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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

A PROJECT REPORT ENTITLED

DEVELOPMENT OF AN EFFICIENT PUBLIC TRANSPORT SEARCH PORTAL FOR GHANA

BY

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SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF SCIENCE IN COMPUTER SCIENCE AND ENGINEERING

PROJECT SUPERVISOR

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DECLARATION

I declare that this project is my own work. It is being submitted for the degree of BSc Computer Science and Engineering in the University of Mines and Technology (UMaT), Tarkwa. It has not been submitted for any degree or examination in any other University.

.....
(Signature of candidate)

.....Day of .....(Year).....

ABSTRACT

Information about public transport operators and terminals in Ghana and most Africa countries, where transportation by road is a major means in relation to routes they operate, departure times, fares and location is not easy to come by when planning trip ahead unless you visit these terminals where information is readily available in most cases; sometimes relying on word of mouth from other travelers which could be valid or invalid. This project seeks to make it easier for travelers to find the required information on transport terminals in Ghana for effective trip planning and decision making. In conclusion a public transport search web portal application was developed. The application was developed using data collected and mapped into OpenStreetMap database, the data was extracted, cleaned and analysed in QGIS and used to create a geodatabase; using PostgreSQL and PostGIS to suit the needs of this project. The geodatabase can also be accessed by other stakeholders externally without interacting with the web application.

This project wok is dedicated to my mother, Mary Assana Kudjoe, Jamila Adams Prince Ahiabu and Okatachie Afrifa Amankwaa. Your unending love and supports is highly appreciated.

Not forgetting users, contributors and supporters of Libre/Free and Open Source Software initiatives.

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CHAPTER 1

INTRODUCTION

This chapter presents a statement of the problem tackled in this project work, with specific focus on the motivation for conducting the project. Further the chapter highlights the objectives of the project, expected outcomes as well as methods employed for the accomplishment of the objectives. Finally, the tools and facilities used, the scope and organization of the project work are discussed.

1.1 Problem Statement

Road transport service provided by both formal and informal sectors in Ghana is by far the most popular and principal means of conveying passengers, goods and other services between any two or more locations (Aidoo *et al.*, 2013). Some reports have it that, road transport accounts for over 95% of all passenger and freight traffic and about 97% of all passenger miles in Ghana (UNESCO Report, 2010, p. 195), a country that is experiencing rapid demographic and economic growth. The vast majority of passengers commuting between places, be it *intra-city* or *inter-city*, mostly rely on public road transport services in the form of privately owned or corporate taxis, *tro tros* (shared minivans), buses commuting between major cities.

In spite of the heavy reliance on public road transport services by the general populace in Ghana, finding transport terminals which offer reliable road transport services is not as easy as it should be. The difficulty in finding transport terminals is attributable to the fact that little or no information about the availability of transport services and their locations is accessible to the public. Additionally, the non-existent of a means to compare transport fares by various service providers often makes it difficult for the potential passenger to make the right choices. It is the goal of every potential passenger to find the fastest, safest and most cost-efficient means of transiting from one location to another.

Inspired by the aforementioned shortcomings of the existing public road transportation system, this project seeks to develop road transport terminal search tool aimed at mitigating, if not eliminate entirely, these problems with the public road transport industry.

1.2 Project Objectives

The specific objectives of this project include the following:

- To develop a web application that provides detailed information about transport terminals in Ghana to mitigate the difficulty in finding transport terminals and also to provide a platform for to compare other factors by travelers.
- To provide reusable data that can be accessed in mobile and desktop applications that support Geo Uniform Resource Identifier (URI) scheme.
- With Global Positioning System (GPS) supported devices, the work also provides a means of navigating to destination based by incorporating existing mapping solution such as
  - OSMAnd
  - MAPS.ME
  - Google Maps
  - Apple Maps
  - Marble
  - Google Earth

1.3 Project Outcomes

The following will be achieved at the end of the project:

- An web application;
- A detail map of selected transport terminals on OpenStreetMap.

1.4 Methods Used

The methods to be used for the project are as below:

- Literature review on proposed topic
- Study and understanding of online maps (creating, updating, deleting);

- The system will be developed on a handful of local machines, but with scalability and ease of deployment on any kind of infrastructure;
- The system will be prototyped in Python programming language and Django web framework. If this language proves good enough for deployment purposes it will be used in the final product;
- Survey and crowd-sourcing information on some transport terminals to facilitate database creation;
- QGIS will be used to clean and analyze data collected;
- Spiral software development model.

1.5 Tools and Facilities Used

The facilities required for this project include:

- University of Mines and Technology (UMaT) library;
- Internet;
- General search engines as such Wikipedia and DuckDuckGo;
- Open Source software repositories such as GitHub;
- OpenStreetMap;
- Documentation of any software or libraries used.

1.6 Scope of Work

This works seeks to aid travelers acquire detailed information on selected bus terminals in Ghana. This is to enable better trip planning, reduce time taken finding these terminals and also allowing passengers to compare transport fares and choosing the best option they can afford. Further more the application only indicates source and destination terminals and works in the any modern web browser such as Mozilla Firefox or Google Chrome.

1.7 Organization of Project

This project is divided into five chapters. The first chapter talks about the problem to be solved, the objectives, the methods, tools and facilities used, and project outcomes. The second chapter discusses relevant literature and related works. The third chapter discusses how the problem was solved. The fourth chapter talks about the operation of the developed application. The project concludes in the fifth chapter where, limitations and recommendations for future improvements were discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In this chapter, a comprehensive review of literature relevant to this projected work is presented. The chapter looks into some historical background with regards to the road transport industry in Ghana, followed by categorization of road transport. Additionally, the chapter sheds light on the structure of the transport sector, major operators as well as the existing technologies related to road transport in Ghana.

2.2 Historical Background

Transportation is a system or means by which people or goods location (move) with respect to time. Transportation is key to the movement of people, goods and services leading to development. In Sub-Sahara and most African countries, the major means of transportation is by road transport.

Transportation in Ghana dates back to pre-colonial era. Most major roads and railway lines were constructed by the Europeans to facilitate the movement of natural resources and raw materials such as timber, gold and bauxite to generating communities to the coastal areas. Transport in all its modes is one of the most important catalysts for development *(cite)*. After independence road transportation remains a major player in Ghana's economy connecting all ten administrative regions of Ghana.

2.3 Categories of Road Transport

Road Transport in Ghana can be grouped into 4 main categories:

- Urban
- Express Services
- Rural-Urban
- Rural

2.3.1 Urban

The urban category comprise mostly of residents in urban areas commuting to and from work, school and other places of convenience. It is usually carried out by private taxis, personal cars, *tro-tros* and state owned transport services.

2.3.2 Express Services

Express services are on-demand transportation services, which could be in the form of taxis, buses and minivans. As far as the Ghanaian road transport industry is concerned, the expresses services are relatively unpopular compared with other existing categories. However, emergence of technology is steadily changing attitude towards express services due to the fact that their accessible is now easier than before.

2.3.3 Rural-Urban

Rural-Urban transportation is by far the most popular category of public transportation in Ghana, as well as a major factor in Rural-Urban migration. Market trading in the urban centres of Ghana is a predominantly female economic activity and is a fundamental element in the survival strategies of many low-income households. Petty trading is the predominant form of commercial activity and as such, given the financial constraints inherent in this form of trading, necessitates regular travel between wholesale markets and selling places on the part of female traders. Female traders make the most use of the public road transport system, in combination with supplementary services such as portering, to meet their travel needs (Grieco *et al*., 1995).

2.3.4 Rural

This is transportation mainly within rural areas. Depending on the status of each rural area transportation could range for donkey pulled carts, foot, bicycles and motorcycles, taxis and minivans in average conditions.

2.4 Transport Owners, Structure and Operators in Ghana

Transportation service owners and operators in Ghana can be classified as:

- Private
- Government
- Private-Government

2.4.1 The Industry Structure

Within the main metropolitan areas of Ghana, there are two main forms of public transport operations (Finn *et al.*, 2009):

***Tro-tro* (mini buses) and shared taxi services** These are managed by unions and cooperatives and offer services along defined routes, usually between terminals or lorry parks/stations. These operations suffer from a number of quality problems including:

1. operation of a fill and go system which can result in long delays for users in the offpeak, and difficulty to board along the route;
2. large numbers of vehicles parked at terminals in the off-peak leading to congestion, inefficiency, and long hours for drivers;
3. lack of incentives for vehicle owners to improve their vehicles or to train their drivers properly.

Large bus services These are mostly provided by the new Metro Mass Transit (MMT), a quasi-private company that receives favourable financial support from the government.

2.4.2 Operating unions and associations

Individually or privately operated transport services are members of unions or associations. These unions and associations serve as regulatory and mouth-piece to each of their members (Fouracre *et al.*, 1994). There are three major operating unions and associations.

Ghana Private Road Transport Union The Ghana Private Road Transport Union (GPRTU), a national union, is reported to have about 90% of the *tro-tro* and shared taxi business. The fundamental units are locals, which operate the individual routes and branches, which are regional clusters of locals. GPRTU represents the interests of both drivers and of vehicle owners.

Progressive Transport Owners Association The Progressive Transport Owners Association (PROTOA), is a national association that operates both tro-tro and shared taxi business and is organized along the same structure as the GPRTU. PROTOA mainly represents the interest of owners.

Ghana Co-operative Transport Association The Ghana Co-operative Transport Association (GCTA) is a national association also organized along the lines of GPRTU and represents interest of both owners and drivers.

Other private operators Other private operators, such as Agate, Kingdom Transport, and Pergah Transport among others, are companies operating several buses and offering a range of services including contract service, urban services, and intercity services.

Ghana Road Transport Coordination Council Ghana Road Transport Coordination Council (GRTCC) is an umbrella body of all transport operators in Ghana, including the unions and associations, other locally based associations, and other operators (both passenger and road haulers). GRTCC represents the interests of road transport operators, especially in negotiating with the Government of Ghana for transport tariffs and assistance in acquisition of buses.

2.4.3 Operators

Transport operators or owners are individual, state owned or both private and government partnerships managing the affairs of a particular union or brand. Major operators in Ghana include the following.

Intercity STC Limited Intercity bus transport is a popular means of traveling between cities and aligning villages and towns in Ghana. Its services include freight and passenger movements from one location to the other. For this service

to be provided, a company has to be formed. As a result of that there have been concerted attempts by various past Governments of Ghana to offer intercity bus transport service to her citizen. One of such efforts is the establishment of Intercity State Transport Company (ISTC). But there is a number of private transport operators of which Ghana Private Road Transport Union (GPRTU) offers about $70-80\%$ of passenger and freight traffic. This is an off shoot of intra urban dominance of GPRTU of $70-80\%$ (Abane, 2011). GPRTU has been able to co-opt other intercity bus transport operators by sharing some of its terminals/stations with other transport companies/union such as VVIP/VIP, DIPLOMAT. Aside this, some private owners or operators like VIP/VVIP, DIPLOMAT for instance are either members or former members/executives of the union. Other unions/transport operators in the industry are Concerned Drivers Union, Progressive Transport Owners Association and Co-operative (Ojo *et al.*, 2014).

Insert map of STC Terminals across Ghana

Metro Mass Transit Metro Mass Transit Limited, Ghana was established in 2001 by the former President of Ghana, John Kuffour who directed the re-introduction of public mass transport in the metropolitan and municipal areas to ensure safe, affordable, efficient and reliable movement of Ghanaians. Since then, the Government has been actively promoting public mass transportation (Olateju *et al.*, 2009). MMT receives financial support from the Government and currently operates about 500 buses of which some 200 operate in the greater Accra area (Finn *et al.*, 2009).

Aayalolo Aayalolo Bus Rapid Transit(BRT) system has recently been inaugurated. Since November 2016, the company has been running three services on the Amasaman-Tudu/ Accra Central corridor. There are plans to roll out the Adenta-Tudu/Accra Central corridor and subsequently, another service along the Tema Beach Road-Tudu/Accra Central corridor. There are plans to replicate the BRT mass transit services in other major Ghanaian cities. Prior to the Aayalolo bus service (Agyemang, 2017).

2.5 Maps

A map is a graphic representation or scale model of spatial concepts. It is a means for conveying geographic information. Maps are a universal medium for

communication, easily appreciated and understood by most people, regardless of language or culture. Maps record the geographical information that is fundamental to reconstructing past places, towns, even cities.

2.5.1 Digital mapping

Digital mapping is the process by which a collection of data is compiled and converted into a virtual image. The primary function of this technology is to produce maps that give accurate representation of a particular area, detailing major road arteries and other points of interest. The technology also allows the calculation of distances from one place to another.

The roots of digital mapping lie within traditional paper maps. Paper maps provide basic landscapes similar to digitized road maps, yet are often cumbersome, cover only a designated area, lack many specific details such as road blocks etc. In addition, there is no way to update a paper map except to obtain a new version. Conversely, digital maps, in many cases, can be updated.

Early digital maps had the same functionality as traditional maps, that is, they provided a 'virtual view' of roads generally outlined by the terrain encompassing the mounding area. However, as digital maps have grown with the expansion of GPS technology in the past decade, live traffic updates, points of interests and service locations have been added to enhance digital maps to be more user conscious *cite*. Digital maps heavily rely on a vast amount of data collection over time.

2.5.2 Existing Technologies

Digital maps have changed the perception of maps and introduced much flexibility compared to paper maps. Existing technologies such as OpenStreetMap, Google Maps, Bing Maps and Taximap provides web map services and that captures transportation information but not into much detail. Taximap on the other hand seeks to localize this (Vinet and Griffin, 2014).

OpenStreetMap OpenstreetMap (OSM) is a collaborative project started in England in 2004 by Steve Coast. The aim of OSM is to create and provide free geographic data. The project aims to compensate the lack of free data because geographic data, even freely available, are provided with licenses restricting the use of information and the creativity according to project leaders. The data are

distributed under the license Creative Commons Attribution-ShareAlike 2.0 license. This license allows using the data completely freely, in condition to distribute any derived data under the same license. For instance, corrected OSM data cannot be sold. Data stored in OSM by contributors of the project are modelled and stored in tagged geometric primitives. For example, a road is a polyline with tags *highway= primary, oneway= no and name= N10*. Geometric primitives are of three types: points, paths (polylines) and relationships (linking points and paths with tags) that are not really geometric primitives. The surfaces are represented by close paths. Data are available from any area specified for export in a specific XML based format. It has to be translated if anyone wishes to use the data in another application. Data is captured using GIS software adapted to OSM data with editing functions to create OSM geometric primitives and tag them. Different software exists to edit and capture OSM data (Potlatch, JOSM, Merkaartor). OSM applications currently aim to foster mapping creativity of potential contributors of geographic data (Girres and Touya, 2010).

Google Maps Google Maps is a propitiatory tool for navigation. Google Maps is used by many people around the world. Google has an online database of structures; which is better covered in most developed countries compared to developing countries. Searching for places of interests is done by geocoding - *converting names or addresses of places to a location on a map* or reverse geocoding - *converting latitudes and longitudes to a readable address or name*. Google Maps is made possible through Volunteered Geographic Information (VGI) and other third party proprietary data sources. Adding, modifying and deleting features from Google Maps has recently become difficult for a new contributor. Google Maps like OpenStreetMap could also fail to pin point the exact location of a terminal.

Taximap Taximap is a social enterprise start-up and public transport search portal in South Africa. It provides information about minibus taxi routes, fares and operating hours with commuters. Information about on over 800 mapped routes are available. The platform rely on user feedback to keep the routes up-to-date and accurate, by encouraging users to leave feedbacks. Taximap does well by telling the exact Taximap has one drawback by not allowing users of the platform to specify both their departure and destination locations (Neumann *et al.*, 2015).

2.6 Software Review

2.6.1 Arch Linux

The Arch Linux operating system was most suitable for my project. Arch Linux is a native Linux based operating system produced for computers with chipsets based on i686 and x86-64 architectures (Griffin, 2002); it was chosen because of its simplicity, community involvement and a well documented wiki and community support (Vinet and Griffin, 2014).

2.6.2 Python

Python is an object oriented, interpreted programming language. It runs on a wide variety of systems which include Linux, Unix, Mac OS, Windows, BSD, etc. It also has several implementations, such as IronPython which runs on .NET CLR, Jython, amongst others (Van Rossum, 2007).

2.6.3 Django

Django is a popular Python Web Development Framework. It is dubbed the web develoment framework from developers with deadline. Django was born from the newsroom as a framework for development new and media related web applications (Holovaty and Kaplan-Moss, 2009).

2.6.4 Emacs

Emacs was the development environment used to develop this project. It was initially released in 1976 and active development continues to date. Its flexibility is one of its major advantages. Amongst other things, it provides a text editor with efficient key bindings and a method for interacting with inferior shells such as Python shell. What this means is that, after a line code has been written, it can be directly sent to the Python interpreter, where the code is executed and the results are shown immediately. This makes exploratory development much more efficient and streamlined (Stallman, 1981).

2.6.5 Java OpenStreetMap Editor

Java OpenStreetMap (JOSM) is an extensible editor for OpenStreetMap. It supports loading GPX tracks, background imagery and OSM data from local sources as well

as from online sources and allows to edit the OSM data (nodes, ways, and relations) and their metadata tags. JOSM is an open source. JOSM was used for the initial processing of data collected and uploading into OpenStreetMap (Ciepluch *et al.*, 2009).

2.6.6 Leaflet

Leaflet is the leading open-source JavaScript (JS) library for mobile-friendly interactive maps. Weighing just about 38 KB of JS, it has all the mapping features most developers ever need (Cheng *et al.*, 2017).

2.6.7 PostgresSQL

The database management system which is more suitable for my proposed system is PostgreSQL. PostgreSQL is an open source relational database management system that began as a University of California, Berkeley project. PostgreSQL was selected above MySQL and MSSQL (Microsoft SQL Server) because it's open source and great support for extensions. PostGIS extension provides a great support for geographic data (Obe and Hsu, 2011). It also powers OpenStreetMap and Skype databases.

It has enterprise class features such as SQL windowing functions, the ability to create aggregate functions and also utilize them in window constructs, common table and recursive common table expressions, and streaming replication. These features are rarely found in other open source database platforms, but commonly found in newer versions of the proprietary databases such as Oracle, SQL Server, and IBM DB2. What sets it apart from other databases, including the proprietary ones we just mentioned, is the ease with which you can extend it without changing the underlying baseand in many cases, without any code compilation. Not only does it have advanced features, but it performs them quickly. It can outperform many other databases, including proprietary ones for many types of database workloads.

CHAPTER 3

SOFTWARE DESIGN AND ANALYSIS

3.1 Overview

In this chapter, the software (Public Transportation Search Web Portal) development life cycle has been discussed.

3.2 Software Development Process Model

A software development process model is simply the process by which an organization develops software (Mayo and Johnson, 2016). It is broken down into several phases, and there are different criteria for each phase (Marciniak, 1994). The software development model chosen here is the spiral model. This model was chosen due to the exploratory nature of the project.

The spiral model cycles through four quadrants, each representing a particular development phase Boehm (1988). The cycle is shown in Figure 3.1.

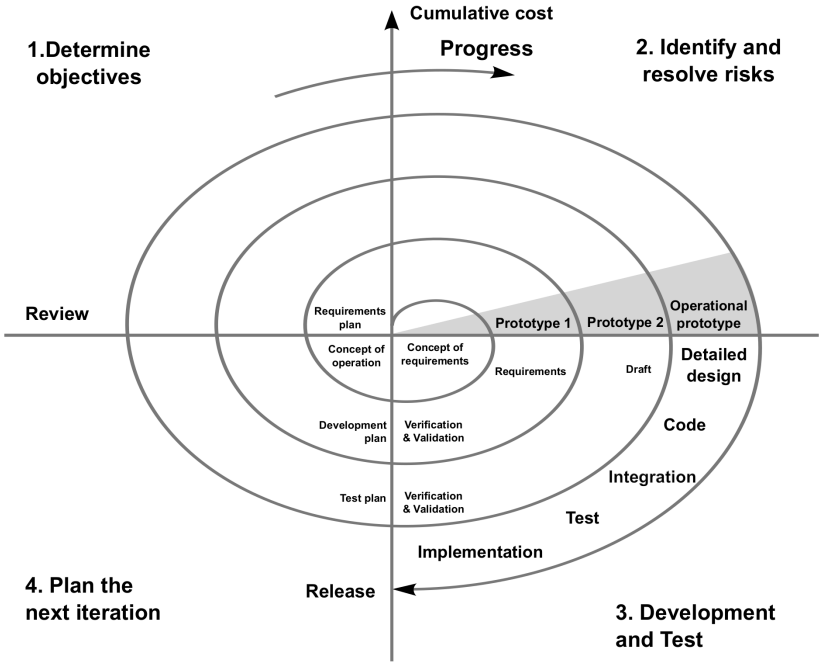

Figure 3.1: The Spiral Model of Software Development (Boehm, 1988)

3.2.1 Phases of the Spiral Model

The phases of the spiral model include the following:

Determine Objectives, Alternatives and Constraints During this phase the objectives for the iteration, and it's alternatives and constraints are investigated.

Evaluate Alternatives, Identify and Resolve Risks The risks involved in the iteration of development are examined, and solutions are found. Additionally, this phase also evaluates the alternatives to the chosen strategy.

Develop and Verify the Next Level Product The development of the product takes place in this phase. For each cycle a different methodology may be used during this phase. For instance, the waterfall model can be used for

Plan Next Iteration During this phase, with all the information gained from the past cycles, the next iteration is planned.

3.2.2 Advantages of the Spiral Model

The advantages of the Spiral Model are as follows:

- It enhances risk avoidance;
- A different methodology can be selected for each iteration; and
- It can incorporate the Waterfall, Prototype and Incremental methodologies.

3.3 Feasibility Studies and Analyses

Feasibility studies are some preliminary studies undertaken to know whether the project is feasible or not, given a number of circumstances. These studies include; technical, time frame, availability of funds, legal and ethical issues, availability of funds and resources, operation and marketing.

3.4 Requirements Gathering

A number of questions were asked and answers determined from stakeholders and other interest groups during requirements gathering. Some these questions include:

- Where is the system going to be used? (Ghana)
- Who is going to use the system? (Traveler)
- What data should be input into the system? (Text)
- What Software Development Life Cycle (SDLC) model to be used? (Spiral)
- What type of output information will the system give? (Text and map data)

3.4.1 Cost Analysis

Since this is a software only project we will not concern ourselves with price of hardware. However, the price of the hardware is directly to the resources used, which were analysed in the feasibility study. Therefore it is concluded hat this system will depend on the size of data being added to the database and traffic to application.

3.4.2 Risk Analysis

The two main risks involved in this project are the security risks anyone hosting services on the internet will face, and the risk of invalid data or information added by staff or administrator to the database.

The first risk is mitigated by limiting the surface area of the system exposed to attackers and by strengthening the components which have been exposed. In this system, the only such component is the search front-end. The search front-end only has read access to the database. Since the information stored therein is public, the only thing a malicious actor can do with this is cause a Denial-of-Service (DoS) attack. Appropriate steps will be taken to mitigate this.

The second risk somewhat complex to identify in some cases. Data will pass through several stages of validation and clean up before being made available to the public in order to provide them with the right information.

3.4.3 Use Case Diagram

A Use Case diagram depicts how the users interact with the system. It describes which operations the system can perform and the users as shown in Figure 3.2 below.

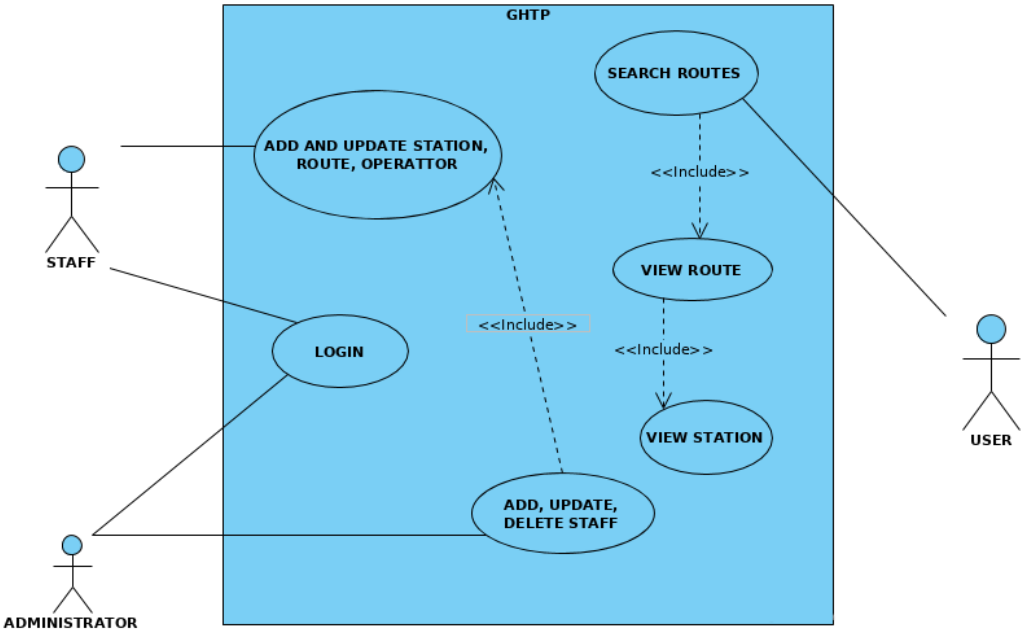

Figure 3.2: Use Case Diangram

3.4.4 Activity Diagram

An activity diagram visually presents a series of actions or flow of control in a system similar to a flowchart or or data flow diagram

An activity refers to a particular operation of a system. The operations in this system are modeled in to the the activity diagram in Figure 3.3 below.

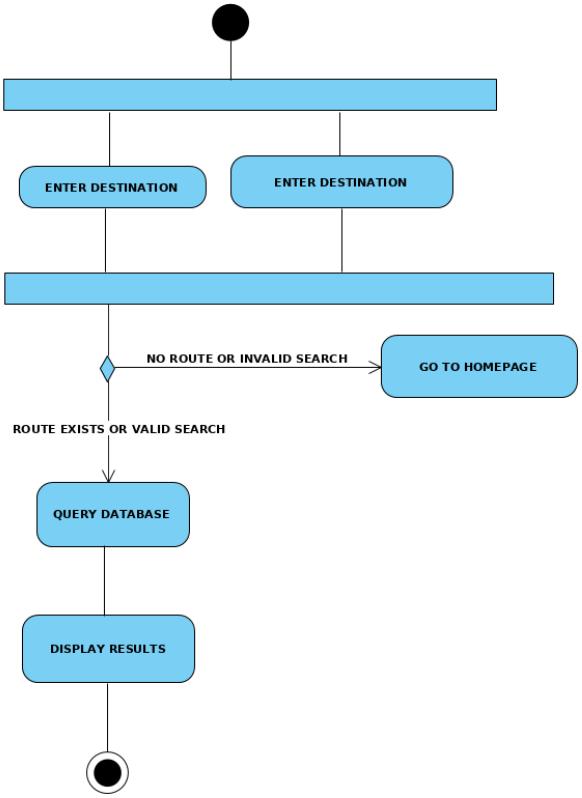

Figure 3.3: Activity Diagram

3.5 Implementation

The application is set into operation at the implementation stage. This includes how data is taken by the system, what form of data is taken by the system, where the data is kept, how the data is processed and what form of information is outputted. The first step was to collect and map out transport terminals detailed information in some parts of Ghana; including but not limited to:

- Name
- Location (*Town name*)
- Location (*Longitude and Latitude*)
- Contacts (*Phone, Email, Website, Operator*)
- Operators (*STC, GRPTU, VVIP, VIP*)
- Destinations
- Departure times

- Vehicle types

The mapped data was uploaded to OpenStreetMap database. After the mapping of the lorry stations, the mapped data was extracted and processed in QGIS before being imported into the projects local PostgreSQL based database.

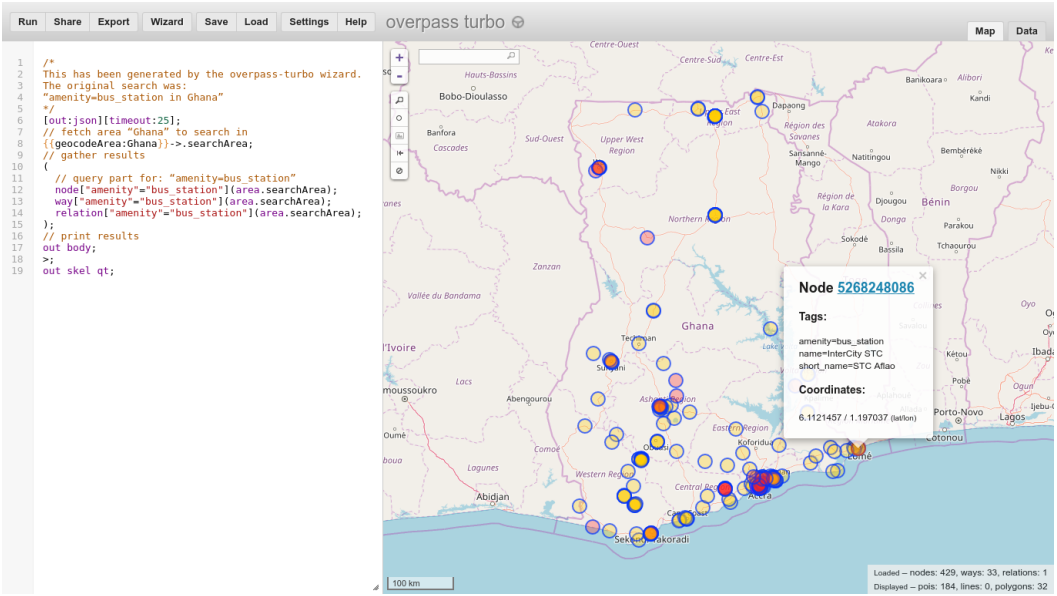

Figure 3.4: Extracting mapped data from OpenStreetMap

3.5.1 Data Collection

Data was collected using smartphones and handheld GPS receivers. The following information were collected from the selected lorry stations. Some of these information were collected by survey and crowdsourcing tickets. Some of the data recorded include:

- Name;
- Operator;
- Departure time;
- Fares; and
- Available destinations.

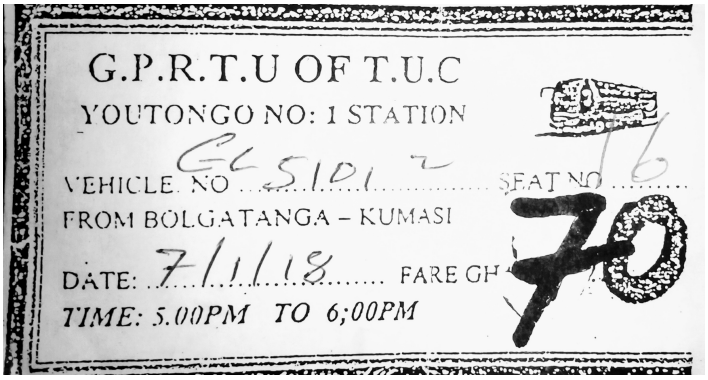

Figure 3.5: Sample bus ticket

Figure 3.6: Information available within terminals

3.5.2 Mapping Transportation Terminals

The following steps were taken in the mapping out process:

- Go to *https://www.osm.org* in a modern web browser such as Firefox of Chromium;
- Searched for town or city where lorry station is to be mapped; and
- Area was edited by using JOSM editor as shown in Figure 3.7;
- Marking out specific areas (buildings, routes (roads, walkways) and the stations are either mapped as points or closed ways (polygons);
- Naming and describing of points, areas or routes.

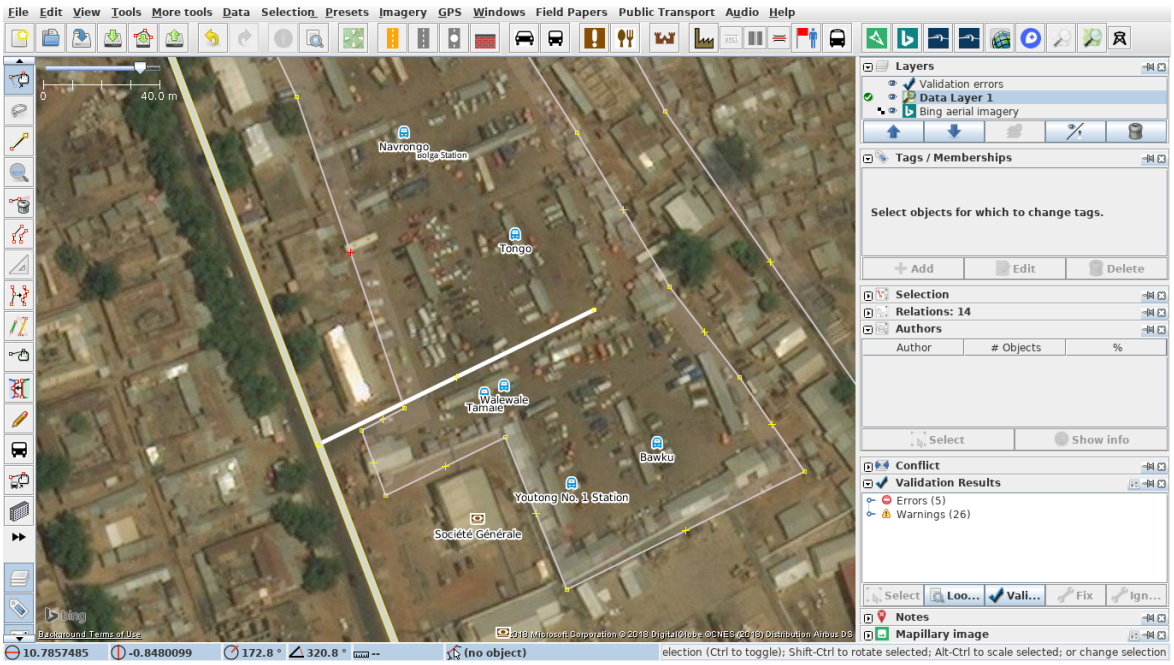

Figure 3.7: Mapping Bus Station into OpenStreetMap

3.5.3 Rendering of maps and Routing

The map showing location various stations was rendered using Leaflet. Routing from departure station is done on the web using the Open Source Routing Machine (OSMRM) Car and OpenStreetMap as a basemap. When the routes and stations locations are accessed from a smartphone with any map based application such as OSMAnd, MAPS.ME, Google Maps, etc they will be prompted to choose an option or else it is opened in a web browser.

CHAPTER 4

SYSTEM OPERATION

4.1 Overview

This chapter discusses pertinent operations of the system developed in this project work.

4.2 System Operation

When users visit the homepage of the web application, they are presented with a search form which allows them to enter both their *departure* and *destination* towns or cities. The applications takes text input, it then searches the routes database for routes containing searched text in departure and destination. The search results are displayed if routes exist, displaying some information as shown in Figure 4.2. The routes departures and destinations have been geo-coded (converting the name or address of an area, point or route to the location; i.e. Latitude and Longitude) enabling user to have a fair idea of each route and stations location.

The user can view detailed information of each available routes, station and operator. The user also gets turn by turn routing information of each by selecting *Go*, this is done by using the Open Source Routing Machine (OSRM) Application Programming Interface (API) which is embedded into OpenStreetMap as shown in Figure 4.3, if done on a smartphone, location based applications could also be used. The user can also view departure and destination stations detailed information with an overview map below as shown in Figure 4.5; and can also geo located in OpenStreetMap or a location based mobile application by selecting *Go* in Figure 4.4.

4.3 Front End

The front end consists of part of the system that can be viewed by visitors.

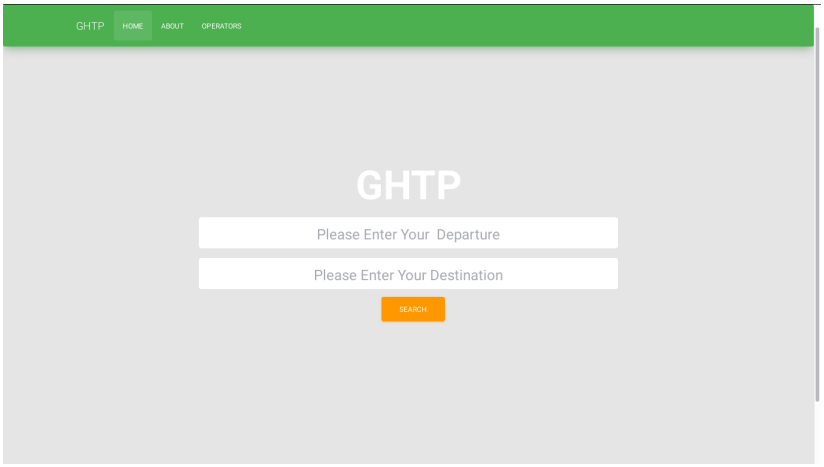

Figure 4.1: Homepage

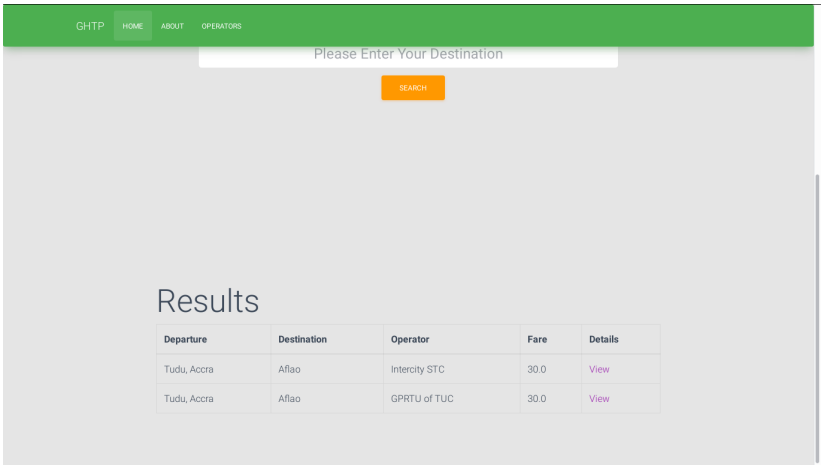

Figure 4.2: Search results

Figure 4.3: Route information

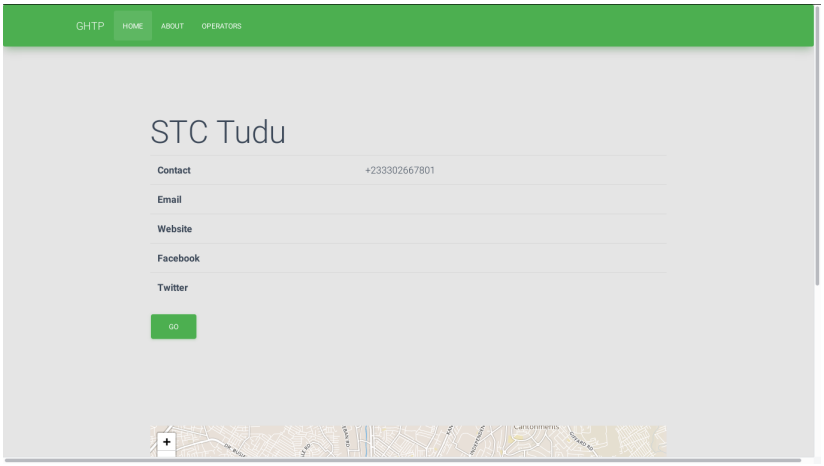

Figure 4.4: Station information

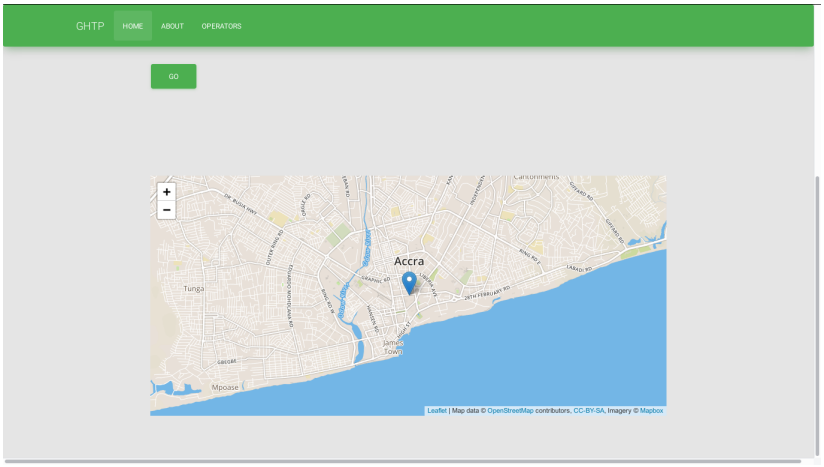

Figure 4.5: Station location mini map

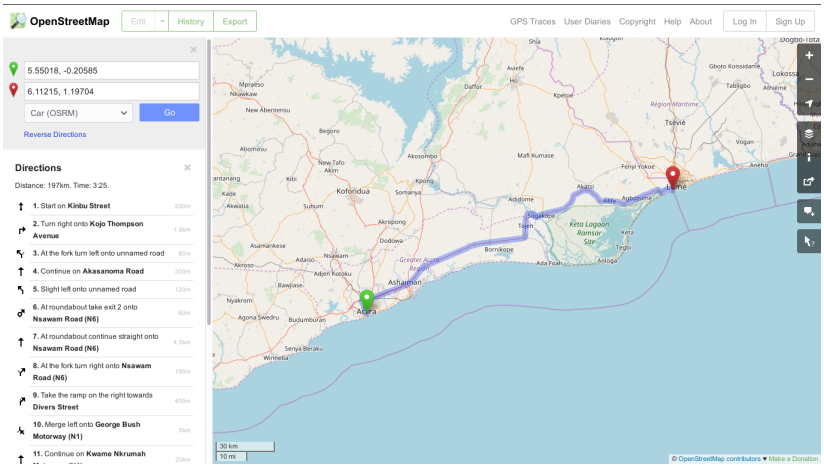

Figure 4.6: Turn by turn routing using from departure to destination using OSRM API

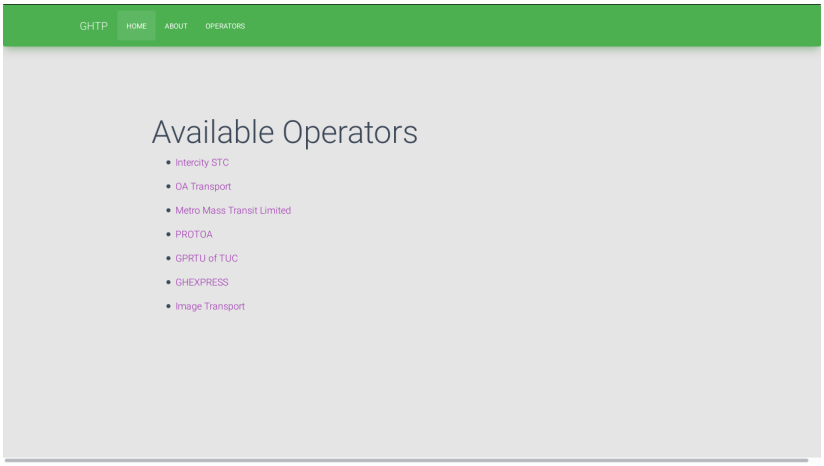

Figure 4.7: Available transport operators

4.4 Back End

The back end is the administrative side of the system. Administrators and staffs with appropriated privileges can perform various functions such us adding, modify or deleting stations, operators, routes and staffs.

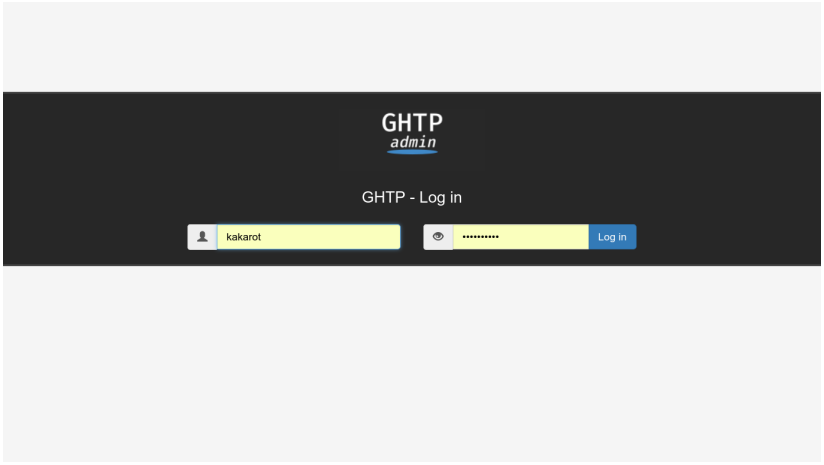

Figure 4.8: Administration login

The administration provides shortcuts to various features available and history of recent activities.

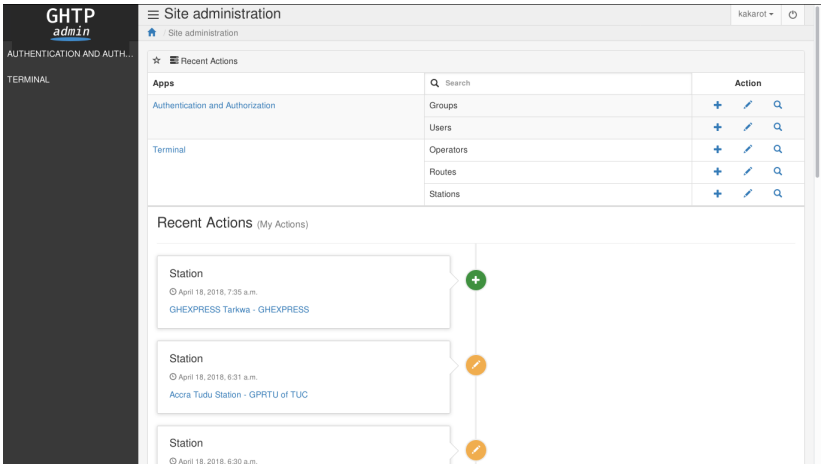

Figure 4.9: Administration Dashboard

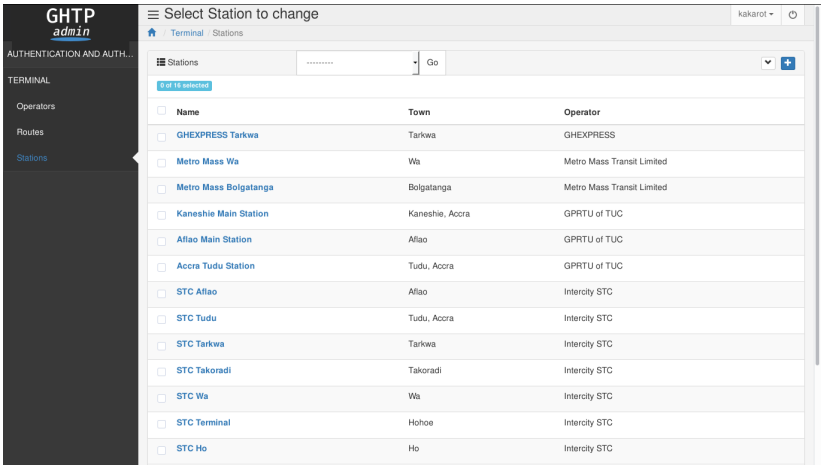

Figure 4.10: Managing stations

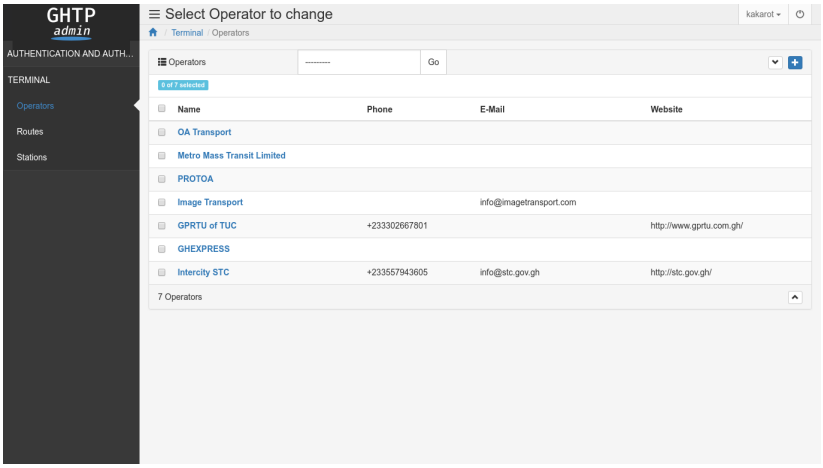

Figure 4.11: Managing operators

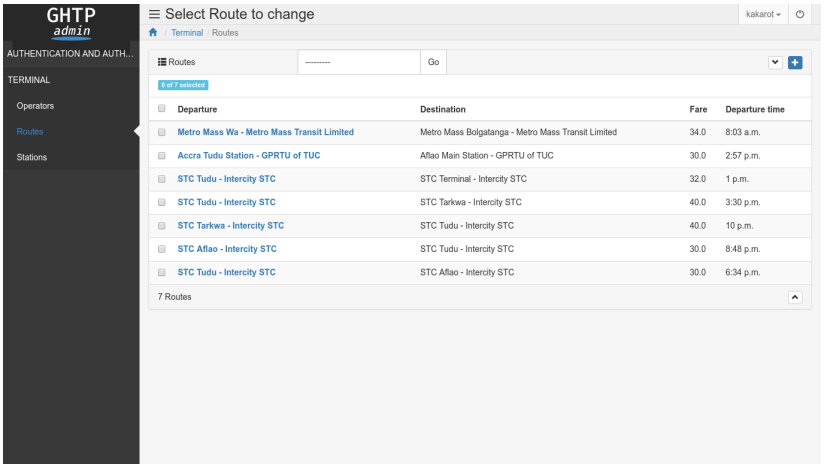

Figure 4.12: Managing Routes

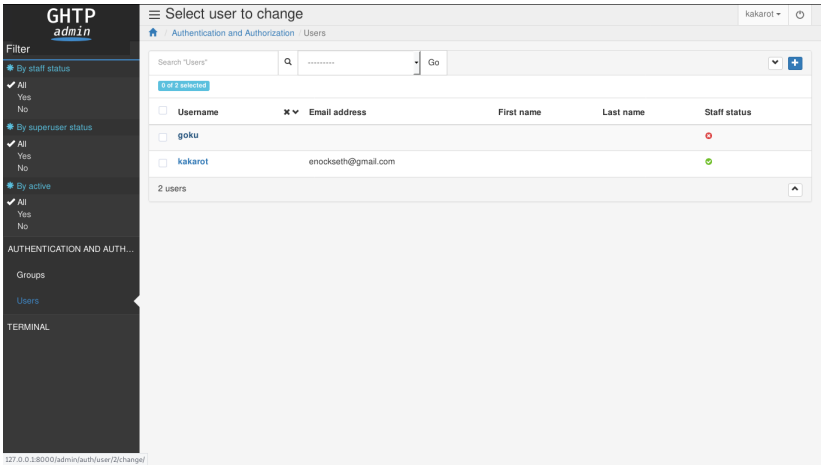

Figure 4.13: Managing users

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

In this project, a web application was developed to help travelers find detail information whcih always available on arrival at the various terminals and stations but not readily available to them prior to starting to their journey. To accomplish this project, some terminals and stations were clearly mapped on OpenStreetMap. After mapping, the data was extracted and further processed to create a geodatabase using PostgreSQL and PostGIS. The data was rendered with Leaflet. Search and routing functionality were subsequently added. The developed application has map rendering and text based interaction to input and output features. It can therefore be concluded that the application will improve trip planning and easy access to information only available within terminals to travelers hence saving time and other resources.It could also be adopted by Ghana Tourism Authority to help tourists find their way around Ghana transport network.

The future objective is to deploy the application making it available for public use in Ghana.

5.2 Recommendations

This project recommends that users should be able to book seats from the platform and also support voice input for the visually impaired as well. The system should get users current location and find nearest available departure stations for their routes. Also a commenting system for users to interact and share experiences about each route.

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APPENDIX A

A SAMPLE CODE FOR MODELS

```
from django.contrib.gis.db import models
from django.template.defaultfilters import slugify
from django.contrib.gis.geos import Point
from datetime import datetime

from phonenumber_field.modelfields import PhoneNumberField


class Operator(models.Model):
    name = models.CharField(max_length=200)
    description = models.TextField(blank=True)
    email = models.EmailField('E-Mail', blank=True)
    website = models.URLField(blank=True)
    phone = PhoneNumberField(blank=True)
    facebook = models.URLField(blank=True)
    twitter = models.URLField(blank=True)
    instagram = models.URLField(blank=True)
    slug = models.SlugField(unique=True)

    def save(self, *args, **kwargs):
        self.slug = slugify(self.name)
        super(Operator, self).save(*args, **kwargs)

    class Meta:
        verbose_name = "Operator"
        verbose_name_plural = "Operators"

    def __str__(self):
        return self.name


class Station(models.Model):
    id = models.AutoField(primary_key=True)
    operator = models.ForeignKey(Operator, on_delete=models.PROTECT, nu
    #operator = models.CharField(max_length=20)
    town = models.CharField(max_length=20)
    name = models.CharField(max_length=100)
    phone = PhoneNumberField(blank=True)
    phone2 = PhoneNumberField('Phone 2', blank=True)
    region = models.CharField(max_length=2, blank=True)
    longitude = models.FloatField(blank=True, null=True, verbose_name='
```

```
    latitude = models.FloatField(blank=True, null=True, verbose_name='L
    mpnt = models.PointField(blank=True, null=True, srid=4326)

    def save(self, *args, **kwargs):
        #if self.latitude and self.longitude:
        self.mpnt = Point(self.longitude, self.latitude)
        super(Station, self).save(*args, **kwargs)
        #else:
         #    mpnt = models.PointField(srid=4326)
         #    self.latitude = mpnt.centroid.x
          #   self.longitude = mpnt.centroid.y


    class Meta:
        verbose_name = "Station"
        verbose_name_plural = "Stations"

    def __str__(self):
        return "%s - %s" % (self.name, self.operator)


class Route(models.Model):
    title = models.CharField(blank=True, max_length=100)
    departure = models.ForeignKey(Station, related_name='departure_stat
    destination = models.ForeignKey(Station, related_name='destination_
    description = models.TextField(blank=True)
    fare = models.FloatField(default=0.00)
    departure_time = models.TimeField(auto_now=False, auto_now_add=Fals
    vehicle_type = models.CharField(max_length=10, blank=True)
    route_id = models.CharField(blank=True, max_length=10)
    ref = models.CharField(blank=True, max_length=10)
    slug = models.SlugField(unique=True, null=True)
    last_updated = models.DateTimeField(default=datetime.now, blank=Tru

    def save(self, *args, **kwargs):
        self.slug = slugify(self.title)
        super(Route, self).save(*args, **kwargs)

    class Meta:
        verbose_name = "Route"
        verbose_name_plural = "Routes"

    def __str__(self):
        return "%s — %s" % (self.departure, self.destination)
```