SERVICE-BASED APPROACH TO GEOPORTALS' ARCHITECTURE

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Abstract. This paper describes the author's view on service-based designing of geoportals. The above mentioned approach consists in the decomposition of the geoportal on amount of integrated the Web geoservices.

The cloud computing technologies and Web solutions, wich base on such technologies and implement data access and working with the data in the Web, are widely used in recent years in geoinformatics. One of such Web-based solutions are geoportals that aggregate access ways to distributed spatial data and processing tools. In current interpretation the geoportal, as a special case of Web-GIS, should provide users with spatial data and metadata access and also with the processing tools that allow to solve a wide range of tasks, from displaying to analysis. In correspondence with Service Oriented Architecture (SOA) conception the services are the basic parts that compose the geoportal structure and functionality in general.

The technologies of services for the geodata providing are good standardized by Open Geospatial Consortium (OGC) and International Organization for Standardization (ISO). The main problem of its integration into geoportals is the conceptualization problem of any specific geoportal. However, the technologies of spatial data processing and analysis tools are the least developed and standardized at this time. The only WPS (Web Processing Service) international standard specifies how to create spatial data processing Web services.

This paper briefly illuminates the author's experience in geoportals development and highlights the possible technologies of hybrid Web geoprocessing services that allow an analytical processing of spatial data by user's choice, either server-side or client-side.

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Introduction.

Geotechnology is an essential part of information technologies and Web technologies. Spatial search and query is already a standard way to access information on the Web search portals.

The international standards for the presentation and use of spatial data in the Web are actively developed. For example

such geospatial standardization organizations are known as the ISO committee for Geographic information and Geomatics (ISO/TC211)[1], the Open Geospatial Consortium (OGC) [2], the European Commission in the frames of Infrastructure for Spatial Information in the European Union (INSPIRE) [3].

Current methods of spatial data presenting and using in Web are widely utilize conceptions of WEB 2.0 [2] and Cloud Computing [3]. Also at the current stage of the Web geo-technologies evolution the turn occurs from simple representation of spatial data in the Web to growth and expansion of methods and techniques for data manipulating in the Web interface using Web services and Web applications.

However OGC standards for Web geoservices (such as WMS [6], WFS [5] and WCS [4]) are data services and even WPS (Web Processing Service) [7] standard defines the rules for delivery data processing results to the user instead data processing tools, so the WPS in fact is also a data service.

Interactive and analytical tools are typically implemented as geospatial Web applications, i.e. Web GIS software, based on some Web mapping server (MapServer[4], Geoserver[5], etc.), Web mapping framework (OpenLayers[6], Leaflet[7], etc.) or Web mapping platform (Degree[8], 52north[9], Zoo-project[10], etc.). These solutions are usually narrowly specialized and are not applicable for treating a wide range of tasks.

Thus, the most actual tasks are the development of methods and technologies of creating interfaces for data users and data producers as well as development of technologies for deployment and implementation of analytical tools and data processing facilities in the Web.

Geoportals and Web services. Geoportals is a specific type of geospatial Web solutions. These are resource gateways that allow to aggregate the distributed spatial data in a single Web portal interface and, manipulate with the distributed data via the portal using a Web geoservices. The main classification feature of geoportals is the open architecture in the sense that geoportals represent different spatial data and metadata from different sources in the one frame.

Currently there are some main types of the geoportals can be identified:

– National geoportals which are compose the national spatial data infrastructures;

– Domain specific geoportals which are covers a spectrum of tasks, such as satellite imagery geoportals, educational and scientific geoportals, etc.;

[1] http://www.iso.org/iso/iso_technical_committee?commid=54904
[2] http://www.opengeospatial.org
[3] http://inspire.ec.europa.eu/
[4] http://www.mapserver.org/
[5] http://geoserver.org/
[6] http://www.openlayers.org
[7] http://leafletjs.com
[8] http://www.deegree.org/
[9] http://52north.org/
[10] http://www.zoo-project.org/

– Thematic geoportals wich devoted to solving problems of some thematic or case area, i.e. weather monitoring, cadastral geoportals, and other.

The list of types that we identified above will be growth in closest time probably.

Specific tools and procedures of the data using are typically implemented basing on service-oriented architecture (SOA) in the form of separate Web services with a standardized program interface (i.e. WMS, WFS, WCS, WPS, etc.). The geoservices becomes the modularity units when creating complex Web applications – Web GIS. Similarly the Web geoservices can be a design elements when creating a geoportal.

One of the INSPIRE directives points directly that Spatial Data Infrastructure Geoportal should present a standard amount of services such as: discovery, view, download, transformation and invoke spatial data services [1]. At the same time the INSPIRE geoportal launched in 2011[11], as well as the Russian federal geoportal launched in 2012[12], are only able to search and browse the data until recent time.

It is important to note that mentioned in the title approach to geoportals' architecture blurs the borders between geoportals and Web GISs. Having five basic GIS components, such as data, software, hardware, humanware and methods, the geoportal can be defined as a distributed Web GIS. However it should be remembered that there is a second interpretation of "GIS" term, that is the GIS is a class of software. By analogy, Web GIS in the second interpretation can be defined as GIS software that is implemented in accordance with the Software as a Service model (SaaS) [8] for user interface implementation. As a result the terms "Web GIS" and "geoportal" can not be used as full synonyms.

Service-based approach. Thus the geoportal is an open and scalable (due to services integration) system. When considering the architecture of some geoportal from a point of view of service-based structure, it can be distinguished the three levels of its services (Fig. 1):

– Internal services are an essential part of software kernel of the geoportal and its interface. These services constitute the core functionality of geoportal (search, display and visual manipulation, uploading and downloading data) hosted on geoportal and accessible through its interface;

– Connected services are hosted on the same server with the geoportal but functionally independent and can be ported to other Web resources (e.g. widget engines or WMS/WFS/WCS/WPS hosted with geoportal). These services are attached to geoportal with the source data and interface. These services are available for use as part of the geoportal or for external use, and may be pointed as geoportal extensions;

– External services are fully independent. External services may be

[11] http://inspire-geoportal.ec.europa.eu
[12] http://nsdi.ru

available on geo-portal but hosted on other network resources. These services can be called up outside of the visual interface of geoportal and regardless of the geoportal.

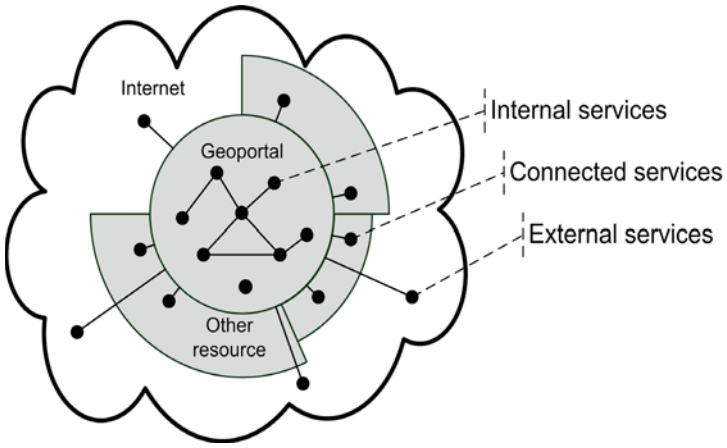

Fig.1. Service-based decomposition of geoportal architecture.

A case study of Nevsky Kray Geoportal. Presented opinion on service-based architecture of geoportal was formulated in the context of designing Nevsky Kray Geoportal[13] (Geoportal on Region of Neva river in loose translation) in 2012-2014. Nevsky Kray Geoportal is the regional level geoportal of scientific and referential domain. The area of interest of the Nevsky Kray are the territories of Saint-Petersburg city and Leningrad region (Russia). The Geoportal provides users with a descriptive information and spatial data on this territory as like with some Web geoservices.

Domain specific and Thematic geoportals usually provide a large number of different services for data manipulation unlike Infrastructure geoportals. The Nevsky Kray as the resource for different types of users includes all three types of mentioned services (Internal, Connected and External). However the data published on Geoportal are very diverse (from satellite imagery to statistical information and documents). As a consequence for the study and use of the data features it is necessary to have complex of user interfaces. In connection with this Geoportal services combined into complexes – something like multi services. These complexes are indicated in Figure 2 as cores.

[13] http://www.geoportal-nevsky.spbu.ru

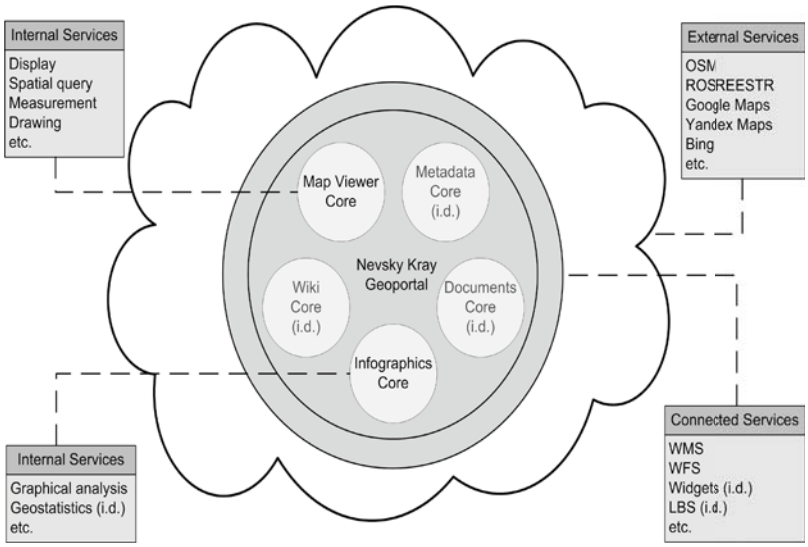

Fig.2. Services configuration of the Nevsky Kray Geoportal (i.d. means 'in development').

Each core is separated due to the using of different basic server-side software. For example the Map Viewer Core is based on Geoserver Web mapping server software and OpenLayers Web mapping framework. This core allows viewing the cartographic data, comparing maps and visually analyzing them. The general cartographic content for Map Viewer Core are the Connected map data services that provide access to archival and newly com-posed thematic maps of the region, as well as a number of External Web mapping services of a general character (e.g. general geographic, traffic and satellite maps) and thematic character (e.g. weather and cadastral maps, maps of administrative boundaries, etc.). Infographics Core based on PHP/JavaScript engine that is specifically designed for dynamic interactive visualization of spatially referenced statistical data.

Map Viewer Core allows to display and use within the Geoportal of the External and Connected services through WMS/WFS/WCS stack of standards.

Some of the services involves the implementation of Connected functionality. For example service for the collecting of user information about the dangerous objects or adverse incidents location and showing them on the map – User Reports Service. This service is already implemented through the Map Viewer Core interface as one of the map interaction tools. Additionally the service being developed as widget interface

which will allow integration into external sites expanding the audience of users.

Being an open architecture system the Nevsky Kray Geoportal not only allows to display External WMS/WFS in its interface, but also to redirect the user to the original Web sites that implements selected service. The redirection performed using previously chosen extent of the map.

A case study of Geoinf.js library. Infographics is a complex of graphical data representation methods in an easy comprehensible way [9]. In case of a schematic graphical representation of the spatial data the term "geoinfographics" is used. Infographics and geoinfographics today are widely presented in the Web. However this knowledge area is developing separately from Web Mapping and Web GIS technologies.

Geoinf.js (previously named as Geoinfographica.js [10]) is a JavaScript library for the spatially referenced statistical data Web publishing. The library authors are Anton Terekhov (code development) and Evgeny Panidi (idea and design). Development was started in 2013.

In general the library is a framework for fast and easy PDF-like publishing of the statistics in the form of charts, graphs and schematic maps. Imagery are published in the form of the container, which is then embedded into a Web page.

Geoinf.js allows:

– To publish data without using of specialized server-side software;

– To embed geoinfographics into any Web page;

– To provide interactivity with the user, including the ability to perform animated data;

– To display vector data (using SVG vector format);

– To store the published data together with the website data (using the GeoJSON format).

Geoinf.js can generate SVG images using the built-in styles and display them on a Web page using another JavaScript library Leaflet (Fig. 3).

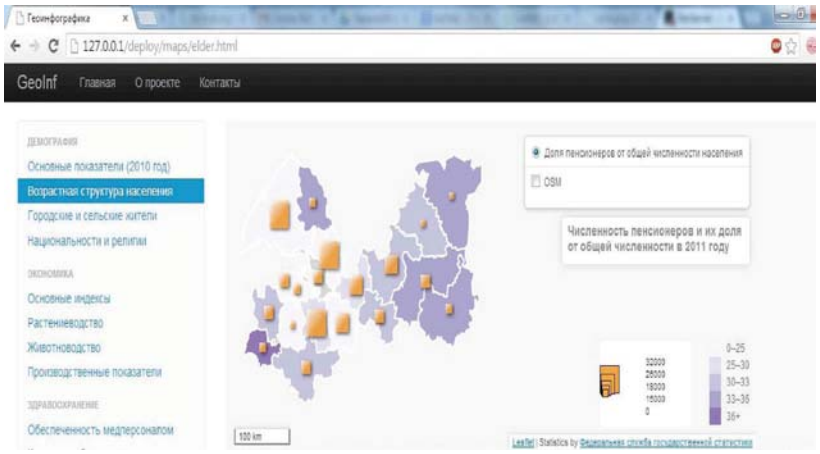

Fig.3. Schematic map generated using Geoinfographica.js.

Source data for the generating of geoinfographics should be submitted using Geo-JSON format (e.g. using export from Quantum GIS[14] or other desktop GIS). These data are converted to SVG image. Additionally the visibility settings and display styles for the maps and charts layers are adjusted.

The next step of framework development should be the providing of a graphic user interface for configuration of the generated geoinfographics.

Geoinf.js is used as a Connected service on Nevsky Kray Geoportal[15]. It shows the technology of integration of the applied JavaScript based services with geoportal.

A case study of geoportal-based hybrid geoprocessing Web services. A special type of problems which occurs when working with spatial data are the problems of numerical data analysis and data processing. Current Web geoservices for geospatial data processing are overwhelmingly focused on server-side processing and are not applicable in situations when the user can not send data to external server (due to commercial or legal restrictions or a significant amount of the data). One of the solutions for this situation is the development of technologies for client-side geoprocessing Web services. However there are no standards for such type of the geoprocessing services. All modern client-side computing technologies are not ready tools for working with spatial data.

Our practical research experience in spatial data processing shows that processing on the server side and the client

[14] http://www.qgis.org
[15] http://www.geoportal-nevsky.spbu.ru/geoinf/

side (firstly seemed to be contradictory concepts) actually can effectively complement each other. If the geoprocessing Web service is implemented as a hybrid (i.e. capable to run on server and client side using the same analytical library) it allows maximum flexibility and ability to manage computing resources and data access policy while retaining the advantages of the SaaS model.

The main difficulty of the hybrid geoprocessing Web services development is the poor software infrastructure for geospatial data processing. For example in VBScript[16] or JavaScript[17] technologies almost all functionality should be built from scratch. Also, when using Java it is only possible to use a small number of geospatial libraries.

At the same time the Python[18] being open source software is widely used in desktop GIS applications allowing to use all desktop GISs functionality. Moreover Python is widely used in scientific research and has a large number of specially compiled geospatial libraries (such as GDAL[19], Proj.4[20] and other). However the Python application cannot be implemented directly as a Web services.

Python can be used to develop WPS basing on Zoo-project or PyWPS[21] platforms. In both cases, Python applications appears running on the server side and the user interactions are realized using WPS standard. That is why Python has great potential as a geoprocessing language. The author and his colleagues have focused on finding ways to create a complete technology that lets to create a hybrid (client/server-side) geoprocessing Python Web services (Fig. 4).

At the first stage the approach was formulated that assumes author's idea of the implementation of Python geoprocessing tool with two additional modules. The first is the module supporting the running of the tool on the server side as WPS. The second is a module for installation of the tool as desktop GIS module (e.g. Quantum GIS module). Thus the same geoprocessing code can be delivered to the user in two parallel ways. The user can select the way of using the tool and as a result select server- or client-side calculation method. The geoportal prototype for publishing of Web geoprocessing services was developed for approval of this technology[22] (user interface code development – Eduard Kazakov and Anton Terekhov, core code development – Eduard Kazakov).

[16] http://msdn.microsoft.com/en-us/library/t0aew7h6.aspx
[17] http://en.wikipedia.org/wiki/JavaScript
[18] http://www.python.org
[19] http://www.gdal.org
[20] http://trac.osgeo.org/proj/
[21] http://pywps.wald.intevation.org

[22] http://195.70.211.131

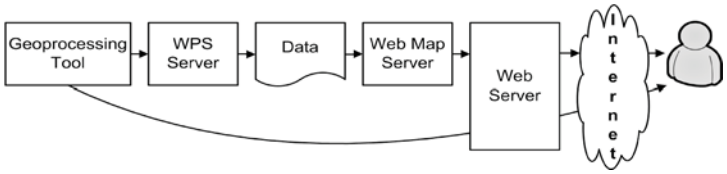

Fig.4. Hybrid model of geoprocessing Web-services.

Roadmap for geoprocessing Web services. Possible ways of development of the hybrid Web geoprocessing services technologies the author and his colleagues consider in the following solutions:

– Development of geoprocessing tools with double interface (WPS and the ability to install as desktop GIS module);

– WPS server emulation on the user's computer and running a geoprocessing tool in the form of WPS by choice, either server-side or client-side in a virtual environment (an idea proposed by Eduard Kazakov);

– Using of standard client-side computing technologies and development of the new libraries for geoprocessing applicable for these technologies.

At the current stage of research the following scheme is adopted as a basic solution:

– The Python has been chosen as the programming language for development;

– Implemented in Python geoprocessing algorithms are connected with external libraries (GDAL, Proj.4, NumPy[23], SciPy[24], etc.) if it is necessary;

– Created tool appears published as WPS using PyWPS platform;

– Additionally the tool equipped with an installer that allows to download and install it as a desktop GIS module (for Quantum GIS).

However, two other technologies are also worth an attention and require further research and effectiveness matching. For example the third technological way has potentially great opportunities based on the availability of Jython[25] that is Java Runtime Environment (JRE) compatible implementation of the Python. Potentially the using of this implementation makes it possible to combine the capabilities of Python as the language of geoprocessing with the flexibility of Java as the industrial technology of Web services that can be run on the server side (e.g. on the Zoo-project platform) and on the client side (running as Java Applet or using Java Web Start[26] (JavaWS) technology).

Conclusions.

[23] http://www.numpy.org/
[24] http://www.scipy.org/
[25] http://www.jython.org
[26] http://www.java.com/ru/download/faq/java_webstart.xml

All mentioned projects are in the early stages of development now and only shows the first results. Some of which it is necessary to emphasize as is follows:

– Service-based approach helps to formalize the structure of geoportal during the design and development;

– Classification of the geoportals and Web geoservices requires further development;

– The creation of hybrid geoprocessing Web services is possible using current technologies, but requires an assessment of the effectiveness of various basic techniques.

Online processing of geospatial data, remote sensing data and their derivatives is a promising trend, due to the accumulation and the constantly growth of data archives, as well as their significant resource consumption. For publishing of allowing to perform this processing Web services the geoportals can be used that allows to provide an access to wide range of distributed data and Web geoservices.

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All mentioned case study projects are conducted with the author's direct participation. The heading research base for projects is Department of Cartography and Geoinformatics of Saint-Petersburg State University (Russia).

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