ACTIVE SPY: DESIGN AND IMPLEMENTATION OF A SCALABLE GIS SERVER FOR REAL- TIME TRACKING OF MOBILE ASSETS ALONG WITH INCORPORATION OF SERVICE- ORIENTED METROPOLITAN ACTIVE SPACE

by

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ABSTRACT

This project presents a novel concept of active spaces in physical outdoor environment like a metropolitan city. The on- going research in “Active Spaces” at *University of Illinois at Urbana-Champaign* has been extended. The project proposes to extend the boundaries of an Active Space from an indoor environment to a metropolitan level (i.e. city, district or country level) and terms this innovative concept a “Metropolitan Active Space (MAS)”. This environment- aware module informs mobile users of the nearest places of interest. These may include business advertisements, and utility services such as ATM, gas stations, mosques, schools, colleges, and banks. While their mobile assets roam about in the city; the online system notifies the owners of the mobile assets of their surroundings in a context- aware fashion. Besides this, the project also focuses on the design and implementation of a web- based system to track and manage mobile assets in a real- time environment. Tracking mobile assets such as laptops, wheel chairs, mobile phones, luggage etc in addition to automobiles has become a necessity in today’s insecure world rather than a luxury. Being an entirely web- based solution, it relieves the users of being limited to a particular desktop machine where the software is installed. Only open-source tools and technologies have been used in this project. Use of expensive and licensed GIS softwares has been avoided. Thus the overall system is in compliance with the spirit of pervasive computing and finds manifold applications in the tracking and GSM industry.

DEDICATION

In the name of Allah, the Most Beneficent, the Most Merciful

To our dear parents and families!!!

To the friendliest grandfather, Mr Yamin & beloved brother Imran…......Saira

To my dearest brothers & sister, Faisal, Umar and Masuma ……………..Sana

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LIST OF ABBREVIATIONS

Active Server Pages: ASP

Asynchronous Javascript And XML: AJAX:

Context- Providers Presence Component: CPPC

General Packet Radio Service: GPRS

Geographical Information Systems: GIS

GLObal NAvigation Satellite System: GLONASS

Global Positioning System: GPS

Location- Aware Services: LAS

Metropolitan Active Space: MAS.

Mobile Asset: MA

Monitor, Analyze, Plan, and Execute: MAPE:

Multimedia Interfaces Presence Component: MIPC

Navigation Satellite Tracking And Ranging: NAVSTAR

Object Oriented Programming: OOP

Personal Digital Assistants: PDAs

Real-Time Kinematics: RTK

Service-Oriented Architecture: SOA

Visual Basic Script: VB Script

Work Breakdown Structure: WBS

Chapter 1

INTRODUCTION

1.1 Overview

This chapter gives an overview of the main driving forces behind the conception and development of the proposed system. The idea of the project has been introduced in detail supported by in- depth background study. This chapter also summarizes the feasibility assessment report in addition to defining the scope of the project. The complexity of the project has also been highlighted. In the end, minimum requirements and deliverables have been listed.

1.2 Introduction

The emergence of Internet technology provides an ideal information- sharing environment. It opens a vast potential to improve the traditional Geographical Information Systems (GIS) in various directions including spatial data access and dissemination as well as spatial data exploration and geo-visualization. By using web-based GIS, end users can search and query analysis for spatial information from anywhere around the globe with out purchasing any expensive GIS software. Web- based facilities management using web-based GIS is one of the most popular areas. It overcomes the limitation of usage for only domestic users in specific area under LAN environment. Moreover, even general users who are alien to the basic concepts of GIS can grasp geographic information visually.

Today one can easily argue that GIS discipline has penetrated into core business operations. Every business relies on “place” information. In many situations immediate or real-time access to place information is essential, either because the spatial data itself is critical, or because the spatial information is a tightly integrated component of a broader mission-critical application. How common is it today for casual users of the World Wide Web to look up restaurants in a distant and unfamiliar city, and expect to find driving directions from their hotel? Or peruse the web sites of their favorite consumer products (cars, bicycles, watches, stereos) and expect to locate dealerships within a specified radius of the user’s postal code?

All this served as an inspiration for the project under discussion. The project aims to take advantage of increasing advancement in the field of GIS coupled with internet- centric environment to create a web-based mobile assets tracking system that operates in a real- time environment. Keeping in mind the attractive location- based services and increasing power of communication among machines and environment, the project also takes inspiration from the idea of Active Spaces to come up with an innovative idea of a Metropolitan Active Space (MAS). It allows users to register for their places of interest. Along with tracking their assets, the system intimates them of these places when their particular asset registered for that place is in its vicinity.

1.3 Problem Statement

The project aims to design and implement a scalable GIS server for real- time tracking of mobile assets along with incorporation of service- oriented metropolitan active space.

1.4 Background

While the development of a scalable GIS server falls into the domain of *Distributed computing* with particular emphasis on *Geographic Information Systems*, the second module belongs to a relatively immature field of *Ubiquitous Computing.*

1.4.1 Ubiquitous Computing

Ubiquitous computing integrates computation into the environment, rather than having computers which are distinct objects. Promoters of this idea hope that embedding computation into the environment and everyday objects would enable people to interact with information-processing devices more naturally and casually than they currently do, and in whatever location or circumstance they find themselves. The goals set by the researchers in the field of ubiquitous computing make implicit the involvement of *Mobile Computing*.

1.4.2 Mobile Computing

Mobile computing extends distributed computing in a direction where the services of such a system are available to a user regardless of location and more importantly, changes in location [14]. Wireless networking eliminated the need to remain tethered to a wired, static infrastructure and yet avail of the services of a distributed system. A distributed system with mobile hosts thus consists of a wired infrastructure of static hosts (representing a conventional distributed system) that connects areas of wireless coverage ('cells') to mobile computers. Mobility of computers is not obtained for free. The ability to be mobile introduces a set of new constraints that are not associated with the desktop computers. The goal of mobile computing is therefore, to provide users with a comparable level of service as would be available to them from a distributed system of static computers, without compromising their ability to move.

1.4.3 Context- Aware Computing

The aim of context- aware computing is to enable applications to adapt to situational change in an attempt to improve the interaction between the user and computer. This can be achieved by providing a specialized interface, automating tasks or adjusting program settings to provide a unique and personalized experience. Examples of context include the group of people a user is currently with, the types of equipment and communications technology available, and a user's physical location.

1.4.4 Location- Aware Services

Different from traditional computing paradigm, location is specific information to mobile computing. Computer applications that utilize location information can provide location specific services that are more attractive to users. Here, the term location is used to refer to the generic concept of a place or situation occupied by a designated user or object. Software applications that employ location are termed as

"Location Aware Services" (LAS) and are being increasingly explored within context aware mobile applications [44].

1.5 FEASIBILITY STUDY

Due to the fast- paced and extremely mobile lives these days, it would be a "dream come true" scenario for people if their assets can be tracked and they can remotely view their movement in a real- time environment. Assets of an organization, primarily automobiles mostly operate outside the organizations boundaries. The management of these assets becomes even more difficult for organizations whose primary business is the transportation of goods. These organizations face challenges such as on-time delivery, safety of assets, reducing the cost of shipments and efficient scheduling. Conventional asset management systems update the state of assets before and after a trip. These systems provide no means to monitor the assets while they are in transition. GPS (Global Positioning System) technology, wireless networks and the high quality of geospatial data has made real-time monitoring of assets possible. Amongst the other contributing factors are the ever- increasing computing power and more potent software development tools.

As the real-time monitoring systems are a mix of technologies from diverse domains, it is therefore not cost- effective for an organization to own a dedicated system of its own. The organizations interested in monitoring their mobile assets prefer to hire these services from companies specialized in mobile assets tracking.

The industry is currently undergoing a radical revolution as a result of advancement in the GIS field. Emphasizing the dire need of tracking systems, Mr V. Sanjeevi, Managing Director and CEO of the Chennai-based e-Logistics Pvt Ltd, India comments,

"A 10 per cent increase in the productivity of the automobiles would mean a total annual saving of some Rs 20,000 crore. And this is possible only through a foolproof, easy to operate tracking system."

The GIS field itself has also experienced a rapid expansion, largely triggered by the advent of relatively low-cost, high-accuracy surveying GPS receivers. The GIS field is concerned with the use of computers to input, store, and output, analyze, and display geographic information, that is, the use of computers for mapping applications.

Today, GIS map-based applications are used in a wide array of everyday uses. GIS can be applied in golf, allowing golf carts to be tracked and providing players with a digital hole-by-hole layout of the golf course, their current location on the course, and the exact distances to bunkers, water hazards, the pin, etc. More serious applications include the navigational systems used to guide ships and airplanes in foggy conditions.

Rapid advancement in GIS- related technologies coupled up with increasing human desire to be virtually controlling all his/ her assets make a "Web- Based Mobile Assets Tracking System in a Real- Time Environment" the need of the hour. Recently, real- time tracking technologies have brought some breakthrough in these areas: commercial automobile operations, fleet management, dispatching, emergency rescue, hazard material monitoring, and security. A mobile assets tracking system extends the scope of vehicle tracking systems and encompasses all forms of mobile assets from a mobile phone (which can help to track criminals) to wheel chairs (tracking whom can keep us informed of the whereabouts of special persons). Keeping the growing interests of users in location- based services; the system also caters for introducing context- awareness into the metropolitan environment. As mobile assets roam about in the city, their owners are notified of the nearest places of interest such as utility services or business advertising services. Thus the project complies with and promotes the spirit of pervasive computing.

1.6 SCOPE

As the real-time systems depend on field monitoring (GPS) and communication (wireless) devices, prototyping of such systems is a difficult task. One of the project's objectives is to create test environments that can simulate real-time set-up without using GPS devices and wireless communication services. In order to evaluate the prototype, sufficient test data has been collected. The project allows remote users to have access to their assets through the internet.

Taking inspiration from the idea of context- aware physical spaces, we extend this concept to a metropolitan environment. As the users move along in a metropolitan area, it would be extremely useful if they can be notified about the nearest places of interest. We propose to merge the metropolitan and computational infrastructures into a single integrated "Metropolitan Active Space". Given below is a hierarchical organization of these concepts illustrating how these ideas fit together to achieve the objective of the project. Thus figure 1.1 clarifies the scope of the project.

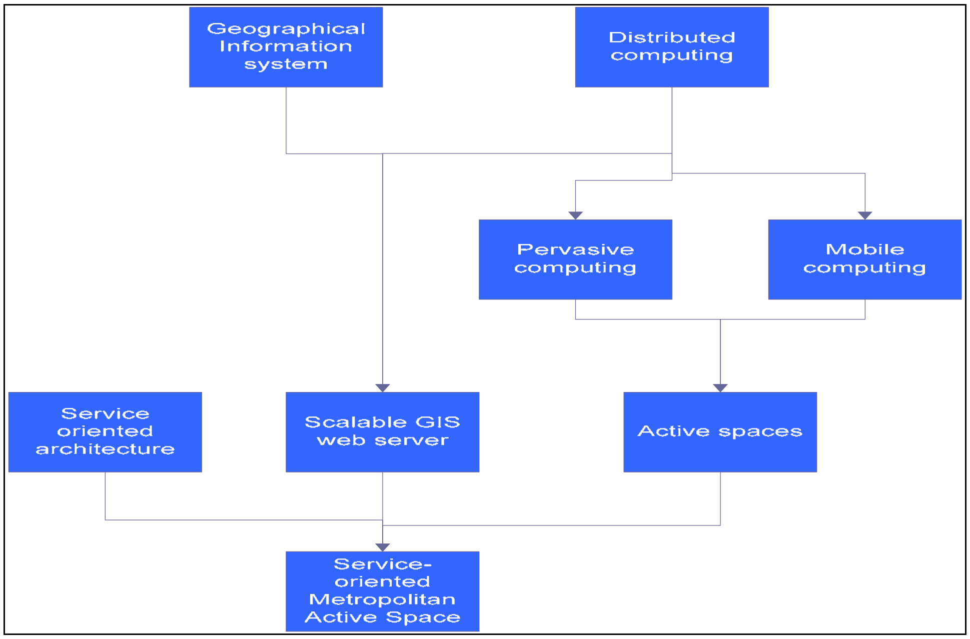


Figure 1.1: Hierarchical Representation of Project Scope.

1.7 DISSERTATION OUTLINE

Chapter 2 gives an overview of the planning stage highlighting the objectives of the project. Requirements have been specified in detail apart from analyzing the risks and constraints associated with the project. Chapter 3 summarizes the literature studied for the project in detail. The innovative concept of a "Metropolitan Active Space" has been explained at length in chapter 4. Chapter 5 thoroughly explains the design of the system and discusses the role of each module in the overall system in depth. Chapter 6 focuses on major implementation issues. Testing process has been explained in chapter 7 which is followed by five appendices, the first one consists of use case design of the system. Second and third focus on sequence and collaboration diagrams respectively. The fourth appendix has a step- by- step user manual and last one lists the research papers accepted by international conferences during the course of the project.

Chapter 2

PROJECT PLANNING

2.1 OVERVIEW

The work on this project started with the background studies. Different topics studied during the initial literature review are summarized in the literature review section. Along side, the work on formal planning was started in order to determine the exact nature of project activities, the resources required and the realistic time estimates. The planning was divided into the following phases [35]:-

2.2 PROJECT DEFINITION

2.2.1 Aims

The aims of this project will be as follows:

• To review the scientific literature, technology and context for computer aided mobile assets tracking and context- aware services constituting an active space.

• To design and implement a prototype mobile assets tracking system along with the incorporation of service- oriented metropolitan active space.

2.2.2 Objectives

The project has been divided into two major modules.

i. Design and Implementation of a Scalable GIS Server for Real- time Tracking of mobile assets
ii. Incorporation of Service- Oriented Active Space composed of Location- Aware Mobile Entities and Context- Aware Metropolitan Services

2.3 PROJECT GOALS

2.3.1 GOALS of MODULE - I

i. Provision of seamless access to GIS software capabilities on the Internet, thus relieving users of the desktop- based GIS software limited to the machine on which the software has been installed as well as any restriction of geographic boundaries
ii. Real- time online location tracking and visualization of mobile objects esp. automobiles as opposed to demand oriented SMS based tracking
iii. Online user authentication mechanism
iv. Maintenance of data security and integrity since the maps (in their original format available at the server) are highly confidential and costly
v. User- friendly rendering of the maps on the web with optimum utilization of available client and server resources

2.3.2 GOALS of MODULE - II

i. Development of a system that realizes the theoretical concept of an active space and extends its scope from an indoor environment to encompass an outdoor environment
ii. Devising a communication mechanism so that all metropolitan services are accessible to mobile entities in the active space
iii. The services should act in a context- aware manner thus taking in account the user’s surroundings and environment
iv. Design of an architecture that is compliant with Service Oriented Architecture

2.4 REQUIREMENTS

In order to meet the above stated objectives effectively, the following are the envisaged functional requirements:-

2.4.1 Functional Requirements: -

i. Render digital map on the web:
   - Preferably the client should not need to install any particular software or tool to view the map in internet explorer.
   - The client should dynamically read the data stored in the digital map and provide an interface to various features of the map
   - It should not take more than 1 second for the client to load the digital map

ii. Map Manipulating features
   - The web module should provide basic map manipulating tools such as:
   - Zooming in/ out, panning, box zooming, pan- based zooming in/ out, etc

iii. Layer Manipulating features
   - A digital map has several layers such as a layer representing main roads, another layer for railway tracks, etc. So the web module should allow user to control major features of the layers such as:
   - Switch on/ off a particular layer
   - Change the color of the layer

iv. Track mobile assets in real- time environment
   - The tracking module should be able to show the real- time movement of mobile assets on the map.
   - User should be able to track multiple mobile assets too simultaneously.

v. Location- aware module
   - The location aware module should intimate the user about the nearest place of interest. This should not take place in a query- based fashion but it should be a self- invoked service that

becomes active when the context is suitable. This is the fundamental requirement of a context-aware system.

vi. GPS Data

- As the prototype is to be tested in the lab, real-time data cannot be connected during the development process. In order to simulate GPS data of mobile assets, the prototype should have an additional component to generate simulated data about the geographical location of mobile assets.
- The simulator should constantly send the geographical location of the mobile assets which are being tracked.

vii. Online User Authentication

- Since the system is web- based, online user- authentication mechanism should be implemented
- If the user is already logged in, he/ she should not be allowed to log in to the system again.

viii. Reports

- The user should be able to view reports regarding the mobile assets too.
- He/ she should also be able to view their pdf version too so that he/ she can save or print the report for future use.

ix. Web- based mechanism for user and mobile assets management

- A web- based mechanism should also be provided for administrator for user and mobile assets management tasks.

2.4.2 Non- functional Requirements: -

Keeping the performance considerations of the overall system in mind, given below are the non- functional requirements:-

i. Scalability

ii. User- friendliness

iii. Performance Efficiency

2.5 DEVELOPMENT PROCESS

The project involves development of reusable software components that should adapt to the changing requirements. This requirement makes the model an adaptive object-oriented software component. Adaptive software is an improved form of object-oriented software that supports evolutionary development. It uses an incremental life-cycle model rather than the traditional sequential life-cycle models [10]. The prototyping technique has been preferred using Object Oriented Programming (OOP) environments. The preferred models are the incremental model and spiral model to avoid risks and perfect the requirement definition during the process of prototyping. The prototyping helps to generate more ideas and refine the product. The concept of prototyping- oriented incremental software development is taken from [37]. Figure 2.1 describes the prototyping- oriented incremental software development life cycle.

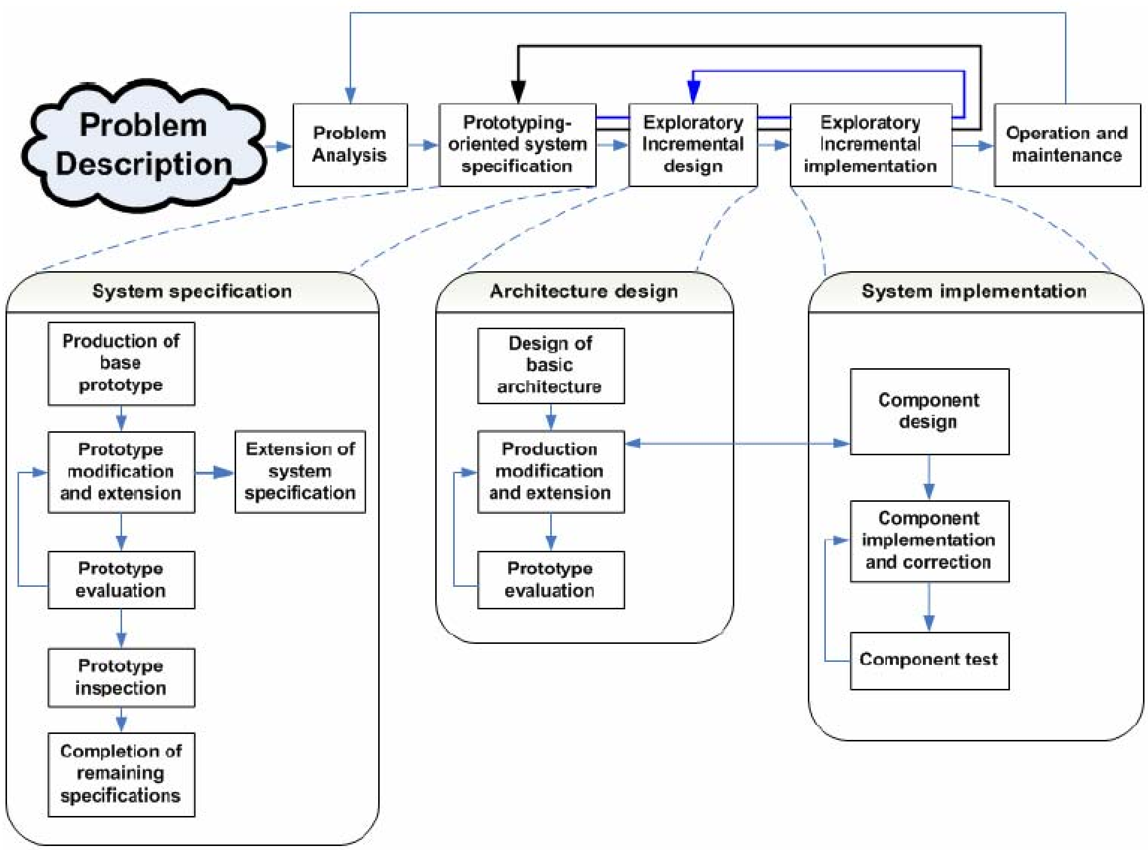


Figure 2.1: Prototyping-Oriented Incremental Software Development [13]

The model shown in figure 2.2 is used for refining the design requirement during the system specification process. After collecting the basic requirements, a base prototype is developed and the additional requirements are gathered using this prototype and the final design is refined based on these requirements. However, stage – 3, as shown in the Figure 2.2, is repeated up until a certain point in the life cycle of the project. After achieving the desired objectives or reaching the time limit, the experiments with the prototype are ceased and the final prototype design is started.

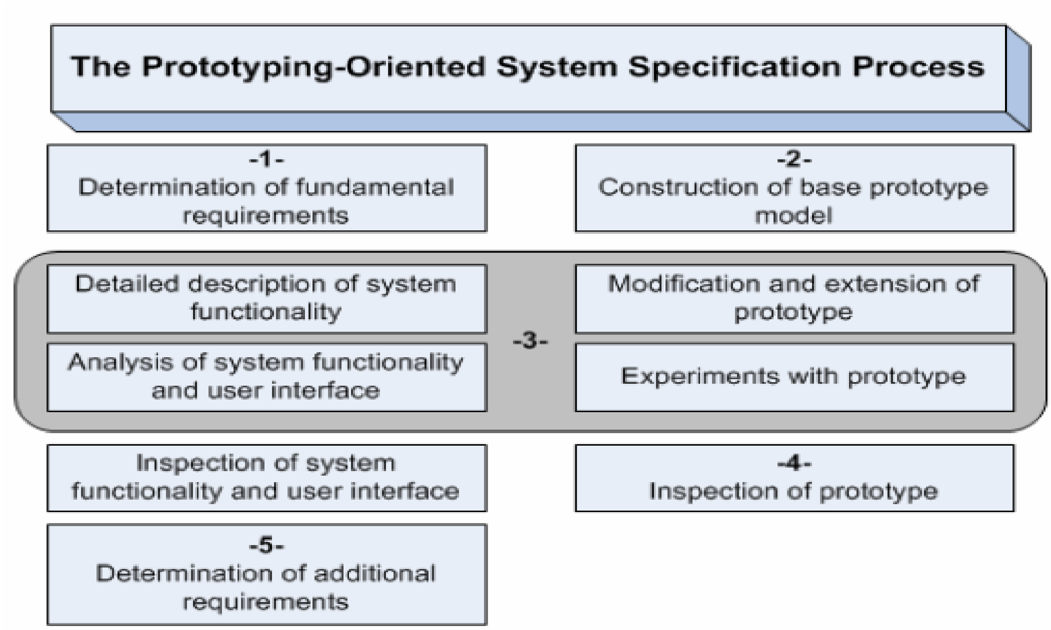


Figure 2.2: The Prototyping-Oriented Software Specification Process [13]

2.6 PROJECT SCHEDULE

In order to schedule various project activities within the available time, the project was decomposed into manageable tasks. Considering the three basic aims of the project (see section 2.2), a work breakdown structure (WBS) was defined. The project was divided into five main phases.

2.6.1 Project planning and literature review phase

During this phase, the project aims and objectives were defined. Project minimum requirements were identified and a list of deliverables was prepared. Most of the time was dedicated to literature review. During the same period, software libraries and other development tools were also learnt.

2.6.2 Project operations phase (design & implementation)

As the development process was incremental, the design and implementation phases were conducted concurrently. The base prototype was developed as per the plan.

2.6.3 Project operations phase (testing & evaluation)

Testing and evaluation was then done. Test cases were designed after a thorough exercise and evaluation was done. The final demonstration was shown to internal and external supervisors for comments and feedback.

2.6.4 Project report construction phase

Work on final project report continued throughout the project life cycle. Moreover, the diagrams to illustrate the prototype design were created during the design phase. Notes on various design, implementation, testing and evaluation activities were kept up to date. These efforts eased the pressure while writing the final report. Figure 2.3 shows the project schedule. The black diamond shows the milestones.

2.6.5 Project management phase

Project management was an ongoing activity. Microsoft Office Project was used to manage the daily schedules and project milestones. Regular meetings were conducted with the project supervisors throughout the course of the project.

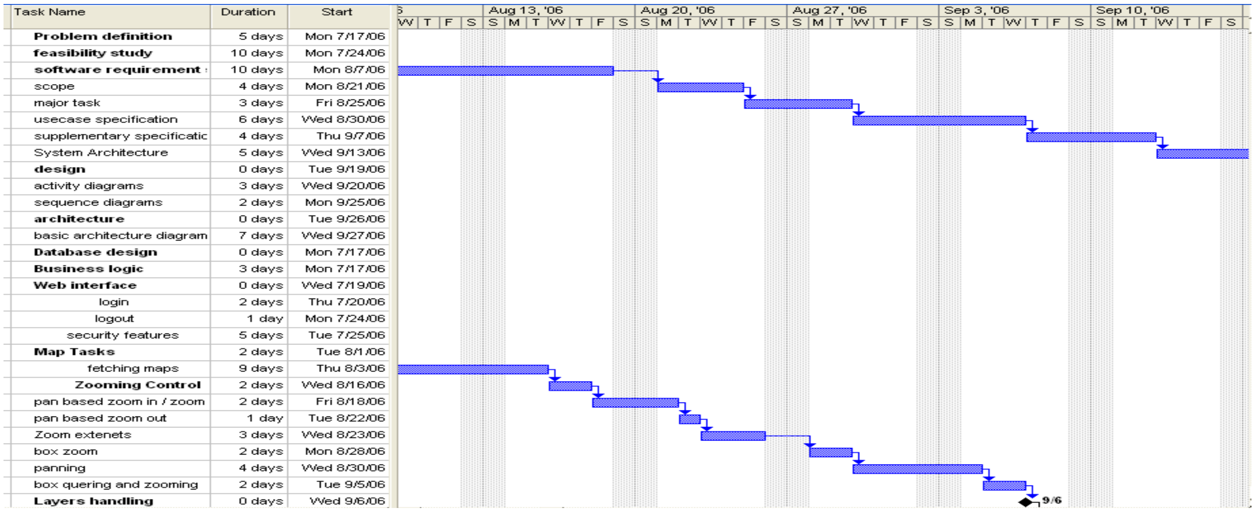


Figure 2.3: Project Schedule

2.7 PROJECT CONSTRAINTS

Following are the two constraints of the project that are visualized at the planning stage.

- The digital map available to us was in the form of ESRI shape files. So all tools, techniques and methods were selected keeping in mind this constraint.
- Because of resource/ time constraints, it is not possible to test the prototype by connecting it to real-time tracking assets using wireless networks. Therefore, simulated test environments have been used for collecting GPS data of mobile assets.

2.8 RISK MANAGEMENT PLAN

2.8.1 Risk Summary

The section below identifies the risks and discusses the risk management strategies that will be used, including mitigation, avoidance, and/or prevention strategies for the most significant risks.

2.8.2 Strategies

Some of the high- priority risks (stated in order of preference) are given below:

Table 2.1: Major Risks and Strategies

Risk	Description	Strategy
R1	Web programming languages might take some more time than the chunk allotted in the schedule as developers have no prior experience of web	Prevention

	programming	
R2	Time management is underestimated	Mitigation
R3	Trouble with open- source tools/ software being used in project software development	Mitigation
R4	Requirements can be unclear or change at later stages of project	Prevention
R5	Reusable software component contains error.	Avoidance

2.8.3 Risk List

2.8.3.1 R1: Learning Web Programming Languages

Description

Since the project under consideration is entirely web- based, know- how of web programming skills is a must. Due to the inexperience of developers in area of web programming, not being able to learn these languages within the specified timeframe is a potential risk.

Impacts

Since the project involves major web- based module, it would be badly affected if web programming skills are not mastered within specified time thus affecting the grades of the students undertaking the project.

Indicators

Inability to develop error- free programs in the selected languages.

Mitigation Strategy

Start learning the selected languages right from the start of the project so that by the time development phase starts, the developer has sufficient experience and confidence on his/ her command on these languages.

Contingency Plan

Due to the strong object- oriented programming skills of the developers undertaking the project, the probability of this risk is very low. Yet if such a situation arises where these languages have not completely been mastered, forums/ groups can be consulted. The errors/ bugs encountered can be sent to active ones out of them to take advantage of immediate and satisfactorily detailed replies.

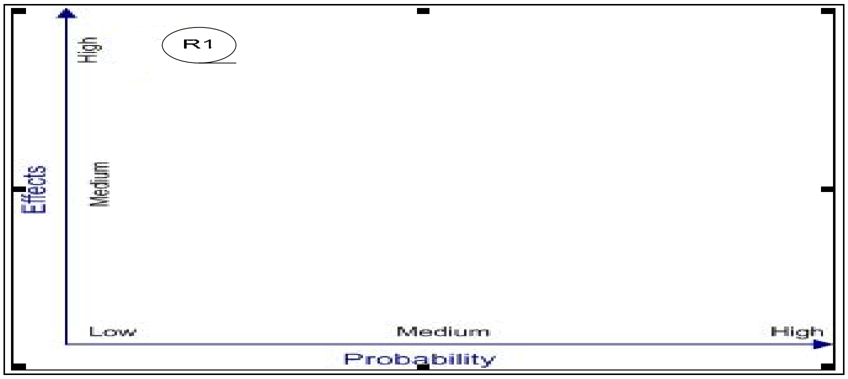


Figure 2.4: Probability v/s Effects Graph of R1.

2.8.3.2 R2: Time Management

Description

The time scheduling of the project may be under estimated and time allocated for each module may be impractical.

Impacts

The project would not be completed within the specified time frame thus affecting the grades of the students undertaking the project.

Indicators

Inability to meet the deadlines of the milestones as specified in the project timetable.

Mitigation Strategy

Give sufficient margin/ cushion period for every milestone at the time of preparing project schedule to cater for any such delays. Once the project has started, track all the activities of the project seriously and make sure that every task meets its deadline.

Contingency Plan

If any particular task takes more time than is allotted to it in the schedule, try to adjust that extra time in the next milestones by employing extra working hours. Emphasize on larger and more important modules first and work on secondary and supplementary features later.

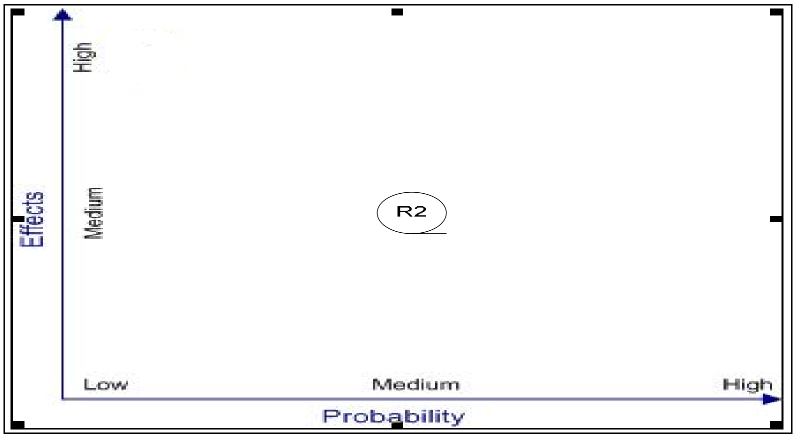


Figure 2.5: Probability v/s Effects Graph of R2.

2.8.3.3 R3: Trouble with Open- Source Tools

Description

Mostly, open- source tools have a list of known bugs or a stable version is not released. Also, it is not a rare scenario that proper tutorials and worked- out examples are not available for open- source tools. Compatibility of such tools with languages being used by the users of these tools is also an issue that's troublesome at times. All these facts when combined give rise to a big risk.

Impacts

Some modules in the project may rely on such tools; therefore their implementation may highly be affected.

Mitigation Strategy

Always try and test new tools by using them in small program with simplest functionality that is required of the tool in the project. Then use it in the desired module.

Contingency Plan

Start working on those parts of project that don't rely on these tools. In mean time, try to fix the problem and consult others through related forums or groups.

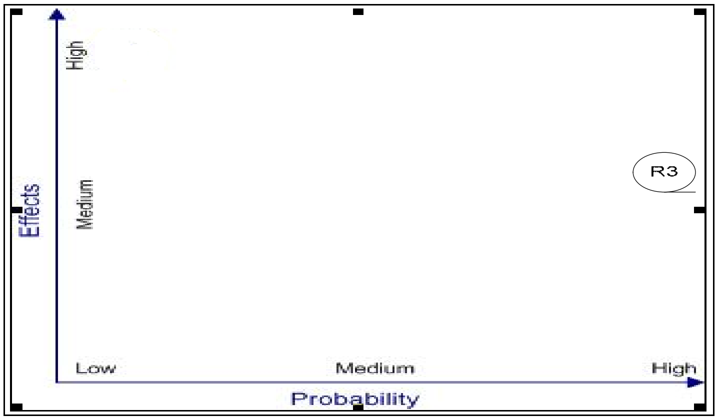


Figure 2.6: Probability v/s Effects Graph of R3.

2.8.3.4 R4: Change in Requirement

Description

There may be a change in software requirements at a later stage during the course of the project. This risk is of very common type in commercial software development. In our case, the probability of this risk is very low.

Impacts

This may lead to an indefinite period of delay in project and in often cases software design has to be changed.

Mitigation Strategy

Detailed discussion with the concerned persons, in our case, the project supervisors at the time of documenting Software Specifications.

Contingency Plan

Design and implement the software in such a way that it can accept as many changes as it can. Modular approaches help in such scenarios.

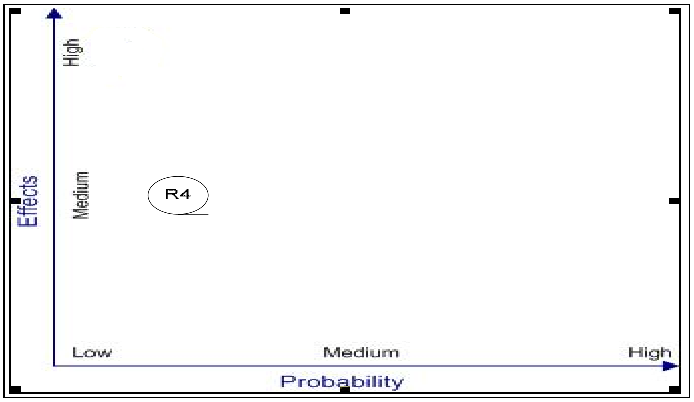


Figure 2.7: Probability v/s Effects Graph of R4.

2.8.3.5 R5: Errors in Reusable Component

Description

Reusable component i.e. a component on which other modules in the system are dependent may contain errors and can't be used further in the project.

Impacts

Reusability saves time and monitory resources. Errors in reusable components wipe out these advantages of reusability.

Mitigation Strategy

Develop these components earlier during the development phase so as to have ample time to fix the encountered bugs or in worst case scenario, develop a replacement.

Contingency Plan

Try to correct to problem if possible in short time as the time spent in correcting the problem would definitely be lesser than re- developing the module.

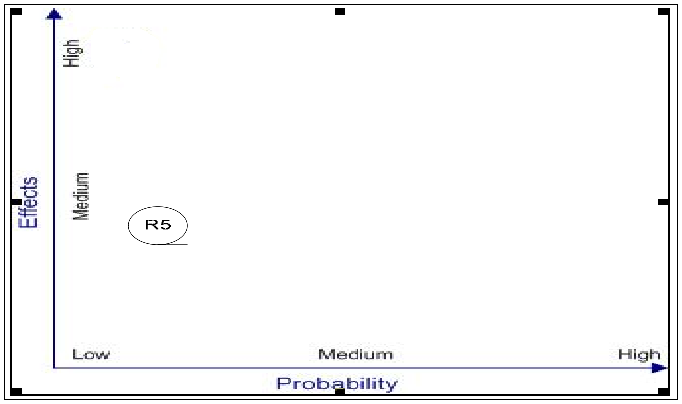


Figure 2.8: Probability v/s Effects Graph of R5.

2.9 Conclusion

This chapter discussed the aims and objectives of the project in detail. Besides covering the requirements specification and feasibility study details, the project contains a thorough risk management plan too. Thus the chapter summarizes the planning phase of the project.

Chapter 3

LITERATURE REVIEW

3.1 OVERVIEW

ActiveSpy is a GIS application that uses real-time data for geographical visualization. The data and technology used in this prototype come from different domains. Positional data is sent to the system indicating the positions of various mobile assets. The computational models integrate positional data with geospatial data and make real-time geographical visualization possible. The integration of these diverse datasets and technologies requires clear understanding of geospatial data, GPS and wireless networks. In the literature review, focus remains on these issues. Since location- aware services form a major part of the system, techniques of determining location have also been discussed. A review has also been conducted of various context- aware applications that are found in literature.

3.2 GEOGRAPHIC INFORMATION SYSTEMS

An information system is used to capture, model, store, retrieve, share, manipulate and present user data. The GIS is the category of information systems that, additionally, takes into account the geographical location of the data. [38] defines GIS as "a computer-based information system that enables capture, modelling, storage, retrieval, sharing, manipulation, analysis and presentation of geographically referenced data".

3.3 LOCATION INFORMATION

Knowledge of the location of users and equipment is a prerequisite for the support of context-aware applications. Locating physical objects is itself a distinct research area which involves the development of location hardware devices, software storage structures, and mechanisms to enable location-based querying. Location devices may give a location directly, such as in the case of GPS receivers. A location device can also take the form of a tag, attached to a user or device which periodically communicates with a fixed receiver infrastructure. With knowledge of the positions of receivers, the location of the tagged object can be determined. As far as the user is concerned, the gathering of location information should be as non-invasive as possible.

3.3.1 Techniques for Determining Location

Location is the most important information required by all metropolitan services. Here's a brief review of techniques found in the literature for tracking geographical location of an object. There are four main categories of location tracking technologies used to determine the location of a user or physical object in an indoor environment

i. Infra-red (IR) – Fixed beacons receive IR signals from transmitters worn on the body to determine location. IR has short range, and objects and sunlight can interfere with the signal. Systems such as Active Badge [7] and Cricket [4] use IR tracking.

ii. Proximity – Detecting when something is near an object. For detecting physical contact, pressure or touch sensors are used. This technology is the basis for Smart Floor [5].

iii. Ultrasonic – This method calculates location using some triangulation from short pulses of ultrasound emitted from a transmitter worn on the body to beacons installed in the roof. As the range is limited, many beacons must be installed, increasing the cost and deployment effort. One such implementation of ultrasonic tracking is Active Bats [6].

iv. Radio Frequency (RF) to determine the objects location. Recently available RF commercial software products such as the Ekahau Positioning Engine [8] and AeroScout [9] use wireless network infrastructure to determine location, as does MS RADAR [10].

3.4 WHAT IS GPS?

GPS stands for "Global Positioning System" and is a way of locating a receiver in three dimensional spaces anywhere on the Earth, and even in orbit about it. It was developed and is still maintained by the U.S. military.

3.4.1 How GPS works?

In order for GPS to work, a network of satellites was placed into orbit around planet Earth, each broadcasting a specific signal, much like a normal radio signal. This signal can be received by a low cost, low technology aerial, even though the signal is very weak. The signals that are broadcast by the satellites carry data that is passed from the aerial, decoded and used by to the GPS software. The information is specific enough that the GPS software can identify the satellite, its location in space, and calculates the time that the signal took to travel from the satellite to the GPS receiver. Figure 3.1 illustrates the GPS working.

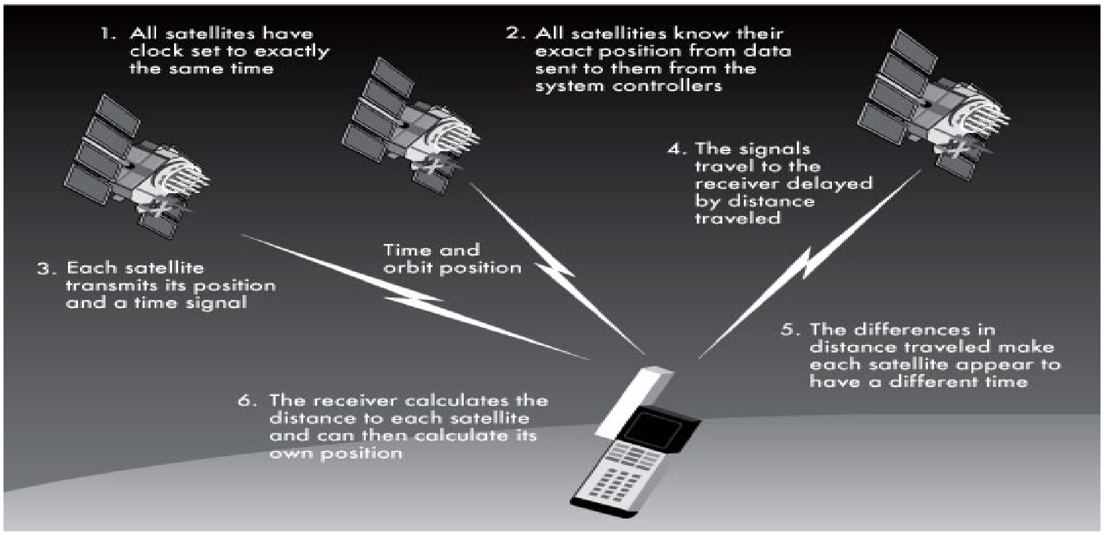


Figure 3.1: Illustration of GPS working.

The working principle is very similar to that which is used in orienteering – if you can identify three places on your map, take a bearing to where they are, and draw three lines on the map, then you will find out where you are on the map. The lines will intersect, and, depending on the accuracy of the bearings, the triangle that they form where they intersect will approximate your position, within a margin of error.

GPS software performs a similar kind of exercise, using the known positions of the satellites in space, and measuring the time that the signal has taken to travel from the satellite to Earth. The result of the "trilateration" (the term used when distances are used instead of bearings) of at least three satellites, assuming that the clocks are all synchronized enables the software to calculate, within a margin of error, where the device is located in terms of its latitude (East-West) and longitude (North-South) and distance from the center of the Earth.

3.4.2 Timing & Correction

In a perfect world, the accuracy should be absolute, but there are many different factors which prevent this. Principally, it is impossible to ensure that the clocks are all synchronized. Since the satellites each contain atomic clocks which are extremely accurate, and certainly accurate with respect to each other, we can assume that most of the problem lies with the clock inside the GPS unit itself.

There are a few solutions. However the solution that was chosen uses a fourth satellite to provide a cross check in the trilateration process. Since trilateration from three signals should pinpoint the location exactly, adding a fourth will move that location; that is, it will not intersect with the calculated location. This indicates to the GPS software that there is a discrepancy, and so it performs an additional calculation to find a value that it can use to adjust all the signals so that the four lines intersect.

3.5 WIRELESS NETWORKS

Wireless network services are vital for managing the real-time systems spread over larger geographic areas. Modern mobile phones not only provide voice communication but also extend the data transfer services such as internet and email. General Packet Radio Service (GPRS) coupled with the GSM network offers networking services for data transfer at moderate speeds [27]. This technology is considered to be between the second and third generation mobile technology.

Mobile RTK (Real-Time Kinematics) combines the mobile and GPS hardware. This emerging technology uses low-cost GPS and internet-enabled wireless phones to fix the position and pass it to the network [11].

3.6 CONTEXT- AWARE APPLICATIONS

Context-aware applications are a large and important subset of the overall set of ubiquitous computing applications, and have already demonstrated the advantages gained from the ability to perceive the surrounding environment [12], [2], [1]. Such applications however remain difficult to develop and deploy, with no widely accepted programming model available.

The mobility of devices also raises challenges in the areas of communication due to factors such as dynamically changing network addresses and system configurations, susceptibility to disconnection and low bandwidth [15].

3.7 CONCLUSION

The literature review helped in making important design decisions. The study re-emphasized the need to develop a modular and interoperable system. The issues associated with the GPS and context- aware systems will have to be considered during the design and the testing of the prototype.

Chapter 4

CONCEPTUAL DESIGN

4.1 OVERVIEW

Since the project works on an innovative idea of a Metropolitan Active Space (MAS), this chapter is aimed at explaining the roots of the concept and how it was developed and conceived passing through several stages.

4.2 ACTIVE SPACES

All physical spaces have an associated geographical location, define some physical boundaries and have some semantic meaning associated (an office and a kitchen are both rooms but the tasks performed in each of them are different). All these properties confer a particular personality to every physical space, which in turn dictates the type of entities expected in the space (e.g. physical devices, computational services and people), the way in which those entities interact and finally the services that the physical space hosts.

Coined by the researchers at University of Illinois at Urbana- Champaign, the term “Active Space” describes a model that maps the abstract perception of a physical space as a computing system, into a first class software entity. An Active Space encapsulates contextual information related to the physical space, and allows interaction with the physical space, both interactive and programmatically. Physical properties associated to the space affect the execution of applications, in the same way that the execution of applications affects the physical properties of its associated physical space. [16] defines an Active Space as a bounded physical space coordinated by a context-based software infrastructure that enhances the ability of mobile users to interact and configure their physical and digital environments seamlessly.

Gaia [17] is a distributed middleware that provides the core support necessary to construct general-purpose Active Spaces. [17] argues for a general system for ubiquitous computing environments, which exports and coordinates the resources contained in a physical space, and therefore facilitates the development of ubiquitous applications.

Active spaces consist of physical spaces – such as offices, lecture and meeting rooms, homes, hospitals, campuses, train stations and cities - that are augmented with computing devices integrated into an environment. The objective of these devices is to provide information to and obtain information from users of the space helping them to perform activities they would not be able to perform otherwise or helping them to perform conventional activities more easily.

4.3 CONTEXT AWARE SERVICES

Context awareness is a term from computer science that is used for devices that have information about the circumstances under which they operate and can react accordingly. Context aware devices may also try to make assumptions about the user's current situation. Context awareness is used to design new user interfaces, and is often a part of ubiquitous and mobile computing [41].

4.4 METROPOLITAN ACTIVE SPACE (MAS)

This project proposes to extend the boundaries of an Active Space from an indoor environment to a metropolitan level (i.e. city, district or a country level) and terms it as a "Metropolitan Active Space (MAS)". MAS aims to provide users with a dynamic and computationally rich habitat where data, applications, and digital services are omnipresent and accessible anytime and anywhere. This particular effort at the realization of an innovative active space which consists of i) mobile objects, each of which is aware of its geographical location, and ii) context- aware services.

As mentioned above context- aware services have information about the environment in which they are operating. These services depend upon the location and surroundings of the consumer and make an intelligent effort to offer best possible services to the user. Same are going to be the features of the services being deployed in the project. The services which would be the part of our MAS shall be metropolitan in nature which may include business advertising services, utility services(such as ATM, gas stations, mosques, schools, colleges and institutions, banks) etc and many others. Thus MAS, as proposed here, truly complies with the goal set by Context- awareness [3, 15] i.e. adapting the surroundings to the user preferences, tasks, group activities, and the nature of the environment.

4.5 SERVICE ORIENTED METROPOLITAN ACTIVE SPACE

The participants of our active space (mobile objects and context- aware services) shall follow service-oriented architecture for communication among one another. All the metropolitan services shall play the role of Service Providers while the mobile objects are going to be the Service Consumers. The middleware layer that we intend to develop for the realization of above- described MAS is going to play the role of a Service Broker thus being the most crucial part of the architecture. Figure 4.1 illustrates the conceptual design of a metropolitan active space and helps understand the mapping of the idea to fundamental concept of a service- oriented architecture.

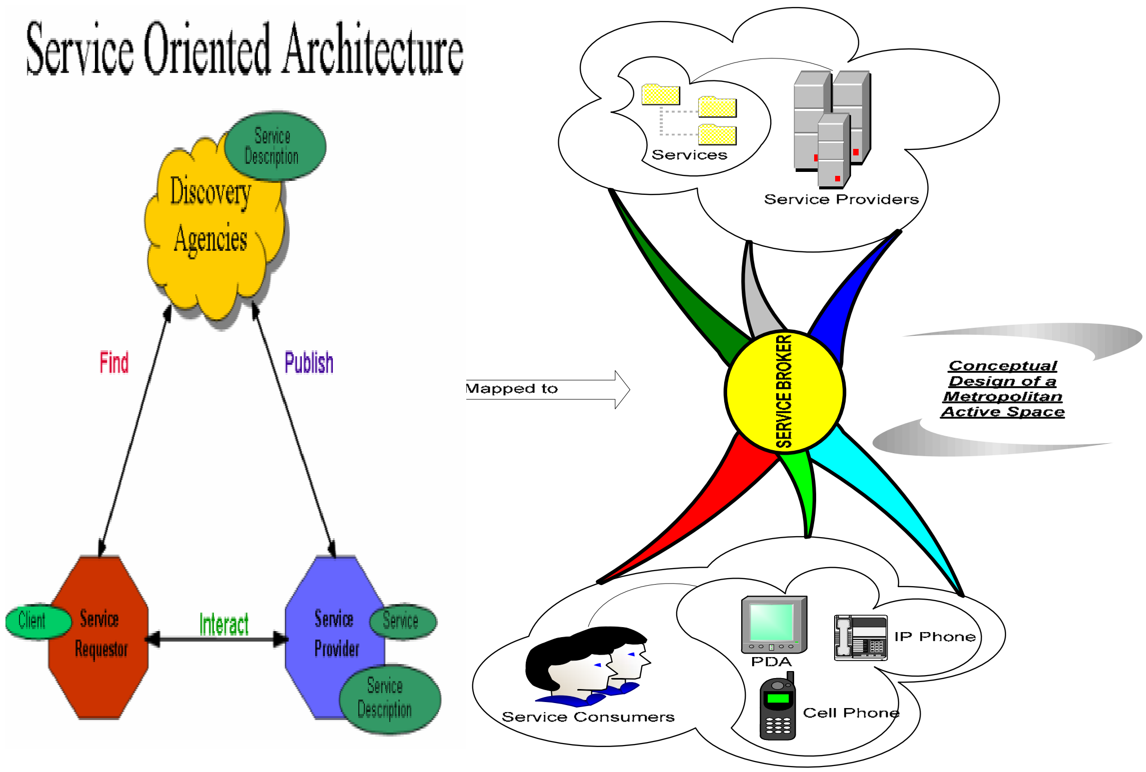


Figure 4.1: Conceptual Design of a Metropolitan Active Space

In commerce, a broker is a party that mediates between a buyer and a seller. In this particular case, the broker is going to allow service providers to register with the middleware and categorize them accordingly and on the other hand, it is going to make all subscription arrangements on part of the service consumers. It shall also be responsible for handling all coordination issues among the service providers and consumers.

4.6 RELATED WORK

There are several projects related to digitally enhancing physical spaces. They provide solutions for particular scenarios and specific types of applications. The Microsoft Easy Living project [29] focuses on home and work environments and states that computing must be as natural as lighting. The main properties of their environments are self-awareness, casual access and extensibility. HP is working on CoolTown [30], which proposes adding web presence to physical spaces. The Web paradigm is extended to physical spaces, which contain infrared beacons that provide URLs related to the physical space. The web browser is used as the standard application GUI and one of the key aspects is the dynamic creation of customized web pages according to contextual parameters. Finally Georgia Tech's Classroom 2000 [31] preserves and augments electronic notes taken by students and teachers by attaching and synchronizing audio, video and annotations to class notes

Chapter 5

SYSTEM DESIGN

5.1 OVERVIEW

This chapter describes the design process of the project in detail. The chapter starts with an introduction of the project design process. Various models of distributed computing have been discussed along with their advantages and disadvantages. The choice of model to be followed in this project has been justified then. After describing general system architecture, each functional component is discussed separately. Design of both modules of the system has been addressed individually. Overall working of the system has also been discussed in detail followed by conclusion section.

5.2 INTRODUCTION

The design of the project is based on the system specifications envisaged during the requirement phase (see section 2.4). The most important consideration is to design and develop a flexible and adaptable solution that is extensible and fulfils the changing requirements. ActiveSpy has a complex design owing to its dependence on multidiscipline technology (GPS, spatial data, GIS tools, Active spaces, context- aware computing). Moreover, as the shape of the final product is not obvious at the early stages of design, therefore, a top-down design technique is followed. A top-down design begins with the analysis of the requirement definition and does not take into account the implementation details [20]. Ideally, the design phase should be independent of the implementation tools and techniques.

Keeping in mind that the project has two major modules, “Separation of concerns” has been adopted as the underlying theme during design process. Our approach is to decouple adaptive techniques from basic application functionality [36]. In doing so, both modules can be designed independently and integrated at later stages of the project. Figure 5.1 illustrates the use of decoupled modules in the design of the system.

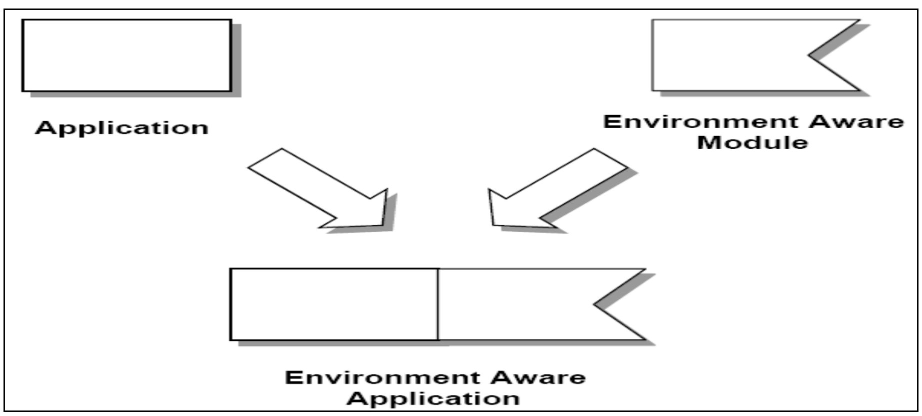


Figure 5.1: Decoupled Modules

5.3 FUNDAMENTAL REQUIREMENTS

The fundamental requirement of a real-time tracking system is to establish the exact position of the moving object on the surface of the earth. [32, 33, 34] discuss this issue at length.

After the position of an object has been established, the next step is to work out how to use the data about its location. When the precise location of an object is overlaid on a highly accurate spatial data, it provides new opportunities to develop accurate GIS.

In order to make the system real-time, the third requirement is to transfer the precise location of mobile assets to a centralized location in the shortest possible time. The advanced wireless networks have made this possible. Besides, the project also makes an effort to introduce an active space composed of location-based services.

5.4 SYSTEM DESIGN MODEL

Keeping in mind the fundamental requirements needed for the system to work, we took a review of various models that can be used to develop such a system. We reduced to the following approaches:

5.4.1 Stand- alone System

Stand-alone mobile assets tracking system can use GPS equipment to locate mobile assets and collects its position data by a wireless or satellite network. Their geographic coordinates are presented on a digital map within the storage media. In a stand-alone system, there is no any data integrity among the distributed monitoring stations because each monitoring station has its own spatial database [18].

5.4.2 Web- based Client/ Server System.

Web– based mobile assets tracking systems make use of client/ server structured system; a client system can share the spatial data and mobile assets' position data with a connection to a server system. So, the client/server structured system can keep the integrity of data and the cost-effective maintenance of database [20]. Such a system providing all information in real- time requires a leased line connection or dialup-link WAN connection from a server to a client. The motivation is that a web-based information service has no need to install any special program except a browser, and a connectionless protocol is suitable to response to an intermittent user request [9]. Figure 5.2 shows the standard client server configuration.

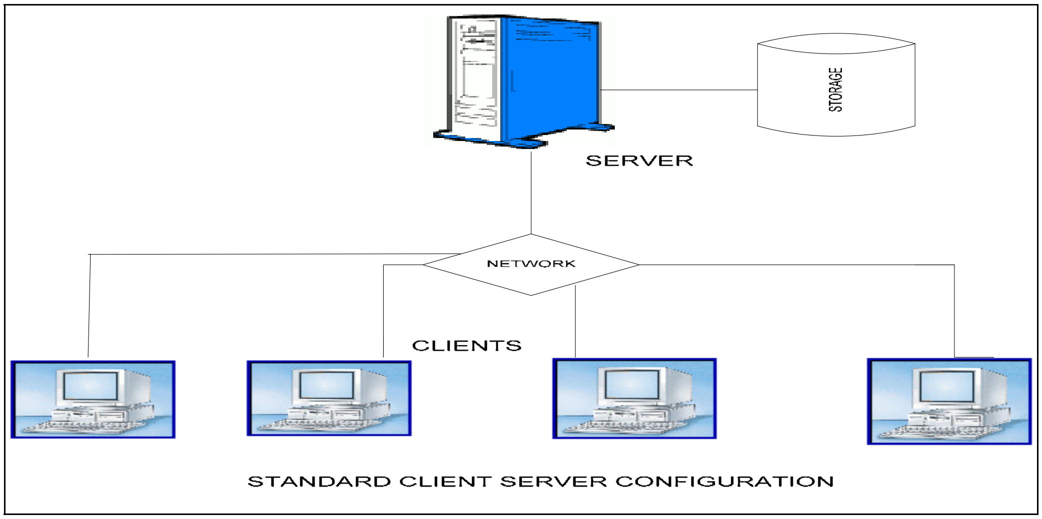


Figure 5.2: Standard Client- Server Configuration

Clients can be "thin", loosely defined as using a graphical user interface (GUI) to access applications that execute on a server; or "fat", meaning that the spatial applications execute on the client platform. On the back end are data servers, providing access to what are often very large sets of both spatial and tabular data through a standard programming or user interface [23].

In other words, a distributed system of nature as the system under consideration can be developed either using server-side strategies or client- side strategies.

5.4.3 Web- based System using Server- side Strategies.

In an internet- based system using server- side strategies, a user can make a request about the mobile asset's position from a Web browser, and then the request is sent across the Internet to a server. After the server processes the request, the response is returned to the user and it is viewed using a Web browser. The advantage of server-side strategies is that if a high-performance server is used, users can access large and complex datasets that would be difficult to transfer across the Internet and process locally on the client. In server-side strategies, every request- no matter how small- is passed to the server and processed and responses must then be returned to the client across the Internet. The disadvantage of server-side strategies is that performance would be affected badly according to the bandwidth and network traffic on the Internet.

5.4.4 Web- based System using Client -side Strategies.

In client-side strategies, server applications attempt to shift some work of their processing to the user's computer. Instead of forcing the server to do most of the work, some of the GIS capabilities are downloaded to the client, or reside there, and data is processed locally. The client-side strategies take advantage of processing power of the user's own computer and the user can control and analyze the data dynamically. The disadvantages of client-side strategies include transferring large amounts of data as well as applets may invoke much response delay from the server.

5.4.5 Web- based System using Hybrid Strategies.

In analogy to this, server-side and client-side strategies can be combined to produce hybrid solutions better matched to capabilities of both the server and client. Tasks that involve heavy database use or complex analyses can be assigned to the faster machine, typically the server. Tasks that involve many controls by the user can be assigned to the client.

5.4.6 Three- tier architecture model

The client/ server architecture discussed in detail above can be improved to bring it in compliance with 3-tier architecture. The three tier software architecture emerged in the 1990's to overcome the limitations of the two tier architecture. The third tier (middle tier server) is between the user interface (client) and the data management (server) components [22]. This middle tier provides process management where business logic and rules are executed and can accommodate hundreds of by providing functions such as queuing, application execution, and database staging. The three tier architecture is used when an effective distributed client/server design is needed that provides increased performance, flexibility, maintainability, reusability, and scalability, while hiding the complexity of distributed processing from the user [19, 21]. Figure 5.3 depicts the three tier distributed client /server architecture design.

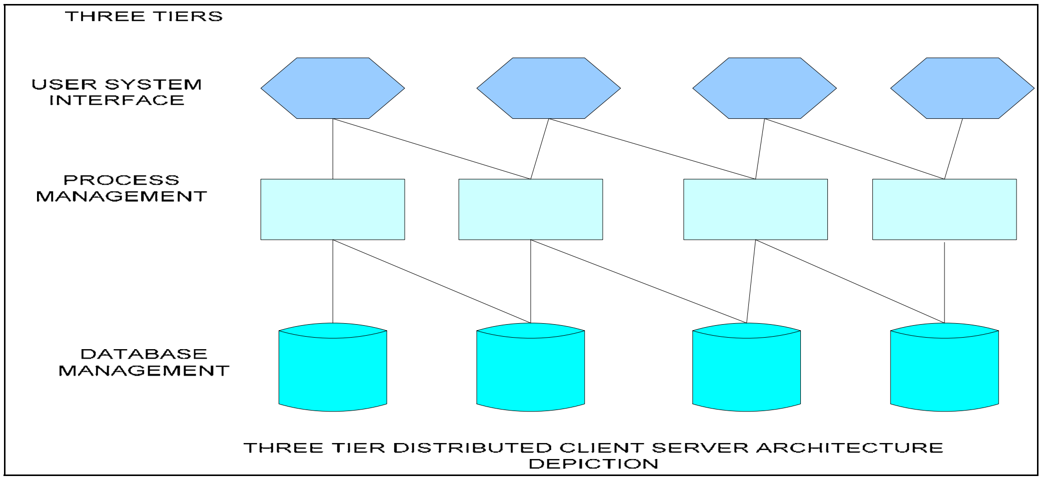


Figure 5.3: Three Tier Distributed Client/Server Architecture Depiction

5.5 SYSTEM MODEL SELECTED FOR THE PROJECT

Because of its extremely limited end- users' access and scope, stand- alone approach was completely written off while designing our system and a web- based model has been emphasized. While mobile assets tracking system involves several maps, huge databases, computation- intensive map- related features on one hand, it also provides several user controls for the customization of the maps such as zooming, panning, changing status/ color of the layers on the map etc. Keeping in view this diversified range of functionalities, hybrid client/ server approach based on three- tier software architecture has been selected to suit this project the best. An amalgamation of server and client- side strategies has been chosen so as to achieve optimized performance and better scalability of the overall system. The figure 5.4 below illustrates the top- level design of the system.

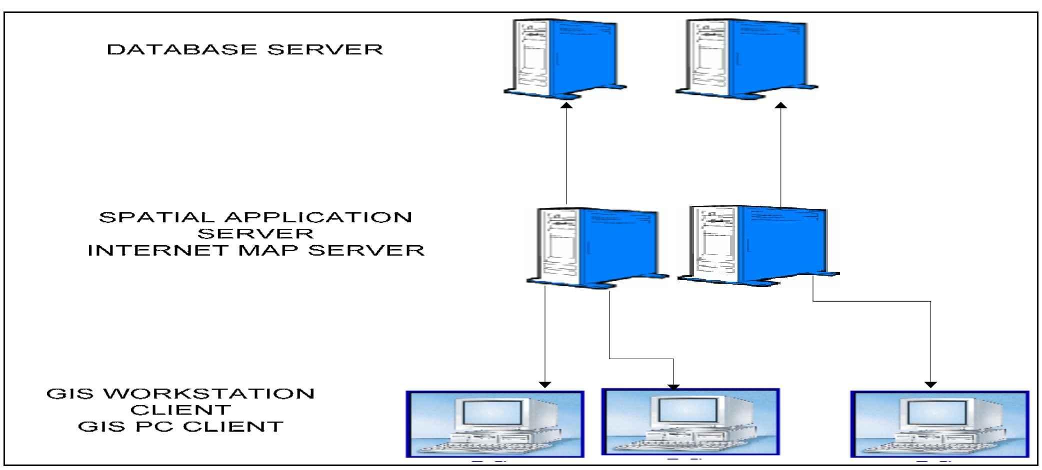


Figure 5.4: Three-Tier GIS Client- Server Configuration.

5.6 MODULE I

5.6.1 System Architecture

The system is composed of five major components i.e. Web Client, Web Server, Map Server, Core Module and Gateway. The next section discusses in detail individual jobs of each component and highlights its importance in the overall system. Overall system layout is depicted in the figure 5.5.

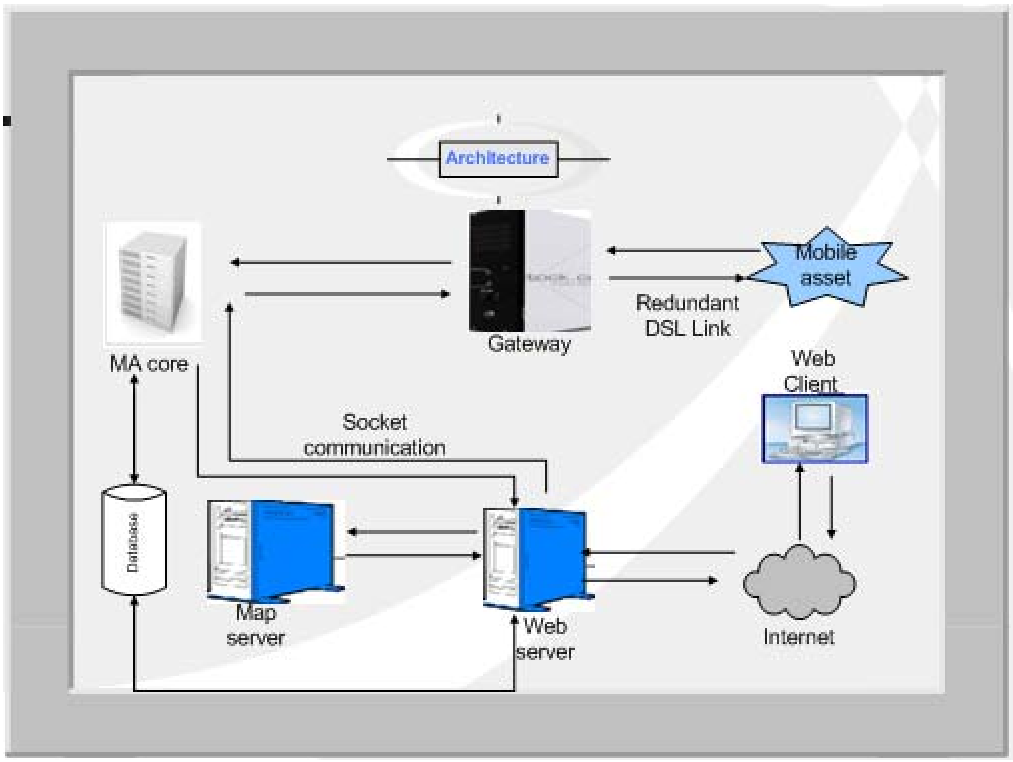


Figure 5.5: System Architecture

5.6.2 Detailed Responsibilities of Each Component

5.6.2.1 Core

Core is a major component of the overall system. It is the central point through which the entire network traffic passes. Its major responsibilities include: data reception from any system component, data analysis, deciding the data destination, formatting the data in such a way that is understandable by the destination node and then, in the end, delivering data to the destination. Detailed architecture of the core is shown in figure 5.6.

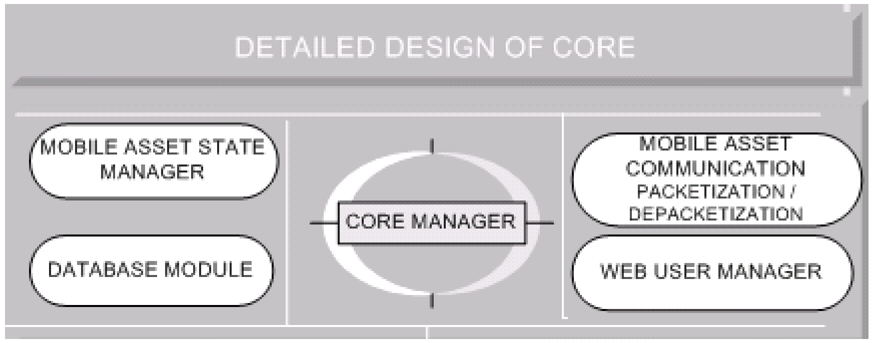


Figure 5.6: Detailed Design of Core

Core Manager. It is the main management module responsible for controlling all other components of Core Module. It has the capability to activate/deactivate other components by activating/de-activating their threads. Its major responsibilities include determining the overall state of the system. Packets categorization and deciding resultant packet type in any given scenario is also its job. It invokes methods of other utility classes thus enabling communication between different components of the overall system. Its principal role in the real- time tracking system is to enable communication between the web components and the gateway.

Mobile Assets State Manager. This module handles all the information related to mobile assets. Its major responsibilities include i) Keeping the geographical location of mobile assets. ii) Updating mobile asset's information. iii) Dispatching mobile asset's information to other components on demand.

Mobile Assets Communication Packetization/ De-Packetization. It is responsible for controlling communication with the mobile assets. It is responsible for the reception of binary packet from other components, decoding the packet according to binary packet format, reading packet contents to extract the required information, reception of raw data, making binary packet according to pre-defined format, sending the packet to other components.

Web User Manager. This module is used to handle web user management functions. It strengthens system security by maintaining a state machine that keeps a record of all the users which are logged into the system at a particular point. In this way, it helps preventing a user being logged into the system from two different web client simultaneously. Similarly, this state machine also keeps a record of all the mobile assets being tracked currently and maintains their latest positions.

Database Module. This module handles database related issues i.e. it processes any access to database, no matter whether it is data retrieval or data insertion. It is responsible for receiving queries from other system components, interacting with database to perform required operations, extracting required results and propagating response back.

5.6.2.2 Gateway

Gateway is a static entity that acts as a router between the mobile asset and Core Module and routes packets between these entities. For transmission of geographical location of mobile assets, GPS receiver may be installed inside the mobile asset and then it can support GPRS to communicate with the gateway, so the gateway needs to be configured accordingly. Detailed architecture of the gateway is shown in figure 5.7.

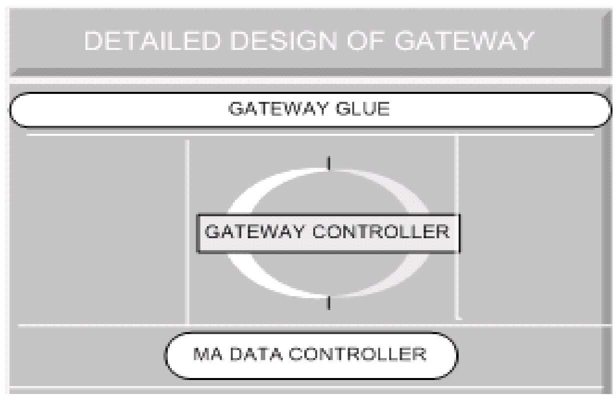


Figure 5.7: Detailed Design of Gateway

Gateway Glue. This is not actually a component rather it is a wrapper between Core and gateway module to hide each other's data.

Gateway Controller Module. It is the main management module responsible for controlling all other components of the Gateway Module. Controller Module passes configuration data to other components. Furthermore Controller Module also does enabling/disabling of different components. Its major responsibilities include: i) acting as Communication entity between different modules ii) configuring other components iii) controlling all the modules of the Gateway component

MA Data Controller. This module is designed to handle GPS data being sent to it by various mobile assets. It is also responsible for communicate this data to the core as and when required.

5.6.2.3 Web Server

Its major responsibility is to act as a bridge between the web client and the core. It also generates various kinds of reports for the owners of the mobile assets in html as well as pdf format so that users can also get the details of the past movement of their assets. It is also responsible for user and mobile assets' management functions like user/ mobile assets' addition, user/ mobile assets' deletion, updating user/ mobile assets' data etc. Also, it designs an access policy and determines user privileges.

5.6.2.4 Map Server

It is a part of the web server factored out for modularity sake. It takes care of all features related to the geographical maps which carry utmost significance in any form of tracking systems. Its major responsibility is to render digital maps on the web by converting various map formats such as .shp to viewable graphic format such as .gif, .png etc. This component is also responsible for displaying individual icons on the map for every mobile asset being tracked in a real- time environment. It also allows the user to locate a specific asset on the map. Apart from these jobs, this component performs a number of tasks related to the customization of the geographical map being displayed on screen. These tasks are listed in table 5.1.

Table 5.1: Functions of Map Server

Reading the number and titles of layers in the map and dynamically loading them in the layers menu
Switch on/ off layers being displayed in a map
Change color of layers in a map
Click- based zoom in/ out operations
Click- based panning of map
Panned zooming in/ zooming out/ panning operations
Zoom area control
Draw/ clear fence on the map
Display multiple mobile assets at appropriate positions on the map
Save/ print/ e- mail the image of map

All these capabilities have been programmed by the developers and do not involve any purchased GIS system thus eliminating any license fees that are required to be paid on regular basis otherwise.

5.6.2.5 Web Client

Its major responsibility is to provide an interface for all the functionalities supported by the web server and the map server. It provides an access to the users to access various map features as well as displays real- time position of mobile asset chosen for tracking. To prevent the assets from any unauthorized access, the project authenticates the users accessing web client not only at the web level but at the business logic level too. Highly interactive and user-friendly web interface also allows the clients communicate with their assets and send commands to and receive acknowledgements and alerts from them. Besides the user can also view and save reports of the status of their mobile assets over any specified period of time. The user also holds complete control over the digital map being displayed and can perform all major operations such as zooming, panning, zoom area, switching on/ off the layers as well as changing the colors of individual layers.

5.6.3 Working of the Overall Module

A GPS simulator simulates the path of mobile asset along which it is moving in the real- time environment. The recorded location data can be stored within the tracking unit, or it may be transmitted to a central location data base, or internet-connected computer, using a cellular (GPRS), radio, or satellite modem embedded in the unit. In this particular case, this information is sent to the gateway module of the system at regular intervals of time. In the design shown in fig 5.5, DSL link is provided for communication between the GPS receiver attached to the mobile asset and the gateway, a system component responsible for all external communication to/ from all mobile assets. Thus a gateway is an interface of the overall system to the external environment.

Real- time data received by the gateway is then sent to the Core for further processing. It is the central entity of the system responsible for enabling communication among all system components, mainly the communication between web server and the gateway.

Database is responsible for keeping users and mobile assets information dispatched by the web server and gateway. Apache web server is being used in the system for its low- cost and high efficiency. Map server contains the digital maps that are displayed on the web client and handles all map manipulation tasks such as panning, zooming, etc. Web client is the network node that provides an interface of the system to owners of the mobile assets being tracked. Client specifies web address in the browser and as a result, system’s website appears on his/ her console through which he/she interacts with the overall system.

5.7 MODULE II

5.7.1 Top- Level Design

Figure 4.1 illustrates the top- level design of this module. The participants of our Active Space (mobile objects and context- aware services) shall follow service- oriented architecture for communication among one another. All the metropolitan services shall play the role of Service Providers while the mobile objects are going to be the Service Consumers. The middleware layer that we intend to develop for the realization of above- described Active Space is going to play the role of a Service Broker thus being the most crucial part of the architecture. In commerce, a broker is a party that mediates between a buyer and a seller. In this particular case, the broker is going to allow service providers to register with the middleware and categorize them accordingly and on the other hand, it is going to make all subscription arrangements on part of the service consumers. It shall also be responsible for handling all coordination issues among the service providers and consumers.

5.7.2 Detailed Design

Figure 5.9 provides a block diagram of the detailed design of the Service Broker component.

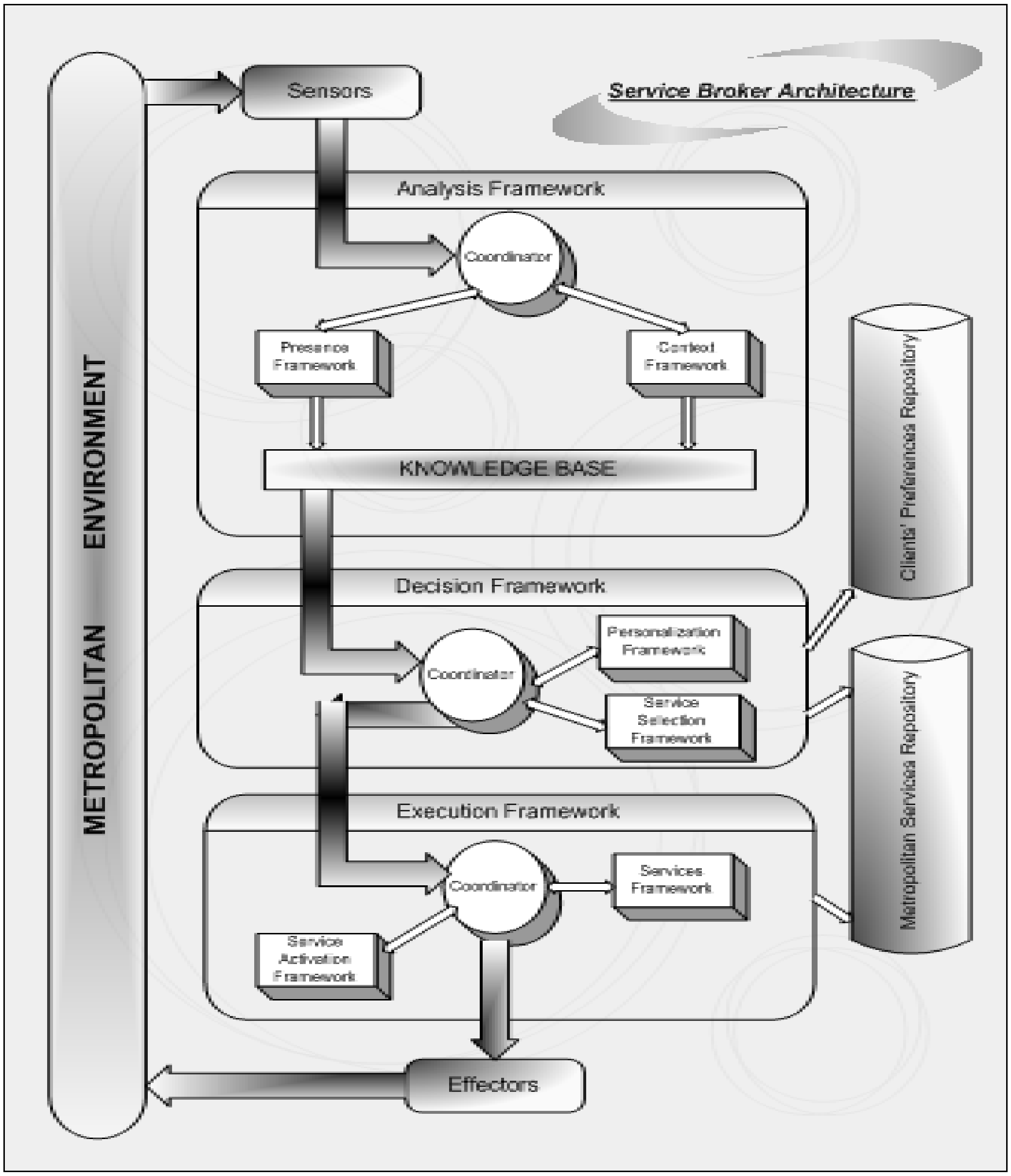


Figure 5.9: Detailed Design of Service Broker.

Sensors. As the name suggests, these are responsible for communicating the external environment stimuli to the system. Information such as the location and motion paths of users and physical objects, and the ambient noise and temperature of the surrounding environment can be used to tailor a user's experience in any given scenario. The Service Broker consists of several sensors, or context providers, that offer information about the current context. In this particular system, the only context information being used is the geographical location so the required sensor for it is the GPS receiver. But the current implementation uses a simulator to send the geographical location of mobile assets at regular intervals.

Context Framework. Service Broker Component aims to use context information to adapt to user behaviors and activities. Our context framework lets applications query and register for particular context information, which helps them adapt to their environment. Other components can infer certain higher-level contexts on the basis of sensed information or derive composite contexts utilizing the input from individual sensors.

Presence Framework. As a resource-aware infrastructure, the Service Broker must maintain updated information about metropolitan space resources. The service is divided into two main components: Context- Providers Presence Component (CPPC) and Multimedia Interfaces Presence Component (MIPC). The CPPC detects the sensors currently available in the mobile device, which periodically send heartbeats to notify the service that they are active. A registry associated with this component is known as Context Providers Registry that maintains a list of available context providers. Applications can use this registry to find providers of the contexts they desire. When a sensor fails to send the heartbeat, the CPPC assumes that it is no longer available—either it has stopped functioning or it crashed—and notifies its coordinator that the sensor has left the metropolitan space. The MIPC detects audio and video interfaces available in the mobile device. This component uses different types of sensors to proactively detect multimedia interfaces. Like its sister component i.e. CPPC, this component also maintains a registry called Multimedia Interfaces Registry that keeps a list of available audio and video multimedia interfaces. This registry is used by Effectors which make use of the suitable interfaces out of the available ones to execute the service on the mobile device.

Knowledge Base. Presence framework as well as Context framework feed their outputs into the knowledge base which now has complete contextual information of the current scenario. The contents of the knowledge base are then fed into the coordinator of the Decision framework to make further decisions.

Personalization Framework. As the name suggests, this framework is responsible to cater to user's individual choices and preferences. For this purpose, Clients' preferences repository is maintained which is filled in by the information provided by the user regarding services of his interest. The contextual information coupled with the user's preferences whose context is under consideration forms the criteria on the basis of which selection of service is made.

Service Selection Framework. This component lies at the heart of the decision making process. Considering the services present in the Metropolitan services repository as candidates, this framework decides which service suits current context and user the best. The selected service's ID is sent by the coordinator of the Decision Framework to the coordinator of Execution Framework.

Services Framework. This framework contains complete information regarding each registered metropolitan service. It clearly states the pre- conditions and the post- conditions for each service which must be satisfied in case of activation of any service.

Service Activation Framework. The selected service is activated by this framework. It contacts the coordinator to acquire execution requirements of the service from Services Framework and activates the service if all pre- conditions are met. Once the service has been executed, this framework also ensures that all post- conditions are satisfied too.

5.7.3 Reminiscence with MAPE Model

The model we have developed is also reminiscent of the MAPE (Monitor, Analyze, Plan, and Execute) model [25, 24], as per the vision of autonomic computing [26, 27, 28] which breaks management architecture down into four common functions: (i) Collecting data (ii) Analyzing data, (iii) Creating a plan of action, and (iv) Executing the plan. The Service Broker Monitors (M) the metropolitan environment by the sensors, Analyzes (A) the sensed information provided by the sensors through the Analysis Framework which is responsible for acquainting the broker with the sensors and multimedia interfaces existing in the surroundings of Metropolitan Active Space and storing this contextual information into the Context Framework. Decision Framework Plans (P) and carves a future plan of action. The Service Selection Framework selects a context- aware service to be executed based on the contents of the Knowledge Base as well as the Clients' preference repository and the Personalization Framework. The Execution Framework, as its name suggests performs the last function of the MAPE model i.e. Executes (E) the selected context-aware service by a collaboration of Services Framework and Services Activation Framework. The Services Framework provides all the information about required parameters for each service available in the Metropolitan Active Space while the Service Activation Framework knows how to execute each service. The coordinator of Decision Framework orders the coordinator of Execution Framework the identity of the service to be executed. The Execution Framework then uses Effectors to actually run the service using suitable audio and video multimedia interfaces.

5.8 CONCLUSION

The result is what we call a service- oriented Metropolitan Active Space (MAS) composed of mobile entities and user- centric, context- aware services. The middleware to be designed in order to realize such an Active Space is aimed to support easy extension of the Active Space making it virtually boundless. The space shall only be restricted by the geographical information of its members, a mandatory requirement for location awareness. The project aims to extend the computational environment beyond the desktop PC, but not only to cantonments or cities but also to countries and in general any arbitrary physical space while being on the move.

Chapter 6

IMPLEMENTATION

6.1 Overview

This chapter discusses some of the important issues addressed during the course of the project. In order to implement the design elaborated in the previous chapter, a lot of research needed to be conducted in order to explore the previous work done and the available tools and techniques that can be used to perform a task. These tasks and the results of the extensive research are described below: -

6.2 Raster v/s Vector Maps

If systems are developed using raster images, such as jpeg and gif, it is necessary to update the entire graphic screen to increase the volume of communication. That is one disadvantage. And raster images cannot be scaled another disadvantage. So mostly the systems are implemented using Shape files, which represent vector data.

6.3 Shape Files

The digital maps of various cities available to us are in form of ESRI shape files. Shapefiles were introduced with the release of ArcView 2 in the early 1990s. In the shape file format, information about a single map is stored in 3 different files with extensions .shp, .shx and .dbf respectively. One file holds the vector data itself (this file usually has a SHP extension), one file holds the record attributes (this is a DBase

III file with a DBF extension) and one file holds an index to the shape file (*.SHX). For more information on the shape file format please refer to [42].

6.3.1 Advantages of Shape Files

A primary advantage of shapefiles is that this simple file structure draws faster than coverage does [43]. This may be why the shapefile data structure was developed for ArcView GIS, a software program that was originally designed for data viewing rather than analysis. The shapefile specification is readily available, and a number of other software packages support it.

6.4 Rendering Digital Maps on Web

The first task at hand has been the rendering digital maps on the web. Shape files need special viewer programs for purpose of being displayed even in desktop environment. Since internet explorer does not support any built- in ESRI shape file viewer, research has been done in this regard to explore a way to display digital maps on the web client.

6.4.1 SharpMap

SharpMap is an OpenSource Map Engine for .NET 2.0 but since its use imposes the condition to use languages of .Net platform. While .Net platform was given a try, it was found that the .Net platform is very heavy on system resources thus posing a serious threat to the speed at which map manipulation operations shall be performed at the web client end. This experience led to the rejection of SharpMap.

6.4.2 Conversion to Flash Movies

Another available alternative was to convert shape files to Flash movies but due to the extremely large size of the Flash movies which would take a lot of time to be displayed on the web, this option was turned down too. After trying and testing a lot of other alternatives, we finally chose to use MapServer.

6.4.3 MapServer

MapServer is an OpenSource development environment for building spatially enabled applications. The MapServer system now supports MapScript which allows popular scripting languages such as php, Perl, and Python to access the MapServer C API. Mapserver has been used in the project to read shape files and convert them to a form suitable for rendering digital maps on the web.

6.5 Client-side scripting

Scripting technologies like JavaScript, JScript, VBScript and others are used on many sites to add extra functionality to a web site. Ranging from simple mouse over image effects, animation, form field validations to complex dynamic menu systems, these scripts enhance the functionality and user experience. The project uses javascript to complement with html.

6.6 Server Side Strategies

Keeping in view the increasing trend of web- based applications; several server- side scripting languages have been developed. VB Script and ASP (Active Server Pages) are Microsoft's contribution in this regard. Due to their dependence on IIS, inability to be cross- platform and closed- source, experts discourage their use. In such a scenario, php is fast strengthening its ground. PHP has been selected for the project because of its three key advantages over competing technologies:

- Designed for the Web
- Ease of Use
- Open Source

6.7 Automatic and Regular Revision of Data at Client End

In a web system using the internet, in many cases communication protocol is restricted to HTTP. The nature of the system under discussion is such that client needs to constantly contact the server for various map manipulation features. Two methods exist for this purpose: server push and client pull.

Server Push

This method transmits data from the server side to clients. Notifying clients is possible just as data are changed. However, draw backs exist: the server needs to maintain a connection with clients; special implementation from the server side is necessary; and the web browsers that can be used are limited.

Client Pull

This method requires data of the server from client sides. Implementation is easy because only a rereading function of the web pages is necessary. This method has been adopted in the current implementation.

6.8 Updating Mobile Asset Location without Reloading Entire Page

A user can track the real- time location of multiple mobile assets at any time. These mobile assets' are shown on a map. When the geographical coordinates of any one of the mobile asset change, its position on the map needs to be changed too. The client regularly reads the latest geographical position of these mobile assets from the core's state machine which maintains these updated positions so as to reduce DB queries. The problem faced here was to update the position of a particular mobile asset instead of reloading the entire page. This is meant to increase the web page's interactivity, speed, and usability. The solution found is explained under: -

6.8.1 AJAX

Ajax, shorthand for *Asynchronous JavaScript* and *XML*, is a web development technique for creating interactive web applications. The intent is to make web pages feel more responsive by exchanging small amounts of data with the server behind the scenes, so that the entire web page does not have to be reloaded each time the user makes a change.

6.9 Bridge to Core State Machine

The communication between the web server and the core takes place via sockets. In the web module, sockets can be opened through php. So the control needs to be transferred from the client side (javascript) to the server side (php) in order to enable communication between web module and the core. After extensive research, following tool was found to help achieve the functionality.

6.9.1 AJAX Agent

Sajax (Simple Ajax Toolkit), is an open source tool designed to help websites using the Ajax framework. It allows the programmer to call PHP, Perl or Python functions from their webpages via JavaScript without performing a browser refresh.

6.10 Client GUI

From sofisticated state- aware menus to pleasant color palettes, attractive icons and cursor for map manipulation functions to use of frames, the GUI has been developed using advanced web GUI development techniques.

6.11 Incompatible Coordinate Systems

Another major issue is the coordinate transformation. The geographical data of various mobile assets being received by the web module from core's state machine is in the form of pair of <latitude, longitude>. When tracing the path of a mobile asset on the map, being displayed at the client end, this form of representing the real- time location of mobile asset is not suitable. Although every point on the digital map corresponds to a <latitude, longitude> pair but this mapping cannot not be directly interpreted by internet explorer. This is so because for any web client, the map being displayed has no meaning except for being mere graphical image.

6.11.1 Mathematical Derivations for Geographical Coordinates ←→ Screen coordinates Inter- conversion

Mathematical calculations are required in this case to derive the correspondence between two coordinate systems i.e. geographical coordinate system and screen coordinate system. Formulae have thus been derived to associate every point on the map being displayed on the client's screen (screen coordinate system) to <latitude, longitude> pair (geographical coordinate system) and vice versa.

Given the top- left and bottom- right points of the map in terms of <latitude, longitude> pairs and width and height of the map being displayed on the screen in terms of screen units, the following formulae may apply.

Conversion of a point from screen to geographic coordinates: -

One unit of screen along x- axis is equivalent to longitude units derived below: -

$Unit\_screen\_x = (1/ (width)_{screen\_coord} * [(bottom\_right\_longitude)_{geo\_coord} - (top\_left\_longitude)_{geo\_coord}])_{geo\_coord}$ → **Equation (1)**

Similarly, one unit of screen along y- axis is equivalent to latitude units derived below: -

$Unit\_screen\_y = (1/ (height)_{screen\_coord} * [(bottom\_right\_latitude)_{geo\_coord} - (top\_left\_ latitude)_{geo\_coord}])_{geo\_coord}$ → **Equation (2)**

Now, given a point on screen along x- axis, its corresponding longitude units can be found as follows: -

$longitude\_equivalent\_of\_screen\_x = [(top\_left\_longitude)_{geo\_coord} + \{ (screen\_x)_{screen\_coord} * (Unit\_screen\_x)_{geo\_coord} \}]_{geo\_coord}$ → **Equation (3)**

Similarly, given a point on screen along y- axis, its corresponding latitude units can be found as follows: -

$latitude\_equivalent\_of\_screen\_y = [(top\_left\_latitude)_{geo\_coord} + \{ (screen\_y)_{screen\_coord} * (Unit\_screen\_y)_{geo\_coord} \}]_{geo\_coord}$ → **Equation (4)**

Conversion of a point from geographic to screen coordinates: -

One unit of longitude on map is equivalent to the number of screen units along x- axis as derived below: -

$Unit\_longitude = [(width)_{screen\_coord} / \{ (bottom\_right\_longitude)_{geo\_coord} - (top\_left\_longitude)_{geo\_coord} \}]_{screen\_coord}$ → **Equation (5)**

Similarly, one unit of latitude is equivalent to the number of screen units along y- axis as derived below: -

$Unit\_latitude = [(height)_{screen\_coord} / \{ (bottom\_right\_latitude)_{geo\_coord} - (top\_left\_ latitude)_{geo\_coord} \}]_{screen\_coord}$

→ **Equation (6)**

Now, given a point in longitude units, its corresponding screen units equivalent along x- axis can be found as follows: -

$Screen\_x\_equivalent\_of\_longitude = [[\{ (longitude)_{geo\_coord} - (top\_left\_longitude)_{geo\_coord} \} * (Unit\_longitude)_{screen\_coord}] + (top\_left\_screen\_x)_{screen\_coord}]_{screen\_coord}$ → **Equation (7)**

Similarly, given a point in latitude units, its corresponding screen units equivalent along y- axis can be found as follows: -

$Screen\_y\_equivalent\_of\_latitude = [[\{ (latitude)_{geo\_coord} - (top\_left\_latitude)_{geo\_coord} \} * (Unit\_latitude)_{screen\_coord}] + (top\_left\_screen\_y)_{screen\_coord}]_{screen\_coord}$ → **Equation (8)**

6.12 User/ MA Manager

This module gives administrator the ability to perform management operations such as add/ delete mobile assets and users.

6.13 Active MA Manager

Implemented as a dynamic array, this client side manager keeps a list of all those mobile assets that are currently being tracked. It also contains their geographical positions retrieved from the core after regular intervals of time.

6.14 Detailed Design of Web Module from Implementation Point of View

In the light of the issues discussed above, the web module's overall structure can now be viewed as a set of a number of components. Figure 6.1 illustrates the design of the web module from implementation point of view.

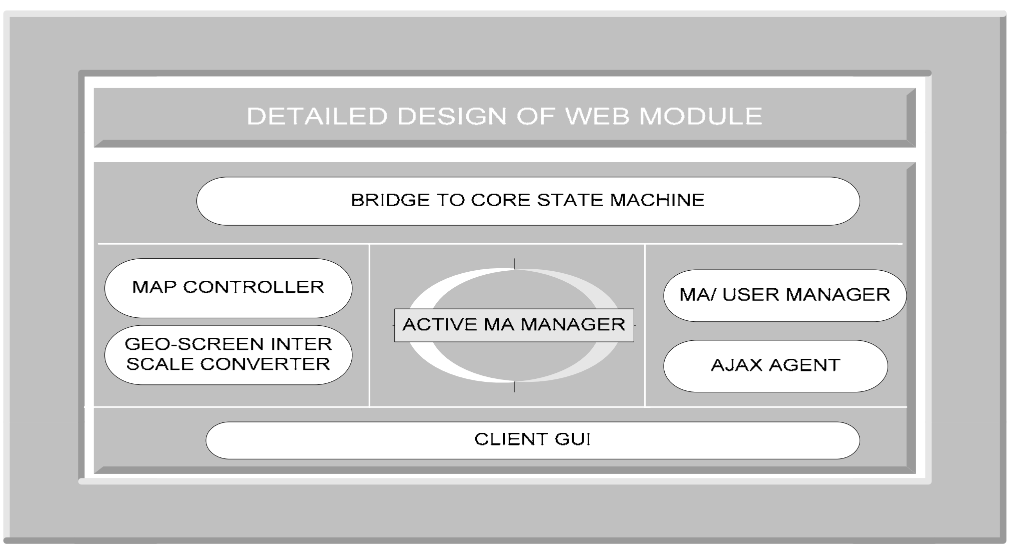


Figure 6.1 Detailed Design of Web Module

6.15 Conclusion

This chapter summarizes the selection of tools and techniques. Apart from that it hints at the technologies employed during the implementation stage of the project. The mathematical equations derived during the project have also been explained. Based upon the selected tools, the modified detailed design of the web module is also shown.

Chapter 7

SOFTWARE TESTING

7.1 OVERVIEW

Software testing is a critical element of software quality assurance and represents the ultimate review of specification, design and code generation. Our software is thoroughly tested based on the specifications of the user. The testing process that we have followed consists of following phases:

7.2 TESTING PROCESS

Figure 7.1 given below is an illustration of the testing process: -

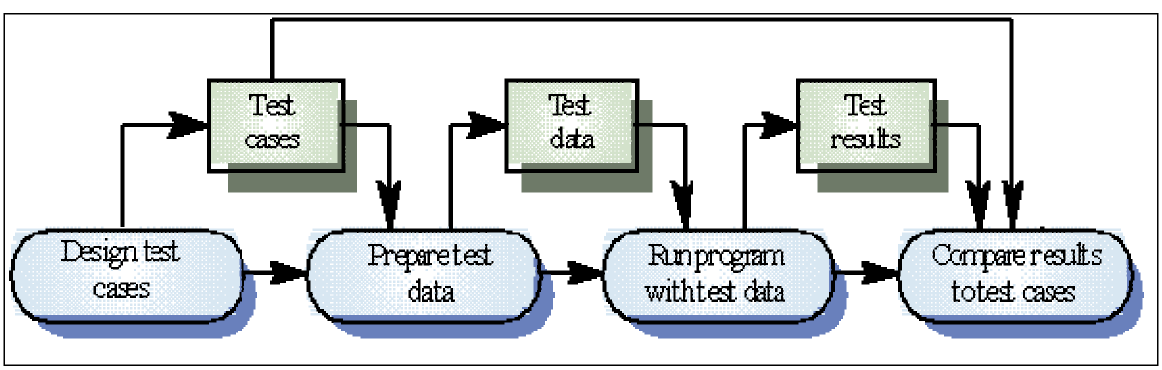


Figure 7.1: Test Data and Test Cases

This process is recursive and cyclic. Testing is done until the reasonable performance measure is achieved. The order in which we perform the testing process is as follows:

7.2.1 Defining Test Cases

A test case is a detailed procedure that fully tests a feature or an aspect of a feature. A test case describes how to perform a particular test. Figure 7.1 illustrates the point at which test case design occurs in the lab development and testing process.

7.2.2 Defining Test Data

After defining test cases, we define what will be the input to the test process. Tests are conducted for both valid and invalid inputs.

7.2.3 Conducting Tests

Once the test data and the test cases are ready, then the system is thoroughly tested. The aim of conducting tests is top highlight the system defects.

7.2.4 Comparing Outcome of the Process with the Predicted Result

Once the outcome of the test process is available, then that is compared with the predicted result of conducting that test. The difference gives the deviation of actual performance from the desired performance.

7.3 COMPONENT/UNIT TESTING

As the modules are developed, they are tested side by side, to remove maximum errors at initial stages.

7.4 INTEGRATION TESTING

Once all the modules are developed, then they are integrated to form a complete system. The errors that might have occurred during the integration process are removed by conducting integration testing.

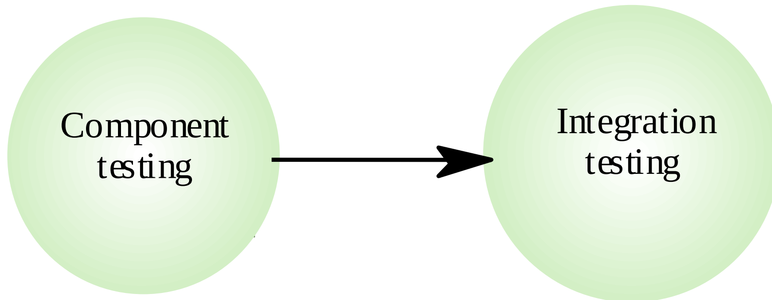


Figure 7.2: Unit to Integration Testing

7.5 TEST CASES

We have defined test cases for checking the application functionality against different user interactions. Each one of them is thoroughly described along with test data, the sequence of steps necessary to conduct the test as well as the results as follows: -

Table 7.1: Normal User Login

T1: Normal User Login	
Purpose	Test that registered users can log in to the system with proper user name and password.
PreRequisites	User is not already logged in User exists and account is still active
Test Data	Username Password
Steps	Visit login page Enter username/ password Press login button
Result	The user is successfully logged in and his/ her home page appears
Status	Pass

Table 7.2: Administrator Login

T2: Administrator Login	
Purpose	Test that administrator can log in to the system with proper user name and password.
PreRequisites	Administrator is not already logged in
Test Data	Username : “Admin” Password
Steps	Visit login page Enter username/ password Press login button
Result	The administrator is successfully logged in and his/ her home page appears
Status	Pass

Table 7.3: Normal Sign Out

T3: Normal Sign Out	
Purpose	Test that user can conveniently sign out his account
PreRequisites	User is already logged in

Test Data	
Steps	User is already viewing his/ her homepage Press “Sign out” link on the top- right corner of the page
Result	The user is successfully logged out and taken to the login page of the site.
Status	Pass

Table 7.4: Zoom In the Map

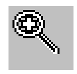
T4: Zoom In the Map	
Purpose	Test that user can successfully zoom in the portion of the map that he/ she wishes
PreRequisites	User is already viewing the map on his/ her homepage The button for the “Zoom In” operation is visible and active
Test Data	Map and “Zoom In” button
Steps	Press the “Zoom In button The mouse cursor changes to  Click with the help of mouse at the selected location in the map which needs to be zoomed in.
Result	That part of the map successfully zooms in
Status	Pass

Table 7.5: Zoom Out the Map

T5: Zoom Out the Map	
Purpose	Test that user can successfully zoom out the portion of the map that he/ she wishes
PreRequisites	User is already viewing the map on his/ her homepage The button for the “Zoom Out” operation is visible and active
Test Data	Map and “Zoom Out” button
Steps	Press the “Zoom Out” button The mouse cursor changes to  Click with the help of map at the selected location in the map which needs to be zoomed out.
Result	That part of the map successfully zooms out
Status	Pass

Table 7.6: Pan the Map

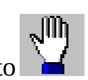
T6: Pan the Map	
Purpose	Test that user can successfully pan the portion of the map that he/ she wishes
PreRequisites	User is already viewing the map on his/ her homepage The button for the “Pan” operation is visible and active
Test Data	Map and “Pan” button
Steps	Press the “Pan” button The mouse cursor changes to  Click with the help of map at the selected location in the map which needs to be panned.
Result	That part of the map successfully pans
Status	Pass

Table 7.7: Box Zooming

T7: Box Zooming	
Purpose	Test that user can successfully zoom in the portion of the map that he/ she selects with the help of a rectangular box

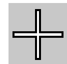
PreRequisites	User is already viewing the map on his/ her homepage The button for the “Box Zoom” operation is visible and active
Test Data	Map and “Box Zoom” button
Steps	Press the “Box Zoom” button The mouse cursor changes to  Draw a rectangular box with the help of mouse to select the boundaries of an area that needs to be zoomed in.
Result	The area of the map inside the selected box zooms in to cover the entire map area
Status	Pass

Table 7.8: Draw Fence

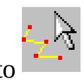
T8: Draw Fence	
Purpose	Test that user can successfully draw fence
PreRequisites	User is already viewing the map on his/ her homepage The button for the “Draw Fence” operation is visible and active
Test Data	Map and “Draw Fence” button
Steps	Press the “Draw Fence” button The mouse cursor changes to  Use mouse to draw a fence of any shape. Press and drag the mouse to draw the fence. If the user picks up the mouse pointer before creating a closed figure, the end point is automatically linked to the starting point.
Result	The fence is drawn in red color on the surface of the map
Status	Pass

Table 7.9: Clear Fence

T9: Clear Fence	
Purpose	Test that user can successfully clear drawn fence
PreRequisites	User is already viewing the map on his/ her homepage The fence is drawn on the map The button for the “Clear Fence” operation is visible and active
Test Data	Map and “Clear Fence” button
Steps	Press the “Clear Fence” button
Result	The drawn fence in red color is cleared
Status	Pass

Table 7.10: View Real- time Movement of Mobile Asset

T10: View Real- time Movement of Mobile Asset	
Purpose	Test that user can view the real- time movement of his/ her mobile asset
PreRequisites	User is already logged in to his/ her homepage The mobile assets menu on the web page is filled with all his/ her registered mobile assets
Test Data	Mobile asset ID
Steps	Right- click the mobile asset ID which needs to be tracked A sub menu shall appear. Choose “Status” to view the real- time movement of the mobile asset
Result	The mobile asset would start being displayed on the map at the point where its traveling right now
Status	Pass

Table 7.11: Get information about the nearest places of interest

T11: Get information about the nearest places of interest

Purpose	Test that user can successfully get alerts of the places of interest nearest to his/ her mobile asset
PreRequisites	User is already logged in to his/ her homepage The mobile assets menu on the web page is filled with all his/ her registered mobile assets
Test Data	Mobile asset ID
Steps	Right- click the mobile asset ID which needs to be tracked A sub menu shall appear. Choose “Status” to view the nearest place of interest
Result	The mobile asset would start being displayed on the map at the point where its traveling right now with a message that would show the nearest place
Status	Pass

Table 7.12: Change Layers’ Status

T12: Change Layers’ Status	
Purpose	Test that user can successfully change the status of various layers in the digital map
PreRequisites	User is already logged in to his/ her homepage The layer exists in the map and has a menu entry in the layers menu
Test Data	Layer name
Steps	Place the mouse pointer on the Layers menu. It shall expand to display sub- menu entries, each containing the name of the layers. Placing the mouse pointer on any particular layer name expands the menu further to display the option of “Change Status” Choose this option by clicking it.
Result	If the layer was switched before performing this operation, it shall be added to map, however if it was switched on before, it shall now be removed from the map
Status	Pass

Table 7.13: Change Layers’ Color

T13: Change Layers’ Color	
Purpose	Test that user can successfully change the color of various layers in the digital map
PreRequisites	User is already logged in to his/ her homepage The layer exists in the map and has a menu entry in the layers menu The layer is switched on i.e. its visible in the map
Test Data	Layer name
Steps	Place the mouse pointer on the Layers menu. It shall expand to display sub- menu entries, each containing the name of the layers. Placing the mouse pointer on any particular layer name expands the menu further to display the option of “Change Color” Choose this option by clicking it. A color palette shall open. Choose the color of your choice
Result	The layer’s color shall be changed in the map as well as in the menu of layers
Status	Pass

Table 7.14: View Reports

T14: View Reports	
Purpose	Test that user can successfully view reports about his/ her mobile assets
PreRequisites	User is already logged in to his/ her homepage
Test Data	Reports Icon
Steps	Click the icon showing “Reports” A form shall appear that would show the type of reports. Choose any one of

	them. Select either one or more or all of registered mobile assets for which you want to generate the report. Press the button “Show Report”
Result	The report shall be generated
Status	Pass

Table 7.15: View Pdf Version of the Reports

T15: View Pdf Version of the Reports	
Purpose	Test that user can successfully view the pdf version of the reports about his/ her mobile assets
PreRequisites	User is already logged in to his/ her homepage He/ she is already viewing the html report
Test Data	Pdf Reports button
Steps	Click the button titled “Generate Pdf Report”
Result	The pdf report shall be generated
Status	Pass

Table 7.16: Add New User

T16: Add New User	
Purpose	Test that a new user can successfully be added to the system by the administrator using web- based interface
PreRequisites	Administrator is already logged in to his/ her homepage
Test Data	User id User name User password Priority
Steps	Click the link “Add” A web- form shall open asking for the parameters for new user addition Fill in the form Click the button titled “Add” to add a new user or “Done” to close the form
Result	If the administrator chose to add a new user by pressing “Add”, user shall be added to the DB and form shall appear again by clearing the input fields If the administrator chose to close the form by pressing “Done”, the form shall be closed
Status	Pass

Table 7.17: Delete Existing User

T17: Delete Existing User	
Purpose	Test that an existing user can successfully be deleted from the system by the administrator using web- based interface
PreRequisites	Administrator is already logged in to his/ her homepage
Test Data	User id User name
Steps	Click the link “Delete” A web- form shall open asking for the parameters for user deletion Fill in the form Click the button titled “Delete” to delete an existing user or “Done” to close the form
Result	If the administrator chose to delete an existing user by pressing “Delete”, user shall be deleted from the DB and form shall appear again by clearing the input fields If the administrator chose to close the form by pressing “Done”, the form shall be closed
Status	Pass

Table 7.18: Add New Mobile Asset

T18: Add New Mobile Asset	
Purpose	Test that a new mobile asset can successfully be added to the system by the administrator using web- based interface
PreRequisites	Administrator is already logged in to his/ her homepage
Test Data	Mobile Asset id User id
Steps	Click the link “Add” A web- form shall open asking for the parameters for new mobile asset addition Fill in the form Click the button titled “Add” to add a new mobile asset or “Done” to close the form
Result	If the administrator chose to add a new mobile asset by pressing “Add”, mobile asset shall be added to the DB and form shall appear again by clearing the input fields If the administrator chose to close the form by pressing “Done”, the form shall be closed
Status	Pass

Table 7.19: Delete Existing Mobile Asset

T19: Delete Existing Mobile Asset	
Purpose	Test that an existing mobile asset can successfully be deleted to the system by the administrator using web- based interface
PreRequisites	Administrator is already logged in to his/ her homepage
Test Data	Mobile Asset id User id
Steps	Click the link “Delete” A web- form shall open asking for the parameters for existing mobile asset deletion Fill in the form Click the button titled “Delete” to delete a existing mobile asset or “Done” to close the form
Result	If the administrator chose to delete a existing mobile asset by pressing “Delete”, mobile asset shall be deleted to the DB and form shall appear again by clearing the input fields If the administrator chose to close the form by pressing “Done”, the form shall be closed
Status	Pass

7.6 CONCLUSION

The chapter explains the testing procedure applied during the project. It gives an overview of the software testing techniques and also describes the test cases in detail. The test cases cover the entire functionality of the system and all test cases have passed successfully.

A- USE CASES

APPENDIX- A

USE- CASES

A

This figure depicts the capabilities that the administrator has in which the data of the user and mobile asset is present in the database. In this scenario, the administrator has the capability of adding a new user. He can also delete already existing user. The administrator can also update an existing user. Also, there is a feature of adding a new mobile asset. The administrator is also capable of deleting and updating a particular mobile asset. The administrator's interface shall be available to him online via the administrator's web page.

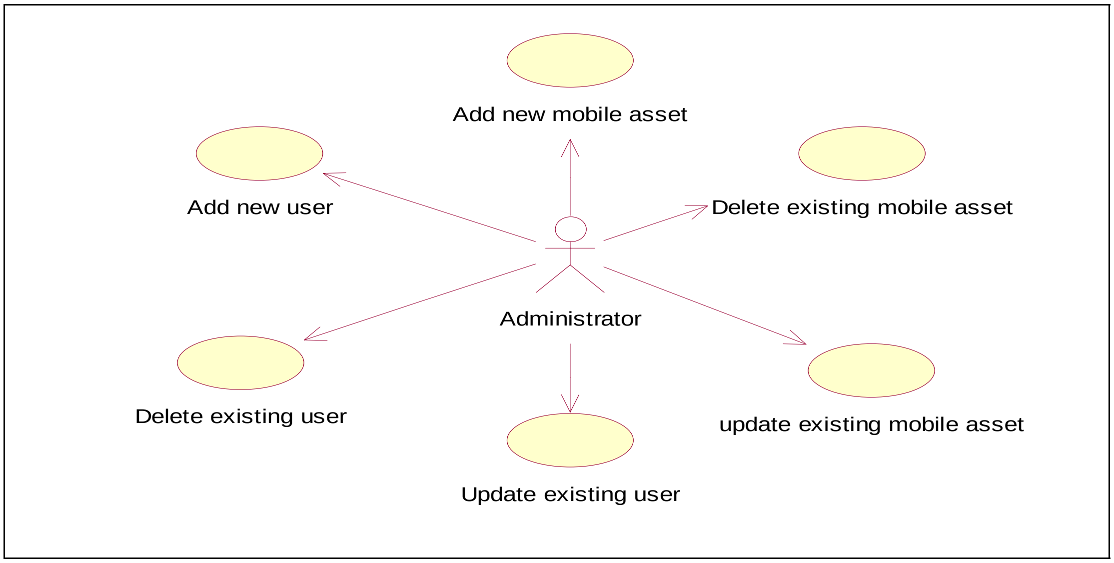


Figure A.1: Administrators use case.

WEB-CLIENT USECASE:

As the proposed system is a web-based system so this use case basically shows how a client can login via web by giving an ID and password .also client can view the movement of mobile assets in real-time. It also provides the feature of finding the nearest place of interest requested by the client. Through this interface the client can also perform manipulation operations on the digital map that include features such as zooming, panning, fencing etc. Also, manipulation of layers can be done based on status and control .after viewing the mobile assets reports can be generated and viewed by the client. Furthermore, the reports can be converted to PDF format after performing these operations the client can logout through the interface.

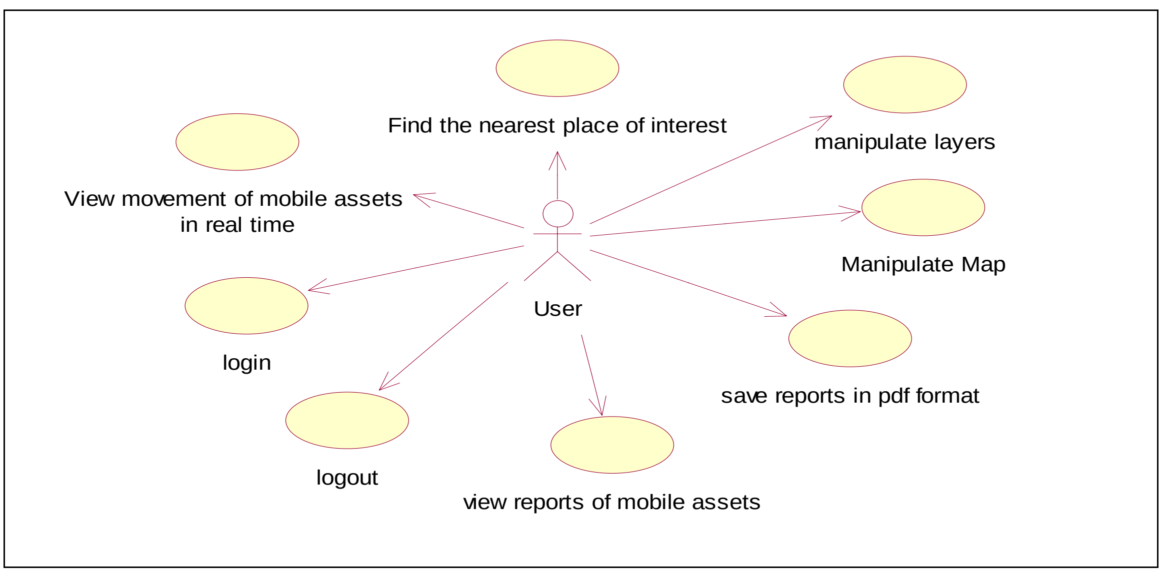


Figure A.2: web-client use case.

MAP OPERATIONS USECASE:

This figure describes how to manipulate a map by performing various operations by incorporating the features of Google earth. Maps have the feature of zoom in and zoom out. Also, there is a feature to pan a particular area, for security purposes a special fencing mechanism is also included in which a mobile asset can be restricted to a particular area by drawing a fence and after that to remove restriction the fence can also be cleared. There is also a feature to zoom a particular area. The system also has the capability of performing pan-based zoom in and pan-based zoom out.

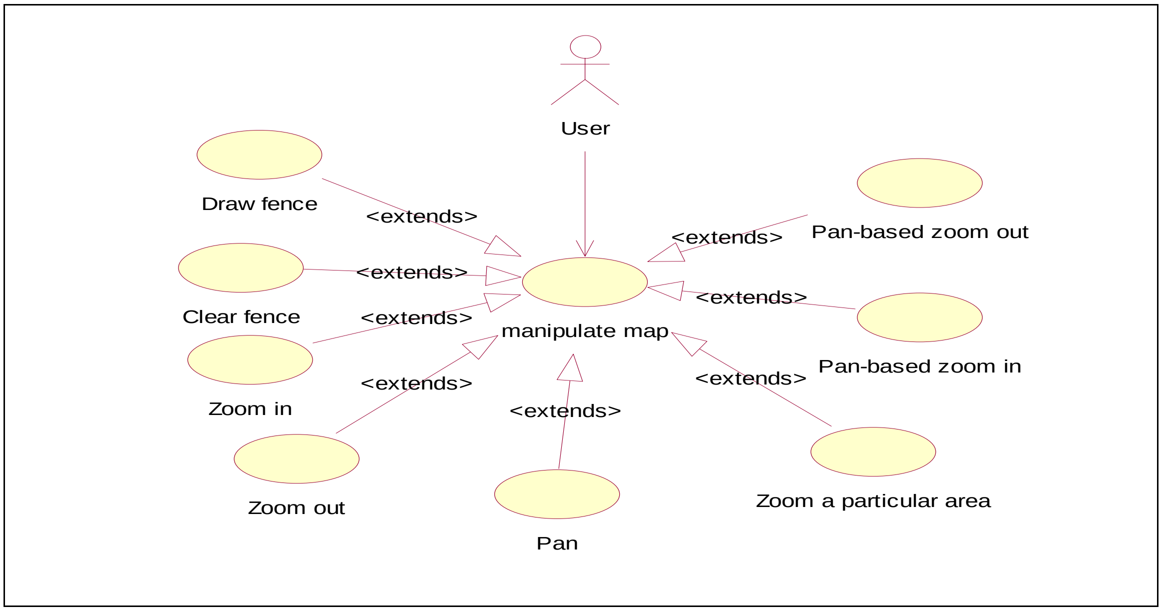


Figure A.3: map operations use case

LAYER OPERATIONS USECASE:

A digital map has several has several layers .the user can manipulate these layers. The three defining characteristics of layers are name, status and color. Since, name can not be changed so only color and status can be manipulated.

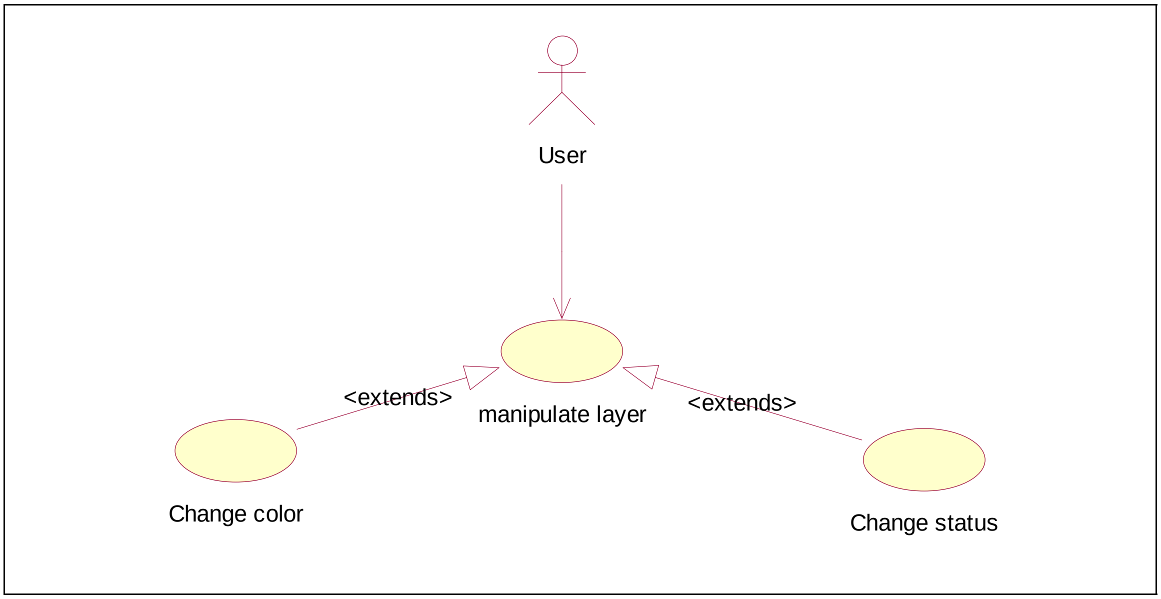


Figure A.4: layer operations use case.

APPENDIX- B

SEQUENCE DIAGRAMS

ll be shown and then client will enter user name and password. The web server will check it from the database and if it is correct .The web server shall also check whether the user is already logged in or not. If not then permission is granted to login and home page is shown to the client.

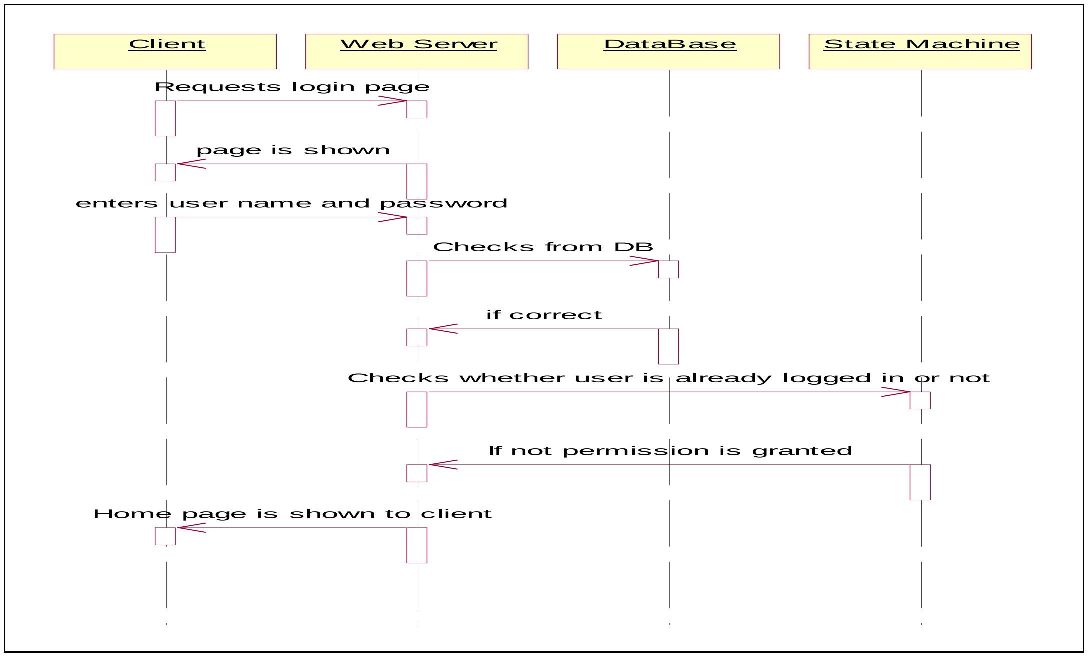


Figure B.1: Administrator/ User Login:

Sign out:

If a client wants to sign out from a particular web page then he shall click sign out and web server shall check the login status from the state machine. After which it will check the status sign-out and message shall be sent to client that user has logged out.

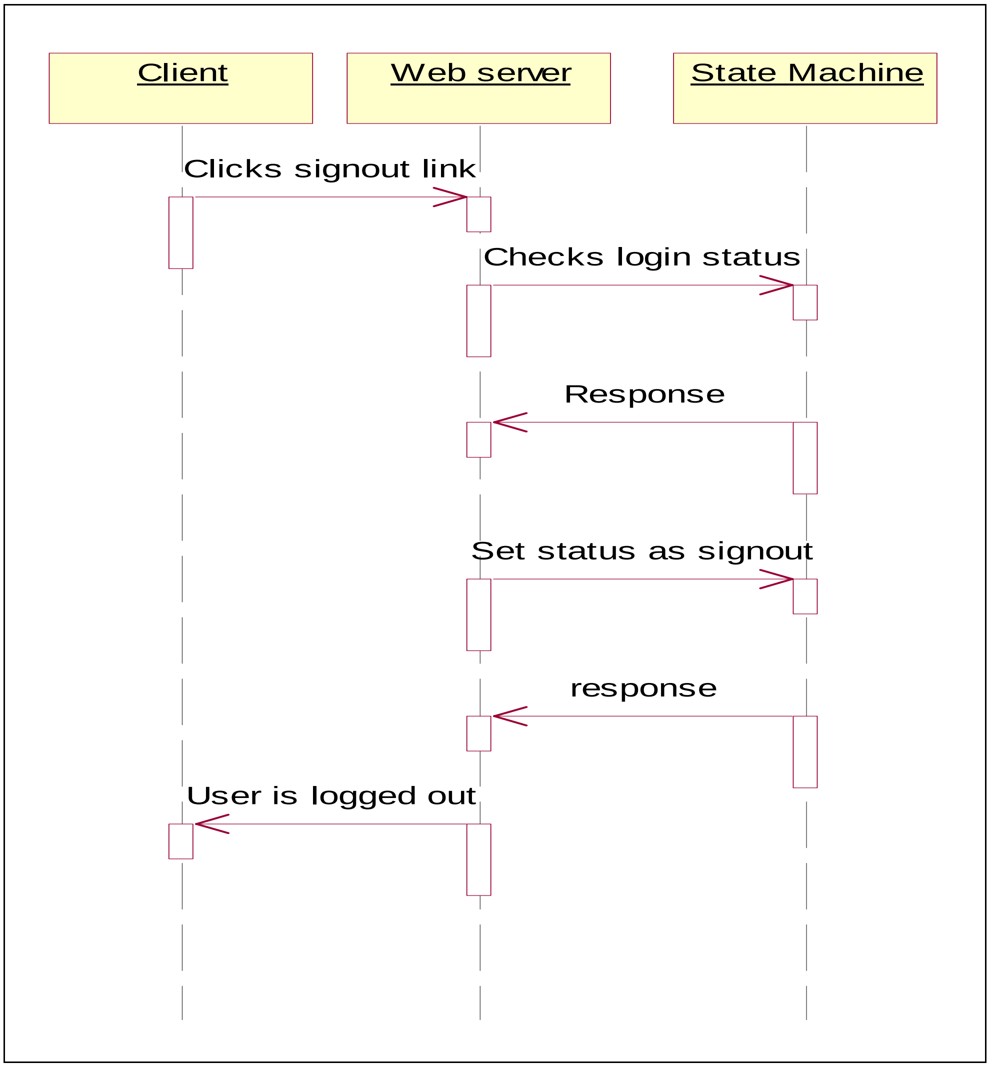


Figure B.2: Sign Out

Map Manipulating Operations:

In the scenario depicted below the web client sends request to web server and web server requests for the map operations from the AJAX agent .The request is then forwarded to the map manager which produces updated map image and sends it to the geo-screen converter for the updating of scale of digital map. After which the updated scale of map is sent to the AJAX agent and updated map is sent back on the request of web client.

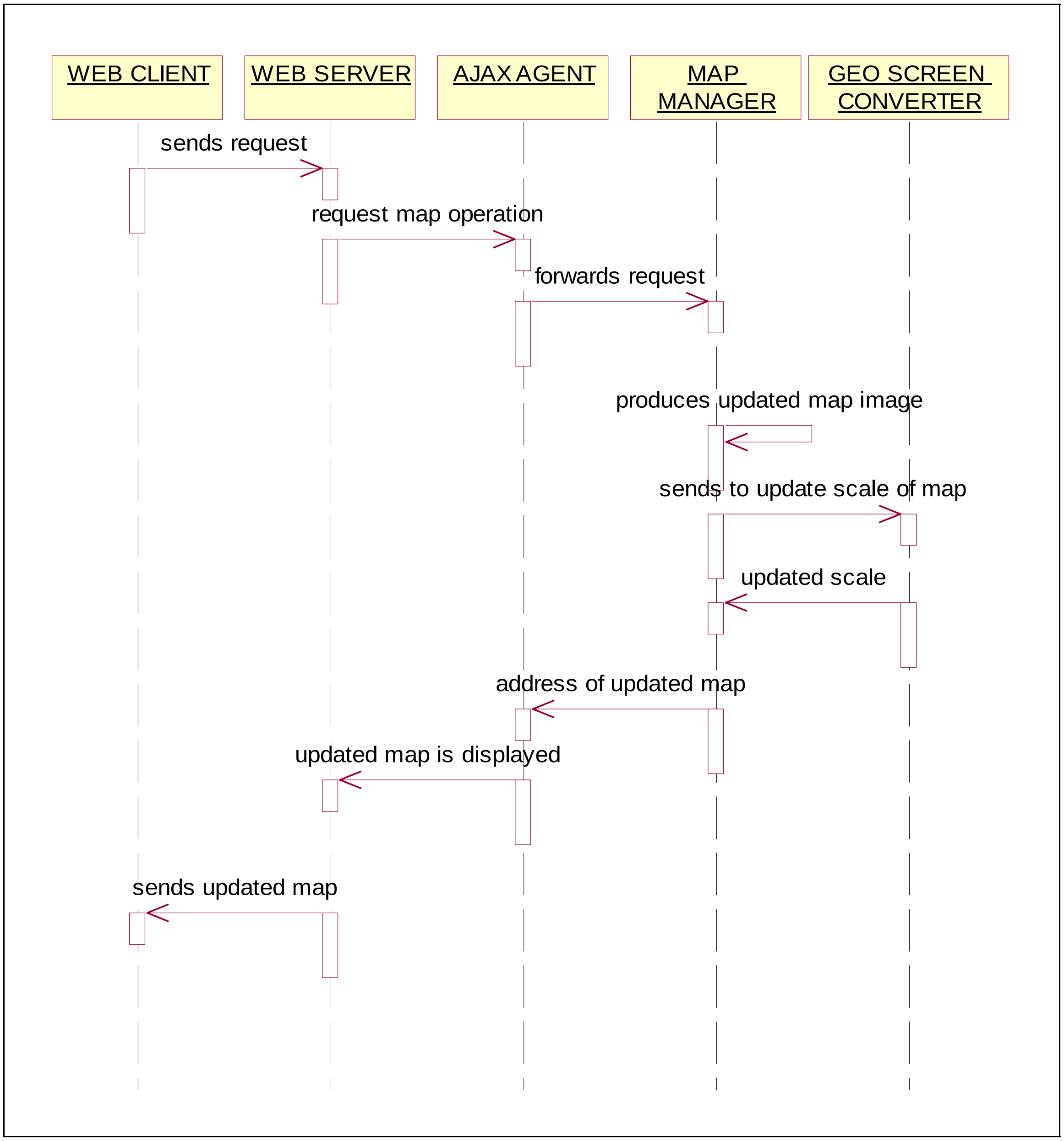


Figure B.3: Map Manipulation Operations

Generating Reports:

The scenario describes when a client wants reports of selected assets from the web server. The web server queries the database. Report is displayed back by the database to the web client and if the client asks for a PDF version the web server then prepares PDF file and displays PDF version for the client.

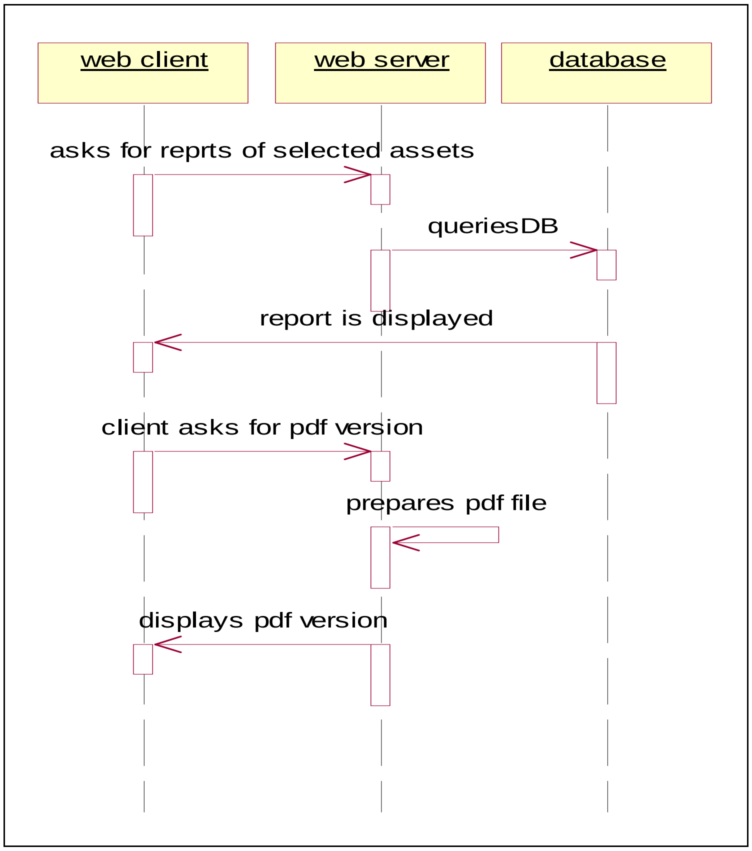


Figure B.4: Generating Reports

User addition:

If a user is to be added then the administrator shall login and clicks add user in the home page. After which a form shall be displayed from the web server and he has to fill that form .Then the administrator clicks on add tab and the form is sent to the database for confirmation. User is then added and after which administrator click “DONE”

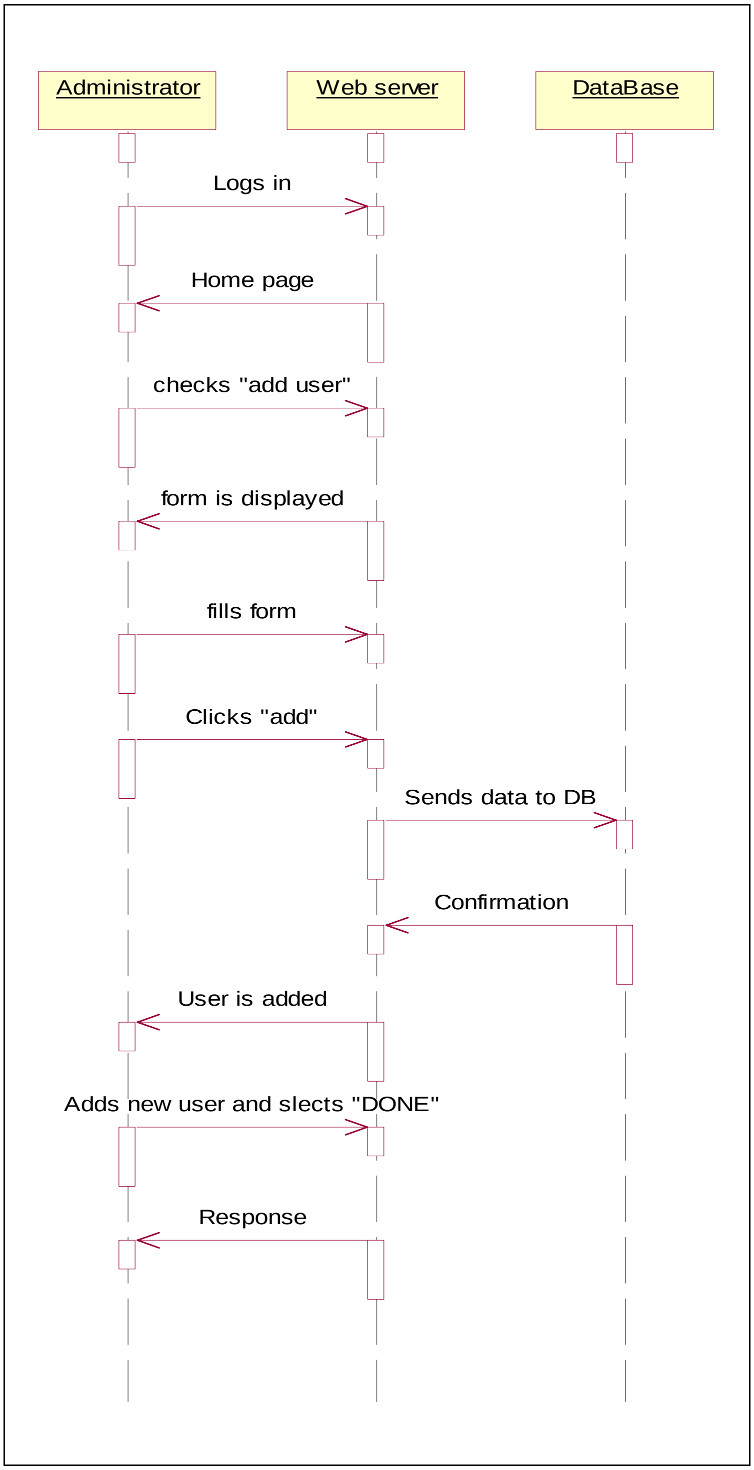


Figure B.5: User Addition

User Deletion

If a user is to be deleted then the administrator shall login and clicks delete user in the home page. After which a form shall be displayed from the web server and he has to fill that form .Then the administrator clicks on delete tab and the form is sent to the database for confirmation .user is then deleted and after which administrator clicks “DONE”

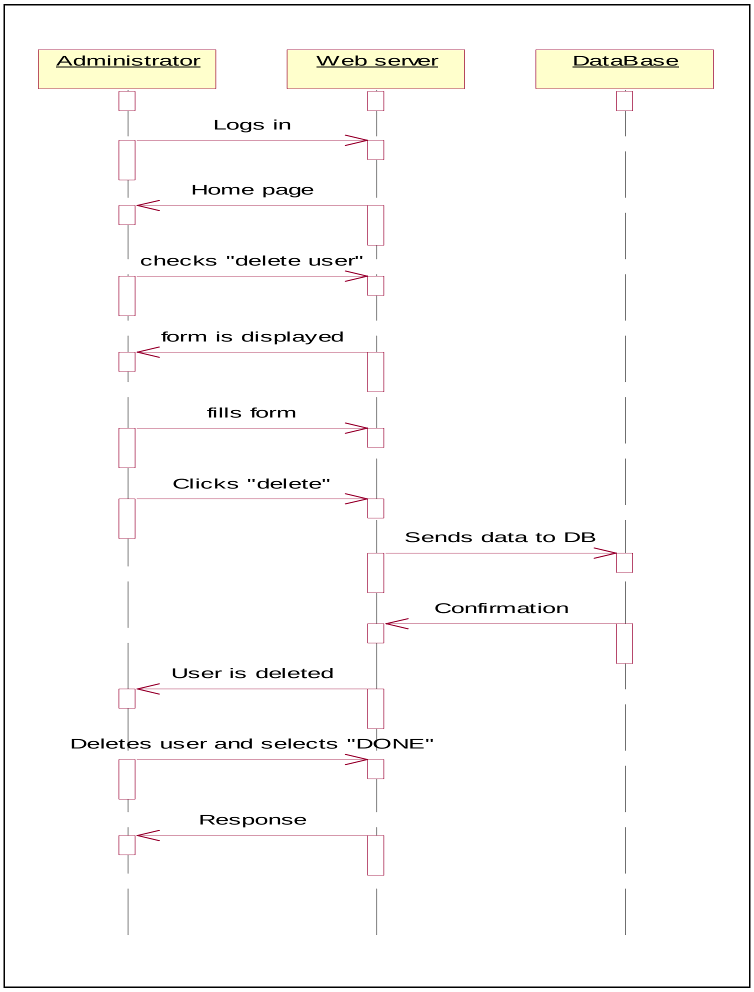


Figure B.6: User Deletion

Mobile Asset (MA) Addition

If a MA is to be added then the administrator shall login and clicks add user in the home page. After which a form shall be displayed from the web server and he has to fill that form .Then the administrator clicks on add tab and the form is sent to the database for confirmation. MA is then added and after which administrator clicks “DONE”

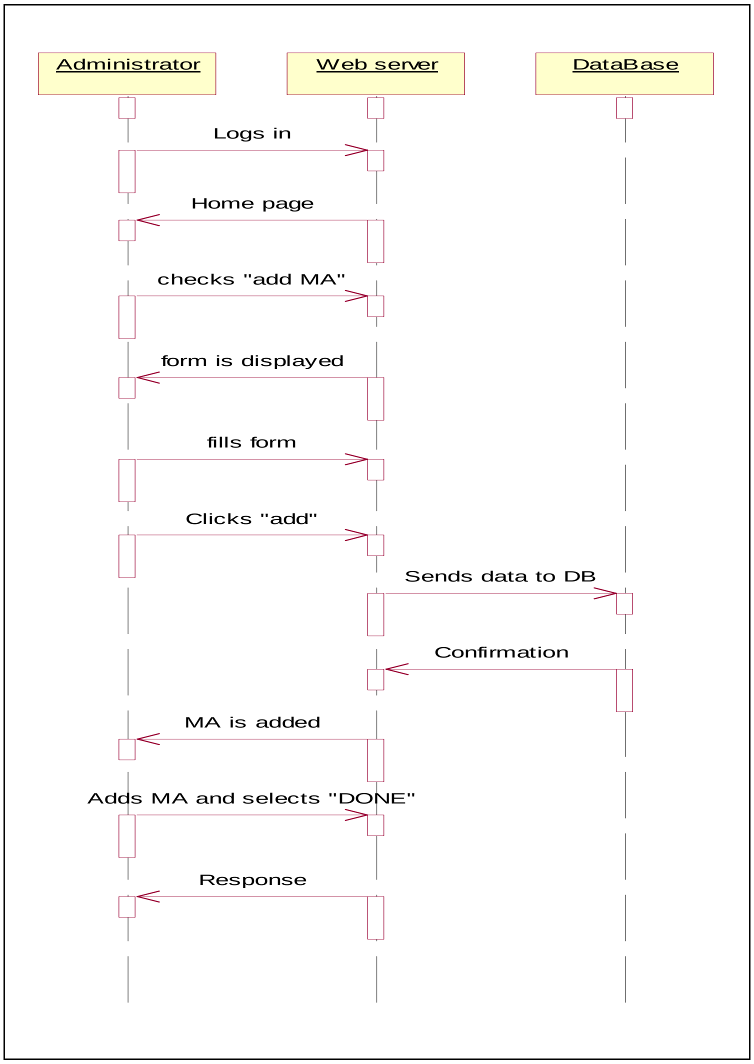


Figure B.7: Mobile Asset Addition

Mobile Asset (MA) deletion

If a MA is to be deleted then the administrator shall login and clicks delete user in the home page. After which a form shall be displayed from the web server and he has to fill that form .Then the administrator clicks on delete tab and the form is sent to the database for confirmation. MA is then deleted and after which administrator clicks “DONE”

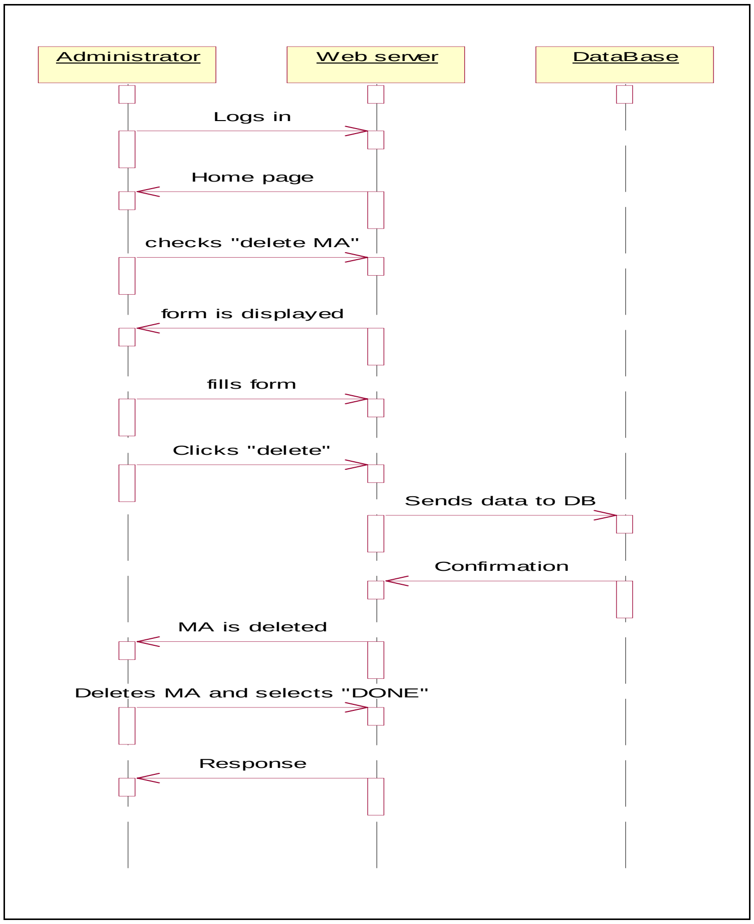


Figure B.8: Mobile Asset Deletion

Get Access to the Mobile Asset

In this scenario, web client sends control request to web sever which through bridge sends it to the core and asks the state machine whether request can be granted or not. After which response is sent back through the bridge, web server and finally to the web client.

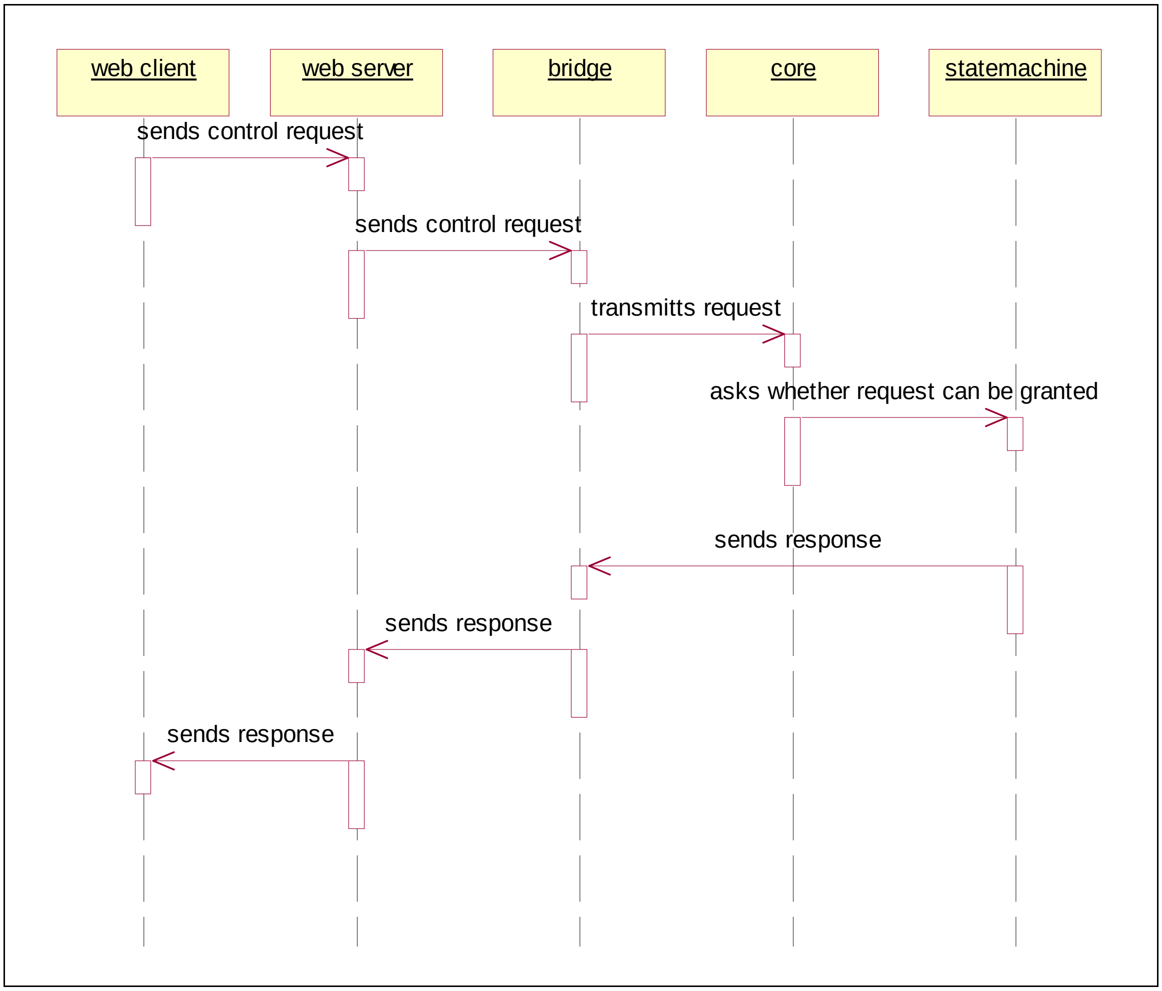


Figure B.9: Get Access to the Mobile Asset

View Real- time Movement of Mobile Asset

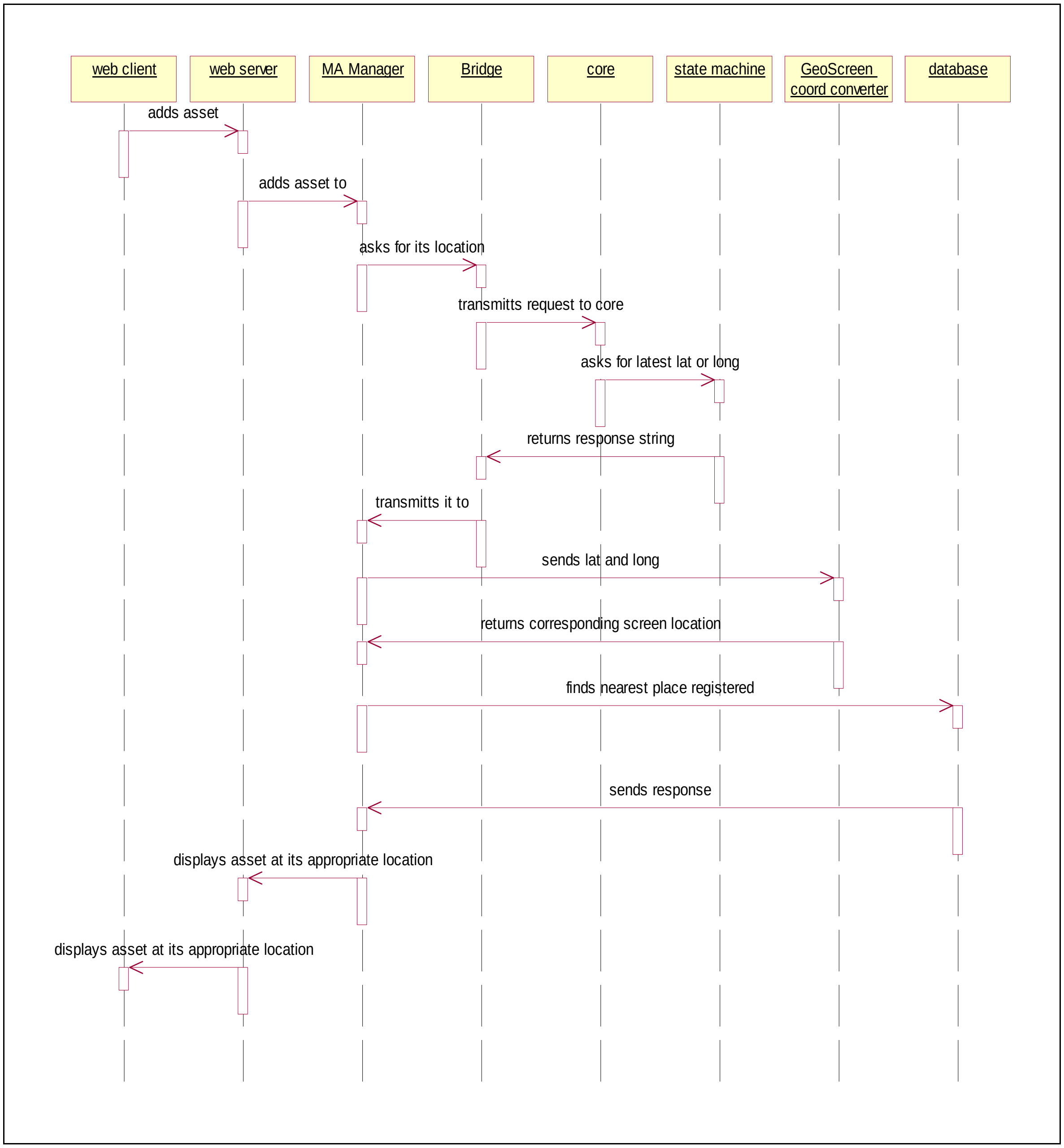


Figure B.10: View Real- time Movement of Mobile Asset

APPENDIX- C

COLLABORATION

Administrator/ User Login

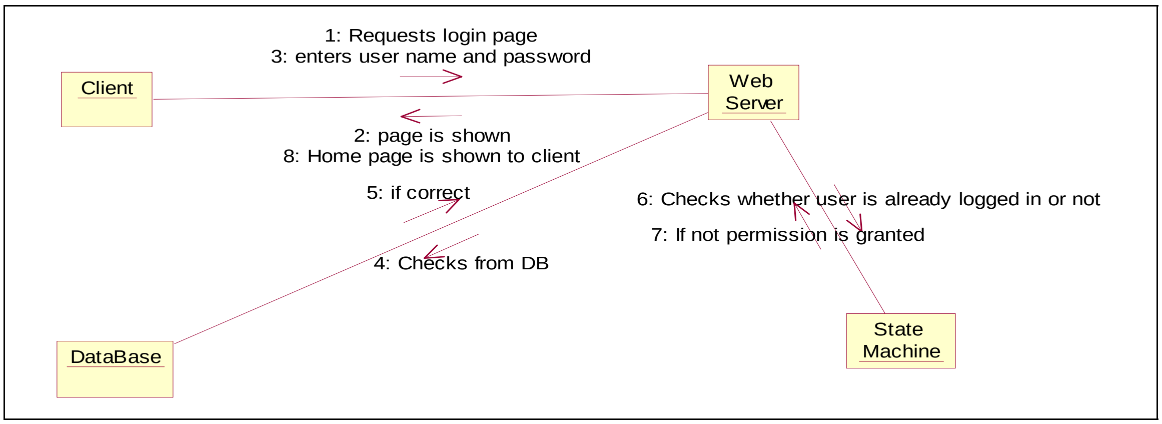


Figure C.1: Administrator/ User Login

Sign Out

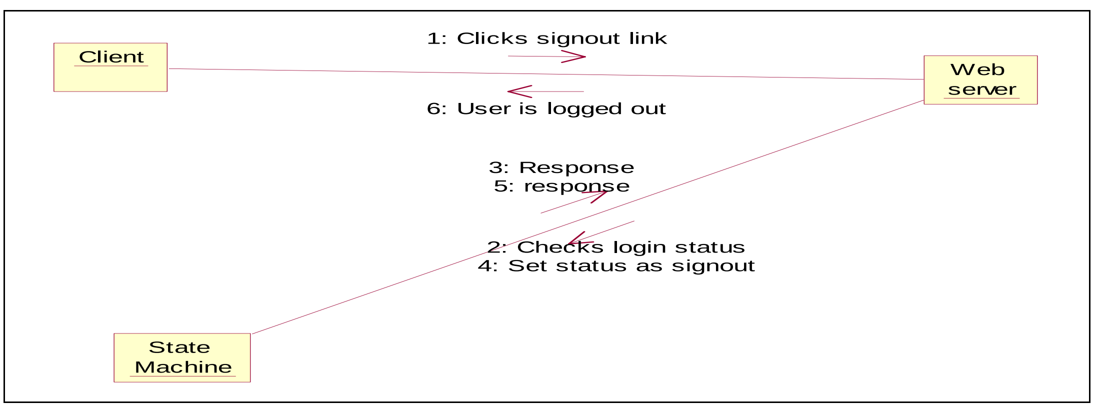


Figure C.2: Sign Out

User Addition

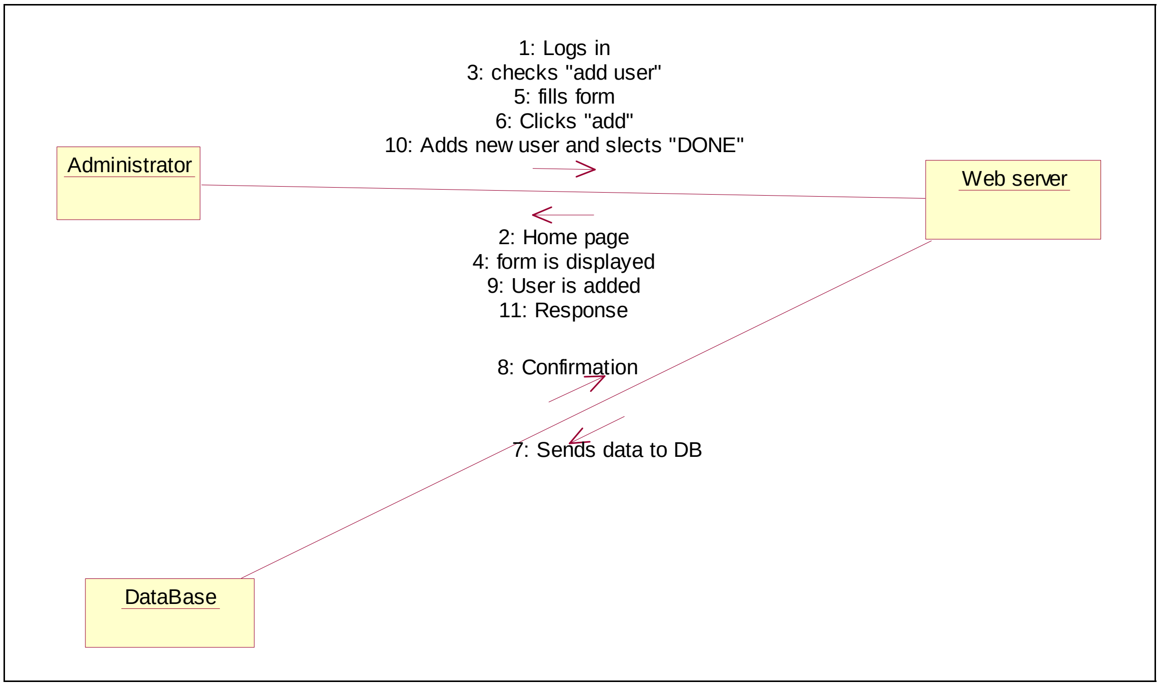


Figure C.3: User Addition

User Deletion

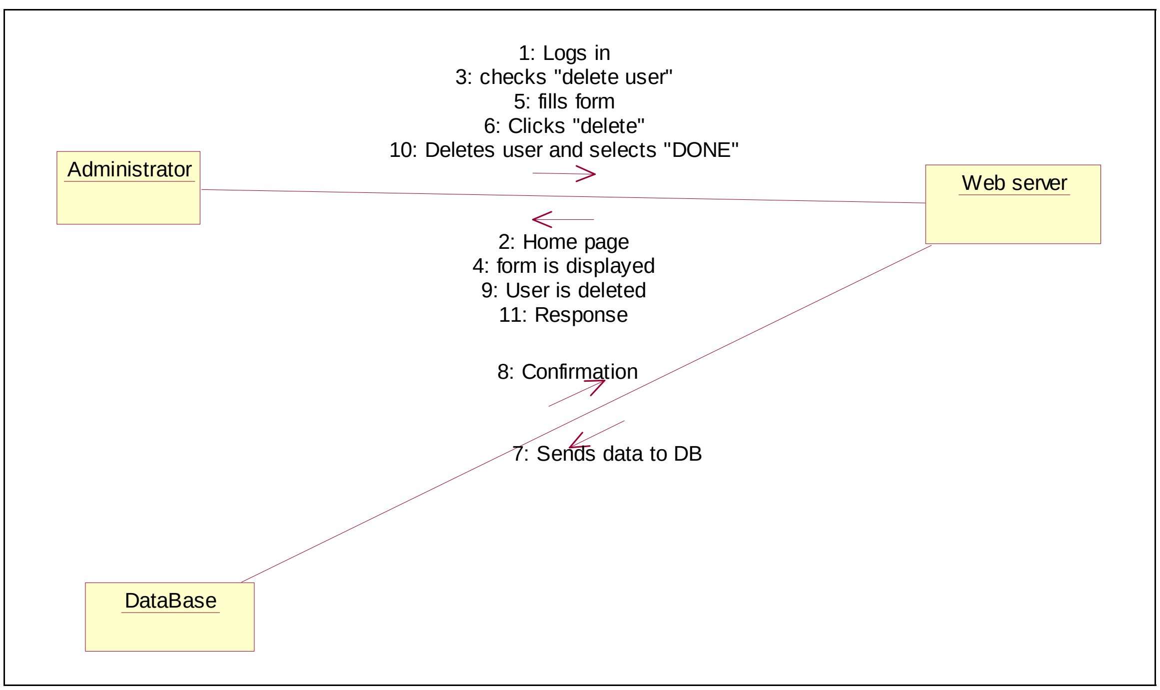


Figure C.4: User Deletion

Mobile Asset Addition

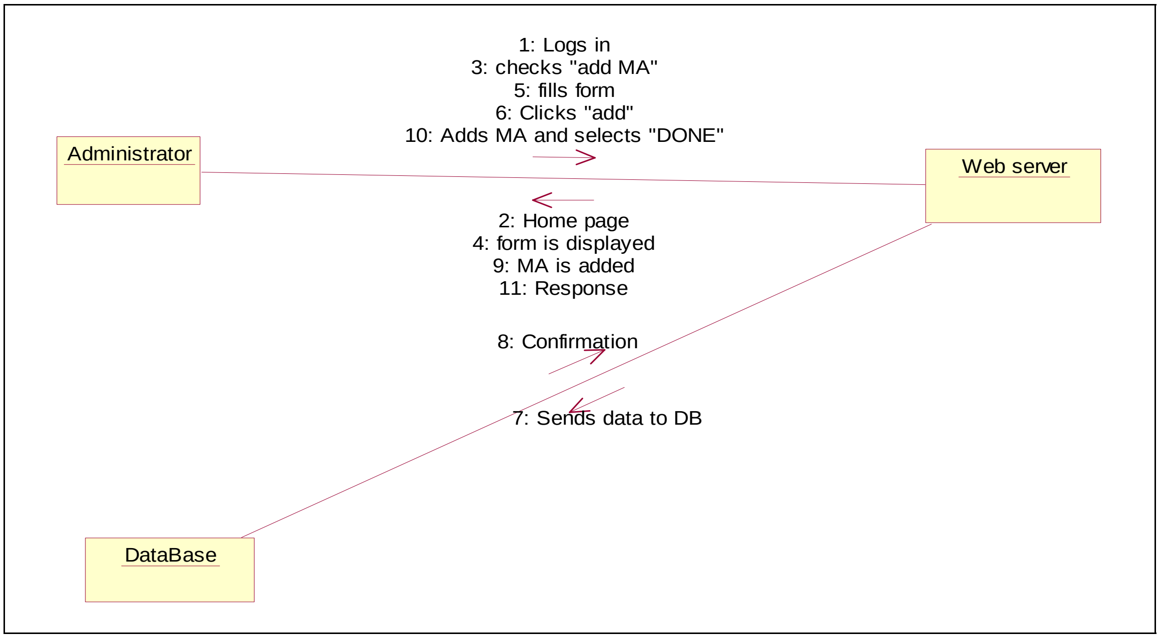


Figure C.5: Mobile Asset Addition

Mobile Asset Deletion

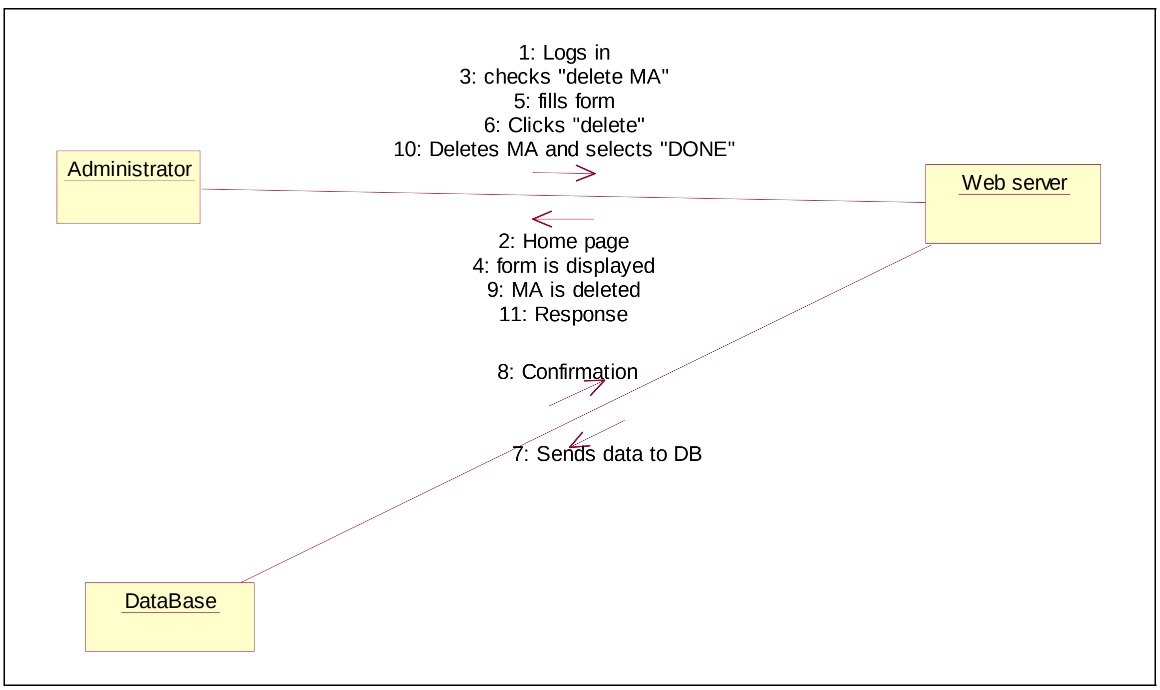


Figure C.6: Mobile Asset Deletion

Get Access to Mobile Asset

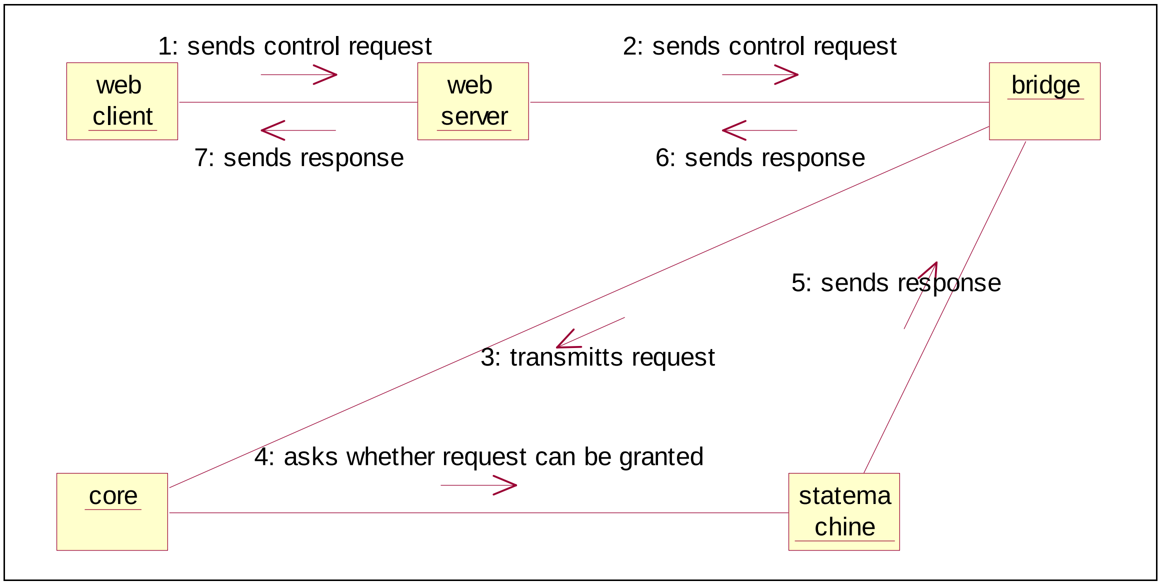


Figure C.7: Get Access to Mobile Asset

View Real- time Movement of Mobile Asset

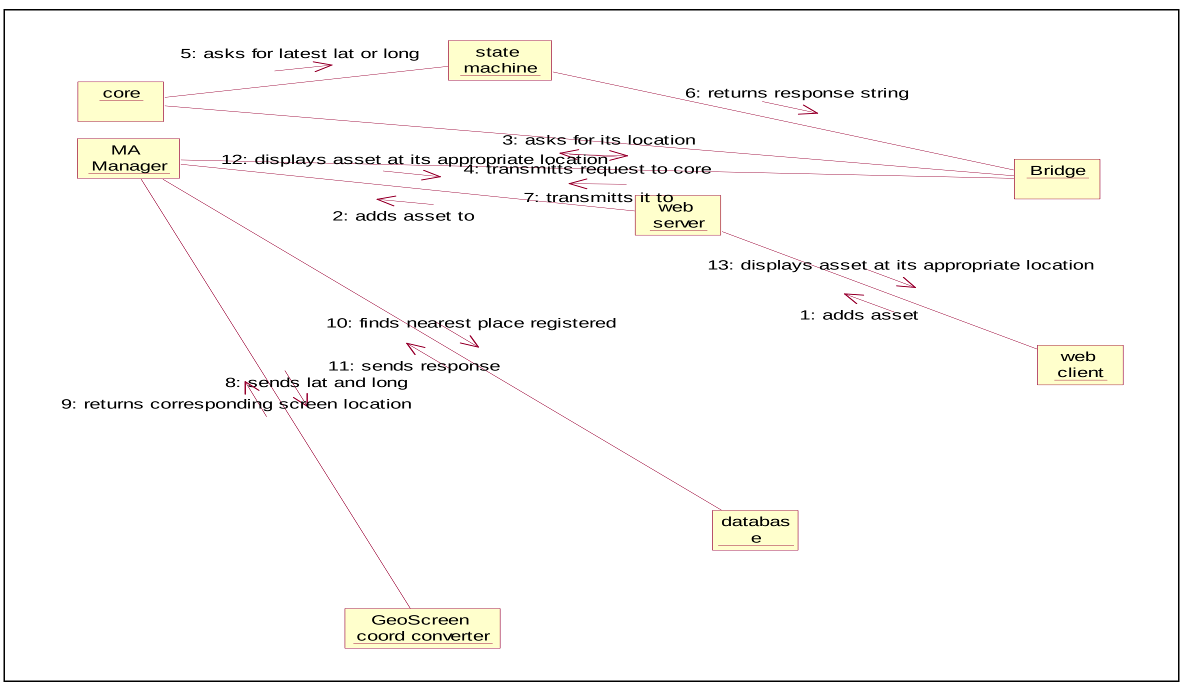


Figure C.8: View Real- time Movement of Mobile Asset

Performing Map Manipulation Operations

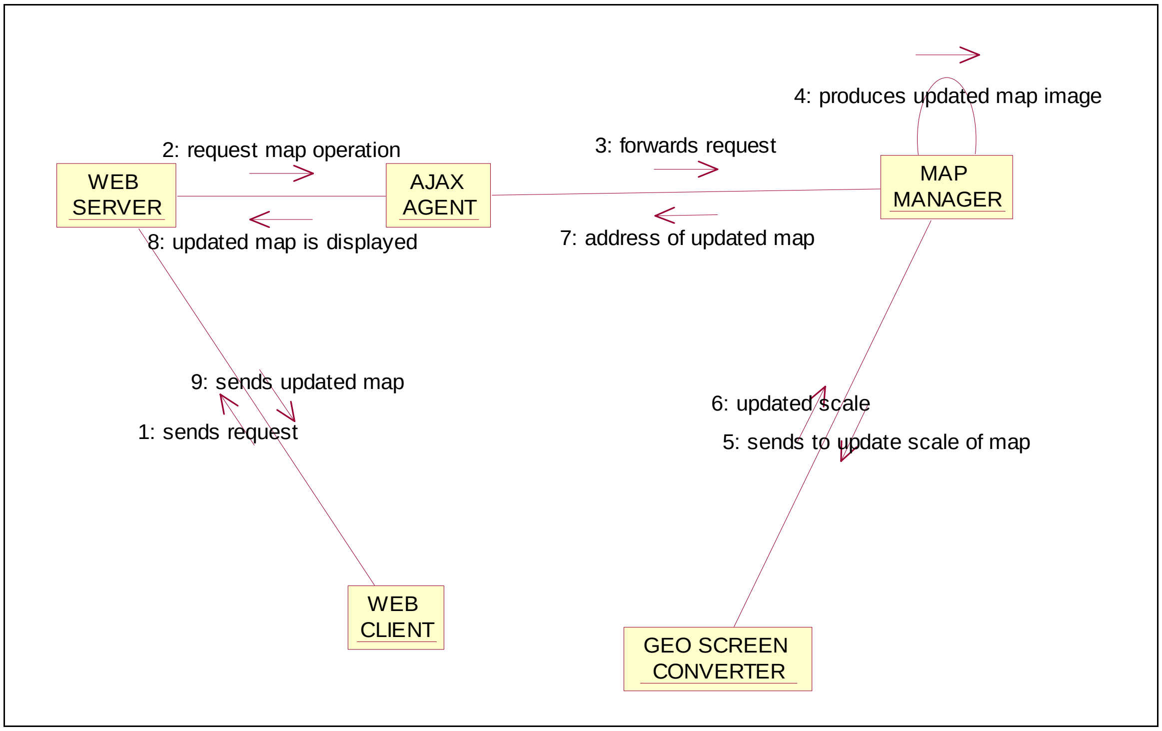


Figure C.9: Performing Map Manipulation Operations

Generating Reports

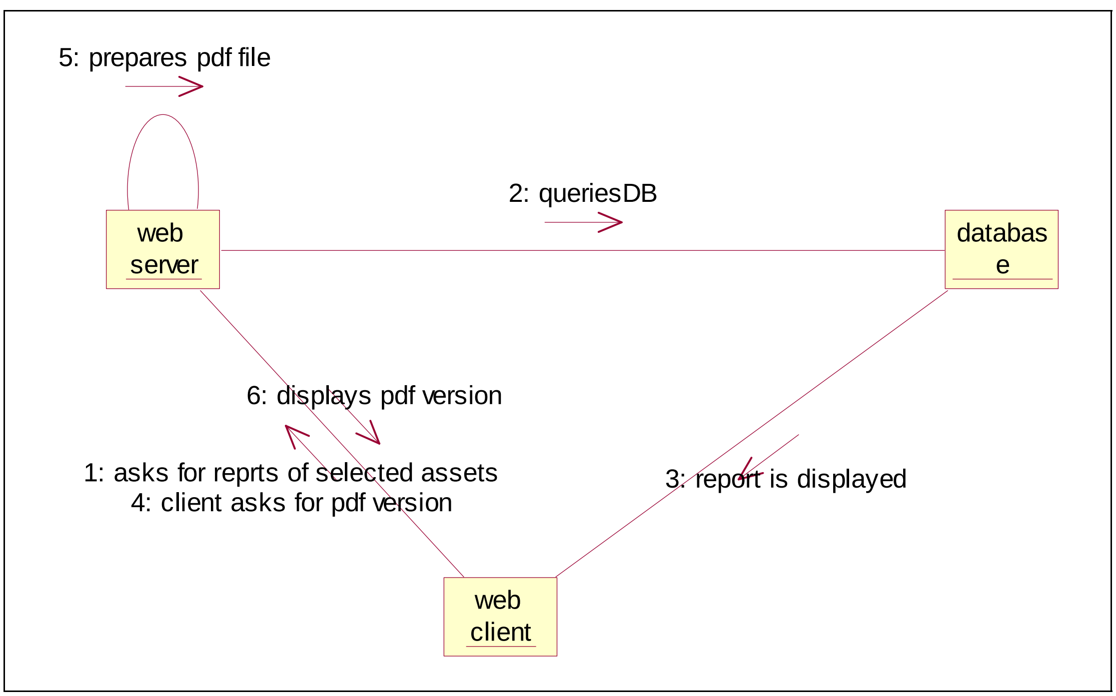


Figure C.10: Generating Reports

APPENDIX- D

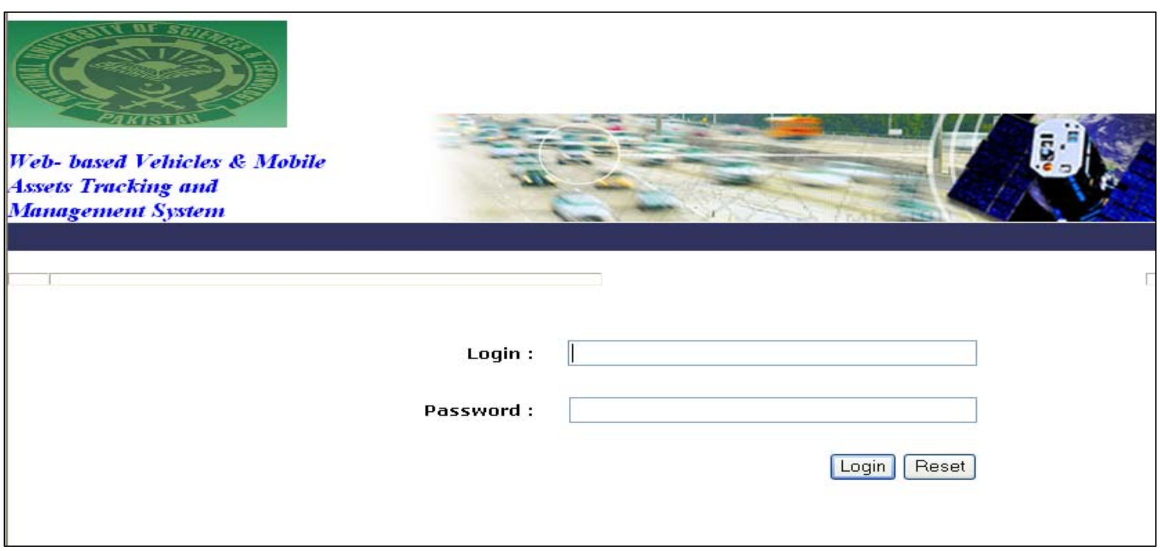
USER MANUAL

STEP 1: Login

ActiveSpy basically has a web- based interface. All users hold their individual accounts which keep record of mobile assets registered with each of them. The user can open his/ her account by entering login name and password in the text fields specified in the figure given below. Furthermore if the user has entered incorrect data or made a mistake while entering user name and password, he/ she can press the “Reset” button in order to clear the input fields. In case of correct login name and password, user needs to press “Login” button to move to the next page. In case of wrong user name or password, an error message is displayed.

Figure D.1: Login interface.

STEP 2: Viewing Home Page

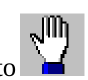


When the user enters login and password, his/ her homepage is displayed. It shows a digital map along with menus, buttons and lists to interact with the services provided by the server. Several features are provided here for manipulating map. These features include zooming in/ out, panning; box zooming, pan- based zooming in/ out, drawing/ clearing fence. As a digital map has several layers so a menu is also provided for manipulating various properties of the layers. Furthermore there is a list of his/ her registered mobile assets that can be selected for tracking their real- time movement. The path traveled is displayed on the digital map. Menu displayed in the top- left corner of the screen has links for viewing reports, directing to home page at any stage during surfing the site and contacting the developers of the site.

Figure D.2: Home Page.

STEP 3: Map Manipulation Operations

As stated above ActiveSpy web client allows the user to perform a number of map manipulation functions.  represents a toolbar that provides icons for all of these operations. Each one of the feature is discussed in detail below.

The button that has been encircled in red provides the capability of panning the map. Once  is pressed, the mouse cursor changes to . User can then click at any location on the map and the map shall be panned using that position as a reference point.

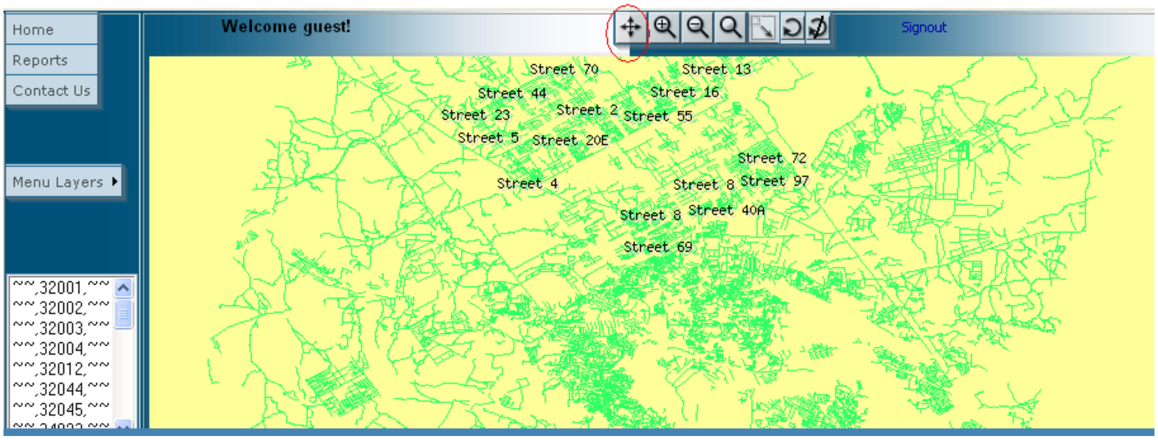
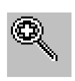


Figure D.3: Map manipulation operations.

The button that has been encircled in red provides the capability of zooming in the map. Once  is pressed, the mouse cursor changes to . User can then click at any location on the map and the map shall be zoomed in using that position as a reference point.

Figure D.4: Zoom in operation.

The button that has been encircled in red provides the capability of zooming out the map. Once  is pressed, the mouse cursor changes to . User can then click at any location on the map and the map shall be zoomed out using that position as a reference point.

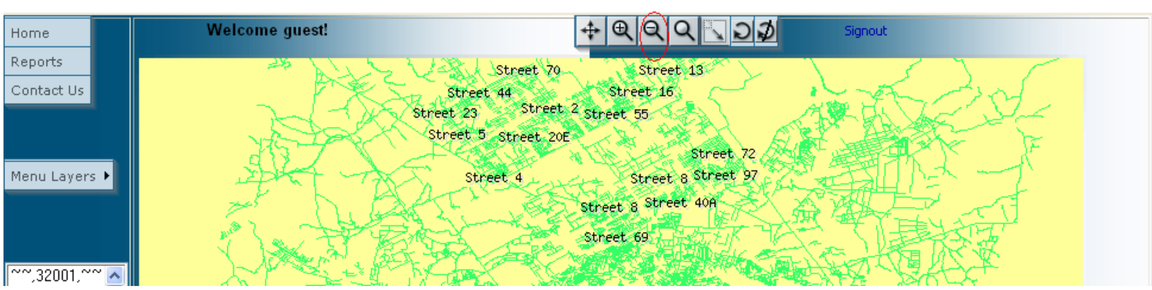


Figure D.5: Zoom out operation.

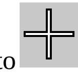
The button that has been encircled in red provides multiple capabilities of pan- based zooming in/ out. Once  is pressed, the mouse cursor changes to . This feature is added for novice user's convenience sake. When the user drags the mouse from top- left to bottom- right diagonally, the map zooms in. When the user drags the mouse from bottom- right to top- left then zoom out operation can be achieved.

Figure D.6: Pan –based zoom in/out.

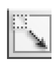
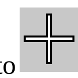
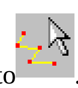
This button encircled in red provides "Box Zoom" feature. This means to zoom in a particular area with the help of a rectangular box. Once  is pressed, the mouse cursor changes to . User can use mouse to create a rectangular box at any location on the map and that particular rectangular area shall be zoomed in to cover entire map area.

Figure D.7: Box zoom operation.

For security purposes a special fencing mechanism is also included in which a mobile asset can be restricted to a particular area by drawing a fence around it. The button that has been encircled in red provides the capability of drawing a fence. Once  is pressed, the mouse cursor changes to . User can then press and drag mouse to draw a fence. At the point where the user releases the map, the fence drawn shall be completed to form a closed figure by connecting its end point to start point.

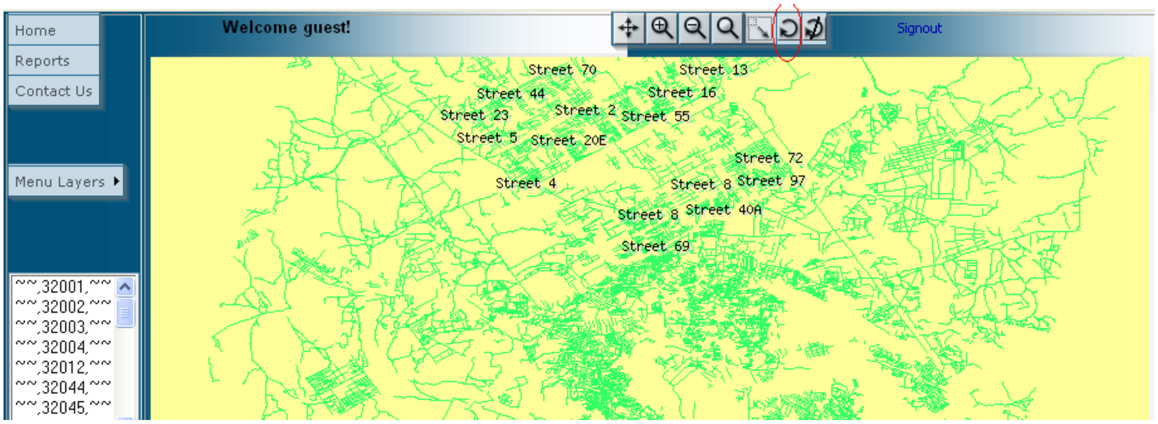


Figure D.8: Fencing operation.

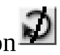
Once fence has been drawn, it can also be cleared through the red encircled button . To clear the fence drawn, user only needs to click this button.

Figure D.9: Clearing fencing operation.

STEP 4: Layer Manipulation Operations

As the digital map has several layers so a menu is also provided for manipulating the defining characteristics of layers. A layer has got following main features: -

i. Name
ii. Color
iii. Status

Besides, the number of layers in a digital map can also vary. When the web client is loaded, it dynamically reads the number of layers that exist in that map and fills the contents of the dynamic menu by reading the names of all layers in the map. In addition it can also read the default colors/ status of layers as defined in the digital map. The menu entry is displayed in that default color so that users can conveniently recognize and differentiate among various layers being displayed. For example, the menu entry "Street" is being displayed in green, this is because the default color for display of this layer has been defined as green in the digital map. The check boxes shown besides layer name in the menu entry indicate the status of that layer. If the box is checked then the status is "on" otherwise it's "off". In the figure given below, the status of the layer title "Street" is "on" as its check box is checked. Rest of the layers are "off" now with the result that map has no other colored layer except for streets being represented in green.

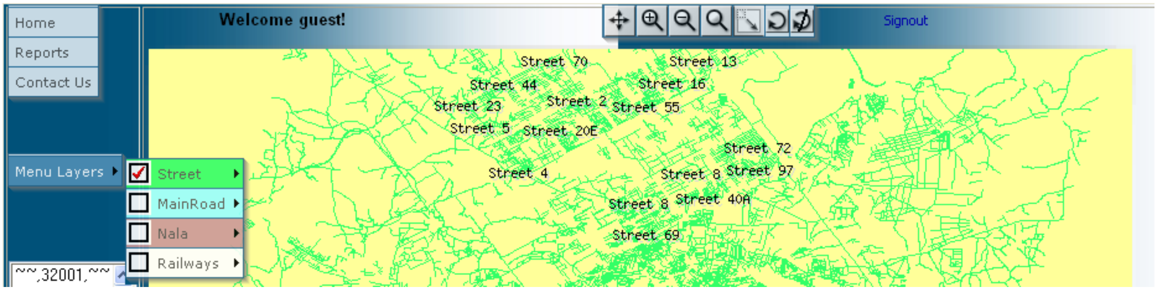


Figure D.10: Layer manipulation operations.

Furthermore the status and the color of the layers can be changed by the user as per his/ her discretion and convenience. As the user places the mouse pointer on the name of the layer, the menu expands to display the following options:

i. Change status

ii. Change color

When the user presses “Change Status” option, the layer is added to the map. This new layer can be identified by the color that is shown by the name of the layer in the menu. The figure given below shows that the status of main roads has been changed and a new layer is added to the map in purple color. The checkbox representing the status of the layer is also checked now.

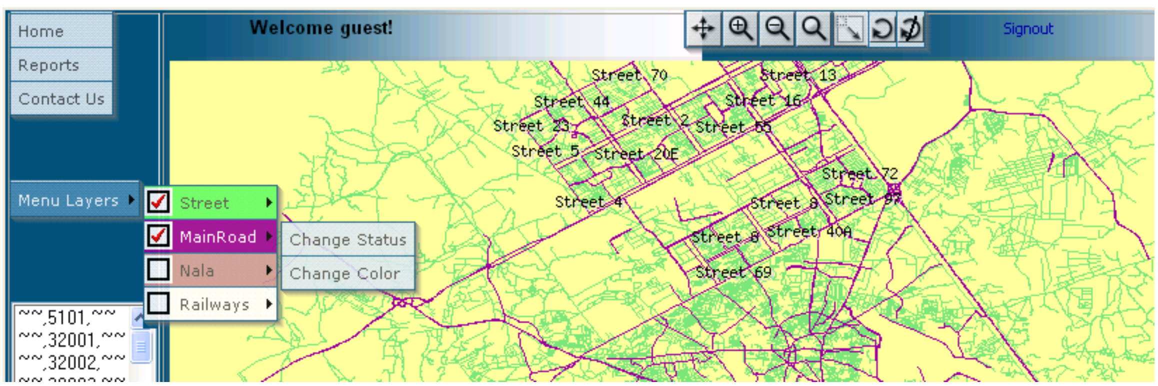


Figure D.11: Status and the Color of the Layers.

In order to change the color of layers the user needs to click on the menu item “Change Color”. It is effective only when the layer is switched on. In case the layer is not visible, choosing this option has no effect. When the user clicks this option for a visible layer, color palette appears from which the user can pick a particular color of his/ her choice for that layer. In the figure below, color palette is shown when the user has selected the option.

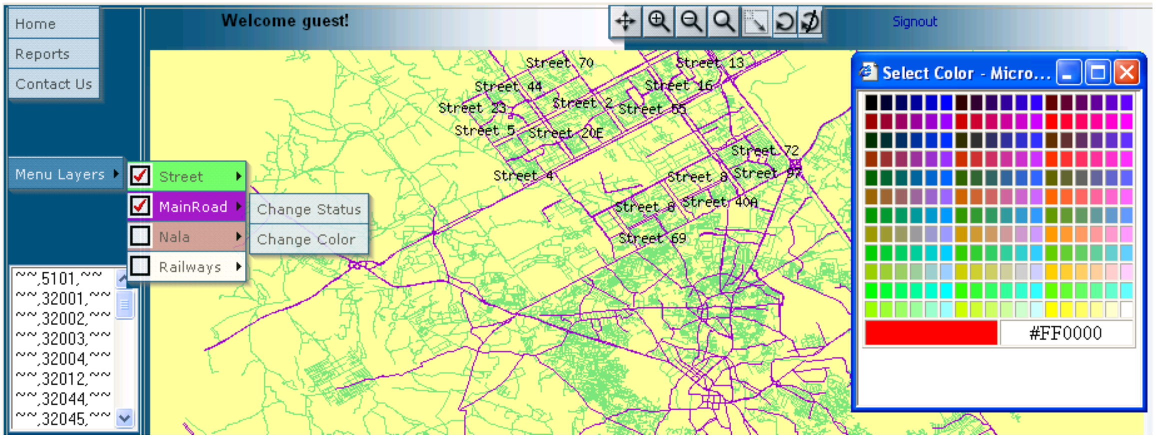


Figure D.12: Change color.

Once the color palette appears and the user selects the color to be displayed then that particular layer appears in the selected color. The figure given above the user selects red color from the palette because of which the figure given below shows that the color of the layer has been changed.

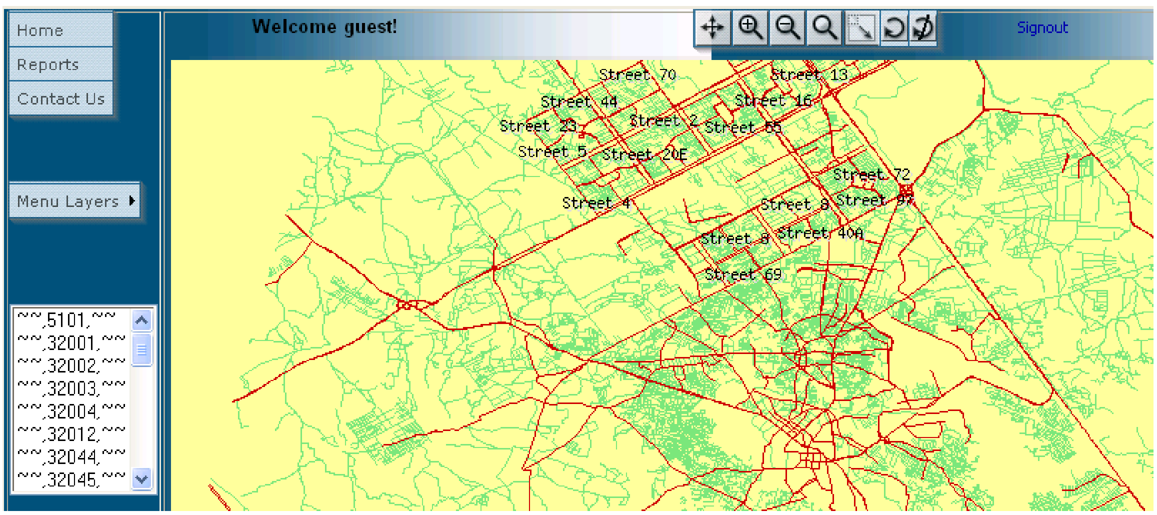


Figure D.13: Changed layer color.

STEP 5: Geographical Coordinates Display

In order to render the digital map on the web, it has been converted to .png graphical format. This gives the users the options to save, print or e- mail the image of the map. As the user moves the mouse pointer over the map area, the status bar at the bottom shows the geographical position in terms of <longitude, latitude> pair. The figure below highlights this position by encircling it in red.

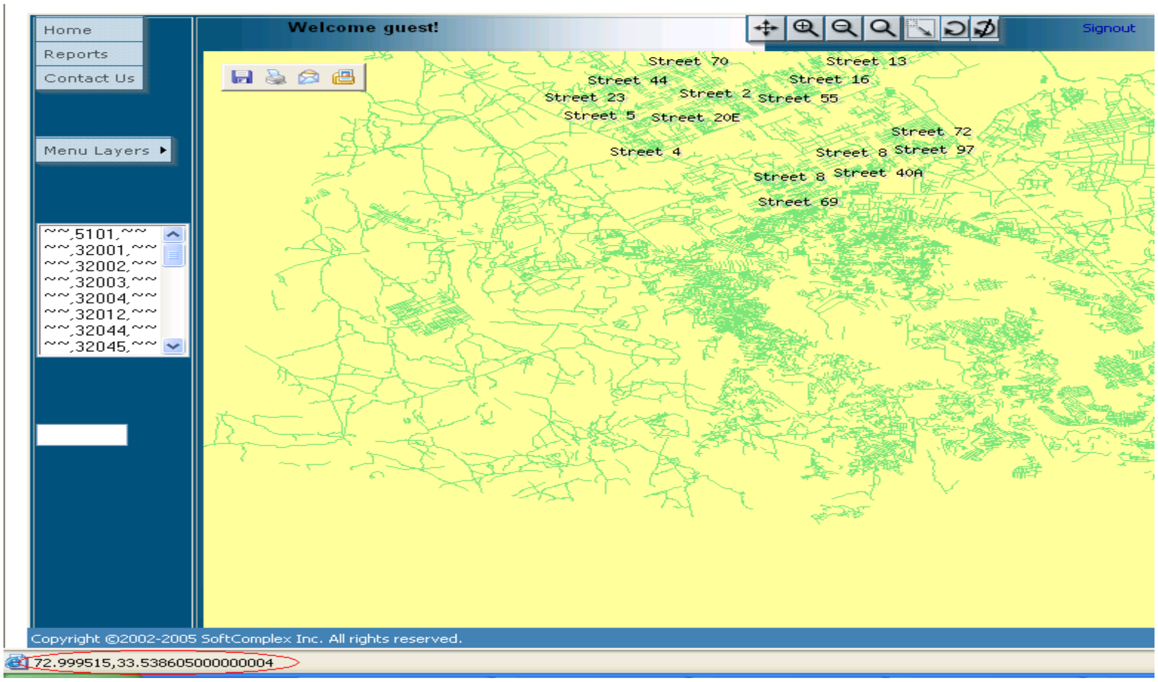


Figure D.14: Geographical Coordinates Display

STEP 6: Mobile Assets Access Privileges

The figure shows a list of mobile assets that can be selected to be tracked in real- time environment. There are basically two kinds of access privileges:

i. Control

ii. Status

"Status" means that user can view the real- time movement of his/ her mobile asset. "Control" means that user has all the privileges that are under the status category as well he/ she can communicate/ control his/ her mobile asset by sending it some commands. In order that these commands actually take effect, hardware circuitry needs to be installed in the mobile asset which is outside the scope of the project.

When the user selects a particular mobile asset in the list box and right- clicks it, a menu appears. Clicking on the "Register" menu item, further options are displayed in the form of a submenu. The figure below shows the menu and options.

Figure D.15: Mobile Assets Access Privileges

For the ease and convenience of user, multiple selections of mobile assets are also possible. Users can press SHIFT or CONTROL keys from keyboard to select multiple assets and right click to see the menu. Now when the user chooses any particular option, it applies to all the selected mobile assets.

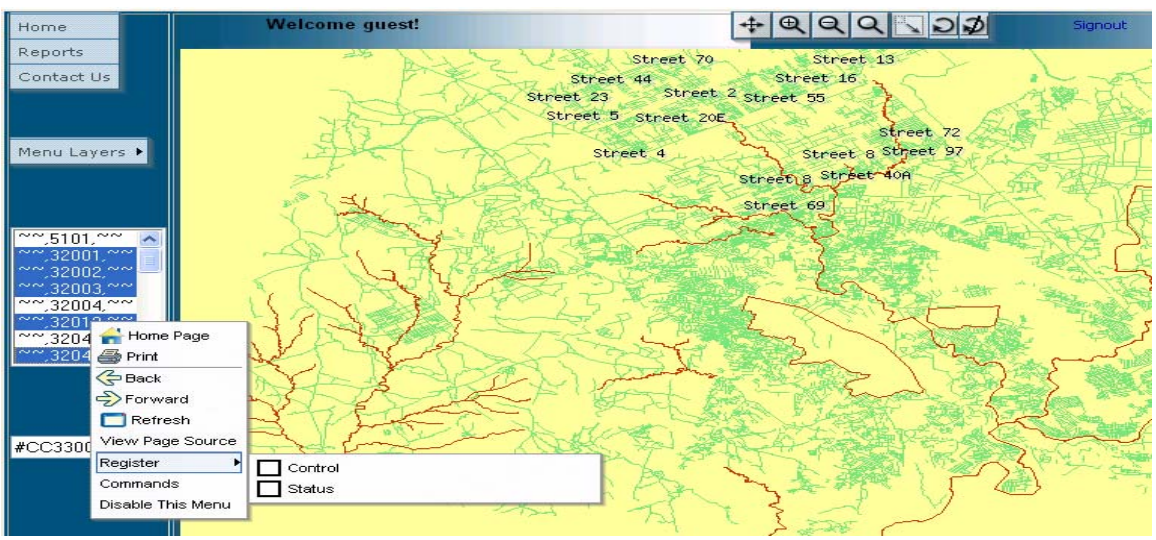


Figure D.16: Multiple Selection of mobile assets.

STEP 7: Viewing Real- time Movement of Mobile Assets

Once the status has been gained, the real- time movement of mobile asset can be displayed on the digital map. Besides the check box is also checked to show that status for this mobile asset has already been gained.

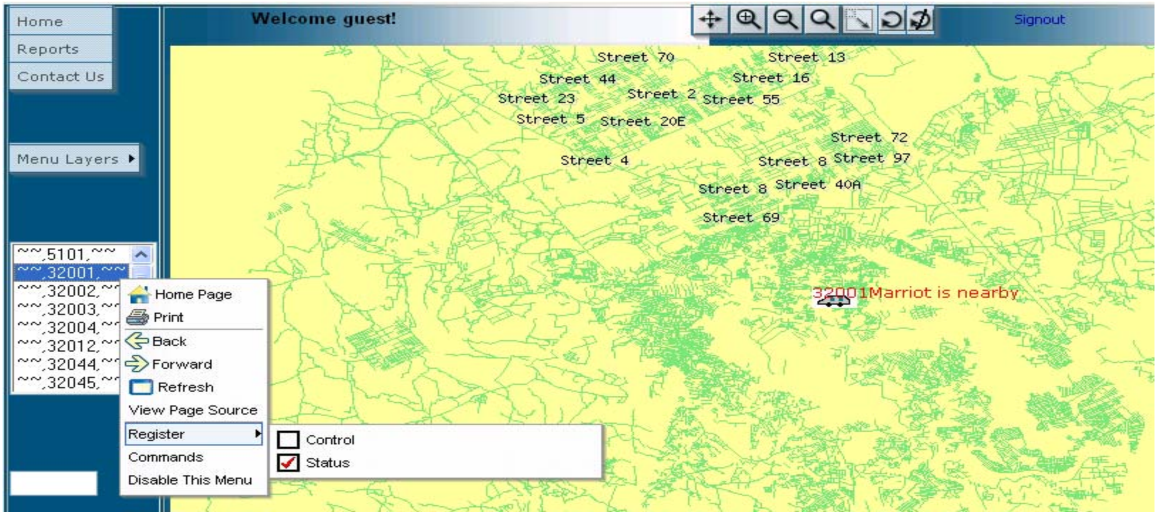


Figure D.17: Viewing Real- Time Movement of Mobile Assets

STEP 8: Communicating With Mobile Assets

Once the control has been gained, the real- time movement of mobile asset can also be displayed on the digital map. Besides the check box is also shown as "checked". Also the figure below shows, once the control is gained, the "Commands" menu becomes active as well for such a mobile asset.

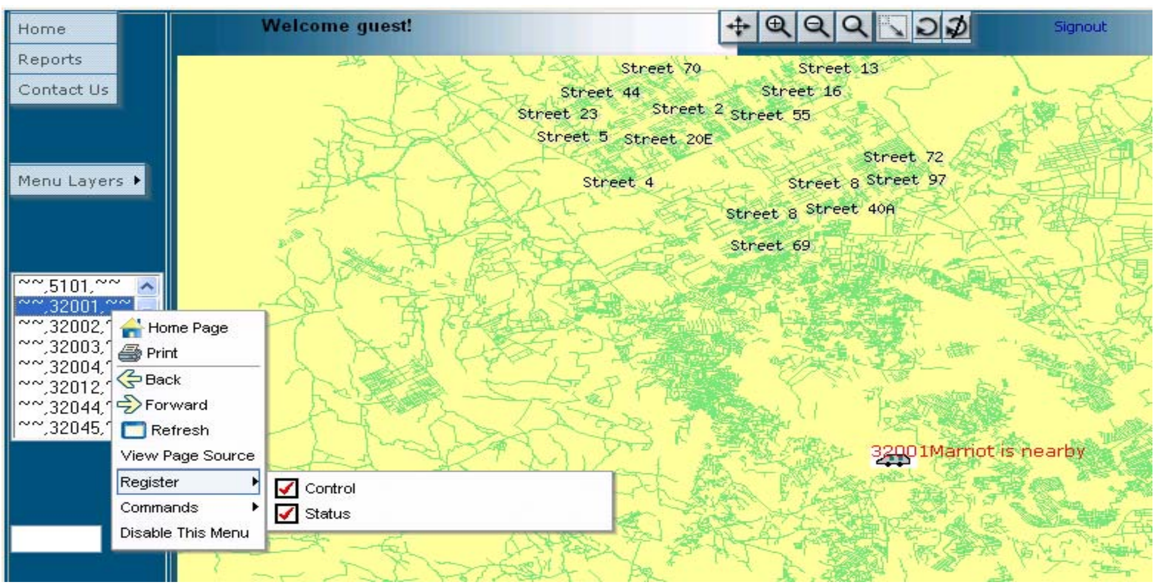


Figure D.18: Communicating With Mobile Assets

STEP 9: Viewing Reports

Further the user can also generate reports by clicking on the reports tab in the menu.

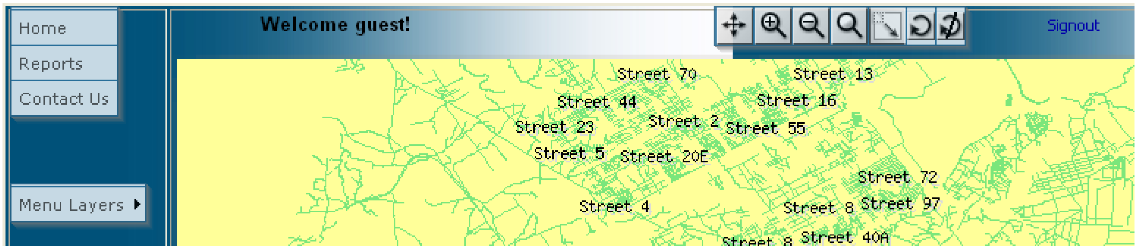


Figure D.19: Viewing Reports

Now the drop down menu of the reports shows the types of reports that can be generated by the server. In the right- hand side panel, there is a list of mobile assets, registered with that user, for which the reports can be generated. User can choose either a particular mobile asset or all the mobile assets.

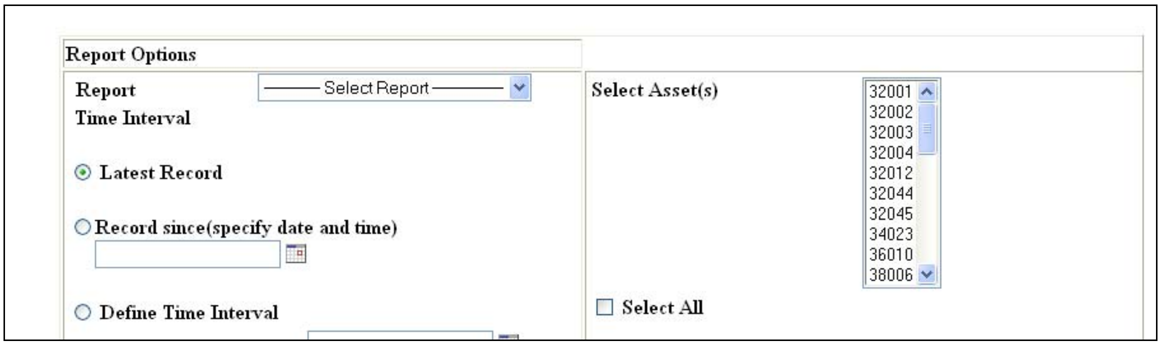


Figure D.20: selection of reports

The figure shows that the report selected is speed violation report and some of the mobile assets have been selected.

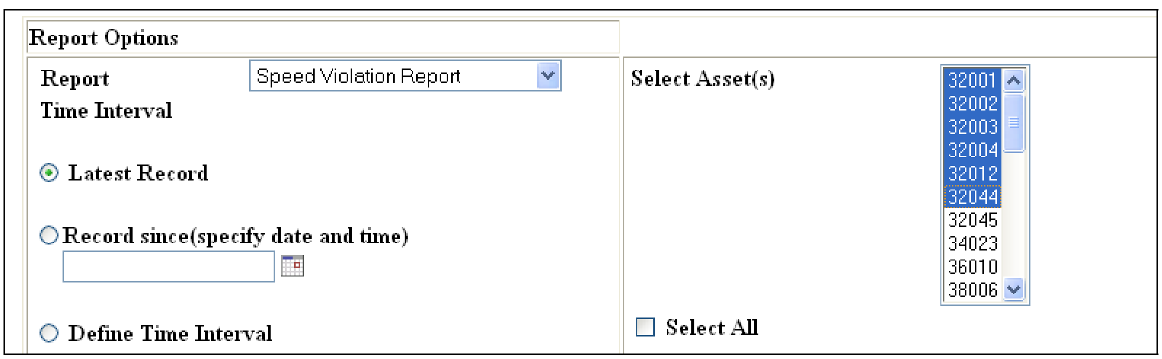


Figure D.21: Selection of Mobile Assets.

Mobile assets can be partially selected or “SELECT ALL” check box is checked to see the reports of all the mobile assets.

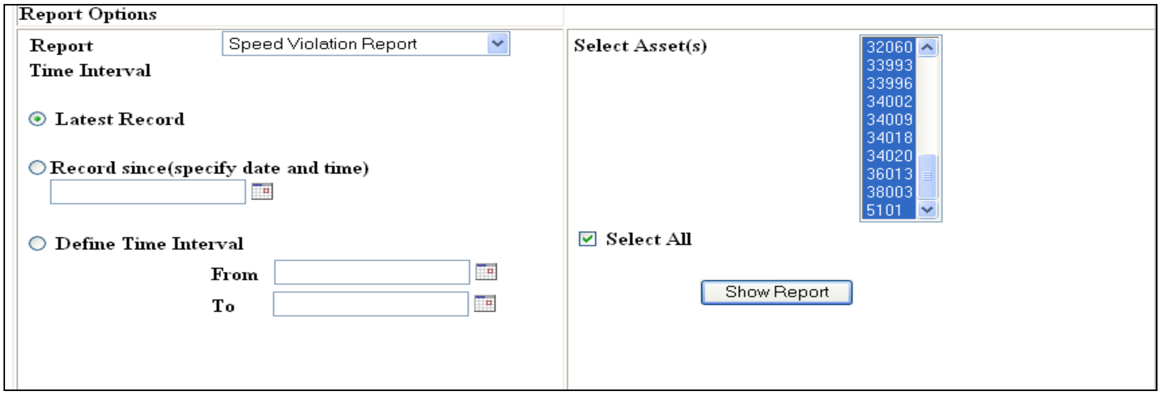


Figure D.22: Multiple Selection Of Mobile Assets.

After that the "Show Report" tab is pressed to generate web- based reports.

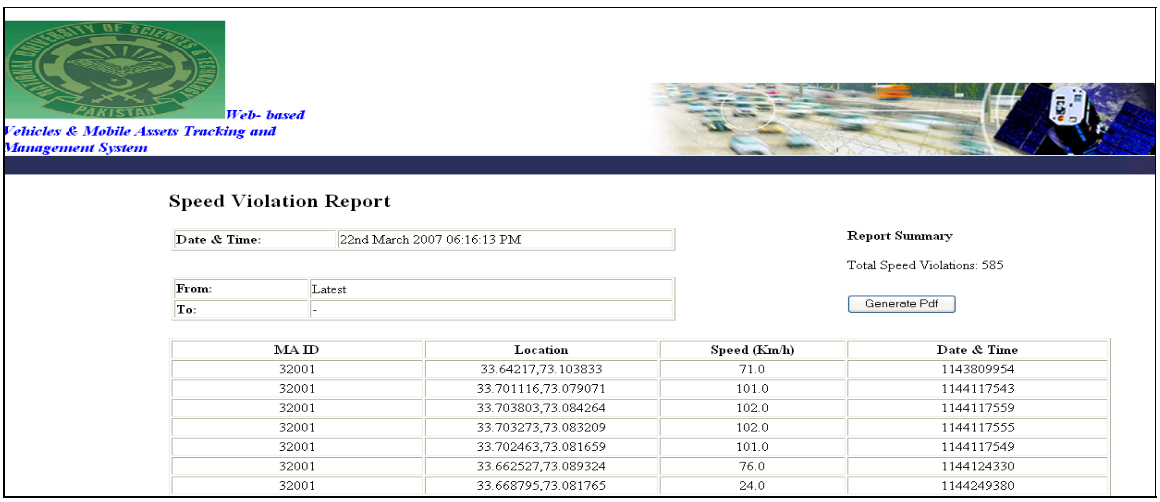
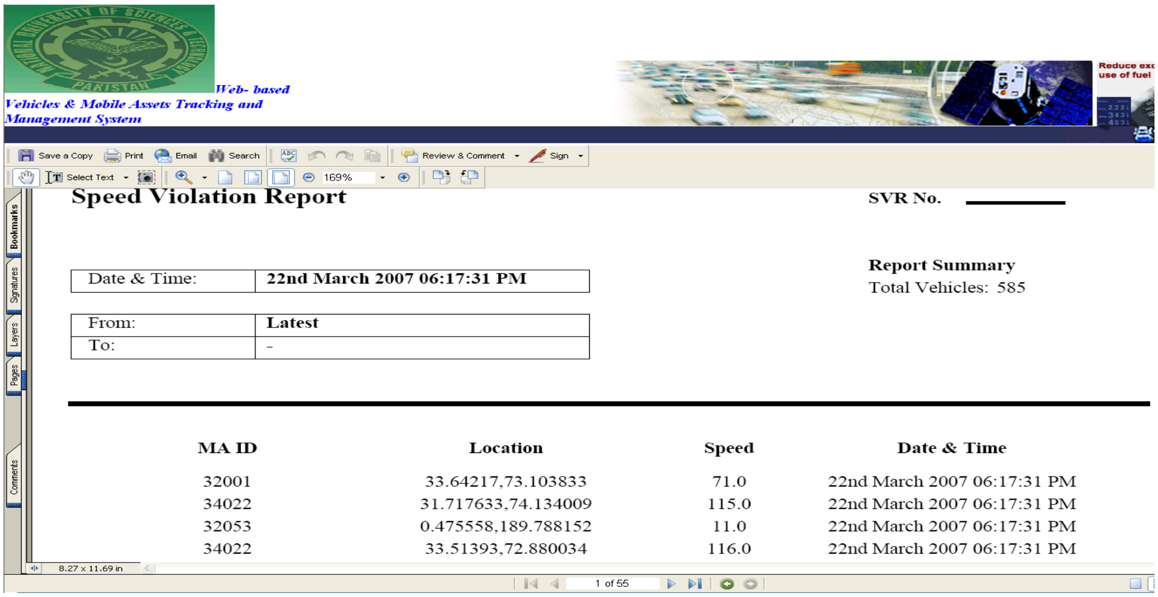


Figure D.23: Generation of Web Page Reports

<u>STEP 10: Generating PDF Version of the Reports</u>

For the convenience of those users who would like to have a hard copy of the report, an added functionality has also been provided to convert the html reports into PDF format. "Generate PDF" button can be pressed to view the .pdf version of the report. The figure given below shows a portion of such report. The user can further scroll down to view the whole document.



Speed Violation Report

SVR No.

Date & Time:	**22nd March 2007 06:17:31 PM**
From:	**Latest**
To:	-

Report Summary
Total Vehicles: 585

MA ID	Location	Speed	Date & Time
32001	33.64217,73.103833	71.0	22nd March 2007 06:17:31 PM
34022	31.717633,74.134009	115.0	22nd March 2007 06:17:31 PM
32053	0.475558,189.788152	11.0	22nd March 2007 06:17:31 PM
34022	33.51393,72.880034	116.0	22nd March 2007 06:17:31 PM

Figure D.24: Generating PDF Version of the Reports

STEP 11: Sign Out

Finally the user can sign out by clicking the link provided on the top- right corner of the screen.

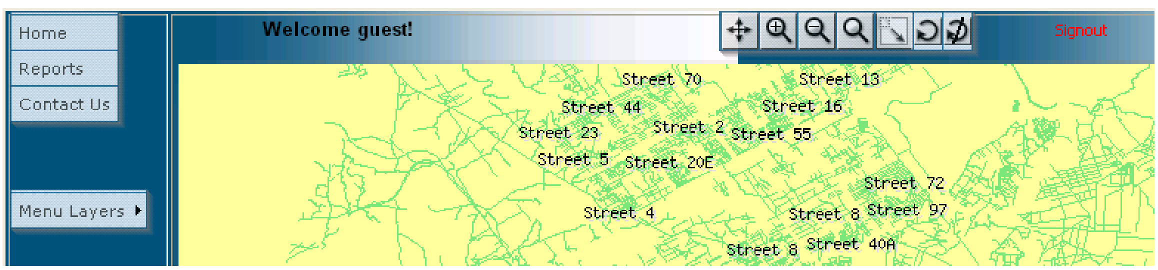


Figure D.25: Sign Out

STEP 12: Administrative Tasks

In order to perform administrative tasks, the following table appears when administrator logs in to his/ her account. An administrator has the authority to manage users as well as their mobile assets. The table provides links that serve as an interface to perform these tasks.

	User	Mobile Assets
1.	Add	Add
2.	Delete	Delete
3.	Update	Update

Figure D.26: Administrative Tasks.

STEP 13: Add New Users

When the administrator clicks “Add” link in the “User” column, the following web form opens asking for the necessary parameters to add a user. Once the administrator has filled the form, he/ she can press “Add” button to add the user in the DB. Once the user has been added, the input fields are cleared so that administrator can add other users too while using the same form. Once the administrator has added all users and no longer needs to add more users, he/ she can press “Done” button to close the form.

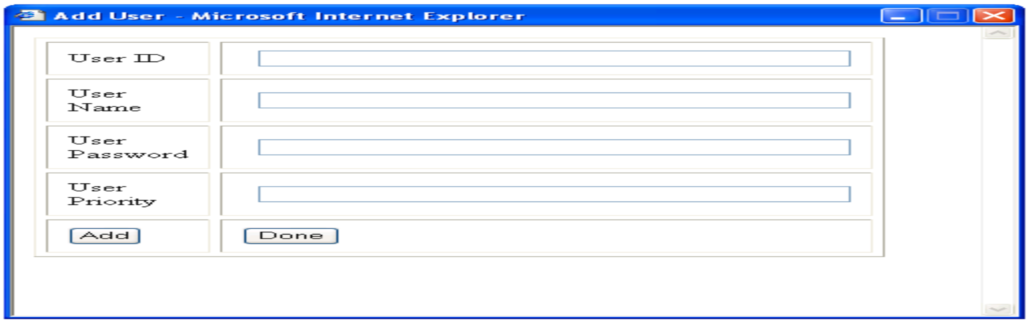


Figure D.27: Add New Users

STEP 14: Delete Existing Users

When the administrator clicks "Delete" link in the "User" column, the following web form opens asking for the necessary parameters to delete a user. Once the administrator has filled the form, he/ she can press "Delete" button to add the user in the DB. Once the user has been deleted, the input fields are cleared so that administrator can delete other users too while using the same form. Once the administrator has deleted all users and no longer needs to delete more users, he/ she can press "Done" button to close the form.

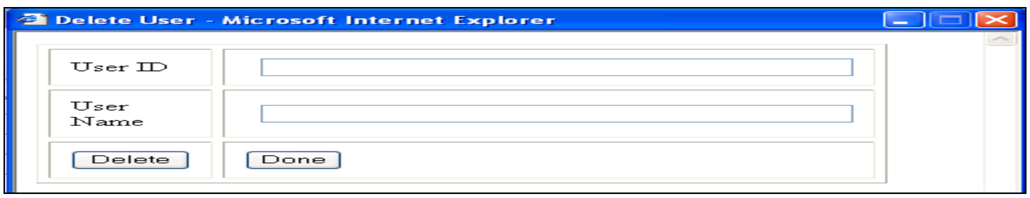


Figure D.28: Delete Existing Users

STEP 15: Add New Mobile Assets

When the administrator clicks "Add" link in the "Mobile Assets" column, the following web form opens asking for the necessary parameters to add a mobile asset. Once the administrator has filled the form, he/ she can press "Add" button to add the mobile asset in the DB. Once the mobile asset has been added, the input fields are cleared so that administrator can add other mobile assets too while using the same form. If no longer needed, administrator can press "Done" button to close the form.

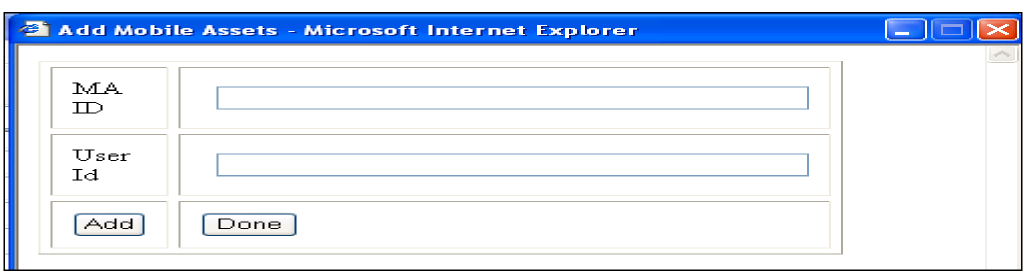


Figure D.29: Add New Mobile Assets

STEP 16: Delete Existing Mobile Assets

When the administrator clicks "Delete" link in the "Mobile Assets" column, the following web form opens asking for the necessary parameters to delete a mobile asset. Once the administrator has filled the form, he/ she can press "Delete" button to delete the mobile asset from the DB.

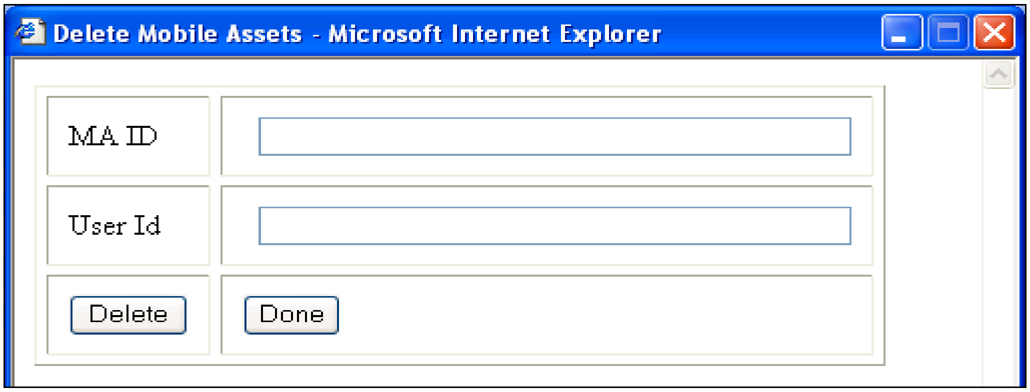


Figure D.30: Delete Existing Mobile Assets

APPENDIX- E

PUBLICATIONS

Space: Introducing Context Aware Services in GSM Networks," accepted at **Second International Workshop on Managing Context Information and Semantics in Mobile Environments (MCISME)** in conjunction with the 8th International Conference on Mobile Data Management (MDM'07), Mannheim, Germany, May 7-11, 2007

- Saira Parvez Khan, Sana Ismaeel, Muhammad Akbar, Shoab. A. Khan, "Web- based System for Real- time Tracking of Mobile Assets," accepted at **Mobile Services-oriented Architectures and Ontologies (MoSO 2007).** The workshop is to be held in conjunction with The 8th International Conference on Mobile Data Management (MDM'07), Mannheim, Germany, May 7-11, 2007

- Saira Parvez Khan, Sana Ismaeel, Muhammad Akbar, Shoab. A. Khan, "Metropolitan Active Space: Introducing Context Aware Services in GSM Networks," accepted in **BNCOD workshop on web information management to be held on 2nd – 3rd July,2007 in Glasgow, Scotland**

- Saira Parvez Khan, Sana Ismaeel, Muhammad Akbar, Shoab. A. Khan, "Web- based System for Real- time Tracking of Mobile Assets," accepted in **BNCOD workshop on web information management to be held on 2nd – 3rd July,2007 in Glasgow, Scotland**

- Saira Parvez Khan, Sana Ismaeel, Muhammad Akbar, Farooq Ahmad, Asim Elahi, “Enabling negotiation between agents and semantic web services,” accepted at **5th Atlantic Web Intelligence Conference 2007 June 25-27, 2007 - Fontainebleau, France**

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