Geo-Enabled Real Time Emergency Response System using Open System Architecture

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DISCLAIMER

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ABSTRACT

With the increase in accidents and other emergency situations, many lives are lost because of delayed response and first aid help. This delay is happening due to many reasons but one of the main reason is the relief-vehicle driver does not know about the emergency location. The study was done for developing a framework which can be successfully utilized in case of any emergency situation. This study deals with the two major phases of emergency management which are preparedness and response and rescue. Information (road network, hospitals, landmarks) about the study area is collected and is then stored in the database for future use.

The study is divided into sub-objectives which when combined will give an emergency response system. Using virtual globe, visualization of study area is done in 3D along with it real time tracking of relief vehicle is done, so as to know where the relief vehicles are. The system is providing emergency intimation facility by call or message; by using the relief vehicle's location and emergency spot, the system is providing with the shortest route. It is also providing with the information about the nearest hospital.

Keywords: emergency, tracking, OpenWebGlobe, location, open source.

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Abbreviations:

API: Application Programming Interface

DFD: Data Flow Diagram

EPSG: European Petroleum Survey Group

ETS: Emergency Tracking System

GeoJSON: Geographic JavaScript Object Notation

GIS: Geographic Information System

GPS: Global Positioning System

GPRS: General Packet Radio Service

GDAL: Geospatial Data Abstract Library

IE: Information Extraction

JS: JavaScript

NER: Named Entity Recognition

NLP: Natural Language Processing

PHP: Hypertext Pre-processor

SRS: Spatial Reference System

WMS: Web Mapping Service

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Chapter 1 INTRODUCTION

Any situation that can cause a sudden risk to human or animal health, their life and property or to the environment is classified as emergency. It is a result of a disaster occurred due to natural phenomenon or technological mishap. To reduce the loss; an immediate intervention is required so that emergency can be confined in a small area and there is no or minimum damage. Emergency management is to avoid and deal with man-made as well as natural disasters. It includes a pre-, during- and post-disaster plan that is to delay or reduce the vulnerabilities or potential damages, minimize the destruction during emergency and reestablishment for the future. The most important task in disaster management is to minimize the difference between the pre- and post-disaster conditions in a community. Disaster cannot be predicted as per their occurrence and impact. They can harm either the environment or property or worst to the resources or civilization present there.

With emergency comes up hazard and disaster. Hazard is any condition which when triggered can cause large scale disasters and emergencies. They can be man-made or natural. Leakage of any poisonous gas or radio-active material can be a man-made hazard while phenomenon like earthquake and volcanic eruptions are natural hazard. A disaster occurs when the impact of a hazard causes severe problems for the people around. The problem can be social and economic (Cutter 1996).

Disasters have a geographical extent and time duration which defines its impact on the environment and surrounding. Responding immediately can reduce the impact of the emergency situation. Since the past 50-60 (Waugh 2000) years the human civilization is trying to manage emergency situations. Emergency management, helping the victims, informing the rescue and relief personnel has evolved from paper and pen to automated system and with integration of GIS it becomes easier to analyze the situations. "Emergency management is a typically multi-disciplinary endeavour, requiring many types of data with spatial and temporal attributes that should be made available to key players in the right format for decision making."(Bhanumurthy *et al.* 2008)

Starting emergency aid quickly can facilitate in saving lives and properties. Organizations like Red Cross, FEMA, E911, 108 or fire brigade organizes these activities. In these centres, an automated guidance system is used which synchronizes the rescue team, emergency aid activities and administrations. Most of the data, required by such applications is of spatial nature and can be located and visualised with the help of maps. Emergency management can be subdivided into the following phase viz. prevention, mitigation, preparedness, response and recovery.

Disaster doesnt happen in a day, they exist throught the life time and have a cycle. This cycle is matched by a series of management phases: establish strategies to mitigate hazards; prepare for and respond to emergencies; and recover from effects

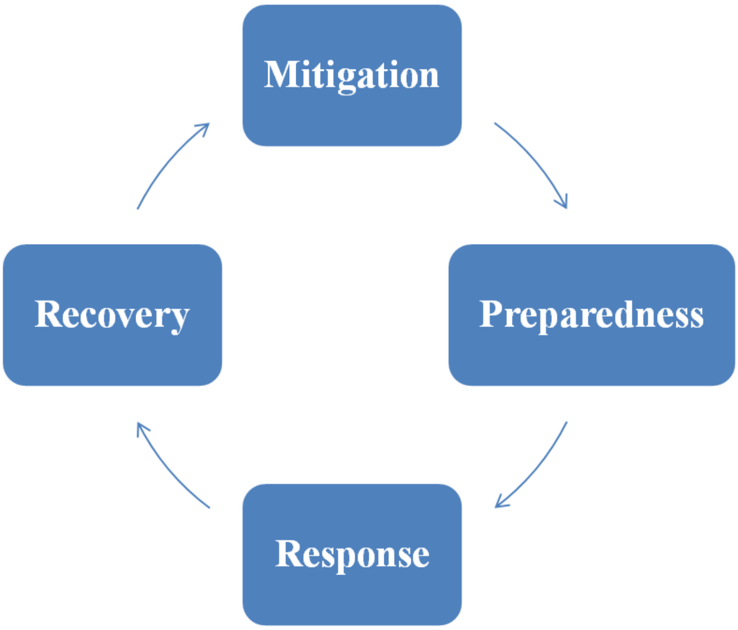


Figure 1-1: Phases in emergency management

Mitigation is the first step towards emergency management; it involves the steps towards reducing the occurrence of any emergency. This includes avoiding activities that can cause an emergency or reducing the effects of unavoidable situations. Preparedness includes making of plans which can be used during the emergency, this improves the chances to deal with the emergency. This generally includes who to call for help, what to do and where to go if a particular situation arises. Response is the step in which many organizations and teams combines together to fight with the disaster and provide assistance to the victims stranded there. This is a very time critical phase; timely intervention can save lot of human, social and economic damage. The last phase is recovery in which assistance is provided for resettlement and rehabilitation to the victims, in this phase we should try to avoid the previous situations, so as to reduce the chances of disaster.

The emergency response team is present in all the steps within the disaster management. Training can be provided to personnel as how to use the application by the organization for pre-disaster management. The main use of the systems is in the response phase, where computer programs give instructions to the rescue teams. In the case of the emergency situation, the emergency call will be accepted and the rescue teams are alarmed and controlled. In the recovery phase, application will store data for training and future use. It can also generate maps to show the expanse of the damage caused by the disaster.

1.1 Location Based Services (LBS)

The advent of different technologies such as wireless networks, Internet, Geographical information systems (GIS) and Global Positioning Systems (GPS), have introduced a new type of information technology called Location Based Service (LBS). LBS is defined as the ability to locate a mobile user geographically and deliver services to the user based on his location. According to Schiller J.(Schiller *et al.* 2004) Location based services can be defined as "services that integrate a mobile device's location or position with other information so as to provide added value to a user". So knowing your location or how far you are from a specific location would not be valuable by itself. Only if it can be related to other location this gives it meaning and value.

A LBS is an information and entertainment service, accessed through mobile devices using the mobile network and employing the ability to make use of geolocation of the mobile device. A LBS services can be used in a variety of contexts, such as health, work, personal life, etc. LBS include services to identify the location of a person or object, such as discovering the closest hospital or the whereabouts of a friend or employee. LBS services include parcel tracking and vehicle tracking services. A positioning component is usually needed in a LBS application to determine the location of user's mobile device. Most of the current LBS services do not require users to input location manually, like entering zip code or street name in LBS application. Instead user's location can be obtained by using some positioning technologies, such as satellite positioning, cellular network positioning, WLAN stations or radio beacons.

1.2 Background:

LBS is a result of combination of three technologies in a single device: internet access on cellular devices, location positioning combined with rich user interfaces. These applications use a GPS-equipped device and is used in applications ranging from 108, E-911 to friend-finder or advertised based on location applications. They are designed in such a way that customers get quick access to local and personalized content according to the user location.

In late 1990's mobile devices supported only SMS and voice transmission along with very few user interface. They have supported very coarse services (using cellular tower triangulation or SMS). The general available LBS came after availability of internet access on cellular devices and Web Access Protocol (WAP). In 1999, WAP enabled phones started to appear on the market providing internet access and a richer user interface than previously available.

In the year 2001 a location aware GPRS service called mMode was launched by AT&T Wireless and Kivera with the goal to provide a friend locator facility (Nussbaum 2004). It objective was to create an enhanced LBS solution for the users who like to stay in contact with their family and friends. The application provided the following capabilities:

- Finding out the information about the location of a family member or friend through cellular device position.
- Routing the driving directions from an address to the cellular device location.
- Provide for selection of a business POI meeting place between two mobile cell phone positions.

With the availability of high resolution touch-screen mobile phones and improved user interface there was an increase in the development of applications with richer interface which is same as of desktop computers. Initially the location was provided by cellular network based localization. With the availability of cheap and small GNSS chipsets more and more mobiles are satellite position enabled. Currently, navigation technologies in consumer devices such as mobile phones are enabling a massive boom in location-based services, with new commercial opportunities based on the ability of users to identify their precise location relative to services, amenities and other people.

1.3 LBS Platform Considerations:

It is important to know the areas that come up with the quality of results obtained from an LBS application. The areas are data mapping and software engine.

1.3.1.1 Data Collection and Capture:

For creation of a location based service, we require different data from different sources. The data required is the road network, landmark geolocation and dynamic data such as real time traffic report. This data can either be acquired by different sources or has to be created by the developer.

1.3.1.1 The road network

The first step in building LBS application is to collect the road network data. A city will contain a large number of road segments. The map data can be converted from raw geographical content into digital format. The data can be captured in many ways like from scanned maps to satellite imagery to manual digitization or using automatic feature extraction techniques. Another approach is to drive a GPS-equipped vehicle on each road segment, keeping a record of every move and direction and taking photographs.

Map data are stored in a vector format composed of line segments (links) representing the roads and connecting points representing intersections or other road features. Each link has start and end points and may also incorporate shape points to model the curvature of the road. In addition to geometry, the data contain feature attributes such as oneway streets, exit signage, prohibited turns and manoeuvres, vehicle-height restrictions, bridges, tunnels, and street addresses.

1.3.1.2 Landmark geolocation:

LBS application is mostly used as concierge services by helping them locate different facilities and businesses in a specified location. They help in answering questions like "Where will I find a nearest ATM?" or "Which is the nearest hospital from my location?" .These applications use landmark and business information which needs to be created for the point of interest database. Assimilating the POI database with the map database creates a detailed, digital representation of the road network and business services available along it.

This landmark database includes the detailed information which is generally found in a phone directory and adds value to the geographic content of the map database. The landmark geolocation data can be collected from different sources and is then combined to form a single comprehensive database. Each record in an individual database is geocoded, or assigned a latitude/longitude coordinate, before being combined with other databases. The resulting database is indexed and each record is assigned a unique identifier so that it can be associated to a link in the map database. Volunteered Geographic Information (VGI) data can also be collected.

1.3.1.3 Dynamic Data:

Travelling from one place to another, we need to have an optimal route between two different points. Conditions like accidents, bad weather, road construction and traffic jams can change the supported traffic speed of the road network. Situations like this can change the fastest route.

We cannot add conditions like daily traffic into the database beforehand. To accommodate changing road features, well-designed Location Engines are designed to work with dynamic data and to use it to supplement and/or override existing map information. Applications like 108 services and fleet management which is time-critical depends on LBS applications with the dynamic data potential as they allow dispatchers to react quickly to conditions.

1.3.1.4 The Location Engine:

The main component of any LBS application is its location engine. It has the software component that adds aptness into the digital map data. For generating good results, quality of LBS modules is important. In location engine, functionalities like routing, reverse geocoding and geocoding are embedded.

1.3.1.4.1 Geocoding and Reverse Geocoding:

In GIS while mapping any place on the map one needs geographical coordinates expressed as latitude and longitude, this can be achieved by geocoding. It converts a street address to (x,y) pair of coordinates, so that it can be placed on the map accurately. It is a feature for all the geospatial applications.

Geocoding becomes a much more difficult process when complete addresses are not available. One of the biggest problems of many Internet-based mapping applications is figuring out misspelled addresses. Although only a few of these applications will choke on abbreviations (e.g., "ln" instead of "lane"), most cannot handle phonetic spellings. Unfortunately, in the real world, we are not always given complete and accurate street names. Another problem arises when there are common street names and ambiguity arises.

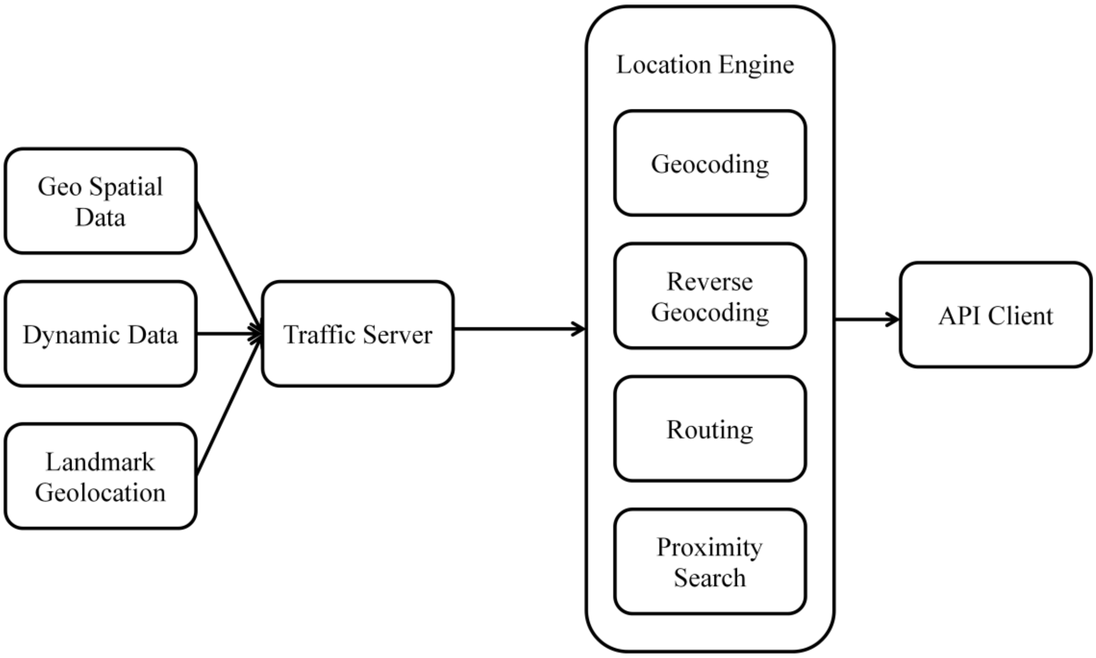


Figure 1-2 : Location Engine architecture

Location engines address this problem by using algorithms like soundex or metaphone, which uses “sound-like” set of rules to perform address matching. This kind of matching increases the ability of the engine to geocode the address after finding it out.

The point location when converted into human readable address or place name, the process becomes reverse geocoding. This kind of process converts coordinates into address which can be understood by users. The derived information then can be used for searching point of interest or finding out navigational route.

1.3.1.4.2 Routing:

The technique of finding out the best route from one point to another point is called routing. The applications display all the available route options along with the travelling time. These routes include fastest route, shortest route, very few tolls, non-freeway route et cetera.

In general while calculating the optimal route attributes are examined which are length of road, one-way indicators, length of link, speed and turn restriction. A routing engine evaluates the numerous ways a driver might travel over the streets, while accounting for various attributes of the street networks. There are usually an enormous number of possible routes between any two points, and the speed and quality of route generation is one of the hallmarks of great LBS engines.

1.3.1.4.3 Proximity Searches:

Proximity searches use POI database information to find businesses or landmarks near a specified location. Users can search for locations of ATMs, gas stations, restaurants, hotels, or other establishments.

1.4 LBS Components:

Most of Location Based Services require several components. Following are the components of LBS – five technological and 1 human related (Schiller *et al.* 2004; Steiniger *et al.* 2006):

- **Positioning systems** – allows geographically localizing of the mobile device both outdoor and indoor using: satellite-based systems, Cell-ID, RFID, Bluetooth, WiMax, Wireless LANs.
- **Communication Network -** the wireless network that allows for transfer of data between user (thought mobile device) and server (service provider). Nowadays it is in most cases wireless internet (e.g. GPRS, 3G, 4G)
- **Service and Application Provider -** the LBS provider, including the software (e.g. GIS) and other distributed services and components that are used to resolve the query and provides the tailored response to the user.
- **Data and Content Provider -** service providers will usually not store and maintain all the information, which can be requested by users. Therefore geographic base data and location information data will be usually requested from the maintaining authority (e.g. mapping agencies) or business and industry partners (e.g. yellow pages, traffic companies).
- **Mobile Devices** – any portable device that has capabilities to utilize stated above components of LBS, for example: mobile phones (including smartphones), tablets, palmtops, personal navigation devices, laptops etc.

- **User** – operator of the mobile device and the person that is utilizing potential of modern mobile device and infrastructures in order to get value added information or entertainment.

1.5 Emergency services in India

1.5.1 Ambulance service (108)

108 emergency services is the public private partnership between state governments and private EMS providers which provides free 24 hours emergency service. It has integrated medical, fire and police services in India. GVK-EMRI started it in Hyderabad and today it is present in 17 states and 2 union territories in India. 108 is a toll free number from cellular devices and landlines, generally it takes 18 minutes to reach the help to the emergency spot. A first aid is provided to the victim while transporting from emergency location to the nearest hospital for further treatment. Whenever any emergency is reported, the operator asks for the information about the type of emergency, number of people injured and their condition, the place from where the call is made and caller's name and contact number if required for some assistance.

1.5.2 Police Service:

In some cases like theft, hit and run etc police forces also needs to be informed and they a have a common dialling number 100, where any complaint can be lodged and the police force starts working on it. This service is especially important if there is a crime in progress and intervention in it can save lives.

1.5.3 Fire Brigade:

Fire has been viewed as a force both beneficent and destructive. The destructive potential of fire poses a threat to our life, property and resources and it has been a major reason for the destruction of life as much as it has been a vital means and source of sustenance for mankind. The role of public fire protection services is to save life and property from fire and allied incidents and to minimize the outbreak of fires and its consequential loss within the jurisdiction of its responsibilities. A common dialing number 101 is provided for intimating about fire services.

1.6 Information Extraction and Toponym Resolution:

Automatic processing of natural language with accuracy and high-speed is in need at present times, when it can be used for many applications ranging from getting knowledge from a simple text message to making ontology for an application. The text can be structured and unstructured. Information retrieval in a structured text is relatively simple and pre-processing is required when we are dealing with unstructured text. The very important task of text mining is to extract the information, with the general goal is to discover structured information, relevant and useful facts for the text.

Toponym when segregated is divided into two greek words, '*tópos*' and '*ónoma*' which means place and name. According to Leidner (Leidner 2008) "Toponym Resolution (TR) is the mapping from occurrences of names for places as found in a text to a representation of the extensional semantics of the location referred to (its referent), such as a geographic latitude/longitude footprint"

For example, in the following sentence,

Hello. An accident just happened in kalidas road. Please help
The following information can be extracted:
ConditionIn (Accident, serious)
Placein (Kalidas Road)

This kind of information can be used in other applications, can be provided to database management systems and search engines for providing services."The best information retrieval systems can retrieve texts that have a reasonable likelihood of being relevant to one's general concerns. However, getting the information out of the text that is required for solving someone's problem still requires a human to actually read the texts | a time consuming process that can easily swamp the available resources"(Appelt *et al.* 1993).

When extracting the information from any text, we face many challenges like ambiguity, data is not structured, and lot of processing is required. Ambiguity also arises when we have to map the extracted information into geographical space. There can be ambiguity of name, like for example the same is name of place and person as well. In India, we name the different placemarks on the name of some famous person like a veteran soldier or a leader. We also have ambiguity between places meaning there will be more than one place with the same name like pragati vihar is the name of a colony which can be found in Delhi and Dehradun. In the same way we have mayur vihar and mayur, the latter one is name of a person and the other one is name of a colony. Over the course of time, many cities and places have changed their name, like madras became Chennai now. There is also a problem of synonymy, which means one place having different names, the city Dehradun is a perfect example of this which is also known as dehradoon, doon, dehra doon.

Spatial and temporal entities ground events in space-time, and this relationship is vital for applications such as map generation, geographic information retrieval, question answering and event tracking. A human can automatically determine from the context which is the intended referent due to their reasoning and intelligence but when automating the process, the machine cannot distinguish between the two until some algorithm or machine learning is done. Therefore there is a need for toponym data model which can resolve the machine issues.

This then can be used with emergency management during database creation phase, when we can resolve geo-geo ambiguity (two or more places having the same name) or during the intimation about emergency when a person informs via text message or call. During a call, the operator can still ask and confirm the location but when only a text message is being received then information extraction through toponym data model helps a lot to avoid ambiguity and confusion.

1.7 Role of LBS in emergency management:

If an emergency happens (car accident, fire in a flat, etc.) somebody will transmit an emergency call to the centre of the rescue team. There the scheduler acquires the incoming emergency call with the necessary criteria including location, time, type, persons which are involved, etc. in the emergency. This information is the solicited input for the decision support module of the Emergency Management and Response Team (EMRT). The next step is to dispatch the emergency forces. The EMRT will submit, on the basis of the acquired information, the available resources and the alarm plans to the necessary emergency units. The scheduler system automatically proposes which team to send and alerts the emergency team. Along with the alarm, scheduler also send important information like location, route to the location, type of emergency to the dispatched rescue team. During the emergency mission the emergency units are controlled and additional information which is needed to handle the emergency can be requested from the emergency call centre (e.g. queries from hazardous material databases). All steps, from the time of the emergency call to the status of the emergency forces like the location of the vehicles or the used equipments to the end of the emergency mission, are logged by the EMRT to a protocol. In the post-processing phase all missing data of the emergency will be completed and a report of the emergency mission is generated and saved in a database.

The main GIS functionality of EMRT is a function that uses geocoded addresses. This function is required in order to enable finding the location of the emergency site. The addresses are usually organised in a dataset, which include the necessary geographic information, e.g. coordinates. In addition to this function, the emergency location can be entered via the street name or ordinary geographical coordinates. The second important GIS function is the network analysis. In the network analysis the shortest or the fastest way between the position of the emergency forces and the emergency site is calculated. This function uses miscellaneous parameters, such as one-way-streets and turn restrictions. Applications designed for ambulances use the function of the "travelling salesman problem" for calculating the cheapest way between the location of the patients and the health care centres (hospitals, foster homes, medical specialists). The acquired routes are then shown on the cartographic visualisation tool and sent as GPS-coordinates or as a textual list of directions to the emergency vehicles.

The cartographic visualisation of emergency sites is another important function of EMRT. It is usually presented on a digital map which can be completed with tactical symbols, simple drawings and labels. With the help of GPS transmitters the current position of the vehicles is acquired and visualised with symbols on the map. In additional layers, buildings with high exposure, like hospitals, schools, hotels, etc. can be displayed on the map or retrieved from special building databases. Other GIS functions included in the graphic display of EMRT are the measurement of routes and surfaces and the query of specific emergency data.

1.8 Role of social media:

With the growth of many micro-blogging platforms and social media, news in the internet platform is gaining popularity. Information related to disaster can be extracted from the web. Web 2.0 provides the feature of tag and collective intelligence. These tags present can be used to search, describe feature or extract information. With the use of pattern recognition, social network analysis and information extraction EMRS can learn about the emergency situation and dispatch the relief vehicle to the emergency location rather than waiting for the intimation.

1.9 IVR and emergency response:

IVR, short for Interactive voice response, is a phone system technology that allows a caller (or call recipient) to choose options from a menu. Generally an IVR presents a message and then provides a list of options to the caller. The caller makes selections by touching a phone key or by speaking into the phone.

The use of IVR during an emergency can prove to be a highly effective tool when mass communication is required to deliver important messages to a community. Automated emergency messages can be delivered when an emergency response center is unavailable or has limited personnel. Community alerts can be sent with sufficient information provided to call recipients. IVRs can provide critical information 24 hours a day during an emergency. If callers need to locate the nearest shelters during a disaster, the IVR can use caller information (such as caller id or zip code) to locate the closest emergency support center.

Virtually any information that needs to be provided to the public or first responders can be programmed into the IVR. But as emphasized above, the ability to speak with an operator must be provided at all levels of an IVR menu.

An IVR can also be effectively used when administering the IVR phone system itself. During an emergency, an administrator can use an IVR to control the emergency broadcast. The IVR can prompt the administrator for a PIN number to gain a secure access to the phone system. The actual emergency message can then be either selected using the IVR or recorded over the phone. The administrator then selects groups or individuals to be called by making touch phone selections from an administrative IVR menu. Finally the emergency voice broadcast can be initiated by selecting an option from the phone key menu. This ability allows emergency administrative personnel the flexibility to launch an emergency notification using any landline or cell phone from anywhere with phone service.

1.10 Motivation and problem statement:

Location is an essential component of life today since knowing where we are and how far we are from a specific location is very valuable to us. It helps in saving time and increases efficiency of any system. Moreover, knowing the Geographical location of any person or object adds a powerful new dimension to Information Services and decision-making. *Taking quick decisions is essential in case of any emergencies or possible delays in the selected path. This is where, LBS (Location Based Services) plays a crucial role.*

We are trying to take visualization into another dimension that is visualization in 3D. 3D visualization will be provided so as to make understanding in hilly terrain easier (easy visualization), more realistic and exact location can be pin-pointed (greater accuracy). "Integrating 3D technology into our application is the next step since it allows users to interact with and view products from every angle." In the application the client should not be dependent on any software; it should run on the browser without any plugin.

There are cases where the same name is given to a person as well as a place, which gives rise to ambiguity. To reduce this name-name or name-place ambiguity toponym disambiguation and resolution has to be used. *A model needs to be developed which can point to the most appropriate location.*

1.11 Research Questions and Research Objectives:

The purpose of this project is to develop indigenous open system architecture for geo-enabled real time emergency response. The main objectives of the research are given below

- Development of geospatial database for Emergency Response System in part of Uttarakhand state.
- Real time tracking of ambulances in 3D geo-visualization system.
- Design and development of online Emergency Response System using open system architecture:
    - Reporting of emergency to the relief center.
    - Preparation of rescue and response plan which includes:
        - Selection and display of shortest route from control room to the emergency spot
        - Selection and display of point location of relief center and different hospitals within the area of interest
        - Query tool for attribute and location identification

The research objectives have to be answered from the research questions framed below.

- How to design a geo-Relational Database Management System (geo-RDBMS) for static and dynamic data (data received from ambulance through mobile applications)?
- How can we visualize real time tracking in a 3-D environment?
- What will be the methodology and designing technique behind Emergency Response System?
  - How will emergency be reported to the relief center?
  - What will be the different steps in planning of rescue and response plan?

1.14 Thesis Outline:

Chapter one is the introduction which gives introduction about emergency and location based services then describes about the background of location based services. The reasons for conducting this study are given as motivation further explaining about the problem statement. The research objectives and research questions are further elaborated.

Chapter two is the literature review which discusses about the similar studies done earlier by various researchers and scientist. The subtopics in which this chapter briefly explains are the work done in the field of emergency response and location based services. It also includes previous work on toponyms and 3D visualization using OpenWebGlobe.

Chapter three describes the study area selected and the various data inputs used for this study. It also describes about the field work done and various open source software required.

Chapter four describes the research methodology adopted for the work. Explaining every procedure followed, the chapter focuses on the development of emergency response system and its various counterparts. It also describes the data flow and process flow for different steps.

Chapter five discusses the results. The software developed and its outputs are explained in the chapter. It explains the software developed and its various features available.

Chapter six concludes the study discussing the results. It also discusses the problems, answers the research questions and describes the future work to be extended from this study.

Chapter 2 LITERATURE REVIEW

The literature was studied to address the aims: understanding of the research area, focus on the research questions, planning of the data collection approach, clarification of the meaning of the terms, proper identification of the framework. The most important task was to understand the research domain which is emergency and disaster along with its management. Going through the literature, the focus was on how to develop a system which can fulfil the needs of relief organizations and the system should be very easy to understand. Then the focus was on understanding the meaning of different terms, and then in developing a framework which can fulfil the objectives and answer to the research questions.

The main focus is to provide a timely response system during the times of emergencies and disasters. Disasters and emergencies are part of our life since one can remember. Emergency response is an area which is gaining a lot of interest but the publications in this field are limited as compared to others. The result, analysis and conclusion of prior publications must be in accordance with the conditions as of now, so as to have proper validation and verification. The work of D. McEntire , T. Drabek and E. Quarantelli in the field of disaster and emergency management has very high creditability that they are cited even after more than 25 years of publications.

No person, community or country is immune to disaster. Thus disaster preparedness, rescue and rehabilitation are the way to cope up with the disaster or emergency. This emergency can be very small or can spread very fast if a timely response is not provided. Organizations like FEMA, Red Cross or 108 prepare for any kind of emergency be it a terrorist attack or any man-made or natural disaster. (Haddow *et al.* 2007; Schafer *et al.* 2008)

Emergency response and management needs information and information technology to study the data, do analysis and provide some kind of result to provide fast relief. An effective processing of information should produce digital representation for a common operational picture. These representations ensures that vital and necessary information goes to the appropriate decision-makers to make correct decisions, and from a holistic perspective give strategic direction to emergency responders (Jungert *et al.* 2006). Study by Camp and colleagues in the year 2000 on fire-fighters' work on emergency location concludes that radio communication can be enhanced by prototyping radio communication attributes that tackle the structure of emergency response work level (Camp *et al.* 2000) .

Response to any emergency starts with the mitigation, preparedness and response to it, which is often followed by rehabilitation and reconstruction of assets. Cutter (Cutter 2003) highlights the use of GI science in various steps of emergency management cycle. It also raises the problem faced during emergency situations like user interface, if it is understandable or not; data quantity and quality, real time information and data support, integration of various different data and technologies. Using Geographic information system in emergency management a decision support system is developed for Douglas county in the state of Kansas (Gunes *et al.* 2000). This involves not only crisis reactive response but also to find out the ways to minimize and avoid the ways to repeat the same situations. The system was developed for flood management, which then automated the task of determining the flood probable areas and integrating the results with other spatial information.

There has been a constant growth in field of mobile technologies and wireless infrastructure. This has also change how they can be used to support emergency response. When network connectivity for mobile and distributed actors is less difficult, the attention has been shifted to investigating and formulating design principles and specifications on information systems for emergency response management (Turoff *et al.* 2004; Yuan *et al.* 2005) .In the system, to improve communication among all levels of emergency actors, a secure and redundant infrastructure becomes increasingly important in order to provide integration between mobile and centralized information systems. The improvements of mobile technology capability have initiated a range of studies focusing on how information technology is used by field operative personnel such as police officers, fire-fighters and medical personnel. Considerable attention has been focused on the information technology artifacts in use and the design of such artifacts.

Increase demand to modern technologies and interest in utilizing geospatial information servers to provide useful information and services to mobile users though wireless networks plays a very important factor to LBS advancement. LBS (Cunningham III *et al.* 2010; Junglas *et al.* 2008; Portman *et al.* 2005; Rao *et al.* 2003) is can be taken as a smaller set from a larger one called context aware services, which are information and electronic services which change their behaviour according to the parameter , like location, activity, time or identity, to reflect the context. “Understanding Location based services (LBS) technology and identifying its key components behind service providing then shed some light on the limitation preventing the technology advancement”(Thamer Abulleif). LBS have already proven to be useful as people need information related to their position. Such information is especially important when there is an emergency situation, under stress and in unfamiliar environments. Questions like “where can I find certain assets”, and “how do I get there?” are already offered and well supported by many systems. By using a user’s location a warning message or any kind of safety information can also be sent if they are in defined geographic area, for example if there are chances of flood or hurricane a warning message can be broadcasted to everyone in the geographic boundary.

Conventionally LBS can be used to find the location of person sending SMS or distress phone call. Recently these services are exploited and used in several countries to enhance the already established emergency channels (like internet, television, landline telephones, sirens and radio) as a means to communicate and send time sensitive information. It can also be used to send geoSMS (Namiot 2010; Namiot *et al.* 2012) and zoning a particular area during an emergency or disaster, and if someone enters into that zone a warning message can be displayed or a message is broadcasted in the geozone (Arnold *et al.* 1996). Broadcast alert solution can be provided to notify wireless subscribers within a specific geographic location of emergency alerts which includes alerts like floods, earthquakes, forest-fire, avalanche et cetera.

"The OGC Open GeoSMS Standard provides developers with an extended Short Message Service (SMS) encoding and interface to facilitate communication of location content between different LBS (Location-Based Service) devices or applications. SMS is the open text communication service standard most commonly used in phone, web and mobile communication systems for the exchange of short text messages between fixed line or mobile phone devices" (OGC). GeoSMS is easy to implement and very lightweight. It also provides interoperability between the geospatial and mobile applications that implement OGC standards.

In the operation of location based services GIS plays an important part. LBS is greatly dependent on GIS as it has provided with a well organized methodology to model the terrain and real world structures into digital geographical data format, providing users with reference points to match user's location. It also facilitates in location based emergency by providing maps of same area over a span of time to record the environmental and other changes, and to observe any sign of risk and vulnerability.

Edwardes (Edwardes 2007) in his research considered the issue of how geography must be considered and re-introduced into LBS. This is different from most other work which focuses more on technical issues in relation to the merging of different technologies while giving less importance to geographic considerations. A simplistic systems of spatial representation, or emphasise particular aspects within an LBS in isolation, such as activity, maps, or location modelling, when these can be better dealt through the more holistic viewpoints that geography offers. The emphasis here was on identifying and implementing such a consolidated approach employing different geographical perspectives as a unifying framework

There are many techniques to find out location of the user by aerial triangulation, wireless network, GPRS. Location Based Services using Android Mobile Operating System (Amit Kushwaha 2011) gives us an idea about the android based open source mobile phone a user can access the hardware directly and design customized native applications to develop Web and GPS enabled services and can program the other hardware components like camera etc. A dynamic data model for mobile GIS (WenzhongShi 2009) gives us the advantages of using a dynamic database instead of a conventional one stating the response time becomes $1/3^{rd}$. Issues with spatial temporal integration in mobile databases, their working and real time application performances and on-line queries are also discussed.

Management services like asset and fleet management, provides the location and tracking services for user groups. It can include logistic or shipment supervisor, who can keep a check on the work and status of employees. It can also be used by parents on their children or for tracking of visitors or during adventure sports when the vulnerability is high. The services can range from asset visualization to geofencing or finding the location of stolen object or vehicle. These attributes can be defined according to the user's requirement and the range is very vast.

Presently in market there are many vehicle tracking system available which operates on different form, some are stand-alone models and others follow client-server architecture. While a stand-alone system will improve the performance in terms of speed but client-server architecture will be better in terms of cost. Vehicle monitoring system based on GSM, GIS and GPS proposed by Hui Tan for china's growing logistic industry ensures better management and dispatch of vehicles (Tan 2010).Automatic generation of alarm according to the real time road conditions makes this research unique, it is not solely based on the pre-planned routes which becomes futile in case of any unexpected factor which can arise during vehicle dispatch.

In their research, Cathey and Dailey (Cathey *et al.* 2003) have presented a generic technique for the prediction of transit vehicle arrival/departure. It identifies the activities that are essential in performing the task of prediction, it also relates all the activities in a component based framework. Three components are identified, tracker, predictor, and a filter, which are required for using the automatic location of the vehicle to place it in time and space and to anticipate the arrival/departure at a selected location.

"Mobtrack:24(Miloš Vojinović June, 2011) enables position tracking, monitoring of basic (speed, acceleration, movement, contact) and additional telemetric parameters (fuel level and consumption, vehicle's hydraulics operation, engine temperature, cargo area, etc.). The system also provides alerting on alarm situations and reporting. Mobtrack:24 is used as standalone system, but due to its open architecture, it is easy to integrate it with some business information system". Wanga and Luib discussed the core components of LBS in detail providing a prototype for demonstrating the methodology of upgrading a 2D LBS system to the 3D LBS one (F. Wanga 2008).

Brovelli and Magni have tried to implement solutions for mobile GIS by using Open Source technologies. A client-server solution is provided by using a Java servlet inside Apache Tomcat servlet. Java Mapscript, mapserver and some other classes are used to provide with GIS functionalities. They have also discussed technological aspects of Mobile GIS along with some applications. Other topics like making mobile GIS context aware, integration of the application with the position of user, finding solution to problem of slow speed and connection cost is dealt with. (Brovelli *et al.* 2007).

A GIS (geographical information system) gazetteer is created for referencing place, place name and its geographical coordinates (latitude/longitude). Gazetteer is a "list of geographic place-names and their coordinates. Entries may include other information as well, such as area, population, or cultural statistics. Atlases often include gazetteers, which are used as indexes to their maps. Well-known digital gazetteers include the U.S. Geological Survey

Geographic Names Information System (GNIS) and the Alexandria Digital Library Gazetteer"(ESRI)."The geographical properties of words have recently begun to be exploited for geolocating documents based solely on their text, often in the context of social media and online content. One common approach for geolocating texts is rooted in information retrieval."(Roller *et al.* 2012)

Information retrieval has always been a topic in demand of researchers and a lot of work has been carried out in this field. Increased demand to modern technologies and interest in utilizing geospatial information in our daily life to provide useful information and services to end users is a very important factor in advancement in the field of GIS. An important approach to text mining involves the use of natural-language information extraction. Methods and implemented systems for information extraction approaches and results are summarized on mining real text corpora of biomedical abstracts, job announcements, and product descriptions, along with the challenges that arise when employing current information extraction technology to discover knowledge in text are discussed by Mooney and Bunescu (Mooney *et al.* 2005). A framework for text mining, DISCOTEX (Discovery from Text EXtraction), is presented which uses a learned information extraction system to transform text into more structured data which is then mined for interesting relationships. (Nahm *et al.* 2002).

With the development of many information extraction techniques like Named entity recognition(NER), Rule-based approach, Statistical learning approach, Hidden Markov model(HMM), Maximum Entropy Markov model, Conditional random fields(CRF) , Relation Extraction, Feature Based Classification, Supervised and Unsupervised learning methods user has option to choose between the technique depending upon the information to be extracted (Jiang 2012). The use of unified, relational, undirected graphical models for information extraction and data mining, in which extraction decisions and data-mining decisions are made in the same probabilistic “currency,” with a common inference procedure—each component thus being able to make up for the weaknesses of the other and therefore improving the performance of both (McCallum *et al.* 2003).

Nathanael and Jurafsky describe an approach to template-based IE that removes this requirement and performs extraction without knowing the template structure in advance. Our algorithm instead learns the template structure automatically from raw text, inducing template schemas as sets of linked events (e.g., bombings include detonate, set off, and destroy events) associated with semantic roles (Chambers *et al.* 2011). Information extraction (IE) distills structured data or knowledge from unstructured text by identifying references to named entities as well as stated relationships between such entities. IE systems can be used to directly extricate abstract knowledge from a text corpus, or to extract concrete data from a set of documents which can then be further analyzed with traditional data-mining techniques to discover more general patterns (Mooney *et al.* 2005)

Banerjee and others (Patwardhan *et al.* 2005) searched also in the textual definitions of synsets connected to the synsets of the word to disambiguate. Wikipedia was used by

Overell (Overell *et al.* 2006) to develop WikiDisambiguator, which takes advantage from article templates, categories and referents. Leidner (Leidner 2004) uses heuristic and supervised machine learning algorithm for removing geo-geo ambiguity. A taxonomy for TD methods that extends the taxonomy for Word Sense Disambiguation methods has been proposed in Buscaldi and Rosso (Buscaldi *et al.* 2008). According to this taxonomy, existing methods for the disambiguation of toponyms may be subdivided in three categories: map-based: methods that use an explicit representation of places on a map; knowledge-based: they exploit external knowledge sources such as gazetteers, Wikipedia or ontologies; data-driven or supervised: based on standard machine learning techniques.

Kevany (Kevany 2003) identifies eight different shortcoming categories each with at least five individual challenges. The most prominent constrains identified by Cutter (Cutter 2003) , ESRI, and Kevany (Kevany 2003) are that (a) users need extensive training to operate a GIS, (b) group work functions have not been implemented, (c) real-time data are often not accessible, (d) data formats are sometimes incompatible, and (e) the data quality frequently does not match the requirements. In the light of 9/11 many researchers and developers are working on the removal of these shortcomings, e.g. the integration of real time data (Kwan *et al.* 2005), interoperable GIS (Rocha *et al.* 2005) and improvements in spatial data infrastructure (Maguire *et al.* 2005).

"Geospatial information is critical to effective, collaborative decision-making during emergency management situations; however conventional GIS are not suited for multiuser access and high-level abstract queries. Currently, decision makers do not always have the real time information they need; GIS analysts produce maps at the request of individual decision makers, often leading to overlapping requests with slow delivery times". In order to overcome these limitations, a paradigm shift in interface design for GIS is needed. Rauschert and others attempted to overcome analyst-driven, menu-controlled, keyboard and mouse operated GIS by designing a multimodal, multi-user GIS interface that puts geospatial data directly in the hands of decision makers (Agrawal *et al.* 2004; Rauschert *et al.* 2002a; Rauschert *et al.* 2002b).

During the response phase of any emergency or disaster, the organizational structure should be based on the strong co-operation between several departments like the health services, fire department, municipality, police stations and the local government. The scale of emergency defines the size of organization required. In their paper on location interoperability for Medical Emergency Operations (van der Togt *et al.* 2005), they argue through a process oriented approach on location, can improve the quality of somatic health care process during disaster. This can be done by providing and sharing relevant information across different organization and within the healthcare. E-911, in the United States of America, uses location services to locate an emergency call from a cellular or fixed phone. The location can be provided by the operators in case of emergencies. On studying the accuracy was the following: (1) for network-based solutions: 100 meters for 67% of calls, 300 meters for 95 percent of calls; (2) for handset-based solutions: 50 meters for 67% of calls, 150 meters for 95 percent of calls (Zagami *et al.* 1998).

Emergency management requires decision makers in an Emergency Operation Centre to (a) gain fast access to critical geospatial data, (b) rely on team work and derive information from geospatial data collaboratively, and (c) coordinate and execute decisions quickly. Successful geoinformation technology needs to meet these requirements; otherwise the technology might not be used in response and rescue missions (Fuhrmann *et al.* 2008; Van Oosterom *et al.* 2006). This tells us what the drawbacks of present developed software and approaches are. It also informs us what is required as of now and what approach one should follow.

Presently the hospitals operates an emergency system which is very basic that is they don't have tools like mobile communication, digital maps et cetera. Communication between the base hospital and ambulance unit is done by walkie-talkie or radio based. All the emergency and distress calls (that is 108 or 911) will be channelled to a centralised unit, called "Call Centre". This centre then appoints one ambulance to the disaster location, which is equipped with only two medical personnel including one driver. In normal circumstances the injured person will be then transported to the hospital without any details information being relayed to the base hospital. This approach does not give prior information to the hospitals about the extent of severity or emergency happened.

A system has to be developed which will focus on the third level, which is providing communication channel between ambulances and hospitals. This will be providing support in two directions: guiding the ambulances to the place of accident (especially important in large urbanized city areas) and supplying with the information about the condition of the injured people before transporting them to the hospital. It may also happen that due to damages or construction of roads or houses (as the disaster situation develops), the transportation of the patients has to be postponed and the injuries have to be treated locally.

Rahman and Zalantova proposed a pre-emergency hospital system for Malaysia by describing the present hospital scenario and highlighting the need of LBS for managing the emergency situations and the scenes between ambulance and the emergency unit at the base hospital (Rahman *et al.* 2006).

3D information is rapidly increasing, which is partly due to the fast data acquisition techniques such as terrestrial laser scanning and photogrammetry. 3D data can bring people more vivid presentations of the real world, for example, a person walks in a virtual world surrounded by 3D simulated reality objects for tourism or shopping, or a scientist estimates the climate disaster via an interactive 3D scene. Therewith 3D GIS has been paid more attentions in GIScience, including researches on 3D data modelling, visualisation, query and analysis. Although implementing 3D GIS is not an easy task, those promising and attracting features represented by 3D virtual world will be widely spread and extended to the current 2D GIS step by step. The state-of-art technology towards 3D LBS is also analyzed(Zlatanova *et al.* 2002; Zlatanova *et al.* 2003) along with discussing the approach for 3D visualization and complex analysis with 3D structuring and topology.

3D visualization is more intuitive in stress situations (Zlatanova *et al.* 2004), and during disasters like flood or earthquake, exact information can be gained through visualizing the situation in 3D. It gives very good idea on the loss or area disturbed especially when we know the terrain is not flat and there are many human made building which are have more than 2 floors.

Openwebglobe (Loesch *et al.* 2012) developed by Loesch and team is based on HTML5 and WebGL. The OpenWebGlobe SDK consists of two main parts: first, the OpenWebGlobe Viewer part, it consists of a JavaScript library which allows the integration of the OpenWebGlobe into custom web-applications. Second, the OpenWebGlobe Processing Tools, a bundle of tools for bulk data processing, e.g. tiling or resampling of large geospatial data sets. This pre-processing is required by the viewer part to enable scalable fragment-based, streamed download and visualization of data. It is a "highly performant, extensible and rapidly evolving alternative to commercial virtual globes"

Chapter 3 STUDY AREA and DATA USED

3.1 Study Area

The study area selected for the study is Dehradun city. Nestled in the mountain ranges of the Himalaya, Dehradun is one of the oldest cities of India and is declared as the Provisional Capital of the Uttarakhand State. Dehradun is in the Doon Valley on the foothills of the Himalayas nestled between two of India's mightiest rivers — the Ganges on the east and the Yamuna on the west. The city is famous for its picturesque landscape and slightly mild climate.

The headquarters of many National Institutes and Organizations like ONGC, Survey Of India, Forest Research Institute, Indian Institute of Petroleum etc are located in the city. Some of the premier educational and Training Institutes like Indian Military Academy, RIMC (Rashtriya Indian Military College), Indian Institute of Remote Sensing (IIRS), Indira Gandhi National Forest Academy (IGNFA), Lal Bahadur Shahstri National Academy of Administration (LBSNAA) etc are also there in Dehradun. (2014a)

3.1.1 Geographic location of Study Area

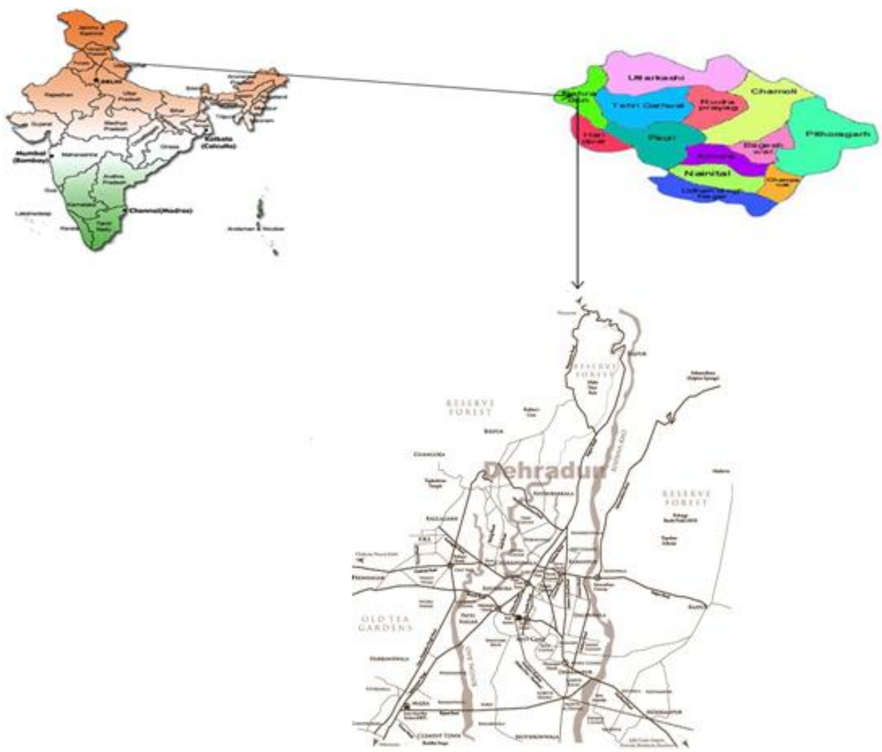


Figure 3-1 Study Area Map Dehradun (*NIC* 2014)

Dehradun lies between 29° 58’ and 31°2’ 30” North latitudes and 77° 45”and 78°18’ 30” East longitude. Located at an altitude of 640 meters above the mean sea level, it has an area of 3088 square kilometers.

3.2 Data Used

To achieve the specific objectives and answer the research questions, primary as well as secondary data has been used in the study.

3.2.1 Primary Data:

IRS P6 (Ressoucesat-1) Linear Imaging Self Scanner-IV (LISS IV) satellite imagery of the Dehradun city for the year 2013 was used as the primary geographic data source. For elevation CartoDEM, from Cartosat 1 was used. The following are the specification for LISS IV image and CartoDEM.

LISS IV
Satellite Sensor Name: LISS IV
Resolution: 5.8 m (MSS)
Bands: Green, Blue and Red
Swath: 23km (MSS)

CartoDEM

CartoDEM is an Indian National DEM generated from Cartosat-1 stereo data. Cartosat-1, launched in May, 2005, is an along track (aft −5°, Fore +26°) stereo with 2.5 m GSD, give base-height ratio of 0.63 with 27 km swath. The operational procedure of DEM generation comprises stereo strip triangulation of 500 × 27 km segment with 10 m posting along with 2.5 m resolution ortho image and free—access posting of 30 m has been made available (bhuvan.nrsc.gov.in). A multi approach evaluation of CartoDEM comprising (a) absolute accuracy with respect to ground control points for two sites namely Jagatsinghpur -flat and Dharamshala- hilly; second site i.e. Alwar-plain and hilly with high resolution aerial DEM, (b) relative difference between SRTM and ASTERDEM (c) absolute accuracy with ICESat GLAS for two sites namely Jagatsinghpur-plain and Netravathi river, Western Ghats-hilly (d) relative comparison of drainage delineation with respect to ASTERDEM is reported here. The absolute height accuracy in flat terrain was 4.7 m with horizontal accuracy of 7.3 m, while in hilly terrain it was 7 m height with a horizontal accuracy of 14 m. While comparison with ICESat GLAS data absolute height difference of plain and hilly was 5.2 m and 7.9 m respectively. When compared to SRTM over Indian landmass, 90 % of pixels reported were within ±8 m difference. The drainage delineation shows better accuracy and clear demarcation of catchment ridgeline and more reliable flow-path prediction in comparison with ASTER. The results qualify Indian DEM for using it operationally which is equivalent and better than the other publicly available DEMs like SRTM and ASTERDEM.

Applications of CartoDEM:

- Contour generation
- Drainage network analysis
- Quantitative analysis of run-off & soil erosion
- Volume-area calculations
- Design of hydraulic structures
- Design of new road, rail & pipeline alignments
- Watershed planning
- Urban utility planning
- Landslide zonation
- River configuration studies & flood proofing
- Fly through visualization

DEM is one of the important input for creation of ortorectified image product. All imagery, whether it is obtained from airborne or space-based sensors, has inherent problems. There are distortions caused by the angle between the camera / sensor and the ground, distortions from the movement of the camera through the air or space, and distortions created from variations in terrain. The image data must be prepared in a way that removes distortion. This process is called orthorectification.

By giving the appropriate inputs, a rigorous model can be computed that corrects for the distortions introduced by the camera optics, viewing angles, and terrain relief. With an accurate calculation of this model, pixel and line locations in unreferenced imagery can be mapped to real world positions on the earth's surface. This results in a planimetrically correct image. The scale of the image is uniform, and usually created to match popular map scales. The orthorectification process transforms imagery from a simple picture into a valuable source of information from which information can be extracted.

Orthorectification converts imagery into map-accurate form by removing camera and terrain related distortions through the use of sensor and terrain (elevation) information. The resulting orthoimages can be directly applied in remote sensing, Geographic Information System (GIS) and mapping applications. After ortho-correcting images to pinpoint accuracy, image data can be combined with GPS, elevation, CAD, and other geospatial layers, creating a rich database for planners. Classification, 3D visualization and change detection, can support applications ranging from transportation corridor planning to pollution plumes, urban tree canopy health, and groundwater supply

3.2.2 Secondary Data:

Secondary data involved digitizing vector objects from LISS IV satellite imagery to create the road layer for Dehradun city area.

3.3 Open Source Products:

Implementation of Emergency Response System was done by using Open Source products. They all are available free of cost from their respective websites. Below is the brief introduction of the software used.

- *OpenGTS* – It is used for developing a system for tracking of emergency vehicles.
- *GeoServer* - Dehradun's road network layer, hospital layer and landmark layer was published using GeoServer
- *PostgreSQL* - The different landmark location was stored into the database for further use.
- *Quantum GIS* - It was used to digitize the dehradun city's road network for shape file creation.
- *uDig*- It is a GIS software which is used to customize styles, which can be imported into GeoServer, namely hospitals, landmarks.
- *Openlayers*- Openlayers were used to publish the shape files with the defined custom style.
- *OpenGeo suite*- OpenGeo Suite is a complete geospatial platform for managing data and building maps and applications across web browsers, desktops, and mobile devices
- *Android ADT* - To customize an android application.

3.4 Field Survey:

While telling anyone about the address, it becomes easier if we can guide them through landmarks like school, hospital, shopping mall et cetera. It also becomes easier to locate a particular address if we know the places surrounding it. It was also observed that the road network of Dehradun city is not defined the way other metropolitan city has. Without any clear landmark, it was becoming difficult to track a vehicle. It would also help to pin point the exact location in case of any emergency. Therefore it was decided to collect the prominent landmarks like police station, fire station, hospitals, hotels, schools and colleges within the study area.

We can add these landmarks location on the map, as an added value. It would serve operator information about various places, in case required during emergency call.

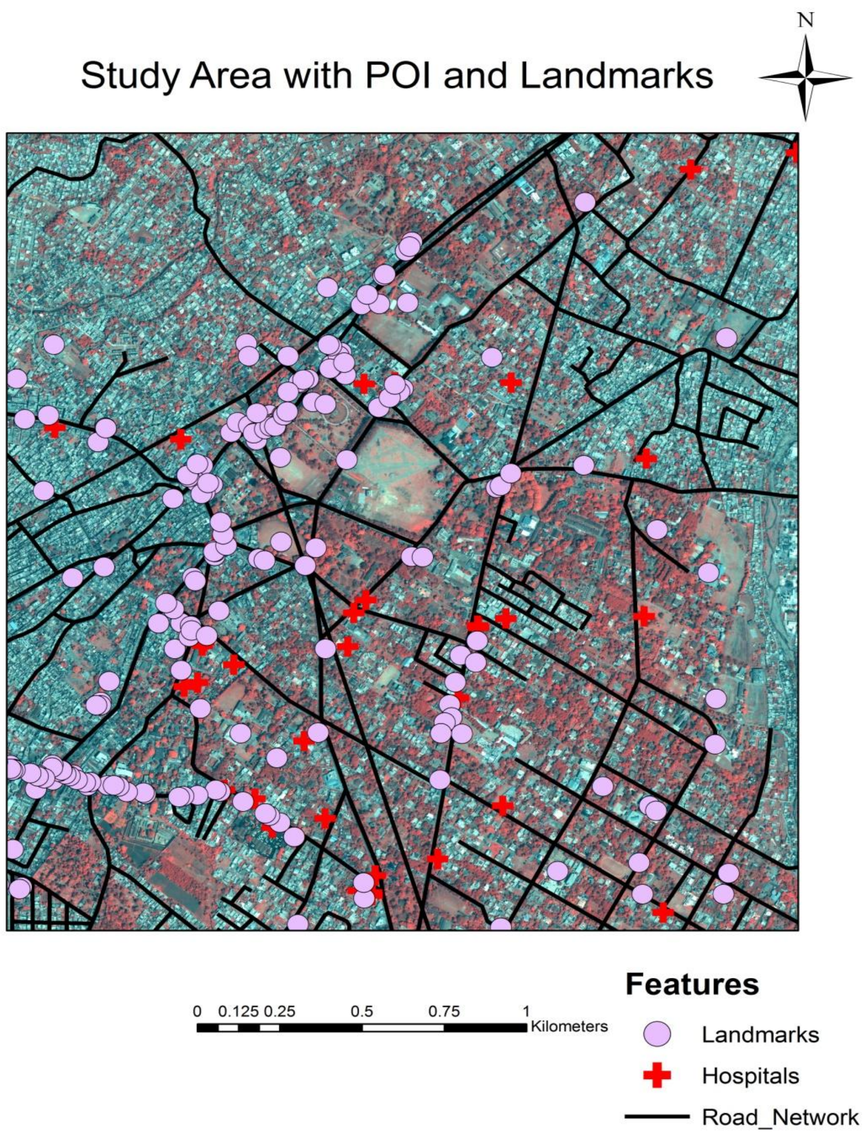


Figure 3-2: Study area with landmarks

In order to complete the above task a field survey was undertaken in the month of August and September to collect around 600 points with the help of mobile device Sony Xperia Z, which takes GPS for obtaining the location. Its accuracy was found to be 10-15m. The points were collected in the mobile phone's database and were transferred to the server for further processing. Survey time is the most time consuming but it's the best and most reliable way to obtain point location.

3.5 Hardware and Software Requirement:

3.5.1 Software Requirement:

3.5.1.1 Open GPS Tracking System (OpenGTS):

OpenGTS (Martin 27 May 2014) is an open-source application which can be used for tracking of vehicle and devices. More than 110 countries are using it successfully. It is written in java and can be customized according to the user requirements. It provides a generic back-end for viewing and applying query on GPS-related data. It can operate independently on any tracking protocol or device format. It is compliant with OpenDMTP (Open source Device Monitoring and Tracking Protocol)) but also supports other device protocol formats. OpenGTS is designed to independent of device and protocol on the server side. A specific Device Communication Server (DCS) is required to communicate with the remotely placed GPS device and to place the data in the SQL database for viewing on the digital map. We can simultaneously track more than one vehicle using OpenGTS. Following are the features of OpenGTS.

- Operating System independent: It is written in Java including Apache Tomcat for web service deployment and MySQL for database store.
- Multi User: Each account can handle many users with each having unique login and controlled access within.
- Independent GPS tracking: Devices from various manufacturers can be tracked. It supports tracking devices like Aspicore GSM tracker for Nokia Samsung, and Sony Ericsson phones phones, Sanav GX-101, Andriod phones, face protocol, MotoDMTP GPS tracking support for Motorola boost mobiles.
- Mapping service: OpenGTS has support of OpenLayers/OpenStreetMap along with Google Maps, Microsoft Virtual Earth and Mapstraction.
- Reports: Reports can be customized in summary or in detail to show data for a specific device or vehicle.

3.5.1.1.2 System Architecture:

Below is the figure showing the basic system architecture of OpenGTS. Various DCS runs as segregated process on Java. The servlets for web-interface or other DCS run inside a servlet container. DCS are the modules which receives the location from the GPS device.

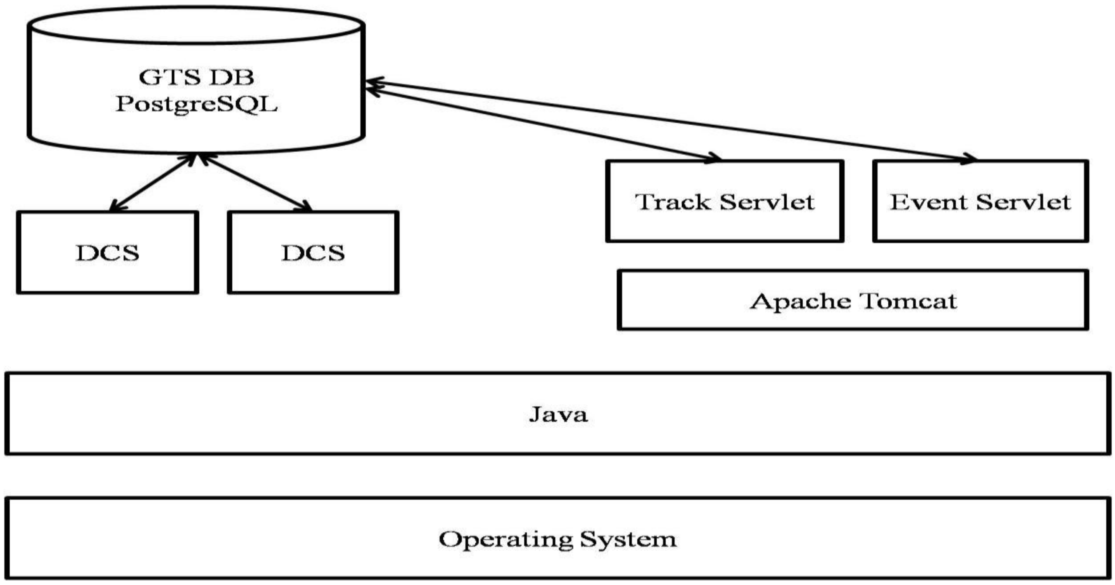


Figure 3-3 : System Architecture

3.5.1.2 WebGL (Web Graphics Library)

It is a JavaScript API for rendering interactive 3D graphics and 2D graphics within any compatible web browser without the use of plug-ins (2014b). It can be used with HTML for some part of page or background very easily. Its code is written in JavaScript and GPU unit of computer is used to execute the shader code. For the application to run successfully, the browser should support WebGL.

3.5.1.3 Android ADT (Android Developer Tools)

It is a plug-in for Eclipse, which is an integrated development environment; which extends the capabilities of eclipse by allowing us to set up new projects, creating an application user interface. On the basis of Android Framework API, it allows us to add packages; lets us to debug the application and allows to export the application (.apk files) for distribution.

ADT provides GUI access to many of the command line SDK tools as well as a UI design tool for rapid prototyping, designing, and building of application's user interface. It also comes with the XML editors, emulators and various options for debugging. It is also integrated with other tools like Traceview, android, Pixel Perfect, Hierarchy Viewer, DDMS, adb and ProGuard.

ADT can either be configured with already installed eclipse or an ADT bundle can be downloaded from the internet. For configuration we can use the option of install new software within eclipse and after selecting the ADT plug-in we can install it (ADT 2014).

3.5.1.4 PostgreSQL/PostGIS

PostgreSQL is an ORDBMS (Object Relational Database Management System). The different landmark locations, hospitals details and road network are stored into the database. This data was sent into geoserver for publishing. The geolocation received from remote device is also stored into the database. PostGIS is used to provide the spatial objects for PostGreSQL. It then allows queries related to mapping and location information (Leidner 2004).

3.5.1.5 OpenGeo Suite

It is a complete geospatial platform for managing data and building maps and applications across web browsers, desktops, and mobile devices. It contains GeoExplorer, GeoServer, GeoWebCache and PostGIS. Geoexplorer allows to publish maps and it is customizable. GeoServer loads data from PostgreSQL and is used to publish it as WMS in openlayer format. GeoWebCache allows to cache tiled images from various sources (BoundlessGeo).

3.5.1.6 Quantum GIS (QGIS)

QGIS is an open source alternative to ArcGIS. It allows user to view, analyse and edit spatial data. QGIS is used to digitize the road network.

3.5.1.7 uDig

uDig is an open source styling editor, written in Java. It is used to edit and style the shapefiles before publishing for better visualization.

3.5.2 Hardware Requirement

3.5.2.1 Central Controlled Unit

It is the main processing system of whole application. It should be able to handle heavy traffic flow. Therefore a high-end computer was used to configure openGTS. A static public re-routable ip was also provided to the machine. This ip can be accessed from outside the firewall.

3.5.2.2 GPS Device

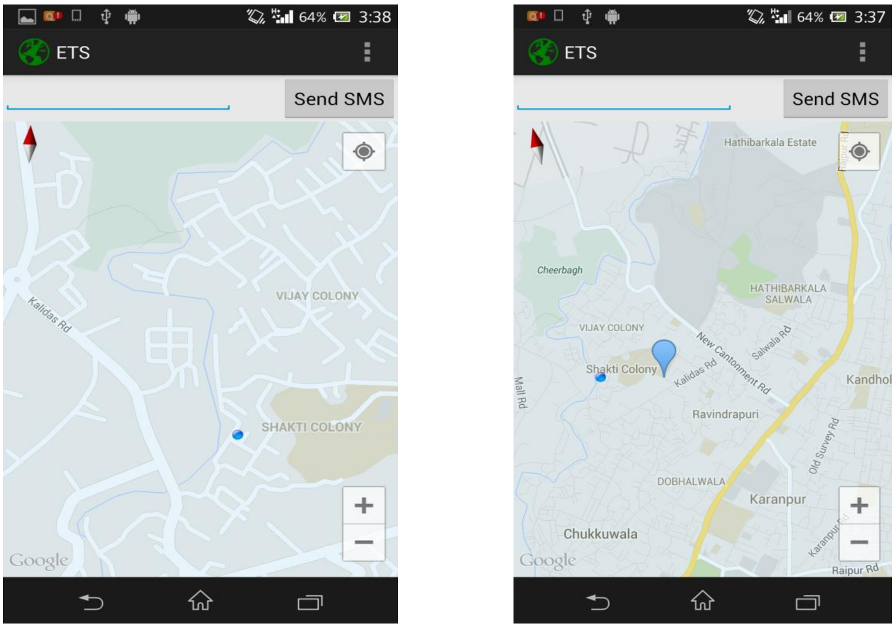


Figure 3-4 ETS for sending location

A remote device which will send the geolocation to the Device Communication Server. For sending the location a device is required which has the capability to access the GPS location and can send it while adhering to http based communication protocol. For this we have used Xperia Z, which is an android phone and GPS and GLONASS enabled. An android application ETS (Emergency Tracking System) was written which will send the latitude, longitude, IMEI number, Timestamp (which includes date and time). IMEI number was used as the primary key and to identify the device during tracking. In the android code, the server address was fixed which was the public ip of the machine along with the port number on which the application was installed. The application was sending the geolocation after every 20 seconds to the server.

Chapter 4 METHODOLOGY

An emergency response plan needs to be robust, accurate and precise. This plan should be made such that it can easily function in almost all the cases. Emergency response system in itself is a fairly large system which can be further subdivided into various sub-systems and each of them will have a different approach.

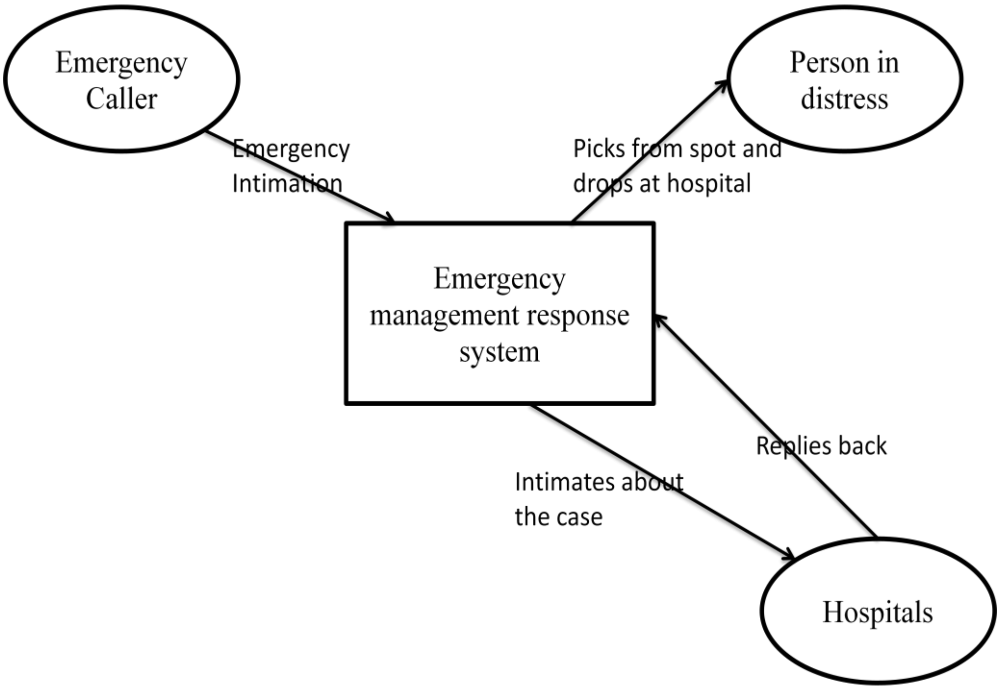


Figure 4-1: Context level DFD for EMRS

The very basic task of the application is shown in figure 4.1, whenever an emergency caller intimates the EMRT about the emergency or accident, it sends ambulance to pick up the person from hospital and drops the person off to the hospital. The system also informs the hospital about the emergency (type of emergency, number of causality and how much time is required) and the hospital reverts to the EMRT. This data is then stored into the database for record and training purposes.

The very first step while developing an emergency response plan is to know all the features present in the particular area which includes road network, relief centers, hospital and landmark geolocation for emergency spot identification. The proposed study uses data from different sources as road network, landmarks and schools, digital elevation model from CartoDEM. Firstly a Geo-RDBMS is created to store dynamic and static data. In this Geo-

RDBMS data from different sources is stored and this data is of different types that is points, line, polygon, isolines etc. Steps in database creation are:

- Data collection and analysis
- Building a conceptual model
- Building and validating logical data model
- Designing physical schema

Volunteered geographic information (VGI) from various sources such as gazetter data, data from OpenStreetMap, Bing map etc is collected. This data is then analyzed for missing values and gaps. The gaps are then filled by manually digitizing or editing the dataset. Landmark and hospital data is created with the use of GPS enabled device. This data is then analyzed for redundancy and for toponym disambiguation and resolution. It involves the task of assigning geographic location to any name. Different entities and relationship between them is defined which attempts to resolve any ambiguity, if present, which ensures that there is no problem with different interpretation of concepts and terms. A logical data model is created and validated for any kinds of errors and then physical schema is designed for data storage.

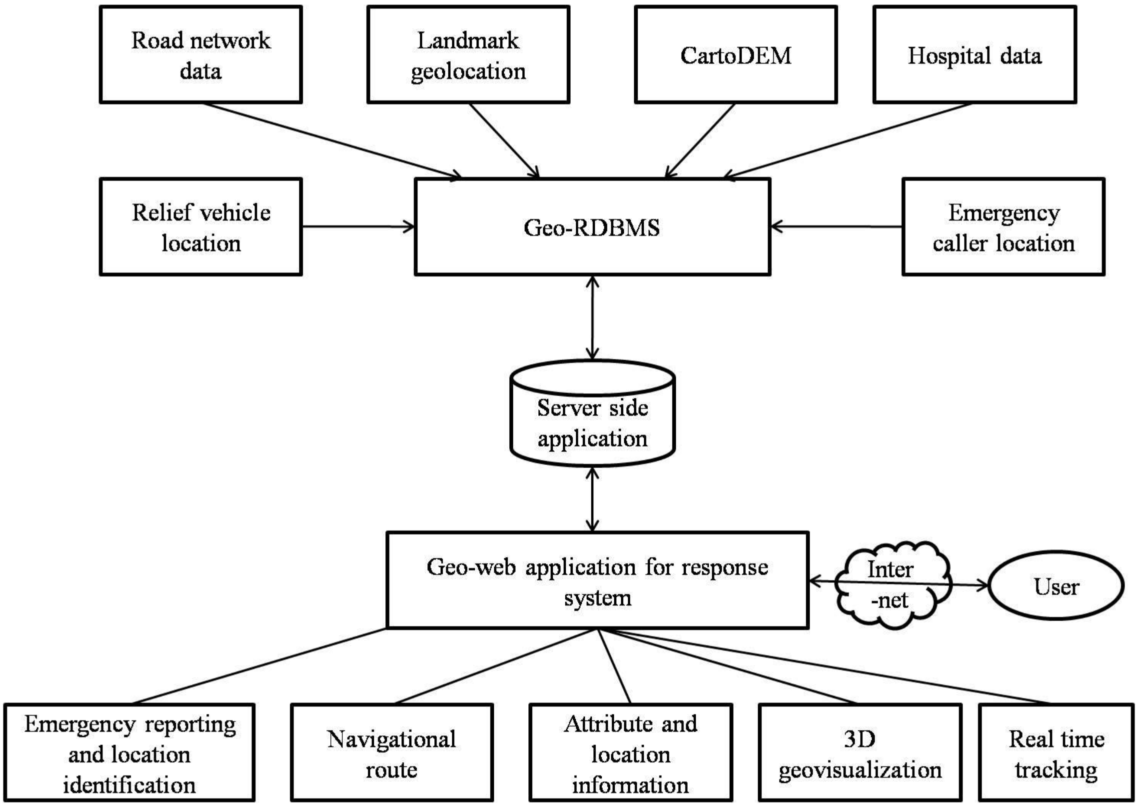


Figure 4-2: Methodology

Figure 4.2 shows complete methodology designed for emergency response system in this study. Data collected from various sources are inserted into the database. A thick server side application is developed for receiving the location, firing queries on the database and displaying information. Client side application is thin so that the users need not to install any plug-in or software to use the application. A thick server means that all the processing, data is on the server and it's client side is thin application; which means that the client will need to communicate with the server on which processing is done. There is no need to install any software or plug-in on the client machine to use the application, they just need to be connected to the cetral server via internet.Thin client allows to manage the softwares installed on the user's machine.

Real time tracking of ambulance is done and is then displayed in 3D geo-visualization on the plug-in free web browser. For tracking, the ambulance has a phone whose operating system is Android and an application is developed and stored in it which sends the latitude and longitude information after every 5 to 8 seconds, which is again customizable according to the user's requirement. This information is stored in the database and is used for tracking purpose and height profile is added with the use of cartoDEM of the area, which is done by preprocessing the cartoDEM which can then be used by openwebglobe. The height profile gives EMRS can monitor the last current location of all the relief vehicles, it can view vehicles in a group as well and in case of any fault in the vehicle it can be communicated to nearby en route vehicle for the backup.

Emergency can be reported to the relief center via a call or a text message. This EMRS can also work as a control centre with a common dialing number and all the calls or messages will be served with EMRS. The location or buffer of location where relief and rescue is required will be displayed on the computer's browser in relief center. This location can be identified by:

- By the use of GPS service.
  If the caller has enabled GPS facility in his/her cellular phone then the location within the accuracy of 5m will be displayed on the computer screen
- By intimating about emergency through call
  A person when intimating about the emergency will also inform about the location. The accuracy of this location depends upon the precision with which information is shared.
- By information extraction through the text message which informs about the emergency and its location.
  A person can inform about emergency even through a text message stating the type of emergency and the location in which the emergency has occurred. In this the accuracy depends upon the precision of location provided in the text message. Information for the keyword and landmark identification will be retrieved from the text message using natural language processing. The identified landmark will be then displayed on the browser.

4.1 Shortest Distance

A rescue and response plan is provided which includes the shortest possible route from the relief centre to the emergency spot. This shortest route is calculated on the basis of time required to travel from one point to another, type of traffic allowed on the road (one-way or both-way), the width and elevation of the road. We have provided weight on the basis of elevation of the road, curvature of the road and the traffic density present in the road at the given time. Elevation and curvature information was stored into the database and was used from there but the traffic information is dynamic and changes after every few minutes. This real time data can be collected by sensors and passed into the database for further processing. The weight was calculated by taking average of the DEM value on the starting and ending point of the road, this weight was then stored into the database.

```
gpspoint=shf.nodes()[353]
#because hospital nodes dont fall on the road network
newhosplist=[]
for value in hosplist:
    for points in shf.nodes():
        if abs(list(points)[0]- value.points[0][0])<=0.001 and abs(list(points)[
# for finding the shortest path and shortest length
i=flag=0
for value in newhosplist:
    try:
        Distance=networkx.shortest_path_length(shf,gpspoint,value,weight='LENGTH
        shortestpath=networkx.shortest_path(shf,gpspoint,value,weight='LENGTH')
        if  flag==0 or Distance<Shortestdistance:
            Shortestdistance=Distance
            shortestlength=shortestpath
            flag=1
    except networkx.NetworkXError: x=0
    except networkx.NetworkXNoPath: x=0
#Creating the output - Required distance, path
print "The distance from the gps point to the nearest hospital: ",Shortestdistan
outputpath=networkx.Graph()
for everynode in shortestlength:
    outputpath.add_node(everynode)
    if i!=0: outputpath.add_edge(everynode, shortestlength[i-1])
    i+=1
```

Figure 4-3: Shortest distance code snippet

For calculating the shortest route, we wrote a python program. This program imports pyshp and networkx library and then finds the shortest route using A* algorithm (Nosrati *et al.* 2012). The shortest route is saved as a shape file and this is then displayed as a WMS using geoserver. Figure 4.3 shows the snippet of the code for calculating the shortest distance. Pyshp is the python module which supports python program to read and write ESRI shape files. Networkx is also the python module which allows python program to create, manipulate and study the structure and functions of complex networks. A* algorithm is a computer algorithm used to traverse the nodes and find out the shortest between the nodes. It uses a best-first search and finds a least-cost path from a given initial node to one goal node. As the algorithm traverses the graph, it follows a path of the lowest expected total cost or distance, keeping a sorted priority queue of alternate path segments along the way.

Just after the emergency the victims will be transferred to nearest hospital for first aid and from there they can be shifted to multispecialty hospital for further treatment. For this we have modified the code to take the input from the user and using Common Gateway Interface (CGI) module we read the input check the condition if the speciality matches otherwise refer to the nearest multispecialty hospital.

```
form = cgi.FieldStorage()
#because hospital nodes dont fall on the road network
newhosplist=[]
for value in hosplist:
    for points in shf.nodes():
        if abs(list(points)[0]- value.points[0][0])<=0.001 and abs(list(points)[
# for finding the shortest path and shortest length
i=flag=0
for value in newhosplist:
    if speciality=='multispeciality' or speciality==form.getvalue('spec'):
        try:
            Distance=networkx.shortest_path_length(shf,gpspoint,value,weight='LE
            shortestpath=networkx.shortest_path(shf,gpspoint,value,weight='LENGT
            if  flag==0 or Distance<Shortestdistance:
                Shortestdistance=Distance
                shortestlength=shortestpath
                flag=1
            except networkx.NetworkXError: x=0
            except networkx.NetworkXNoPath: x=0
#Creating the output - Required distance, path
print "The distance from the gps point to the nearest hospital: ",Shortestdistan
outputpath=networkx.Graph()
for everynode in shortestlength:
    outputpath.add_node(everynode)
    if i!=0: outputpath.add_edge(everynode, shortestlength[i-1])
    i+=1
networkx.write_shp(outputpath,"C:/Users/Desktop/output")
projectionsystem=open("C:/Users/Desktop/output/edges.prj",'w')
```

Figure 4-4: Shortest route to specialized hospital

The time required to travel from one place to another depends upon the distance and speed, in hilly terrain the speed is less due to the slope of roads; so there can be cases, when the shortest distance doesn't necessarily takes the minimum time to reach from point A to point B. Considering this case we included the elevation of the study area to find out the shortest route. We decided to use the smart terrain algorithm(ST) as explained by Yu (Yu *et al.* 2003). Since the algorithm was developed using the existing GIS software, it is easy to use with our application. Unlike other algorithms (Collischonn *et al.* 2000; Douglas 1994), the smart terrain algorithm considers that not all the paths can be isotropic.

The code was written in python and we have used CartoDEM for height profile. Since its raster data, we use neighbourhood cells to form the connection and find the shortest route between two points; it uses Rook's (4 cell), Queen's (8 cell) and knight's (16 cell) pattern to connect the cells with each other. We have used the equations created by Yu (Yu *et al.* 2003) for calculating the spatial distance and the slope. The equations are:

$$D'_{(o,p_i)} = \sqrt{u^2 + (H_{p_i} - H_o)^2} \qquad \text{where i= 2,4,57} \qquad (1)$$

$$D'_{(o,p_i)} = \sqrt{2u^2 + (H_{p_i} - H_o)^2} \quad \text{where i= 1,3,6,8} \quad (2)$$

$$D'_{(o,p_i)} = \sqrt{5u^2 + (H_{p_i} - H_o)^2} \quad \text{where i = 9-16} \quad (3)$$

In equation 1-6 H_i is the height of the cell, u is the horizontal width of each cell (depends upon the DEM being used), D is the spatial distance from point O_i (center) to P_i For calculating the slope, we used

$$\theta_i = \arctan\left(\frac{H_{p_i} - H_o}{u}\right) \quad \text{where i = 2,4,57} \quad (4)$$

$$\theta_i = \arctan\left(\frac{H_{p_i} - H_o}{\sqrt{2u^2}}\right) \quad \text{where i = 1,3,6,8} \quad (5)$$

$$\theta_i = \arctan\left(\frac{H_{p_i} - H_o}{\sqrt{5u^2}}\right) \quad \text{where i = 9-16} \quad (6)$$

We then calculated the anisotropic cost for traversing from one cell to another one. Using anisotropic cost surface we can restrict the direction of vehicle's movement according to the characteristic of terrain. The equation used for this is

$$CC_{(O,P_i)} = D'_{(O,P_i)}\left(\frac{C_o + C_{p_i}}{2} + \theta_i weight\right) + CC_0$$

Now the algorithm will calculate the most probable path and then will check if there is a bridge or tunnel in that. Then will calculate whether the connection is true or false one, for the connection to be true it should have only two intersection. The algorithm then provides with the shortest route. ST algorithm is more suitable for identifying the new road layout based on DEM.

EMRS can dispatch vehicles according to the size of the road tracks. The road network created includes the width of the roads. So according to the width the ambulance can be dispatched for example if the track is narrow then a small relief vehicle should be sent instead of a big ambulance. Since we are using WebGL based solutions and the profile of DEM can be done under spatial analysis, hence we are unable to find the width using DEM.

4.2 Vehicle Tracking

For tracking of vehicle, geolocation of the device is required. We can get latitude/longitude by using GPS. Android phone/tablet receives the GPS signals from the satellite and sends the information to the server via GPRS packet after a predefined time interval. The information sent is namely location, timestamp and IMEI number. The server program then inserts this information into the database for further processing and then display on the web interface. The interface displays the location of vehicle and it can be combined with other information if required.

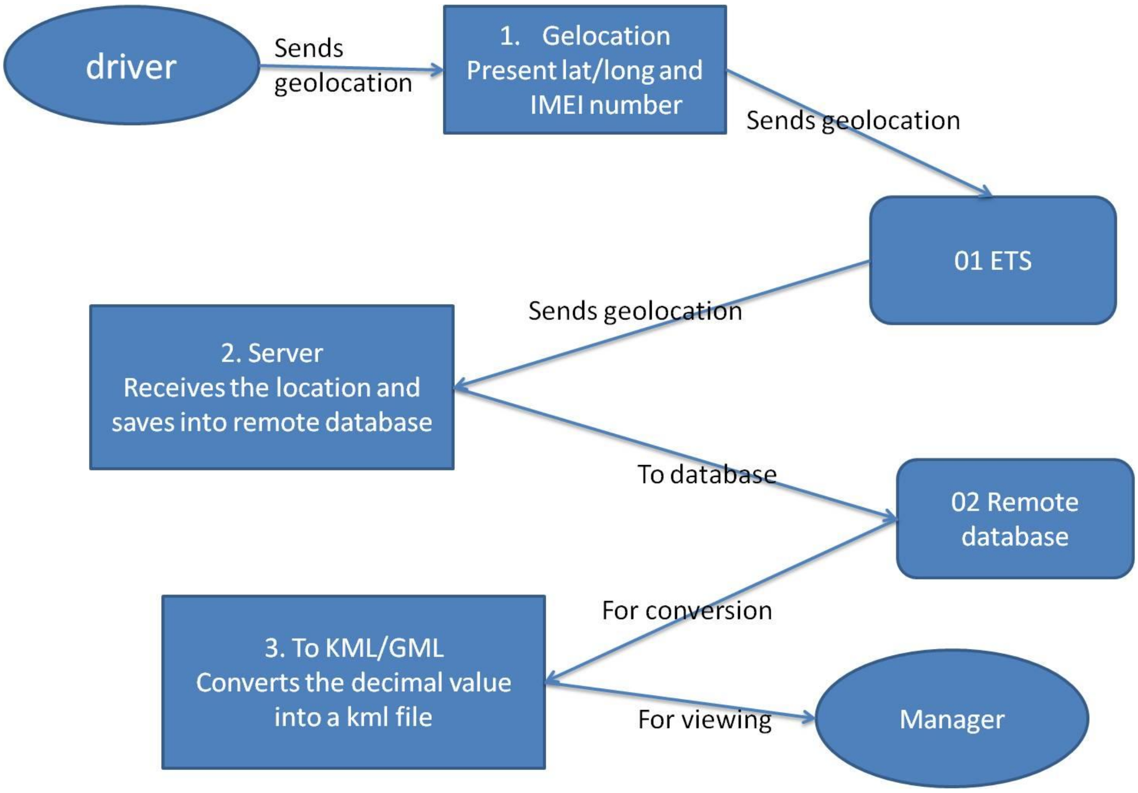


Figure 4-5: DFD for vehicle tracking

4.3 3D visualization:

3D visualization is done using OpenWebGlobe (http://www.openwebglobe.org/about/ 2014). It helps build 3D application in browser. This uses WebGL which enables the applications to run on the browser without any plug-in. We can use different types of data with it like elevation data, 3D objects, image files etc. It has two components, one is to visualize the data on the web interface and other one is to pre-process the data.

4.3.1 Visualizing data:

We have used OpenWebGlobe within the HTML tags. A JavaScript library is included which allows us to integrate it with other web applications.

```
        layer   : "World500",
        service : "i3d"
    };
    var trial_img =
    {
      url : ["http://localhost:8090/Openwebglobeprocessing/bin/process"],
      layer : "trial",
      service : "owg"
    };
    var elvSRTM_CH =
    {
        url     : ["http://localhost:8090/Openwebglobeprocessing/bin/process"],
        layer   : "trialelev",
        service : "owg"
    };


    ogAddImageLayer(globe, imgBlueMarble500);
    ogAddImageLayer(globe,trial_img);
    ogAddElevationLayer(globe, elvSRTM_CH);
    ogSetRenderFunction(ctx, OnRender);
    ogSetBackgroundColor(ctx, 0.2,0.2,0.7,1);
}


</script>

</head>
<body onload="main()" style="padding:0px; margin:0px; overflow:hidden;">
    <div style="text-align: center">
    <canvas id="canvas"></canvas>
    </div>
```


Figure 4-6: Code snippet of web application

4.3.2 Data Preprocessing:

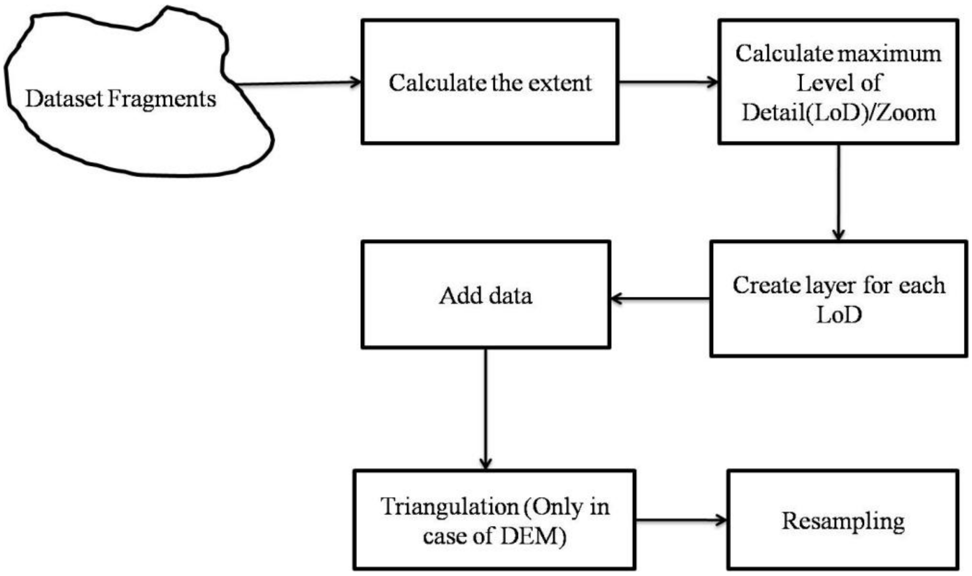


Figure 4-7: Steps in data pre-processing (Loesch *et al.* 2012)

OpenWebGlobe allows to use different types of data which needs to be brought into a common platform and format. This pre-processing is usually done to make the data fit for our usage. It includes transformation of the reference system, calculation of extent, creation of layers and compression or encryption of data (Christen *et al.* 2011). A Quadtree format is followed and the same is used while creating tiles. For pre-processing VC++ code is used, which is provided by the developers and then the code is executed using command prompt giving the inputs.

Calculate the extent: This is the first step, it does not performs any actual operation on the data but it calculates the extent and maximum number of zoom. The maximum number of zoom depends upon the resolution of the image. For example if we are using LISS IV which has 5.8m spatial resolution, we can have only 17 level of zoom. 17 level of zoom means that the image can be displayed upto this extent only, after it the pixels will start breaking and it'll become coarse. If the level of details is higher, it'll require more processing.

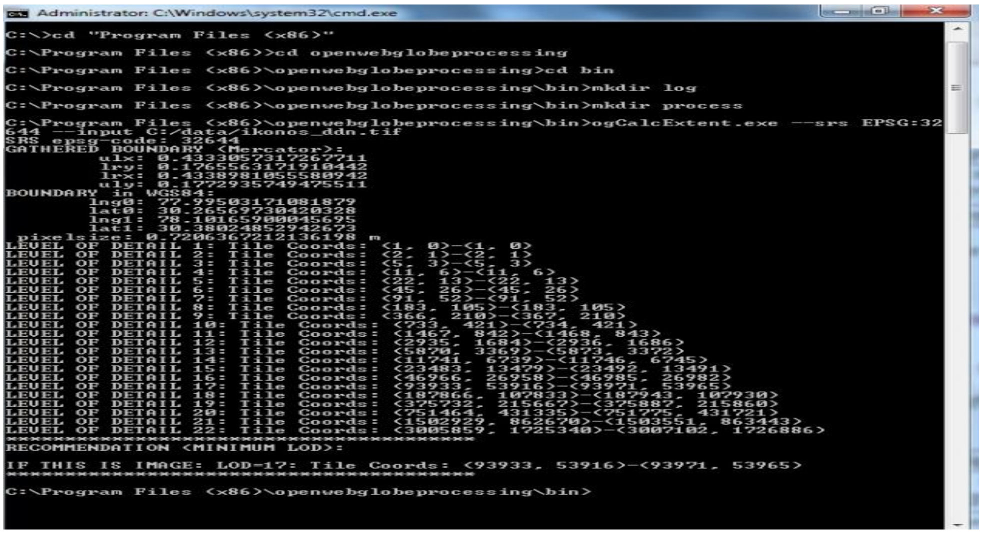


Figure 4-8: Calculation of extent

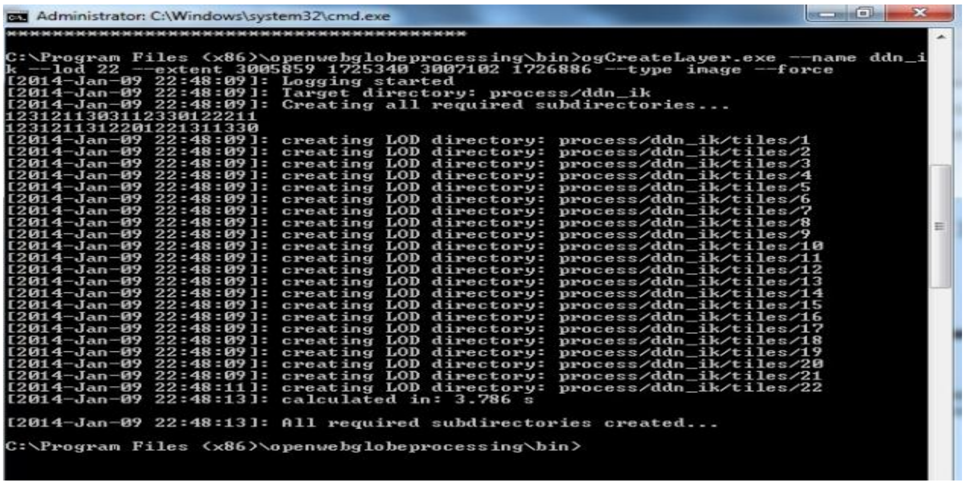


Figure 4-9: Calculation of Level of Detail

Create layer for each LoD: For each level of detail or zoom a layer is created, this layer is then called upon whenever required. This is equivalent to creating tiles of the image, so that the large files can be read easily and less bandwidth is consumed while transferring it over the internet.

Add data: The next step is adding the data into the layers. The image data is added on top of each layer in the case image and elevation data is added in case of Digital Elevation Model(DEM). The data is added according to the different level of zoom. For example in the level of zoom 22, it will have maximum amount of data and it'll take a lot of time as compared to any other zoom level of the same image. This is a CPU intensive process and time required is according to the memory available, processing speed and the resolution of image.

Triangulation: The next step is to triangulate the data which is done only for DEM. Delauny's triangulation (Devillers *et al.* 2003; Wu *et al.* 2004) technique is used. We can give the number of maximum points we want in a tile.

Resampling: The last step in data preprocessing is resampling of image. In this the remaining level of zoom are calculated. The output is in GeoJSON format. The image pre-processing completed now.

4.4. System Architecture

The system uses client-server architecture. It has the following components:

- Apache Tomcat Server 7.0
- GeoServer 2.4.3
- PostgreSQL Server (Database) 9.3
- Remote GPS enabled device
- Web-browser based UI

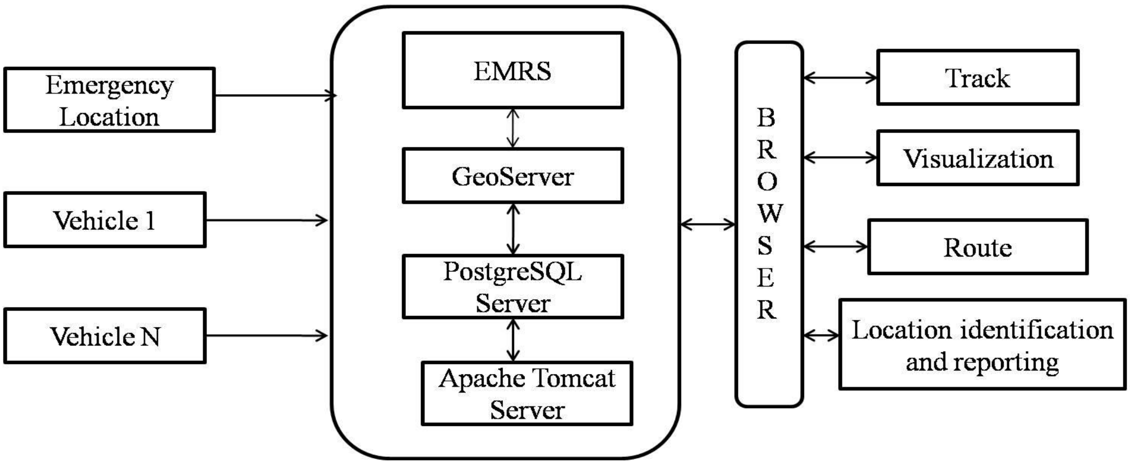


Figure 4-10: System Architecture of EMRS

The remote GPS enabled device sends the geolocation to the server via http based communication protocol using GPRS. This location is then sent to the database server. Tomcat Apache is hosting the application EMRS and it delivers it on the browser through for client use.

4.5 OpenGTS installation and configuration

Unlike any other software, openGTS doesn't comes with an executable file. It has to be build manually. It also has some prerequisite before building for successful built and installation. It requires following packages running in the local machine.

- Java Compiler: It is a compiler for Java. It is Java Development Kit (JDK) providing with the run-time environment; used for openGTS compilation.
- Apache "Ant": It is used for automatically building software. It requires java language and it compiles, runs and executes programmes.
- Apache Tomcat: It is used to provide "pure java http-web environment". Java pages and servlets can run on it.
- PostgreSQL database: It is used to store the GPS location received.
- PostgreSQL JDBC driver: It is used to provide connectivity between the database and java application.

4.5.1 Setting up the environment variables:

Setting the environment variables is done to provide the environment for running the application. It is basically done to add the path of the packages installed, so that the application can find them during execution process. Environment variables have to be set to their respective installation directories of the Java, Ant and Catalina packages.

4.5.2 Compile the openGTS library

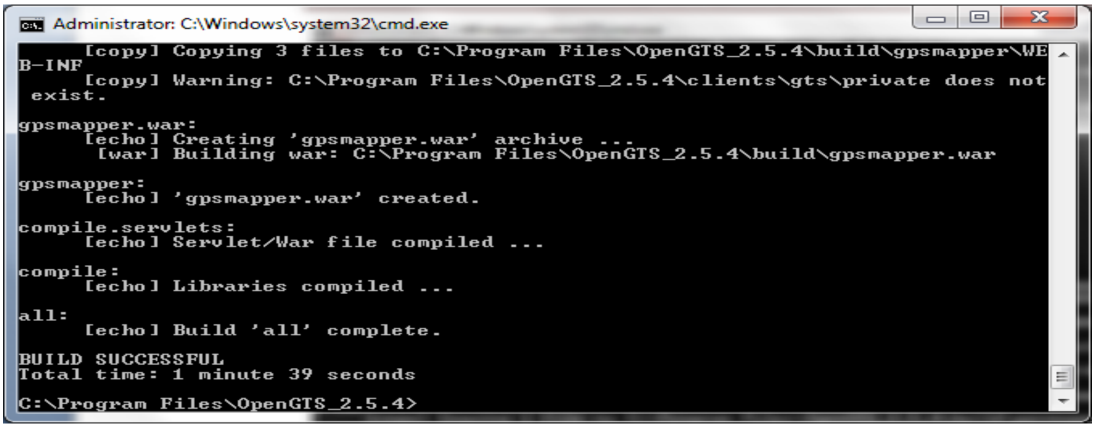


Figure 4-11 OpenGTS configuration

Using Apache Ant, the library and servlets are compiled. They are the java and web archive. It contains the option for web-interface, DCS and other web accessible data. The build directory created after compilation, contains the important files such as track.war file which has web interface Track servlet, events.war file which has web accessible EventData access servlet and gprmc.war file which has a support server for http based device communication server.

4.5.3 Initialize database

PostGreSQL database is loaded through the command prompt and the GPS location is then stored into the database. The database will contain all the tables required for processing. The application comes with MySQL as the database but we configured it with PostgreSQL as we are using it for the whole application and the geolocation can be easily used for other steps.

4.5.4 Creating track.war

A track.war file is created and then deployed on tomcat, for the process to start. It contains the web interface, classes, to provide with the geolocation captured from remote device.

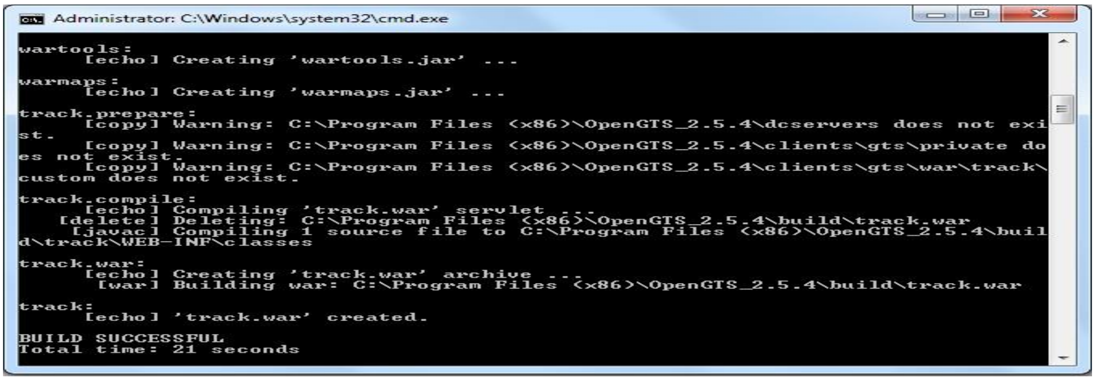


Figure 4-12: Track.war configuration

4.5.5 Installing events.war

The "events.war" is created and then deployed on Apache Tomcat for downloading selected portions of a sequence of events over the web. It is used with web based mapping applications for providing near real time tracking.

4.5.6 Configuring DCS

A device communication server needs to be configured. This will listen for the geolocation, which a remote GPS device will send. We have configured http based communication protocol as it was the most suited with our application.

4.5.7 Mapping service

OpenGTS supports OpenStreetMap (OSM) as the default mapping service which is a collaborative project to create a free editable map of the world. The base maps added were of Google, Bing and Geoserver which are supported by OpenGTS. GeoServer is open source software which allows users to share and edit geospatial data. The api keys for Google and Bing were generated and were used. The api key Google was stored in private.xml only while Bing did not require to be placed in private.xml.

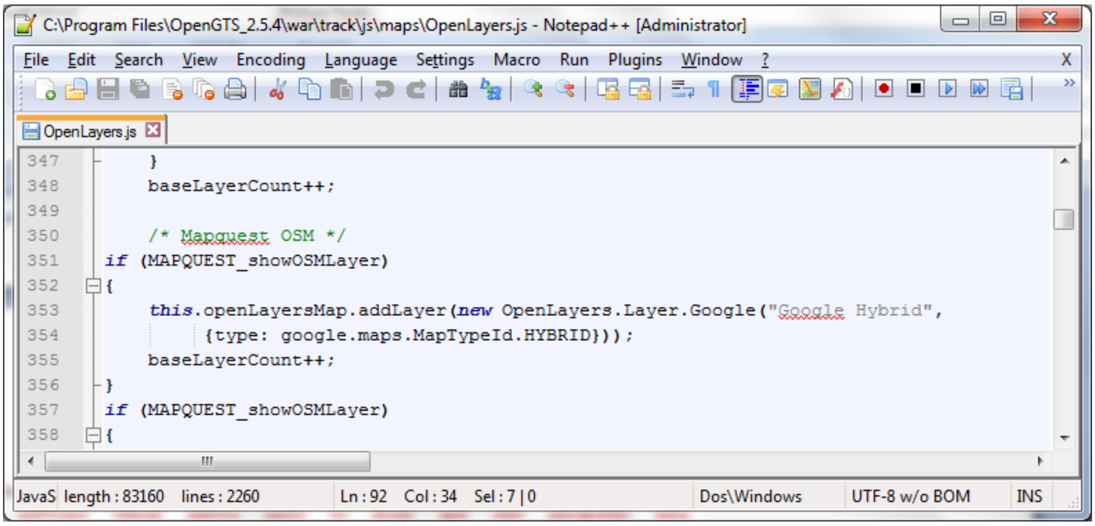


Figure 4-13: Google layer configuration

4.6 Integration of GeoServer with OpenGTS

To publish our own data as one WMS layer into the application, it was necessary to integrate it with GeoServer. It was a very challenging task as OpenGTS is an open-source project, so there was no help. It became clear for integration we need to configure private.xml, openlayers.java and openlayers.js.

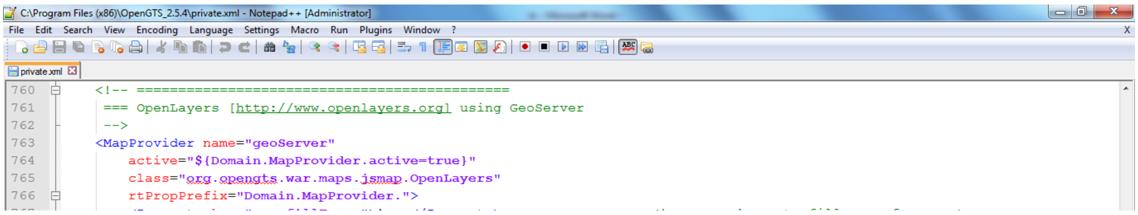


Figure 4-14: Private.xml file configuration

In private.xml we edited the map provider section, by giving details of our local geoserver and WMS layer to be displayed.

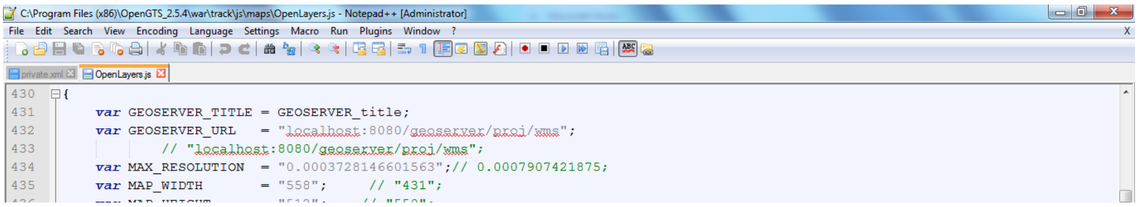


Figure 4-15: Openlayer.js file configuration

Service definition and source code is defined in openlayers.js; we edited openlayers.js by giving the WMS details. These details were bounding box, maximum zoom, name of layer etc. In openlayers.java we needed to add the path and properties for integration. The changes are visible in the following files

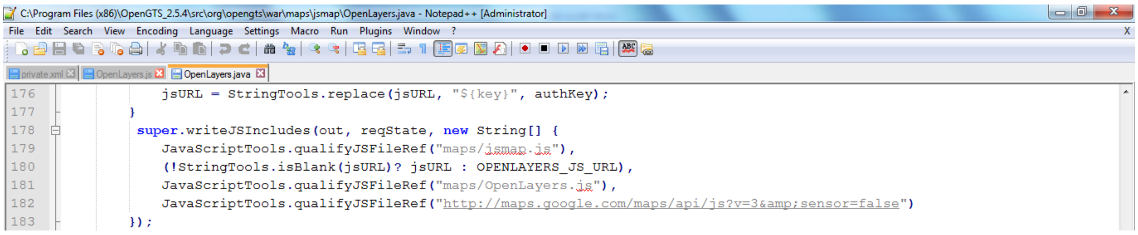


Figure 4-16: Openlayers.java file configuration

4.7 Intimation about the emergency

A user can intimate about emergency by either giving a call or sending a text message. User can intimate using any regular service provider. If the user is giving call, the operator can receive the call and fill in the details about emergency in a form. The operator will fill the name of person calling, contact number, place of emergency, kind of emergency and the status of people caught in emergency; these values are then stored into the database and from there the further processing starts.

When a user is intimating via a text message, he or she will send the text stating about the emergency and the message then will be updated into the database, a toponym data model for information extraction system will work on it, it will then find the location of emergency and will relay this information for further use.

Figure 4.16 displays the process flow for extracting the information from text and then mapping it on the geographical space using toponym data model. We are assuming the device on which the message is received has Android operating system; we have written a small application which reads the message from internal memory of the device and then pushes it into the database for further processing. Then using linguistic analysis and with the help of the different gazetter and databases we try to fill out the different information into the pre-defined templates and then this information is used for further processing.

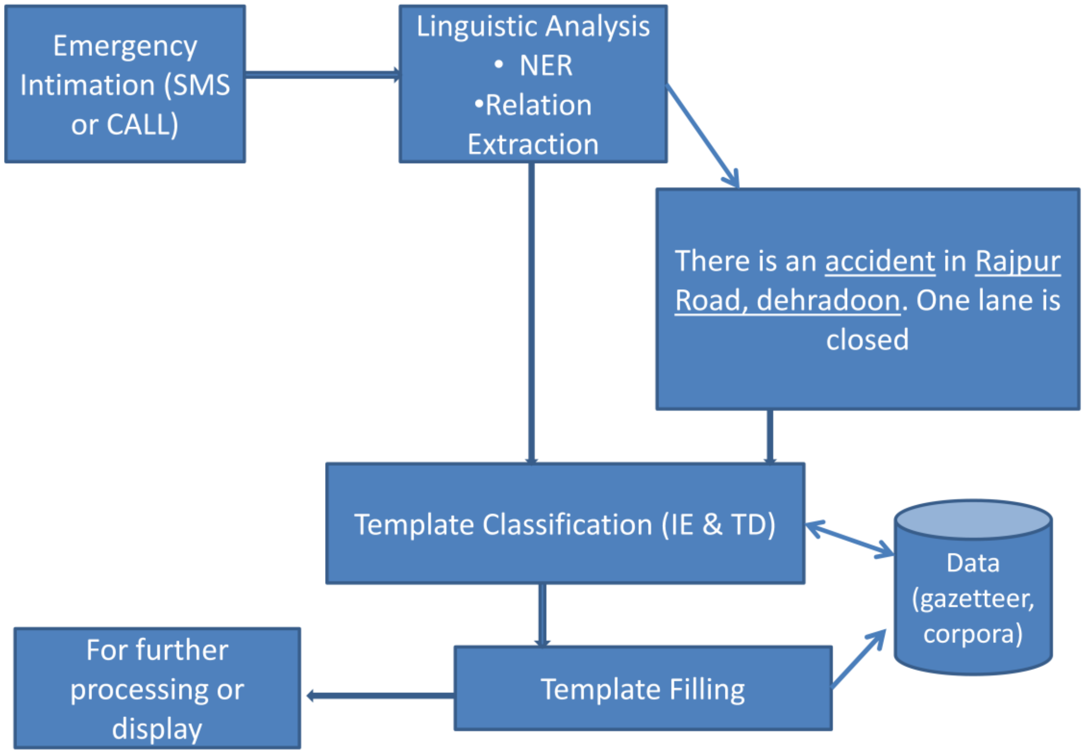


Figure 4-17: process flow for IE

There can be cases when the place has many names, for example Dehradun city; it is also known as Doon, Dehra Dun, and Dehra Doon. Storing all of the names into the database will cause redundancy and take unnecessary storage. For this we used a simple technique, we removed the vowels and spacing from the name and then matched the name into the database form the one which user used, if more than 90% of the text matches then we assume the user was talking about that location only. This technique worked fine in case of misspelt places and when there is not much difference in the spelling of names but failed when there was a short name for the place like ddn or doon in case of Dehradun. There are many available open source software for extracting information from text viz Standford NER, GATE, Lucene search engine, marven apache nlp. We have used python nltk library to do the processing after reading the message from the database.

The EMRS unit for getting information through text message can avoid geo-geo ambiguity by segregating messages coming from nearby regions. Using Stanford NER and training the dataset it can be achieved successfully.

Chapter 5 RESULTS and DISCUSSIONS

Open-source software (OSS) is computer software with its source code made available with a license in which the copyright holder provides the rights to study, change and distribute the software to anyone and for any purpose (Laurent 2004). Open source products include Open Office, the internet browser Mozilla Firefox, Wikipedia, the GNU/Linux operating system and its derivative Android, an operating system for mobile devices. The following points have motivated us to use the open source software:

- Cost effective: Open source software provides an alternative to the proprietary software. Since we don't have to buy any proprietary software, the cost of the whole study reduces. We have used QGIS as an alternative to ArcGIS, PostGIS/PostgreSQl for the database as an alternative to the commercial product.
- Technology neutral: Open source products are not dependent on any platform; they can work on any operating system. The EMRS developed in the study is not dependent on client's operating system and browser.
- Compatibility with existing system: Open source software is compatible with the already developed systems. Two or more open software can be used together to develop a new system. We have used OpenGTS along with OpenWebGlobe to obtain the results; along with it we have used geoserver and geoexplorer.
- No license dependency: Open source software comes under GNU/MIT license, which is open to everyone, thus there is no need of license which is also an issue with the proprietary system. The EMRS developed can run on any number of machines without the requirement of licensing.
- Interoperability: We can achieve information and data interoperability by using open source software and their standards. Using OGC standards we have used WMS service to overlay the road network layer, landmark and hospital geolocation. Geoserver was used to provide the WMS service. The shortest route calculated is also displayed by converting into JSON format.
- Editable: Open source software or system can be customized according to the user's requirement; additional features can be added to dedicate the system for a specific task.
- Full control of the developer: While using open source software, the developer has complete control over it and can very easily add new features into the software.

With the help of remote sensing, we can obtain the satellite imagery, elevation, meteorological information etc. The imagery and elevation is available of the remote and inaccessible area as well. Satellite imagery and aerial photographs play an important role in general mapping, as well as GIS data acquisition and visualization. First, they help provide a solid visual effect. It is easy to put spatial concepts into perspective with visual effects. Another role is to provide a basis for gathering spatial information for example features such as roads, vegetation, and water.

This information is successfully utilized in the development of EMRS. The elevation is used to visualize the terrain profile and the satellite imagery is draped over it. This provides better visualization and the location can be displayed more precisely. In case of emergency like forest fire, we can mark the starting point of fire and the area to which it can spread, and by sending timely and efficient response it can be tackled on time.

Any data when shown in a visualization effect leaves higher impact as compared to the data presented in tabular format. We can visualize the spatial data in form of maps and provide them as services (WMS, WFS, WCS). Analysis can be done on the data like operations requiring attribute of one class or operations requiring attribute and location information of a class or operations which creates a new class.

GIS based EMRS would need to support functions like zoom, pan, buffer creation, attribute and location identification, navigational route, shortest distance, query and selection of data based on attribute or location. It should also be able to track the users, give search and rescue plan, transportation support, environmental protection. A system like EMRS is of great use in the state like Uttarakhand, which is disaster prone. It lies in seismic zone IV and V and is prone to flash floods, landslides and many accidents and health issues. EMRS can be used to provide fast relief and response service. In case of mass casualties the system will inform other hospitals, NDRF and the government officials for help and faster relief. EMRS database has the contact information of all the hospitals, their specialization and officials in case of any emergency.

If there is an outbreak of a communicable disease, we can map it in EMRS and study the possible factors, way of communication of the disease; this information can be provided to the hospitals and it can be used to minimize the people getting affected by it.

If an emergency caller intimates about the bus accident, the caller will inform about the place of accident, type of accident, if it is a mass causality or not. The information is then stored into the EMRS database, accident location is displayed on the map and emergency team is dispatched. The EMRS then displays the shortest route to the location and from the location to the nearby hospital. The geolocation of the emergency team dispatched is monitored in the control room; any information required can be transmitted to them by communicating. As soon as the emergency team will reach the accident location, the system will start to show the route from the vehicle’s current location to emergency spot. ERMS also provides the facility to intimate the concerned hospital about the accident for prior preparation.

With the reoccurrence of disasters like flash floods, landslides etc the EMRS becomes more important as in the case of a big disaster relief and rescue force is sent by NDRF, Indian army and they are not entirely familiar with the terrain of the state. EMRS can help them by guiding which path to choose, which hospital to inform and how to reach on the emergency spot with minimum time required for travelling.

The information about different hospitals like the specialization, medical facilities, contact information and address is stored in the ERMS database. In case of a mass causality, the victims are taken to nearest hospital for first aid relief and from there once their condition is stabilized; they are referred to the specialized hospitals for further treatment.

5.1 Web Interface:

Web interface is the link between the user and the software/system running on any server. It is the starting page of the application, which the user utilizes by calling a HTML page on the server in which application is installed.

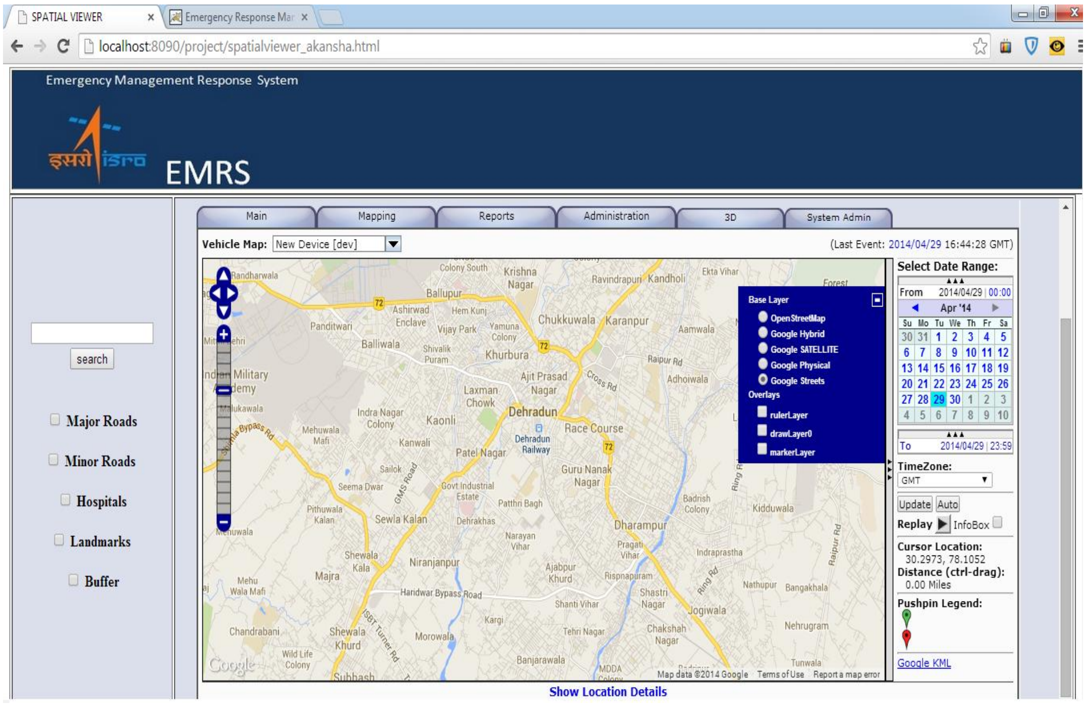


Figure 5-1: Web Interface for application

Fig 5.1 shows the screenshot of web interface. In the figure we can see the option for various functionalities like search box, check boxes, zooming and panning. The interface is divided into three parts, the top one or header is for the application logo. On the left side is the panel which a user can check or uncheck for various GIS layers. It gives user an option to overlay major roads, minor roads, hospitals, police station, fire station and landmarks on the top of the map of the city. It also provides with the search box, which gives suggestion to the user on typing the name of the place to be searched. Along with the above there are options for tracking of vehicle, creating a geozone in case of emergency, checking the user report in case of vehicle tracking. The buttons on the top-left are 3D, mapping, reports, shortest route. Details of the buttons are:

- 3D: This button is link for another page which allows the user for visualization in a virtual globe.
- Mapping: This button allows viewing the tracks of different emergency vehicles being tracked
- Reports: This button is for viewing of various emergency situation reports, especially during the tracking process.
- Shortest Route: This button lets user view the shortest route from their current location to the nearest relief facility that is hospitals.

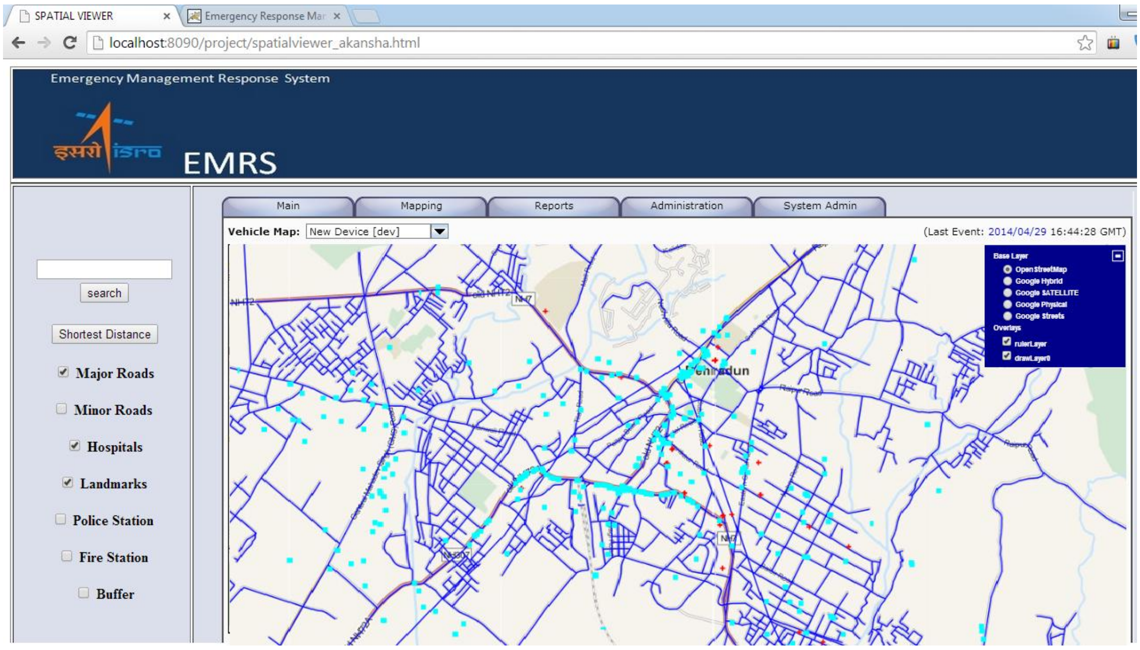


Figure 5-2: Web interface with different layers

In figure 5.2, we can see various layers overlaid on the base map. These layers are the road network of the city, hospital, landmark, police station and fire station location of the Dehradun city is also displayed. This dataset was created by collecting various points and digitizing the road network. To differentiate among the various layers, every layer was represented with different symbols and colours. Hospitals are displayed by a red-colour cross sign and police station with black colour cross sign. Road network is also classified as major road and minor road, thickness and colour of road is used to distinguish between them.

5.2 Tracking of vehicles:

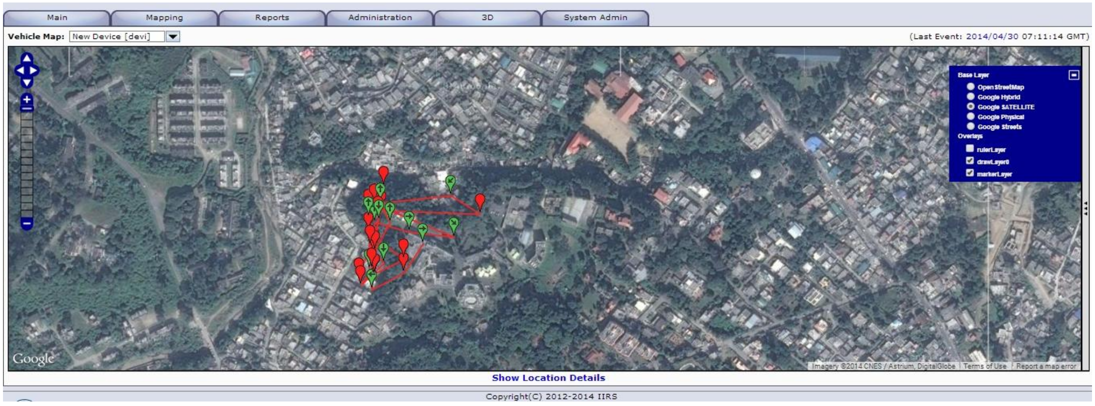


Figure 5-3: Tracking of vehicle

Vehicle tracking system can be divided into two parts. The first part is the application which will receive the current location of the user and will send to the server .The second is the web interface which displays this current position of vehicle on the top of map for the client (manager) to view.

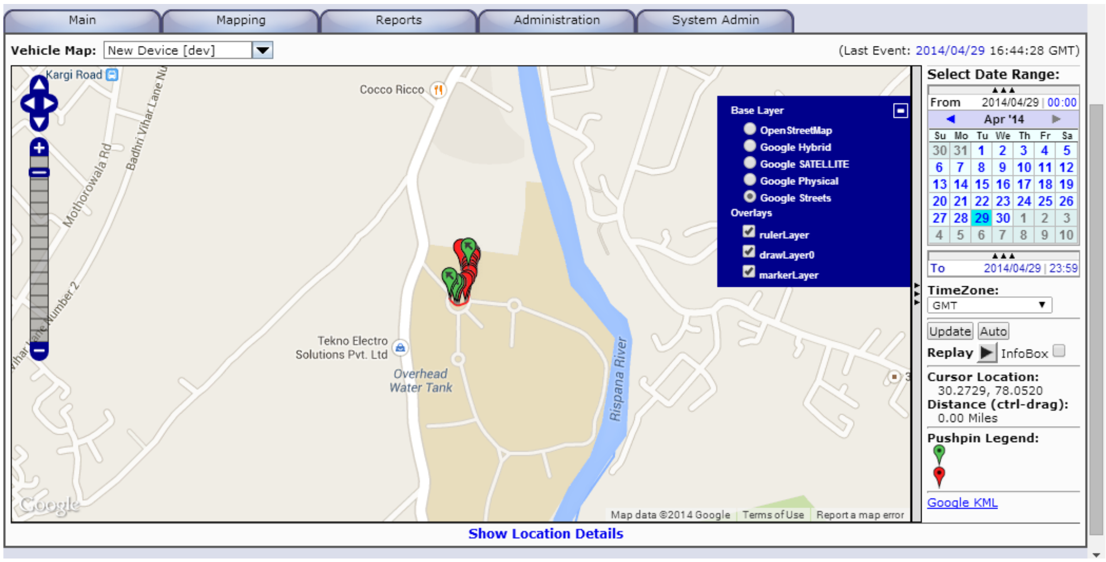


Figure 5-4: Vehicle tracking with base layer as google street map

Fig 5.3and 5-4 shows the real time tracking of vehicle. On the web interface, we can see where the vehicle is going, on which direction it is moving and an idea about the speed. Green marker is used when the device is moving and red one is used when the device is at stationary position. A layer switcher is also added, which allows the user to toggle between different map layers, provided by bing layers, openstreetmaps, google maps and geoserver. Panning and zooming functions are also present.

It also provides an option to track vehicles individually and in a group. While tracking group location, the interface displays the last received location of vehicle. On hovering the mouse over the device pushpin (marker), it shows the vehicle details. The vehicle details are its name, unique id, time, gps location, altitude. Whereas when we track individually, it shows the complete track of the vehicle. The relief vehicles coming back from dropping the patients to the hospitals will inform the EMRS by sending the message 1. This is then stored into the database and can be used to send to another emergency spot from the current location only.

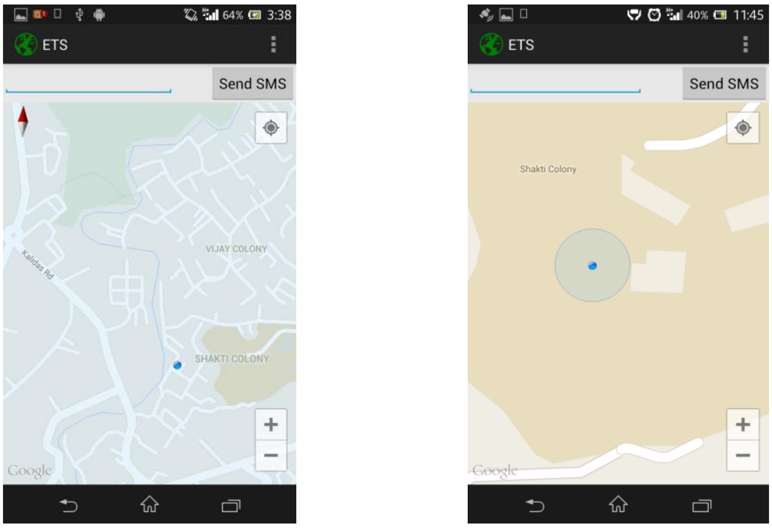


Figure 5-5 : application interface for android device

Fig 5.5 is showing the application interface. It was assumed that the emergency vehicle has a cellular device for communication purpose. This device is GPS/GPRS enabled and runs on Android operating system. We have opted for Android platform because it is easy to operate and used by majority of mobile users. Since the application was developed for testing purpose, we have provided the domain and server address in the code itself and user need not to do change anything.

5.3 3D-Visualization

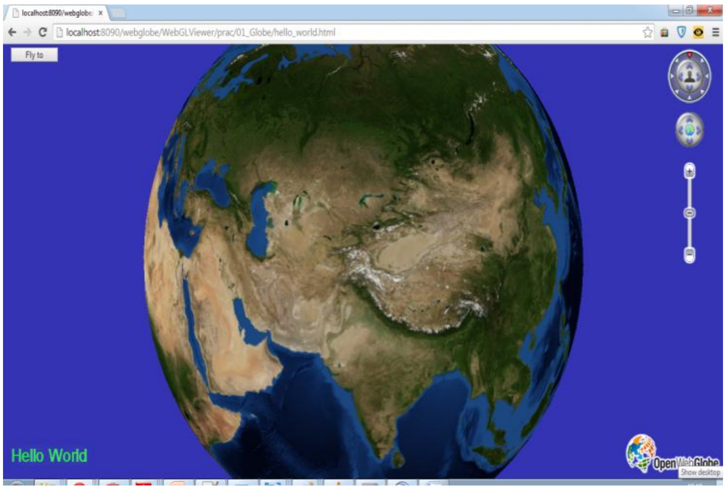


Figure 5-6: Visualization in OpenWebGlobe

A 3D visualization is achieved with the help of virtual globe (OpenWebGlobe). It can also be said as a 3D model representing earth or any other geographical feature. Whenever the user clicks on 3D button, visualization page opens up. On the top-left there is a button fly-to, which takes the camera to the study area using its bounding box. The data in this area is pre-processed and is then transmitted over the internet.

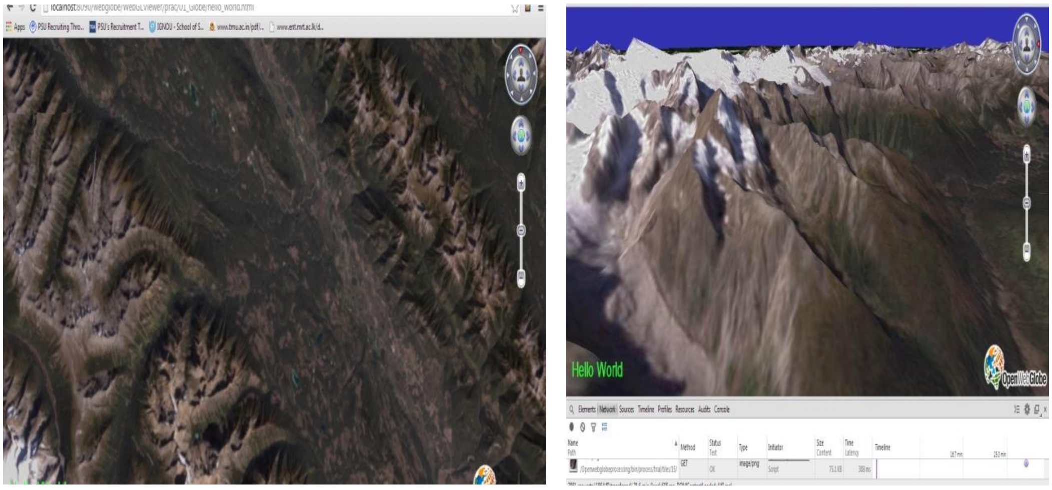
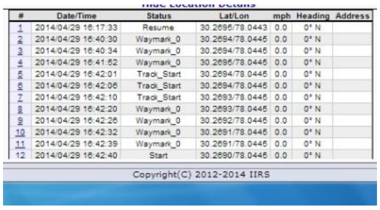


Figure 5-7: Visualization using OpenWebGlobe

5.4 Report

Report button gives user the option for getting a detailed report about any emergency. This also has an option for getting report during tracking incident as well. In case of tracking event report includes date, time, direction where the vehicle is travelling, latitude and longitude of the vehicle when travelling. In case of emergency, the report includes place of incident, unique id of vehicle dispatched and name of hospital or relief center.



#	Date/Time	Status	Lat/Lon	mph	Heading	Address
1	2014/04/29 16:17:33	Resume	30.2695/78.0443	0.0	0° N	
2	2014/04/29 16:40:30	Waymark_0	30.2694/78.0445	0.0	0° N	
3	2014/04/29 16:40:34	Waymark_0	30.2694/78.0445	0.0	0° N	
4	2014/04/29 16:41:52	Waymark_0	30.2695/78.0445	0.0	0° N	
5	2014/04/29 16:42:01	Track_Start	30.2694/78.0445	0.0	0° N	
6	2014/04/29 16:42:06	Track_Start	30.2694/78.0445	0.0	0° N	
7	2014/04/29 16:42:10	Track_Start	30.2693/78.0445	0.0	0° N	
8	2014/04/29 16:42:20	Waymark_0	30.2693/78.0445	0.0	0° N	
9	2014/04/29 16:42:26	Waymark_0	30.2692/78.0445	0.0	0° N	
10	2014/04/29 16:42:32	Waymark_0	30.2691/78.0445	0.0	0° N	
11	2014/04/29 16:42:39	Waymark_0	30.2691/78.0445	0.0	0° N	
12	2014/04/29 16:42:40	Start	30.2690/78.0445	0.0	0° N	

Copyright(C) 2012-2014 IIRS

Sno	Unique ID	Place of accident	Date	Time	Hospital name
1	355666055522451	Ashley Hall	4/5/14	13:53	Doon Hospital
2	355666055522451	kumar stores	9/5/14	18:53	Doon Hospital
3					
4					

Figure 5-8: Report for vehicle and emergency case

5.5 Shortest Route

Whenever the user clicks on the button, a shortest route for the nearest relief center is displayed on the map. This route takes the vehicle's present location as on input and then searches for the nearest hospital, which is then displayed on the map.

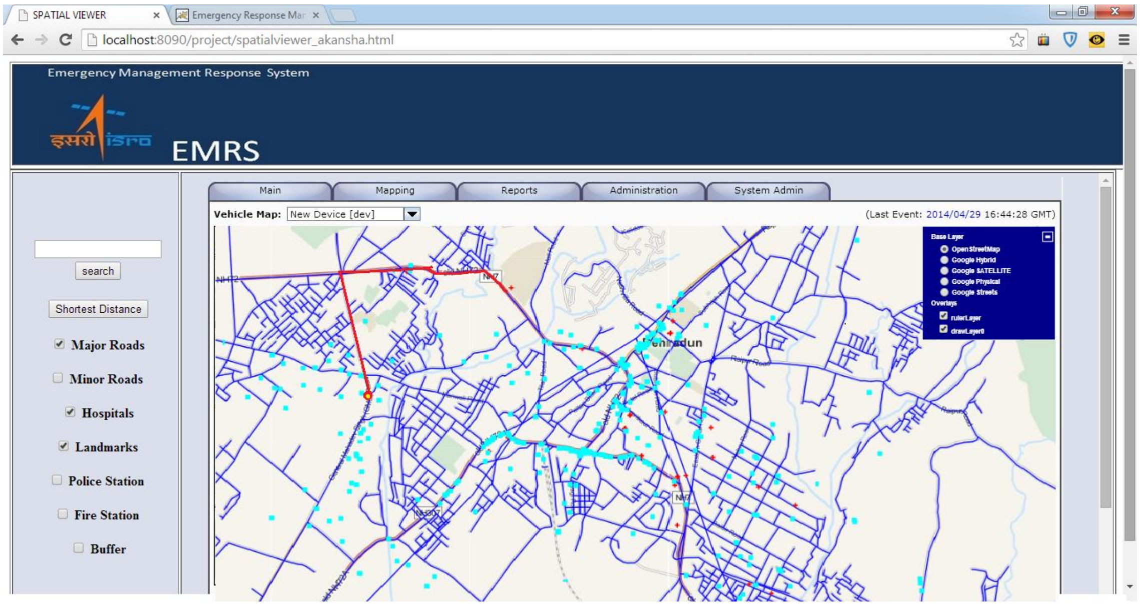


Figure 5-9: Shortest route using A* algorithm

Figure 5.9 shows the shortest route using A* algorithm, this the user gets whenever he/she clicks on the shortest distance button, it will call python program which will compute the shortest route according to the user's current position and then will save the route as the shape file. Since emergency response system is an automatic system, the shape file should also be loaded into the browser automatically. After a lot of research we decided to try two techniques to display the shape file into browser; first is to display it as a WMS layer and the other one is to convert into GeoJSON format and then display it on the browser. We tried both the techniques, for displaying it into the geoserver by using geoloader by scholars lab and rest config api with python to push the shapefile into the geoserver. For conversion into GeoJSON format we used GDAL library and ogr2ogr function.

When processing for small files, GeoJSON was showing good results but if the shape file is of large size then it was taking a lot of time for processing and it was becoming clumsy. So then we decided to use geoloader by scholars lab (freely available in github), in this while configuring we provided with the url for geoserver, username, password and the EPSG code for SRS. We can then load the shape file by using the following code into the PHP code.

Geoloader geonetwork load/path/to/output_shapefile.sh

We have also used the Smart Terrain (Yu *et al.* 2003) algorithm for finding out the shortest route when the elevation of the area is also taken into account. For this we used the classified (Land Use Land Cover) image of Dehradun and CartoDEM for elevation. Figure 5.10 shows the result of the above algorithm; since it was applied on the classified image (raster data); it is not including the road network when calculating the shortest distance instead it is calculating the spatial distance between two cells and the cost on each cell according to the elevation and then giving the shortest route. We have modified the ST algorithm to consider only one LULC class, so it is giving the route according to the network available.

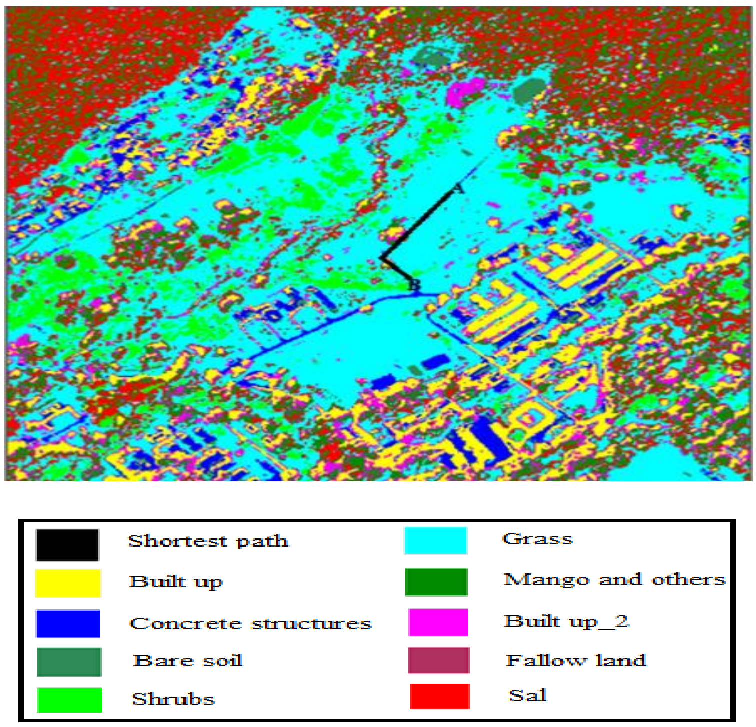


Figure 5-10: using ST algorithm with the LULC classes

In figure 5.10 point A is the user's current and point B is the destination. The algorithm works very nicely in case when there is a difference in height between two points but when there is less or no difference then A* algorithm works well. ST algorithm also requires lot of computation time and memory storage.

5.6 Intimation of emergency:

Whenever the user intimates about emergency, he/she will give the detail about the emergency and the place where the emergency has actually happened. We have created an application named *secure messages* is written, this reads the message and then stores into the database for further processing. The message is also displayed on the device and stating the name of landmark or place.

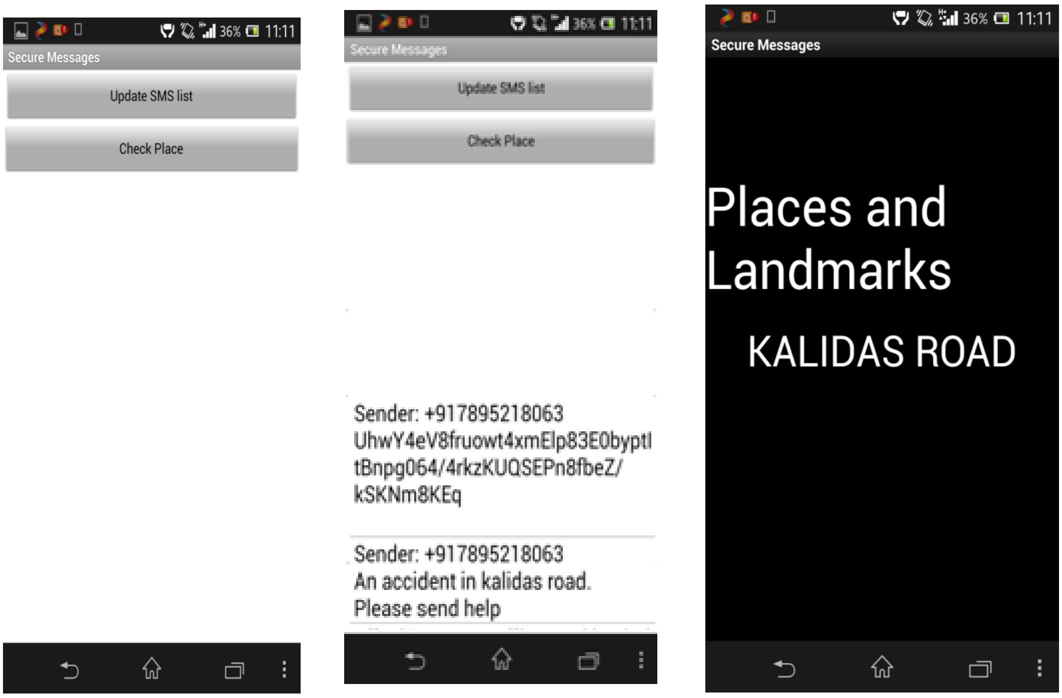


Figure 5-11: Screenshot for the application secure messages. (a) when the application is installed (b) after updating the SMS list (c) the name of place

Fig 5.11 displays the case when the test message was sent to the device and from there the information was extracted and displayed into the browser. The location was displayed by creating the buffer. This buffer contains the area within which emergency has happened.

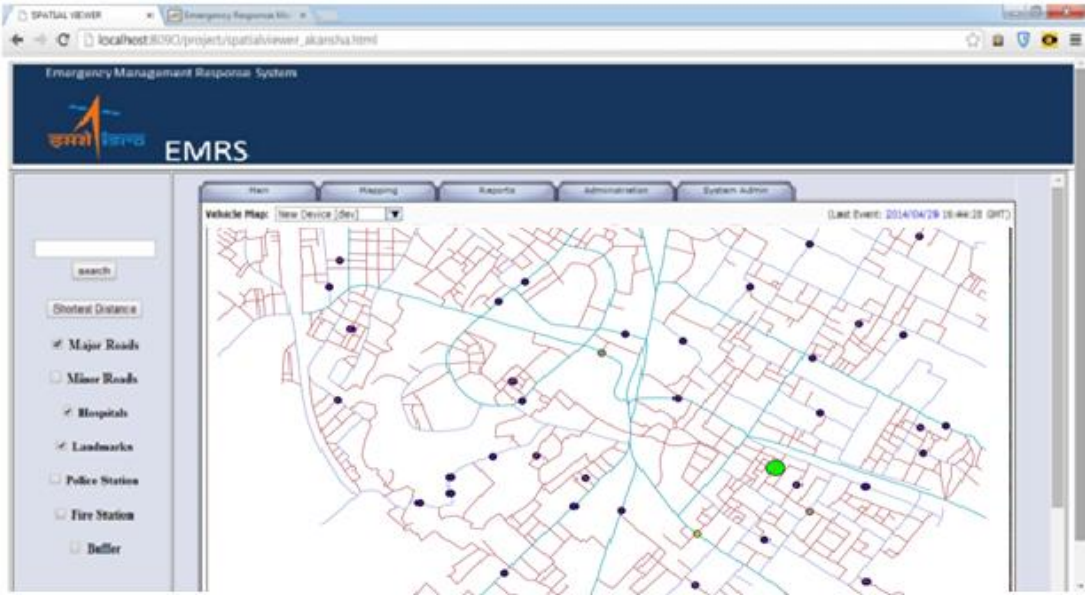


Figure 5-12: Information extracted shown as buffer

For the figure 5.12 the message received was 'emergency near HIT College. Please send someone its urgent.' The location was extracted and the database was searched for it and then was displayed by creating a buffer around the point.

We also created one small application for geoSMS, which takes in user's location and then send it to the other person. The geoSMS application has to be installed on the user's device. This can be used whenever the user doesn't have any idea about the surrounding and wants some help. This location can be then displayed over the Google map for better understanding.

5.6 On field test:

For validating the application, we did a survey around the city and I drove around the city and the real time location location of device was displayed on the browser. A geo-zone buffer was generated in between, which highlighted all the facilities and the vehicles within the area. The width of the buffer was selected by the user. This geo-zone buffer is created on the location from where we receive distress or emergency call. A geozone is a geographical extent defined by the user to specify the extent to which the disaster can affect. From a point we used the button for shortest route and the same was displayed on the browser.

Chapter 6 CONCLUSION and RECOMMENDATION

6.1 Conclusion:

The study was proposed for developing a system which can pinpoint to the location (±15 m) and help in reducing the response time during emergencies. Geolocation and contact information of various places including hospital, police station and fire-station was collected; this can facilitate in passing timely information to all the relief centers and to reduce the time delay. Having the real time location of relief vehicles and ambulances helps in easier coordination and can be dispatched from one place to another very swiftly. Tracking also helps in keeping a check on the situation, if under any unforeseen condition the relief vehicle is struck at some place or if the driver is speeding up.

Visualization in 3D using virtual globe was done successfully; in hilly terrain 3D visualization helps in easy understanding of situations and this can be successfully used in the case of flood or landslide to find out the area with the maximum impact, according to the slope and the structure of the place, it can help drivers (who generally don't drive in mountainous region) to know about the terrain and what to expect while driving through one. Tracking and visualization components were achieved individually but integrating both of them is still a challenge. The virtual globe can be easily visualized over the browser without the need of any plug-in or any additional software.

Intimation about emergency was done successfully using message or call facility. User's location can be retrieved using geoSMS, message, GPS or when informed on call which can be made from a mobile device or landline. Since we have created the database for point locations, it became very easy to identify the places and reduced the communication time. This location helped in further processing of the system. Other features such as shortest route, geozone creation, attribute and location identification were successfully created and tested.

6.2 Answer to the research question

1) **How to design a geo-RDBMS for static and dynamic data?**

Ans. A geo-RDBMS was designed which had static as well as dynamic data. The static data was created which included Road Network, Hospital locations, Landmark location, Police Station, Fire Station. The road network is a complete road network that is, it contains roads, nodes, junction and information about the roads as well (whether it is one-way or bidirectional, if there is any flyover etc).The dynamic data was received through the android application and this was stored in database in another table which is adding row every time a geo-location is sent to it. This table contains the geo-location received, unique ID of the device (here we are IMEI number) and the time at which location was sent. The database had some tables whose values are constant that is not changing frequently and some tables were updated continuously as the location of their related device (vehicle) changes.

2. How can we visualize real time tracking in a 3-D environment?

Ans. Real time tracking means tracking while the vehicle is moving. For this an Android application was developed which will send the geo-location within every 5-10 seconds and this will be automatically pushed into the database, from which on-the-fly KML will be generated to be displayed on the browser. For 3D environment, a virtual globe was used and data was pre-processed.

Q3. What will be the methodology and designing technique behind Emergency Response System?

Ans. For developing the methodology we have referred to the literature and have had meetings with the people working in 108. We reviewed on what is already available for us to use and what is the requirement emergency response team is having, and what is the shortcoming in already available data/software as per the requirements. Instead of "re-inventing the wheel" we decided to use the already existing open source solutions in order to achieve our goal. The technique raises two main questions, which are answered below.

a. How will emergency be reported to the relief center?

Ans. Emergency can be reported via a call or text message. For reporting emergency through call, a call can be made and the person receiving calls can fill in the details manually. While intimating through text message an Android application has been developed which will send the geo-location of the person sending the text message. If the device user doesn't have the option of android device, they can send the message stating the location and kind of emergency from which information can be extracted.

b. What will be the different steps in planning of rescue and response plan?

Ans. According to the literature, the most important thing in planning a response to any emergency is that we should always try to confine the emergency in terms of loss be it animal, property, lives or household. We should also take care that the rescuers does not become the secondary victims there. A timely response should also be provided. The various steps under this are finding the emergency location, providing the shortest route to the relief team, gathering knowledge about the emergency that is what is the scale of emergency, what kind of emergency is it, dispatching the relief vehicles and intimating hospitals about it.

This included finding out the shortest route, with and without considering the elevation, which was developed in python language using A* algorithm and Smart terrain algorithm, the result was then displayed over the browser. A buffer (geozone) option was used, so as to find out all the facilities near the affected area.

6.3 Limitations and Recommendations:

Based on the study the following recommendations are made.

- Development of a framework for applications without internet: Presently the software is dependent on telephone network and internet connectivity, but there are times during disaster when there is no communication facility. Focus should be given on developing something for the scenario that is offline data can be collected by using the alternative method. A backup plan can also be prepared in advanced and can be used if there is no internet connectivity.
- Level of Detail: To improve the details in the different regions and providing with indoor tracking and navigation for better quality and precision.
- Taking more towards 3D visualization: For better visualization and understanding, we can try taking LBS towards 3D.
- Improving the precision and accuracy of CartoDEM: vertical and horizontal accuracy of the CartoDEM can be improved by taking many GCP points while creating the DEM from two cartosat images. This improved accuracy will be of much help in hilly terrain especially in search and rescue operations of flood, landslide or earthquake.
- The Android application *secure messages* can be further improved to display the name of place into the map as destination and user's present location as source and then the shortest route can be displayed using google direction API.
- The application can also be extended to another operating system platform like iOS or Windows. This application can installed into all the devices by the manufacturers themselves. We can aware the users to install the application.
- An IVR system can be integrated with the EMRS to record and accept emergency calls automatically.
- EMRS can monitor the internet media for information for emergency news to initiate the response rather instead of waiting for the intimation.

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