Preparing a New Generation of Environmental Information Systems

Martin Breunig and Serge Shumilov

Abstract

Obviously, sustainability in the information society cannot be realized efficiently without new computer science techniques and software architectures. Furthermore, data services should be available to support the worldwide management of environmental problems. Also open method services should be provided. In this paper it is stated that geoscientists - being on duty of examining environmental problems - should cooperate with computer scientists to meet the coming challenges. These challenges particularly touch the modelling and management of 3D/4D and multimedia data, the control of very large data sets, the integration of heterogeneous data sources and the cooperation between distributed environmental information systems. We focus on the system integration aspects describing the way from monolithic software systems to a new generation of distributed environmental information systems. Finally we give an outlook on our future research.

Zusammenfassung

Offensichtlich kann Nachhaltigkeit in der Informationsgesellschaft nicht effizient ohne neue Computertechniken und Softwarearchitekturen realisiert werden. Ausserdem sollten Datendienste verfügbar sein, um das weltweite Management von Umweltproblemen zu unterstützen. Auch sollten offene Methodendienste bereitgestellt werden. In diesem Artikel wird festgestellt, dass Geowissenschaftler - im Dienste umweltrelevanter Problemstellungen - mit Informatikern zusammenarbeiten sollten, um den kommenden Herausforderungen entgegenzutreten. Diese Herausforderungen betreffen insbesondere die Modellierung und Verwaltung von 3D/4D und multimedialen Daten, die Kontrolle sehr gros-

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2 Institute for Environmental Sciences, University of Vechta, P.O. Box 1553, D-49364 Vechta, e-mail: mbreunig@iuw.uni-vechta.de, Internet: http://www.iuw.uni-vechta.de

3 Serge Shumilov, Department of Computer Science III, University of Bonn, Roemerstr. 164, D-53117 Bonn, e-mail: shumilov@cs.uni-bonn.de, Internet: http://www.cs.uni-bonn.de

1. Introduction

There have been many helpful proposals for standards and infrastructures to describe heterogeneous geodata and methods. Especially the Open GIS Consortium (OGC) proposal with it’s simple feature specification (OGC 2001) gives a framework which GIS vendors and users have considered in their data interfaces. In this paper we do not focus on the data integration aspects, but it is stated that the system integration - also often called ”interoperability” stressing the communication aspect - with it’s open source thinking is the key to the realisation of a new generation for environmental information systems (EIS). We are discussing three ”milestones” on the way from monolithic to open and mobile EIS.

2. System architectures

From an architectural point of view, specific geoinformation systems (GIS) can be seen as components for more general environmental information systems (EIS). Obviously, the interaction between these components has to be further examined (Breunig 2001). This research deals with new infrastructure architectures and with the development of ”individual toolkits” to support the needs for specific environmental software systems for the public and private sector. We distinguish between three system architectures of scientific environmental software:

1. environmental information brokers (e.g. map server);
2. remote geo computation services (e.g. the CORBA approach, OMG 1999);
3. local geo computation services (e.g. the Java approach, SUN 2000).

Obviously, the first system architecture is the most simple and therefore the most used architecture for the internet-based access on environmental data. The idea is to load remote data of a client to your local application. However, such independent map servers and also today’s GIS cannot be used as communicating components of environmental information systems. The other two architectures enable distributed computing between different components of EIS. That is why we will discuss these two architectures in more detail.
3. Three milestones on the way to develop a new generation of environmental information systems

The three milestones below are the building blocks for our vision providing environmental component software (Szyperski 1998) with interoperating components to be "plugged into" a flexible system architecture.

**Milestone 1: Developing geo kernel database systems.** Today’s environmental information systems have a closed system architecture. Therefore, the interaction between different environmental information systems is extremely difficult. Furthermore, they are mainly designed to manage 2D data. What is needed is a new generation of open data base kernel systems. In milestone 1 we outline the principles of GeoToolKit, the prototype of a 3D/4D geo-database kernel system (Balovnev et al. 1997) developed in the Collaborative Research Centre 350 at Bonn University.

The idea of geo-database kernel systems like GeoToolKit is to provide a class library for geometric objects. The applications can inherit this spatial functionality and add their specific application-specific functions. Figure 1 shows the relationships between the central classes of the GeoToolKit object model. A *Space* is a special object container class for sets of spatial objects that takes care for the efficient retrieval of its elements according to their position in space, i.e. exactly in space or with a spatial interval. Spatial objects can be inserted into a space or again be removed or the user can search for a set of spatial objects. Let an interval in the 3D Cartesian coordinate system be defined as a cube with axis-parallel surfaces (BoundingBox). The class *Space* serves as the main root point for spatial access methods (*AccessMethod*) on the embedded objects (*Spatial Object*). To enable an efficient retrieval, a space should at least have one index.
The class Space can be extended in that way that it is also responsible for the transaction management during the access to the spatial objects. With the spatial objects, spatial predicates, spatial functions and spatial operators can be executed.

**Milestone 2: Developing an architecture for interoperable environmental information systems.** Hitherto, the interaction between different environmental information systems is mostly realised by file transfers between different software tools. However, the remote data and methods exchange should be realised online by remote data and methods access. Milestone 2 therefore corresponds to the second kind of mentioned system architectures (CORBA approach).

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**Figure 1: GeoToolKit object model**

**Figure 2: General schema of CORBA based integrated architecture**
We present an open CORBA-based system architecture that connects two existing geo-scientific software tools – the geological 3D modelling and visualisation tool GOCAD and the geophysical 3D modelling tool IGMAS – via an object-oriented adapter technology (Shumilov/Breunig 2000) with a GeoToolKit-based application specific 3D/4D database - GeoStore (see figure 2).

The distributed GeoToolKit-based geo-database management system GeoStore (Bode et al. 1994) that is through CORBA concurrently accessible for multiple clients from different platforms and programming environments provide an open access to the data for various remote geo-applications. However, the long duration of geo-transactions would require long locks for those database objects that have been requested by the user query. That is why a checkIn/checkOut mechanism has to be provided for version control.

**Milestone 3: Developing portable geoscientific components to be used in environmental information systems.** Milestone 3 corresponds to the third kind of the mentioned system architectures (Java approach) (Bergmann et al. 2000). This approach has all benefits of the previous, plus an additional possibility to perform some simple, not computation-intensive methods in the client side. Here some parts of the server's functionality can be represented as a set of portable Java components (applets). We give an example of a Java component - a user interface for management of geological 4D data (see figure 3) (Siehl 1993; Shumilov/Siebeck 2001).
Conclusions and Outlook

The three milestones described above can be seen as sequential steps to be run through in each environmental information system project. However, they can also be interpreted as milestones in the development of computer science. In this case the technology described in the second milestone (CORBA approach) can bee seen as "outstripped" by the technology of the third milestone (Java approach). At least it can be noticed that these technologies are growing together (CORBA/Java/XML).

There is even a new milestone to be recognised for future projects. This is the use of mobile computing technology (e.g. micro Java approach). Obviously, the limitations of today’s mobile devices like mobile telephones and personal digital assistants (PDA) force the developers of environmental information systems to rethink cartographic visualisation and to develop new methods for the data access in such mobile information systems.
We have presented three milestones on the way to a new generation of distributed environmental information systems. Following the approach presented in this paper, we intend to work in our future research on a general infrastructure for geo-based services. GeoStore and GeoToolKit should be integrated into an open GIS architecture. We will also focus on the examination of database aspects and system architectures for new mobile GIS and EIS.

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Bibliography