CHAPTER 5 ANALYSIS AND DESIGN

5.1 INTRODUCTION

In this chapter we discuss about the high-level architecture of analysis and design of the proposed system. The domain analysis and the requirement elicitation are also elaborated in this chapter. Then we discuss about general and specific requirements of the proposed system. Subsequently in this section we concentrate on identifying of functional and non-functional requirements of the system. At the latter part of this chapter, the design methodology and top-level design are explained with their associated modules.

5.2 DOMAIN ANALYSIS

The domain is restricted to movement tracking of vehicles at near real-time. Within the main domain following sub areas are also well thought-out during the course of study.

- Analyze the feasibility of the system, understand how it works and design the system using unified modeling language (UML).
- Store an eXtended Markup Language (XML) based output (coordinates) from LBS to a Database.
- Develop an application to find the accurate location of tracking vehicle using the coordinate which has received and represent it on to a base map.
- Perform a mathematical calculation to locate the position on the base map.
- The polling is done in every 5-minute by the tracking application and get the reply to the request with position data to draw the movement on the map.
- Include the facility of multiple vehicles tracking at the same time.
- Include the facility of "Geo Fencing":- eg: Draw a polygon on the map and give an alert to the tracking user when a vehicle enters into that restricted area.
- Include the facility of Zoom-In/ Zoom-Out and the facility of magnifying the image on the map.
- Load different layers of vector maps and label identified places.
- Decide a suitable mobile device to be mounted on each tracking vehicle which will be monitored by the proposed tracking system.

5.3 GENERAL DESCRIPTION OF THE PROPOSED SYSTEM

The proposed vehicle movement tracking solution is developed to introduce an economical solution for real-time vehicle tracking for small and medium-sized enterprises (SMEs). The positioning information of tracking vehicle is to be obtained from the Location Based System (LBS) and is accessible from monitoring station machine (MSM) via the Internet. The vehicle tracking system is designed to track the movement of multiple vehicles with a minimal time lag (Providing near real-time tracking). The location and movement of the vehicles can be remotely monitored through the application with on-screen map displays. Each tracking vehicle must be equipped with a GSM/GPRS modem and a tracking SIM, to be tracked by the proposed vehicle tracking system.

The Tracking application (the Monitoring Station Machine) is implemented on a computer workstation or server class PC, and that has the communication with LBS via the Internet, in order to get required location information of tracking vehicles. This tracking application provides a Graphical User Interface (Tracking GUI) to tracking user. The centralized tracking application allows tracking user to be physically located far away from the vehicles being tracked, and allows them to track vehicles in several geographically distant locations at once. The GUI consoles of tracking application provides the tracking user with a graphical map display of the area that is being tracked, a list of all active vehicles, and statistics such as longitude, latitude, time and status for any active vehicle. The proposed vehicle tracking application is expected to perform well in any environmental condition such as heavy rain and harsh surroundings. But the proposed system is not expected to give an accurate answer when tracking vehicles are going under tunnels or subways, where it can have low signal coverage.

5.3.1 PRODUCT PERSPECTIVE

This product (the Tracking Application) is more interactive part of a large system. Basically this product receives location coordinate from the car unit which is fixed on each tracking vehicle. The car unit is a special GSM device with a tracking SIM. The location data (coordinates) are fed into the system through the LBS. The proposed vehicle tracking system is deployed with support of several interconnected systems.

5.3.2 PRODUCT FUNCTIONS

The main function of the system is to receive location data from the LBS and decodes them in order to properly depict the real ground locations of tracking vehicles on the base map. The other main functions are implementing of all the features that have been identified in the analysis and design phase.

5.3.3 USER CHARACTERISTICS

The proposed system will significantly be useful for tracking fleets for small and mid-ranged enterprises (SMEs), and also potential in security and government authorities.

5.3.4 CONSTRAINTS ASSUMPTIONS AND DEPENDENCIES

The accuracy of this system will depend on number of BTSs in a particular tracking area; so higher the number of BTSs, greater the accuracy. This system will accurately work at certain regions according to above constraint. The accuracy in Colombo city limits is within a 500m radius. The response time of the proposed system also depends on the response time of the GSM network and the LBS. It is assumed that the LBS will always give accurate location information upon requests. It is also assumed that availability and accessibility of GSM network and its backend system are high and there is no down time in the GSM network and the LBS. The proposed system will be implemented only with Colombo regional map as a pilot project. It is assumed that the precision of location coordinates within a 500m to 2km radius in Colombo region. It is also assumed that, the system might diverse from its normal operation under the circumstances of low signal strength areas such as inside tunnels and subways. The system might not perform well under extreme conditions such as high voltage and high noise areas which may cause to damage the strength of the microwave signals.

5.4 SPECIFIC REQUIREMENTS

Most specific requirements of proposed GPS based vehicle tracking system are identified in this section. Functional requirements and non-functional requirements such as usability, reliability, performance constraints, supportability, design constraints and interfaces designs including software, hardware and communication interfaces are considered.

5.4.1 FUNCTIONAL REQUIREMENTS

During the process of requirement elicitation phase, most important functional and non-functional requirements have been captured with the proposed vehicle tracking system. By having interviews with senior management, some members in the middle and operational management, it could identify the most of the outline objectives of the proposed system. Then all the functional requirements are stated and non-functional requirements such as usability, reliability, performance constraints, supportability, design constraints and interfaces designs including software, hardware and communication interfaces are decomposed into several sub topics and discussed underneath. Identified functional requirements are as below;

- Capability of viewing the tracking vehicle's position on a geographical base map.
- The system shall provide a facility to maintain a layered base map (Mainly the area of Colombo).
- The system shall provide a facility to authenticate the tracking user by user-id and the password.
- The system shall provide a facility to enter MSISDN number to locate the tracking automobile.
- The system shall plot the location of tracking vehicles on the base map.
- The system shall make available facility to scroll the map left, right, bottom and up.
- The system shall provide a facility to track the location of multiple objects at a same time. i.e.: multiple automobile / vehicle.
- The system shall provide facility to maintain the history including past tracking data with the system.
- The system shall provide zoom in/out facility on the map and magnifying facility on the map.
- The system shall provide a facility to geo-fencing.
- The system shall provide add and remove facility of map layers in the main GUI window.
- The system shall provide facility to rotate the base map left and right.
- The system shall provide add and remove facility of tracking vehicles and geo-areas (restricted areas) from the system.

5.4.2 USABILITY REQUIREMENTS

The objective is to ensure that user and usability requirements are well defined and integrated into vehicle tracking system's requirements specification. The purposes of usability methods at this stage are to collect information about the hardware devices, tasks and environments, and to agree what aspects should be formalized as requirements.

- The hardware device (GSM/GPRS modem) which will be used in automobile should be unsophisticated and affordable.
- These hardware devices should be tiny and could be easily fixed on tracking vehicles.
- While it is in operation, the activity of such car unit should not be identifiable to the person who drives the vehicle.

5.4.3 RELIABILITY REQUIREMENTS

The system should be designed for maximum reliability and flexibility. Thus the following reliability requirements were identified.

- Low cost reliable tracking device to be installed in the vehicles.
- The proposed system will be totally relied on the GSM network and the LBS. Therefore the reliability of those dependant services will be taken into consideration when measuring the reliability of the proposed system.
- Expected overall system reliability is 99.0%.
- Mean Time between Failures (MTBF) will be four hours.
- Mean Time to Repair (MTTR) will be two hours.

5.4.4 PERFORMANCE REQUIREMENTS

The vehicle tracking system's performance characteristics are outlined in this section. Include specific response times, accuracy and the system performance.

- Offer real-time tracking with minimum latency. Latency will depend on the internet speed as well as other factors. It should be noted that latency is not an issue in the context of the use of this system. Therefore a latency of 30 seconds is deemed acceptable.
- In order to get coordinate to the system accurately, the car unit should operate properly without sending erroneous data.

- Response time should be minimal. It should be less than three minutes.
- The system shall operate properly 24/7 days.
- Accuracy of the result should be within the acceptable level. It should be within 500m to 2km radius in the actual scenario.
- Dynamics of map should be created with zoom in/out facility.
- Cost effectiveness with respect to a same commercial application.

5.4.5 SUPPORTABILITY REQUIREMENTS

Here it indicates requirements that will enhance the supportability or maintainability of the vehicle tracking system.

- This software should require the internet facility to get connected to the LBS system.
- Special tracking enabled SIM with a minimal subscription fee.
- This system should work from any where, when there is a direct connection to the internet from the Monitoring station machine.
- This software can be improved to a great extent to cover all over the country when there is a strong GSM network coverage is set up.

5.4.6 DESIGN CONSTRAINTS

The following identified all design constraints on the vehicle tracking system being built. Here it has identified software languages, database requirement, prescribed use of developmental tools, architectural and design constraints and some purchased software packages.

- UML will be used to design the system. There are two ("Rational Rose" and "Poseidon Community Edition") UML tools will be evaluated and one will be selected.
- JAVA, Java2 platform standard edition 5.0 Development Kit (JDK 5.0) can be selected to develop the system.
- MySQL server version: 5.0.15-nt will be selected as backend Database.
- Additional tools and technologies will be used are Photoshop, Macromedia Dream weaver MX, Eclipse SDK 3.1.1, HTML and XML.
- ArcGIS version 9.1 will be used to generate and edit geographical maps.

5.4.7 USER INTERFACES

User interface GUI requirements with the vehicle tracking system have been established below. The vehicle tracking system is developed and verified for the user interface requirements. Human Computer Interaction (HCI) concepts are considered.

- There shall be a login into the system. Then a tracking user will enter a tracking number (mobile number of the tracking SIM) and press search for tracking.
- GUI will capture the current position of vehicle.
- The GUI should appear as same as a commercial tracking application. It should encompass with proper JAVA look and feel to get this done.

5.4.8 HARDWARE INTERFACES

Specific hardware requirements for car unit and monitoring station machine that, vehicle tracking application going to be resided on, have been affirmed as follows.

- The software system should be running on a computer workstation or server class PC or a high-performance laptop PC with minimum of following configuration. CPU: Pentium-IV or newest/ RAM: 512Mb (minimum) / HDD: 30 GB / VGA Mem: 64Mb / 56K Modem / (IR Optional).
- There should be an easy access to the internet from the Monitoring station machine that the tracking software is running on.
- Tracking device should be a portable one and should be battery powered & rechargeable. (i.e.: GSM modem or Basic GSM mobile phone)
- Tracking device should be mounted and hidden to the user (i.e.: Driver).

5.4.9 SOFTWARE INTERFACES

The following more specifically confirms software requirements with the vehicle tracking system.

- Designing should be done using Unified Modeling Language as Rational Rose.
- The backend Database should be MySQL server version: 5.0.15-nt.
- The development software should be JAVA JDK 5.0 or JDK 1.4.2.
- Vector map should be used in this implementation. ArcGIS version 9.1 should be used to get required *shape (.shp)* map files.

5.4.10 COMMUNICATIONS INTERFACES

The following has identified all communication requirements and interface type to the Internet and to other systems such as location based system.

- There should be an internet connection through a leased line, Dialup connection or a GPRS connection to from Monitoring Station server in order to get connected to the LBS.
- The communication protocol used should be TCP/IP.

5.5 METHODOLOGY USED FOR REQUIREMENT ELICITATION

The main requirement of the project was based on the problem domain, and information given by the University, ideas created during initial deliberations with my supervisor while the project charter was developed. Then the management of the chosen organization and head people in various operation teams were interviewed in the process of information gathering. By interviewing senior management, some members in the middle and operational management, it was able to identify the most of the outline objectives. The Administrative officers who attached to the transport department gave their inputs based on the problems they face in day to day operations. Those input were concerned more in implementing the possible outputs of the system. Then few of the key people from *Environmental Science Division (EMSO LTD)* were consulted when identifying and integrating a proper geographical map on to the system.

The evolutionary software development methodology is practiced in development of this system. Based on the initial user requirements elicitation, a prototype was developed to grab some doubts in users mind more precisely. Then the system was developed in more explorative manner with the evolutionary prototype model. The model was applied to discover the user requirement with several iterations. Then it was more helpful to create mock forms and tables quickly to simulate the final outcome. The designing phase of the proposed system is started and carried out as a parallel activity to the user requirement elicitation phase. This was started in somewhere middle in the requirements elicitation phase and carried out with several top-level designs and iterations of the proposed architecture, until it persuades with most appropriate model for the vehicle movement tracking system.

5.6 TOP LEVEL DESIGN

The first step in the designing of the vehicle tracking system was the segmentation of the system into its fundamental components. The proposed vehicle tracking system consists of three main components namely; tracking application (Monitoring Station software), location based services and the car unit. Since the most important component of this system is the tracking application, more emphasis is paid on the design of the tracking application. The designing was done with Unified Modeling Language (UML) and all necessary artifacts; including Use case diagram, Class diagram and Sequence diagrams are attached as supplementary materials in appendixes. Following figure 5-1 shows the top-level design of the vehicle movement tracking system.

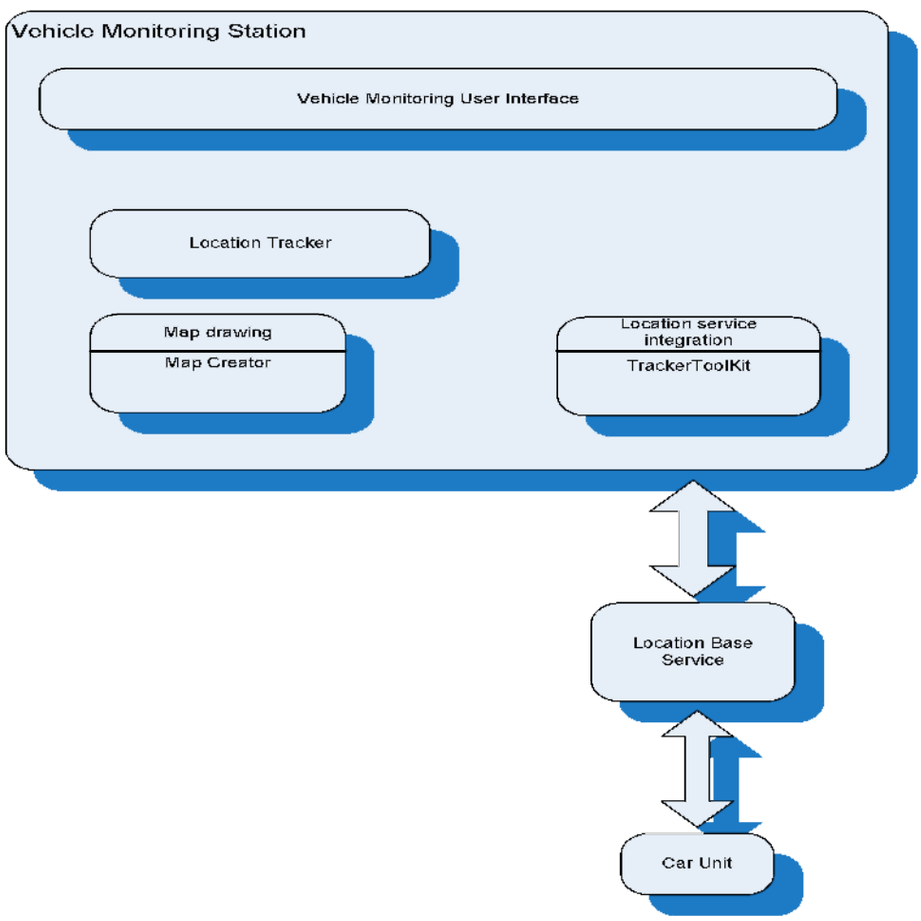

Figure 5-1: Top Level Design of Vehicle Tracking System

5.6.1 SOFTWARE DESIGN

The most suitable language for this application is Java. Therefore this tracking application (Monitoring Station software) is written in high level Java programming language. Following advantages are focused in order to select Java for this application. Supportability, platform independency and object oriented feature leads the reusability of classes and components. Therefore Java is chosen as the preferred language as its object oriented approach will enable me to update easily and quickly and modify the program, over the several versions of it to write, over the course of completing it.

The design architecture of this entire system is Client/Server based. The tracking software acts as the server module whilst car unit with tracking SIM performs the client activity. The tracking software is able to send a request to the LBS with appropriate mobile number to be tracked. To complete this operation, it must perform an action by connecting to a URL in the LBS in order to send an envelope to appropriate car unit. This application is developed to perform all the functional requirements that were identified during requirements elicitation phase. The basic operation of this application is quite straightforward.

At the software designing phase, the object-oriented programming was followed. First it was designed the low-level object classes. And then the following classes were identified and designed. Identified main classes are namely; *LoginWindow*, *DBConnection*, *MainWindow*, *MainWorkspace*, *RestrictedArea*, *Track*, *User*, *RestrictedAreaWindow*, *LoginWindow*, *UserWindow*, *VehicleWindow*, *Map*, *ControlPanel*, *TrackerToolkit*, and *Location*. A couple of supporting classes identified are; *HistoryTableModel*, *RestrictedAreaTableModel*, *TrackerTableModel* and *TrackerTableRenderer*. Each class was first laid out in skeleton form at the beginning, and then the code was written to implement the functions as designed. The Rational Rose package was used to create use case and class diagrams to guide the design and to maintain logical relationships between objects. A main use case diagram, high-level class diagram and main sequence diagram are created and those UML artifacts are shown in *Appendix B*.

5.6.2 GRAPHICAL USER INTERFACE DESIGN (GUI)

Non-functional requirements were considered in GUI design. The usefulness of a real-time vehicle tracking system is greatly reduced if a tracking user finds it difficult to interact with the system. Therefore some useful Human Computer Infarction (HCI) principle were applied when developing in the tracking GUI. Great care was taken in the design of the GUI for this vehicle tracking system. A professional Java "*look & feel*" was introduced to the application as in commercial tracking application GUIs. The uniformity of fonts and icons was maintained. All the icons were designed while maintaining the consistency among their characteristics in terms of size, colors, metaphor, and level of their realism. And icons were visually balanced in the GUI. Visual distinctions of icons were also considered as a significant factor when designing it.

5.6.3 DATA BASE DESIGN

A relational database is developed for the application in terms of maintaining the information of vehicle data, positioning data, geo-fencing area data, tracking date and time and user information. The database consists of four tables namely; *restrictedarea, track, trackheader and user.* An ER-diagram of the database design and the table structures are shown in the *Appendix C.*

5.6.4 CAR UNIT

The car unit is the data source for this application. Tracking SIM that is installed in the car unit will reply to the request with accessible location information. This device is preferably a GMS/GPRS modem with 24V DC power. It has to be properly mounted in the tracking vehicle. A valid GSM tracking SIM-card must be inserted into the car unit (through a slot inside). The SIM-card must be enabled for sending SMS text messages and enough credit must be available to send SMSs. Therefore, it must have enough balance in the account for SMS messages.

5.6.5 SECURITY AND THE INTERNET CONNECTION

This application uses global Internet to connect to the LBS interface where it receives positioning information from tracking vehicles. Therefore, the Internet connectivity must be available to the Monitoring station machine for full time. It is recommended to keep this Monitoring station machine behind a firewall in order to prevent from

unauthorized access to the system and to avoid from possible security vulnerabilities. Therefore it is recommended to harden up the internal network with a *"Check Point NGX R60"* fire wall system which includes advanced inspection technologies, such as stateful inspection, application intelligence and malicious code protection.

5.7 SUMMARY

In this chapter it was focused on the analysis and design of proposed vehicle movement tracking system. We went through domain analysis and requirement elicitation. Then we discussed about general and specific requirements of the proposed system. It was also identified functional and non-functional requirements of the system. Afterward we talked about design methodology and top-level design of the same. The top-level design was de-composed into several modules and we discussed about each of them. In the next chapter our aspiration is to have an idea about implementation of the proposed vehicle movement tracking system.