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A Ride Sharing System for University Community

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ABSTRACT

In Ghana, vehicular transportation is the commonest and widely used means of mobility which contributes a significant amount to economic development. Despite these benefits, there are however numerous challenges commuters experience such as queuing, communication difficulties, missing of destinations among others. Private individuals who use their own cars equally encounter high fuelling cost, traffic congestion and other related problems. In this paper, an online ride sharing and booking system is proposed to enable owners of private cars to offer empty seats to other users. This proposed system design was tested in a campus environment to ascertain its feasibility in densely populated areas. The online booking system which is mobile, and web-based software application proved very efficient for user registration, travel advertisement, booking, geo-location and routing, online payment systems as well as notification systems to handle all necessary aspects of the entire booking and ride sharing system. Thus, this system substantially eliminates the problems faced by both drivers and passenger and help reduce carbon emissions.

Keywords: Carpooling; taxi booking; ride sharing; fare; travel; transport.

1. INTRODUCTION

Travelling, which involves moving or transporting from one place to another, has become an integral part of our lives as human beings. In our modern day, it has become impossible for one to stay for a long time without having to move from one place to another. People may move from one place to another for the purposes of work, school, trade, vacation, family reunion, just to name a few. With the evolution in the transportation sector, people can now rely on very powerful and sophisticated vehicles such as airplane, trains, cars, ships, and bicycles to get to their destinations faster and easier. In Ghana, the most common means of transportation is by car. Most people personally own cars and transport companies also offer services by providing long buses to people. For long distance travels, most people who do not have cars have to move from their homes and carrytheir luggage to the various stations to book seats. Car owners, who mostly drive with free seats available, also must incur huge fuel and toll costs alone. Huge vehicular traffic is caused on the roads since every car owner uses his own car with empty seats. The rate of carbon emissions into the atmosphere is also increased in the process. Finally, time which could have been used for productive work is wasted as commuters spend more hours on the roads than necessary.

At the Kwame Nkrumah University of Science and Technology (KNUST), private car owners who use their cars alone must spend a lot of money on fuel due to high fuel prices. Having many private cars on the road with just car owners driving causes traffic and increases the rate of Carbon emissions into the atmosphere. Due to traffic,commuters spend more time on the road, and this reduces productivity. Most students who do not own cars face a stressful period in joining public transport services.Often, they may be required to pay extra transportation fees to get to public transport stations. Mostly, students must walk from their residence to the roadside beforethey can get access to vehicles to their destination. This is very stressful and inconvenient formany of them. Sometimes, they waste most of the little time they have just waiting for vehicles to come their way. There are so many issues that arises with this situation; most of them get late for their classes and other appointments, some even miss their exams and quizzes just to mention a few of the problems. Furthermore, there are certain dangers that students face when they board these public transports, one of these dangers is robbery.

Also, it's quite difficult getting vehicles at night, most of the public vehicle drivers do not workat night thus making it very difficult to move around during the night. Walking from the hostelto the roadside at night too is very dangerous as students encounter theft case, rape case, and sometimes murder cases. One issue that is very alarming is when student get sick at nightand there is no car to transfer the victim to the hospital.

In response to this problem, we intend to create *CampusRide* - a mobile application and a web application that would serve as a platform for running a carpooling (ride sharing) service to help mitigatethe problem. This project seeks to connect car owners with students who do not own cars based on the two parties having a common location and destination. Car owners offer empty car seatsto those without cars and in so doing, save them from travel stress, unnecessary charges, and certain dangers. Non-car owners also help car owners reduce travel expense which primarilyconsist of fuel cost. When people team up to travel together, the number vehicles on the roads decrease and hence traffic is reduced. Reduced traffic means a reduction in rate of Carbon emission thereby serving as a preventive mechanism for global warming which has become a global crisis. Carpooling and ridesharing services exists in most places with a substantial number of car owners. These places may include school campuses and local communities. This makes the scope for implementation almost unlimited. The scope of this research work is aimed at targeting all car owners within KNUST. It entails coupling mobile and web booking technologies with traveling. To achieve this a web application and an android application would be built to allow users get access to booking and offering services.

2. RELATED WORKS

Ride sharing and booking systems have contributed significantly to the progress of human mobility due to technological evolution. Its importance has resulted to a few models designed to realize convenient transportation, tracking of autonomous vehicles [1] and resolving challenges associated with carbon emissions [2, 3].

In [4] is presented a real time high-capacity ride-sharing system based on an integer linear program (ILP) formulation. This proposed mathematical model employed a reactive anytime optimal algorithm having a scalable real time performance that assigns passenger travel requests to a pool of vehicles of different carrying capacity. A passenger's travel request contains a time of request, pickup location, and drop-off location. Per the model, a valid assignment of travel requests to vehicles are returned by the algorithm, refined over time, and converged to an optimal solution. Provided with enough computational resources, the optimal assignment for current requests and time are made available else the best solution found is returned. Even though this system is suited for autonomous vehicles, operates in real time and re-balances idling vehicles to high demand areas, it is however less suited for mobility in rural areas.

In [5], a real time smart carpooling and ride sharing system using android application was proposed. The application software managed by an administrator was designed to enable users access the platform with required credentials. A rider publishes travel information on the platform to find passengers to share the ride with. As per the available travel information, a passenger makes a request which includes the meeting time and place via a smart phone. A global positioning system (GPS) device is used to locate the position of both users. Payment options available allow passengers to pay for their ride. Tracking of scheduled trips, reduction in fuel wastage and effective monitoring of transaction histories incorporated in this system provides convenience to users nonetheless, it is not cross platformed.

A few works have presented different algorithmic approaches regarding car sharing [6-8]. A multi-objective mixed-integer linear program (MILP) model presented in [9] supports tactical and strategic planning for one-way car sharing system. Based on relevant parameters such as vehicle relocation, vehicle charging requirements and many more, the model offers enough opportunities for sensitive analysis and decision making. Decisions associated with the allocation of strategic assets are considered by the model and in effect benefits both the operator and users. Though the model provides convenient mobility and help reduce carbon emissions, it is howbeit capital intensive to implement and cannot be generalized since its dependent on the model parameters used.

In reference to the models showcased in [10-12], a geographic information systems (GIS) analysis was employed in ride sharing. [11] presented a GIS-based approach to identify probable meeting points and an assessment scheme to suitably rate them for ridesharing. This method primarily consists of identification, assessment, filtering of meeting point and simulation. This model identified fuel stations, turning areas, side road intersections and free public parking areas as its potential meeting points. These potential meeting points are assessed based on few influencing factors such as parking quality, seating, shelter, and illumination. The filtering process founded on reduction parameters such as passenger rating, random selection and proximity to arterial roads are employed to reduce the meeting points to the desired number. Simulations are performed to ascertain how the desired number and location of the meeting points affect the use of ridesharing. Even though this model reduces traffic congestion, CO_2 emissions and fuel wastage due to detours taken in picking passengers, since a limited number of identified meeting points were utilized, it limits the amount of likely available meeting locations. Thus, less effective for rural mobility.

The booking systems adopted in ride-sharing services have experienced a huge impact because of technological advancements. Unlike manual booking systems, data gathered from the usage and characteristics of user preferences for car sharing as expressed by [13,14] have shown that digital booking systems have dominated and populated ride-sharing systems. Digital booking through mobile phone applications, web-based systems, alternative online platforms, and algorithms [15-17] have resolved several challenges associated with car sharing. In relation to [17], a web-based platform was proposed to allow users worldwide to make reservations or book their travel requests. A database developed using PHP codes enabled users to register and make reservations thus allowing the firm to efficiently manage the services provided. Due to the advanced booking system employed, the waiting time by customers are eliminated. However, this system requires routine server inspection and maintenance of the websites which in effect is capital intensive.

3. MATERIALS AND METHOD

There are a few existing systems which have been established based taxi booking, carpooling or ride sharing technologies. The technologies used in these systems are mainly GPS and Navigation and Map Services. Table 1 contains some common technologies used in taxi booking and carpooling.

Table 1. Common Technologies

Technology	Description
GPS Location	A global navigation satellite system that provides geolocation and time information to a GPS receiver. GPS receivers are devices that receive data from multiple satellites to obtain a position as to where the user of the GPS is located. A GPS receiver requires at least three data signals from the satellites. To identify the position in three dimensions which include longitude, latitude, and elevation, four satellite data signals are required. GPS receivers can be stand-alone or integrated into other devices. Presently most smart smartphones are equipped with GPS receivers.
Navigation and Maps Services	These are Application Programming Interfaces (API's) that receive web requests and provide geo-location and routing services through web responses. Navigation and Maps services can be integrated into any web or mobile application that requires its functionality. The most common navigation and maps API's is Google's Location and Maps APIs on cross platform.

Some of these systems service providers like Uber and Hailo are now the main players of the existing systems. Table 2 contains the mode of operation of these two global players.

Table 2. Existing system providers

Company	User Interface Software	Mode of Operation
Uber [18]		UBER is an American worldwide online transportation network company. It renders taxicab and vehicle for hire services and allows registered drivers to use their personal cars to run taxi services under their terms and conditions. Uber develops, markets, and operates the UBER app. The app comes in two forms: the driver's app and the user's app. Both appsare integrated with the geo-location and routing services which identifies user's current position, displays the cars in the neighbourhood and build the best route for driver with real time navigation. Geo-location and routing services are achieved by using Google's Location and Maps APIs for android and Core Location framework and Map Kit framework for region monitoring and suggesting best routes and directions respectively in IOS. The Uber user's app allows a user with a smartphone to submit trip requests by taking their current geographical location and their set destination. The software program then automatically forwards the request to an Uber driver who is nearest to him through the app via a push notification, alerting the driver of the location of the user. After confirming the request, both the driver and

		the user can track each other on the map provided. Uber drivers and users can directly register to the service either from their mobile applicationor the website. Potential drivers need to fill and submit application form using the drivers' app or online. Then they would have to visit any of the Uber inspection stations where their vehicle would undergo some background check. Only those who meet the requirements per the Uber driver's terms and policies would eventually become certified Uber drivers.
Hailo [19]		Hailo is a UK-based ride-hailing app launched in 2011. It is available in morethan 20 cities including London, Barcelona, Madrid, and Osaka and almost across Ireland. Hailo just like Uber, has made taxi booking quite easy and fast. It operates with CRB (Criminal Records Bureau) checked drivers. Just like Uber, the Hailo system is also equipped with geolocation and routing services. All other operations with respect to bookings, payments and general registration of drivers and users are similar

3.1 CampusRide System Architecture

As shown in Figure 1, the key components of the CampusRide system are the database system, notification system, administrator's panel, and users' device. All relationships between any two systemsor devices are as illustrated with the arrows.

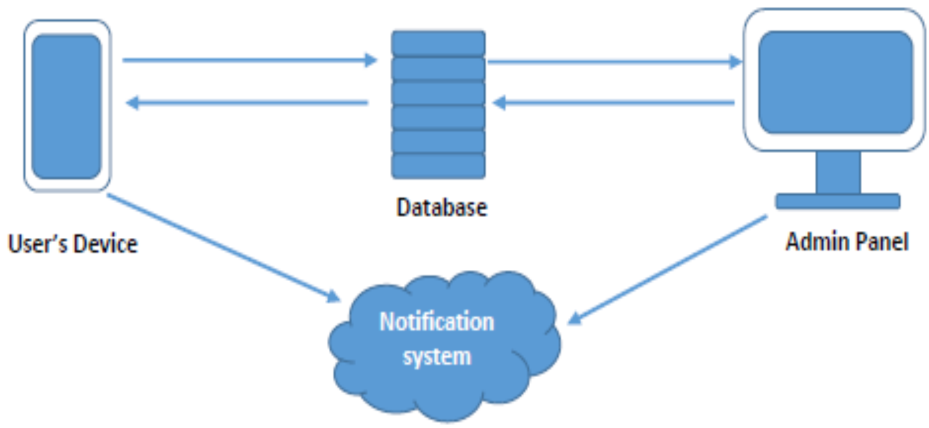

Figure 1. CampusRide System Architecture

The user's device can be any smartphone with WiFi or mobile data internet connectivity. This runs our mobile software application called TechMate. The database is a cloud-based storage system, and the admin panel is and desktop or laptop pc which runs the CampusRide software application that interface seamlessly with the cloud database. The CampusRide system identifies two (2) system users: administrator and end-user. Administrators are responsible for maintaining the system's hardware and software. They perform roles which include adding, deleting, modifying, activating, and deactivating other users. End-users are users who ultimately use the computer system. They are those who the system is designed for. End-users of every system provide requirements from which the system is built.

3.1.1 End User System Requirements

A survey was undertaken at the begin of the project and the information gathered was used to define the end-user requirements. The end-user system requirements describe what the end-user does or should be able to do with the system. These include all activities that the user must be able to perform. With the use of the analysis performed on the data that was received from potential users through verbal interviews and questionnaires, the user requirements for the CampusRide system were constructed. In the requirement construction process, redundant requests were combined to form a common request. Not all identified requirements were considered to have a high priority. User requirements that received high priorities were mandatory for the software's development. Full description of all priority levels and the full user requirements can be found in Table 3 and Table 4 respectively.

Table 3. User priority scale

Classification	Definition
High	The requirement must be featuredin the system.
Medium	The requirement is required but could wait until a later release
Low	The requirement is an enhancement and could possibly be added if resources permit

Table 4. User requirements and priority

ID	User Requirement Description	Priority
1	The user should be able to register an account on the system	High
2	The user should be able to login with a valid email address and password	High
3	The user should be able to logout after logging in	High
4	The user should be able to add a registered car to his profile	High
5	The user should be able to offer a ride	High
6	The user should be able to book seat(s)	High
7	The user should be able to send messages to other users	Medium
8	The user should be able to receive messages from other users	Medium
9	The user should be able to receive notifications from the system	High
10	The user should be able to cancel a booking	High
11	The user should be able to update or modify his personal details	High
12	The user should be able to call other users via the phone's voice call system	High
13	The user should be able to receive calls from other users	High
14	The user should be able to access his travel and booking history	High
15	The user should be able to send account verification request	High
16	The user should be able to pay for bookings online	Low
17	The user should be able to confirm a journey	High
18	The administrator should be able to verify a user	High
19	The administrator should be able to activate a user	High
20	The administrator should be able to deactivate a user	High

3.2 Campus Ride Functional Requirement and Use Cases

All data obtained from survey ie. user requirements and all other information from the information gathering process were analysed and transformed into application specific requirements for the TechMate and CampusRide system software management application. With this information, use cases which describe functional requirements were developed and actors were also identified.

3.2.1 TechMate Use Cases

Use Case is a list of actions or event steps that define interactions between an external role or an external actor and a system. Actors are human or other external systems that can interact with the system by providing or consuming services. Actors can either be primary or secondary. Primary actors request for services from the system while secondary actors provide services for the system. For the TechMate System, we could identify and classify the following actors as either primary or secondary as indicated in Table 5.

Table 5. TechMate actors

Primary Actors	Secondary Actors
Users (Can either be a driver or passenger)	Notification system
	Payment system
	Administrators

With actors identified the relationships between each actor and the system were also identified. These relationships were model to form use cases or functional requirements for the actors in the system. All use cases have been described in the Table 6.

Table 6. TechMate use cases

ID	Use Case
1	Login
2	Register
3	Logout
4	Modify account
5	Offer ride
6	Book seat
7	Pay for seat(s)
8	Cancel Booking
9	Cancel offer
10	Call user
11	Receive call
12	Send notification
13	Receive notification
14	View bookings
15	View offers
16	View travel history
17	Add registered car
18	Verify user
19	Pay user(driver)
20	Receive payment
21	Confirm ride
22	Send verification request
23	Add user
24	Delete user
25	Activate user
26	Deactivate user
27	Construct notification message

The use cases identified were used as guidelines for the design and implementation of the whole system and have been captured as a single representative use case diagram in figure 2 to show the general functionalities and architecture of the system.

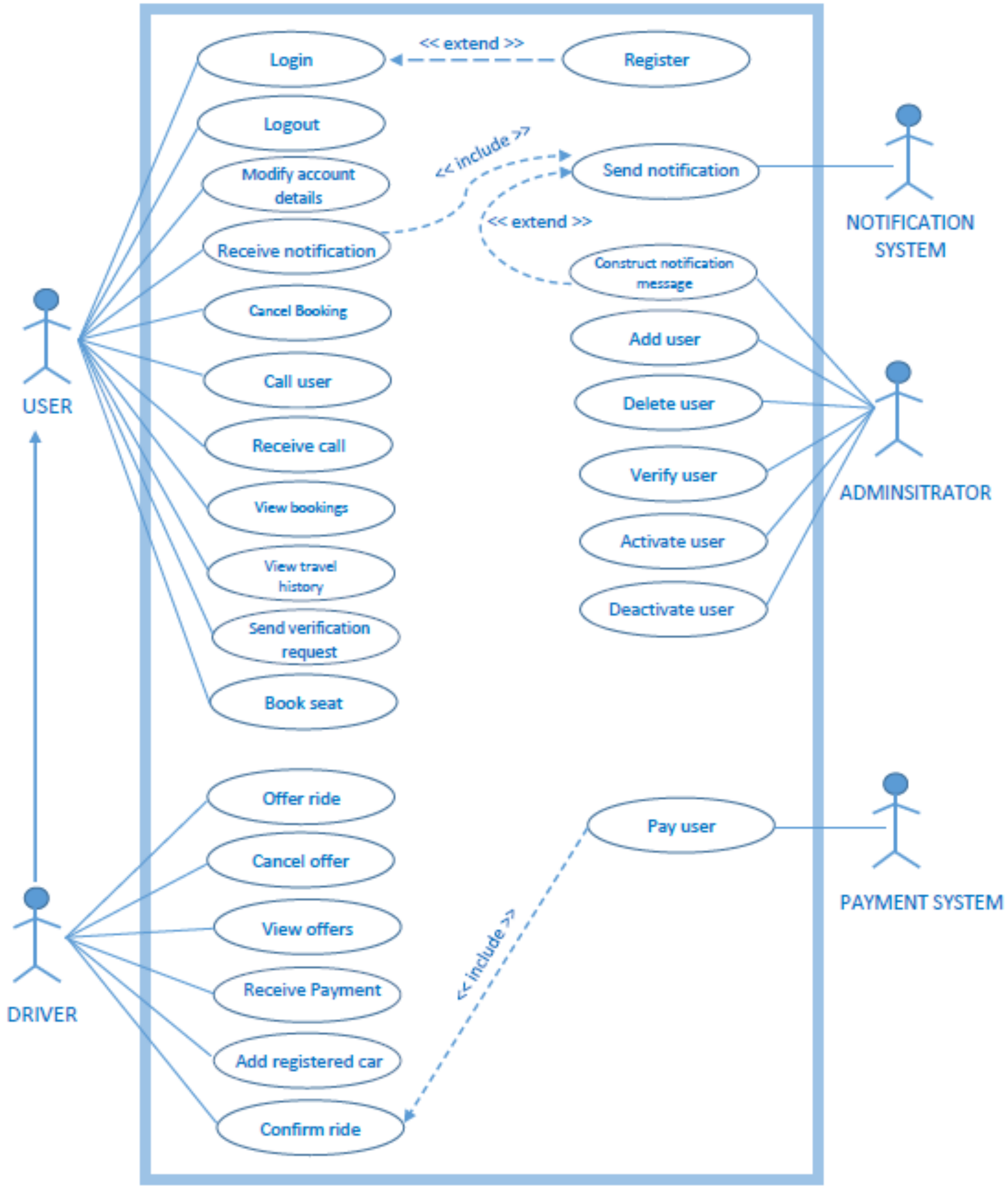

Figure 2. TechMate Use Cases

3.3 CampusRide Database Modelling

To model the CampusRide cloud database, all the items or entities (ie. User, booking, offer, message, car etc.) and their relationships were identified. For every identified entity, attributes were also identified. All entities with their corresponding attributes and relationships between them are explained with illustrations in Figure 3.

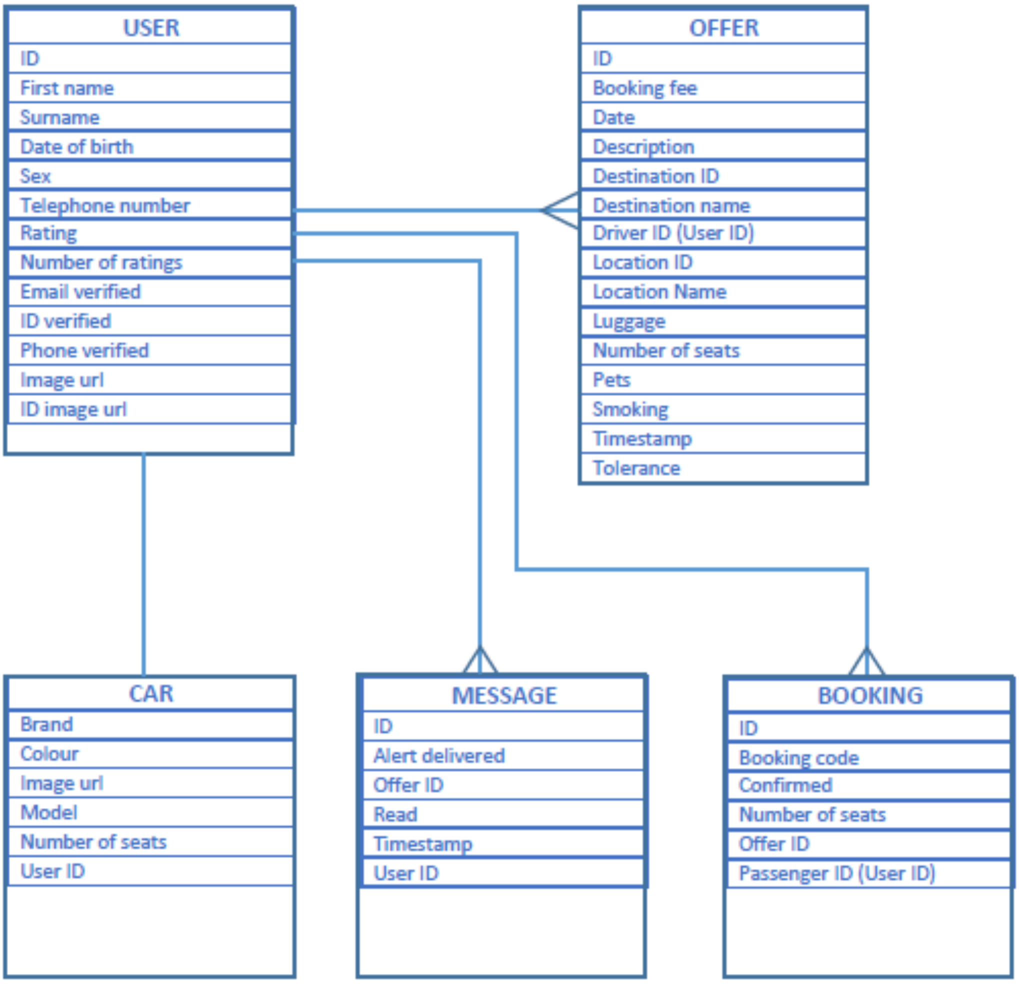

Figure 3. CampusRide database ER model

Figure 4 depicts sample images from the firebase console showing how values have been stored in the database. Firebase uses node-like structure where attributes are displayed on the right and their corresponding values displayed on the left under each entity. IDs are random strings generated by firebase. A database record is implemented as a sub node under entities which form the main nodes.

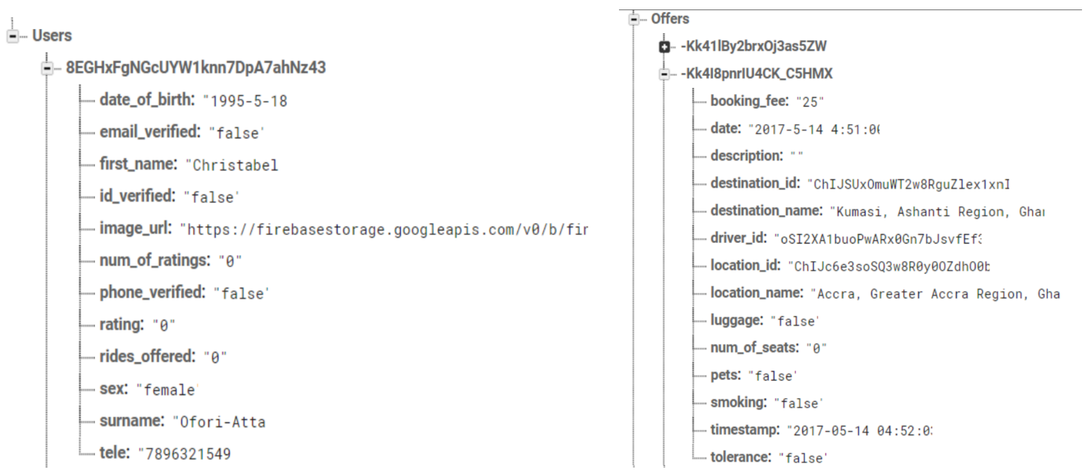

Figure 4. CampusRide sample database content

3.4 CampusRide Mobile Software Application

The TechMate software application user interface, as shown in Figure 5 (GUI background image [20]) provides users with all necessary functionalities they need to interact with the CampusRide management software system. This section is dedicated to describing all functionalities and the steps involved in their execution. All functionalities that are described here have already been captured in the use cases.

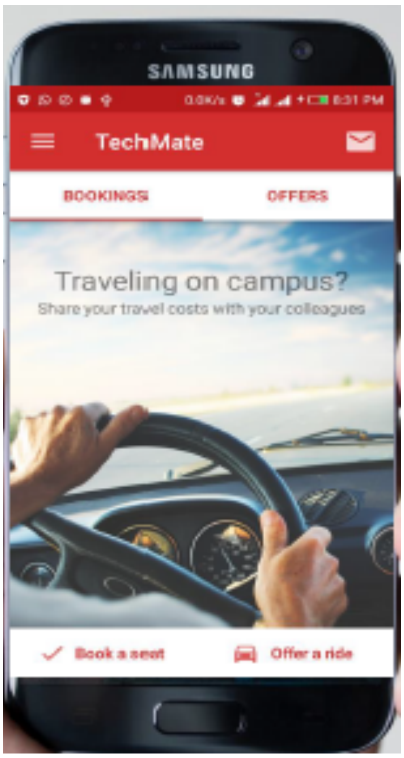

Figure 5. TechMate GUI application

3.4.1 TechMate Use Registration

All users who do not have an account would be required to register before they can access any of the other functionalities. Registration requires a user to provide several basic information such as email address, password, first name, surname, telephone number, sex, and date of birth. The user will also be required to add a profile picture. Figure 6 shows screen shots of the registration process and the corresponding activity flow chart is provided in Figure 7.

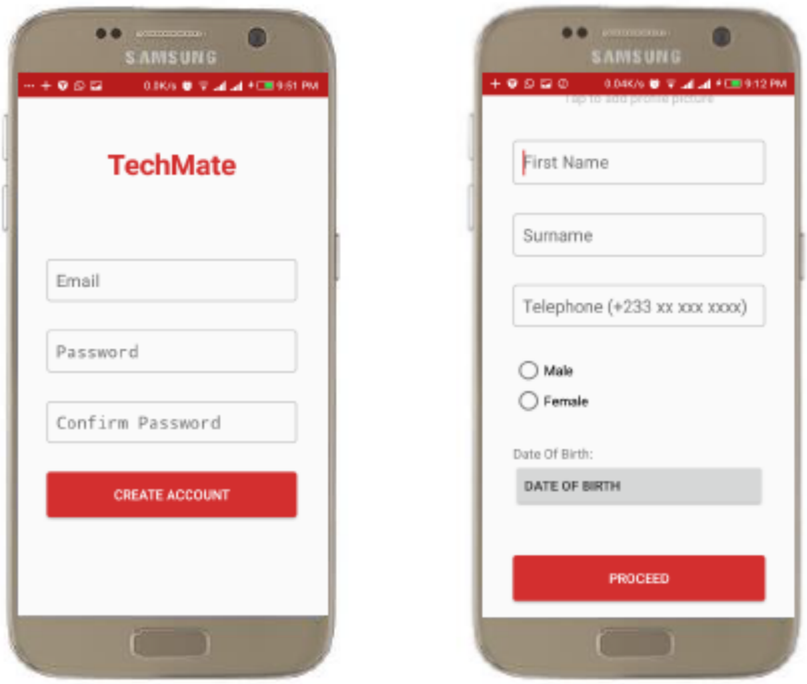

Figure 6. TechMate User Registration

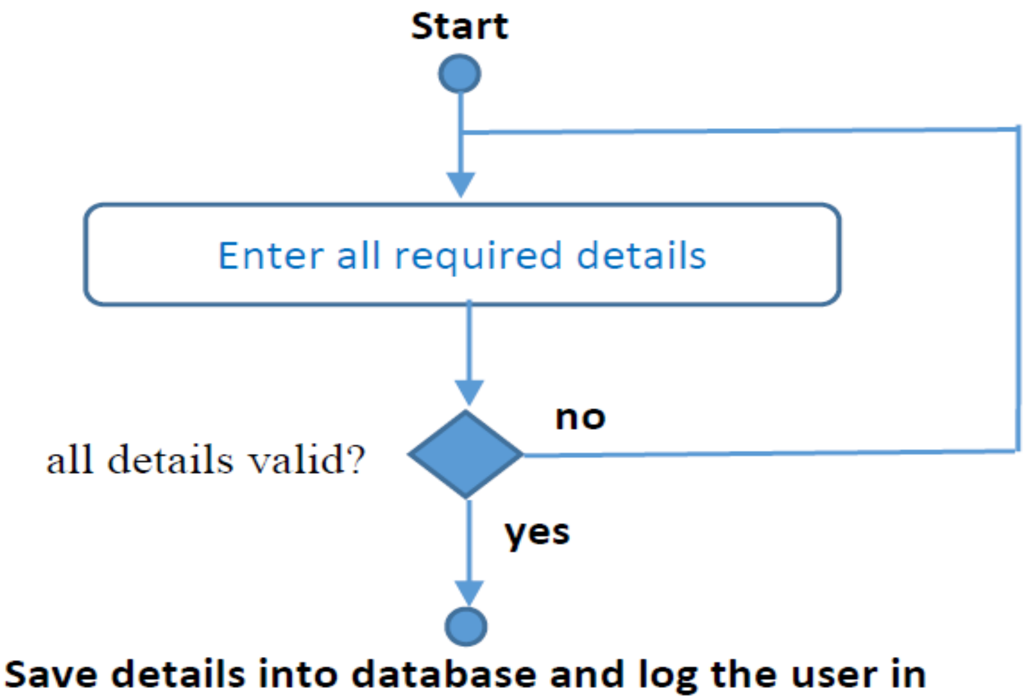

Figure 7. Registration process flow chart

3.4.2 TechMate Use Login

Users who already have accounts can login by providing valid and matching login credentials. These credentials include the user's email and password. Figure 8 represents the login process and the corresponding flow chart.

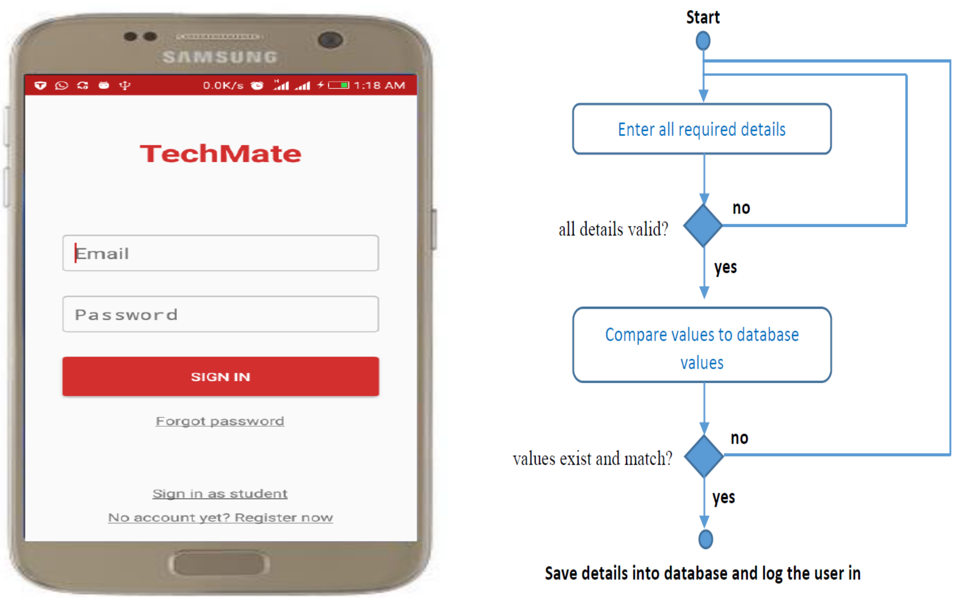

Figure 8. User login and flow chart

3.4.3 TechMate Offer Ride

All users who have verified their telephone numbers and ID's and have a car profile can offer a ride. To offer a ride, the user would have to set his location and destination and then specify the number of seats he wants to offer. Finally, the user would have to set the date and time for the journey. Figure 9 depicts the ride offer process and its flowchart.

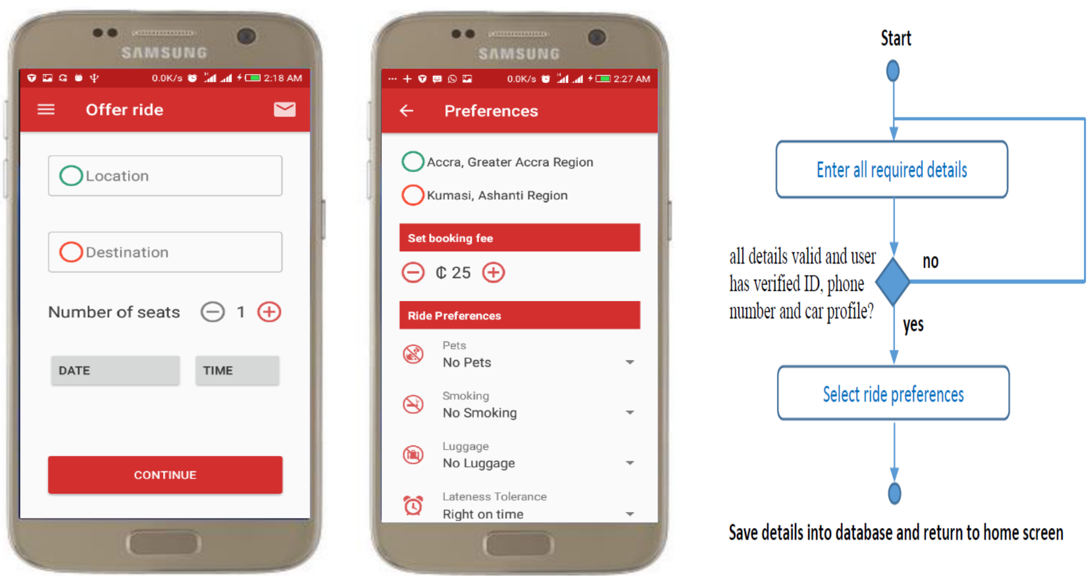

Figure 9. TechMate Ride Offer process

3.4.4 TechMate Book Seat

Users need no verification to book seats for an offer that has been offered by another user. The booking process is like that of the offer ride process. To book a seat, the user only enters his location, destination, and the number of seats he wants to book. A match is found if the location and destination entered by a user is equal to the location and destination in the database or the location is within 5 km of the location in the database and the two destinations are equal. This searching algorithm used is termed as the Same Destination SimilarLocation (SDSL) algorithm. Figure 10 depicts the process as well as a flowchart of booking a seat.

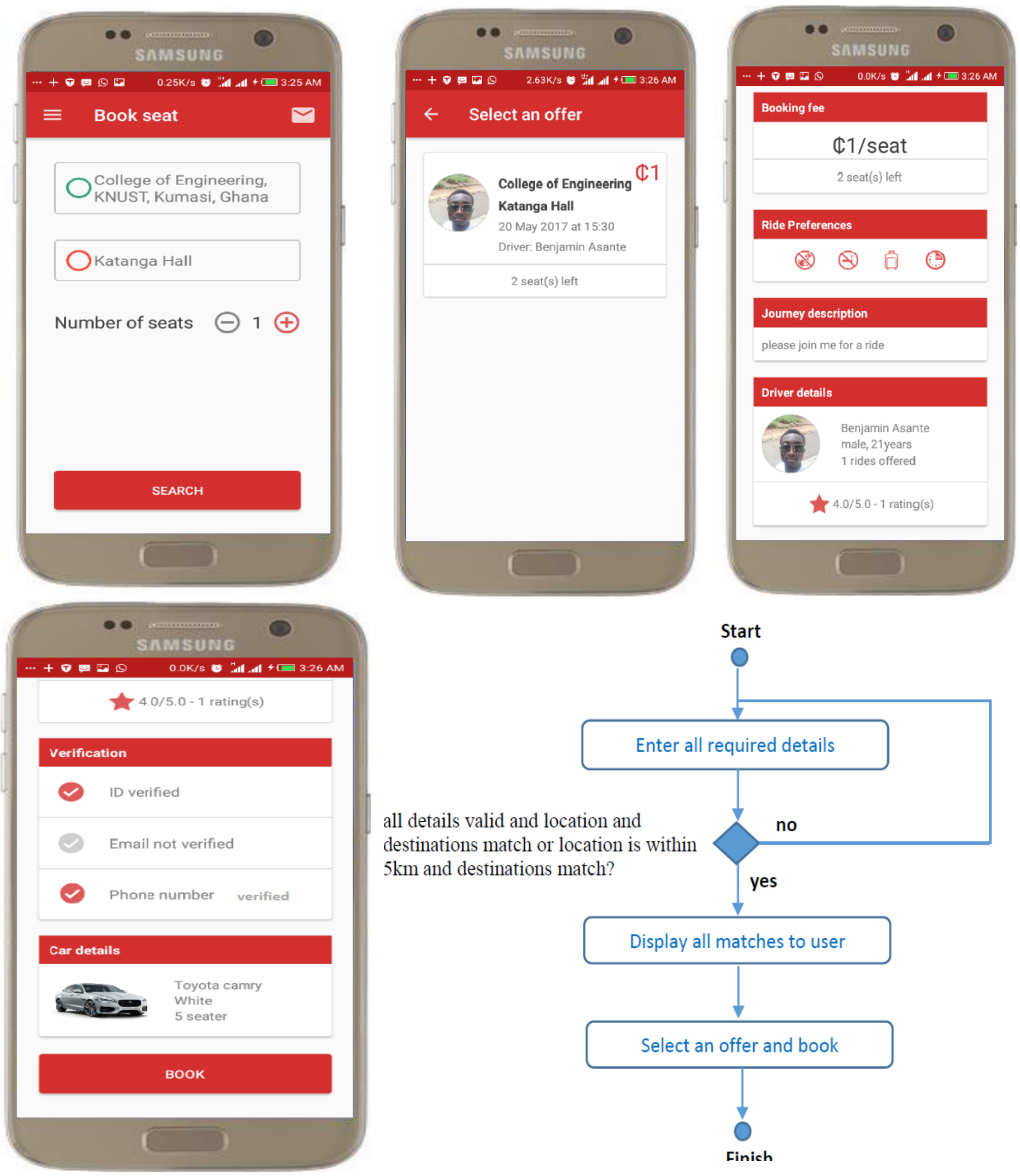

Figure 10. TechMate Seat Booking process

3.4.4 TechMate Confirm Ride

After every successful journey, the driver would have to confirm the ride to prompt the user or passenger for payment. To confirm a ride the driver would have enter booking codes that were given to the user after booking the seat. A valid entry of booking codes will prompt theuser to pay the respective amount to the driver in cash or per POS. Figure 11 represents the process and the flowchart of the ride confirmation.

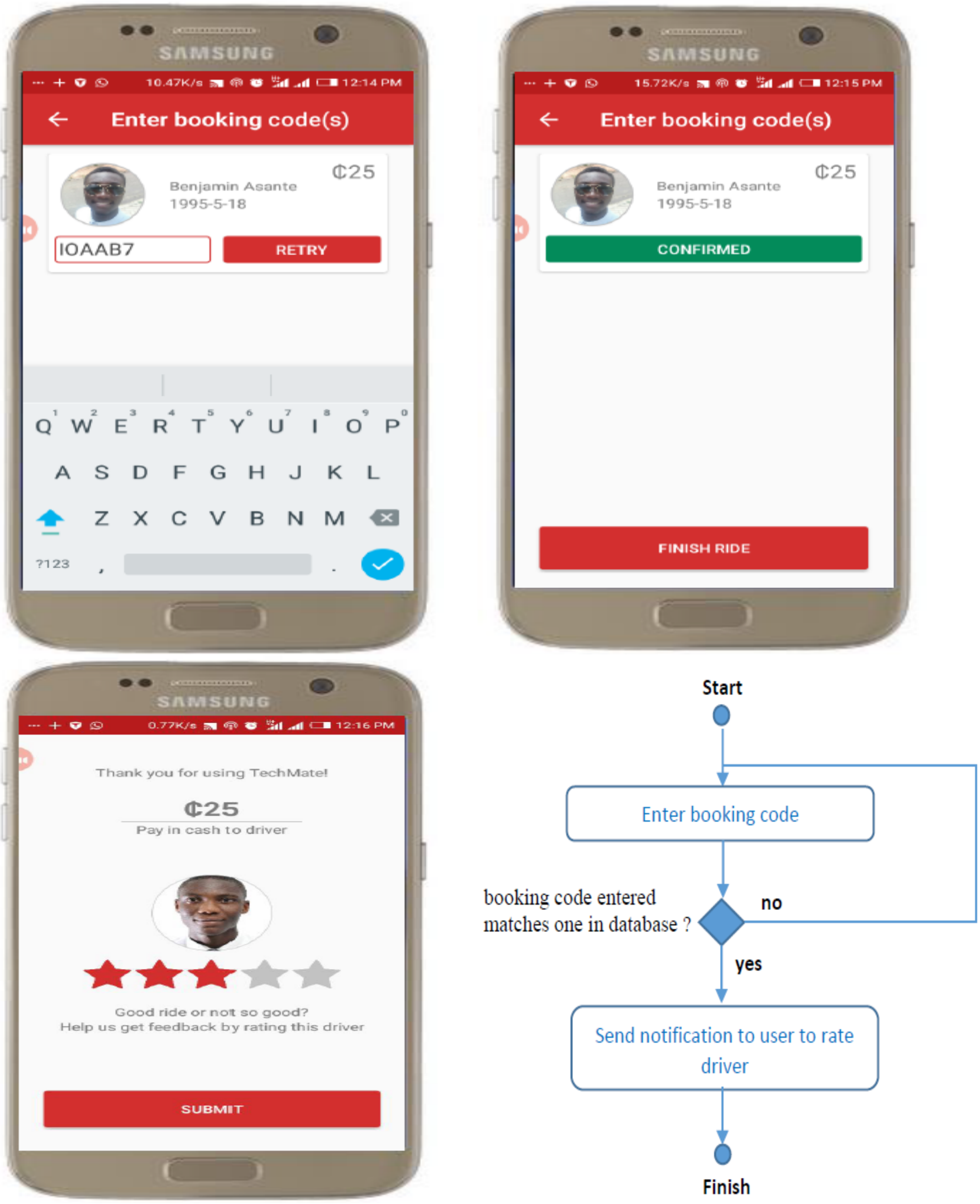

Figure 11. TechMate Confirm Ride

3.5 CampusRide Web-based Software Application

The CampusRide web-based software application was built using HTML, CSS, JavaScript, Angular JS, Firebase, MySQL, and PHP. The web-based system application has a section known as the admin portal where administrators can perform their roles effectively. These administrative roles have already been stated in the use cases and diagrams in previous sections in this write up. The CampusRide application has all the features to run well on android operating system but limited on others. Future works would solve this challenge and expand feature where necessary. The GUI of the CampusRide software would generally be used for user registration and login to review, edit and manage account and others. Future works would expand to add other nice to have features. Figure 12 shows the CampusRide software management graphical user interface (GUI)

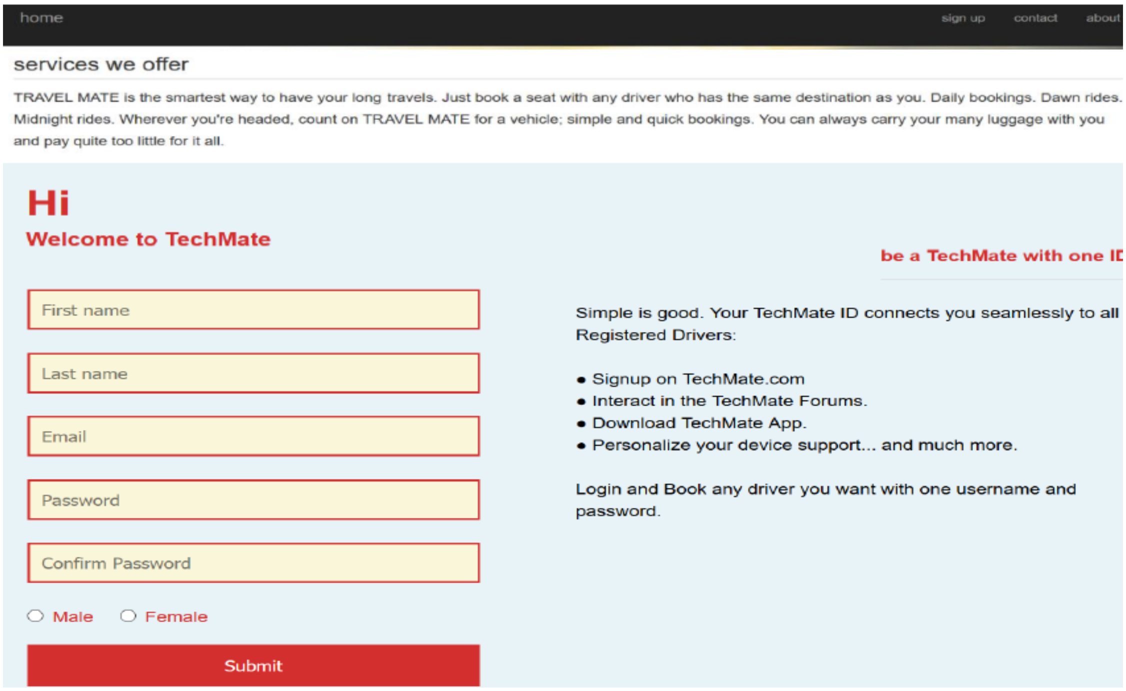

Figure 12. CampusRide Software GUI

4. RESULTS AND DISCUSSION

The CampusRide system was tested vigorously using the following test methods or scenarios:

- Unit test
- Integration test
- System test and
- Usability test

4.1 Unit Test

All units of the TechMate Application were tested to ensure that each one of them were producing the desired results as per the requirements stated and the input. Key processes which include user registration, login, sign-out, offer ride, book seat, edit profile, add car profile, verify phone number, verify ID, verify email, confirm ride, and rate driver were tested during this process. For each of them, the necessary error handling was done to ensure stability of the system and mitigate crashes. After unit testing, all units that are supposed to work together were integrated to form composite units and tested.

4.2 Integration Test

Here, all composite units were tested as a whole unit. In so doing data output from one sub-unit that would be passed to the next sub-unit is passed through a verification phase to ensure that it is valid and correct. For the TechMate application there were four identified composite units which are ride offering, seat booking, user registration and profile or edit setup. The units and steps followed during the integration test are illustrated in Figure 13.

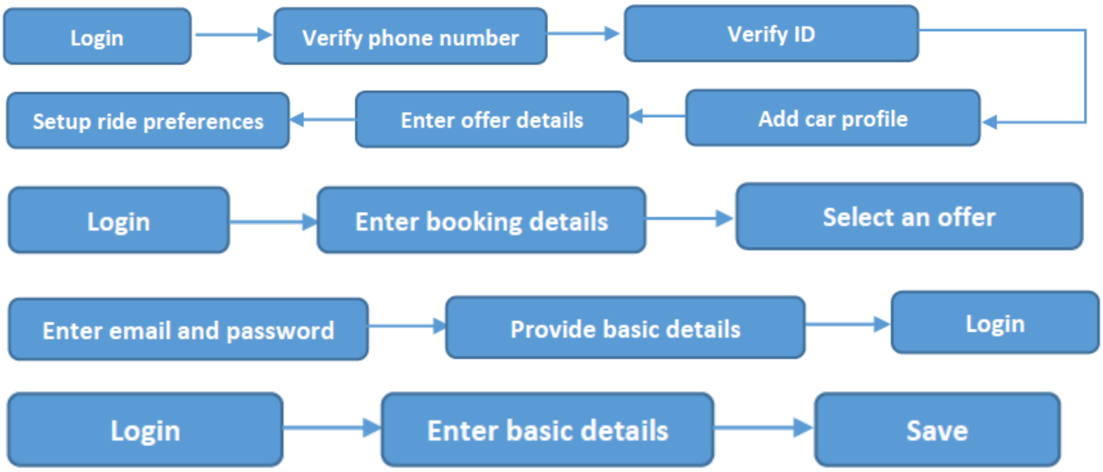

Figure 13. Integrated test steps

4.3 System Test

The TechMate application was tested on various android platforms ranging from Jellybean to Mush mellow. Although the application was designed for a minimum android operating system requirement of ice-cream sandwich, those devices were quite outmoded and hard to comeby, hence we could not test the application on Ice-cream sandwich. New discoveries were made with a series of tests made on the targeted platforms. Errors that were encountered on specific platforms were mitigated and this made the TechMate application robust and has a high level of stability across targeted platforms.

4.1 Usability Test

Usability test was performed to evaluate how user friendly the application was with respect to the graphical user interface (GUI). For this, a group of 20 individuals were given the TechMate application software to test. The table 7 contains results that were obtained from reports made by the group.

Table 7. Usability test report

QUESTION	YES	NO
Was the GUI user friendly?	20/20	0/20
Were you able to learn how to use the application easily?	18/20	2/20

5. CONCLUSION

Unlike most taxi and carpooling applications where applications are developed separately for drivers and passengers, CampusRide exists as a two-in-one software application thereby requiring all passengers and drivers to download only one application. This saves them a lot of space on their devices. Carpooling thrives on the extent of its community. This means that the greater the number of people who are on the service the better the chances of getting a ride to you preferred destination. With a never-ending surge in fuel prices, and the high demand to subsidize travel expense by private car owners, this service seems more to thrive in Ghana and other developing countries. We can look forward to a decrease in vehicular traffic on our roads and a reduction in travel expenses and stress if this carpooling service is well implemented in the KNUST community and the country as a whole. Currently, the CampusRide mobile application runs only on Android and iOS due to time constraints and limited resources. Future works would expand mobile application to Windows, Linux and Others in order to target the greater portion of people who use those devices. The Firebase console was used as our administrator's panel without building one from the scratch. However future works should look at a more independent administrator's panel with more custom features and functions to perform.

The inclusion of the cashless payment such as Slydepay, Mpower, MoMo, GPay etc which would require online payment systems would also be nice to have. If data needed from Ghana DVLA cannot be obtained for the ID verification, then the normal point of terminal POS registration where drivers visit these points or terminals and do manual verification there could be used. In this case uses would be required to provide all valid details which include driver's license ID, full name, address among others.

CONFLICT OF INTERESTS

The authors would like to confirm that there is no conflict of interests associated with this publication and there is no financial fund for this work that can affect the research outcomes.

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