

Service-oriented Information and Analytical System of Estimation of Influence of the Lithosphere Model on Dynamic Parameters of Rocky Soil Oscillations from Earthquakes of Southern Baikal Region

Anatoliy V. Klyuchevskii
Institute of the Earth's Crust SB
RAS
Irkutsk, Russia

Gennadiy M. Ruzhnikov
Matrosov Institute for System
Dynamics and Control Theory
SB RAS
Irkutsk, Russia

Vyacheslav V. Paramonov
Matrosov Institute for System
Dynamics and Control,
Irkutsk Scientific Center SB
RAS
Irkutsk, Russia

Andrey A. Mikhailov
Matrosov Institute for System
Dynamics and Control Theory
SB RAS
Irkutsk, Russia

Roman K. Fedorov
Matrosov Institute for System
Dynamics and Control Theory,
Irkutsk Scientific Center SB
RAS
Irkutsk, Russia

Vladimir M. Dem'yanovich
Institute of the Earth's Crust SB
RAS
Irkutsk, Russia

S. Demberel
Institute of Astronomy and Geophysics,
Mongolian Academy
Ulaanbaatar, Mongolia

Abstract

The region of Southern Baikal belongs to the territories with high seismic activity. However, the issues of complex assessment of the influence of the lithosphere model on the dynamic parameters of the rock ground vibrations from earthquakes are insufficiently studied. It should be taken into account that the research is based on monitoring, storage and processing of large amounts of distributed Spatio-temporal data. To assess the impact of the lithosphere model on the dynamic parameters of rock ground vibrations from earthquakes in the region of Southern Baikal, a service-oriented information-analytical system (IAS) of geoportal type is developed. It allows integrate heterogeneous thematic databases and by using services to resolve challenges of modelling, comparison and assessment of dangerous geological processes occurring in the region.

1 Introduction

The region of South Baikal belongs to the territories with high seismic activity. For which issues of the dynamic interaction of mobile areas with the platform block at the neotectonic stage and the patterns of the Late Cenozoic fault formation [Kly09]. Comprehensive assessment of the influence of the lithosphere model on the dynamic parameters of rocky ground earthquakes [Kly12], haven't been sufficiently studied. Thus, endogenous geological processes pose a serious danger and require study including the usage of modern information and telecommunication technologies. This justifies the relevance of creating an information-analytical environment (IAS) using a service-oriented paradigm (SOA).

SOA is a concept of building an information system architecture from weakly interconnected parts based on services – isolated components with fixed interfaces (API) that perform certain functions. Compared with the well-known concepts, the use of SOA provides a higher-level development of IAS that allows reduce the process and timelines for their creation. Thus, the development of IAS, providing analysis and evaluation of such processes is a relevant task.

2 Conceptual basics of information–analytical system creation

The paper is devoted to the task of creation of IAS with service–oriented architecture. This type of architecture allows to integrate heterogeneous databases of monitoring and use Web–services to identify and study dangerous geological processes in the region. It is possible to use both local and distributed in the Internet network Web–services. The system provides the possibility of using models, algorithms, and data that developed and provided by various researchers. The IAS allows visualise the results of geological processes modelling and zoning of seismic hazard, as well as the formation of thematic maps variety.

It should be taken into account that researches are based on monitoring, storage, and processing of large volumes of Spatio-temporal data, which have the following specificity:

- Spatial distribution of seismic stations.
- Weak expansion of infrastructure for data exchange monitoring.
- Large volumes, Spatio-temporal character, and different format data of monitoring.
- The localisation of storage and data processing systems.

According data spatial nature, the emphasis was made on OGC standarts [Byc16] usage and conceptual basics of spatial data infrastructure of integrational type. This emphasis allows provide the following:

- accounting the requirements of software standardisation and unification;
- implementation of distributed information resources, based on a service– oriented paradigm, organisation and creation principles;
- open–access and usage of spatial data (SD) and metadata through services according to OGC specifications (WMS, WCS, WFS, CSW, KML, etc.);
- the usage of not only Web, SaaS –services, services of search and obtaining SD, analysis and processing (cartographic Web–applications, as well as Web– applications with GIS functionality, etc.);
- creation of thematic geoportals and data storage and processing centres (DPC);
- continuity of existing spatial and thematic information resources.

Creation of a service–oriented IAS for assessing the influence of the lithosphere model on the dynamic parameters of rocky ground vibrations from earthquakes includes:

- creation of a geoportal and basic infrastructure components of IAS;
- formation of subsystems for effectively filling bases of thematic and spatial data of seismic activity;
- adaptation and implementation of original models of stress–strain state, seismicity, zoning, earthquake analysis of large lithospheric blocks;
- formation of a set of interconnected models in the form of a complex of WPS services for solving problems of seismic activity analysis;
- organisation in the IAS of a distributed ”cloud” information and computing process with parallelization elements to speed up the computing process.

The geoportal-type IAS is aimed at integrating various-format earthquake monitoring data received by seismic stations, various research groups, as well as the use of their processing services [Par13].

The proposed approach provides the ability to download heterogeneous spatiotemporal thematic IAS data, including those contained in catalogs and bulletins of earthquakes in the southern Baikal region. IAS allows you to build a variety of thematic maps, as well as visualize the results of modeling of geological processes and zoning of seismic hazard.

Attracting Web-based technologies allows us to expand the scope of IAS without the need to install specialized software for each workplace.

As part of the creation of IAS, to study the general seismic zoning of the territory, a web service has been developed that provides an analysis of the geological and geophysical features of the natural environment combining the geological structure, topography, geodynamic factors and seismicity. The service allows the study and accounting of the features of the focal environment and physical processes occurring in the focal zones of earthquakes in the southern Baikal region. These features are associated with the geological structure, structure, material composition, stress-strain state and deformation rate of the focal medium and are due to geodynamic factors and seismic conditions.

3 The main elements of an information analytical system

The structure of the geoportal type IAS developed at the Institute of Theoretical and Applied Mathematics of the SB RAS includes the following components as shown on Figure 1:

- The service and geodata management system provides general geoportal management, provides functions: a file manager, access control for data and services, publishing and displaying data sheets, and launching geoprocessing methods for data.
- Data storage system (SHD) - software and hardware for reliable data storage, guaranteeing storage, uninterrupted operation and high speed of reading / writing data. Storage access is done using the file manager. Each user is provided with a directory within the storage system. Creation of a directory and allocation of appropriate rights is performed by the CMS.
- The FTPS server (File Transfer Protocol + SSL) is designed to provide access to the storage system file system. Simplifies the loading and unloading of large amounts of data. Managed by FTPS server using CMS.
- Metadata server - contains a catalog of metadata and provides storage, processing of metadata.
- The PostgreSQL database management system (with the PostGIS extension for processing spatial data) is designed to store user datasets and geoportal service information. The PostGIS extension allows you to store spatial data and implements support for OGC standards.
- SMDServer - designed to visualize maps on the Internet. Provides high speed display of graphic and attribute information.
- WPS - server (Zoo-Project) - provides local and distributed on the Internet geo-processing of raster and vector data, organizes access to desktop GIS, geo-modeling packages and program interaction via the Web interface.
- MapServer is an open-source server GIS, launched through the CGI (Common Gateway Interface), an environment for creating cartographic Web services, and displaying custom maps.

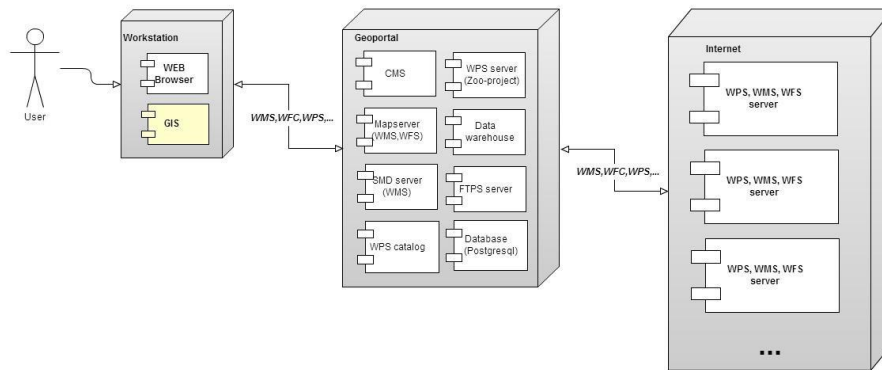


Figure 1: IAS architecture

The data obtained as a result of distance and field studies are usually stored in the form of separate spreadsheets, Excel and CSV formats. Each of the researchers adheres to the recommendations for the presentation of data, but independently chooses the structure and model of their organization. The heterogeneity of data formats requires their pre-processing for further correct loading into an integrating DBMS.

Integration of heterogeneous data related to the same subject area in the form of relational tables provides the ability to more fully present the description of the subject area and conduct analysis taking into account many characteristics. However, for the correct data integration, it is required to ensure the high quality of the primary material. Otherwise, the analysis of the data set will be difficult. In order to bring semi-structured data into a relational view and go directly to the load in the integrating database, an original loading service software interface is proposed that provides the ability to load “flat” tables into a relational database. In the future, this will greatly simplify the ability to perform data operations. To bring data to a relational view, it is proposed to use the TabbyXL [Shi19] tool. The canonical form of presentation of the tables, enriched by meta-information about the specifics of the data, is loaded into the target table of the database of the information-analytical system.

The result of many years of research on the seismic South Baikal region is the creation of a number of computational models. FORTRAN’s language was usually used for their development, since it was popular in the scientific community since the 50s of the 20th century, and is still used today. However, the current implementation of the information-analytical system involves the development of services in C++. Therefore, to automate the creation of WPS services, a tool based on the f2c translator from FORTRAN to C++ was developed. This service allows you to semi-automatically broadcast from FORTRAN to C++.

4 Conclusion

The developed prototype of a service-oriented information-analytical environment for assessing the influence of the lithosphere model on the dynamic parameters of rocky vibrations from earthquakes in the South Baikal region with spatial analysis functions. It allows monitoring and a comprehensive analysis of the seismotectonic situation and decision-making on the prevention and minimization of risks resulting from hazardous geological processes.

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