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The Formation of Regional Spatial Data Infrastructure

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In this paper the major characteristics of spatial data, its infrastructure and main components are discussed. Herein, spatial metadata and software and technical support for geoportals, as well as their services are examined. In this work technologies of development of applied geoinformational web-systems (geoportals) are discussed. Within the paper the software architecture and web services of the geoportal of Institute of Computational Modeling of Siberian Branch of Russian Academy of Sciences is presented.

Keywords: geoportal, web cartography, web mapping, geospatial data, geodata, Internet Geoinformational System, geospatial metadata catalogue, cartographic web-service, WMS-service.

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Формирование региональной инфраструктуры пространственных данных

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В статье обсуждаются основные характеристики пространственных данных, их инфраструктура и ее основные компоненты. Рассматриваются пространственные метаданные и программно-технологическое обеспечение геопорталов, их сервисы. Изучены технологии разработки прикладных геоинформационных веб-систем (геопорталов). Представлена архитектура программного обеспечения геопортала ИВМ СО РАН.

Ключевые слова: геопортал, веб-картография, геопространственные данные, веб-ГИС, каталог пространственных метаданных, картографический веб-сервис, WMS-сервис.

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1. Introduction

Spatial data is digital data concerning spatial objects, including information on their location and features, on their spatial and non-spatial attributes. Spatial data is data on geographical objects, which represents the formalized digital models of material or abstract objects in the real or virtual world.

The full description of spatial data consists of two interrelated parts: these are positional data and non-positional data, i.e. descriptions of spatial location and thematic content of the data, of topological and geometric, as well as attributive data (geometry and semantics). Spatial and temporal data is used for consideration of temporal aspects. A representation of spatial data, or a model of spatial data is a way of a digital representation of spatial objects, or a type of a structure of spatial data. Spatial data can be represented as regular network, as well as vector and attributive models. Within a regular network model the whole territory that is being explored is divided into the elements of a regular network, or cells, and is subdivided into raster models and GRID-models by value type. A vector model represents spatial data basing on vectors. Graphic primitive, i.e. the point, linear and polygonal ones, are the major ones among them.

2. Elements of the Spatial Data Infrastructure

Large amounts of stored, processed and used spatial data, as well as the development of modern informational technologies and Internet has changed methods of information representation, of search and access to this information, of its processing, analyzing and visualization methods. In this context, metadata which is expository information on the structure and meaning of the data, as well as applications and processes by the means of which the data is manipulated, has an important role [1].

Metadata is data about data, i.e. catalogues, directories, registers, metadata-bases and other forms of descriptions of digital and analogue data sets comprising information on its composition, content, status (actuality and updatableness), on its genesis (ways and conditions of its origination), on its location, quality (its completeness, consistency and validity), on its formats and forms of presentation, on access, on acquisition and usage conditions, on copyright, property and related rights for this data. Metadata databases, including those comprised in cartographic data and geoinformational systems, can provide a medium of inventory of informational resources, be involved in existing informational systems and databases, as well as they can be used in searching and estimating the origins of spatial data [2].

Along with spatial data, informational technologies of mass gathering, storage, processing and usage of such data as Earth Remote Sensing data, digital maps and plans, digital spatial and temporal data originated by global satellite positioning systems (GPS/GLONASS), digital geodetic field survey data and laser ground and aerial survey data, has received wide recognition. This determined the creation of the spatial data infrastructure for the purpose of effective territory spatial data resources organization and control, of means of accessing cartographic (traditional and digital) resources, as well as metadata in various diagrams that have gridding and/or geographical reference to external informational objects available on standard protocols. The spatial data infrastructure also refers to a hierarchically regulated system (information environment) which is built using informational technologies and based on common data and metadata standards, as well as a network of geographical informational nodes (geoportals and metadata catalogues) [3].

The formation of the Spatial Data Infrastructure (SDI) on different levels is being carried out with varying success for more than 20 years by now, and it includes global, national, interstate (European, Asia and Pacific Region countries etc.), regional, municipal, sectoral, corporate and other levels. Within each of such projects tasks on detection, formal definition of the following major components of the spatial data infrastructure are solved:

- *Basic spatial data* that can provide the base for location (positioning) of all other spatial and non-spatial (attributive or thematic) ones;
- *Spatial metadata and accessing mechanisms* that include metadata databases located in the network of servers, gateways and portals, available through the information interchange centres and facilitating data search among the multitude of storages, funds, databases located at their bearers, as well as they include standards and programming tools for metadata-base creation and accessing;
- *Standards on spatial data*, including standards on spatial data models, geodetic provision, spatial and temporal coordinate systems, representation formats in spatial databases, interchange formats, metadata, data accuracy and quality, digital maps and cartographic methods, classifiers of particular thematic data types up to standards on notion and nomenclature instrument.

Within the notion of the spatial data infrastructure which has gained ground up to this moment, spatial data is positioned as information and telecommunication system providing access to spatial data dispensing resources for citizens, economic entities, state and municipal authority bodies, as well as data distribution and interchange in the global public informational network with the purpose of increasing of its production and usage efficiency.

A geoportal is one of the systematically important elements of the spatial data infrastructure. A geoportal is a software and technical tool for spatial data operation. Its major task is provision of media and storage services to users, as well as spatial (geographical) data cataloguing, publicizing and loading; filtration across the metadata and interactive web-visualization; as well as provision of the direct access to geospatial data basing on cartographic web-services [4].

In the context of spatial data, a geoportal is a software and technological solution, the functional capabilities of which are defined by its services:

- *Searching services*, allowing to search spatial data sets and geoservices basing on the corresponding metadata, as well as to plot the metadata content;
- *Visualization services* providing, at least, capabilities of viewing the data, navigating through images, scrolling through them, data scaling and graphic overlay, as well as plotting of the appropriate information comprised in the metadata;
- *Information downloading services* allowing to copy spatial data sets or its fragments and providing the direct data access, when possible;
- *Data conversion services* enabling to transform spatial data sets to provide its interoperability;
- *Services for signaling to other (remote) servers*.

Basing on functions performed, geoportals can be divided on sectoral (The Federal Geoinformational System of Territorial Planning, Public Cadastral Plan, Demeter System of Federal Service for Veterinarian and Vegetarian Sanitary Supervision), corporate (Roscosmos geoportal), scientific and educational, investment and others [5].

3. The Geoportal of ICM SB RAS and its components

Researches and developments in the field of the spatial data infrastructure on the regional level have been carried out at Institute of Computational Modeling of Siberian Branch of Russian Academy of Sciences (ICM SB RAS) for somewhere 10 years now. This work resulted in the creation of software and technological tools for applied geoinformational web-system (geoportals) construction. The procedure of quick implementation of applied geoinformational web-systems has been developed, and the appropriate program and technological, informational and computational software, such as storage, processing and spatial data analyzing (including satellite images) services and media, along with applied program and user interface repositories, access authorization media within the structure of the geoportal and spatial data catalogue, cartographic web-visualization system, auxiliary and applied web-services have been created [6].

Software and technological tools that are being developed represent high-level repositories of functions and classes, application templates directed at the end user. These provide an operational solution of the following tasks:

- Maintenance and storage of digital cartographic materials, raster images of the location enabling the univocal addressing and positioning of objects in the regional (municipal) infrastructure;
- Navigation through informational cartographic resources, visualization and analysis of spatially oriented data on unified digital maps;
- Interaction with cartographic and attributive resources (databases) of third party applied information systems;
- Solution to various spatial tasks using resources of the spatial data storage (spatial search, object creation etc.);
- Provision of access to the system using modern geoinformational system technologies and interfaces.

As of today, the geoportal of Institute of Computational Modeling of Siberian Branch of Russian Academy of Sciences (Fig.1) represents a set of software and technological tools consisting of the following elements [7, 8]:

- *Data storage subsystem* within which the support of all the formats of popular geoinformational systems (ArcGIS SHP, MapInfo TAB, etc.) and spatial databases, such as PostgreSQL/PostGIS and others is provided.
- *Geoportal resources catalogue*, which is a metadata management subsystem, a database and a program repository set (API) for various operations with resources on the base of web-services on SOAP protocol.
- *Administration system of Data Control Geoportal*. The main task of this is the registration of informational resources in the Catalogue, entering and editing of metadata. Further functions relate to the distinctions of access rights, metadata import from third party WMS-resources and its applicable registration in the catalogue and others.
- *"GeoExpress" style layer and map designing editor*. This is a Windows-based program designed for creating and editing of a style map design. This program forms a XML-description of the geoportal style layer and map design and saves it in the Resource Catalogue database;
- *Resource (metadata) catalogue user web-interface*, which is a web-application designed for navigation through the resources registered in the system, and search among these resources.

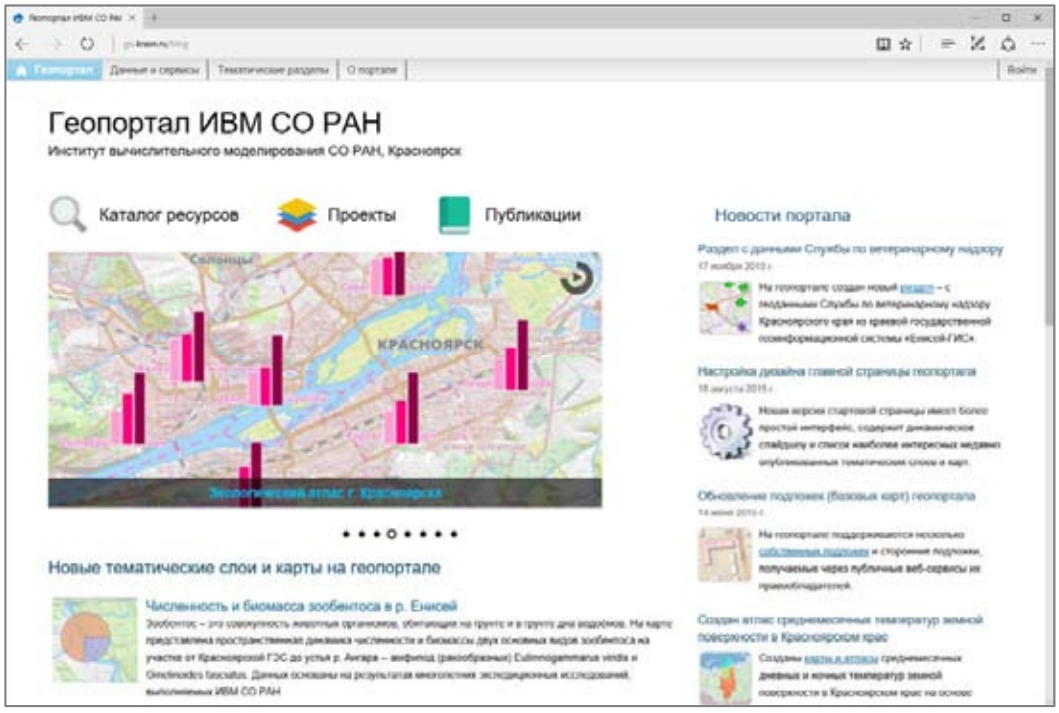

Fig.1. The User Interface of the Geoportal of ICM SB RAS

It provides navigation though the Resource Catalogue with regard to the multiple resource classification and filtration on different criteria, as well as creation of user data sets ("Shopping Cart") and others;

- *Cartographic web-visualization user web-interface (subsystem),* which is a web-application for representation of maps and particular geodata layers of the geoportal though the web-interface. A capability to mark various background cartographic substrates such as Yandex, Google, 2GIS and others (more than 40 items) should be specially noted;
- *Web-publication control subsystem*. While in the first version of the geoportal this subsystem was a series of services based on 1C-Bitrix software, now it is a complex of media for the formation of geoportal thematic sections on the base of Drupal web content management system;
- *Cartographic web-services*, which include address search, geocoding, routing, watercourse constructing and others. These services are designed for work carried out as a part of third party applied geoinformational systems.

Software and technological tools based on the geoportal of Institute of Computational Modeling of Siberian Branch of Russian Academy of Sciences has successfully proved itself as a program and technological base for resource-intensive informational and analytic systems on the regional level for tasks on different subjects, such as the informational support of the sectoral management (in the field of health care, education and transport management), ecological monitoring and estimation of the environment conditions, regional social and economical development forecasts and centralized informational provision of cartographic data. Bodies of executive authorities are customers of these

systems. Developments based on these technologies may prove to be the base for the regional spatial data infrastructure of Krasnoyarsk region [9].

4. Access to the geoportal spatial data

The geoportal of ICM SB RAS presents several types of public (user and program) interfaces:

- User web interface for a standard web browser;
- Cartographic web services based on the OGC international standards;
- Application Program Interfaces (API) for geoportal cartographic data visualization;
- Informational services for third party applied systems.

For the direct access to spatial data the protocols Open Geospatial Consortium (OGC), such as Web Map Service (WMS), Web Map Tiling Service (WMTS) and others are used; they allow access to the geoportal resources from applied user programs directly such as ArcGIS, MapInfo, QGIS etc., as the support of these protocols is integrated into most of the modern geoinformational systems. Thus, at first the users can become acquainted with thematic maps via the interface, and then link them by a web-service to their geoinformational system project for data analyzing: geoinformational software, such as an application for Windows, is usually used for this purpose. OGC protocols imply not a "picture" transition via a web-service only, but also running queries on table object data of the linked map layers (Fig. 2).

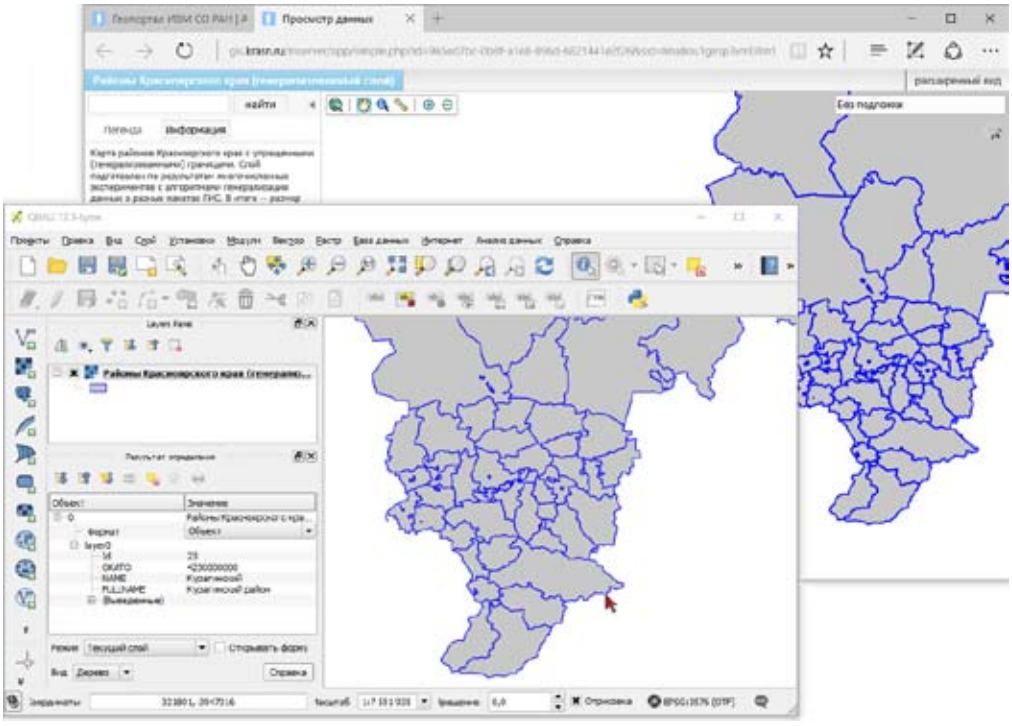

Fig. 2. There are two ways of representing geoportal spatial data by the example of thematic layer with the administrational and territorial division of Krasnoyarsk region, such as the web-interface for the standard Internet Explorer web-browser (on the background) and the WMS-layer in the applied QGIS-program (on the foreground): Here in the information "Defining result" window the WMS GetFeatureInfo query results are represented (the click was performed on the contour of Kuraginsky municipality of Krasnoyarsk region)

Fine adjustment of parameters of map and particular layers representation via a web-interface and web-services is performed in the “GeoExpress” editing program. Using it, a registered geoportal user can form personal spatial data sets, save them in the virtual “My Documents” folder and further represent the data in his/her applications by means of OGC protocols [10, 11].

5. Conclusions

The discussion concerning issues of the formation of the national Spatial Data Infrastructure in Russia started somewhere about 15 years ago, and the Concept of Creation of the Russian Spatial Data Infrastructure developed by the experts of Geoinformational System Association was authorized with the Order of the Government of the Russian Federation in 2006. This was what finally brought the issue of the Spatial Data Infrastructure to the state level. At the present time the work on creation of regional Spatial Data Infrastructure elements is in progress in no less than a half of regions in Russia, including Krasnoyarsk region. The major issues in the implementation of the projects are: insufficient information awareness of potential users concerning capabilities of operating with spatial data and the poor legislative and regulatory frameworks. The development of systems and services such as the geoportal of Institute of Computational Modeling of Siberian Branch of Russian Academy of Sciences may be of help in finding solutions to these issues.

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