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Increasing FAIRness by Sustainable Modelling of Interactions of Parties with Land Administration Systems

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Key words: LADM, FAIR, OGC API, Process, Interaction.

SUMMARY

In recent years, mobile and web applications are being used extensively and availability of data, including geospatial data has increased dramatically. With the outbreak of Covid-19 this was emphasised even more. The emphasis from large IT systems has shifted towards modular service-oriented systems. This allows easier upgrading and adding of specific components.

OGC standards have been available since early 2000s with aim to provide a common base for the dissemination of geospatial data. These standards are mostly depending on XML format to provide data and metadata. In the current technological stack, XML became unsuitable, too complex to handle by various clients (mobile/web applications, various devices). That has been addressed by OGC as well and in 2018 activities on the new set of OGC API standards has started. The overall of these standards follows the overall aim of OGC, to make geospatial data FAIR (Findable, Accessible, Interoperable and Reusable).

Land Administration System (LAS) data also have a geospatial component and have been extensively using OGC standards for dissemination. Land Administration Domain Model (LADM) provides a common conceptual model for modelling LAS. LADM is being revised and the second edition having a wider scope by adding support for modelling marine spaces, land valuation and spatial planning. It also brings changes on existing classes related to land registration to address issues recognized by a wide range of scientists and practitioners involved in LADM. However, LADM is missing support for modelling various interactions that are available in the current technological environment. Nowadays LAS data are usually published via web applications (geoportals) where users can in an interactive manner browse LAS data. LADM supports modelling only formal procedures such as registering a building, splitting a parcel, retrieving a certificate (map, ownership).

This paper is focused on a standard-based implementations of interactions of people to LAS data and explores options to make land administration processes and data FAIR. We first define a hierarchical organization of interactions of parties with LAS. Then, we integrate the concept of LADM into the current version of LADM Edition II and show how existing formal processes and LADM classes *LA_Source* and *VersionedObject* are integrated with interactions. At the end, we present how these interactions fit into the concepts defined by OGC API standards. Also, to prove feasibility of developed concept, we give an example of implementation with open-source library pygeoapi which is an OGC API Reference Implementation.

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1. INTRODUCTION

Nowadays, most developed countries' land administration systems (LAS) are managing their business processes digitally and are, up to a level, accessible over the web. Reasonably, with the outbreak of Covid-19 disease the interest of governments for simple digitalization (electronic communication, of-site work etc.) but also for digital transformation (digital implementation of business processes) has increased significantly (Aristovnik, et al., 2021; Gabryelczyk, 2020). Any level and direction (outwards or inwards bound) of digital interaction of external parties with state administration bodies has suddenly become an important task to implement. The importance of digital transformation of cadastre within the process of development of e-government was elaborated a decade ago by (Hull & Whittal, 2013). The developed six stages emphasize the importance of digital interactions of cadastre initiated by sharing of digital data and information between government institutions (Government to government - G2G), over e-communication with the citizenry. Online sharing of information facilitates electronic transactions, ultimately aiming at the situation where public services and governance transactions are exclusively electronically mediated.

Various jurisdictions achieved different levels of implementation of e-government concepts. It is based on their available resources, national level of digital awareness and especially the level of digital awareness of the parties actively involved in various LAS processes. Those that started early with digitally outsourcing of various aspects of cadastral data updating process are now revising statuses of their systems. Some of the problems those are facing are fragmentation of services involved in the process and a too-heavy reliance on specific software vendors (Olfat, et al., 2020). Some jurisdictions consider renewal of their existing system's operational processes based on LADM concepts and following the contemporary SOA (Govedarica, Radulović, & Sladić, 2021).

Large monolithic IT systems are rarely built nowadays and component/module-based systems interconnected by web services became de facto a standard. This approach allows breaking down the system into smaller components that are easier to manage. Standardized structure of Application Programming Interfaces (APIs) and increased interactivity of web applications have resulted in implementing and using many web applications.

Land Administration Domain Model (LADM) can significantly facilitate design and implementation of LAS by providing an out-of-the-box understanding of basic data related concepts. The first edition of LADM represents a conceptual and platform independent model describing basic classes and their attributes of LAS. Since its first release in 2012, LADM has gained an interest of many researchers and practitioners. The second release of LADM (LADM Edition II) has a wider scope such as modelling additional topics (marine spaces, land valuation, spatial planning), better relationship with observation data, support for processes and encouraging implementations (Lemmen, et al., 2021).

However, whilst the technology is there, and the static data models well known, often there still exists a lack of basic understanding of non-technical types and modalities of interactions between (in the decreasing order of importance and complexity):

- System to system
- System component to system component
- Active internal/external party to data
- Passive external party to data

This in turn sometimes results in too long implementation projects which result in less than perfect, too expensive and hard to maintain implementations of mechanisms for interacting of people with LAS data.

This paper is focused on a standard-based implementations of interactions of people to LAS data and explores options to make land administration processes and data FAIR (Wilkinson, et al., 2016). The FAIR data or FAIR data principles (Findable, Accessible, Interoperable, and Reusable) represent a set of guiding principles proposed by scientists and organizations to support the reusability of digital assets (Wilkinson, et al., 2016). The principles mark an important refinement of the concepts needed to give data greater value and enhance their propensity for reuse, by humans and at scale by machines. These principles have been accepted by different institutions worldwide. The OGC's (Open Geospatial Consortium) mission is to make location information FAIRer. Findable and Accessible properties define that data should be accessible by appropriate people, at an appropriate time, in an appropriate way. Interoperable and Reusable properties mean that data should be described with metadata in an appropriate machine-readable form. As is with any authoritative data, increasing FAIRness of the LAS data and processes should contribute to the overall transparency of the underling system managing it. This in turn should facilitate the real estate market and the economy in general.

In order to achieve this goal, we first build a general, high-level framework for describing and defining interactions of people (parties) with the LAS data, based on the LADM and by extending the LADM. We then explain how the concept of interactions can be integrated in LADM Edition II and associated with existing classes representing LAS objects and LAS processes. Finally, we give an example on how the concept of interactions in LAS can be implemented using the emerging OGC API standards, which in turn should facilitate its FAIRness.

The paper is organized as follows. Following the introduction, in section two we build a conceptual framework and a data model for various types of interactions of parties with LAS in general. The third section shows how LADM can be extended with the support for interactions of parties with LAS. The fourth section gives two examples of publishing LAS data via OGC API Features standard. Section five summarizes the paper's outcomes and offers possible directions for the future research on the topic.

2. INTERACTIONS OF PARTIES WITH LAS DATA

Land administration systems are public registers. This means that everyone has the right to access the data. This usually includes formal procedures such as changing the ownership, registering a building or issuing a certificate. But also, it includes a right of a person to inspect LAS data. In the past, this usually meant that a person could visit cadastral office and inspect cadastral maps. However, in real life and for general population such visits occurred only when a person had real, formal reason to do so. Nowadays, majority of LAS make their data available via OGC services and via web applications, geoportals. People are checking LAS data by the means of geoportals daily and not only pushed by formal reasons. If interactions of people with the data are properly modelled within LAS and since there is a large number of such interactions, useful information could potentially be extracted. For instance, decision makers can get information where there is an increased interest for LAS data and based on this take various actions. Such information combined with other information such as business structure and the population could bring additional information as well.

Research on the topic of interactions of people to LAS data is sparse and mostly dealing with formal LAS processes. (Navratil & Frank, 2004) proposed hierarchical approach for modelling processes, going from the two most general types of processes, inscription and data retrieval to more specific activities. Sladić et al. (2020) followed their approach and proposed a hierarchical organization of processes in Serbian cadastre. Other authors (Navratil & Frank, 2007; Ferlan, Šumrada, & Mattsson, 2007; Zevenbergen, Frank, & Stubkjær, 2007) analysed special types of processes in specific cases and countries in order to deduct common properties of recognized processes. (Sari, 2010) also analysed various aspects of processes in Indonesia. (Vranić, Matijević, & Roić, 2018; Vranić, Matijević, Roić, & Vučić, 2021) focused on actual data modification workflows and proposed an extension of LADM to support modelling of processes within LADM by adding a new class LA_Process modelled as descendant of LA_Source. Later this approach has been adopted in LADM Edition II directly within the class LA_Source. Still, none of the researched tried to create a general framework for modelling interactions of people with LAS data.

Therefore, in order to detect and classify the types of interactions of people (parties) with the LAS data we start with the general types of interactions with the data, being:

- Data manipulation (Creating/Updating/Deleting)
- Retrieval of raw data
- Retrieval of processed data (i.e. extracting information from the data)

The three types of interactions can further be subdivided into read-only and read-write types.

- Read-write
  - Data manipulation (Creating/Updating/Deleting)
- Read-only
  - Retrieval of raw data
  - Retrieval of processed data (extracting information from the data)

Data manipulation in general is a complex process. Typically, read-write interactions are complex since various rules and constraints must be obeyed to maintain the consistency and correctness of the data during read-write operations. This has been extensively covered in (Vranić, Matijević, & Roić, 2018; Vranić, Matijević, Roić, & Vučić, 2021) and included in the LADM Edition II. Data manipulation type of processes matches one of the most general types of LAS processes called inscription, as defined by (Navratil & Frank, 2004).

Raw data retrieval interactions are simple read-only operations and require only a well-established data form (e.g. syntax/format/schema) and a sound data transfer mechanism (files, web services). A party retrieving the data uses appropriate tools outside of LAS to process and/or visualize them.

In different scenarios, parties cannot handle raw data themselves and need some simple processing of the raw data to be executed by LAS. For instance, a party wants to know what the area of a specific spatial unit is, or what is the identification number of a spatial unit located at a specific point of interest. Or, in an even simpler scenario, a party wants to visually inspect a geometry of a spatial unit (potentially overlayed over other various visualized geospatial data sets) to determine whether it looks appropriate for a certain purpose. Some processing of the raw data is needed before delivery to the requesting party in order to fulfil such requirement.

The processed data is data that has been specifically identified, possibly restructured or reformatted, possibly graphically visualized in accordance to some specific or a general user requirement. An example of a simple processed data retrieval interaction is a view (i.e. visualization) service which graphically displays boundaries of spatial units for a requested area of interest. Another example of processed data retrieval interaction would enable users to apply various search criteria to the data to select (and retrieve or visualize) specific subset of the data with the purpose of answering a question on interests of parties to land. Typically, geoportals on a high level or geospatial web services (OGC web services) on a low level serve such purposes.

Besides all the three aforementioned, there exists one more type of interaction of parties to LAS data, simple predefined processes. Simple predefined processes enable users to generate specific predefined or even legally prescribed data subsets. Within such processes a party will typically execute a simple sequence of steps which will identify the subset of the data that the party needs and will convert it into some, usually a predefined form or format. This actually is a process type of interaction since the data needs to be located, extracted and converted in accordance with a prescribed flow rather than exposing a set of functionalities which can be used to arbitrarily search and visualize the data as is with raw and processed data retrieval interactions. Such process-based interactions are simple since no complex data manipulation operations need to be executed during their execution. The typical example of such a simple process-based interaction is generating a certificate (e.g. ownership certificate, graphical display of a spatial unit, etc.).

Based on the discussion above, we now organize interactions in a hierarchical manner with two basic types being simple interactions and complex interactions. Simple interactions do not modify LAS data and can easily be implemented so those are raw and processed data retrieval and simple process interactions. Complex interactions are interactions which modify LAS data and will typically require significant resources in order to be implemented. The concept is visualized using a UML class diagram (Figure 1).

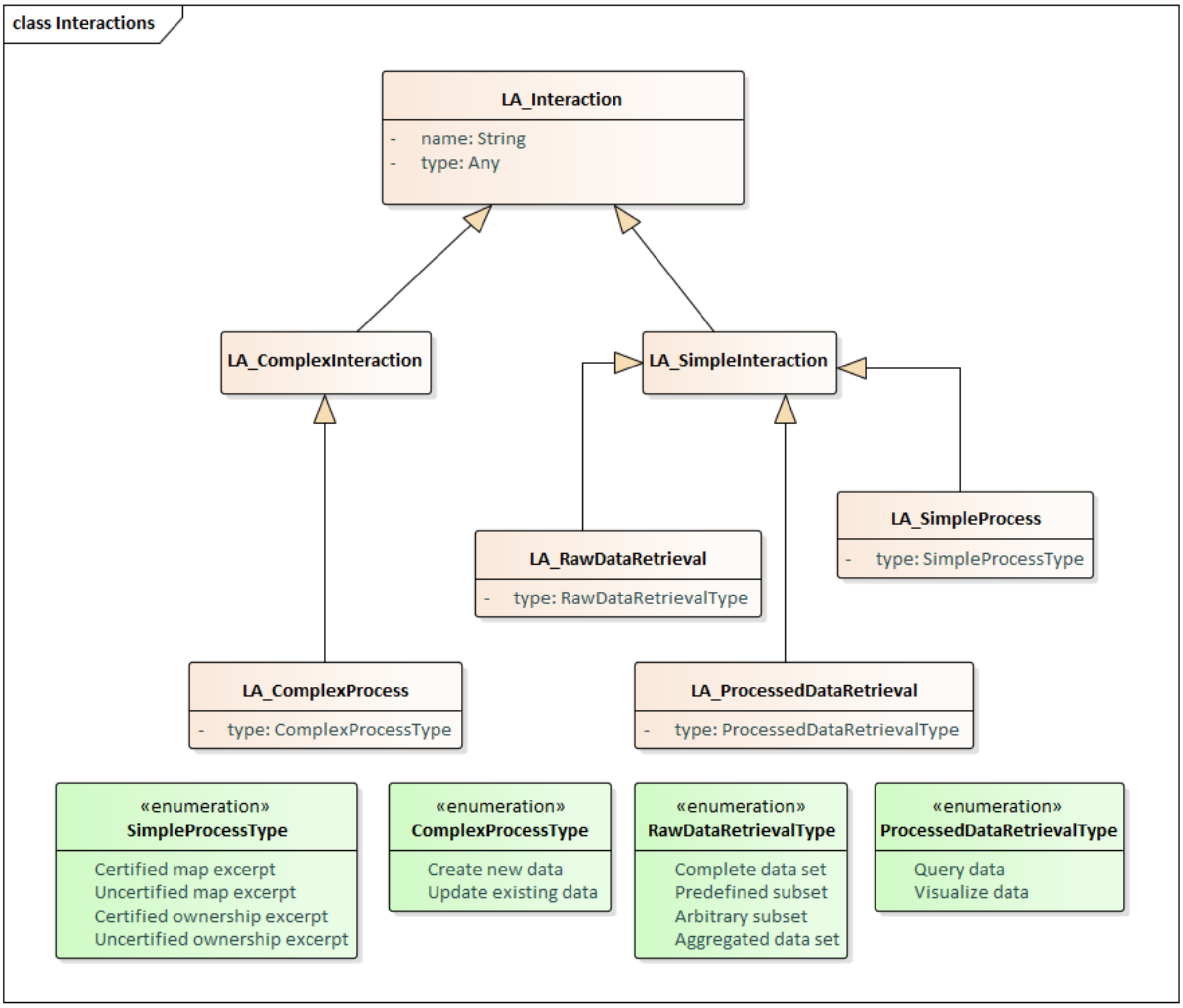


Figure 1. The class diagram showing the hierarchical organization of interactions

Within the following section we explore the options for integration of the developed concept into LADM itself.

3. EXTENDING LADM TO SUPPORT INTERACTIONS

3.1 Dynamic Component of LADM – as is

The two existing classes *LA_Source* and *VersionedObject* have been revised in LADM Edition II. Also, an assoication has been added between those two classes to improve the management of dynamic component of LADM. This allows instances of *LA_Source* to be versioned and allows descendands of *VersionedObject* to have a reference to an event which caused their change. Since all LADM classes are descendants of class *VersionedObject* this means that all LADM classes share the same temporal behaviour. This was defined and discussed earlier by (Vranić, Matijević, & Roić, 2018; Vranić, Matijević, Roić, & Vučić, 2021). Class *VersionedObject* is an abstract class used in the LADM to manage temporal component. It provides optional *begin* and *end Lifespan* and *Valid* timestamps. This enables reconstruction of the state (database or real world) at any point in time (Thompson & van Oosterom, 2021). *LA_Source* is included in the Part 1 to support any kind of a source.

The association between *LA_Source* and *VersionedObject* is shown in more detail on the following figure (Figure 2). *LA_Source* represents a process/event in LAS which caused the change in registration.

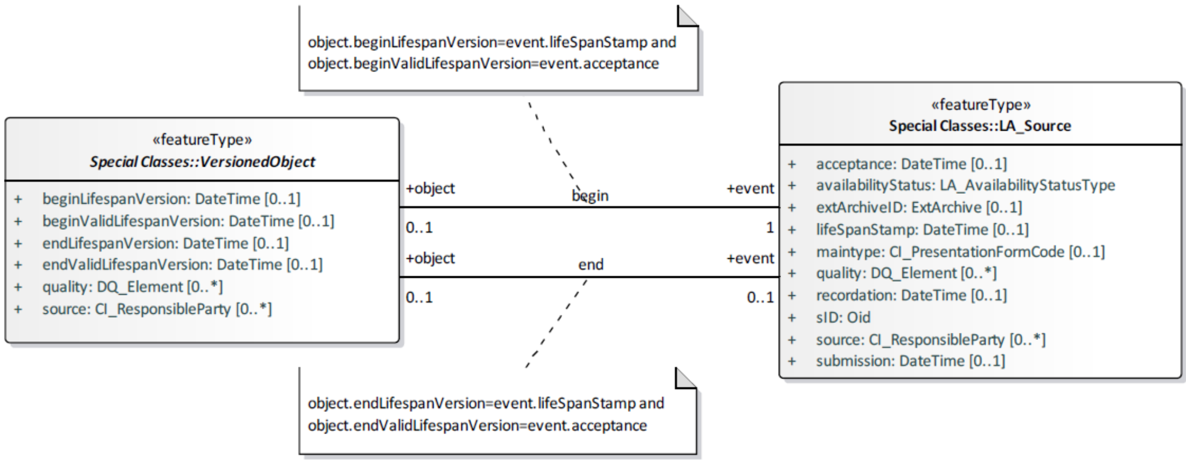


Figure 2. The associations between LA_Source and VersionedObject (Lemmen, et al., 2021)

3.2 Extending the Dynamic Component of LADM by Introducing Interactions

Based on the discussion in section two, we now show and elaborate on the UML class diagram which introduces interactions in LADM (Figure 3). Interactions (class *LA_Interaction*) are associated to class *VersionedObject* with an optional relationship. An instance of *VersionedObject* can be optionally associated to one or more interactions. This allows for creating of interactions on specific subsets of the data (e.g. only some data is accessible to a specific interaction) The three simple types of interactions, LA_RawDataRetrieval, LA_ProcessedDataRetrieval and LA_SimpleProcess are direct descendants of the class LA_Interaction and do not require associating to LA_Source.

Further, we redefine class *LA_Source* as a descendant of the class *LA_Interaction The class LA_ComplexProcess* is defined previously by (Vranić, Matijević, & Roić, 2018; Vranić, Matijević, Roić, & Vučić, 2021) as a descendant of the class *LA_Source* thereby inheriting properties of *LA_Interaction.* Complex processes are such interactions which change the LAS data.

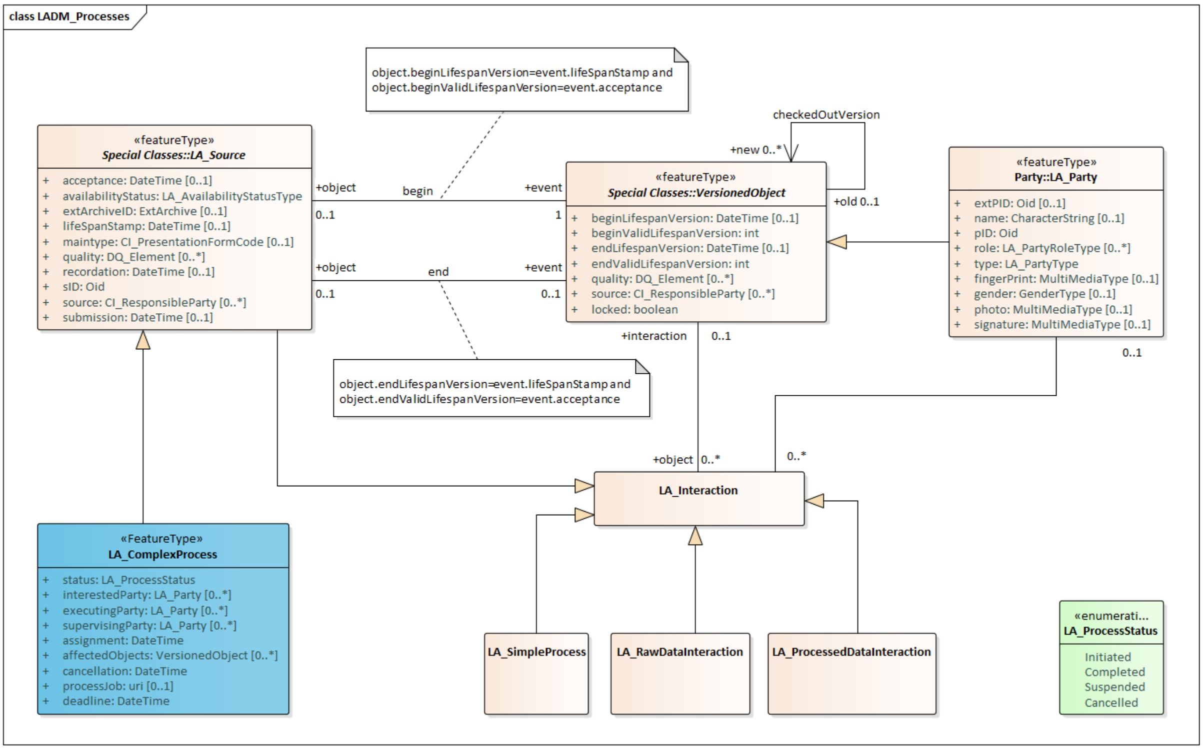


Figure 3. Extended LADM with the support for interactions

Within subsequent phases of development of this concept, probably the aspect of types of parties related to types of interactions should also be investigated.

4. TECHNOLOGICAL ASPECTS OF INTERACTIONS

4.1 OGC API

In recent years, Web APIs have been extensively used in web, cloud and mobile applications. A special architectural type of APIs are RESTful APIs (Felding, 2008) which defines principles how the resources are addressed and transferred via HTTP, regardless of the programming language implementing it. In last few years it has become a predominant web service design model, displacing SOAP and WSDL-based interface design which relied on XML, mainly because of the simplicity which RESTful APIs bring. Web applications have started to be used increasingly by Google's implementation of AJAX (Asynchronous Javascript and XML) concept in their applications Gmail and Google maps. AJAX enabled the website fragments to be loaded without the need for reloading entire website which was a common approach until then. AJAX is a paradigm utilizing a set of web development techniques, relying on various existing web technologies. Both, RESTful APIs and AJAX are mostly using JSON for object serialization, instead of XML, mainly because of its simplicity. AJAX enables the interactivity of web sites, while RESTful APIs bring the simplicity in the API design and implementation. The two put together has made web applications to be used increasingly. Another momentum for API usage is the development of mobile applications. Nowadays, phones are extensively used. Mobile applications are being used for collecting and visualizing data. Having several channels for managing the data, increased the usage of APIs by multiple applications. With the development of Web, geospatial data have been increasingly published on the web.

A set of OGC WxS standards (Web Map Service – WMS, Web Feature Service – WFS, Web Coverage Service – WCS, Web Processing Service – WPS, Catalogue Services for Web – CSW) has been developed in early 2000s and has defined the structure and access methods to different types of geospatial data, relying extensively on XML format which was state of the art at that time. Since then, a lot has changed. Web and mobile applications are now being used on a massive scale. After the release of Google maps, numerous geospatial web applications have been published. The WxS standards have been implemented and used in these applications, but XML has been continuously replaced by JSON since it is lighter and easier to parse by programming languages.

OGC is continuously following the development of technologies and therefore in 2018 initiated activities on a new set of OGC standards called OGC API, utilizing the benefits of APIs to increase the usage of geospatial data. OGC API is defining resource-centric APIs adopting the modern web development practices without making references to any of existing web technologies since they are changing rapidly and continuously. Some of OGC API standards, covering different domains are:

- Features,
- Maps,
- Processes,
- Coverages,
- Records.

OGC API Features are an upgrade of the domain which was handled previously by WFS, maps previously handled by WMS, processes by WPS, coverages by WCS, metadata records by CSW. These legacy WxS standards are the basis for new OGC API standards. WxS standards are not being replaced by OGC API, but rather provide a simpler and more straightforward alternative.

OGC API Features specifies how features in a dataset can be accessed in manner independent of the underlying data store by defining discovery and query operations (OGC, 2019). Discovery operations enable clients to interrogate the API to determine its capabilities and retrieve information about this distribution of the dataset, including API definition and metadata about the feature collections provided by the API. Query operations enable clients to retrieve features from the underlying data store based upon simple selection criteria, defined by the client.

OGC API Features provides following resources listed in Table 1.

Table 1. Resources provided by OGC API Features

Resource	Path	HTTP method	Parameter
Landing page	/	GET	N/A
Conformance classes	/conformance	GET	N/A
Feature collections	/collections	GET	N/A
Feature collection	/collections/{cID}	GET	cID (in path)
Features	/collections/{cID}/items	POST	cID (in path)
Feature	/collections/{cID}/items/{fID}	GET	cID, fID (in path)

OGC API Features define six requirement classes for encodings in order to make the standard modular and reduce the dependency on the current state-of-the-art. The main requirement class is Core which specifies requirements that all Web APIs have to implement. The Core does not mandate a specific encoding or format for representing features or feature collections. Four optional requirement classes depend on the Core and specify representations for these resources in commonly used encodings for spatial data on the web:

- HTML,
- GeoJSON,
- Geography Markup Language (GML), Simple Features Profile, Level 0 and
- Geography Markup Language (GML), Simple Features Profile, Level 2.

Especially HTML representation is important here since it enables providing built in GUIs (graphical user interfaces) into the API itself, thus enabling a simple out-out-of-the box access to the data and processes to any non-professional user. Other encodings can be implemented as well. The Core does not mandate any encoding for the formal definition of the API either. A possible option is the OpenAPI 3.0 specification. A special requirement class for OpenAPI 3.0. has been specified and it depends on the Core. Alternative encodings of API definitions can be used as well, such as: OpenAPI 2.0. (Swagger), OWS Common 2.0. capabilities or WSDL.

There are already existing implementations of OGC API Features in practice. INSPIRE recently endorsed good practice on OGC API Features as an INSPIRE download service. The good practice document proposes a technical approach for implementing the requirements set out in the INSPIRE Implementing Rules for Network Services [IRs for NS] based on the OGC API - Features standard. The approach described is not legally binding and shows one of several ways of implementing INSPIRE Download services (INSPIRE-MIG, 2021).

OGC API Processes standard builds on the OGC Web Processing Service (WPS) 2.0 and defines the processing interface to communicate over a RESTful protocol using JSON encodings (OGC, 2021). Even though WPS makes computational processing services accessible via web services, the new OGC API Processes standard provides a newer and more modern way of programming and interacting with resources over the web as well as a better integration into existing software packages. It enables the execution of computing processes and the retrieval of metadata describing process' purpose and functionality. The definition of a process in OGC API Processes standard is quite generalized and specifies it as an umbrella term for any algorithm, calculation or model that either generates new data or transforms some input data into output data as defined in WPS 2.0 Standard.

4.2 Implementing Interactions Using OGC API

Typically, today geoportals are implemented to make available processed data retrieval interaction to the general public. Besides (and often in conjunction to) that, geospatial web services are also implemented to make available both raw and processed data retrieval interactions. Geoportals are geospatial information systems which are complex and expensive to both implement and maintain. Geospatial web services are much simpler to implement and therefore can quickly be made accessible and are less expensive to both implement and maintain, however in the current versions (WxS) often too complex for general public to use. Also, meta-catalogues, as typically separate information systems must be integrated with geoportals which introduces another level of complexity into implementing an overall geospatial data/information infrastructure.

Exposing LAS processes and data through API would allow users/computers to understand which are available LAS processes and data without the need for the knowledge about LA domain. This is particularly useful for users outside of LA. Landing page would present available collections (datasets) and processes. Then from that point on, user can explore each collection, retrieve features from each collection and search based on some basic parameters. Process descriptions provide basic information about LAS processes (input/output values, endpoint). This information could be used to actually use LAS process or to include a process in a custom workflow defined by user.

In this section we therefore explain how application of OGC API standards can increase the FAIRness of LAS data by enabling cheaper and easier access to the data and processes to a wider audience. Hierarchical structure of API endpoints allows easier browsing of available data and processes for non-expert users. Now we show how described interactions on LAS data can be integrated with OGC API concepts. LAS datasets (parcels, buildings, utility network) match to OGC API collections with a possibility to have multiple collections for one LAS dataset. In this case, each collection can have its file format, coordinate system, geographical coverage or subset. Consequently, different types of interactions can be used to publish LAS data. For instance, parcels can be published as several collections:

- Parcels in GeoJSON format via OGC API Features as a type of raw data retrieval interaction (predefined subset),
- Cadastral map certificate PDF format via OGC API Maps as a simple process,
- Parcels (in INSPIRE compliant data model) in XML format via OGC API Features as a type of raw data retrieval interaction (predefined subset).

Besides publishing LAS data by means of interactions (via OGC API), the interactions itself can be published as OGC API processes. This allows to reuse exposed interactions in external applications or program scripts. For example, following interactions could be published and used by users:

- Retrieving cadastral certificates,
- Retrieving spatial information about the object (coordinates, area),

- Quality control of files containing cadastral data (in case of preparing cadastral changes).

Figure 4 shows a possible scenario how API endpoints could be organized in a LAS. The figure shows collections (of features) and processes. But other types of collections could be included such as maps or coverages. Each level in the hierarchy has a link to the next level. For instance, user can browse collections, then selecting a collection “Parcels” he/she can retrieve the list of parcels. If the list is paginated, meaning that only a subset of first n rows is retrieved, standard HTTP header links are provided for navigating the items. By selecting certain item (i.e. parcel) details about the item are provided. The same behaviour is available when using the API within another application or a program script. The same logic applies for other OGC API standards, processes, maps, etc.

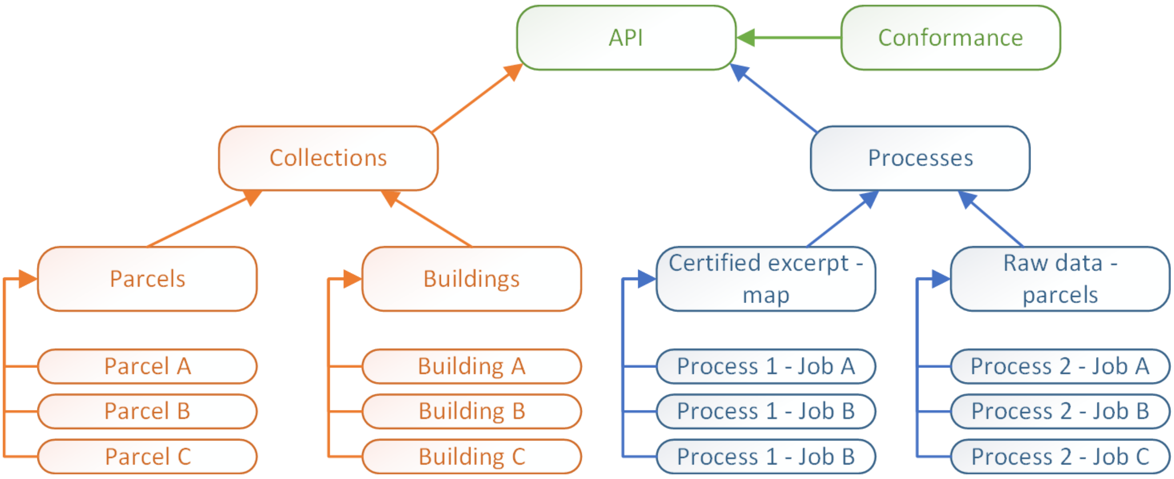


Figure 4. Possible hierarchy of LAS API endpoints

Figure 5 shows a landing (initial) page of the test LADM API. It is implemented with a library pygeoapi[1]. The pygeoapi is certified OGC Compliant and an OGC Reference Implementation which provides a tool for management of geospatial data with OGC API endpoints. Pygeoapi support different data providers which can be configured and used such as PostgreSQL, MongoDB, ElasticSearch, GeoJSON, filesystem, etc. The landing page shows a list of available collections of datasets, spatiotemporal assets and processes in HTML format. It is possible to retrieve this content in other formats as well, such as JSON. **Figure 6** shows a list with metadata about available API endpoints.

[1] https://pygeoapi.io/

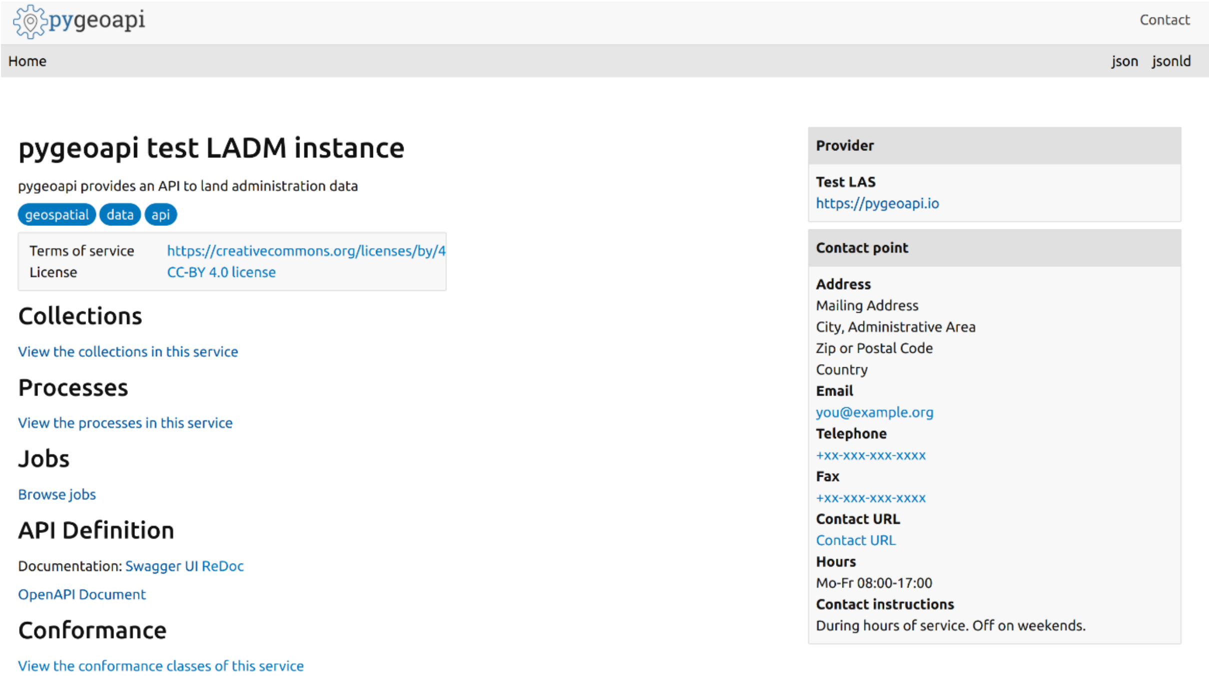


Figure 5. The main API Landing page (HTML)

The content in JSON format is suitable for computer-based data processing. It provides the structure of the API and a possibility to recursively parse the content to each specific feature. For each collection it is possible to define a set of queryables, i.e. a set of attributes which can be used for filtering the results. Besides these feature specific filtering attributes, it is possible to use a set of standard attributes for filtering such as: bbox (return features within certain bounding box), datetime (return features within certain time period). Each API endpoint must support a limit parameter to return only the first n items which is quite important from the system's performance perspective. Also, each response should include a standard HTTP Link headers (next, prev, first, last) which allows the navigation through results. This allows using the collections with a basic knowledge about the structure of the API without any domain knowledge since all API endpoints are functioning in the similar manner.

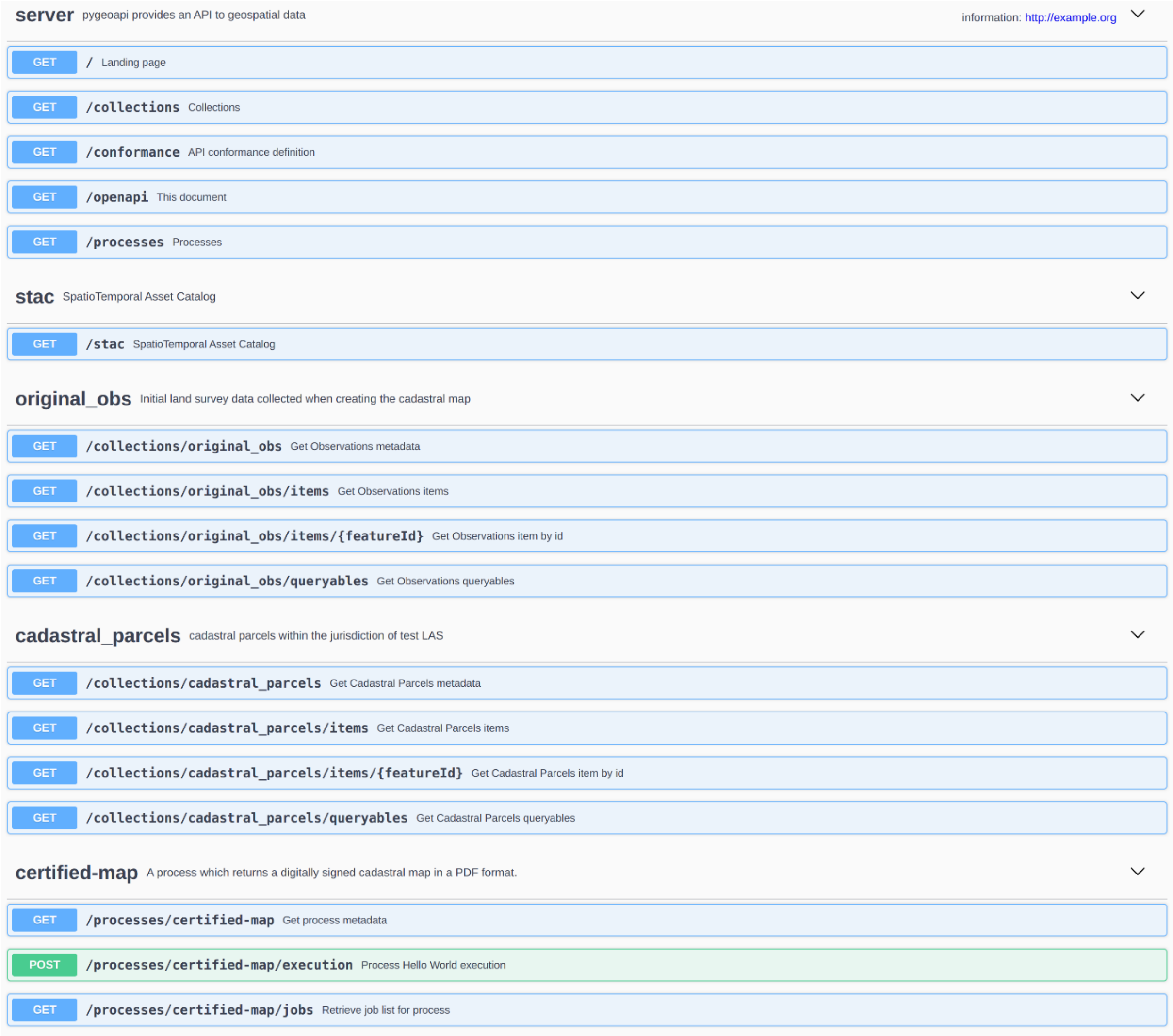
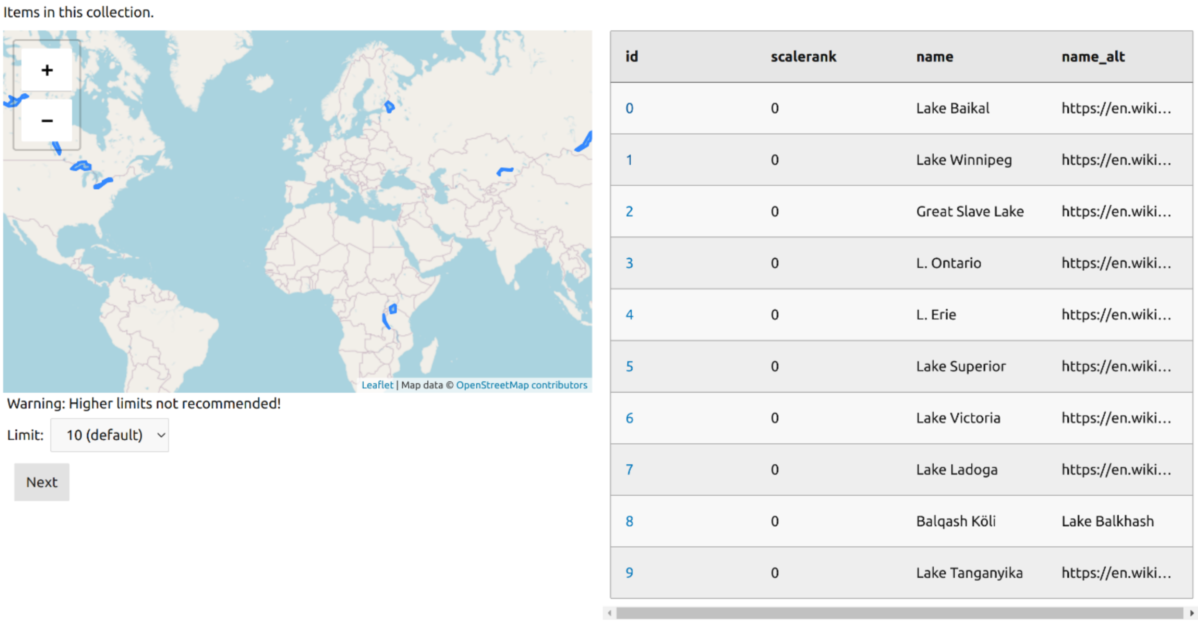


Figure 6. The available API endpoints with metadata and examples for usage

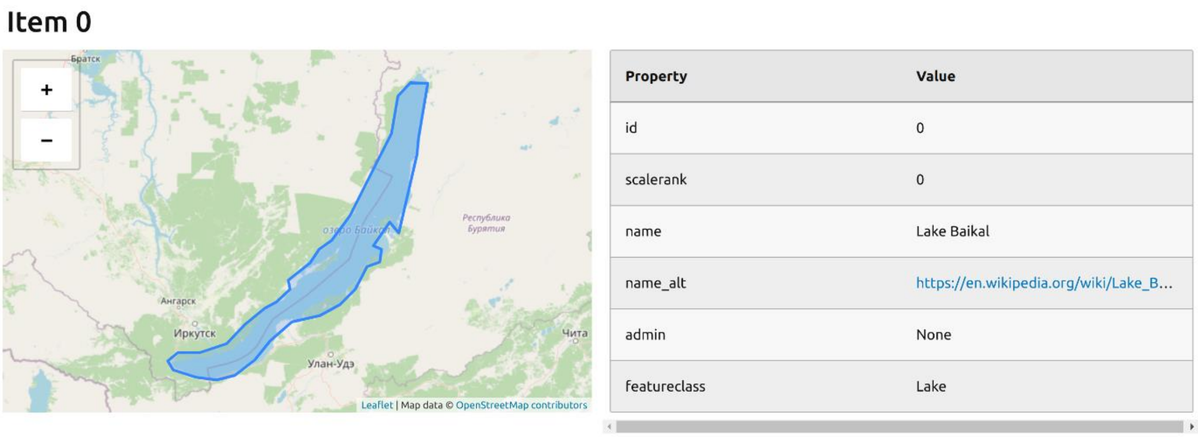
Figure 7 shows how described API endpoints are implemented with pygeoapi in a simple user interface for browsing the collection items. By using the API endpoint /collections/cadastral_parcels/items, a list of parcels is retrieved and visualized on the web interface. Since cadastral parcel is a geospatial dataset, it can be visualized on the map as well.



id	scalerank	name	name_alt
0	0	Lake Baikal	https://en.wiki...
1	0	Lake Winnipeg	https://en.wiki...
2	0	Great Slave Lake	https://en.wiki...
3	0	L. Ontario	https://en.wiki...
4	0	L. Erie	https://en.wiki...
5	0	Lake Superior	https://en.wiki...
6	0	Lake Victoria	https://en.wiki...
7	0	Lake Ladoga	https://en.wiki...
8	0	Balqash Köli	Lake Balkhash
9	0	Lake Tanganyika	https://en.wiki...

Figure 7. A simple user interface for browsing the collection items

By clicking on the specific feature, details are provided for that feature (Figure 8). This information is retrieved by calling the API endpoint /collections/cadastral_parcels/items/0, where zero represents the selected feature identifier.



Property	Value
id	0
scalerank	0
name	Lake Baikal
name_alt	https://en.wikipedia.org/wiki/Lake_B...
admin	None
featureclass	Lake

Figure 8. A simple user interface to inspect the details about specific feature

5. CONCLUSIONS AND FURTHER RESEARCH

In this paper we introduced a term of interaction of parties with LAS which we integrated into LADM to explore options to make land administration processes and data FAIR. OGC API standards define modular API parts that spatially enable Web APIs in a consistent way. The proposed adoption of the OGC API Features standard provides a modern approach for the dissemination of the LAS data. Undoubtedly it is a way how to increase the FAIRness of LAS data and enable its easier usage.

The reason for introducing the general term of interaction is the fact that LADM currently recognises only formal procedures such as registering a building or issuing cadastral certificate. These types processes are also subtypes of interactions, however they only cover the domain of core formal operation of the register. Many modern LAS publish their data on the web through geoportals and web services. Many users are browsing these data daily. There exist also initiatives to make data open and accessible by everyone. One example is INSPIRE directive. All this requires modelling of interactions of people to LAS data properly. We defined interactions in a hierarchical manner which is generic and not related to any technology. The detected interactions follow the standard LAS use cases which can be further extended or specialized.

Having defined interactions, we then integrated them into the LADM. We focused on classes *VersionedObject* (parent class to all other classes in LADM) and *LA_Source* (used for modelling processes). We made an optional association between newly defined class *LA_Interaction* and class *VersionedObject*. Also, we defined *LA_Source* as a descendant class of *LA_Interaction* since LAS processes which change LAS data are a type of interaction between parties and LAS data as well.

Finally, we give an example how to implement interactions with OGC API standards, focusing mainly on OGC API Features. Each LAS dataset can be published via several OGC API endpoints where each API endpoint represents a different interaction. For instance, parcels can be published as a raw data retrieval interaction via OGC API Features, but also can be published as a simple process type of interaction where the output would be cadastral certificate.

This paper showed the compatibility between the concept of interactions integrated in LADM and OGC API standards. The aim of this paper was to provide a generic framework for modelling interactions which can be specialized further in any LAS. The OGC API standards provide a modern means for standard-based dissemination of LAS data, i.e. implementing interactions.

LADM Edition II and OGC API standards are both in the progress of creation. Different contributions could be provided to both. The concept of interactions could be extended with the aspect of types of parties related to types of interactions. Also, since there are a lot of OGC activities aiming at providing feedback from scientists and practitioners on OGC API standards it would be beneficial to provide use cases relevant to LAS or to provide example implementations of LAS by means of OGC API by customizing any of OGC reference implementations.

REFERENCES

Aristovnik, A., Kovač, P., Murko, E., Ravšelj, D., Umek, L., Bohatá, M., . . . Tomaževič, N. (2021). The Use of ICT by Local General Administrative Authorities during COVID-19 for a Sustainable Future: Comparing Five European Countries. Sustainability, 13(12). doi:10.3390/su132111765.

Felding, R. T. (2008). Architectural Styles and the Design of Network-based Software Architectures. Irvine: University of California.

Ferlan, M., Šumrada, R., & Mattsson, H. (2007). Modelling property transactions. In J. Zevenbergen, A. Frank, & E. Stubkjær, Real Property Transactions: Procedures, Transaction Costs and Models. IOS Press.

Gabryelczyk, R. (2020). Has COVID-19 Accelerated Digital Transformation? Initial Lessons Learned for Public Administrations. Information Systems Management, 37(4). doi:10.1080/10580530.2020.1820633

Govedarica, M., Radulović, A., & Sladić, D. (2021). Designing and implementing a LADM-based cadastral information system in Serbia, Montenegro and Republic of Srpska. Land Use Policy, 109. doi:10.1016/j.landusepol.2021.105732.

Hull, S., & Whittal, J. (2013). Good e-Governance and Cadastral Innovation: In Pursuit of a Definition of e-Cadastral Systems. South African Journal of Geomatics, 2(4).

INSPIRE-MIG. (2021). Technical guidelines for setting up an INSPIRE Download service based on the OGC API-Features standard. European Commission. Dohvaćeno iz https://github.com/INSPIRE-MIF/gp-ogc-api-features/blob/master/spec/oapif-inspire-download.md

Lemmen, C., Alattas, A., Indrajit, A., Kalogianni, E., Kara, A., Oukes, P., & van Oosterom, P. (2021). The Foundation of Edition II of the Land Administration Domain Model. Smart Surveyors for Land and Water Management - Challenges in a New Reality. FIG.

Navratil, G., & Frank, A. (2004). Processes in a cadastre. Computers, Environment and Urban Systems, 28(5). doi:10.1016/j.compenvurbsys.2003.11.003

Navratil, G., & Frank, A. (2007). Hierarchies in subdivision processes. In J. Zavenbergen, A. Frank, & E. Stubjaer, Real Property Transactions: Procedures, Transaction Costs and Models (pp. 27-80). IOS Press.

OGC. (2019). OGC API - Features - Part 1 - Core. Open Geospatial Consortium.

OGC. (2021). OGC API - Processes - Part 1: Core. Open Geospatial Consortium.

Olfat, H., Atazadeh, B., Rajabifard, A., Mesbah, A., Badiee, F., Chen, Y., . . . Briffa, M. (2020). Moving towards a single smart cadastral platform in Victoria. International Journal of Geo-Information, 5. doi:10.3390/ijgi9050303

Sari, K. (2010). The Workflow of Maintenance of Cadastral Data as based on Land Administration Domain Model (LADM) A case study in Indonesia. University of Twente.

Sladić, D., Radulović, A., & Govedarica, M. (2020). Development of process model for Serbian cadastre. Land Use Policy, 98. doi:10.1016/j.landusepol.2019.104273

Thompson, R., & van Oosterom, P. (2021). Bi-temporal foundation for LADM v2: Fusing event and state based modelling of Land administration data 2D and 3D. Land Use Policy, 102. doi:10.1016/j.landusepol.2020.105246

Vranić, S., Matijević, H., & Roić, M. (2018). Application of Workflow Management System to the Modelling of Processes in Land Administration Systems. 7th Land Administration Domain Model Workshop. Zagreb, Croatia: FIG.

Vranić, S., Matijević, H., Roić, M., & Vučić, N. (2021). Extending LADM to support workflows and process models. Land Use Policy. doi:10.1016/j.landusepol.2021.105358

Wilkinson, M., Dumontier, M., Aalbersberg, I., Appleton, G., Axton, M., Baak, A., . . . Boiten, J.-W. (2016). The FAIR Guiding Principles for scientific data management and stewardship. Scientific Data, 3(1). doi:10.1038/sdata.2016.18

Zevenbergen, J., Frank, A., & Stubkjær, E. (2007). Real Property Transactions: Procedures, Transaction Costs and Models. IOS Press.

BIOGRAPHICAL NOTES

Saša Vranić graduated at University of Zagreb, Faculty of Geodesy in 2009th with a diploma thesis “Interface of cadastral database”. In 2018, received a PhD from the University of Zagreb for the thesis “Modelling transactional workflow management system over spatial component of cadastral parcels”. After graduation he worked in Croatian geoinformatics company Geofoto LLC for several years as GIS Consultant on projects of implementing spatial information systems. From 2012 to 2018, he was employed at the University of Zagreb, Faculty of Geodesy as University Assistant on Chair for land surveying. Since 2018 he is a freelance GIS consultant/programmer, working mainly as a project manager for a Slovak based company KAJO on several European H2020 projects. His main research interests are geospatial web applications, spatial databases, geospatial standards, and land administration systems.

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