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Construction of Geographic Information System of Corporate Level in Geological Prospecting

Maxim A. Spikin*,
Vladimir A. Pozdnyakov and Sergey S. Hudyakov
Siberian Federal University
79 Svobodny, Krasnoyarsk, 660041, Russia

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The paper describes the experience of application of geographic information technologies and methods of processing of the Earth remote sensing data for solving practical tasks in the search for hydrocarbon deposits. The most important feature of technological processes in this sphere is the necessity to analyze large flows of spatially distributed data of different nature in real time. We propose a service-oriented approach to organize a geographic information system (GIS) in order to optimize the solution of tasks in nature management and exploration for oil and gas studies.

Keywords: GIS, geoinformation technology, geographic information system, earth remote sensing data, geodatabase.

Introduction

Currently, there is a tendency in exploration work that volumes of diverse data are constantly increasing, the range of current tasks is expanding, the number of applied methods and technologies of prospecting and exploration of mineral resources, particularly oil and gas, is growing. As a result, there are difficulties in operational management and analysis of large flows of heterogeneous data that leads to a slowdown in the speed of decision-making. Topological nature of information makes it possible to create a single information-analytical system and integrate data of different production services and departments. The integration of different data types and structures into a single information space substantially increases the information content and the effectiveness of researches. Exploration for hydrocarbon reserves in geographical and geological conditions of Eastern Siberia is a very complex and financially costly task. The necessity to optimize the processes of handling of large amounts of heterogeneous data appeared because of the given factors. One of the solutions for this task is the application of geographic information systems based on object-oriented technologies and the Earth remote sensing data (RSE) [1-3]. The geographic information system that we offer makes it possible to carry out a sophisticated spatial analysis of data, provides a wide range of tools and supports operations with objects of industrial and financial activities of oil companies, namely: wells, pipelines, roads, hydrography objects and human settlements, infrastructure, geophysical

* Corresponding author E-mail address: spikin@mail.ru

profiles and seismic sounding points, the elements of oil fields infrastructure and natural ecosystems, various documents and other data.

Problem statement

In exploration for oil and gas the effectiveness of managerial decision-making on basis of the results of heterogeneous data interpretation depends directly on the quality and possibility of prompt and complex use of retrospective and current data of geological, geophysical and environmental studies. Such data typically have geospatial nature. Fig. 1 shows a general scheme of spatial data use in processing of geological and geophysical information. However, even at the contemporary stage of development of geographic information technologies a lot of organizations often allow inefficient use of spatial and archival data in processing and interpretation of geological and geophysical information.

The analysis of this scheme can distinguish interrelated problems, namely: the inefficient use of spatial data and the use of spatial data of bad quality, which significantly reduces the effectiveness of processing and interpretation of geological data.

The problem of inefficient use of spatial data and geographic information technologies is primarily related to the absence or lack of understanding of the processes of creation and processing of spatially distributed information, lack of specialists in the field of digital cartography with a clear understanding of the processes. One of the solutions for this problem can be engaging specialists into analytical groups who have necessary skills and practical experience in the field of cartography and geographic information technologies.

The problem of quality of spatial data also takes place. It implies the use of redundant, irrelevant and sometimes false information and also reduces the effectiveness and accuracy of data processing. Some departments of different oil and gas companies often use «raw» and unverified information obtained from dubious sources while processing and interpreting geological and geophysical data. [2] A typical example of this is a significant difference between coordinates and altitudes of points of geophysical observations (pickets of geophysical profiles and boreholes) and their actual horizontal and vertical positions. This kind of discrepancy may be due to both objective and subjective reasons.

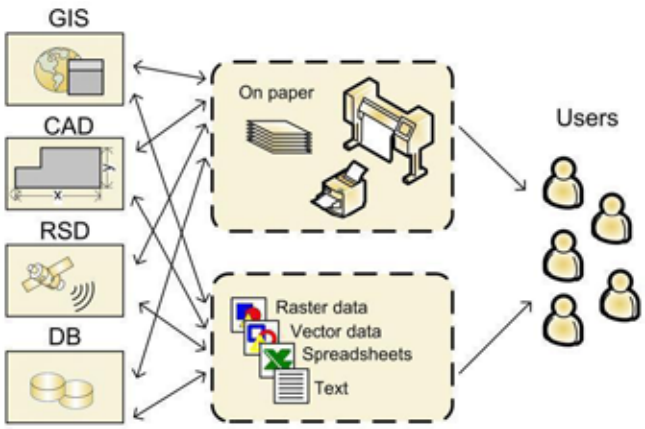

Fig. 1. A general scheme of spatial data use

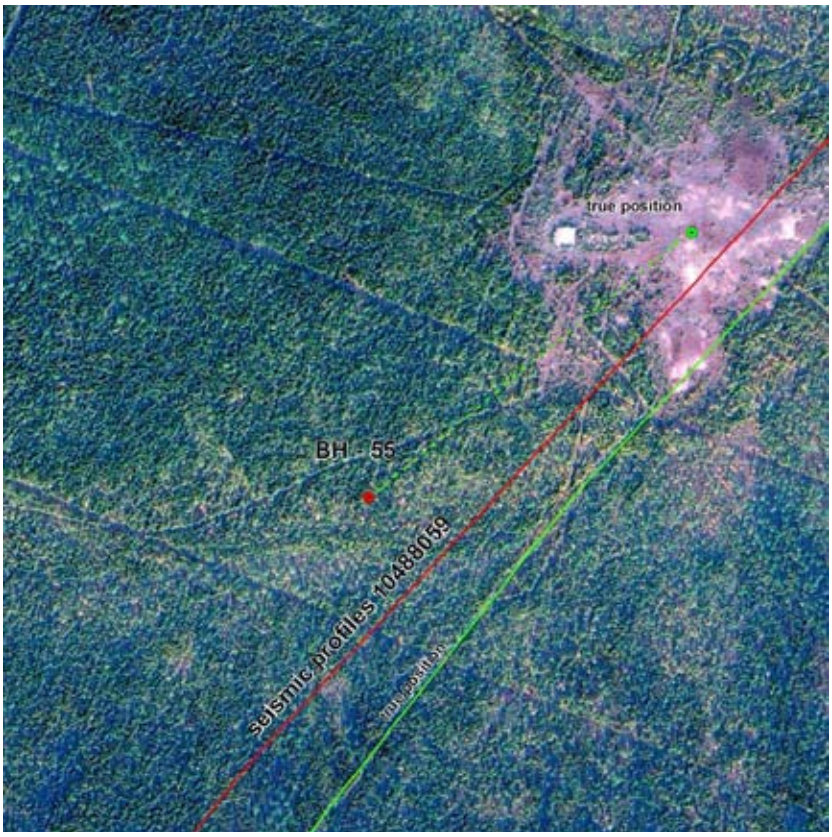

Fig. 2. The example of discrepancy between spatial positions of seismic profiles and wells and their actual positions

Fig. 2 clearly shows the discrepancy between a spatial position of seismic profiles and wells and their actual position. The true position of the objects was found by using the results of high-precision satellite imagery. The analysis of spatial data revealed that more significant errors took place several times, and it can be connected with improper determination of positions under severe conditions of Eastern Siberia. It should be mentioned that this type of errors can be revealed and corrected by verification on basis of modern high-precision remote sensing techniques [3].

Considering the problem of data quality it is also necessary to consider the question of openness of spatial data and copyright to them. The data should be presented in an open form of digital cartographic information and at the same time should keep enough information about the investigated objects.

GIS application as the way to improve the effectiveness of exploration work

The present-day specialized geographic information systems are quite complex, functionally redundant and costly software. This makes users work with software that is relatively easy to understand and use, including, for example, vector and raster editors. It again leads to an inefficient use of information resources. We think that the development of a specialized GIS and its application in production departments will help to create a united geo-information resource on basis of which the

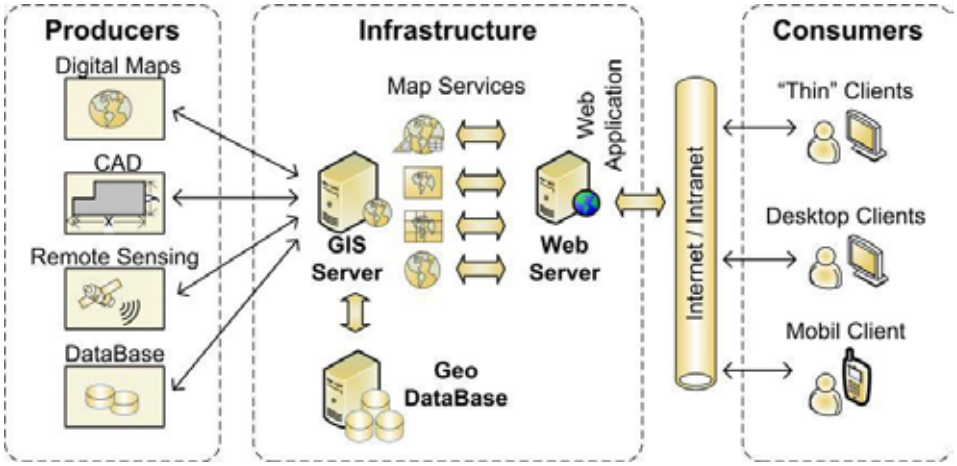

Fig. 3. The diagram of a service-oriented GIS of corporate level

results of field geological and geophysical research of the studied Earth interior objects, topographic surveying, remote sensing data and other subject information will be fully integrated. This integration will help to improve the quality of interaction between elements, get rid of redundancy and use function of storage and data management most effectively.

The solution of the problem that is considered in the given article should be found in the area of already known or developed specialized GIS and technologies of processing geological and geophysical information. Typically, during the development of such GIS, structured data are stored in specialized databases of corporate level, where the main integration component is a spatial component. In this case the functions of management, storage and database access are assigned to the GIS.

Currently, web-mapping technologies that let a broad range of people use geological and geophysical data without experience of work with complex specialized software and necessary qualifications became widely used. Data services are used for implementation of this technology, and a regular Internet browser serves as a tool for access to them. In this case, technical functioning of GIS is hidden from the end user that facilitates not only using but servicing the system.

A GIS based on the service-oriented architecture (SOA) is a very convenient technological solution to implement distributed systems of access to spatial data. When designing an SOA GIS geographic data and functions are implemented as separate web services, which are then combined in a layered data structure and rendered in a user interface, for example, in a Web browser using a «thin» client technology. A functional diagram of such a service-oriented GIS of corporate level is shown in Fig. 3.

It is necessary to point out the main advantages of using the concept of service-oriented architecture (SOA) in GIS: all the logic of the system functioning and data storage are implemented on the server; a clear structure of the information system: data providers, infrastructure and users; saving on the cost of client software and system maintenance; high fault-tolerance and distribution of the elements of the system; the ability to integrate with existing enterprise information systems. Without going into technical details, the algorithm of actions of the service-oriented GIS user is as follows: the user opens a web browser; logs into the system; gets his/her own set of data and functions in accordance with his/

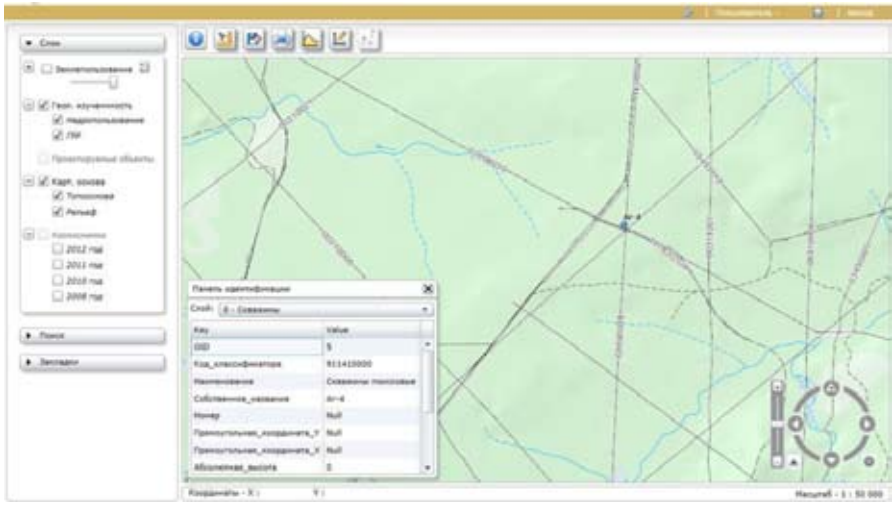

Fig. 4. The example of a user interface for the access to GIS data

her roles (rights) in the system. The example of the developed on basis of SOA software interface for the access to GIS data is presented in Fig. 4.

Thus, the use of service-oriented architecture for GIS development makes it possible to form a new group of users of spatially distributed information that is a group of «special experts» in the effective use of heterogeneous spatial data without specific knowledge about GIS. In other words, the end user, using spatially distributed mapping and analysis services as layers and web applications, gets a full-fledged GIS without using complex multi-specialized software.

Discussing results

The use of the proposed approach to the implementation of the tasks of processing geological and geophysical information affects the quality of managerial decision-making. Practice shows that in performing work the optimal basis for integration process is a spatial component, as most of the studied objects have a clear position in three-dimensional coordinate space. In this case it is easy to compare and interrelate objects of ground infrastructure and objects of geological environment (Fig. 5, 6). The integration framework in oil and gas exploration is normally the results of digital cartography that include digital topographic base (including digital terrain and relief models), orthophotoplans on basis of satellite imagery of high spatial resolution as (Fig. 5). This makes it possible to position different geological objects of study in the real three-dimensional coordinate space with maximum accuracy (Fig. 6), in particular, create reliable geostatistical and hydrodynamic models of hydrocarbon deposits.

Fig. 6 is the example of using a superposition of some materials stored in specialized databases for situational analysis of geological and geophysical information. Data and results of geological and geophysical research are displayed in real three-dimensional coordinate space. In addition, all current and retrospective attribute information about geological and geophysical objects under study (results of well logging, materials of core hole research, the results of processing and interpreting seismic data, etc.) is in full access.

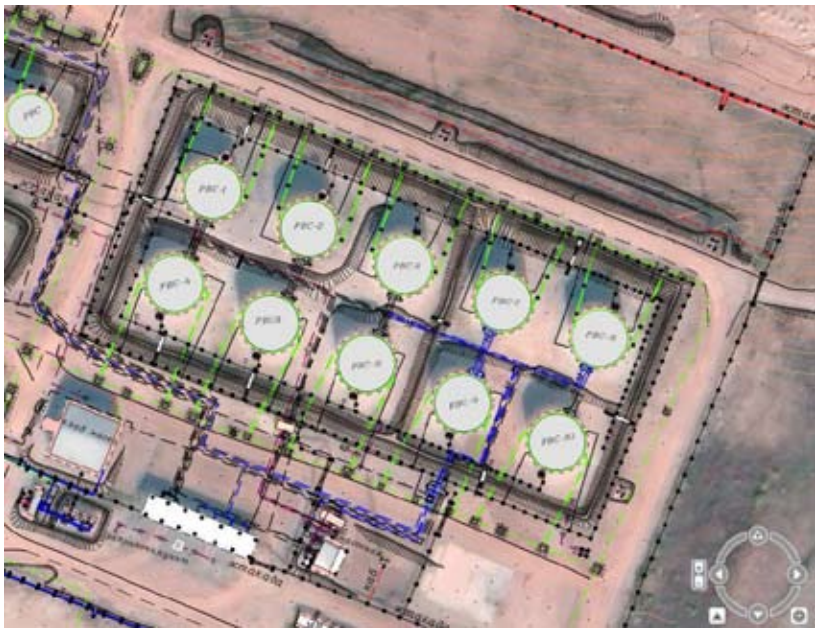

Fig. 5. The example of integrating orthotransformed results of high-precision satellite imagery (orthophotoplans) and digital terrain models (DTM)

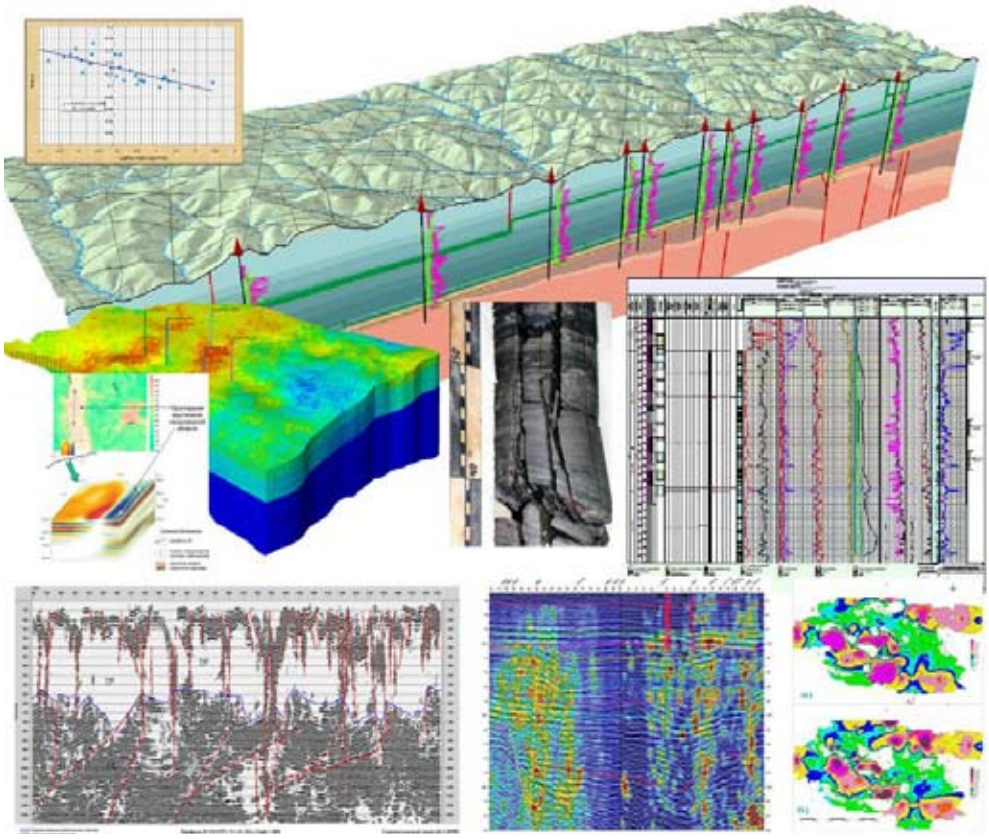

Fig. 6. The example of integration geological and geophysical data into a single project

Conclusion

It is shown that the use of service-oriented architecture of building GIS will optimize the process of solving environmental problems in exploration for oil and gas. A scheme for implementing a service-oriented enterprise GIS is offered. Completed testing of the system with respect to spatially distributed data of geological and geophysical studies is made.

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Построение геоинформационной системы корпоративного уровня при проведении геологоразведочных работ

М.А. Спикин,
В.А. Поздняков, С.С. Худяков
Сибирский федеральный университет,
Россия, 660041, Красноярск, пр. Свободный, 79

В статье изложен опыт применения геоинформационных технологий и методов обработки данных дистанционного зондирования Земли для решения практических задач при поисках месторождений углеводородов. Важнейшей особенностью технологических процессов в этой области является необходимость анализировать в режиме реального времени большие потоки пространственно-распределенных данных различной природы. Предложен сервис-ориентированный подход к организации геоинформационной системы (ГИС) для оптимизации решения задач природопользования и при нефтегазопоисковых исследованиях.

Ключевые слова: геоинформационные технологии, геоинформационные системы, дистанционное зондирование Земли, база геоданных.