Infrastructural approach and geospatial data processing services in the tasks of territorial development management

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Abstract. The technology for creating an information and analytical environment (IAE) for spatial data processing based on the use of spatial data infrastructure (SDI) components and a service-oriented paradigm was proposed for the management of territorial development. The environment is characterized by its spatial nature and distribution of territorial information resources. At the same time, emphasis is placed on the transition from a standard SDI, as an access medium for the exchange of spatial data, to an SDI of an integration type, as an environment for access, exchange, creation, storage of new sets of spatial and thematic data and processing services. The use of Service-oriented Architecture (SOA), open standards by OGC (Open Geospatial Consortium), Web technologies, standardization of the browser's interface and Web services, allowed to move from local to distributed and "cloud" computing in which information and computing resources are provided as Web services. The technology for creating an information and analytical environment involves the use of sets (combinations) of thematic Web services with standardized interfaces integrated with standard protocols (SOAP, WSDL, etc.).

1. Introduction
The management of territory development is a multidimensional process, viewed as the combination of social, ecological, economic goals, which is managed through a wide range of strategies, programs, concrete actions and administrative decisions to ensure sustainable and balanced reproduction of the economic, social and natural potentials of the territory aimed at improving living standards of the population. The effectiveness of the territorial development directly depends on the level of informatization and the availability of objective data.

At present, there is a gap between the formation of territorial information resources and their use in the preparation and support of management decision-making. This is due to:

• increasing volumes and distribution of territorial information resources of state authorities of local government (SALG), institutions of the scientific and educational complex (SEC),
business, etc., implemented on different platforms and located in distributed and heterogeneous networks;

- localization (private use) of information systems, models and data in the SALG, SEC, as well as the complexity of their inclusion in the solution of complex problems of territorial development management;
- limitations associated with the use of legacy programming;
- weak use of the service-oriented paradigm in SALG;
- inadequate efficiency of existing information and analytical systems (platforms) providing information services for SALG, SEC, business and population;
- limited use and creation of distributed geoportal information and analytical systems (platforms) for processing spatial and thematic data for SALG, SEC, business and population, etc.

Territorial informatization is formed on spatially embedded levels, but large volumes of distributed, multi-format data limit their use in systemic problem-oriented analysis of the features of territory development.

Modern decision-making software for the support of the territory development management should include service-oriented information and analysis environment for processing distributed spatial and thematic data, using open OGC standards for interoperability, Web technologies for standardizing the browser interface and Web services. This makes it possible to move from local to distributed and "cloud" computing, in which information and computing resources are provided to the user as WPS (Web Processing Service) services. The transfer of processing and storing of SALG data using remote servers allows to simplify their updates, maintenance and implements such functionality as openness, scalability, provision of common classifiers, availability of data and processing services, etc. [1].

Thematic WPS-services and their combinations provide the solution of specific tasks and carry out processing of distributed spatial and thematic data, integrated use of analytical and forecast models, means of displaying and visualizing the results. Spatial information functionality is used for the formation, processing and storage of spatial data, implementation of territorial sampling and imaginative visualization of the results in the IAS.

The article considers the creation of geoportal service-oriented information and analytical environment for managing territorial development, as well as its thematic WPS-services.

2. Models and Methods
An infrastructural approach to the formation of IAS [2] was used in order to make decisions on the management of territorial development. The approach is based on:

- considering the requirements of standardization and unification of software and technical and regulatory support;
- using modern principles of organizing and creating distributed information systems based on SOA [3];
- free access and use of spatial data and metadata through services using OGC specifications (WMS, WCS, WFS, WPS, CSW, KML, etc.) [4];
- using not only Web, SaaS, search and retrieval services for spatial data, but also services for correct data creation, analysis and processing (including complex ones) (cartographic Web applications, as well as Web applications that have GIS functionality and etc.);
- introduction of orchestration (service management) to combine small Web services into more complex, higher-level ones that can be included in the management processes [5];
- creation of geoportals, data storage and processing datacenters;
- continuity of existing spatial and thematic information resources of the territories.

Using SOA, OGC standards, Web technologies, WPS-services and geoportals at the creation of IAS allows to obtain not only infrastructural, but concrete results, taking into account the mode of operation of already existing information management systems for territorial development.
The main component of the service-oriented IAS is the geoportal, which is a common point of access to information resources and processing technologies and supports the exchange of spatial information between users, as well as transmitting in a special form data on the design and methods of information presentation (figure 1) [6]. The basic components of a typical geoportal are: data and service catalogs, subsystems for starting services and displaying data; a system of input and editing of relational data with spatial attributes, providing access to data services within the framework of the WPS standard [7].

![Figure 1. The structure of a typical geoportal](image)

The multifunctionality of territorial development tasks justifies the need for creation of a cluster of thematic geoportals that support the exchange of spatial and thematic data and Web services for their processing based on OGC standards, which increases load balancing of the data network and simplifies the usability of the system [8]. The set of templates for new geoportal instances in a form of virtual machines based on different platforms for deploying WPS services was developed. The PostgreSQL DBMS is used to store spatial data. The use of a common DBMS for all geoportals in cluster makes it possible to simplify data exchange and use various user tables in queries. Mapserver and SMD Server are required to display spatial data in accordance with the WMS standard. Mapserver displays the constantly changing data in the PostgreSQL database. Compared to other systems, SMD Server displays static data at high speed without the use of caching systems.

For a comprehensive analysis of data or the application of processing services, unification is carried out by additional information (structural specifications) on the tables. To automate the search for services and data, a specification is developed in JSON format that defines service input data, describes the structures of relational tables. This specification can be converted into one of commonly used standards (XSD, WFS, WSDL-S). In addition to the standard fields of data set names and field descriptions (name, data type), structural specifications contain: metadata in accordance with ISO 19115; units for numeric data; possible values for enumerable data types; controls. The controls implement the methods needed to form the user interface for adding, editing, and displaying attribute data.

Structural specifications are used to create tables, search for relevant data services and are stored in a specialized catalog and arranged in hierarchies. A mechanism has been developed for converting relational data to DBF or SHAPE (if there are spatial attributes) for applying them as input to WPS services. The IAS implements the tasks of forming, integrating and transmitting data, launching services, organizing the computing process in the cloud infrastructure, presenting results, etc.

The catalog of thematic WPS-services was created, it includes following services:
- monitoring and analysis of the socio-ecological and economic situation of the territories;
• ranking of territories by local and integral indicative indicators;
• spatial analysis and assessment of trends in the formation of the transport system of the territory;
• monitoring of changes in the floristic composition of the territory depending on its socio-economic development;
• vegetation index;
• SRTM radar survey data processing;
• calculation of the density of point and linear objects in cells of a regular grid;
• decryption of the GRID data set using the classifier and the method of reference vectors;
• converting spatial data of various formats;
• primary statistical data processing;
• ETL integration of unstructured tabular data, etc.

Combinations of WPS services are implemented as programs in the JavaScript language, which allows reducing the task of setting the interaction between services to the task of writing a standard program in one of the most common functional languages [9]. When the service combinations are executed, automatic parallelization and scheduling of the executed services occurs in order to reduce the overall execution time of the combination [10]. The process of executing combinations is resistant to changes in the distributed environment (switching nodes on and off, varying times of execution of services, etc.).

3. Results and Discussion
Due to the backbone nature of spatial data and the digital model of the territory, a geoportal information and analytical environment that uses distributed spatial and thematic data is an effective tool for collecting, processing, analysing information, and modelling possible ways to improve the territorial development process. Structurally, the geoportal IAS is invariant to the organizational structure of the territorial management system.

IAS uses distributed and "cloud computing" in which information resources of processing, data storage are provided as Web services. WPS standard allows specifying any calculation (algorithms, models, spatial data processing functions, etc.), setting the data format and how to transfer it, gives access to the geoprocessing functions, defines how to start and end the process and how to obtain results. The data required for WPS service can be obtained over the data network or be available on the server. To conduct analytical calculations on the territorial development, as a rule, combinations or orchestrations of small services are used and implemented as applications or portals at higher levels. Transferring the processing and storage of territorial administration data to remote servers allows to simplify its update, maintenance and implements such functionality as openness, scalability, provision of common classifiers, availability of data and services for their processing, etc.

4. Conclusion
The effectiveness of the use of the infrastructure approach for the creation of a geoportal information and analytical environment for the territorial development was presented. The characteristics of the environment are: large volumes of spatial and thematic data and its distribution, application of a service-oriented paradigm, OGC standards, Web technologies and compositions of distributed thematic WPS-services.

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