

Acknowledgements

Next to the Almighty Allah (SW), I would like to express my deepest gratitude to my advisor, Dr. Dida Midekso, for his helpful ideas, guidance and suggestions he gave me while doing this work.

Next, I would like to extend my very sincere and special thanks to all Anbessa City Bus Enterprise workers that provided me with the necessary information and individuals who were willing for interview and gave the document.

Lastly, I would like to offer many thanks to my family for their uncountable contribution. My wife, sisters and my best friends, you all have part for who I am today. Dad and wife, I have no word to express my feeling to thank you. Thank you for your understanding, support and unconditional love you have always been giving me.

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Abbreviations and Acronym

AAU	Addis Ababa University
ABC	Anbessa City Bus
ACBE	Anbessa City Bus Enterprise
ACBRIS	Anbessa City Bus Route Information System
APIs	Application Program Interfaces
DBMS	Data Base management System
GIS	Geographical Information System
GIS-T	Geographical Information System for Transportation
GPS	Global positioning system
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
IIS	Internet Information Service
KML	Keyhole Markup Language
MBACBRIS	Mobile Based Anbessa City Bus Route Information System
PHP	Hypertext Preprocessor
PTRP	Public Transport Route Planner
RDBMS	Relational Data Base Management System
SQL	Structured Query Language
XML	Extensible Markup Language

Abstract

Public transport plays a great role in assisting people to travel from one location to another especially in cities. The delivery of information related to public transportation assists passenger to preplan their trip/journeys and save their time that should have been spent asking around or looking for their information from other source. Based on Addis Ababa city administration information, the city serves 3.74 million people. The city bus transport is an important element of city infrastructure. At the present time, most of the people in Addis Ababa city people prefer to travel by city bus as their primary choice. However, today because of the complex bus route lines, it is obvious that an online mobile web application bus route inquiry may help people plan their travel and find the best route number. Currently, in Addis Ababa city there is no reliable source of ACB route information that is easily accessible to passengers.

Different techniques are used to collect information about public transportation mainly on ACB transportation service in Addis Ababa including interviewing passenger and ACBE worker, document review, literature review and the Internet.

In this work, we designed and implemented Anbessa city mobile based route information system to assist travelers to preplan their trip/journey by giving them a platform where Anbessa city bus information and routes could be accessed. The system was evaluated with 22 users (passengers and ACBE workers) and the overall performance of the system is found to be encouraging.

KEYWORDS: Online Mobile web application, GIS, Anbessa city bus, route information system

CHAPTER ONE: INTRODUCTION

1.1 Background

Addis Ababa, which is the capital city of Ethiopia, has an expanded area of over 540 sq.km and is situated at an altitude of about 2500 meters above sea level. Administratively, the city is subdivided into 10 sub cities, 99 kebeles and 28 woredas. Addis Ababa is also an unofficial capital city of Africa, largely due to the fact that it hosts various international organizations such as the African Union, United Nations and so on. Based on the 2013 city population estimation report, the population size of the city is around 3.17 million (3,174,000), constituting 3.8% of the country's population [1].

On a daily basis around 3.6 million journeys happen, with 2.2 million people using public transport. An estimated 60.2 % use taxis, 11 % Anbessa buses, 5 % private cars and 3 % government, NGO and other types of vehicle. The roads of Addis cover around 2,200 km, and are used by approximately 116,297 vehicles. From this, 93,972 cars, 6,795 cabs, 9750 minibuses (blue van)/Higer buses and 816 Anbessa buses. The Anbessa bus can carry more than 100 passengers, with 30 seats and more than 70 standing. These buses cover 54,000 km and give service to half-a-million people [2].

The 454 Higer buses cover 47 routes and give service to 172,250 people. The research also shows that out of 3.6 million journeys, 2.2 million are covered by public transport, leading to a gap of 1.4 million [3].

The first public transport service to arrive in Addis Ababa, the Anbessa City Bus Service Enterprise was established in 1943 with five military vehicles running only five routes. Today, Anbessa has around 816 busses, including the 500 Bishoftu buses, which are assembled locally by Metals and Engineering Corporation (MetEC). Currently, the enterprise dispatches the buses from Legahar, Merkato, Piazza and Megenagna stations. There are also about 1,640 check points, where passengers get the services of the buses from 6:15 Am to 2:30 PM daily on 119 routes. It also has four service centers at Yeka, Shegole, Mekanisa and Akaki, where there are workshops, gas stations, stores and offices. Each bus has a capacity of more than 100 passengers (30 seated and 70 standing). These buses cover a collective distance of 54,000 km daily and provide their services to 1.5 million people, as indicated in the 2006/07 to 2010/11 five year strategic document of the City Administration[4].

Alliance Transport Services S.C has recently started providing public transportation services with 25 buses on 5 routes. A number of Higer buses are also providing service to the public.

The commonly called minibus taxis are also giving service to the public. According to the Addis Ababa Transport Authority branch office, the number of minibus is registered as 9,901 and their average daily operational capacity is estimated at 8,911. They are serving about 1,372,294 passenger trips a day. They operate on any route they like, but recently, the transport authority has announced plans to conduct a zonal dispatch arrangement program for the minibuses. The fares the minibuses are charging are regulated. However, during peak hours and in the evenings, they force passengers to pay nearly double the normal fare. Minibus taxis operate without timetable schedules. The operation principle is fill-and-run. On most taxi terminals, taxis wait in queues to be filled. The consequence of this is long waiting times on routes with few passengers and inconvenience of passengers as they are forced to walk to the nearest taxi terminal and suffer from the expected wait until the taxi is filled. Taxi queues at terminals are managed by order attendants (*tera askebariwoch*).

Most of the sedan taxis are 'Lada' (Russian brand) taxis, which operate on a contract basis. They are usually found around the hotels and big supermarkets. Since they charge more money, only high income groups are getting services from these taxis. Just like lack of data on the number of passengers, there is no record on daily kilometer run of minibus taxis. The situation is aggravated by the fact that odometers of most taxis are not functional. However, information gathered through interviews with taxi drivers and owners combined with the information on route distances and estimates obtained from the Transport Authority, the daily kilometer run is expected to be 130. The overall daily kilometer run by the industry is estimated to be around 800,000 [6].

1.2 Statement of the Problem

Public transport route information systems have been widely used in many large cities around the world. Many websites offer trip planning services for large metropolitan areas, or even on national level. In cities with such a system, any person with the purpose of using public transport can access the system to gain valuable information.

It is not always easy to use public and private transport service to move around Addis Ababa. Finding travel plans for non-recurrent trips is not an easy task even for residents of Addis Ababa. Often, passengers begin their journey without a plan and gather information on their way.

There is a big problem in both accessibility and availability of information about how a person

could navigate from one place to another and what types of transportation to use to reach to the desired destination. The ultimate solution is usually to ask people nearby for information. The reliability of this information is limited to availability of the person to ask from and also on that person's knowledge, language barriers and the willingness to share the information plus the level of accuracy of the information. This research project proposes a mobile web application as a solution of above. The application is limited to only ACB routes and stations as well as ACB route numbers around Addis Ababa city.

In the application, the user is able to choose an origin/source as well as a destination station. The application then returned comprehensive route information and ACB information to the user. The request returned route information showing a list of stations by name from origin to destination and what bus number(s) to take. Station information was stored in a relational database on the server side. On the client side was a browser or a mobile phone device

Today the public transport system of the city of Addis Ababa which mainly consists of the city bus and shared taxi is facing significant challenges due to the following key and general problems:

- The continued spatial growth of the city horizontally or urban sprawl, is becoming a major cause for the increase of travel distances. This phenomenon discourages people from resorting to non-motorized transport modes such as walking and cycling and results in an increased demand for public transport.
- Furthermore, the demand for public transport services in Addis Ababa is growing at a rapid rate due to the continued rise in population. This is apparent from the mismatch between the estimated growth of need and the reality i.e. the growth rate of transportation was estimated to show an increase of 45,000 trips per year [2].

However, the current reality shows that the growth rate is 64,300 per year [2]. What makes the situation worse in Addis Ababa is that there is no route information system that helps the public to gain information on the public transport system of the city.

1.3 Objective

1.3.1 General Objective

The general objective of the project is to develop mobile based ACB route information application that enables users to get information about routes and the bus route information from any ACB check point to another and visualize the route using digital map of Addis Ababa city.

1.3.2 Specific Objective

This work aimed at developing a mobile and desktop web application that enabled users to get the bus route information from any possible point to another and visualize the route on Google map or on Google Earth application.

The following are the objectives of this research project:

- Study the transportation system of the public transport/ ACB in Addis Ababa city
- Design architecture of ACBIS
- Develop prototype of a system
- Evaluate the prototype by ACB passengers

1.4 Scope and Limitation of the Project

The scope of this work is to develop an online mobile and desktop ACBRIS that offers:

- Display ACB routes information: bus number, source, destination, tariff, and pass-through
- The resulting route and station names from the origin to destination station can be visualized on a map.

The main public transport services in Addis Ababa are those of Anbessa City Bus Enterprise, Alliance city bus, Higer bus and taxis. This project is limited to the services provided by Anbessa city buses. The recently introduced train service is not included for the reason that they have less network coverage and lack of adequate information on their service routes.

As stated earlier, the services provided by Anbessa and taxis are extended to the surrounding towns of Addis Ababa. However, as the main objective of the project is specific within Addis Ababa, services offered to locations outside of the city are not included and in this work, no

existing and functional automated bus schedule or timetable was found in use in the whole of Addis Ababa city.

1.5 Methodologies and Techniques

1.5.1 Data Collection

In order to attain the general and specific objectives of this project, a number of methods will be applied. Study the city bus transportation route guiders which are available in Ethiopia through interview and literature review for better understanding of the problem domain. The detail activities done are the following;

- Collect and review secondary data from selected city bus transportation service enterprise for the purpose of requirement determination; and
- Conduct an interview with selected individuals about the desirable system they need to have in relation to proposed mobile public transportation route/journey planner system.

1.5.2 Development Tools

Different tools were used to accomplish this project. Microsoft Project is used to prepare system analysis phase. For design phase, we choose rational rose UML tool because this tool has fully object-oriented feature that helps for the preparation of system design. We include PHP, HTML, CSS, WampServer5, JQuery and JavaScript for developing web application for mobile platform and desktop, mHotspot for connecting mobile device and local host device, MySQL for developing the backend of the database, Global Positioning System (GPS) for collecting geographic coordinates, ArcGIS 10.1 for managing spatial and non-spatial data, KML for Internet based map, and Google Maps is a desktop and mobile web mapping service application and technology provided by Google, offering satellite imagery, street maps, and Street View perspectives.

1.5.3 Usability Testing

During the interface design process, usability evaluation has an important role that includes interactive cycle of designing, prototyping and evaluation. A number of passengers and stakeholders will be participating in the evaluation of the system. This evaluation helps to assess the ability of the application regarding user performance and approval.

1.6 Organization of the Document

The report is organized as follows: the second chapter presents the literature review. The third Chapter describes related work. Chapter Four presents the proposed system. Chapter Five describes the system architecture of the proposed system. The prototype is discussed in Chapter Six. Lastly, Chapter Seven presents conclusion and future works.

CHAPTER TWO: LITERATURE REVIEW

2.1 Public Transportation

Public transportation is a particularly attractive method of travel in urban areas. Travelers choose public transportation for a variety of reasons including: reduced cost, environmental concerns and convenience. Transportation services and facilities are essential for the future well-being of the individuals. Public transport can offer significant advantages in areas with higher population densities, due to its smaller physical and environmental footprint per rider and the problems associated with mass private car ownership and use (high parking charges and high levels of traffic congestion). A balanced public transportation system utilizes all available means of travel cooperatively and in a mutually complementary manner to provide a global service for the needs of the community. The global problem of how to offer a good quality service to the passengers, while respecting certain constraints (e.g. design and operating cost, compliance to standards, eventual revenues etc.) is complicated and requires tradeoffs at various stages of the process. In urban areas the demand for buses is unevenly distributed over space and time. It is usually impractical to directly connect all origin-destination pairs with bus routes due to limited economic and social resources. In such cases a bus transit network with limited accessibility and mobility is effective in serving the demand and consists of several bus routes and transfer centers [8].

Types of Public Transport System Services

In the transit industry, the public transport service can be provided in several operating configurations, such as a fixed-route service or a paratransit service [10]:

- **Fixed-route service:** It's a transport service mode where a bus travels along the same route at regular times each day and has regular bus stops along the route. This type of service occurs where there is sufficient population and/or employment density to support higher transit volumes. Days of operation and service hours vary by route or according to transit user numbers.
- **Paratransit service:** Para transit is an alternative mode of flexible passenger transportation that does not follow fixed routes or schedules. Typically, minibuses are used to provide paratransit service.

This service occurs where transit trips are served on demand with regular routing and scheduling of services, typically in lower population density areas, or to accommodate elderly or disabled riders.

New service concepts combining characteristics of both fixed-route and Paratransit, such as deviated-route services, are being tested in some countries to provide some regularity of service and to improve transit accessibility for all riders.

2.2 Geographical Information System (GIS)

A geographic information system (GIS) integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. A GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared. GIS technology can be integrated into any enterprise information system framework. It can store and show information about geographical features e.g. roads, buildings, cities, vegetation and other features. GIS is superior to a traditional map in data search and analysis [11].

GIS is a powerful tool that can be used in road networks, resource mapping and environmental monitoring. GIS can answer questions about “**what**” and “**where**”. “What” refers to the feature type and its attributes and “where” refers to a geographical location in the real world.

2.2.1 Representing the Real World in GIS

Geographical data describe locations and characteristics of the real world. Geographical data models include raster and vector data models. Geographical data models are mathematical models used to represent geographical objects and surfaces.

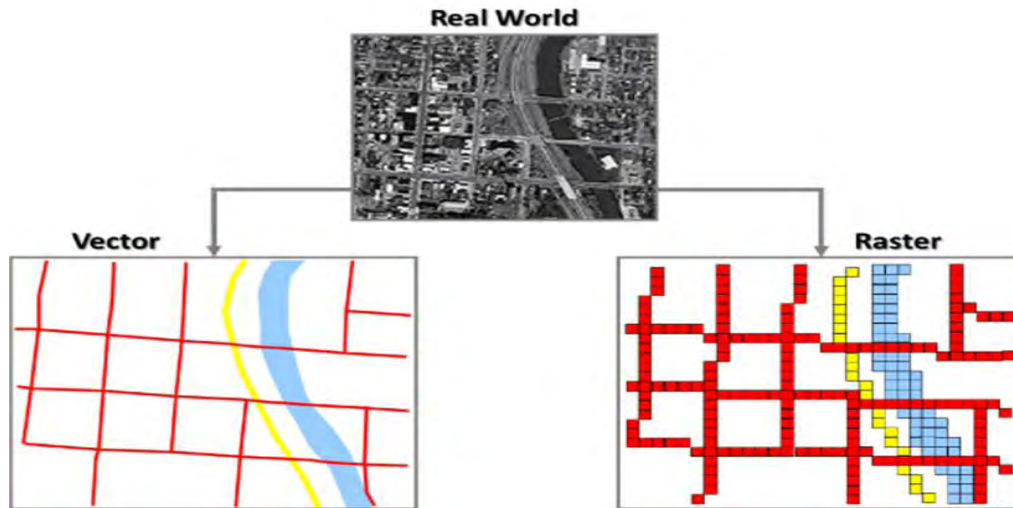


Figure 2.1: GIS Data Models Representation

A) Raster: Based on a cellular organization that divides space into a series of units. Each unit is generally similar in size to another. Grid cells are the most common raster representation. Features are divided into cellular arrays and a coordinate (X, Y) is assigned to each cell, as well as a value. This allows for registration with a geographic reference system. A raster representation also relies on **tessellation**: geometric shapes that can completely cover an area. Although many shapes are possible (e.g. triangles and hexagons), the square is the most commonly used. Resolution is an important concern in raster representations. For a small grid, the resolution is coarse but the required storage space is limited. For a large grid the resolution is fine, but at the expense of a much larger storage space. In Figure 2.1, the real world (shown as an aerial photograph) is simplified as a grid where the color of each cell relates to an entity such as road, highway or river.

B) Vector: The concept assumes that space is continuous, rather than discrete, which gives an infinite (in theory) set of coordinates. A vector representation is composed of three main elements: points, lines and polygons. **Points** are spatial objects with no area but can have attached attributes since they are a single set of coordinates (X and Y) in a coordinate space. **Lines** are spatial objects made up of connected points (nodes) that have no width. **Polygons** are closed areas that can be made up of a circuit of line segments. In Figure 2.1, the real world is represented by a series of lines (roads and highway) and one polygon (the river). A real-world entity could be

represented by different types of vector features depending on the map scale used in an application (e.g. a road can be represented as a line at a smaller scale or as a polygon at a larger scale.)

2.2.2 Role of GIS in Transportation

The major components of a GIS are software, data, hardware, procedures and people. The software captures, analyses, stores and displays the spatial information. According to Hanson [13], GIS can address complex tasks for example constructions and transportation planning. Transportation planning involves visioning, plan implementation, programming and finally maintenance of the whole system. Establishing goals or objectives of the transportation planning creates the visioning aspect of the project while planning aims at producing transportation map.

Figure 2.2 shows that the GIS-T conceived as the union of an enhanced Transportation Information System (TIS) and an enhanced GIS [14]. The necessary enhancement to existing TISs is the structuring of the attribute database to provide consistent location reference data in a form compatible with the GIS, which in turn has been enhanced to represent and process geographic data in the forms required for transportation applications.

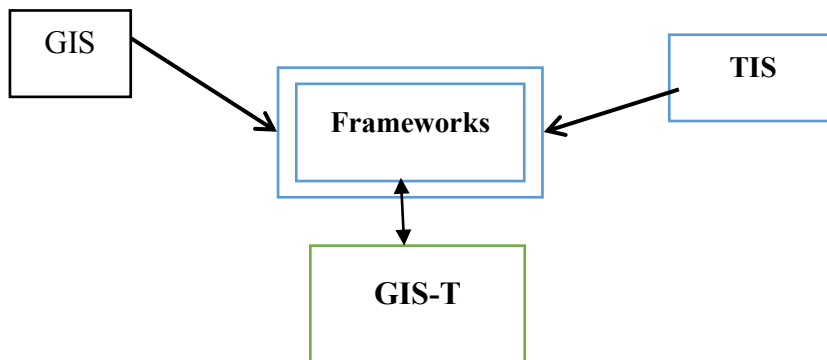


Figure 2.2: GIS-T as the merger of an enhanced GIS and TIS

This does not imply that databases must be redesigned according to the constraints imposed by commercial software. In fact, one of the required enhancements to off-the shelf GIS software is the ability to link with and utilize all or nearly the entire linearly referenced highway data collected and maintained by transportation agencies.

What it does imply is that the attribute databases use a database schema for the concept of location translatable into the location schemas used in the GIS spatial databases (the databases

containing the digital base maps) so that the content of the former can be unambiguously correlated with the content of latter, so that queries can span both kinds of databases, and so that separate attribute databases can be integrated through their use of location schemas translatable into the ones used by the GIS software. In addition to improved management of linearly referenced data, necessary enhancements to GIS software include better modeling and analysis of transportation networks.

2.3 GIS-T Analysis and Modeling

GIS-T applications have benefited from many of the standard GIS functions (query, geocoding, buffer, overlay, etc.) to support data management, analysis, and visualization needs. Like many other fields, transportation has developed its own **unique analysis methods and models**. Examples include shortest path and routing algorithms (e.g. traveling salesman problems, vehicle routing problem), spatial interaction models (e.g. gravity model), network flow problems (e.g. minimum cost flow problem, maximum flow problem, network flow equilibrium models), facility location problems (e.g. p-median problem, set covering problem, maximal covering problem, p-centers problem), travel demand models (e.g. the four-step trip generation, trip distribution, modal split, traffic assignment models, and more recent activity-based travel demand models), and land use-transportation interaction models. While the basic transportation analysis procedures (e.g. shortest path finding) can be found in most commercial GIS software, other transportation analysis procedures and models (e.g. travel demand models) are available only selectively in some commercial software packages. Fortunately, the component GIS design approach adopted by GIS software companies provides a better environment for experienced GIS-T users to develop their own custom analysis procedures and models. It is essential for both GIS-T practitioners and researchers to have a thorough understanding of transportation analysis methods and models [15]. For GIS-T practitioners, such knowledge can help them evaluate different GIS software products and choose the one that best meets their needs. It also can help them select appropriate analysis functions available in a GIS package and properly interpret the analysis results. GIS-T researchers, on the other hand, can apply their knowledge to help improve the design and analysis capabilities of GIS-T. Due to the increasing availability of tracking data that include both spatial and temporal elements, development of spatio-temporal GIS analysis functions to help better understand the dynamic movement patterns in today's mobile world has attracted significant

research attention in recent years. GIS-T applications are one of the leading GIS application fields. Many GIS-T applications have been implemented at various transportation agencies and private firms. They cover much of the broad scope of transportation and logistics, such as infrastructure planning and management, transportation safety analysis, travel demand analysis, traffic monitoring and control, public transit planning and operations, environmental impacts assessment, intelligent transportation systems (ITS), routing and scheduling, vehicle tracking and dispatching, fleet management, site selection and service area analysis, and supply chain management. Each of these applications tends to have its specific data and analysis requirements. For example, representing a street network as centerlines may be sufficient for transportation planning and vehicle routing applications. A traffic engineering application, on the other hand, may require a detailed representation of individual traffic lanes. Turn movements at intersections also could be critical to a traffic engineering study, but not to a region-wide travel demand study. These different application needs are directly relevant to the GIS-T data representation and the GIS-T analysis and modeling issues discussed above. When a need arises to represent transportation networks of a study area at different scales, what would be an appropriate GIS-T design that could support the analysis and modeling needs of various applications. In this case, it is desirable to have a GIS-T data model that allows multiple geometric representations of the same transportation network. Research on enterprise and multidimensional GIS-T data models discussed above aims at addressing these important issues of better data representations in support of various transportation applications [28]. With the rapid growth of the Internet and wireless communications in recent years, a growing number of Internet-based and wireless GIS-T applications can be found [16]. Web sites such as Google Maps and MapQuest are frequently used by people to get driving directions. Global positioning system (GPS) navigation systems also are available as a built-in device in vehicles or as a portable device. Coupled with wireless communications, these devices can offer real-time traffic information and provide helpful location-based services (LBS) (e.g., finding the closest ATM location and reporting the estimated travel time to reach the ATM location based on the current traffic conditions).

Another trend observed in recent years is the growing number of GIS-T applications in the private sector, particularly for logistics applications.

2.4 GIS and Network Analysis

GIS-T requires special data structures to represent complexities in transportation networks and application of networks algorithms for determination of optimum paths. Transportation network data model includes use of turntables, linear referencing, traffic lines and non-planar networks. A linear referencing system enables storage and maintenance of information or events that take place in a given transportation network e.g. road quality and traffic flow [15]. Furthermore, a network is said to be a network if only topology and connectivity between nodes and arcs exists. Transportation networks are usually represented as nodes and links. This network could represent flow of people, goods or vehicles. A network can be represented graphically as directed links as arcs and undirected links as edges and arcs intersect at a node [16]. However, most GIS software only utilize simple geometric entities such as points, polygons and lines and cannot handle data such as underpasses, overpasses, origin destination flows, complex paths and intermodal transfers like example motor way to railway line [16]. A network differs from a graph by the fact that a network can accommodate weights or costs assigned to various arcs. Planar networks require that all arcs intersect at a node. The relationship between nodes and arcs is referred to as network topology [15]. In making the public transportation route networks; network analysis was used where arcs intersecting at nodes were used. Costs or weights were also assigned to the arcs.

2.5 Vehicle Routing within a Network

There are many procedures employed in solving networking routing problems in GIS-T. Usually, these problems are simple to comprehend and to state but sometimes very hard to model and solve mathematically. For the purpose of this study, only node-arc routing problem is discussed where key events in the routing occur at nodes e.g. bus transfer points, passengers alighting and boarding at bus stops. The performance of GIS-T application is dependent on the comprehensiveness of the data model adopted and how well nodes, links and other related information are organized and stored in GIS database [28].

2.6 Web and Mobile Device Technologies

In developing a Java based mobile journey planner, understanding the components and features available in mobile devices as well as the mobile computing environment is important. A journey planner application was developed to run on mobile phones in addition to the online version. Only brief overview is given to give the reader some clues about the terminologies as well as technologies employed in the project. Web technologies used in the development of the browser based application have been mentioned but not in deep details.

2.7 Developing a Mobile Phone Web Application

Mobile Information Device Profile (MIDP) defines the behavior of the application to be made. The application must inherit a *MIDlet*. A *MIDlet* acts like the main method in standard java applications. It can have the following states: loaded, active, paused and destroyed [18] as shown in Figure2.3. In the development of the mobile version, a journey planner *MIDlet* was developed. The components of the MIDlet included a user interface that included forms, choice groups and commands.

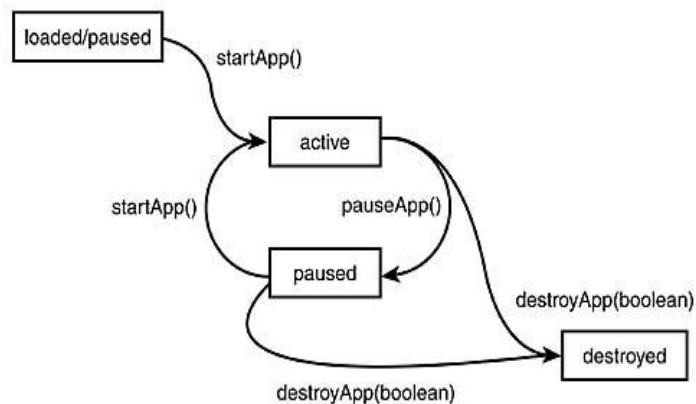


Figure 2.3: The life cycle of a MIDlet, Source [18]

2.8 The development of Android web Application

According to statistics in February 14, 2013 [19], Android occupies 71.1% of the global Smartphone operating system market share. This shows that the Android operating system occupies a very important position in smartphone operating system. Therefore, in the development of a prototype in Mobile Based public transport journey planner system, we first

develop an android application. People can download a variety of Android mobile application in android stores, and there are many android applications that provide the smart mobility service such as Google maps [20]. Android operating system [21] has four main levels from the bottom up which are Linux kernel layers, library, application software architecture and application. The application includes four components which are activities, broadcast receiver, service and content providers. Therefore, android mobile application is the best choice to provide the smart mobility service now.

2.9 Web Mapping

After the routes are computed, the application needs to display the computed route on a map on the internet. Some aspects of web mapping were considered as this helped in understanding the concepts behind displaying a map on the Internet. Web mapping is the process of designing, generating and publishing maps on the internet. Web mapping offers real time maps, frequent update of maps and sharing of geographical information. Moreover, internet offers a good platform and a medium to facilitate launching of map services on the net [21]. However, these services face several challenges e.g. low display resolution, limited bandwidths, slow Internet connections especially for mobile phones. Currently, fully interactive maps as well as static maps services are available on the World Wide Web.

In this study, web maps were used in showing the route map as the online application had the functionality of web map. The goal was to give as much information to a user including information that was viewable on a route map.

2.10 Web Map Service Technology

To understand the technology and concept in web map services, it is worth to consider what really happens behind the scenes in order to have a map delivered on the client's browser or machine after request is passed to the web server. When a HTTP request for a map is launched to a web server, this server communicates with map application server that in turn returns a map to the client. The map server is interfaced with a spatial database. On the client side, a web browser with supporting technology e.g. Java script loads the map on the clients browser. In this project, a route map for the user chosen origin and destination stations was plotted on the client browser so then the user was able to view the plotted route for the journey. In the Internet, there are various web

mapping services available including Bing maps, Yahoo and Google Maps. Due to the flexibility in use, popularity, map quality and better customization features, the research preferred Google maps web mapping service to the others. This meant that the journey planner application development would employ Google maps API.

2.11 Google Maps API

Google maps API is the most widely used web mapping service across the globe. It utilizes advanced geocoding capabilities and delivers secure map content over the browser [22]. Google maps offer a variety of APIs enabling powerful functionality in delivering map content into various applications. Personalized maps can be embedded in personal websites as the Maps API is a free service. Further the API offers capabilities for manipulating maps through JavaScript functions [21]. In order to display feature data on Google maps or Google earth applications, the application support use of KML as geographical data file format. For the purpose of testing and comparing of performance, route maps was drawn using either KML or JavaScript technologies with the former made by server scripting while the latter implemented on client browser. KML technology is discussed in the following section. In this application, Google Maps was used to show the route map. Further, route data in KML format could also be downloaded and viewed in Google Earth application.

CHAPTER THREE: RELATED WORK

Following an extensive research and relevant consultations regarding existence and the implementation of a similar or ongoing project in the Addis Ababa City, comprehensive information on Addis Ababa mobile based ACB route information system project has never been done or implemented. However, there have been several attempts towards development of Public transport route planner for Addis Ababa in Addis Ababa University [7].

However, more information about how it worked and whether it was released for use by the public could not be obtained. Furthermore, this service was not accessible by the researcher for hands on experience on its functionality. The relationship between these previous work(s) and this project is that, both share one goal of providing information on directions to the end user about moving from one place to another.

Other route planner found is Implementation of Route Finder for Addis Ababa city [23]. Information about the popularity in active use, accessibility and availability of this route finder was not adequately established in the course of this project. However, the route finder focuses on showing the shortest route from one direction to another especially it is used for car/drivers not used for public transportation users.

As far as this thesis is concerned; these finders were treated as attempts to give direction services. The main aim of this project is to provide information on routes and ACB for user chosen origin and destination search for directions and buses in addition to a route map.

Hyderabad City Bus information Service

In India, Hyderabad city, a reliable and up to date bus information service was developed years ago and is currently still in use. According to Praveen Kumar, Varun Singh (2005), this bus information service acts as a journey planner service where all information needed in travelling could be found easily and in one package at any time when needed.

This service allows a user to search for best transport connections between an origin and destination using all buses, trams, commuter trains and metros. It also includes walking edges in

case a user needs to walk some distance to the first stop or from the last stop in order to reach the destination. This service also provides real time information (arrival and departure) at bus stops and transfer points. At the time of this research, this service provided additional services including incorporation of a route map showing the path followed from origin to destination.

Dublin Bus Passengers Information Service (DBPIS)

In Ireland, Dublin bus passenger information service was developed and still gives a service for passengers. According to Eamonn Fallon (2000), the following lists are the main functionality of DBPIS: when the passenger enters origin and destination the system display static information such as bus Timetable/Scheduling and route information and Geographical data such as the location of bus stops and stations.

DPIS consists of the following main components:

The GIS Service provides an interface to a database of geographical information consisting of

- **Centre-line road vector data:** This is a network of interconnected line segments. Each line segment corresponds to a theoretical line running down the Centre of an actual physical road.
- **Bus Route vector data:** This is that subset of road vectors that make up one particular bus route. It is different to road vector data in that the set of road vectors that make up a bus route have a direction, whereas individual road vectors are bidirectional.
- **Bus stop data:** The GIS service provides access to the list of bus stops. Each bus stop is geo-coded, which means its x, y co-ordinate is given a human readable name. Each bus stop also can be queried for the street it is on.
- **Street names:** A list of street names is provided along with the set of road vectors that make up that street. The GIS Service also provides functionality to overlay the bus stop data onto the bus route vector data.

The HTTP Document: This component serves the user interface to the user agent. A user interface is chosen to match the characteristics of the user agent on the first request of that user agent. After that, the chosen user interface tree handles all interactions.

Personal Mobile Traveller Information Service (PROMISE) Project

The PROMISE project is primarily concerned with the development of a personalized traveller information service that can be viewed on a personal mobile terminal. Its objective is to provide travellers with a range of easy-to-use multimodal traveller information services. The project is heavily user-focused, in the hope that it will produce commercially viable services that consumers will want and will pay for. While the PROMISE project focuses on passenger/public transport information systems only the research results relevant to passenger/public transport information systems.

The most important conclusions of the PROMISE are summarized below:

- Travellers emphasized the need for a wide and diverse range of information/services. They want more than just pre-trip and on-trip planning and guidance information.
- There is a need for dynamic services, not only those that provide access to real-time information, but also those that warn of any changes and/or react to those changes.
- People wanted to access the mobile information services through a small personal device similar to a mobile phone or PDA.
- People were interested in accessing the PROMISE information services at home, at work (on a PC) and through a fixed terminal on the public transport vehicle. The basic PROMISE service concept is to provide two core services:
 - Pre-trip and on-trip planning
 - Travel related information services

Table 3.1: Over View of Related Project

Services	PTRP[7]	Route Finder [23]	Hyderabad Bus system	Dublin Bus passengers information service
Detail bus Information	No	No	Yes	Yes
Browser based	No	Yes	Yes	yes
Route/trip distance	Yes	Yes	Yes	Yes
Client/server application	No	Yes	Yes	No
Accessed by mobile	No	No	No	Yes
Bus Route map	No	No	Yes	No
Direction	No	Yes	Yes	No

Summary

Table 3.1 shows the comparison between the related works. Yes and No denotes the availability of a given feature respectively. In this work, we will implement all the sources indicated in Table 3.1. The proposed system did not provide real time connection information since it was based on basic bus route information without considering of time factor.

CHAPTER FOUR: SYSTEM REQUIREMENT ANALYSIS

The literature review conducted provided a base to consider the possible opportunities, limitations, standards, and current status of performance evaluation. Generally, it also indicted the major problems that are hindering development of ACBRI system in Ethiopia.

Having considered the output of literature review, requirement elicitation is done to identify the specific requirement for the Ethiopian context. To identify the requirements, interview and document review has been conducted with ACBE. The enterprise has an office which is delegated for managing of ACB transportation route guiders system and developed manual guiders or planner systems. The requirement elicitation has also showed that the enterprise don't have as such a well-studied anticipated outputs for ACB route guider for passengers. To measure awareness of individual interview has been collected with individuals and it has shown that the level of awareness on ACB route/journey guiders is insignificant.

Considering the result of requirement elicitation, standard of vital public transportation route planner systems, the context of the country, and hope of customers, requirements of the proposed system are set. A requirement is a feature that the system must have or a constraint that it must satisfy to be accepted by the client. The requirement elicitation yielded the specification of the system written using natural language, so that the client can understand.

4.1 Functional Requirement Analysis

Functional requirement is an area of functionality that the ACB route information system must support.

Therefore, the major functions of this system that are generalized as a reason for the development of the system are:

- The system should update bus information(Bus number, tariff, source, origin, timetable), route information (geographical points, route ,route map) record of database
- The ACBRI system should generate necessary information about route and ACB transportation service for passengers.
- The ACBRI system should register the route (source name, destination name, checkpoint latitude and longitude) and Anbessa city bus information and administrator account.

- The ACBRI system should display route path, bus and other necessary information

4.2 System Model

4.2.1 Use case and Actor

Use cases are used during requirements elicitation and analysis to represent the functionality of the proposed system. Use cases focus on the behavior of the system from an external point of view. A use case is used to describe a function provided by the system that yields a visible result for an actor. An actor describes any entity that interacts with the system, such as a user, another system and the system's physical environment. The identification of actors and use cases resulted in the definition of the boundary of the system that is, in differentiating the tasks accomplished by the system and tasks accomplished by its environment. The actors are outside the boundary of the system, whereas the use cases are inside the boundary of the system. The following Use Case and Actors are identified for the proposed system call Mobile Based ACB Route Information System (MBACBRIS). Use case diagram of MBACBRIS is shown in Figure 4.1.

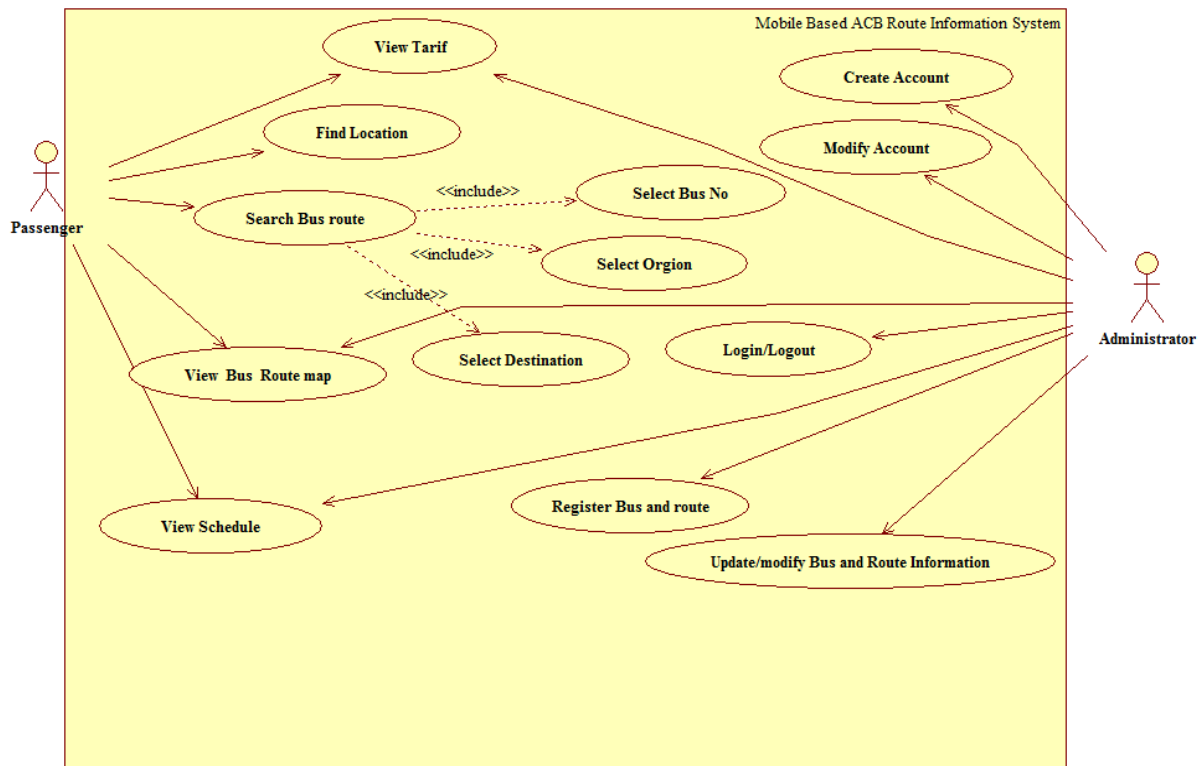


Figure 4.1: Use Case Diagram for ACBRI System

4.2.1.1 Descriptions of Actors

- **Administrator:** a person who is responsible for controlling all activities of the system such as register bus and route information, create account, Modify account(change password or Id),Update/modify bus and route information(update location, bus number, tariff, source, destination..) and can view bus schedule, bus route map and tariff.
- **Passenger:** a person who accesses the system and uses the ACB transportation system.

4.2.1.2 Use case descriptions

Use case name: Create Account

Actor(s): Administrator

Purpose: This use case allows the Admin to create account for itself

Pre-condition: The administrator must be launch the system

Post condition: The administrator will have privileges to modify/update the system

Flow of Events:

1. The Administrator wants to create account
2. The Administrator chooses Login/Register link
3. The system displays register and modify system links
4. The Administrator clicks on register link and fill necessary information and click on register button
5. The system checks the username entered by the Admin [**Alternative 5**]
6. “Account created successfully” message displayed to the administrator.

Alternative path 5: [the Admin enters existing Name or required field in the blank form.]

5.1. The username exists or fill in the required fields Message will be display.

5.2. The system resumes at step 4

Use case name: Update/modify bus and route information

Actor(s): Administrator

Description: the administrator modify/update the ACB route information

Pre-condition: the Administrator launches the system and login

Post condition: the system information like route, bus, schedule, location and others updated

Flow of events:

1. The administrator want to modify /update system
2. The Administrator choose login/Register link
3. The system display modify/update forms and

4. choose which one of the system want to update(bus, route, bus time table)
5. fill necessary information and click update/delete button
6. The system check the filled components are exists or not.[**Alternative Path 6**]
7. “Update/delete/add successfully” message display to the admin

Alternative path 6: [the Admin enters existing route no, bus no/primary key during add information or required field in the blank form.]

6.1. The primary key name exists or fills in the required fields Message will be display.

6.2. The system resumes at step 5

Use case name: login

Actor(s): Administrator

Description: The administrator login to the application in order to be able in the future to save modified journey planned or re-call old ones

Pre-condition: The administrator must be register and launch the system

Post condition: The administrator start use the system in order to perform update/delete..

Flow of events:

1. The administrator wants to login the PTRP system
2. The administrator starts PTRP System
3. The system displays home page and different links, then clicks on login/register link
4. The administrator insert his/her own user name, password and clicks on Login button
[**Alternate 4**]
5. The system display administrator pages

Alternative Path 4: [Incorrect password and/or user name]

4.1. The system display, “Unknown Password or User Name”, Error Message

4.2. The system resumes at step 4

Use case name: view schedule/tariff

Actor(s): Passenger and Administrator

Description: the actors views the bus information in order to arrange their own time and other

Precondition: The actors must be launch the system

Post condition: the actors view bus information

Follow of events:

1. actors want to launch the system

2. The system display home page
3. Actors click on view link menu and display view page
4. Actors click what he/she want to view
5. Fill required information if the page have fill components.[**Alternative 5**]
6. Click on view/submitted button
7. The system display actors selected information

[Alternative 5]: incorrect input

- 5.1.The system display bank page or the no record message
- 5.2. The system resumes at step 5

Use case name: Find Location

Actor(s): passenger

Description: this use case allows getting transportation service location on map information, especially new comer passenger in the city.

Pre-condition: The actor launches the system

Post- Condition: The passenger gets information about ACB transportation system to reach the destination from current location based on map.

Flow of events:

1. The passengers must launch the system
2. The system display home page
3. The actors click on route info linked menu
4. Click on Route map linked button
5. The system display location form and click on location/checkpoint name on the left side of the map
6. Fill necessary information and click search button [**Alternative 6**]
7. The system display location information by text form or by map

[Alternative 6]: Incorrect input

- 6.1.The system display empty message on page
- 6.2.The system resumes at step 6

Use case name: Logout

Actor: Administrator

Description: The administrator can logout from the system after finished the job inside the system

Pre-condition: The administrator wants to launch the system and login

Post-condition: logout successfully

Flow of events:

1. The admin click on logout link
2. Display Logout Success fully

Use case name: search route

Actor: Passenger

Description: The passenger plan their own journey by selection source and destination

Pre-condition: The passenger wants to plan journey/trip by using MBACBRI system

Post-condition: The passenger plan the journey/trip

Flow of Events:

1. The passenger launch the system
2. Display the home page and click on search route linked menu
3. Select source and destination [**Alternative 3**]
4. Click on search button
5. Display bus information

[Alternative 3]: Select unregistered source or destination

3.1. The system display empty message

3.2. The system resumes at step 3

4.2.2 Class Diagram

The most basic objects in the ACB transportation route information system are checkpoint, administrator, route, schedule and bus. Figures 4.2 describe classes, including their associations, attributes and operations

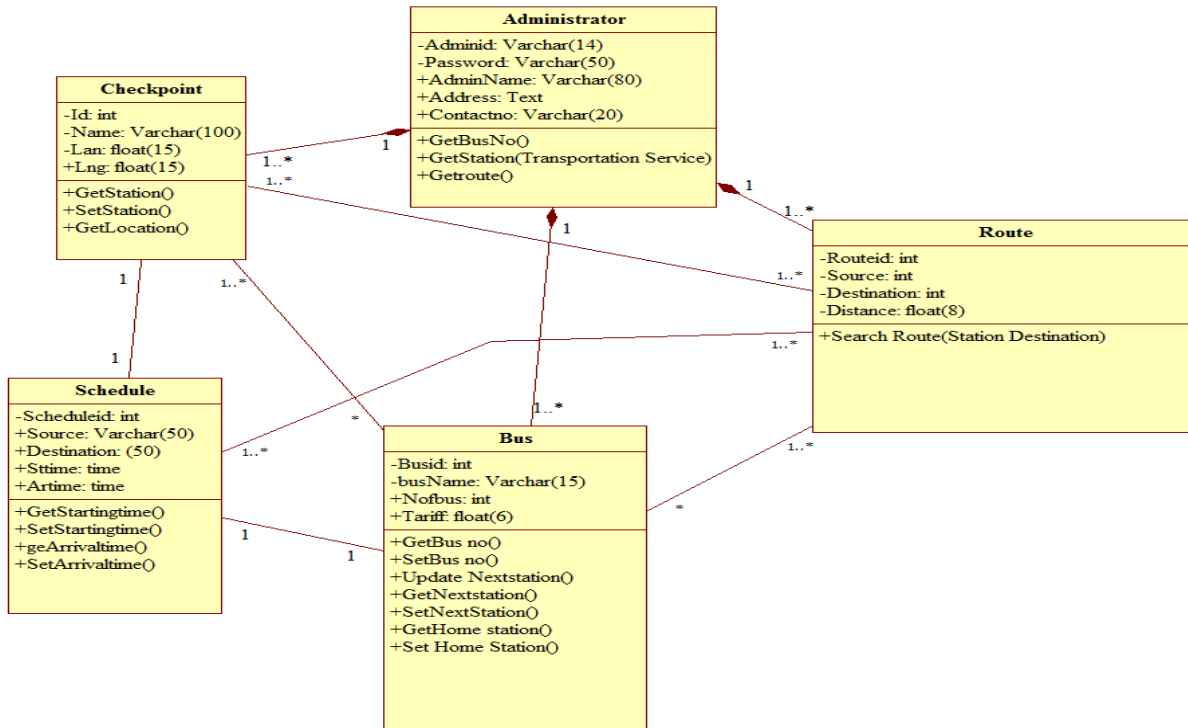


Figure 4.2: Class Diagram of ACBRIS

4.2.3 Sequence Diagram

Sequence diagram are used to formalize the behavior of the system and to visualize the communication among objects. Since it is useful for identifying additional objects that participate in the use cases and describe patterns of communication among a set of interacting objects, the diagram is developed for each use case. An object interacts with another object by sending message. The reception of a message by an object triggers the execution of an operation, which in turn may send messages to another object. Arguments may be passed along with a message and are bound to the parameters of the executing operation in the receiving message.

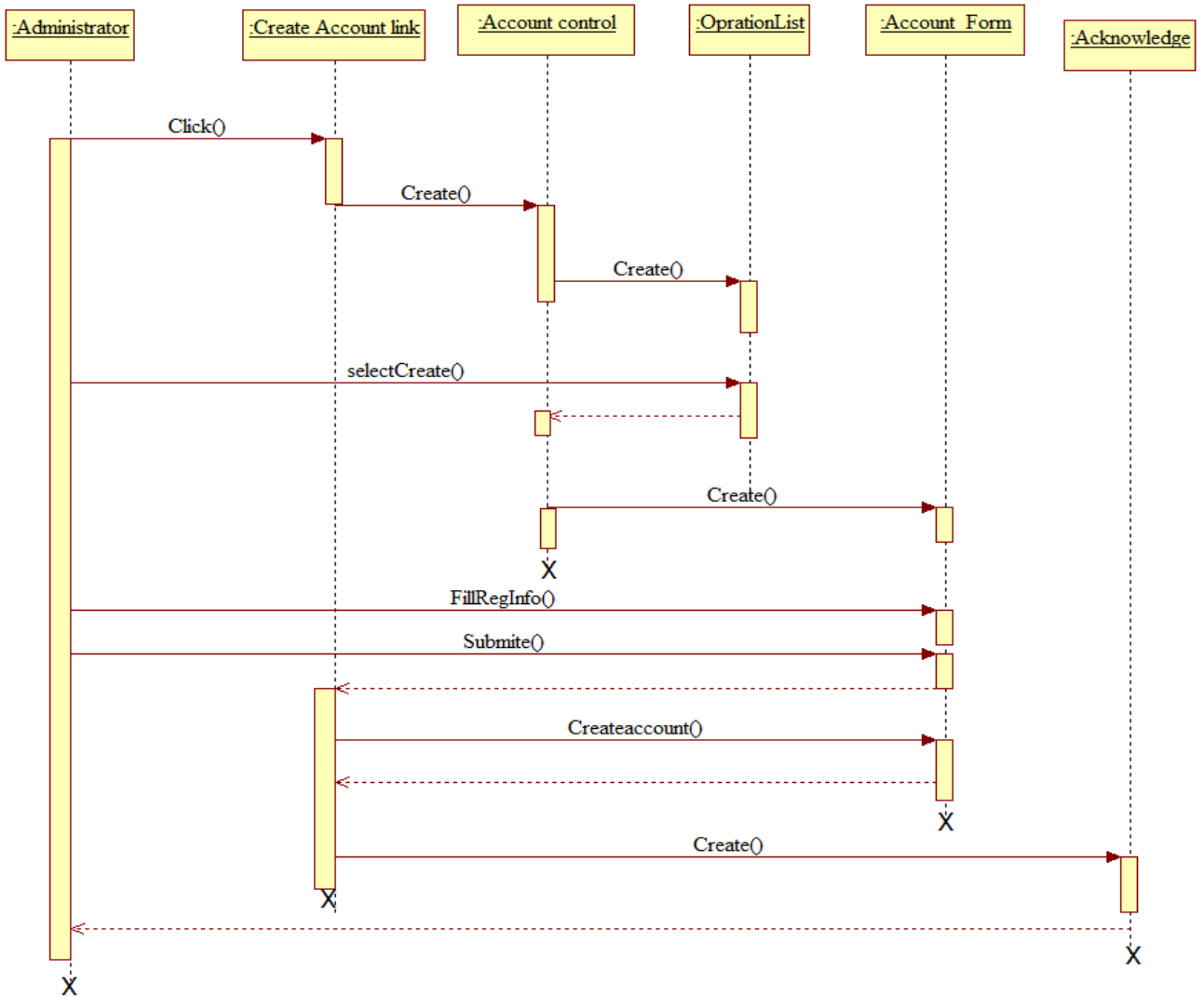


Figure 4.3: Create Account Sequence Diagram

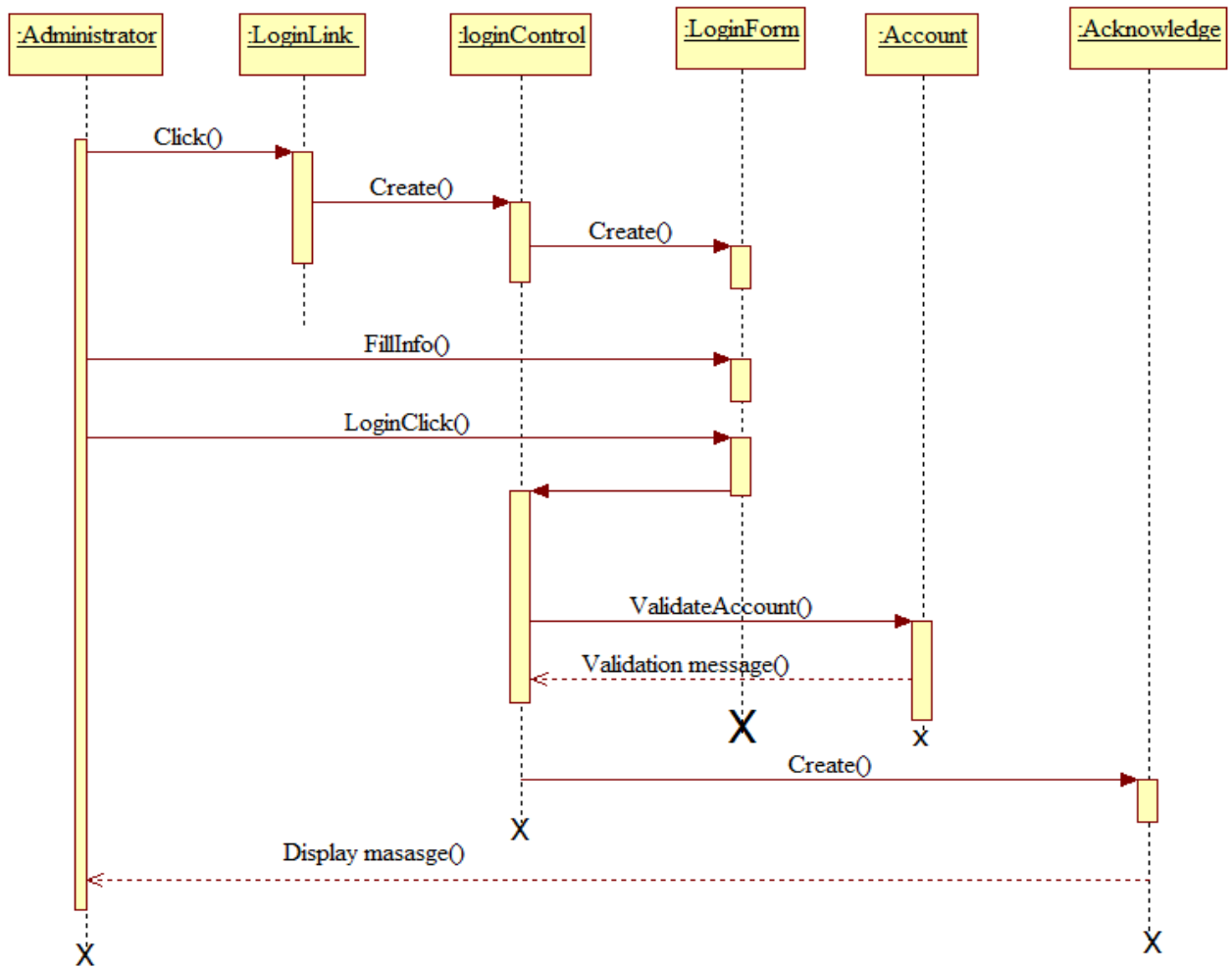


Figure 4.4: Login Sequence Diagram

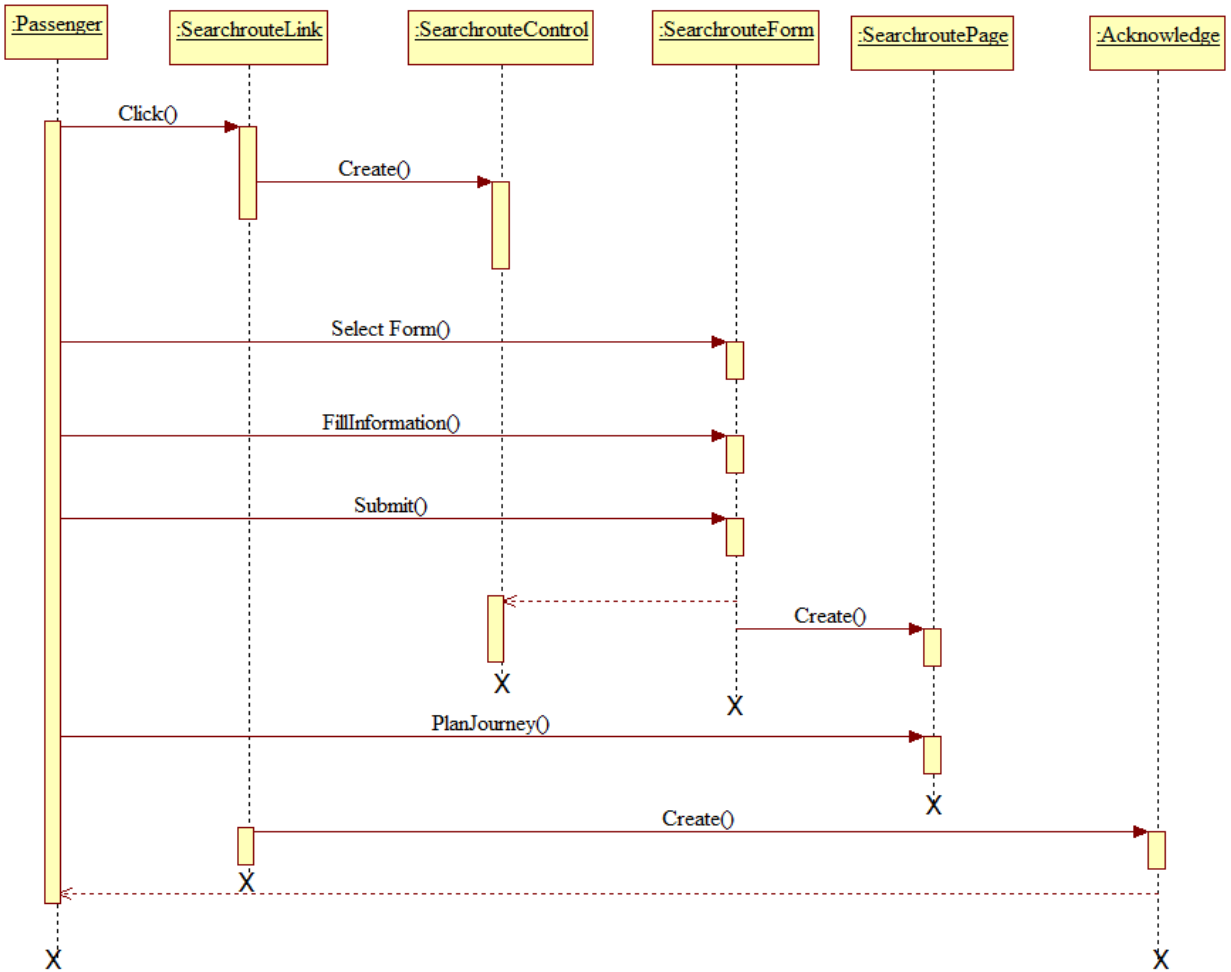


Figure 4.5: Search Route Sequence Diagram

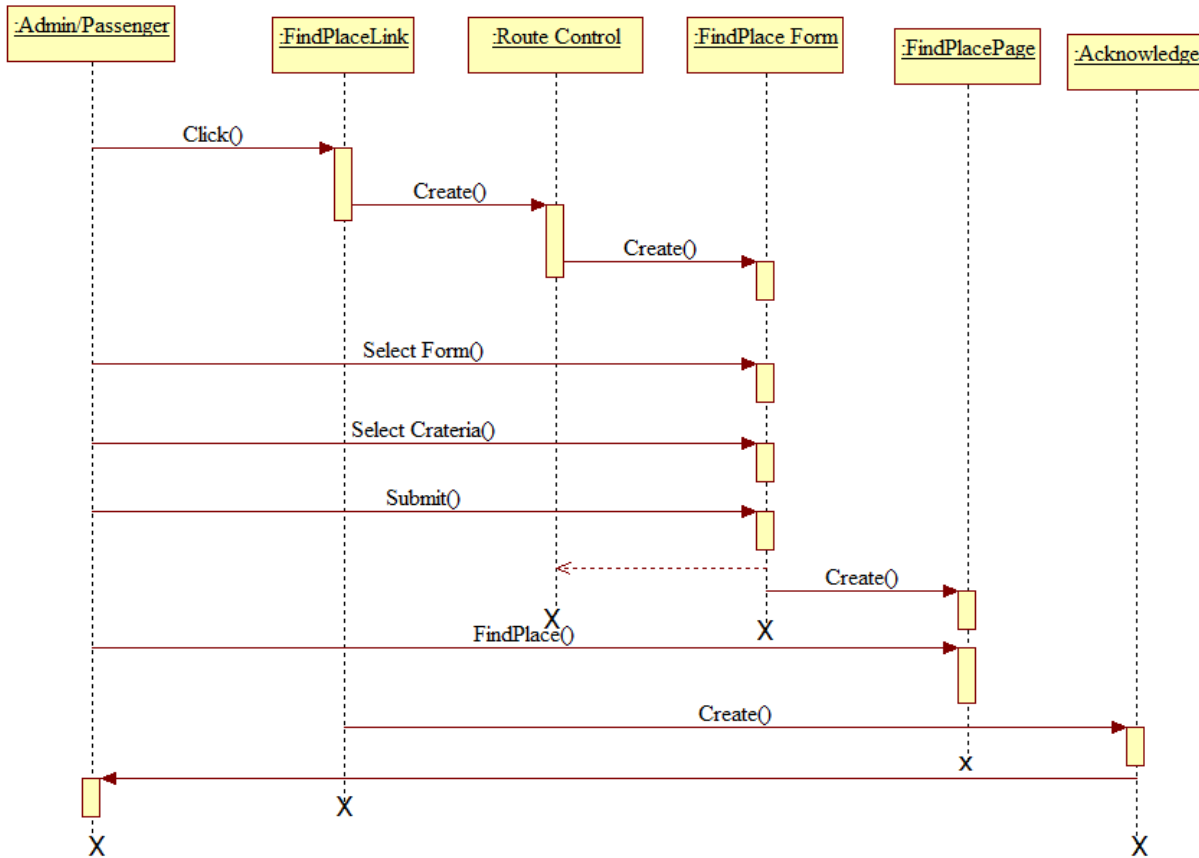


Figure 4.6: Find Location Sequence Diagram

4.3 Nonfunctional Requirements

Nonfunctional requirements specification is done to identify aspects that are visible to the user but not directly related to the functionality of the system. These include constraints on the performance of the system, its security, its user interface, its documentation, the resources it consumes, and its quality.

User Interface and Human Factors

This system will be used by two main groups of people: first an authorized administrator of ACBE can use. Second it can be used by the passengers that use ACB transportation services. Since some of the passengers in the city and new comer passengers out of the city might not have enough knowledge to accesses website applications through their mobile, we will prepare user

guide to demonstrate every steps of the system in order to make it easy to use the ACB transportation service.

- Interaction of users with the system should be through graphical user interface.
- The user interface should be user friendly and attractive.
- The navigation facility should be flexible.
- The user interface should be consistent in terms of format of page, background color, font and size.

Performance Requirements

- Since the system is web based the performance can be directly affected by the quality of hardware, robustness of the software and network traffic. So the response time should be reasonable.
- Reasonable number of concurrent accesses should be enabled.

Hardware Requirements

The system has to be able to run with minimal and reasonable memory and processing power demand. As a web application the concurrent number of users vary, so to enable handling the worst case the server has to have multiple modems, super processing capability, large storage capacity, and redundant storage devices.

Security Issues

- The system is modified and manage only by authenticated administrator
- The passengers can access system without any privileges.
- Strong access right control should be implemented on methods for user with different privilege level.
- Preferable if Transport Layer Security mechanism is implemented to protect from eavesdroppers' during communication.

Error Handling

- The system must be able to validate all input to their assigned value and display
- The system must be able to valid all input to their assigned value and display informative message to user.
- Well-structured client side validation should be implemented for ease of functionality.

Documentation Requirements

- The overall development process should be documented including the Requirement Analysis, System Design, and Implementation details.

CHAPTER FIVE: SYSTEM ARCHITECTURE AND DESIGN

During requirement elicitation and analysis phase the services that are intended to be provided by the system are identified but they are not defined internally and logically how they work. System design is the change of the analysis model into a system design model. During system design, design goals, decomposition of the system into smaller subsystems, architecture of the system and persistent data management are defined.

5.1 Design Goal

Design goals represent the expected qualities of the system and provide a consistent set of criteria that must be considered when making design decisions. Most of the design goals of the system are inferred from the non-functional requirements and the application domain will follow the same set of criteria. The design goals can be generally grouped into performance criteria, dependability criteria, maintenance criteria and end user criteria.

- **Performance Criteria**

Response time: The system should provide as fast response as possible, at least before the session expires in registering bus and route records, and displaying information. In order to minimize the time it takes to provide response, interface design has not included any large graphic files and middle-tier processing code is made as efficient as possible. Of course, the bus route map and graphical information might take a bit more time to be displayed, which might be seen as a trade-off.

Throughput: The system should be able to support a number of users at a time using the available bandwidth of the system. The MYSQL DBMS used in the system development supports a number of users' concurrent access of the database without consistency problem.

- **Maintenance Criteria**

Modifiability: The system should be easily extensible to the need of the ACB data formats availability and to add new functionalities to the system. The system is built from several more or less independent classes which can be used as a standalone application or replaced by

other classes. This makes the system easy to change the existing functionality or add new ones when the need arises.

Portability: The system should be easily portable to different platforms. As the PHP languages achieved platform independence through the Common Language Runtime (CLR), the end user can use the system using any browser such as Google Chrome, Opera UC browser, Firefox and Internet Explorer.

- **Dependability Criteria**

Robustness: ability to survive invalid user input is assured during data input, updating and deletion of data by providing some information about the error and then the system resets itself to the previous safe state.

Reliability: in order to maintain the difference between specified and observed system behavior we try to test it as much as possible.

Security: the system does not allow non-authorized users using a form based authentication.

- **User Criteria**

Utility: The system must address the possible functional requirement of the system users. Consequently, all the functional requirements identified in the preceding chapter have been implemented in the system.

Availability: the system should be available for any legitimate users as long as the service provider is available or it is not shut down by the system administrator.

5.2 Architecture of the System

The architecture of the public transportation route/journey planner is designed to be client-server application that encloses three layers namely **Client Layer**, **Middle Layer** and **Data Layer**, as depicted in Figure 5.1.

The Client Layer is the applications user interface encloses administrative registration, search route, find location/place, and views, modify the system and client side application that are running on the web browser of user machine. The system administrator and other users of the system directly interact with the system through graphical user interface. This layer interacts with the middle layer to make requests to display the information that are retrieved from the data layer and shape files are retrieved from KML file on the page.

The Inner/Middle Layer of ACB route/journey information system encloses map server, web server and KML. The map server is a set of server-side mapping controls and components that allow adding map in to web application through KML.

The keyhole markup language (KML) is an XML based markup language designed to annotate and overlay visualizations in 2-D, web-based online maps or 3-D earth browser. The KML file includes specifications for various features for display with in Google Earth, Maps and mobile, and other 3-D Earth (geobrowser) programs. It's features set include place markers, 3-D models, text description, image, polygons and so on.

The web server handles all the HTTP requests coming from the client machines. It also manages the responses that are returned to the client machine.

Data Layer manages the actual data being stored in the database. It is implemented using MySQL. The database accepts the SQL statements and executes it by DBMS components and then returns the required output to the applications.

The following are definitions of entity and property that are stored in data base:

- Administrator list (user name, Id, password, Address)
- Route (route name and geographical points: source and destination, distance)
- Bus information list (bus number, number of bus in one route, tariff, timetable, station name)

- Link was defined by two nodes (one at each end), link name and a string of coordinates that make up that link

Detailed system architecture may be shown in the complete document in the future. It consists of the following features:

- Browser based and mobile application both are used web server.
- Google maps server connection to overlay KML on map to plot route data.
- Database (MYSQL) RDBMS.
- Graphical user interface where user interacts with the system.

These are the features that will be developed and interfaced to enable the realization of the project goals. The development of the application incorporates the development of each of the above features.

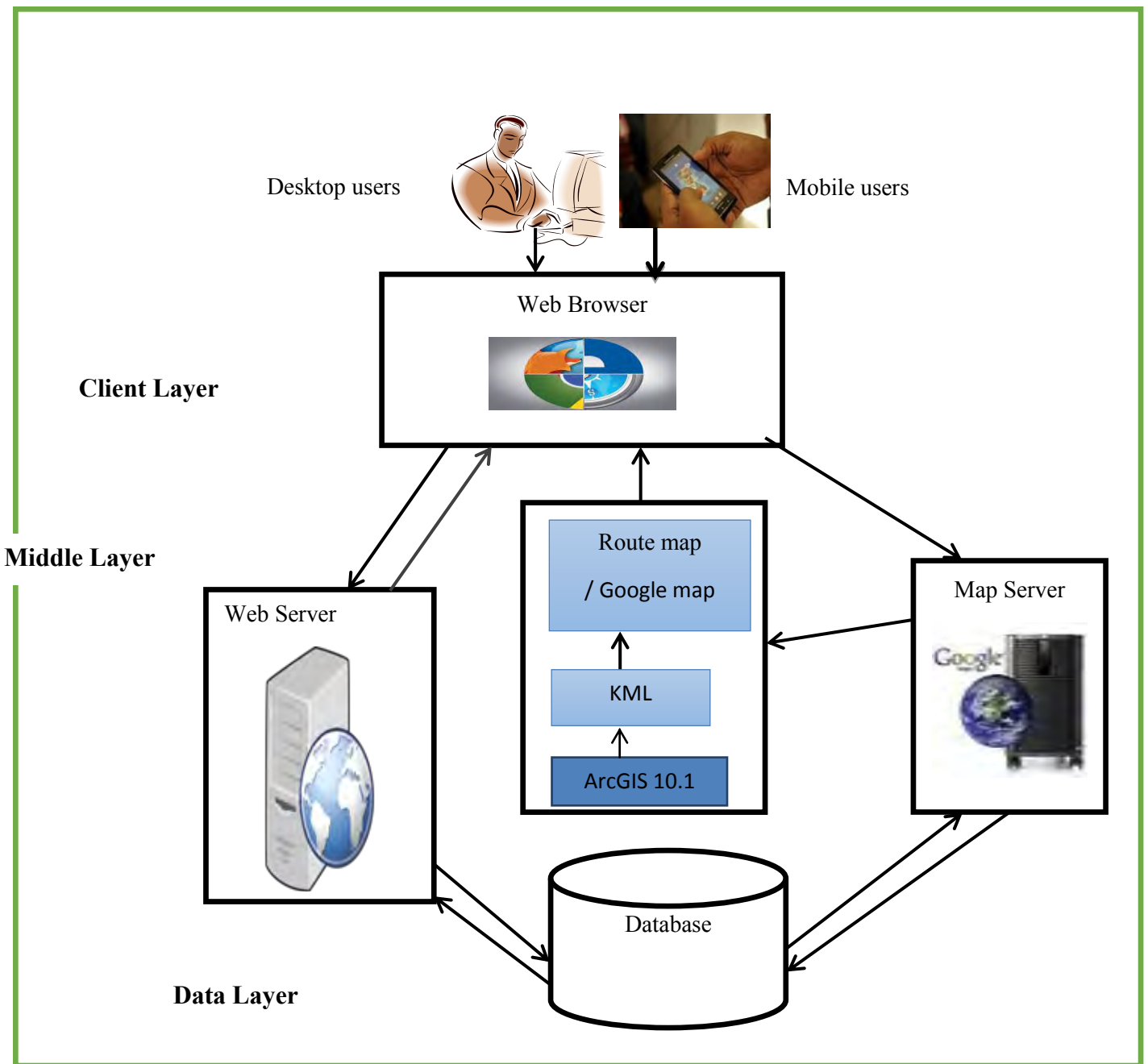


Figure 5.1: Architecture of ACBRIS

5.3 Mobile based Route Information System

Conceptualized system architecture for the proposed MBACBRIS system is shown in Figure 5.1. Figure 5.2 shows the components used in the design of the mobile web application.

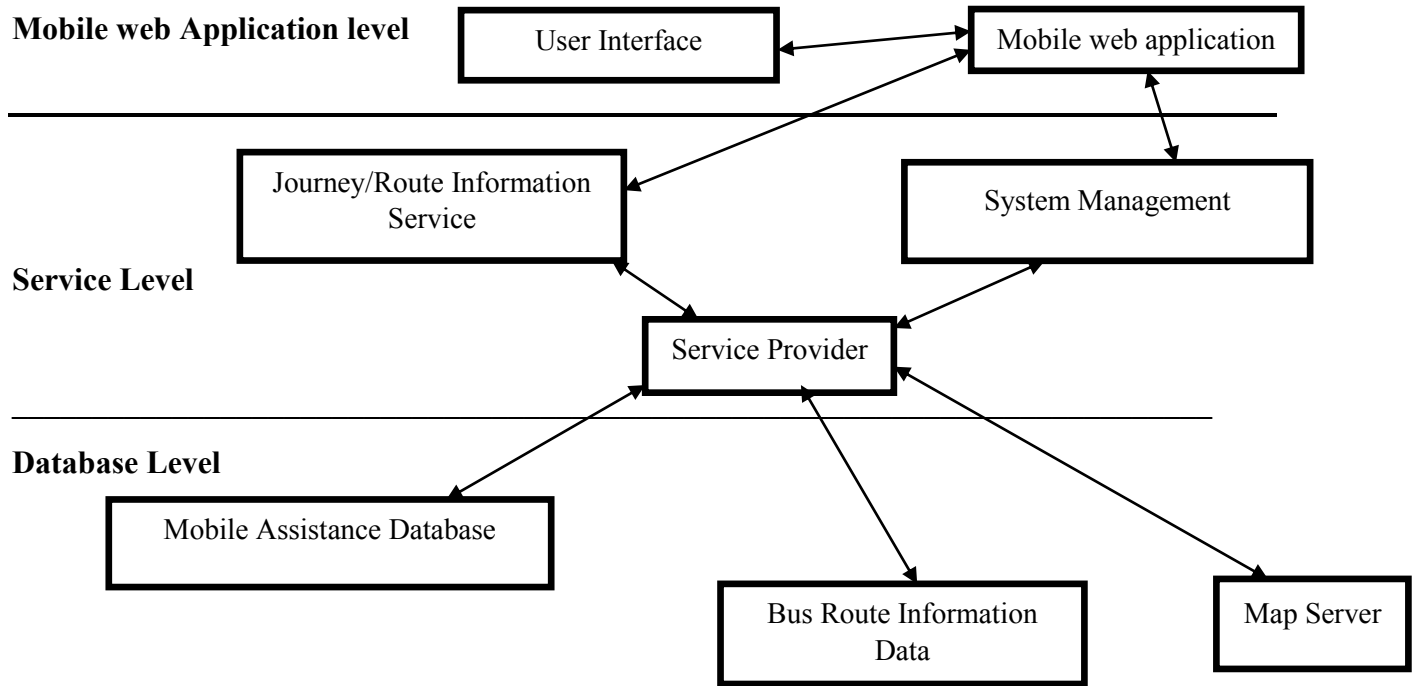


Figure 5.2: Architecture of ACBRIS for Mobile Web Application

As shown in Figure 5.2, mobile web application of ACB route information system can be divided into three levels which are mobile web application level, service level and Database level. Mobile web application level concludes two parts: the user interface and mobile web application parts. The user interface includes the interface of log in, registration, change password, homepage which shows maps, account management, bus route management, journey/route list, apply settings, appropriate services.

Mobile Web Application Level is used to get the information which users input in the interface, then handle the information and post it to the server. When mobile web application levels receive the response from the server, it will show the result of the response to passengers.

The Service Level includes two services, one is the service for route /journey information and another one is the service for system management. Service level is used to receive the request or information which posts from mobile web application, then control and use the database to handle

the request and information. Both service level and mobile application level can be seen as the controller in the structure of MVC (Model View Controller).

Database Layer has three data sources which are route/journey data, open data includes general transit feed specification (GTFS) and open street map (OSM) and mobility assistant database which can save the data from the service of account management and journey management.

The connection between Android web application and server is based on Hypertext Transfer Protocol (HTTP) [24], which is the protocol of today's Internet, new streaming approaches have been developed [25,26,27]. The Hypertext Transfer Protocol (HTTP) is an application level protocol for distributed, collaborative, hypermedia information systems [26]. HTTP is a text-based packet and stateless. Generally, HTTP is used to communicate in the architecture of client and server. The client sends its request using an HTTP-GET packet, which is then transported to the server using the TCP/IP protocol family. The main application for HTTP is the Internet.

5.4 Subsystem Decomposition

The MBACRI system provides different services. To effectively provide these services as per the goals specified, the system is decomposed into different main subsystems. Figure 5.3 presents the subsystems:

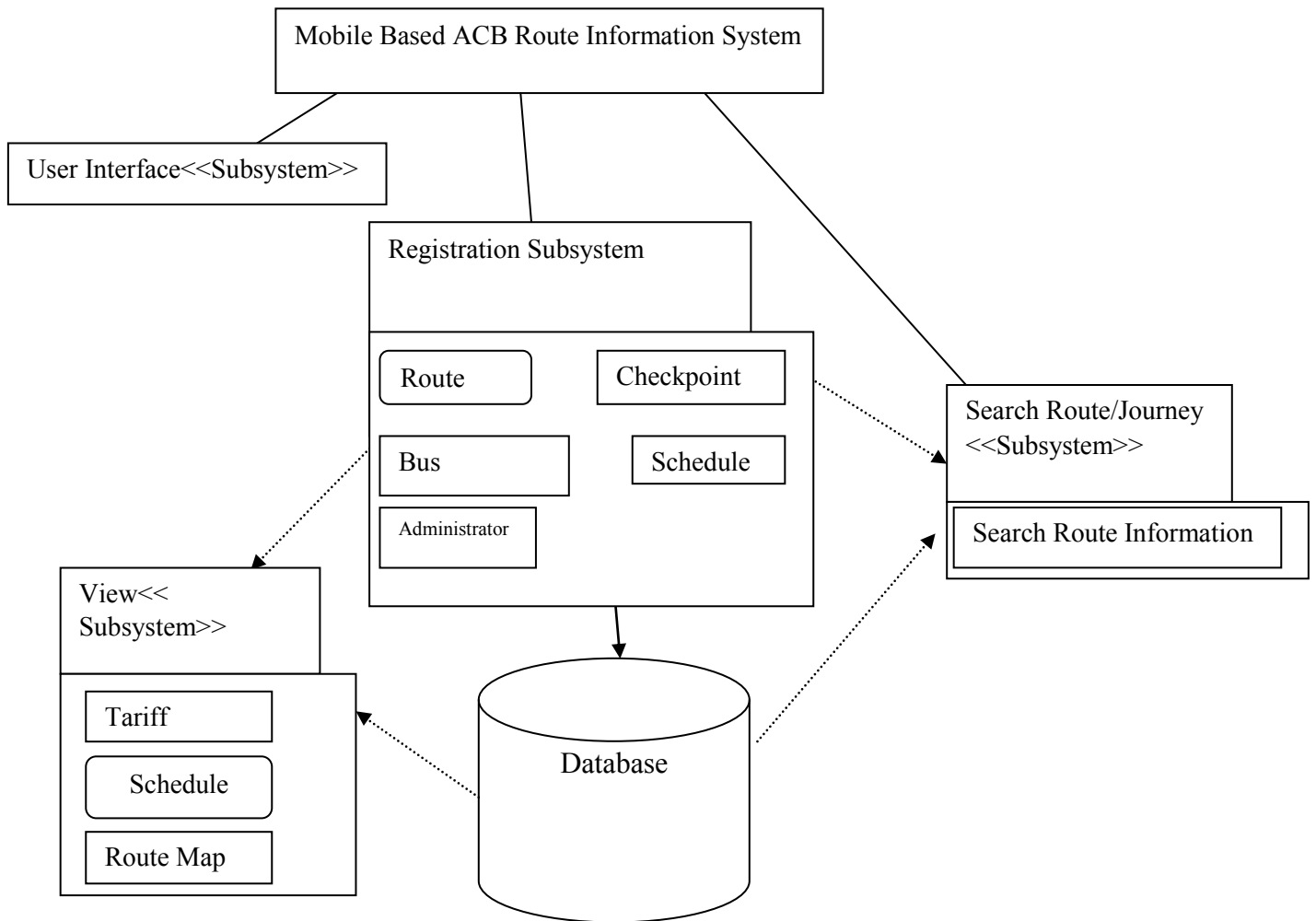


Figure 5.3: Subsystem Decomposition of MACBIS

The Search route/Journey subsystem is used to enable finding ACB station for a new comer in the city and give information journey to passenger for managing their time and cost.

The view subsystem is used to enables the user to see the source/destination, path on the map and see tariff and schedule of the buses. Furthermore, it helps the users to easily identify the best transportation services (bus number) and nearest station.

The registration subsystem enables the system administrator to add all information about routes, locations, vehicles and stations.

5.5 Hardware /Software Mapping

This section shows the relationship among the nodes and the independent components in the system. The deployment diagram shown in the Figure 5.4 shows the nodes and components of the system. The diagram includes a mobile web application deployed on a mobile device, the web application server where all the functionalities are deployed on, and the database server. As the system is a web based, the client nodes will have web browser component and the web server will have IIS.

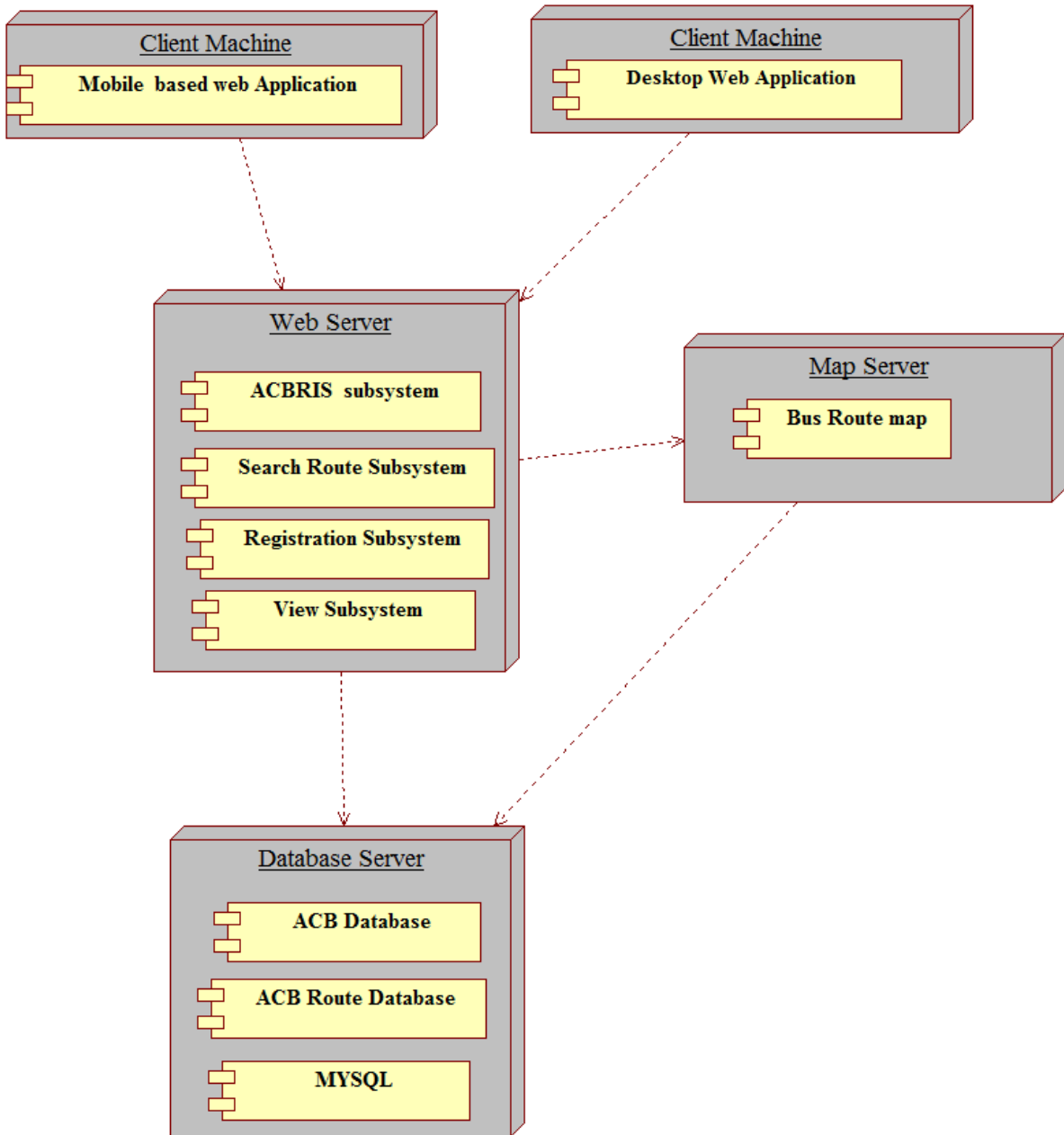


Figure 5.4: Deployment Diagram of ACBRIS

5.6 Persistent Data Management

Persistent data management deals with how the persistent data are stored and managed. Information related to route/journey, ACB, tariff, station, schedule and other related information are persistent data and stored in a database management system.

In order to store data persistently in a database, those entity classes identified in analysis model of class diagram of ACBRI system are transformed into tables and attributes of the classes are also mapped into tables fields. Figure 5.5 depicts the system’s relational model that handles data relation, integration and persistent data management.

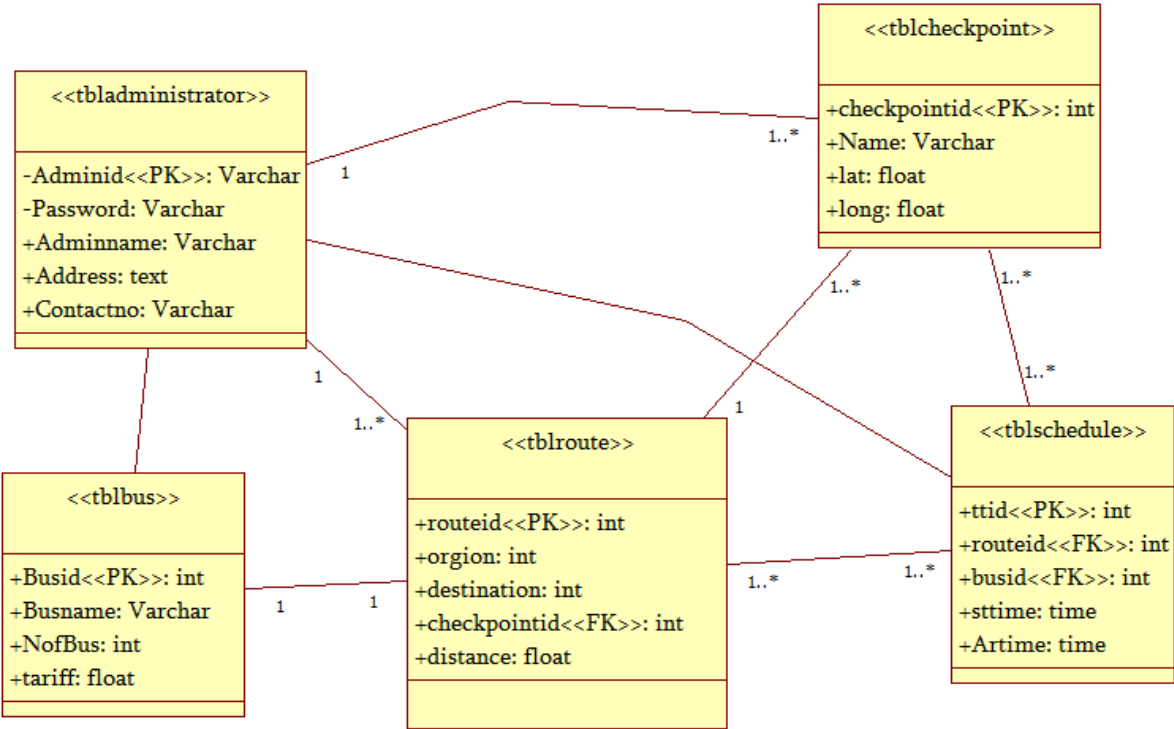


Figure 5.5: Relational Model of MBACBRIS

5.7 Access Control Policy

Since there are two groups of users MBACBRIS with different access privileges to different services and data, the access control policy is presented using access control matrix. The implementation of access control policy will enhance the security of MBACBRIS at low level. Hence, the two actors of this system have different accesses of the system.

This access control is represented using access control matrix. In the access control matrix, rows represent actors and columns represent classes. Each cell in the matrix represents access right and list of operations that can be executed on instance of the class by the actor. An empty cell

represents that the actor is denied access to the corresponding class. The access control matrix defined for the system is shown in Table 5.1.

Table 5.1: Access control matrix of MBACBRIS

Actors	Class				
	Route	Checkpoints	Bus	Time table	Administrator
System Administrator	Regroute()	Regcheckpoint()	Regbus()	Regtimetable()	Changeaccount()
	Modifyroute()	Modifycheckpoints()	Regroute()	Modifytimetable()	Changepassword()
	Viewroute()		Modifybus()	Viewtimetable()	
			Viewbusinfo()		
Passengers	Viewroute()	Viewcheckpoint()		Viewtimetable()	
	Searchroute()		Viewbusinfo()		
	Viewroutemap ()		Searchbusno()		

CHAPTER SIX: PROTOTYPE DEVELOPMENT

6.1 Development Tools

The system can run on desktop and on different mobiles that support wireless/Wi-Fi connection. Tools that are used to design and implement the proposed system are the following:

WampServer5: is a Windows web development environment. It allows creating web applications which contain different components such as Apache, PHP and a MySQL database. Alongside, PhpMyAdmin allows managing easily the web databases. Apache is the most popular open source web server.

JavaScript: is used for *client-side behavior*: broadly speaking, actions that are beyond the scope or capability of HTML or CSS. For example, HTML will mark up a table of data on a web page, and CSS can be used to present that tabular data attractively, but allowing the user to sort that information – changing the order of rows in the table is beyond the ability of both.

JQuery: is a fast, small, and feature-rich JavaScript library. It makes things like HTML document traversal and manipulation, event handling, animation, and Ajax much simpler with an easy-to-use API that works across a multitude of browsers. With a combination of versatility and extensibility, jQuery has changed the way that millions of people write JavaScript.

PHP: is a widely used general-purpose server-side scripting language designed to produce dynamic web pages. It is also *secure*, allowing confidential storage and retrieval of user data.

mHotspot: is a free software which converts your windows 7 and 8 laptop into a virtual wifi router and creates a secure Wi-Fi hotspot. You can share single internet connection (LAN, Ethernet, Data-Card, 3G/4G, Wi-Fi) for multiple devices like laptops, smartphones, android phones, PDAs, Ipads etc.

MySQL: is the most popular open-source database, used by huge number of websites around the world (among them, you will find Google, YouTube, Wikipedia, Facebook, Flickr, etc).

Internet information service 7: is used to enable the secure socket layer security service

HUAWEI Y300-0151 mobile with Android 4.1.1: is used to check the system interface work properly on a mobile device.

6.2 Application Environment

Home: the MBACBRIS Home Page is the entry point to the application. It can be opened using [URL:http://XXX.XXX.XXX/Anbessa_Bus/main.html](http://XXX.XXX.XXX/Anbessa_Bus/main.html) from this page, you can see about Anbessa city bus enterprise. On this page, the passengers access the other links/menu without any authentication, however they can't access administrator page. To access the system using mobile device, the user must be on the Wi-Fi and create connection between access point and device.

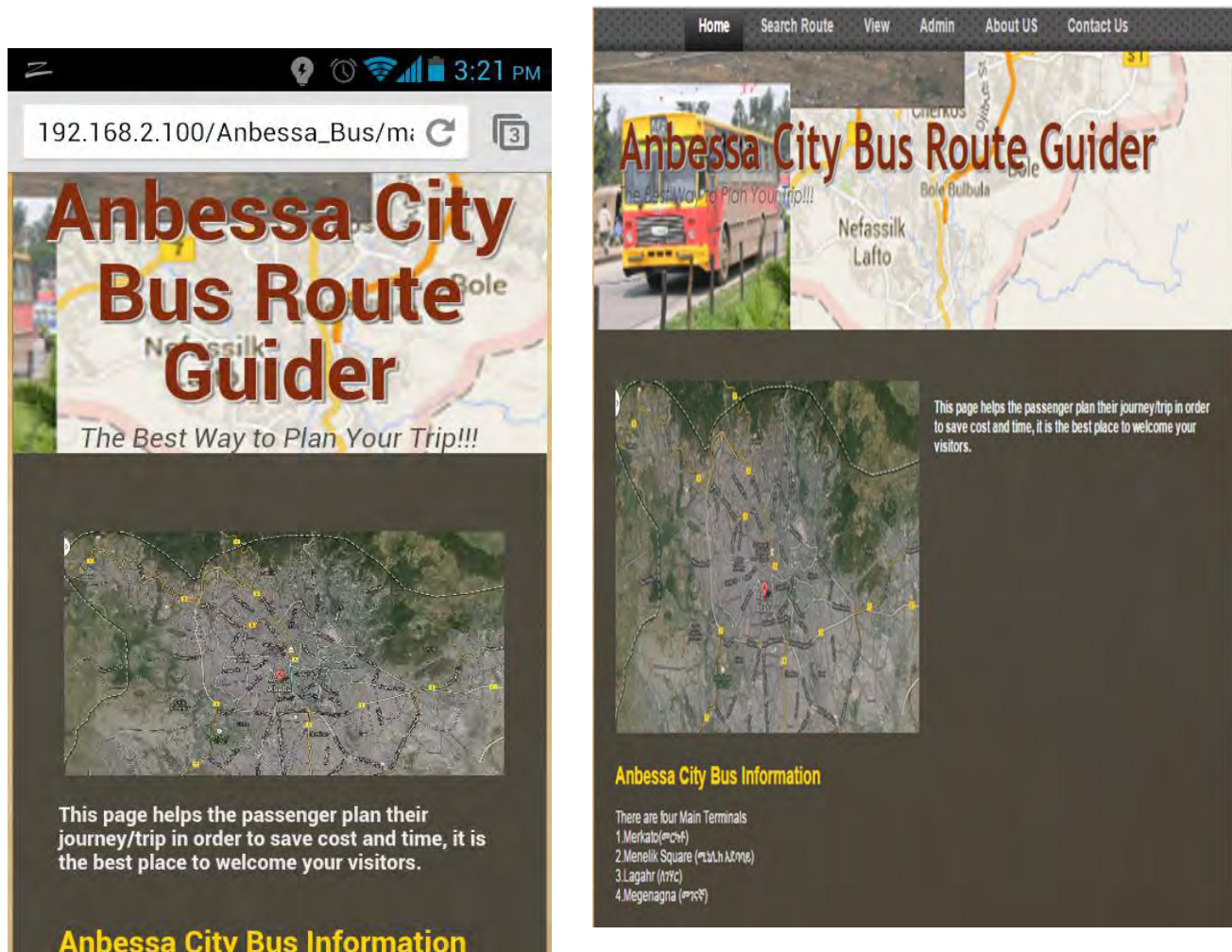


Figure 6.1: Screenshot of Home Page on Desktop and Mobile Device

Search Bus Route: This component is responsible to show the route information when the passengers selected source and destination. Screenshot of search route/journey is shown in Figure 6.2.

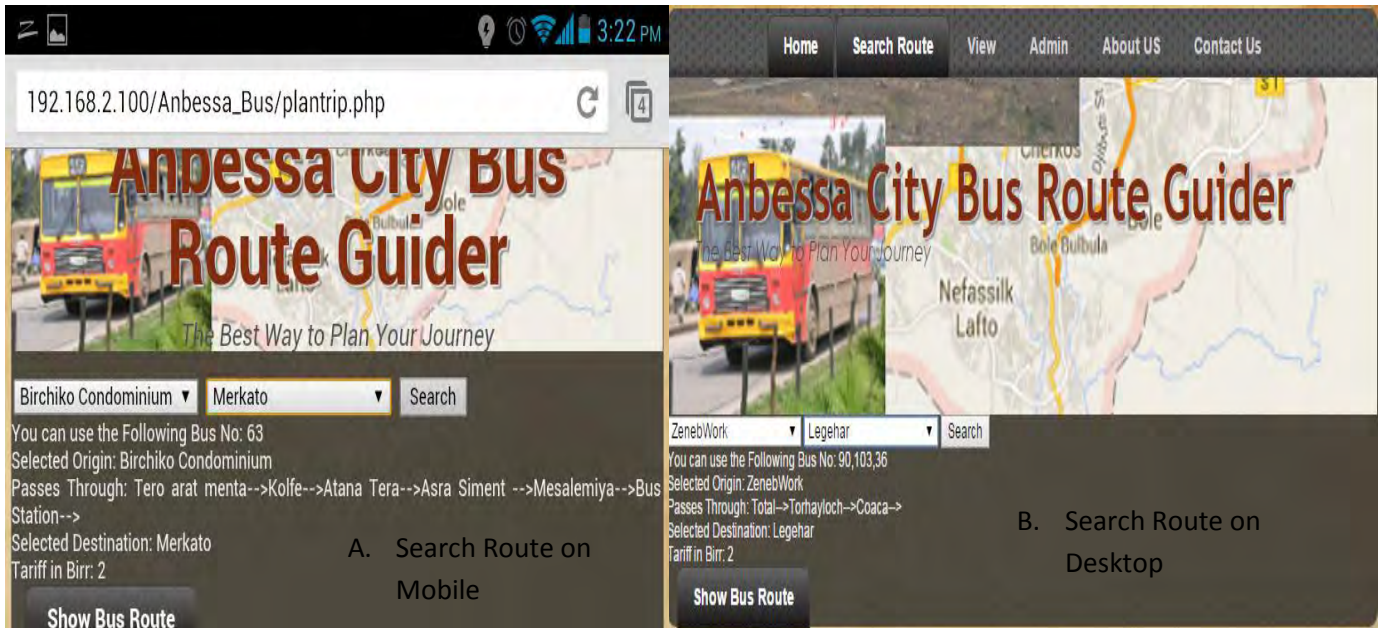


Figure 5.2: Screenshot of Search Route page on Desktop and Mobile Device

View: This subsystem is responsible to show Anbessa city bus transport service information such as time table of each bus, view detail information of bus and route map. Screenshot of view shows on Figure 6.3.

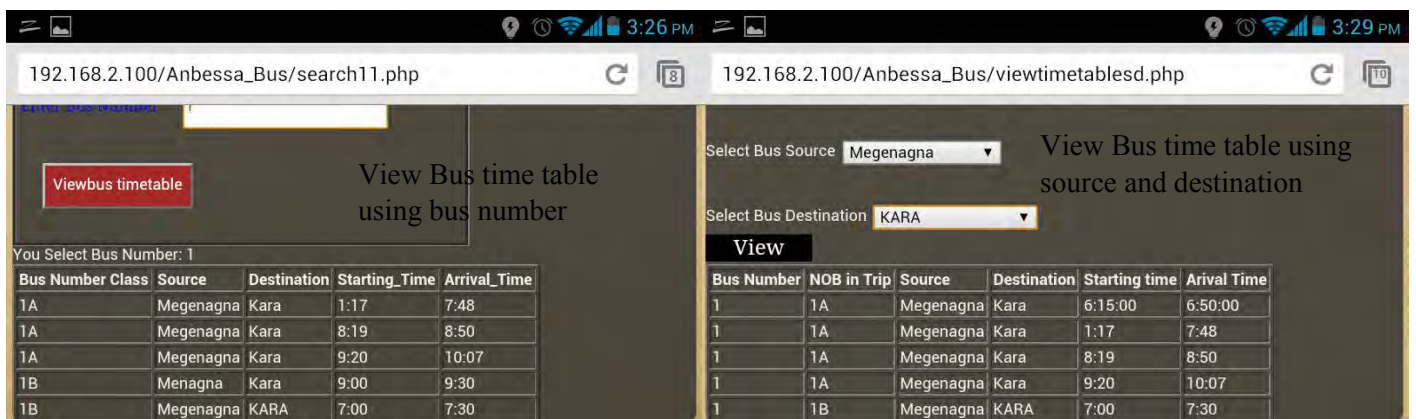


Figure 6.3: Screenshot of View Bus Timetable Using Mobile Device

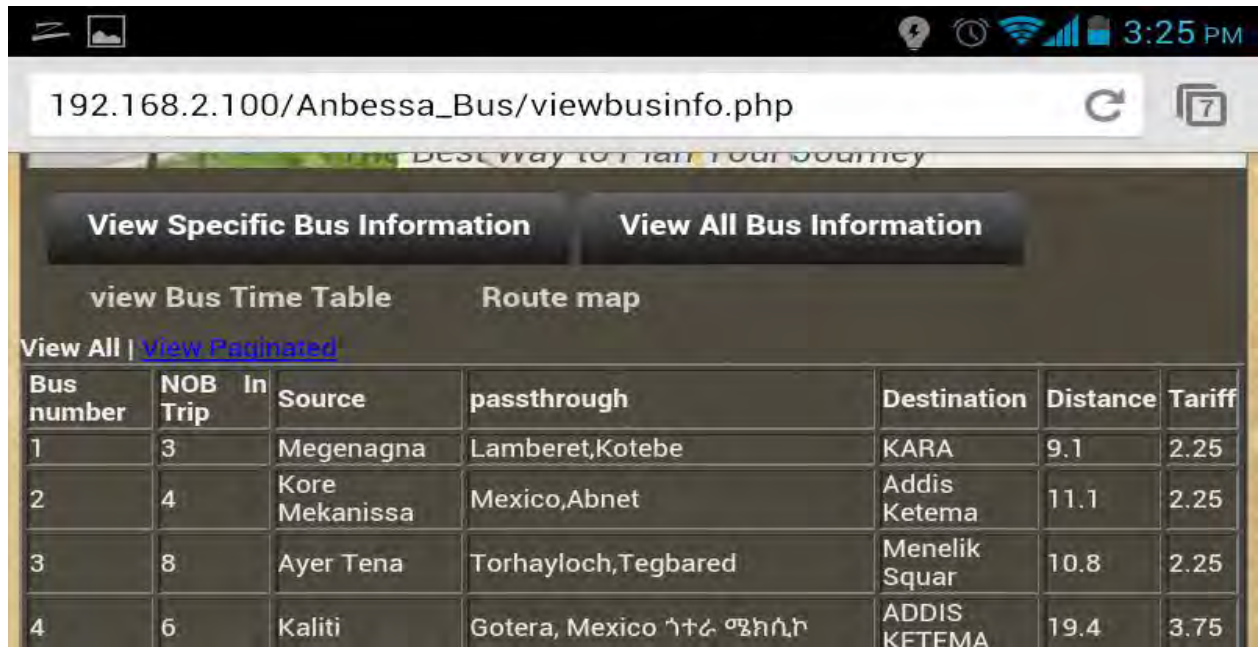


Figure 6.4: Screenshot of View ACB Information Using Mobile Device

Home PlanJourney View Admin About US Contact Us

Long Trip Bus Information

The Best Way to Plan Your Journey

View Specific Bus Information View All Bus Information view Bus Time Table Route map

View All [View Equipment](#)

Bus number	NOB In Trip	Source	passthrough	Destination	Distance	Tariff
1	3	Megenagna	Lamberet, Kotebe	KARA	9.1	2.25
2	4	Kore Mekanissa	Mexico, Abnet	Addis Ketema	11.1	2.25
3	8	Ayer Tena	Torhayloch, Tegbared	Menelik Squar	10.8	2.25
4	6	Kaliti	Gotera, Mexico ተተራ ጭከሲኮ	ADDIS KETEMA	19.4	3.75
51	4	BETEL HOSPITAL	Torhayloch, Abnet	ADDIS KETEMA	10.9	2.25
63	3	ADDIS KETEMA	ዊንነት፣ አጠና ተራ፣ ኮልፊ ድልድይ	MIKILILAND	9.1	2.25
90	6	BETEL HOSPITAL	ZenebeWork, Torhayloch, Mexico	LEGEHAR	10	2

View ACB Route

View Bus Info view Bus Time Table Time Table by Start and Destination Route map

Route map Megenagna terminal

View All [View Equipment](#)

view Anbessa City Time Table using Bus Number

ENTER BUS NUMBER

Viewbus timetable

You Select Bus Number: 1

Bus Number Class	Source	Destination	Starting_Time	Arrival_Time
1A	Megenagna	Kara	1:17	7:48
1A	Megenagna	Kara	8:19	8:50
1A	Megenagna	Kara	9:20	10:07
1B	Menagna	Kara	9:00	9:30
1B	Megenagna	KARA	7:00	7:30

View ACB time table

Figure 6.5: Screenshot of Viewing Route Information and Timetable on Desktop

View bus route map: The ACB route map is generated from coordinate data stored in database. The KML was output from a PHP script and overlaid on a map. Overlaying KML file on Google maps produced the following output in Figure 6.6 below.

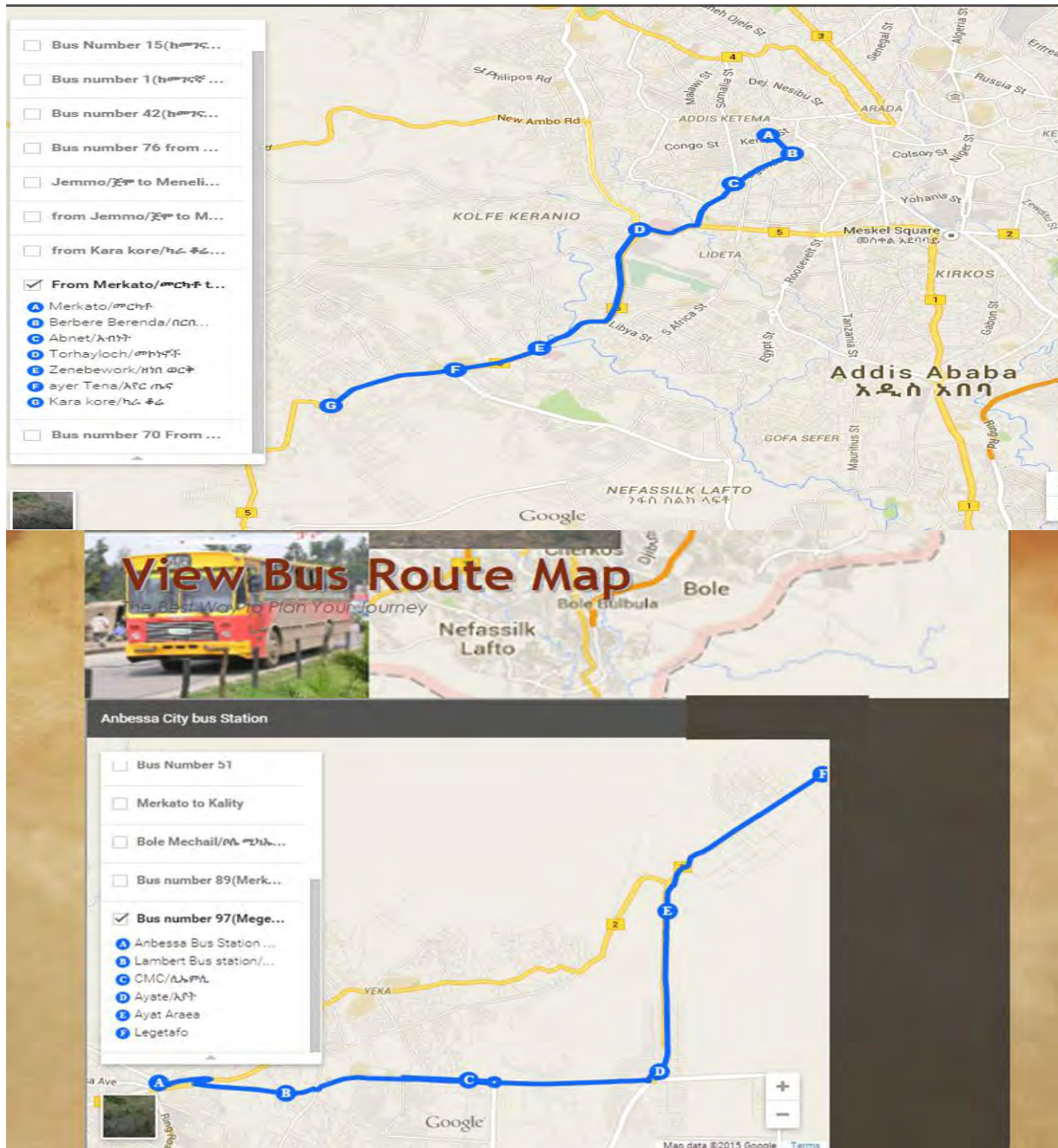


Figure 6.6: Screen Shot of Bus Route Map

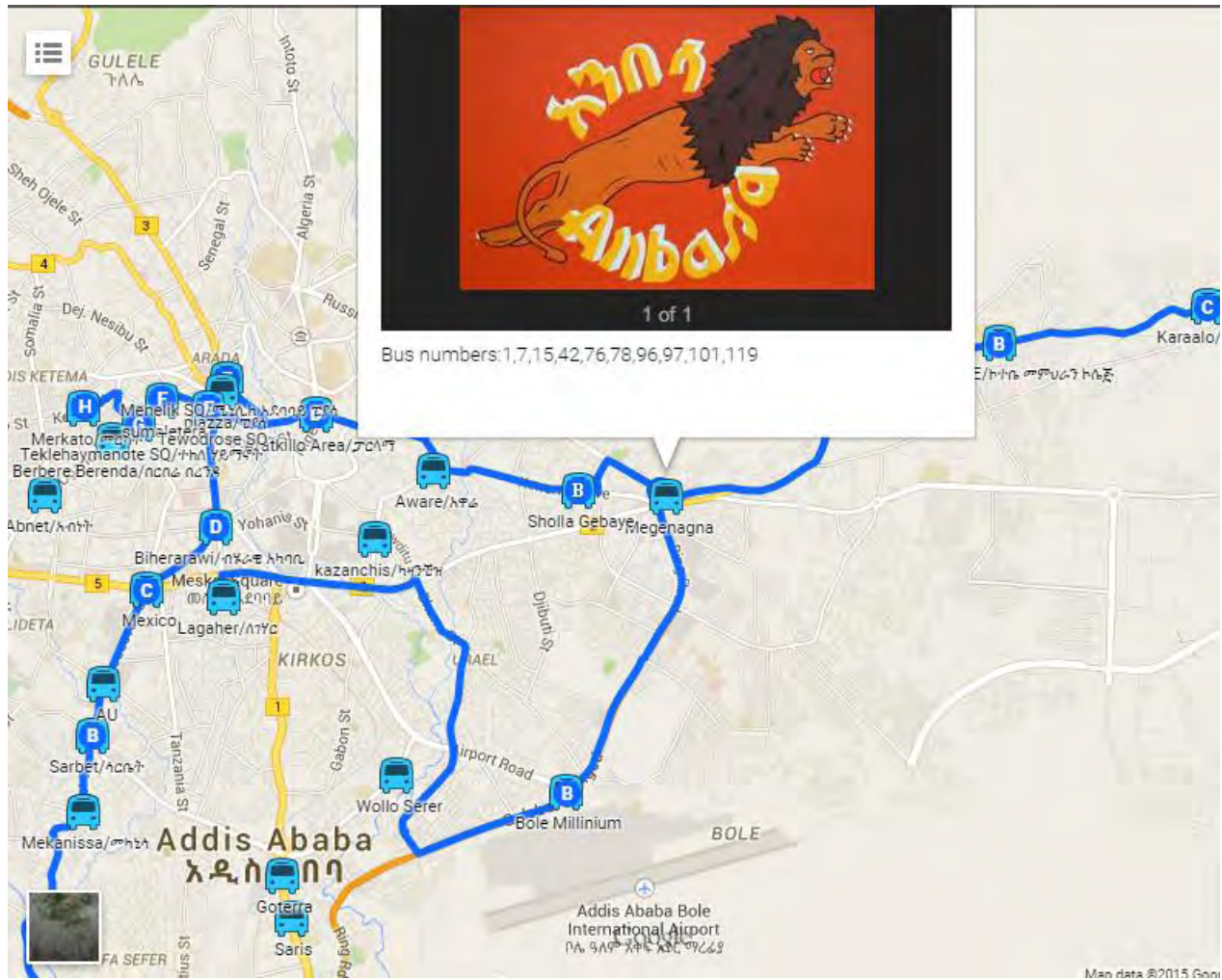


Figure 6.7: View Bus Number Station on Map

Administrator: The administrator component is designed for modifying route information using administrator authentication. On this subsystem the administrator can add and modify all necessary information related to ACB transportation service.

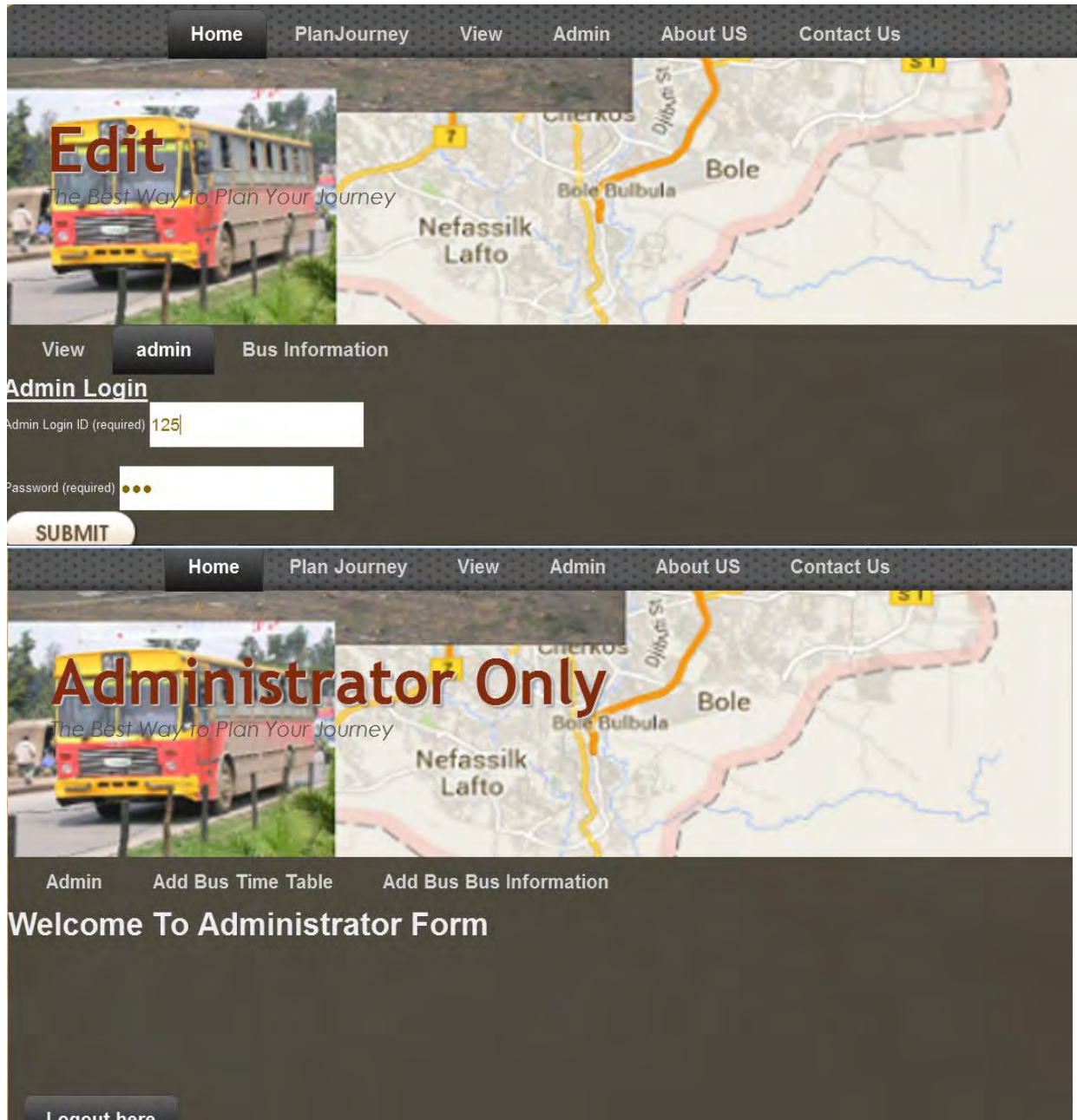


Figure 6.8: Screenshot of Admin Login Page

The screenshot shows a web form titled 'Update Bus Information'. At the top, there are three tabs: 'Update Bus Information' (active), 'View Bus Information', and 'view Bus Time Table'. The form contains the following fields and values:

- Bus Number: 103
- Number of bus per trip: 4
- Select Source: PIAZZA
- Pass through: Tewodros, SQ, Beherawi, Mexico, Torhayloch, ZenebeWork
- Select Destination: AYER TENA
- Distance: 8.9
- Tariff: 2.25

At the bottom of the form, there are four buttons: 'Submit', 'Update', 'Reset', and 'Close'.

Figure 6.9: Screenshot of Adding New Bus Information

6.3 Application Testing

System testing is a rigorous task to undertake especially in testing web based applications. This is due to the fact that a diversity of tests and approaches may be used in performing the tests.

Functionality Tests

This focused on the overall coherence of the site's objectives and output or if the application met its objectives and purposes with reference to user requirements and user stories stated in the methodology. This was conducted by cross referencing of user expected results with the output results from the service. This was similar to benchmarking the application by comparing its results to those on the ground. Input forms were also validated to check for invalid inputs. Orphaned pages, navigational links and buttons were also tested.

Usability Testing

This involved testing of the product with passengers in Addis Ababa city. The testing was more interested in observing and analyzing how the users completed tasks e.g. searching for routes, checking bus numbers, termini and destinations. This information later helped to analyze or determine user satisfaction of the application. This test was meant to test the design and flow of design logic and if the displayed results were satisfactory to a user. The main aim was to determine the design flaws, missing parts and to gather user experience. To enhance

usability and ease of use of the site, images and brief instructions were included in the application. Every page contained a menu and navigational links.

Questionnaire is an inquiry approach which has chosen to use for interface and functionality evaluation as a way to gather more data and feedbacks from users. We prepared simple questions that helped the users to answer the questions without any difficulty. We used twelve closed end questions answered by passengers; in case of time management to complete the questionnaire. The questions spanned across the various application tests mentioned in the application testing namely functionality, performance, compatibility, and usability and interface tests. The main aim was to capture feedback from various cross sections of users with varying income levels, educational, mobile or computer literacy and so on from the general population.

Firstly, it was purported that the most probable target user group composed of young and middle age people. These were people who often have access to Internet and computer and in most cases used mobile phones and computer often.

The evaluation of the prototype was done by passengers. We have used random sampling methods to select representative number of participants. There are 22 participants we have used in different age level and occupation levels. Some participants were can't understand the questionnaire by themselves but we interprets the questioner in to Amharic.

All of the participants evaluate the system using our laptop as server and their own mobile as client side. The participant gives their own recommendation and feedbacks based on their understanding. Before conducting the evaluation process, we explain some demonstration about the aim of the system and its prototype to participants. After demonstration the prototype, participants were provided with respective questions. There are five degrees of likers scales strongly agree(5),agree(4),less agree(3),disagree(2),strongly disagree(1) is used for the responses of the questions, the reason using this five likers for decrease the complexity of question and easy to interpreted by the participants. The questionnaires were distributed among the users in the form of hard copies. The designed questionnaire can be found in appendix 2.2.

Result of Testing

According to the user feedback obtained from 22 users in different age range and from different professional, educational back grounds and income levels the results have been presented below in the Table 6.1 and 6.2 and Figure 6.8. The results have been presented in percentages (Out of the total number of participants who took part in the test). Questionnaires and brief oral interviews were used to capture the user feedback. As result in table 6.1 there are 12 questionnaires which related to the design, organization of user interface, functionalities and compatibilities of the prototype.

Table 6.1: Summarized of the questionnaire results

Question No.	Participant Responses				
	5	4	3	2	1
1	17	4	1	0	0
2	11	8	3	0	0
3	16	4	2	0	0
4	11	10	1	0	0
5	14	4	4	0	0
6	15	6	0	1	0
7	11	7	2	2	0
8	14	6	1	1	0
9	13	6	0	2	1
10	6	5	4	4	3
11	11	5	4	2	0
12	11	8	2	1	0
Total	150	73	24	13	4

Key: 5= Strongly Agree, 4=Agree, 3=Less agree, 2=Disagree, 1=Strongly Disagree

Generally, based on Table 6.2 and Figure 6.8, shows that the 56.82 % of passengers/users are strongly agree that means the prototype well organized, compatible and fulfills the functionalities, 27.62% of passengers are agree on the prototype, 9.09 % of passengers are less agree, 4.9% of passengers are disagree on some parts of prototype and 1.52% of passengers/users are strongly

disagree. It is values showing here that “Strongly Agree” and “Agree” always positive impression, encouragement on the system and “Strongly disagree” always negative impression concerning usability.

Table 6.2: Analysis of Testing

Answer	Passenger	
	Number of Marked answered by users	Percentages (%)
Strongly Agree	150	56.82
Agree	73	27.65
Less Agree	24	9.09
Disagree	13	4.92
Strongly Disagree	4	1.52
Total	264	100

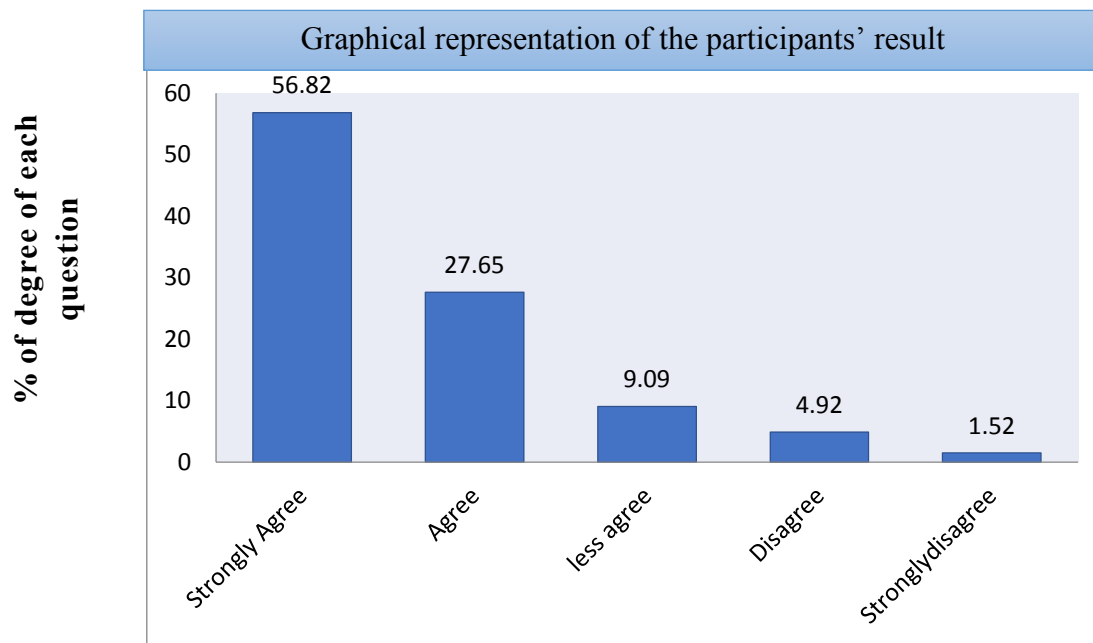


Figure 6.10: Graphical Analyses of Passengers

CHAPTER SEVEN: CONCLUSION AND FUTURE WORK

7.1 Conclusion

This project illustrates the mobile based public transport route planner system in Addis Ababa city and focused on mobile web application for Anbessa City bus route planner prototype.

From the project's objectives, mapping of some existing Anbessa city bus route for the study area including all stops, and bus check point was done. It is difficult to cover all parts of public transportation route because there is a lack of adequate data and the Anbessa city bus covers large distance over other.

In this system, the users could search from ACB routes based on source and destination. The searched results should list stations/checkpoints along the trip, display trip distance, time table and a map of a route.

Considering the specific needs and facts of passengers, we have designed and implemented a MBACBRIS used to provide bus route information for passengers and used to manage bus route information easily for ACBE workers. The prototype is implemented and tested in ACBE. The system tested on different mobile models (Huawei, Samsung, Nokia, and T-Mobile) which are support Wi-Fi connection and the evaluation shows successful implementation of the mobile web application. The system can run any mobile device which has internet browser. In addition, since the application is web based and it needs Internet connection that is provided by local ISP.

By reviewing the overall results from the usability test, questionnaires and interviews, we conclude that the ACBE prefer to use the implemented application. Although MBABRIS has many features, it could be possible to offer feedbacks, recommendations and to design more additional features and interfacing for the system that are easily to use, attractive and fulfill user's requirements.

7.2 Future Works

Some of the possible future works that strengthens the system so that it will be more useful and be somewhat complete and as well be capable of supporting the different functionalities needed related to public transport(ACB) route/journey information system are listed as follows:

- Implementing real time Information System: This is possibly the most useful public transport information; it provides the user with information about delays, cancellations, extra departures, or any other sudden changes in the public transport system.
- Most potential passengers of the system are Amharic language speakers. Therefore, the developed system can be enhanced by incorporating Amharic language at the interface and data storage level and making it multilingual.
- Implementation of route KML overlay as an alternative to JavaScript in plotting of routes as JavaScript contributed to overall slow loading of the map.
- A multimodal journey planner/guider is an IT system able to propose a set of one or more transport services answering at least the question “How can I go from location A to location B at a given departure/arrival time and under which conditions”. The most common point of access is via specific web service and mobile phones. When implement this concept in to the future work the system will be more effective and attractive.

REFERENCES

- [1] Federal Democratic Republic of Ethiopia Population Census Commission, Summary and Statistical Report of the 2007 Population and Housing Census. Population Size by Age and Sex, Addis Ababa, December 2008.
- [2] Report on statistical indicators of public transport performance in Africa, *Union Internationals des Transports Publics International Association of Public Transport*, Vol.3, April 2010
- [3] http://www.dezetube.com/article_read.php?a=448 visited on November 2013.
- [4] <http://addisfortune.net/articles/seventy-years-of-anbessa-buses>,by Yetneberk Tadele Fortune staff writer, Published on June 09, 2013 [Vol 13 ,No 684], visited on November 2013
- [5] Jonathan E. Campbell, Michael Shin, Geographic Information System Basics, Lard bucket Publisher, ed.1, 2012
- [6] IBIS Transport Consultants Ltd., 2005, Study of urban public transport conditions in Addis Ababa, Ethiopia
- [7] Addisu Andarge(2010).Public Transport Route Planner for Addis Ababa, *unpublished Master's Thesis*, Department of Computer Science, AAU, Addis Ababa, Ethiopia
- [8] Dejene Mengistu (2013). Modeling and Analysis of City Bus Scheduling System: Case of Anbessa City Bus Service Enterprise (ACBSE), *Master's Thesis*, Department of Computer Science, AAU, Addis Ababa, Ethiopia
- [9] Vukan R. Vuchic(2007). Urban Transit Systems and Technology, WILY Publisher
- [10] Richard Weiner (2008). Integration of Paratransit and Fixed-Route Transit Services, *Transit Cooperative Research Program*, Vol.76
- [11] <http://gis.com/content/what-gis> Visited on March ,2014
- [12] http://www.esri.com/what-is-gis/overview#top_five_panel, visited on 8, March 2014
- [13] Hanson S (2004).The Geography of Urban Transportation, 3rd edition. Guilford Press, New York
- [14] A P Vonderohe, L Travis, R L Smith (1993). V Tsai, NCHRP Report 359,Adaptation of Geographic Information Systems for Transportation ,*National research Council*, Washington Dc

- [15] Hensher D. (2004), Handbook of Transport Geography and Spatial Systems, Blackwell Publishing Ltd, Ed.5, London, UK.
- [16] Harvey J, Shih-Lung S., GIS-T Data Models. Excerpts from Geographic Information Systems for Transportation: Principles and Applications, *Oxford University presses* (Online).
- [17] <http://2012books.lardbucket.org/books/geographic-information-system-basics/s08-data-models-for-gis.html> visited on 5 April 2014
- [18] <http://www.developer.com/java/j2me/article.php/1561591/MIDP-Programming-with-J2ME.htm> ,visited on April, 2014
- [19] <http://www.idc.com/getdoc.jsp?containerId=prUS23946013> ,visited April ,2014
- [20] http://en.wikipedia.org/wiki/Google_Maps visited on April, 2014
- [21] <https://developers.google.com/maps/documentation/javascript/tutorial>, Visited on April ,2014
- [22] http://www.google.com/intl/en_uk/enterprise/earthmaps/maps.html#utm_campaign=en%26utm_source=en-ha-emea-nosk%26utm_medium=ha%26utm_term=google%20maps%20API, visited on April ,2014
- [23] Ayele Admassu (2008). Implementation of Online Route Finder for Addis Ababa City, *unpublished Master's Project*, Department of Computer Sciences, AAU, Addis Ababa, Ethiopia
- [24] R. Fieldning, J. Gettys, J. Mogul, H. Frystyk, L. Masinter, P. Leach, and T. BernersLee. Hypertext Transfer Protocol (HTTP/1.1). IETF Network Working Group, Available from: <http://tools.ietf.org/html/rfc2616>.
- [25] J. Y. B. Lee. (2005). Scalable continuous media streaming systems: Architecture, design, analysis and implementation. John Wiley & Sons, Ltd. Kong Kong, China
- [26] R. Pantos and W. May. HTTP Live Streaming, version 6. IETF Internet-Draft [updated 2011, March 31; cited 2011, April 6]. Available from: <http://tools.ietf.org/html/draft-pantos-http-live-streaming-06>.
- [27] T. Stockhammer. Dynamic Adaptive Streaming over HTTP - Standards and Design Principles. ACM Multimedia Systems Conference (MMSys). 2011, February 23-25. San Jose, California, USA.
- [28] <https://people.hofstra.edu/geotrans/eng/methods/ch1m4en.html> visited on December, 2014

Appendix

Appendix 1: Sequence diagram

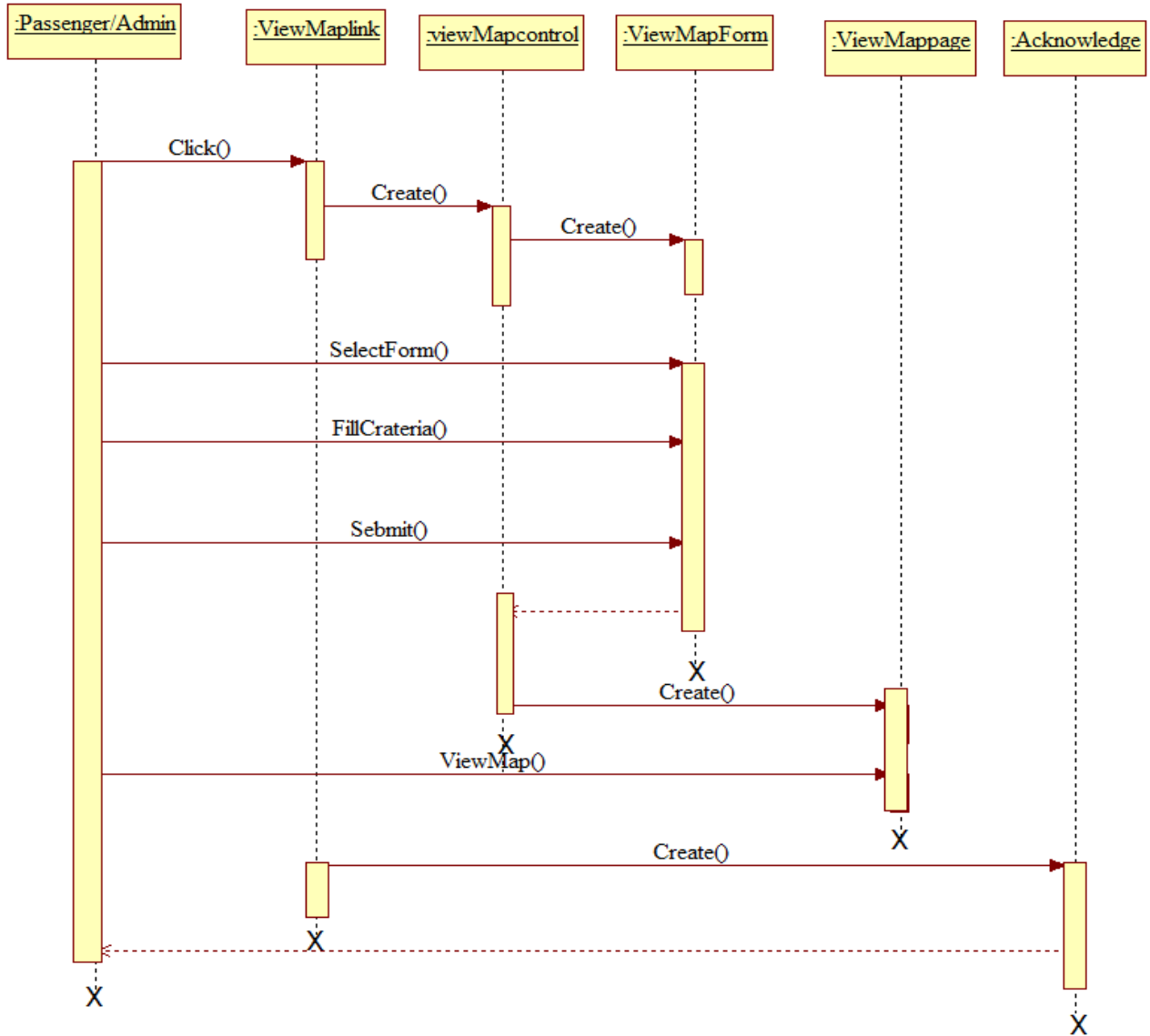


Figure 1.1: View Bus Route Map Sequence Diagram

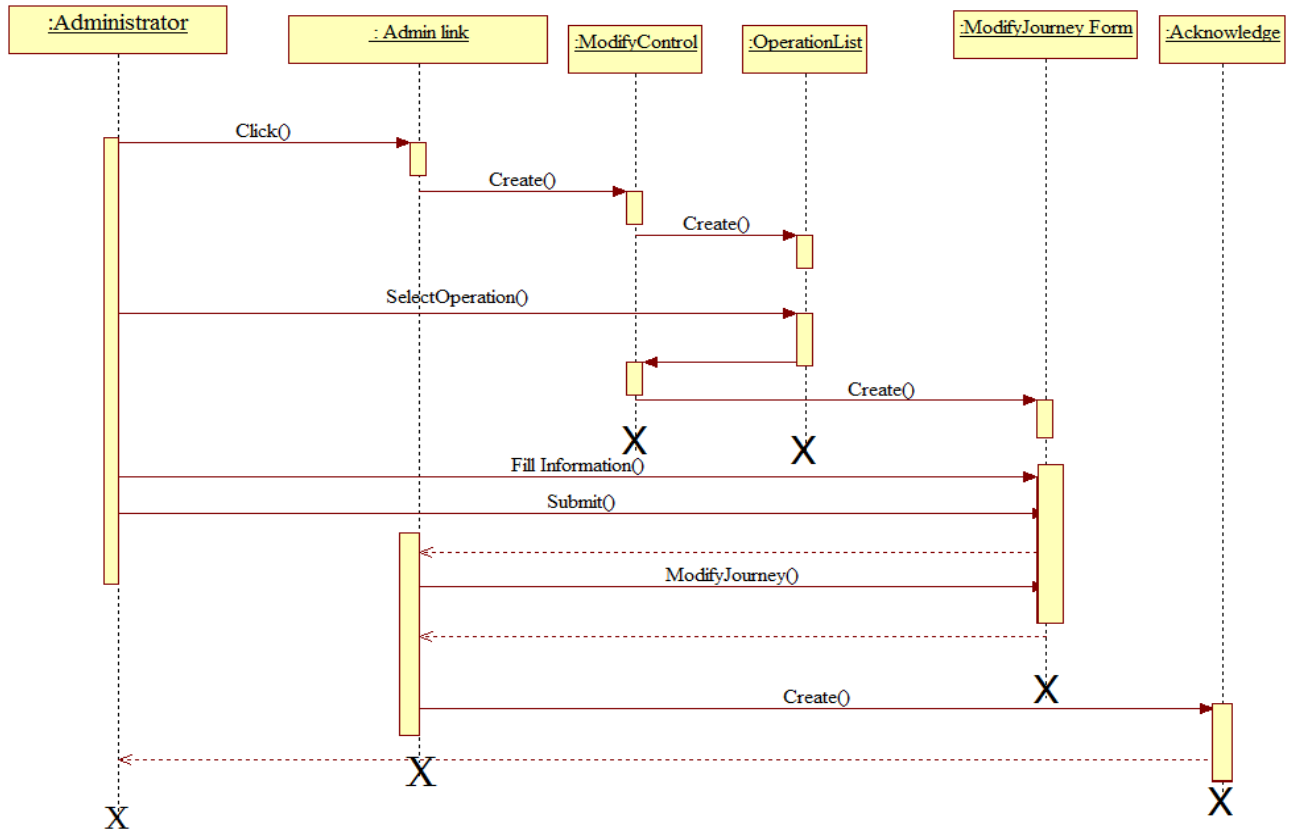


Figure 1.2: Modify system sequence diagram

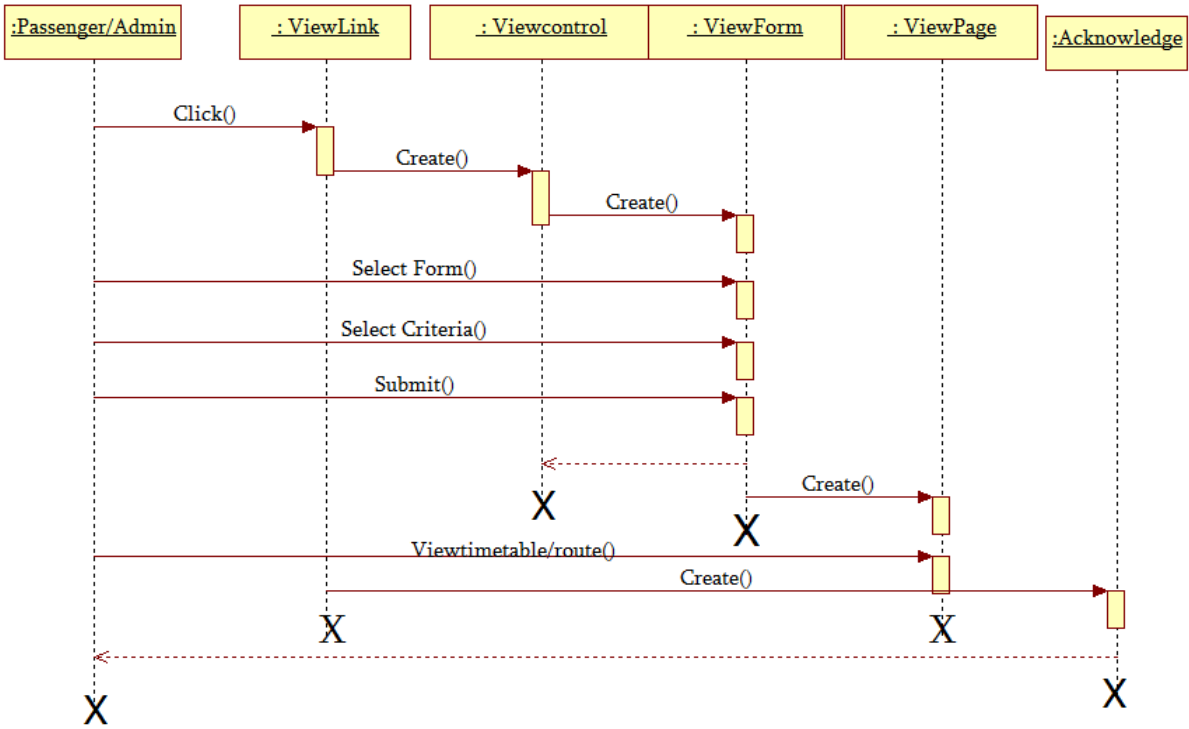


Figure 1.3: View Sequence diagram

Appendix 2 Passenger Interview and Questionnaire

Appendix 2.1

Passenger interview

1. What is the benefit of Anbessa City Bus Transportation for you?
2. When you used Anbessa city Bus?
3. How many years you used Anbessa City Bus transportation service?
4. What is the drawback of Anbessa City Bus Transportation service?
5. Which transport is comfortable for you
 - A) Taxi
 - B). City Bus
6. Do you have any complaint on Anbessa city bus?
7. What is the big challenge travel from one place to another place in Addis Ababa city?

Appendix 2.2

Application Testing Questionnaire for users

Place of test: _____ Date: _____

Participant's Name: _____

Email: _____ Phone No. : _____

Participant's Occupation: _____

No	Questionnaire for usability Evolution	Evaluation value				
		5	4	3	2	1
1	The system is clear, easy and understandable					
2	Information presented/displayed on screen is easy to comprehend quickly					
3	The system provides appropriate information for passengers					
4	Link are clear and unambiguous					
5	The system solves complexity of asking bus no for a single route					
6	The user interface is well organized and functional					
7	Did you understand the functionality of each links					
8	The system meets the overall required functionalities about ACB route information					
9	This system incorporates all necessary information of ACB like route information, bus time table, etc.					
10	The route map is loaded quickly					
11	The response time of the system is fast					
12	The route map is basic for passenger					

5: strongly agree, 4: Agree, 3: Less Agree, 2: Disagree, 1: Strongly Disagree

Declaration

I, the undersigned, declare that this project is my original work and has not been presented for a degree in any other university, and that all source of materials used for the project have been properly approved.

Declared by:

Name: _____

Signature: _____

Date: _____

Confirmed by Advisor:

Name: _____

Signature: _____

Date: _____