[1]Distributed and interoperable GIS for planning and emergency management in Indian mines

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Abstract

Mining is a dynamic operation, and needs timely information for short term and long term planning and associated risk analysis. In fulfilling this need, organisations spend a significant part of their budgets on data collection. However, data collection and tactical planning in these organisations is often carried out rather in a disjointed manner, and as a result effective utilization of such information becomes a concern. The importance of wide scale computerization and adoption of management information system is heightened by mining disasters especially in underground coal mines.

We propose to address this problem by prototyping an Internet-based Distributed Geographic Information System (GIS) that would help to access distributed data across heterogeneous environments and help in integrating planning, operational, and geoscience data. Such a system would help practicing mining professionals in better understanding and interpretation of data and improve the evaluation of risk for various mining scenarios. For this research project we propose to collaborate with Indian Institute of Technology-Kharagpur, Coal India Limited (CIL) and Rolta India Limited. The project would comprise five work components viz., Project Administration, User-Needs-Analysis, Data Collection & Data Preparation, Pilot Project Design and Technology transfer activities. Such a project is expected to foster the NSDI initiative of the Government and the ministry on how Internet and GIS can work together for providing access to distributed data (spatial & non-spatial) located at geographically isolated locations and shared dynamically for decision-making.

Introduction

Mining is an important economic activity, and accounts for a sizeable part of the fiscal and foreign revenues in India. As an industry, the mineral and metallurgical industries

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constitute the bedrock of industrial development as they provide the basic raw materials for most of the other industries. Although productivity has been increasing with expansion of existing projects, opening of new mines, introduction of new technologies and with the closing down of small mines, there remains a need for further improvement of productivity in line with India's march for development. The 10th and 11th Five-year plans indicate mammoth growth in the infrastructure sector, which essentially calls for an all-round development of the mineral industry. This entailed revisions of the regulatory frameworks for mining, with a view to creating a more conducive environment for foreign investment, as well as the privatization of state-owned mining enterprises.

However, such pressure for more productivity increases the risk of operation, environmental degradation including social-economic impacts. While the environmental impact of mining has broadly been addressed by mining legislations and the requirements of international financial institutions, more attention is required to increase the level of safety, reduce the level of mine accidents and to the socio-economic impact from mining activities. The prevalence of capital-intensive surface mining has led to an increased loss of land, a critical resource in many rural communities, as well as the renewed focus to increase production of underground coal mines for high quality coking coal can reduce the level of safety of operation.

In an open world both decision-making & consequences have global implications. It becomes an imperative that issues like operational safety, environmental and social impacts are viewed deeper from a development perspective. The industry needs to adapt an integrated information system for development planning, emergency management and collective decision-making. Experience from the industry shows that data within most organizations are managed in a disjointed manner. The level of computerization is also quite low and many operations are carried out manually. Wherever computerization has taken place, information's are stored in a number of different databases with varying formats and on application platforms with varying technology. Islands of technology and information silos with little or no integration or interfaces are in use and it is apparent that important strategic decisions are made based on incomplete and/or outdated information.

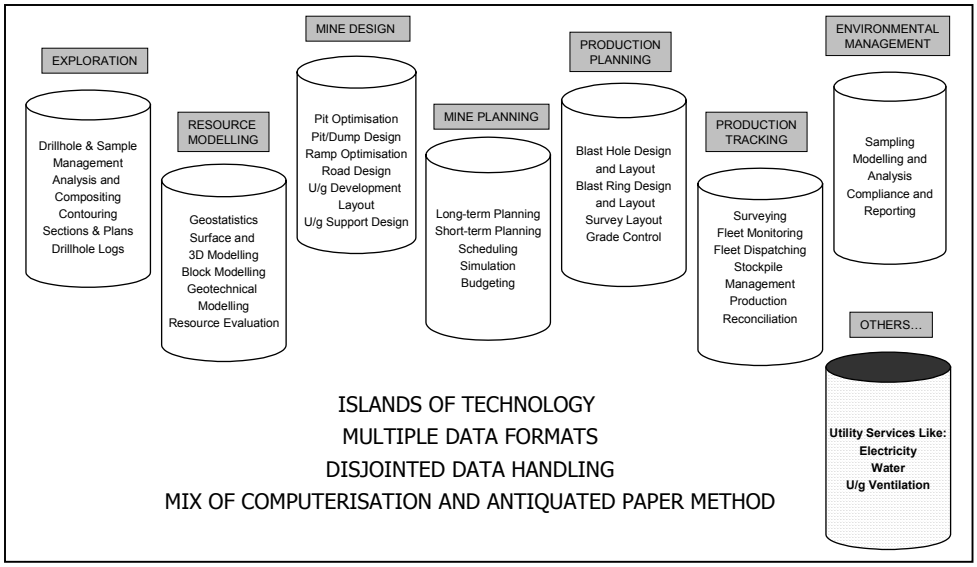

Fig 1- Lack of shared IT infrastructure

Improvements in the tactical planning/decision making processes are likely if related data can be organized effectively and made available easily and in a timely manner. This project proposes to address this problem by prototyping an Internet-based Distributed GIS, that support interoperable processing with specialized geo-spatial models and data (like mine design, environmental models etc.), provides access to heterogeneous geo-data, and enables delivery of universal geo-spatial services to any client with access to the Internet. It aims to study in details the business process and community semantics, with emphasis to identify and understand the structure existing within the coal mining industry in the country and the ways in which individual components within this community articulate with one another. It is expected that such a methodology would foster the NSDI initiative of the Government and the ministry on how Internet and GIS can be used to access distributed data (spatial & non-spatial) located at geographically isolated locations and shared dynamically for decision-making.

The Study Area

Coal is the most important source of energy for electricity generation in India. Bulk of electricity generated (about 65.7 %) is from thermal power stations, which depend upon coal as feedstock. In addition, other industries like steel, cement, fertilizers, chemicals, paper and thousands of medium and small-scale industries are dependent on coal for

their process and energy requirements. The coal industry in the country has been the pacesetter for industrial and economic development. India is currently the third largest hard coal producer in the world. Coal India Limited (CIL) is the synonym of coal sector in India contributing 86 per cent of countries coal production. It operates through eight subsidiaries- seven producing subsidiaries and the eighth for mine planning and design consultancy. These include Eastern Coalfields Ltd (ECL), Bharat Coking Coal Ltd (BCCL), Central Coalfields Ltd (CCL), Northern Coalfields Ltd (NCL), Mahanadi Coalfields Ltd (MCL), South Eastern Coalfields Ltd (SECL), Western Coalfields Ltd (WCL) and Central Mine Planning & Design Institute Ltd. (CMPDIL).

Coal India currently has 484 mines and 18 coal beneficiation plants spread over eight states. It is the second biggest corporate employer in the world, with approximately 5.3 lakh employees and miners including 19,000 professionals of different disciplines. Since its inception in 1975, Coal India has been steadily increasing its contribution to the country's domestic coal supply. Compared to the coal production of 79 million tonnes in 1974-75, Coal India produced 268 million tonnes of coal during 2000-01 and plans to reach a level of 350 million tonnes by the year 2006-07.

The phenomenal growth of the Indian Coal Mining Industry is mainly due to opencast mining, which proved to be more productive and economical to cope with the growing demand of coal. Eighty per cent of coal production during the year 2000-01 was contributed by open cast mining projects. With economic liberalization and consequent reduction of import duty on coal, India can no longer rely on opencast mining alone. It is important that a balance is achieved between open cast and underground operation with an aim to improve the overall coal quality and environmental standards.

Experts both within and outside the organization are in favour of giving top priority to underground mining, which has largely been neglected in the last two decades. However, underground operation poses great challenges caused by the complex geo-mining condition and the unscientific mining in most existing underground mines by private organizations operating before nationalization of the coalmines.

Problem Statement

Mining is a dynamic and risky operation. It needs timely and accurate information to monitor trends that indicate a change in risk status. Lack of such information has led to fatal accidents many a times. In fact around 800 lives has been lost in the past two decades in mine accidents in the country. Investigations into all underground mine accidents reveals that mine maps were not updated. This surely reflects on poor management and violation of safety norms. However it also points to the practical difficulty of manually managing huge data generated during mine operation, and regular updating of maps with the same.

Huge amount of data are generated from mining operation. Yet they could not be managed and utilized in an effective manner. It is true that CIL has introduced Information Technology (IT) in many areas including use of application software for geo-scientific data evaluation, GIS for managing database of maps of its mining areas and GPS guided production monitoring and control system in some open cast mines. It is also developing a common network for communication called CoalNet and CMPDIL is developing a GeoDatabase for underground mines in ECL. But till date these efforts has been less than sufficient.

The routine operations in most of the producing projects are still done manually. Projects use the antiquated paper method for site investigation reports and maps. The information retrieval is done through different registers and record books. The communication is through post and fax. Although acceptable, this method is time consuming, costly and also difficult to maintain and update. Again IT systems in use do not interoperate. For example, surveying software used by CMPDIL and supplied with survey instrument cannot communicate with mine planning software in NCL, supplied by a different vendor. UNIX based mine design software used in Rajhmahal open cast project (the biggest project in ECL) cannot communicate with the Windows based resource modelling software, procured a few years ago; surface topographic grids and coal seam data available in the former cannot be reused. While CMPDIL uses ESRI and AutoDesk product, producing subsidiary BCCL uses Intergraph product. Inconsistent data formats, incompatible applications, and different computer platforms has led to the

emergence of islands of technology. In spite of vast amounts of data generation, mine managers lack the information they need to make sound strategic decisions.

Proposed Solution

Geospatial information is crucial to the decision making process when planning for resource development, project management and emergency response in mining. To this end, the research project seeks to provide models, methods, and tools for prototyping a Distributed GIS that integrates mine planning, operational, and geosciences data into a visual mine process that will provide mine managers with a better understanding and interpretation of their data and improve the evaluation of risk for various mining scenarios.

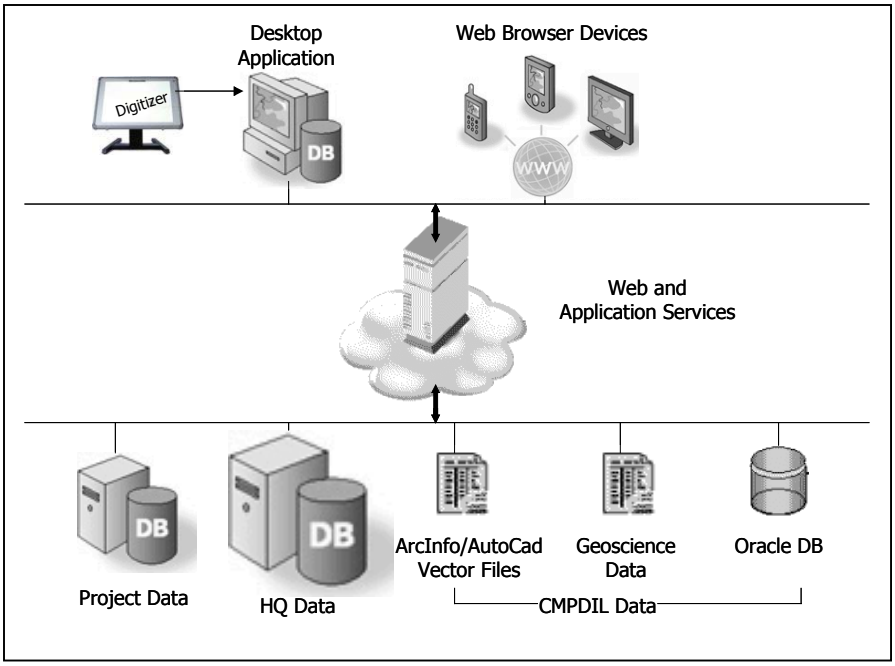

Figure-2 Three-tier client server architecture

The proposed system would be a three-tiered client-server application designed to accommodate a World Wide Web (WWW) or workstation client (Figure 2). It is to enable;

- Distributed data access across heterogeneous data environments- The intention is to build a standardized web services infrastructure for cross-site data access, integration and analysis raised by heterogeneous data formats. Web Services architecture is the logical evolution of object-oriented analysis and design. As in

object-oriented systems, some of the fundamental concepts in Web Services are encapsulation, message passing, dynamic binding, and service description and querying. Microsoft .NET framework which facilitates Web service development in a language independent manner by using XML (eXtensible Markup Language) for formatting data and SOAP for communicating over standard HTTP channels to exchange requests and results. XML being supported by all major operating systems and platforms, XML web services will enable communications between disparate systems.

- Interoperability with specialized mining application systems- The project intends to use XML for exchanging exploration and mining data, including boreholes, geophysics and analytical data, so that data can be exchanged between software applications, and between offices. Models of information in the exploration and mining industry often go beyond the capabilities of mainstream GIS because of the true 3-D nature of the domain. The intention of this project is to leverage the early achievements made in the XMML (eXploration and Mining Markup Language) project. XMML is encapsulated as a platform-neutral, text-format "message" that can be transferred using standard web technology, so that data can easily be exchanged between software applications, between offices, and between data-managers on a transactional basis. It is compatible with both generic (e.g. GIS, CAD, DBMS, spreadsheet, web-browser) and specialized (geology modeling, resource estimation, mine-planning, simulation and visualisation etc) software.

- Communication with mobile devices- This is to provide location-based information to users of mobile devices and providing facility for bi-directional communication with server. The project intends to use IntelliWhere On-Demand and IntelliWhere Location Server from Intergraph, to test how a worker with a PDA can access project information while working in mines and also edit and mark up potential changes to map data and return that to the enterprise as updates. Providing maps and engineering data by way of mobile computing devices—through either in-office download or a wireless link—can bring obvious benefits to mine managers and mine workers. Using mobile computing technologies, and specifically mobile GIS, organizations can transfer data efficiently between field crews and offices,

thereby eliminating the need to travel to the office to grab hardcopy maps or drawings.

The planning process in CIL is distributed within CMPDIL, subsidiary head quarters (HQ) and producing projects. Strategic mine plans which contains yearly plans within a five or ten-year period are generally decided in collaboration with CMPDIL and subsidiary HQ. At the beginning of every production year, mine planning, and production engineers meet to formulate, review and/or modify existing strategic plan. Based on overall corporate policies, production history, ore inventory, equipment availability, and utilization, a strategic plan is formulated or modified to reflect the future direction. After the approval of the strategic plan from HQ, projects break it into operating and achievable targets within the framework of a tactical plan. The tactical plan is dynamic and must be revisited on a continuous basis to reflect technical, operational, and economic changes. During such changes projects requires interacting with HQ and CMPDIL either for guidance or for data not available with the project. What is required is an online system connecting all stakeholders and enabling dynamic data sharing and data integration. The project aims to demonstrate how a shared IT infrastructure within an organization can present key performance indicators at a mine manager's desk.

An important goal of the project would be to support multiple levels of access to distributed spatial data. This can be achieved by building modular collections of data services. Standards likely to be evaluated and potentially used include OpenGIS, FGDC metadata, and middleware standards like Web Services. Tools that are to be used in the project are WebGIS software from Intergraph like GeoMedia WebMap and IntelliWhere Location Server, GeoMedia GIS and IntelliWhere On-Demand hand held client application, Oracle Object-relational database and Microsoft's distributed object framework .NET for building web services application. Programming languages those may be used in combination are Java, C++, C #, Visual Basic and XML.

Conclusion

Building a shared interoperable information infrastructure within an organization and into everyone's work practices poses great challenges, especially when it is for a traditional industry like mining. An important research focus of the project thus would be the new organizational structure that is required for implementing an online, interoperable

information infrastructure. In this context, this project is very timely, as the national government takes initiative for establishment of a National Spatial Data Infrastructure in the country. Implementation of an NSDI initiative is also a process of organisational change management. Moreover, there is also a strong case for institutional as well as individual level capacity building as there are evidences that suggests that many organisations experiences great difficulties in adapting to new responsibilities. Outreach activities and regular interaction with the industry during the project is expected to significantly contribute in capacity building of participating institutions.

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