APPLICATION OF SERVICE ORIENTED GIS IN AGRICULTURE

D. SLADIĆ, A. RADULOVIĆ, M. GOVEDARICA

University of Novi Sad, Faculty of Technical Sciences, Trg Dositeja Obradovića 6, Novi Sad, Serbia

Trg Dositeja Obradovića 6, Novi Sad 21000; email address: dudab@uns.ac.rs

Abstract: *The need for properly maintained geospatial data has imposed the development of spatial data infrastructure at national, regional and global level. National Spatial Data Infrastructure (NSDI) reduces redundancy and allows for easy access, participation and sharing of spatial data on the principles of interoperability. Given the great importance of land and soil, it is necessary to effectively organize agricultural records and that they contain well-structured data. Agricultural data should be well organized, and the data should be well structured so that interoperable systems can be realized, in order to become part of the national geospatial data infrastructure. Data model for GIS in agriculture should be based on Land Parcel Information System (LPIS), as well as on the recommendations of the INSPIRE Directive and the relevant legislation. Many different applications can be implemented for this data model, among them is application for advisory service. Service oriented architecture (SOA) is proposed architecture for this solution.*

Key words: *data model, INSPIRE, LPIS, agriculture, advisory service*

INTRODUCTION

Geographic Information Systems – (GIS) represent a new, modern technology for analysis and spatial data processing. GIS is a system for managing spatial data and their associated attributes. In the strictest sense, it is a computer system capable of downloading, storing, analyzing and displaying geographic information. In a more general sense, it is a software tool for mapping and cartography, which allows users to create interactive queries, analyze spatial information and edit data. GIS connects precisely located spatial data with tabular databases and thus provides the user to visualize their relationship. GIS connects layers containing various information on the position, which allows a better understanding of the space.

Modern GIS systems are migrated to a distributed computing platform and form Spatial Data Infrastructure (SDI). The term Spatial Data Infrastructure is used to refer to a basic set of technologies, policies and institutional arrangements to facilitate the availability of and access to spatial data. SDI provides the basis for a finding and assessment of spatial data, as well as applications for all users and suppliers of data at all levels of government, the commercial sector, non-profit organizations, academic institutions and the general public.

Spatial data infrastructure is based on a three-tier client-server architecture which consists of the following elements: Spatial databases with a system for managing the database, process management - the application server and the user interface - the client application.

In order to enable the establishment of NSDI, it is necessary to adopt recommendations and standards related to spatial data. Standards are intended to prevent or minimize wasteful duplication of spatial data collection and system development efforts. The national spatial data infrastructure should be based on the ISO 19100 series of standards regarding the structure of geographic information and implementation basics, whereas software applications should be developed to meet OGC (Open GIS Consortium) interface specifications. NSDI relies also on national standards, since they define data content, and they represent an authority for the data themselves. A spatial data infrastructure built in such a manner represents a base for connection with other national data infrastructures and establishment of infrastructure at the international level, which would not be possible without the application of standards.

INSPIRE

The need to develop an NSDI has resulted in the adoption of recommendations included in the INSPIRE Directive. The adoption of the INSPIRE Directive is the result of the geographic awareness at a high political level in the European Union and the realisation that numerous users need fast and efficient access to geographic data from various local, global and regional sources. The INSPIRE concept envisages the establishment of an interoperable EU spatial data infrastructure, which will provide users with integrated data and services. The Directive contains 35 general provisions, which define principles derived from fundamental spatial data infrastructure principles. The general objective of the INSPIRE Directive is the creation of a coherent EU spatial data infrastructure from spatial data bases at different levels and a unique integrated system. The Directive includes Annex I, II and III, which define spatial data themes to which the Directive applies, i.e. terms referring to spatial data sets. The unique interpretation of these terms should contribute to the harmonisation of sets of spatial data and services, i.e. semantic interoperability. The goal of the Directive is to set the general rules of the establishment of spatial data infrastructures in the European Union, i.e. implementation rules which define the technical regulation of interoperability and harmonisation of sets of spatial data and services. The implementation of NSDI should be progressive, whereby the priority of implementation themes is established in advance. The Directive is binding for all EU member states, whereas for candidate states, it represents an important part of negotiations in the procedure of obtaining full membership.

The data model of a certain system defines the level of interoperability of this system with other systems. Therefore, modelling is the most important step in the development of an interoperable system. The model is composed of classes, which represent groups of facilities of similar characteristics described by attributes. Data model for cadastral parcels consists of 4 classes: *Cadastral parcels* represent generic information locators. INSPIRE parcels are connected to national registries, so other data pertaining to the parcels, such as rights and bearers of rights, can be accessed through them; *Cadastral zonings* are the intermediary areas (such as municipalities, sections, blocks, …) used in order to divide national territory into cadastral parcels; *Cadastral boundaries* represent boundaries of parcels where absolute positional accuracy information is recorded for the cadastral boundary; *Basic property units* are the basic units of ownership that are recorded in the land books, land registers or equivalent.

The data model of INSPIRE cadastral parcels is compatible with LADM (Land Administration Domain Model), a data model presented in ISO 19152 standard. LADM is a broader model than INSPIRE cadastral parcels, since it includes additional information on rights and bearers of rights, outside the framework of INSPIRE parcels. The goal of LADM is to define a basic cadastral system model, which will enable easier communication within a country or between countries, based on a unique ontology. The basic domain model proposed by this standard contains several main classes: LA_SpatialUnitGroup serves to model administrative units, while the LA_SpatialUnit class serves to model spatial units. The LA_Party class represents people or organizations that have certain rights, restrictions or responsibilities in relation to the spatial units with certain shares (LA_RRR class). The LA_BAunit class incorporates all the rights, restrictions and responsibilities of one or more person in relation to a certain number of spatial units, so that the share amount in the ownership equals 1.

Figure 1 shows how the model of the INSPIRE cadastral parcels can be derived from the description of the domain model. The LA_SpatialUnit class is the basis for CadastralParcel, LA_BAUnit is the basis for BasicPropertyUnit, and CadastralZoning for LA_SpatialUnitGroup. The newly formed attributes are located inside the classes, as well as those who are added by the class itself. This shows that the necessary data required for the Cadastral Parcels of the INSPIRE Directive can be accessed though the description.

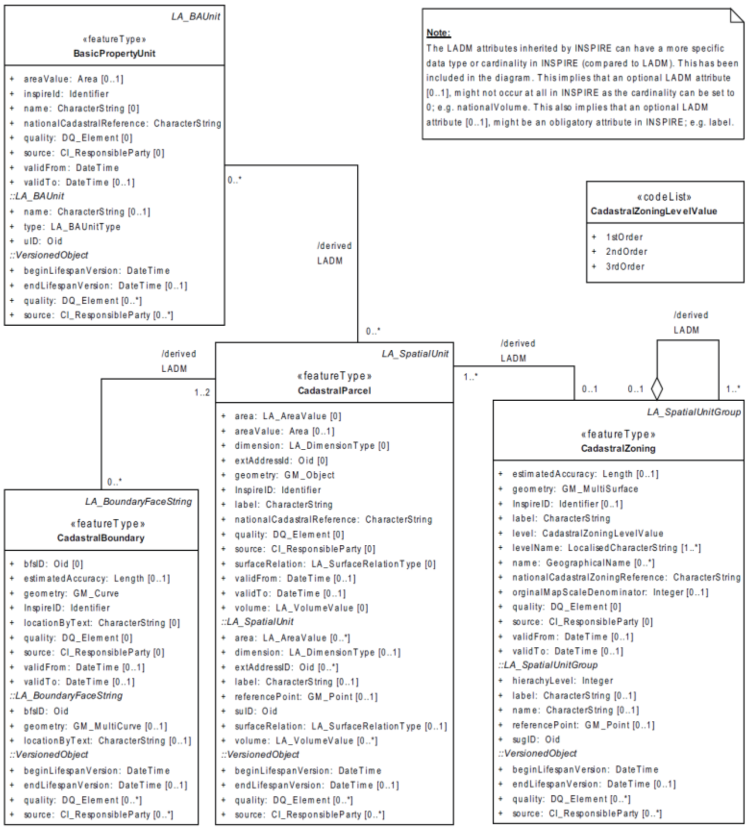

Figure 1 - The link between the INSPIRE cadastral parcel and the LADM

LAND PARCEL IDENTIFICATION SYSTEM – LPIS

Land Parcel Identification System (Land Parcel Identification System - LPIS) is a system that establishes a database that records the actual use of agricultural land. The aim of the LPIS is to get a clear picture of how the land is used for agricultural production, regardless of the crop that is grown. Such a regulated and transparent system is a prerequisite for obtaining EU subsidies for agricultural production. LPIS is an integral part of the Integrated

Administration and Control System (IACS), which EU member states allocate, monitor and control payments to farmers and it represents the geospatial component of the system. The aim of the IACS system is the management of subsidies to agricultural production is an important aspect of the Common Agricultural Policy (CAP). Therefore, the LPIS is a graphic record of all the land area used for agricultural production in order to control subsidies from the state.

The basic concept used in this system is *declared agricultural land parcel* which the applicant (farmer) for the subsidies declares in his application. The farmer describes each part of the land that is used for agricultural activities and encloses a sketch of the land. On the basis of such declared agricultural parcels the payments are calculated and administrative control is performed. Given the dynamics of agricultural activity, the boundaries of the declared agricultural land is unstable or subject to frequent changes, so the concept of a *reference parcel* is introduced, to avoid the burden of procedures for maintaining data. The reference parcel is used as the basic unit of LPIS system for identifying *declared agricultural parcels*. One *reference parcel* may contain more *declared agricultural parcels*.

EU regulations specify that the reference parcel can be either cadastral parcel or production block. However, the problem of using the cadastral parcel is that it can contain a part that is not used for agricultural production, and that the boundaries of the agricultural production are outside of the scope of the real estate cadastre. This stems from the fundamental difference between LPIS and cadastral system: LPIS deals with farmers and users of land for agricultural production, which may be owned or rented, while cadastre is primarily concerned with land owners, who may not be the same person, although cadastre by definition also supports other forms of land-related rights, such as the right to use the land. However, traditional cadastral systems as legacy systems are often not able to administer all these other kinds of rights and registration of farmers and their rights in the cadastral system which is concerned as an obstacle in relation to the LPIS system. Therefore, ISO19152 introduces the concept of a parcel (*SubParcel*) which plays the role of reference parcels when a connection between LADM and LPIS system is needed.

Figure 2 shows the basic concepts of the LPIS system and their relationship with LADM. The class *Reference Parcel* represents a reference parcel and is inherited by the classes: *Spatial Agricultural Parcel*, *Farmer Block*, *Physical Block*, *Cadastral Parcel* and *SubParcel* representing spatial agricultural land, agricultural block, physical block, cadastral parcel and part of the parcel. The class *Cadastral Parcel* is inherited from the class *Spatial Unit* of LADM.

LPIS system is established based on the following maps:

- digital orthophoto (DOF) in the scale of 1:5000, which serves as a basis for interpretation and determination of agricultural land for agricultural holdings;
- digital cadastral maps (DCM) used as control data for the interpretation of land on orthophotos;
- Digital Terrain Model (DTM) to determine the slope and elevation
- The register of spatial units containing information about municipal boundaries, and cadastral municipalities which are required to establish and maintain the system.
- The above spatial data must be available for the whole country and must not be older than 5 years.

Through the years of experience with the LPIS system it has been found that a large percentage of declared agricultural parcels is incorrect, compared with the real situation. Therefore, the process of declaring is improved with the establishment of identifying land parcels, on the basis of orthophotos if possible. These otrtofoto images are the basis for performing the administrative checks. The imagery necessary for the creation of orthophotos, can be satellite or airborne images of high resolution, conventional aerial photographs, or already available orthophotos can be used. The aim is to detect the difference between the actual and declared agricultural land, based on the orthophoto.

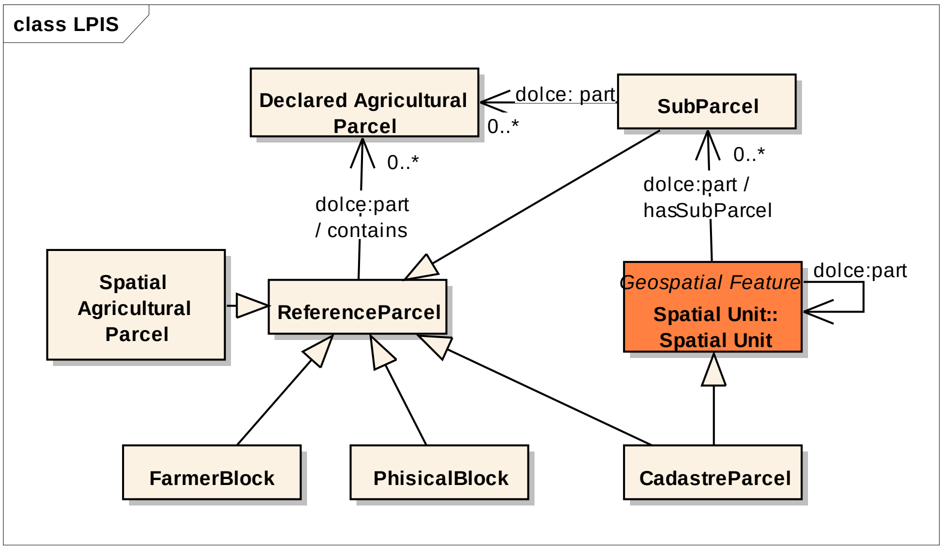

Figure 2 – The link between the *Declared Agricultural Parcel* and *Reference Parcel*

GIS DATA MODEL FOR ADVISORY SERVICE

Data model for the GIS of agriculture is based on: standards in the field of GIS: ISO 19100 series and OGC, INSPIRE directive, LPIS and advisory service data model. To specify a database for Agricultural stations and Advisory service an object methodology is used. The data model is based on the basic initial assumption that it is necessary to spatially determine all relevant information on agricultural stations and the need to secure flexible system to integrate different types of users and processes over the data base.

The data model for the advisory service has been designed based on the form that farmers fill about their land and agricultural production in Vojvodina. It has been extended to more detailed information on crop production and is based on ISO 19100 series of standards. Figure 3 shows the structure of the package of the data model for the advisory services. This data model consists of two application schemes: Advisory services (package *savetodavna sluzba*) and ISO 19100 series of standards. First application schema contains all the relevant information related to the selected farm, and the other contains the elements of the ISO 19100.

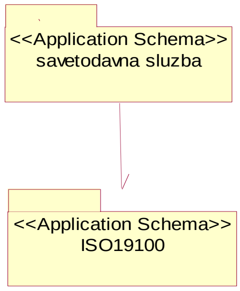

Figure 3 – Package structure of the data model for the advisory service based on ISO 19100 series

Figure 4 shows the contents of the package *Advisory Service*. The contents of this package are other packages that apply to different types of information related to advisory services. These are:

- Package *Apstraktne klase* (abstract classes) includes abstract classes that are inherited by other classes of the data model.
- Package *Kodne liste* (code lists) contains the code list for the default values of certain attributes.
- Package *Opšti slojevi* (general layers) includes cities, municipalities, cadastral municipalities, way of use…
- Package *Poljoprivredna stanica* (agrictultural stations) includes information related to agricultural station and advisors.
- Package *Obrasci kartona o odabranom gazdinstvu* (records about selected farm) includes information about farmers land.
- Package *Biljna proizvodnja* (crop production) includes information related to sampling, analysis of soil moisture, weeds, pests and irrigation, pest control and weed control, fertilization, etc.
- Package *Administracija* (administration) includes information related to the users of the system and their roles.

This data model contains information about agricultural stations, advisors and their observations during the field work, farms, mechanization, economic indicators (costs, incomes, the total value of crop and livestock production) etc. It also contains information about crop production such as plant species, soil fertilization, protection of plants, laboratory analysis, expert recommendations, etc.

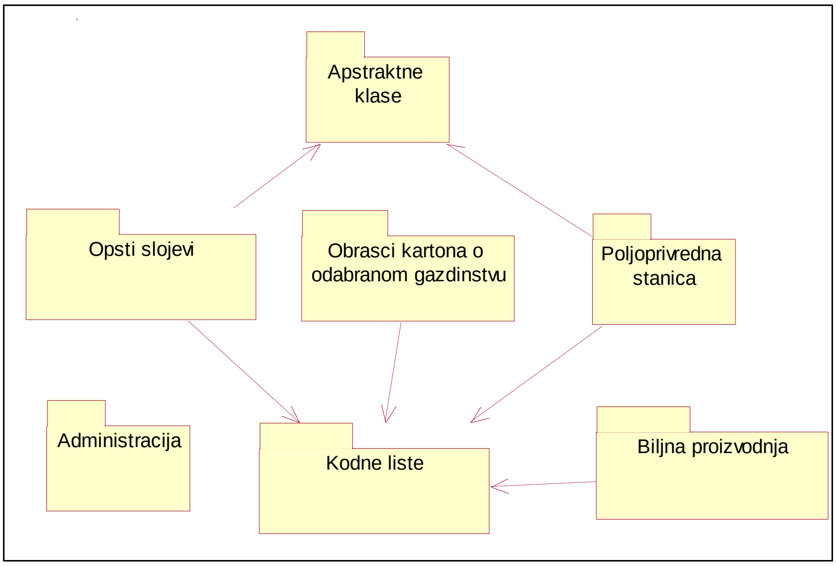

Figure 4 – Package structure of the data model for the advisory service

PILOT INSTALLATION

Pilot installation of service oriented GIS in agriculture was implemented using three-tier architecture and ERDAS Apollo as a middleware. Three-tier architecture includes client and server application and a database. The client application is responsible for the interpretation of user requests and sends these requests to the application server which needs to process and send back a response to the client. To access and retrieve data, a server application addresses the database. Communication protocol of the client and server and their interfaces are implemented in accordance with OGC standards. This pilot installation is based on the data model developed for the advisory service of Autonomous Province of Vojvodina which is based on international standards and recommendations (LADM, INSPIRE, LPIS) as described in previous sections. An example of application of such a distributed GIS system has been shown on the example of workflow in LPIS system.

Figure 5 shows the workflow that is being implemented in order to control the match of declared agricultural land and crops with the actual situation. The first part of the workflow is locating and loading of base maps: orthophoto maps, cadastral maps, digital terrain models and register of spatial units. Search Criteria include resolution, a spatial filter to the appropriate area, temporal filter for the relevant time period and weather they are certified. Base maps are downloaded from the corresponding OGC WFS and WCS services, and are displayed via WMS service. It is also needed to get data on declared agricultural parcels. Using classification of satellite or airborne imagery the land cover of certain agricultural crops can be determined. This process can be done with WICS (Web Image Classification Service) service. Comparing the results of the classification with declared agricultural parcels by the applicant, through OGC Web Processing Services, it may decide on the approval or rejection of subsidies, as well as its amount. OGC services used for this workflow are shown in the Table 1. The result is shown on the Figure 6, where the identified declared agricultural parcels can be seen as well as the locations of soil samples.

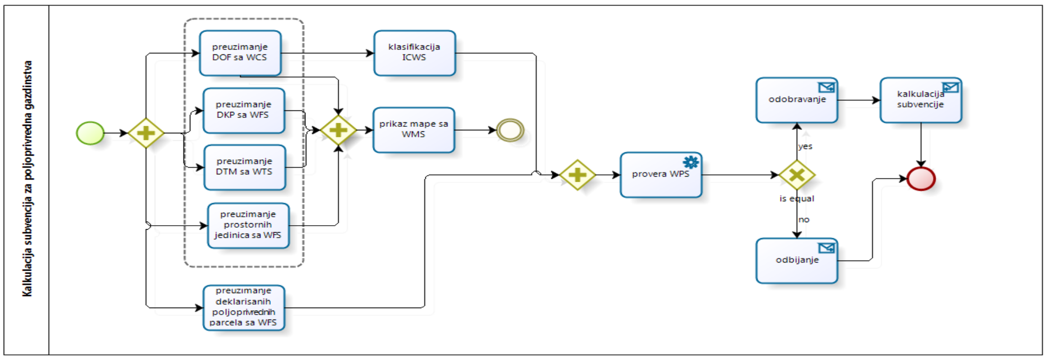

Figure 5 – LPIS workflow

Table 1.

Tasks and services of the LPIS workflow

Task	Type of service	Service address
Retrieval of DOF	WCS	http://147.91.174.83:8080/erdas-apollo/coverage/ikonos
Retrieval of DCP	WFS	http://147.91.174.83:8080/erdas-apollo/vector /cspoljo
Retrieval of DTM	WTS	http://147.91.174.83:8080/erdas-apollo/coverage/DEM
Retrieval of spatial units	WFS	http://147.91.174.83:8080/erdas-apollo/vector/cskn
Retrieval of declared agricultural parcels	WFS	http://147.91.174.83:8080/erdas-apollo/vector/zrenjanin
Map display	WMS	http://147.91.174.83:8080/erdas-apollo/map/map
Classification	ICWS / WFS	http://147.91.174.83:8080/erdas-apollo/vector/clc
Check	WPS	http://localhost:8080/wps/WebProcessingService
Process of approval and calculation of subsidis	Web service	http://localhost:8080/calc/services/subcalc?wsdl
Retrieval of soil samples	WFS	http://147.91.174.83:8080/erdas-apollo/vector/cspoljo

Figure 6 – The link between the *Declared Agricultural Parcel* and *Reference Parcel*

CONCLUSIONS

The current trend to migrate software on a distributed platform (software as a service concept) has shown several advantages concerning GIS and the use of spatial data. These advantages include readily available up-to-date data about land and agricultural production via Internet, the possibility to combine those data with data from other systems and to use only those parts of the system that are needed for certain purposes. This paper describes such a system developed for advisory service in Vojvodina in accordance with relevant national and international standards and recommendations. Pilot installation showed the possibility to integrate such system in Spatial Data Infrastructure on national and international level so that everyone can benefit from agricultural data.

BIBLIOGRAPHY

1. NEBERT, D., (2004): Developing Spatial Data Infrastructures: The SDI Cookbook. Online: http://www.gsdi.org/docs2004/Cookbook/cookbookV2.0.pdf.

2. PERCIVALL, G., (2002): The OpenGIS Abstract Specification, Topic 12: OpenGIS Service Architecture, Version 4.3. Open Geospatial Consortium, Inc., pp. 78.

3. RADULOVIĆ (RISTIĆ) A., GOVEDARICA M., SLADIĆ D., JOVANOVIĆ D., PRŽULJ Đ, (2011): Modeling cadastral records as part of national spatial data infrastructure. International Multidisciplinary Scientific GeoConference - Surveying Geology & mining Ecology Management - SGEM, Vol. 2, No. 11, UDK ISSN 1314-2704, ISBN 978-954-91818-1-4, Sofia, Bulgaria; Albena, Str. 629-636.

4. GOVEDARICA, M.; PETROVAČKI, D.; SLADIĆ, D.; RADULOVIĆ (RISTIĆ), A.; JOVANOVIĆ, D.; PAJIĆ, V.; VRTUNSKI, M.; RISTIĆ, A. (2012): Environmental data in Serbian spatial data infrastructure - Geoportal of ecology, Journal of Environmental Protection and Ecology, 2012, ISSN: 1311-5065.

5. INSPIRE, http://inspire.jrc.ec.europa.eu/

6. ISO / TC211 Geographic Information / Geomatics, www.isotc211.org

7.ISO 19152: Geographic information – Land Administration Domain Model (LADM), http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=51206

8. INSPIRE, http://inspire.jrc.ec.europa.eu/

9. http://ies.jrc.ec.europa.eu/our-activities/support-for-member-states/lpis-iacs.html

10. Open Geospatial Consortium, http://www.opengeospatial.org/

11. http://www.hexagongeospatial.com/products/ERDAS-APOLLO/Details.aspx