



A Web based Road Traffic Accident Reporting System for Ethiopia

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Table of Contents

List of Tables	i
List of Figures	ii
Abbreviations and Acronyms	iii
Abstract	iv
CHAPTER ONE: INTRODUCTION	1
1.1 Background Information	1
1.2 Statement of the Problem	2
1.3 Objectives.....	4
1.3.1 General Objective	4
1.3.2 Specific Objectives	4
1.4 Scope of the project.....	4
1.5 Methodology.....	4
1.5.1 Data Collection.....	4
1.5.2 Tools.....	5
1.6 Significance of the Project	5
1.7 Organization of the Report	6
CHAPTER TWO: LITERATURE REVIEW	7
2.1 Road Accident Database	7
2.1.1 Scope of Road Accident Database	8
2.1.2 Potential Users of Road Accident Data	11
2.2 GIS for Road Accident Data Management	12
2.3 International Practice in Accident data Management.....	13
2.3.1 Accident Recording	13
2.3.2 Accident Location Referencing	15
2.3.3 Data storage.....	15
2.3.4 Exchange of accident data	16
2.3.5 Analysis and Reporting.....	16
CHAPTER THREE: RELATED WORK	18
3.1 Road Safety Management System (RSMS)	18
3.2 TRACKView	19
3.3 Road Crash and Victim Information System (RCVIS)	19
3.4 Accident Reporting System (ARS)	20
CHAPTER FOUR: OVERVIEW OF THE ROAD TRAFFIC ACCIDENT	21

REPORTING SYSTEM IN ETHIOPIA.....	21
4.1 Accident Data Recording.....	21
4.2 Accident Location Referencing	24
4.3 Data Storage.....	24
4.4 Exchange of Data	24
4.5 Analysis and Reporting.....	25
CHAPTER FIVE: REQUIREMENTS ANALYSIS	27
5.1 The proposed system Data Items (Fields).....	27
5.2 Functional Requirements.....	28
5.3 Non-functional Requirements	29
5.4 The Analysis Model	29
5.4.1 Use case models.....	29
5.4.2 Sequence Diagrams.....	36
5.4.3 Activity Diagram	38
5.4.4 Class Diagrams	40
CHAPTER SIX: SYSTEM DESIGN.....	41
6.1 Design Goals.....	41
6.2 Architecture of the system	43
6.3 Subsystem Decomposition.....	44
6.4 Deployment Diagram	46
6.5 Persistent Data Management	48
6.7 User Interface Design.....	49
CHAPTER SEVEN: PROTOTYPE OF THE SYSTEM	50
CHAPTER EIGHT: CONCLUSION AND FUTURE WORK	58
8.1 Conclusion.....	58
8.2 Future Works	59
References.....	60
Appendix A: Sequence Diagrams	A
Appendix B: Structured Interview	D
Appendix C: Accident Recording Form.....	E
Appendix D: Accident Report Form.....	F
Declaration:	G

List of Tables

Table 2.1 Common Data Parameters in Accident Data Recording	14
Table 4.1 Existing system data items	22
Table 5.1 Data items for the new Proposed System	27

List of Figures

Figure 2.1 Active National Level Accident Data System	10
Figure 4.1 Hierarchical Reporting System of Road Accident Reports	26
Figure 5.1 Use Case Diagram of RTARS	30
Figure 5.2 Sequence Diagram for the Accident Registration Use Case	36
Figure 5.3 Sequence Diagram for the Find Record Use case	37
Figure 5.4 Sequence Diagram for View Report Use case	37
Figure 5.10 Activity Diagram of the RTARS	39
Figure 5.11 Class Diagram of the RTARS	40
Figure 6.1 Architecture of the RTARS	43
Figure 6.2 Subsystem Decomposition of RTARS	45
Figure 6.3 Deployment Diagrams of RTARS	47
Figure 6.4 The Database tables and their relationships of the RTARS	48
Figure 6.5 User Interface of RTARS	49
Figure 7.1 Home page of the system	50
Figure 7.2 Log in form	51
Figure 7.3 Traffic police officer registration form	52
Figure 7.4 (a) General accident registration form	53
Figure 7.4 (b) Driver and Vehicle registration forms	53
Figure 7.4 (c) Passenger and pedestrian registration form	54
Figure 7.5 general accident reports	54
Figure 7.6 Driver accident report	55
Figure 7.7 Traffic Accidents by Year and Region	55
Figure 7.8 Accident Location Displayed on a map	56
Figure 7.9 Searching Accident record	57
Figure 5.5 Sequence Diagram for View Map Use case	A
Figure 5.6 Sequence Diagram for Log in Use case	A
Figure 5.7 Sequence Diagram for Create Account Use case	B
Figure 5.8 Sequence Diagram for Update Account Use case	B
Figure 5.9 Sequence Diagram for Delete Account Use case	C

Abbreviations and Acronyms

ADO.NET: ActiveX Data Object NET work

ASP: Active Server Page

C#: C-Sharp

GIS: Geographic Information System

GPS: Global Positioning System

HTTP: Hyper Text Transfer Protocol

IIS: Internet Information Service

RTARS: Road Traffic Accident Reporting System

SQL: Structured Query Language

Abstract

This project work has designed and implemented a web based Road Traffic Accident Reporting System (RTARS) for Ethiopia which will enable traffic police offices and other road safety stakeholders to get summarized online traffic accident information at various levels easily and quickly.

System requirements have been rigorously collected from the federal police commission central traffic accident analysis department and by consulting related literatures and software products which are used in other countries. The design and implementation of the system is done in accordance to the identified functional and non functional requirements.

The system has different subsystem to meet its core functionalities. An administration subsystem authenticates administrators and traffic police officers to login to the system and executes their defined task. The accident registration sub system allows the traffic police officer to enter and submit road traffic accident details using a simple to use wizard based interface. A report and query subsystem enables any interested users of the system to view some predefined reports and find particular accident records. Moreover the system is implemented with Amharic language interface for maximizing its usability and it can also displays an accident location on Google map.

Keywords: Road Traffic Accident, Road Traffic Accident Reporting System, National Road Accident Database System, Car Accident Data System, Web based Road Accident Reporting System; GIS- enabled Road Accident System, Car Crash Data Management System.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

A road traffic accident (motor vehicle collision, motor vehicle accident, car accident, or car/road crash) is when a road vehicle collides with another vehicle, pedestrian, animal, or geographical or architectural obstacle which can result in injury, property damage, and death [1].

Road traffic injuries are global problems affecting all sectors of society. According to the World Health Organization (WHO) more than 3000 people die on the world's roads every day, tens of millions of people are injured or disabled every year [2]. A recent United Nations Economic and Social Commission report also revealed that the number of road traffic accidents increases every year in the world and that these accidents kill around one million people and injures 23 million others and 85% of the fatalities occur in the developing countries [3].

Road traffic accident also brings huge economic loss to the global economy in every fiscal year. According to [4], the annual cost of road crashes is in excess of US \$500 billion, and in the developing world the estimated cost is about US \$65 billion each year. Due to the scarcity of costing data for African countries, it is difficult to make a precise cost of road crashes in Sub-Saharan Africa. The current estimate of cost of crashes in the continent is US\$ 3.7 billion per year.

Road accident in Ethiopia is one of the worst accident records in the world, as expressed per 10,000 vehicles [5]. Some places might contribute more to the accident than others. Addis Ababa, takes the lion's share of the risk having higher number of vehicles and traffic and the cost of these fatalities and injuries has a great impact on the socio-economic development of the society [6]. Every year, around 300 people are killed on Addis Ababa's roads and 1500 are lightly and seriously injured. The government has launched several campaigns, such as "Think!" and Road Safety Campaign (RSC), to help people become aware of road safety issues and try to reduce road accident [7].

A study by [8] has shown that the country's traffic accidents in the last three years, for example, have increased by 17 per cent and fatalities increased by 10 per cent which is in the range of 129 and 145 per ten thousand motor vehicles. The situation is likely to be even more severe than shown in the statistics due to the possible significant under-reporting.

In Ethiopia, the Federal Police Commission is responsible for national accident data collection, processing and reporting after collecting and compiling these data from regional offices. Regional offices of the traffic police are responsible for the recording of all traffic accidents under their jurisdictions. In each region woreda police station, accident data are processed and reported manually [7].

1.2 Statement of the Problem

The major difficulties in improving road traffic accidents worldwide are the lack of commitment by governments to tackle the situation; the lack of knowledge about what to do about the situation, and the lack of data to determine accident causes [9]. To date, road safety in Ethiopia has received insufficient attention at the national and regional levels. This has resulted in part from lack of information on the magnitude of the problem and its preventability [7].

The Ethiopian Traffic Enforcement Agency (ETEA) hopes to reduce traffic accidents death by 35% before 2013. ETEA has invested considerable resources in research and development to create a “driver education, administrative, and management system” to end the driving death epidemic [10].

But such and other initiatives would achieve their goals if they are supported by up-to-date Information about traffic accidents from any part of the country. A national level integrated road traffic accident recording and reporting system would supply more up to date road accident information which will assist the traffic police and other local government departments to become more effective in preventing road accidents. The road accident data can be used in a number of ways to help target the limited resources available for reducing the road accident cost. The traffic police can determine where and what type of enforcement campaigns will be most effective; what areas of driver training and testing should be emphasized; and what legislation needs to be enacted or amended.

According to [7], in Ethiopia, road traffic accident reports compiled from the kebeles and weredas are submitted to the pertinent regional police commissions on a monthly basis. A yearly report from the regional police commission will then be submitted to the federal police commission to generate national level road traffic accident report.

Given the current data processing and reporting of the road traffic accidents from the regional kebele and wereda to the federal level, the reports that will be generated will be much delayed and error-prone. This in turn would make the decision making process of the police offices and other stakeholders (insurance companies, law enforcing agencies) late from taking actions costing more citizens' life and property damages each day and each year.

Furthermore, much of the information in the reports collected by police is needed for the traffic police's own activity, primarily, to enforce the law and carry out prosecutions. But, some of the accident data are of no direct interest or use to the police, but are vital to the work of other organizations [7]. Such data could also be made used by other organizations for vital decision making, if there is an online web based system that makes the data easily accessible to the organizations.

An automated state of the art of the technology (especially web-based application systems) is common in other countries for alleviating and solving such kind of traffic accident data processing and report sharing problems. An automated web based road traffic accident reporting system can provide a number of benefits over the current road traffic accident reporting system used by the Ethiopian government police commission. Some of these include;

- Lower costs of processing and report communication
- Centralized data which is easy to secure, backup and share
- Updates can be made easily. Almost always up to date, than a year long update
- Increased availability at any time, any where
- Automatic generation of different reports with different formats and reduction of erroneous report generation

1.3 Objectives

1.3.1 General Objective

The general objective of this project is to develop a web based Road Traffic Accident Reporting System (RTARS) for Ethiopia that would allow traffic police offices and other road safety stakeholders to get summarized traffic accident information at various levels easily and quickly.

1.3.2 Specific Objectives

The specific objectives of the project are:

- To enable searching for any relevant accident record quickly that is registered from any corner of the country
- To facilitate various standard report and statistics generations at different levels quickly
- To provide online accident events/ incidents registration and communication
- To allow traffic police officers, insurance companies, road and transport authorities to access and see road accident reports of their interest
- To mark and display accident locations on a digital map
- To develop a prototype of the system

1.4 Scope of the project

The RTARS project is limited to the development of a Web based Road Traffic Accident Reporting System for Ethiopia based on a nationwide road accident database which is to be populated with data as accidents occur and registered online. The system is developed to be easily used with Amharic language.

1.5 Methodology

1.5.1 Data Collection

For the purpose of requirement elicitation for the new system, primary data from the federal police commission and other potential organizations such as insurance companies for their accident data recording and reporting requirements, has been collected and analyzed.

Traffic accident reporting systems designed and implemented in other countries have been also consulted for incorporating key and useful design and implementation features with the current system.

1.5.2 Tools

Different tools have been used for different purposes in the analysis, design and implementation of the RTARS. Among these tools: ASP.NET 3.5 for developing the web applications, C# for writing the application's script, Visual studio 2008 SQL Server data base designer for developing the back end data base.

1.6 Significance of the Project

The project's result could be applicable in different areas benefiting different target groups. The main beneficiaries could be the following.

- Traffic police officers are the main users of the system in registering traffic accidents, submitting or communicating it, initiating report generation and using the reports to take appropriate actions.
- Citizens, NGOs and media can get access to accident statistics and take necessary action with the help of local government.
- Insurance Companies whose insured was involved in an accident can also use the system to get current and up-to-date information about their client and take measure.
- Ethiopian Road Authority for identifying those roads which might have caused repeated traffic accidents and improve these road standards.
- Fire fighting and rescue department to provide prompt rescue services.
- Ministry of Transport and Communication to identify and monitor which of those licensed drivers and registered vehicles by the ministry are causing repeated accident.

1.7 Organization of the Report

The project report is organized in to seven chapters including this introduction chapter. The second chapter presents a review of literatures related with the subject. The third chapter revised related works (products) that are developed abroad. The fourth chapter gives description of the existing road traffic accident recording, analysis and reporting system. The fifth chapter discusses the requirements analysis and the sixth one discusses the system design of the system. The seventh and the last chapter present the prototype and, conclusion and future work of the system respectively.

CHAPTER TWO: LITERATURE REVIEW

Existing literatures related with the subject of road traffic accident recording, analysis and reporting systems are reviewed, summarized and presented under the following sections. Each of the topics in the sections has introduced one or more useful elements or features to be considered with the new proposed system (RTARS).

2.1 Road Accident Database

In order that governments are fully aware of the level of road safety, it is necessary to collect Information on road accidents and to keep data in a form that allows analyses to be undertaken if and when needed (i.e., a database). Only through analysis of accident data can an understanding be achieved of when, where, and how accidents occur [11].

The availability of road accident data is a prerequisite for each efficient road safety management system. Comprehensive, up-to-date, accident data is needed for recognition of the scope of road safety problems and for raising public awareness. Reliable and relevant data enable the identification of the contributory factors of the individual accidents, and an unveiling of the background of the risk behavior of the road users. It offers the best way to explore the prevention of accidents, and ways to implement measures to reduce accident severity [12].

According to [12] to effectively analyze, compare and make informed decisions from the data in the accident database, it is necessary to fulfill the following basic characteristics.

- Accuracy (to exactly describe the individual parameters)
- Complexity (to include all features within the given system)
- Availability (to be accessible to all users)
- Uniformity (to apply standard definitions)

Potential sources of these data include [13, 12]:

- police crash data
- hospital and medical data
- insurance data
- vehicle operators

The structure of road accident database is interesting whereby it naturally covers the three factors that influence accidents that are road user, vehicle and road environment. It is not therefore surprising that this structure is used all over the world to manage road accident records [14].

Commonly, road accident database has three main tables: the general information table (describing accident details); vehicle and driver information table; and injury information table. Each table maintains the report number variable. The variable will act as the key to link (one-to-many relationship) between the tables in the database. Structure of the database is kept to the minimum number of tables to enable query to be executed easier as most queries involve multiple tables [15, 11, 16].

According to [16, 11], each accident must have its own unique reference number to avoid duplication and to aid quick reference. In order that individual databases from different regions in a country can be easily combined to provide a comprehensive national database, this reference number can be a combination of a number of different fields like the serial number of the incident given by the police station at which it was reported; the year (assuming records begin again at the start of each year); and the individual police station identifier (which may be a combination of state or region and probably district codes).

For most purposes the database needs to be able to answer the following questions [16, 11, 13]:

- **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: poor light, weather, road surface condition and
- **why** or **how** did collision occur: collision type, driver fault type.

2.1.1 Scope of Road Accident Database

Depending on the level of data coverage in the database and level of availabilities to different user groups (that we referred to it as “Scope”), a road accident database can be designed and used at different levels. These are international, national, regional or local levels.

At the macro or ***national*** level it can be used to help central government decide on safety policy (e.g. compulsory seat belt wearing or motorcycle helmet wearing). At a ***regional*** level it can be researched to help regional authorities make appropriate decisions (e.g. on local police campaigns on drink-driving, child safety education). Where the computerized database was originally envisaged to be of most benefit is at the ***local*** level where the database can be used by local engineers and other agencies to determine where the main problems are on the network they are responsible for and, indeed, can be used in the black spot location identification process [16].

Road traffic accident is a global problem affecting all countries in the world. Thus, not only road safety stakeholders in a country need to have a national level integrated database of such accident records, but also there should be world-wide (***international***) or two or more countries cooperating in designing and using a common road accident database for exchange of statistics/reports and applying common effort in alleviating/finding solution to the common problem. The European Union's road accident database is a good example of such kind of database.

In order to easily undertake accident analysis and comparison within member states, the European Union is developing a Europe-wide accident database. This program has resulted in the International Road Traffic and Accident Database, (IRTAD) and the Community Accident Database on Roads in Europe, (CARE). The development of a Community-wide road accident database was strongly supported by road safety professionals as an essential tool for informed decision-making to combat effectively the huge road safety problem throughout the European Union. IRTAD has already become a valuable source for comparative analysis of road safety developments in different countries. It is the only international database that explicitly looks at historical consistency and international comparability of data on roads, traffic and accidents [17].

Due emphasis should be given in designing and implementing a national level database so as to bring ease of processing and producing national reports by providing uniform data elements and entry forms to all regional jurisdictions. According to [18], at a national level, with many separate jurisdictions responsible for crash data, there are difficulties with entities having

different data sets, methods, uses & definitions. Several countries can find it difficult to aggregate good data and produce meaningful national analysis and reports. Listed are some of the issues:

- Over one year delay in producing reports
- Usually ends up producing standard statistical tables or annual data
- No clear strategies, planning or identification and solutions of specific problems possible
- No scientific way to evaluate effectiveness of programs until it is too late
- National coordination of crash data done poorly around the world. Even in countries like UK, US, Australia etc coordination of data for use nationally is poor
- Collection of crash data is often carried out at lower levels of jurisdictional responsibility
- This distributed collection means that the national process is usually the passive receipt of aggregated data centrally.

Thus, to [18], all these issues can be resolved by implementing a single comprehensive “active” Crash Data system at a national level as depicted in Figure 2.1.

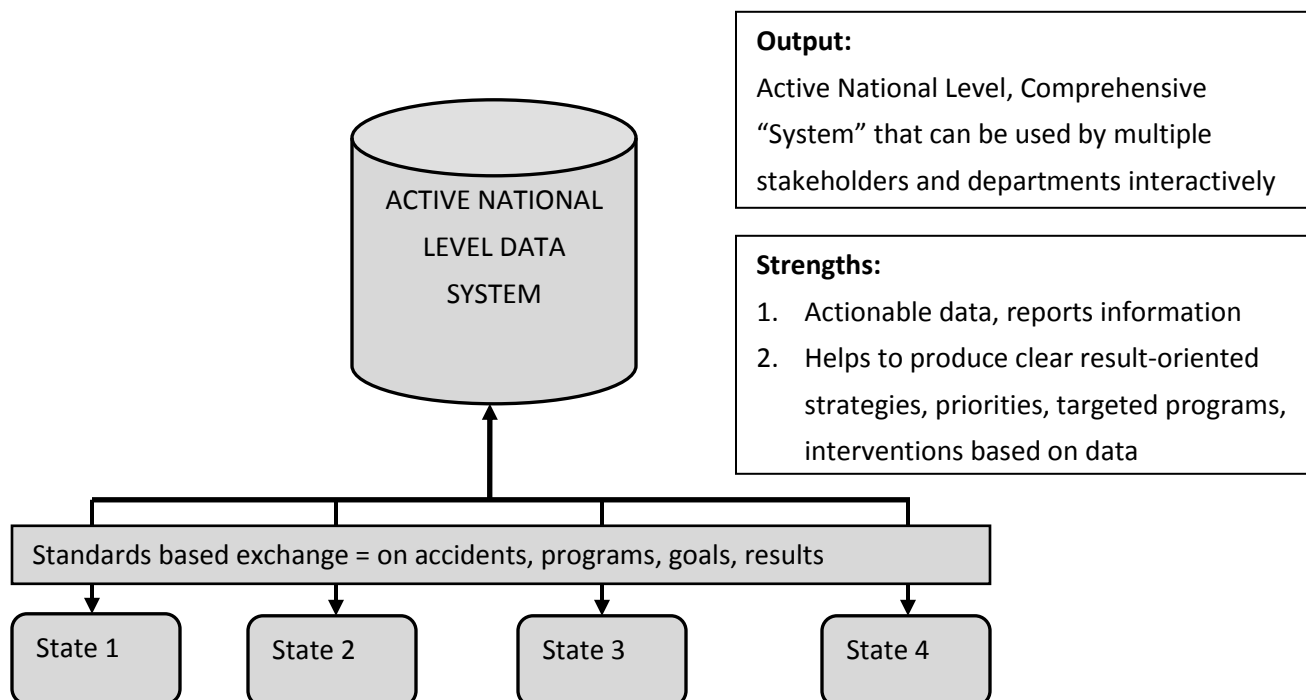


Figure 2.1 Active National Level Accident Data System

There are considerable benefits from such a system. National analysis would be at a detailed rather than at an aggregated level mainly used for statistical reporting. Policies and strategies supported by such analysis would better meet the national needs and provide better coordination of activities at national and jurisdictional level. Detailed national crash data base could be made available to all agencies contributing to road safety, and those in need of road crash data at a national level [18].

2.1.2 Potential Users of Road Accident Data

In order to help in reducing the number of road accident and fatalities, the availability of a reliable and comprehensive road accident database system is critical to understand the pattern of accident causation. And this must be made accessible to all those bodies able to contribute to accident reduction. Indeed, it is likely that an unreliable or inaccessible database will only lead to inefficient management of road safety [15, 16].

Road traffic accident can be of interest to different agencies; the police, if the vehicle is going too fast, the highway authority, if the road is poorly maintained, and the educational department for lack of awareness of safety measures. Accident information can therefore prove to be useful to different stakeholders and can be used for the following commonly, referred to as the three “E’s” [19]:

- Enforcement
- Engineering
- Education

Generally, accident data can be used at different levels by several groups of people with different road safety interests. These include road safety officers and highway engineers, vehicle design engineers, police, lawyers, road safety researchers, politicians, teachers, statisticians, insurance companies, emergency services (ambulance, fire fighting service), public drivers, statisticians, education services and members of the public etc. They all tend to have slightly differing needs and reasons for wanting the data. These include [20, 16, 13, 11]:

- identify high risk/problem groups
- identify high risk hazardous locations
- designing safety schemes and devices

- justification for highway planning
- enforcement planning
- education and training
- insurance claims
- make international comparisons
- evidence for prosecution
- evaluate effectiveness and monitor achievement of targets

It is necessary, therefore, for all concerned to have access to a relevant sub-set of the accident data, or for them to maintain their own independent database consisting of a sub-set of the original data with a common link for interconnectivity. It is well recognized that a program of traffic accident reduction schemes, based on an accurate and comprehensive database of accident information, will enable authorities to achieve a substantial reduction in the number of traffic accidents. It should therefore be a requirement of a successful system that it meets the needs and aspirations of all these and other stakeholders.

2.2 GIS for Road Accident Data Management

GIS is a Geographic Information System that represents features on the earth, such as buildings, cities, roads, rivers, and states, on a computer. People use GIS to visualize, question, analyze, and understand this data about the world and human activity. Often, this data is viewed on a map, which provides an advantage over using spreadsheets or databases [21].

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. GIS allow the identification of locations where crashes are overrepresented within a community, and offer the ability to graphically identify accidents and query the accidents by type and cause [22].

Many highway agencies have been using GIS for analyzing accident data. The GIS based application combines the information collection capabilities with the visualization. Using the system, the user can merge accident and roadway data, match the accident data and locations, analyze the data using fixed segment, sliding and spot analysis, calculate frequency and rate of accidents, select a variable for stratification to calculate mean and standard deviation of accident rates and frequencies and sort the sections based on selected criteria [23].

GIS allows a user to see crash locations on a map interface. Several mapping functions can be added to allow the user to go to different map locations. These include zoom in, zoom out, panning, and so forth. The user is able to visualize crashes on the maps based on crash parameters.

GIS software can generally be used to create [24]:

- Location map showing accidents spots
- Digital Terrain Model at the accidents spots
- Road traffic accidents distribution by types i.e. fatal, serious and slight injuries and time (day light or night)

This information forms a basis for determining:

- whether the vertical and or horizontal alignment needs to be re-designed and or a full rehabilitation of the road done, and or ;
- a road intersection needs to be improved so that grade separation can be introduced and or ;
- the road furniture needs to improved to avoid road users making ambiguous decisions when obtaining services from the road facility.

2.3 International Practice in Accident data Management

Several countries have some well developed practical accident data management systems and practices that are worthy to be considered in the current proposed system and in the future expansion/improvement of the proposed system. Those countries that we have easily accessed some literatures about their accident data management systems and practices are summarized and presented in the following sections. The countries reviewed are Cambodia, Malaysia, United Kingdom, Abu Dhabi, Sweden, Kenya, Australia, United States and New Zealand.

2.3.1 Accident Recording

The data items identified and recorded in most countries are similar except there are some variations in the level of detail and variations due to difference in definitions of the collected data items and values.

Police officers are the ideal data collectors in almost all countries, as they usually are one of the first to be called to an accident site.

Though, pen and paper are still commonly used medium for accident data recording and collection, electronic methods such as Mobile Data Terminals (MDT's) are already being used in some countries like Australia, UK and several states in US. Electronic filling in of accident forms would not only accelerate the entire collection procedure, and thus improve it, but also minimize the potential for data inconsistency.

The basic accident data parameters appearing on accident report forms in many of the countries which have generally been found to be useful to satisfy most of the needs of the various interested bodies can be summarized in the following categories [11,15,16,19].

Table 2.1 Common Data Parameters in Accident Data Recording

General Details	Road Type	Environmental Condition	Precise Location
<ul style="list-style-type: none"> • Report no • Year • Month • Date • Time • Region/State • District code • Police station no. • Severity • Collision Type • No. of casualties • No. of cars • Vehicle damage cost 	<ul style="list-style-type: none"> • Class of road/road no. • Carriageway type/no. of lanes • Speed limit • Junction type • Road width • Road shoulder width 	<ul style="list-style-type: none"> • Light condition • Road lighting • Road surface condition • Road surface quality • Weather • Geometry • Hit & run • Road works 	<ul style="list-style-type: none"> • Map reference • Longitude • Latitude • Y-coordinate • Kilometer post • Location description • Accident description
Vehicle/Driver details			
<ul style="list-style-type: none"> • Vehicle model • Vehicle type • Vehicle damage • Vehicle ownership • Registration no. • 		<ul style="list-style-type: none"> • Driver age • Driver sex • License no. • License status • Seat belt/Helmet • Alcohol/Drugs suspected 	

Casualty Details	
<ul style="list-style-type: none"> • Type of road user • Age • Sex • Race • Severity • Passenger location 	<ul style="list-style-type: none"> • Pedestrian location • Pedestrian movement School Pupil

2.3.2 Accident Location Referencing

In most forms several information are provided to locate the accident place. These include the street name, highway number, intersection number, or milepost information. The use of geographic coordinate of the accident location is practiced in most countries, and this is not determined in the field but back in the police office with the help of a map. Some states in the USA, Sweden, Australia and some regions in the UK have started to use GPS as a tool to reference an accident [25, 19]. GPS is highly relevant particularly in urban areas where smaller meter accuracy is needed to locate direction. The use of GPS together with GIS maps stored on MDT's is a trend now for accident data recording.

2.3.3 Data storage

As stated above, in all countries, the authority responsible for entering and storing national road accident data is the police force, while other authorities are ordinarily responsible for maintaining road accident databases. More than one road accident database is maintained in many countries, mainly by hospitals, insurance companies, or ministries which are rarely linked. The data collected by the police at national level are transferred to the responsible authority and entered in the respective database. Commonly used database management software for managing the data includes Oracle, MySQL, SQL and Access.

In Sweden and Australia it was found that there is a plan to cross-reference the accident data with other information such as hospital data, thus enabling a further level of quality assurance and data sharing between concerned agencies. Police accident databases are often a component of larger police databases and information is linked to driver and vehicle databases.

2.3.4 Exchange of accident data

The exchange of accident data between the police offices and other interested stakeholder organizations for further analysis and their own decision making purpose is made through different methods. This exchange of data was found to be done by the following common methods;

- Publishing on the Internet
- hard copy transfer (printouts)
- Soft copy transfer (CD, flash etc.)
- Sharing data with Wide Area Network

Countries like Sweden and Australia have an already established system of an on line linkage of accident databases between police, local authorities, hospitals, and other interested organizations such as research and statistics institutes.

2.3.5 Analysis and Reporting

Underreporting is considered as a major limitation in most countries. Only injury related or high value property damage accidents are reported and considered in general analysis. All countries reviewed had a requirement to produce standard sets of accident statistical reports on a periodic basis. First level accident analysis are usually carried out by the local police offices to produce a summarized report or statistics which are usually required to be presented to local or national level institutions. And then after these institutions might perform more detailed analysis to meet their decision making need.

Some type of road accident data or variables appears to be more frequently used by different stakeholders in accident analysis independent of the country. A study by [26] shows that, 22 out of 29 variables are highly used by half or more of the stakeholders in six countries, while it seems that the variables mostly used by the stakeholders (over 70% of the stakeholders use them) are those related to the road user's gender, injury severity and accident type, as well as to the collision type. Other important road accident variables for the various stakeholders (over 50% of the stakeholders use them) concern: person class, vehicle type, speed limits, road and area type, alcohol/drug test, road surface conditions, region, junction control, security equipment, road markings, junction type, number of lanes, vehicle maneuver, carriageway type, lighting conditions and pedestrian movement. At the same time, the least used variables when conducting

road accident data analyses, are related to driving license, age, nationality and hit and run accidents.

The software systems being used for analysis purpose relatively vary in different countries from an in-house developed once to commercially available systems in the form of desktop based or web based and GIS enabled forms.

CHAPTER THREE: RELATED WORK

The existing road accident reporting system products appear in general in two forms as Desktop application (using Mainframe or Microcomputer) and Web-based. Recently, both types of the application categories could be also GIS enabled for ease of visualization of accident locations and accident analysis.

Web based applications are more complex and powerful for accident data access and sharing than desktop applications. Web based applications are developed on top of international, national or regional road accident databases and made accessible through the Internet or Intranets. But, desktop applications are designed to run on a local database of a standalone computer. Some web based applications are reviewed in the following sections.

3.1 Road Safety Management System (RSMS)

RSMS is a software product from India's transportation IT systems provider, IBS software. It is an accident database management system that redefines the way road crash data is managed. RSMS allows the police to record a host of information regarding road crashes (in the form of circumstances related to humans and vehicle(s) involved and road at the time of the crash). The software is GIS enabled, allowing users to pinpoint the exact geographic location of the crash by directly plotting on a map or using GPS handsets to obtain coordinates. This integrated information is then available in a format of choice to multiple stakeholders, (traffic police, road engineering departments, motor vehicles departments, insurance companies, healthcare, and non-government agencies involved in road safety) which can help them scientifically plan and implement appropriate intervention measures to reduce road accidents/enhance road safety [27].

RSMS has three versions [28]:

1. **RSMS enterprise**: web based , country level application
2. **RSMS Lite**: web based, province level application
3. **RSMS desktop**: single, local installation

As a web-based system, RSMS facilitates easy data entry from multiple locations ensuring ready availability of live data for all authorized users whenever required. Since data drives decision

making, delay in actions, arbitrariness and inconsistent planning to reduce road accidents due to cumbersome paper-based reporting processes, inconsistent and inaccurate reporting, lack of availability of data and a heavy backlog would all be a thing of the past. The product can be used by customers of both developing countries and those with mature road networks [27].

RSMS has six major sections: Accident Recording Engine, GIS Engine, Safety Analysis Engine, Standard Reports, Dynamic Standard and Spatial Query Builder and Administration and Tools sections [28].

3.2 TRACKView

TRACView is an Internet based application that was developed to help law enforcement agencies and insurance companies in US and Canada manage and access traffic accident reports in a more efficient manner [29].

TRACView Benefits include:

- Flexible searching tools to help you find the report quickly and easily.
- Allow multi-jurisdictional data sharing and searching.
- A comprehensive system to facilitate web accessible availability of accident reports for insurance companies, officers and citizens.
- Remove the police department from the billing and request fulfillment process.
- Reports are available from work or home, 24 hours a day via the Internet.
- Reports are converted to PDF format making them easy to view, save, print and email.
- Reports are accessible usually within 24 hours of being scanned.
- Reports cannot be modified, maintaining report integrity.

3.3 Road Crash and Victim Information System (RCVIS)

The objective of the RCVIS is to provide governments and development stakeholders in Cambodia with accurate, continuous and comprehensive information on road crashes and victims for the purposes of increased understanding of the current road safety situation, planning appropriate responses and policy, and evaluating impact of current and future initiatives [30].

RCVIS collects, centralizes, analyses and disseminates information provided by three different sources: Traffic police, Public health facilities, Private clinics. Traffic police officers, hospital and private clinic staffs of all the 24 Cambodian provinces/cities; all use uniform RCVIS data collection forms.

Traffic police officers along the main Cambodian national roads are now equipped with GPS devices to accurately identify road crashes location. By accurately locating road traffic accidents, precise digital maps can be produced and help to identify black spots, a key element for understanding the nature of accidents, prioritizing actions to reduce accidents and measuring progress[30].

3.4 Accident Reporting System (ARS)

ARS, GIS based web application which provides details of all the road accidents in Pune [one of the largest city found in India] region. It is a software application developed for Traffic Police Department to enter all details of an accident and exact location of the accident. Innovative use of map technology makes it possible to view all accidents on map of Pune. It can generate various reports and useful statistics based on accidents data. This helps Traffic Police to identify accident prone areas and analyze causes behind accidents. Necessary action can be then taken to prevent future accidents [31].

ARS key features includes:

- Simple form to enter all important details of an accident such as details of people involved, vehicles involved, cause of accident, road and weather conditions.
- Detail map of Pune region with facility to Zoom In, Zoom Out and Quick Zoom. Exact accident spot can be located on the map
- Police jurisdiction boundaries are shown on the map
- Search feature to quickly find out relevant accident from all accident data
- User can specify accident parameters, form query and see results on the maps to get the insight
- At a click of button, twenty different types of reports (accident statistics) can be generated based on accident data
- All reports and results on map can be easily printed for offline use

CHAPTER FOUR: OVERVIEW OF THE ROAD TRAFFIC ACCIDENT REPORTING SYSTEM IN ETHIOPIA

The collection and reporting of road traffic accident data in Ethiopia is the responsibility of the traffic police. All accidents, whether non injury or injury, are required to be reported and investigated by the traffic police at the time and scene of the accident. Information about the existing system has been collected mainly through a structured interview (Appendix B) method. We can summarize the general accident recording and reporting situation by looking at five main areas: accident data recording, accident location referencing, data storage, data/information exchange, and analysis and reporting.

4.1 Accident Data Recording

Road accidents are currently recorded using pen and paper. A form (shown in Appendix C) is used to record the basic accident related data at the accident site by the traffic police officer. The form is uniformly used in all police stations throughout the country, to record all the injury and non injury accidents. An accident to be recorded as a road traffic accident by the local traffic police officer, it should involve three things: the vehicle, the road and the person/animal or any object resulting in fatality or injury or property damage. For example, a tractor killing a man on a farm land is not an accident that will be recorded as traffic accident.

At the scene of an accident, the officer attends the accident, collects data and makes a decision on fault at the scene. Witnesses are also registered for those injury accidents to serve as a witness in the courts. Besides photographs and sketches of the accident, location is taken for better description of the accident location

The traffic police accident data form contains a number of data items concerning the accident; vehicles involved, people (driver, passenger, and pedestrian) involved, road and weather condition etc. These detail data items or fields which are around 30 and their expected coded values are identified and presented with the following table. The full Amharic version of the report form from which the translation is made is annexed in Appendix D.

Table 4.1 Existing system data items

S/N	Data Item/Field	Domain(expected value)
1	Accident Day	{Monday, Tuesday ... Sunday}
2	Accident Hour	{1-2, 2-3 ... 23-24,24-1}
3	Driver Age	{<18, 18-30,31-50, >51, Unknown}
4	Driver Sex	{Male, Female, Unknown}
5	Driver Educational Level	{Illiterate, Basic Education, Elementary, Junior, High School, Beyond High School, Unknown}
6	Driver-Vehicle Relationship	{Owner, Employee, Other, Unknown}
7	Driver Driving Experience	{No Driving License, <1 Yr. , 1-2, 2-5, 5-10, > 10 , UK}
8	Vehicle Service Age	{<= 1 yr. ,1-2, 2-5, 5-10, > 10 yr, UK}
9	Vehicle Type	{Pedal Bicycle, Motor Bicycle, Automobile, Station Wagon, Pickup<=10 Quintal, Truck 41-100Q, Truck pulling Trailer, Taxi, Public<=12 sit, Public 13-45, Public >46, Train, Other, UK }
10	Vehicle Ownership	{Government, Public, Military, Police, Private, Core Diplomat, UN, AU, International Organzn., Other, UK}
11	Vehicle Contributing Circumstances	{Brakes, Steering, Exhausted Tires, Light, Other Mechanical deficiencies, Unknown}
12	Road Type	{Country Side Connecting, Province Connecting, Rural Road, Urban Road}
13	Accident Area	{Rural Town, Outside of Rural Town, School area, Factory area, Worshipping area, Market area, Temple area, Hospital area, Office area, Residential area}
14	Road Separation	{One-way, Two-way not divided, Divided with Island, Divided with street painting, Divided with broken painting }
15	Roadway Alignment	{Straight & Level, Straight & hill crest, Straight on grade, Curve & Level, Curve on Grade, Hilly, Sloppy, UK}
16	Road Geometry Type	{Non-Junction, Four-way intersection, T-intersection, Y-intersection, Five point or more}

17	Roadway Surface Type	{Concrete Asphalt, Asphalt, Gravel, Dirt }
18	Roadway Surface Condition	{Dry, Wet, Muddy, Other}
19	Light Condition	{Day Light, Dusk, Down, Dark-Lighted Roadway, Dark-roadway not lighted, Dark-Unknown road way lighting}
20	Weather Condition	{clear, foggy, cloudy, sleet or hail, heavy rain, sever crosswind, blowing sand, hot, cold, other}
21	Vehicle Maneuver	{Entering Traffic Lane, Leaving Traffic Lane, Turning Right, Turning Left, Making “U” turn, Overtaking, Straight ahead, Backing, Starting Traffic Lane, Parking Maneuver, Others, Unknown}
22	Manner of Collision	{Rear End, Head-on, Angle, Sideswipe-same direction, Sideswipe-opposite direction, Rear-to-rear, Others, Colliding with Animals, Colliding with Pedestrian, Colliding with Objects, UK}
23	Pedestrian Maneuver	{Crossing Traffic Light, Crossing Zebra, Leaving Motor Vehicle, Working on Motor Vehicle, Standing, Playing, Laying, Other, Unknown}
24	Driver Contributing Circumstances	{Failed to yield to vehicle, Failed to yield pedestrian, Disregard traffic light or signals, Driving too fast, Overtaking, Improper turn, Improper lane change, Improper parking, Running off road, Drinking, Drugs, Asleep, Illness, Cell phone, Physical Impairment, UK}
25	Victims(Driver, Pedestrian, Passenger) Age & Sex	{<18 yrs, 18-30, 31-50, >51} {Male, Female}
26	Injured Animals	{No. of Dead Animals, No. of Injured Animals}
27	Vehicles Damage Extent	{No. of Vehicles Severely Damaged, No. of Vehicles Slightly Damaged}
28	Accident Severity	{Death, Severely Injured, Slightly Injured, Property Damage}
29	Property Damage	{“Birr” Amount}
30	Traffic Police Officer Name	{Officer Full Name}

4.2 Accident Location Referencing

There was no formal system for location referencing and it had been acknowledged for a long time as a fundamental deficiency in the accident records. Ethiopia only recently has established a street and building addressing systems in some urban areas, but this is not used by the general public and the various offices. In rural areas, the kilometer post to the nearest town or city is used to reference the accident location. Accident location therefore was still being 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. But, recently GPS is being acquired through the help of World Health Organization (WHO) fund, and expected to be used to accurately locate accident locations.

4.3 Data Storage

The accident data collected from the accident location is filled in the police stations with the accident record paper form and usually kept on shelves and file cabinet boxes. Every accident data is recorded and stored on one separate accident data form. Those reports compiled and aggregated at different periods from the individual accident records are also filled together in the same fashion at all level of traffic police stations. Such manual storage, retrieval and processing of accident data needs more time and effort of the traffic police force.

Very recently, the Ethiopian National Road Safety Coordination Office has developed a system called Road Accident Database. The system is a desktop application that can allow traffic police officers store their data electronically, retrieve their records easily and compute the primary level of data aggregation to produce the main reports required. It is also known from the interview that this system is by now under pilot study and will be deployed for all regions' police stations after the required desktop computers are acquired for the offices through the World Bank fund grant allocated to the task.

4.4 Exchange of Data

The accident data collected, compiled and stored by the traffic police are the interest of other institutions as well other than the police itself who uses the data to enforce the law and carryout

prosecution. The main beneficiaries of such data(usually in statistical report forms) are the Ethiopian Central Statistical Authority, The Ethiopian Roads Authority, Ethiopian Transport and Communication Minister, researchers and Interpol(as Ethiopia is member country).The exchange of data between police offices and these and other interested or stakeholder institutions is carried out mainly on paper format(hard copy). When a requesting letter is presented, the data/report is sent with a signed and sealed letter. This exchange of data relatively takes longer period of time for both parties.

The Road Accident Database that is mentioned earlier and found in its pilot test state as well does not facilitate or support electronic way of data exchange. It is designed to be used on a local stand alone system and could not be available also through the Internet or Intranets.

4.5 Analysis and Reporting

General statistical reports with the report form shown in Appendix D are produced periodically by the traffic police offices at different levels after some minimal data analysis is done manually. These reports are expected to be produced daily, monthly, semi annually and annually. The reports can be communicated from districts (Wereda) to Zone, from Zone to Region and from Region to Federal office and could also be made available for local and national authorities as per their need from the respective level traffic police offices. The hierarchical reporting system is better depicted in Figure 4.1.

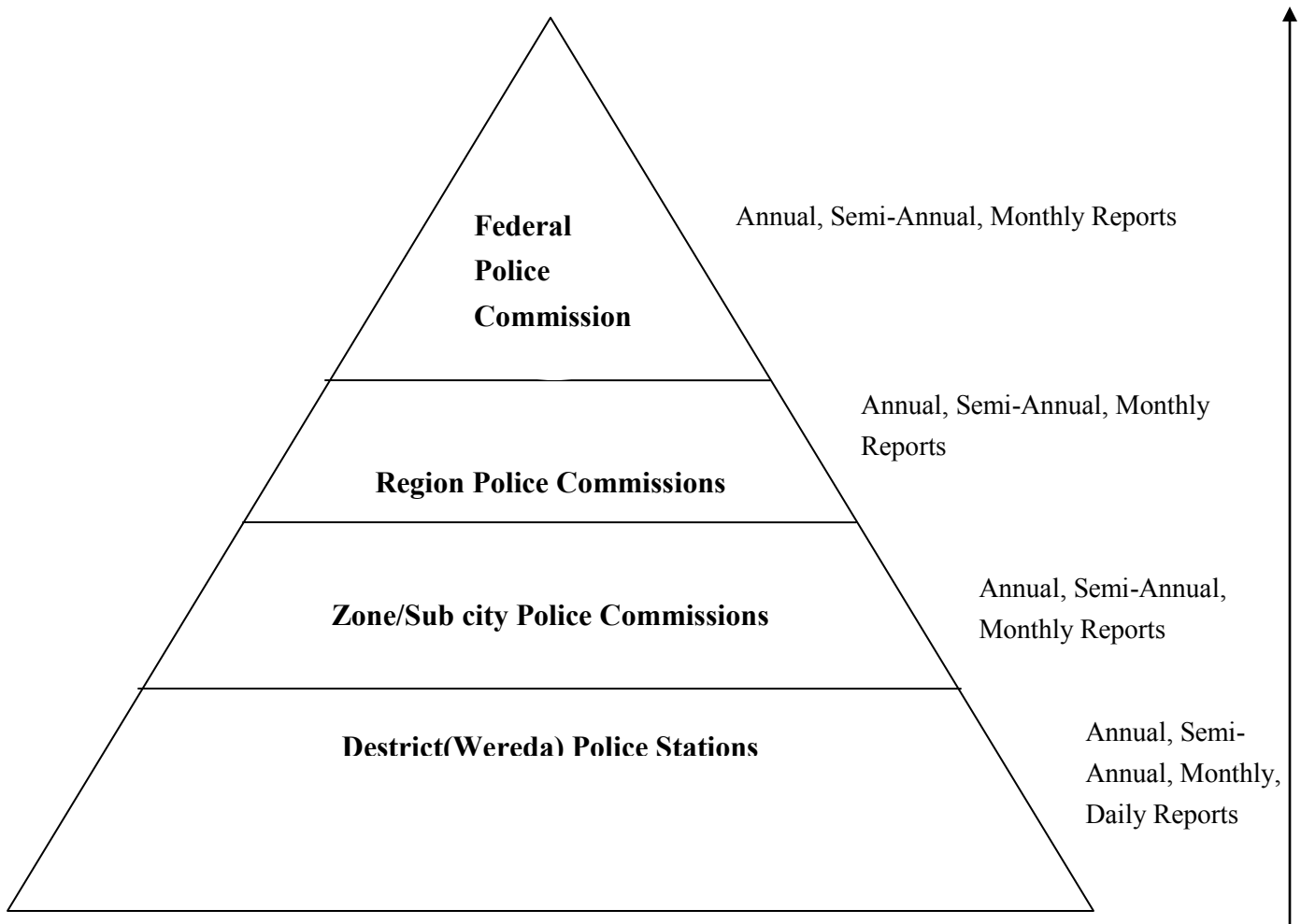


Figure 4.1 Hierarchical Reporting System of Road Accident Reports

The existing system of accident reporting classifies accidents into four accident severity classes, namely: fatal, serious injury, slight injury and property damage. As shown in Appendix D, it is against these parameters that most statistical reports are required to be analyzed and produced.

The manual way of doing the analysis of data has made the traffic police to create a predefined fixed reports containing general crash statistics and do not allow to make rigorous data analysis. Another deficiency identified is that it takes long for the reports to be compiled and made available. Thirdly, the information provided is not exact as there is no proper linkage between the hospitals and the police. For instance, if death occurs within one month of the crash, then the crash is considered fatal. Unfortunately, this is rarely reported to the police for updating.

CHAPTER FIVE: REQUIREMENTS 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. The data items proposed for the new system, functional and non-functional requirements and the analysis models for the RTARS is presented with the following sections.

5.1 The proposed system Data Items (Fields)

The proposed system needs to address more additional data items in addition to those specified by the existing system in Table 4.1. This is to address national accident data requirements than local once alone as it has been also reflected in the related literatures reviewed concerning national accident database design. Thus, for the proposed system (RTARS), the following data items or fields are identified, organized and presented.

Table 5.1 Data Items for the new Proposed System

Road Accident General Description			
1	Accident ID	24	Property Damage Cost Estimate
2	Year	25	Photos Taken?
3	Month	26	Severity of Accident
4	Date	27	Weather Condition
5	Day	28	Light Condition
6	Hour	29	Road Separation
7	Region/City Administration	30	Road Surface Type
8	Zone/Subcity	31	Road Width
9	District (Wereda)	32	Road Surface Condition
10	City	33	Road Junction Type
11	Kebele	34	Accident Type
12	No. of Vehicles involved	35	Accident Contributing Causes
13	No. of Drivers dead	36	Investigating Officer Name
14	No. of Drivers with Heavy Injury		
15	No. of Drivers with Slight Injury		Description of Accident Location
16	No. of Passengers Dead	37	Road Number
17	No. of Passengers with Heavy Injury	38	Road Name
18	No. of Passengers with Slight Injury	39	Accident Area
19	No. of Pedestrian Dead	40	GPS Reading –Latitude
20	No. of Pedestrians with Heavy Injury	41	GPS Reading-Longitude
21	No. of Pedestrians with Slight Injury	42	Nearest KM post Reading
22	No. of Animals Injured	43	Accident Location Distance from Nearest KM post
23	No. of Animals Dead	44	Reference Landmark

45	Accident Location from Reference Landmark		Description of Driver
		71	Driver's Name
	Description Of Vehicle	72	Sex
46	Vehicle Number	73	Age
47	Vehicle Name	74	Profession
48	Vehicle Age	75	Driver Condition
49	Vehicle Model	76	Injury Severity of Driver
50	Vehicle Ownership	77	Driver License Number
51	Vehicle Type	78	Hit and Run?
52	Vehicle Maneuver	79	License Issue Place
53	Vehicle Damage Extent	80	Driver's Address(Region/city Admin, Zone, Wereda, City, Kebele, House No)
54	License Plate #	81	Driver-Vehicle Relationship
55	Speed-Estimated	82	Driver's Driving Experience
56	Vehicle Related Deficiency	83	Drivers Education Level
57	Vehicle Damaged Parts	84	Driver Errors
58	Vehicle Owner Name	85	Nationality
59	Insurance Company Name		
60	Insurance Policy No		Description of Injured Pedestrian
61	Insurance Expiry Date	86	Pedestrian Number
		87	Pedestrian Name
	Description of Injured Passenger	88	Sex
62	Passenger Number	89	Age
63	Passenger Name	90	Address(Region/city Admin, Zone, Wereda, City, Kebele, House No)
64	Sex	91	Injury Severity of Pedestrian
65	Age	92	Pedestrian Maneuver
66	Address(Region/city Admin, Zone, Wereda, City, Kebele, House No)	93	Profession of Pedestrian
67	Injury Severity of Passenger	94	Health Condition
68	Seating Position	95	Hospital Name
69	Profession of Passenger		
70	Hospital Name		

5.2 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 requirements of the RTARS are the following:

- Register road traffic accident

- Generate various reports
- Mark and display accident location on a digital map
- Allow searching of road accident record using different parameters

Behavioral requirements describing all the cases where the system uses the functional requirements are captured in the use cases presented by the use case diagram illustrated in Figure 5.1.

5.3 Non-functional Requirements

Non-functional requirements (also known as quality requirements), are requirements which impose constraints on the design or implementation (such as performance requirements, security, or reliability).

The following are the main lists of the system's non-functional requirements:

- The system should not allow unauthorized users to register and alter accident records.
- The central server has to be provided at secured area and made always available
- The system must be simple and easy to be used by all its potential users
- The main database on the server has to be back up regularly at least at the end of every day
- The system should be platform independent and support every user
- The system should be extendable or scalable to future needs

5.4 The Analysis Model

The analysis models to the system are represented with the use case diagram, sequence diagrams, activity and class diagram.

5.4.1 Use case models

A Use Case model captures Use Cases and relationships between actors and the system. It describes the functional requirements of the system, the manner in which outside entities (actors) interact at the system boundary, and the response of the system. The use case diagram of RTARS is illustrated in Figure 5.1.

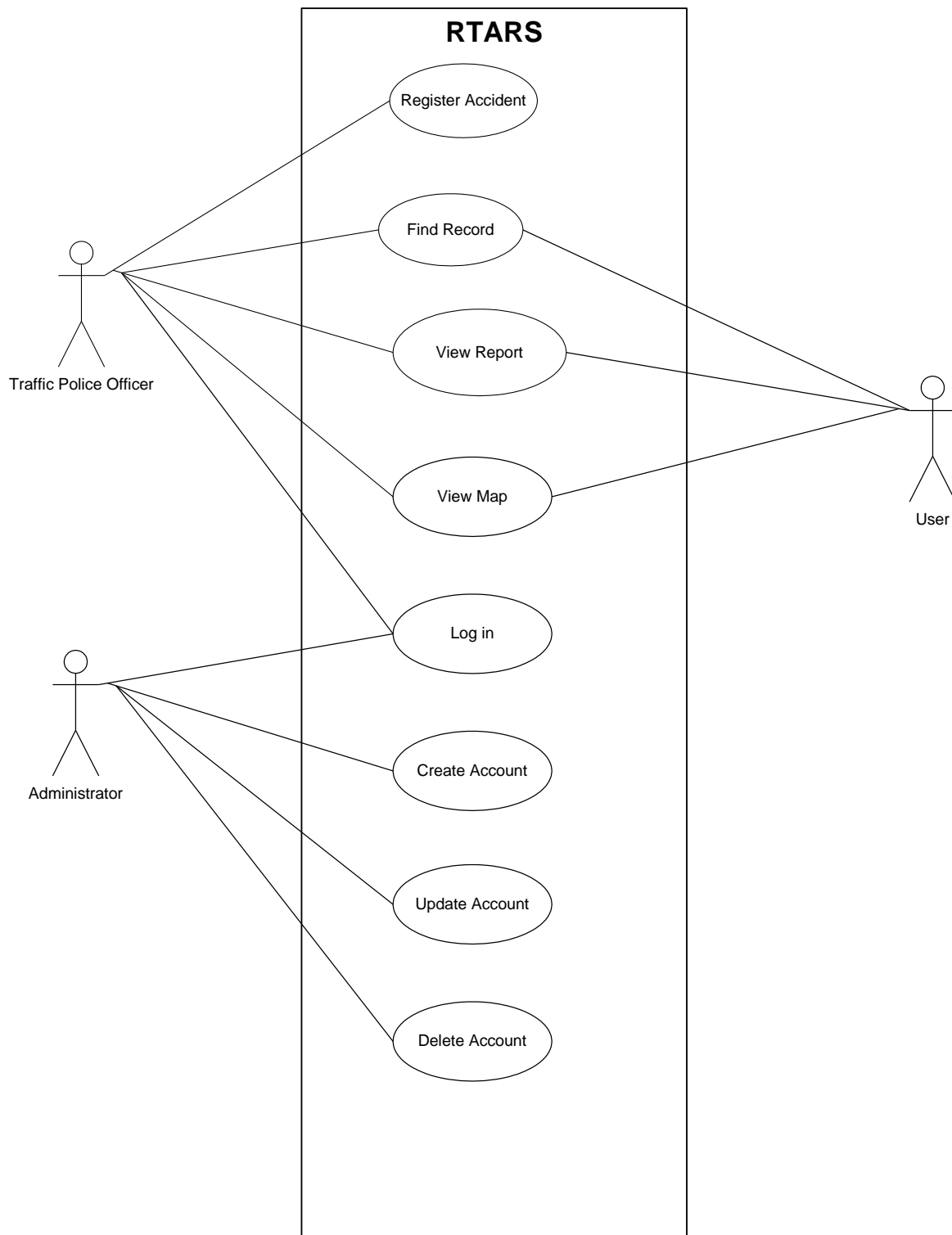


Figure 5.1 Use Case diagram of RTARS

5.4.1.1 Actor Description

The actors that interact with the system are traffic police officer, administrator and any user of the system. They are described here in brief.

Name: Traffic Police Officer

Description: a Traffic Police Officer is a person who is responsible for registering and reporting a road traffic accident of his/her jurisdiction

Name: Administrator

Description: Administrator is a person who is responsible for creating and modifying traffic police officers accounts who will have the authority/privilege to register accident records to the system.

Name: User

Description: A user is any individual or organization (say traffic police offices, insurance companies, transport and road authorities etc.) that accesses and use the system for their own various road accident related information in Ethiopia.

5.4.1.2 Use Case Description

The use cases presented in Figure 5.1: register accident, find record, view report, view map, log in, create account, update account and delete account are described in detail in this section.

Name: Register Accident

Actors: Traffic Police Officer

Description: Allows a legitimate traffic police officer to register a road traffic accident

Precondition: the traffic police officer should already have an account to log in

Flow of Event:

- 1) A traffic police officer will record and bring the accident details from the field
- 2) The traffic police officer logs in to record accident details
- 3) Traffic police officer fills in accident details and submits to the system [Alternate A]
- 4) The system registers the record
- 5) The system displays acknowledgement message
- 6) The use case ends

Post condition: Accident record is registered in the system

Alternative flow of events

Alternative flow A: Missed required field/s or incorrect information

A3. The system displays data entry error message

A4. The system resumes at step 3

Name: Find Record

Actors: Traffic Police Officer, User

Description: Allows a traffic police officer or any user to find a particular accident record

Precondition: the record to be searched should already exist in the system

Flow of Event:

- 1) A user wants to search accident record/s that fulfils a certain criteria
- 2) The user will activate "search record" option
- 3) The user enters the parameters that she/he wants to search with
- 4) The user submits the search criteria
- 5) The system searches and displays those records that meet the criteria [Alternate A]
- 6) The use case ends

Post condition: A list of record/s will be displayed as the search result

Alternative flow of events

Alternative flow A: No matching record is found in the database

A5. The system displays "no matching record" message

A6. The system resumes at step 4

Name: View Report

Actors: Traffic Police Officer, User

Description: Allows traffic police officers and all other users to access and view road accident reports

Precondition: The user should know the website address of the system

Flow of Event:

- 1) A user needs to get road traffic accident information in Ethiopia
- 2) The user opens his/her browser and types the website address of the system
- 3) The user chooses and views his/her preferred report
- 4) Use case ends

Post condition: The user has able to access and view different accident reports

Name: View Map

Actors: Traffic Police Officer, User

Description: Allows traffic police officers and all other users to access and view road accident location on Google Map

Precondition: The user should know the URL of the system

Flow of Event:

- 1) A user needs to get road traffic accident information in Ethiopia
- 2) The user opens his/her browser and types the URL of the system
- 3) The user choose and view his/her preferred report
- 4) The user can also choose to see that accident location on a Google Map
- 5) Use case ends

Post condition: The user is able to access and view different accident locations on a map

Name: Log in

Actors: Traffic Police Officer

Description: Enables a traffic police officer to log in to the system to register accident records

Precondition: The user (traffic police officer) should have an account in RTARS

Flow of Event:

- 1) The user wants to register a road traffic accident record to the system
- 2) The user activates and access log in form
- 3) The user provides correct user name and password [Alternate A]
- 4) The system displays accident registration form
- 5) The use case ends

Post condition: The user will be able to access the accident registration form to enter records

Alternative flow of events

Alternative flow A: user failed to provide correct user name and/or password

A3. System displays “incorrect user Id or password” error message

A4. Use case resumes step 3

Name: Create Account

Actors: Administrator

Description: Allows the administrator of the system to create accounts for traffic police officers

Precondition: the administrator should get the list of traffic police officers that are responsible for recording road traffic accidents

Flow of Event:

- 1) The administrator wants to register new traffic police officer to the system
- 2) The administrator has received police officer details
- 3) The administrator activates the create account form
- 4) The administrator entered all the required detail information [Alternate A]
- 5) The system registers the user [Alternate B]
- 6) The system displays acknowledgement message
- 7) The use case ends

Post condition: User account is created

Alternative flow of events

Alternative flow A: Required information is missing or incorrect information

A4. The system displays “missed field or incorrect information” error message

A5. The use case resumes at step 4

Alternative flow B: User ID already exists

B5. The system displays “User name already exists” error message

B6. The use case resumes at step 5

Name: Delete Account

Actors: Administrator

Description: Allows the administrator to delete accounts

Precondition: the account to be deleted should already exist in the system

Flow of Event:

- 1) The administrator activates “Delete Account” option
- 2) The administrator submits the user ID to be deleted [Alternate A]
- 3) The system displays confirmation message
- 4) The system deletes the account
- 5) The system displays acknowledgement message
- 6) The use case ends

Post Condition: Selected account will be deleted

Alternative flow of events

Alternative flow A: Non existing record

A2. The system displays “no such ID” error message

A3. The system resumes at step 2

Name: Update Account

Actors: Administrator

Description: Allows the administrator to delete accounts

Precondition: the account to be updated should already exist in the system

Flow of Event:

- 1) The administrator activates “Update Account” option
- 2) The administrator submits the user ID of the record to be updated [Alternate A]
- 3) The system updates the account
- 4) The system displays acknowledgement message
- 5) The use case ends

Post Condition: Selected account will be updated

Alternative flow of events

Alternative flow A: Non existing record

A2. The system displays error message

A3. The svstem resumes at step 2

5.4.2 Sequence Diagrams

Sequence diagrams show the interaction between participating objects in a given use case. They are helpful to identify the missing objects that are not identified in the other analysis object models. Thus, the interaction between objects in each of the above use case diagram is depicted with the following sequence diagrams and in those annexed at Appendix A.

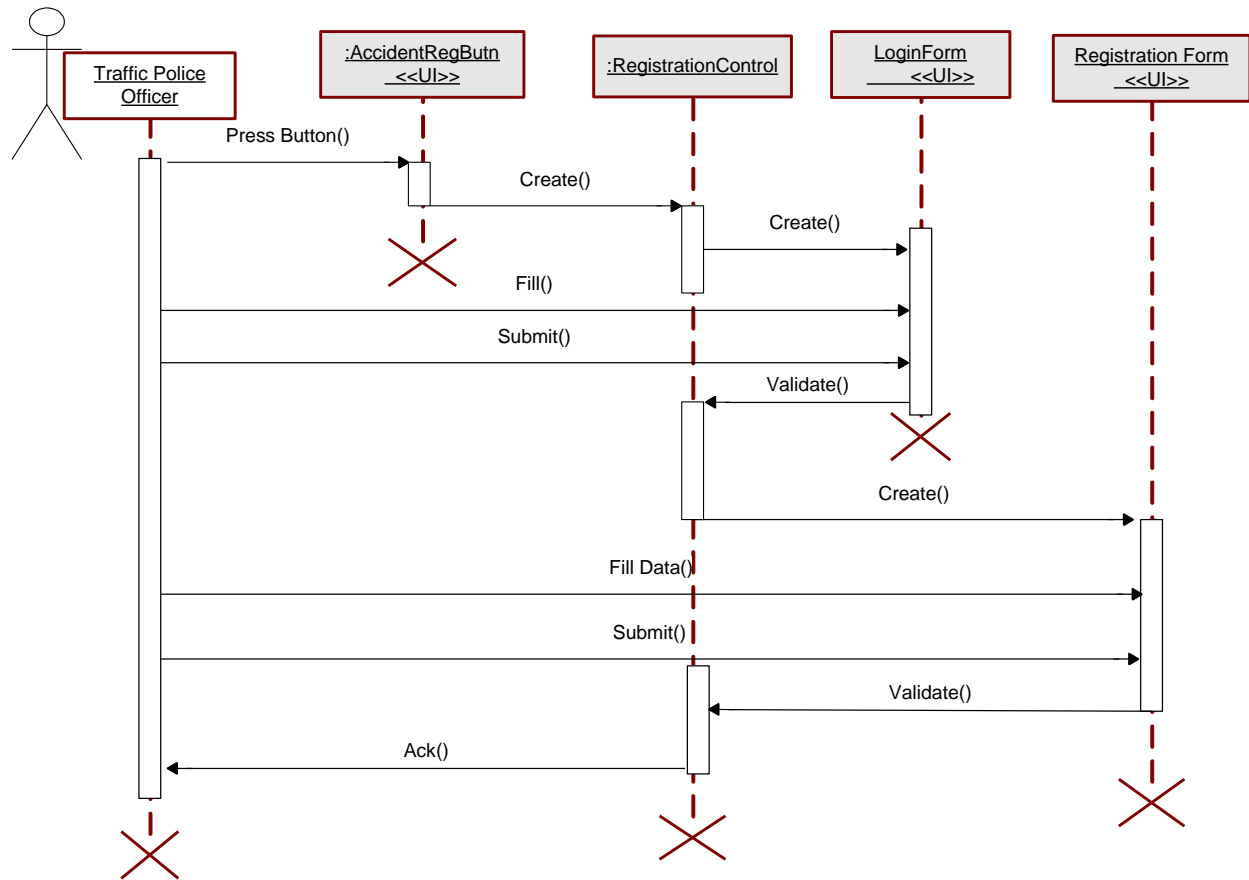


Figure 5.2 Sequence Diagram for the Accident Registration Use Case

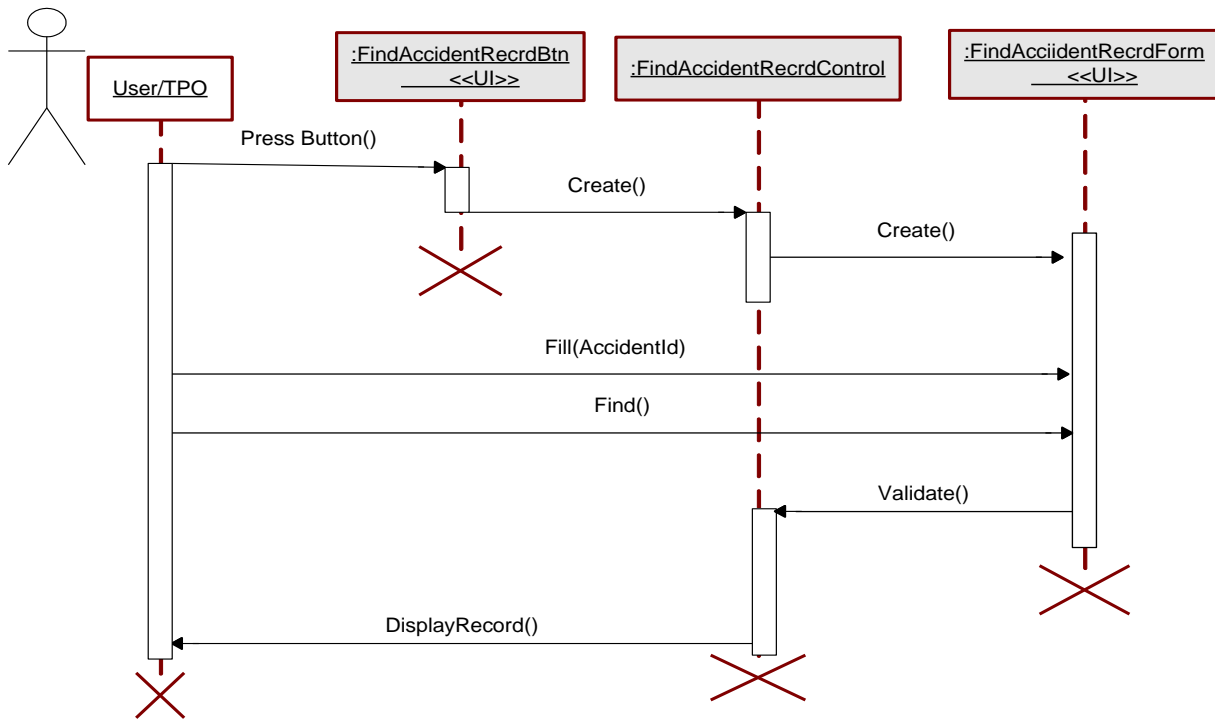


Figure 5.3 Sequence Diagram for the Find Record Use case

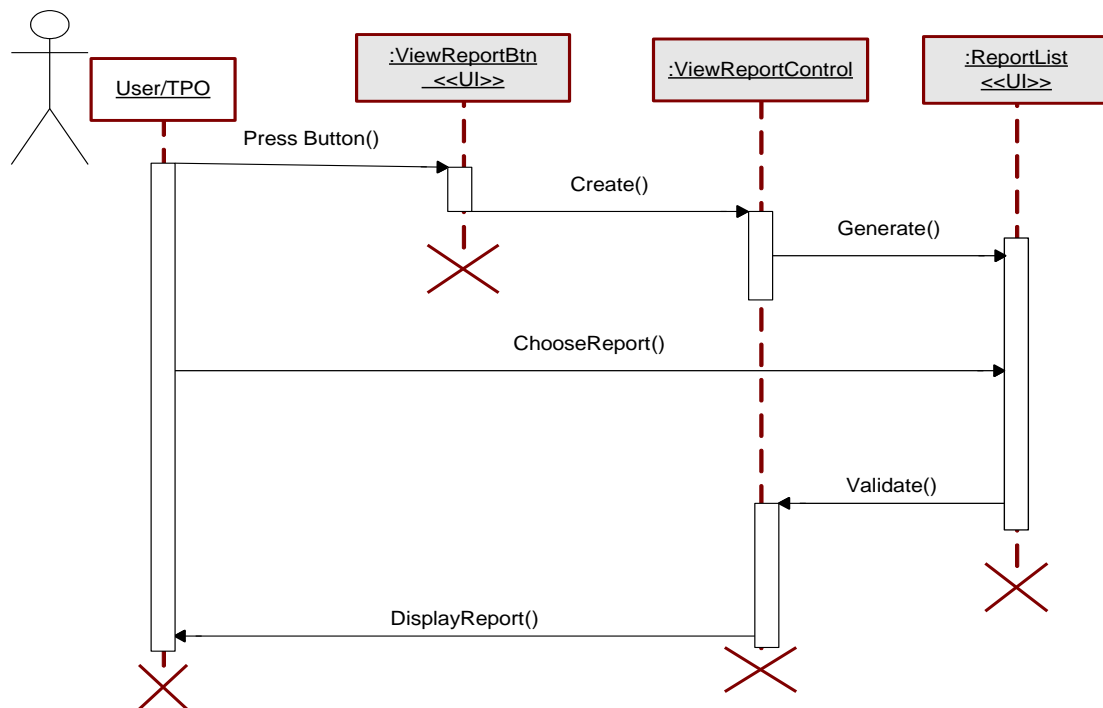


Figure 5.4 Sequence Diagram for View Report Use case

5.4.3 Activity Diagram

An activity diagram graphically represents the sequence of activities of a system.

The UML use case diagram was used to create the UML activity diagrams for each of the functional units of RTARS as presented in Figure 5.10.

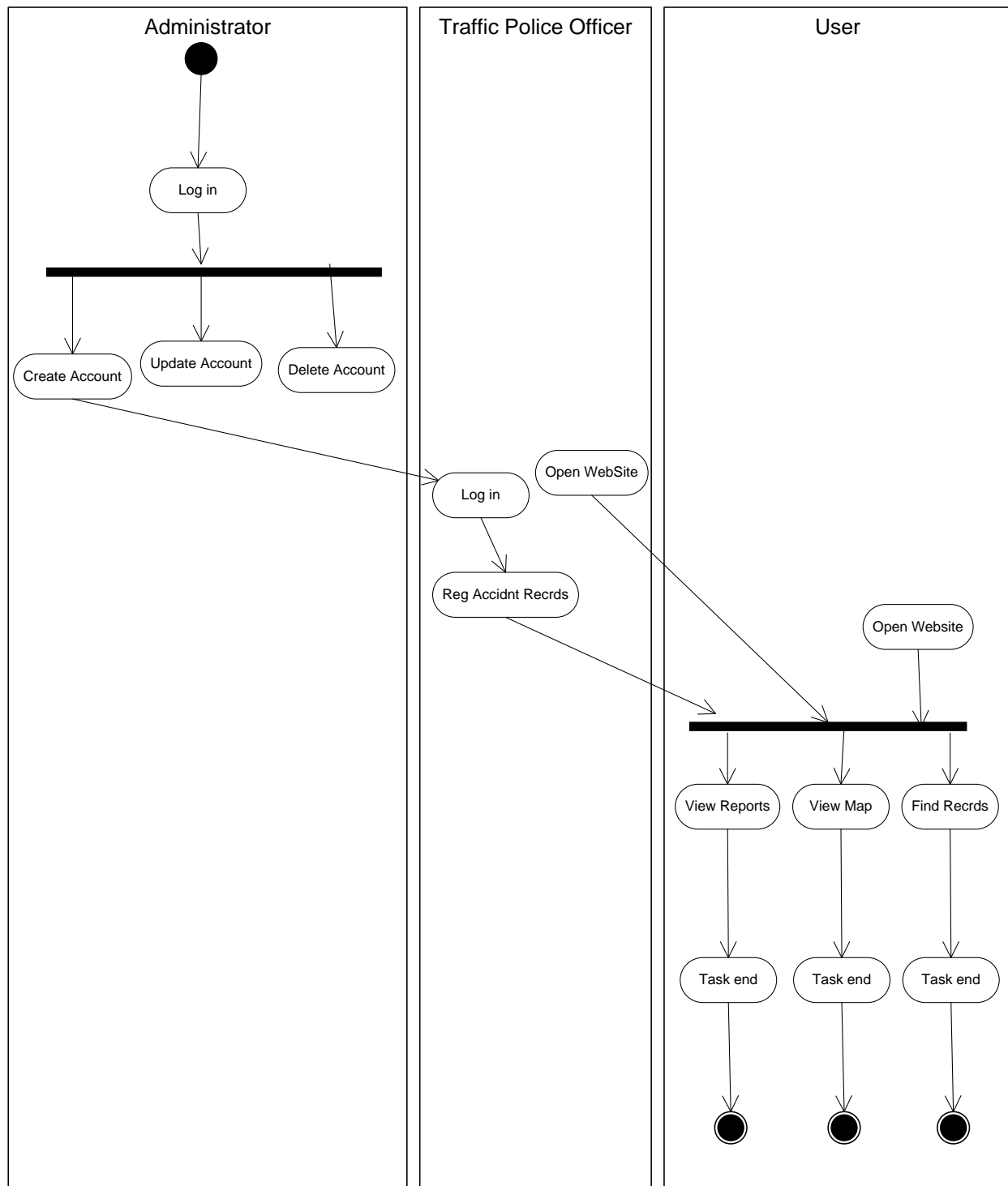


Figure 5.10 Activity Diagram of the RTARS

5.4.4 Class Diagrams

Class diagrams are used to describe the structure of a system in terms of classes, attributes, operations, and association of objects in the class. The class diagram of RTARS is presented in Figure 5. 11.

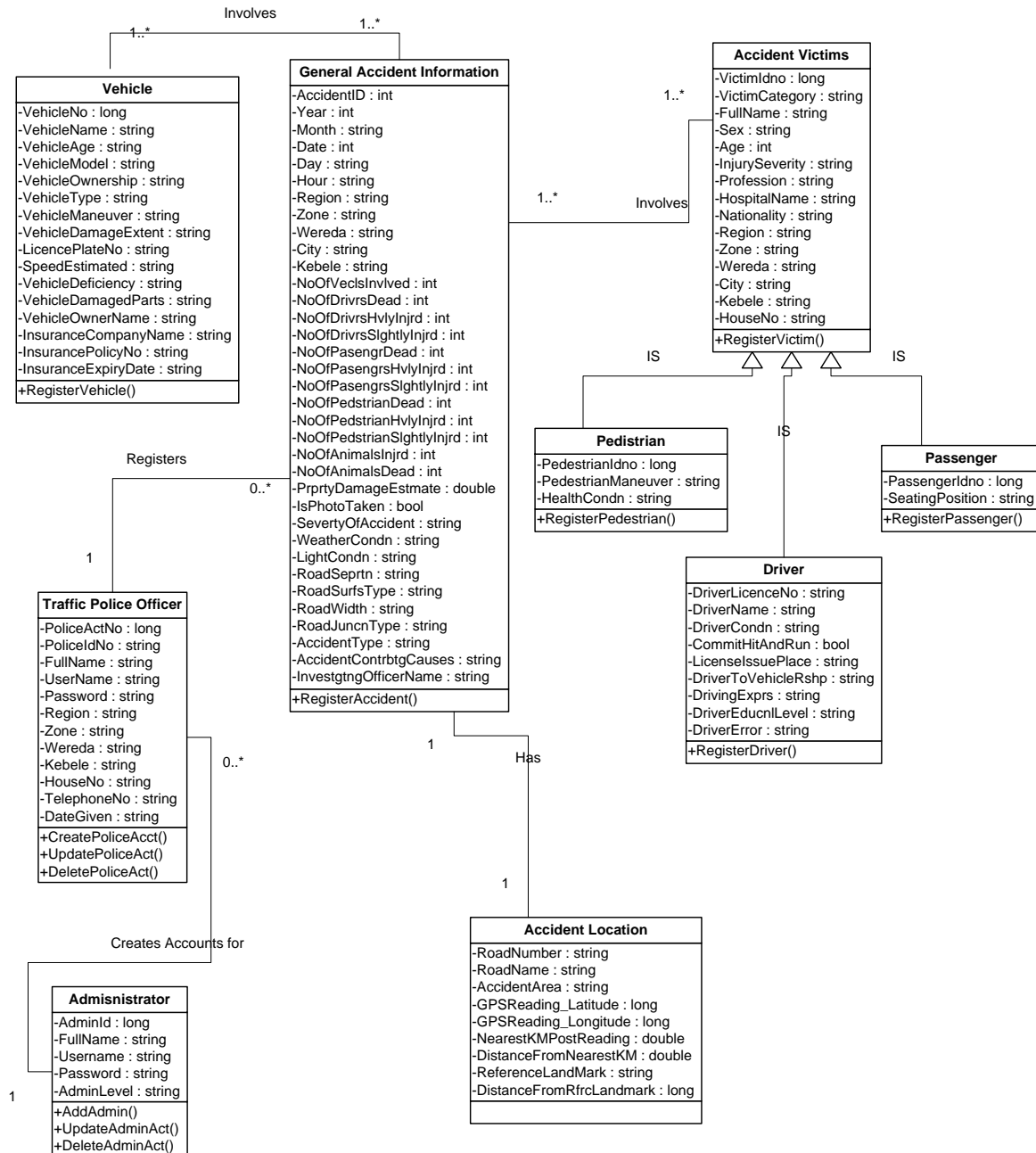


Figure 5. 11 Class Diagram of the RTARS

CHAPTER SIX: SYSTEM DESIGN

The proposed system is designed based on the functional and non-functional requirements and analysis models defined in the preceding chapter. Consequently, the design goals, architecture, subsystem decomposition, deployment diagram, persistent data management and user interface of the new system have been identified, designed and presented in this chapter.

6.1 Design Goals

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

Performance Criteria

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

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

Maintenance criteria

Modifiability: the system should be easily extensible to the need of the government accident data formats availability and to add new functionalities to the system. The system is built from several more or less independent classes which can be used as a standalone application or replaced by other classes. This makes the system easy to change the existing functionality or add new ones when the need arises.

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

Dependability criteria

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

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

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

User Criteria

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

Usability: The system should be user friendly, and easy to learn and use. The system is designed in Amharic language to maximize its usability. Moreover the general accident information page and the accident victims (driver, pedestrian and passenger) registration page have been made accessible all together from a single main window in a wizard form for ease of usability.

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

6.2 Architecture of the system

At a high level, the architecture of an application defines how different parts of the system are organized and logically separated yet ensuring that they work together. The architecture used for the system is three tiers Client-Server architecture: client tier, middle/web tier and the data tier as illustrated in Figure 6.1. Such architecture is one of the most commonly used type of architecture for web-based applications as it provides greater application scalability, high flexibility, high efficiency, lower maintenance, and better reusability of components.

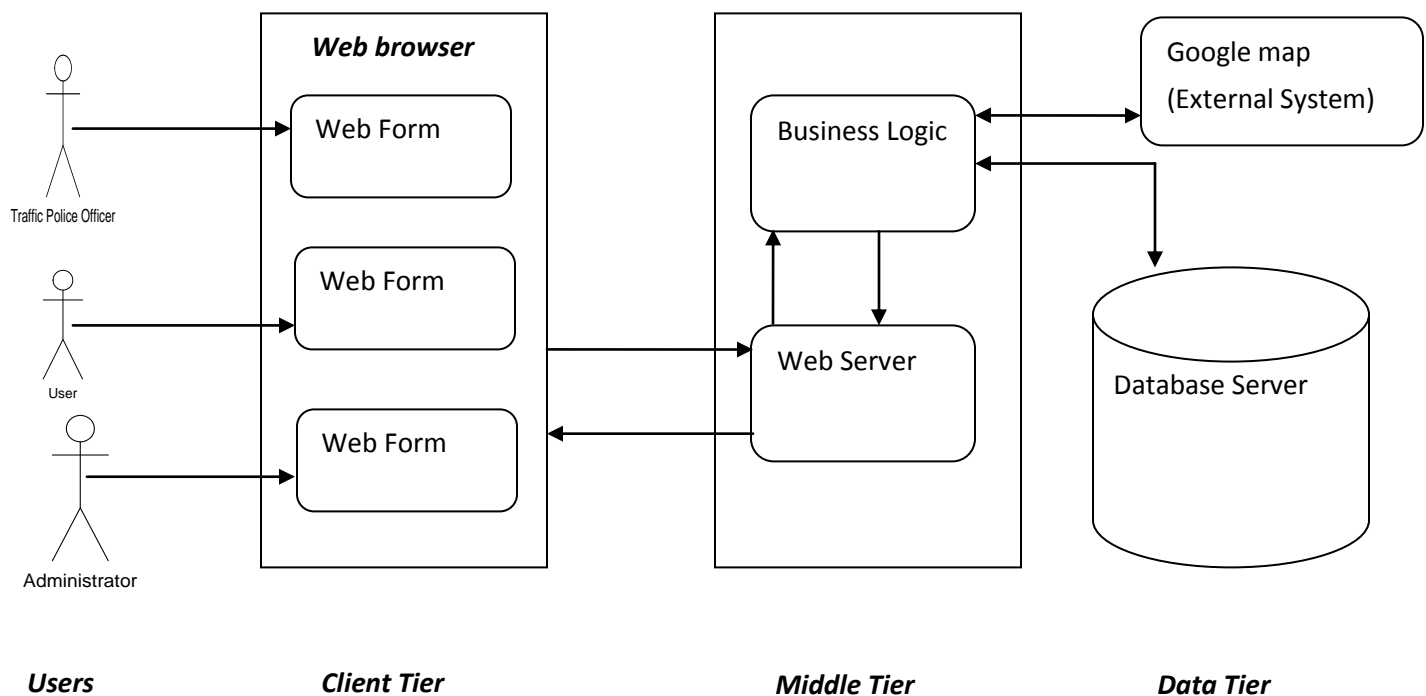


Figure 6.1 Architecture of the RTARS

The client tier is the application's user interface containing data entry forms, report access links and client side application that are running on the web browser of the user machine. The traffic police officer, the administrator and other users of the system interact directly with the application through this user interface. It interacts with the web/application server to make requests and to retrieve data from the database. It then displays to the user the data retrieved from the server.

The middle tier contains two parts of the RTARS application, i.e., the web server (application server) and the business logic. The web server (IIS) handles all HTTP requests coming from the client machines. The requests could be a request for adding new records, displaying existing records, or a request for report generation and others. It is also the web server which manages the responses that is forwarded to the client machines.

The business logic tier is responsible for handling all the core functionalities of the system such as input validation, performing calculations, report generation, access and retrieval of any data required by the client. When the data is submitted from the client machines, first it will be handled by the functions of the web server and then transferred to the business logic for processing. Again, the business logic processes the data and sends it either to the database or back to the web server, this is determined by the type of service required. It also interacts with an external system called Google Earth to display accident locations on a map.

The data tier layer is concerned with the data storage and persistence issues. It is implemented using an SQL database. The database can either be stored on the web server itself or on a different machine; however it needs to be easily accessible by the web server.

6.3 Subsystem Decomposition

In order to reduce the complexity of the system analysis (application domain) tasks of the system we have identified smaller parts called classes in chapter five. Similarly, to reduce the complexity of the system design (solution domain), we decompose the system into simpler parts, called subsystems, which are made of a number of solution domain classes. Each subsystem can be represented as a directory containing all the files implementing the subsystem with a set of related operations that share common purpose so as to provide service to other subsystem. While performing subsystem decomposition we considered the two basic concepts namely coupling and coherence. Figure 6.2 shows the subsystem decomposition of the system.

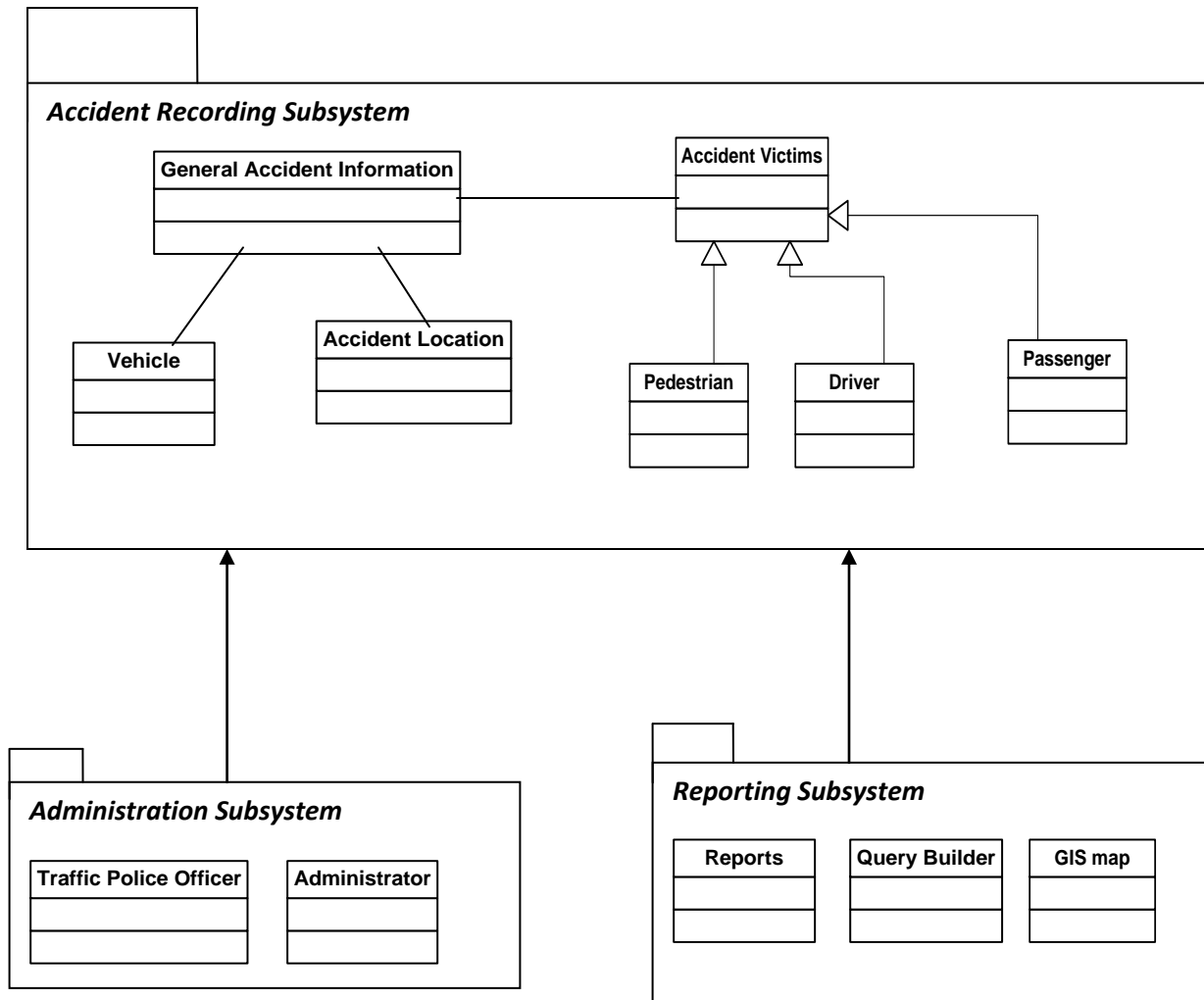


Figure 6.2 Subsystem Decomposition of RTARS

The Accident Recording Subsystem is responsible for registering all the accident related data starting from the general information about the accident and accident location to the vehicles and accident victims (driver, passenger and pedestrian) involved in the crash to the system. As an occurrence of an accident triggers the need for recording vehicles involved and accident victims details, the general accident information class interacts with these respective classes.

The administration subsystem enables the administrator to manage user accounts (traffic police officer and other lower level administrator accounts). The management includes creation of new accounts, removing the existing accounts and modification of accounts.

The reporting subsystem generates routine reports like accidents based on severity, accidents classified according to type of area, time, weather conditions, and road conditions, day of the week, vehicle types, and passenger/pedestrian casualty statistics. It also displays the specific location of those accidents contained in the report on a map. In addition, it helps to create user-defined query or constraints and view sub-sets of accident data that meets the user search criteria.

6.4 Deployment Diagram

A deployment diagram of a system shows the hardware/software mapping (which components would be part in which hardware node and so on). The subsystems (components) of RTARS identified in the preceding section are mapped onto the client and server nodes as shown in figure 6.3 deployment diagram.

The client program (the web browser) will communicate with those ASP.NET applications (subsystems) residing on the web-server through an HTTP connection. And those subsystem components on the web server communicate with the data base system through an ADO.NET connection.



Figure 6.3 Deployment Diagrams of RTARS

6.5 Persistent Data Management

Persistent data management deals with how the persistent data are stored and managed and it outlives a single execution of the system. Information related to accidents, vehicles, injured people, drivers, and other related information are persistent data and hence stored on a database management system. This allows all the programs that operate on the RTARS data to do consistently. Moreover, storing data in a database enables the system to perform complex queries on large data sets.

In order to store data persistently in a database those class objects identified in the class diagram of RTARS are mapped into tables and the attributes into fields to the respective tables. The tables of the system with their respective fields and the relationships that exist between the tables are illustrated in Figure 6.4.

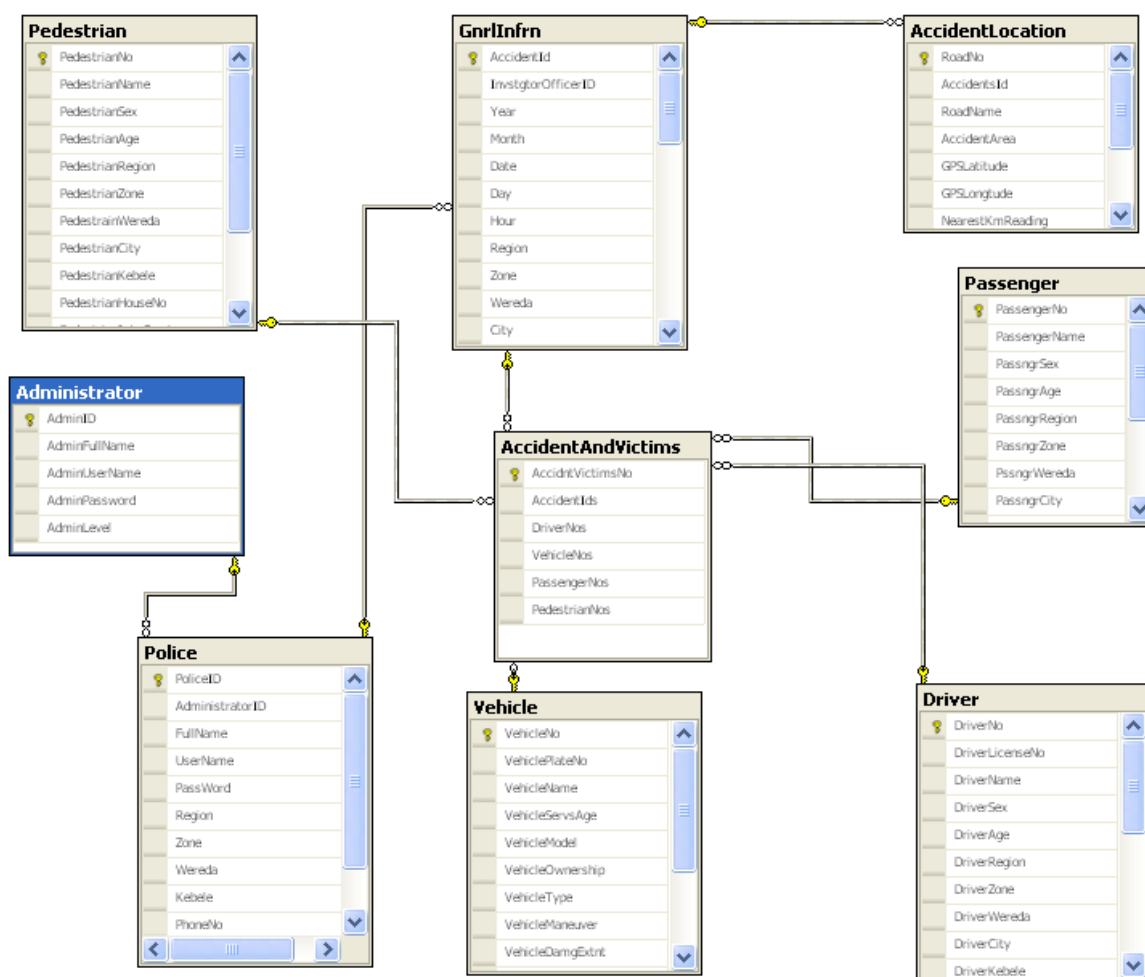


Figure 6.4 The Database tables and their relationships of the RTARS

6.7 User Interface Design

The user interface designed for the system starts with a main interface window (homepage) that contains a button link to the main tasks of the system namely View Reports, Search Accident Record and Log In.

Activating the “View Reports” link button opens a window which allows users to choose and see different varieties of accident reports and the accident location map. The “Search Accident Record” button link allows users to open a search page (window) that accepts search parameters from users, searches the records and displays the result. The “Log In” button allows an authorized user to log in as an administrator or as a traffic police officer to the system. For an administrator a window that allows him/her to create, rename or delete an account will be opened. For the traffic police officer a window that allows him/her to register accident records will be displayed. The user interface of the system depicted in figure 6.5 shows the interfaces organization hierarchically.

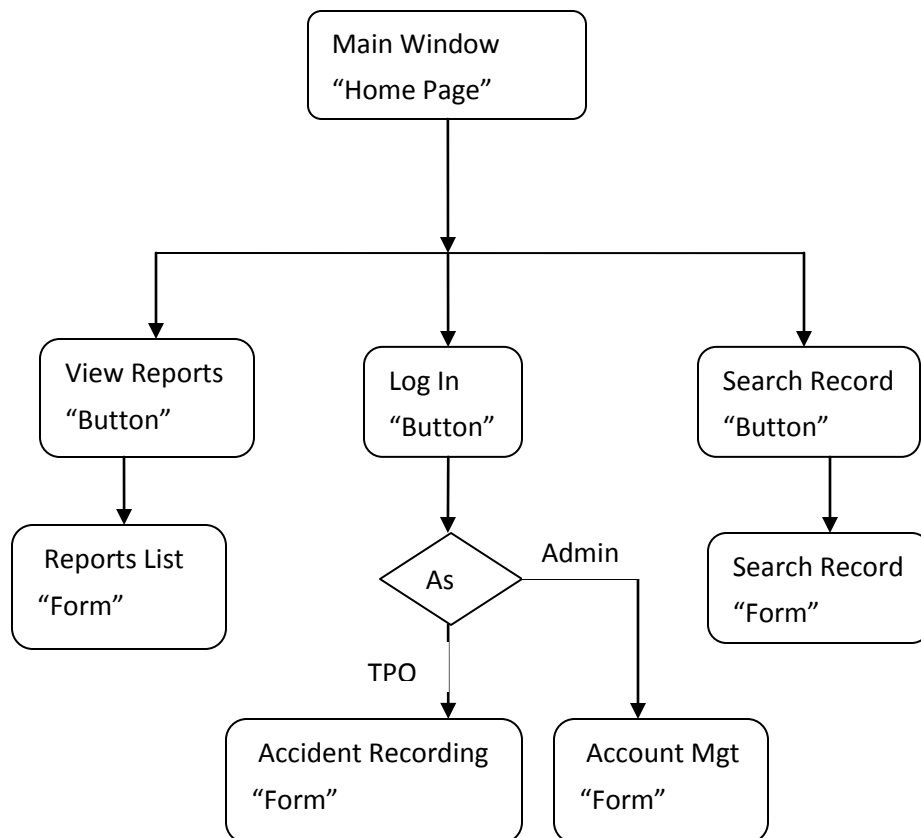


Figure 6.5 User Interface of RTARS

CHAPTER SEVEN: PROTOTYPE OF THE SYSTEM

The prototype of the system (RTARS) is designed and implemented with various development tools and other supporting external systems. ASP.NET 3.5 is used to develop the server side of the web application and C# is used to write the script/code used behind the web pages. External systems such as Microsoft Virtual Earth API for displaying accident locations on a Google map and TavulteSoft Keyman 6.0(geez Unicode software) for creating Amharic language based user interface and reports have been also employed.

The system implemented has an accident registration, accident record searching, administration and reporting main subsystems which can be initiated from home page presented in Figure 7.1.



Figure 7.1 Home page of the system

Administration subsystem

This subsystem performs authentication of users (administrator or police) category to log in to the system with a valid credentials (user name and password) for handling their system defined jobs. This subsystem when initiated from the “መመዝገብ” link button a snapshot as shown in Figure 7.2 is displayed requesting the user for a valid user name and password combination.

The screenshot shows a login form with the following elements:

- Title:** መመዝገቢያ ቅጽ (አካላዊ ለተሰማቸው ተጠቃሚዎች ብቻ)
- Fields:**
 - የዘር ኔም:** A text input field containing the value 'ሀይሌ'.
 - የይለፍ ቃል:** A password input field represented by six dots.
 - ምድብ:** A dropdown menu with a blue arrow icon. The dropdown is open, showing three options: 'ፖሊስ' (highlighted in blue), 'አድሚኒስትሬተር', and 'ፖሊስ'.
- Buttons:** A button labeled 'ግባ' (Login) is positioned below the dropdown menu.
- Text:** A line of text to the right of the button reads: 'ዕባክዎን ትክክለኛውን መረጃ ያስገቡ'.

Figure 7.2 Log in form

If the user has successfully logged as administrator (“አድሚኒስትሬተር”), he/she will be prompted with a data entry form for registering, modifying and deleting traffic police officers information as shown in Figure 7.3.

የትራፊክ ፖሊስ ኦፊሰር መመዝገቢያ ቅጽ

የፖሊስ መለያ ቁጥር	<input type="text"/>
ሙሉ ሥም	<input type="text"/>
የዘር ኔም	<input type="text"/>
የይስፍ ቃል	<input type="text"/>
ክልል/ከተማ አስ.	<input type="text" value="ሀረሬ"/> ▼
ዞን	<input type="text"/>
ወረዳ	<input type="text"/>
ቀበሌ	<input type="text"/>
ሥልክ	<input type="text"/>

ለካውንቱን የፈጠረዉ እድሜነበትፊተር መለያ ቁጥር

ለካውንቱ የተፈጠረበት ቀን

Figure 7.3 Traffic police officer registration form

Accident Registration Subsystem

If the user logged as a police (“ፖሊስ”) from the log in form of figure 7.2, the accident registration form wizard as displayed in figure 7.4 (a, b, c) will be displayed to allow the traffic police officer to enter and submit accident data to the system.

As shown in the wizard, the user(traffic police officer) can move back and forth from the first main form that will accept general accident detail to the driver and vehicle page, and to the passenger and pedestrian page with the next(“ወደፊት”) and back(“ወደኋላ”) buttons in filling that particular accident details before submitting the records. The system will not allow the user to pass to the next step window, if some required fields are not filled or wrong data is entered, rather it displays error message and prompts for re entry.

Figure 7.4 (c) Passenger and pedestrian registration form

Reporting Subsystem

Though endless form of reports can be generated and might be required from the system, those general statistical and summarized reports usually required against the severity of accident and some other additional few reports are implemented and generated for demonstration.

Those reports included in the following figures are initiated from the home page, when the user chooses the reports (“ሪፖርቶች”) button.

የአደጋው ትክክለኛ መግለጫ												
የአደጋው መለያ ቁጥር	ዓ.ም.	ወር	ቀን	ሰዓት	ክልል	ዞን	ከተማ	የተከሰተበት ቦታ	የበረታታው ዓይነት	የአደጋው ዓይነት	የመንገደኛው ዓይነት	የአደጋው መግለጫ
11	2001	መስከረም	1	ሰኞ	1-2	አዲስ አበባ	አረባ	አላ	2	በቀን ብርሀን	ጭጋማ	በመዝገብ
12	2003	ህዳር	10	ማክሰኞ	12-13	አዲስ አበባ	ጉራሌ	አላ	3	በቀን ብርሀን	ጭጋማ	በመዝገብ
13	2002	መስከረም	10	ማክሰኞ	12-13	አዲስ አበባ	ጉራሌ	አላ	3	በቀን ብርሀን	ጭጋማ	በመዝገብ
14	2001	ሰኔ	10	ሀሙስ	2-3	አዲስ አበባ	ጉራሌ	አላ	2	በቀን ብርሀን	ጭጋማ	በመዝገብ
15	2002	ሰኔ	10	ሀሙስ	2-3	አዲስ አበባ	ጉራሌ	አላ	2	በቀን ብርሀን	ጭጋማ	በመዝገብ

Figure 7.5 general accident reports

የፖሊስ አደጋ መግለጫ													
ዓ/ም	ጾታ	ቀን	ሰዓት	ሰዓት	ክልል	ከተማ	የአደጋው አስከፊነት	የመንገዱ ስም	የፍሬም ስም	የመንገዱ ፍቃድ ቁጥር	የሰሌዳ ቁጥር	የኢንሹራንስ ድርጅት	የመርማሪው ስም
2001	መስከረም	1	ሰኞ	1-2	አዲስ አበባ	አለ	ሞት	ምድራክ መንገድ	በባቸው መሰለ ግርማ	2000	67890	ኒያሳ	አሰሩ መዝገቡ
2001	መስከረም	1	ሰኞ	1-2	አዲስ አበባ	አለ	ሞት	ምድራክ መንገድ	ለማ በቀለ አለሙ	1000			አሰሩ መዝገቡ
2003	ህዳር	10	ማክሰኞ	12-13	አዲስ አበባ	አለ	ሞት	ቴዎድሮስ መንገድ	ለማ በቀለ አለሙ	1000	12345	መድን	አሰሩ መዝገቡ

Figure 7.6 Driver accident report

የትራፊክ አደጋዎች በክልል እና አ/ም			
ዓ/ም	ክልል	የአደጋው አስከፊነት	ብዛት
2001	አዲስ አበባ	ሞት	2
2002	አዲስ አበባ	ሞት	3
2003	አዲስ አበባ	ሞት	1

Figure 7.7 Traffic Accidents by Year and Region

Accident locations can also be displayed on maps for ease of visualization of accident areas. Though, due to very low scaling precision of the Google earth map display of Ethiopia's land mark geo referencing, it give some better insight of where an accident location is. For example the figure shown in 7.8 shows Addiss Ababa as an accident location as pointed by red marker symbol on Google map, when the user chooses to view an accident location in addition to the report. The Microsoft Virtual Earth API at the top of the map figure allows the user to rotate and zoom the map to any point that he wants to see more road paths and directions easily.

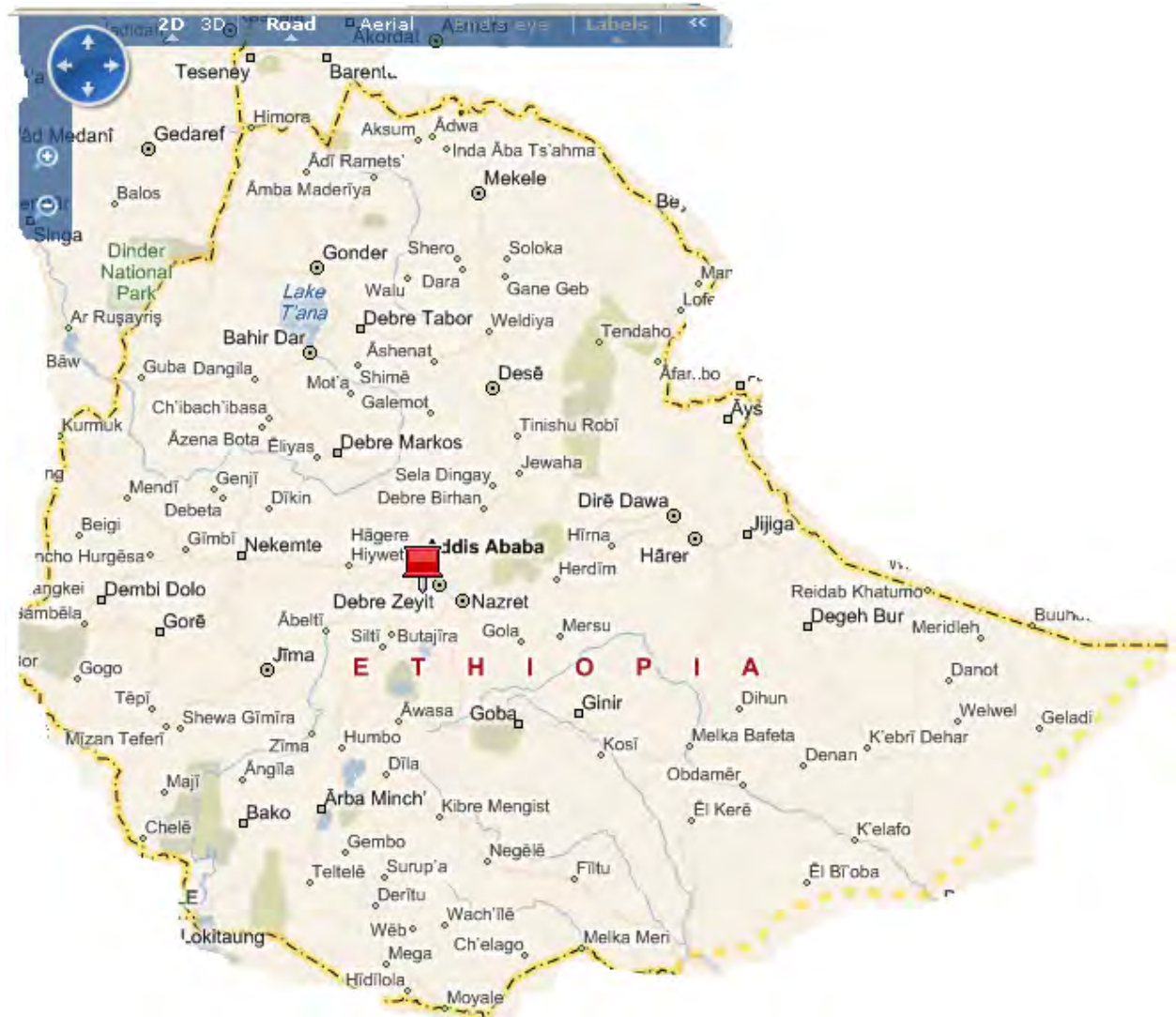


Figure 7.8 Accident Location Displayed on a map

Searching a record

The system also 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. The snapshot of the search component which can be initiated by choosing (“የአደጋ ሪከርድ መፈለግ”) button from the home page looks like as figure 7.10.

ሙሉ ስም

ለምለም መሀመድ ክድር

ቀን

ወር

ዓመት

ፈልግ

የአደጋ መደብር	የመንገዱ ስም	ከተማ/ደረጃ	የሽራ ስም	የታሪክ መደብር	ዲግሪውንስ	አዋረኛ	ተሳፋሪ	ቀን	ወር	ዓመት	መርማሪ ሊሰ
11	ምዕራባዊ መንገድ	አዲስ አበባ	የጥቅምት ወር	67890	ኒያላ	መሰረተ መለኮ ወልደ	ለምለም መሀመድ ክድር	1	መስከረም	2001	አሰሩ መዝገቡ
12	ቅምጥ መንገድ	አዲስ አበባ	የጥቅምት ወር	12345	መድን	ዳንኤል ለሙሉ ነጋ	ለምለም መሀመድ ክድር	10	ህዳር	2003	አሰሩ መዝገቡ

Figure 7.9 Searching Accident record

CHAPTER EIGHT: CONCLUSION AND FUTURE WORK

8.1 Conclusion

Alleviating the catastrophic road traffic accident needs a nationwide or even global level movement and decision over various facets of road safety. For the different stakeholders to pass the right decision and take action, organized and timely information should be available to all of them. In Ethiopia the existing road accident data collection, processing and reporting task is still done basically using a manual system, yet Ethiopia is one of the countries with the worst accident records in the world, especially as expressed per 10, 000 vehicles .

In this project, we developed a web based road traffic accident reporting system for Ethiopia which also has GIS enable feature. This kind of road traffic accident data collection, analysis and reporting systems are commonly used in other countries to assist all those road safety stakeholders decision making process. Hence, traffic police offices, road engineers, insurance companies, mass media, statistical authorities, the general public etc. can easily get and share timely information from such systems.

Such a system could also generate some of the main pre defined reports required by the different parties automatically in a tabular and graphical manner as required. Accident records that occur at any corner of the country can easily be searched by different parameters. In addition, accident locations can be visualized online on Google map.

Moreover, the system has been designed and implemented with an Amharic language interface for maximizing the usability of the system.

8.2 Future Works

Though, the RTARS system has tried to implement most of the functional requirements required and defined for the system, there are some more additional tasks to be addressed and others to be handled extensively as it has been learned from related systems or products being used in other countries. These include the following:

- 1 Designing and implementing Mobile Data Terminal(MDT) system for ease of accident data collection through small handheld digital devices
- 2 GIS based road traffic accident analysis system which can apply different spatial data analysis to uncover various accident patterns
- 3 Integrated Vehicle and Driver files road accident analysis system for extensive national accident patterns in relation to vehicles and drivers

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- [30] “RCVIS”, retrieved from <http://www.roadsafetycambodia.info/action2> on March 22, 2010.
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Appendix A: Sequence Diagrams

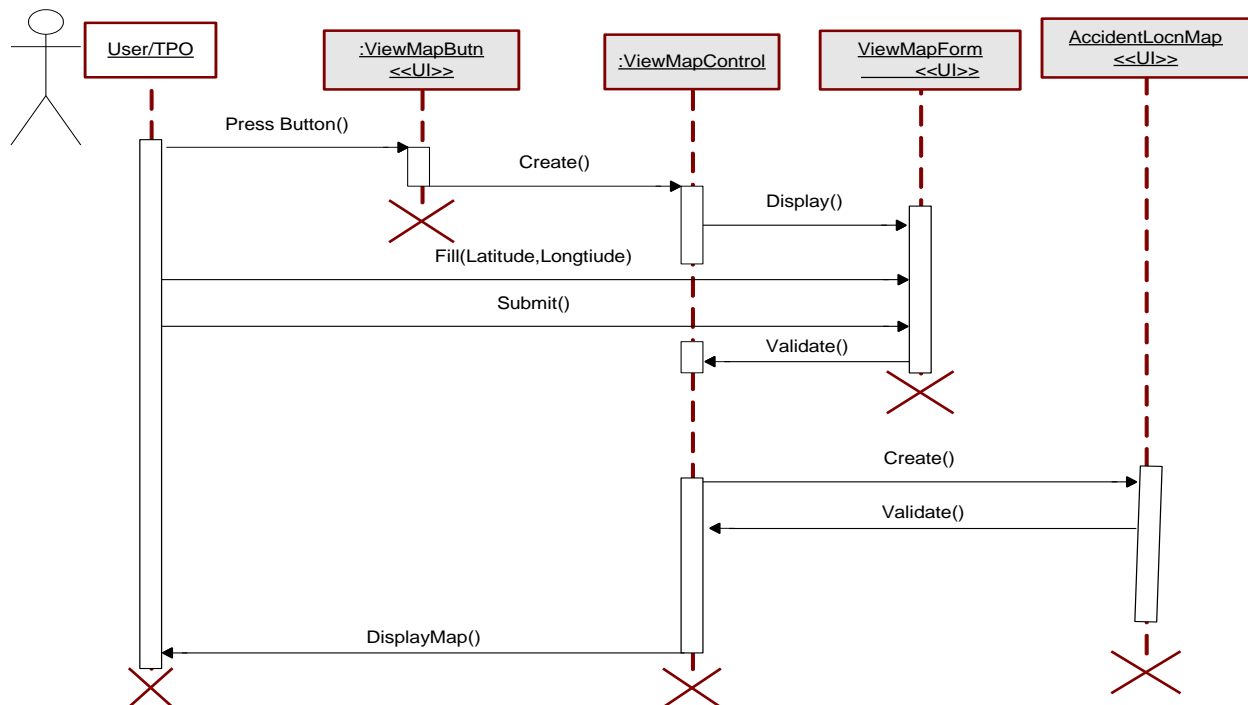


Figure 5.5 Sequence Diagram for View Map Use case

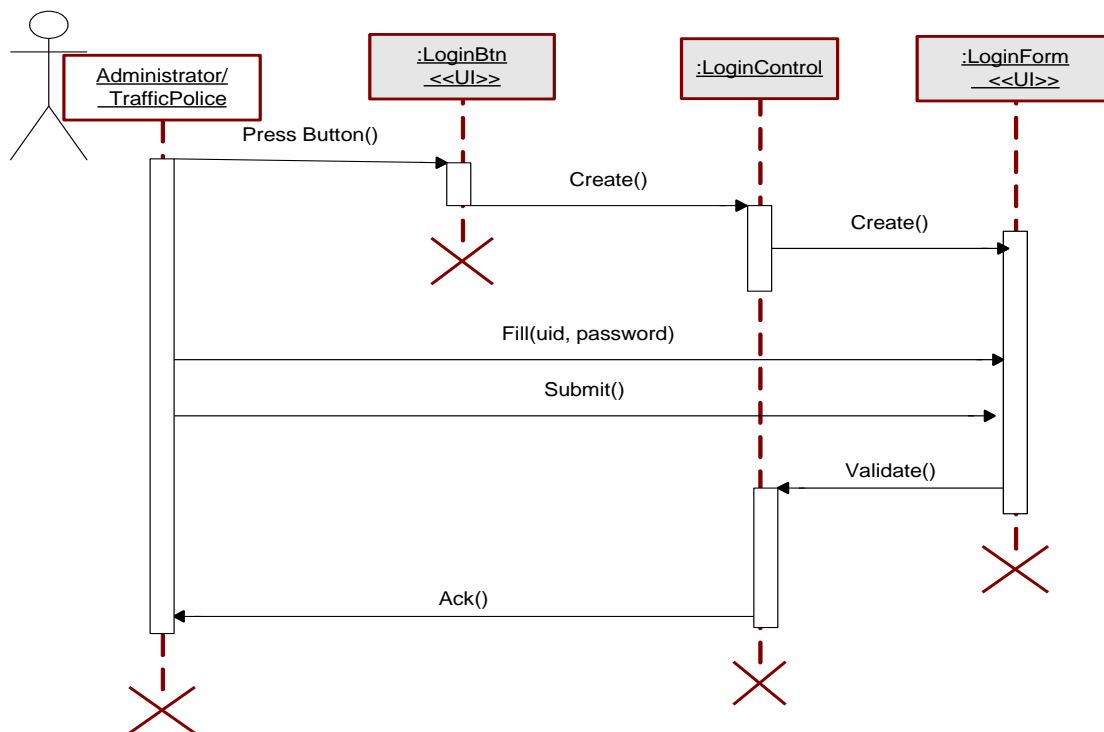


Figure 5.6 Sequence Diagram for Log in Use case

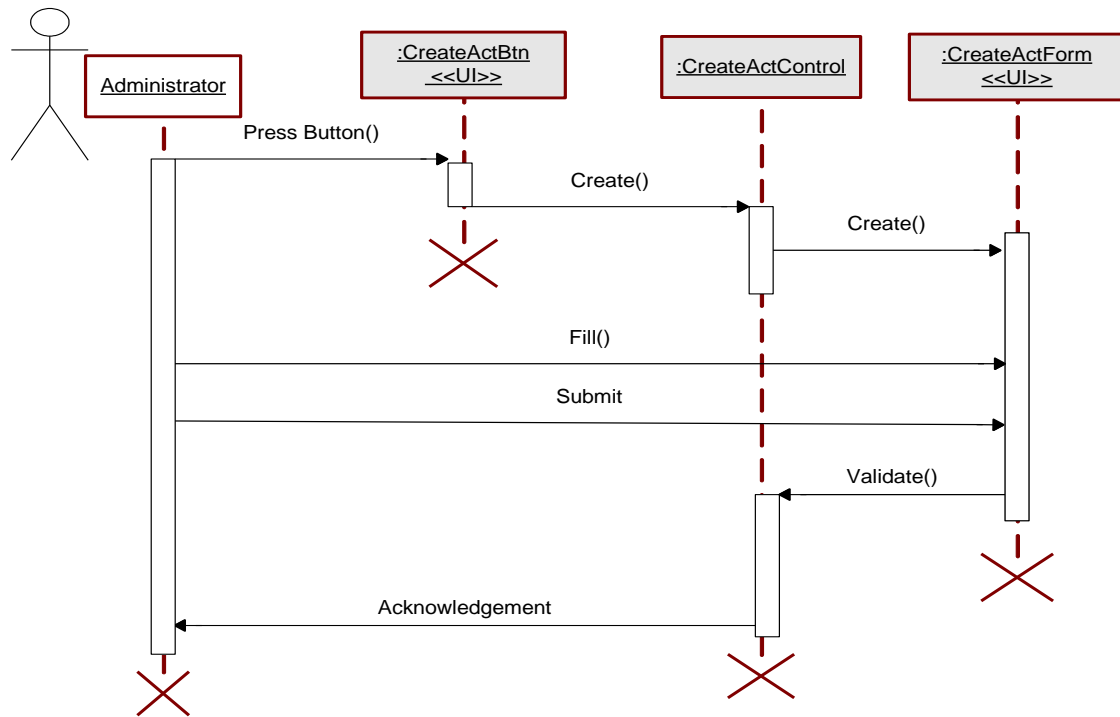


Figure5. 7 Sequence Diagram for Create Account Use case

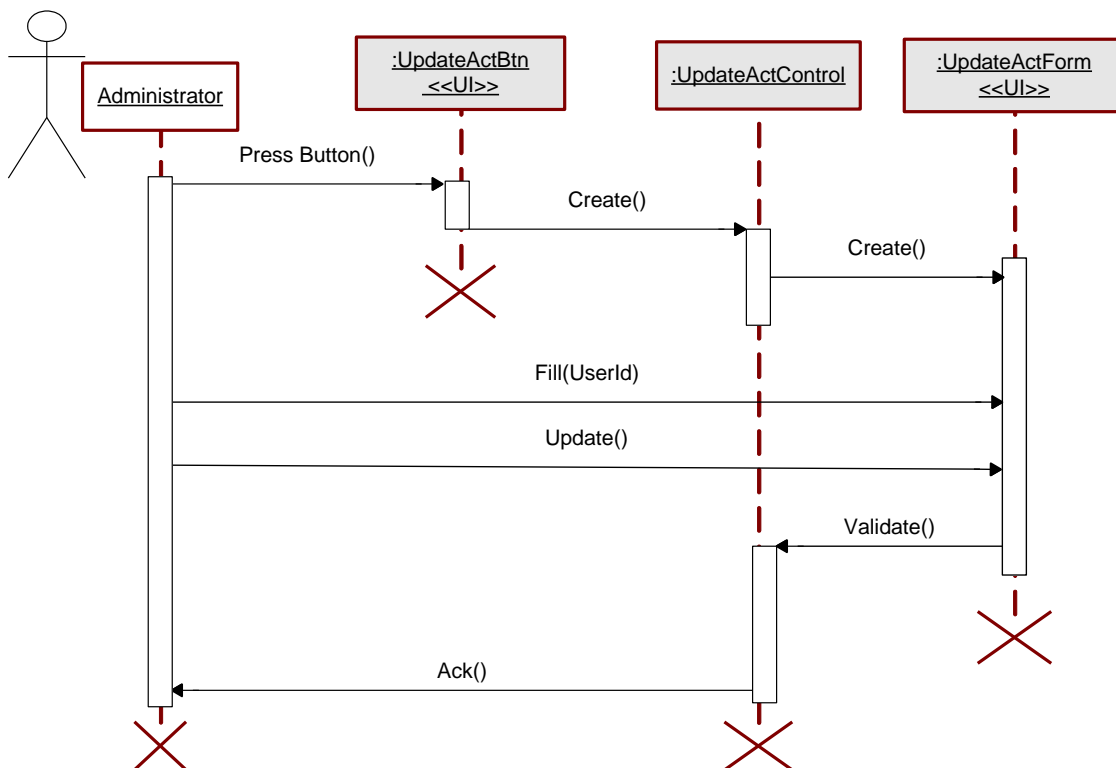


Figure5. 8 Sequence Diagram for Update Account Use case

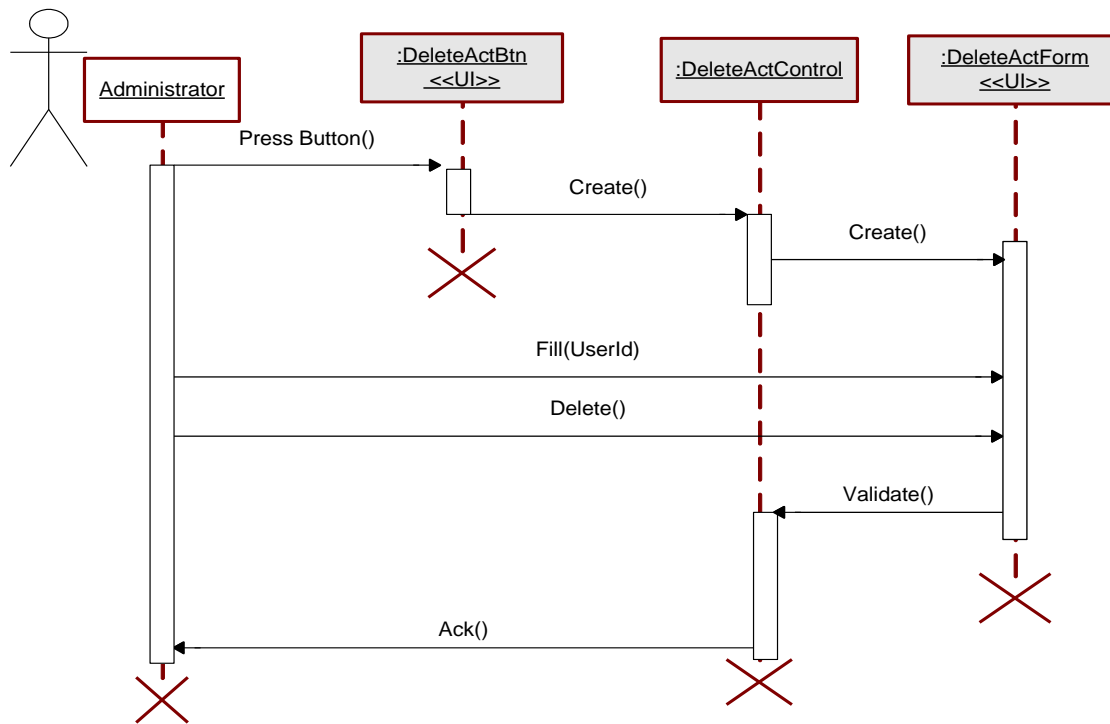


Figure 5.9 Sequence Diagram for Delete Account Use case

Appendix B: Structured Interview

1. What is a road traffic accident in Ethiopian context?
2. How do you describe the existing road accident reporting system from Districts, Regions to the federal level?
3. Accident recording:
 - I. What Data items/fields to be recorded and domain values of each data item?
 - II. What format? (Paper form or electronic form)
 - III. Are there unregistered or not reported accident?
4. Accident location referencing:
 - I. What methods of referencing the accident location are used? (Street names , general land marks, GPS coordinate or other)
5. Data storage:
 - I. With what form? (On paper, Flat file or Database form)
 - II. How it is organized or filed?
6. Data or Information exchange:
 - I. With which institutions?
 - II. With what format? (printouts, meetings, soft copies, Internet, LAN or other)
 - III. How often?
7. Analysis and reporting:
 - I. How it is done? (manually, semi automated, or fully automated)
 - II. How often?
 - III. What type?
8. What problems do you face with the existing reporting system if there are at all?
9. What future plans are there with regard to the road traffic accident data recording and reporting system at a national level?

Declaration

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

Declared by:

Name: _____

Signature: _____

Date: _____

Confirmed by advisor:

Name: _____

Signature: _____

Date: _____

Place and date of submission: Addis Ababa, June 2010.