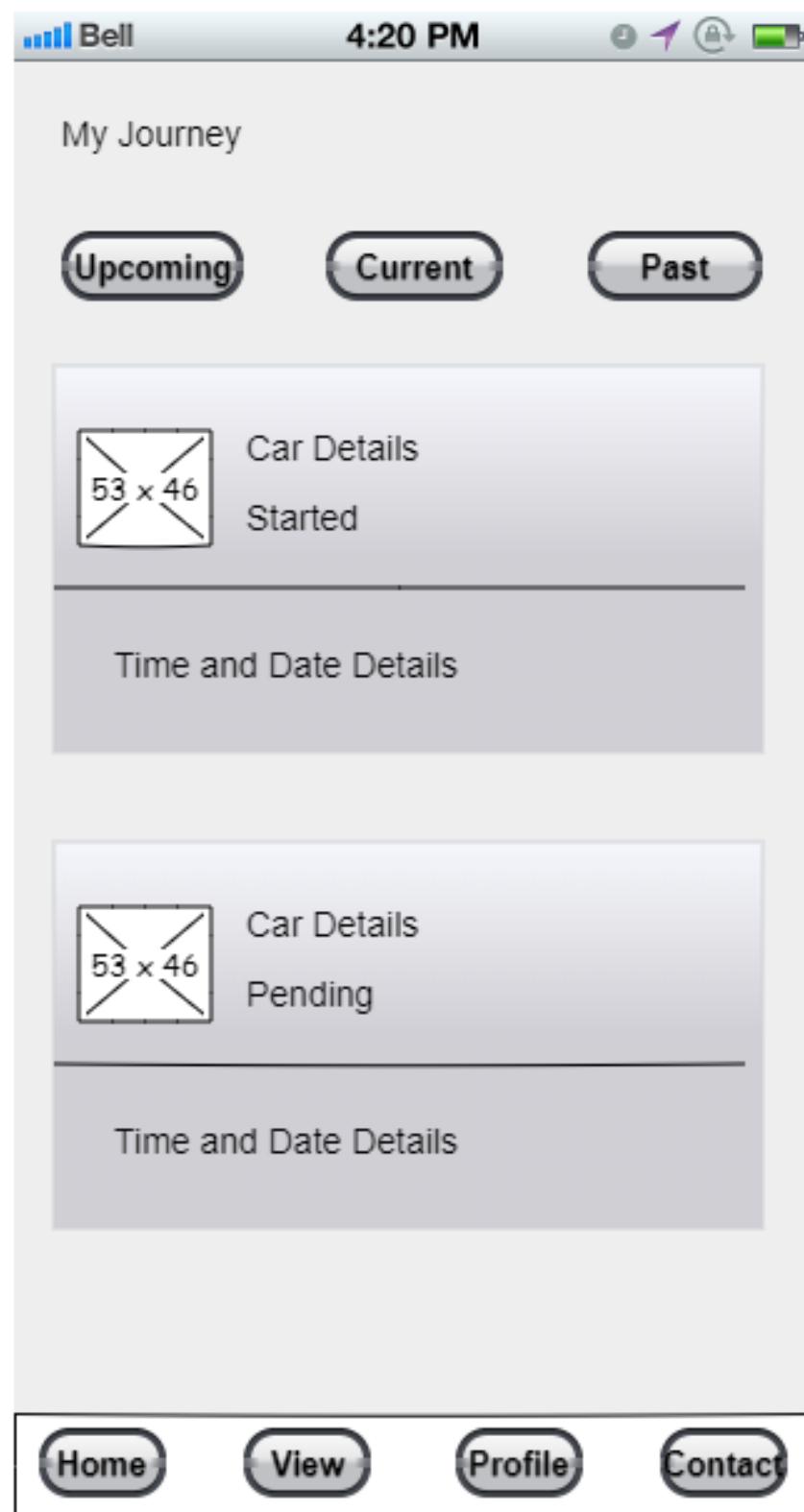


Figure 43: Interface for Manage Journeys Page

7.2.3.16 Register a New Car Activity (Driver)

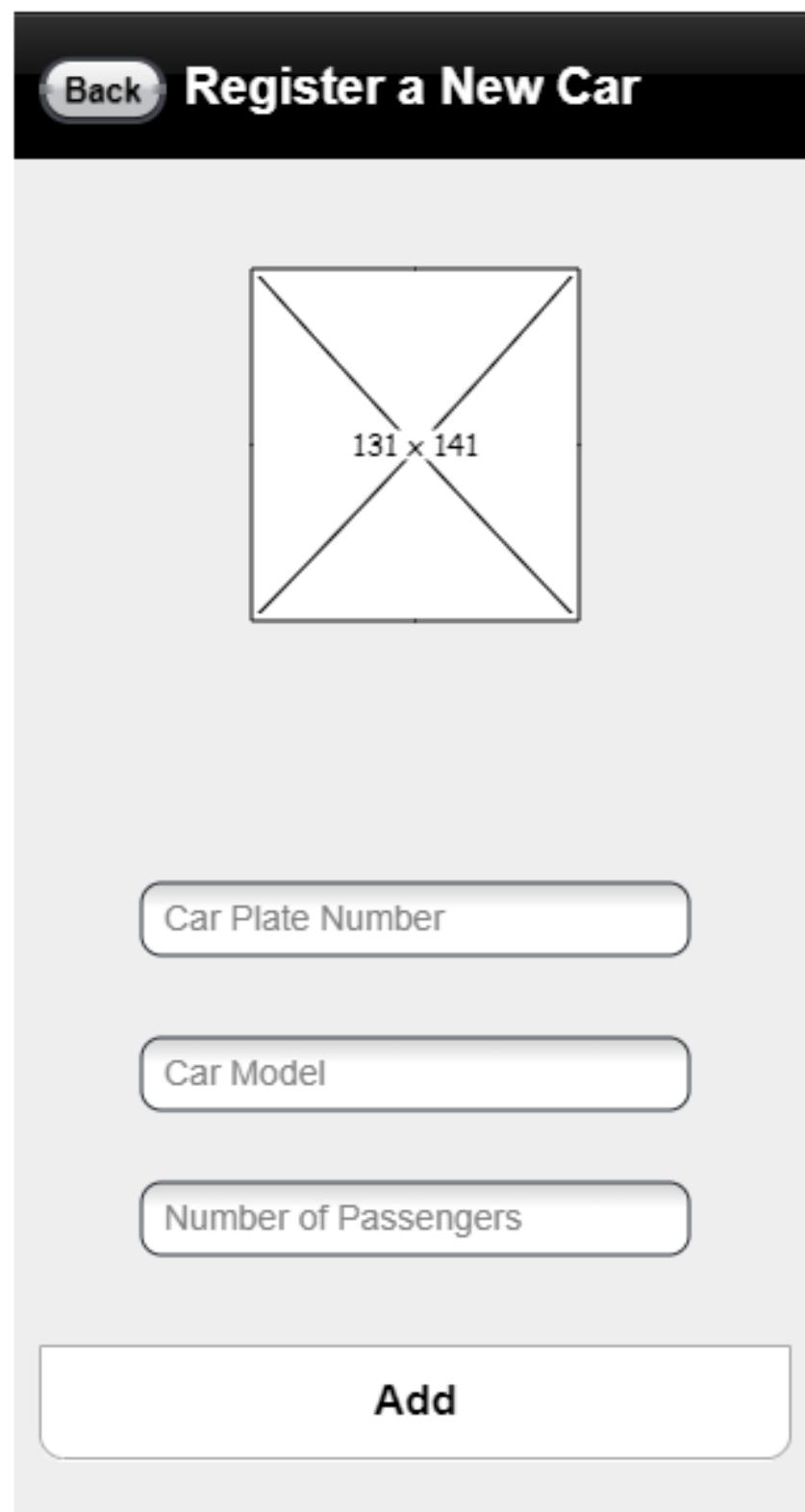


Figure 44: Interface for Register a New Car Page

7.2.3.17 Manage Cars Activity (Driver)

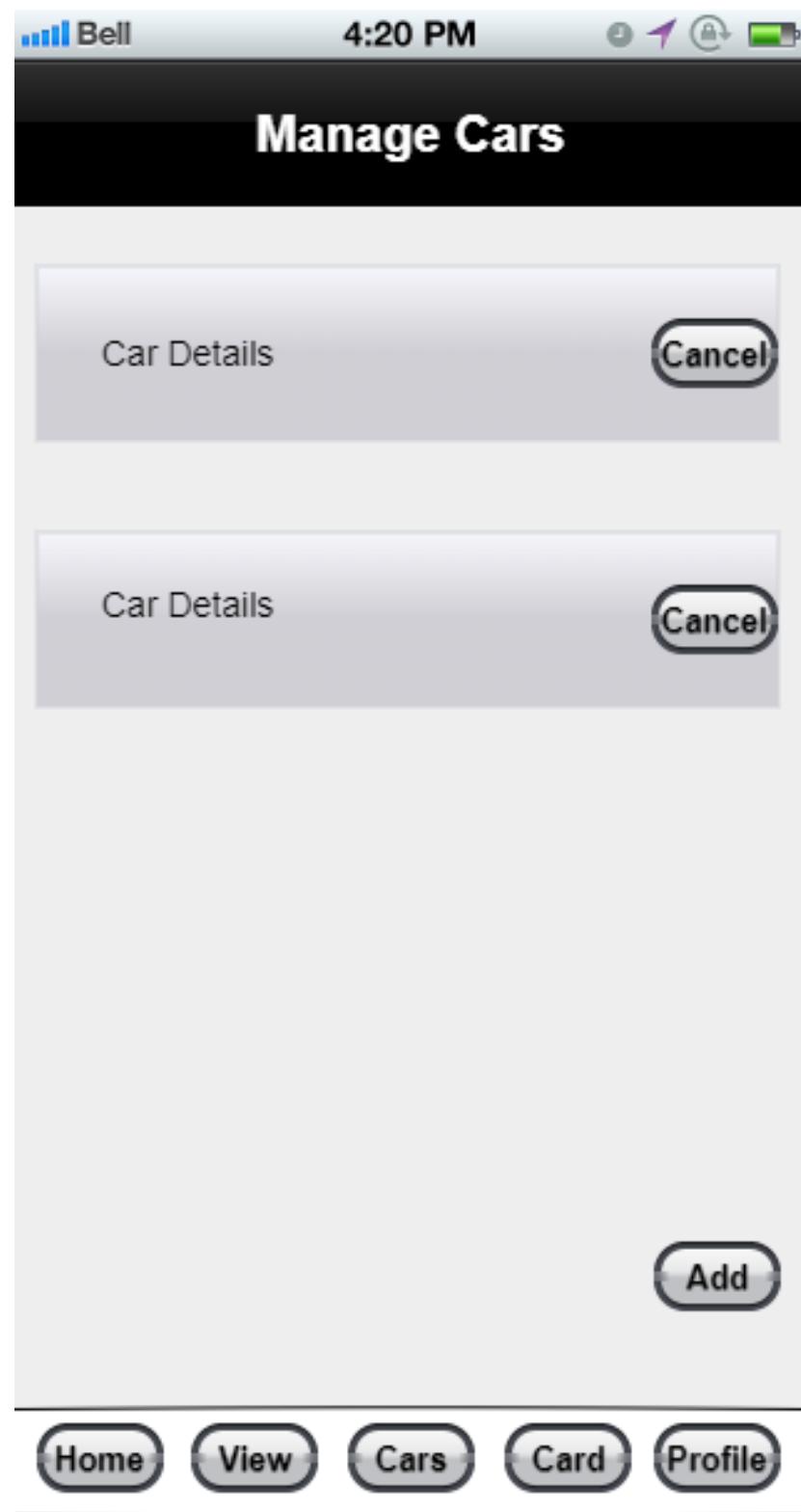


Figure 45: Interface for Manage Cars Page

7.2.3.18 Add Path Activity (Driver)

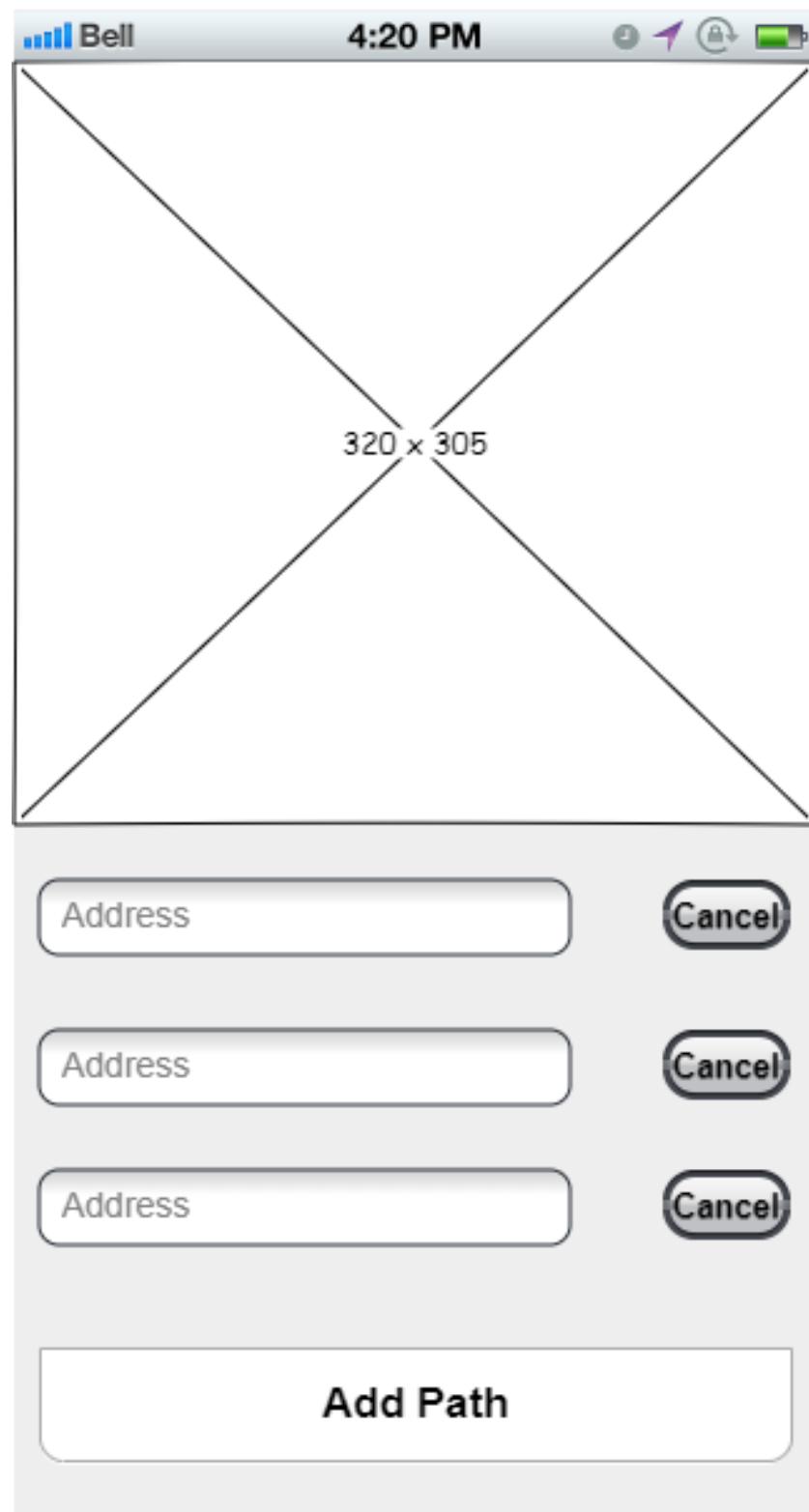


Figure 46: Interface for Add Path Page

7.2.3.19 Manage Paths Activity (Driver)



Figure 47: Interface for Manage Paths Page

7.2.3.20 Complete Journey Activity (Driver)

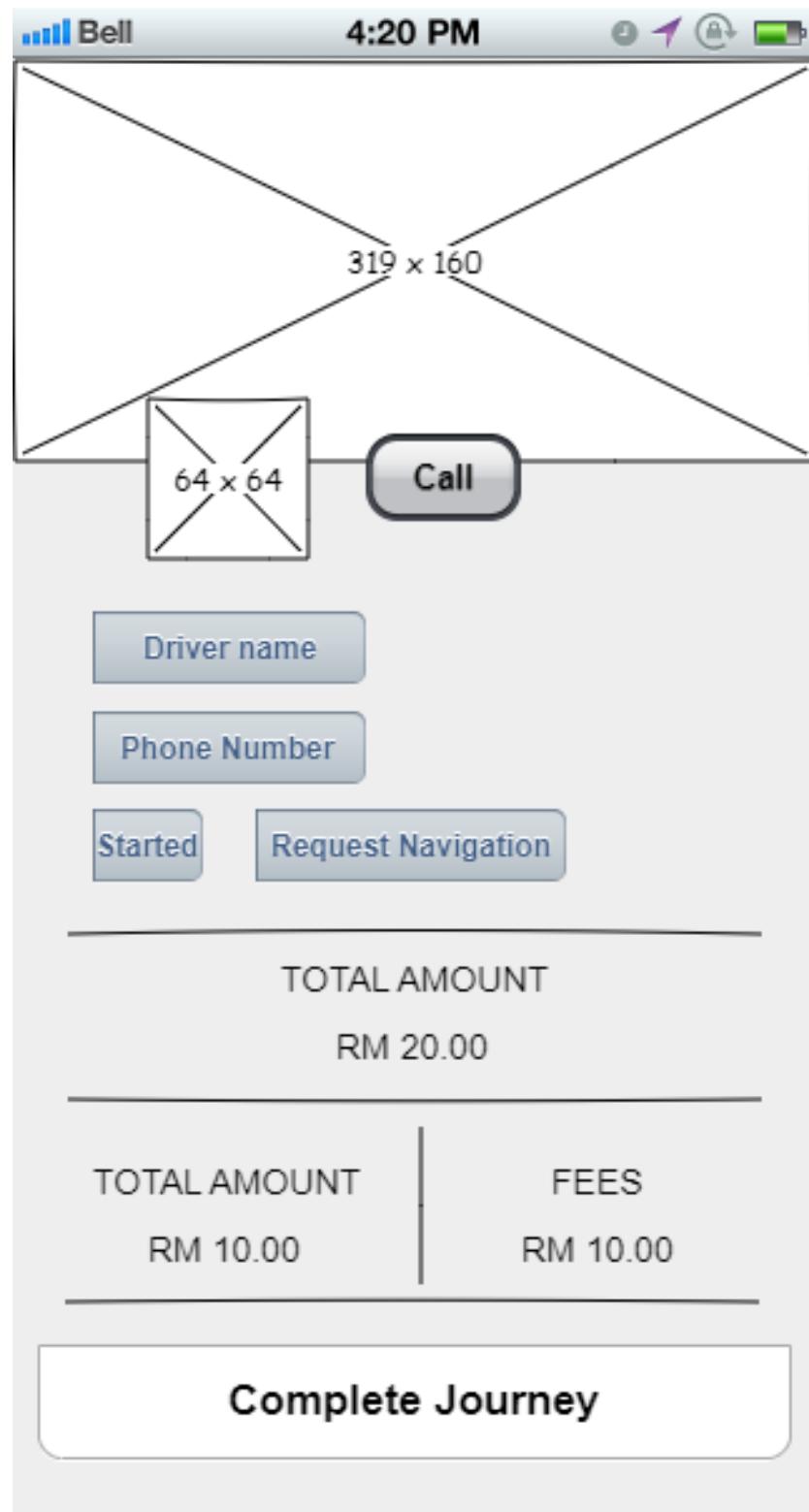


Figure 48 :Interface for Complete Journey Page

7.2.3.21 Verify or Accept Journeys Activity (Driver)

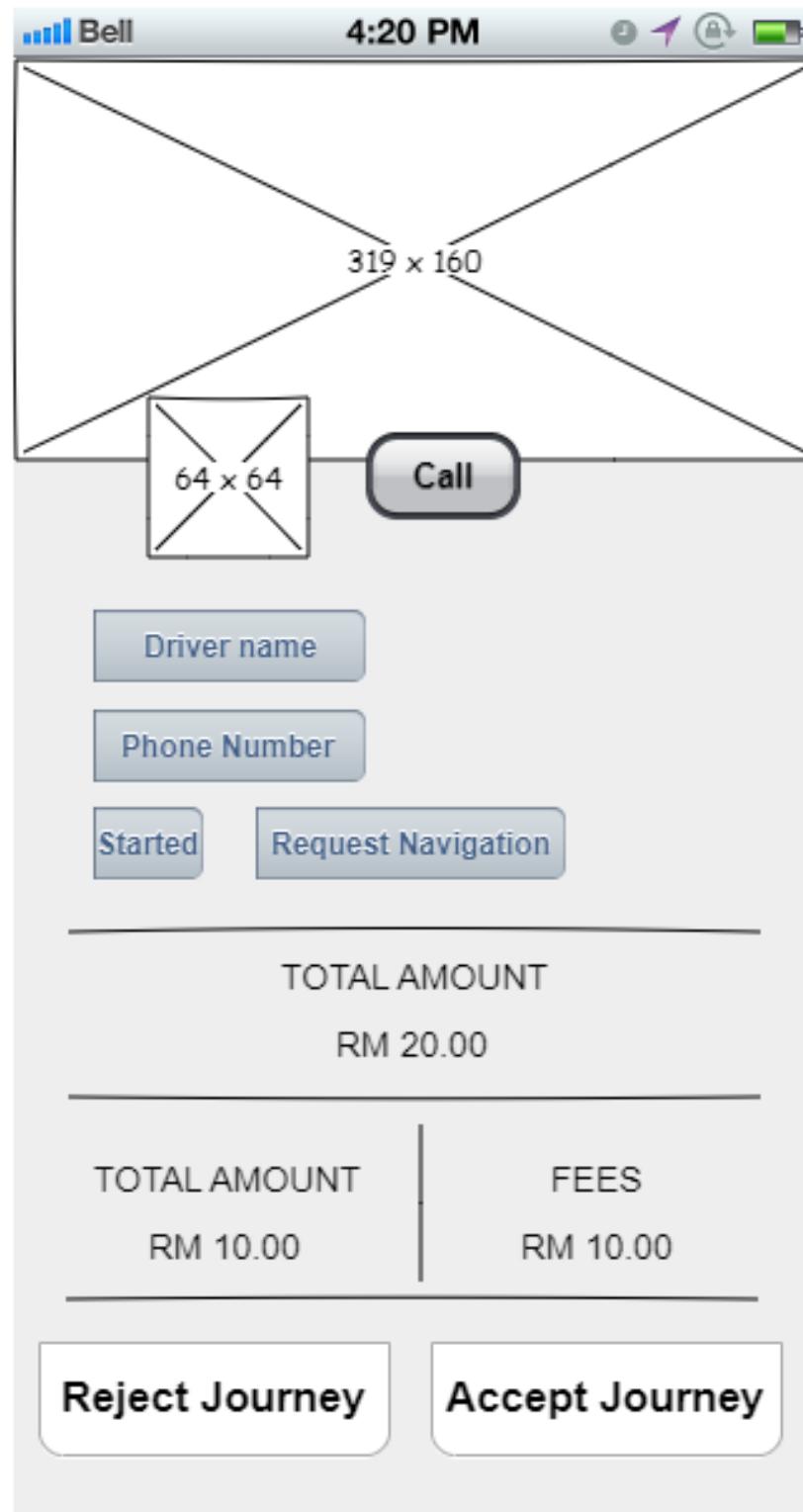


Figure 49: Interface for Verify or Accept Journeys Page

8 Project Plan

8.1 Details of the release plan

A release plan can be classified as a crucial element for an application as it is designed to capture the software releases with the help of a timetable. In certain scenarios, multiple releases are done within a significant period of time in order to manage the overall optimization of the project. Moreover, a release plan is also needed to monitor the deployment of a software in a much more coordinated and systematic manner. In relation to that, a release plan is devised for the implementation of Easy Ride mobile application which comes in three different versions. Each version of the application incorporates certain fascinating upgrades to enhance the overall user experience and to provide more options to the users. The features and functionalities that are included in all the three versions of Easy Ride mobile application are further discussed below.

8.1.1 Version 1.0 of Easy Ride Carpooling Mobile Application

The first version of Easy Ride includes the basic functionalities which are required for users to access the application without any trouble. For instance, this version incorporates a registration page which allows new users to register as a passenger. Other than that, a login page has also been included in order to allow registered users to access the system. In this version, the users are able to manage their profile information and they can even send feedback to the system administrator. Other than that, dummy information about journeys has been included in the application for the users to explore the journey functionalities by entering the corresponding starting point, destination and time. With this, the administrator and developer are able to comprehend what are the functionalities that are highly sought by the targeted users.

- a) Login
- b) Registration
- c) Manage profile
- d) Send feedback to administrators
- e) Explore the journey functionalities by entering the required information

8.1.2 Version 2.0 of Easy Ride Carpooling Mobile Application

The second version of Easy Ride includes some of the core features of the application. In this version, Google Maps API has been integrated to provide users with a much more interactive and fascinating user experience. All the journey search results will be shown as markers on Google Maps and the users can simply choose one to view the detailed information about the journey. Moreover, the users can manage their credit card information via the platform as the application is integrated with Stripe API. As soon as a journey completes, the users can make payment to the driver via the registered credit card. In this version, the users have the privilege to become a driver by verifying their license, identification card, phone number and email. As soon as all the information are verified, the user can now explore the features and functionalities of drivers. As a driver, the user is now able to create rides by adding the starting point, date, time, waypoints and destination. They will receive a notification if a passenger requests for a particular ride. Besides that, they can even manage their car information throughout the application.

- a) Integration of Google Maps API
- b) Manage credit card information
- c) Make payment after a journey completes
- d) Verify license, identification card, email address and phone number to become a driver
- e) Manage car information (Driver)
- f) Create rides by inputting required information (Driver)
- g) Receive notification if a passenger requests for a particular ride. (Driver)

8.1.3 Version 3.0 of Easy Ride Carpooling Mobile Application

The second version of Easy Ride mobile application has been significantly improved by incorporating some fascinating and enhanced features. In this version, both passengers and drivers are capable to manage the status of all the booked journeys. The drivers are able to view their earnings as soon as a journey is completed. Besides that, the drivers are capable to upload their car images when registering a new car into the system. Since security is one of the main concerns in this project, various security elements have been implemented in the system to protect user's information and to prevent unauthorised intrusions. For instance, JSON Web Token has been integrated for secure transmission of data between the client device and server. Besides that, in this version, Bcrypt Hashing has been added to provide additional security for user's credentials which will be hashed before storing in the database. Moreover, code obfuscation is done with the use of JavaGuard library to make the source code difficult for the potential hackers to understand when they attempt to perform reverse engineering. Besides that, fingerprint authentication has also been included in this third and final version to make the payment processes secure and reliable. The overall user interface and user experience have been enhanced in this version by adding more graphical images and icons.

- a) Manage journey information
- b) View earnings (driver)
- c) Upload car images (Driver)
- d) Implementation of JSON Web Token
- e) Implementation of Bcrypt Hashing
- f) Code Obfuscation
- g) Fingerprint authentication when making payment
- h) Enhanced user interfaces and user experience.

8.2 Test Plan

8.2.1 Test Plan for Unit Testing

The following section briefly highlights the test plans that are used when conducting unit testing of Easy Ride mobile application.

8.2.1.1 Login Test Plan

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
1.1	Clicks sign in button with empty email address and empty password	Email Address Text Field: Empty Password Text Field: Empty	Displays “Email Address or Password cannot be empty” message		
1.2	Clicks sign in button with email address and empty password	Email Address Text Field: kogilan97@gmail.com Password Text Field: Empty	Displays “Email Address or Password cannot be empty” message		
1.3	Clicks sign in button with empty email address and password	Email Address Text Field: Empty Password Text Field: Kogilan6571@	Displays “Email Address or Password cannot be empty” message		
1.4	Clicks sign in button with invalid email address and valid password	Email Address Text Field: koigli@gmals.com Password Text Field: Kogilan6571@	Displays “Incorrect Email Address or Password” message		

1.5	Clicks sign in button with valid email address and invalid password	Email Address Text Field: kogilan97@gmail.com Password Text Field: 2343fggfd	Displays “Incorrect Email Address or Password” message		
1.6	Clicks sign in button with invalid email address and invalid password	Email Address Text Field: koigli@gmals.com Password Text Field: 2343fggfd @	Displays “Incorrect Email Address or Password” message”		
1.7	Clicks sign in button with valid email address and password	Email Address Text Field: kogilan97@gmail.com Password Text Field: Kogilan6571@	Displays “You have successfully logged into the system” message and redirect to the homepage		
1.8	Clicks the ‘Don’t have an account? Register’ Text	-	Directs to home Sign Up Page		

Table 25: Login Component (Test Plan)

8.2.1.2 Sign Up Test Plan

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
2.1	Clicks ‘Sign Up’ Button with empty email address, username, phone number, password and confirm password	Email Address Text Field: Empty Username Text Field: Empty Phone Number Text Field: Empty Password Text Field: Empty Confirm Password Text Field: Empty	Displays ‘Textfields cannot be empty’ message		
2.2	Clicks ‘Sign Up’ Button with invalid email address format	Email Address Text Field: kogilan97.com Username Text Field: Kogilan97 Phone Number Text Field: 60143644558 Password Text Field: Kogilan97@	Displays ‘Invalid Email Address’ message		

		Confirm Password Text Field: Kogilan97@			
2.3	Clicks ‘Sign Up’ Button with an existing email address	Email Address Text Field: kogilan97@gmail.com Username Text Field: Kogilan97 Phone Number Text Field: 60143644558 Password Text Field: Kogilan97@ Confirm Password Text Field: Kogilan97@	Displays ‘email address already exists’ message		
2.4	Clicks ‘Sign Up’ Button with unmatching password and confirm password	Email Address Text Field: kogilan97.com Username Text Field: Kogilan97 Phone Number Text Field: 60143644558 Password Text Field:	Displays ‘password and confirm password do not match’ message		

		Kogilan9@ Confirm Password Text Field: Kogilan97@			
2.5	Clicks ‘Sign Up’ Button with valid information	Email Address Text Field: kogilan97@gmail.com Username Text Field: Kogilan97 Phone Number Text Field: 60143644558 Password Text Field: Kogilan97@ Confirm Password Text Field: Kogilan97@	Displays ‘successful registration’ message and redirects to the login page		
2.6	Clicks ‘Already have an account? Sign in’ Text	-	Redirects to the Login Page		

Table 26: Sign Up Component (Test Plan)

8.2.1.3 Feedback Test Plan

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
3.1	Clicks ‘Contact Us’ option from the bottom navigation bar	-	Directs to the Feedback Page		
3.2	Clicks ‘Call Support’ button	-	Calls the administrator of the application		
3.3	Clicks ‘Submit’ button with empty feedback	Feedback Text Field: Empty	Displays “Feedback cannot be empty” message		
3.4	Clicks ‘Submit’ button with a feedback	Feedback Text Field: Test Message	Displays “Feedback has been sent to the administrator” message		

Table 27: Feedback Component (Test Plan)

8.2.1.4 Find a Ride Test Plan

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
4.1	Clicks ‘Home’ option from the bottom navigation bar	-	Redirects to the ‘Find a Ride’ page		

4.2	Clicks the ‘Find a Ride’ button	-	Redirects to the Maps Page and shows the current location		
4.3	Clicks the calendar icon	-	Shows a calendar		
4.4	Clicks the Set button after choosing a date and time from the calendar	-	Captures and displays the date and time		
4.5	Clicks the drop-down menu	-	Shows Pickup Location and Drop off Location text fields.		
4.6	Clicks Start button with empty pick up location and drop off location	Pickup Location TextField: Empty Drop off Location TextField: Empty	Displays ‘Choose pickup location and drop off location” message		
	Clicks Start button with valid pick up location and drop off location	Pickup Location TextField: Taman Puchong Perdana Drop off Location TextField: Bukit Jalil	Displays the route in a map and shows all the available rides in the form of markers		
	Click a marker from the map	-	Displays a tooltip with the respective driver’s name, phone number and price.		

	Clicks the tooltip	-	Books a journey and a notification is sent to the driver		
--	--------------------	---	--	--	--

Table 28: Find a Ride Component (Test Plan)

8.2.1.5 Manage Journeys (Passengers) Test Plan

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
5.1	Clicks ‘Journeys’ option from the bottom navigation bar	-	Redirects to the ‘My Journeys’ Page	-	-
5.2	Clicks ‘Upcoming’ fragment in the page	-	Shows all the upcoming journeys of the user in a recycler view		
5.3	Clicks ‘Current’ fragment in the page	-	Shows all the current journeys of the users in a recycler view		
5.4	Clicks ‘Past’ fragment in the page	-	Shows all the past journeys of the users in a recycler view		

5.5	Clicks a specific journey	-	Shows detailed information about the journey including the driver's phone number, starting point, destination, driver's name, total amount and car.		
5.6	Clicks 'Cancel' button of a specific journey	-	Removes the journey from the fragment and notifies the driver via the application.		
5.7	Clicks 'Pay Now' button of a specific journey	-	Shows the total amount for the journey		
5.8	Swipe Left in the page	-	Proceed to fingerprint authentication section		
5.9	Place the fingerprint on the fingerprint scanner	-	Authenticates the fingerprint and send payment to the driver via the registered card		

Table 29: Manage Journeys Component - Passenger (Test Plan)

8.2.1.6 Manage Profile (Passengers) Test Plan

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
6.1	Clicks the 'Profile' option from the bottom navigation bar	-	Redirects to the Profiles page	-	-
6.2	Clicks the 'Verification' option in the page	-	Redirects to the Verifications page	-	-
6.3	Clicks the 'Verify' Button beside the email address	-	Sends a verification link to the user's email address. When the user clicks the link, the button name is changed to 'Verified' and become disabled.		
6.4	Clicks the 'Verify' Button beside the phone number	-	Sends a 4-digit pin to the user's phone number		
6.5	Inputs the 4-digit number and clicks the 'Verify' button	Four-digit pin: 1234	The button name is changed to 'Verified' and become disabled.		
6.6	Clicks the 'Verify' Button beside the Identification Card text	-	Opens the camera with MicroBlink SDK		

6.7	Scans the identification card with the camera	-	Verifies the text in the identification card and the button name is changed to ‘Verified’		
6.8	Scans any other object with the camera	-	Displays ‘Error’ Message		
6.9	Clicks the ‘Verify’ Button beside the Driving License text	-	Opens the camera with MicroBlink SDK		
6.10	Scans the driving license with the camera	-	Verifies the text in the driving license and the button name is changed to ‘Verified’		
6.11	Clicks the ‘Left Arrow’ icon in the Verifications page	-	Redirects to the Profiles Page		
6.12	Clicks ‘Logout’ option in the page	-	Logs out the user from the system		
6.13	Clicks ‘Switch to Driver’ option when all the verifications are done	-	Redirects to the Driver’s Main Page		

6.14	Clicks ‘Switch to Driver’ option without verifying any of the requested information	-	Shows ‘Complete the verifications’ message		
6.15	Clicks ‘Payment’ option the page	-	Redirects to the Payment Page		
6.16	Clicks ‘Add a credit/debit’ card option	-	Displays three different Text Fields with a card icon		
6.17	Enter blank card number, expiration date and security code	Card number Text Field: Blank Expiration Date Text Field: Blank Security Code Text Field: Blank	Add Credit card button is disabled with less opacity		
6.18	Begins typing the card number	-	Displays the number on the card as the user types. Displays Visa or MasterCard icon based on the user’s input		

6.19	Begins typing the expiration date	-	Displays the expiration date on the card as the user types		
6.20	Clicks add/debit card button with the valid card number, expiration date and security code	Card number Text Field: 4444 4444 4444 4444 Expiration Date Text Field: 12/9 Security Code Text Field: 957	Sends a Stripe API call and get the token which will be saved in the database. ‘Successful Card Registration’ message is displayed		
6.21	Clicks ‘Delete the Card’ button	-	The card details are removed from the page. ‘The card is successfully deleted message’ is shown		

Table 30 : Manage Profile Component(Test Plan)

8.2.1.7 Manage Paths (Driver) Test Plan

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
7.1	Clicks on the Home button from the bottom navigation bar	-	Redirects to the ‘Paths’ page. All the previously	-	-

			created paths are shown in a recycler view.		
7.2	Clicks on ‘Offer Ride’ text	-	Displays a menu with Pickup Location text field and Drop off Location text field		
7.3	Clicks Start button with empty pickup location and drop off location	Pickup location Text Field: Empty Drop off location Text Field: Empty	Displays ‘pick up location and drop off location cannot be empty’ message		
7.4	Clicks Start button with valid pickup location and drop off location	Pickup location Text Field: Bukit Jalil Drop off location Text Field: Puchong Perdana	Displays a map in which the pickup location and drop off location are shown as markers.		
7.5	Clicks on a particular location on the map	-	Displays a marker on the map and adds the location as one of the waypoints		
7.6	Clicks more than five times on the map	-	Displays ‘Maximum stops added’ message		
7.7	Clicks the ‘Cancel’ icon beside each waypoint	-	Removes the waypoint from the list		

7.8	Clicks the spinner on the page	-	Shows the registered car plate numbers of the driver		
7.9	Clicks ‘Add Path’ button with blank Path name	Path Name Text Field: Empty	Displays ‘Path name cannot be empty’ message		
7.10	Clicks ‘Add Path’ button with a valid Path name	Path Name Text Field: Work Path	Adds the path in driver’s homepage and stores the information in the database. Displays ‘successfully added’ message. Directs the user to the ‘Paths’ page		
7.11	Clicks one of the added paths	-	Displays detailed information of the path including the starting point, ending point, time, waypoints and chosen car		
7.12	Clicks the ‘Delete’ button	-	Removes the path from the list and displays ‘Successfully Removed’ message		

Table 31: Manage Paths Component - Driver (Test Plan)

8.2.1.8 Manage Cars (Driver) Test Plan

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
8.1	Clicks the 'Cars' option from the bottom navigation bar	-	Shows all the cars that have been previously added by the driver in a recycler view	-	-
8.2	Clicks the 'Add' icon on the page	-	Redirects to the 'Car Registration' page	-	-
8.3	Clicks on the car icon	-	Allows the user to upload a car image from their local storage	-	-
8.4	Clicks 'Add' button with empty car plate number, car model, car image and number of passengers.	Car Plate Number Text Field: empty Car Model Text Field: empty Number of Passengers Text Field: empty Car Image File Upload: empty	Shows 'The car plate number, car model, car image and number of passengers cannot be empty' message		
8.5	Clicks 'Add' button with valid car plate number, car model,	Car Plate Number Text Field: BLY 8729	Registers the car details into the system and		

	car image and number of passengers.	Car Model Text Field: Toyota Camry Number of Passengers Text Field: 4 Car Image File Upload: {{car image}}	displays 'Successful car registration' message		
8.6	Clicks the 'Cancel' button on the car list	-	Removes the car information from the list and displays successful deletion message		

Table 32: Manage Cars Component - Drivers (Test Plan)

8.2.1.9 Manage Journeys (Drivers) Test Plan

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
9.1	Clicks 'Journeys' option from the bottom navigation bar	-	Redirects to the 'My Journeys' Page	-	-
9.2	Clicks 'Upcoming' fragment in the page	-	Shows all the upcoming journeys of the driver in a recycler view		

9.3	Clicks ‘Current’ fragment in the page	-	Shows all the current journeys of the driver in a recycler view		
9.4	Clicks ‘Past’ fragment in the page	-	Shows all the past journeys of the driver in a recycler view		
9.5	Clicks a specific journey	-	Shows detailed information about the journey including the passenger’s details, pickup point, drop off point, time, total amount, total earnings, and fees.		
9.6	Clicks ‘Accept’ button of a specific journey	-	Changes the status to Accepted.		
9.7	Clicks ‘Reject’ button of a specific journey	-	Changes the status to Rejected and the journey is moved to ‘Past’ fragment		
9.8	Clicks ‘Complete’ button of a specific journey	-	Changes the status to Completed and the journey		

			is moved to ‘Past’ fragment		
9.9	Clicks ‘Start button of a specific journey	-	Changes the status to Started and the journey is moved to ‘Current’ fragment		

Table 33: Manage Journeys Component - Drivers (Test Plan)

8.2.2 Test Plan for User Acceptance Testing

User Acceptance Testing for Travellers

Name	
Occupation	
Testing Date	
Start Time	
End Time	

Components	Grade				
	1	2	3	4	5
1. Graphical User Interface (GUI)					
2. User Experience (UX)					
3. System Interaction					
Fulfilling Objectives					
a. Offers a reliable and secure carpooling platform					
b. Shows detailed description of journeys					
c. Make effortless transactions					
4. System Validation					
5. System Satisfaction					
6. No errors					

1: Bad

2: Poor

3: Fair

4: Good

5: Excellent

Recommendation and Comments

9 Implementation

9.1 Screenshots

9.1.1 Splash Screen

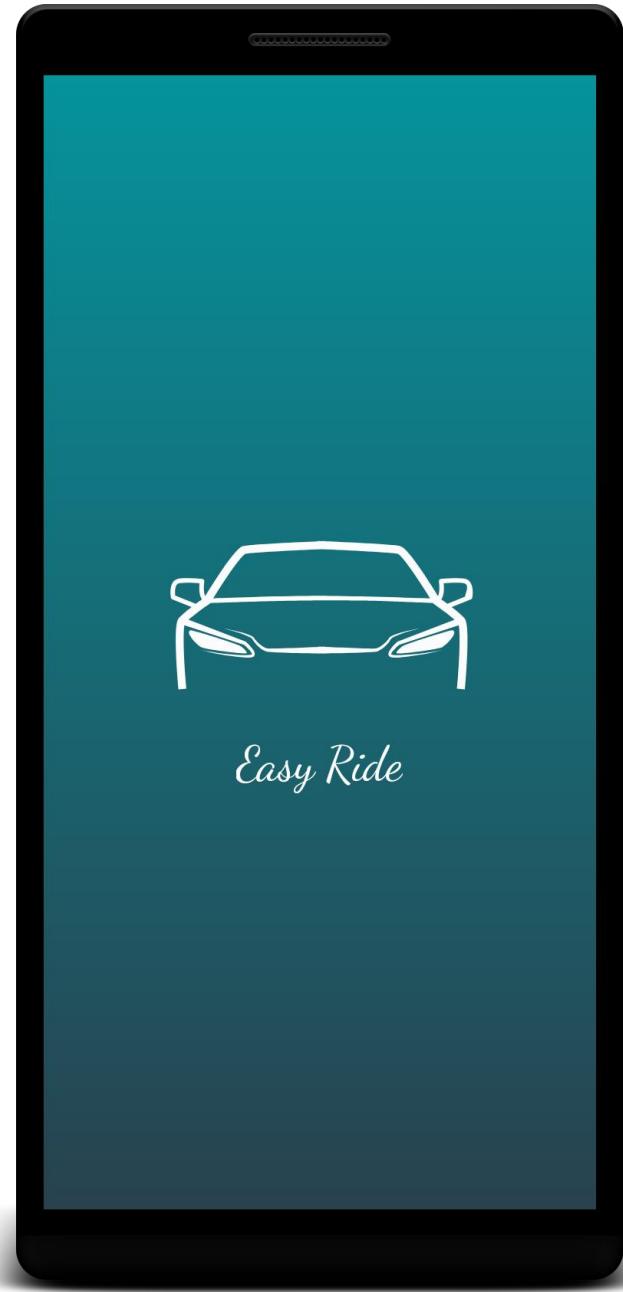


Figure 50: Splash Screen

Once the user launches the application, he or she will be directed to this interface. An animation has been included where the logo of Easy Ride fades in before proceeding to the next interface. This interface also works as a middleware to check whether the user has already logged into the application.

9.1.2 Sign-in Activity

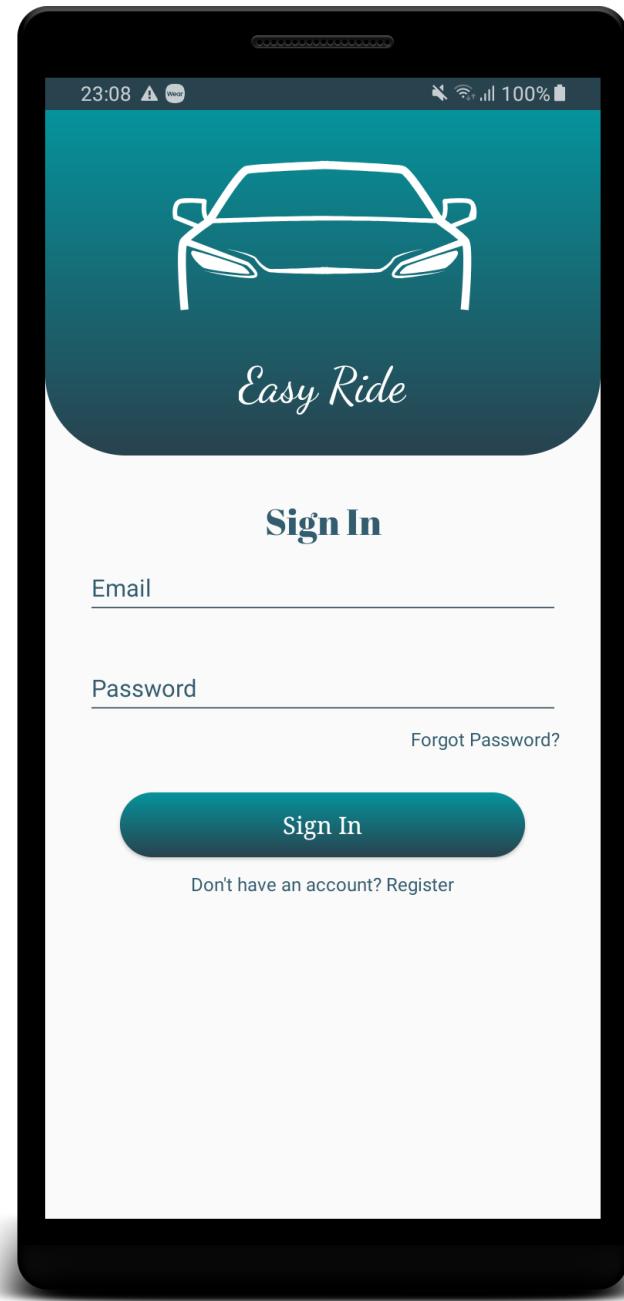


Figure 51: Sign In Activity

If the splash screen does not detect any earlier logged in session, the user will be redirected to the sign-in page as shown in the image above. In this page, the users are required to input their email address and password in order to access the functionalities of the application. Proper validations are included in this page to prevent users from unintentionally providing false credentials.

9.1.3 Sign Up Activity

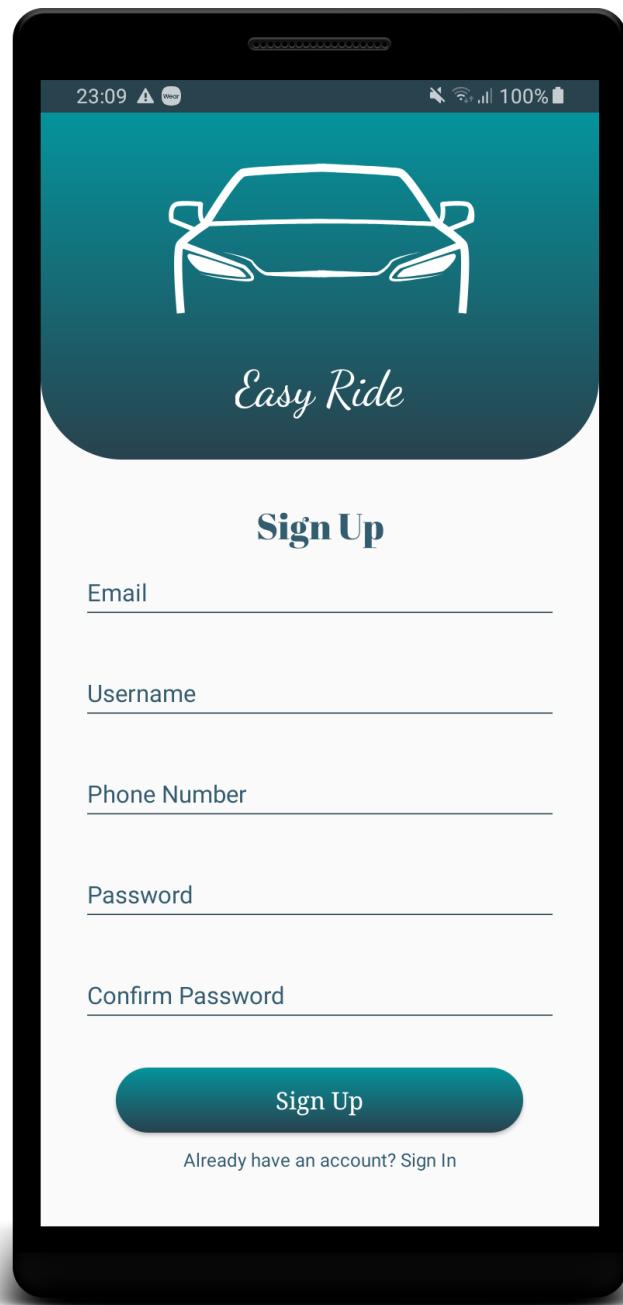


Figure 52: Sign Up Activity

This is the registration page in which the first-time users are able to register into the application by providing their email address, username, phone number and password. Users are required to input a unique email address and valid phone number which will be later used for verification processes. Moreover, an error message is displayed if the password and confirm password do not match. As soon as the user inputs all the valid information and clicks Sign Up button, 'You have successfully registered into the application' message is displayed.

9.1.4 Feedback Activity

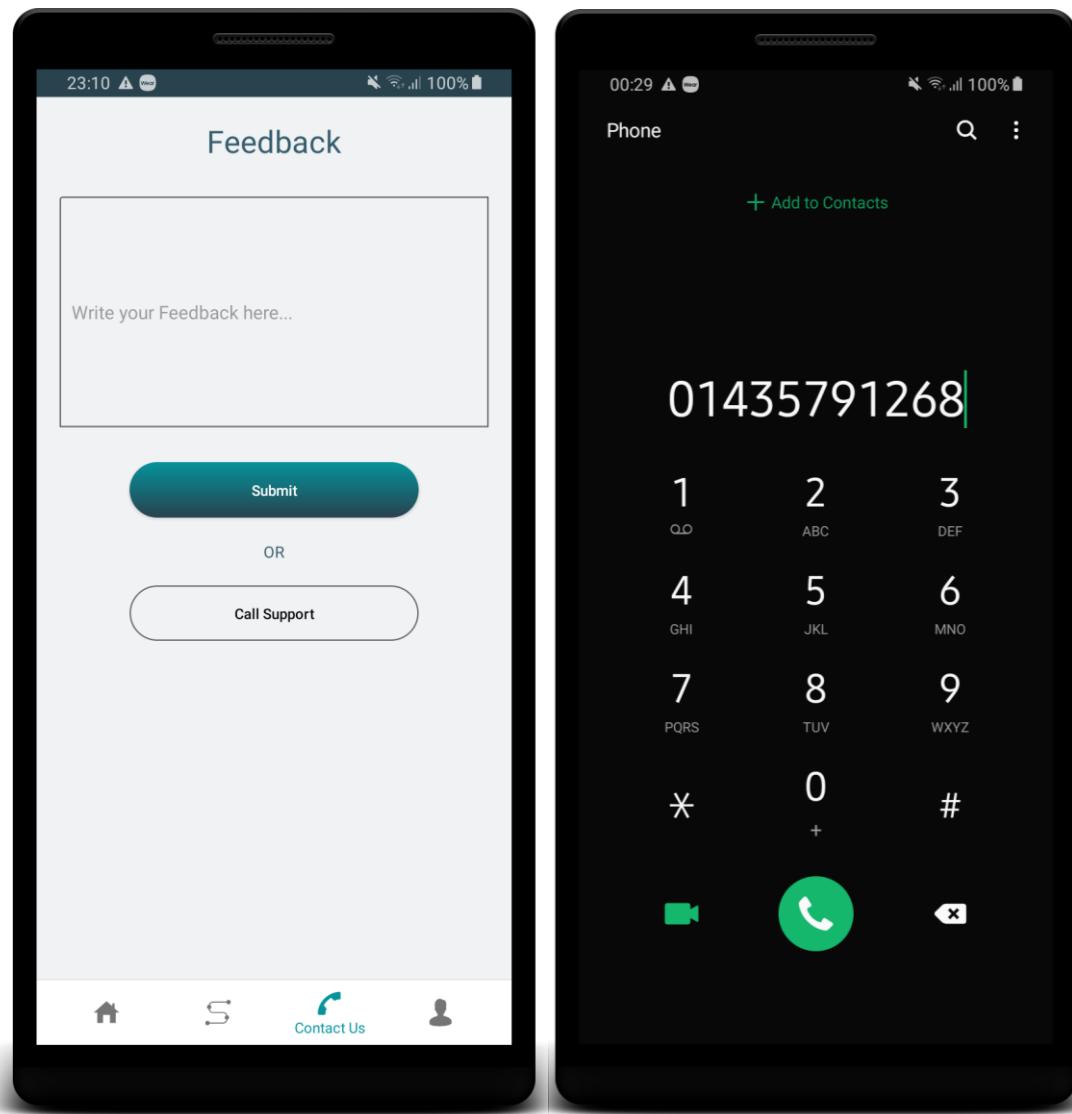


Figure 53: Feedback Activity

Registered users are capable to provide feedback via the system. When the user clicks the 'Contact Us' option from the bottom navigation bar, he or she will be directed to the feedback page as shown above. In this page, the users are able to write recommendations or comments regarding the system to administrators. On the other hand, if the user requires an immediate assistance, he or she can simply call the administrator by clicking the 'Call Support' button.

9.1.5 Find a Ride Activity (Passenger)

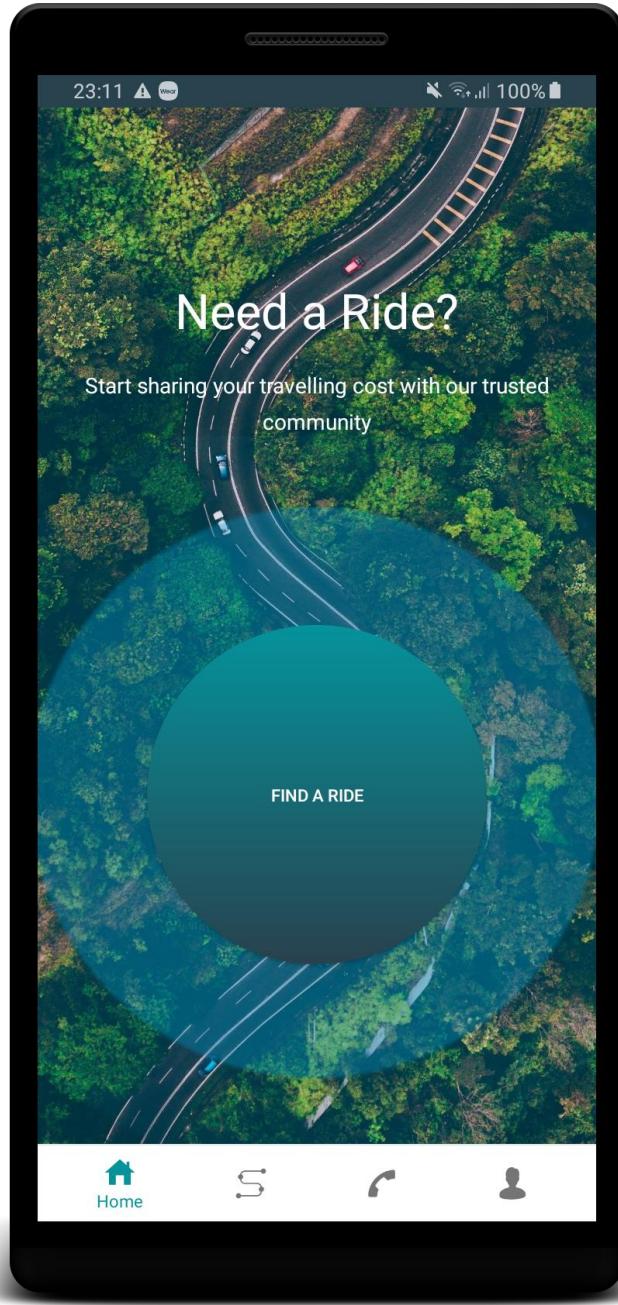


Figure 54: Find a Ride Activity

When the user clicks the 'Home' option from the bottom navigation bar, he or she will be directed to the page shown above. This interface comes with a fascinating ripple animation which provides the users with a better user experience. Passengers who would like to find a ride can simply click the animated button.

9.1.6 Show Current Location Activity (Passenger)

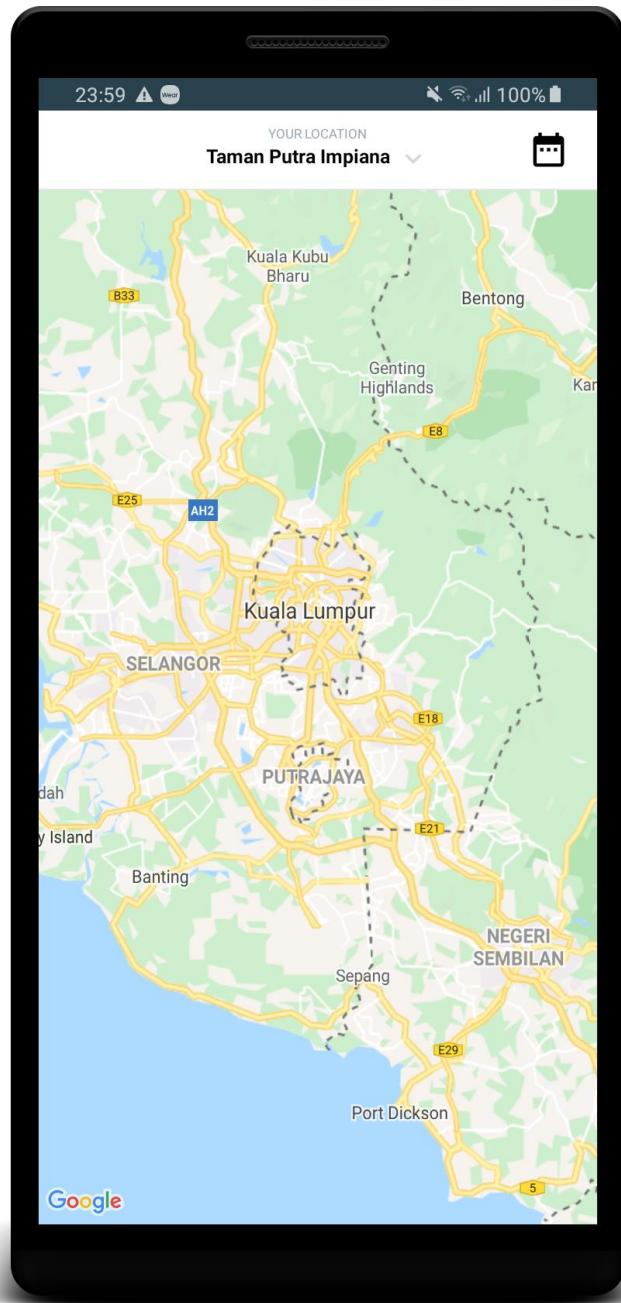


Figure 55: Show Current Location Activity (Passengers)

As soon as the user clicks the ‘Find a Ride’ button, he or she will be navigated to the page shown above. With the implementation of Google Maps, this page shows the current location of the user.

9.1.7 ‘Select Date and Time’ Activity (Passenger)

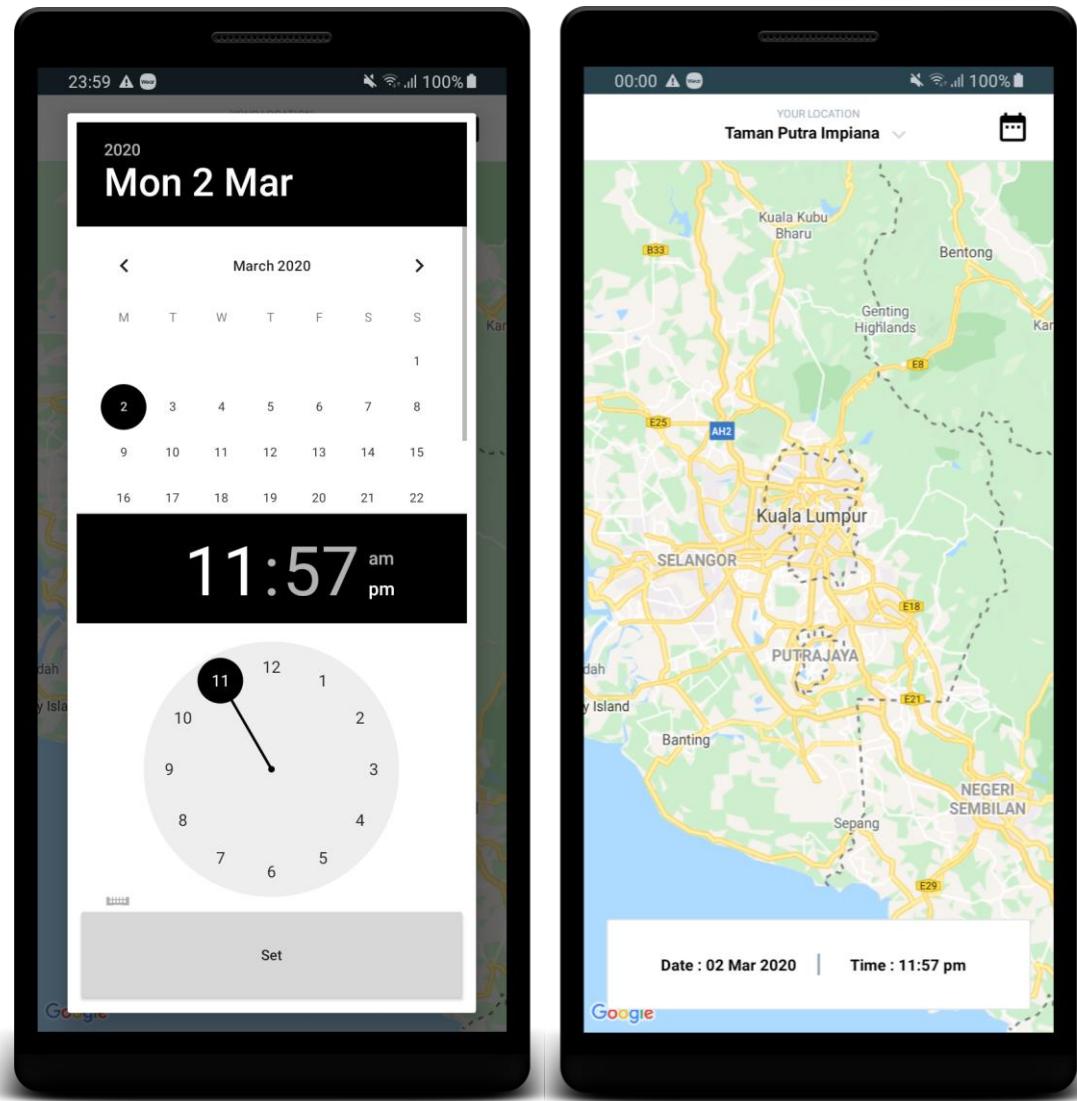


Figure 56: Select Date and Time Activity

When the user clicks the calendar icon in the previous page, a new screen is displayed to allow the user to input the date and time of their desired ride. Once the user inputs the date and time and clicks the ‘Set’ button, the user will be redirected to the previous page which now has a card view that shows the chosen date and time.

9.1.8 Choose Pickup Location and Drop off Location with Autocomplete for Address Activity (Passenger)

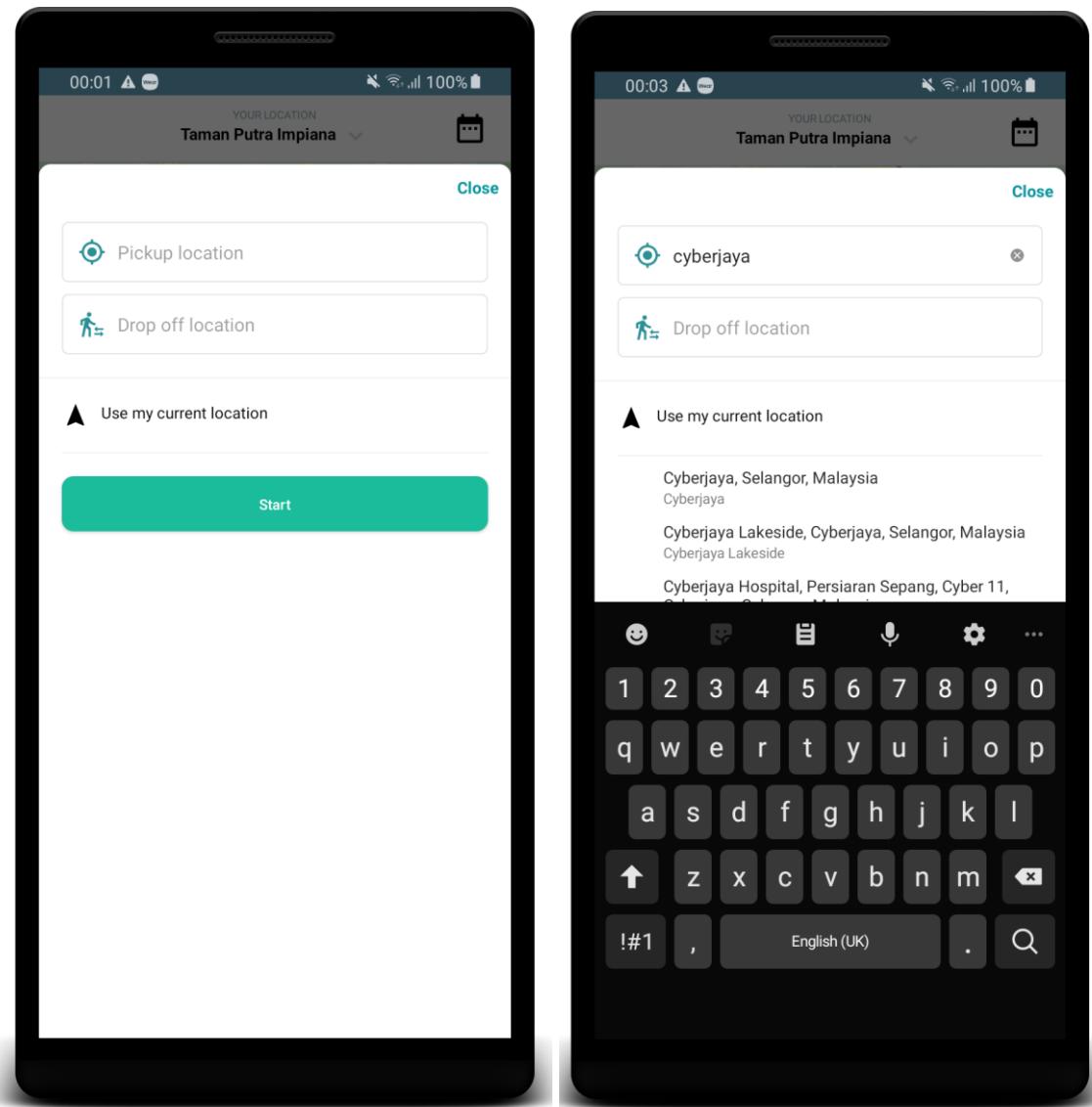


Figure 57: Choose Pickup Location and Dropoff Location Activity (Passenger)

The above interface is displayed when the user clicks the drop-down list in the previous page. This page allows the user to input the pick up location and drop off location of their desired ride. When the user begins typing the location in the text fields, the Google Maps AutoComplete feature shows all the possible locations based on the user's input. Besides that, if the user wants to input his or her current location as the pickup point, he or she can just click the 'Use my current location' text shown in the page.

9.1.9 Show Available Rides and Book a Ride Activities (Passenger)

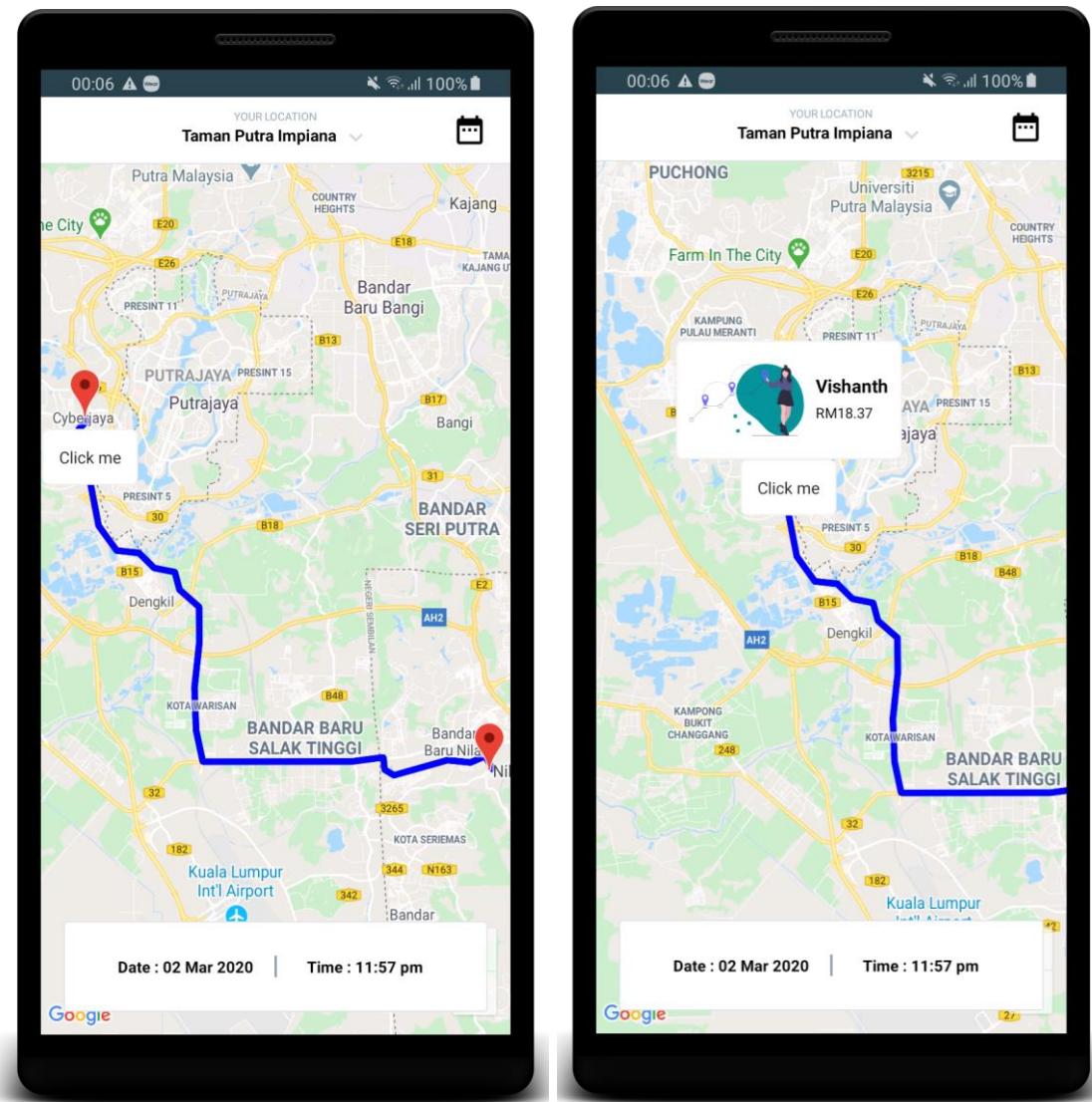


Figure 58: Show Available Rides Activity (Passenger)

Once the passenger clicks the start button after inputting his or her desired pickup location, drop off location and time, he or she will be presented with the screen shown above. A polyline is created between the passenger's pickup point and drop off point to indicate the route. All the available driver rides that meet the requirements of the passenger are displayed on the map with a 'Click Me' option. When the user clicks the option, an alert dialog appears with the information of the driver's name and overall travelling cost. If the user is interested to join the ride, he or she simply needs to click the pop-up option.

9.1.10 Cancel Journey Activity (Passenger)

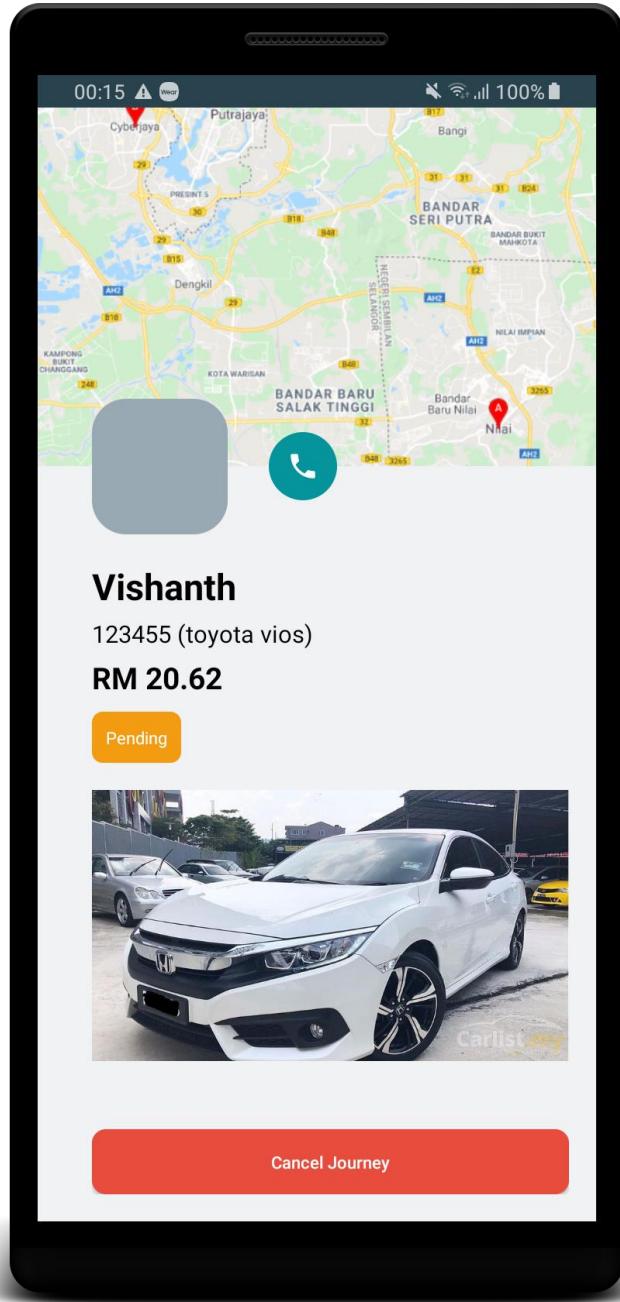


Figure 59: Cancel Journey Activity (Passenger)

When the passenger books a journey, he or she will be navigated to the page shown above. This page contains some of the detailed information about the driver including the driver's name, car number, car image and car model. On the other hand, the user has the privilege to cancel the journey by clicking the 'Cancel' button which will notify the respective driver.

9.1.11 Manage Journeys Activity (Passenger)

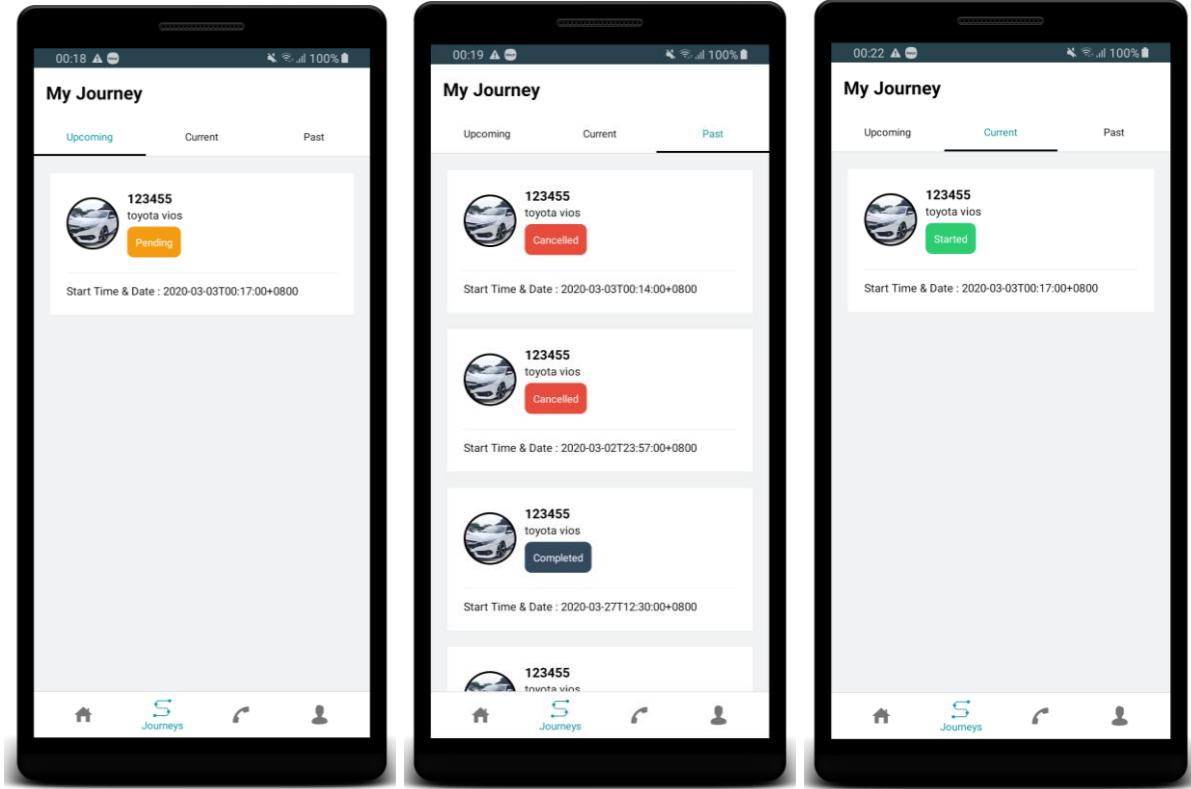


Figure 60: Manage Journeys Activity (Passenger)

This page comes with three different fragments in order to help the passengers to manage their journeys in a more systematic and organised manner. The functions of each fragment has been deliberately discussed in the list below.

- **Upcoming** – This fragment contains all the newly booked journeys which need to be approved or declined by the drivers
- **Current** – This fragment contains all the journeys that are taking place at the moment.
- **Past** – This fragment contains all the journeys that are either successfully completed or rejected by the driver.

9.1.12 Current Journey Details Activity (Passenger)

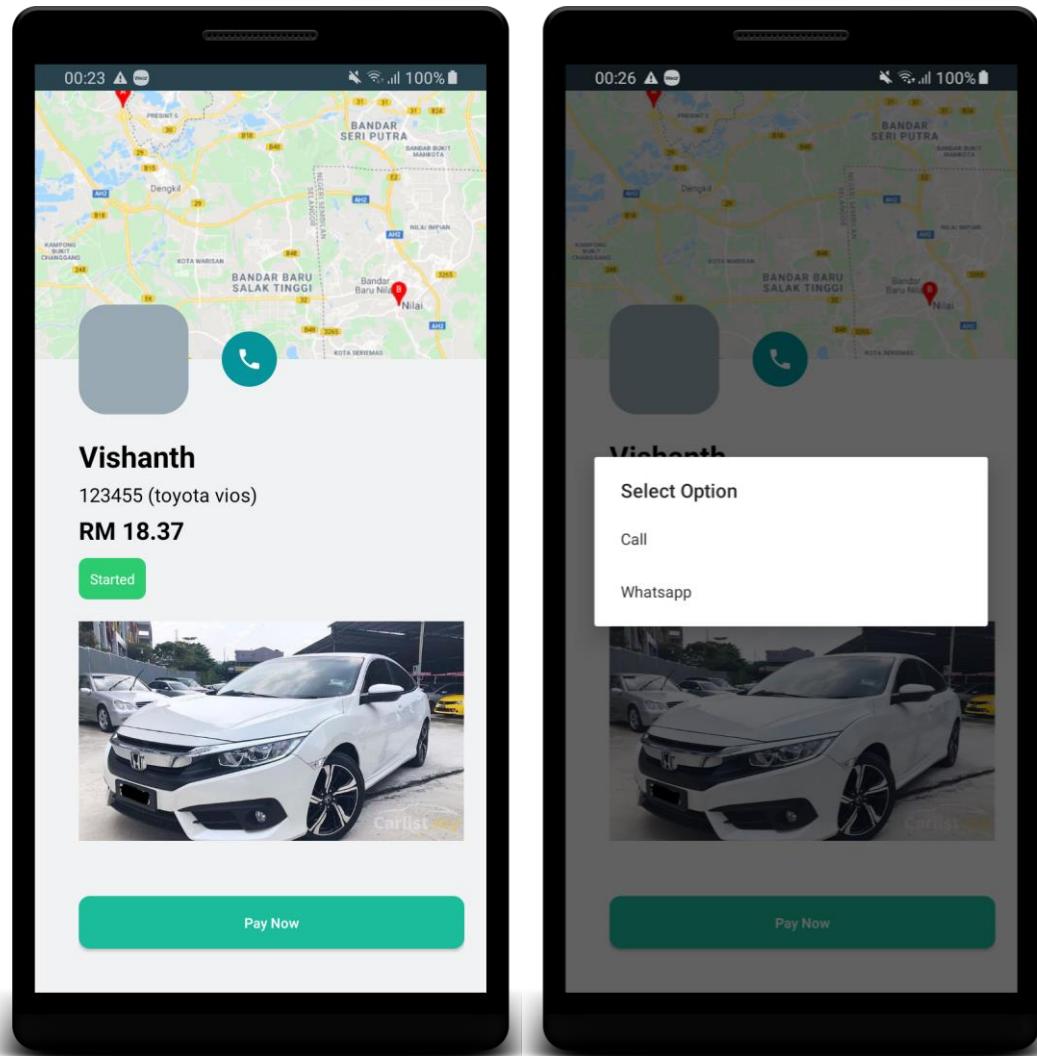


Figure 61: Current Journey Details Activity (Passenger)

If the passenger wishes to see the detailed information about a current journey, he or she can simply click the specific journey from the previous page. The passenger is able to make a call or send a WhatsApp message to the driver by clicking the call icon in the page.

9.1.13 Make Payment

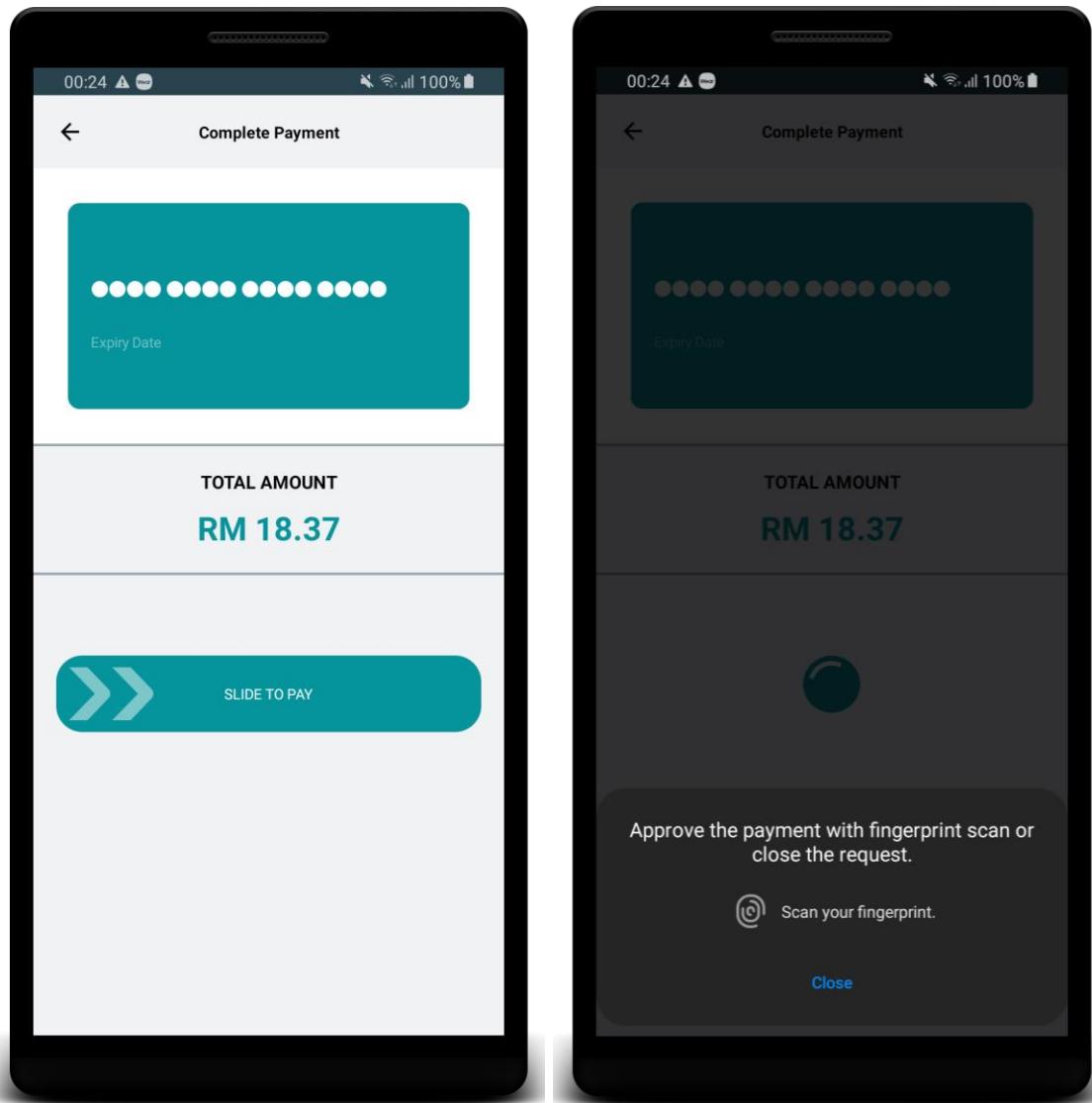


Figure 62: Make Payment Activity (Passenger)

Once the journey is completed, the passenger is required to make a payment to the respective driver via the visa or credit card which was previously added by the passenger. The passenger is required to slide right on the screen in order to make the payment. A fingerprint authentication takes place where the passenger needs to scan their fingerprint before proceeding to the payment section.

9.1.14 Completed Journey Activity (Passenger)

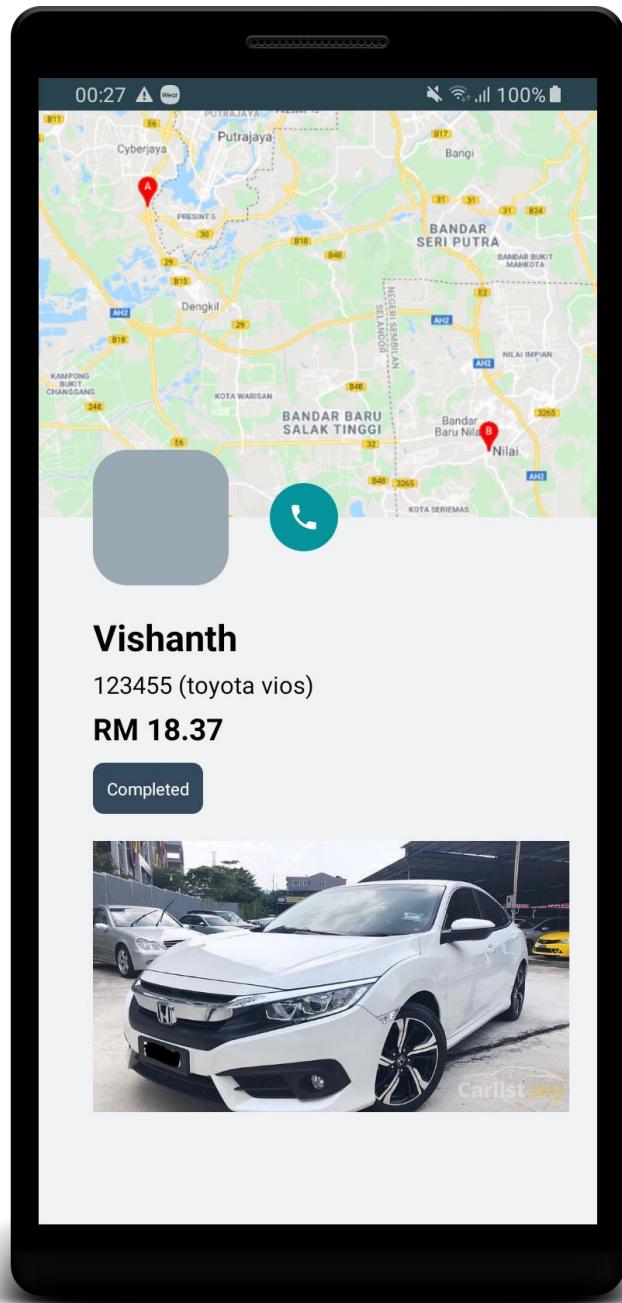


Figure 63: Completed Journey Activity (Passenger)

As soon as the journey is completed and the payment is made, the passenger will be redirected to the screen shown above. The status of the journey is changed to ‘Completed’.

9.1.15 Manage Profile Activity (Passenger)

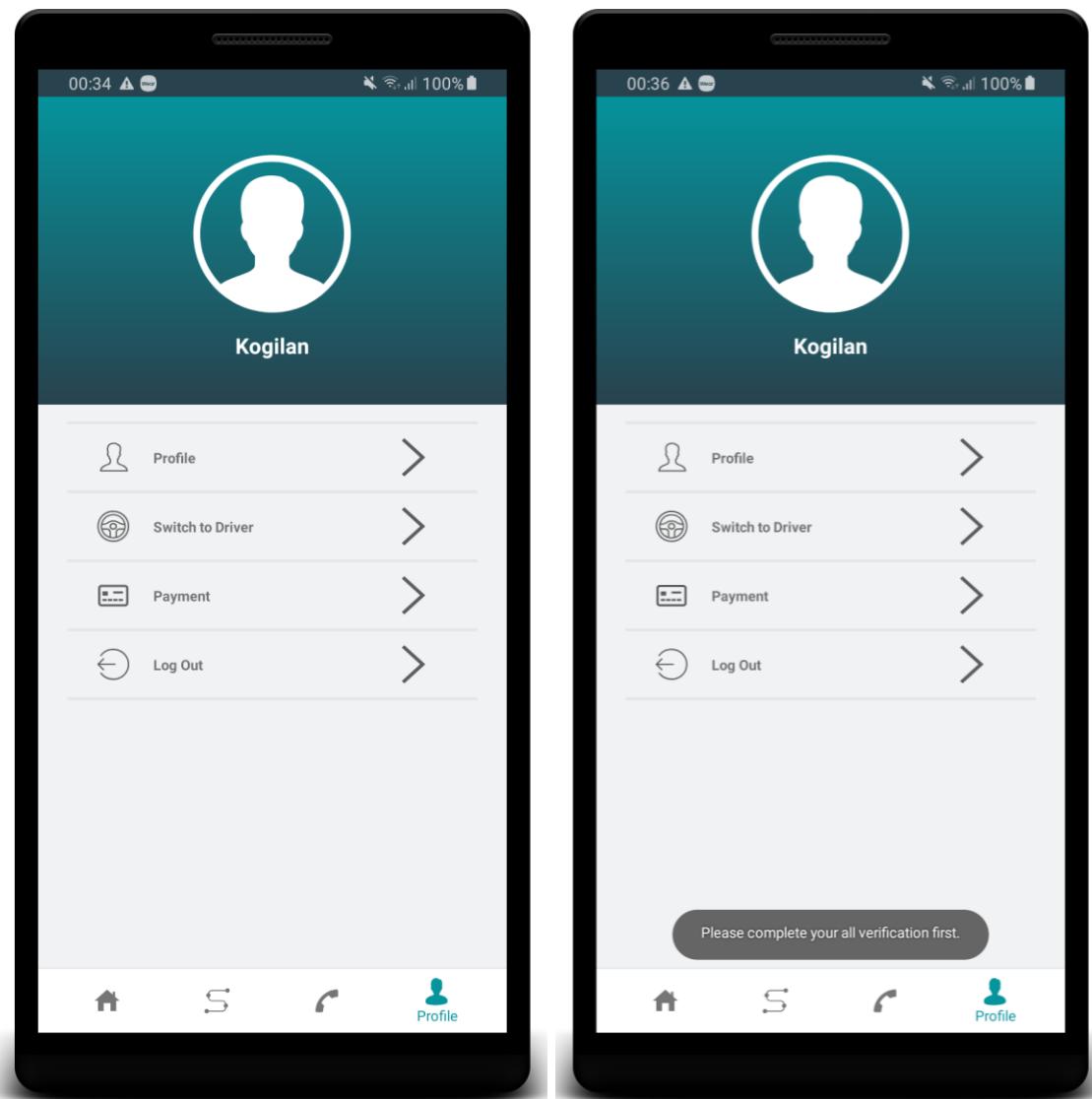


Figure 64: Manage Profile Activity (Passenger)

When the passenger chooses the ‘Profile’ option from the bottom navigation bar, he or she will be redirected to the page shown above. The passenger is able to perform a couple of function in this page. If the passenger wishes to log out from the application, he or she can choose the ‘Log Out’ option in the page. The passenger can manage their credit card information by clicking the payment option. On the other hand, the passenger can also become a driver by clicking the ‘Switch to Driver’ option in the page. However, the passenger is ought to complete all the verifications in the profile page in order to become a driver.

9.1.16 Manage Verifications Activity (Passenger)

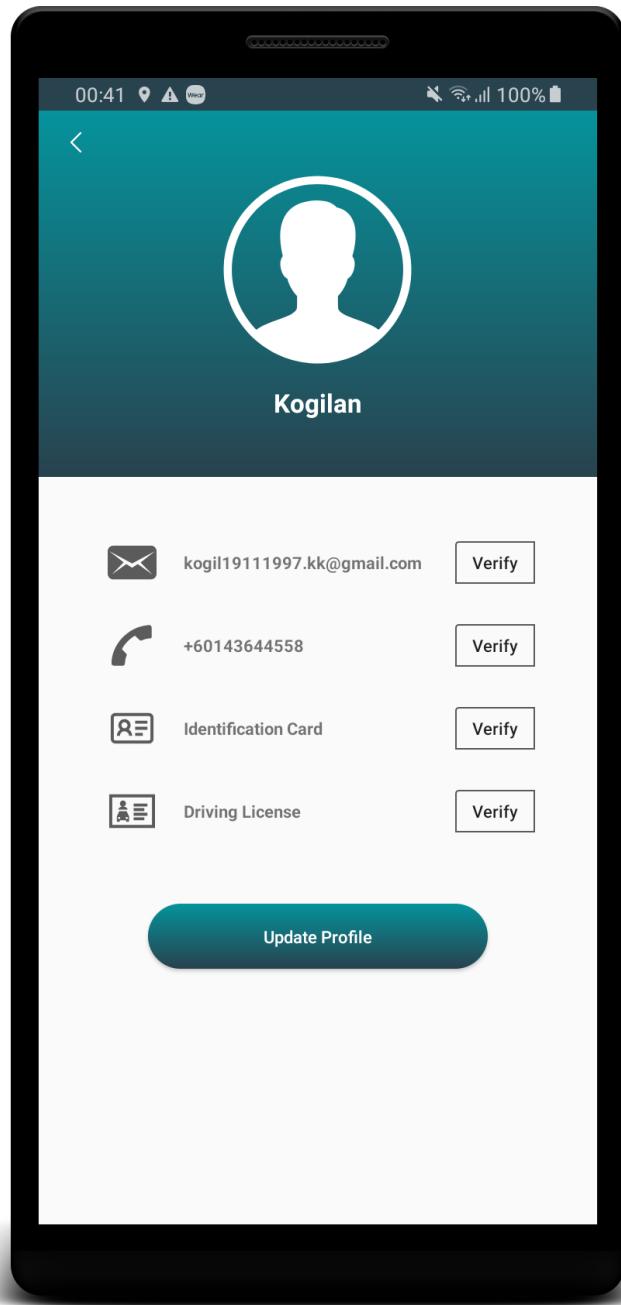


Figure 65: Manage Verifications Activity (Passenger)

The passenger is required to complete all the verifications displayed in the screen above in order to become a driver within the application.

9.1.17 Email Verification Activity (Passenger)

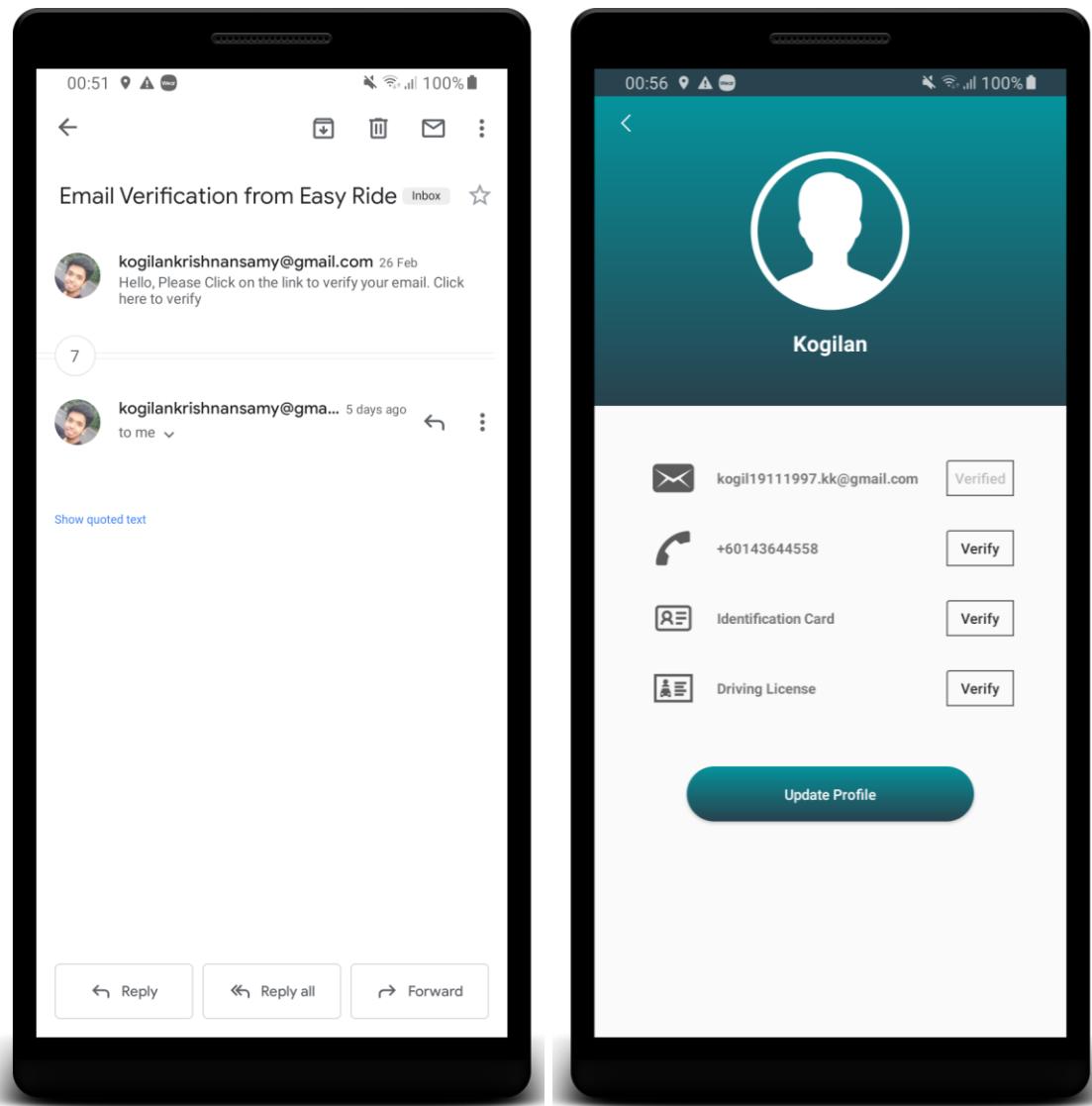


Figure 66: Email Verification Activity (Passenger)

When the passenger clicks the ‘Verify’ button next to the email address, a link is sent to the passenger’s mailbox. When the passenger clicks the link, he or she is directed to a webpage that shows ‘Email verification has been successfully done’ message. If the passenger can successfully verify their email address, the ‘Verify’ button becomes disabled and changed to ‘Verified’.

9.1.18 Phone Verification Activity (Passenger)

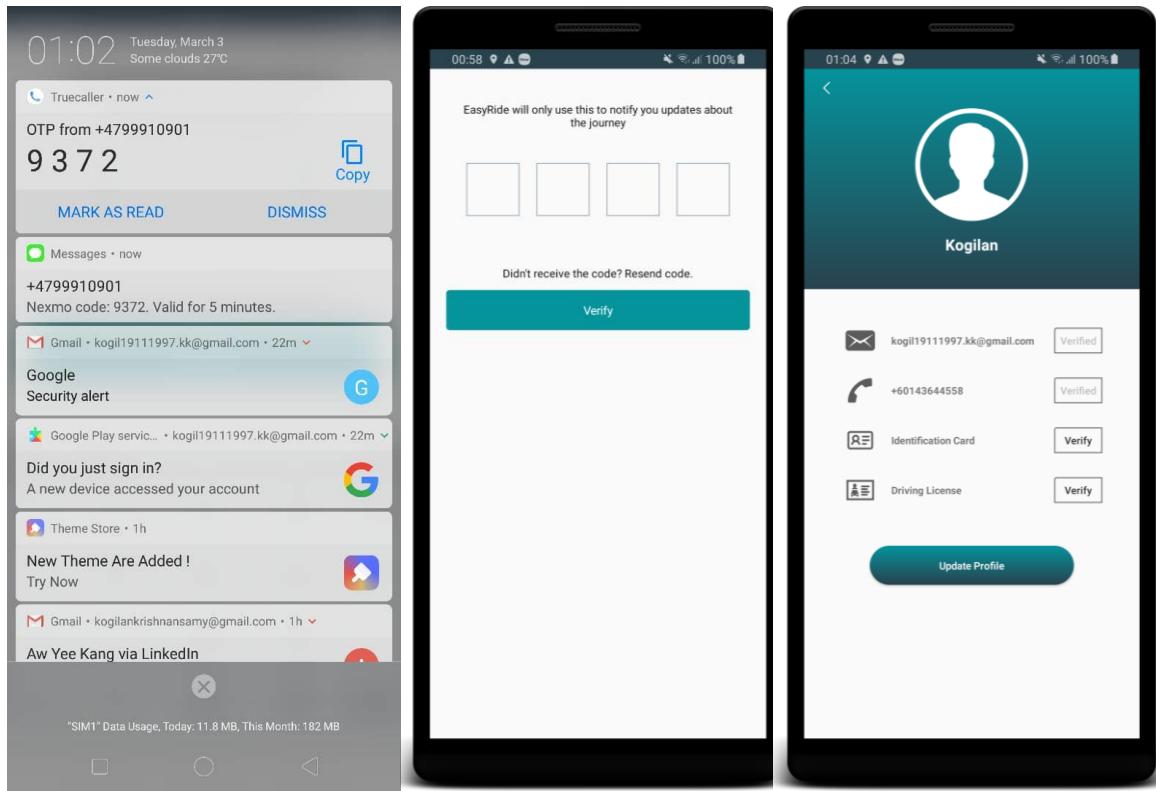


Figure 67: Phone Number Verification Activity (Passenger)

When the passenger clicks the ‘Verify’ button next to his or her phone number, a 4-digit pin is sent to the passenger’s mobile phone. The passenger is required to input the 4-digit pin in the text fields and click the ‘Verify’ button. If the passenger is able to successfully verify his or her phone number, the ‘Verify’ button becomes disabled and changed to ‘Verified’.

9.1.19 Driving License Verification Activity (Passenger)

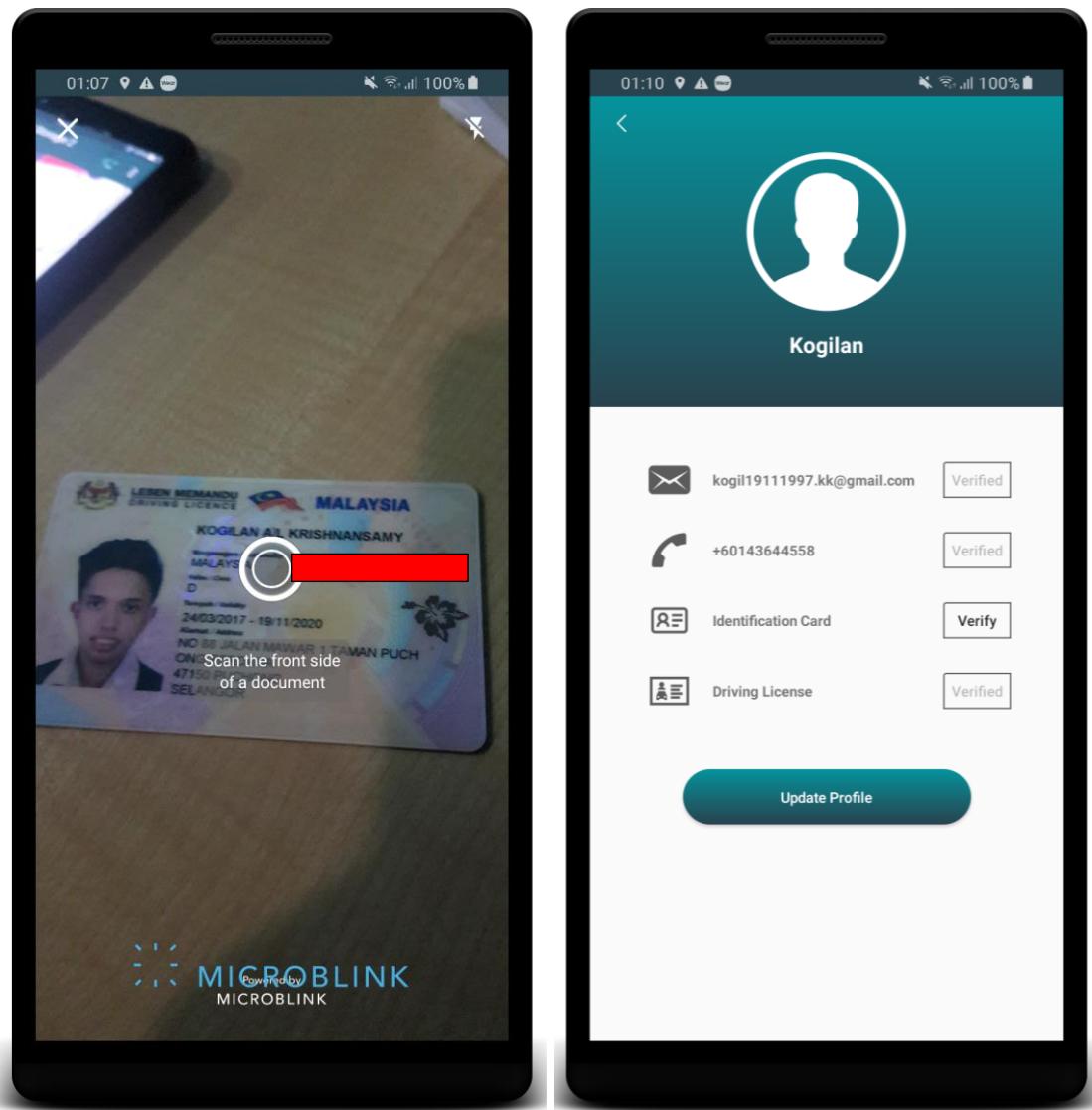


Figure 68: Driving License Verification Activity (Passenger)

When the passenger clicks the 'Verify' button next to the 'Driving License' text, the passenger is prompted with a camera integrated with MicroBlink. The passenger is required to scan his or her identification card with the MicroBlink camera to verify whether the passenger is a Malaysian citizen. The camera captures the text on the card and verifies the information. If the passenger is able to successfully verify his or her driving license, the 'Verify' button becomes disabled and changed to 'Verified'.

9.1.20 Identification Card Verification (Passenger)

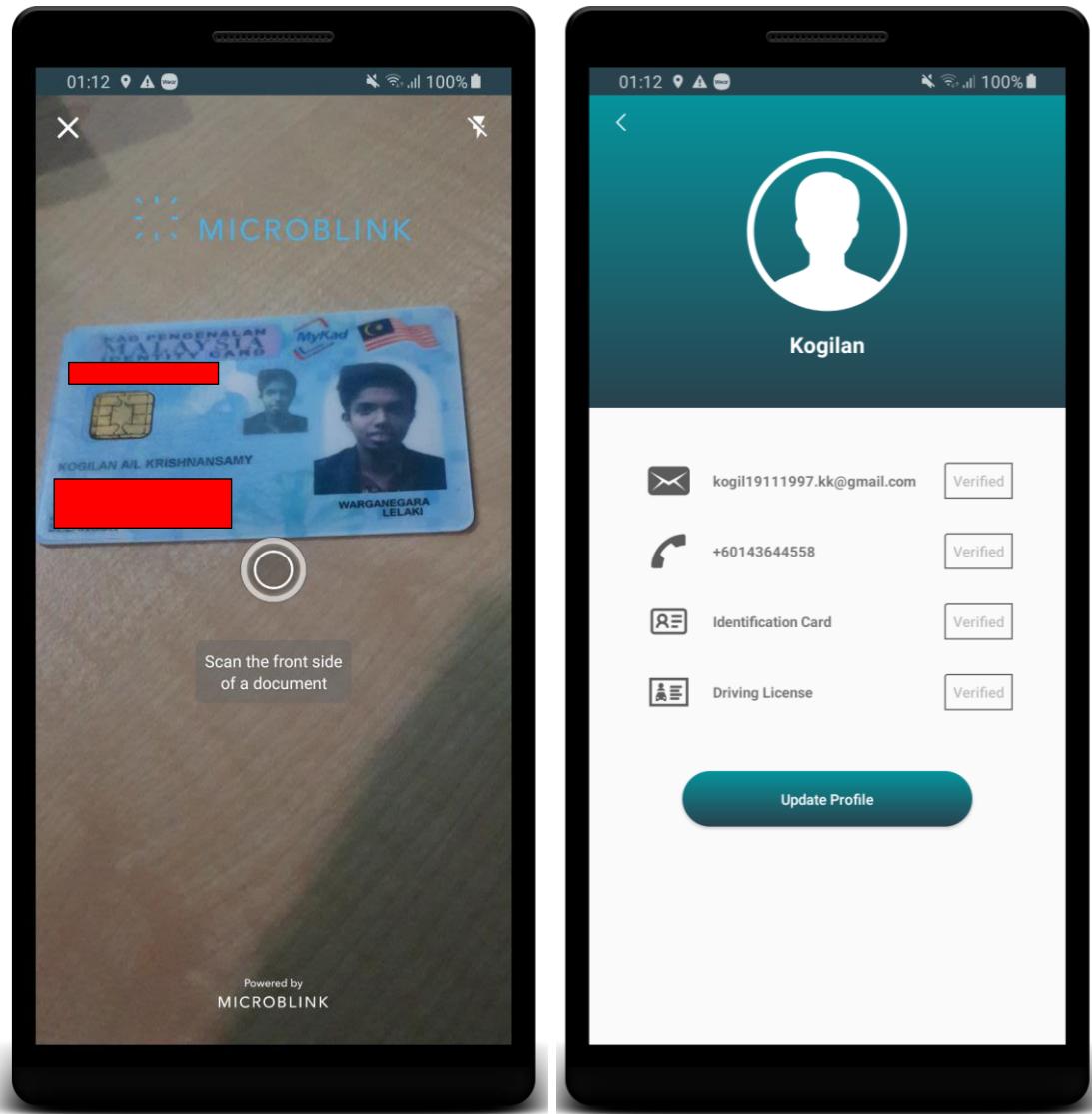


Figure 69: Identification Card Verification (Passenger)

The verification of passenger's identification card is done exactly similar to the verification process of the passenger's driving license. When all the four information is verified, the passenger can now become a driver and able to offer rides.

9.1.21 Manage Cards Activity (Passenger)

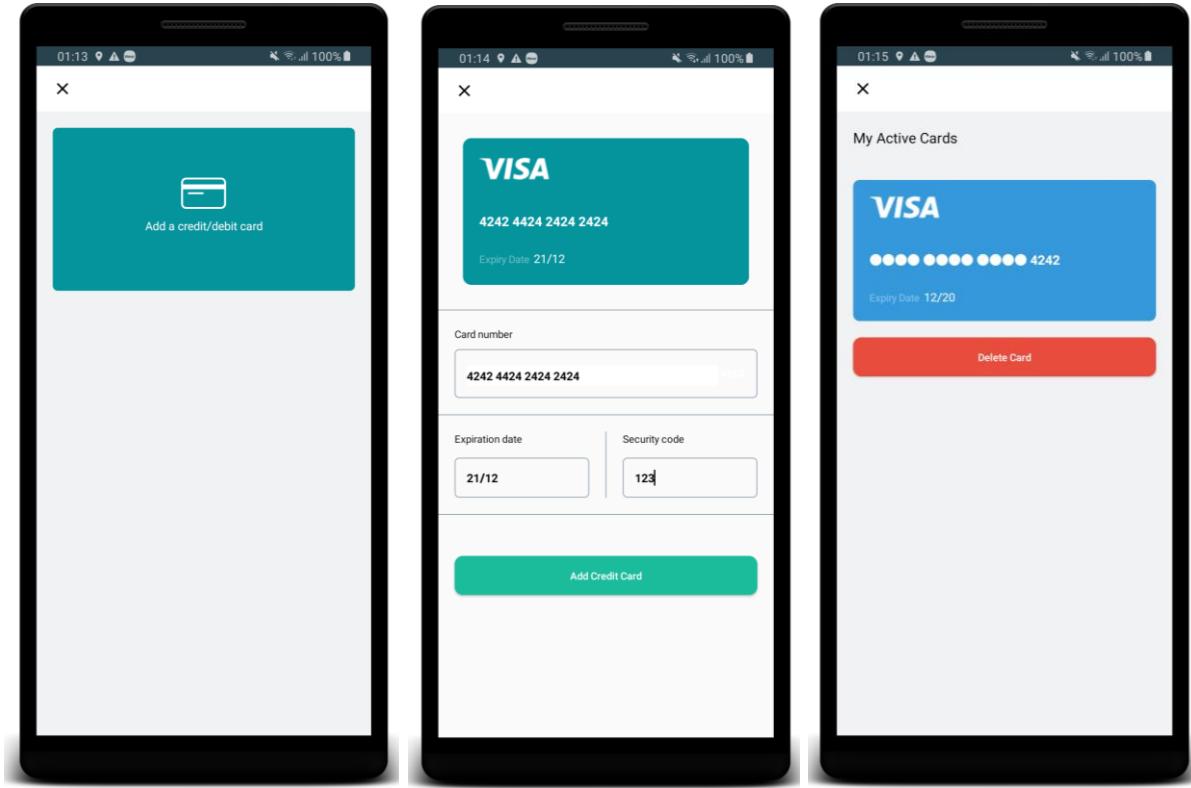


Figure 70: Manage Cards Activity (Passenger)

Passengers are able to manage his or her credit card details in this activity. Upon clicking on the payment option in the ‘profile’ page, the system will verify in the background whether a credit card has already been added by the passenger. If the system does not detect any added credit card, the first screenshot will be shown to the passenger. When the passenger clicks on the card image, he or she is prompted to the ‘Add Credit Card’ page as shown in the second screenshot. In this page, the passenger is required to provide a credit card number, expiration date and security code in order to integrate the credit card within the system. Visa logo appears if the added credit card is a visa card whereas Mastercard logo appears if the added credit card is a Master card. All the credit card information are tokenised with the help of Stripe before storing in the database. On the other hand, the system also allows the passenger to delete the credit card from the system as shown in the third screenshot.

9.1.22 Manage Paths Activity (Driver)

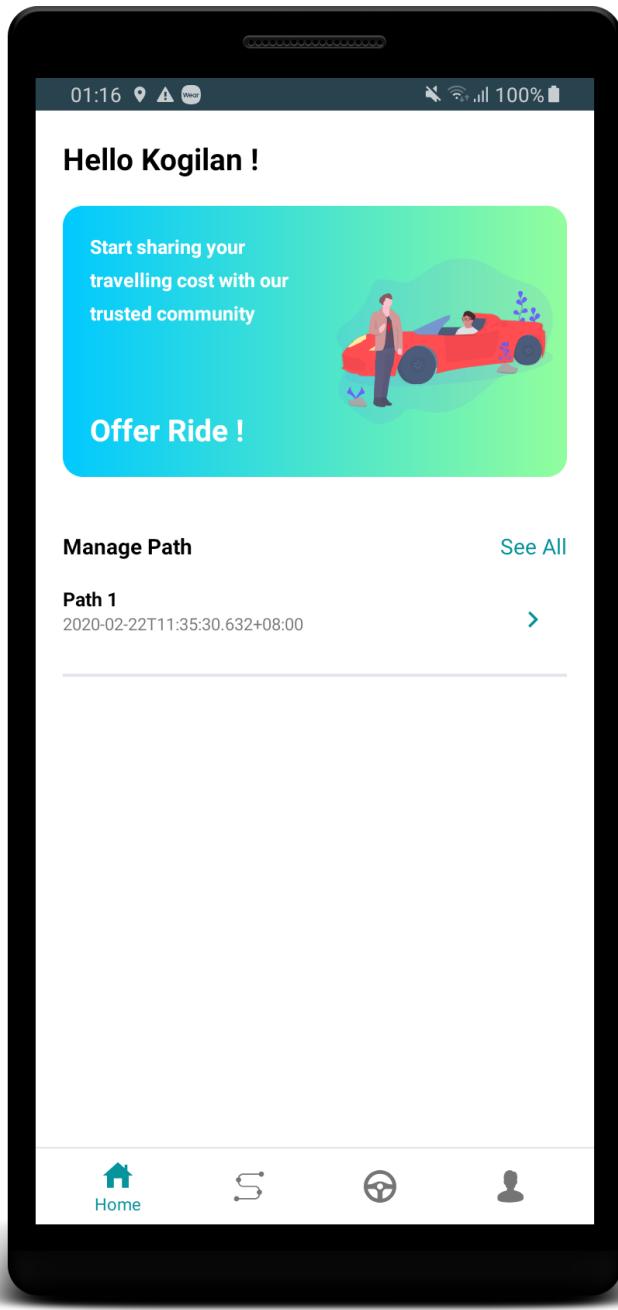


Figure 71: Manage Paths Activity (Driver)

When a passenger clicks ‘switch to driver’ link in the profile page, he or she is redirected to the driver panel and now able to access all the driver functionalities. The new driver is able to manage his or her rides in the page shown above. In order to view the detailed information of a ride, the driver is required to click on the specific ride from the recycler view. If the driver wishes to add a new ride, he or she just needs to click the ‘Offer Ride’ text shown on the card view.

9.1.23 Choose Start Location and End Location with Autocomplete for Address Activity (Driver)

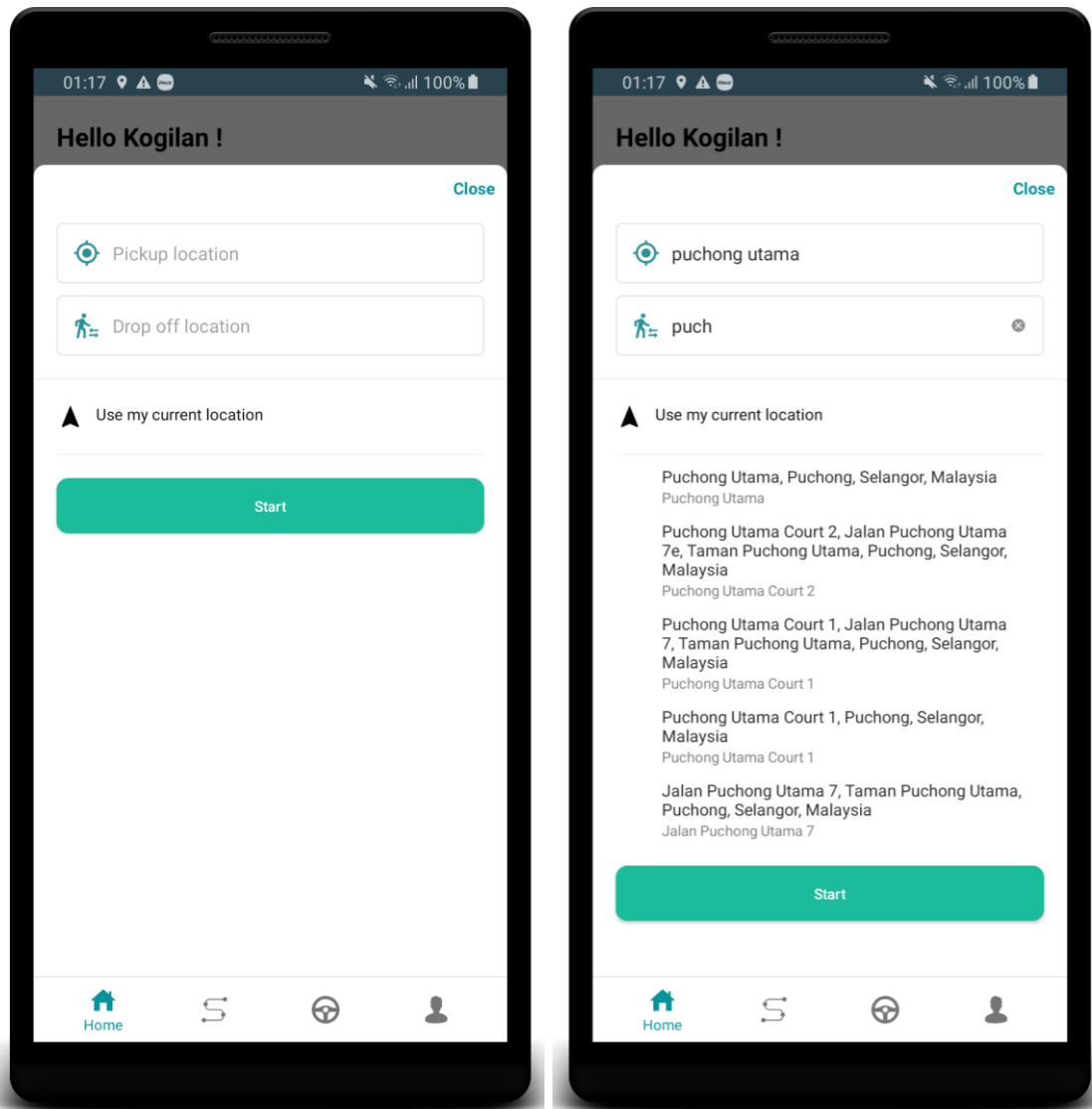


Figure 72: Choose Start Location and End Location (Driver)

When the driver clicks the ‘Offer Ride’ text from the previous interface, he or she will be navigated to the page shown above. This page allows the driver to input the starting location and destination of their ride. When the driver begins typing the location in the text fields, the Google Maps AutoComplete feature shows all the possible locations based on the driver’s input. Besides that, if the driver wants to input his or her current location as the pickup point, he or she can just click the ‘Use my current location’ text shown in the page.

9.1.24 Enter Path Name and Choose Car Activity (Driver)

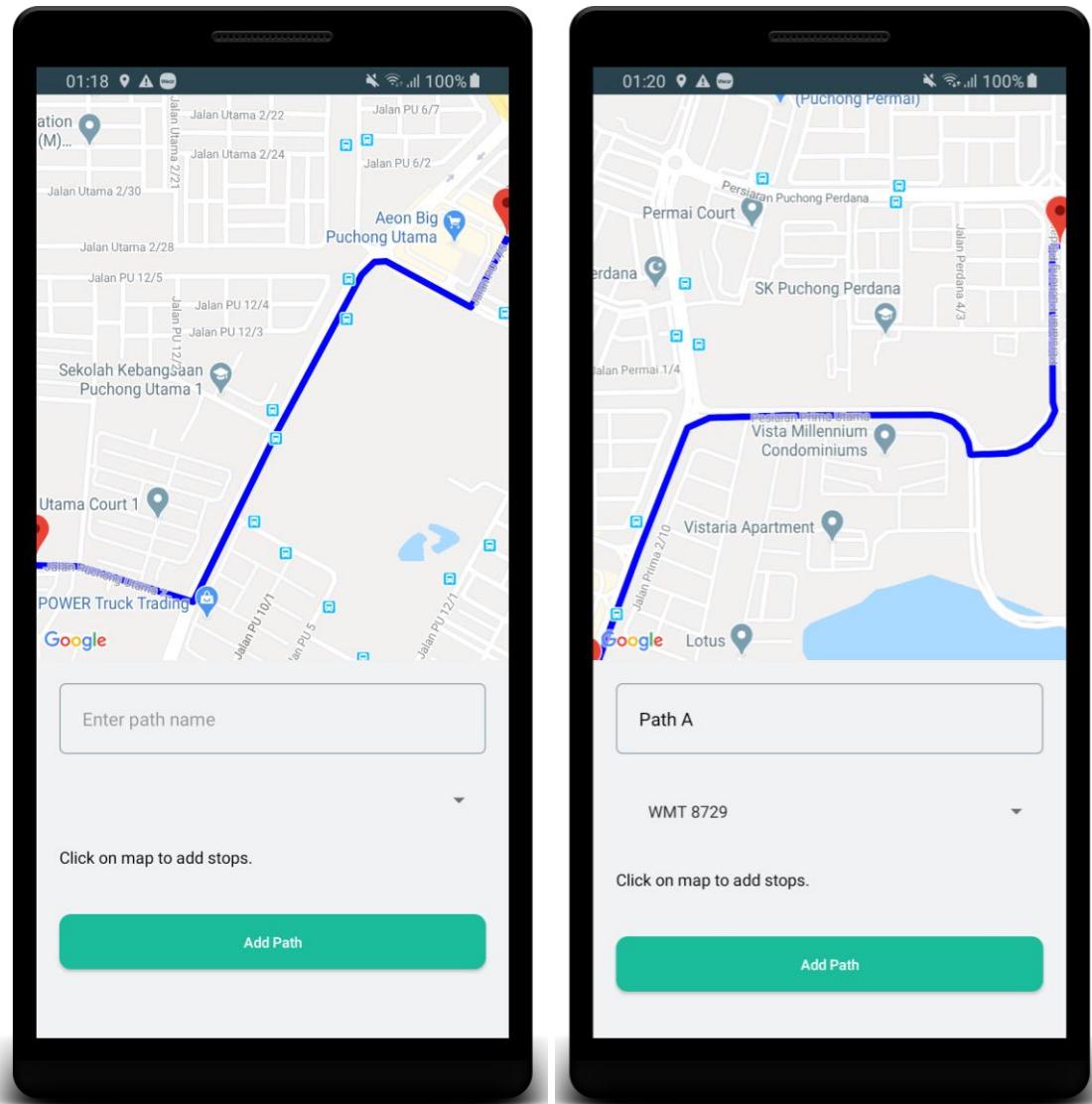


Figure 73: Enter Path Name and Choose Car Activity (Driver)

Once the driver clicks the start button after inputting his or her starting location, destination and time, he or she will be presented with the screen shown above. A polyline is created between the driver's starting point and destination to indicate the route. Then the driver is required to input the path name and choose which car they would like to use for the journey.

9.1.25 Create Waypoints / Pickup Points Activity (Driver)

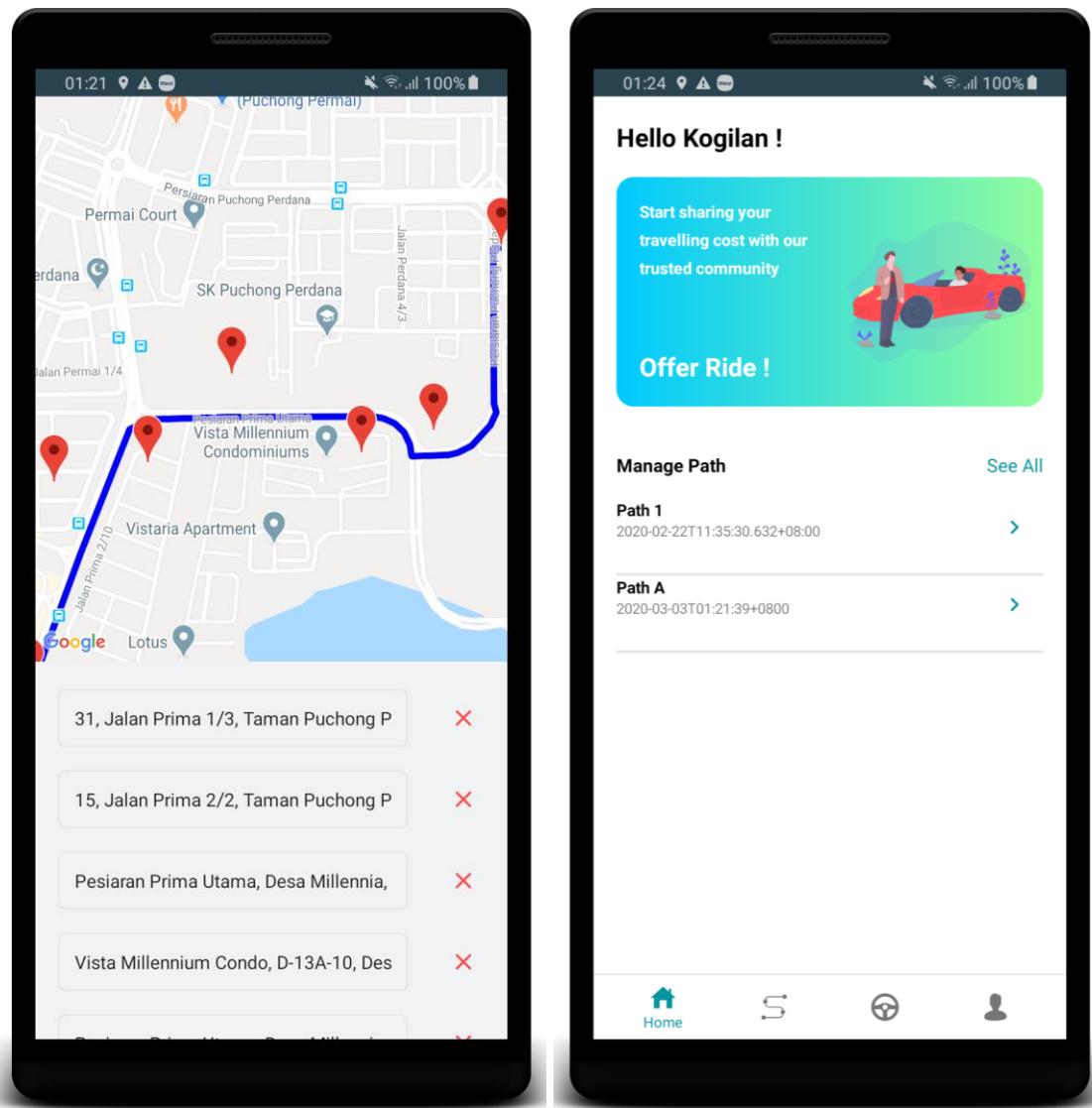


Figure 74: Create Waypoints / Pickup Points Activity (Driver)

The driver has the privilege to select the waypoints from where they would like to pick up the passengers during the journey. They can choose the waypoints simply by clicking on the map and the waypoints are added dynamically in the form of text fields as shown in the image above. If the driver accidentally selects a waypoint, he or she can simply remove it by clicking the ‘cancel’ icon beside the waypoint. The drivers are restricted from adding more than five waypoints throughout the journey. The new journey will be added to the recycler view as soon as the driver clicks the ‘Add Path’ button.

9.1.26 Manage Journeys Activity (Driver)

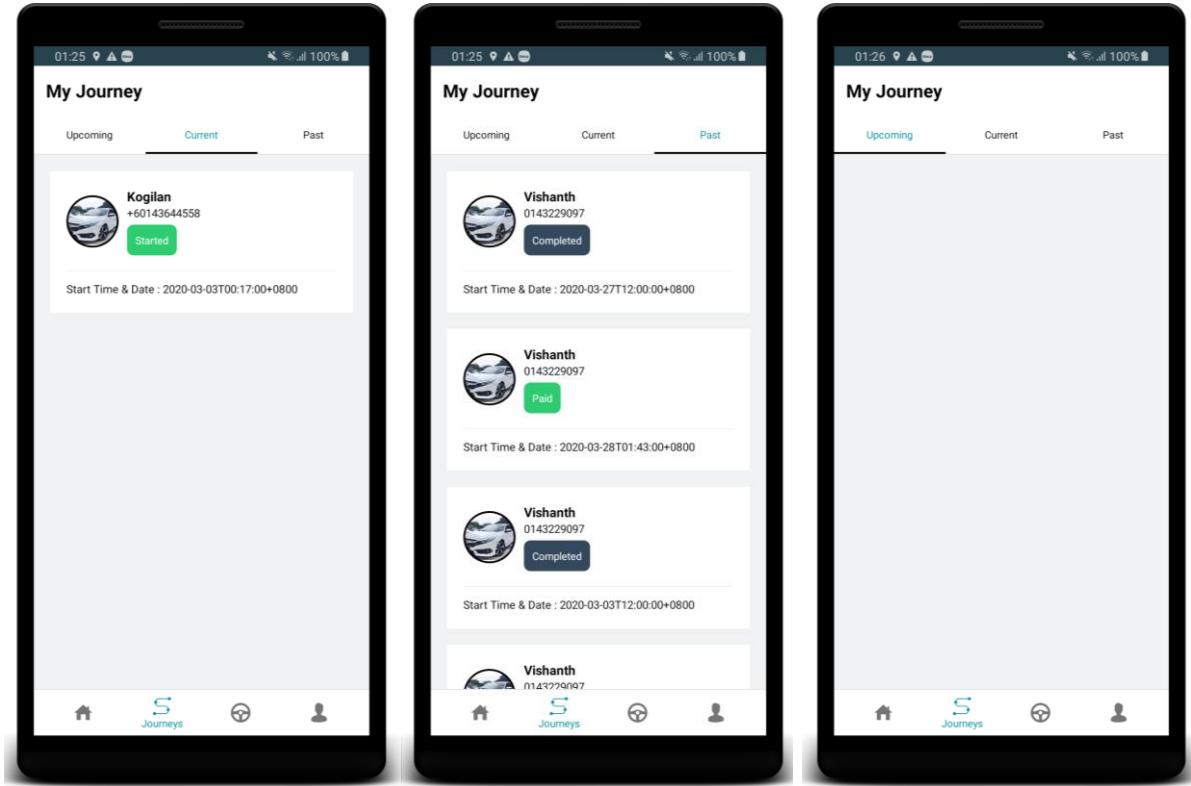


Figure 75: Manage Journeys Activity (Driver)

This page comes with three different fragments in order to help the drivers to manage their journeys in a more systematic and organised manner. The functions of each fragment has been deliberately discussed in the list below.

- **Upcoming** – This fragment contains all the newly booked journeys which need to be approved or declined by the drivers
- **Current** – This fragment contains all the journeys that are taking place at the moment.
- **Past** – This fragment contains all the journeys that are either successfully completed or rejected by the driver.

9.1.27 Approve or Reject Activity (Driver)

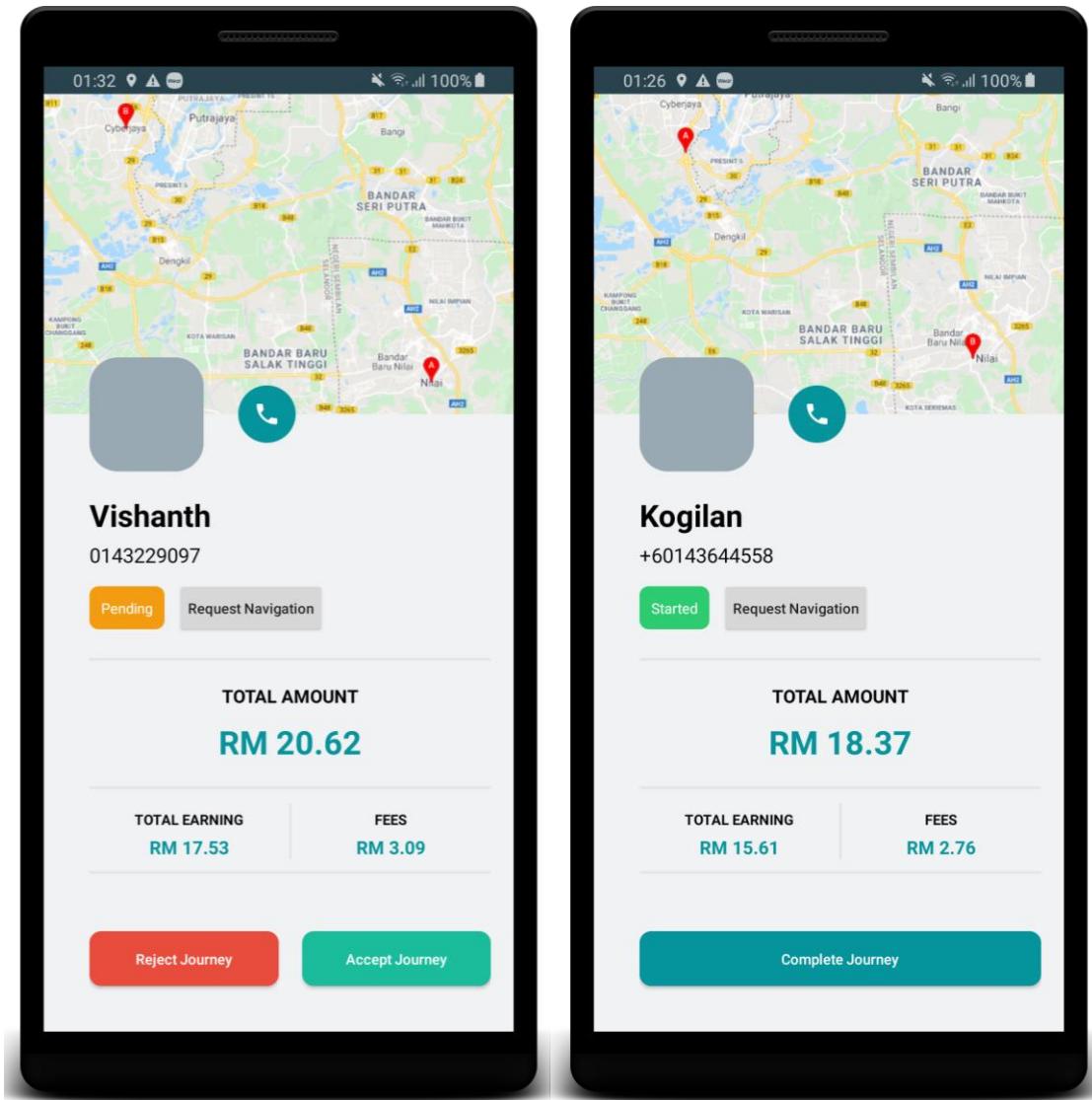


Figure 76: Approve or Reject Activity (Driver)

When a passenger requests for a ride via the application, the driver of the ride will be notified. The driver has the privilege to either accept or decline the requested journey. When the driver accepts the journey, the status is changed from ‘Pending’ to ‘Accepted’. On the other hand, when the driver declines the journey, the status is changed from ‘Pending’ to ‘Rejected’. Moreover, when the driver starts one of the accepted journeys, the status is changed from ‘Accepted’ to ‘Started’. The system calculates the overall cost of the ride based on the passenger’s pickup point and drop off point. Certain amount is deducted from the total cost for administration fees and the remaining will be paid to the driver.

9.1.28 Complete Journey Activity (Driver)

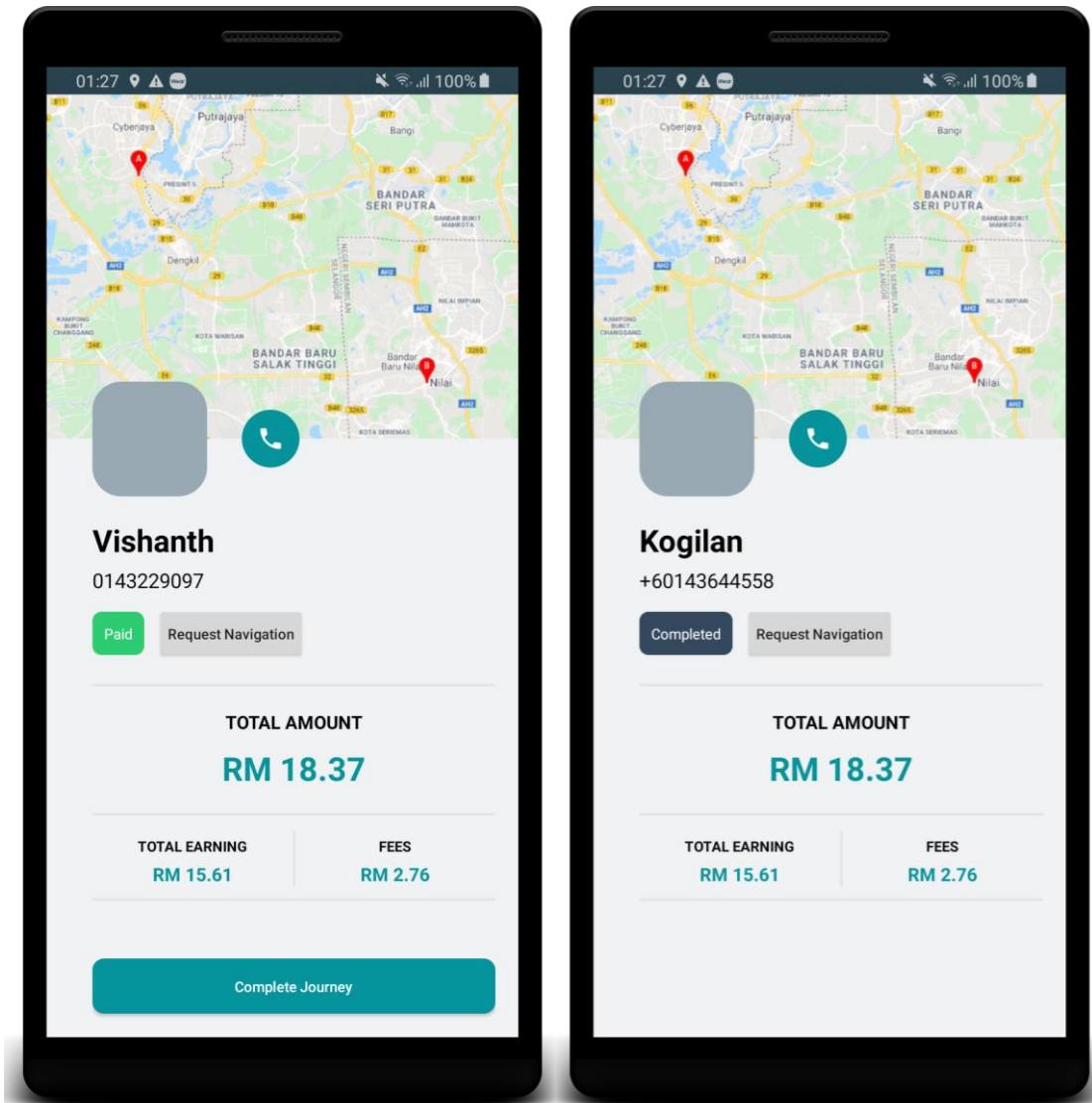


Figure 77: Complete Journey Activity (Driver)

When a passenger pays for the specific journey, the status is changed from ‘Started’ to ‘Paid’. After the driver drops off the passenger, he can click on the ‘Complete Journey’ button and the status is changed from ‘Paid’ to ‘Completed’.

9.1.29 Manage Cars Activity (Driver)

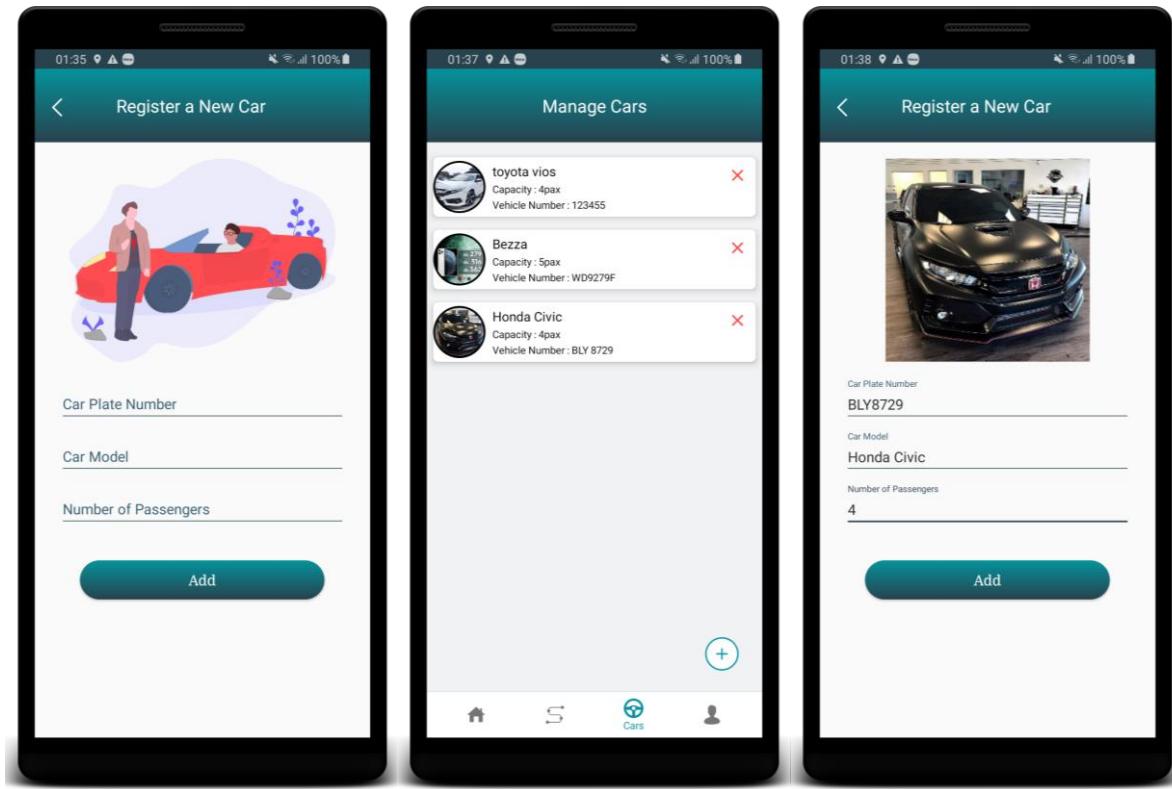


Figure 78: Manage Cars Activity (Driver)

When the driver clicks the ‘Cars’ option from the bottom navigation bar, he or she will be redirected to the ‘Manage Cars’ page. All the car details of the specific driver are shown in a recycler view. The driver can simply remove a car from the list by clicking the ‘Cancel’ icon at the top left corner of each card view. If the driver wishes to add a new car into the list, he or she needs to click the ‘Add’ icon at the bottom right corner of the page as shown in the second screenshot. The driver is required to enter the car plate number, car model, number of passengers and upload a car image in order to register a car into the system. The cars’ details of the driver will be used when creating a new journey.

9.2 Sample Codes

9.2.1 Front End (Android)

9.2.1.1 Implementation of RX Java

```
    @Override
    public void OnAddCarDetails(String carplateno, String carmodel, String pax, Uri uri) {

        JSONObject object = new JSONObject();
        try {
            object.put( name: "userid", EasyRideStorage.getInstance().getPrefUserId());
            object.put( name: "email", EasyRideStorage.getInstance().getPrefEmailAddr());
            object.put( name: "carnumber", carplateno);
            object.put( name: "carmodel", carmodel);
            object.put( name: "capacity", pax);

        } catch (JSONException ex) {
            ex.printStackTrace();
        }
        RequestBody body = RequestBody.create(MediaType.parse("raw"), object.toString());

        mAPIInterface.addNewCar(body).subscribeOn(Schedulers.io())
            .observeOn(AndroidSchedulers.mainThread())
            .subscribe(new Subscriber<MainCarsClass>() {

                @Override
                public void onCompleted() {

                }

                @Override
                public void onError(Throwable e) {
                    DriverAddCarActivity.showError(e.toString());
                }

                @Override
                public void onNext(MainCarsClass mainCarsClass) {
                    uploadImage(mainCarsClass.getCarDetailsClass().getId(),uri);
                    // DriverAddCarActivity.onNext(mainCarsClass.getMessage(), mainCarsClass.getStatus());
                }
            });
    }
}
```

Figure 79: Code Snippet for RX Java

RxJava is a robust implementation of Java VM that includes Reactive Extensions (a complete library for creating asynchronous and event-based functions with the use of observable sequences). RxJava. It comes with a strong programming dimension to maintain a proper sequence of data and events (Akarnkd, 2016). RxJava made the operations of filtering and retrieving information from database a lot easier with Observables. This library also provides a strong compatibility to use method references and lambda expressions (Luis Pereira, 2016). RxJava has been integrated in this project to handle asynchronous requests with multithreading.

9.2.1.2 Car Adapter Class

```
public class CarAdapterClass extends RecyclerView.Adapter<CarAdapterClass.CarHolder> {

    private Context context;
    private List<CarDetailsClass> cars;
    public CarAdapterClass.itemClickListener mCallback;

    public CarAdapterClass(Context context, List<CarDetailsClass> cars) {
        this.context = context;
        this.cars = cars;
    }

    @NonNull
    @Override
    public CarHolder onCreateViewHolder(@NonNull ViewGroup parent, int viewType) {
        View view = LayoutInflater.from(context).inflate(R.layout.row_layout, parent, attachToRoot: false);
        return new CarHolder(view);
    }

    @Override
    public void onBindViewHolder(@NonNull CarHolder holder, int position) {

        CarDetailsClass carDetailsClass = cars.get(position);

        holder.txtcarnumber.setText("Vehicle Number : " + carDetailsClass.getCarnumber());
        holder.txtcapacity.setText("Capacity : " + carDetailsClass.getCapacity() + "pax");
        holder.txtcarmodel.setText( carDetailsClass.getCarmodel());

        holder.btnClose.setOnClickListener(new View.OnClickListener(){
            @Override
            public void onClick(View view) {
                if(mCallback!=null){
                    mCallback.onItemClicked(carDetailsClass.getId());
                }
            }
        });
    }
}
```

Figure 80: Code Snippet for Car Adapter Class

An adapter class can be elucidated as a static implementation of all relevant methods from an event interface listener. Adapter class plays a significant role when handling most of the events that are defined in a specific event listener interface (Java 2 Novice, 2019). Based on the code snippet above, Car Adapter Class has been defined by extending the Recycler View adapter and only the relevant methods are implemented. The car details model class has been called to create and bind with a view holder which will be later displayed in the form of recycler view.

9.2.1.3 API calls

```
public interface APIInterface {

    @POST("/users/login")
    Observable<UserModalClass> getUserDetails(@Body RequestBody body);

    @POST("/users/login")
    Observable<UserModalClass> getUserLoginDetails(@Body RequestBody body);

    @POST("/users/register")
    Observable<UserModalClass> getUserRegistration(@Body RequestBody body);

    @GET("/users")
    Observable<UserModalClass> getUser();

    @GET("/journeys/viewjourney/{id}")
    Observable<UserModalClass> getUserJourney(@Header("x-access-token") String authToken, @Header("userid") String userID, String id);

    @GET("/journeys/driver/{id}")
    Observable<UserModalClass> getDriverJourney(@Header("x-access-token") String authToken, @Header("userid") String userID, String id);
}
```

Figure 81: Code Snippet for API calls

As shown in the image above, all the REST API calls of the system are defined in the API interface. Different HTTP methods are used in the system to handle different types of HTTP operations. For instance, POST method is used to handle create operations whereas PUT method is used to handle update or replace operations. JSON objects, parameters and headers are passed to the URL before performing the API call. All the sensitive information is stored in the header section of the URL for security purposes. Moreover, the URL is required to have a JWT token which will be verified in the back-end server.

9.2.1.4 Logo Fade in Animation

```
protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_splash);
    logo = (ImageView) findViewById(R.id.easyapplogo);
    logotext= (TextView) findViewById(R.id.easyapplogotext);

    Animation myanim = AnimationUtils.loadAnimation( context: this,R.anim.anim_splashscreen);
    logo.startAnimation(myanim);
    logotext.startAnimation(myanim);
    getWindow().setFlags(WindowManager.LayoutParams.FLAG_FULLSCREEN, WindowManager.LayoutParams.FLAG_FULLSCREEN);
    new Handler().postDelayed(new Runnable(){
        @Override
        public void run() {

            if(EasyRideStorage.getInstance().getAuthToken() != null || EasyRideStorage.getInstance().getPrefLoggedIn()) {
                Intent i = new Intent( packageContext: Splash_Activity.this, RiderMainActivity.class);
                startActivity(i);
                finish();
            } else {
                Intent i = new Intent( packageContext: Splash_Activity.this, LoginActivity.class);
                startActivity(i);
                finish();
            }
        }
    }, splashtimeout);
}
```

```
<?xml version="1.0" encoding="utf-8"?>
<alpha
    xmlns:android="http://schemas.android.com/apk/res/android"
    android:fromAlpha="0.0"
    android:toAlpha="1.0"
    android:duration="5000">

</alpha>
```

Figure 82: Code Snippet for Fade In Animation

The above code clearly demonstrates how the logo fade in animation has been implemented in the system when the user starts the application. The animation has been set to 5 seconds in the XML page within the alpha tags. As soon as the fade in animation ends, the user will be directed to the homepage of the application.

9.2.1.5 OkHttpClient Implementation

```
@Provides
@ApplicationScope
OkHttpClient getOkHttpClient(HttpLoggingInterceptor httpLoggingInterceptor) {
    Interceptor interceptor = new Interceptor() {
        @Override
        public okhttp3.Response intercept(Chain chain) throws IOException {
            Request newRequest = chain.request().newBuilder()
                .header("Accept", "application/json")
                .header("Content-Type", "application/json")
                .build();
            return chain.proceed(newRequest);
        }
    };

    return new OkHttpClient.Builder()
        .addInterceptor(interceptor)
        .addInterceptor(httpLoggingInterceptor)
        .build();
}
```

Figure 83: Code Snippet for OkHTTP Client Implementation

OkHTTP has been extensively used throughout the application to ensure the JSON response received from the Web API to be on the right Content-Type and serialized. Moreover, OkHTTP Client also functions as a logging interceptor in which it stores all the fundamental logs of the fetched responses.

9.2.1.6 Show Card Method

```
@Override
public void onShowCard(Card card) {
    if(card != null){
        no_avail_card.setVisibility(View.GONE);
        avail_card.setVisibility(View.VISIBLE);
        if(card.getBrand().equals("Visa")){
            card_type.setImageDrawable(ContextCompat.getDrawable(context: this, R.drawable.ic_payment_white_visa));
        }else{
            card_type.setImageDrawable(ContextCompat.getDrawable(context: this, R.drawable.ic_payment_master_card));
        }

        String lastTwoDigits = "";
        tv_card_number.setText("\u25cf\u25cf\u25cf\u25cf \u25cf\u25cf\u25cf\u25cf \u25cf\u25cf\u25cf\u25cf \u25cf\u25cf\u25cf\u25cf "+card.getLast4());
        lastTwoDigits= String.valueOf(card.getExp_year()).substring(String.valueOf(card.getExp_year()).length() - 2);
        tv_validity.setText(String.valueOf(card.getExp_month())+"/"+lastTwoDigits);
        EasyRideStorage.getInstance().setCreditCardAdded(true);

    }else{
        no_avail_card.setVisibility(View.VISIBLE);
        avail_card.setVisibility(View.GONE);
    }
}
```

Figure 84: Code Snippet for Show Card Method

The code snippet above is used to show all the payment details on a card icon. If the brand of the card is ‘Visa’, the icon is changed to Visa logo whereas if the brand of the card is ‘Master’, the icon is changed to Mastercard logo. Moreover, the logic shown in the code snippet above helps to display the expiry month and year in the correct format.

9.2.1.7 Implementation of MicroBlink SDK

```
MicroblinkSDK.setLicenseKey( "sRwAAAAAdY29tLmZpkmFseWVhcnByb2pl" +
    "Y3QuZWFeXJpZGVQhs7jCvPdd9ASuCT7th7Bc7uBQydaKix5CgRUiPd9RlwGj" +
    "O5V8s29gyKfI3uCgv6A8lDMz5OnmenirKnMTId9yAhdh8RwxNi0S8rp4k/Z7BeZFM2oeU" +
    "DFynDXjXXP1+ZubQR3T6vcxLu+xzB4XYFD53ttk71TfJdzl2HDSBnhVyGiCCKjgeq5F/iGKCw" +
    "uVynIsxZi18655hPao2vzZBcJql2Li551BZPz2iTM4EdLf2gXhi3bbQTIzotP6DlFCGepvcr/HoUBqo=", context: this);
```

```
public void startScanning() {

    // Settings for BlinkIdActivity
    BlinkIdUISettings settings = new BlinkIdUISettings(mRecognizerBundle);

    // tweak settings as you wish

    // Start activity
    ActivityRunner.startActivityForResult( activity: this, MY_REQUEST_CODE, settings);
}

@Override
protected void onActivityResult(int requestCode, int resultCode, Intent data) {
    super.onActivityResult(requestCode, resultCode, data);

    if (requestCode == MY_REQUEST_CODE) {
        if (resultCode == Activity.RESULT_OK && data != null) {
            // load the data into all recognizers bundled within your RecognizerBundle
            mRecognizerBundle.loadFromIntent(data);

            // now every recognizer object that was bundled within RecognizerBundle
            // has been updated with results obtained during scanning session

            // you can get the result by invoking getResult on recognizer
            BlinkIdCombinedRecognizer.Result result = mRecognizer.getResult();
            if (result.getResultState() == Recognizer.Result.State.Valid) {

                if(icFlag==1)
                {
                    mPresenter.OnICVerify();
                    icFlag=0;
                }
                if(licenseFlag==1)
                {
                    mPresenter.onLicenseVerify();
                    licenseFlag=0;
                }
            }
        }
    }
}
```

Figure 85: Code Snippet of MicroBlink SDK

The above code snippet briefly demonstrates how MicroBlink SDK has been integrated in the application to capture the information from driving license and identification card via text recognition processes. The license key of MicroBlink has been configured in the main class. When the user scans the identification card, the system verifies and captures the information through Activity Runner class. If the information is valid, the system sends a API Call to the web server and change the verification status to ‘Verified’.

9.2.1.8 Car Model Class

```
public class CarInfo {
    public String _id;
    public String userid ;
    public String emailaddress ;
    public String carnumber;
    public String carmodel;
    public String capacity ;
    public String createdAt;
    public String updatedAt ;
    private String image_file;

    public String getImage_file() { return image_file; }

    public void setImage_file(String image_file) { this.image_file = image_file; }

    public String get_id() { return _id; }

    public void set_id(String _id) { this._id = _id; }

    public String getUserId() { return userid; }

    public void setUserid(String userid) { this.userid = userid; }

    public String getEmailaddress() { return emailaddress; }

    public void setEmailaddress(String emailaddress) { this.emailaddress = emailaddress; }

    public String getCarnumber() { return carnumber; }

    public void setCarnumber(String carnumber) { this.carnumber = carnumber; }

    public String getCarmodel() { return carmodel; }

    public void setCarmodel(String carmodel) { this.carmodel = carmodel; }
```

Figure 86: Code Snippet for Car Model Class

The code snippet above briefly demonstrates how the car model class has been implemented in the application. This class acts as the bridge between the presenter class and view class. As soon as the user calls a method within the model class, the view model has been invoked and the respective state is changed. When the API call is initiated to retrieve all the car details from the database, the information is fetched and set in the model class before being presented in the view.

9.2.1.9 Implementation of Google Maps

```
public void onMapReady(GoogleMap map) {
    mGoogleMap = map;

    UiSettings mapSettings = mGoogleMap.getUiSettings();

    mapSettings.setCompassEnabled(false);
    mapSettings.setZoomControlsEnabled(false);
    mapSettings.setRotateGesturesEnabled(false);
    mapSettings.setMapToolbarEnabled(false);
    mapSettings.setTiltGesturesEnabled(false);

    if (initCoordinates == null)
        initCoordinates = new LatLng( 3.141767, 101.686830);

    mGoogleMap.setMyLocationEnabled(true);
    initLocation();

    if (initCoordinates != null) {
        moveToPointSmooth(initCoordinates);
        initCoordinates = null;
    } else
        mGoogleMap.moveCamera(CameraUpdateFactory.newLatLngZoom(new LatLng( 3.141767, 101.686830), 10f));

    mGoogleMap.setOnCameraMoveListener(this);
    mGoogleMap.setOnCameraIdleListener(this);
    mGoogleMap.setOnMapLongClickListener(this);

    onMyLocationClick( view: null);

    // location layer
    map.setMyLocationEnabled(false);
}
```

Figure 87: Code Snippet for Google Maps Implementation

As mentioned earlier, Google Maps SDK has been widely used throughout the application to provide the users with navigation functionalities. UI of the map has been customised with UISettings class in order to give it a more sophisticated and modern look. The coordinates of a specific location are retrieved from the map with the help of markers. Moreover, polylines are drawn on the map if the user chooses two different locations.

9.2.1.10 Fingerprint Authentication for Payment

```
FragmentActivity activity = this;

if (executor != null) {
    final BiometricPrompt biometricPrompt = new BiometricPrompt(activity, executor, new BiometricPrompt.AuthenticationCallback() {
        @Override
        public void onAuthenticationError(int errorCode, @NonNull CharSequence errString) {
            super.onAuthenticationError(errorCode, errString);
            if (errorCode == BiometricPrompt.ERROR_NEGATIVE_BUTTON) {
                // user clicked negative button
                runOnUiThread(new Runnable(){
                    public void run() {
                        new Handler().postDelayed(new Runnable(){
                            @Override
                            public void run() {
                                // task success! show TICK icon in ProSwipeButton
                                // false if task failed
                                swipe_button.showResultIcon( isSuccess: false );
                            }
                        }, delayMillis: 2000);
                    }
                });
            }
        }
    });

    @Override
    public void onAuthenticationSucceeded(@NonNull BiometricPrompt.AuthenticationResult result) {
        super.onAuthenticationSucceeded(result);
        //TODO: Called when a biometric is recognized.

        if(journeyID!=null && dateTime != null && price != null)
            mPresenter.chargePassenger(journeyID, dateTime, price);
    }
}
```

Figure 88: Code Snippet for Fingerprint Authentication

Biometric authentication has been integrated with the mobile application when the user makes payment for every successful ride. The code snippet above checks for the availability of fingerprint scanner within the mobile application and require the user to perform fingerprint authentication when making payments. The implementation of this feature specifies what actions should be perform when the authentication succeeds or fails.

9.2.2 Back End (Node.js)

9.2.2.1 Configuration of routes

```
const express = require('express');      File is a CommonJS module; it may be converted to an ES6 module.
const journeys = require('../controllers/journeys_controller.js');
const verifytoken = require ('../api/helper/jwtauth.js');

const router = express.Router();

router.post('/newjourney', journeys.createJourney);
router.get('/viewjourneys/:journeyStatus', verifytoken.checkToken, journeys.viewJourneyDetails);
router.get('/viewsinglejourney/:journeyId',verifytoken.checkToken, journeys.viewSingleJourney);
router.get('/driver/:journeyStatus',verifytoken.checkToken, journeys.viewDriverJourneyDetails);
router.get('/driverOne/:journeyId',verifytoken.checkToken, journeys.viewDriverSingleJourney);

router.post('/driverAccept/:journeyId',verifytoken.checkToken, journeys.driverAccept);
router.post('/driverReject/:journeyId',verifytoken.checkToken, journeys.driverReject);
router.post('/driverStart/:journeyId',verifytoken.checkToken, journeys.driverStart);
router.post('/driverComplete/:journeyId',verifytoken.checkToken, journeys.driverComplete);
router.post('/passengerCancel/:journeyId',verifytoken.checkToken, journeys.passengerCancel);

module.exports = router;
```

Figure 89: Code Snippet for Route Configurations

The code snippet above demonstrates how the public routes and private routes are configured within the Express application. When the user sends a HTTP request to the back-end server, the server verifies the URL and pass it to the corresponding function and method. Public routes are created to send request without the need of any authentication whereas private routes validate the token in the URL before sending the request.

9.2.2.2 Password Hashing using Bcrypt

```
        bcrypt.hash(req.body.password, 10, function (err, hash) {
            console.log(hash);
            if (err) {
                next(err);
            } else {
                users.create({
                    username: req.body.username,
                    password: hash,
                    email: req.body.emailaddress,
                    phone: req.body.phonenumber,
                    emailverification: false,
                    phoneverification: false,
                    icverification: false,
                    licenseverification: false,
                    approle: "Passenger"
                }, function (err, result) {
                    if (err)
                        next(err);
                    else

                        res.json({
                            status: true,
                            message: "Successfully Registered",
                            product: result,
                        });
                });
            }
        });

        bcrypt.compare(req.body.password, userInfo.password, function (err, result) {
            if (result == true) {
                const token = jwt.sign({
                    email: userInfo.emailaddress
                },
                tokenconfig.secret, {
                    expiresIn: 86400 // expires in 24 hours
                }
            );
        });
    });
}
```

Figure 90: Code Snippet for Password Hashing using Bcrypt

Bcrypt is nothing but a hashing function which helps to create a platform for password security that expands in relation to the computational and processing power (Dan Arias, 2018). Due to the fact the Bcrypt provides a one-way road to security, it cannot be easily decrypted by potential hackers. This function has been implemented in the system to hash the password of registered users before storing it in the database.

9.2.2.3 Integration of JSON Web Token (JWT)

```
let jwt = require('jsonwebtoken');
const config = require('../config/token.js');

let checkToken = (req, res, next) => {
    let token = req.headers['x-access-token'] || req.headers['authorization'];

    if (token) {
        jwt.verify(token, config.secret, (err, decoded) => {
            if (err) {
                return res.json({
                    success: false,
                    message: 'Token is not valid'
                });
            } else {
                next();
            }
        });
    } else {
        return res.json({
            success: false,
            message: 'Auth token is not supplied'
        });
    }
};

module.exports = {
    checkToken: checkToken
}
```

Figure 91: Code Snippet for Integration of JSON Web Token

JSON Web Token will be used to define a compact and self-contained way for securely transmitting information between the client device and server. As soon as a user logs into the application, a JSON Web token is created and stored in the shared preferences. When the user sends a new request to the server, the JSON Web token is added to the head section of the URL. Then, the token is verified in the web server before executing the intended functions and services. Once the user logs out of the application, the token is terminated. The user needs to request for a new token every time they log into the system.

9.2.2.4 Configuration of Mongoose and MongoDB

```
const mongoose1 = require('mongoose');
const mongoDB = 'mongodb+srv://Kogilan:kogilan97@easyride-5ic0q.mongodb.net/test?retryWrites=true&w=majority';

mongoose1.connect(mongoDB, { useNewUrlParser: true, useFindAndModify: false, useUnifiedTopology:true }).then(()=>
{
  console.log("Successfully connected to the database");
}).catch(err => {
  console.log("could not connect to the database. Exiting now...", err);
  process.exit();
});
mongoose1.Promise = global.Promise;

module.exports = mongoose1;
```

Figure 92: Code Snippet for the Mongoose and MongoDB configurations

As mentioned in the technical research part of this documentation, MongoDB has been used as the primary database for the system. Therefore, certain configurations have been done in the server side in order to access the database and retrieve all the requested details as shown in the code snippet above. Besides that, mongoose which is a dependency of MongoDB is used in the system to simplify the functions of MongoDB and makes the codebase even more robust and organised.

9.2.2.5 Email Verification

```
var sendPromise = new AWS.SES({
    apiVersion: '2010-12-01'
}).sendEmail(params).promise();
sendPromise.then(
    function (data) {
        console.log(data.MessageId);

        return res.status(200).send({
            status: true,
            message: 'A verification email has been sent to your email address',
        });
    }
).catch(
    function (err) {
        console.error(err, err.stack);
        return res.status(200).send({
            status: true,
            message: err,
        });
    }
);
```

```
verifiedEmail: function (req, res, next) {
    console.log(req.protocol + "://" + req.get('host'));
    if ((req.protocol + "://" + req.get('host')) == ("http://" + host)) {
        console.log("Domain is matched. Information is from Authentic email");
        if (req.query.id == rand) {
            console.log("email is verified");
            res.end("<p>Email " + senderEmail + " has been Successfully verified </p>");
            users.updateOne({
                email: senderEmail
            }, {
                $set: {
                    emailverification: true
                }
            },
            function (err, userinfo) [
                if (err) {
                    next(err);
                } else {
                    console.log("Email verification has been done");
                    res.end("<p>Email verification has been successfully done</p>");
                }
            ]
        } else {
            console.log("email is not verified");
            res.end("<p>Bad Request</p>");
        }
    } else {
        res.end("<p>Request is from unknown source</p>");
    }
},
```

Figure 93: Code Snippet for Email Verification

Code snippet above briefly demonstrates how the system verifies the email address of a registered user with the help of AWS SES. The credentials of AWS SES have been predefined and stored in a different file within the web server. Once the user clicks the verify link in the email, another API call is sent to the server which then validates the email address of the respective user.

9.2.2.6 Phone Verification

```
makePhoneRequest: function (req, res, next) {
    console.log(req.params.phoneNumber);
    nexmo.verify.request({
        number: req.params.phoneNumber,
        brand: "Nexmo",
        code_length: "4"
    }, (err, result) => {
        console.log(err ? res.json({
            status: true,
            result: err,
        }) :
        res.json({
            status: true,
            message: "A verification token has been sent to your phone",
            result: result,
        })
    })
},
});
```

Figure 94: Code Snippet for Phone Verification

Code snippet above briefly demonstrates how the system verifies the phone number of a registered user with the help of Nexmo API. As soon as the user's phone number is fetched, the system sends a 4-digit verification pin to user's mobile phone. The user is requested to input the four-digit pin and click 'Verify' button. Then, the back-end server receives the information and sends to Nexmo API for further verifications.

9.2.2.7 Upload Image to S3

```
aws.config.setPromisesDependency();
aws.config.update({
    accessKeyId: "AKIAVTBIYANF56RFPM6M",
    secretAccessKey: "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",
    region: "us-east-1"
});
const s3 = new aws.S3();
var params = {
    ACL: 'public-read',
    Bucket: "car-images-easyride",
    Body: fs.createReadStream(req.file.path),
    Key: `uploadImage/${req.file.originalname}`
};

s3.upload(params, (err, data) => {
    if (err) {
        console.log('Error occurred while trying to upload to S3 bucket', err);
    }
    if (data) {
        fs.unlinkSync(req.file.path); // Empty temp folder
        const locationUrl = data.Location;
```

Figure 95 : Code Snippet for Uploading Image to S3

AWS services have been extensively used throughout the development of the system. Code snippet above briefly explains how Amazon S3 is configured to store the static car images uploaded by the registered drivers. When a user uploads an image, Amazon S3 responds back with a URL which is then stored in the database for future use and reference.

9.2.2.8 Calculate price based on the distance

```
calculate: function (req, res, next) {
    var totalDistance = distance1(req.body.startLat, req.body.startLong, req.body.endLat, req.body.endLong);
    var cost = ((totalDistance / 1000) * 1).toFixed(2);
    console.log(cost);

    res.json({
        status: true,
        message: "Cost has been calculated",
        totalCost: cost
    })

    function distance1(lat1, lon1, lat2, lon2) {
        var R = 6371; // km (change this constant to get miles)
        var dLat = (lat2 - lat1) * Math.PI / 180;
        var dLon = (lon2 - lon1) * Math.PI / 180;
        var a = Math.sin(dLat / 2) * Math.sin(dLat / 2) +
            Math.cos(lat1 * Math.PI / 180) * Math.cos(lat2 * Math.PI / 180) *
            Math.sin(dLon / 2) * Math.sin(dLon / 2);
        var c = 2 * Math.atan2(Math.sqrt(a), Math.sqrt(1 - a));
        var d = R * c;
        return Math.round(d * 1000);
    }
},
```

Figure 96: Code Snippet for Calculating Price

Code snippet above briefly shows how the price is calculated for a specific journey. Some advanced mathematical equations are involved in this section to calculate the price based on the starting coordinate and ending coordinate provided by the user. After the price is calculated, the system rounds off the number to two decimal points and sends back to the user.

9.2.2.9 Credit Card Tokenization

```
stripe.tokens.create({
  card: {
    number: req.body.card_number,
    exp_month: req.body.exp_month,
    exp_year: req.body.exp_year,
    cvc: req.body.cvc
  }
}, function (err, token) {
  // asynchronously called
  if (err) {
    res.json({
      status: false,
      message: err.message
    })
  } else {
    creditCardModel.create({
      user_id: req.body.user_id,
      brand: token.card.brand,
      country: token.card.country,
      exp_month: token.card.exp_month,
      exp_year: token.card.exp_year,
      fingerprint: token.card.fingerprint,
      token: token.id,
      last4: token.card.last4,
    })
  }
})
```

Figure 97: Code Snippet for Credit Card Tokenization

Due to the fact that credit card details are highly confidential and critical, it is illegal to store user's credit card information in the database. Therefore, the system has been designed and developed in a way to handle the privacy issues by tokenizing user's credit card information via Stripe API. As soon as the credit card details are given to Stripe API, it performs tokenization and responds back with very minimal information which will be stored in the system's database.

10 System Validation

10.1 Unit Testing

Unit testing can be classified as one of the most fundamental phases in the development of a software. In unit testing, all the individual components of a system are tested and verified for bugs and runtime errors. Developer of Easy Ride has conducted a detailed unit testing based on the test plans and verify every single component of the system in order to eliminate unintentional errors.

10.1.1 Login

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
1.1	Clicks sign in button with empty email address and empty password	Email Address Text Field: Empty Password Text Field: Empty	Displays “Email Address or Password cannot be empty” message	Displays “Email Address or Password cannot be empty” message	Pass
1.2	Clicks sign in button with email address and empty password	Email Address Text Field: er. Password Text Field: Empty	Displays “Email Address or Password cannot be empty” message	Displays “Email Address or Password cannot be empty” message	Pass
1.3	Clicks sign in button with empty email address and password	Email Address Text Field: Empty Password Text Field: Kogilan6571@	Displays “Email Address or Password cannot be empty” message	Displays “Email Address or Password cannot be empty” message	Pass

1.4	Clicks sign in button with invalid email address and valid password	Email Address Text Field: koigli@gmails.com Password Text Field: Kogilan6571@	Displays “Incorrect Email Address or Password” message	Displays “Incorrect Email Address or Password” message	Pass
1.5	Clicks sign in button with valid email address and invalid password	Email Address Text Field: kogilan97@gmail.com Password Text Field: 2343fggfd	Displays “Incorrect Email Address or Password” message	Displays “Incorrect Email Address or Password” message	Pass
1.6	Clicks sign in button with invalid email address and invalid password	Email Address Text Field: koigli@gmails.com Password Text Field: 2343fggfd @	Displays “Incorrect Email Address or Password” message”	Displays “Incorrect Email Address or Password” message”	Pass
1.7	Clicks sign in button with valid email address and password	Email Address Text Field: kogilan97@gmail.com Password Text Field: Kogilan6571@	Displays “You have successfully logged into the system” message and redirect to the homepage	Displays “You have successfully logged into the system” message and redirect to the homepage	Pass
1.8	Clicks the ‘Don’t have an account? Register’ Text	-	Directs to home Sign Up Page	Directs to home Sign Up Page	Pass

Table 34: Login Unit Testing

10.1.2 Sign Up

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
2.1	Clicks ‘Sign Up’ Button with empty email address, username, phone number, password and confirm password	Email Address Text Field: Empty Username Text Field: Empty Phone Number Text Field: Empty Password Text Field: Empty Confirm Password Text Field: Empty	Displays ‘Textfields cannot be empty’ message	Displays ‘Textfields cannot be empty’ message	Pass
2.2	Clicks ‘Sign Up’ Button with invalid email address format	Email Address Text Field: kogilan97.com Username Text Field: Kogilan97 Phone Number Text Field: 60143644558 Password Text Field: Kogilan97@	Displays ‘Invalid Email Address’ message	Displays ‘Invalid Email Address’ message	Pass

		Confirm Password Text Field: Kogilan97@			
2.3	Clicks ‘Sign Up’ Button with an existing email address	Email Address Text Field: kogilan97@gmail.com Username Text Field: Kogilan97 Phone Number Text Field: 60143644558 Password Text Field: Kogilan97@ Confirm Password Text Field: Kogilan97@	Displays ‘email address already exists’ message	Displays ‘email address already exists’ message	Pass
2.4	Clicks ‘Sign Up’ Button with unmatching password and confirm password	Email Address Text Field: kogilan97.com Username Text Field: Kogilan97 Phone Number Text Field: 60143644558 Password Text Field:	Displays ‘password and confirm password do not match’ message	Displays ‘password and confirm password do not match’ message	Pass

		Kogilan9@ Confirm Password Text Field: Kogilan97@			
2.5	Clicks ‘Sign Up’ Button with valid information	Email Address Text Field: kogilan97@gmail.com Username Text Field: Kogilan97 Phone Number Text Field: 60143644558 Password Text Field: Kogilan97@ Confirm Password Text Field: Kogilan97@	Displays ‘successful registration’ message and redirects to the login page	Displays ‘successful registration’ message and redirects to the login page	Pass
2.6	Clicks ‘Already have an account? Sign in’ Text	-	Redirects to the Login Page	Redirects to the Login Page	Pass

Table 35: Sign Up Unit Testing

10.1.3 Feedback

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
3.1	Clicks ‘Contact Us’ option from the bottom navigation bar	-	Directs to the Feedback Page	Directs to the Feedback Page	Pass
3.2	Clicks ‘Call Support’ button	-	Calls the administrator of the application	Calls the administrator of the application	Pass
3.3	Clicks ‘Submit’ button with empty feedback	Feedback Text Field: Empty	Displays “Feedback cannot be empty” message	Displays “Feedback cannot be empty” message	Pass
3.4	Clicks ‘Submit’ button with a feedback	Feedback Text Field: Test Message	Displays “Feedback has been sent to the administrator” message	Displays “Feedback has been sent to the administrator” message	Pass

Table 36: Feedback Unit Testing

10.1.4 Find a Ride

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
4.1	Clicks 'Home' option from the bottom navigation bar	-	Redirects to the 'Find a Ride' page	Redirects to the 'Find a Ride' page	Pass
4.2	Clicks the 'Find a Ride' button	-	Redirects to the Maps Page and shows the current location	Redirects to the Maps Page and shows the current location	Pass
4.3	Clicks the calendar icon	-	Shows a calendar	Shows a calendar	Pass
4.4	Clicks the Set button after choosing a date and time from the calendar	-	Captures and displays the date and time	Captures and displays the date and time	Pass
4.5	Clicks the drop-down menu	-	Shows Pickup Location and Drop off Location text fields.	Shows Pickup Location and Drop off Location text fields.	Pass
4.6	Clicks Start button with empty pick up location and drop off location	Pickup Location Text Field: Empty Drop off Location TextField: Empty	Displays 'Choose pickup location and drop off location' message	Displays 'Choose pickup location and drop off location' message	Pass

	Clicks Start button with valid pick up location and drop off location	Pickup Location Text Field: Taman Puchong Perdana Drop off Location TextField: Bukit Jalil	Displays the route in a map and shows all the available rides in the form of markers	Displays the route in a map and shows all the available rides in the form of markers	Pass
	Click a marker from the map	-	Displays a tooltip with the respective driver's name, phone number and price.	Displays a tooltip with the respective driver's name, phone number and price.	Pass
	Clicks the tooltip	-	Books a journey and a notification is sent to the driver	Books a journey and a notification is sent to the driver	Pass

Table 37: Find a Ride Unit Testing

10.1.5 Manage Journeys (Passengers)

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
5.1	Clicks 'Journeys' option from the bottom navigation bar	-	Redirects to the 'My Journeys' Page	Redirects to the 'My Journeys' Page	- Pass
5.2	Clicks 'Upcoming' fragment in the page	-	Shows all the upcoming journeys of the user in a recycler view	Shows all the upcoming journeys of	Pass

				the user in a recycler view	
5.3	Clicks ‘Current’ fragment in the page	-	Shows all the current journeys of the users in a recycler view	Shows all the current journeys of the users in a recycler view	Pass
5.4	Clicks ‘Past’ fragment in the page	-	Shows all the past journeys of the users in a recycler view	Shows all the past journeys of the users in a recycler view	Pass
5.5	Clicks a specific journey	-	Shows detailed information about the journey including the driver’s phone number, starting point, destination, driver’s name, total amount and car.	Shows detailed information about the journey including the driver’s phone number, starting point, destination, driver’s name, total amount and car.	Pass
5.6	Clicks ‘Cancel’ button of a specific journey	-	Removes the journey from the fragment and notifies the driver via the application.	Removes the journey from the fragment and notifies the driver via the application.	Pass

5.7	Clicks ‘Pay Now’ button of a specific journey	-	Shows the total amount for the journey	Shows the total amount for the journey	Pass
5.8	Swipe Left in the page	-	Proceed to fingerprint authentication section	Proceed to fingerprint authentication section	Pass
5.9	Place the fingerprint on the fingerprint scanner	-	Authenticates the fingerprint and send payment to the driver via the registered card	Authenticates the fingerprint and send payment to the driver via the registered card	Pass

Table 38: Manage Journeys (Passengers) Unit Testing

10.1.6 Manage Profile (Passengers)

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
6.1	Clicks the ‘Profile’ option from the bottom navigation bar	-	Redirects to the Profiles page	Redirects to the Profiles page	- Pass
6.2	Clicks the ‘Verification’ option in the page	-	Redirects to the Verifications page	Redirects to the Verifications page	- Pass
6.3	Clicks the ‘Verify’ Button beside the email address	-	Sends a verification link to the user’s email address. When the user	Sends a verification link to the user’s email address. When the user	Pass

			clicks the link, the button name is changed to ‘Verified’ and become disabled.	clicks the link, the button name is changed to ‘Verified’ and become disabled.	
6.4	Clicks the ‘Verify’ Button beside the phone number	-	Sends a 4-digit pin to the user’s phone number	Sends a 4-digit pin to the user’s phone number	Pass
6.5	Inputs the 4-digit number and clicks the ‘Verify’ button	Four-digit pin: 1234	The button name is changed to ‘Verified’ and become disabled.	The button name is changed to ‘Verified’ and become disabled.	Pass
6.6	Clicks the ‘Verify’ Button beside the Identification Card text	-	Opens the camera with MicroBlink SDK	Opens the camera with MicroBlink SDK	Pass
6.7	Scans the identification card with the camera	-	Verifies the text in the identification card and the button name is changed to ‘Verified’	Verifies the text in the identification card and the button name is changed to ‘Verified’	Pass
6.8	Scans any other object with the camera	-	Displays ‘Error’ Message	Displays ‘Error’ Message	Pass
6.9	Clicks the ‘Verify’ Button beside the Driving License text	-	Opens the camera with MicroBlink SDK	Opens the camera with MicroBlink SDK	Pass

6.10	Scans the driving license with the camera	-	Verifies the text in the driving license and the button name is changed to ‘Verified’	Verifies the text in the driving license and the button name is changed to ‘Verified’	Pass
6.11	Clicks the ‘Left Arrow’ icon in the Verifications page	-	Redirects to the Profiles Page	Redirects to the Profiles Page	Pass
6.12	Clicks ‘Logout’ option in the page	-	Logs out the user from the system	Logs out the user from the system	Pass
6.13	Clicks ‘Switch to Driver’ option when all the verifications are done	-	Redirects to the Driver’s Main Page	Redirects to the Driver’s Main Page	Pass
6.14	Clicks ‘Switch to Driver’ option without verifying any of the requested information	-	Shows ‘Complete the verifications’ message	Shows ‘Complete the verifications’ message	Pass
6.15	Clicks ‘Payment’ option the page	-	Redirects to the Payment Page	Redirects to the Payment Page	Pass
6.16	Clicks ‘Add a credit/debit’ card option	-	Displays three different Text Fields with a card icon	Displays three different Text Fields with a card icon	Pass

6.17	Enter blank card number, expiration date and security code	Card number Text Field: Blank Expiration Date Text Field: Blank Security Code Text Field: Blank	Add Credit card button is disabled with less opacity	Add Credit card button is disabled with less opacity	Pass
6.18	Begins typing the card number	-	Displays the number on the card as the user types. Displays Visa or MasterCard icon based on the user's input	Displays the number on the card as the user types. Displays Visa or MasterCard icon based on the user's input	Pass
6.19	Begins typing the expiration date	-	Displays the expiration date on the card as the user types	Displays the expiration date on the card as the user types	Pass
6.20	Clicks add/debit card button with the valid card number, expiration date and security code	Card number Text Field: 4444 4444 4444 4444 Expiration Date Text Field: 12/9 Security Code Text Field: 957	Sends a Stripe API call and get the token which will be saved in the database. ‘Successful Card Registration’ message is displayed	Sends a Stripe API call and get the token which will be saved in the database. ‘Successful Card Registration’ message is displayed	Pass

6.21	Clicks ‘Delete the Card’ button	-	The card details are removed from the page. ‘The card is successfully deleted message’ is shown	The card details are removed from the page. ‘The card is successfully deleted message’ is shown	Pass
------	---------------------------------	---	---	---	------

Table 39: Manage Profile (Passengers) Unit Testing

10.1.7 Manage Paths (Driver)

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
7.1	Clicks on the Home button from the bottom navigation bar	-	Redirects to the ‘Paths’ page. All the previously created paths are shown in a recycler view.	Redirects to the ‘Paths’ page. All the previously created paths are shown in a recycler view.	- Pass
7.2	Clicks on ‘Offer Ride’ text	-	Displays a menu with Pickup Location text field and Drop off Location text field	Displays a menu with Pickup Location text field and Drop off Location text field	Pass

7.3	Clicks Start button with empty pickup location and drop off location	Pickup location Text Field: Empty Drop off location Text Field: Empty	Displays ‘pick up location and drop off location cannot be empty’ message	Displays ‘pick up location and drop off location cannot be empty’ message	Pass
7.4	Clicks Start button with valid pickup location and drop off location	Pickup location Text Field: Bukit Jalil Drop off location Text Field: Puchong Perdana	Displays a map in which the pickup location and drop off location are shown as markers.	Displays a map in which the pickup location and drop off location are shown as markers.	Pass
7.5	Clicks on a particular location on the map	-	Displays a marker on the map and adds the location as one of the waypoints	Displays a marker on the map and adds the location as one of the waypoints	Pass
7.6	Clicks more than five times on the map	-	Displays ‘Maximum stops added’ message	Displays ‘Maximum stops added’ message	Pass
7.7	Clicks the ‘Cancel’ icon beside each waypoint	-	Removes the waypoint from the list	Removes the waypoint from the list	Pass
7.8	Clicks the spinner on the page	-	Shows the registered car plate numbers of the driver	Shows the registered car plate numbers of the driver	Pass

7.9	Clicks ‘Add Path’ button with blank Path name	Path Name Text Field: Empty	Displays ‘Path name cannot be empty’ message	Displays ‘Path name cannot be empty’ message	Pass
7.10	Clicks ‘Add Path’ button with a valid Path name	Path Name Text Field: Work Path	Adds the path in driver’s homepage and stores the information in the database. Displays ‘successfully added’ message. Directs the user to the ‘Paths’ page	Adds the path in driver’s homepage and stores the information in the database. Displays ‘successfully added’ message. Directs the user to the ‘Paths’ page	Pass
7.11	Clicks one of the added paths	-	Displays detailed information of the path including the starting point, ending point, time, waypoints and chosen car	Displays detailed information of the path including the starting point, ending point, time, waypoints and chosen car	Pass
7.12	Clicks the ‘Delete’ button	-	Removes the path from the list and displays	Removes the path from the list and	Pass

			'Successfully Removed' message	displays 'Successfully Removed' message	
--	--	--	--------------------------------	---	--

Table 40: Manage Paths (Driver) Unit Testing

10.1.8 Manage Cars (Driver)

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
8.1	Clicks the 'Cars' option from the bottom navigation bar	-	Shows all the cars that have been previously added by the driver in a recycler view	Shows all the cars that have been previously added by the driver in a recycler view	- Pass
8.2	Clicks the 'Add' icon on the page	-	Redirects to the Car Registration' page	Redirects to the Car Registration' page	- Pass
8.3	Clicks on the car icon	-	Allows the user to upload a car image from their local storage	Allows the user to upload a car image from their local storage	- Pass
8.4	Clicks 'Add' button with empty car plate number, car	Car Plate Number Text Field: empty Car Model Text Field: empty	Shows 'The car plate number, car model, car image and number of	Shows 'The car plate number, car model, car image and	Pass

	model, car image and number of passengers.	Number of Passengers Text Field: empty Car Image File Upload: empty	passengers cannot be empty' message	number of passengers cannot be empty' message	
8.5	Clicks 'Add' button with valid car plate number, car model, car image and number of passengers.	Car Plate Number Text Field: BLY 8729 Car Model Text Field: Toyota Camry Number of Passengers Text Field: 4 Car Image File Upload: {{car image}}	Registers the car details into the system and displays 'Successful car registration' message	Registers the car details into the system and displays 'Successful car registration' message	Pass
8.6	Clicks the 'Cancel' button on the car list	-	Removes the car information from the list and displays successful deletion message	Removes the car information from the list and displays successful deletion message	Pass

Table 41: Manage Cars (Driver) Unit Testing

10.1.9 Manage Journeys (Drivers)

Test Case ID	Description	Test Condition	Expected Result	Actual Result	Status (Pass/Fail)
9.1	Clicks 'Journeys' option from the bottom navigation bar	-	Redirects to the 'My Journeys' Page	Redirects to the 'My Journeys' Page	Pass
9.2	Clicks 'Upcoming' fragment in the page	-	Shows all the upcoming journeys of the driver in a recycler view	Shows all the upcoming journeys of the driver in a recycler view	Pass
9.3	Clicks 'Current' fragment in the page	-	Shows all the current journeys of the driver in a recycler view	Shows all the current journeys of the driver in a recycler view	Pass
9.4	Clicks 'Past' fragment in the page	-	Shows all the past journeys of the driver in a recycler view	Shows all the past journeys of the driver in a recycler view	Pass
9.5	Clicks a specific journey	-	Shows detailed information about the journey including the passenger's details, pickup point, drop off point, time, total	Shows detailed information about the journey including the passenger's details, pickup point, drop off point, time, total	Pass

			amount, total earnings, and fees.	amount, total earnings, and fees.	
9.6	Clicks ‘Accept’ button of a specific journey	-	Changes the status to Accepted.	Changes the status to Accepted.	Pass
9.7	Clicks ‘Reject’ button of a specific journey	-	Changes the status to Rejected and the journey is moved to ‘Past’ fragment	Changes the status to Rejected and the journey is moved to ‘Past’ fragment	Pass
9.8	Clicks ‘Complete’ button of a specific journey	-	Changes the status to Completed and the journey is moved to ‘Past’ fragment	Changes the status to Completed and the journey is moved to ‘Past’ fragment	Pass
9.9	Clicks ‘Start’ button of a specific journey	-	Changes the status to Started and the journey is moved to ‘Current’ fragment	Changes the status to Started and the journey is moved to ‘Current’ fragment	Pass

Table 42: Manage Journeys (Drivers) Unit Testing

10.2 User Acceptance Testing

User acceptance testing plays a crucial role as it is one of the important procedures which has to be conducted before the actual system is being deployed into the market. By conducting user acceptance testing, the developers will be able to make sure that the system developed meets the requirements that have been proposed. If the customers are not satisfied with a particular function, their feedback will become the basis of new requirements and the process of design, implementation, test and listen repeats. In contrast, if the customers are satisfied with the function, the iteration ends there and the design for the new iteration starts. In relation to this project, the developer has chosen 5 different users, from daily travellers who commute by car and also users who rely on public transportation. Since the system developed does not require users from different walks of life, the user acceptance testing was conducted with these 5 different users. The collected responses stated below.

User Acceptance Testing for Travellers

Name	Haridasan Balakrishnan
Occupation	Software developer
Testing Date	14 February 2020
Start Time	13.20pm
End Time	13.45pm

Components	Grade				
	1	2	3	4	5
1. Graphical User Interface (GUI)					√
2. User Experience (UX)					√
3. System Interaction				√	
Fulfilling Objectives					
a. Offers a reliable and secure carpooling platform					√
d. Shows detailed description of journeys				√	
e. Make effortless transactions					√
4. System Validation					√
5. System Satisfaction					√
6. No errors					√

1: Bad

2: Poor

3: Fair

4: Good

5: Excellent

Recommendation and Comments

Functionality of the application is great, much needed in the market right now.

User Acceptance Testing for Travellers

Name	Sushmita
Occupation	Freelance Yoga Trainer
Testing Date	17 February 2020
Start Time	10.15am
End Time	10.35am

Components	Grade				
	1	2	3	4	5
1. Graphical User Interface (GUI)					√
2. User Experience (UX)				√	
3. System Interaction					√
Fulfilling Objectives					
a. Offers a reliable and secure carpooling platform				√	
f. Shows detailed description of journeys					√
g. Make effortless transactions					√
4. System Validation					√
5. System Satisfaction					√
6. No errors				√	

1: Bad

2: Poor

3: Fair

4: Good

5: Excellent

Recommendation and Comments

The application is almost bug-free and smooth in terms of performance

User Acceptance Testing for Travellers

Name	Maximus Hooi
Occupation	Clerk
Testing Date	17 February 2020
Start Time	14.50pm
End Time	15.20pm

Components	Grade				
	1	2	3	4	5
1. Graphical User Interface (GUI)					√
2. User Experience (UX)					√
3. System Interaction					√
Fulfilling Objectives					
a. Offers a reliable and secure carpooling platform					√
h. Shows detailed description of journeys					√
i. Make effortless transactions				√	
4. System Validation				√	
5. System Satisfaction					√
6. No errors					√

1: Bad

2: Poor

3: Fair

4: Good

5: Excellent

Recommendation and Comments

Fingerprint authentication before payment is good to make sure legit users perform transactions.

User Acceptance Testing for Travellers

Name	Mohd Iqbal
Occupation	Web Programming Trainer
Testing Date	24 February 2020
Start Time	18.40pm
End Time	19.10pm

Components	Grade				
	1	2	3	4	5
1. Graphical User Interface (GUI)					√
2. User Experience (UX)				√	
3. System Interaction				√	
Fulfilling Objectives					
a. Offers a reliable and secure carpooling platform					√
j. Shows detailed description of journeys					√
k. Make effortless transactions					√
4. System Validation					√
5. System Satisfaction					√
6. No errors					√

1: Bad

2: Poor

3: Fair

4: Good

5: Excellent

Recommendation and Comments

Application looks great. Could include reward systems in the future

User Acceptance Testing for Travellers

Name	Magentira Kumar
Occupation	Student
Testing Date	28 February 2020
Start Time	13.50pm
End Time	14.15pm

Components	Grade				
	1	2	3	4	5
1. Graphical User Interface (GUI)				√	
2. User Experience (UX)					√
3. System Interaction					√
Fulfilling Objectives					
a. Offers a reliable and secure carpooling platform					√
l. Shows detailed description of journeys				√	
m. Make effortless transactions					√
4. System Validation				√	
5. System Satisfaction					√
6. No errors				√	

1: Bad

2: Poor

3: Fair

4: Good

5: Excellent

Recommendation and Comments

Well-functioning application. Please release the application soon.

Outcome of User Acceptance Testing

Category	Graphical User Interface (GUI)												
Result	<table border="1"> <thead> <tr> <th>Score</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0 (0%)</td> </tr> <tr> <td>2</td> <td>0 (0%)</td> </tr> <tr> <td>3</td> <td>0 (0%)</td> </tr> <tr> <td>4</td> <td>1 (20%)</td> </tr> <tr> <td>5</td> <td>4 (80%)</td> </tr> </tbody> </table>	Score	Percentage	1	0 (0%)	2	0 (0%)	3	0 (0%)	4	1 (20%)	5	4 (80%)
Score	Percentage												
1	0 (0%)												
2	0 (0%)												
3	0 (0%)												
4	1 (20%)												
5	4 (80%)												
Analysis	The result above shows that majority of respondents are satisfied with the overall implementation of Graphical User Interface (GUI). This proves that, the user interface is attractive and perceptive enough for the users. Thus, there were no major issues found by the testers while experiencing the user interface.												

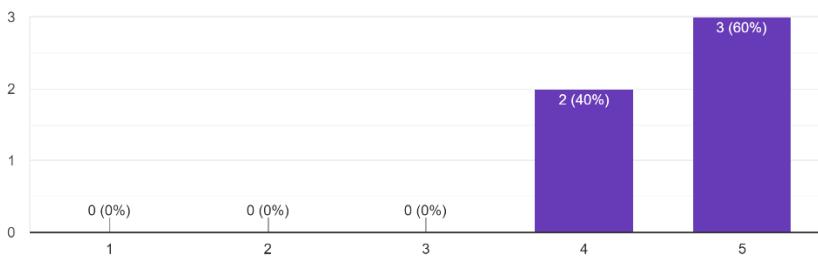
Category	User Experience (UX)												
Result	<table border="1"> <thead> <tr> <th>Score</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0 (0%)</td> </tr> <tr> <td>2</td> <td>0 (0%)</td> </tr> <tr> <td>3</td> <td>0 (0%)</td> </tr> <tr> <td>4</td> <td>2 (40%)</td> </tr> <tr> <td>5</td> <td>3 (60%)</td> </tr> </tbody> </table>	Score	Percentage	1	0 (0%)	2	0 (0%)	3	0 (0%)	4	2 (40%)	5	3 (60%)
Score	Percentage												
1	0 (0%)												
2	0 (0%)												
3	0 (0%)												
4	2 (40%)												
5	3 (60%)												
Analysis	Based on the data obtained above, 3 out of 5 respondents are totally satisfied with the user experience. This proves that the majority of respondents are actually satisfied with the user experience.												

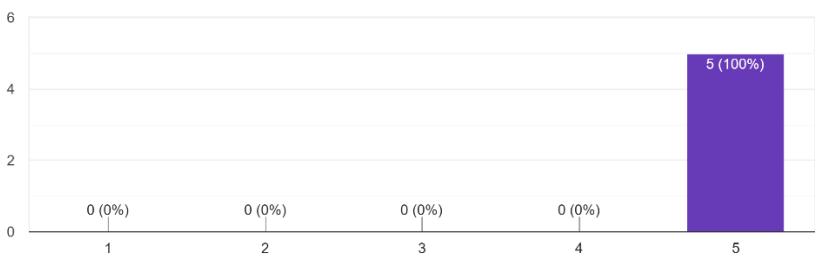
Category	System Interaction												
Result	<table border="1"> <thead> <tr> <th>Score</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0 (0%)</td> </tr> <tr> <td>2</td> <td>0 (0%)</td> </tr> <tr> <td>3</td> <td>0 (0%)</td> </tr> <tr> <td>4</td> <td>1 (20%)</td> </tr> <tr> <td>5</td> <td>4 (80%)</td> </tr> </tbody> </table>	Score	Percentage	1	0 (0%)	2	0 (0%)	3	0 (0%)	4	1 (20%)	5	4 (80%)
Score	Percentage												
1	0 (0%)												
2	0 (0%)												
3	0 (0%)												
4	1 (20%)												
5	4 (80%)												
Analysis	The result above shows majority of the respondents are satisfied with how the interaction works in the system. This might prove that the navigational structure of the system is well implemented and can be worked more in terms of achieving high usability.												

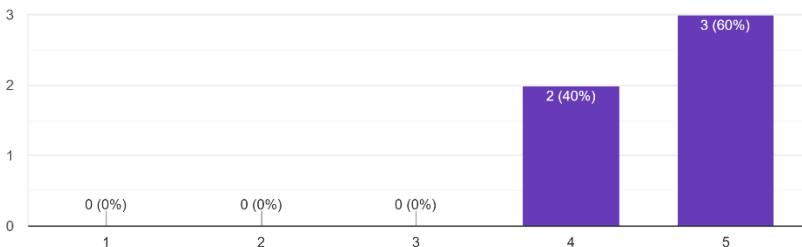
Category	Fulfilling Objectives: Offers a reliable and secure carpooling platform												
Result	<table border="1"> <thead> <tr> <th>Score</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0 (0%)</td> </tr> <tr> <td>2</td> <td>0 (0%)</td> </tr> <tr> <td>3</td> <td>0 (0%)</td> </tr> <tr> <td>4</td> <td>1 (20%)</td> </tr> <tr> <td>5</td> <td>4 (80%)</td> </tr> </tbody> </table>	Score	Percentage	1	0 (0%)	2	0 (0%)	3	0 (0%)	4	1 (20%)	5	4 (80%)
Score	Percentage												
1	0 (0%)												
2	0 (0%)												
3	0 (0%)												
4	1 (20%)												
5	4 (80%)												
Analysis	Based on the results obtained above, the respondents believe that the developed system is safe and reliable to use. The application is developed in a way where sensitive user information is handled in a confidential manner. Vital security technologies such as JWT token, fingerprint authentication and also Bcrypt hashing are included in the system in order to only allow legitimate users to handle their own data to achieve a high level of security.												

Category	Fulfilling Objectives: Shows detailed description of journeys						
Result	<table border="1"> <thead> <tr> <th>Score</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>4</td> <td>40%</td> </tr> <tr> <td>5</td> <td>60%</td> </tr> </tbody> </table>	Score	Percentage	4	40%	5	60%
Score	Percentage						
4	40%						
5	60%						
Analysis	The result obtained above shows that 3 out of 5 users are totally satisfied whereas the remaining 2 respondents have chosen satisfied as a score. This clearly shows that the developed system provides detailed information about driver's name, driver's car model, colour, number plate and more. The respondents feel that they have been served with adequate amount of information associated with their journeys						

Category	Fulfilling Objectives: Make effortless transactions						
Result	<table border="1"> <thead> <tr> <th>Score</th> <th>Percentage</th> </tr> </thead> <tbody> <tr> <td>4</td> <td>80%</td> </tr> <tr> <td>5</td> <td>20%</td> </tr> </tbody> </table>	Score	Percentage	4	80%	5	20%
Score	Percentage						
4	80%						
5	20%						
Analysis	The result above portrays that the respondents are thoroughly satisfied with how the payment method works with this system. The payment process in the application ensures that smooth transaction can be done by the users via debit or credit card.						

Category	System Validation												
Result	 <table border="1"> <thead> <tr> <th>Score</th> <th>Count (%)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0 (0%)</td> </tr> <tr> <td>2</td> <td>0 (0%)</td> </tr> <tr> <td>3</td> <td>0 (0%)</td> </tr> <tr> <td>4</td> <td>2 (40%)</td> </tr> <tr> <td>5</td> <td>3 (60%)</td> </tr> </tbody> </table>	Score	Count (%)	1	0 (0%)	2	0 (0%)	3	0 (0%)	4	2 (40%)	5	3 (60%)
Score	Count (%)												
1	0 (0%)												
2	0 (0%)												
3	0 (0%)												
4	2 (40%)												
5	3 (60%)												
Analysis	<p>Based on the result above, there was a total of 3 respondents who gave a high score while testing the system validation. There was some minor validation issue occurred which caused the remaining 2 respondents to give a lower score. Further works will be done in order to clearly fix the issues in the long run.</p>												

Category	System Satisfaction												
Result	 <table border="1"> <thead> <tr> <th>Score</th> <th>Count (%)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0 (0%)</td> </tr> <tr> <td>2</td> <td>0 (0%)</td> </tr> <tr> <td>3</td> <td>0 (0%)</td> </tr> <tr> <td>4</td> <td>0 (0%)</td> </tr> <tr> <td>5</td> <td>5 (100%)</td> </tr> </tbody> </table>	Score	Count (%)	1	0 (0%)	2	0 (0%)	3	0 (0%)	4	0 (0%)	5	5 (100%)
Score	Count (%)												
1	0 (0%)												
2	0 (0%)												
3	0 (0%)												
4	0 (0%)												
5	5 (100%)												
Analysis	<p>In general, all respondents are satisfied with the functionalities of the system. It can be said that the system testing turned out to be a success and proven that the system has provided immense amount of satisfaction for the users.</p>												

Category	No errors												
Result	 <table border="1"> <thead> <tr> <th>Score</th> <th>Count (%)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0 (0%)</td> </tr> <tr> <td>2</td> <td>0 (0%)</td> </tr> <tr> <td>3</td> <td>0 (0%)</td> </tr> <tr> <td>4</td> <td>2 (40%)</td> </tr> <tr> <td>5</td> <td>3 (60%)</td> </tr> </tbody> </table>	Score	Count (%)	1	0 (0%)	2	0 (0%)	3	0 (0%)	4	2 (40%)	5	3 (60%)
Score	Count (%)												
1	0 (0%)												
2	0 (0%)												
3	0 (0%)												
4	2 (40%)												
5	3 (60%)												
Analysis	Based on the results, 2 respondents have given a low score compared to the remaining 3 respondents who gave a high score. This was due to some noticeable bugs while testing the system. The bugs which showed up then was resolved.												

Category	No errors
Result	<p>Well functioning application. Please release the application soon.</p> <p>Application looks great. Could include reward systems in the future</p> <p>Functionality of the application is great, much needed in the market right now.</p> <p>Fingerprint authentication before payment is good to make sure legit users perform transactions.</p> <p>The application is almost bug-free and smooth in terms of performance</p>
Analysis	All the respondents have given feedbacks and recommendations that can be taken into considerations. The other recommendations suggested will be updated as a future enhancement.

10.3 Summary

To summarize, extensive unit testing and user acceptance testing are performed with careful planning in order to gather some in-depth insights about the system. Each and every unit of the system has been iteratively tested to make sure the system delivers the expected functionalities and free from unintentional bugs. Besides that, memory optimization and network handling of the system can be effectively monitored and managed throughout unit testing. On the other hand, the recommendations and feedbacks received from user acceptance testing enable the developer to fully comprehend the requirements and needs of the users. Based on the users' feedback, the developer will try to improvise the overall system features and functionalities in the future implementation.

11 Conclusion and Reflection

11.1 Critical Evaluation

The accepted framework was chosen, upon considering the degree of feasibility of the project from the developer's viewpoint. However, in the presence of comparative and alternative frameworks, the accepted experimental design was given the trust to deliver desired outcomes for the stakeholders. Here, the developer has registered a significant confidence on the accepted framework, executed for Easy Ride. The confidence instilled, correspondingly harbours risks and limitations. As an accountable researcher cum developer, the author has addressed the limitations and potent challenges of the project in chapter 1.

In spite of the fact that the proposed system provides significant benefits, there are several limitations to be assessed and evaluated before proceeding with the implementation phase. One of the major challenges that may occur upon the deployment of this system is the difficulties in finding potential customers and end-users. It cannot be denied that, car owners or travellers will give a sceptical look when they first hear about the system as they might think that the system is exposed to several security risks. Therefore, a detailed and comprehensive documentation which describes about the system functionalities must be prepared and distributed to the travellers and potential customers to make them understand that the proposed system is highly reliable, trustworthy and does not involve any security risk.

On the other hand, lack of knowledge and unfamiliarity with the technologies behind sophisticated security features can also be considered as one of the limitations in the development of this carpooling system. Since the system is planned to be developed by incorporating some advanced security features such as Bcrypt Hashing, in-depth technical knowledge on those features is highly required. Therefore, innumerable number of studies must be done by the developer to grasp relevant technical knowledge before developing the system. Furthermore, there are high chances for the entire system to turn out to be futile if there is no systematic project plan. This is because the carpooling mobile application comprises a few convoluted functions which require a careful and thoughtful planning.

Moreover, all deliverables were not able to be offered at the requested time due to time constraint and the bustling timetable of the developer, where it significantly impacted the progression of the project to achieve its objectives. Due to the above fact, the accepted framework was not fully completed. However, the crucial parts of required capacities were at

least fulfilled. The remaining deficient highlights were then added as future directions of the project. As a lesson learnt, the Gantt chart of the related future projects should be revised according to the resources and the dependencies between tasks.

Other than time constraint, the developer also faced hurdles in retrieving references and parallel models for the current project as similar systems established in the globe are silent and enigmatic for young developers. Companies or organizations that offer such similar systems as their primary services to their customers, tend to privatise the internal functional domains of the system to the external world. The opaqueness of significant information transfer was a challenge for the developer during the initial stage of the project execution.

Furthermore, the current project should be able to secure the data flow by encrypting the information between the user's interface and the server. This aspect values confidentiality and security of the users and the overall stakeholders. This project fully deals with an unencrypted flow or Hypertext Transfer Protocol (HTTP). Thus, creating an alarming situation for both users and business collaborators as the system lacks a crucial security feature. Due to the charges that are being applied to purchase an SSL certificate (HTTPS), the developer could not create a HTTPS environment for the current system. In the future directions, the current project will be further enhanced by purchasing an SSL certificate for better security.

On the other hand, since the current system would be newly introduced to the Malaysian market, there is a high inclination for the users and stakeholders to face some hitches when using the application for the first time. Henceforth, clear commands and 24/7 provision should be prearranged to the users to ensure that they comprehend all the functionalities and workflow of the system. The adaptation of the proposed system to the Malaysian market would be unpredictable and a preliminary test is required to forecast the impacts of the proposed system to the community and the ecosystem.

In the end, the developer has improved his aptitudes, coding talent, time management and research execution in the process of developing, Easy Ride. The guidance and supervision provided by the developer's supervisor have uplifted the confidence and the enthusiasm of the developer to execute the current project, smoothly.

11.2 Conclusion

Various researches have been done with careful deliberation in order to gather some comprehensive information that are associated with the proposed carpooling mobile application. The results of the studies have mentioned that a fully integrated carpooling application is highly sought by Malaysian travellers who currently rely on public transportation. From researcher's perspective, the proposed mobile application will also be beneficial for car owners as the overall transportation costs can be shared with the passengers. If developed and implemented well, this proposed system has the potential to help thousands of travellers to communicate with each other and share journeys. All travellers need a medium to travel, but not everyone owns a motorized vehicle. Therefore, this mobile-based carpooling application is intended to close the transportation gap and provides a robust medium for travellers to share journey and fulfil their own travelling needs. If the proposed mobile application reaps huge profits and receives great acclamation from the end-users, there is a huge potential for the application to be expanded to different regions and countries.

12 References

1. Abdelfatah, A. S., 2015. Evaluating the Sustainability of Traffic Growth in Malaysia. *Journal of Traffic and Logistics Engineering*, 3(1), pp. 6-11.
2. Agile Alliance, 2018. *Extreme Programming*. [Online]
Available at:
[https://www.agilealliance.org/glossary/xp/#q=~\(filters~\(postType~\(~'post~'aa_book~'aa_event_session~'aa_experience_report~'aa_glossary~'aa_research_paper~'aa_video\)~tags~\(~'xp\)\)~searchTerm~'~sort~false~sortDirection~'asc~page~1\)](https://www.agilealliance.org/glossary/xp/#q=~(filters~(postType~(~'post~'aa_book~'aa_event_session~'aa_experience_report~'aa_glossary~'aa_research_paper~'aa_video)~tags~(~'xp))~searchTerm~'~sort~false~sortDirection~'asc~page~1))
[Accessed 16 March 2018].
3. Airbrake.io, 2018. *Extreme Programming: What Is It And How Do You Use It?*. [Online]
Available at: <https://airbrake.io/blog/sdlc/extreme-programming>
[Accessed 16 March 2018].
4. Akarnkd, 2016. *RxJava: Reactive Extensions for the JVM*. [Online]
Available at:
[https://github.com/ReactiveX/RxJava#targetText=RxJava%20is%20a%20Java%20VM,programs%20by%20using%20observable%20sequences.](https://github.com/ReactiveX/RxJava#targetText=RxJava%20is%20a%20Java%20VM,programs%20by%20using%20observable%20sequences)
[Accessed 20 September 2019].
5. Ali, M., 2018. Analysing Vehicular Congestion Scenario in Kuala Lumpur Using Open Traffic. *Indonesian Journal of Electrical Engineering and Computer Science*, 10(3), p. 875~882.
6. Android Authority, 2019. *I want to develop Android Apps — What languages should I learn?*. [Online]
Available at: <https://www.androidauthority.com/develop-android-apps-languages-learn-391008/>
[Accessed 18 September 2019].
7. Android Studio, 2019. *Android Studio*. [Online]
Available at: <https://developer.android.com/studio>
[Accessed 20 September 2019].
8. Anon., 2016. Taxi Design Review: Malaysia Context. *International Journal of Science, Environment and Technology*, 5(5), p. 2782.

9. Anon., 2017. Enterprise collaboration systems: addressing adoption challenges and the shaping of of sociotechnical systems. *International Journal of Information Systems and Project Management*, 5(1), pp. 5-23.
10. Ariffin, R. N. R., 2013. The challenges of implementing urban transport policy. *The 3rd International Conference on Sustainable Future for Human Security* , 17(3), p. 469 – 477.
11. AWS, 2019. *AWS Elastic Beanstalk*. [Online]
Available at: <https://aws.amazon.com/elasticbeanstalk/>
[Accessed 10 February 2020].
12. Bellis, M., 2019. *Hailing: History of the Taxi*. [Online]
Available at: <https://www.thoughtco.com/hailing-history-of-the-taxi-1992541>
13. Bharadwaj, S., 2017. Impact of congestion on greenhouse gas emissions for road transport in Mumbai metropolitan region. *Transport research procedia*, Volume 25, pp. 3538-3551.
14. Bouza, A., 2018. *What is Digital Transformation, Digitalization, and Digitization*. [Online]
Available at: <https://medium.com/api-product-management/what-is-digital-transformation-digitalization-and-digitization-c76277ffbdd6>
15. Bright Hub, 2016. *The Extreme Programming LifeCycle*. [Online]
Available at: <https://www.brighthubpm.com/methods-strategies/88996-the-extreme-programming-life-cycle/>
[Accessed 1 May 2018].
16. Bright Hub, 2018. *Extreme Programming : Iteration Planning*. [Online]
Available at: <https://www.brighthubpm.com/methods-strategies/92832-extreme-programming-iteration-planning/>
[Accessed 20 March 2018].
17. Bungga, F., 2017. Fake spare part, original part price tag. *HM Online*.
18. Chan, M., 2018. *Socar launches car-sharing programme in Malaysia*. [Online]
Available at: <https://paultan.org/2018/01/24/socar-launches-car-sharing-programme-in-malaysia/>
[Accessed 21 10 2019].

19. Clear Bridge Mobile, 2019. *[Infographic] A Guide to Mobile App Development: Web vs. Native vs. Hybrid*. [Online]
Available at: <https://clearbridgemobile.com/mobile-app-development-native-vs-web-vs-hybrid/>
[Accessed 25 September 2019].
20. Dahalan, D., 2015. Youth confidence in the quality of public transport services: The case of Greater KL, Malaysia. *Malaysian Journal of Society and Space*, 11(9), pp. 12-22.
21. Dan Arias, 2018. *Hashing in Action: Understanding bcrypt*. [Online]
Available at: <https://auth0.com/blog/hashing-in-action-understanding-bcrypt/>
[Accessed 01 February 2020].
22. Dávideková, M., 2016. Digitalization of Society: Smartphone - a Threat?.
International Research Conference Management Challenges, Volume 8, pp. 315-317.
23. Dayangku, S., 2019. *Vulcan Post*. [Online]
Available at: <https://vulcanpost.com/678373/malaysia-ryde-vs-grab-app/>
[Accessed 15 January 2020].
24. DB-Engines, 2019. *System Properties Comparison MongoDB vs. MySQL vs. PostgreSQL*. [Online]
Available at: <https://db-engines.com/en/system/MongoDB%3BMySQL%3BPostgreSQL>
[Accessed 20 September 2019].
25. Deloitte, 2015. *Transport in the Digital Age*, UK: Deloitte Touche Tohmatsu Limited.
26. Department of Statistics Malaysia, 2019. *Consumer price index 2019*. [Online]
Available at:
https://www.dosm.gov.my/v1/index.php?r=column/ctwoByCat&parent_id=105&menu_id=bThzTHQxN1ZqMVF6a2I4RkZoNDFkQT09
[Accessed 21 October 2019].
27. Explorable, 2017. *Advantages and Disadvantages of Surveys*. [Online]
Available at: <https://explorable.com/advantages-and-disadvantages-of-surveys>
[Accessed 17 September 2018].

28. Ferrarese, M., 2019. *Grab Penang: 5 reasons why it's better than taxis*. [Online] Available at: <https://www.penang-insider.com/why-uber-grab-are-better-than-taxis-in-penang/>
29. Global e-Sustainability Initiative, 2019. *Green Information Systems for Sustainability*. s.l.:Efosa Carroll Idemudia.
30. Google Developers, 2018. *Develop Android apps with Kotlin*. [Online] Available at: <https://developer.android.com/kotlin> [Accessed 20 September 2019].
31. Google Maps Platform, 2019. *Overview*. [Online] Available at: <https://developers.google.com/maps/documentation/android-sdk/intro#targetText=With%20the%20Maps%20SDK%20for,an%20response%20to%20map%20gestures>. [Accessed 25 September 2019].
32. Hafezi, M. H., 2017. Passengers Preference and Satisfaction of Public Transport in Malaysia. *Australian Journal of Basic and Applied Sciences*, 6(8), pp. 410-416.
33. Ho, C. K., 2018. *How Grab's CEO steered it from a garage in Malaysia to Southeast Asia's most valuable tech unicorn*. [Online] Available at: <https://www.scmp.com/tech/article/2157177/how-grabs-ceo-steered-it-garage-malaysia-southeast-asias-most-valuable-tech> [Accessed 21 10 2019].
34. Hsien, A. H., 2018. *Riding on e-hailing services*. [Online] Available at: <http://www.focusmalaysia.my/Property/riding-on-e-hailing-services>
35. Intellipaat, 2019. *What is Elastic Beanstalk in AWS ?*. [Online] Available at: <https://intellipaat.com/blog/what-is-elastic-beanstalk-in-aws/> [Accessed 13 September 2019].
36. Ismail, A., 2018. Traffic Impact Assessment on a New Commercial Development in the Neighbourhoods of Ampang Town in Selangor. *Jurnal Kejuruteraan*, 5(7), pp. 43-51.
37. Ismail, R., 2015. Passengers Preference and Satisfaction of Public Transport in Malaysia. *Australian Journal of Basic and Applied Sciences*, 6(8), pp. 410-416.

38. Java 2 Novice, 2019. *What is adapter class?*. [Online]
Available at: https://www.java2novice.com/java_interview_questions/adapter-class/
[Accessed 3 February 2020].
39. KOTING, S. B., 2017. EVALUATION AND IMPROVEMENT OF
ACCESSIBILITY TO URBAN RAIL TRANSIT SYSTEM IN KLANG VALLEY,
MALAYSIA. *FACULTY OF ENGINEERINGUNIVERSITY OF MALAYA KUALA
LUMPUR*, 2(3), pp. 1-8.
40. Lau, A., 2019. *Why anti-Grab taxi drivers get no sympathy*. [Online]
Available at: <https://www.malaymail.com/news/opinion/2019/03/11/why-anti-grab-taxi-drivers-get-no-sympathy/1731219>
41. Lebuhraya Lembaga Malaysia, 2019. *Enhancing Users Satisfaction Through
Innovation and Financial Re-Engineering*, Kuala Lumpur: Lembaga Lebuhraya
Malaysia.
42. LEESAN, 2018. *Does Malaysia have the best taxi service in the world?*. [Online]
Available at: <https://www.star2.com/travel/2018/10/13/malaysia-best-taxi-service-world/>
43. Len, A. W. T., 2019. *Tackling Urban Traffic Congestion–synergising towards
integrated Strategies – synergising towards integrated strategic*. Kota Kinabalu,
Insight .
44. Little, A. D., 2017. *Digital platforms in freight*. [Online]
Available at: <https://www.adlittle.de/de/node/22204>
[Accessed 20 September 2019].
45. Lokman, T., 2017. PM: Malaysia on course to reduce carbon emissions by 40 pct by
2020. *New straights times*, 3 December .
46. Luis Pereira, 2016. *Why should we use RxJava on Android*. [Online]
Available at: [https://medium.com/@lpereira/why-should-we-use-rxjava-on-android-c9066087c56c#targetText=Reactive%20Extensions%20\(Rx\)%20are%20a,write%20clean%20and%20simpler%20code.](https://medium.com/@lpereira/why-should-we-use-rxjava-on-android-c9066087c56c#targetText=Reactive%20Extensions%20(Rx)%20are%20a,write%20clean%20and%20simpler%20code.)
[Accessed 20 September 2019].
47. Madziwa, M. N., 2016. *Interviewing as a data collection method*. [Online]
Available at: <https://www.linkedin.com/pulse/interviewing-data-collection-method->

munyaradzi-madziwa/

[Accessed 20 September 2019].

48. Mahirah, K., 2015. Valuing Road User's Willingness to Pay to Reduce Traffic Congestion. *Asian Social Scienc*, 11(25), pp. 48-57.
49. Manogaran, S., 2017. Analysis of Vehicular Traffic Flow in the Major Areas of Kuala Lumpur Utilizing Open-Traffic. *AIP*, 2(32), pp. 020013-1 - 020013-7.
50. Masirin, M. I. M., 2019. Review on Malaysian Rail Transit Operation and Management System: Issues and Solution in Integration. *International research and innovation summit* , 226(2), pp. 1-7.
51. Medium Corporation, 2019. *Data Privacy Concerns: An Overview for 2019*. [Online] Available at: https://medium.com/@the_manifest/data-privacy-concerns-an-overview-for-2019-2cce4a79aa6f8 [Accessed 4 August 2019].
52. Minhans, A., 2013. Transport Cost Analysis of City Bus and Private Car Usage in Johor Bahru, Malaysia. *Jurnal Teknologi*, 25(13), pp. 25-31.
53. Mire, S., 2019. *What's The Future Of Transportation? 16 Experts Share Their Insights*. [Online] Available at: <https://www.disruptordaily.com/future-of-transportation/>
54. MongoDB, 2019. *MongoDB and MySQL Compared*. [Online] Available at: <https://www.mongodb.com/compare/mongodb-mysql#targetText=Why%20use%20MongoDB%20instead%20of,applications%20more%20efficiently%20at%20scale.> [Accessed 19 September 2019].
55. Monterail, 2018. *6 Main Reasons Why Node.js Has Become a Standard for Enterprise-Level Organizations*. [Online] Available at: <https://www.monterail.com/blog/nodejs-development-enterprises> [Accessed 24 September 2019].
56. Mukti, I. Y., 2018. Challenges in Governing the Digital Transportation Ecosystem in Jakarta: A Research Direction in Smart. *Digital Ecosystem*, 9(14), pp. 8-10.

57. Mustapha, N. H. N., 2015. Outflow of traffic from the national capital Kuala Lumpur to the north, south and east coast highways using flow, speed and density relationships. *Journal of Traffic and Transportation Engineering*, 2(8), pp. 14-18.
58. Nptcel, 2018. *Generation of traffic congestion*. [Online]
Available at: https://nptel.ac.in/courses/105101008/584_Congestion/point2/point.html
[Accessed 3 August 2019].
59. Nsubunga, J., 2019. *Cousins pretended to be taxi drivers so they could kidnap and rob drunk people*. [Online]
Available at: <https://metro.co.uk/2019/06/08/two-cousins-kidnapped-robbed-drunk-people-posing-taxi-drivers-9873285/>
60. Odhiambo, D., 2018. *System Design in Software Development*. [Online]
Available at: <https://medium.com/the-andela-way/system-design-in-software-development-f360ce6fcbb9>
[Accessed 5 February 2020].
61. Orxy, 2018. *Goldfinger - Library that simplifies fingerprint integration*. [Online]
Available at:
https://www.reddit.com/r/androiddev/comments/7uqh6h/goldfinger_library_that_simplifies_fingerprint/
[Accessed 22 September 2019].
62. Oxford Economics, 2019. *Oxford Economics*. [Online]
Available at: <https://www.oxfordeconomics.com/>
[Accessed 20 October 2019].
63. Patro, N., 2018. *Choose the best — Native App vs Hybrid App*. [Online]
Available at: <https://codeburst.io/native-app-or-hybrid-app-ca08e460df9#targetText=Hybrid%20apps%20are%20native%20apps.app%20store%20like%20native%20app.&targetText=Hybrid%20apps%20are%20built%20using,for%20Android%2C%20Swift%20for%20iOS.>
[Accessed 22 September 2019].
64. Performatix, 2019. *What you need to know about Proguard Android?*. [Online]
Available at: <https://www.perfomatix.com/proguard-android/#targetText=Proguard%20is%20free%20Java%20class,methods%20using%20obfuscation%20and%20minification%20to%20reduce%20the%20size%20of%20your%20apk%20file.>

0short%20meaningless%20names.

[Accessed 25 September 2019].

65. Philstar.com, 2019. *Grab introduces new app features, enhanced services for 'Better Everyday' initiative*. [Online]
Available at: <https://www.philstar.com/lifestyle/business-life/2019/02/20/1893096/grab-introduces-new-app-features-enhanced-services-better-everyday-initiative>
[Accessed 21 10 2019].
66. Quora, 2017. *What is the use of Retrofit in Android?*. [Online]
Available at: <https://www.quora.com/What-is-the-use-of-Retrofit-in-Android>
[Accessed 22 September 2019].
67. Quora, 2017. *Why is Java preferred for developing an Android app?*. [Online]
Available at: [Based on the comparison done among Java, Kotlin and React Native, the most suitable](#)
[Accessed 27 September 2019].
68. Reina, R., 2019. *What's The Future Of Transportation? 16 Experts Share Their Insights*. [Online]
Available at: <https://www.disruptordaily.com/future-of-transportation/>
69. Rideshare, 2018. *How does carpooing work*. [Online]
Available at: <https://rideshare.org/question/how-does-carpooling-work/>
[Accessed 26 June 2019].
70. Rouse, M., 2019. *Amazon Cognito*. [Online]
Available at: <https://searchaws.techtarget.com/definition/Amazon-Cognito>
[Accessed 17 September 2019].
71. Saccomani, P., 2019. *Native Apps, Web Apps or Hybrid Apps? What's the Difference?*. [Online]
Available at: <https://www.mobiloud.com/blog/native-web-or-hybrid-apps/>
[Accessed 25 September 2019].
72. SearchSoftwareQuality, 2018. *Better software through debugging and unit testing -- Unit testing, Extreme Programming and TDD*. [Online]
Available at: <http://searchsoftwarequality.techtarget.com/tutorial/Better-software->

through-debugging-and-unit-testing-Unit-testing-Extreme-Programming-and-TDD
[Accessed 22 March 2018].

73. Shahee, S., 2018. *The Benefits of Carpooling*, California : UC Berkeley.
74. Shahidad, S., 2014. Assessment of Greenhouse Gas Emission Reduction Measures in Transportation Sector of Malaysia. *Jurnal Teknologi*, 70(4), p. 1–8 .
75. Shukri, F. A. A., 2013. An Overview of Fleet Maintenance and Operating Cost: Key Components and Methods. *International Journal of Commerce, Business and Management*, 2(6).
76. Sinar Harian, 2017. Workshop owner act rude. *Sinar Harian News*.
77. SmartDraw, 2020. *Use Case Diagram*. [Online]
Available at: <https://www.smartdraw.com/use-case-diagram/>
[Accessed 10 February 2020].
78. Susilawati, S., 2018. The Study of Location Specific Lane Change Impacts on Traffic Delay using Extended Cell Transmission Model. *MATEC Web of Conferences*, 203(12), pp. 1-7.
79. Sustainable Mobility for All, 2017. *Global Mobility Report 2017*. [Online]
Available at: <http://www.sum4all.org>
[Accessed 20 September 2019].
80. Tan, D., 2019. *Paultan.org*. [Online]
Available at: <https://paultan.org/2019/10/16/singapores-ryde-carpool-app-launches-in-malaysia-klang-valley-no-commission-drivers-keep-100-fares/>
[Accessed 15 January 2020].
81. Techopedia, 2019. *Android Operating System*. [Online]
Available at: <https://www.techopedia.com/definition/25106/android-operating-system>
[Accessed 3 October 2019].
82. Techopedia, 2019. *Database Management System (DBMS)*. [Online]
Available at: [https://www.techopedia.com/definition/24361/database-management-systems-dbms#targetText=A%20database%20management%20system%20\(DBMS\)%20is%20a%20software%20package%20designed%20and%20validate%20this%20](https://www.techopedia.com/definition/24361/database-management-systems-dbms#targetText=A%20database%20management%20system%20(DBMS)%20is%20a%20software%20package%20designed%20and%20validate%20this%20)

data.

[Accessed 20 September 2019].

83. The Drum, 2019. *Grab fined by Singapore government for data breach in email marketing campaigns*. [Online]
Available at: <https://www.thedrum.com/news/2019/06/12/grab-fined-singapore-government-data-breach-email-marketing-campaigns>
[Accessed 22 September 2019].
84. The Ministry of Transport Malaysia, 2017. *TRANSPORT STATISTICS MALAYSIA*, Malaysia: s.n.
85. Times, N. S., 2019. Government plans to spend RM450m on electric buses. *Budget 2020*, p. 2.
86. Tutorials Point, 2018. *Unit Testing*. [Online]
Available at:
https://www.tutorialspoint.com/software_testing_dictionary/unit_testing.htm
[Accessed 29 April 2018].
87. Tutorials point, 2018. *UML - Class Diagram*. [Online]
Available at: https://www.tutorialspoint.com/uml/uml_class_diagram.htm
88. University of Twente, 2018. *Data Collection Methods*. [Online]
Available at: <https://www.utwente.nl/en/bms/datalab/datacollection/methods/>
[Accessed 20 September 2019].
89. Verghis, M. A., 2015. *TRANSFORMING URBAN TRANSPORT*, Bangkok: MALAYSIA ECONOMIC MONITOR.
90. Visual Studio Code, 2019. *Visual Studio Code*. [Online]
Available at: <https://code.visualstudio.com/>
[Accessed 19 September 2019].
91. Wahab, M. A. F. A., 2017. Automotive Consumerism in Malaysia with Regard to Car Maintenance. *Journal of the Society of Automotive Engineers Malaysia*, 1(2), pp. 137-153.
92. Wells, D., 1999. *Release Planning*. [Online]
Available at: <http://www.extremeprogramming.org/rules/planninggame.html>
[Accessed 19 March 2018].

93. World Bank, 2019. *World Bank*. [Online]
Available at: <https://www.worldbank.org/>
[Accessed 20 October 2019].
94. World Health Organisation Malaysia, 2019. *World Health Organisation Malaysia*.
[Online]
Available at: <https://www.who.int/countries/mys/en/>
[Accessed 20 October 2019].
95. Yahaya, N., 2019. *TOWARDS SUSTAINABLE TRANSPORTATION SYSTEM: MALAYSIAN EXPERIENCE*. Tanjung Malim, Faculty of Science and Technology University Malaysia Terengganu.
96. Yoo, Y., 2010. *Digitalization and Innovation*, Tokyo: IIR Working.
97. Zakhar Yung, 2018. *Python vs. Ruby vs. Node.js – Which Platform Is a Fit for Your Project?*. [Online]
Available at: <https://railsware.com/blog/python-vs-ruby-vs-node-js-which-platform-is-a-fit-for-your-project/>
[Accessed 29 September 2019].

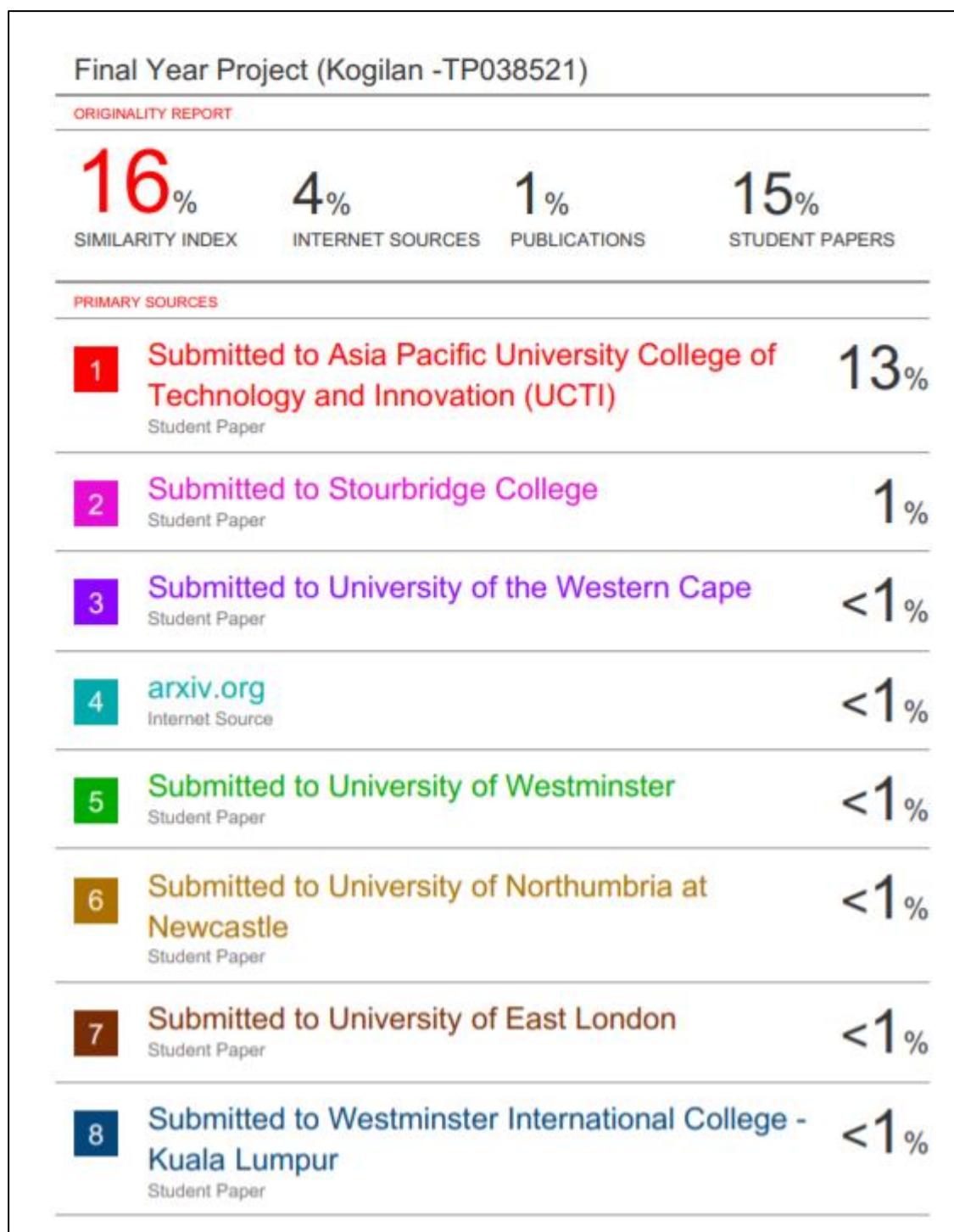
13 Appendices

13.1 Project Investigations Feedback and Learning Contract Form

13.2 Log Sheet (8 Log Sheets)

13.3 FYP Poster

13.4 First Two Pages of Turnitin Report



9	www.jespersenpodium.com Internet Source	<1 %
10	www.techopedia.com Internet Source	<1 %
11	slides.com Internet Source	<1 %
12	Liping Fu. "Scheduling dial-a-ride paratransit under time-varying, stochastic congestion", <i>Transportation Research Part B: Methodological</i> , 2002 Publication	<1 %
13	Submitted to Informatics Education Limited Student Paper	<1 %
14	www.dragapp.com Internet Source	<1 %
15	Submitted to University of Greenwich Student Paper	<1 %
16	nbo.nic.in Internet Source	<1 %
17	littlegoblin.de Internet Source	<1 %
18	esource.dbs.ie Internet Source	<1 %
19	worldwidescience.org	

13.5 Project Proposal Form

Title - Secure Carpooling Mobile Application (Easy Ride)

Introduction

When one thinks about sharing rides, one's mind will definitely steer towards the word 'carpool'. Carpool can be elucidated as an arrangement between two or more individuals to make a planned journey in a single car, typically to the same destination where each person takes turn to drive the others. In certain carpool scenarios, there will be only one car owner who drives other commuters to the desired destination (Rideshare, 2018). Practicing carpools can significantly reduce a person's overall travelling cost which includes tolls and fuel expenses. On the other hand, carpools are also considered to be an environmentally friendly approach as sharing journey mitigates traffic snarl-up on the roads, greenhouse gas emissions and the need for additional parking bays. Despite the fact that carpools reap huge benefits to both drivers and passengers, some people are deeply sceptical and afraid to practice carpools. This is because of the unfamiliarity of fellow companions and safety concerns. It should be clear now that there is a lack of a reliable platform which encourages and builds trust among individuals to carry out carpools. Therefore, a secure carpools platform (Easy Ride) will be developed in this project in which commuters who do not possess a car can look for someone nearby who owns a car and travels to the same location. This platform will be designed and developed as a mobile application to bring greater convenience to the users.

Problem Statement

It is undeniably true that the number of vehicles on road is increasing tremendously from day-to-day. Based on the article published by Paulton in 2017, vehicle registrations in Malaysia has already hit a staggering number of 28.2 million units. As the number of vehicles on road increases, the rate of traffic congestion or colloquially known as traffic jam also increases. The debate over the term 'traffic congestion' is compendious and universal. When the vast majority of people use private automotive vehicles and seek to drive during rush hours, the roads get severely congested. Other than that, when the world is overpopulated with motorized vehicles, the environment is getting severely affected due to the carbon and greenhouse gas emissions. This relatively contributes to global warming and climate changes. From a different perspective, the cost of private transportation is high as the automotive owners tend to spend a lot of money to cover the toll, car maintenance and fuel expenses. Henceforth, all the mentioned

primary problems here occur due to the overpopulation of cars and the absence of a digitalised platform which offers carpooling.

Project Aims

To develop a secure mobile application that promotes the practice of carpooling among travellers in Malaysia. This system is hoped to establish a reliable and convenient platform for travellers to share journeys to their desired destinations.

Project Objectives

- To allow the drivers and passengers to offer and search for journeys respectively
- To provide a greater flexibility and allow more individuals to share journey and save money.
- To create a better environment by reducing carbon emissions from vehicles
- To establish a secure data flow by encrypting the information retrieved from the users.

Literature Review

The influence of digitalization has opened pathways for new ideas and opportunities to reduce cost and different ideas by opening up new business models (Baron, 2017). The transformation of digital ecosystem has been a key reason for the birth of digital urbanization. This urbanization has been creating significant challenges to the people and government in terms of resources, infrastructures and also energy. According to United Nations in 2014, an estimation of 54 percent of the world's population was residing in urban areas. But by 2050, a total of 66 percent of the world population is estimated to start living in urban areas all over the world (Mukti and Prambudia, 2018). Hence, as the amount of population is seen to increase at urban areas, the problem of mobility in urban areas has seen to be rising as well. This is supported by World Bank Group (2014) where it is stated that the annual passenger traffic on roads will exceed 50 percent higher when compared to 2015.

Massive Traffic Congestion

The typical routine in Malaysia is driven by the interaction of traffic, drivers and streets. Traffic flows vary with time and place; mostly throughout the day as it fluctuates with peaks in the morning and in the evening. Many places may have very high volume of traffic due to active economic activities, for example in the main business district of major cities. But other places, including leisure roads, may have to account for heavy traffic only on weekends and holidays. The design and construction of such an installation require proper planning and appropriate engineering judgment, which are not predictable. Congestion occurs when the traffic number

is much higher than that of existing road installations (the capacity). The Level of Service (LoS) of such facilities deteriorates when the amount of traffic reaches the capacity of the existing facilities. Because of changes in their convenience, i.e. reduced speed, longer travel time or longer time at road intersections, the users of the affected highway would experience lower LoS. All these made them lose valuable time that could have been used for other useful and more successful enterprises.

Emission of greenhouse gases

A number of research studies found that carpooling would reduce emissions of greenhouse gases (GHG). Bharadwaj (2017) reports which were based on a model simulation claimed that individual passengers minimize the emission of GHGs by about 4% to 5%. from a personal travel plan. An estimated 7.2 million tons of GHGs in each year can be saved in Malaysia, if every 100 cars are added with additional passengers (Shahidad, 2014). The study also estimates that Malaysia can save 68.0 million tons, with one passenger added on 10 vehicles annually in Malaysia (Lokman, 2017). The SMART2020 study also focuses on the possibility of lowering carbon dioxide emissions by 70 million to 190 million tonnes, by the use of information technology and communications technology (ICT) such as app-based carpooling to improve road efficiencies (Global e-Sustainability Initiative, 2019).

High Transportation Costs

Carpooling provides Malaysians with several financial and fiscal incentive as identified in the research of Koting (2017). This is supported by (Masirin, 2019)'s article that claimed that carpooling is a cost-effective strategy to alleviate traffic and minimize additional road and public transit capacities, facilitating growth in transportation resources and personal performance. His study found that casual carpooling can significantly reduce energy consumption for 15 commuters, which means that the same number of passengers can use express bus services at a lower cost. The figure below shows the bar graph for share of transport cost in accordance of household income.

Shukri (2013) asserted that cost of maintenance and operating of a vehicle is increasing. Wahab(2017) added that some general car workshops appear to mislead customers by asking them the wrong issues or problems, so that additional costs are charged for the service. Consumers often believe that some mechanics have coerced them to substitute some of their vehicle parts that have been considered defective or unusable, even though that is not the case

(Bungga, 2017). There are also concerns about misbehaviour and failures to treat customers with good behaviour or disrespectful actions (Sinar Harian, 2017)

Deliverables

In short, Easy Ride is a secure mobile application which promotes carpooling among drivers and passengers who travel to the same location. Some fundamental features have been included into the application to enhance the overall efficiency and user-friendliness.

As soon as the users launch the application, they will be prompted to the login page in which they have to input their respective username and password. If they do not own an account, they will be directed to the registration page which requires them to create a new account. Once they log into the application, they will see an option either to offer a car ride or search for a particular ride. If the user wants to offer a car ride, he is required to upload a picture of his identification card and driving license for security purposes. After the system verifies the user's credentials, he is able to offer a car ride by inputting the starting point, destination, time and overall travel expenses. On the other hand, if the user wishes to search for a particular journey which fulfils his or her travel needs, he or she needs to input all the requested information and click 'search'. If the journey matches the requirements of the user, they can book a ride with the car owner at the agreed time.

Supervisors

- 1) Mr Amad Arshad
- 2) Ms Sathiapriya Ramiah
- 3) Dr Julia binti Juremi
- 4) Mr Tanveer Khalil Shaikh

13.6 Project Specification Form

Project Title - Secure Carpooling Mobile Application (Easy Ride)

Project Background

When one thinks about sharing rides, one's mind will definitely steer towards the word 'carpool'. Carpool can be elucidated as an arrangement between two or more individuals to make a planned journey in a single car, typically to the same destination where each person takes turn to drive the others. In certain carpool scenarios, there will be only one car owner who drives other commuters to the desired destination (Rideshare, 2018). Carpooling is an economically efficient and rational approach. This is because it can significantly reduce a person's overall travelling cost which includes tolls and fuel expenses. The more the commuters in the carpool, the less the travelling expenses will be. On the other hand, carpooling is also considered to be an environmentally friendly approach as sharing journey mitigates traffic congestion on the roads, greenhouse gas emissions and the need for additional parking bays.

According to the research carried out by Environment Canada (2018), air pollution caused by vehicles is severely linked to various health-related issues such as skin allergies, respiratory diseases and asthma. Hence, by practicing carpool, these health problems can be gradually alleviated. In addition to that, travelling alone causes stress and makes the overall journey boring and tedious. Through carpooling, the commuters can make new acquaintances and turn a loneliness journey into a cheerful one. Despite the fact that carpooling reaps huge benefits to both drivers and passengers, some people are still deeply sceptical and tentative about carpooling. They are overwhelmed with a lot of questions such as :

- Where to find a travelling companion who travels to the same location?
- Will the travelling schedule of the driver clash with the passengers?
- Is it safe to travel with a complete stranger via carpool?
- If there is a digital platform for carpooling, how secure is the passengers' information?
- Is the information of the registered passengers safe and confidential?

Considering all these questions, it should be clear now that there is a lack of a reliable platform which promotes the concept of carpooling among individuals. Therefore, a **well-secure carpooling platform (Easy Ride)** will be developed in this project in which commuters who do not possess a car can look for someone nearby who owns a car and travels to the same location. This platform will be designed and developed as a mobile application to bring greater

convenience to the users. Moreover, the proposed application will be reinforced with various security features in order to prevent vulnerabilities and maintain data integrity.

Problem Context

It is undeniably true that the number of vehicles on road is increasing tremendously from day to day. Based on the article published by Paulton in 2017, vehicle registrations in Malaysia has already hit a staggering number of 28.2 million units. As the number of vehicles on road increases, the rate of traffic congestion also increases. When the vast majority of people use private automotive vehicles and seek to drive during rush hours, the roads get severely snarled-up; leading to various problems. People who stuck in heavy traffic may be late for work, causing them to waste their valuable time and becomes less productive (Nptcel, 2018). From a different view, when the world is overpopulated with motorized vehicles, the environment is also getting severely affected due to the carbon and greenhouse gas emissions. This relatively contributes to global warming and climate changes.

Most of the people tend to neglect the use of public transportation and decide to own a vehicle without thinking about the expenses. The overall cost of private transportation is comparatively high, and the automotive owners are forced to spend a lot of money to cover the toll, car maintenance and fuel expenses. Moreover, nearly all the vehicles moving in traffic are single occupancy which means there are no other passengers in the vehicle except for the driver. Carpooling seems to be a reasonable and coherent way to overcome these problems. However, people tend to give a doubtful and anxious look when they are recommended with this approach. This is mainly because of the unfamiliarity of fellow companions. In a few carpool events, passengers are forced to travel with a complete stranger which may create a little inconvenience and discomfort. The entire journey would be odd as some passengers develop a queer feeling within themselves, thinking that the stranger will threaten or cause harm to them. The situation will get even worse if the strangers are reluctant to share any of their personal information or reveal too much about themselves.

Although there are several carpooling platforms available via online, data privacy remains a huge concern among the commuters. According to a survey by McAfee, 40% of people feel that their personal information stored in a mobile application is not safe and widely exposed to various threats (Medium Corporation, 2019). In conjunction, it is terrifying to know that even huge corporations such as Facebook and Panera Bread have experienced data breaches that put millions of personal data of their clients into the hands of cyber perpetrators (Medium

Corporation, 2019). This will eventually lead to various privacy, integrity and confidentiality issues.

Taking all these problems into consideration, it can be deduced that security is one of the major issues which obstruct certain commuters to practice carpooling in their daily lives. Henceforth, all the mentioned primary problems here can be overcome with the presence of a digitalised platform which offers secure and reliable carpooling services.

Rationale

The proposed mobile application brings huge advantages to the community and environment by creating an efficient carpooling ecosystem. Connecting people and creating a strong culture of sustainability will be the primary purpose of this application as it serves a path for people to reach out and connect with more commuters. Besides fostering social networks, this application is defined to be cost-effective as it helps the drivers and passengers to share the overall travel expenses. Apart from that, the implementation of this application will definitely offer convenience and hassle-free solution to those who stay in places which provide limited public transportation facilities. If deployed and managed well, this application can be considered as a strong alternative for public transportation. Furthermore, this application is also aimed to maintain and protect users' data integrity through the integration of various security features. Data privacy and confidentiality will be no longer an issue as the application will be developed in a way to handle potential threats and vulnerabilities. When considering the outcome of the application, there are two types of benefits:

Tangible Benefits

- Encourages a digitalized way of carpooling
- Promotes a greener environment by reducing the number of single-occupancy cars in the road
- Establishes a wide social network of automotive owners and commuters
- Develops a systematic way of keeping track of all carpooling activities
- Maintains the validity and integrity of users' data
- Commuter's time, money and travelling costs can be saved.

Intangible benefits

- Allows commuters to have a joyful journey without being struck with loneliness or boredom
- Reduces overall traffic congestion in the road

- Creates satisfaction among vehicle owners who would be helping the passengers to commute
- Fosters a safe and reliable travelling experience as all the users' information are verified and validated upon registration

Nature of Challenges

Since the proposed application is intended to provide seamless carpooling experience to the users, all the pre-defined challenges need to be analysed and addressed in an effective manner. One of the leading challenges would be to understand and perceive the requirements of the targeted users. This issue can be solved by choosing the correct and most-suitable data gathering techniques which clearly outline what the user expects from the proposed application. On the other hand, creating trust and assurance among users would be another primary challenge because the application requires the users to deal with strangers. Proper verifications need to be done upon registration to authenticate and validate the credentials given by the new users. This approach will definitely instil trust and belief among people that the application is reliable and safe to use.

Furthermore, as the application requests and stores some of the personal information of the users, securing their information from potential threats would be the biggest challenge in this project. Implementing strong security features such as Tokenization, Bcrypt Hashing, Code Obfuscation and Session Handling are highly recommended to prevent any sort of cyber exploitation. Besides that, a secondary database is required to make the application to be highly available in the event of system failover. Apart from that, since the application would be newly introduced to the market, there is a high tendency for the users to face some difficulties when using the application for the first time. Henceforth, clear instructions and 24/7 support should be given to the customers to ensure that they comprehend all the functionalities and workflow of the system.

Project Objectives

- ❖ To analyse the current transportation problems in Malaysia
- ❖ To find out the perspectives and expectations of targeted users towards carpooling
- ❖ To learn and integrate carpooling functions in the proposed system
- ❖ To learn and implement various security features in order to protect the system from vulnerabilities and unauthorised intrusions.
- ❖ To evaluate whether the needs and expectations of the users are met upon system deployment

Deliverables

In short, Easy Ride is a secure mobile application which promotes carpooling among vehicle owners and passengers who travel to the same location. Some fundamental features have been included into the application to enhance the overall efficiency and user-friendliness.

As soon as the users start the application, they will be prompted to the login page in which they have to input their respective username and password. If they do not own an account, they will be directed to the registration page which requires them to create a new account. Once they log into the application, they will see an option either to offer a car ride or search for a particular ride. If the user wants to offer a car ride, he is required to upload a picture of his identification card and driving license for security purposes. After the system verifies the user's credentials, he is able to offer a car ride by inputting the starting point, destination, time and overall travel expenses. On the other hand, if the user wishes to search for a particular journey which fulfils his or her travel needs, he or she needs to input all the requested information and click 'search'. If the journey matches the requirements of the user, they can book a ride with the car owner at the agreed time.

Since security is one of the main concerns in this project, various security features will be implemented throughout the application to secure users' data. For instance, JSON Web Token will be used to define a compact and self-contained way for securely transmitting information between the client device and server. Apart from that, this system also aims to provide one-way road to security by hashing passwords through the implementation of Bcrypt Hashing. Besides that, code obfuscation will be done with the use of JavaGuard library to make the source code difficult for the potential hackers to understand.

Needed Resources (Hardware and Software)

The minimum hardware requirements needed to successfully carry out and meet the project objectives are:

1. Computer (for development purposes)

- Minimum 4GB RAM but 8GB RAM is recommended for ideal usage
- CPU Processor – minimum Intel core i5 processor or AMD A10
- Minimum free disc space of 20 GB

2. Mobile Device (for deployment and testing purposes)

- Minimum 2GB RAM but 4GB RAM is recommended for ideal usage
- CPU Processor – Quad core processor with 1.2GHz of clock speed
- Minimum free disk space of 200 MB

3. Other Peripherals

- Mouse – To control the cursor and perform certain actions by clicking
- Keyboard – To input functions and characters into the computer by pressing certain buttons or keys
- Monitor – to display required information in pictorial format

The minimum software requirements needed to successfully deploy a fully functional mobile application are:

1. Operating System

- Microsoft Windows 7 and above
- Android Lollipop 5.0 and above

2. Integrated Development Environment

- a. Android Studio 3.1.3 and above (For Front-end Development)
- b. Visual Studio Code (For Back-end Development)

3. AWS Services

- a. Amazon Cognito (to provide authentication and authorization)
- b. AWS Elastic Beanstalk (to deploy back-end application)
- c. Amazon API Gateway (to create and maintain APIs)

4. Planning and Documentation

- a. Microsoft Word
- b. Microsoft Project

5. Database Management Systems

- a. MySQL

6. Browsers

- a. Google Chrome or Microsoft Edge

7. Version Control Software

- a. Git
- b. SourceTree

Access to Information

In order to successfully accomplish this project, it is highly necessary for the developer to obtain proper guidance from the supervisor and lecturers. Through frequent meetings with the supervisor, the developer would be able to obtain some in-depth insights and clarification on the project requirements. Another method of getting information would be by conducting interview and questionnaire which enables the researcher to study the preferences and expectations of the targeted users.

User Involvement

The users who are mainly involved in this proposed application are drivers, passengers and administrators. Data gathering techniques will be used to gather the preliminary requirements that the user wants from the application. On the other hand, these users are also extensively involved in testing phases to make sure the system delivers all the required functionalities and meets the project objectives.

Academic Research

Books

1. Name: Android App Development for Dummies
Author: Michael Burton
Publication Date: 09 March 2015
Publisher: John Wiley & Sons Inc

2. Name: High Performance MySQL
Author: Baron Schwartz
Publication Date: 04 May 2012
Publisher: O'Reilly Media, Inc, USA

3. Name: AWS Certified Solution Architect Official Study Guide
Author: John Stamper
Publication Date: 08 December 2016
Publisher: John Wiley and Sons Inc

4. Name: Data Security: Laws & Safeguards
Author: Paulus R. Wayleith
Publication Date: 13 November 2018
Publisher: Nova Science Publishers

Online Resources

1. Lee, J., 2017. *Vehicle registrations in Malaysia hit 28.2 million units*. [Online]
Available at: <https://paultan.org/2017/10/03/vehicle-registrations-in-malaysia-hit-28-million-units/>
[Accessed 3 August 2019].

2. Medium Corporation, 2019. *Data Privacy Concerns: An Overview for 2019*. [Online]
Available at: https://medium.com/@the_manifest/data-privacy-concerns-an-overview-for-2019-2cce479aa6f8
[Accessed 4 August 2019].

3. Money Crashers, 2019. *The Benefits of Carpooling and How to Incorporate It Into Your Life*. [Online]
Available at: <https://www.moneycrashers.com/carpooling-benefits/>
[Accessed 3 August 2019].
4. Nptcel, 2018. *Generation of traffic congestion*. [Online]
Available at: https://nptel.ac.in/courses/105101008/584_Congestion/point2/point.html
[Accessed 3 August 2019].
5. Rideshare, 2018. *How does carpooing work*. [Online]
Available at: <https://rideshare.org/question/how-does-carpooling-work/>
[Accessed 26 June 2019].
6. uOttawa, 2019. *BENEFITS OF CARPOOLING*. [Online]
Available at: <https://www.uottawa.ca/parking/carpooling/benefits-of-carpooling>
[Accessed 3 August 2019].

Brief description of the development plan for the proposed project

After much considerations and deliberations, the developer chose **Extreme Programming** as the methodology to develop the proposed carpooling mobile application. Generally, Extreme Programming (XP) can be elucidated as a flexible methodology that places huge emphasis on the development of high-quality software (Agile Alliance, 2018). It cannot be denied that this framework comprises an effective programming or coding approach which usually involves large and complex projects. Since agile principles play a fundamental role in this methodology, it is highly advised to focus more on process repetitions and requirements change. Similar to other agile software development methodologies, XP is designed to provide iterative and small frequent releases throughout the project; allowing both customers and team members to evaluate and scrutinize the project's development from time to time (Airbrake.io, 2018). Extreme Programming implements a conducive environment which makes the developers to be highly productive and efficient in achieving the project's goals. This framework has already been proven to be very successful at many corporations and has produced fruitful results.

Due to the fact that Easy Ride is a system with multifarious functions, XP framework is considered to be the best choice in this project. XP is designed to focus on the implementation of new engineering principles. Adhering to XP's principles, the following phases need to be meticulously carried out to fulfil the overall project requirements.

1) **Planning**

Release Planning

In general, the main purpose of having a release plan is to outline the *user stories*² that will be implemented for each system release. Release plan comprises a set of rules that permits everyone who is involved in the project to contribute their own ideas and make decisions. Since commuters, administrators and programmers play a prominent role in the development of Easy Ride, they are privileged to suggest some components which can be implemented. Distinct iterations must be analysed in advance before each iteration begins. The release planning of Easy Ride can be categorised into four basic attributes which are resources, quality, scope and time. No one is authorised to govern any of the four attributes. If by any chance someone makes an amendment in one of those attributes, others will be affected too (Wells, 1999).

² Tool in agile software development to capture a description of a software feature from an end-user perspective **Invalid source specified**.

Iteration Planning

The objective of having an iterative planning is to create iterative schemes for the project tasks. Customers have the rights to choose the user stories from the sequence of release plans. The chosen user stories are divided into distinct tasks which will be then executed accordingly by the developer. If a programming task is difficult, the developer of Easy Ride should estimate and propose a longer time for the respective task. The primary goal of conducting this meeting is to evaluate and stabilize the list of user stories that the developer is going to deliver in the near future (Bright Hub, 2018).

2) Designing

An iteration of Extreme Programming begins with designing. Without a functional design, the developer will not be able to understand the mutual relationship between the data and system functionalities. Therefore, relevant logical and physical designs should be presented earlier before the actual implementation takes place. A good design helps the programmer to avoid dependencies which means changing one part of a program will not impact the other parts of the program. The following are some of the principles and guidelines that the developer of Easy Ride should follow during the designing phase (Bright Hub, 2016).

- Avoid convoluted designs
- Place more importance on simplicity
- Use good naming convention for the entities and attributes
- Implement clear design patterns
- Make full use of object-oriented technology and explore potential solutions for a specific problem.

3) Code

This is where the actual implementation comes in. Programmer starts to write code based on the user stories collected from release and iteration planning. A small change in the source code can bring a greater repercussion to the entire system, thus, high level of attention is required during this phase. It is undeniably true that a complete source code defines a complete program. Once the developer of Easy Ride system completes the coding without any error, a fully functional system can be deployed for the use of customers.

4) Acceptance Testing

Acceptance Testing can be defined as a testing technique used to decide whether or not the software meets the requirement specifications (Tutorialspoint, 2018). In other words, acceptance testing is carried out to test and evaluate each user story during the development phase. A user story can only be considered as complete if it passes acceptance test without any error. End-users of Easy Ride are accountable to revise the validity of the acceptance tests and highlight the mistakes to the developer for further amendments. For instance, if a particular function of Easy Ride doesn't align with the proposed business needs, the administrative staff should quickly report to the developer before he or she proceeds with further implementations.

5) Unit Testing

Unit testing can be classified as one of the most fundamental phases in Extreme Programming. In unit testing, all the individual components of a system are tested and verified for bugs and runtime errors. Generally, XP programmers practice test-driven development (TDD) which needs an intensive style of unit testing (SearchSoftwareQuality, 2018). Developer of Easy Ride should place a greater emphasis on unit testing and verify every single component of the system in order to eliminate unintentional errors.

6) Listening

Listening and obtaining customer feedback is one of the fundamental mechanisms of Extreme Programming. After the program has been deployed, the developer is accountable to get feedback from both the administrators and end-users. The basis of feedback is the customers' acceptance tests. If the customers are not satisfied with a particular function, their feedback will become the basis of new requirements and the process of design, implementation, test and listen repeats. In contrast, if the customers are satisfied with the function, the iteration ends there and the design for the new iteration starts. Taking this into consideration, the developer

of Easy Ride should constantly ask for customer feedback and immediately make relevant changes if required.

Brief Description of the Evaluation and Test Plan for the Proposed Project

Success Criteria

The success of the proposed application is heavily dependent on the application's features to provide seamless carpooling experience to commuters. Through the application, the vehicle owners would be able to offer a car ride effortlessly without any hassle. At the same time, the passengers should be able to search for the available journeys based on their travel needs. On the other hand, the success rate of this project also relies on data integrity and security. In order to instil trust among people that the application is safe to use, various security features need to be implemented to secure users' information. Before deploying the mobile application in production, the application must undergo several series of testing to make sure it functions well without any error.

Unit Testing

Unit testing is done in all the software development projects. The main objective of this testing is to make sure the application performs well in accordance to the defined functional requirements. The individual components of the system are tested and verified for bugs and runtime errors. For instance, the user registration page of the application will be tested to examine if the details inputted by the user are correctly saved in the database.

Integration Testing

After successful completion of unit testing, integration testing would be done to ensure the individual components of the application are able to interact and work together with each other. This testing enables the developer to understand that the integrated components of the application are able to produce expected results. For instance, as soon as the user inputs all the requested details and registers an account, he or she needs to be directed to the profile page.

User Acceptance Testing

User Acceptance Testing is a type of testing carried out by the end users to examine that the system is well-designed and performs according to the predefined user preferences. For instance, before the mobile application is deployed to production, potential commuters would need to use all the features

13.7 Ethics Form

Office Record Date Received Received by whom	Receipt Student name: Kugilan Krishnanony Student number: 10028021 Received by: Date: 10/9/2019
--	---

**ACADEMIC RESEARCH ETHICS
DISCLAIMER**

Declaration about ethical issues and implications of research proposals to be included on project application forms

Project Title: Secure Carpooling Mobile Application (Easy Ride)

The following declaration should be made in cases where research project applicants for a particular project and the supervisor(s) for that project conclude that it is not necessary to apply for ethical approval for a research project.

We confirm that the University's guidelines for ethical approval have been consulted and that all ethical issues and implications in relation to the above project have been considered. We confirm that ethical approval need not be sought.

Kugilan Krishnanony _____ Kugila _____ 10/9/2019
Name of Research Project Applicant Signature Date

Anand Arulachalam _____ A7 _____ 10/9/19
Name of Research Project Supervisor / _____ Arulachalam _____
Signature Date

Office Record:	Receipt – Fast-Track Ethical Approval
Date Received:	Student name <i>Kigilan Krishnasamy</i>
Received by whom:	Student number <i>TP378521</i> Received by Date <i>10/9/2019</i>

**APU
FAST-TRACK ETHICAL APPROVAL FORM (STUDENTS)**

Tick one box: TAUGHT POSTGRADUATE project UNDERGRADUATE project
 TAUGHT POSTGRADUATE MODULE assignment
 TAUGHT UNDERGRADUATE MODULE assignment

Title of Specialism on which enrolled

Tick one box: Full-Time Study or Part-Time Study

Title of project *Secure Carpooling Mobile Application (Easy Ride)*

Name of student researcher *Kigilan Krishnasamy*

Name of supervisor/ *Mr Amjad Arshad*

Student Researchers- please note that certain professional organisations have ethical guidelines that you may need to consult when completing this form.

Supervisors/Module Tutors - please seek guidance from the Chair of the APU Research Ethics Committee if you are uncertain about any ethical issue arising from this application.

		YES	NO	N/A
1	Will you describe the main procedures to participants in advance, so that they are informed about what to expect?	✓		
2	Will you tell participants that their participation is voluntary?	✓		
3	Will you obtain written consent for participation?	✓		
4	If the research is observational, will you ask participants for their consent to being observed?	✓		
5	Will you tell participants that they may withdraw from the research at any time and for any reason?	✓		
6	With questionnaires and interviews will you give participants the option of omitting questions they do not want to answer?	✓		
7	Will you tell participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs?	✓		
8	Will you give participants the opportunity to be debriefed i.e. to find out more about the study and its results?	✓		

If you have ticked No to any of Q1-8 you should complete the full Ethics Approval Form.

		YES	NO	N/A
9	Will your project deliberately mislead participants in any way?		✓	
10	Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?		✓	
11	Is the nature of the research such that contentious or sensitive issues might be involved?		✓	

If you have ticked Yes to 9, 10 or 11 you should complete the full Ethics Approval Form. In relation to question 10 this should include details of what you will tell participants to do if they should experience any problems (e.g. who they can contact for help). You may also need to consider risk assessment issues.

		YES	NO	N/A
12	Does your project involve work with animals?		✓	
13	Do participants fall into any of the following special groups? Note that you may also need to obtain satisfactory Criminal Records Bureau clearance (or equivalent)	Children (under 18 years of age) People with communication or learning difficulties Patients People in custody People who could be regarded as vulnerable People engaged in illegal activities (eg drug taking)	✓ ✓	
14	Does the project involve external funding or external collaboration where the funding body or external collaborative partner requires the University to provide evidence that the project had been subject to ethical scrutiny?		✓	

If you have ticked Yes to 12, 13 or 14 you should complete the full Ethics Approval Form. There is an obligation on student and supervisor to bring to the attention of the APU Research Ethics Committee any issues with ethical implications not clearly covered by the above checklist.

STUDENT RESEARCHER

Provide in the boxes below (plus any other appended details) information required in support of your application.
THEN SIGN THE FORM.

Please Tick Boxes

I consider that this project has no significant ethical implications requiring a full ethics submission to the APU Research Ethics Committee.	<input checked="" type="checkbox"/>
Give a brief description of participants and procedure (methods, tests used etc) in up to 150 words. A questionnaire is conducted among the potential end-users to gather their system requirements and needs. These requirements enable the researcher to have more in-depth insights about what the end-users really want to see in the mobile application. On the other, interview will be conducted with security analysts to assess the potential vulnerabilities and security risks of the proposed mobile application.	
I also confirm that: ii) All key documents e.g. consent form, information sheet, questionnaire/interview are appended to this application.	
Or ii) Any key documents e.g. consent form, information sheet, questionnaire/interview schedules which need to be finalised following initial investigations will be submitted for approval by the project supervisor/module leader before they are used in primary data collection.	<input checked="" type="checkbox"/>

Signed Kegile
(Student Researcher)

Print Name Kogilan Krishnasamy Date 10/9/2019

Please note that any variation to that contained within this document that in any way affects ethical issues of the stated research requires the appending of new ethical details. New ethical consent may need to be sought.

The completed form (and any attachments) should be submitted for consideration by your Supervisor/Module Tutor

**SUPERVISOR/MODULE TUTOR
PLEASE CONFIRM THE FOLLOWING:**

Please Tick Box

I consider that this project has no significant ethical implications requiring a full ethics submission to the APU Research Ethics Committee	<input checked="" type="checkbox"/>
i) I have checked and approved the key documents required for this proposal (e.g. consent form, information sheet, questionnaire, interview schedule)	<input checked="" type="checkbox"/>
Or	
ii) I have checked and approved draft documents required for this proposal which provide a basis for the preliminary investigations which will inform the main research study. I have informed the student researcher that finalised and additional documents (e.g. consent form, information sheet, questionnaire, interview schedule) must be submitted for approval by me before they are used for primary data collection.	

SUPERVISOR AND SECOND ACADEMIC SIGNATORY

STATEMENT OF ETHICAL APPROVAL (please delete as appropriate)

1) THIS PROJECT HAS BEEN CONSIDERED USING AGREED APIIT/SU PROCEDURES AND IS NOW APPROVED

2) THIS PROJECT HAS BEEN APPROVED IN PRINCIPLE AS INVOLVING NO SIGNIFICANT ETHICAL IMPLICATIONS, BUT FINAL APPROVAL FOR DATA COLLECTION IS SUBJECT TO THE SUBMISSION OF KEY DOCUMENTS FOR APPROVAL BY SUPERVISOR (see Appendix A)

Signed.....  Print Name..... *Andrea Lek* Date..... 10/9/19
(Supervisor/2nd Marker)

Signed..... Print Name..... Date.....
(Second Academic Signatory)

Office Record	Receipt - Appendix A (Fast-Track Ethics Form)
Date Received:	Student name: Kigilan Krishnansamy
Received by whom:	Student number: TPU18521
	Received by: _____
	Date: 10/9/2019

**APPENDIX A
AUTHORISATION FOR USE OF KEY DOCUMENTS**

Completion of Appendix A is required when for good reasons key documents are not available when a fast track application is approved by the supervisor/module leader and second academic signatory.

I have now checked and approved all the key documents associated with this proposal e.g. consent form, information sheet, questionnaire, interview schedule.

Title of project Secure Computing Mobile Application (Easy Ride)

Name of student researcher Kigilan Krishnansamy

Student ID: TPU18521 Intake: UC3F1906 JTCISS

Signed: MZ Print Name: Anand Arulselvi Date: 10/9/2019
(Supervisor/2nd Marker)

13.8 Gantt Chart

