Framework for Location Based Emergency Services in India

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Framework for Location Based Emergency Services in India

by

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I certify that although I may have conferred with others in preparing for this assignment, and
drawn upon a range of sources cited in this work, the content of this thesis report is my
original work.
Signed …………………………

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This document describes work undertaken as part of a programme of study at the International
Institute for Geo-information Science and Earth Observation. All views and opinions expressed
therein remain the sole responsibility of the author, and do not necessarily represent those of the
institute.
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Abstract

Advancement in wireless communication industry has led to the popularity of the mobile devices, in particular the mobile phones, which have now become the necessity of day-to-day activity of the normal human being in most part of the world. This popularity has created a kind of addiction for the services like short message services (SMS), friend finder, games, entertainment etc. People have now started demanding services that can be delivered any time anywhere, called Location Based Services (LBS). In the last few decades apart from the wireless communication industry, LBS have created lot of hype in the geoinformation industry especially in the western countries, but in India, it has just started growing. On one hand the geographic information helps in providing information on basis of where, when, what and how, and wireless communication helps in providing the location of the service requester i.e. the user. Hence to exploit the benefits of location-based services these two technologies should go hand in hand, which requires integration. The integration of these two technologies should also help in a time critical situations where quick and efficient response could save the lives of people i.e. at the time of emergency. In most of the emergencies users are not able to tell their exact location that further hinders the rescue and response action. Also one of the reasons of the delayed response is the lack of availability of spatial data to the emergency responders. This problem can be solved with the integration that requires a flexible framework where the services can be added or removed any time without affecting the whole framework, which is difficult in the current client server architecture and requires more flexible framework.

In order to develop framework for the emergency location services three main players were identified that are bound together by the geographic information. The existing and the proposed nodes of the Indian NSDI would handle the needs of the geographic data at the required scale. The framework was first analyzed in client server architecture for a use case in fire emergency, but due certain drawbacks of the client server architecture. The agent-based approach has been used to design the framework. Keeping key properties of agent’s in mind the framework was divided in to four main domains and the agents in each domain were identified. Once the framework is set the intelligence i.e. ontology, was constructed for the emergency domain before which the information flow of entities from different viewpoint and the hierarchal tree was constructed, which helps in bridging the gap between the user queries and the system architecture. Then to answer the queries the ontology for the facility and route concept was constructed. When agent migrates from one domain to another what sort of message they carry was analyzed in KQML. Lastly for achieving the interoperability in the framework the transport protocol and the location encoding languages were proposed and then the overall framework was proposed.

Key words: NSDI, Location Based Services, GIS, Agents, Ontology, Interoperability
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### Acronyms

<table>
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<th>Description</th>
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<tbody>
<tr>
<td>ACL</td>
<td>Agent Communication Language</td>
</tr>
<tr>
<td>APIs</td>
<td>Application programming interfaces</td>
</tr>
<tr>
<td>CGALIES</td>
<td>Coordination Group On Access To Location Information</td>
</tr>
<tr>
<td>ECC</td>
<td>Emergency Control Centre</td>
</tr>
<tr>
<td>ELS</td>
<td>Emergency Location Services</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FCC</td>
<td>Federal communication commission</td>
</tr>
<tr>
<td>FIPA</td>
<td>Foundation for Intelligent Physical Agents</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information Systems</td>
</tr>
<tr>
<td>GML</td>
<td>Geographic Markup Language</td>
</tr>
<tr>
<td>GSDI</td>
<td>Global Spatial Data Infrastructure</td>
</tr>
<tr>
<td>HTTP</td>
<td>Hyper Text Transfer Protocol</td>
</tr>
<tr>
<td>ISO</td>
<td>International standards organization</td>
</tr>
<tr>
<td>KQML</td>
<td>Knowledge Query Manipulation Language</td>
</tr>
<tr>
<td>LBS</td>
<td>Location Based Services</td>
</tr>
<tr>
<td>LIF</td>
<td>Location Interoperability Forum</td>
</tr>
<tr>
<td>MLP</td>
<td>Mobile Location Protocol</td>
</tr>
<tr>
<td>MPC</td>
<td>Mobile Positioning Centres</td>
</tr>
<tr>
<td>NSDI</td>
<td>National Spatial Data Infrastructure</td>
</tr>
<tr>
<td>OGC</td>
<td>Open Geospatial Consortium</td>
</tr>
<tr>
<td>OMA</td>
<td>Open Mobile Alliance</td>
</tr>
<tr>
<td>OpenLS</td>
<td>Open Location Service</td>
</tr>
<tr>
<td>OWL</td>
<td>Ontology Web Language</td>
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<tr>
<td>PDAs</td>
<td>Personal Digital Assistance</td>
</tr>
<tr>
<td>POIX</td>
<td>Point of interest Exchange Language</td>
</tr>
<tr>
<td>PSAPs</td>
<td>Public Services Answering Points</td>
</tr>
<tr>
<td>SDI</td>
<td>Spatial Data Infrastructure</td>
</tr>
<tr>
<td>SMS</td>
<td>Short Message service</td>
</tr>
<tr>
<td>SOAP</td>
<td>Simple Object Access Protocol</td>
</tr>
<tr>
<td>SQL</td>
<td>Structured Query Language</td>
</tr>
<tr>
<td>TCS</td>
<td>Tata consultancy services</td>
</tr>
<tr>
<td>USMA</td>
<td>United States Mapping Agency</td>
</tr>
<tr>
<td>WAP</td>
<td>Wireless Application Protocol</td>
</tr>
<tr>
<td>WGS</td>
<td>World Geodetic reference system</td>
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<tr>
<td>XML</td>
<td>Extensive Markup Language</td>
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1. Introduction

1.1. Overview

Advancement in wireless communication industry has led to the increasing popularity of the mobile devices in particular mobile phones, which have now become the necessity of the normal human being in most part of the world. This popularity has created a kind of addiction for the services like short message services (SMS), friend finder, games, entertainment etc. People have now started demanding services that can be delivered any time any were these types of services are called Location Based Services (LBS). LBS is a new buzzword in the geoinformation sciences and, is attracting number of people in the industry. LBS cover a wide range of applications complementing traditional paper maps, guides, and Internet, thus helping users to find local facilities such as pubs, bars, restaurants or shops etc. Other application could be to provide location related traffic and weather updates. This Location dependent technology is intended to help people ‘any time’ & ‘anywhere’. Some benefits of LBS in case of an emergency could be to convey the locations of nearest petrol pump, hospitals or the police station etc. to the user. These services can be provided in different ways in the form of maps, text or directions. It is believed that a single map can speak more than a thousand words and are of course easier to understand, than reading text.

According to Karimi & Hammad, (2004), “Unlike GIS that manage all vector and attribute data locally using proprietary data structure and data model, LBSs rely on structured query language (SQL) to access locally hosted content, and XML and simple object access protocol (SOAP) interfaces to incorporate syndicated online content. Building up on structured query languages, interfaces, encodings and protocols it becomes possible to chain basic LBS functions (e.g., Geocoding, mapping, routing, real time traffic) for the creation and delivery of a end-users service.” In any requirement of LBS, interoperability is imperative and “geographic data is fundamental to LBS” (ordnance survey, 2004).

Geographic information helps in providing information on basis of where, when, what and how, and wireless communication helps in providing the location of the service requester i.e. the user. Hence to exploit the benefits of location-based services these two technologies should go hand in hand, which requires integration. With the initiation of NSDI in India, an independent data exchange format called, National Spatial Data Exchange (NSDE) has been proposed (URL: 1). Hence, the present research will attempt in developing the framework for two powerful technologies i.e. the Geoinformation technology & wireless communication, so as to provide Interoperable framework for the emergency location services in India.
1.2. **Problem Definition**

In present scenario, emergency situation in India is mainly dealt with the information by the fixed telephone users and the emergency responders react to it, and plan their route to emergency without having access to spatial data. Considering the case of hit and run accident on the road if user wants to find out the location of the nearest hospital or medical shop etc. then, they usually wonder how can I make use of my mobile. Now the question is how the information should be provided to the user, in the form of text or in the form of maps, the obvious answer is maps, as they are “the best means of depicting spatial information, and are hence an essential element of LBS” (Dao *et al.*, 2002). So, to make LBS a reality there are certain missing components that are required to be identified one of them is the lack of standard framework for providing LBS in India, technological constraints (positioning technology and the data source). Similarly, LBS should make use of existing data that are organized and maintained in different software and are located in different servers of mapping organization as stated in Zlatanova & Verbree, (2004).

In India NSDI, geospatial data would be available at the scale of 1:50,000. But, for successful implementation of LBS, geospatial data at much higher scales are required. At present there are certain missing components in the NSDI that are need to be addressed. So, in order to tackle this problem NSDI framework shall be extended to include higher scale maps that are useful for location-based services and with a specific use case in emergency services. Thus, the integration of geographic information and the LBS would help in solving the problems pertaining to geospatial data and the interoperability required by the different location based services, especially in the Emergency location services. Integration also, requires knowledge in different domains; certain semantics have to be defined explicitly which can be done using the concept of ontology, which helps in sharing and exchange of spatial data also. Thus, ontology helps in providing “specification of a conceptualization” in a particular domain (Gruber, 1993).

Though LBS has several applications in different domains, the present research would concentrate on the use case in emergency location services (ELS). A scenario discussed below can be considered as one of the reason for the integration of these two technologies: Consider a case of industrial fire, an emergency call is made from the incident site which is received and routed by the telecom service provider to the nearest fire control centre. Unfortunately, the fire fighter reaches to the incident spot very late and the fire causes a lot of destruction. The delay in the arrival could be due to traffic jam, inadequate planning for reaching the destination, use of non-updated or insufficient maps, no understanding between the telecom operators for sharing the spatial information and could be many more. Had the emergency responders access to geo-coded spatial data, they could have planned their route efficiently and at the same time the telecom service provider could inform the traffic approaching that particular area, to plan their route accordingly, so that emergency responders can reach the spot on time.

Keeping in mind all the above needs, following points are to be addressed

- Who will have rights for holding this node?
- Possible standards to make it compatible with the NSDI
• Possible data formats for transferring the spatial information from one node to another.
• What could be the possible benefits of proposed framework?
• Who will get these benefits?

1.3. Motivation

At the time of emergency most of the callers are not able to tell the exact location of self because of which there is delay in emergency response. With the advancement in the communication industry there are researches, which stress on finding the exact location of the caller. With the Unite State’s F.C.C (Federal communication commission) mandate, the location issue would be well taken care of by the industry. But, the issues related to spatial information sharing still need much research. Assuming Indian NSDI would have spatial data at needed scale through value added nodes (police, fire & rescue, hospitals, disaster management, traffic & weather etc.), one can utilize this data for location-based services. For example, if the location of the caller can be shown at the map on the desktop P.C of the call receiving station (i.e. ECC) then they can know the exact area of the caller, which will help in speedy dispatch and reduced response time.

1.4. Research Objective

The main objective of the research is:
“To develop NSDI based conceptual framework for interoperable location based services in India, which can bridge the gap between relevant standards used in Indian NSDI, with a use case in emergency location services”.

1.4.1. Research Questions

In order to meet the objective of research work the following research questions need to be answered:
1. What are the main requirements in a use case of emergency location services from the Geo-informatics point of view?
2. What are possible methods for the transfer and exchange of geospatial information to a proposed framework from the Indian NSDI?
3. What role does Ontology play in the integration of the framework?
4. How can we bring interoperability between the NSDI and proposed framework?

1.5. Approach: A Glimpse

The study has been absolutely technologically approached as shown in figure: 1.1. With the initial literature review, problem area has been identified; following which, research objective and research questions have been formulated. In order to find the answers to research questions, help has been taken from secondary and primary sources by way of literature review and ‘experts comment’ respectively. The study of literature and analysis of the experts comment have been
used to further identify and analyze the requirements in emergency location services and possible gap areas that need to be tapped.

![Figure: 1.1 Approach a Glimpse](image)

After setting up the technical framework, a specific use case has been identified and has been dealt in more detail. Towards the final stages of the work, the framework has been discussed in the light of the findings and finally, recommendations and conclusions have been made.

1.6. Thesis Structure

The structure of the thesis is organized as follows:

Chapter-1. Gives an overview of research work, problem definition, motivation, research questions, methodology and thesis structure.

Chapter-2. Looks in to the various works done in the field location based emergency services in U.S and Europe, initiatives in India and other related research around the world.

Chapter-3. Discusses SDI initiatives in India; Location based services – types & requirement, existing architecture and the summary.

Chapter-4. Provides analyzed and clarified view on types of emergency services, role of GIS and LBS in emergency services, different phases of emergency management and the spatial data required. This chapter answers the research questions no 1.

Chapter-5. Works out the development of possible framework, methodology required in information sharing, transfer and exchange. Thus answering question no 2, 3 & 4.

Chapter-6. Finally, conclusions and recommendations based on the proposed framework.
2. Literature Review

2.1. Global Development towards Interoperable Systems

It has been believed that interoperability is a “capacity to transfer data from one computer to another without the transformation loss” as stated by Seth, (1999); though this can be understood in a number of ways, but the basic idea is to provide a modern information systems environment that can communicate openly. The concept of interoperability came into existence due to number of distributed heterogeneous systems. According to Seth, (1999), the era of interoperability can be divided into three generations. Generation 1: approximately covering the period of roughly 1985 mainly dealing with the interoperability in multi-database systems and federated databases systems. Generation 2: a decade long ending in 1995, dealt with the propagation of the structured databases, & semi-structured data, and then with the help of visual media spreading it onto the World Wide Web. Some of the advantages of this era were the achievements in system interoperability dealing with the heterogeneity of systems, data, and other representational levels, Support to a broad variety of data, metadata and lastly the use of knowledge representation, reasoning for handling different terminologies. This generation, also helped in achieving increased standardization, which, significantly helped in achieving syntactic and structural interoperability. Generation 3 started in 1996 and is still continuing. This generation is semantically more challenged with the increase in global connectivity and variety of heterogeneous digital data in existence. This generation brought many organizations helping in standardization of the data, protocols, languages, interfaces etc. Some of the main organizations are, OGC (open Geospatial consortium) in the field of web services, OpenLS (Open Location Services initiatives) for the standardization effort in Location based services (started in October 2002) and the ISO (International standards organization) initiatives.

2.2. Initiatives in Spatial Data Infrastructure (SDI) and their Standardization Efforts

Also in generation 3, increasing need has been recognized for geospatial data, which led to the establishment of SDIs (Spatial data infrastructures) and later on to the NSDI at the national level and GSDI at the global level. These SDIs will be treated as the one stop portal for the dissemination of the geospatial data to the community. According to Federal Geographic Data Committee (URL: 2), the concept of NSDI first started from the United stated of America in October 1990, before which there was increased need for developing the computer assisted automated systems in different cartographic agencies, it was recognized that these cartographic requirements will be related to “points and areas on the ground to the social, economic, and ecological framework of our society and to present these relationships in digital form. The advent
of the digital computer was ushering in a new revolution in mapping”, which later on gave rise to
the “development of a national digital spatial information resource, linked by criteria and stand
dards, that will enable sharing and efficient transfer of spatial data between producers and
users.” This resource was recognized as NSDI, which will provide current, and accurate
geospatial data readily available for the economic growth, social progress and environment
stability at local, national and global level.

International organizations like International Standards Organization (ISO) and Open Geospatial
Consortium (OGC) has taken initiative in standardization of geographic data (ISO/TC 211); “one
impact of the ISO/TC 211 effort has been the adoption of UML as a modelling language for the
Framework Data Standard”. Whereas the OGC undertook the development of a set of
specifications in the areas of WWW services, a Geographic Markup Language (GML), and
location based services. Their standardization efforts in the framework data “provides many of
the services and specifications by which implementation can occur. Also, the development of
GML schemas has been supported through the OGS’s Open Web Services 2.0 Testbed” (URL: 1).

In India, Department of Space and Ministry of Science & Technology started the initiative of
NSDI in 1996. They have identified seven main components mainly the standards, metadata,
nodes & GIS servers, search & access protocol, electronic clearinghouse, and the user interface.
The latest development in the Indian NSDI is the release of its taskforce report in January 2001
and the metadata report version 3.0. Still not much work is done and much leeway is left for the
improvement of the NSDI for providing the value added services (like the location based
services) to the potential users (URL: 2)

2.3. Emergency Location Based Services and Standardization Initiatives
at International and National Level

Now that abundant of geospatial data is available under one roof, the question is, how it should be
used for the benefit of the general public. On the other hand location based emergency services is
the kind of service that requires spatial data apart from location accuracy. As stated by Chen, A
(2004) “Location-based services historically were built as stand-alone applications that didn't
communicate easily with other applications and systems. Open standards, therefore, will be a
necessary catalyst for LBS growth.”

Similarly, in any requirement of LBS, interoperability is imperative (Karimi & Hammad, 2004)
and also, geographic data is fundamental requirement to LBS. It is believed that to make LBS a
reality, one has to make use of existing geospatial data that are organized and maintained in
different software and are located in different servers of mapping organization (Zlatanova &
Verbree, 2004). Interoperability in LBS is closely related to the development of interoperable
distributed systems, which can be achieved through standardization of APIs (Application
programming interfaces) and protocols that helps in better communication in distributed
environment (Karimi & Hammad, 2004). Location interoperability forum (LIF), WAP forum and
OGCs OpenLS initiative is a great step towards standardization in the area of location based services. According to Toronen, (2003) and Karimi & Hammad, (2004), Motorola, Nokia and Ericsson initiated LIF in 2000. LIF did great amount of work (Toronen, 2003) before ceasing its operation and consolidating with open mobile alliance (OMA) in 2002, these works are in the area of mobile location protocol (MLP) or Mobile Location Query API that serves as the interface between the location server and the location-based client. The de-facto choice of the protocol is the HTTP but the possibility of using simple object access protocol (SOAP) cannot be neglected, as SOAP bridges the gap between the HTTP and XML based standard protocols, and used for the information exchange in decentralized distributed environment (Gruber & Winter, 2002). Wireless Application Protocol (WAP) is a communication protocol that is mainly suitable for micro browsers running on WAP enabled mobile devices; this WAP protocol is based on the HTML, XML and TCP/IP Internet protocol. WAP has also developed a Location framework for communication between the mobile stations & the mobile positioning centres (MPC) that fits into WAP (Karimi, & Hammad, 2004). There were three different specifications (Location framework overview, location protocols and the location XML document formats) proposed by the WAP in collaboration with LIF, which was approved by the WAP Forum, but were not included in a conformance release and the work is still continuing in the OMA. Similarly, the work done by the OpenLS (URL: 3), in developing the specification for the interfaces that “facilitates the use of location and other forms of spatial information in the wireless Internet environment. The purpose of the Initiative is to produce open specifications for interoperable location application services that will integrate spatial data and processing resources into telecommunications and Internet services infrastructure.”

For providing the location based services in different application domain considerable amount of study and research was conducted in different parts of the world to find out the best available technology some of the studies for providing emergency services are E911 in U.S wherein the telecom service provider has to provide certain level of accuracy to the emergency responders or PSAPs (Public Services Answering Points) as stated in Jeganathan et al., 2004; Chen, A (2004); Dao et al., (2002); Kerton & Kerton, (2003); Kleiman, E., (2004). Study conducted in Finland (Toronen, 2003) for providing the personal navigation service architecture was the great step in critically evaluating the background and the standards associated with the personal navigation especially its service architecture, Concepts & interpretation of metadata and associated information related to intelligent transportation systems were critically reviewed. The service architecture is introduced in document in Core Service Architecture for personal navigation (PAM Deliverable 7 V0.99) and Personal Navigation Service Architecture: Survey of Background and Standards (PAM Deliverable 6 V 2.0, 2003)

According to the stated in CGALIES, (2002), With over 250 million GSM phones users in European Union (EU), statistics reveal that 90 million European citizens travel abroad at least once a year and more then 65% of them feel insecure when they are on travel as most of the mobile callers do not know where they are when they make emergency calls. Over 40 million calls are mobile calls received by the emergency service operators each year out of which
emergency could not be dispatched to approximately 2.5 million calls each year. Keeping in mind all the statistics of EU a similar kind of study was conducted to provide the Emergency Location services (E112) in European union. The coordination group on access to location information (CGALIES) conducted this study on emergency services and submitted the final report to the EU on February 2002 (Cgalies final report V 1.0) wherein they have worked out the minimum standards and requirement to location accuracy and location reference system, minimum standards on databases standards for PSAPs and the costs required for the implementation of the was closely studied. Mr. Louis Michel, Vice Prime Minister and Minister of Foreign Affairs, Belgium revealed in First European 112 Conference and Exhibition, Brussels 1st December 2003, that “Although some work is now underway, much more needs to be done to detect common grounds for emergency services over Europe and reinforce them” (URL: 4).

According to the statistics (URL: 5), there were 9 million subscribers in India at the end of 2002, and it is expected to grow to 120 million mobile subscribers by 2008 as forecasted by cellular operators association in India. The study conducted by the Tata consultancy services (TCS) (Agrawal & Agrawal, 2003) in order to provide the location-based services in India was more or less parallel to the study conducted by the CGALIES group of EU but the study was not too extensive. In the current scenario there are 70 mobile operators in India (URL: 6) out of which only Hutch operator in Delhi (URL: 7) is providing the location-based service (emergency services) in Delhi. To the best of my knowledge no other operator is in India is providing these kinds of services to the user and also they are mainly concentrating on the routing of the calls to the nearest emergency centres and still there is no provision to the access of spatial data to the users or to the emergency centres receiving the calls.

2.4. Development in Location Based Services (LBS)

There are overview articles in the field of location-based services (Montalvo and Ballon, 2003; Dao et al., 2002; Battson & Zhao, 2004) which talks about the business model & issues for LBS, taxonomy & overview on location based services and market challenges. Similarly there are papers like those by Ahmed, (2004); Prasad, (2003); Kleiman, (2002); Magon & Shukla, (2001); Sen & Sengupta, (2003); Chin & Huang, (2003); Tarle, (2002), which mainly discuss the concept & reality, promising technology (mainly positioning technology), different applications, challenges and the standardization required in the field of location based services.

Apart from the location technology there is a need for spatial databases that help in providing the services to the users. The integration of these two powerful technologies i.e. geospatial and mobile wireless technology will open new doors of innovation, like the work proposed for visually handicapped people by Jeganathan et al., 2004. Ravada, (2003) has done research in this area wherein the main aim was to make the spatial data management easier and more natural to user or applications of location based services. One of the reasons for this is that the conventional relational databases do not have the technology that is required to handle the spatial data, as it requires the database to understand more complex data types like point, arc and area and the
relationship between them. A research by Monteiro de Farias et al (2003) is a step towards developing an object-oriented model for dynamic geographical information systems and location based services where he has depicted a collaborative diagram for sending and receiving messages in case of emergencies. Now when moving towards the real world application of location based services in particular the emergency services apart from E911 (the ‘E’ is for Enhanced) there is a research done by Boondao et al., (2004) wherein she has developed a model for crime control in Thailand, which helps police officers in monitoring the crime in the city or in any part of the city, searching for the criminals and also real time crime update using can be done using PDAs.

The main hindrances in the field of emergency services are the input data and the standardization methods. ISO TC 215/SC N is a step towards standardization of the emergency data sets framework. This was released just for discussion in 2001, most of the data sets are related to the emergency medical services and patient data, though full data might not be useful but the existence of certain meaningful data can be utilized at hand.

Barttoli, (year not known), has described a scenario of civil emergency and based on that what type of client server architecture it should have, format for data, communication protocol to be used is described in the research and finally it produces a prototype that uses PDA with the mobile phone working on an open software Superwaba for running the prototype application.

2.5. Ontology usage in LBS

LBS require information from heterogeneous sources, which means extraction of information from distributed sources plays an important role in this. There has to be a structure in terms of hierarchy or taxonomy in the heterogeneous data sources so as to extract relevant information, also these sources should be semantically strong and must accomplish interoperability in the system. Using ontology helps in solving these problems as stated by Ibach etal, (2004). Similarly Gruber, (1993), has described ontology as the specification of the conceptualization. This conceptualization provides ways to understand and represent the relationship that the human can understand. At this juncture there is a need to understand concept and process of information extraction from distributed databases and one of them is the concept of ontology. Research carried out by Lemmens & De Vries, (2004) in the field of WWW for information extraction used the concept of ontology, stating that lot of web services are coming up these days and also the location based services, but it is difficult to find out whether they can be used in combination with each other or not. Using ontology they semantically described the location based web services. They used specified inputs and outputs of the web services so as to characterize the location-based services using location ontology, which was, constructed using OWL (ontology web Language) DL subset as referred in Dean & Schreiber, (2004). Similarly, Flury et al., (2004) used OWL for modelling location ontology for context aware services. Their approach was to categorize the location determination solution (form diverse location sensing technologies) “based on abstract mathematical model of space according to which do, implicitly or explicitly, define the location information that they provide as an output.”
Yu et al., (2003a, 2003b and 2003c), has done extensive research in the field of location based spatial modelling using ontology, collaborative framework using different concepts of ontology and profile based framework using for location-based services. In spatial modelling using ontologies and in collaborative framework approach the author introduced the concept of global, local, shared & integrated ontologies and also mediators & integrated ontologies. The author also considered the semantics in heterogeneous sources and the diverse users viewpoints in a scenario where a user is visiting the new city. When a user fires a query then the mediator directs these queries to different shared ontologies, which holds together the local ontology. Integrated ontology wrap the query answers received from different ontology and redirect it to the user. The user profile approach helps in improving the efficiency and precision of querying the spatio temporal information in location-based services. Kerschberg et al., (2004) used the concept of agent-based ontology for searching over heterogeneous databases using semantic web services, keeping in mind the idea that the integration of the data and knowledge from multiple heterogeneous sources is one of the most common problem faced by the scientific community.

Similarly, in Tryfona and Pfoser, (2001) ontologies were used to support the exchange and sharing of the information. They have described the fundamental of mobile ontologies because of the reasons that, ontology is long praised for interoperability. In his latest research he described different data categories mainly the domain data, content data and the application data, and then later on described the ontology in each category of data with its relation in a use case of tourist LBS.

2.6. Summary

There is scope left in the field of LBS, as not much work has been done in India on location-based services except for a few studies like the Jeganathan et al., 2004 where the concept of utilizing LBS for visually handicapped people has been proposed. Agrawal & Agrawal, (2003) did only the feasibility study on the location-based services. Similarly, Prasad, (2003) Magon & Shukla, (2001); Sen & Sengupta, (2003) all have talked about the issues and overview on LBS, concepts and challenges relating to that but, no one have come forward for the framework design of LBS. One of the reasons why LBS has not been exploited in India I the fact that it requires data from distributed heterogeneous sources, which requires careful framework of interaction. Also, this framework should be flexibility enough so that services can be added or removed, without disturbing the whole framework. Because of the autonomy and the mobility of the agents the utilization of the agents in the framework can be exploited. But, these agents require intelligence (ontology), which helps them to negotiate and migrate to other domains. For this domain ontologies must be built. This motivated me further to develop a framework using agents that are committed to ontologies (especially in emergency services) and there is much scope left for using ontology where two different technologies (i.e. geospatial & mobile wireless) can be integrated for the application in emergency location services.
3. Technological Needs

3.1. Spatial Data Infrastructure in India - NSDI

There exists abundant amount of geo-spatial data in India. A number of government organizations like Survey of India (SOI), Geological Survey of India (GSI), Department of Space (DOS), Forest Survey of India (FSI) etc. are involved in its creation, but each organization has different formats for the spatial data created by them. The lack of standard data format sometimes leads to same data collection by different organizations thereby wasting time, effort, money, and the manpower. In order to avoid these redundancies in data collection, and to bring better coordination between different mapping agencies, a task force has been setup which is called NSDI Task force which is one stop portal for all the geospatial data, this task force has proposed a framework and components for it as illustrated in figure: 3.1 and figure: 3.2. This NSDI task force will act as a single body, which will decide, data standards, formats, specifications for the data and the database handled by the different mapping organizations (URL: 1).

The outcome of this task force is the NSDE (National Spatial Data Exchange) proposed format, that is “independent of platform or GIS software which is structured to incorporate various types of data element like vector data on topology as well as various types of thematic data along with associated attributes data, image data, DEM data, coded raster GIS data etc. The proposed NSDE format is the extension of Digital Vector Data (DVD-3) format devised by the survey of India (SOI) to represent SOI topo-sheet data in digital form along with the point, line, polygon” (Vaishnav et al., 2001).
Since then, the Department of Science & Technology (DST) and the Department of Space (DOS) in India took up the initiative of NSDI, so the access of data is mainly given to the government agencies only and not to the private agencies. As in the case of United States wherein people can have free access to data, in India at the moment, “the non-accessibility of spatial information to the private sector is yet another major concern” (URL: 1).

3.2. Location Based Services (LBS)

“The ability to identify the exact geographical location of a mobile user at any time opens to range of new, innovative services, which are commonly referred to as location-based services (LBS)” These LBS are the services that utilize the geographic information to serve mobile users (URL: 8). “By joining wireless content information with this location technology, relevant and significant services can be made available” (URL: 2).

By exploiting the location information of a mobile client, LBS will play a bigger role in the future ahead. As stated in Kerton & Kerton, (2003), wireless phones and wireless location devices are defined as the driving force of future GIS. Today, when mobile communication is moving ahead from 2G technology to 3G technology and people are having access of checking emails, browsing the internet on the mini browser of their mobile devices, this technology will definitely leave a valuable impact in the market (Rainio, 2001). There are different mobile device working on a variety of technologies that are available in Appendix-A, which support LBSs but to achieve this there are certain requirements and rules that must be fulfilled which are further discussed in the chapter.

Opportunities are being created by these devices for new LBS “that rely on having a spatial background usually in map form with Georeferenced point of interest and other relevant information” (Stillwell et al., 2004), these geospatial information on the mobile devices will surely be “more intelligent then paper maps” by providing access to wide range of services like traffic and weather updates. Providing medical help, movie information or restaurant guide are a few other examples of LBS in today’s world.

As stated in (Frank et al., year not known) “GISs contain many of the components necessary for LBS as they provide the basic tools and, hence, make LBS functionally possible. Three additional fundamental aspects, however are required for GISs to provide added value services are: mobility, distributiveness, and egocentric awareness”.

- **Mobility** for decades GISs was used on the desktop computers mainly interacting with the real world features in a simulated environment on the desktop computer. On the other hand, LBS when used in the field helps the user to interact with their surroundings and “to support these interaction GISs need to become mobile”.

- **Distributiveness** means the processing capacity and the memory of the mobile device that can support different applications of LBS. “Such a distributive system may include a thin
client in the form of a mobile device, a connection to the Internet, an application server, and a database management system. This structure allows the data to be stored and managed in one place. Complex processing occurs at a different place, finally, leaving the mobile device with the manageable task of coordinating the user’s interaction in the field”.

- **Egocentric Awareness** spatial data are generally in the form of birds-eye-view where what user sees in the real world is the perspective view. Hence, GIS helps in translating the perspective view into the birds-eye-view, and “this translation and content management is based on the distributed system’s awareness of the user’s position, orientation, and task at hand”.

### 3.2.1. Killer Applications of Potential Technology - LBS

There are enormous applications of LBS in different domains some of them are given in Table 3.1 below:

<table>
<thead>
<tr>
<th>Domain</th>
<th>Application services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entertainment services</td>
<td>Movie, personal messaging (live chats with friends), hotels, tourist spots etc.</td>
</tr>
<tr>
<td>Billing services</td>
<td>Zoned-based pricing options</td>
</tr>
<tr>
<td>Information services</td>
<td>Traffic &amp; weather updates, yellow pages, news, stocks and sports, business alerts,</td>
</tr>
<tr>
<td></td>
<td>restaurant location &amp; booking etc.</td>
</tr>
<tr>
<td>Safety services</td>
<td>Emergency service (Police, fire &amp; rescue, hospital), crime control, road side assistance etc.</td>
</tr>
<tr>
<td>Tracking and Navigation services</td>
<td>In-car navigation, fleet (ship) management, Child tracking, friend finder etc.</td>
</tr>
</tbody>
</table>

When somebody is in emergency and would like to know the nearest medical shop, then this service (LBSs) will help in providing the details of nearest medical shop to them, also the route to the medical shop can be displayed on their mobile phone, this is just a small example of how LBS can contribute in the emergency services.

### 3.2.2. Basic Requirements in LBS

The most important requirement in LBS is that, user must have Mobile handset through which he/she can communicate; also user must be aware of the services provided by their telecom operators. Apart from these, LBS is built upon three basic blocks, which are major requirements in providing the location-based services, they are as under:

- Wireless communication system (Mobile switching centre, base station and handsets) (Dao et al., 2002)
- Positioning technology (GPS, A-GPS, Non-GPS etc.)
- Spatial databases and GIS Non-spatial databases (services, billing and demography)
**Wireless communication system:** This consists of huge infrastructure of mobile switching centres (MSC), base station (BS), and handsets. Base station is responsible for communication link between base stations and handsets by making use of HLR (Home location register that contains subscribers registration and service profile information) and VLR (visiting location register that keeps the information about the customer roaming in to another area). (Dao et al., 2002)

**Positioning technology:** There are different positioning technologies available, which can be categorized as – Network location method and satellite based location method.

- **Network location method:** “E-TOD (enhanced time of difference) and TOA (Time of arrival) methods are based on measuring time delays between the base station and the mobile device”, which gives good results in open areas, but there exists multi-path signal problem in urban areas (Toronen, 2002). Similarly, Cell ID based method is most commonly used which requires network to identify base terminal station through which mobile phone is communicating. This method is used for GSM, GPRS and WCDMS networks. But its accuracy depends up on the size of the cells, i.e. bigger the cell size lesser will be the accuracy and vice versa (Agrawal & Agrawal, 2003).

- **Satellite location method:** It gives good location accuracy but in the urban areas loss of signal and sufficient number of tracked satellite is a major problem. This problem is solved by the use of assisted GPS (A-GPS) technique, which is standardized positioning technology for GSM networks; also this technique does not support the existing handsets, so user has to purchase new handsets. Unlike GPS, A-GPS uses the assistance data from the network operator “to enable a GPS receiver to provide a position fix, even in challenging environment” (CGALIES, 2002). Location accuracy in meters and the accuracy assessment, coverage of different technology is given in Appendix-B.

**Spatial databases:** These are the most important requirement in LBS, as it help in manipulation of spatial data, allows complex analysis, support vector and raster format and have certain common characteristics like location, attribute, form, and relationships with other objects (Battson et al., 2004). Non-spatial databases – Includes data related to demography, psychograph, cell size, cell sector size etc.

**3.2.3. Geodetic Datum and Coordinate system**

Utilization of GIS and LBS need a common understanding of datum’s and projections. The reason behind this is that, the earth surface do not have perfect shape and size everywhere, i.e. it is undulating. Thus, geodetic datum varies from country to country. The selection of wrong datum for the LBS would affect the positional accuracy that might lead to an error of kilometres. The United States Mapping Agency (USMA) has developed a reference system called World Geodetic reference system of 1984, WGS-84, which is widely adopted world over for satellite navigation system (Agrawal & Agrawal, 2003). In location-based services, the cell sector (coverage area of a particular tower) has coordinated in X & Y, but the data in data domain are in WGS 84 system, which means geographic latitude and longitude. So in order to fetch data from
the data or NSDI domain based on the position, I have used the converter agent that will convert the location on the caller from X & Y to geographic latitude and longitude.

Similarly, in the context of spatial information, projection plays a major role as this helps in predicting the absolute spatial location, for this UTM (Universal Transverse Mercator) is considered to be the best coordinate system. As it divides the whole world into 60 longitudinal zones, with each zone 6m wide apart from each other (URL: 9).

3.2.4. Integrating All Components

According to (URL: 5), to achieve these services there exists a need for integration, which is based on three different rules they are as follows:

- Use data to derive application.
- Make application development easy.
- Develop superior user interface.

Data driven application can be of two types dynamic and static data. Car navigation, which is a kind of dynamic data navigation user, can save, delete, edit addresses, maps etc. dynamically. Where as static data is nothing but the periodic or regular updates or the information about the restaurant listing, ATM content are the static data, as “they can not be augmented directly by the user”. Apart from the dynamic and static data, need for real time information also exists especially in a case of emergencies, for example in any type of emergencies responders would like to follow the route that has less traffic. Similarly, in case of fire emergencies, emergency responders would also like to know the direction and speed of the wind. These things must be kept in mind while designing the framework.

Application can be made easy by providing easy to use plug and play “customized applications for wireless carriers, for example one wireless carrier might want to offer only a list of restaurants to users, while another carrier may wish to incorporate restaurant reviews. The same basic functionality is used for application, meaning that the second application only requires the application to be slightly reconfigured-not entirely recoded”.

User interfaces are designed so that user can jump from one application to another logically. This helps in asking the question like “I have this ……what can I do next?” and this can be achieved if keypad entries by the user can be minimized. Integration is required because at the time of emergency when the ECC receives call, there should be a mechanism or system that provides geographic data based on the location of the incident. So that rescue team can be dispatched in the shortest possible time.

3.2.5. Mobile Service Architecture

According to Karimi & Hammad, (2004), “To fully realize the benefits of LBSs, the design of system architecture becomes paramount”. Especially in the case of wireless LBS that requires
robust architecture, “this generally means a consolidation of database, application servers, and tools for reason of performance, scalability and cost-effectiveness”. Hence, delivery of location services is a challenging task because of the dynamic nature of the mobile client.

On the first tier are the basic spatial data services, which are continuously updated by the value added service developers. Second tier utilizes the spatial data from the first tier to build the information services. “On this level different source of spatial data are possibly integrated, specific location dependent information is added, and the resulting information product is offered to the next layer in the architecture. In this process the location of the actual user, available from the applied mobile device technology, might also be made use of”. The third tier has two views it is easy to use directory services facilitating the discovery of location-based services and from the service providers view to adapt “the resulting service information appropriately for each category of information end user devices” (Toronen, 2003).

![Four-Tier Technical Architecture of Mobile Service](image)

**Figure: 3.3 Four-Tier Technical Architecture of Mobile Service (Modified from Toronen, 2003)**

### 3.3. Agents, Ontology and Communication

#### 3.3.1. Utilization of Agents

The origination of the agents started from the diverse field of software engineering. It is very difficult to give exact definition of the agents that includes all the things. Agents are small in size and work in conjunction with other agents representing their social ability. Agents depict certain properties like they are autonomous, adaptive, mobile, collaborative, flexible, proactive, they can be personalized and facilitate real time interaction with the server (Singh, 1998 & Zipf & Aras, 2002). “Agents allow encapsulation and distribution at component level”. These “agents can be inserted at different level of service aggregation. Agent sharing common ontology can
communicate with each other, reason, plan and execute tasks”. One of the most robust parts of agents is that they are autonomous and mobile. Mobile property has attracted lot of attention of using agents in distributed systems, information retrieval, artificial intelligence etc.

### 3.3.1. Categories of Agent

Agents can be broadly categorized as stationary and mobile agents. Stationary agents are the ones that interact or coordinate the activities within a specific domain for example; it can assign tasks to various mobile agents so that they can communicate with agents in different domains. Where as mobile agent has the ability to communicate with other agents in different domains or in the remotest domains. Since, LBS requires large amount of data to be processed, the utilization of the mobile agent in LBS can be explored so that most of the processing is left at the server side and less at the client side.

### 3.3.1.2. Advantage - Agent

According to Singh (1998), Zipf et al (2002), One of the advantages of using agents is that they communicate on what, not how. They autonomously decide what operations to perform and what data to access for others. Also, to perform appropriate and efficient queries agents can exploit their knowledge of local information. Mobile agents can move between computers in a network. Which helps in retrieving the information from the distributed systems. Also, the queries can be performed at the remote side without having to transfer the raw data to the owner’s computer or mobile phones first, which would likely waste considerable bandwidth. As mentioned by Calhau et al, (2004), agents help in doing most of the computation at the server side leaving the client side for faster access. Agent technology provides powerful flexibility in such a way that new functionality can be implemented very easily just by adding few more agents.

### 3.3.2. Why Use Ontology?

Gruber, (1993), defined ontology as a “specification of conceptualization. Conceptualizations are nothing “but ways in which human understand and represent the world” (Bittner, 2004) as described in Gruber, (1993). Hence, ontologies provide vocabulary (or unique names of concepts) that defines the meaning of the terms and the relationships that can exist between. In the context of artificial intelligence, ontology represents the concept of knowledge sharing where relationship within the concept can exist for an agent or a community of agents. “We build agents that commit to ontologies and we design ontologies so we can share knowledge with and among these agents” (Gruber, 1993). So agents depict known actions if they are committed to ontologies. This can be seen when a client interacts with an agent by making logical assertion & passing queries. The advantage of using ontology is that it helps in avoiding the problems related to inconsistency and poor understanding among the communication parties. As stated by Ibach etal, (2004), for accomplishment of interoperability on high level of semantics, one has to agree on a suitable ontology which helps in specifying terminology and relationship in a specific application domain.
Later to represent the ontology, Ontology web language (OWL) as specified by the W3C. It utilizes the RDF schemas for the demonstration of relationships like class, sub-class, property sub-property, domain, range and instances. OWL allows user to write explicitly the formal conceptualization of the domain using RDF schemas, which further helps in achieving the interoperability between applications in the domains. All this gives my work the foundation for constructing the framework that is based on agent mechanism committing to domain ontology.

3.3.3. Agent Communication Languages (ACL)

Two agent communication languages that are popular in the field of agent technology are FIPA ACL and KQML (Knowledge Query Manipulation Language).

**KQML** – It has a rich depth of communication based on the speech act theory. KQML also allows exchange of knowledge by sending messages known as performatives. KQML is considered as the toughest language in the domain of ACL as it requires strong background of artificial intelligence, which makes it even more complex for the programmers, developers and software engineers for using it in the agent based systems. But one of the most important properties of KQML is that it is message-oriented language i.e. it is independent of transport mechanism (TCP/IP, SMTP, SOAP or other), content language (SQL, Prolog etc.) and ontology assumed by content (Singh, 1998).

**FIPA ACL** – Foundation for Intelligent Physical Agents a non-profitable organization whose goal is to provide specifications (rather than saying how to build agent platforms) for the agent based applications, services and equipments, which helps in maximizing interoperability across agent based systems. FIPA ACL is built upon the success of KQML, which is based on speech act theory. The messages that are supplied by the agents are wrapped in a performatives called ACL. FIPA has launched Micro FIPA-OS a toolkit that is aimed for PDA’s and smart mobile phones. Although it has only been tested for PDAs at the moment and researches are going on for the development of toolkit that can work on smart phones. Further information can be obtained from their websites i.e. for KQML http://www.cs.umbc.edu/kqml/ and for FIPA http://fipa.org

3.4. Summary

In order to make LBS a reality it is imperative to have spatial databases as these databases will help in providing the required services to the users. But if different telecom services provider uses variety of spatial databases which suits their existing underling technology (proprietary databases, network protocols) then this might cause problem to the users who are not committed to that telecom operator (roaming user) especially at the time of emergencies. So, in order to avoid these possible problems there is a need to integrate these two powerful technologies i.e. GI technology & the communication technology is required for an application of emergency location services. For this the system must provide flexible, efficient and robust. So that quick and efficient response can be taken up by the emergency organizations. For this the agents that are committed to the domain ontology must be exploited.
4. Requirement Analysis for Emergency Location Services

4.1. Overview

With the rapid increase in population and industrialization it is realized that huge population will live in the metropolitan cities or more specifically in a congested cities because of which common man is vulnerable to various kinds of risks existing from different kinds of emergency situation in urban life. Emergency could be of any type from man-induced to natural, but need for every kind of emergency is a quick and focused response without which the life and property of common man is at risk.

“Police, fire and emergency medical services are the first responders” (Sharma et al, 2004) in any emergency situation, but lack of timely information and the geospatial data to the responders in planning the response to the emergency has made it difficult for them to reach at the incident site on time. This is even worse when there is lack of coordinated response and communication even between the different emergency responding authorities/organizations (URL: 10). Timely access to incident location and geospatial data to the responders will help in providing crucial help.

With the rapid advancement of IT and communication industry, it has now become possible for different emergency responders to share, access and use each other’s information using mobile technologies (URL: 10). Emergency location service has emerged as a new boom where, world is concentrating heavily at the moment. With the emergence of E911 in U.S and E112 in Europe people have started accepting emergency location service as a lifesaver for them.

GIS has changed the landscape of LBS that will play a major role in the coming years. This will strengthen the role of emergency and other services to a much greater extent. We will see this in the following subheadings of this chapter how the GIS and LBS can benefit this emerging service and what are the requirements for this.

4.2. Role of GIS and LBS in Emergency Location Services

The technological advancement of Geographic information system (GIS) has improved the decision-making process of planners and managers, especially in a case where, accurate spatial information and quick response can save the life & property of the common man. With the

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1 “An emergency is a deviation from planned or expected behavior or a course of events that endangers or adversely affects people, property, or the environment” (URL: 11).
initiations of spatial data infrastructure (SDI) in different countries, one can expect the authenticated data under one roof. Which might solve the problems pertaining geospatial data. According to (URL: 12), “The merger of GIS and IT technology has led to significant information technology advancement which have had a profound impact on emergency management. The utilization of location based technology solutions and the accessibility of this information via the Internet or wireless media allows local, state and federal agencies to prepare for and put procedures in place for natural or man-induced disasters”. The most crucial aspect of emergency is to effectively manage the flow of information and transfer it to the right authority at the shortest possible time.

The combination of spatial data and the location information helps in reducing the response time. For example in case of building fire had the emergency responders have access to information about the building floor plans and store material through a mobile device (PDA or Simputer) they can respond to fire in a very effective way. Similarly, fleet management of fishing boats helps fishermen in finding the potential fishing zones in the sea or coastal areas, and also save their lives from weather related disasters.

Mobile communication technology can play a vital role in improving the response time, by providing the location of the incident site to the responders and also live traffic feeds to the emergency responders. Hence the present research would focus on delivering the required information to the emergency responders so that the response time can be reduced.

4.3. Type of Emergencies

Emergencies could be of various types, for example violent strikes, mob attack, terrorist attacks etc are one type of emergency and roadside assistance is another type of emergency (especially in the case of car break down). But for simplicity let us divide the emergency in two major categories i.e. Man induced & Natural disasters (Sharma et al, 2004).

- **Man-Induced or Accidental:** These are the type of emergency that can be planned or unplanned in nature for example planned emergencies can be terrorist attack, building fire etc. and unplanned could be road accident, prison break, truck and train spill, medical help and also the urban fire.

- **Natural Disaster:** These are the emergencies that are purely unplanned in nature and are more disastrous then the man induced disasters. Some example of these are floods, forest fire, cyclone hit etc.

Out of all the emergency, fire is the only type of emergency that is unpredictable and can be man-induced (planned and unplanned) and natural. Similarly emergencies can be defined in different scales as shown in Table: 4.1, but the concentration of this thesis would be on the emergencies at the city level as one can expect users to carry their mobile phones in the city and also, there is good positional accuracy expected at city level i.e. in urban areas 100m ~ 500m, which further
degrades to 1000 meters or 1km in sub-urban and rural areas due to poor coverage area and reduced connectivity.

**Table: 4.1 Emergencies in Different Scales**

<table>
<thead>
<tr>
<th>SCALE</th>
<th>EMERGENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1million To 1:250,000</td>
<td>Earthquake, Nuclear attacks, chemical &amp; biological attacks, Cyclone and hurricane etc.</td>
</tr>
<tr>
<td>1:50,000 To 1:25,000</td>
<td>Earthquake, disease spread, forest fire, drought, floods etc.</td>
</tr>
<tr>
<td>1:10,000 To 1:2000 or less</td>
<td>House fire, Road accident, road side assistance, prison break, medical emergency, pipeline burst etc.</td>
</tr>
</tbody>
</table>

**4.4. Technologies and the Driving Forces**

In order to tackle the above said emergencies there are certain technological driving forces that are required in emergency location services as shown in figure – 4.1. In the figure we expect user that will provide the first report of the incident, the wireless network will assist in location management based on which the GIS data sources and the real time data would be utilized for running the application. This will be further delivered to the ECC, and later the experts will analyze the extent of the damage.

![Figure: 4.1 Technologies and Driving Forces for the Emergency Location Services](image-url)
4.5. Different Phases in Emergency Management (URL: 11)

There is no escape from any type of disasters, but they can be minimized or avoided if emergency responders get information at the right time and follow certain phases of emergency management that are applicable to all type of emergencies. As stated in (URL: 11), each phase is interconnected and is discussed in detail below. In general there are five basic steps out of which, preparedness and response are the most important steps for which every emergency organization should always be prepared for.

Planning – Proper planning helps in analyzing and documenting the possibility of emergency and its impact on the life and property. This phase plays a crucial role in urban areas as it reduces the chances of fire and other man-made emergencies.

Mitigation – This phase helps in eliminating or reducing the probability of a disaster e.g. building restriction in potential flood zones.

Preparedness – This phase helps mitigation when a disaster cannot be prevented. In this phase various organizations (government, NGOs etc.) develop plan to save the lives and property of mankind prone to damages of disaster. For example, installing early warning system, etc. can play a substantial amount of role. Also, wireless communication can help in providing live traffic & weather feeds that can be useful for the emergency responders in planning their route.

Response – It is designed for providing the emergency assistance to the victim of disaster (e.g. search and rescue, emergency medical help, food and shelter etc.). They help in stabilizing the situation and also help in speedy recovery of damaged system.

Recovery – “Activities necessary to return all system to normal or better”. These can be of two types i.e. short-term recovery (temporary housing, food & water cleanup etc.) and long-term recovery (e.g. rehabilitation, financial assistance, providing employment to victims, and community planning etc.)

4.5.1. Geospatial Data Requirement at Different Phases of Emergency Management

A step has been taken in identifying the requirement of geospatial information at different phases of emergency management (Table: 4.2). Further, this spatial information should be maintained at local, state and national a level for which a strong database must be created that helps in analyzing and predicting the emergencies at the right time.
Table: 4.2 GIS Involved in Different Phases of Emergency Management

<table>
<thead>
<tr>
<th>Planning</th>
<th>• Mapping the data on street and pipeline network, building areas, power lines, storage facilities etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitigation</td>
<td>• What are the facilities in high hazard areas that require immediate repair work?</td>
</tr>
<tr>
<td></td>
<td>• Where are fire hazard zones and what features constitute the fire hazard?</td>
</tr>
<tr>
<td></td>
<td>• Spread of fire based on wind direction and speed.</td>
</tr>
<tr>
<td></td>
<td>• Based on topography feature GIS can predict the course of floods.</td>
</tr>
<tr>
<td>Preparedness</td>
<td>• Where should fire station be located if 5 minute response time is required?</td>
</tr>
<tr>
<td>Response</td>
<td>• How many ambulances are required and where they should be located?</td>
</tr>
<tr>
<td></td>
<td>• What evacuation route should be selected?</td>
</tr>
<tr>
<td></td>
<td>• What route should be selected for the emergency dispatch?</td>
</tr>
<tr>
<td></td>
<td>• Where are the closest hydrant, electric units and the hazardous material?</td>
</tr>
<tr>
<td></td>
<td>• Access to floor plan of the building where fire has occurred.</td>
</tr>
<tr>
<td></td>
<td>• What are the blocked roads and what are the traffic conditions en route to the emergency?</td>
</tr>
<tr>
<td>Recovery</td>
<td>• GIS with GPS helps in locating damaged facilities, the amount of damage etc.</td>
</tr>
<tr>
<td></td>
<td>• GIS can display areas where a service has been restored and/or the work in progress.</td>
</tr>
</tbody>
</table>

4.6. Geospatial Requirement in a Use Case of Fire Emergency

In case of fire accident, although the fire department may respond quickly but the lack of knowledge about the location, causes, extent of the fire and traffic conditions would aggravate the situation further, which might add to the problems. Similarly, the mitigation program might get hampered where the fire vehicle even reaches the area of the fire, and lack of water further delays the response time. Thus the whole program needs to be coordinated with water supply to provide more fire hydrants, water tanks and also with the police and the medical assistance (Thapar et al, 200).

Rescue, relief and rehabilitation operations can be well planned if up to date relevant information is available emergency responders. Since most of the data required are spatial in nature and can be located on a map as discussed with the experts, but still the right data is hard to find at the time of emergency. In Table: 4.3, an analysis has been done in order to identifying the requirements of geospatial data and the source through which this data should come from, in a use case of fire.
emergency (urban fire & forest fire), and the gas pipeline burst. From the point of view of standardizing the emergency data ISO TC 215/SC N has made a report, which is “Emergency Data sets Framework”, though the concentration is not at the geoinformation but certain meaningful data can be used at hand.

Table: 4.3 Identification of the data layer required from different data sources.

<table>
<thead>
<tr>
<th>Type of Emergency</th>
<th>GIS or Geospatial Data Required</th>
<th>Feature Type</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban fire</td>
<td>Road network</td>
<td>Line</td>
<td>State municipal authority</td>
</tr>
<tr>
<td></td>
<td>Ward boundaries</td>
<td>Polygon</td>
<td>Municipal authority</td>
</tr>
<tr>
<td></td>
<td>Jurisdiction of each fire station</td>
<td>Polygon</td>
<td>Fire authority</td>
</tr>
<tr>
<td></td>
<td>No of fire station in ward</td>
<td>Point</td>
<td>Fire authority</td>
</tr>
<tr>
<td></td>
<td>Water supply pipeline</td>
<td>Line</td>
<td>Municipal authority</td>
</tr>
<tr>
<td></td>
<td>No. of houses in a jurisdiction</td>
<td>Polygon</td>
<td>Municipal authority</td>
</tr>
<tr>
<td></td>
<td>No. of hospitals in each ward</td>
<td>Point</td>
<td>Public health authority</td>
</tr>
<tr>
<td></td>
<td>No. of hydrants</td>
<td>Point</td>
<td>Fire authority</td>
</tr>
<tr>
<td></td>
<td>Floor plan in cad file</td>
<td>Line</td>
<td>State planning department</td>
</tr>
<tr>
<td></td>
<td>Population in the area of incident</td>
<td>Point</td>
<td>Census department</td>
</tr>
<tr>
<td></td>
<td>Hazardous material in the vicinity of the incident</td>
<td>Polygon</td>
<td>Municipal Authority</td>
</tr>
<tr>
<td></td>
<td>Wind direction and speed data</td>
<td>Attribute</td>
<td>State meteorological department</td>
</tr>
<tr>
<td></td>
<td>Road capacity (speed and time)</td>
<td>Attribute</td>
<td>Traffic node</td>
</tr>
<tr>
<td>Forest fire</td>
<td>Topographic data (contour)</td>
<td>Line</td>
<td>Survey of India</td>
</tr>
<tr>
<td></td>
<td>Forest cover area</td>
<td>Polygon</td>
<td>Forest Survey of India</td>
</tr>
<tr>
<td></td>
<td>Transportation network</td>
<td>Line</td>
<td>Forest Survey of India</td>
</tr>
<tr>
<td></td>
<td>Slope and aspect data (Raster)</td>
<td>-</td>
<td>National Remote Sensing Agency (NRSA)</td>
</tr>
<tr>
<td></td>
<td>Transportation network</td>
<td>Line</td>
<td>Forest Survey of India</td>
</tr>
<tr>
<td></td>
<td>Airport in the vicinity forest</td>
<td>Point</td>
<td>Air port Authority of India (AAI)</td>
</tr>
<tr>
<td></td>
<td>Wildlife habitat</td>
<td>Attribute</td>
<td>Ministry of environment and forest.</td>
</tr>
<tr>
<td>Type of forest</td>
<td>Attribute</td>
<td>State meteorological department</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>-----------</td>
<td>---------------------------------</td>
<td></td>
</tr>
<tr>
<td>Fuel in the forest</td>
<td>Attribute</td>
<td>Forest Survey of India</td>
<td></td>
</tr>
<tr>
<td>Any habitation if the forest</td>
<td>Attribute</td>
<td>Forest Survey of India</td>
<td></td>
</tr>
<tr>
<td>Any river flowing through forest</td>
<td>Line</td>
<td>Ministry of Water Resources</td>
<td></td>
</tr>
</tbody>
</table>

**Major Fire Accident**

<table>
<thead>
<tr>
<th>Gas pipeline</th>
<th>Pipeline network</th>
<th>Line</th>
<th>Private (GAIL etc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road network (optional)</td>
<td>Line</td>
<td>Municipal authority</td>
<td></td>
</tr>
<tr>
<td>Carrier (type of gas)</td>
<td>Attribute</td>
<td>Private (GAIL etc)</td>
<td></td>
</tr>
<tr>
<td>Pressure of gas in pipe</td>
<td>Attribute</td>
<td>Private (GAIL etc)</td>
<td></td>
</tr>
<tr>
<td>Land use</td>
<td>Polygon</td>
<td>Municipal Authority</td>
<td></td>
</tr>
<tr>
<td>No of houses</td>
<td>Point</td>
<td>Municipal Authority</td>
<td></td>
</tr>
</tbody>
</table>

4.7. **Filling the Gaps - In NSDI**

Maintaining the data sets required in different organizations will help in sharing the information at different stages of emergency. Most of the emergencies need information related to pipelines, buildings layouts, electrical distribution, drainage system, population and so forth. As most emergencies do not “allow time to gather these resources” (URL: 8) there exists a need for a system that helps in faster information flow. Especially in the case of urban fire where fire fighters not only save the lives from fire risks but also rescue humans from building/house collapse, drowning, road accident and other emergencies. Hence, sharing information not only helps maintaining interoperable data but also at the same time helps in responding to emergency faster by taking right decisions. The interoperable systems not only improve the speed of response, but also help emergency responders to take effective measures.

Further according to (Sharma et al, 2004), “to access the damage and carry out emergency planning and response exercise, it is essential to overlay the out comes on a map having features such as industries, residential areas, schools, markets, road, rails etc. Also, the resources required such as fire and spill control, medical aid etc. to combat the emergency situation”. Keeping in view all the data and resources required there would be “linkages of various databases, it has been considered appropriate to use GIS tools for emergency planning and response”.

Geospatial data repository i.e. NSDI in India, contains geographic data at the required scale for the large scale emergency such as forest fire as identified in Table-4.3 but the data for handling the city level emergency does not exist, which has also been identified in table – 4.3. So,
stakeholders contributing to the emergency services must be identified, as to fill in the gap in the NSDI. Some of the main stakeholders identified are police, fire & rescue, public health department for medical services, urban planning organization etc. These organizations as shown in figure: 4.2 must come forward to develop an infrastructure that could contribute to the Indian NSDI in the near future.

Figure: 4.2 Requirement Analyses for the Possible Emergency Stakeholders that can be a part of NSDI

Similarly, figure: 4.3a, 4.3b, 4.3c &4.3d shows the parameters and their relations in the database model for the organization identified as the stakeholders in the emergency services. There could be many more attributes, but for the identification purposes small amount of attributes has been put in the database.
FRAMEWORK FOR LOCATION BASED EMERGENCY SERVICES IN INDIA

Figure: 4.3a Different Parameters & their Relations in Fire & Rescue Department Database Model.

Figure: 4.3b Different Parameters and their Relations in the Hospitals Database Model.

Figure: 4.3c Different Parameters and their Relations in the Police Department Database Model.
4.8. User Needs From Emergency Location Services

According to Rainio (2001), ELS allows users to find his own location, nearest emergency management centre, services and resources they provide etc. Similarly, in case of fire emergency the user at the emergency site can ask for the hospitals within the proximity of ‘X’ km?, best route to reach there etc. Hence, user from emergency site might ask these possible answers:

- Where am I? (Static)
- Where is the nearest hospital from my current location? (Static)
- Which is the best route to reach there? (Dynamic)
- …And could be many more?

Also, these queries can be defined based on their nature like static query or dynamic query. By dynamic here I mean real time information, i.e. when user sends the query ‘How do I reach there?’ Then the system or the mechanism should provide the best possible route based on the dynamic or real time parameters such as traffic conditions, weather etc. in that area. Although daily conditions can not be
4.9. Summary

Everyone faces some sort of emergency, big or small in his or her day today life. Of course, these cannot be prevented, but timely information about the location of the incident to the emergency responders and access to geospatial data to them will help in reducing the response time. Hence, Location based services are required to be used in time critical situations, where every second counts. This requires robust and up-to-date GIS database and the real time dynamic databases also. The municipalities should come forward in establishing these databases and also the emergency centres i.e. police, fire, hospitals and NGOs etc. Though, there is no provision at present in NSDI to include these nodes, but the presence of them might solve the problems of related data required at different levels of emergency management & planning and for the standardization of the datasets required in it. Certain initiatives at international level has been take by ISO TC 215/SC N, in setting up the standards for “Emergency Data sets framework”, though whole data might not be useful but existence of certain meaningful data can be utilized at hand. Similarly, there is a need for a system that helps in speedy information flow, which is a main focus of the thesis and is discussed in chapter-6.
5. Framework Development

5.1. Background

In the context of location based emergency services there could possibly be three main players i.e. the user (who reports the incident), the mobile operator or the wireless network provider (helps in proper communication and routing the call to the nearest emergency centre) and the emergency organization (who are responding the emergency). These emergency services must be ubiquitous for the nomadic users as termed by Yu et al., 2003c. These three players are bind together by the geographic information at each step for the user and the emergency organization (chapter-4). Similarly, for the mobile operators the geographic information helps in required for deciding the location of the transmitting towers their coverage area and the cell sizes. Binding all the players with geographic information can be visualized as shown in figure: 5.1.

![Figure: 5.1 Three Players that are bind together with the Geographic Information](image)

Assuming that the geospatial data required by the emergency services for effective and speedy response are available and is provided by the geospatial repository i.e. Indian NSDI this can be seen by setting up the whole scenario in to client server architecture as shown in figure: 5.2. Considering the actual scenario where user at the time of emergency calls the emergency number (emergency number depends up on country to country), his call is then routed to the nearest emergency control centre by the mobile operator. But, once the call is routed to the nearest ECC they might want to have access to the maps with the position of the user or the incident on to it.
WORKING OF THE SYSTEM (BROAD VIEW)

1. User dial the emergency number and inform about the incident and the location.
2. Based on the user location (latitude and longitude) the relevant geospatial data is fetched from the NSDI.
3. This data is routed to the nearest emergency centre in the same way the call is routed.
4. The emergency control centre sends their rescue team to the site of incident
5. Rescue vehicle is tracked by the ECC.
6. The route taken by the vehicle is send to the LBS and
7. Then the information of the incident in a particular area is send to the users in that area just for the event notification.

In order to have clear view of the client server architecture, an interaction diagram has been made, which further gives insight to the system as shown in figure: 5.3. But in the mobile environment, different devices are being used by the user, which works on variety of protocols provided by the different mobile service provider. This further restricts the usability of the client server architecture. So, in this heterogeneous environment a technological framework is required that is flexible enough to accommodate the heterogeneity of the wireless communication environment and the limitations of network bandwidth and processing capabilities. In order to overcome this problem the applicability of the agents and ontologies can be exploited because of its properties that allows them to work in distributed heterogeneous environment.
5.2. Framework Approach

In this section I would like to point out certain important properties of the agents based on which the framework is developed. Agents are nothing but the software entities that are capable enough to take decisions on behalf of the user, which shows the autonomy of the agent. These decisions are based up on the intelligence (ontology) to, which they are committed. This intelligence helps agents to negotiate (cooperation) and migrate (mobility) to other domains in order to complete the task. This mobility of agent helps in transporting the network information and messages (query) from one domain to another.

Since, ELS needs coordination between different Geographic information and the wireless communication technology, these properties of agents will help in the development of a flexible framework, in which services can be added or removed as and when required. Hence with these types of properties agents can work without worrying about the network bandwidth or device requirement etc.
5.2.1. Technical Framework

The ELS framework is divided into four different domains i.e. the user domain, the wireless domain, the data or the NSDI domain and the emergency domain. Agents in each domain were identified so as to further analyze what task each agent has to carry within and outside the domain. For further simplifying the agent functioning these agents were categorized into stationary agent (domain agent) and the mobile agents. Each domain is represented by the domain interface agent (each domain interface agent acts as a gateway agent for that domain) that passes on the request information to the Domain manager, this domain manager is a stationary agent that further assigns work to different mobile agents. These agents can also be treated as giver agent and the taker agent.

5.2.2. Framework Domain Description

The domain wise description of the framework as shown in figure: 5.4 is given below:

5.2.2.1. User Domain

User domain consists of agents that are capable of sensing the user requirements and on behalf of them. UIA (user interface agent) senses the user preferences and activates the domain manager. The domain manager based on the information received from the UIA; assigns tasks to other agents in the domain. Once the domain manager identifies the agent, these identified agents then precede to the other domain to further carry out the assigned task. This domain (figure: 5.4a) also consists of user event agent, which can be activated or deactivated by the user depending up on the user requirements. One of the important property of event agent here is that although the user can modify and set their own events the full writes are with the mobile operator. That means, even if this agent is deactivated by the user, important emergencies related information can still be provided by the service provider. This is useful in case when an event notification is to be sent at the time of emergency to all the users approaching that area.

5.2.2.2. Wireless Domain

When user initiates the task the agent from the user domain moves to wireless domain and pass on the request to the WIA (wireless interface agent). This request is passed on the WDM (wireless domain manager) as shown in figure: 5.4b. WDM initiates two agents simultaneously i.e. the registry agent and the location metadata agent. The registry agent registers the profile of the user, where as the location metadata agent searches the user location by using the location metadata search engine, which identifies the tower through which the request is received. Once the location of the user is identified the converter agent further converts it to geographic latitude and longitude. This domain also has the router agent that performs two task i.e. based on the location route the agent to the data domain and once the required data is identified from the data domain it is again sent back to the wireless router agent for further delivering it to the ECC.
5.2.2.3. Data Domain or the NSDI Domain

As shown in figure: 5.4c, DIA (data interface agent) on receiving the request from the WDA (wireless domain agent) transfer the request to DDM (data domain manager), it simultaneously initiates two actions i.e. metadata agent checks the requested metadata of the data domain and the query agent checks the type of query (static or dynamic) and the type of ontology required to answer the query. If the required ontology is available the agent further moves to resource agent, but if the required ontology is not available the agent moves to the ontology builder that builds the required ontology and updates the ontology manager. Resource agent fetches the required data and sends it to the map agent that further helps in proper visualization of the fetched data and sends it to the router agent of the wireless domain.

5.2.2.4. Emergency Domain

EIA receives the information along with the required geospatial data from WDA as shown in figure: 5.4d. After analyzing the data it uses time ontology agent so that the data can be sent on the basis of time. First in a standby mode it sends data to the control room manager, which initiates alarm agent. Secondly, alarm agent transfers the data to the PC on board the rescue vehicle for the on move mode. Thirdly, when the rescue team is on site they send data to the control room manager this requires a specialized agent i.e. information agent. The information agent also provides the position of the rescue vehicle to the control room manager which immediately sends it to the wireless domain which is then transferred to the users in that area and when the rescue team is on site it sends the information which are essential for carrying out the damage assessment to the control room. Once the data is delivered to control room it utilizes the application agent (Aa) for carrying out the damage assessment.

Figure: 5.4a Agents in User Domain.
Figure: 5.4b Agents in Wireless Domain.

Figure: 5.4c Agents in Data or NSDI Domain.
Figure: 5.4d Agents in Emergency Domain
5.2.3 Interaction Diagram

After identification of the agents in each domain (section 5.2.2), the interaction diagram as shown in figure: 5.5 has been developed. The interaction diagram helps to model the behaviour of agents in the framework. Certain symbols and annotations used in the interaction diagram are described as under.

**User Domain:**
- UIA – User Interface Agent
- TA – Text Agent
- NA – Number Agent
- UEA – User event agent
- UDA – User domain agent

**Wireless Domain**
- WIA – Wireless Interface agent
- RA – Registry agent
- LMA – Location metadata agent
- CA – Converter agent
- RA – Router agent
- WDA – Wireless domain agent

**Date or NSDI Domain:**
- DIA – Data Interface Agent
- MA – Metadata agent
- RA – Resource agent
- MA – Map agent

**Emergency domain:**
- EIA – Emergency interface agent
- TOA – Time ontology agent
- AA – Alarm agent
- IA – Information agent
- AMA – Application module agent

- **Condition box either, or**
- **Synchronized message**
- **Simple message**
- **Simultaneous action**

- **Event Activation**
  - **Lifeline of the task**
Figure: 5.5a Agent Interaction Diagram for the Framework – Part 1
Figure: 5.5b Agent Interaction Diagram for the Framework – Part 2
Figure: 5.5c Agent Interaction Diagram for the Framework – Part 3
5.3. Ontology in Framework

“Agents are committed to an ontology if its observable actions are consistent with the definition in the ontology” as stated by Gruber (1993). Hence agents are committed to specific conceptualization of a specific domain that further helps in knowledge sharing and reuse. These ontologies can be built in different ways, firstly by showing how the term is used in different fields carry the same meaning. Secondly, based on the particular meaning of the term in first defining the conceptual modelling, which is required to achieve information or knowledge sharing. Though the construction of ontology is very difficult and time consuming, in the thesis I have made an attempt to construct conceptual modelling of ontology for the emergency domain and for the facility and route concept. But before constructing ontology the information flow of entities from different viewpoint (in a use case of urban fire) has been constructed which helped in the development of a hierarchal tree representing heterogeneous data sources. Hence this hierarchal concept helps in development of concepts and relationships in a particular domain.

5.3.1. Information Flow of Entities from Different Viewpoint in Urban Fire

When a user makes a call, apart from the basic data (a map displaying the location of the incident, road network and the possible extent i.e. a buffered area of the incident), which is delivered to the emergency responding authority, they might need certain basic information from the user just by visual observation from the incident site. Through visual observation the user can approximately identify the location of the incident and/or their location, by telling the name of the road or any landmark near by etc. user also can identify whether there is any fuel that can further aggravate the situation for example petrol or a gas station, wood stocks etc. also user can help in identification of the resources that can help in controlling and reducing extent of damage. On the basis of the visual recognition of the ECC, one may ask for more detailed information from the data domain i.e. NSDI domain for example these data could be population statistics of that area (incident area), type of building, road network, weather data and the resource nearby. But whole information from the rescue teams point of view the whole data might not be useful except for the location of the incident, access route, and resources around the incident as shown in figure: 5.6. These information is based on time i.e. required information must be passed to the authorities at an appropriate time i.e. standby mode, on move and onsite mode.
Figure: 5.6 Information flow in a use case of fire emergency.
5.3.2. Hierarchal Tree for the Construction of Multiple Ontologies

Based on the information flow of entities in section 5.3.1 from different point of view a hierarchal tree can be constructed that helps in the identification of distributed heterogeneous sources, which further helps in the construction of multiple ontologies. This tree helps in the smooth navigation of the queries by breaking them in to number of sub-queries. As each data is not available at one node but distributed nodes. The concept of tree helps in reducing the computational load at one node, which further increases the efficiency and the speed of the system. Hence this allows bridging the gap between the user queries and the system architecture (Yu et al., 2003a).

![Hierarchal Tree of the Distributed Heterogeneous Data Source for Constructing Multiple Ontologies](image)

Figure: 5.7 Hierarchal Tree of the Distributed Heterogeneous Data Source for Constructing Multiple Ontologies

5.3.3. Modelling Ontology for Emergency Domain

Based on the concept of information flow in section 5.3.1 and the hierarchal tree structure as discussed in section 5.3.2 ontology for emergency domain has been constructed. Figure: 5.8 shows the ontology schema of emergency domain, which supports the representation in a domain that are semantically richer and are more useful. The class emergency is defined as
having categories and scales. Since the concentration is at the urban fire emergency, the locations are required so as to identify the place of fire or where the incident has occurred. This fire can be manmade/accidental and/or natural, but I am only considering manmade/accidental fire emergency where the location is very important. Similarly if user tells the address then there are certain properties like street, pin code, landmark etc., which plays a crucial role in identifying the place of fire. Once the place is identified it is easy to identify the type of area where the fire has occurred e.g. residential area or industrial & commercial area. Each emergency is handled by specialist organization in connection with the other organization like fire emergency is mainly handled by the fire department directly but police and medical services are also involved. Also some real time sources are required like the weather, traffic nodes. These data can be collected from some online sources, the servers or the URLs for further delivering the needs of the emergency services.

For representation of the ontology in a domain, an ontology web language (OWL) is used; it utilizes the RDF schemas for the demonstration of relationships. Some of the RDF schemas are class, sub classes, property, sub property, domain range and instances. OWL allow user to write explicitly the formal conceptualization of the domain using RDF schemas, which further helps in achieving the interoperability between applications in the domains. Hence for the emergency domain the expressions written in OWL are given below.

```xml
<owl:Class rdf:ID="Emergency"/>

<owl:Class rdf:ID="category">
  <rdfs:subClassOf rdf:resource="emergency"/>
</owl:Class>

<owl:Class rdf:ID="scale">
  <rdfs:subClassOf rdf:resource="emergency"/>
</owl:Class>
```
Figure: 5.8 Conceptual model of ontology in Emergency domain
According to W3C specification (URL: 13), “This use of the rdf:about="&ont;#x" syntax is a critical element in the creation of a distributed ontology. It permits the extension of the imported definition of x without modifying the original document and supports the incremental construction of a larger ontology”. “The fundamental taxonomic constructor for classes is rdfs:subClassOf. It relates a more specific class to a more general class. If X is a subclass of Y, then every instance of X is also an instance of Y. The rdfs:subClassOf relation is transitive. If X is a subclass of Y and Y a subclass of Z then X is a subclass of Z”.

<owl:Class rdf:ID="manmade">
  <rdfs:subClassOf>
    <owl:Class rdf:about="&emergency, category"/>
  </rdfs:subClassOf>
</owl:Class>

<owl:Class rdf:ID="fire">
  <rdfs:subClassOf>
    <owl:Class rdf:about="&emergency, manmade"/>
  </rdfs:subClassOf>
</owl:Class>

<owl:ObjectProperty rdf:ID="has"/>

<owl:ObjectProperty rdf:ID="fire has type">
  <rdfs:domain rdf:resource="#fire"/>
  <rdfs:range rdf:resource="#type"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="fire has location">
  <rdfs:domain rdf:resource="#fire"/>
  <rdfs:range rdf:resource="#location"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="location has address">
  <rdfs:domain rdf:resource="#location"/>
  <rdfs:range rdf:resource="#address"/> 
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="location has regions">
  <rdfs:domain rdf:resource="#location"/>
  <rdfs:range rdf:resource="#region"/> 
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="regions has municipalities">
  <rdfs:domain rdf:resource="#regions"/>
  <rdfs:range rdf:resource="#municipalities"/> 
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="municipalities has wards">
  <rdfs:domain rdf:resource="#municipalities"/>
  <rdfs:range rdf:resource="#wards"/> 
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="regions has divisions">
  <rdfs:domain rdf:resource="#regions"/>
  <rdfs:range rdf:resource="#divisions"/> 
</owl:ObjectProperty>
5.4. Facility and Route Concept

The ontologies are built for smooth navigation of queries so that the required details can be passed on to the user. For common query described in chapter – 4, i.e. where am I?, where is the nearest facility from my current position? And how do I reach there? are analyzed form two different viewpoints i.e. the user at the site of incident for finding the location of the hospitals nearest to him and the emergency responders to find out the route from their base station to the incident site. In order to access the route input parameters are used by the user and by the emergency responders, which are given as under in Table: 5.1

<table>
<thead>
<tr>
<th>View point</th>
<th>Query</th>
<th>Input Parameters</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>User</td>
<td>How do I reach there?</td>
<td>User current location, destination location (name, or landmark)</td>
<td>When the user is at the site of incident and wanted to help the victims of incident.</td>
</tr>
<tr>
<td>Emergency responder</td>
<td>How do I reach there?</td>
<td>From ECC to incident site</td>
<td>They would like to know the best possible route to the incident site, based on real time information of traffic and weather.</td>
</tr>
</tbody>
</table>

In order to process these queries mobile agents pass the query to stationary agents. These stationary agents then utilize the domain ontology as shown in figure: 5.9, to process the query based on different routing algorithm. As discussed in Shekhar et al, (2004), route should be determination based on two service the first deals with the determination of the new route by providing input parameters like the start location, end location, optional way points and other criteria’s like the shortest, fastest, easiest route, route for pedestrian or avoid U-turns, particular street etc. the second is related to finding the new route with the minimum overlap with the existing route etc.

![Figure: 5.9 Agent using Domain Ontology for Query Processing](image-url)
Figure: 5.10 Query Process using Facility and Route Concept Ontology
But keeping in mind the emergency situation the responders would like to reach as soon as possible to the incident site. They would not like to feed in the information like avoid U-turns or pass through this, instead they would like to have the route based on the traffic conditions from the starting point to the destination point, the weather condition in case of fire emergency etc. Keeping in mind the complex conditions at the time of emergency I have constructed ontology for the concept of facility & route query (shown in figure: 5.10) i.e. how the query will utilize the ontology.

For route finding there are different algorithms available like the Dijkstra’s Algorithm (Shekhar et al, 2004), which utilizes the path length from node to node in order to compute the shortest route. Similarly the Best fit A* algorithm is based on the concept of predicted total path i.e. actual distance from initial to current node or to the target node. This algorithm is considered to be the best for finding the shortest route as it uses the semantic information from a domain. Similarly, if a user at the site of incident wants to know the nearest facility (hospital) then the query can be fired in different ways as shown in Table: 5.2.

<table>
<thead>
<tr>
<th>Query</th>
<th>Parameters</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where is X from my current location?</td>
<td>User current location, X location (name)</td>
<td>Considering that user in this case knows the name of the hospital approximate location but cannot really see where it is.</td>
</tr>
<tr>
<td>Where is the nearest X from my current location?</td>
<td>User current location, facility type (police, hospital etc.)</td>
<td>In this case our assumption is that user just want to know the nearest facility from his current location. Where nearest means diameter of 1km. This knowledge is built with in the system.</td>
</tr>
<tr>
<td>Show me the facility with in the proximity of 5km?</td>
<td>User current location, buffering area of say 5km, facility type.</td>
<td>Here user has itself defined the searching area.</td>
</tr>
</tbody>
</table>

Shekhar et al, (2004), Has categorized the query on different basis like the point query, range query and the nearest neighbour query. First two queries in Table: 5.2 can be treated as the point query whereas the third can be treated as the range query. So these queries can be mathematically expressed as under:

**Point query**

Based on first query in table: 5.2 if a user wants to know the location of spatial object $S$ then mathematically it might look like this.

$$Q (p) = \{ S \cap p \mid S \cap G \neq f \neq f \}$$

Where, $S$ if the spatial object and $G$ is its geometry of spatial object.
**Proximity query**

Given a query polygon $Q_p$ of all spatial object $S_f$ which intersect $O_p$ mathematically can be represented as:

$$\text{PRQ} (p) = \{ S_f \in p \mid S_f.G \cap f = f \}$$

The ontology for facility & route concept in figure: 5.10 it can also be expressed in OWL. Here I define this by based on the hierarchal concept of the facility (hospital, police station etc.) search and the route search. In this two parameters have been decided the input and the output parameters for the query processing. I have assumed that the input parameter is fed and for the output how the ontology will be used for representing the route query is described in OWL language as under:

```xml
<owl:Class rdf:ID="facility and route concept"/>
<owl:Class rdf:ID="location">
    <rdfs:subClassOf rdf:resource="facility and route concept"/>
</owl:Class>
<owl:Class rdf:ID="feature">
    <rdfs:subClassOf rdf:resource="facility and route concept"/>
</owl:Class>
<owl:Class rdf:ID="line">
    <rdfs:subClassOf>
        <owl:Class rdf:about="&facility&routeconcept, feature"/>
    </owl:Class>
</owl:Class>
<owl:Class rdf:ID="road">
    <rdfs:subClassOf>
        <owl:Class rdf:about="&facility&routeconcept, line"/>
    </owl:Class>
</owl:Class>
<owl:ObjectProperty rdf:ID="has"/>
<owl:ObjectProperty rdf:ID="road has identification">
    <rdfs:domain rdf:resource="#road"/>
    <rdfs:range rdf:resource="#identification"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="road has access">
    <rdfs:domain rdf:resource="#road"/>
    <rdfs:range rdf:resource="#access"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="road has traffic">
    <rdfs:domain rdf:resource="#road"/>
    <rdfs:range rdf:resource="#traffic"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="road has surface">
    <rdfs:domain rdf:resource="#road"/>
    <rdfs:range rdf:resource="#surface"/>
</owl:ObjectProperty>
<owl:ObjectProperty rdf:ID="road has topology">
```
Similarly, for the point query it can be expressed in OWL as:

```xml
<owl:Class rdf:ID="point">
    <rdfs:subClassOf>
        <owl:class rdf:about="&facility&routeconcept, feature"
    </rdfs:subClassOf>
</owl:Class>

<owl:Class rdf:ID="hospital">
    <rdfs:subClassOf>
        <owl:class rdf:about="&facility&routeconcept, point"
    </rdfs:subClassOf>
</owl:Class>

<owl:ObjectProperty rdf:ID="has"/>
    <owl:ObjectProperty rdf:ID="hospital has location">
        <rdfs:domain rdf:resource="#hospital"/>
        <rdfs:range rdf:resource="#location"/>
    </owl:ObjectProperty>
```

5.5. Agent Communication

Agents in each of the four domains are identified and the domain knowledge is built to which agents are committed. Now, the communication mechanism is needed for identifying the message content, the communicative act, identification of the sender and the receiver, ontology and the interaction protocol that is used. Two examples of agent communication language are FIPA ACL ∗ and the KQML ∗ ∗ (as described in chapter – 3). I have used KQML as the communication language to show what agents carry when they move in and out of the domain. KQML is used for the reason that it is independent of the transport mechanism, content language, and the ontology assumed by the content (Singh, 1998). Since I am representing only the agents that are moving in & out of the domain so for simplicity the agent is represented by their domain names.

---

* Foundation for Intelligent Physical Agents  
** Knowledge Query Manipulation Language.
5.6. Interoperability in the Framework

Interoperability plays a major role “when lives are at risk, every second counts and quick access to critical information could mean life and death situation” (Thapar et al., 2000). Similarly interoperability among various emergency organizations is a critical feature needed for emergency responders. For this an efficient system is needed as most of the emergency responders are using different heterogeneous platform be it communication or be it related to the Geoinformation system.

At the time of emergency more then one emergency organizations are involved which might require access to same data. But due to heterogeneity of system most of them are not able to communicate between each other. But in order to achieve interoperability there are certain standards that must be followed these standards are in terms of languages and protocols. Similarly when agents communicate they also require interoperable platform. There are different standard organization working in this are some of them are OGC, W3C, LIF etc.
In agent-based framework for agent communication as described in previous section 5.5, I have used the agent communication language called the KQML. The language consist of three basic layer i.e. KQML message content, communication and message. The beauty of KQML is that it is independent of content syntax, transport mechanism (TCP/IP, SMTP or another) independent of content language (KIF, SQL or another) and independent of ontology assumed by the content. Keeping this in mind I have utilized two XML based dialects the GML and POIX for the encoding of the location and geographic information this problem will be solved too much greater extend. As discussed with Mr. Carl Reed, CTO and Executive Director of Open Geospatial consortium through personal communication via email, the development of GML are under progress for small handheld devices, but in the mean time the developers can make use of specific schemas from the GML 3.0. Also it has been suggested further that there is no need for the using SVG when using the GML as GML default style (defaultstyle.xsd), which can be used for the visualization purposes.

Similarly, for transport of message requires a communication protocol. For this SOAP has been identified as the best protocol as this supports the HTTP and XML based messages and bridges the gap between the protocols also. One of the simple SOAP message in case of fire emergency can be viewed in a SOAP body as give in under. For more on the POIX and SOAP is given in Appendix-C.

```
Event: emergency
From_ID: xxx
<soap: body>
<em: emergency>
  <type>fire</type>
  <material>wood</material>
  <alarms>2</alarms>
</em: emergency>
</soap>
```

Example of a Simple SOAP message body carrying fire message.

Hence the final framework would look like as shown in figure: 5.11. But only the one way flow of encoding language and the transport protocol is shown and not the two ways. SOAP was proposed as the transporting protocol everywhere and the POIX was proposed as the encoding language for the location of the user on the user device.
5.7. Summary

In order to develop a framework for the location based emergency services three main players were identified i.e. the user, the mobile operator, and the emergency organization where each of the three players are bind together by the geographic information. The framework was analyzed in client server architecture in a use case of fire emergency. But there are certain drawbacks of the client server architecture i.e. they are not flexible enough to accommodate the heterogeneous system, which causes the limitations of the bandwidth and the processing capabilities. Keeping all that in mind the agent based approach has been used to design the framework. This approach has been used because of key properties of the agent’s i.e. autonomous, intelligent, social, mobile etc. keeping these properties in mind the framework was divided in to four main domains and the agents in each domains were identified. Once the framework is set the intelligence i.e. ontology, was constructed for the emergency domain before which the information flow of entities from different view point and the hierarchal tree was constructed, which helps in bridging the gap between the user queries and the system architecture. Then to answer the queries the ontology for the facility and route concept was constructed. Similarly when agent migrates from one domain to another what sort of message they carry was analyzed in KQML. Lastly for achieving the interoperability in the framework the transport protocol and the location encoding languages were proposed.
6. Conclusions and Recommendations

Emergency responders play a crucial role in the society, but in the Indian scenario they are equipped with less advanced communication and Geoinformation technology, which are the main cause of late response. Any person can face emergency, any time, anywhere. This means that the emergency services should be ubiquitous. Ubiquitousness of the services is possible with the wireless technology i.e. wireless communication technology that will help in providing the location where the service is to be provided. Mere telling the location to the service provider (emergency responder) might not solve the problem, but if we map this location and deliver it to them, then it becomes simple for the service provider to know where and how exactly the service is to be provided. This requires the integration of two above said technologies i.e. the geoinformation and the wireless communication technology and this integration requires the robust and flexible framework. In this thesis I have made an attempt to design a framework for the emergency location services by identifying the possible gap areas and dealing with them.

Research Question 1: What are the main requirements in a use case of emergency location services from the Geo-informatics point of view?

The question has been analyzed in three different parts i.e. emergency, location and the geoinformation services. Firstly, the role of GIS and LBS has been identified, which later on helped in identifying the technologies and the driving forces that can play a major role in emergency location services (figure: 4.1). In the case of ‘Emergency’ it could be of two types i.e. natural and accidental or man-induced. Based on the type, these emergencies can occur in different scales say large scale and small-scale. Each scale has been analyzed to identify what datasets (spatial and non-spatial data) should come from which stakeholders node, concentrating only on the emergencies at the city level where not only location, we need some landmarks also, which very important and can be made available with existing wireless communication technology. Then with the specific use case i.e. fire emergency the geographic layers (table: 4.3) have been identified. Each emergency has certain phases that help in managing them, be it natural or accidental or man-induced, large scale or small scale. Each phases have certain geoinformation requirement that has been identified and must be maintained at the local, state and country level. Later with the existence of the geospatial data repository i.e. NSDI, in India, it was further analyzed whether the above identified datasets and also emergency data providing nodes are present or not, if not then it was further proposed to have some basic node with the database schema model as proposed (figure: 4.3). Location has been seen from the technological point of view. Also, which technologies whether network based or satellite based can provide what type of location accuracy has been discussed in chapter-3. The location and the specification part would be well taken by the industry, but in the current state of existence it is a foremost requirement to have a framework that can accommodate heterogeneous technologies that can be utilized in the field of emergency services.
Research Question 2: What are possible methods for the transfer and exchange of geospatial information to a proposed framework from the Indian NSDI?

The basic idea is to provide access of geographic information along with the location information mapped on it to the ECC (Emergency Control Centre) when they receive the call about the incident. For providing access to geographic information to the emergency responders, there exists a need for robust and flexible framework. Firstly a possible client – server architecture was developed which broadly identifies the working of the framework. This was further improved when the interaction diagram for the same has been developed. The current wireless communication technology has certain constraints, like limited bandwidth and processing power, which might be solved with the release of 3G communications in the near future. But in the existing scenario a system is required that is flexible so that at any time services can be added or modified without affecting the whole structure of the system.

Agents have been proposed in the field of artificial intelligence and in the field where heterogeneous technologies are used, because of its specialized properties i.e. they are proactive, autonomous, mobile and social. These agents are nothing but the software entities that behave or act on behalf of the user. Keeping this in mind I have divided the whole framework in four domains i.e. the user, wireless, data or the NSDI and the emergency domain. On the basis of these domains the agents in each domain were identified which will work on behalf of the user when the task is initiated. These agents were further categorized as stationary and the mobile agents. Stationary agent resides within a particular domain and assigns the task to other mobile agents when the request is received from the other agents. Once the agents are identified in each domain for broader insight to the system, interaction diagram has been developed which shows the interaction among and within the agents of same and different domains. In order to develop an agent system one should always be careful that agents are committed to ontologies of a specific domain and these ontologies help in sharing the knowledge required by the agents and also help in avoiding the problems related to inconsistency and the poor understanding of the communication parties.

Research Question 3: What role does ontology play in the integration of the framework?

In order to develop more powerful agents ontologies were developed, but before that analyses were done to design the ontologies. Firstly the information flow of the entities was developed from the different points of view i.e. from the view of user, ECC, and the Rescue team. This is designed by keeping in mind that the right amount of information is delivered to the right people at the right time. This information flow was further analyzed to construct a hierarchal structure that is semantically strong to support further construction of the multiple ontologies. The beauty of constructing the tree is that, they help in logically answering the queries by breaking them in to number of sub queries. This requires the domain ontology that will answer these queries. After identifying the information entities and constructing the tree emergency domain ontology was constructed in which the relationship between the classes, sub classes and the instances were developed. This emergency domain ontology (figure: 5.8) helps in easy navigation to other sub domains within that. It was further reflected using ontology web language (OWL) specified by the W3C. OWL helps in developing fundamental taxonomies by using RDF (Resource Description Framework) schemas of OWL, which helps in relating more specific class to a general class.
Now once the ontology for the emergency domain is set the needs were identified based on the different queries (i.e. where am I? Where is the nearest facility? & How do I reach there?) in terms of basic input parameters that must be adopted to answer them from the users and the emergency responders point of view. To tackle this problem ontology for facility and route concept was developed (figure: 10), which are useful in formulating the queries and easy navigation to the domain. This input information is brought to the domain by the mobile agent in the form of request to process this query and is received by the stationary agent in the domain. Once the required information to answer the query has been identified in the ontology it is passed on to the other mobile agent, which helps in processing these queries, i.e. it has certain algorithm encapsulated (route algorithm, point query algorithm, proximity algorithm etc.) in it. Now that the ontology is set for agents, to exchange information, it further requires a communication medium. For this purpose different ACLs (Agent communication languages) are available but I have used the concept of KQML (Knowledge Query Manipulation Language), which is independent of transport mechanism, content language and the ontology that helped in showing what transport protocol, content and type of ontology the agent is using, keeping in mind the interoperability of the whole mechanism.

**Research question 4:** How can we bring interoperability between the NSDI and the proposed framework?

Interoperability among the emergency organization is necessary. Because at the time of emergency different organizations are required to share information that will help in the speedy response to the emergency thereby saving the lives of the people. The framework design is interoperable so as to provide speedy response at the time of emergency. Interoperability in the framework is achieved by defining the proper or appropriate language and the protocols. Protocols have been chosen as most of the emergency organizations use proprietary protocol, which are main hindrances in the interoperability and might not support the geographic information. Keeping in mind these problems I have used two XML based language i.e. GML (not below v 3.0) and the POIX (Point of Interest Exchange). GML support the encoding of geographic as well as the location information, and POIX only supports the location information transfer and encoding. If POIX is used only at the user domain then this might help in transferring the user location at the wireless domain without affecting the processing power of the handset. Similarly, for the transport protocol SOAP (Simple object access protocol) has been used as it helps in bridging the gap between the HTTP and XML based protocols. SOAP has been proposed as one of the protocol, which can be utilized in the location based services by the Open Geospatial consortiums OpenLS initiatives. At the same time this also helps in achieving the interoperability that will assist in data sharing which are required at different levels of the framework. Hence figure: 5.11 shows, the proposed architecture with proposed transport protocol and encoding language, but only one way flow is designed in figure:5.11.

**Recommendations**

Absence of emergency related databases and researches on how the different technologies can be utilized and integrated for efficient and speedy response to the emergencies should be researched in detailed. From the proposed framework in the thesis the immediate recommendations would be:
Emergency organization should take initiative for the creation of emergency data infrastructure that can be further utilized in time critical emergencies as and when required. These authorities should also allow the use of their data by other emergency responding authority. But at this stage the main hindrances in the ELS are the lack of GI technology to these emergency organizations. Lack of awareness on how this technology can help them to respond in speedy and efficient way requires training and education in the field of geographic information.

Since only the small portion of the domain ontology is designed in this research, designing the ontology for other domains can also be further researched. Most of the emergencies require data based on time so ‘Time’ based ontology should also be looked into for further research.

In case of fire emergency it should also be kept in mind that some nodes like weather etc. require 4D GIS that involves dimensions in X, Y, Z and T. the development of such a node should be carefully handled as it involves time dimensions where the phenomena is continuous. Also, Indian NSDI should come forward for adding up the private nodes such as traffic nodes. And people from the communication industry should come forward for the development of such a framework.
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(URL: 9), WWW Site http://www.dmap.co.uk/utmworld.htm (accessed on 29.10.2004).


(URL: 13) WWW site http://www.w3.org/1999/06/NOTE-poix-19990624/ (accessed on 12-07-2004)
Appendix-A  Handsets And Technology

There are enormous no of handsets available in the market with the various technologies that support LBS. Some of them are given in Table below. These are the devices, through which a client can send a request to the remote server requesting for the required location base services. The requested information will be retrieved from the GIS databases depending up on the type of request from the client) and after reformatting it will be sent to the client browser application.

<table>
<thead>
<tr>
<th>Mobile device</th>
<th>Resolution (in pixel)</th>
<th>Memory type &amp; size</th>
<th>Operating system</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tablet P.C</td>
<td>1024 x 768</td>
<td>DDR, SDRAM 256MB, Video memory 48MB</td>
<td>Win XP tablet PC edition</td>
<td>CDMA 2000, GPRS, GSM, WLAN (802.11b)</td>
</tr>
<tr>
<td>Simputer*</td>
<td>240 x 320</td>
<td>DRAM 32MB, Flash RAM 16/32MB</td>
<td>GNU/Linux 2.4.18</td>
<td>Soft-Modem Algo. V34/v17 Data/ Fax Modem</td>
</tr>
<tr>
<td>PDA</td>
<td>320 x 240</td>
<td>Flash 16MB, RAM 16MB</td>
<td>Win CE</td>
<td>USB/ serial connectivity, expansion slots</td>
</tr>
<tr>
<td>Wrist phone</td>
<td>96 x 64</td>
<td>-</td>
<td>-</td>
<td>CDMA, GSM and GPRS.</td>
</tr>
<tr>
<td>Mobile Phone</td>
<td>176 x 208</td>
<td>Flash memory 6MB, 32 to 64 MB memory card</td>
<td>Symbian</td>
<td>CDMA, GPRS and Bluetooth</td>
</tr>
</tbody>
</table>

* Indian version of PDA, especially being made for the Indian defense forces and are now available for the civilian use.
Appendix-B

Cellular Network Location Method

Technology capability – Horizontal Accuracy. (Source: CGALIES, 2002)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Rural</th>
<th>Urban</th>
<th>Urban extreme</th>
<th>Indoor users</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell ID</td>
<td>1–35 km</td>
<td>50m–1km</td>
<td>50m–1km</td>
<td>No change unless there is a Pico cell</td>
<td>Cell shape can be returned. Possibility of incorrect sector</td>
</tr>
<tr>
<td>Cell ID and Timing Advance</td>
<td>1–35 km</td>
<td>50m–1km</td>
<td>50m–1km</td>
<td>No change unless there is a Pico cell</td>
<td>Radial distance can be improved for ranges above 550m. Possibility of incorrect sector.</td>
</tr>
<tr>
<td>E-OTD</td>
<td>50m–150m</td>
<td>50–150m</td>
<td>100–300m</td>
<td>Site degradation but penetrates well indoor.</td>
<td>Mobile needs to see at least 3 BTS. Falls back to cell/TA if unavailable.</td>
</tr>
</tbody>
</table>

Satellite Location Methods (Source: Toronen, 2003)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Coverage</th>
<th>Infrastructure cost</th>
<th>GSM/UMTS standard</th>
<th>Accuracy Results, m</th>
<th>Accuracy results based on</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>Good, problems indoors and in city centers</td>
<td>None</td>
<td>Yes</td>
<td>20</td>
<td>Test results in.</td>
</tr>
<tr>
<td>A-GPS</td>
<td>Good+, indoor and city coverage possible</td>
<td>High</td>
<td>Yes</td>
<td>17-51</td>
<td>Test results for hybrid A-GPS/E-OTD method in urban and indoor environments (67% of time).</td>
</tr>
<tr>
<td>Galileo</td>
<td>Good, problems expected indoors and in dense urban areas</td>
<td>None</td>
<td></td>
<td>1-10</td>
<td>Design goals of the system to be developed.</td>
</tr>
</tbody>
</table>
Appendix – C Languages and Protocol

POIX (Point of interest exchange markup language)
POIX is used to define the “location information” using XML. “In contrast to GML, POIX is intended to only to indicate a location of a mobile host and its structure is simple enough to be supported by portable terminals and car navigation systems”. A set of DTDs is used to describe location information (e.g., point, latitude, longitude, speed, direction etc.), at present this is available only for recommendation to W3C (Karimi & Hammad, 2004). According to W3C specification (URL: 13) “POIX is a common baseline for exchanging location data via e-mail and embedding location data in HTML and XML documents”. Mobile device developers, location-related service providers, and server software developers can use this specification.

```xml
<?xml version="1.0" encoding="Shift_JIS" ?>
<!DOCTYPE poix PUBLIC "-//MOSTEC//POIX V2.0//EN" "poix.dtd">
<poix version="2.0">
  <format>
    <datum>wgs84</datum>
    <unit>degree</unit>
  </format>
  <poi>
    <point>
      <pos>
        <lat>35.7611</lat>
        <lon>139.7700</lon>
      </pos>
    </point>
    <name><nb>Tokyo Station</nb></name>
  </poi>
</poix>
```

**Example: 2** Simple description of notifying the location. (Source: W3C)
Two forums mainly LIF (Location interoperability forum) and WAP are laying down the specification for standards protocols to be used in LBS they are discussed one by one as under.

**LIF** – LIF in 2001 proposed the use of MLP, “which in an application-level protocol for the positioning of mobile terminals”, and is independent of network technology and positioning method. MLP consist of multilayered structure of protocols that includes HTTP and SOAP (Karimi & Hammad, 2004). At present OpenLS request and response for wireless device are through HTTP only, but there are plans to use SOAP profiles for OpenLS test bed also.

**SOAP (Simple Object Access Protocol)**
SOAP is proposed by W3C (URL: 13). It is a transport protocol, which bridges the gap between the HTTP and XML based protocols. “XML document can be searched stored or transfers via XSLT (extensive style sheet Language) for example in to markup languages HTML and WML. DDT or
XML schemas are a tool to verify certain structure of an XML document” (Gruber et al., 2002). Because of its freeness with the XML and HTTP, it is considered to be the lightweight protocol which helps on exchanging the information in a decentralized distributed environment (URL: 13). According to Gruber et al., (2002), “SOAP message consists of three parts:”

**SOAP envelopes** that contain the information on what is in the message, which should deal with it, also if it is optional or mandatory, it consist of SOAP header and body. Although SOAP header is optional but if present, must immediately follow the opening envelope (root) XML tag. **SOAP encoding** rules define a serialization mechanism that can be used to exchange instances of application-defined data types.

**SOAP RPC** representation defines conventions that can be used to represent remote procedure calls (RPC).

SOAP message request can be transported in HTTP post request with SOAPMethodName as an invocation header, below a minimum simple SOAP HTTP header is given.

```
POST /objectURI HTTP/1.1
Host: www.foo.com
SOAPMethodName: urn:develop-com:Itraffic#getstatus
Content-Type: text/xml
Content-Length: xxxxx
```

Similarly, HTTP payload of a SOAP request in XML can also be invoked as shown below:

```
<?xml version='1.0'?><SOAP:Envelope
xmlns:SOAP='urn:schemas-xmlsoap-org:soap.v1'><SOAP:Body>
<i:getstatus
xmlns:i='urn:develop-com:Itraffic'><traffic>23-05w</traffic></i:getstatus>
</SOAP:Body></SOAP:Envelope>
```

Once the SOAP:Envelope and SOAP:Body, elements, are over the root element SOAP: Body matches the qualifies namespace tag SOAPMethodName. This delicacy is allowed so as to process call without parsing XML, using HTTP based infrastructure. The advantage of using XML is that it can import information (URL: 13)
WAP (Wireless Application Protocol)
WAP is a communication protocol, which consist of relative, simple and compact version of XML, for accessing information “from micro powers running on small handheld device. WAP is based on HTML, XML and TCP/IP internet standards” and have made a WAP location framework given in fig-5.2 (Karimi & Hammad, 2004). WAP also support the inclusion of wireless bitmap files (Wbmp). Thus it is very much possible to send a request to a geographic service through a WAP client and return the result in the form of embedded bitmap.

WAP Location Framework

WAP brings TCP and HTTP to mobiles, through not meant for surfing the Internet but, can be used for searching small amount of information like time table, restaurant guide etc. With the existence of WML, WAP automatically converts the visual content from HTML to WML. One of the problems with WAP is that it does not tolerate errors. Since, WML and HTML both are dialects of XML, the possibility of transferring the geographic data can be explored using this.