A SECURE SERVICE ORIENTED ARCHITECTURE BASED MOBILE SDI MODEL FOR MINERAL RESOURCES MANAGEMENT IN INDIA

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Abstract: *Economic growth rate of any country largely depends on the development of mineral sector. Then, the level of technology employed for meeting the extraction conditions must meet environmental norms. Exploration of mineral resources in India and mining is a ready application for technologies for ensuring productivity and efficiency. Use of Geographical Information System (GIS) in mineral resources management is of great help, where each stakeholder can access, use and exchange spatial and non-spatial data for social, economic and environmental activities. With development of communication and information technology, integration of heterogeneous repository of data from the different data sources can be achieved by using Spatial Data Infrastructure (SDI). At the present scenario, the dynamic updating of data, data analysis, data visualisation and data uploading are lacking in most of the information system in GIS environment. For real time integrated mineral resources information monitoring, it is essential to integrate information system with geospatial database. Visualisation of integrated mineral resources information is possible on the desktop environment with the help of GIS. But it is not sufficient for updating the data in dynamic environment. It may be possible to perform dynamic tasks like update, analysis and visualisation of mineral resources information through the mobile devices with the modern high end mobile communication infrastructure. It makes it possible and very useful to take the decision at anytime from anywhere in the world. The data repositories can also be timely updated with the help of common mobile devices from any location, of course with security measure in place. In the present work, a three tier secure framework has been proposed for the mobile based SDI Model for the better management of mineral resources information infrastructure with the use of mobile devices by the integration of geospatial database. The interaction between the various services in the proposed Model has been modeled by using Unified Modeling Language (UML) use case and activity diagrams.*

1 INTRODUCTION

Mineral Resource exploration is an important economic activity, which contributes significantly to the economy of India. The Country exports a variety of minerals which are in abundance its geographically diverse regions. On the other hand, in long run, mineral resources are limited, precious and non-renewable. Mining sector is facing an increased challenge on account of globalisation and the level of technology employed and the environmental norms, thereby necessitating new initiatives for meeting the new challenges of cost-effective extraction, which require proper management and standardisation. The standardisation and scientific management not only provide the efficient use and exploitation of mineral resources but also relates to social sustainable development (Samaddar et al., 2010). There is a need to make coordinated efforts to encourage greater investment in exploration and mining as well to integrate modern technologies like GIS, Remote Sensing and GPS to increase the productivity and efficiency of mining sector. That leads to establish a well organised Mineral Resources Information Infrastructure with the help of GIS technology in India (Paul and Das, 2006).

GIS has wider applications in decision making, storage of various kinds of data, bringing data and maps to a common scale to meet users' need, superimposing, querying and analysing the large amount of data and designing and presenting final maps and reports to administrator and planner (Broueckner and Orasa, 2008). GIS can deal with large amount of spatial data at different scales as well as non-spatial data for deriving useful information in maps/ tabular form.

With the integration of web technology with GIS, it gives rich functionalities in terms of spatial data sharing on the Web. It can provide a real time and dynamic way to represent information through maps on the Web. So there is a need to establish a well organised Spatial Data Infrastructure (SDI) which is a portal where each stakeholder can access, use and exchange spatial data for social, economic and environmental application.

Geospatial Web Service is one of the key technologies required for development and implementation of SDI. Design and implementation of SDI is used with Service Oriented Architecture (SOA) which may be used for sharing mineral resources information on the Web enabling the investors to quickly look into the problems and prospects of investment in mineral resources exploitation in India (Alesheikh et al., 2002).

With the addition of mobile communication technology, GIS has wider applications in decision making, storage of various kinds of data, bringing data and maps to a common scale for user need, superimposing, querying and analysing the large amount of data, and designing and presenting final maps and reports to the administrators and planners. GIS technology deals with the large amount of spatial data and non-spatial data for deriving useful information on maps as well as tabular forms for better understanding of development of information infrastructure required for offering web services in mining sector (Barik et al., 2009).

2 MINERAL RESOURCES INFORMATION MANAGEMENT: INDIAN SCENARIO

India is endowed with significant mineral resources. It normally produces 89 minerals out of which 4 are fuel minerals, 11 metallic, 52 non-metallic and 22 minor minerals. The entire metallic production is accounted for by iron-ore, copper-ore, Chromite and/or zinc concentrates, gold, manganese ore, Bauxite, lead concentrates, and silver. Amongst the non-metallic minerals, 92 percent of the aggregate value is shared by limestone, Magnesite, Dolomite, Barytes, Kaolin, Gypsum, Apatite & Phosphorite, Steatite and Fluorite.

The public sectors contributes over 88 percent of the total value of mineral production. Public sector enterprises like the National Mineral Development Corporation, Kudremukh Iron Ore Company, Steel Authority of India Limited and Orissa Mining Corporation dominate the iron ore sector. Two public sector enterprises - National Aluminum Company and Bharat Aluminum Company, account for over 66 percent of aluminum production in India. Hindustan Copper Limited predominates the copper ore mining sector, zinc-lead ore mining and processing is dominated by Hindustan Zinc Limited. Bharat Gold Mines, a public enterprises of the Government of India and Hutti Gold Mines Limited (a Government of Karnataka undertaking), are engaged in the mining of gold. Rajasthan State Mines and Minerals Limited and Andhra Pradesh Mining Development Corporation predominate the mining of rock Phosphate and Barytes respectively (Internet-1, 2015).

However, the information so far available from bulletins of different agencies, or at some specific websites, are not comprehensive or easily available. For exploitation of mineral resources however, it is important to have a better understanding and perception of the geographical location, production, user base, port and transport facilities, electricity, skill manpower, availability of experts and various agencies etc. This may be well achieved through a spatial information system with geographic references. Further, in the era of globalization, it is important to make this information available on the Web for ready access to the world community for FDI etc. This will also give a great scope for the expertise, especially the site specific expertise available in the Country to put forward their skills which would be required by the investors any way. This also will be a powerful tool for the policy makers and government for mineral resources management while implemented in the specific manner. The Government must frame some simple but implementable norms for that and the sectors irrespective of being government or private should come forward for a agreeable protocol for common benefit.

Thus, the role of a GIS based information system in mineral resources from the perspective of the user is an urgent need. In the present era of information age, new tools and technologies have emerged to collect, store, retrieve and analyze various types of information related to mineral deposits. Today, Two GIS packages, M.R.I.S and MINFO are used for mineral resources information management which are derived from the concept of MERIGOLD, a database on gold deposits of Australia. But both have not the capability of web enabled although it has greater efficiency in analysis WeBSAS is another WebGIS system which provides the web capability for sharing of data through web (Ayachi,2005 and Roy et al.,2001). But the WeBSAS is very difficult to implement and it does not support Open Geospatial Consortium (OGC) specification. These challenges cause barriers in extensively sharing mineral resources data and restrain the effectiveness in understanding and responding to proper management. To overcome these challenges in mining sector, mapping and sharing of mineral resources information in a secure framework based on OGC specifications under GIS environment is the need of the hour.

3 SOA BASED MOBILE SDI MODEL

SDI provides an environment within which organizations interact with technologies to foster activities for using, managing and producing geographic data. The core components of SDI can be viewed as policy, networking, standards, people and data. An integrated SDI model not only provides spatial data, value-added services for end-users, but also involves other important issues regarding interoperability, plugability, security, policies and networking. Geospatial web services are integral part for the development and implementation of SDI Model (Rajabifard et al.,2002). For implementing of any SDI model, following thin client-server architecture has been proposed in which most of the processing takes place at server side (Puri et al., 2007).

In terms of managing number of geospatial web services, SOA recognises processing load and tries to construct flexible, distributed, re-configurable and dynamic service system which can meet service requirement and information on web for the development of SDI. The component in the SOA is service and a chaining system of services through the composition of services i.e. a well defined set of ordered actions. Each service does not depend on other services as it is stateless and self contained. Figure 1 shows three major functionalities in SOA based SDI.

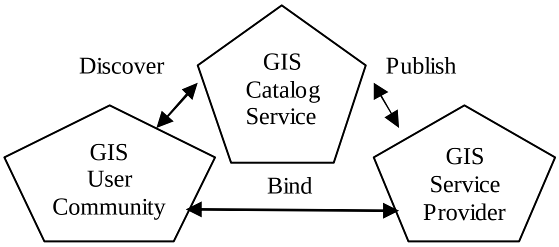

Figure 1: Three major functionalities in SOA (Xiaolin, 2005)

In development of SDI, the major focus has been on SOA based geospatial web service by using spatial data, which may be grouped into data service, processing service and catalog service. Data service is tightly coupled with specific data sets on which it operates and offers Web Coverage Service (WCS), Web Feature Service (WFS) and Web Mapping Service (WMS). In SOA based SDI, there are three types of key actors i.e. service requester or GIS user community, GIS service provider and GIS catalog service. Catalog service may also be called registry service or broker service with discover-bind-publish operation. However, the functionality remains similar in most of the applications in registry service. Catalog service helps the requestors to discover or find the appropriate services. Service providers publish all their services for consumer to use by using "publish" method (vaccari et al.,2009).

In the ubiquitous era, for geospatial web services in SDI Model to become a universal communication paradigm, mobile devices enabled with web services should be considered. Mobile GIS is an integrated technological framework for the access of geospatial data and location-based services through mobile devices in secure way, such as Pocket PCs, Personal Digital Assistants (PDA), or smart cellular phones. For mobile GIS applications, it requires an efficient interaction framework for mobile web services in SDI Model. Mobile GIS applications are also implemented in distributed environment with the help of common client-server model. Mobile Data Service (MDS) is one of architecture for implementing geospatial web services in mobile client. A light mobile GIS framework has been proposed and implemented on J2ME and mobile scalable vector graphics (SVG). The proposed framework uses the specification of mobile SVG, the specification of mobile XML and the rules for spatial data organizing (Yeon-Seok and Kyong-Ho, 2009,Li et al.,2004 and Samaddar and Barik, 2013).

4 OBJECTIVE OF THE PRESENT WORK

The main aim of the present work is to propose a three-tier secure framework for mobile based SDI Model for efficient management of mineral resources information infrastructure with the use of mobile device by integrating geospatial map data. It has defined the prototype development by using win-win spiral model. The interaction between the various services has been modeled by using Unified Modeling Language (UML) use case and activity diagrams.

5 METHODOLOGY ADOPTED

The main focus on the secure framework has been on the use of a practical approach to explore and extend the concept of SDI in mining sector. It should provide an effective and efficient means of sharing geospatial data and non-spatial data on the web using GIS in a secure way. Figure 2 shows the proposed three- tier secure SOA based SDI architecture of mineral resources in which the basic over view of service provider, service consumer and catalog service are being shown.

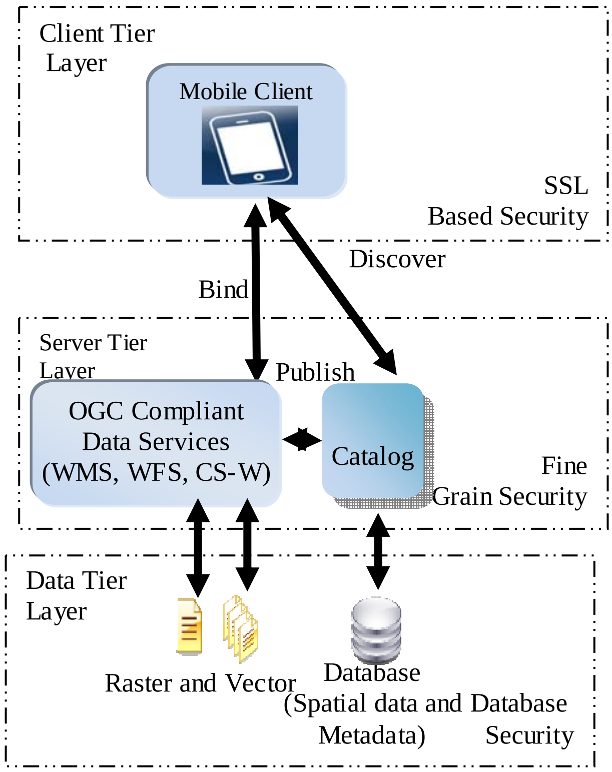

Figure 2: Proposed Secure Framework for Mobile based SDI Model

In the proposed framework, it focuses on OGC compliant web services using vector and raster data. 'Admin' is the system administrator. 'Admin' is managing the data and gives authority to the different mobile users. There are various categories of administrative services. For example, Catalog is updated by 'catalog admin'. This architecture fulfils the most sophisticated workflow for development of the mobile based SDI Model. Figure 2 shows the flow of information for the development of Mobile based SDI Model in the present work. Web plays one of the important factors for widespread information infrastructure in Mobile SDI Model development. Since, it is characterised by free flow of information in an insecure channel, and so it requires high security measures. Different methods have been used to protect the transfer of data over the Web. This includes encryption, in which data is transformed and a decryption key is generated for the receiver of the data. So for secure transaction of spatial data over the web, different security measures have been described which have been developed and implemented in different phases.

Information Security is usually seen as a combination of three core principles: Confidentiality, Integrity and Availability (CIA) (Kabbani, et al.,2010). By keeping these three core security principles, the three-tier Security architecture has been proposed for the developed Secured SDI Model. From the above figure, it is proposed to achieve the principle of CIA. Confidentiality can be achieved by the SSL Based Security Integration. Fine Grain Security is meant to focus on integrity of services where as Database Security is to focus on the availability of the data to the authenticate user.

In the proposed three-tier Security Architecture, the middle layer is technically divided into two parts: one is Applications Server and other is GIS Server. GIS Server is responsible for supplying the correct data according to the application as per the user role. Therefore, the security features between Application Server and GIS Server requires Fine Grain Security elements such as role base access control mechanism. For that easy to implement mechanisms like discretionary access control mechanism and mandatory access control mechanism may be used. Role base access control mechanism in a preventive way accesses the data tier and ultimately the data will reach the application layer passing through the security mechanism of the data tier and application layer. The user role is defined at the very beginning at the web client layer by providing authorised access after authenticated verification of the user identity.

Secure data communications can be achieved through Hypertext Transfer Protocol Secure (HTTPS) protocol. HTTPS is a combination of the Hypertext Transfer Protocol with the SSL/ TLS Protocol to provide encrypted communication and secure identification of a network web server. HTTPS connections are often used for payment transactions on the World Wide Web and for sensitive transactions in corporate information systems. The main idea of HTTPS is to create a secure channel over an insecure network. This ensures reasonable protection from eavesdroppers and man-in-the-middle attacks provided that adequate cipher suites are used and that the server certificate is verified and trusted (Nayak and Samaddar, 2010).

The proposed secured Mobile SDI Model features a role-based security system which defines fine-grained security at the service tier layer. For each layer of the service, the administrator can configure the security settings which has been authorised/denied different service access as per user role. The fine grain security has been successfully implemented in GeoCat Manager Module. In GeoCat Manager Module, Administrator has the access for giving privilege to the users according to the availability of services. It generally focuses on the security in PostgreSQL where both spatial and non-spatial data have been stored. Database security in PostgreSQL is addressed at several levels.

6 PROTOTYPE DEVELOPMENT

The prototype development of the mobile based SDI model is based on Jacobson’s method of Object Oriented Software Engineering (OOSE) method that capture the actors of the system and their behavior for each of the design stages which involves the formation of models. Figure 3 shows the complete process model for development of mobile based SDI model.

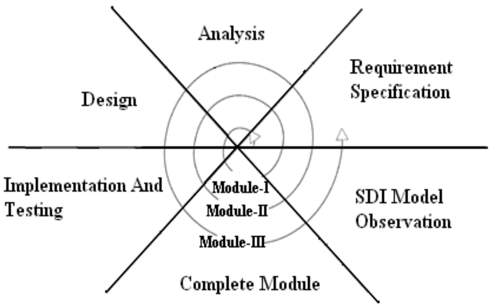

Figure 3: Process Model for mobile based SDI model – Customisation of Win-Win Spiral model

In OOSE approach, the software development process adopts the steps including requirements specification, analysis and design, implementation and testing, complete module and model observation (Mall, 2014).

Requirement Specifications

The requirements stage of application design aims to specify the behavior of the framework from the perspective of a user which has been shown in Figure 4.

A use case specifies a sequence of actions, including variants that the system can perform and yield an observable result of value to a particular actor. Figure 4 shows the Use Case Model which specifies how a user would interact with the system to identify the various systems.

In the present work, the use case model has been associated with three types of users, i.e., administrative user, general mobile user and developer. The

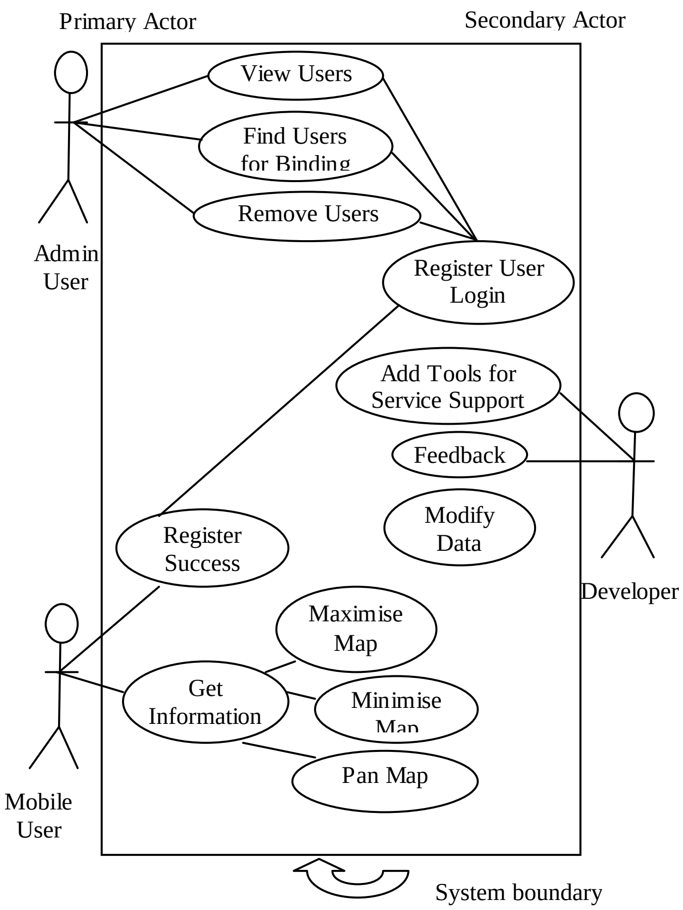

Figure 4: Prototype of Use Case Model

administrative user will have the authority to view, delete and find existing users which are associated with this system. The general mobile user has the variety of option like login, logout, register, get-information, maximise map, minimise map, pan feature, get-coordinate, upload files and download files.

Even an object diagram can have different annotations depending on guard conditions. System sequence diagrams depict the flow of actions in a sequence considering one action at a time. The domain model (complete or partial) is obtained on the basis of all the above models and that completes the modeling the static nature of the application. The dynamic nature of the application is captured through a number of modeling schemes like action diagram, collaboration diagram, state chart diagram etc.. The complete modeling of mobile based SDI model is out of scope of this paper. A number of modeling schemes are used for analysis, further refinement and subsequent design.

Analysis and Design

The underlying algorithms for formulation of prototype fall within the analysis portion of the OOSE life cycle. The thematic layers created include maps of India with state boundaries and different mineral resources information. The flow of processes in the system is captured in the form of state chart diagram that need to be translated into design element of the software. In present work, activity diagram describes the workflow behaviour of secure mobile based SDI model and are shown in Figure 5.

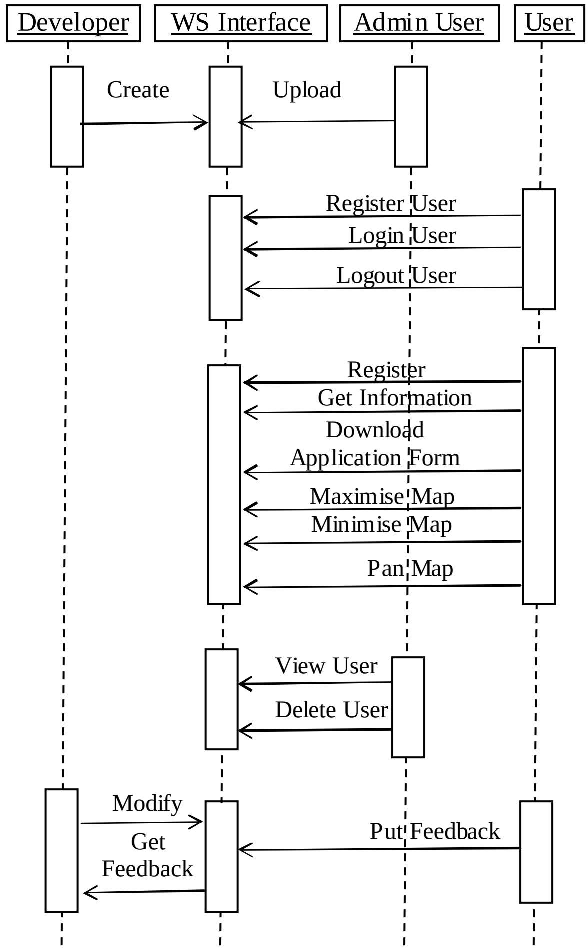

Figure 5: Activity Diagram for mobile based SDI model

A preliminary activity diagram, as a result, is obtained in Figure 5 that can be refined further depending upon the various iterations of earlier steps of design under the guidelines of OOSE.

Complete Module

The framework consists of three main modules, e.g., Module-I for registration, Module-II for mineral resources information Mapping, and Module-III for Utility Services. Module-I describes the detailed process to register the user for authentication. After registration process, user can use the framework with various operations like registering a mineral resources information. Module-II gives detailed viewing mineral resources information mapping in terms of various factors associated with availability in India. Module-III describes utility services, i.e., management of user level security aspects, and uploading/ downloading features for all operations mentioned above in the activity diagram. The mobile based SDI model framework developed has been shown using two illustrations. Figure 6 shows the mineral resources information database creation in Quantum GIS.

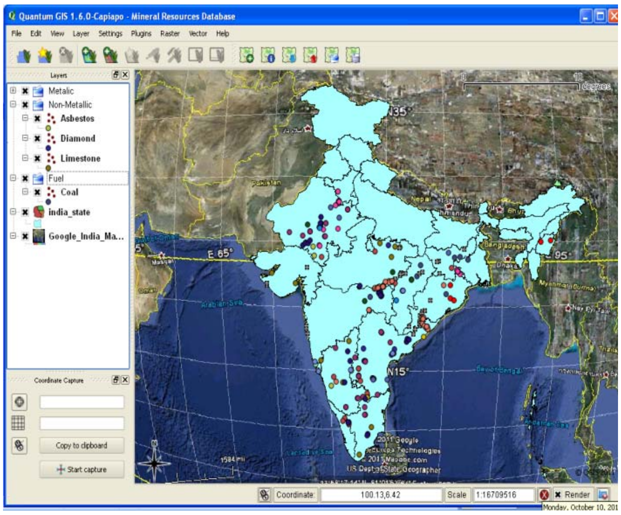

Figure 6: Mineral Resources Geospatial Database in Quantum GIS

7 CONCLUDING REMARKS

A secure framework for Mobile based SDI Model mineral resources information infrastructure has been proposed and the prototype with certain simplification of operation has been tested for its primary function i.e. mineral resources geospatial database has been created. The present research work is focused at adopting OGC standards for registering, creating, accessing, integrating, sharing and testing the mineral resources information on the Web. The proposed framework adopts a modular and flexible structure, and provides an efficient mechanism for the generation and delivery of value-added spatial information to extend the concept of secure SOA based SDI Model in the field of mining sector, particularly at national level. It has been planned to develop and implement the prototype by using Open Source GIS at a later stage contributing to Open Source Movement.

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