



Addis Ababa University
College of Natural Sciences

GIS Based Road Traffic Accident Management System:
The case of Addis Ababa

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GIS Based Road Traffic Accident Management System:
The case of Addis Ababa

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Abstract

The issue of road safety, especially in the developing world, has already become multidimensional; that is, it has become an economic, social and health issue. Currently, studies shows that road traffic accidents in Ethiopia specifically in Addis Ababa city are pressing problems which need urgent attention as it has damaging consequences on the health and economic development of the city. There is no formal system for accident location referencing in Addis Ababa, consequently, it makes it difficult to treat accident spots with proper road safety measures. In addition, since there is no GIS based system available which effectively locate accident prone locations it is difficult to identify these hazardous locations. Identification of hazardous or most vulnerable accident locations (black spots), types of accidents and persons involved, form the basis for road safety policy design. A more flexible database with location details is necessary if road safety priorities are going to be more accurately identified and to take remedial measures to mitigate the existing problem.

In this work, we have developed a system that is web based GIS system which convey accident locations directly on a map, perform spatial analysis such as black spot analysis and spatial query. In addition, it generates different kind of summarized reports in different printable file formats. The system has subsystems to manage road traffic accidents, to manage traffic accident offenders, to manage road traffic accident spatial and non-spatial data, to manage reports and finally, to manage system users. The system has an Amharic interface which enhances its learnability and will make it user friendly for end users.

The functional requirement was gathered comprehensively by interviewing police officers and investigators from Addis Ababa Police Commission. Furthermore, related literatures and best practices from abroad were reviewed to enable us design and implement the system efficiently.

The developed system was evaluated by domain experts and stakeholders. The usability test conducted has indicated that the performance of the system was very good and it meets its objective.

Keywords: Black Spot, Geoserver, GIS, Jasper Soft, JSF, Postgres, Road Traffic Accident

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Acronyms and Abbreviations

API	Application Programming Interface
FOSS	Free Open Source Software
GIS	Geographical Information System
GIS-RAV	GIS based Road Accident View System
GPS	Geographical Positioning System
GRTAMS	GIS Based Road Traffic Accident Management System
HTTP	Hypertext Transfer Protocol
IDE	Integrated Development Environment
ITCR	Illinois Traffic Crash Reports
JDBC	Java Database Connector
JPA	Java persistence Application Programming Interface
OGC	Open Geospatial Consortium
ORM	Object Relational Mapping
POJO	Plain Old Java Object
RTA	Road Traffic Accident
SAS	Statistical Analysis Software
SLD	Style Layer Descriptor
SQL	Structured query Language
TAIS	Traffic Accident Information System
TAVS	Traffic Accident Viewing System
URL	Uniform Resource Locator
WFS	Web Feature Service
WMS	Web Map Service

XHTML Extensible Hyper Text Markup Language

XML Extensible Markup Language

CHAPTER ONE: INTRODUCTION

1.1 Background

Road traffic accident (RTA) defined as “an accident that occurred on a way or street open to public traffic; resulted in one or more persons being killed or injured, and at least one moving vehicle was involved. Thus, RTA can be occurred when a collision between vehicles; between vehicles and pedestrians; between vehicles and animals; and/or between vehicles and fixed obstacles” [1].

RTA is a major global public health challenge, as statistical figures prove every year about 1.2 million people are killed and more than 20 million are injured or disabled globally [1]. According to the World Bank and United Nations Economic Commission for Africa study, it was confirmed that Ethiopia has one of the highest fatality rates per vehicle in the world. It is in excess of 100 fatalities per 10,000 vehicles. It is the largest number in relation to countries like Kenya and United Kingdom, where the figure is about 19 and 2 per 10,000 vehicles, respectively [1].

The work of Hailu and Teshager [2], shows that road traffic accidents in Ethiopia are problems which need urgent attention as it has damaging consequences on the health and economic development of the country. Therefore, immediate preventive action should be taken to mitigate the increasing number of road traffic accidents which are the main causes for fatalities and injuries in roads and streets. An efficient strategy to improve road safety is to equip traffic policemen with state of the art technologies and applying other preventive measures.

Road traffic laws and policies depend on a large number of factors. Making a correct decision for traffic management can be difficult because decision makers need to analyze and absorb a large quantity of information. This information can be vague and sometime conflicting in nature. Therefore, there is a need for a better control and a reliable and consistent system to help simplify the traffic decision making process.

Currently, there is no formal system for accident location referencing in Addis Ababa. This is a fundamental deficiency in the accident records kept by the Addis Ababa police

commission. The attending officers are supposed to use their discretions to describe the location of the road accident, but most of them do not attach much importance to accident location and simply ignore this attribute. In certain cases, very ambiguous descriptions, such as “a long a given road A”, are used. Generally, accident locations are described in words and in general terms with often a road name, or the nearest landmark known to the traffic police officer used. Which makes it difficult to treat accident spots with proper road safety measures.

Identification of hazardous or most vulnerable accident locations (black spots), types of accidents and persons involved, form the basis for road safety policy design. In safety analysis, different aspects of location's accident history including crash frequency, severity, type and environment, may be used to identify hazardous locations. Because funds for safety work may be limited, it is vital to identify the most hazardous roads and locations which may require urgent remedial measures. Currently, since there is no GIS based system available which effectively locate accident prone locations, it is difficult to identify these hazardous locations.

This work proposes a GIS based road traffic accident management system to support traffic police officers to correctly identify accident locations and black spots to improve road safety in Addis Ababa city.

1.2 Statement of the Problem

The issue of road safety, especially in the developing world, has already become multidimensional; that is, it has become an economic, social and health issue. Since road traffic accidents have damaging effect, currently in Addis Ababa and the country at large it is one of the major issues in different media including televisions, radios, magazines, newspapers and social networking websites. By virtue of this fact, accidents on the city's road network have claimed the lives of citizens each year accompanied by substantial economic loss.

According to the Ethiopian Road Authority report, about 1700 deaths announced each year in road accident with another 7000 reported injuries [3]. The number could be even double, since there may be unreported accident victims to the Police and the possibility of underreporting or unregistered injuries and fatalities. Subsequently, underreporting is one of

the problems for data credibility. The largest road accident problem is caused by drivers' error [3]. Which accounts for 81% of the total annual accident. This directs the government to exert maximum effort to reduce the accident by creating awareness for drivers and take extra care when issuing driving licenses. Furthermore, to put strict rules and regulations in place to further mitigate road traffic accidents [4]. Improvement of the road infrastructure help for the reduction of road traffic accidents. Accidents occur at both constructions as well as operation phases of roads. The major causes during construction phase are attributed to absence of warning signs at critical spots in the construction sites. During operation phase, absence of signs, damages on and theft of signs, and road features related to geometry contribute to deterioration of road safety. Above all, it is found that the human factor shares the bulk of road crash causes. "A motor vehicle is more than 5 times as likely to cause a fatality in Ethiopia than in Zambia or Botswana and more than twice as likely as a motor vehicle in Tanzania or Kenya"[3].

Individual accidents are not electronically registered, consequently, analysis is limited. For instance, it is not possible to sort out accidents by sex and analysis for any patterns with time or month(s) of the year [3].

Most related works reviewed demonstrate that road traffic accident management systems exists generally in two forms as GIS based desktop and web applications. Both help to easily visualize accident locations and accident analysis. Most of these works are developed for specific locations and specific problem domains that will make it very difficult to be used in any location. In addition, these products are very expensive and subjected to licensing issues.

Currently, all stakeholders (Addis Ababa road Authority, Addis Ababa transport Authority, Insurances, etc.) are not working in synchronized and coherent way. As a result, we get fragmented and disparate data, which is not useful to identify key causes of accidents, to take swift intervention measures, to generate better policies and procedures which help to reduce road traffic accidents and improve road safety by taking proactive measures. However, when stakeholders access and generate reports from the same system which will provide accurate and reliable data, it will enable them to take fast and appropriate intervention measures. The collaboration of all stakeholders is critical for the effectiveness

of such systems to be developed as it insures that there is better and more systematic information available for updating and keeping the integrity of the road traffic accident data management system database.

Traffic police officers at the scene of the accident use visual estimation of the distance from land marks known to them to locate the accident as having occurred close to the said land mark. In other cases, the location of the road traffic accident is recorded as being along a given road or in a given residential area. This type of referencing is not very helpful for accident spot treatment in terms of road redesigning or reengineering and development of other road safety measures which are meant to reduce road accidents at specific locations. In case of a long road, for example, it is difficult to determine where exactly along the said road the accident occurred.

There is a need for cities in developing countries like Ethiopia to focus on evolving technologies in GPS and GIS that are most promising in terms of improving quality, accuracy, completeness and timeliness of road accident data. In addition, it help in understanding the relationship between crashes, their distribution and the environment in which they occur. This is crucial in developing location-specific road safety countermeasures. This will not only enhance reliability of results on which sound safety policy and planning may be based, but will also reduce the demands on traffic police officers and traffic police investigators.

Currently, since there is no formal system with spatial data analysis in Addis Ababa Police Commission, it is difficult to identify accident prone locations (black spots) in Addis Ababa. Where there are high concentrations of road accidents with fatalities. Determination of black spots is the first step to improve the level of traffic safety on the roads. Interventions in places of accumulation of fatal road traffic accidents are considered one of the most effective approaches in prevention of traffic accidents on roads. A more flexible database with location details is necessary if road safety priorities are going to be more accurately identified and remedial measures to extenuate the existing problem.

1.3. Objective

General Objective

The general objective of the project is to design and implement GIS based road traffic accident management system.

Specific Objectives

To achieve the general objective of the study, the specific objectives are:

- To review different literatures on the subject area.
- To asses and understand the existing traffic accident management practice.
- To extract implicit and explicit knowledge on types of car accidents, major causes and mitigation measures.
- To model and represent knowledge acquired from domain experts
- To design the architectures of the system
- To build a system for GIS based road traffic accident management system
- To evaluate the performance of the system

1.4 Methodology

1.4.1 Data Collection

To conduct the project, primary data was collected from domain experts from Addis Ababa Police commission. To acquire relevant knowledge for designing the system, interview and document analysis techniques was employed.

1.4.2 Development Technologies

In this project work, the system was implemented using java language on eclipse neon version which is an IDE. For the web application, JSF will be used to create web user interfaces and Apache Tomcat will be used as web server to handle client requests. Postgresql database and its spatial data extender PostGIS will be used to store both spatial and non-spatial data in an integrated way. In addition, Geoserver will be used to allow users to share, process, analyze, query and edit geospatial data from Postgresql database. Lastly, Jasper Soft will be used as a reporting tool to generate different kind of RTA reports.

1.5 Scope and Limitations

This project is limited on designing web based GIS road traffic accident management system for Addis Ababa city, which supports Amharic language.

1.6 Application of Results

The findings of this project:

- Will benefit traffic polices and investigators to register and georeference accident location. In addition, to view graphically using maps and for analysis purpose such as black spot analysis and spatial query.
- Will benefit insurance companies for identifying vehicles and clients involved frequently in fatal accidents.
- Will help Addis Ababa road authority to identify and take measures on roads with high accident rates.
- Will help policy makers to prepare road safety policies based on the causes of accidents.
- Will help ordinary citizens to be vigilant while driving or crossing roads with high accident frequencies by providing related information.

1.8 Organization of the Rest of the Thesis

The rest of the thesis is organized as follows. Chapter Two presents literature reviewed on the subject domain. The Third Chapter discusses related works done or related systems developed. Chapter Four presents requirement analysis. The Fifth Chapter outlines how the proposed system was designed. Chapter Six presents the system. Finally, the last chapter presents conclusion and future work.

CHAPTER TWO: LITERATURE REVIEW

2.1 Geographic Information System

“In general, GIS may be defined as a computer-based information system, which attempts to capture, store, manipulate, analyze and display spatially referenced and associated tabular attribute data, for solving complex research, planning and management problems. In road safety research, GIS is a tool with great potential for structuring information to improve monitoring and evaluation of road accident study and assist in related Policy decisions” [5]. There are several advantages of GIS and some of them are described below.

Traditionally, accidents are dissected by requesting desired information from the non-spatial accident database to visually display related quantitative information. The use of GIS has added another magnitude which changed the way to assess accidents. GIS has the capability for connecting to different database types including Microsoft Access and Oracle which enables it to extract accident data from different platforms. Moreover, some of the powerful statistical analyses software provide a service to connect to GIS, which makes it possible for running complicated statistical models, and directly view the results of the model diagrammatically in GIS. It has its strength in providing visual and logical capabilities to precisely model and represent spatial features. GIS has flexibility in modeling spatial objects to appropriately satisfy the specific requirement of the user or application which makes it very interesting. GIS provides tools and applications for spatial data manipulation, spatial data query and analysis, and for map operations [6].

2.2 Road Traffic Accident Database

Existing accident data record by traffic police do not reflect the actual cause of road accident, and less useful for scientific analysis [7]. A comprehensive data collection is required to identify exact causes of accidents and for design of counter measures.

For most purposes, the database needs to be able to answer the following questions [8]:

- where accidents occur: location by map coordinates, road name and kilo meter post
- when accidents occur: by year, month, day of week, time of day
- who was involved: people, vehicles, animals, roadside objects
- what was result of collision: worst severity of injury or property damage
- what environmental conditions existed: poor light, weather, road surface condition

- why or how did collision occur: collision type and driver fault type

2.3 Users of Road Traffic Accident Data

Sharing up-to-date and consistent road traffic accident data is of paramount importance to different agencies that play key role for improving road safety. It is important for the police, if the vehicle is going too fast; for the highway authority, if the road is poorly maintained, and for the educational department for lack of awareness of safety measures.

Road traffic accident information can be used for stakeholders as three “E’s” [9]:

- Enforcement
- Engineering
- Education

2.4 Application of GIS for Road Traffic Accident Data Management Systems

The major reason for the rapid increase in the usage of Geographic Information Systems (GIS) is its capability to analyze and represent spatial elements such as land use, population density, population distribution, socio-economic elements, environmental factors which have strong influences on road traffic accident occurrence [10]. GIS has many functionalities which make it popular for use, among them are to geocode crash locations, to display accident sites on maps, to efficiently integrate and handle data from several sources. It was used to identify road section collisions, to discover snow related collision sites and to identify road sections and junctions with high pedestrian and bicycle related collisions by using spatial statistical techniques.

2.5 Key Functionality of Road Traffic Accident Data Management Systems

Most road traffic accident data management systems existing in the world have four basic components to the way an accident data operates:

- ❖ accident recording
- ❖ accident data storage and retrieval
- ❖ Accident reporting & analysis.
- ❖ Accident Location referencing

2.5.1 Accident Recording

Maintaining comprehensive road accident database and analysis system will play an integral role and it is an imperative element in road safety and to find factors contributing for the increasing figures of road traffic accidents [11]. Moreover, it provides techniques for

gathering of valuable, precise and valid data, to organize road safety visions and it will infuse better understanding on the sources of road traffic accidents. Even though different countries use different data fields for capturing accident data, Table 2.1 summarizes the most common ones [8,9,11].

Table 2.1 Common Data Fields of Traffic accident [8, 9, 11]

General Details	Road Type	Environmental Condition	Precise Location
<ul style="list-style-type: none"> ▪ Accident Id ▪ Year ▪ Month ▪ Date ▪ Time ▪ Region/State ▪ Police Station reference ▪ Severity ▪ Collision Type ▪ Number of vehicles involved ▪ Number of casualties ▪ Contributory factors code 	<ul style="list-style-type: none"> ▪ Class of road/road number ▪ Carriageway type/no.of lanes ▪ Speed limit ▪ Junction type ▪ Road width ▪ Roadshoulder width 	<ul style="list-style-type: none"> ▪ Light condition ▪ Road lighting ▪ Road surface condition ▪ road surface quality ▪ Weather ▪ Junction control ▪ Geometry ▪ Hit & run ▪ Road works 	<ul style="list-style-type: none"> ▪ Map reference ▪ X-coordinate ▪ Y-coordinate ▪ Kilometer post ▪ Location description ▪ Accident description
Vehicle /Driver Details			
<ul style="list-style-type: none"> ▪ Vehicle type ▪ Vehicle damage ▪ Length of skid marks ▪ Vehicle Owner 		<ul style="list-style-type: none"> ▪ Driver age ▪ Driver sex ▪ License no. ▪ Seat belt/helmet ▪ Alcohol/drugs suspected 	
Causality Details			
<ul style="list-style-type: none"> ▪ Type of road user ▪ Age ▪ Sex ▪ Severity of injury ▪ Passenger location 		<ul style="list-style-type: none"> ▪ Pedestrian location ▪ Pedestrian movement ▪ Passenger location ▪ School pupil 	

2.5.2 Accident Data storage and Retrieval

For GIS based systems, there must be a database which incorporates both spatial and non-spatial data. Retrieval of data also must be easy and user friendly. In addition, the database must be efficient for analysis and reporting purposes. Extra care must be taken to select efficient database based on data size, speed of accessing data and the ability to support spatial data. Oracle, Postgresql, DB2 will fit for this aim. Finally, the database must be sharable and available for all allowed stakeholders for update and enquiry.

2.5.3 Accident Reporting and Analysis

The system must support different kind of reports using different kind of conditions so that it will be of great benefit for analyzing different scenarios that will help in finding the root cause of accidents and to propose policies, procedures and safety measures which will play a key role in reducing road traffic accidents and improving road safety. In addition, GIS based systems may benefit from using GIS built-in analysis functions for analyzing further.

2.5.4 Accident Location Referencing

Accident location is a very crucial element in road traffic accident data. There are different ways to locate accident locations. We can use highway number, street name, building or shopping mall near the scene of the accident. But the advent of global positioning system (GPS) device which is a satellite-based navigation system along with GIS makes it very precise and easy to locate accident places. As a result, precise identification of the accident location will improve safety analysis and in identifying black spots.

2.6 Black Spot Identification and Analysis

In cities, towns, but also in rural areas road traffic accidents often cluster at specify places. These are often junctions, but may also be private access roads, curves, railways, high way, roundabout, crossings, hill tops, narrow road street or bridges.

Even though, there is no universally accepted definition of a black spot, the above mentioned places generally named as an accident black-spot, a term used in road safety management to denote a place where road traffic accidents have historically been concentrated. The accumulation of these accidents on these locations may be attributed to various reasons, such as narrow roads or junctions in a straight road, so oncoming traffic is invisible, poor or concealed road warning signs, hidden intersection on highways. Moreover, it may be resulted from defective geometric design of roads for instance, wrong slope, and weak design of lanes, defective circular junctions and poor pedestrian passageways.

2.6.1 Identification of Accident Black spots

Black spot identification is important for road safety. If not, resources can be wasted on sites that are incorrectly identified as potentially unsafe. But sites that are truly unsafe can go untreated and remain unsafe. Therefore, black spot identification is an essential step for treating hazardous locations. Globally, there are different techniques to identify black spot locations. The methodologies vary from location with known high accident records to complicated location where the expected accidents to occur and the possibility to improve road safety are decided.

Hazardous location or black spots are identified on facts such as, recorded accident data, traffic volume and traffic flow, which is determined by multiplying the number of vehicles on a given road or traffic network by the average length of their trips measured in kilometers. Using methods such as, field investigations, past studies, questionnaires and interviews, etc. can be additional information for the accident data. To classify a road segments as black spots different countries adopt different methods. Among these different techniques, the following techniques are very important and common ones:

1. Critical crash rate factor method: this method labels a particular location as black spot if the car crash rate on this location is higher than the average .Since traffic crashes are random occurrences and can be considered as rare events, it is not possible to identify hazardous locations simply on the basis of the number of car collisions or accident [12].
2. Number of accidents (crash frequency) method: This is the simplest method that uses the number of car crashes or accidents at a location to identify its safety performance. Locations with more than expected number of accidents are categorized as hazardous locations [13].
3. Accident density method: The accident density is calculated from the number of accidents per unit length for a segment of the road. Segments with more than expected number of accidents are categorized as black spot locations [14].
4. Accident rate (Crash rate) method: This method uses accident numbers divided by vehicle exposure to provide rates such as accidents per million entering vehicles per spot location and accidents per million vehicle-miles for segment of the roads. Locations with higher than expected rate are categorized as hazardous locations [15].

5. Severity index method: The concept of this method is that the number of fatal and/or injury accidents at a location or segment of a road are given a greater weight than property-damage-only accidents. Cautions should be exercised to select the proper weights when using this method. The weights should ideally be based on socio-economic values [14].

2.6.2 Analysis of Accident Black Spots

GIS is a very effective tool in analyzing accident black spots. Its advantage is that it can present both the geographical positions of the accidents and the information about the accident details.

Hazardous locations can be identified using one of the following criteria [16]:

Accident with Casualties: all the accidents with victims will be selected from the accident database and analysis will be done on it to identify whether it fulfills black spot features.

Accident Cost: using specific cost amount as standard caused by road accidents and analysis is done on it to display it as hazardous location on a map

Number of People Involved in an Accident: The number of people involved in an Accident may be used as an indicator for a black spot

Accidents Involving Pedestrians: pedestrians are the most endangered group in a traffic accidents and more pedestrian causality in an accident implies how hazard the location is and the work needed to improve its infrastructure

Night Time Accidents: as these kinds of accidents increase, it demonstrate, the need for fixing defective traffic lights and to improve the sight on the road. At the same time, it will indicate how vulnerable the location is for accidents.

Peak Hours Accidents: the increase in these accident types is used to showcase the number of people using the road at peak hours (morning and afternoon). Accordingly, it will clearly present the location as a candidate for a black spot and for an immediate mitigation measure to be taken.

Based on the interview received from Addis Ababa police commission officials, a black spot in Addis Ababa is defined as a location within 150 meters radius where from road traffic accidents occurring at this location for one year period at least four or more of them are fatal. As a result, black spot locations are identified using number of road traffic accidents with fatal consequences. The classification and ranking among black spot locations depends

on the number of fatalities caused by road traffic accidents occurred on those hazardous locations annually.

CHAPTER THREE: RELATED WORK

Different kinds of GIS based applications have been developed for road traffic accidents around the globe. This chapter reviews some of the available GIS based road accident data management systems.

3.1 Development of a Web GIS Supported Road Traffic Accident Data Management System: A Case Study of Nairobi County

The main objective in developing this system is to use the ability of Web GIS in management of road traffic accident related data for Nairobi County to improve road safety, to automate the existing manual system, and to improve data access time which was limited only to office working hours [17]. In addition, it has the following specific objectives:

- To develop a spatial database for road accident incidences in the Nairobi County;
- To develop a web user interface that accesses the database
- To construct a logic tier that links the database with the user interface

The system was developed using free open source web GIS tools and Postgresql is used as database with Postgis as spatial database extender.

Accident statistics, hospitals and police stations data were provided without spatial information. To address this shortcoming, their locations were inferred from Google Earth Imagery where location was marked and saved as Keyhole Markup Language (KML) files. These were then loaded in Quantum GIS and converted to shape-files and attributed accordingly so that to be used with those open sources free GIS tools.

The system provides

- Public website on the Internet which provides end-to-end experience for data users from data access to data analysis to sharing or dissemination.
- Road traffic accident reporting
- Accident location using Google maps based on textual description of the accident
- Map display for visualization of accident sites
- Analysis and reporting using different techniques such as :
 - Box plots to give information about means of various accident data grouping
 - Pie charts for different kind of reporting

3.2 Geographical Kerala Accident Management System (GeoKAMS)

GeoKAMS [18] is an accident data management system for Kerala state in India that facilitates efficient recording and analysis of road accident data. GeoKAMS ensures collaboration among traffic police, road engineering departments, motor vehicles departments, insurance companies and non-government agencies involved in road safety. The software can be integrated with the police records and can be maintained by the crime records bureau, traffic police stations and/or road engineering departments. GeoKAMS has six modules:-

- ❖ Accident report form: This module is used to capture all manual accidents registered by Kerala police officers. The computer operators will input all accident information on the system. Handheld scanners were used to input accident diagrams.
- ❖ GIS engine: this is used to display accidents on digital maps and to do spatial analysis and to identify hazardous locations.
- ❖ Analysis engine: this module provides different kinds of analysis such as cross tab analysis, stick analysis, kilometer analysis, and produce collision diagrams.
- ❖ Standard reports: this module produces different kind of reports such as accidents based on severity, accidents classified according to type of area, time, weather conditions, road conditions, day of the week, vehicle types, passenger/pedestrian casualty statistics.
- ❖ Dynamic query builder: this module allows us to view some parts of accident data.
- ❖ Administration and Tools: this module used to administer the system using access rights and privileges. In addition, it is used for managing all digital map operations and for monitoring purpose.

The application is platform-independent and now works on both Windows and Linux operating systems. Other features include support for multiple databases, support for multiple GIS formats and automatic collision diagram generation with vehicular movements.

3.3 A Road Traffic Management System for Dalian Based on GIS and Web GIS

A road traffic accident management system was developed for Dalian, a Chinese port city based on web GIS. The systems consist of three module, namely Database Module, Shortest Path searching module and Web GIS module [19].

Database Module: a spatial database was prepared manually digitizing and then representing intersections and road segments as points and polylines within GIS from the Dalian map. In addition, corresponding names, widths, traffic volumes, approach numbers to intersections and road segments were added. Map basic programs run behind MapInfo are responsible for analyzing graphic object and attributes, while visual basic programs are responsible to connect, display and manage the outside database and offer photo showing and management functions.

Shortest Path Searching Module: This module provides the visualizations and searching function. To search a path from GIS data in short time and for performance reason, Dijkstra algorithm was used. On the other hand, to save memory space and speed up shortest path searching algorithm, the road network was represented with the arc section principle. Where each arc section is marked with the origin and destination node numbers. Furthermore, to solve the difficulty of searching the path in a short time, the system adopts the method of indexed array that arrange arcs by their origin node number. Therefore, these modules enable users to select start and end node visually and get the shortest-path easily.

Web GIS Module: this module is used for remote access of the system through the server using the client server mode. The server will respond to any remote users' web request. Users can visit GIS database and get page that includes texts and pictures. Remote users are not obliged to install any display plug-in to the browser; all operations and analyses are finished in the server. This method has fully utilized resources of server and reduced the burden of remote user.

3.4 GIS based Road Accident View System (GIS-RAV)

The system is divided into two main functions and two minor functions in four different modules. The main functions are node analysis, distribution plot whereas the minor ones are accident ranking and search engine [20].

Node Analysis: It has location particular or information, location photos, accident analysis functions. The location information displays some location information, for instance, the name of the intersection, node numbers, zone, road system, nearest indicator and road condition. The purpose of location photo is to give the visualization at a particular site. The accident analysis function portrays visualized severity analysis, time analysis, collision analysis and vehicle analysis. The severity analysis performs the accident severity at that

particular location. The severity types are in terms of fatal accident, serious accident, injury accident and damage accident. The time analysis shows the daytime and nighttime accident. The collision analysis performs the collision type that happened at a particular location. The vehicle analysis performs the type of vehicle that is involved in the accident at the selected location.

Distribution Plot

It is used to plot accident distribution, display and overview the overall accident cases in university of Putra in Malaysia. There are a few of distribution plot such as severity plot, time plot, collision plot, and vehicle plot. All types of the distribution plot are based on the user requirement, and this function can be considered as part of the query system provided by GIS-RAV System.

Search Engine

Search engine is one of the most important tools that is used to locate or search a location and accident data directly on a digital map. Basically, the search engine is divided into two parts, which are search location and search accident data. There are two methods for searching, either searching by node number or location name.

Accident Ranking

The ranking function is used for listing the 10 most risky or vulnerable areas for road traffic accidents from the localities understudy by using highway planning unit (HPU).

3.5 A Web based Road Traffic Accident Reporting System for Ethiopia

This is a web based system used for reporting road traffic accident data. Generally, the system consists of four subsystems [21]:

Administration subsystem

The subsystem performs authentication of users (administrator or police) when they log in to the system. It will validate their credentials by using user name and password for handling their system defined jobs.

Accident registration subsystem: Performs registration of accidents by providing registration forms for traffic police officers.

Accident record searching: Allows users to search for a particular accident record by supplying certain parameters of the accident, such as date of the accident or name of the victim

Accident Reporting

These allow users to generate reports based on their requested parameters. The system is implemented with Amharic language interface for maximizing its usability.

3.6 Summary

Different road traffic accident data management systems have been developed and used in many countries in the world. These systems utilize GIS to visualize, analyze and produce different statistical reports for road accidents as they are based on GIS. On the other hand, the locally developed system isn't GIS based; therefore, it lacks much GIS functionality like visualization and analysis of accident data. The systems mentioned above, excluding the local one are very expensive and license based. In addition, they aren't designed for road traffic problems of our local context. Thus, it requires long time, capital and effort to tailor them for our country's context. Furthermore, most of them aren't implemented based on our local languages and terminologies which make it difficult to use and adapt. In conclusion, we propose a GIS and web based system which is implemented using state of the art free open source software which are cheap and easy to use. Moreover, the system should entertain Amharic language for usability and to make it more user friendly for all actors of the system. We found gaps on each work and we filled the gaps. The first work uses Google earth for map processing and lack spatial analysis. Even though, the second work is complex and sophisticated it is not developed using free open source software, as a result it is very expensive and licensed based. Both the third and the fourth work are platform dependent. Finally, since the last work is not GIS based it lacks spatial analysis and visualization of road traffic accident data. We fill all gaps mentioned above since our system was built on very cheap free open source software and GIS tools, uses its own map layers, and developed using java language. Which make it independent on internet for map processing, cheap, platform independent and possess spatial analysis and visualization of road traffic accident data.

CHAPTER FOUR: REQUIREMENT ANALYSIS

Requirements analysis is critical to the success of a development project as it identifies and analyses the requirements for the new system using different models.

To identify the functional requirement, several visits to Addis Ababa police commission have been made. We have collected the requirement data using structured interview (please see Annex A) and secondary documents related to road traffic accident were also reviewed. we observed currently how hazardous location are identified , how accident location is referenced, how accident data is recorded, stored and reported in Addis Ababa Police Commission. In addition, we were briefed on the roles of traffic police officer and traffic police investigator regarding road traffic accident management. We informed that the roles of traffic police officer is to register road traffic accidents on the scene of the accident. On the other hand, the traffic police Investigator decide the offender driver based on the accident data provided by the traffic police officer.

We present our observations in Addis Ababa police commission based on the following main points.

Identification of Black spots (Hazardous locations)

There were different efforts exerted by the Commission to identify hazardous location to mitigate the increasing number of accidents in those hazardous areas. Since the Commission has no automated GIS based system it was done manually .This makes it very difficult and cumbersome to identify those location correctly and to take fast location specific counter measures to reduce the increasing number casualties on those locations.

Accident Location Referencing

There was no formal system for location referencing and it had been acknowledged for a long time as a fundamental drawback in the accident recording. Accident location still described in words in general terms with often a road name and a land mark being used, but if the road was very long, there was no effective way of determining where along the road the accident actually took place.

Data Recording

Road accidents are currently recorded using pen and paper. A form (see Annex B) is used to record the basic road accident related data at the accident site by the traffic police officer. The form is uniformly used in all police stations throughout the city, to record all road traffic accidents. The recording involves at least these three components, such as the driver, the vehicle and victim if there is any human injuries. In addition, property damages will be registered by traffic police officer on the scene. The accident data registration form contains a number of data items concerning the accident; such as, vehicles involved, people (driver, passenger, and pedestrian) involved, road and weather condition etc. and it is registered using Amharic language. (Please see appendix B).

Data Storage

Uniformly in all police stations the accident data collected from the accident location is filled in each police stations with the accident record paper form and usually kept on file cabinet. Every accident data is recorded and stored on one separate accident data form. Those reports compiled and aggregated at different periods. Such manual storage, retrieval and processing of accident data needs more time and effort of the traffic police officers.

Exchange of Data

Exchange of data between Addis Ababa police Commission and stakeholder institutions is carried out mainly on paper format (hard copy). When a requesting letter is presented, the report is sent with a signed and sealed letter. This exchange of data relatively takes longer period of time for both parties.

Analysis and Reporting

General road accident statistical report forms (see Annex C) are used for reporting .Road Traffic accident statistics reports are generated periodically by each sub-city after some minimal data analysis is done manually. These reports are expected to be produced daily, monthly, semiannually and annually. Road traffic reports with fatalities (deaths) are compiled and produced manually be each sub city and send monthly to the head office of Addis Ababa police commission for further investigation and analysis.

The data items proposed for the new system, functional and non-functional requirements and the analysis models for the GRTAMS is presented in this chapter.

4.1 The Proposed System

The proposed system is to use a web based GIS with RTA database to provide functionalities of mapping accidents, identifying black spots where heavy and deadly RTA occurs and for analyzing spatial data. The system will have a user friendly interface so that users with no GIS software skill could easily use the system. The system provides easy to use interfaces to enter RTA data, to view RTA maps with Addis Ababa geo-features, to perform RTA black spot analysis and RTA statistics. In addition, to automate the current manual and paper based approach so that complete data will be available to be utilized to full extent to perform different traffic accidents analysis. This analysis can provide facts as a guide for different agencies to make some intervention measures and contribute for the reduction of road traffic accidents occurring in the city. The system has the following functional and nonfunctional requirements.

4.1.1 Functional Requirements

Functional requirements capture the intended behavior of the system. This behavior may be expressed as services, tasks or functions the system is required to perform.

The functional requirement for the proposed system will include the following:

- Manage spatial and non-spatial RTA data :
 - Register spatial and non-spatial RTA data
 - Update spatial and non-spatial RTA data
 - Delete spatial and non-spatial RTA data
- Perform analysis based on the RTA data:
 - Perform spatial queries by plate number and vehicle types and display them on a map
 - View black spots directly on a map
- Generate reports based on the RTA data
 - Generate different kind of summarized reports based on time range with different file format
 - Generate daily reports with different file format

- Display or view road traffic accidents directly on the map
- Manage drivers/ offenders in accident:
 - Register offenders in accident
 - Update offenders in accident
 - Delete offenders in accident
- Manage system users:
 - Creates system users
 - Updates system users
 - Delete system users

4.1.2 Non-Functional Requirements

Nonfunctional requirements or sometimes defined as quality attributes define system qualities rather than the intended functions of the system. It includes qualities such as user interface, hardware requirements, performance, security, error handling, usability, compatibility.

The non-functional requirement of the system includes:

- The system should provide a web based interface.
- The system should handle run-time errors and invalid inputs from users by giving appropriate error message whenever necessary
- The system should be easy to modify for future upgrade and scalability
- The system shouldn't allow unauthorized user access
- The system shall have appealing user interface

4.2 The Analysis Model

The analysis model of the system is expressed in terms of functional model (use case diagram), object model (class diagram) and dynamic model (sequence diagram).

4.2.1 Use Case Diagram

Use case is defined as the specification of a sequence of actions, including variants, that a system (or entity) can perform, interacting with actors of the system. In general, it is a collection of interactions between external actors and a system.

Typically each use case includes a primary scenario (main course of events) and zero or more secondary scenarios that are alternative courses of events to the primary scenario. The use case diagram for GRTAMS is shown in Figure 4.1.

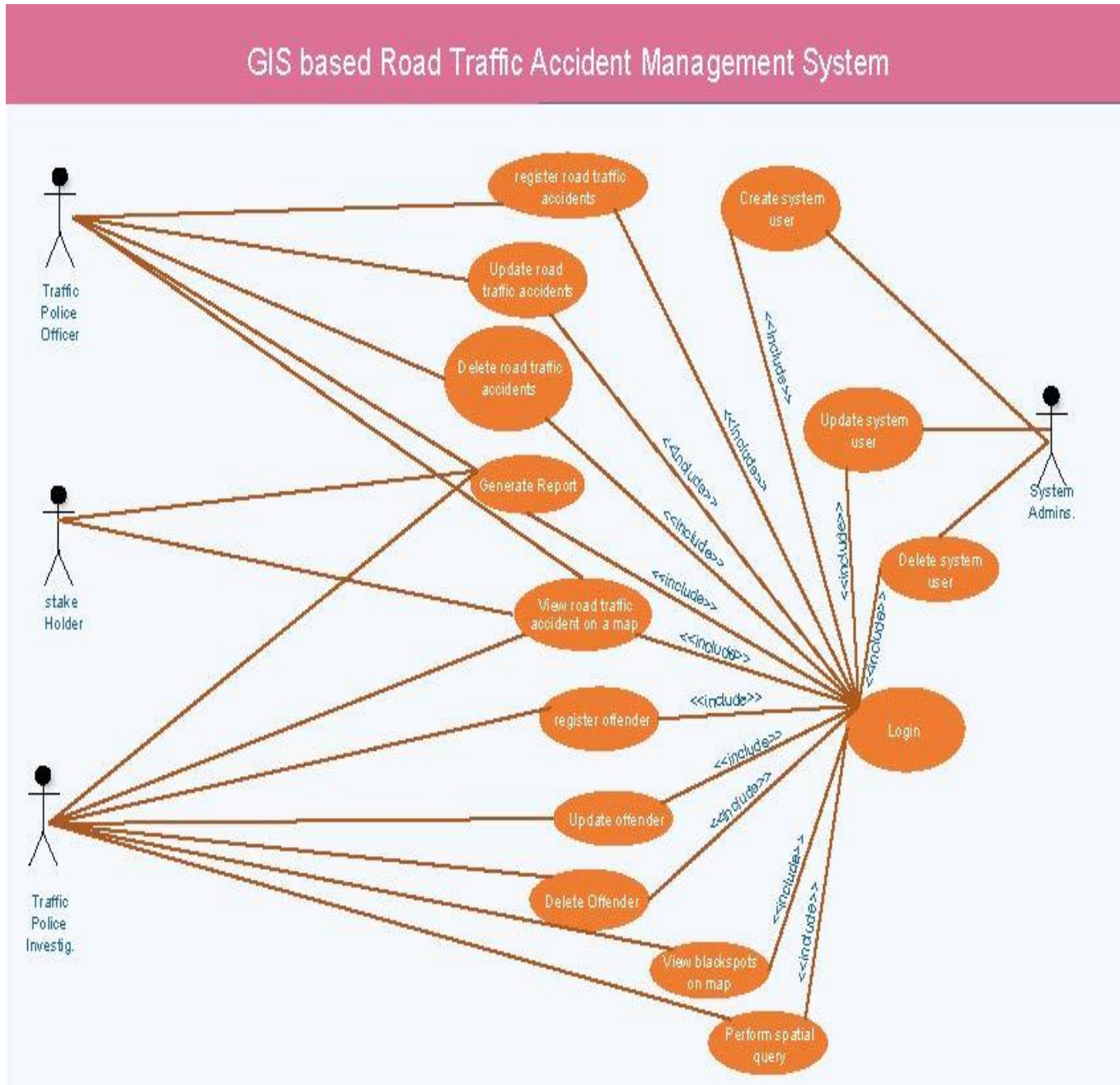


Figure 4.1 Use Case Diagram

Use case Description

From table 4.2 to 4.15 describe all use cases used in the system.

Table 4.1 Description of the Actors

No	Actors	Description
1	Traffic Police Officer	Responsible for registering, reporting Road Traffic accident data.
2	Traffic Police Investigator	Responsible for identifying & registering offenders by analyzing road traffic accident data submitted by traffic police officer.
3	Stake Holder	Allowed to print road traffic data and view them on a map
4	System Administrator	Responsible for creating, updating, deleting, user accounts

Table 4.2 Register Road Traffic Accidents

Use Case name:	Register road traffic accident
Actor:	Traffic Police Officer
Description:	The use case register spatial and non-spatial road traffic data
Precondition:	User should be authenticated.
Normal Flow:	<ol style="list-style-type: none"> 1. The user clicks on [አዲስ የመንገድ አደጋ መመዘገቢያ] from [የአደጋው ምናል] menu. 2. GRTAMS displays a registration page to register spatial and non-spatial road traffic data. 3. The user fills spatial and non-spatial data on the registration page to register road traffic accidents and clicks on [መዘገብ] button. 4. GRTAMS validates, saves into the database and displays successful message if the input data are valid. 5. Use case ends.
Post Condition:	Spatial and non-spatial road traffic data are registered.

Alternate Flow :	4.1 Input data are not valid: 1.GRTAMS displays an error message 2.Normal flow '3' continues
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Table 4. 3 Update road traffic accident

Use Case name:	Update road traffic accidents
Actor:	Traffic Police Officer
Description:	The use case Update spatial and non-spatial road traffic data
Precondition:	User should be authenticated.
Normal Flow:	<ol style="list-style-type: none"> 1. The user clicks on [የትራፊክ አደጋዎችን አስተዳድር] menu from [የአደጋው ምናል] menu. 2. The user then click [ማስተካከያ] button. 3. GRTAMS displays an RTA administration page to update spatial and non-spatial road traffic data. The user fills spatial and non-spatial data on the update page to update road traffic accidents and clicks on [አስተካክል] button. 4. GRTAMS validates, updates into the database and displays successful message if the input data are valid. 5. Use case ends.
Post Condition:	Spatial and non-spatial road traffic data are Updated
Alternate Flow :	4.1 Input data are not valid: 1.GRTAMS displays an error message 2.Normal flow '3' continues

Table 4. 4 delete road traffic accidents

Use Case name:	Delete road traffic accidents
Actor:	Traffic Police Officer
Description:	The use case delete spatial and non-spatial road traffic data
Precondition:	User should be authenticated.

Normal Flow:	<ol style="list-style-type: none"> 1. The user clicks on [የትራፊክ አደጋዎችን አስተዳድር] menu from [የአደጋው ምናል] menu. 2. GRTAMS displays RTA administration page. The user selects and deletes the RTA record by clicking on [ሰርዝ] button. 3. GRTAMS displays successful message to confirm deletion 4. Use case ends.
Post Condition:	Spatial and non-spatial road traffic data are deleted

Table 4.5 Register Offender

Use Case name:	Register offenders
Actor:	Traffic Police Investigator
Description:	The use case registers offenders participating in the accident
Precondition:	User should be authenticated.
Normal Flow:	<ol style="list-style-type: none"> 1. The user clicks on [አዲስ የአጥፊ አሽከርካሪ ውሳኔ መዘግብ] from [የአጥፊ አሽከርካሪዎች የውሳኔ ምናል] menu. 2. GRTAMS displays a page to register offenders. 3. The user fills offenders' information to register and clicks on [መዘግብ] button. 4. GRTAMS validates, saves into the database and displays successful message. 5. Use case ends.
Post Condition:	Offenders are registered.
Alternate Flow:	<p>4.1 The data entered are not valid</p> <ol style="list-style-type: none"> 1. GRTAMS displays error message. 2. Normal flow '3' continues.

Table 4. 6 Update Offenders

Use Case name:	Update offenders
Actor:	Traffic Police Investigator
Description:	The use case updates offenders participating in the accident
Precondition:	User should be authenticated.

Normal Flow:	<ol style="list-style-type: none"> 1. The user clicks on [ገባር የአጥፊ አሽከርካሪ ውሳኔ አስተዳደር] from [የአጥፊ አሽከርካሪዎች የውሳኔ ምናሌ] menu. 2. The user selects the offender and then click [ማስተካከያ] button 3. GRTAMS displays an offender update page to update offenders. The user update data and clicks on [አስተካክል] button. 4. GRTAMS updates into the database and displays successful message if the input data are valid. 5. Use case ends.
Post Condition:	Offenders are Updated
Alternate Flow:	<p>4.1 The data entered are not valid</p> <ol style="list-style-type: none"> 3. GRTAMS displays error message. 4. Normal flow ‘3’ continues.

Table 4. 7 Delete Offenders

Use Case name:	Delete offenders
Actor:	Traffic Police Investigator
Description:	The use case deletes offenders participating in the accident
Precondition:	User should be authenticated.
Normal Flow:	<ol style="list-style-type: none"> 1. The user clicks on [ገባር የአጥፊ አሽከርካሪ ውሳኔ አስተዳደር] from [የአጥፊ አሽከርካሪዎች የውሳኔ ምናሌ] menu. 2. GRTAMS displays a deletion page for the offenders 3. The user selects the offender and then click [ሰርዝ] button 4. GRTAMS deletes the offender and displays successful message 5. Use case ends.
Post Condition:	Offenders are deleted

Table 4.8 View Black spots on a map

Use Case name:	View Black spots on a map
Actor:	Traffic Police Investigator
Description:	The use case enables to view black spots on a map
Precondition:	User should be authenticated.
Normal Flow:	<ol style="list-style-type: none"> 1. The user clicks on [የአደጋዎች ጥቁር ነጥብ መመልከቻ] option from [የካርታው ምናል] menu. 2. GRTAMS display black spots on a map 3. Use case ends.
Post Condition:	Black spots displayed on a map

Table 4. 9 Perform Spatial Query

Use Case name:	Perform Spatial query
Actor:	Traffic Police Investigator
Description:	The use case enables to perform Spatial query
Precondition:	User should be authenticated.
Normal Flow:	<ol style="list-style-type: none"> 1. The user clicks on [የካርታው ምናል] menu. 2. GRTAMS provide options to search road traffic accidents by plate number and vehicle type 3. The user clicks on [ተሽከርካሪዎች ያደረሱትን አደጋ በሰሌዳ ቁጥር በካርታ አሳይ] 4. The user fills the plate number to search accidents caused by the vehicle with this plate number 5. GRTAMS displays requested road traffic accidents on a map 6. Use case ends.
Post Condition:	The requested road traffic accidents displayed on a map
Alternate Flow:	<ol style="list-style-type: none"> 1. The user clicks on [ተሽከርካሪዎች ያደረሱትን አደጋ በተሽከርካሪ አይነት በካርታ አሳይ] menu 2. The user fills the vehicle type to search accidents caused by this

	<p>vehicle type</p> <p>3. GRTAMS displays requested road traffic accidents on a map</p> <p>4. Use case ends.</p>
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Table 4.10 View Road Traffic Accident on a Map

Use Case name:	View road traffic accident on a map
Primary Actor:	Traffic police investigator, Stake holders, Traffic police officer
Description:	In this system use case road traffic accidents are displayed on a map.
Precondition:	User should be authenticated
Normal Flow:	<ol style="list-style-type: none"> 1. The user clicks on [የመንገድ ትራፊክ አደጋዎችን በካርታ ተመልክት] option from [የካርታው ምናሌ] menu. 2. The user fills parameters he need and click search button 3. GRTAMS displays road traffic accidents on a map. 4. Use case ends.
Post Condition:	Road traffic accidents displayed on a map.

Table 4.11 Generate Report

Use Case name:	Generate report
Primary Actor:	Traffic police investigator , Stake holders, Traffic police officer
Description:	In this system use case reports related with road traffic accidents are generated as per the request.
Precondition:	User should be authenticated
Normal Flow:	<ol style="list-style-type: none"> 1. The user clicks on [የሪፖርት ምናሌ] menu. 2. GRTAMS displays options for daily and longer time period reports. 3. The user selects the daily option report is and clicks on [ሪፖርት አውጣ] button. 4. The user inputs the date he wants

	<ol style="list-style-type: none"> 5. GRTAMS generates the required report. 6. Use case ends.
Post Condition:	The selected report type will be generated.
Alternate Flow:	<ol style="list-style-type: none"> 1. The user selects Longer time period reports option 2. The user selects one report type from the seven existing report types 3. the users enters time range for the report 4. The user clicks on [ሪፖርት አውጣ] button 5. GRTAMS generates the required report. 6. Use case ends.

Table 4.12 create system user

Use Case name:	Create system Users
Actor:	System Administrator
Description:	In this system use case system users are created
Precondition:	User should be authenticated.
Normal Flow:	<ol style="list-style-type: none"> 1. System Administrator clicks on [አዲስ ተጠቃሚ መዝግብ] menu. 2. GRTAMS displays a page used to create system users. 3. The system administrator enter information related to the user and clicks on [መዝግብ] button. 4. GRTAMS validates and creates the user and displays successful message if the user is created successfully. 5. Use case ends.
Post Condition:	A system user is created
Alternate Flow:	<p>4.1 If the Input is not valid</p> <ol style="list-style-type: none"> 1. GRTAMS displays error message. 2. Normal flow '3' continues.

Table 4. 13 Update System Users

Use Case name:	Update system Users
Actor:	System Administrator
Description:	In this system use case system users are updated
Precondition:	User should be authenticated.
Normal Flow:	<ol style="list-style-type: none"> 1. System Administrator clicks on [ተጠቃሚ አስተዳደር] menu. 2. GRTAMS displays system users update page. 3. The administrator update information related to the user and clicks on [ቀይር] button. 4. GRTAMS validates and updates the system user and displays successful message if the user is updated successfully. 5. Use case ends.
Post Condition:	A system user is updated
Alternate Flow:	<p>4.2 If the Input is not valid</p> <ol style="list-style-type: none"> 1. GRTAMS displays error message. 2. Normal flow '3' continues.

Table 4. 14 Delete System Users

Use Case name:	Delete system Users
Actor:	System Administrator
Description:	In this system use case system users are deleted
Precondition:	User should be authenticated.
Normal Flow:	<ol style="list-style-type: none"> 1. System Administrator clicks on [ተጠቃሚ አስተዳደር] menu. 2. GRTAMS displays system users to administer page. 3. The administrator select user to be deleted and clicks on [ሰርዝ] button. 4. GRTAMS deletes the system user and displays successful message 5. Use case ends.
Post Condition:	A system user is Deleted

Table 4.15 Login

Use Case name:	Login
Actor:	Traffic Police Investigator, Traffic police officer, Stake holders, system administrator
Description:	In this system use case users are authenticated to sign in to the system
Precondition:	Login page should be loaded.
Normal Flow:	<ol style="list-style-type: none"> 1. The actor enters his/her accounts (user name and password) on the page and clicks on [70] button to access the page he/she is requesting. 2. GRTAMS checks existence of the account if the user enters his/her account correctly. 3. The user logged in to GRTAMS 4. Use case ends.
Post Condition:	The user is logged in to GRTAMS system.
Alternate Flow 1:	<p>2.1 System User exists but user ID or Password is wrong and tried < 3 times :</p> <ol style="list-style-type: none"> 1. GRTAMS displays ‘user name or password error, try again!’ 2. Normal flow ‘1’ continues. 3. Use case ends <p>2.1.1 system User attempts more than three times:</p> <ol style="list-style-type: none"> 1. GRTAMS displays ‘account blocked, contact the system administrator’. 2. Use case ends.
Alternate Flow 2:	<p>2.1 System User does not exists</p> <ol style="list-style-type: none"> 1. GRTAMS displays ‘user name does not exist’ 2. Normal flow ‘1’ continues. 3. Use case ends

4.2.2 Sequence Diagram

A sequence diagram shows the dynamic nature of a system. It shows how objects in the system interact in a given situation with time. In a sequence diagram, time elapses from top

to bottom. Some of the sequence diagram are listed below and the rest of diagrams are given in the annex. Figure 4.2-4.4.15 present several sequence diagrams used in this project.

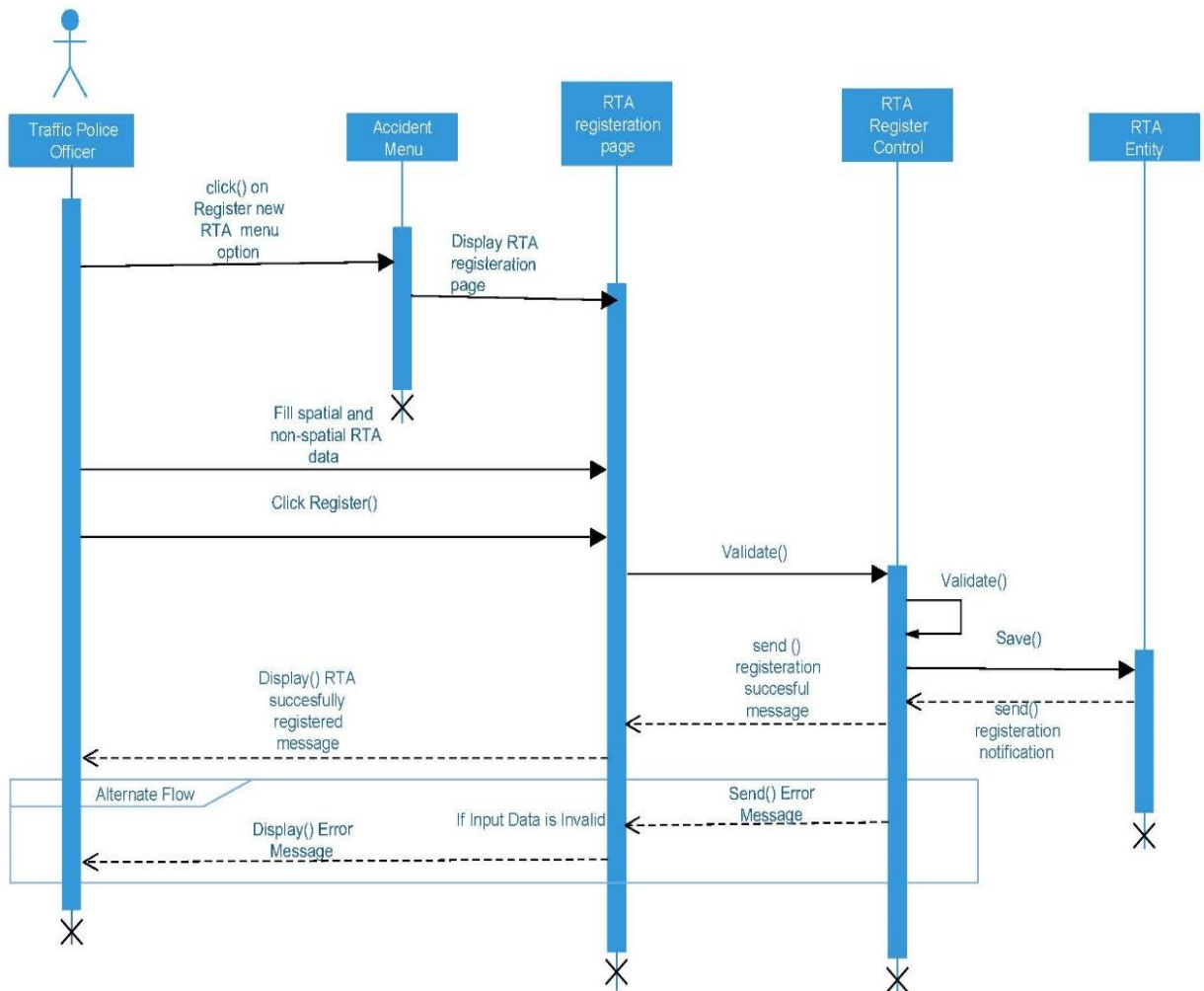


Figure 4. 2 Sequence Diagram for Register Road Traffic Accident

Figure 4.2, shows the instance of registering new RTA by interacting with the register submenu from accident menu, then RTA registration form will be displayed. Then the user

fills the necessary data and clicks on register button. The RTA register control validates and If the RTA data is valid it will display confirmation message that the data is permanently saved to the accident table in the database .If not, the RTA register control validates the data and it will display an error message to the user.

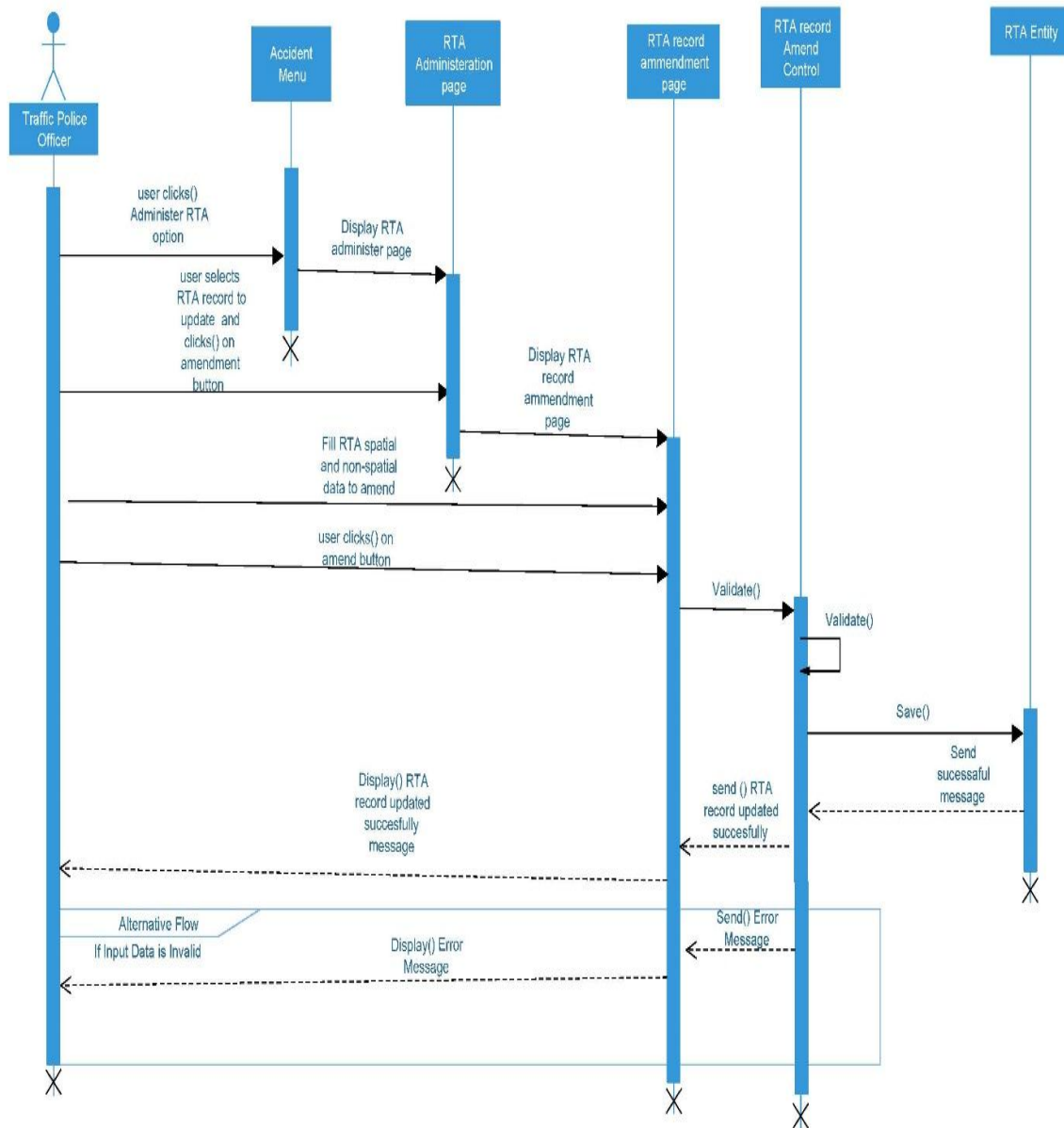


Figure 4. 3 Sequence Diagram Update Road Traffic Accident

Figure 4.3, shows the instance of updating RTA data by interacting with the administer RTA option from accident menu, then RTA administration page will be displayed. Then the user selects the accident record to be amended and update the data and clicks on amend button. The RTA record amend control validates and if the RTA data is valid it will display confirmation message that the data is updated to the accident table in the database. If not, it will display an error message to the user.

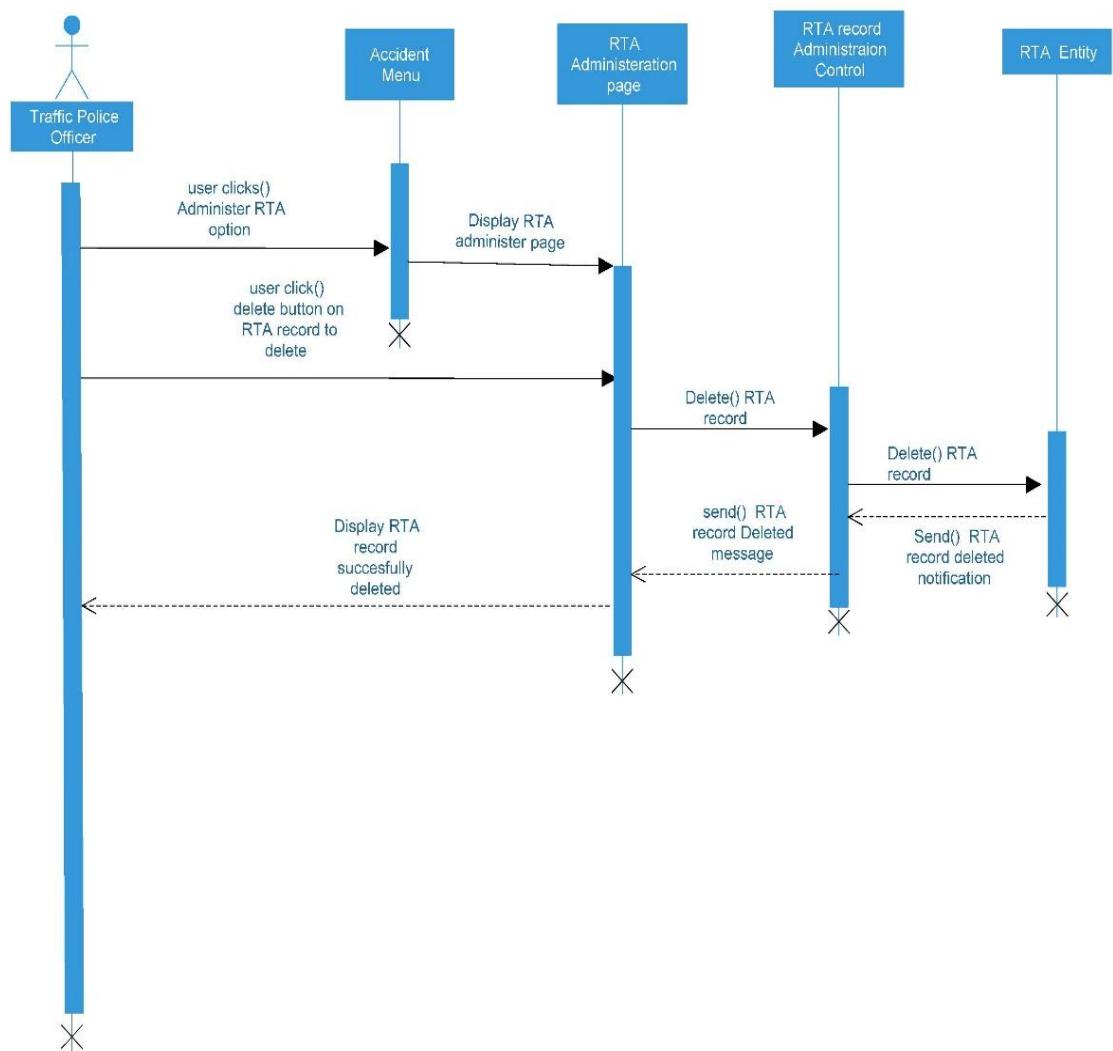


Figure 4. 4 Sequence Diagram for Delete Road Traffic Accident

Figure 4.4, shows the instance of deleting RTA record by interacting with the administer RTA option from accident menu, then RTA administration page will be displayed. Then the user selects the accident record to be deleted and clicks on delete button. The RTA record amend control deletes the data permanently and displays confirmation message that the data is deleted from the database.

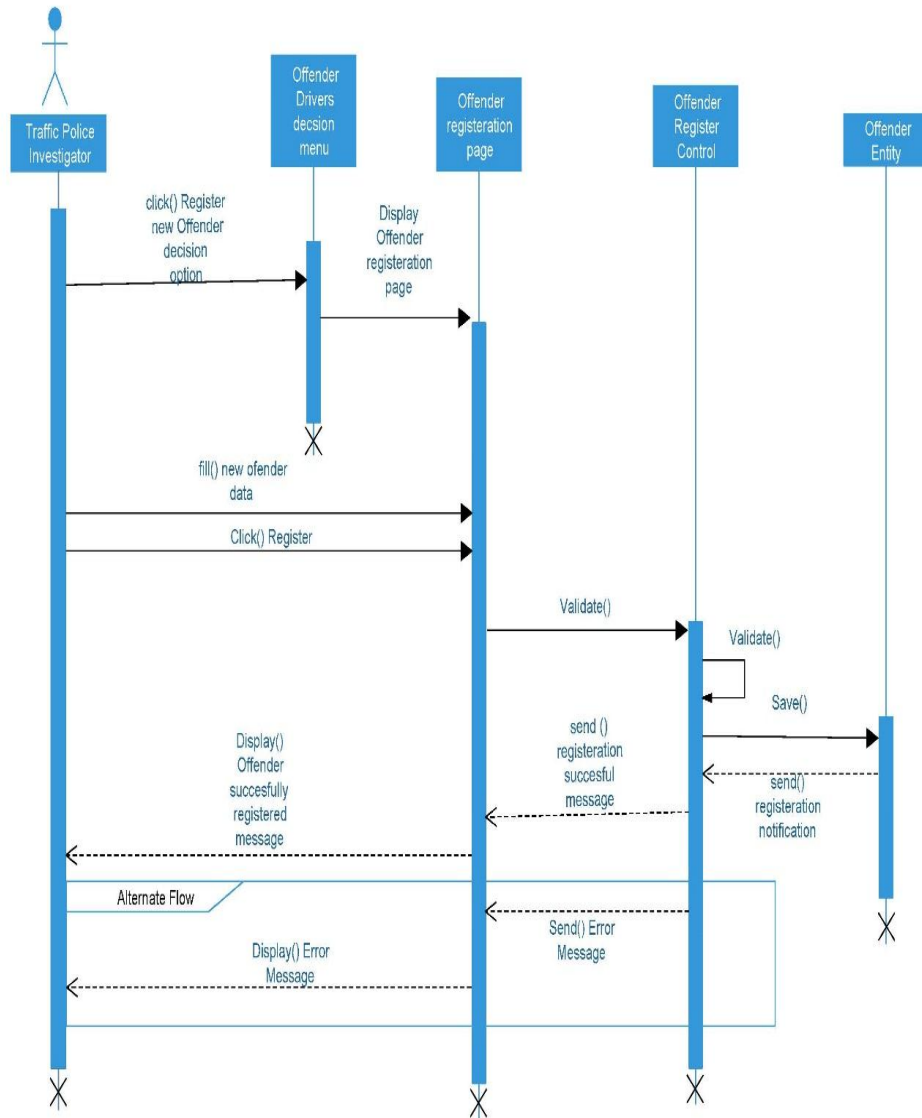


Figure 4. 5 Sequence Diagram for Register Offender

Figure 4.5, shows the instance of registering new offender by interacting with the register submenu from offender driver decision menu, then new offender driver registration form will be displayed. Then the user fills the necessary data and clicks on register button. The offender driver register control validates the data and If the new offender driver data is valid it will display confirmation message that the offender record is permanently saved to the offender table in the database .If not, it will display an error message to the user.

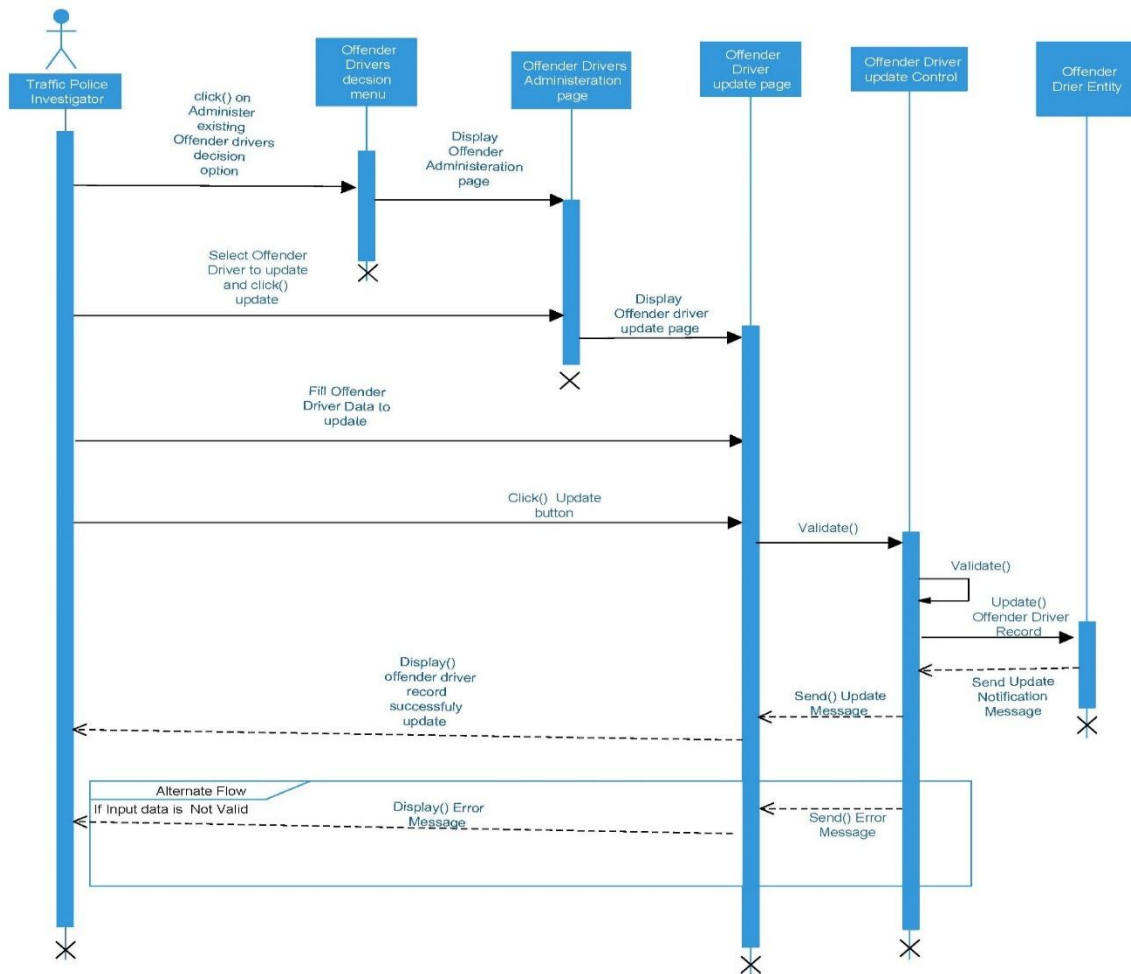


Figure 4. 6 Sequence Diagram for Update Offender

Figure 4.6, shows the instance of updating offender data by interacting with administer existing offender driver decision option from offender menu, then offender driver decision administration page will be displayed. Then the user selects the offender record to be amended and update the data and clicks on amend button. The offender driver update control validates and if the offender data is valid it will display confirmation message that the data is updated to the offender table in the database. If not, it will display an error message to the user.

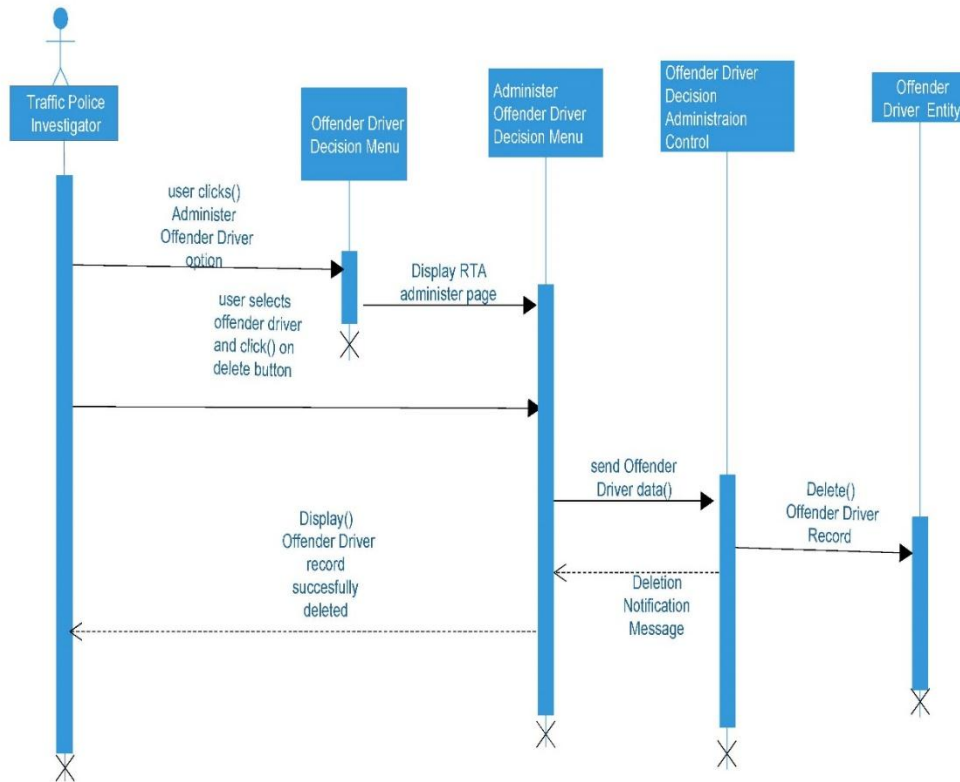


Figure 4. 7 Sequence Diagram for Delete Offender

Figure 4.7, shows the instance of deleting offender record by interacting with the administer offender driver option from offender menu, then RTA administration page will be displayed. Then the user selects the offender driver record to be deleted and clicks on delete button. The offender driver administration control deletes the offender driver record permanently and displays confirmation message that the data is deleted from the database.

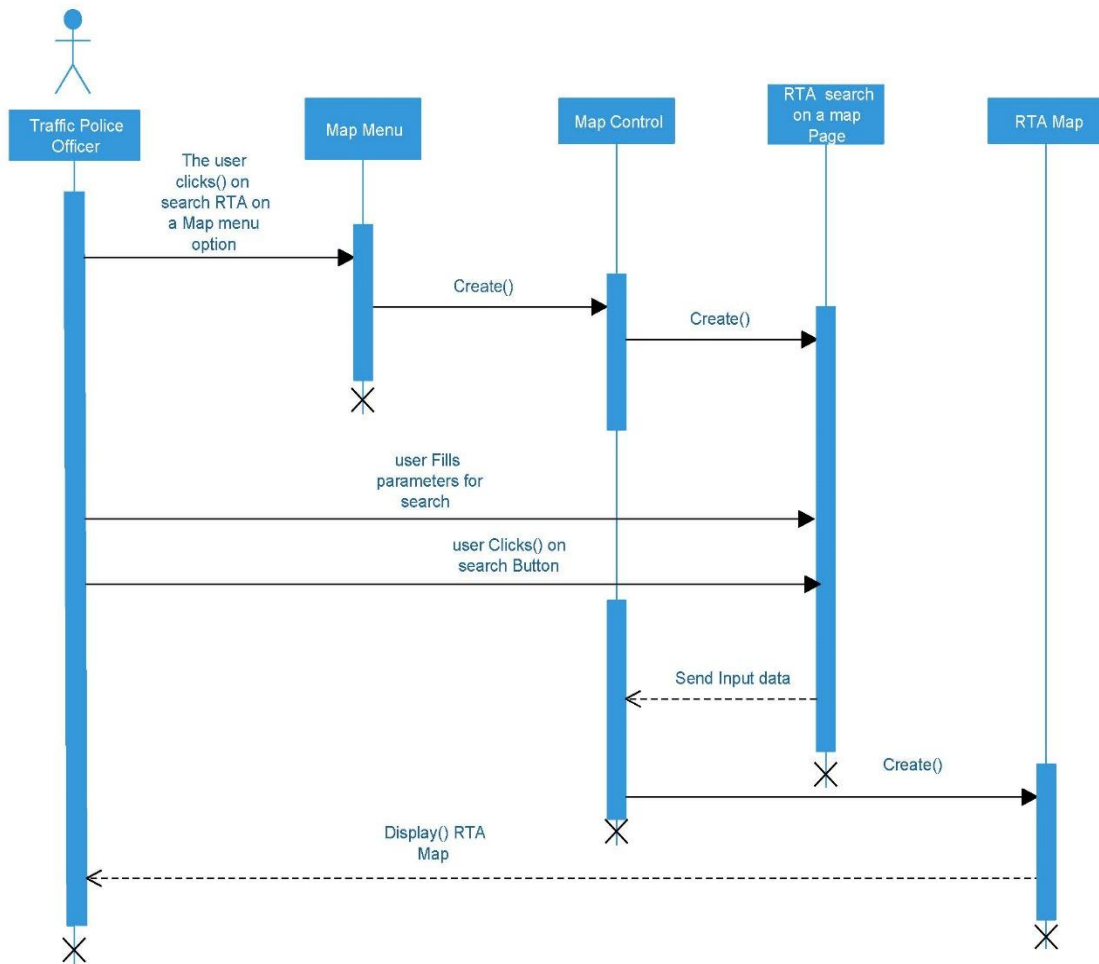


Figure 4. 8 Sequence Diagram for View Road Traffic Accident Data on a Map

Figure 4.8, shows the instance of viewing RTA directly on a map by interacting with the Search RTA on a map option from map menu, then search RTA on a map page will be displayed. Then the user inputs the parameter he want to see on map like type of accident, weather type, light condition and then click search button. The system display RTA map based on the parameter filled.

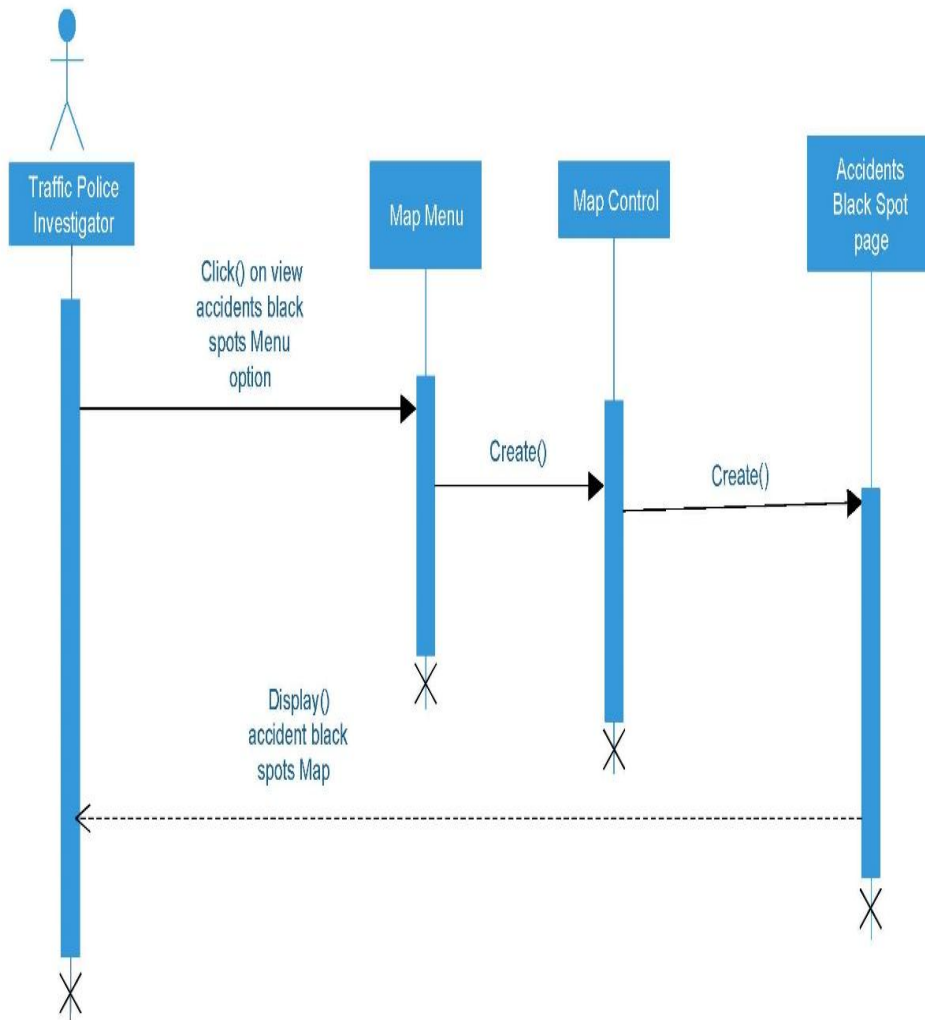


Figure 4. 9 Sequence Diagram for View Black Spots on a Map

Figure 4.9, shows the instance of viewing black spot on a map by clicking on view black spot option from map menu, then black spot map will be displayed.

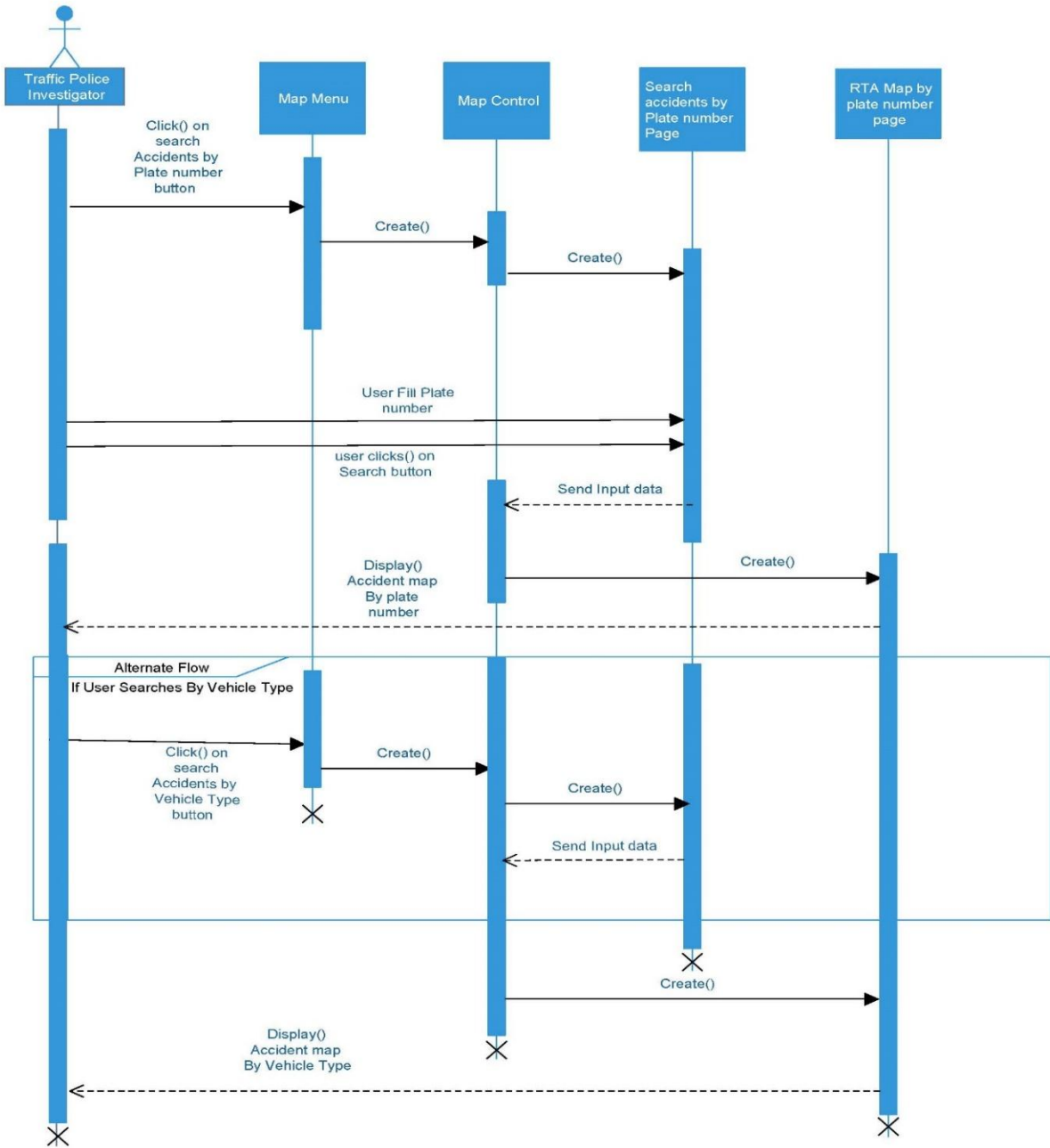


Figure 4. 10 Sequence Diagram For Perform Spatial Query

Figure 4.10, shows the instance of perform spatial query on a map by either searching by vehicle type menu option or plate number menu option from map menu, then the search page based on a menu option selected will be displayed. Then the user inputs the parameter he want to see on the map such as type of accident, weather type, light condition and then click on search button. The system display RTA map based on the parameter filled.

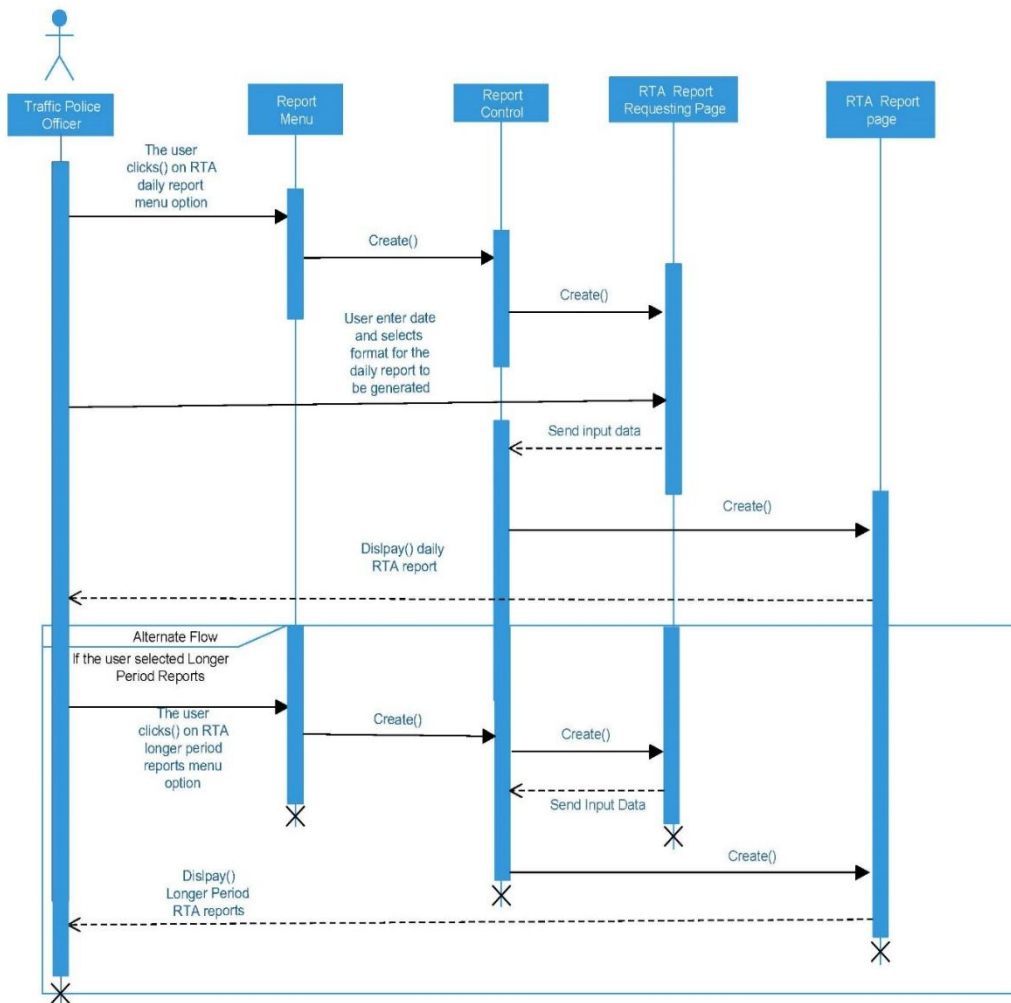


Figure 4. 11 Sequence Diagram For Generate Report

Figure 4.11, shows the instance of generating RTA report. There are daily and long term report type options. The user clicks on report menu and selects the report type he wants and clicks on generate report. The report control generate the report requesting form which need date information and the selected file type .after the user selection a report will be generated based on user selection.

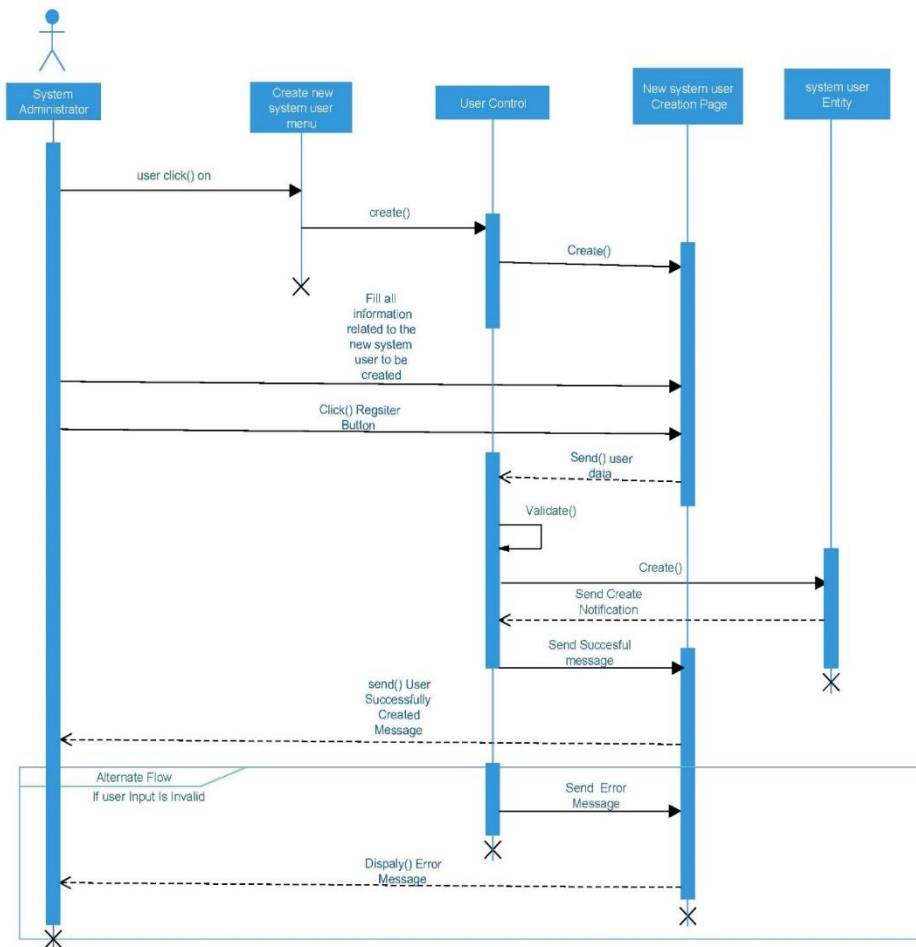


Figure 4. 12 Sequence Diagram for Create System user

Figure 4.12, shows the instance of creating a system user by interacting with create system user option. The user control displays the form to be filled about the new system user. Then the user fills the necessary information and click register. The user control validates the data and if it valid a conformation message will be displayed to the user and system user will be created in the database. If not, an error message will be displayed to the user.

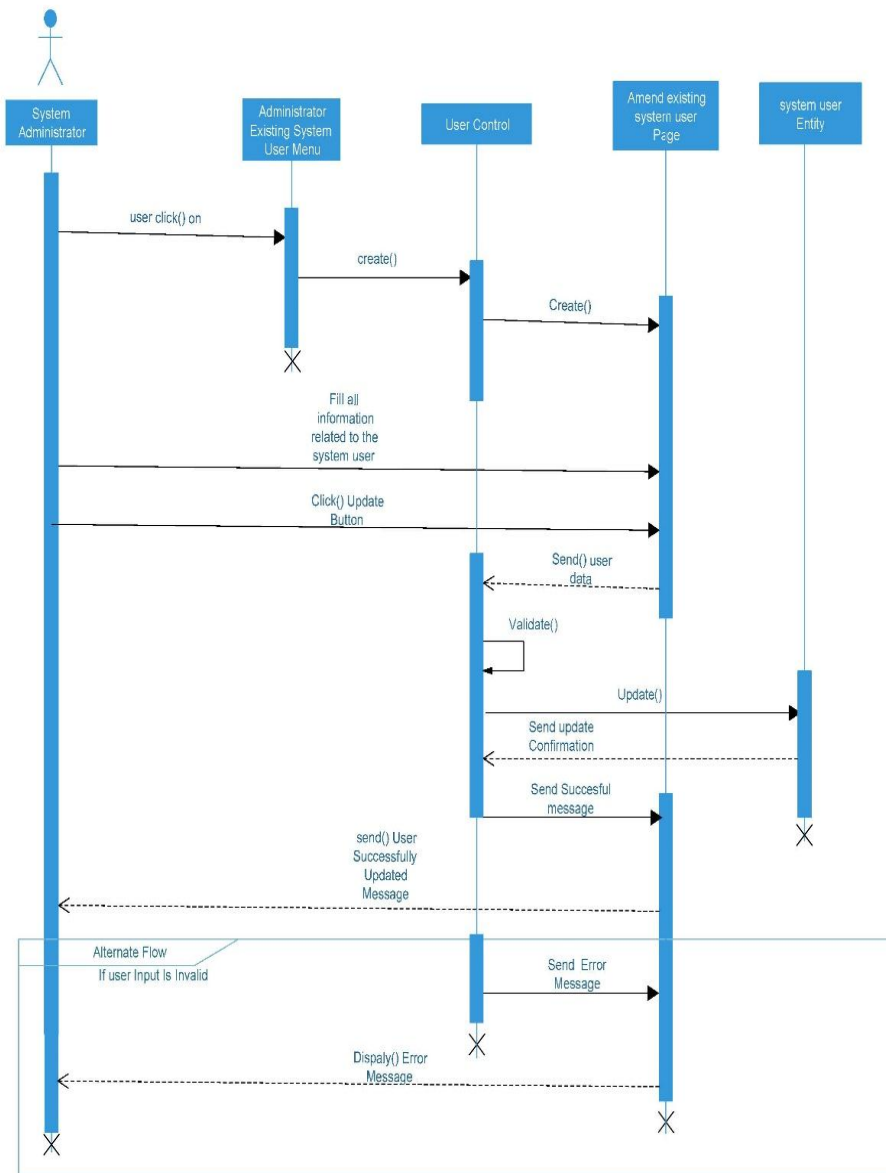


Figure 4. 13 Sequence Diagram for Update System User

Figure 4.13, shows the instance of updating a system user by interacting with administer existing system users option. The user control displays existing user administration page. Then the user selects the user record and click update. The user input update data and click on update. The user control validates the data and if it valid a conformation message will be displayed to the user and system user will be updated in the database. If not, an error message will displayed to the user.

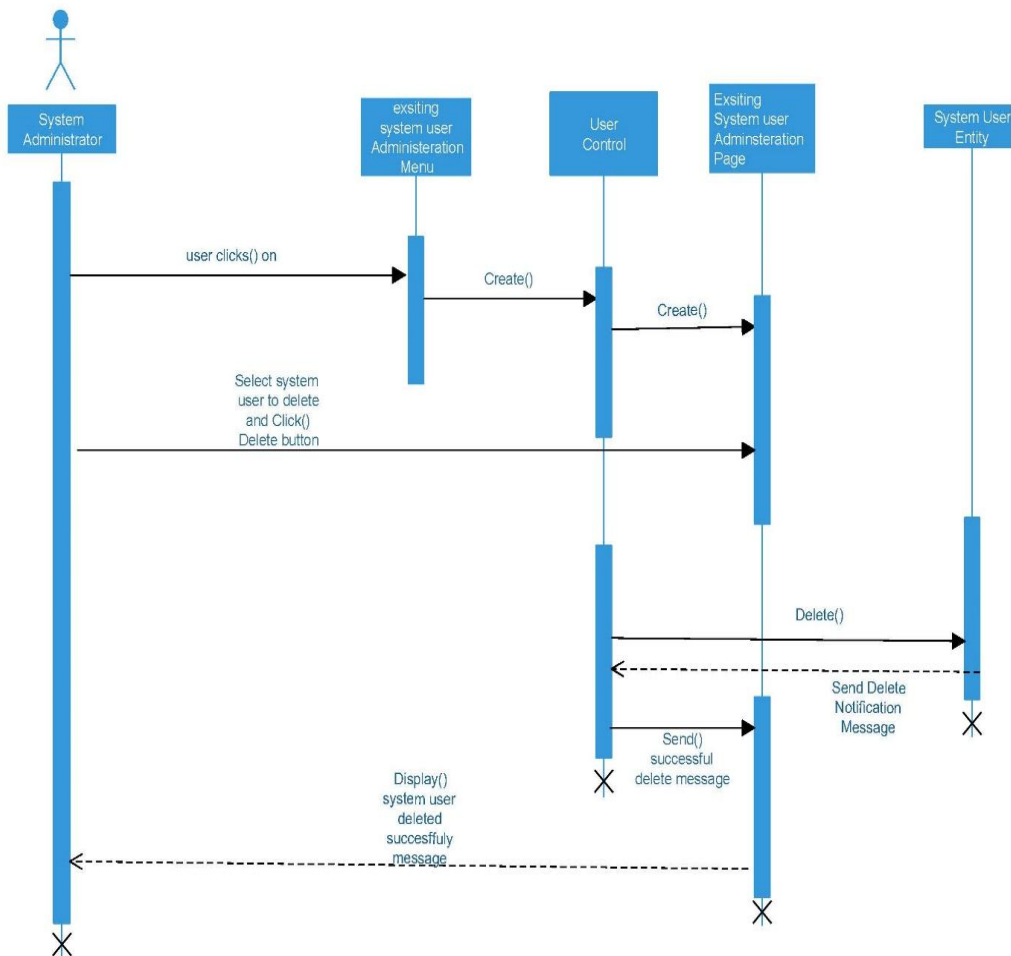


Figure 4. 14 Sequence Diagram for Delete System User

Figure 4.14, shows the instance of deleting a system user by interacting with administer existing system users option. The user control displays existing user administration page. Then the user selects the user record and click delete. Then a confirmation page will displayed to the user that the system user is deleted permanently from the database.

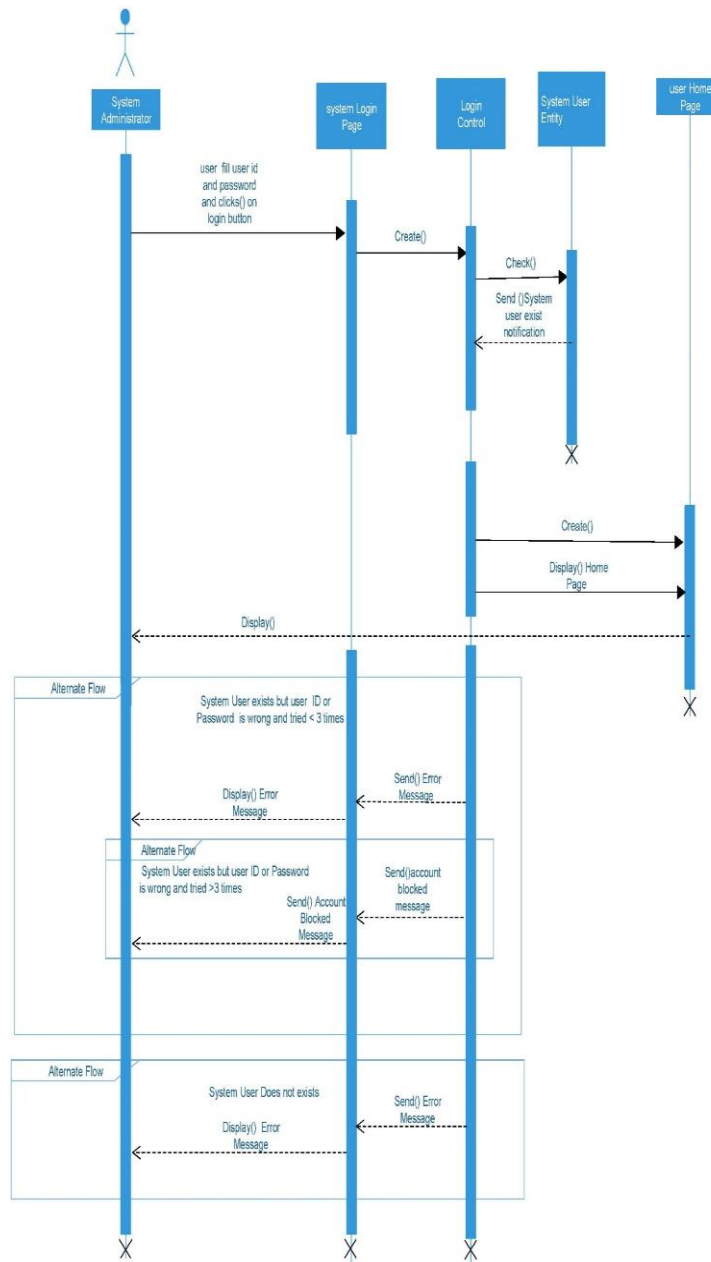


Figure 4. 15 Sequence Diagram for Login

Figure 4.15, shows the instance of logging into the system by interacting with login button after the user input the user id and password. The login control validates the input and if the input is valid it will open home page of the user. If the user does not exist it will display an error message. Else if the user exists and if the password is wrong it displays an error message until three trials. After that it will block the user and displays a message that a system user is blocked.

4.2.3 Class Diagram

The class diagram is a static model that shows the classes and the relationships among classes that remain constant in the system over time. The class diagram depicts classes, which include both behaviors and states, with the relationships between the classes. The identified classes and their relationship are depicted in Figure 4.5.

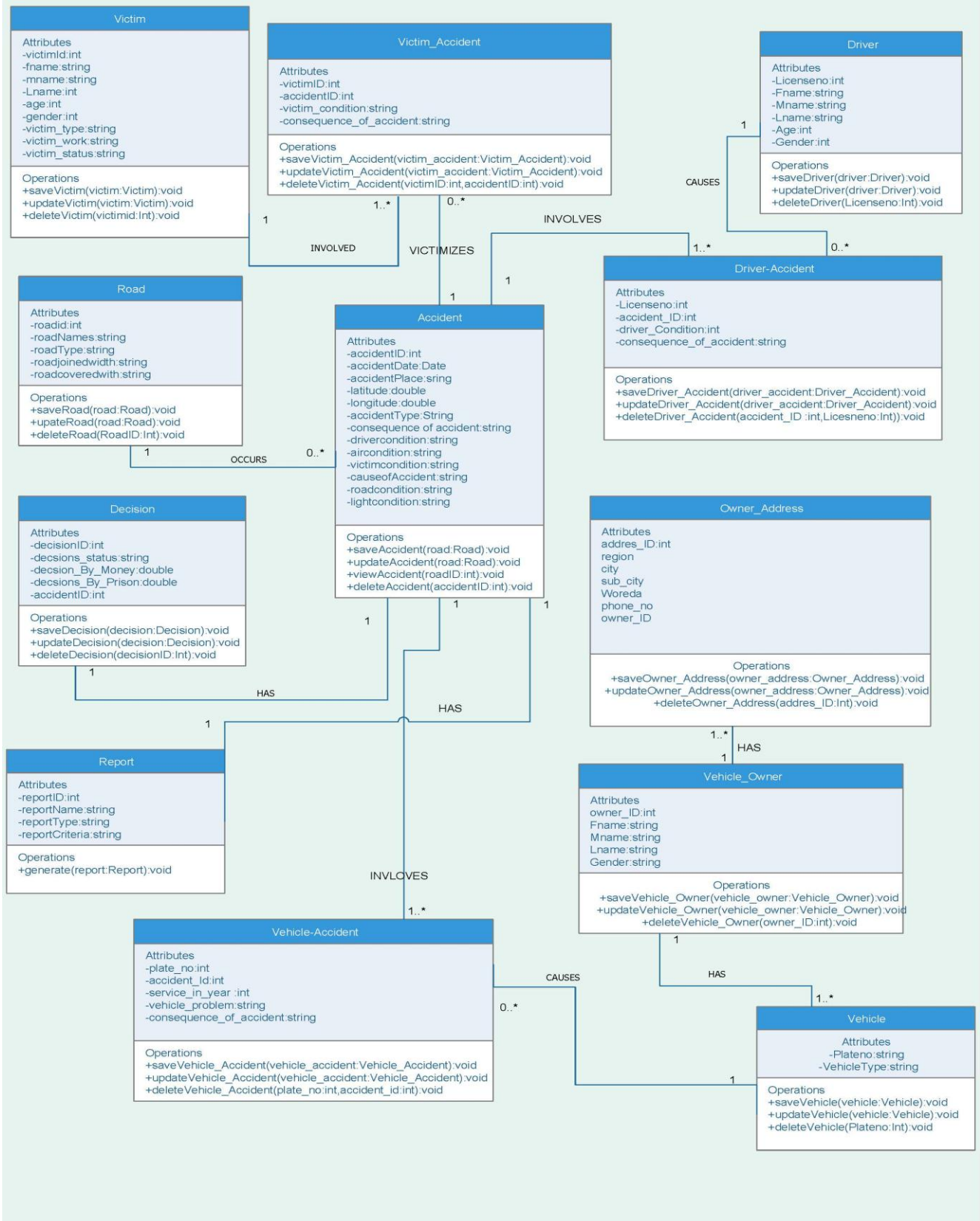


Figure 4. 16 Class Diagram

CHAPTER FIVE: SYSTEM DESIGN

This chapter in general presents how the system is designed by identifying components from the requirement analysis made in the previous chapter. Section 5.1 presents the design goals derived from the non-functional requirements. Section 5.2 presents the architecture of the system which is three tier based. Section 5.3 discusses the subsystems identified. Section 5.4 explains the deployment diagram. Sections 5.5 outlines the persistent data management and finally, in Section 5.6 subsystem interfaces and the services they provide are identified.

5.1 Design Goals

Design goals are constraints considered throughout the designing process of the system. However, in real world all the best goals cannot be satisfied. Thus, a trade-off among design goals is made. In this application, different constraints are considered like data access, security, usability and performance from clients, end users and developers perspectives.

Data Access Vs. Security

GRTAMS has both spatial and non-spatial data accessed by end users. Allowing all the users to access any part of data would make the system vulnerable. The more the data access leads to less security and vice versa. However, having these two functionalities are necessary for the system. Thus, user based authentication and role based access control is used to satisfy these needs.

Usability Vs. Performance

GRTAMS provides service to system users of varying capability and experience. User's need the usability feature of the system to learn easily, to have consistent look and feel, and ease of use. However, these needs of users conflict with the performance features such as response time, simultaneous access and storage capacity of the system. Since both usability and performance features are necessary for the system, the system designed to have consistent pages for easy learning and memorability, to incorporate major functionalities and to distribute processing on different machines for improving the performance of the system and for load balancing. Hence, this design is used to achieve the above conflicting goals.

5.2 Architecture of the System

Architectural design has a critical link between design and requirements, because it identifies the main structural components of a system and the relationships between them. For this system (GRTAMS), three tier architecture is selected. The system architecture for GRTAMS is shown in Figure 5.1.

The presentation layer contains view components which create an interaction with the end user through display of a graphical user interface. The business layer contains models and controllers which have the logic of data manipulation, it serves the presentation layer to have logical interpretation in line with business process of the organization. Spatial service layer is only used when there is spatial data manipulation through a proxy script. This script facilitates communication between a java script framework based user interfaces with the data source to avoid java script security risk. Data access layer gives and accepts data using SQL/JDBC and JPA, which is a Java persistence API for providing ORM mechanism in Java enterprise and standard editions for spatial data manipulation and non-spatial data manipulation respectively.

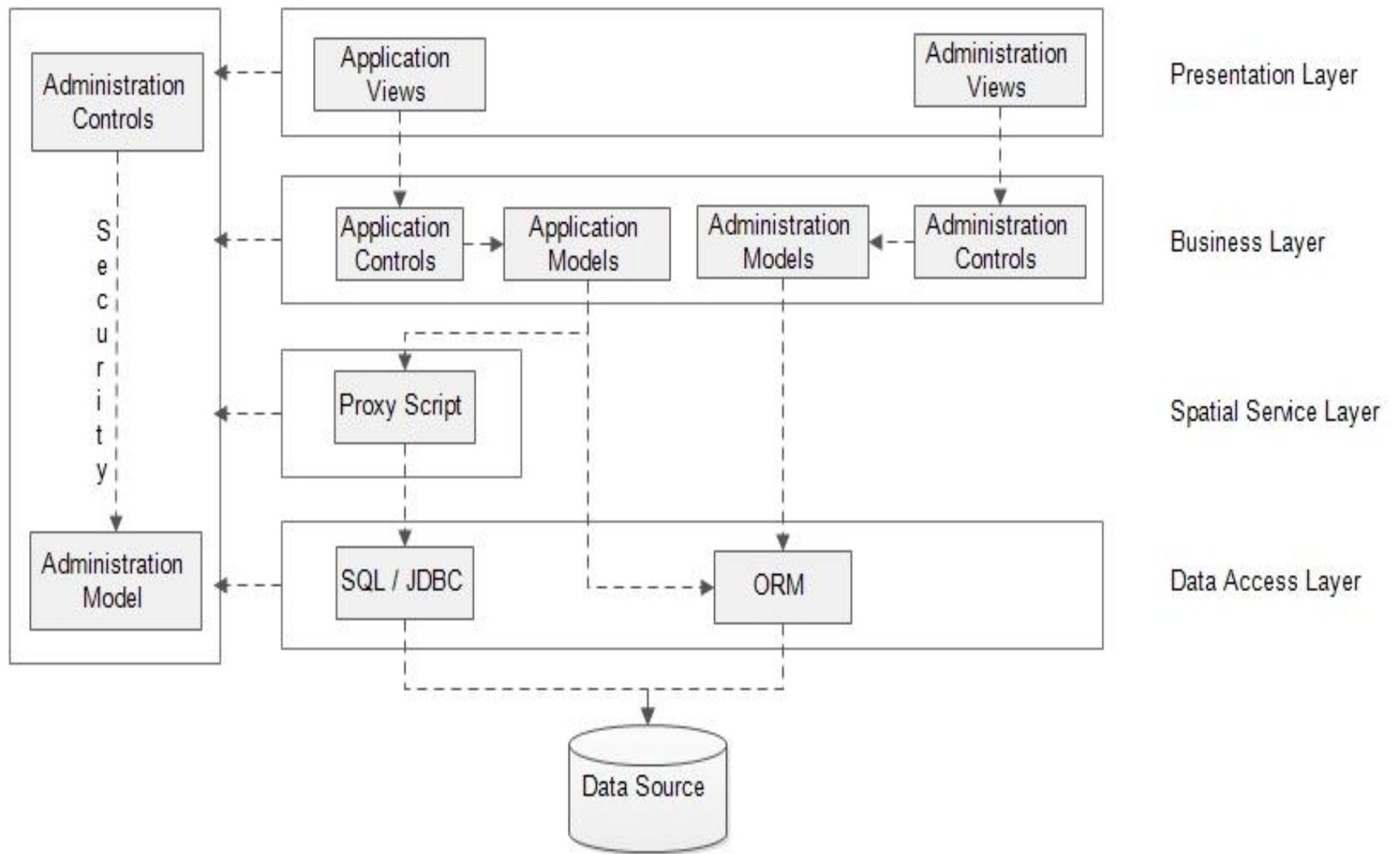


Figure 5.1 System Architecture

5.3 Subsystem Decomposition

A system is decomposed into subsystems in order to decrease complexity of a system so that it will be manageable for implementation and maintenance. GIS based RTAM system is decomposed into seven subsystems based on the following criteria:

1. By making highly related classes/objects on the same subsystem (i.e. by grouping objects depicted from the same use case).
2. By creating a dedicated subsystem for objects used for moving data among subsystems (e.g. User Management, User Interface and Data management subsystem).
3. By minimizing the number of associations crossing subsystems boundaries.

These criteria in general bring high cohesion and low coupling which enhance performance of the system. The sub systems are listed below and their dependency is shown in Figure 5.2.

Accident Management Subsystem: This subsystem manages drivers, cars, roads and victims participating in an accident. It also manages accidents occurred by maintaining both spatial and non-spatial information. In addition, it performs analysis on the data such as black spot analysis.

Offenders Management Subsystem: This subsystem manages an offender that creates the accident and the decisions made.

Report Management Subsystem: This subsystem generates reports related to road traffic accidents in different formats.

User Management Subsystem: This subsystem manages roles of each user by maintaining their access level to the system.

Data access Management Subsystem: This subsystem manages the interaction or connection between the persistent data base and the business domain or application.

User Interface Management Subsystem: This subsystem manages the interaction between the users and the application or business domain.

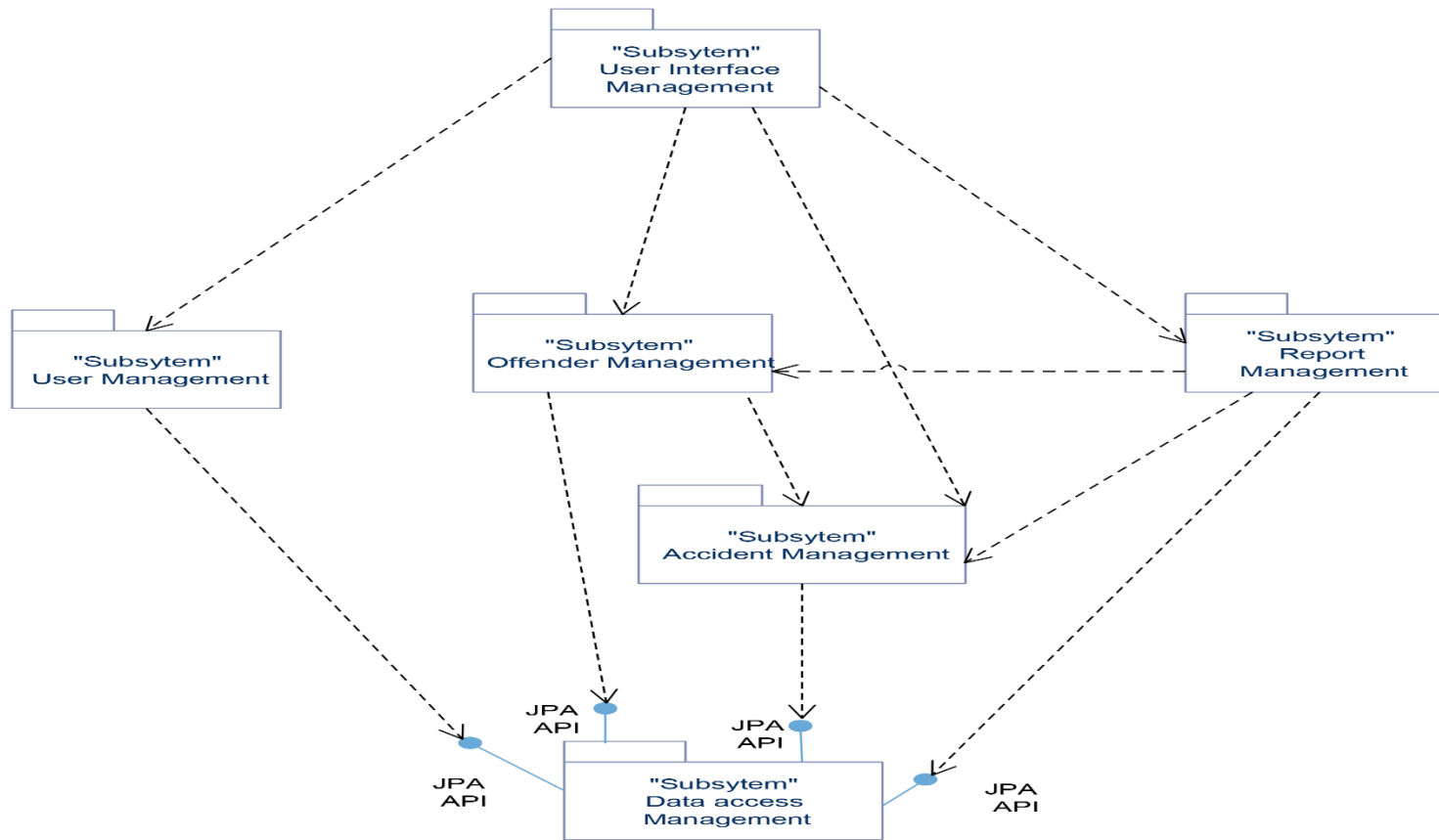


Figure 5.2 Subsystems and their Dependency

5.4 Deployment Diagram

There are lots of practices in organization and deployment of the software components used in GIS web based application systems as stated in Chapter Two. We selected three tier architecture on free open source technologies. In comparison to cost of software licenses, restrictions on use, interoperability, extensibility, ease of use, training resources and performance, free open-source technologies have been proven in recent years to meet and in some cases surpass the abilities of proprietary software to produce effective and robust web-based spatial applications.

The deployment of GRTAMS requires an interaction between client, application server and database server machines. The browser on the client machine parse java script based user interface and HTML documents. The application server machine contains two servers, Apache Tomcat web server and Geoserver. Apache Tomcat web server parses java scripts and proxy scripts. This server sends SQL to the database server machine to retrieve none spatial data and proxy scripts to the Geoserver for spatial data. The Geoserver sends SQL / JDBC to the database server machine in order to retrieve spatial data in the form of block data interpreted by GeoJSON. Geoserver is used for managing geographic information system (GIS) data sources and serving them easily through Web Feature Service (WFS) and Web Map Service (WMS) web services. The deployment diagram shown in Figure 5.3 depicts the distribution of application components on different physical hardware and software components.

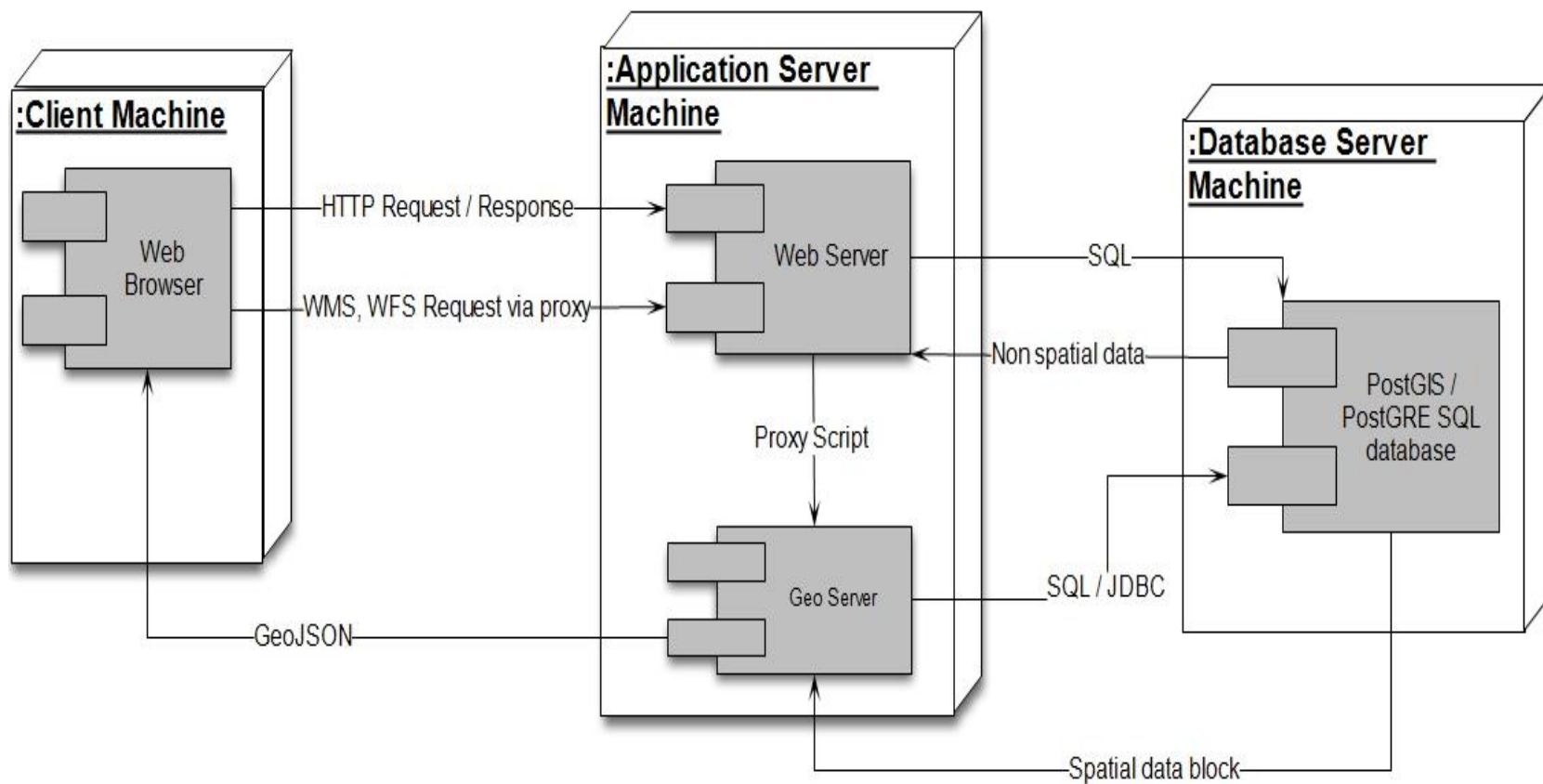


Figure 5.3 Deployment Diagram

5.5 Persistent Data Management

Persistent data management deals with how the persistent data are stored and managed. Information related to accidents, drivers, vehicles, victims, roads 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 GRTAMS are transformed into tables and attributes of the classes are also mapped into table fields. The tables of the database with their respective fields and their relationship among tables are depicted in Figure 5.4 and Table 5.1 shows description of each tables.

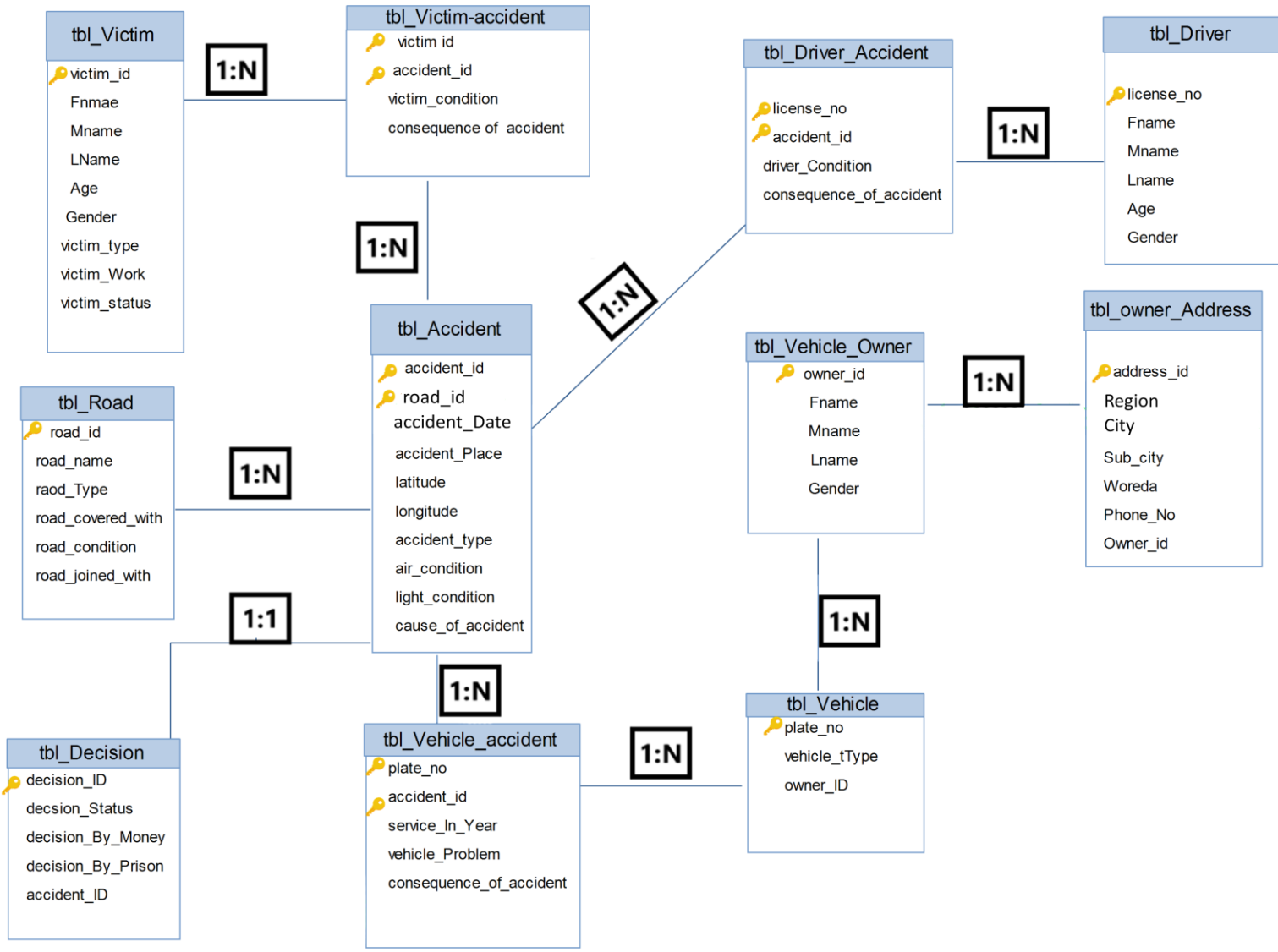


Figure 5.4 Tables

Table 5.1 Description of the Tables

Table	Attribute	Data Type	Constraint	Description
Tbl_Vehicle	Plate_No	Varchar(50)	PK	Holds Plate No of Vehicle
	Vehicle_Type	Varchar(500)	Cannot be null	Holds type of Vehicle
	Owner_ID	Varchar(50)	FK	Holds ID of Vehicle owner
Tbl_Vehicle_Accident	Plate_No	Varchar(50)	PK and FK	Holds plate No of Vehicle.
	Accident_ID	Varchar(50)		Holds ID of an accident
	Service_In_Year	Number	Cannot be null	Holds service of Vehicle during Accident
	Vehicle_Problem	Varchar(1000)	Can be null	Holds problem of Vehicle during the accident
	Consequense_of_Accident	Varchar(1000)	Cannot be null	Holds damage on the vehicle due to Accident
Tbl_Vehicle_Owner	Owner_ID	Varchar	PK	Holds ID of Vehicle Owner
	FName	Varchar	Cannot be null	Holds First Name of vehicle owner
	MName	Varchar	Cannot be null	Holds Middle Name of vehicle owner
	LName	Varchar	Cannot be null	Holds Last Name of vehicle owner
	Gender	Varchar	Cannot be null	Holds gender of vehicle owner
Tbl_Owner_Address	Address_ID	Varchar	PK	Holds first Name of vehicle owner

	Region	Varchar	Cannot be null	Holds Region of vehicle owner
	City	Varchar	Cannot be null	Holds City of vehicle owner
	Sub_City	Varchar	Cannot be null	Holds Sub City of vehicle owner
	Wereda	Varchar	Cannot be null	Holds woreda of vehicle owner
	Phone_No	Varchar	Cannot be null	Holds phone No of vehicle owner
	Owner_ID	Varchar	FK	Holds ID of Vehicle Owner
Tbl_Accident	Accident_ID	Varchar	PK	Holds ID of the accident
	Accident_Date	Varchar	Cannot be null	Holds Date of accident
	Accident_Place	Varchar	Cannot be null	Holds place of accident
	Latitude	Varchar	Cannot be null	Holds latitude of the accident
	Longitude	Varchar	Cannot be null	Holds longitude of the accident
	Accident_Type	Varchar	Cannot be null	Holds type of the accident occurred
	Air_Condition	Varchar	Cannot be null	Holds air condition during the accident.
	Light_Condition	Varchar	Cannot be null	Holds light condition during the accident.
	Cause_of_Accident	Varchar	Cannot be null	Holds possible cause of the accident.
Tbl_Decision	Accident_ID	Varchar	PK and FK	Holds ID of the accident.

	Decision_Status	Varchar	Cannot be null	Holds decision status of the accident.
	Decision_by_Money	Number	Can be null	Holds decision made in terms of money.
	Decision_by_Prison	Number	Can be null	Holds decision made in terms of prison.
Tbl_Road	Road_ID	Varchar	PK	Holds ID of a road at which accident occurs.
	Road_Name	Varchar	Cannot be null	Holds road name at which accident occurs.
	Road_Type	Varchar	Cannot be null	Holds road type at which accident occurs.
	Road_Covered_with	Varchar	Cannot be null	Holds road covered with at which accident occurs.
	Road_Condition	Varchar	Cannot be null	Holds road condition at which accident occurs.
	Road_Joined_With	Varchar	Cannot be null	Holds road joined with which accident occurs.
	Accident_ID	Varchar	FK	Holds ID of the accident occurred
Tbl_Victim	Victim_ID	Varchar	PK	Holds ID of the victim damaged by the accident.
	FName	Varchar	Cannot be null	Holds first name of the victim.
	MName	Varchar	Cannot be null	Holds middle name of the victim.
	LName	Varchar	Cannot be null	Holds last name of the victim.
	Age	Number	Cannot be null	Holds age of the victim.
	Gender	Varchar	Cannot be null	Holds gender of the victim.
	Victim_Type	Varchar	Cannot be null	Holds type of the victim.

	Victim_Work	Varchar	Can be null	Holds work of the victim.
	Victim_Status	Varchar	Can be null	Holds status of the victim.
Tbl_Victim_Accident	Victim_ID	Varchar	PK and FK	Holds ID of the victim.
	Accident_ID	Varchar		Holds ID of the accident.
	Victim_condition	Varchar	Cannot be null	Holds condition of victim.
	Consequence_of_Accident	Varchar	Cannot be null	Holds consequence of the accident.
Tbl_Driver	License_No	Varchar	PK	Holds license No of the driver.
	FName	Varchar	Cannot be null	Holds first name of the driver.
	MName	Varchar	Cannot be null	Holds middle name of the driver.
	LName	Varchar	Cannot be null	Holds last name of the driver.
	Age	Number	Cannot be null	Holds age of the driver.
	Gender	Varchar	Cannot be null	Holds gender of the driver.
Tbl_Driver_Accident	License_No	Varchar	PK and FK	Holds license No of the driver.
	Accident_ID	Varchar		Holds accident id of the accident.
	Driver_Condition	Varchar	Cannot be null	Holds condition of the driver during the accident.
	Consequence_of_Accident	Varchar	Cannot be null	Holds consequence of the accident.

5.6 Access Control

Table 5.2 describes general access controls of the system.

Table 5.2 Access Control

Subsystem	Class	Operation	Actors			
			Traffic Police Officer	Traffic Police Investigator	Stake Holders	System Administrator
Traffic Management	Vehicles	saveVehicleInfo(vehicles:Vehicles):void	✓			
		viewVehiclesInfo(plateNo:string):void	✓	✓	✓	
		updateVehicleInfo(vehicles:Vehicles):void	✓			
	Road	saveRoadInfo(road:Road):void	✓			
		viewRoadInfo(roadID:int):void	✓	✓	✓	
		updateRoadInfo(road:Road):void	✓			
	Driver	saveDriverInfo (driver:Driver):void	✓			
		searchDriverInfo (liscenseNo: string):void	✓	✓	✓	
		updateDriverInfo (driver:Driver):void	✓			
	Victim	saveVictimInfo (victim:Victim):void	✓			
		searchVictimInfo (victimID: int):void	✓	✓	✓	
		updateVictimInfo (victim:Victim):void	✓			

Subsystem	Class	Operation	Actors			
			Traffic Police Officer	Traffic Police Investigator	Stake Holders	System Administrator
Accident Management	Accident	saveAccidentInfo (accident:Accident):void	✓			
		viewAccidentOnMap (accientvictimID: int):void	✓	✓	✓	
		updateAccidentInfo (victim:Victim):void	✓			
Offender Management	Decision	saveDecisionInfo (accident:Accident):void		✓		
		viewDecisionInfo (accientvictimID: int):void	✓	✓	✓	
		updateDecisionInfo (victim:Victim):void		✓		
Report Management	Report	generateReport(reportID: Report):void	✓	✓	✓	
		printReport():void	✓	✓	✓	
User Management	User	createUser (user: User):void				✓
		searchUser (userID: String):void				✓
		grantRole (user: User, role: String):void				✓
		blockRole(user:User,role:String):void				✓

CHAPTER SIX: IMPLEMENTATION

This chapter presents the proposed system. The first section presents a brief information about the developed system. The next section presents the different development technologies used and the screenshots taken from the system. The third section presents the usability test carried out on the system.

6.1 The System

GRTAMS system has been implemented as a multiuser secure web based system that is hosted on standard java based web server.

The implementation of GRTAMS system is done via different technologies which are all FOSS. Java has been used to implement the main business logic and to integrate other technologies used in the implementation. The GIS functionalities has been implemented by different GeoServer components and while reporting has been done in Jasper soft reporting tools. In order to manage different spatial and non-spatial data, Postgres database has been used. Eclipse has been the main IDE for this development even though other tools are also used. The main challenge faced during the implementation was the difficulty to integrate different FOSS technologies used to implement the system.

Functional Description: Since the system requires authentication and it is based on user roles it has different URL's for the system users and for the system administrators. Figure 6.1 depicts logging page for system users.

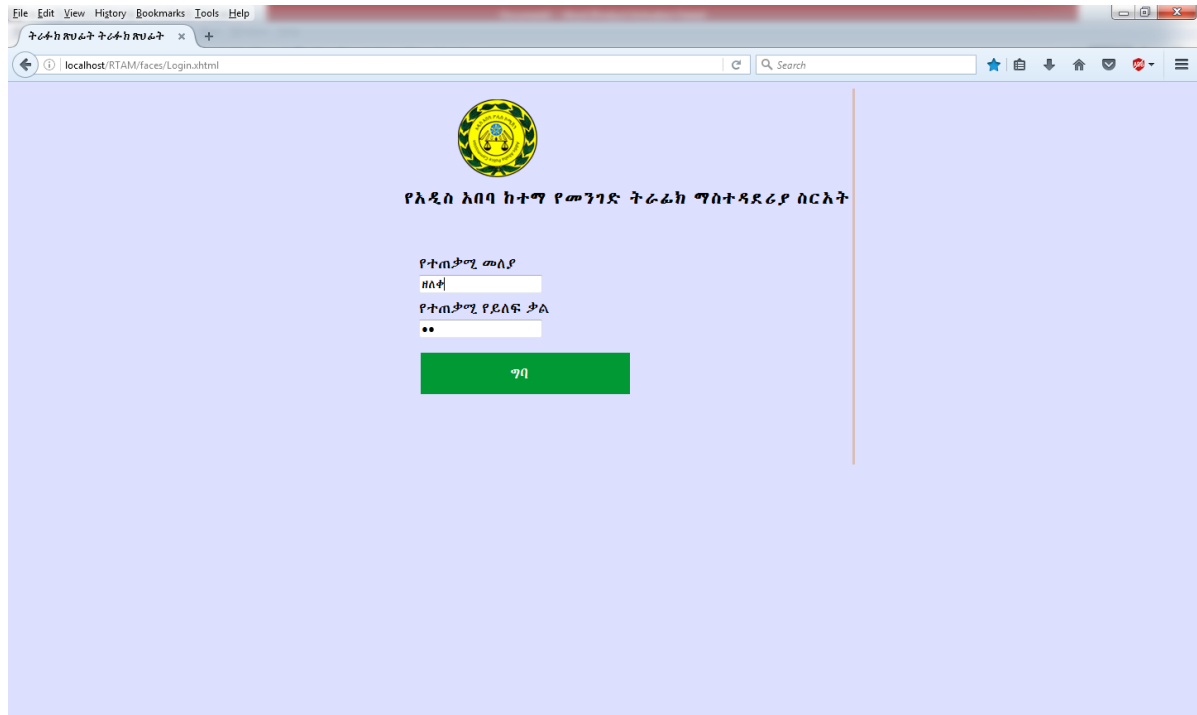


Figure 6. 1 Login Page for System users

In addition, since the system applies authorization, system users view different screens based on their role. Figure 6.1-6.9 show screen shots of system user login page, the home page for a traffic police officer, different ways of searching RTA data directly on a map, registration of RTA data , listing of RTA data ,viewing RTA black spots on a map, and selecting available printable reports.



Figure 6. 2 Home Page for Traffic Police Officer



Figure 6. 3 Page for Searching RTA on a map

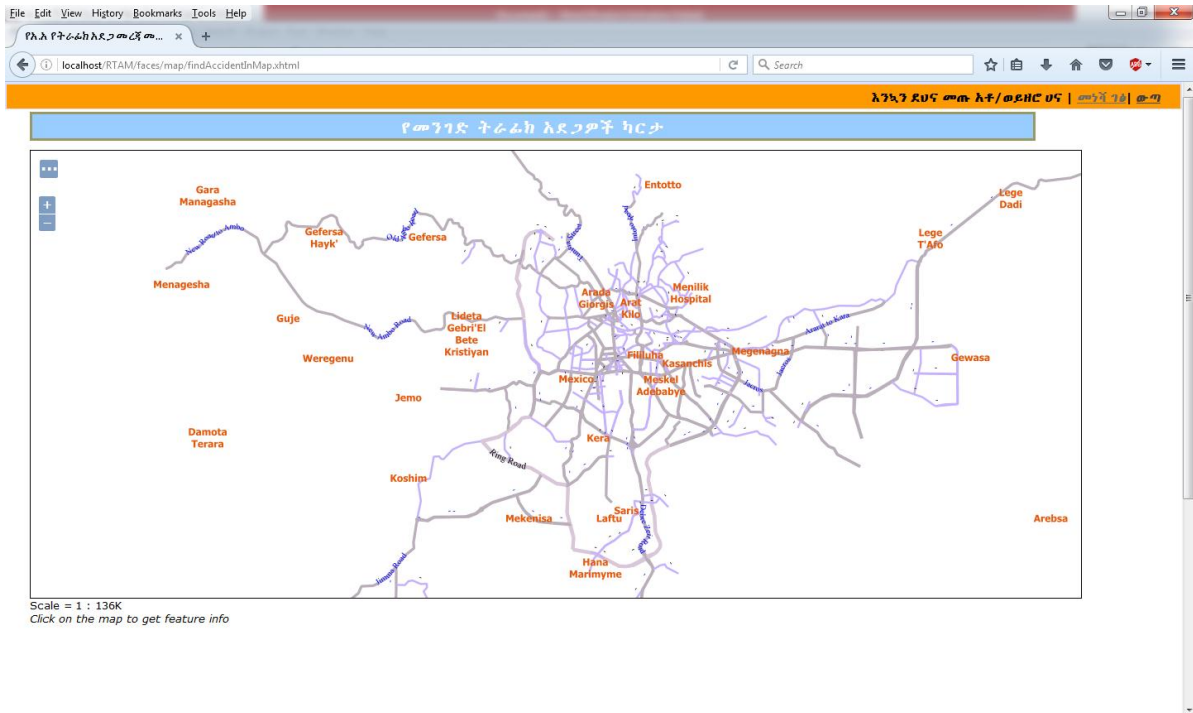


Figure 6. 4 RTA map search result

RTA can be viewed using non-spatial parameters by adding the viewparams parameter to the Geoserver's WMS GetFeature request.

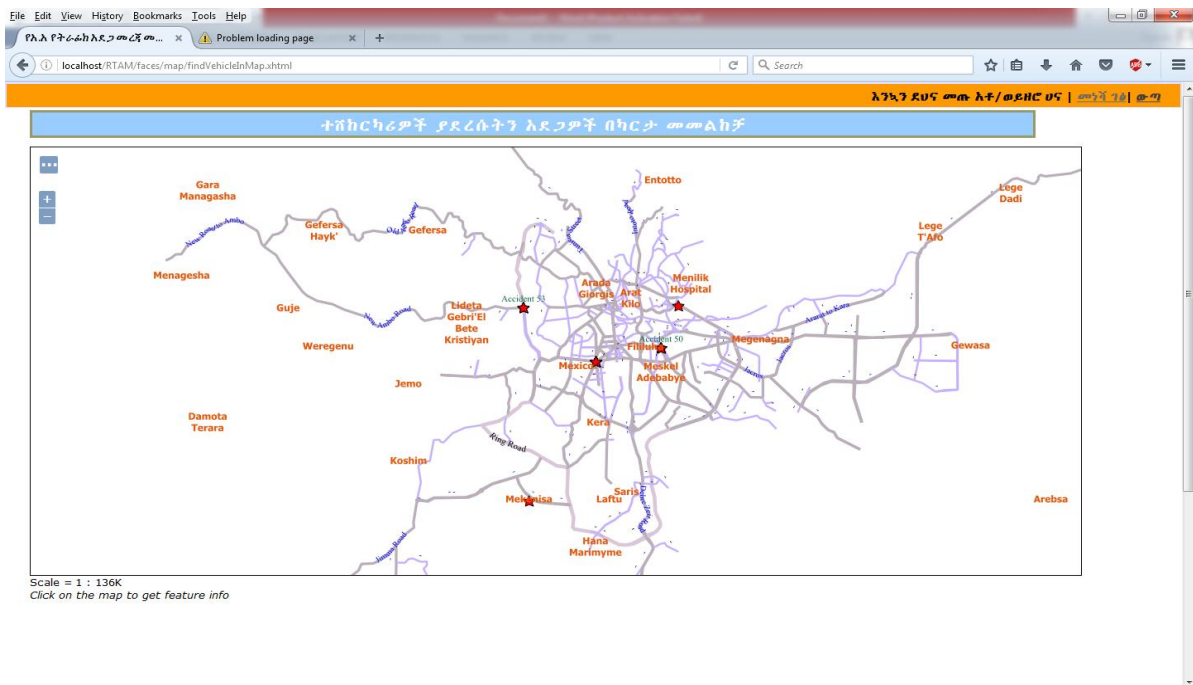


Figure 6. 5 RTA Map Query Result Based on Vehicle Parameter

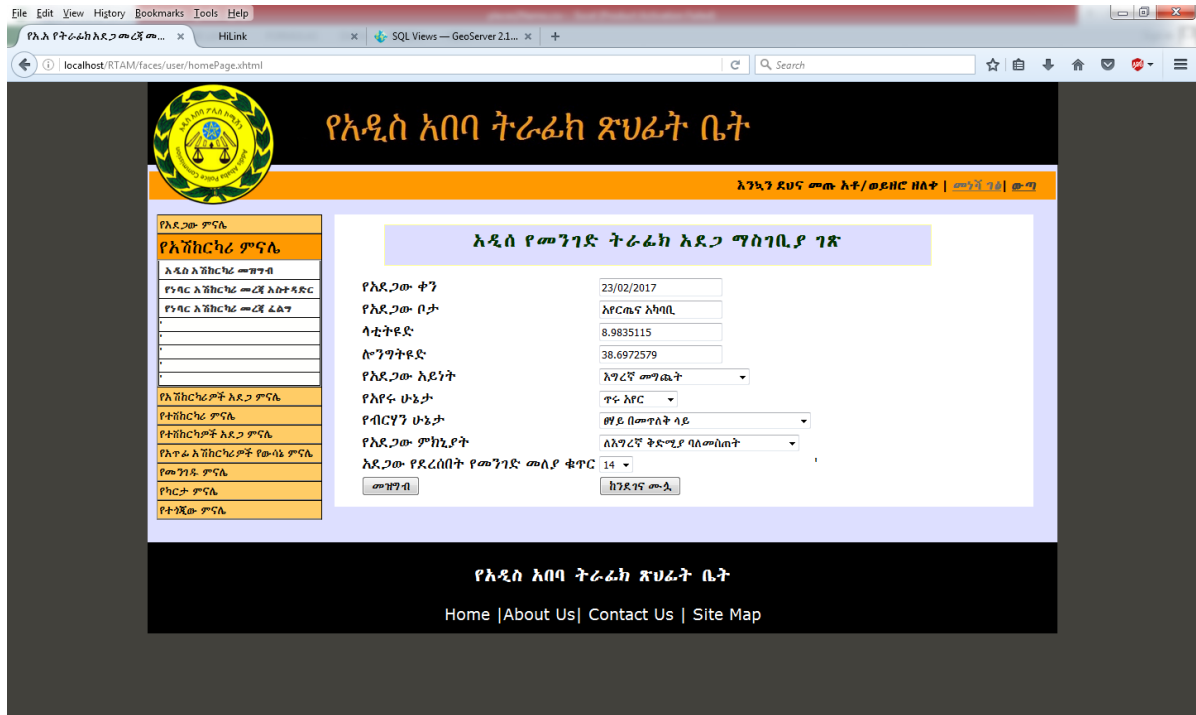


Figure 6. 6 Registration page for road traffic accidents

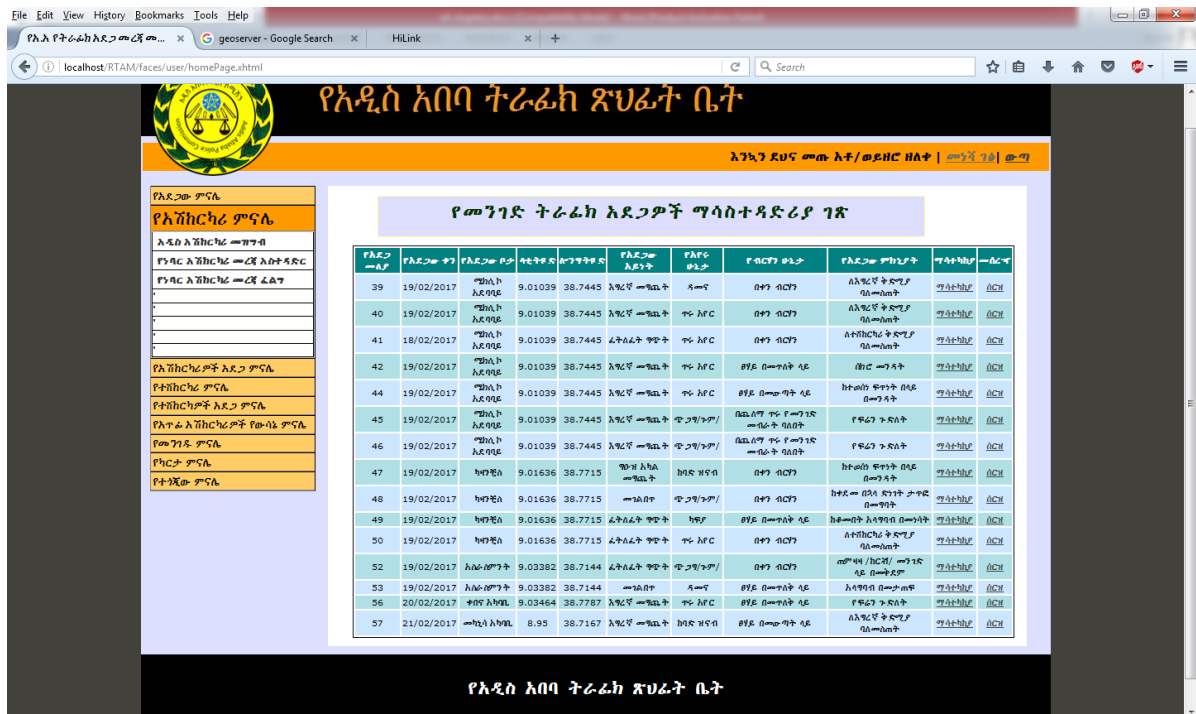


Figure 6. 7 Road Traffic Accidents Management Page

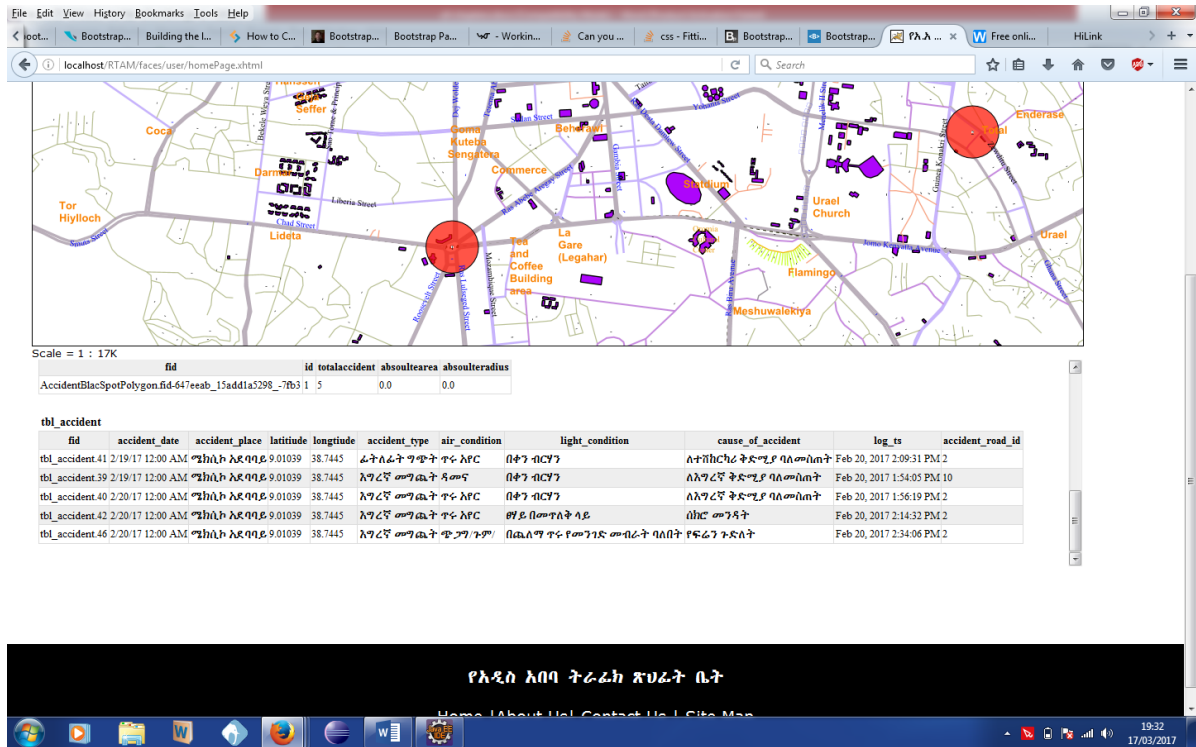


Figure 6. 8 Black Spots

The system also generated different kind of reports with different file formats based on different parameters for longer time period or for daily basis.

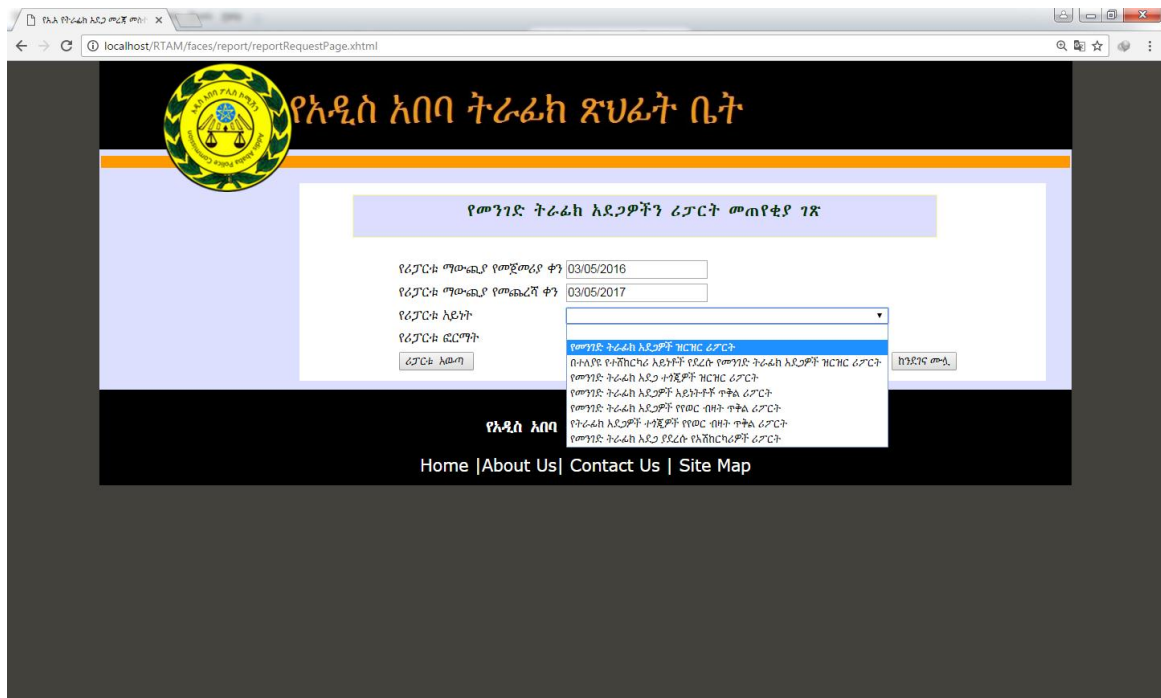


Figure 6. 9 Report Types for Long Time Periods

6.3 Usability Test

6.3.1 Introduction

Testing is the process of evaluating a system to detect differences between actual observed behavior of the developed application and the expected behavior so that to fix bugs and errors. In addition, it will help to assess the feature and quality of the system. In other words, testing is a verification and validation process. For this project, we conducted usability testing. This testing was carried out to evaluate the overall performance of the developed system.

6.3.2 Usability Goal

The goal of the usability test conducted is to assess the system's learnability for first-time users of the system, to evaluate the efficiency and performance of the system, to measure the error tolerability of the system by collecting qualitative data through post-test questioners from domains experts, stakeholder and professionals from other disciplines. A domain expert is an individual who is either a traffic police officer or traffic police investigator who has an experience of working on road traffic accident management.

6.3.3 Target users

The target users are traffic police officers, traffic investigators, stake holders and even individuals who are professionals. To conduct the usability testing we choose traffic police officers and investigators from Addis Ababa police commission, professionals from stakeholder companies, and professional individuals.

6.3.4 Profiles of Evaluators

Table 6. 1 Types of target users

Target users Type	Number
Traffic Police Officer	7
Traffic Police Investigator	5
Stake Holder	4
Professionals from other disciplines	4

Table 6. 2 Work Experiences of evaluators

experience	number
>20 years	2
20-15 years	4
14-10 years	9
9-5 years	3
5-3 years	2

Table 6. 3 Age Range of Evaluators

age	number
21-25	5
26-39	11
40-59	4

6.3.5 Evaluation Methodology

To evaluate the system eight traffic police officers, six stake holders and six professionals from different educational backgrounds were participated. The testing session takes approximately about 30-35 minutes and held at evaluator premise. We prepared questionnaire to each evaluator of the system to conduct the usability testing.

6.3.6 Evaluation Questionnaire

The question was designed to gather quantitative results from target users. The questions in the questionnaire include criteria such as functionality, usability, usefulness, and effectiveness. The designed questions are easy and understandable to make the evaluation process easy. There are 13 question and the taster has only one option to select for each questions. (Please see annex: D).

6.3.7 Evaluation Outcome

After the tasters conducted the usability testing on the developed system, questioners were distributed to each participant. The scale of the questioners was based on a scale of 1 to 5, where (strongly agree=5, agree =4, neutral=3, disagree=2, strongly disagree=1).

The evaluation result is presented in table 6.4.

Table 6. 4 Evaluation Result

Evaluation Questions		Value				
		1	2	3	4	5
1	The System is easy to learn?			4	8	8
2	The System is easy to use?			2	8	10
3	The menu Items well organized and functions are easy to find?			2	8	10
4	The user Interface of the system is pleasant?			4	8	8
5	Are you confident to use the system?			2	8	10
6	The system response is quick?			2	8	10
7	Whenever I make a mistake using the system, I can recover easily and quickly?				10	10

8	The system is helpful to use?			2	10	8
9	Do you think people would learn to use this system very quickly?			2	8	10
10	Do you think that you wouldn't need the support of a technical person to be able to use this system?			4	8	8
11	Do you find the various functions in this system were well integrated?			2	10	8
12	How successful is our software in performing its intended task?			2	10	8
13	What is your overall satisfaction of the system?			2	8	10

After gathering all responses from the questioners provided to the tasters, we found that Percentage of Strongly Agree and Agree response= $45.38\%+46.15\% = 91.53\%$.

Among the respondents 91.53% of the participant have responded with either strongly agree or agree reply for the usability test questions. From the evaluation analysis, we can conclude that the developed system met its objective. The evaluation summary result is presented in table 6.5.

Table 6. 5 Evaluation Summary Result

Question number	Response	Levels					Total
		Strongly agree	Agree	Neutral	Disagree	Strongly Disagree	
1	Frequency	8	8	4	0	0	20
	Percent	40%	40%	20%	0	0	100%
2	Frequency	10	8	2	0	0	20
	Percent	50%	40%	10%	0	0	100%

3	Frequency	10	8	2	0	0	20
	Percent	50%	40%	10%	0	0	100%
4	Frequency	8	8	4	0	0	20
	Percent	40%	40%	20%	0	0	100%
5	Frequency	10	8	2	0	0	20
	Percent	50%	40%	10%	0	0	100%
6	Frequency	10	8	2	0	0	20
	Percent	50%	40%	10%	0	0	100%
7	Frequency	10	10	0	0	0	20
	Percent	50%	50%	0	0	0	100%
8	Frequency	8	10	2	0	0	20
	Percent	40%	50%	10%	0	0	100%
9	Frequency	10	8	2	0	0	20
	Percent	50%	40%	10%	0	0	100%
10	Frequency	8	8	4	0	0	20
	Percent	40%	40%	20%	0	0	100%
11	Frequency	8	10	2	0	0	20
	Percent	40%	50%	10%	0	0	100%
12	Frequency	8	10	2	0	0	20
	Percent	40%	50%	10%	0	0	100%
13	Frequency	10	8	2	0	0	20
	Percent	50%	40%	10%	0	0	100%

CHAPTER SEVEN: CONCLUSION AND FUTURE WORKS

7.1 Conclusion

Currently, road traffic accidents are claiming many lives and property damages in the city. The accident trend shows alarming increase each year. This needs careful analysis and investigation for identifying root causes for the accidents, to take mitigation measures which reduce the number of accidents in the city. There is no formal system for accident location referencing in Addis Ababa, consequently, it makes it difficult to treat accident spots with proper road safety countermeasures. In addition, since there is no GIS based system available which effectively locate accident prone locations it is difficult to identify these hazardous locations. Identification of hazardous or most vulnerable accident locations (black spots), types of accidents and persons involved, form the basis for road safety policy design.

As a result, we need an automated GIS based system for analysis, exact identification of accident locations and visually to locate black spots to help stakeholders to take appropriate action to alleviate deadly accidents from occurring. Based on the above facts, we developed a GRTAMS which focuses on mitigating road traffic accidents existing in our city by automating data recording and storage. It provides spatial analysis function and generate summarized reports for decision making. In addition, since it has GIS capabilities it enables to visualize accidents on a map of the capital; it will make it easy for users of the system to pinpoint location of accidents easily. It will help the police officer, the police investigator, Addis Ababa road authority, insurance companies & other stakeholders for analysis and visualization of accidents. In addition, to enhance the usability of the system we used an Amharic user interface. The developed system was evaluated by domain experts and stakeholders. The usability test conducted has indicated that the performance of the system was very good and it meets its objective.

7.2 Future works

To improve the quality of the system, the following points should be considered.

- Integrating the GRTAMS with other stakeholder's system such as Addis Ababa road authority, insurances, etc. to facilitate exchange of data, to take prompt actions, and to have synchronized system among stakeholders.
- To enable the system to forecast and warn about black spots

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Annex A :Interview Questions

1. What is the main duty of Addis Ababa traffic police commission?
2. In what way road traffic accidents are reported to the commission?
3. Road traffic accident recording:
 - 3.1 What kind of information (data fields) are recorded?
 - 3.2 What kind of methods do you use to record the road traffic accident?
(Paper form or electronic form)
4. Road traffic accident location referencing:
 - 4.1 What techniques do you use to reference road traffic accident locations?
 - 4.2 Do you use Global Positioning System (GPS) to indicate road traffic accident locations?
5. Data storage:
 - 5.1 What kind of methods or techniques do you use to store road traffic accident data?
6. Reporting:
 - 5.1 How often do you prepare reports? (daily, weekly, monthly, yearly)
 - 5.2 How do you prepare reports? (manually, electronically(automated))
7. Analysis:
 - 7.1 What is a black spot in Addis Ababa context?
 - 7.2 Do you analyze and identify hazardous places (black spots)? If there is any is it manually or electronically?
8. What problems do you face with the current system?
9. What is your future plan to improve or change the current road traffic accident management system?

Annex B : Road Traffic Accident Recording Form

የትራፊክ አደጋ መ/ቆጥር _____

አደጋ የተፈጸመበት ቦታ _____ ስለት _____ ዓ/ም _____

የተከሰተው ስም ከአይ.ቲ. _____ ዕድሜ _____ ጾታ _____

የተከሰቱት ብዛት _____ ሴት _____ ዕድሜ _____ የትምህርት ደረጃ _____

የአሽተሽህግግኝነት _____ የግሽከርከር ልምድ _____ የተሽከርካሪነት _____

የሁሉም ቆጥር _____ ግብረትነት _____ የአገልግሎት ዘመን _____

የተሽከርካሪነት _____ መንገድ _____ አካባቢ _____

የመንገድ አካላዊ _____ የመንገድ አቀማመጥ _____

የመንገዱ መጋጠሚያ _____ የመንገዱ ግብዩ _____ የመንገዱ ሁኔታ _____

የብርሃን ሁኔታ _____ የአየር ሁኔታ _____ የተሽከርካሪነት _____

_____ የአደጋው ዓይነት _____ የደረሰው ጉዳት _____

የተጉዳተኞች ብዛት _____ የግብረት ጉዳት ግምት ብር _____

የከሰተው ስም _____ ዕድሜ _____ ጾታ _____

የከሰቱት ብዛት _____ ሴት _____ ዕድሜ _____

ሥራ _____ የአካል ብቃት _____ የከሰተው አካላዊ _____

_____ የአደጋው ምክንያት _____

የመርጫው ስም _____ ከህ የቀረበበት ፍ/ቤት _____

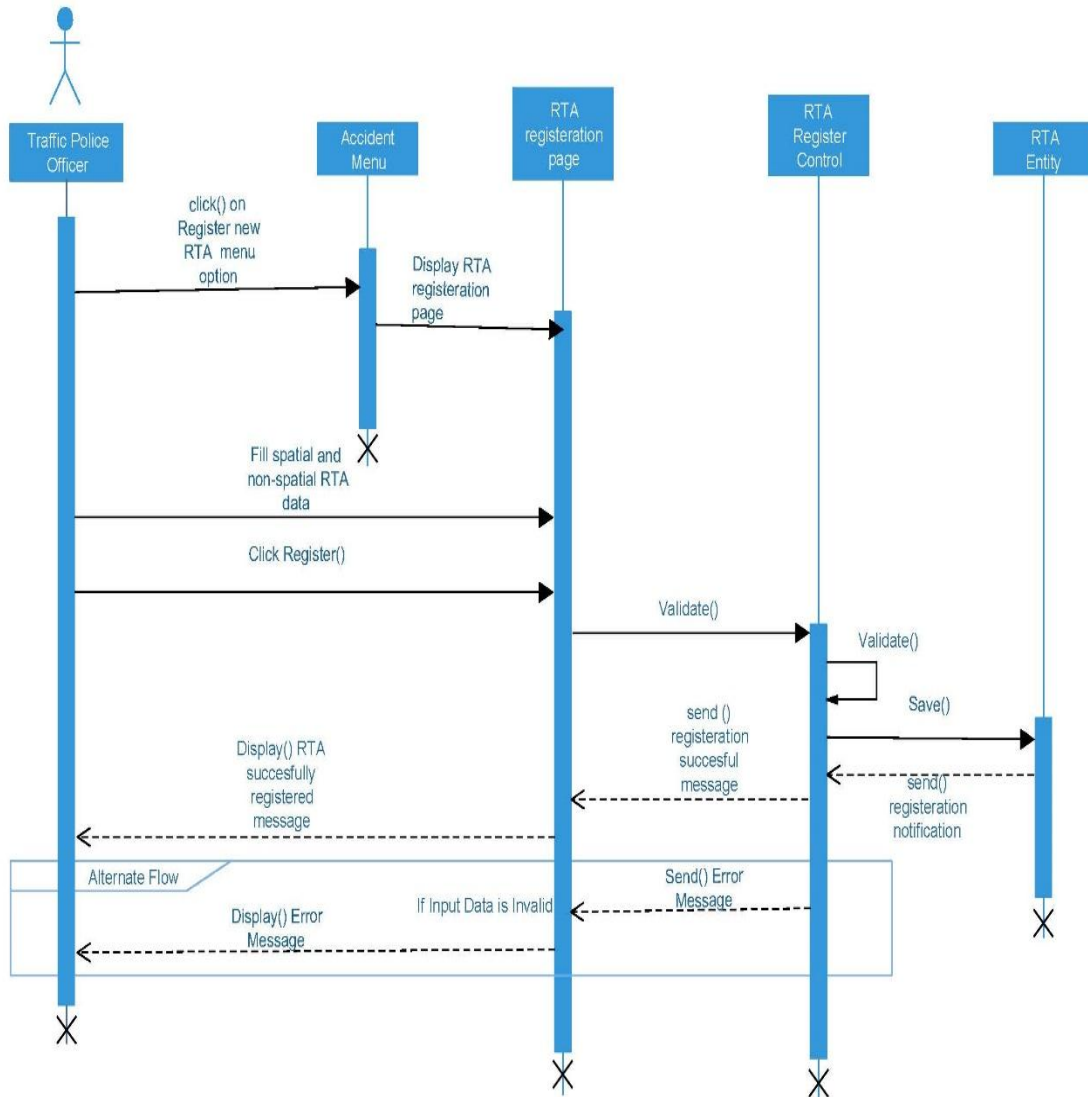
የፍ/ቤት መ/ቆጥር _____ የፍርድ ወጣኔ _____

Annex D: Evaluation Questions

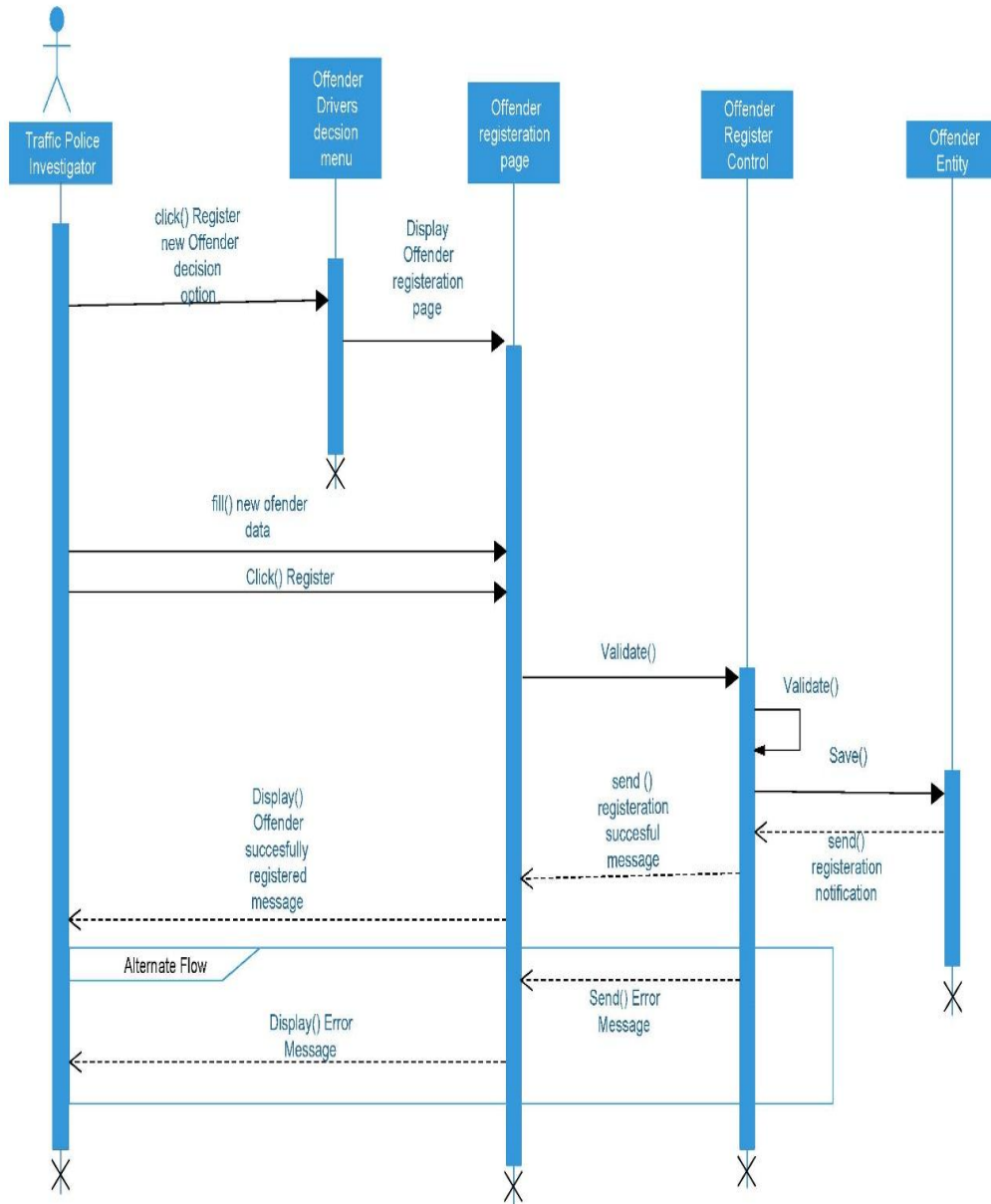
Instruction: Please put (✓) on the level you agree for each evaluation question. The level scale is from 1 to 5. (Strongly agree=5, agree=4, neutral =3, disagree=2, strongly disagree=1).

Evaluation Questions		Levels				
		1	2	3	4	5
1	The system is easy to learn?					
2	The system is simple to use?					
3	The Menu Items are well organized and functions are easy to find?					
4	The user interface of this system is pleasant?					
5	Are you confident to use the system?					
6	The system response is quick?					
7	Whenever I make a mistake using the system, I can recover easily and quickly?					
8	The system is helpful to use?					
9	The system gives error messages that clearly tell me how to fix problems?					
10	Do you think that you would needn't the support of a technical person to be able to use this system?					
11	Do you find the various functions in this system were well integrated?					
12	The system is successful in performing its intended task?					
13	What is your overall satisfaction of the system?					

Annex E: Sequence Diagram for Register Road Traffic Accident



Annex F: Sequence Diagram for Register Offender



Annex H: SQL Query to identify Black Spots

The above black spots depicted on the map are collected using spatial built-in query functions. Sample codes for implementing to collect black spots are listed below. This script is used to collect black spot candidate points.

“

```
SELECT tbl_accident.accident_id,
tbl_accident.accident_date,
tbl_accident.accident_place,
tbl_accident.longtiude,
tbl_accident.latitiude,
tbl_accident.accident_type,
tbl_accident.air_condition,
tbl_accident.light_condition,
tbl_accident.cause_of_accident,
tbl_accident.geog,
tbl_accident.log_ts,
'ጥጥጥ' AS victimcondition,
count(victimentityb.victim_accident_id) AS total_victim
FROM tbl_accident, victimentityb
WHERE tbl_accident.accident_id = victimentityb.victim_accident_id AND
tbl_accident.accident_date <= date(now()) AND tbl_accident.accident_date >= date(now() -
'1 year'::interval) AND victimentityb.victim_condition::text = 'ጥጥጥ'::text
GROUP BY tbl_accident.accident_id
ORDER BY (count(victimentityb.victim_accident_id));
```

“

- The below script defines an area for a black spot location which has candidate black spot points within 150 meter radius and the number of fatality is more than 3 for one year period data. “

```

SELECT row_number() OVER () AS id,
       st_numgeometries(f.gc::geometry) AS accidentno,
       f.gc AS accidentcluster,
       st_astext(f.gc) AS clustergeom,
       geography(st_minimumboundingcircle(f.gc::geometry)) AS hotspot,
       st_area(geography(st_minimumboundingcircle(f.gc::geometry))) AS hotspotarea,
       sqrt(st_area(st_minimumboundingcircle(f.gc::geometry)) / pi()) * 111111.1::double
precision AS hostspotradius,
       sqrt(st_area(geography(st_minimumboundingcircle(f.gc::geometry))) / pi()) AS
hostspotradiuscorrect

FROM ( SELECT geography(st_transform(unnest(st_clusterwithin(fff.accpoint,
150::double precision)), 4326)) AS gc

      FROM ( SELECT st_transform("BlackSpotCandidate1".geog::geometry, 20137) AS
accpoint

            FROM "BlackSpotCandidate1") fff) f

WHERE st_numgeometries(f.gc::geometry) > 3;
“

```

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 duly acknowledged.

Declared by:

Name: Khalid Ahmed

Signature: _____

Date: _____

Confirmed by advisor:

Name: _____

Signature: _____

Date: _____