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A Reliable Mobile Application Package Picker and Delivery System

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Abstract
The need for people to transport goods or send and receive packages across different locations in Nigeria is growing, and the consumers need. Other methods of transporting goods and different companies that handle this transportation have sprung up over the years, but only a small number of these cut across the entire country while still providing an efficient solution. This research presents an innovative solution that simplifies logistics processes for both the consumer and the service provider, from the point of request to the end of delivery, while also addressing other issues involving delivery speed and reliability. The findings of this study show massive agreement with theoretical predictions and a significant improvement over previous research efforts. The work presented in this research has important implications for future studies involving delivery system optimisation and may help solve all problems involving the entire delivery process system in Nigeria and beyond.

Keywords: Reliable delivery system, fast delivery system, mobile application, location tracking, Google map.

1. Introduction

Most existing courier service companies in developing countries, such as Nigeria, use manual management, which is time-consuming (Okemiri, Nweso & Nwebonyi, 2017; Bisandu, 2016; Bisandu et al., 2018). Nowadays, many entrepreneurs and local business owners sell various products to various consumers and deliveries to their customers. Charter large trucks to transport their goods to where they sell them or manually look for people to make their deliveries for them, provided that the point of delivery is remote (Bisandu, et al., 2019). Those people are going or travelling in that direction. Some businesses and individuals own trucks and use them to deliver goods to customers, but this comes at a high cost in terms of purchase and maintenance. There is no means to track parcels in real-time throughout delivery procedures, and despite the increasing number of delivery firms and service providers, none of them gives an easy and uncomplicated way to follow the whereabouts of your packages and items in real-time. Another issue is with delivery locations, where most local areas are tough to locate since they are difficult to navigate and have no clear description. This study aims

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to develop a system in the form of a mobile application that allows people to request pickup and delivery services in different parts of Nigeria (Bisandu, et al., 2020). There will also be an online platform where anyone can register and go through a verification process as a delivery person and use the system to connect with users and assist them in making deliveries to various areas. The following questions are also addressed in this paper:

- What are the fundamental requirements for an on-time, dependable, and efficient delivery system?
- What are the steps to be taken in designing a system that meets these requirements?
- Are all these requirements user-satisfactory?
- What are the features of already existing delivery applications, if any?
- How does this research improve on those features?
- How easy is it to make use of this system?

1.1 Problems with the current method

- No ensured the safety of goods or items.
- No idea of the current whereabouts of the goods once it has left the individual's possession.
- Some drivers try to extort money from individuals trying to send packages.
- The receivers usually have to go to the park or far location within their states to collect their packages or pay extra costs for someone to bring them to them.
- Problems with good and constant communication.

There are several courier services in Nigeria. Some of these services require individuals to bring their packages to their offices to make deliveries, while others use online systems. The majority of these services are only available to businesses and eCommerce companies. Most of the relationships between these companies and courier services require signed agreements that state terms, scheduled payments, and how long that particular courier service will make deliveries for those companies to their customers. Only a few courier services are available for individual door to door delivery and often face the problem of not receiving accurate descriptions of home delivery locations. Some of these courier services are also only available in a few states in Nigeria. Examples of three very popular courier services in Nigeria are DHL, FedEx and GIG Logistics, just to mention a few.

The rest of the paper is organised as follows: The hitches of the existing system and the system design requirements and application flow of the proposed mobile application are explained in Section 2 of this paper.

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The system's implementation and evaluation are explained in Section 3. Section 4 discusses the results of the current system while the summary and conclusion of this work with future works are presented in Section 5.

2. Review of related work

A number of works and proposals concerning improving delivery services and logistics and coming up with new ways of dispatching goods and products have been published. This section is going to look at a few of them.

Igwe and Robert, (2016) provide profound empirical evidence that dedicated investment, information sharing, decision synchronisation and incentive alignment are significant predictors of business performance in the aspect of on-time delivery. The practical implication of this study is that practising managers both in the service and manufacturing industries should take cognisance of the benefits of collaboration concerning these dimensions in their planning operations to build a formidable relationship with partners to enhance performance in the supply chain. Zhang, and Chen, (2014) suggest that As frozen food distribution companies tend to serve rather large numbers of customers in dispersed locations, they must efficiently design routes for vehicles to minimise the delivery cost while maintaining or even improving food and service quality for customers. But this does not only apply to frozen food distribution companies. However, they use the Genetic Algorithm (GA) approach to solve the vehicle routing problem (VRP), which only applies to frozen foods. Jie, Subramanian, Ning, and Edwards, (2015) propose a triadic model based on the Asset-Process-Performance framework that includes e-retailers, delivery service providers and customers to achieve synergy and customer satisfaction in the era of the IoT. They also suggest that e-retailers need to use appropriate criteria to select smart delivery service providers (3PL service providers) to improve customer satisfaction in the IoT era.

These are focused mainly on certain types of products and mostly focused on large companies and e-commerce businesses.

Most existing companies, including e-commerce businesses, have dedicated transport vehicles that run supplies for them. Some of them partner with courier services to make deliveries for them. Some of these services are readily available for individuals, but they come with some limitations that will be addressed in chapter Three and are also mostly limited to certain areas and states in Nigeria. There is hardly a dedicated mobile application where people can request pickup and deliveries across any state in Nigeria.

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3. Development Methodology

The Iterative Enhancement Model was chosen as the software development model for this suggested system. The iterative enhancement approach's primary concept is to break the system into various key modules known as increments and then create each module one by one using the waterfall approach. This model has several phases, each of which provides an increment and improves the requirements iteratively until the final software is developed. All of the requirements for the proposed delivery system's mobile application were identified in this research, and some of the designs and application flow were drawn out. Each module was created, tested, and tweaked until it was fully functional. The next module was then added and developed until it was fully functional. At each increment, all the modules were tested together to confirm that they all functioned properly as a whole.

3.1 Architecture of the proposed system

The application's implementation, as shown in Figure 1, is based on a three-tier architectural pattern, which includes:

- The presentation layer allows the application's users to interact and view the displayed data. The sign-up and sign-in screens, Facebook login screens, delivery request screens, conversation screens, and tracking screens are all part of the UI layer. As shown in Figure 2, this layer was created using react native UI components, and the style was chosen to be compatible with mobile devices. The react native UI components were used to build this layer and style it to fit in mobile devices.
- The Business Layer is where the app's logic is managed based on user interactions. This layer also pulls information from the database layer and shows it on the user interface. Javascript in reacts native was utilised to handle the logic in this layer, and it integrates seamlessly with the Firebase API, Google Services, and other APIs.
- All data sent from the presentation and called from the presentation layers is stored in the database layer. Some background data is also stored in the database to aid the logic layer in executing certain background activities in the application. The Firebase real-time database was used for this layer.

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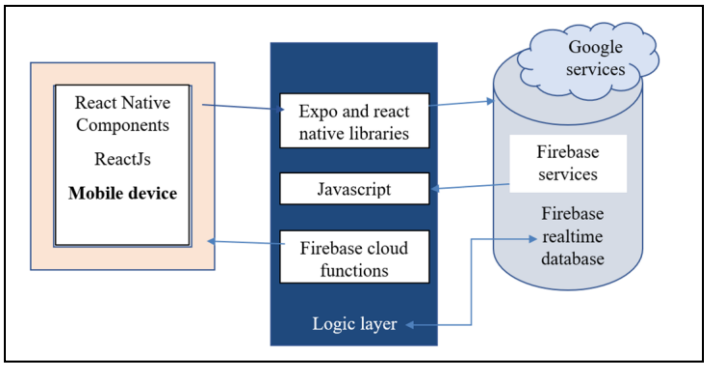

Figure 1: The three-tier architecture of the proposed application

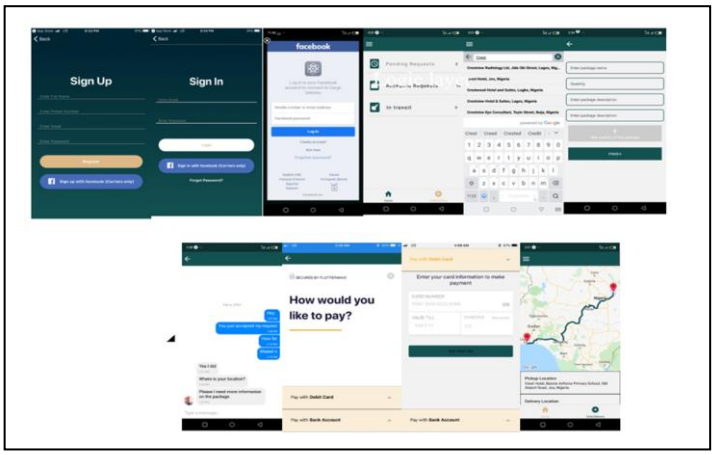

Figure 2: Application presentation layer

3.1.1 System Implementation

In this section, the entire system implementation procedure is discussed. Because courier services are not readily available to every individual in Nigeria, most individuals still use manual means of going to parks to look for drivers going to their desired delivery location to make deliveries for them, especially when it involves sending packages to someone or people in other states.

3.1.1.1 Features and general observations of courier services in Nigeria

- Some of these services provide tracking numbers that you can use to track your package on their site.
- Send you an email once the package is delivered.

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- Available mostly to large businesses and companies.
- Require you to wait for feedback from them about your delivery status.
- In a few cases, information on a package is unavailable when trying to track at a particular time.

3.1.1.2 Advantages of proposed mobile application delivery system

- Available to both individuals and small businesses
- Fixed prices for delivery depending on location
- Constant communication with delivery personnel or courier and supply of information and updates about package within the application
- Real-time tracking of package location on the map
- Allows users to improve their experience by adding their home locations to the database.

3.2 System algorithm (Pseudocode)

Pseudocode is an informal high-level description of the operating principle of a computer program or other algorithm. Below is the pseudocode for the mobile delivery system, as shown in Figures 3 (a) and (b).

```
user launches application from their mobile device
if the user is registered and signed in already:
    system determines from the database if its a regular user or a carrier
        if regular user:
            user is taken to the regular users dashboard
            user is able to view pending requests they've made, accepted requests and packages in transit and also make new requests
            if the bottom tab for new request is clicked:
                user is taken to a mapview where they can select pickup location and delivery location
                when the locations are selected, the route is drawn on the map and the user can click the continue button
                if the user clicks on the continue button:
                the user is taken to a page where they can fill the remaining datails on the package and send the request
                if the request is successful:
                    user is shown a success message and taken back to the main dashboard
                    user request will now be added to the pending requests in his/her profile
                    if request gets accepted:
                        user can now click on the accepted requests list item and view all the accepted requests
                        user can also chat with the carriers that accepted each of the requests to clarify details
                        upon final agreement, the user pays the delivery fee based on distance
                            if payment completes successfully:
                                carrier picks up the package and the package information is added to the packages in transit
                                user can also track carriers location in real time
                                if delivery successful:
                                    a confirmation is sent from the carrier to the user
                                else:
                                    user continues to wait till the package is delivered or a complaint is sent to the support team
        else:
            user is taken to the carrier dashboard
            carrier is able to view pending requests of all users, requests they've accepted and packages with them in transit
            push notifications of new requests are received
            if carrier accepts request:
                request will now be added to the pending requests in his/her profile
```

(3a)

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```
            if carrier accepts request:
                request will now be added to the pending requests in his/her profile
                carrier can click on the accepted requests list item and view all the accepted requests
                carrier can also chat with the users whose requests they accepted to clarify details
                upon final agreement, carrier waits for payment confirmation
                if payment completes successfully:
                    carrier picks up the package and the package information is added to the packages in transit
                    if delivery successful:
                        carrier sends confirmation to the user
                    else:
                        carrier gives feedback to user in chat or call or contacts support
                else:
                    carrier continues to wait for confirmation
else:
    User is taken to the welcome screen
    if registered:
        user clicks on the login button to go to the login page
        if regular user:
            user signs in with the form
            if login completes successfully:
                steps 5 to 25 are carried out
        else:
            user signs in with facebook
            if login completes successfully:
                steps 27 to 42 are carried out
    else:
        user is taken to the registration screen where regular users can sign up with the form and carriers with facebook
        if successful:
            user data is added to the database
            steps 2 to 52 are carried out
```

Figure 3 (a), (b): Snippet of the application pseudocode

The delivery system mobile application was implemented using Expo react-native alongside other platforms and services, including Firebase services, Google services, Android studio emulator for testing, and Visual studio code IDE for writing and editing the codes used in the implementation.

The following subsection discusses the reasons for choosing these technologies.

3.2.1 Expo React Native

- Expo react-native has support for both Android and iOS, which makes it easier to develop applications for both android phones and iPhone by writing code only once
- Expo provides tools and libraries out of the box, making development easier and reducing development time.
- With the Expo client app (for both iOS and Android), it is easier to monitor the progress of applications and test new features while the apps are being built. Developers can publish new versions of the app, which then will be available across different devices through the Expo app
- Expo works well with APIs and libraries

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3.2.2 Firebase

- With Firebase, you can sync the offline and online data through a NoSQL database. This makes the application data available on both offline and online states of the app. This boosts collaboration on the application data in real-time. Here are some of its benefits.
- Firebase helps to address the performance issues of an app by fixing bugs right from its backend solution. It is also equipped with a robust crash reporting feature. Its crash reporting helps deliver intricate and detailed bug and crash reports to address all the coding errors in an app. The reporting feature can group the issues into different categories as per the characteristics of the problem. Here are some of the attributes of this reporting feature.

3.3.3 Visual Studio Code Integrated Development Environment

An integrated development environment (IDE) is a software application that provides comprehensive facilities to computer programmers for software development. The choice of IDE influences the speed of application development; for this research, Visual Studio Code is used, and this is because it can be used with a variety of programming languages. Instead of a research system, it allows users to open one or more directories, which can be saved in workspaces for future reuse. This allows it to operate as a language-agnostic code editor for any language. It supports several programming languages and a set of features that differs per language. Unwanted files and folders can be excluded from the research tree via the settings.

3.3.4 Google Services

Google provides a wide range of API and cloud services that enable developers to use them in applications. The APIs are easy to implement and integrate into applications. The services used in this application from google include Firebase services, google maps, google places, google directions and google geocoder.

3.3.5 Entity Relationship Diagram

The entity-relationship diagram is composed of entity types and the various relationships between them. Figure 4 shows the database entities in the system and how they relate to each other.

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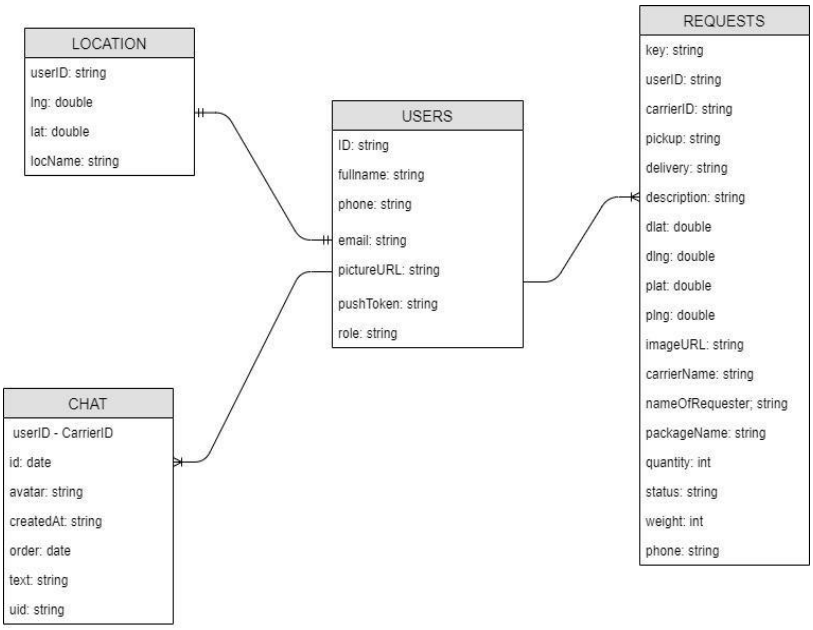

Figure 4: Entity relationship diagram of the application

3.3.6 System design and application flowchart

All the use cases of the developed system is discussed in this section.

3.3.6.1 Use cases

The regular users sign up using the form provided within the application, and their details are stored in the database, the carriers sign up with Facebook and are also stored in the database, and the regular users and carriers are both taken to their respective dashboards as shown in the use cases diagram in Figure 5. If already registered, they are given a page to sign in at any time and go to their dashboards.

The regular users can see their pending deliveries, accepted deliveries and deliveries in transit on their dashboard, and they can also request delivery services where they enter the package details and also the pickup location and delivery location and chat with carriers that accept their requests to give a more accurate description about their packages and locations. Users make payments once the delivery is accepted and can track their packages on the map when they are in transit.

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The carriers see pending requests from all users and can choose to accept anyone most convenient. They also receive notifications of delivery requests. When accepting a delivery request, the carrier can chat with the user to get more details. Once the delivery is completed, the carrier receives its payment.

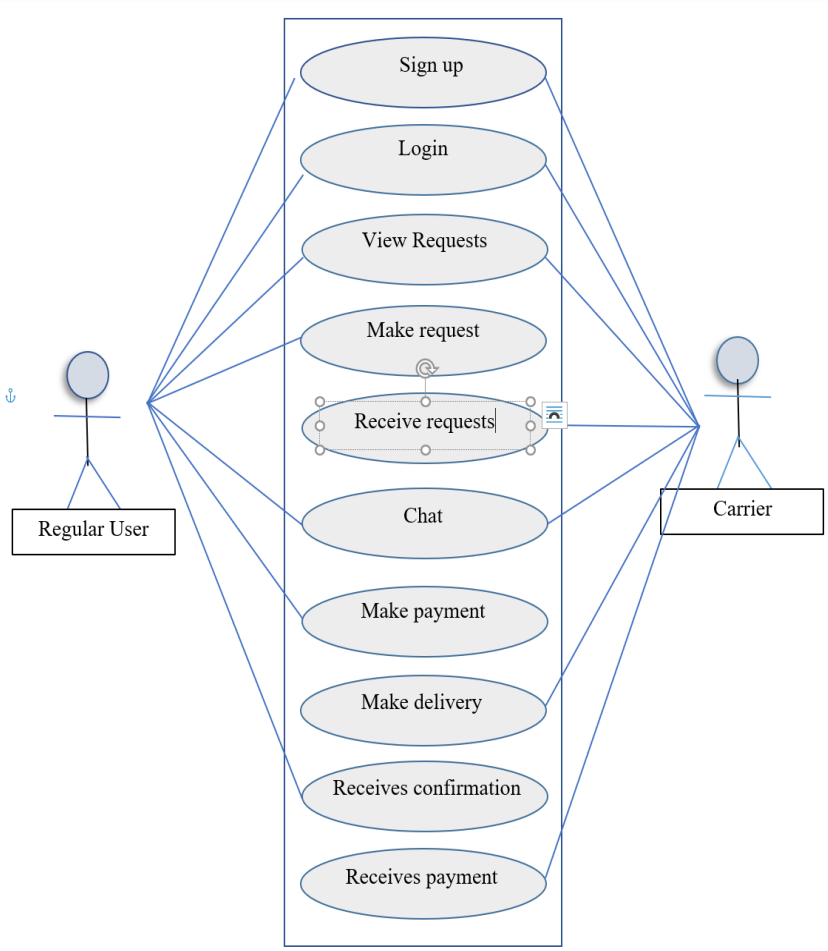

Figure 5: Use case diagram for the mobile application delivery system

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3.3.7 Flow chart

This diagram represents an algorithm, workflow or process, as shown in Figure 6.

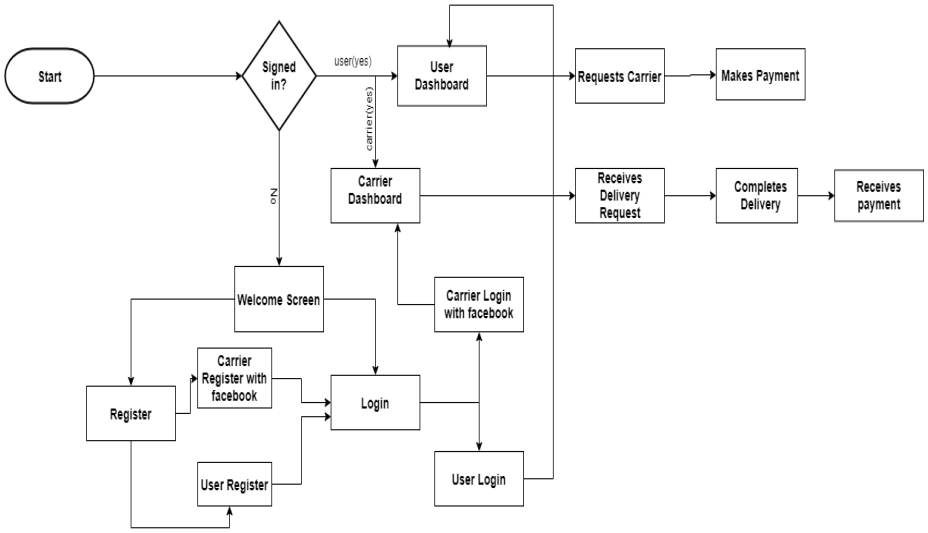

Figure 6: Application flow diagram for mobile application delivery system

3.3.8 Analysis, improvements and design flow of the new delivery system

Apart from the manual management method used by most courier service companies, a few companies provide tracking numbers for each parcel and delivered packages. However, the tracking applications required to input these tracking numbers are not readily available, and most people must rely on third parties to track their packages. Most of the time, location tracking is limited to specific intervals and landmarks. The new approach outlined in this study will address some of these identified limitations.

3.3.8.1 Improvements to the proposed system

- Available to both individuals and small businesses,
- Fixed prices for delivery depending on location.
- Constant communication with delivery personnel or couriers, and as the provision of information and updates about the package the proposed application
- On-the-fly tracking of package location on a map
- It allows users to improve their experience by adding their home locations to the database.

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3.3.8.2 Sequence flow of the proposed system

According to Figure 7, regular users sign up using the application's form. Their information is stored in the database; delivery persons sign up using Facebook, and their information is also stored in the database, and both regular users and delivery persons are directed to their dashboards. If they are already registered, they will be sent to a page where they can sign in and access their dashboards at any time. Regular users can access their dashboard to view pending delivery requests, accepted requests, and packages in transit, as well as request delivery services by entering package details, pickup location, and delivery location, and chatting with delivery persons who accept their requests to provide a more accurate description of their packages and locations. Users make payments once the delivery is accepted, and while their packages are in transit, they can track their real-time whereabouts on the app's map. The delivery personnel see all pending requests from users and can accept or decline them based on their convenience. They are also notified when delivery requests are made. When a delivery request is accepted, the carrier delivery personnel can speak with the user to acquire further information about the delivery. The delivery personnel receives payment once the delivery is completed.

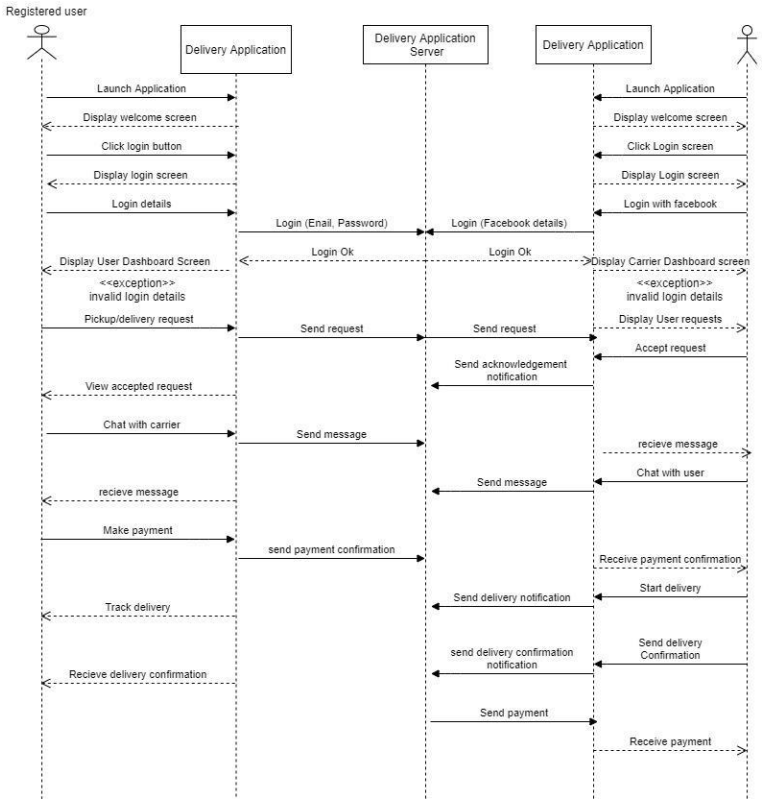

Figure 7: Sequence diagram for delivery system mobile application

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4. Results and discussion

This section discusses the findings from the development application used for this research.

4.1 Application components

The following subsections show various components of the prototype built for the delivery system mobile application.

4.1.1 Welcome screen

The welcome screen is the first page the user sees as the user launches the application (if the user is not logged in). The user can choose to go to the sign-in page if not signed in or the sign-up page if not signed up in Figure 8.

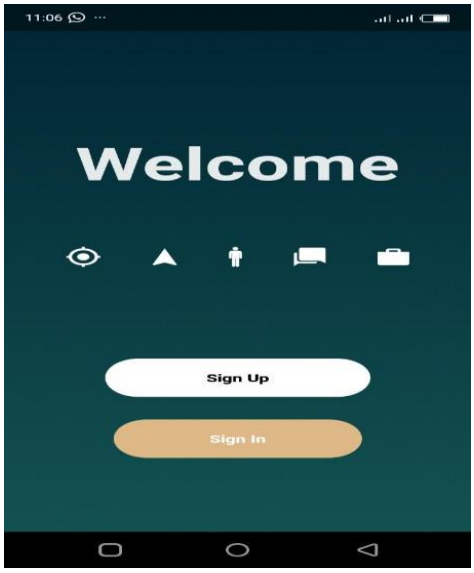

Figure 8: Welcome screen

4.1.2 Sign-Up and Sign-In screens

These screens are available for users to sign up or sign in to the application. The forms are available for regular users, while the Facebook sign-up and sign-in are available for carriers. The diagram below illustrates both screens on an iOS device, as shown in Figure 9.

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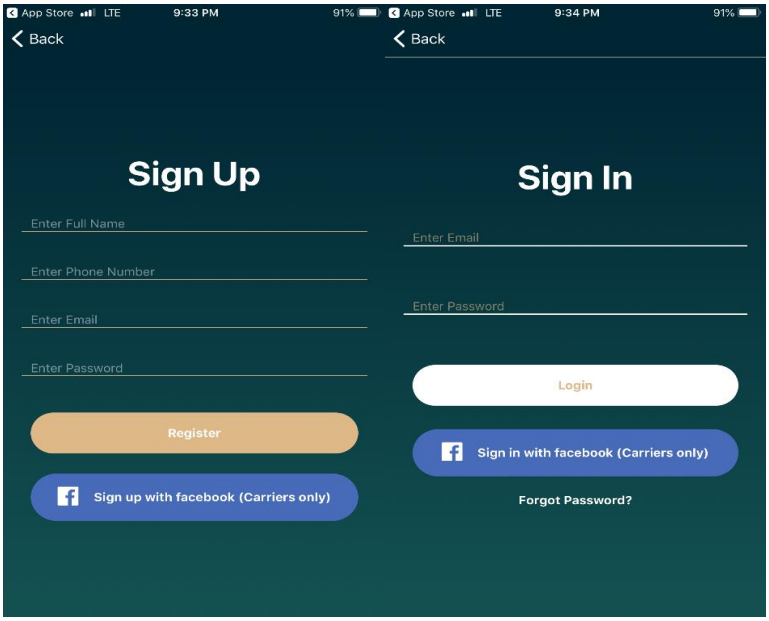

Figure 9: Sign-Up and Sign-In screens

4.1.3 Facebook Login screen

This is where carriers sign into the application. They are prompted to enter their Facebook emails/usernames/phone numbers and password. Carrier details are retrieved from Facebook and added to the database on the first login, as shown in Figure 10.

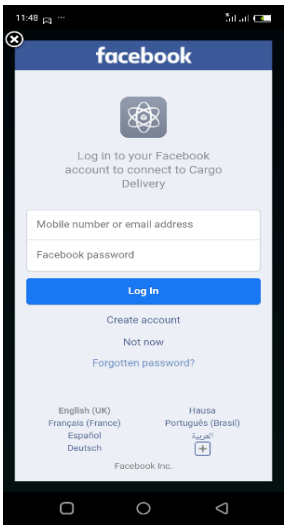

Figure 10: Facebook login screen

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4.1.4 Dashboard screen

This is where users can view pending requests, accepted requests and requests in transit. They can also navigate were to make delivery requests, as shown in Figure 11.

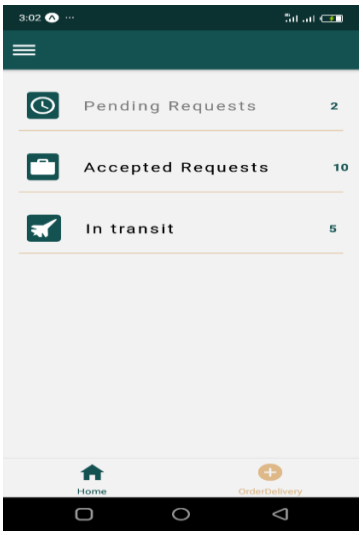

Figure 11: Dashboard screen

4.1.5 Delivery request screens

This is where users can make delivery requests right from selecting pickup and delivery locations to entering the necessary details of the package/goods. Users can also see road routes on the map showing the pickup and delivery points, as shown in Figure 12.

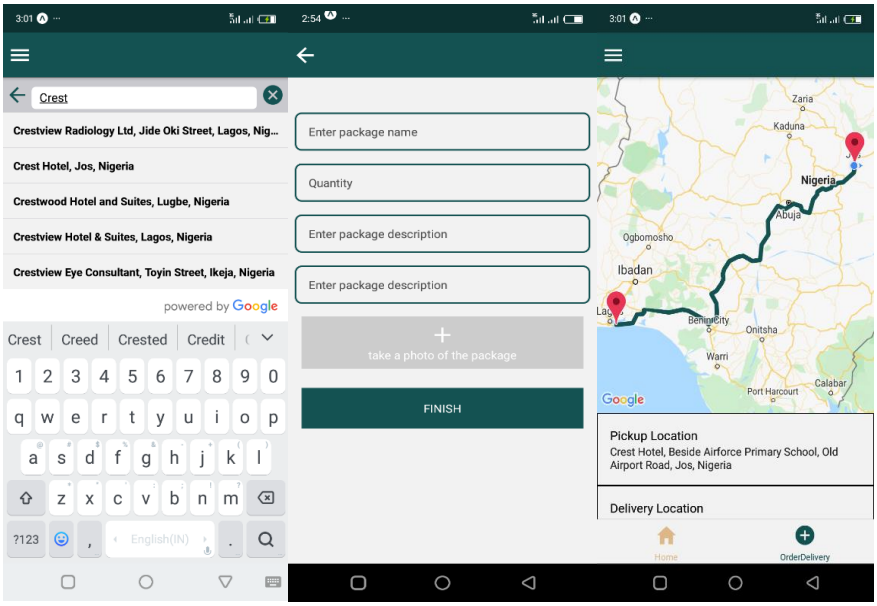

Figure 12: Requests and map screens

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4.1.6 Chat screen

This is where users and carriers can have frequent communications from when the carrier accepts the package until delivered, as shown in Figure 13.

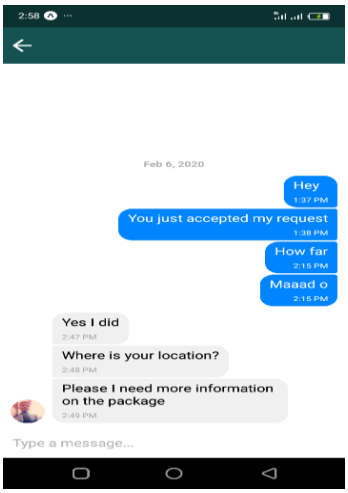
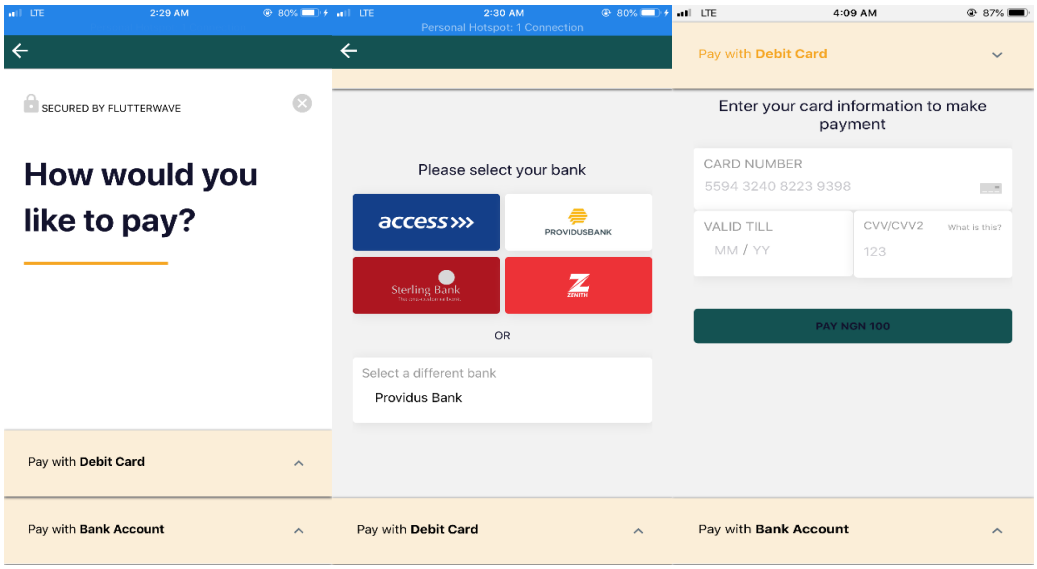


Figure 13: Chat screen

4.1.7 Transaction Screens

This is where the user completes the payment of the standard delivery fee based on location upon agreement with the carrier, as shown in Figure 14 (a), (b).



(a)

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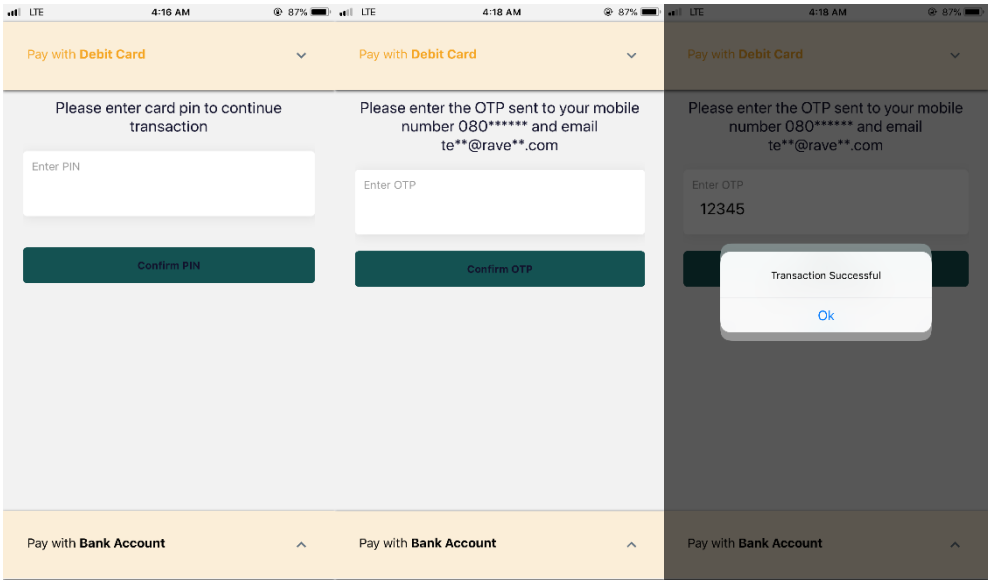

Figure 14 (a), (b): Transaction screens

4.2 Hardware and software requirements

The hardware and software requirements are the required specifications or configuration a device must have to run a particular program or application. The minimum requirements are required for the program to run in the first place, but the better the device specifications, the better the program in question performs on that device

4.2.1 Mobile device hardware requirements

- A mobile (IOS or Android) device that supports General Packet Radio Service (GPRS) and Code Division Multiple Access (CDMA).
- 2. A Qualcomm processor (or equivalent) of a common speed of 1.27MHz or above. 3 for android devices.
- The mobile device should have a minimum disk memory (RAM) of 1GB or higher. 4.
- The mobile device should also be equipped with a minimum disk storage space of 512MB for android devices.
- For iOS devices, the device should also be equipped with a minimum disk storage space of 16gig.

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4.2.2 Mobile device software requirements

- The application will run on Android devices running Android 4.1 or later.
- The application will also run-on iOS devices running on iOS 1.0 or later.

4.3 Evaluation and testing

The evaluation and testing of the system are performed in this section.

4.3.1 Testing

The terms error, fault, bug, and defect are considered to be synonyms in the area of program testing. Program testing aims to help realise/identify all defects in a program. However, in practice, even after satisfactory completion of the testing phase, it is not possible to guarantee that a program is error-free.

The goals of the testing process are:

1. Validation testing: To demonstrate system requirements is met, a successful test shows that the system operates as intended.
2. Defect testing: To discover faults or defects in the software where its behaviour is incorrect or not in conformance with its specification. A successful test is a test that makes the system perform incorrectly and exposes a defect in the system.

The tests that were carried out on the delivery system mobile application were the Installation testing and the Usability testing

4.3.1.1 Installation testing

Installation testing was performed to check if the software has been correctly installed with inherent features and that the product is working as expected.

The application was tested and run-on Android versions 5.1 and above. The application was also tested and was able to run on an iPhone with iOS version 12.1.4

4.3.1.2 Usability testing

Usability testing was performed to check how user-friendly the mobile application is in navigation, ease of use, flexible app controls, etc. It is also known as user experience testing, as shown in Table 1.

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Table 1: Installation test plan result

Tasks	No. of testers	No. of successes
Request delivery	7	7
Chat	8	8
Accept notifications	8	8
Make payment	5	5

4.3.2 Evaluation

The system's functionalities were evaluated to ensure that all the user requirements were met. Other things like ease of use and system reliability were also considered, and after serious evaluation and testing, it was concluded that the application was satisfactory for users.

5. Conclusion and future work

Delivery personnel cannot connect their GPS - based mobile phones to a power source on time. Based on research into how existing systems work, some problems with existing systems, and user requirements, a fully functional working prototype of a delivery system mobile application was implemented in this research. Because it can be installed on smartphones and devices with medium-to-low specifications, this system is very accessible to most people. As mentioned in previous sections, this system resolves many of the issues that people commonly encounter when attempting to make deliveries or have goods delivered to them at various points in time. Future work and research will include ensuring the deployment of this system and ensuring that updates to the application are carried out to fix bugs or issues that may arise in the future and add more features to the system as user requirements increase or change. Tracking chips should also be implemented for packages to improve tracking accuracy and ensure continuous tracking information even when there is a power outage.

5.1 Future work

To ensure the deployment of this system and ensure that updates are carried out on the application to fix bugs or issues that may arise in the future and add more features to the system as user requirements increase or change. To also get through to the government and private sector owners to aid, especially in providing

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vehicles to make deliveries easier for the delivery personnel. Tracking chips should also be implemented to be used on the packages to improve the tracking accuracy of packages and ensure the availability of continuous tracking information being provided even when there is a power outage. The delivery personnel can't get their mobile phones tracked to a power source in time.

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