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DEEP: A new generation software environment for the handling of mineral exploration and mining data

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Abstract

DEEP is an ongoing research and development project which is aiming at a commercially available data handling environment for the exploration and mining industry. This paper presents a brief summary of the results of three years research by an international European consortium which have developed the first prototype of a new environment, DEEP, based on OMT design. DEEP provides a database and applications independent system of services, an system architecture with CORBA compliance and set of tools for further development. The main features of DEEP are the comprehensive data model describing data, attributes and functions for navigation from exploration through to mining, the system architecture including the DEEP Server which provides linking of data between layers and applications, with access to a database. Three different trial applications have been developed using different methods as demonstrators of DEEP and to provide examples of possible ways to interface existing or new applications with DEEP. DEEP incorporates use of industry standard tools and robust components and it is envisaged that DEEI? could become a standard data interchange and set of services for the exploration-mining industry and GIS developments.

Key *words: Mineral Exploration and Mining Software. Data Model .Object Oriented.* OMG. *CORBA.*

1. Introduction

This paper describes an ambitious three year research project undertaken by an experienced industrial consortium to develop a new data handling environment for the exploration and mining industry. The DEEP project set out to address a. range of problems in the mining software industry, in which the researchers were involved, by totalling rethinking the way in which data is used, stored, audited and interrogated, in particular in the transfer between exploration and mining and the handling of qualitative data.

Paths to solutions were identified by adopting an object oriented paradigm and OMT methodologies to prototype an open architecture system that would allow for any application to access, or be developed on top of DEEP, thereby using a DEEP Server, including data linking, a DEEP Data Model and access to a database, and in particular to allow interaction with other DEEP compliant applications.

This interaction is a key feature of the DEEP environment which allows data to be viewed and investigated across different types of applications, thereby providing a powerful interrogation tool in the evaluation of prospects and mining operations.

The current mining software generally are working on flat files, relational databases or on their own specific database system and the main limitations which were identified by the consortium which inspired DEEP are that:

- No existing data models had been developed to allow exploration and mining data to be transferred amongst the large number of existing application programmed
- There is no generally accepted standard for interchange of technical data
- There is a very limited environment for graphically integrating, displaying and interrogating qualitative geological data.
- No suitably complete data model to allow archival storage of qualitative data in particular such that the data can be used in the future for purposes that may not have been pre-defined.

The DEEP consortium have researched the solutions to the above and have developed a prototype which although requires improvements in performance and further development demonstrates the advantages of the environment over current software. The consortium firmly believe that DEEP represents a major advance in data handling concepts with a strong commercial future, whose architectural design is CORBA compliant arid independent of the underlying database and future applications.

z. The DEEP Prototype

DEEP can be considered as consisting of three main parts:

* The DEEI? Data Model
* The DEEP System Architecture
* The Demonstrator Applications

2.1. The DEEP Data Model

The DEEP Data Model is one of the fundermental parts of the DEEP environment and consists of a geological, geographic and spatial data model designed to represent and manipulate all types of exploration and mining data.

The DEEP Data Model is a comprehensive OMT design which was derived through a set of procedures ; specification of data types and functions, definition of the classes of objects and the elaboration of the data model and the validation of the data model to test the navigation.

The definition of the data model includes for each class its attributes and relationships with the other classes using the Paradigm / Plus software tool. Some of the more important aspects in defining the data model are as follows

Defining Class Associations which involved analysing and creating the links between the classes

Defining Class Multiplicity to aid the design and efficiency of the database indexing and access routines

Define Class Functionality which involved identifying functions that will be applied to each class within the data model.

Navigations of the data model defined by the conversion of exploration scenarios into Data Flow Diagrams and cartoon diagrams

For the developer the specification level of the data model design is documented in a hypertext help file.

The DEEI? Data Model consists of four main subsystems :

- Business Subsystem

- Spatial Subsystem
- Geological Subsystem
- Mining Subsystem

For the purposes of prototype demonstration which uses three different applications only the core classes of the full data model have been implemented.

Took for Updating

As part of the ongoing development of the Data Model, tools have developed for managing changes in the core Data Model automatically. These tools used the scripting language of the OMT tool to generate database schema code which would update the database, and also to create new header files for the code in the server and demonstrator software. Future use of these tools provides a simple, easy and effective route for improving the structure and scope of the DEEP Data Model.

Consistency

An important aspect of the use of the DEEP Data Model has been the consistency of Data Model across the levels User - Application - System - Database. This simplifies and strengthens the Object-Oriented view of the Mining and Exploration domains which DEEI? presents, and eases the development of applications and domain-specific functionality since a single model exists at every level.

2.2. The DEEI? System Architecture

Evolution of the Design .

The DEEP System Design has evolved from the concept of a simple client-server architecture to a network of communicating applications, sharing a unified data source and user interface support services. This system is supported by an Object Database and a CORBA-compliant inter application communications service. This is a more evolved design than originally envisaged, and provides for enhanced possibilities to extend the system through the Open Architecture. The DEEP Architecture is summarised on Figure 1.

Evaluation & Selection of Components

The communications medium used by the various modules of the DEEI? system is based on the Common Object Request Broker Architecture (CORBA), which provides a standard mechanism for object-based communication across different process on a single machine, or across a network of machines. The particular implementation of CORBA services chosen was the Orbix product, which remains the truest-to-standard product on the market, and provides robust, well-documented and effective services to the DEEP system.

The common data source for DEEP is an Object-Oriented Database Management System, which allows applications to maintain a common Data Model at all levels of the system. The particular OODBMS chosen was UniSQL, which has simultaneous services for both Object-Oriented navigation and traditional SQL-based database management. Art Object Adapter for the UniSQL database was a primary component of the final DEEP system, and was developed to be independent of the underlying database.

The development of a large and complex system, including Data Model, database interfaces, Object Adapter, Linked Windows and Demonstrator applications, required a large and substantial amount of Object-Oriented design. Additionally, the development was carried out at six centres in five countries, with constant need for collaboration and feedback. The use of the Rumbaugh *Object-Oriented Modelling Technique* (OMT) was a primary enabler of this effort. The Paradigm Plus tool was the particular software product used for this purpose, allowing the development of scripts for generating database and software code automatically from the graphical design.

The initial specifications of the system required that a cross-platform solution would be necessary, due mainly to the diverse nature of the user community. As a result, the user interface technology chosen for the DEEP applications was the freely available InterViews library. This library, which has been ported to all major Unix and PC platforms, is an Object-Oriented GUI. The CORBA-compliant Fresco system is the next generation of this technology.

The OpenGL 3D library is the industry standard for high-performance 3D visualisation and rendering software, and formed the basis for the 3D Demonstrator. However, as was the case throughout the Project, the Demonstrator was not dependent on the individual graphical library used.

Platform and Technology Independence

The use of industry standard components in the DEEP Project has enabled the products to be independent of both platforms and individual software products. This is important as the rapid progress in software development would leave the DEEP system behind if ' tied to any particular software vendor or technology. In fact, this Open Systems approach is one of the main aspects of DEEP as a contribution to software development in the Exploration and Mining industry.

Integration of technologies

The development of DEEP required the use of a number of existing technologies, and the integration of these technologies represents a significant effort. These integrations include:

- UniSQL database - CORBA in the Object Adapter
- CORBA and InterViews event models in the Demonstrators
- OpenGL and InterViews graphics systems in the 3D Demonstrator
- Paradigm OMT Tool and UniSQL in the schema generation tool

CORBA-Compliant Communications

The use of a CORBA compliant Object Request Broker allows for open, scaleable, portable designs to be implemented within DEEI?. The technology also insulates DEEP from future developments in software, as it is now a fully accepted industry standard architecture. Since it is so flexible, it allows the production of tailored suites of applications which will closely match user requirements and resources, as well as the development of specialised software by experts in existing and new domains. New development will not require re-invention of software which already exists for DEEP, so efforts can be concentrated on enhanced functionality in the specialist area of expertise.

Ort the negative side, it is recognised that the existing CORBA services have limits when large numbers of objects are involved. This leads to performance problems which are serious enough to require special methods. The DEEP project has identified circumstances when the CORBA approach cannot be blindly applied, and efforts to alleviate the performance issues have so far met with success.

The Object Adapter and Linked Windows Framework

The Object Adapter and Linked Windows comprise the DEEI? Server, and together they provide a unified basis for the applications using DEEP. The Object Adapter provides CORBA-compliant database access services to the applications, as well as the implementation of the services within the DEEP Data Model. The Linked Windows Framework manages communication of selection information between applications, allowing closer combination of the functionalities contained within the various applications.

2.3. *The* Demonstrator Applications

Three applications have been developed to demonstrate the DEEP environment. Each of the applications have been developed in different ways which illustrate three different paths to create applications on top of DEEI?.

The Map Module

A Map Module has been developed as a new straight Object-Oriented design, using standard user interface components, freely available libraries, and the Rumbaugh OMT methodology throughout the life cycle. It provides a rich set of mapping functionalities through its use if the *ivmaps* software based on InterViews.

The 3D Module

The 3D Module combines DEEP data access with the industry-standard 3D graphics library. The integration of the Interviews Graphical User Interface software and the 3D components was a significant achievement of this development. At the same time, the modular system maintains independence on the underlying 3D rendering technology.

The Geostatistics Module

This development was based on selected use of existing Fortran production code with C++ wrappers. In addition, new facilities were added in ground-up Object-Oriented design for general statistics. Interviews replaced the previous platform-specific user interface for geostatistics.

Comparative **Analysis**

All demonstrators were developed on the basis of an Object-Oriented development paradigm, with communication between development teams an important part of the process, and common usage of aspects of the development. for example the Interviews / CORBA integration.

The demonstrators illustrate three different paths which may be used to create software for DEEP. The Geostatistics Module was created by partially reusing non-Object-Oriented Fortran code; The 3D Module used established industry standard commercial libraries, while maintaining independence of the particular product; and the Map Module combined freely available component libraries.

An important consequence of both the system architecture and the DEEP demonstrator application design is that future applications may be developed in any combination of these ways, promoting reuse of existing legacy investments, in combination with state-of-the-art technology.

3. DEEP : a review

DEEP represents a data handling environment which has been developed in parallel with emerging technologies, taking full advantage of new methodologies. Indeed the development has been fortunate in its timing in that only during the project did all the compliant robust and well tested tools become available to develop all of the components. The system architecture has itself evolved during the project and represents a very rigorous evaluation of a wide range of possible tools and configurations.

The performance of an initial "all-object" pre-prototype was worse than expected by several orders of magnitude. This pointed to an underlying dichotomy in the data access requirements of the DEEP system. In the case of large collections of homogeneous data, such as the Layer structures handle, the object-oriented database and CORBA become unnecessary and perhaps crippling overheads, as they are designed for flexibility and complexity in relatively small quantities. For small numbers of heterogeneous, complex geological data, the "all-object" approach is an excellent way to traverse the Data Model in search of answers which only a combination of applications can provide which the proceeding prototype illustrated. The planned second-generation DEEP system and commercialisation will address these issues and provide more optimised data access pathways for the two sorts of data being manipulated.

For the long term, it is envisaged that a bridge to acceptance for the DEEP concept is to attempt to establish DEEP as an industry standard data interchange format, since its rich Data Model may be used to provide an effective bridge between existing file formats. Tools which could perform conversions to and from various formats would have to be deveIoped for this purpose.

5. Conclusions

The DEEP Data Model is the most fully-developed data model for the Mining and Exploration industries, and has become the subject of discussion with efforts "both within and outside the industry. These include the POSC initiative, which is a highly evolved and widely adopted standard in the petroleum industry, as well as the CSIRO project, which is in the early stages of researching a data model for the mining industry. As the DEEP Data Model exists at present, there is a possibility of migrating or combining parts of all three models in a drive to establish compatibility across industries.

In anticipation of these efforts, the authors consider that a basis exists for establishing an Industry Standards Process based on the DEEI? Data Model.

Future applications using DEEP may necessitate implementation of non-core classes in the data model with possibly some modification to the data model. However, the system architecture and the selection of components is such that the integrity of DEEP will be maintained with new implementations and if changes to the data model are required.

The DEEP system architecture comprises a design and set of components which the authors see as likely to be maintained in the foreseeable future and next phase of development. The use of industry standard components in the DEEP Project results in independence from both platforms and individual software products. The Open Systems approach to the architecture is seen as one of the main aspects of DEEP as a contribution to software development for the exploration industry.

An important part and significant effort of DEEP has been the integration of several different existing technologies.

Another objective of the DEEP project was to define the basis of a new architecture that would include a standard integration platform. In this respect The Common Object Request Broker Architecture and Specification (CORBA) provides important requirements for DEEP. The technology also insulates DEEP from future developments in software, as it is now a fully accepted industry standard architecture, moreover new development will not require re-invention of software which already exists for DEEP. It has also been experienced that CORBA services have limits when large numbers of objects are involved leading to performance problems which still have to be solved.

The DEEI? server comprises an integrated Object Adapter and Linked Windows which provides both CORBA-compliant database access services to the applications, as well as the implementation of the services within the

DEEP Data Model. The Linked Windows Framework manages communication of selection information between applications, allowing closer combination of the functionalities contained within the various applications. Future development of the Linked Windows will involve cross-layer and cross application data modification services.

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Figure 1 Caption. The DEEP System Architecture

FIGURE 1. **DEEP SYSTEM** ARCHITECTURE.