Geospatial Web Services in Real Estate Information System

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Abstract. Since the data of cadastral records are of great importance for the economic development of the country, they must be well structured and organized. Records of real estate on the territory of Serbia met many problems in previous years. To prevent problems and to achieve efficient access, sharing and exchange of cadastral data on the principles of interoperability, domain model for real estate is created according to current standards in the field of spatial data. The resulting profile of the domain model for the Serbian real estate cadastre is based on the current legislation and on Land Administration Domain Model (LADM) which is specified in the ISO19152 standard. Above such organized data, and for their effective exchange, it is necessary to develop a model of services that must be provided by the institutions interested in the exchange of cadastral data. This is achieved by introducing a service-oriented architecture in the information system of real estate cadastre and with that ensures efficiency of the system. It is necessary to develop user services for download, review and use of the real estate data through the web. These services should be provided to all users who need access to cadastral data (natural and legal persons as well as state institutions) through e-government. It is also necessary to provide search, view and download of cadastral spatial data by specifying geospatial services. Considering that real estate contains geometric data for parcels and buildings it is necessary to establish set of geospatial services that would provide information and maps for the analysis of spatial data, and for forming a raster data. Besides the theme Cadastral parcels, INSPIRE directive specifies several themes that involve data on buildings and land use, for which data can be provided from real estate cadastre. In this paper, model of geospatial services in Serbia is defined. A case study of using these services to estimate which household is at risk of flooding using the Web Processing Service (WPS) spatial analysis is described.

1. Introduction
Land and real estates are an important form of material values for the population. If the cadastral system is more organized, greater are investments by the World Bank, and thus the probability of faster economic development of a country is increased. Domain model is the basis of the system and its level of organization is in direct relation to how much the information system is efficient and reliable. In accordance with this, profile of the domain model for Serbia based on the ISO 19152 standard [1] and the national regulations is defined. Over such model, the processes in the cadastre which are necessary for the implementation of a national spatial data infrastructure are analyzed. The test case relates to the use of cadastral geoservices in the process of analysis, prediction and providing measures for protection of material and natural resources in the case of flooding or other natural hazards.
2. Land Administration Domain Model
Land Administration Domain Model- LADM was published in 2012 as an international standard (ISO 19152) of the International Organization for Standardization (ISO). Standard offers a basic model that can be expanded and adapted in order to develop an accurate data model for the relevant country or region. Standardized model allows organizations, both within the country and from different countries to communicate with each other using a common terminology. This model allows the creation of standardized services in the international context in order to enable a simple exchange between systems. Implementation of the model in a particular country implies adding additional attributes, operations, associations and new classes in order to comply with national legislation. Figure 1 shows a procedure for derivation of profile of the domain model for cadastre in Serbia. Above such organized data, and for their effective exchange, it is possible to develop and implement a service model that describes the business processes in the real estate cadastre [2] [3].

![Figure 1. Mapping LADM on Serbian domain model](image)

3. Processes in cadastre
Defining a set of processes in the cadastre refers to defining business tasks in the cadastre that arise from the needs of users - internal in the cadastre and external, who may be holders of rights, the Ministry of Interior, the Government and many other organizations. Real estate cadastre contains various data necessary for executing the processes: technical (alphanumeric and geometric data on real estate) and legal (rights and restrictions on real estate). Processes in the cadastre can be divided into two groups: processes that are changing the data in the system and processes which provide data to be downloaded or reviewed. Using a top-down strategy, processes in cadastre can be decomposed from the general to the individual, with creating the insight into the elements of the subsystem [4].

When defining processes in cadastre it is necessary to foresee that cadastral data are particularly important for the implementation of e-Government. Identification and implementation of e-government services relating to data from real estate cadastre would greatly facilitate the delivery of services to citizens and to the institutions of the state and the private sector. Cadastral data are an essential part of the national spatial data infrastructure (NSDI). For the implementation of geo-spatial data, cadastre can provide information for the themes of the INSPIRE directive [5] relating to cadastral parcels, land use and buildings. Thus, the real estate cadastre should provide processes for the delivery of such data to the geoportal.
The solution lies in a service-oriented architecture (SOA) and web services. Service-oriented architecture can be defined as an IT architecture that supports the transformation of the business environment into a set of loosely coupled services to communicate with each other by exchanging messages or coordinate some activity and thus provide a rounded flow of business processes that they support.

4. Geospatial web services in cadastre
Since the real estate cadastre contains geometric data for parcels and buildings it is necessary to form a set of geospatial services that would provide information and maps for the analysis of spatial data, and for forming a raster image. In addition to the theme Cadastral parcels, the INSPIRE Directive has topics that include information on the buildings and land use. The Open Geospatial Consortium has defined several Open Web Services for accessing (usually geographic) data. There are two basic service sets – the Web Feature Services (WFS) and the Web Map Services (WMS). The WFS is concerned with direct access to data – reading, writing, and updating features. The WMS is concerned with transforming data into a map (image). Based on that following services are formed: ParcelWFS, BuildingWFS, RealFolioParcelWFS, RealFolioBuildingWFS. The first two services provide basic descriptive data about parcels and buildings together with geometry, while the other two provide and display also data about rights and restrictions on real estate. Extraction of data provided by these services may be performed by using filters that are defined in the specification Filter Encoding. If there is a frequent need to see a limited set of data (e.g. parcels by municipalities), a new service for each municipality can be defined. Also if service MunicipalityWFS is defined (returns spatial data of all municipalities), a filter can be applied to find certain municipality by name, and over the obtained data a call of the WPS operation of intersection with ParcelWFS service would give the same result. Data on land use can be distinguished from ParcelWFS by using filter with an attribute that contains data on type of land. This results with services like FieldsWFS, ForestWFS, MeadowWFS, etc. Listed geoservices are shown on figure 2. In analogy, corresponding WMS services can be defined: ParcelWMS, BuildingWMS, RealFolioParcelWMS, RealFolioBuildingWMS, FieldsWMS, ForestWMS, MeadowWMS, etc. These geoservices provide data that can be used as maps in data review and data overlapping.

![Figure 2. Cadastral geoservices](image)

5. Case Study: Determination of households affected by flood
INSPIRE directive in Annex III defines the theme for records on areas of natural hazards. These areas consider dangerous areas characterized as such, according to natural hazards (all atmospheric, hydrologic, seismic, volcanic and flame phenomena that, because of their location, severity and frequency have the potential serious impact on society), e.g. floods, landslides and ravines, avalanches, forest fires, earthquakes, volcanic eruptions. The possibility of determining these zones in Serbia is of great importance in order to assess the risk in emergency situations and in taking appropriate measures to ensure vulnerable locations, and to ensure that the population is evacuated in time. To achieve this, it is necessary to keep records of data and services that would define the zones and provide warning...
services. For Serbian territory it is important to provide services that would determine affected areas and households from flooding. This is particularly important considering the huge human and material losses that Serbia faced by flooding in 2014.

Case study is based on the use of geoservices in a real estate cadastre for identification of parcels and households that are within areas prone to flooding or that are in a particular spatial relation (a cross-section, union, covering, overlapping) with a zone of importance for the analysis of the data. Flood zones are those areas that are near rivers and lakes, and at the same or lower altitude. Due to the sudden increase in the level of rivers and lakes, houses, industrial plants, agricultural areas, sewage systems, transport networks and dams in these locations are directly exposed to danger. Determination of these zones is done by mapping physical surface that are prone to flooding, by marking the highest recorded parameters and the division into zones according to the level of threat. Data which are necessary to determine the zone of vulnerability are digital elevation model, historical satellite images, measurements in the field, the condition of dams and embankments etc. Such data should be collected and provided by the institutions responsible for the implementation of flood protection measures, such as the Republic Hydrometeorological Service of Serbia. Geoservice AffectedZoneWMS shows a map with polygons that point to the affected areas. After determining the flood risk zones, it is necessary to identify which households fall into these zones. This is most easily done on the basis of data from the real estate cadastre, using the specified services. In the previous section geoservices of the real estate cadastre are defined. WMS service RealFolioParcelWMS provides data on parcels containing information on holders of rights, rendered into map. By overlapping the maps obtained from these two services, overlapping of data is also visible (Figure 3).

![Figure 3. Overlapping of maps](image1)

![Figure 4. Overlapping with results](image2)

Based on these data, it is possible to determine which parcels are located in the area of flood risk, and which households are affected. How it comes to geospatial data, analysis can be performed by using spatial intersection operation. As input parameters, this operation receives the geometries of these two layers, so it is necessary to use WFS that deliver the spatial features. Responding WFS services are RealFolioParcelWFS and AffectedZoneWFS.

Web Processing Service (WPS) is an OGC service for publishing of geospatial processes, algorithms and analysis. WPS extends the web map servers with the ability of geospatial analysis. To perform spatial intersection of the data on parcels and vulnerable zones, a WPS extension for GeoServer was
used. GeoServer is an open-source server for sharing geospatial data. GeoServer supports OGC specifications WMS, WFS and WCS, and provides extensions to support WMTS, CSW and WPS specification. GeoServer WPS provides direct integration with other GeoServer services and data catalog. This means that it is possible to create processes based on data and services from GeoServer. It is also possible to store the result of the process as a new layer in data catalog.

WPS defines three operations to locate and execute geospatial processes:

- **GetCapabilities** - returns information about existing services, including services metadata and metadata that describe the available processes,

  ```
  http://localhost:8080/geoserver/ows?
  service=WPS&
  version=1.0.0&
  request=GetCapabilities
  ```

- **DescribeProcess** - returns a detailed description of the requested process available through the service,

  ```
  http://localhost:8080/geoserver/ows?
  service=WPS&
  version=1.0.0&
  request=DescribeProcess&
  identifier=JTS:buffer
  ```

- **Execute** - request for the execution of the process with the specified input values and required output values. The request can be specified as a GET or POST URL within the XML document. POST form is most commonly used because of the complexity of the request.

GetCapabilities operation is carried out to review set of existing processes on GeoServer WPS. For the purposes of determining the spatial intersection a process `gs:IntersectionFeatureCollection` is chosen. DescribeProcess operation for mentioned process provided guidance how to format a call Execute the operation. Below is a POST request to execute the process of spatial intersection (see WPS call code). At the input there are a WFS services with reference to the operations GetFeature for layer doc: `Parcele (RealFolioParcelWFS)` and for layer doc: `Ugrozene_zone_od_poplava (AffectedZoneWFS)`. It is also specified that the first layer keep the whole geometry and data from the field `IMAOCI_BR_PARCELE` in which data on the holders of the right are stored. In this way, the resulting layer will preserve information of interest.

WPS call of Execute operation is presented in following text code.

```xml
<ows:Identifier>gs:IntersectionFeatureCollection</ows:Identifier>

<wfs:GetFeature service="WFS" version="1.0.0" outputFormat="GML2" xmlns:doc="http://www.gitis.rs/proba">
  <wfs:Query typeName="doc:Parcele"/>
</wfs:GetFeature>

<wfs:GetFeature service="WFS" version="1.0.0" outputFormat="GML2" xmlns:doc="http://www.gitis.rs/proba">
  <wfs:Query typeName="doc:Ugrozene_zone_od_poplava"/>
</wfs:GetFeature>

<wps:Data>
  <wps:LiteralData>IMAOCI_BR_PARCELE</wps:LiteralData>
</wps:Data>

<wps:RawDataOutput mimeType="text/xml; subtype=wfs-collection/1.0"/>
</wps:Execute>
```

As a result of the process, a WFS Feature Collection is obtained. The geometry is stored in a standard GML2 format. Together with the geometry, alphanumerical attributes such as parcel number and the name of the holder of the rights are stored.

By defining WMS service over the resulting data, intersection result can be checked. By overlapping with the layer `AffectedZoneWMS`, it can be concluded that extracted parcels are the ones that are partly...
or entirely located in affected zone. By reading alphanumeric data for these parcels, data concerning the right holders whose household are threatened can be obtained (Figure 4).

The order of execution of all services that were necessary to carry out the process of determining households at risk of flooding, can be represented by BPEL process (Figure 5). The Web Services Business Process Execution Language (WS-BPEL), commonly known as BPEL (Business Process Execution Language), is a standard executable language for specifying actions within business processes with web services. Apache ODE executes business processes written in accordance with the WS-BPEL standard. It supports work with WSDL services, but also an expansion for RESTful services (based on HTTP) is under development. OCG services fall into this group of services, although there are versions of the OGC WSDL services. The process involves calling WFS services RealFolioParcelWFS and AffectedZoneWFS. Call of getFeature method returns a collection of spatial features from two layers of data. These collections represent the input to the WPS process of intersection. The result is a feature collection that should be rendered in a map by calling WMS getMap operation.

The result is a map of households threatened by floods in Serbia. Services are at the links:

**RealFolioParcelWFS**
http://147.91.174.83:8080/geoserver/wfs?
  service=wfs&
  version=2.0.0&
  request=GetFeature&
  typeName=doc:Parcele

**AffectedZoneWFS**
http://147.91.174.83:8080/geoserver/wfs?
  service=wfs&
  version=2.0.0&
  request=GetFeature&
  typeName=doc:Ugrozene_zone_od_poplava

**WPS intersection (Listing 1)**
http://localhost:8080/geoserver/wps

**Threatened HouseholdsWMS**
http://localhost:8080/geoserver/wms?
  request=GetMap
  &service=WMS
  &version=1.1.1
  &layers=doc:ParceleUgrozene
  &styles=parcele
  &srs=EPSG:31276
  &bbox=6596950.07,4960543.19,6597999.64,4961916.7
  &width=391
  &height=512
  &format=image/png

WPS has the possibility of chaining process. This involves combining of multiple processes where the output of one process is input into another one. Thus, complex processes can be combined in one request. In this case study, a question of the total area of land parcels at risk from flooding can be asked. The answer to this question can be obtained by creating a complex WPS process. The processes that are necessary to have are: gs:IntersectionFeatureCollection which performs the intersection of two layers, gs:CollectGeometries which transform the feature collection into a single geometry and JTS:area which returns area of the input geometry. The order of execution of these processes is essential. The first should be intersection, then combining result geometries into one and then for that geometry determination of area by built-in JTS algorithm:

\[
gs:IntersectionFeatureCollection \rightarrow \gs:CollectGeometries \rightarrow JTS:area
\]
Figure 5. WS-BPEL description

The sequence of the processes determines how the WPS request is handled. This is done by nesting the first process into the second and the second into the third process. One process produces output data that will be input to another process and thus a single HTTP request can be sufficient to perform complex spatial analysis.

Following code shows the complete WPS request in XML format.

```xml
<wps:Execute...>
  <ows:Identifier>JTS:area</ows:Identifier>
  <ows:Identifier>geom</ows:Identifier>
  <ows:Identifier>gs:CollectGeometries</ows:Identifier>
  <ows:Identifier>features</ows:Identifier>
  <ows:Identifier>gs:IntersectionFeatureCollection</ows:Identifier>
  <wfs:GetFeature service="WFS" version="1.0.0" outputFormat="GML2"
xmlns:doc="http://www.gitis.rs/proba">
    <wfs:Query typeName="doc:Parcele"/>
  </wfs:GetFeature>
</wps:Execute...>
```
The WPS request can be tested with GeoServer’s built-in tool WPS request builder or it can be saved in the XML file, for example poplave_chaining.xml and executed using the a cURL:

curl -u admin:geoserver -H 'Content-type: xml' -XPOST -d@'poplave_chaining.xml' http://localhost:8080/geoserver/wps

The result is a number, the total area of parts of parcels that have been affected by the floods. For the case study, total area affected by floods is 30693.167177505467m².

6. Conclusions

In this paper, a method for specification and development of geospatial services in real estate information system if offered. Model of services contributes to the efficiency and reliability of business procedures, reduces the cost of rapid change and makes it easier to provide and add new services without having to re-implement the functionality. Model of geospatial services provides utilization of all the advantages of cadastral data in the protection of vulnerable areas of the atmospheric, hydrological, seismological and flame phenomena that, because of their location, severity and frequency have the potential serious impact on society. Case study for using cadastral geoservices to identify households that are at risk of floods is described. Main benefits of specified geoservices lie in possibility of their use for implementation of national spatial data infrastructure and in spatial analysis to gain more information in the respective field of research.

References

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