

Analysis of possibilities for linking land registers and other official registers in the Republic of Croatia based on LADM



Mario Mađer^{a,*}, Hrvoje Matijević^{b,1}, Miodrag Roić^{a,2}

^a University of Zagreb, Faculty of Geodesy, Kačićeva 26, 10000 Zagreb, Croatia

^b IGEA d.o.o., Supilova 7/B, 42000 Varaždin, Croatia

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ABSTRACT

Weak or non-existing linkage of official registers in the Republic of Croatia and the data redundancy as an inevitable outcome of such a state are the causes of various unwanted consequences for the relevant public authorities, as well as for citizens and companies as the end-users of that data.

In this paper we present the results of an analysis of the status of the redundancy within the Croatian land administration-related registers. Following the analysis, suggestions are given on how the effectiveness of the analyzed registers can be increased by introducing a linking based on the Land Administration Domain Model (LADM). The proposed linkages were created by extending the Unified Modelling Language (UML) object classes of the LADM. The compliance analysis between registers and the LADM was conducted by using schema matching. Schema matching is a set of techniques used for comparing schemas (usually referred to as data models), and is well known within the database research domain. The results of the analysis were used to determine in which direction to go with extending of the LADM.

All of the outputs of this research can be used to create a strategy for improving the effectiveness of the overall system of registers, which in turn should result in an overall economic progress of the country.

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Introduction

Business and technological systems of public administration are largely based on the registers. Introducing interoperability into the registers is one of the key drivers for optimization of public administration, starting from simple automation of existing processes to the overall transformation of the system and the construction of modern user-oriented services. An additional incentive for such a transformation is a foreseeable need for interoperability between the national system of registers and the EU registers and potentially in the future with the registers of other world countries. The current system of registers in the Republic of Croatia is significantly vertically structured (e-Hrvatska, 2010). This means that registers are usually under the jurisdiction of different public authorities and have no real interaction with other registers. Furthermore, even if

computerized, registers primarily function by “their” already established administrative processes, without taking into consideration whether such or a similar register already exists and how it is organized. Such a condition prevents the introduction of user-oriented solutions and the achievement of increased business and financial effects.

Interoperability is defined as the ability of the system to provide and receive services from other systems and to use such exchanged services for effective interaction, i.e. to enable the sharing of information and knowledge (IDABC, 2004). Interoperability is not achievable without a level of linkage between distinct parts of the system. In order to achieve the interoperability of registers, i.e. a better linkage on a national and international level, the existence of rules, standards, models, methodologies and procedures is needed. Within the Croatian system of registers those prerequisites are not well defined so the possibilities of their improvement have existed.

During the last two decades in the Republic of Croatia, several components of the land administration system have undergone radical changes that are primarily related to the transition from analogue to electronic data processing (Vučić et al., 2013). The land registers were the main subject of the changes. Transitioning of analogue registers to an electronic form significantly simplifies the maintenance of data, increases their quality, availability and

* Corresponding author at: University of Zagreb, Faculty of Geodesy, Kačićeva 26, 10000 Zagreb, Croatia, Tel.: +385 1 4639 222; fax: +385 1 4828 081.

E-mail addresses: mmadjer@geof.hr (M. Mađer), hrvoje.matijevic@igea.hr (H. Matijević), mroić@geof.hr (M. Roić).

URLs: <http://www.geof.unizg.hr> (M. Mađer), <http://www.igea.hr> (H. Matijević), <http://www.geof.unizg.hr> (M. Roić).

¹ Tel.: +385 42 556 700; fax: +385 42 556 701.

² Tel.: +385 1 4639 222; fax: +385 1 4828 081.

transparency, and enables dissemination of information via network services. Despite those advantages, analogue logic as well as the way of thinking have been retained in the newly established electronic environment (Mađer, 2012). Because of that, all of the benefits that the technology surrounding such systems could provide are not fully used. The same premise can also be applied to all other official registers. There is a large number of registers that partially record information about the same features but are not linked (Mađer et al., 2013). The existence of redundant data in the public authorities often leads to situations where information about a feature registered in a register does not match the information about the same feature in some other register. Such a situation is the cause of a variety of unwanted consequences, which is burdensome for the relevant public authorities, but also for citizens, private companies and other end-users of that data.

In an effort to end the current situation and to initiate progress, the idea to use the LADM as a core which primarily covers land registers but can also be extended to the needs of the whole national system of registers has emerged. It was expected that the logic and good ideas implemented into the LADM could be applied to other fields which are outside the scope of the LADM. To achieve this task, an overall analysis of all the official registers needed to be done.

Within our research only the key registers were taken into consideration. Based on the research, the level of redundancy within them was detected. The goal of the analysis was to determine the general condition of the registers and to use the resulting conclusions as a starting point for building a modern and sustainable national system of registers. For this purpose a model of linking of the land registers and other official registers was proposed. The model was built by extending the available LADM model with classes which represent the data outside the scope of the LADM, therefore not modelled as its integral part. Electronic managing of data structured according to the above mentioned model would improve data quality and enable an efficient data exchange among different parts of the system.

The rest of the paper is organized as follows. In “Official registers in the Republic of Croatia” section we first provide a short overview of the official registers in the Republic of Croatia. We present a classification of those registers accompanied with the general definition and the main principles of the concept of key registers. “Research approach” section describes the used methodology and elaborates on how it was implemented to do the actual research. “Analysis of the registers” section gives an insight into the results of the analysis. According to those results, “Model of linking the analysed registers” section gives the overview of UML diagrams, presenting the model of linking the registers based on LADM. “Conclusion” section gives the conclusion.

Official registers in the Republic of Croatia

Much of the information that public authorities collect, maintain, use and make available to others refers to the persons, properties and interests over those properties (Ročić, 2012). This information are maintained in official registers in either an analogue or electronic form, with the latter being nowadays more common. Registers are systematically organized, maintained and regulated lists of specific legally relevant data, facts or rights. By registering the data in official registers, this data becomes information based on which public authorities provide various services to citizens, and citizens use that information to exercise their rights. The importance of the registers is reflected in the daily use of the registered data in the business and private lives of citizens. Every day one encounters a situation where a certificate from a register is needed in order to prove a certain fact, right or legal relationship.

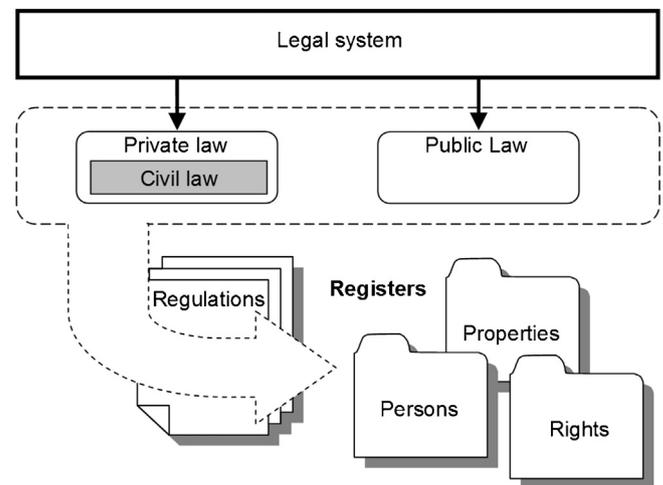


Fig. 1. Position of registers in the legal system.

Well-organized registers are a prerequisite for the smooth progress of legal transactions. The amount and complexity of the information that are maintained by public authorities are constantly increasing. This fact is also caused by the development of technology and is taking place simultaneously with it. A set of possibilities provided by new technologies is constantly increasing. The adoption of technological achievements, especially from the field of information and communications technology (ICT) and their implementation in the system of registers, has enabled easier maintenance, access and sharing of information. This in turn has opened the possibility of collecting additional information that previously weren't collected as their maintenance was technologically too demanding. A large amount of information and a large number of registers require constant supervision and a great care of data, and the associated processes. Processes need to be revised and fully adjusted to new requirements of electronic data maintenance. Public authorities who have jurisdiction over official registers play an important role in this process. They are responsible for controlled spending of taxpayers' money and for proper organization of the data, as well as for initiation of further development of the overall system of registers. Furthermore, the public authorities are responsible for ensuring the technical preconditions for re-use of the public sector information (European Parliament & Council, 2003) which, if available and re-used, may present enormous potential for achieving economic progress.

Classification of official registers

The Croatian legal system is built on Roman law, which is common to the countries of Western Europe. It also provides the classification of official registers (Gavella et al., 1998). According to their content, the registers can be classified into the Registers of persons, Registers of properties and Registers of rights (Fig. 1). These registers are governed by numerous regulations that are largely derived from private law and to a certain extent from public law. Private and public laws are two main branches of the legal system. Generally, private law governs relationships between individuals while public law governs relationships between the individuals and the government as well as the relationships between individuals which are of direct concern to the society. Private law serves the private interests while public law serves common interests.

The core of private law is civil law, which is defined as a set of legal rules governing the relations of natural and non-natural persons regarding the property and deeds. Natural and non-natural

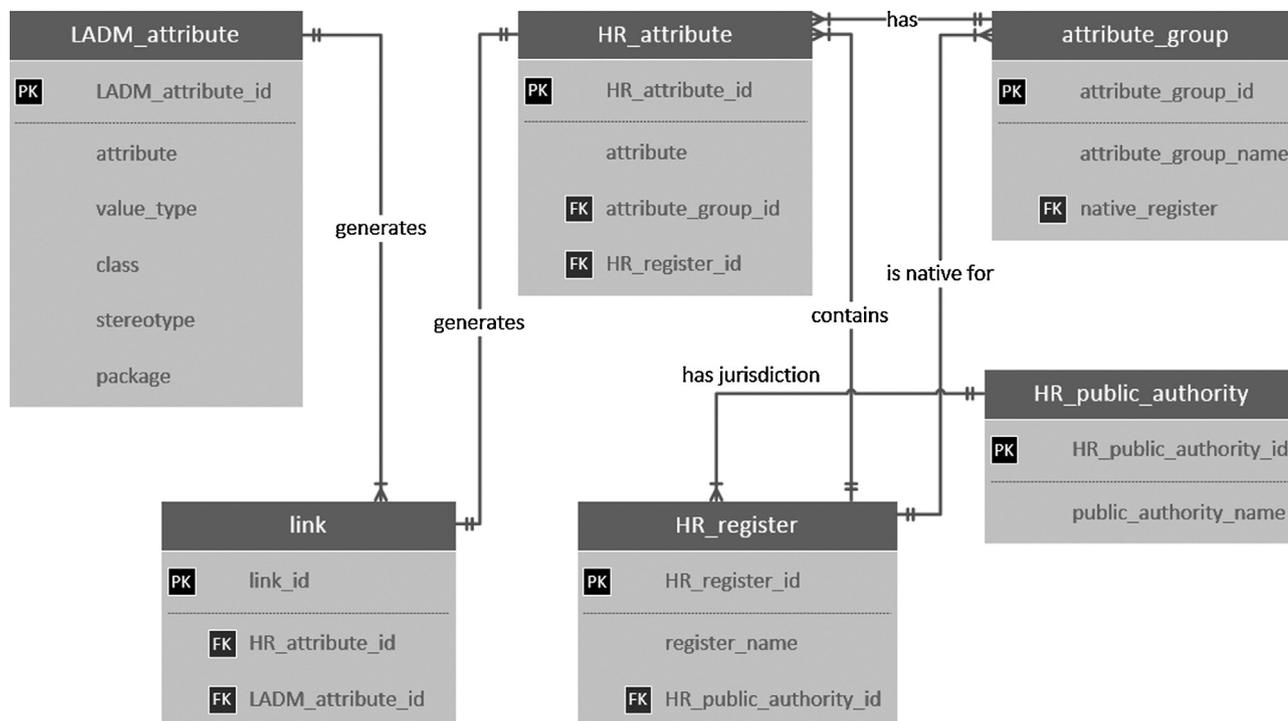


Fig. 2. ER representation of the core data model.

persons are subjects, while property and deeds are the objects of civil law.

Registers that are based on private law i.e. civil law are an essential part of land administration systems. Through these registers, civil law is built into the foundations of the land administration system (Roić et al., 2008).

Key registers

Key registers are primarily those that contain information about the people and the land as well as about their relationships (Ellenkamp and Maessen, 2009). This definition can be extended to other registers which meet a set of requirements and whose data at some point becomes of key significance to the society. The requirements are mostly derived from the knowledge on how the modern system of registers should be arranged. Basically, the data registered in such a register must be original and should not be collected and maintained in any other register. Furthermore, key registers must be regulated by law, their content must be well defined and data quality must be assured. There must be a legal obligation for public authorities and other users to use the data of the key registers. Also it is important to establish procedures and standards for data sharing.

The concept of key registers (or authentic, basic registers) has been introduced by the public administration of the Netherlands (van der Molen and Welter, 2004; Besemer et al., 2006). The aim of the initiative was to create an environment where each of the facts registered gets collected only once, and by the most appropriate public agency. This would lead to the reduction (and eventually to the complete removal) of the redundancy of the collected and registered data. Multiple collection of the identical data always introduces unnecessary additional costs and often leads to inconsistencies of the facts registered. An important idea was to try to keep the number of key registers limited, as to avoid the situation where too many registers have become key registers thus leading to a very complex system which would be hard to maintain

and would become a purpose for itself. This is an important concept which we used while determining the extent of our research also.

Research approach

Our research was motivated by the assessment that Croatian official registers do not meet basic requirements for key registers to the full extent. With redundancy being one of the major problems, we wanted to determine its exact extent. Before we began with the research we defined the objectives to be achieved:

- identification of common attributes of official registers and the LADM
- proposal of the model of linking the official registers
- ensuring the preconditions for the improvement of the national system of registers

Following, we give elaborate on how we conducted the research in order to accomplish the objectives.

Methodology

We have chosen the topic of our research to be the registers directly involved in the process of land administration, which also

Table 1
Registers and jurisdictions.

Register	Public authority
Register of natural persons	Ministry of public administration
Registers of non-natural persons	Judicial authority
Register of personal identification numbers	Tax administration
Land registry	Judicial authority
Cadastré	State geodetic administration
Register of spatial units	State geodetic administration
Utility cadastre	State geodetic administration

Table 2
Attributes of Administrative package found in analyzed registers.

LADM class	Class attribute	Register
LA_AdministrativeSource	availabilityStatus	Land registry
LA_AdministrativeSource	text	Land registry
LA_AdministrativeSource	type	Land registry
LA_BAUnit	name	Cadastre
		Land registry
LA_BAUnit	type	
LA_BAUnit	uid	Cadastre
		Land registry
LA_Mortgage	amount	Land registry
LA_Mortgage	interestRate	Land registry
LA_Mortgage	ranking	Land registry
LA_Mortgage	type	Land registry
LA_RequiredRelationshipBAUnit	relationship	
LA_Responsibility	type	Land registry
LA_Restriction	partyRequired	
LA_Restriction	type	Cadastre
		Land registry
LA_Right	type	Land registry
LA_RRR	description	
LA_RRR	rID	Land registry
LA_RRR	share	Cadastre
		Land registry
LA_RRR	shareCheck	
LA_RRR	timeSpec	Land registry

represent the basic building blocks of the LADM. Instead of an outside-in approach where a catalogue of all the existing registers is created and then each of the registers analyzed, whether it is relevant for the research or not, we have chosen the inside-out approach. Although the outside-in approach would yield an all-encompassing insight into the level of redundancy of the registers, we have chosen the simpler and more straightforward inside-out approach to keep this first-of-a-kind research simple to execute and to interpret. The subsequent researches could involve the entirety of the registers to produce a more accurate overview of the current level of the redundancy. In order to be able to detect the redundancies a fixed point was needed. For that purpose we have used the LADM.

Over the years, the LADM has evolved from the Core Cadastral Domain Model to a sound and consistent core representing the basic of all the land administration systems over the world, including both the legal and the spatial components of land administration (van der Molen et al., 2004; van Oosterom et al., 2006;

Table 3
Attributes of Party package found in analyzed registers.

LADM class	Class attribute	Register
LA_GroupParty	groupID	
LA_GroupParty	type	
LA_Party	extPID	Cadastre
		Land registry
		Register of natural persons
		Register of personal identification numbers
		Registers of non-natural persons
		Utility cadastre
LA_Party	name	Cadastre
		Land registry
		Register of natural persons
		Register of personal identification numbers
		Registers of non-natural persons
		Utility cadastre
LA_Party	pid	
LA_Party	role	
LA_Party	type	
LA_PartyMember	share	

Table 4
Attributes of Spatial Unit package found in analyzed registers.

LADM class	Class attribute	Register
LA_LegalSpaceBuildingUnit	buildingUnitID	Utility cadastre
		Register of spatial units
LA_LegalSpaceBuildingUnit	type	
LA_LegalSpaceUtilityNetwork	extPhysicalNetworkID	
LA_LegalSpaceUtilityNetwork	status	Utility cadastre
LA_LegalSpaceUtilityNetwork	type	Utility cadastre
LA_Level	IID	
LA_Level	name	
LA_Level	registerType	
LA_Level	structure	
LA_Level	type	
LA_RequiredRelationshipSpatialUnit	relationship	
LA_SpatialUnit	extAddressID	
LA_SpatialUnit	area	Cadastre
		Land registry
LA_SpatialUnit	dimension	
LA_SpatialUnit	label	
LA_SpatialUnit	referencePoint	
LA_SpatialUnit	suID	
LA_SpatialUnit	surfaceRelation	
LA_SpatialUnit	volume	
LA_SpatialUnitGroup	hierarchyLevel	
LA_SpatialUnitGroup	label	
LA_SpatialUnitGroup	name	Cadastre
		Land registry
		Register of spatial units
		Utility cadastre
LA_SpatialUnitGroup	referencePoint	
LA_SpatialUnitGroup	sugID	Cadastre
		Register of spatial units

Hespanha et al., 2008; Lemmen et al., 2010). The vast amount of research yielded a model free of redundancy, which kept only the domain specific object classes and attributes within and everything else outside. Because a considerable part of data of the analyzed registers was also the subject of the LADM, we have chosen the LADM to be the starting point of our research. Another important fact has also supported this decision. The LADM has recently gone one step further and become ISO Standard, 19152: Geographic information – Land Administration Domain Model (ISO/TC 211, 2012; Lemmen et al., 2013). Adoption of the LADM as an ISO standard confirms its significance, thus additionally justifying our decision.

The most central task of the research was a comparison of official registers against the LADM. Subject of this comparison were their attributes. In order to collect and classify the attributes of official registers we did a detailed analysis of the current legislation regulating the domain of their data and the manner in which the processes over those data are executed.

The process of comparing two or more data models (also referred to as schemas in the database domain) is called schema matching. Schema matching is the first step in integrating two or more schemas (Batini and Lenzerini, 1986). Schema matching is typically performed manually, supported by a graphical user interface. There are also other techniques to achieve a partial automation of the match operation as reviewed by Rahm and Bernstein (2001). As the objective of schema matching is the search for equivalent or similar elements between two (meta)models, sometimes this process is referred to as (meta)model matching (Lopes et al., 2006). The idea behind schema matching is to take two (or more) schemas as input and produce a mapping between their elements that correspond semantically to each other. There are several approaches to schema matching. Some include the instance

Table 5
Attributes of Surveying and Representation package found in analyzed registers.

LADM class	Class attribute	Register
LA_BoundaryFace	bflD	
LA_BoundaryFace	geometry	
LA_BoundaryFace	locationByText	
LA_BoundaryFaceString	bfsID	
LA_BoundaryFaceString	geometry	Cadastr Register of spatial units Utility cadastre
LA_BoundaryFaceString	locationByText	
LA_Point	estimatedAccuracy	
LA_Point	interpolationRole	
LA_Point	monumentation	Cadastr
LA_Point	originalLocation	Cadastr
LA_Point	pID	Cadastr
LA_Point	pointType	Cadastr
LA_Point	productionMethod	Cadastr
LA_Point	transAndResult	Cadastr
LA_SpatialSource	measurements	Cadastr
LA_SpatialSource	procedure	Cadastr
LA_SpatialSource	type	

level, considering the actual instances of data, while others include only schema level information. Furthermore, there are approaches that consider the element and structure level. Matching can be performed for individual schema elements, such as attributes, or for combinations of elements, such as complex schema structures. Also, matching can be language-based and constraint-based. The linguistic approach is based on names and textual descriptions of schema elements while constraint-based approach bases on keys and relationships. The manual creation of mapping specification is a time-consuming and, therefore, expensive process when a large amount of data needs to be matched. On the other hand, automated matching also has weaknesses. The criteria used to match elements of two schemas are based on heuristics that are not easily captured in a precise mathematical way. Although it can be used for processing a large amount of data in a short period of time, the results are not completely error-free, so depending on the purpose of matching sometimes it requires a manual revision. When choosing the right method of schema matching for a specific task it seems appropriate to consider all advantages and downsides of each method. In the case of our research, considering the relatively small amount of data, it was sufficient to use manual schema matching, especially because of increased reliability of the results. LADM schema was extracted from the ISO 19152 standard, and schemas that represent Croatian registers were built mainly according to the legislation by which the registers are regulated.

Implementation

For the schema matching and the subsequent analysis, a relational database management system (RDBMS) based application was built, in which all schemas were described through a relational model. When properly modelled, collected and loaded into an RDBMS, descriptive data can be easily analyzed in various aspects. We have therefore decided to use this technology as the support for our research. The core of our relational data model is represented by following entity-relationship (ER) diagram created using the Crow's Foot notation (Fig. 2). It shows 6 entities:

- LADM_attribute – contains data about LADM attributes, value types, classes, stereotypes and packages; one LADM attribute can generate one or more links, i.e. it can relate to one or more attributes of official Croatian registers (“one or more” because of the expected redundancy within the Croatian registers)

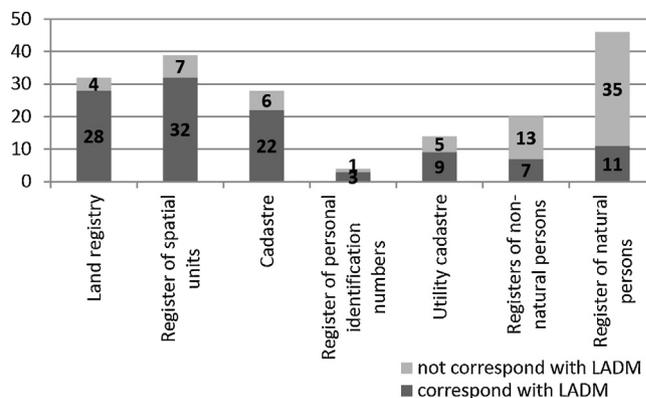


Fig. 3. Compliance of analyzed registers with LADM.

- HR_attribute – contains data about Croatian registers' attributes and related groups and registers; one attribute can generate only one link, i.e. it can relate only to one LADM attribute
- HR_register – contains data about registers and related public authorities; one register can contain one or more attributes and only one register can be native for one or more groups of attributes
- attribute_group – contains data about the attribute group name and the native register for all attributes represented by the group; one group has one or more attributes
- HR_public_authority – contains data about public authorities; one public authority can have jurisdiction over one or more registers
- link – contains data about the recognized relations between LADM attributes and attributes from official registers

By structuring the data in such a way, we expected to accomplish two things: to identify the redundancy and to determine the level of compliance of Croatian official registers to the LADM. As we expected there to be redundancy within the registers (identical attributes with different names in multiple analyzed registers) we introduced a grouping (through attribute_group). Each of the attributes from the HR_attribute was associated with a group. Without such a grouping it would not be possible to detect redundancy. Later this enabled us to do various queries on the data from which subsequent analyses were made.

To be more flexible while handling the data, several modules were produced: a module for identification of attributes, a module used for generation of queries, i.e. structured query language (SQL) statements, and a module for visual representation of results. Through the module for identification of attributes it was possible to consistently store all recognized relations between LADM attributes and attributes of official registers. This was a delicate task because of a lot of ambiguities in the registers, resulting in frequent changes of the recognized relations. These changes were supported by the module for identification of attributes in order to refine the data later used for compliance analysis. The other two modules were used to produce and present results summarized in this paper. Performed analysis demonstrated to what extent the selected official registers comply with the LADM and in which direction to go with its extension. The analysis confirmed previous assumptions about the unsatisfactory state of the data, especially about their redundancy, which directly affects the reliability of information that can be obtained from the official registers. Below are two examples of the manner of retrieving some analysis results.

A thoroughly defined data model enabled our module to generate the following SQL SELECT statement which retrieves the list of all redundant attributes and the total number of their occurrences. The results retrieved by this example were used for

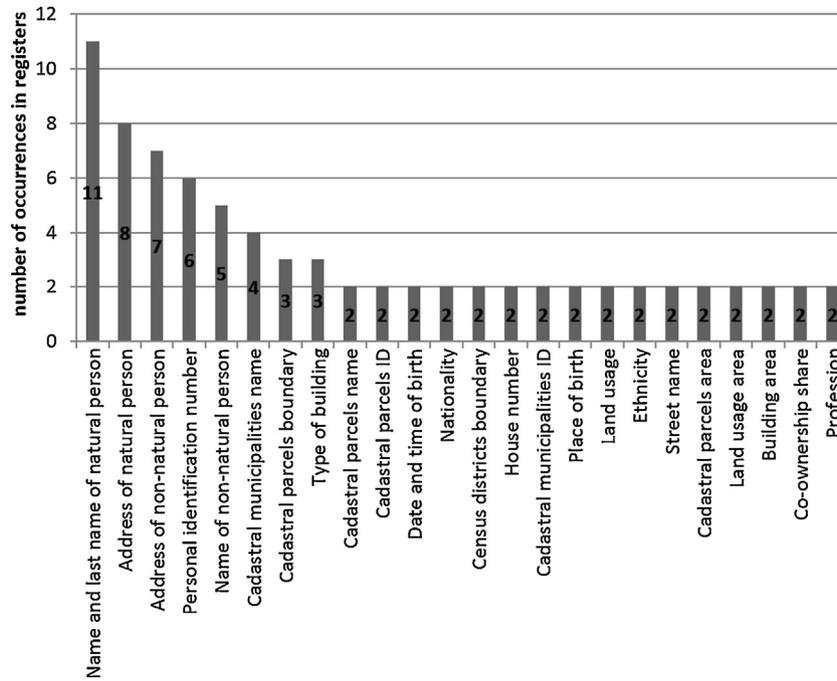


Fig. 4. Redundant data in the official registers.

visual representation of redundant data in the official registers in “The Level of Data Redundancy” section (Fig. 4).

```
SELECT attribute_group.attribute_group_name,
COUNT(attribute_group.attribute_group_name) AS total
FROM (HR_public_authority INNER JOIN HR_register
ON HR_public_authority.HR_public_authority_id=HR_
register.HR_public_authority_id) INNER JOIN
(attribute_group INNER JOIN HR_attribute ON
attribute_group.attribute_group_id=HR_attribute.
attribute_group_id) ON HR_register.HR_register_id=HR_
attribute.HR_register_id
GROUP BY attribute_group.attribute_group_name
HAVING COUNT(attribute_group.attribute_group_
name)>1
ORDER BY COUNT(attribute_group.attribute_group_
name) DESC, attribute_group.attribute_group_name;
```

Another example of a generated SQL SELECT statement is the one that retrieves the list of recognized semantic matching between LADM attributes and attributes of analyzed registers. Based on the results retrieved by this example, tables in “Compliance Analysis” section were formed giving us an insight into the level of compliance to the LADM and suggesting the existence of redundancy.

```
SELECT A.package, A.class, A.attribute,
B.attribute, B.register_name, B.attribute_group_name
FROM (SELECT link.HR_attribute_id,
LADM_attribute.package, LADM_attribute.class,
LADM_attribute.attribute FROM LADM_attribute LEFT
JOIN link ON LADM_attribute.LADM_attribute_id=link.
LADM_attribute_id) AS A LEFT JOIN (SELECT
attribute_group.attribute_group_name,
HR_attribute.attribute, HR_register.register_name,
HR_attribute.HR_attribute_id FROM HR_register INNER
JOIN (attribute_group RIGHT JOIN HR_attribute ON
attribute_group.attribute_group_id=HR_attribute.
attribute_group_id) ON HR_register.HR_register_id=HR_
attribute.HR_register_id) AS B ON
A.HR_attribute_id=B.HR_attribute_id
```

```
ORDER BY A.package, A.class;
```

Analysis of the registers

Conducted research included the analysis of a group of key registers listed in the following table (Table 1). In the following subsections the results of compliance analysis will be presented showing the level of compliance of each register to the LADM, together with the total level of redundancy and the level of redundancy by an individual public authority.

The Register of natural persons actually consists of three registers, each governed separately by the Ministry of public administration: Register of births, Register of wedded, and Register of deceased. Registers of non-natural persons are under the jurisdiction of the Judicial authority and its purpose is to provide legal personality of non-natural persons such as public authorities, companies, corporations, etc. The Register of personal identification numbers is governed by the Tax administration. It keeps data about the permanent identifier of Croatian citizens, non-natural persons established in the Republic of Croatia, as well as all natural and non-natural persons which need to be involved in other formal processes. It was introduced due to general informatization of public administration, better data exchange between public authorities and better control over the properties of citizens and non-natural persons. A land registry is another register under the jurisdiction of the Judicial authority. It keeps data about real property rights, restrictions and responsibilities. The last three registers in the table are under the jurisdiction of the State geodetic administration.

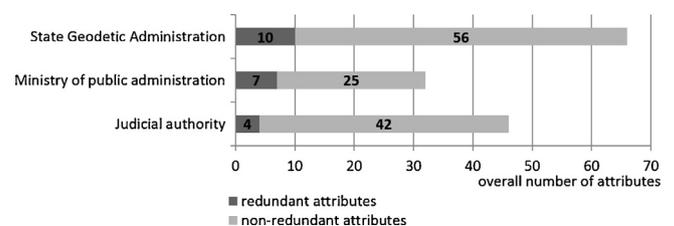


Fig. 5. Redundancy at individual public authorities.

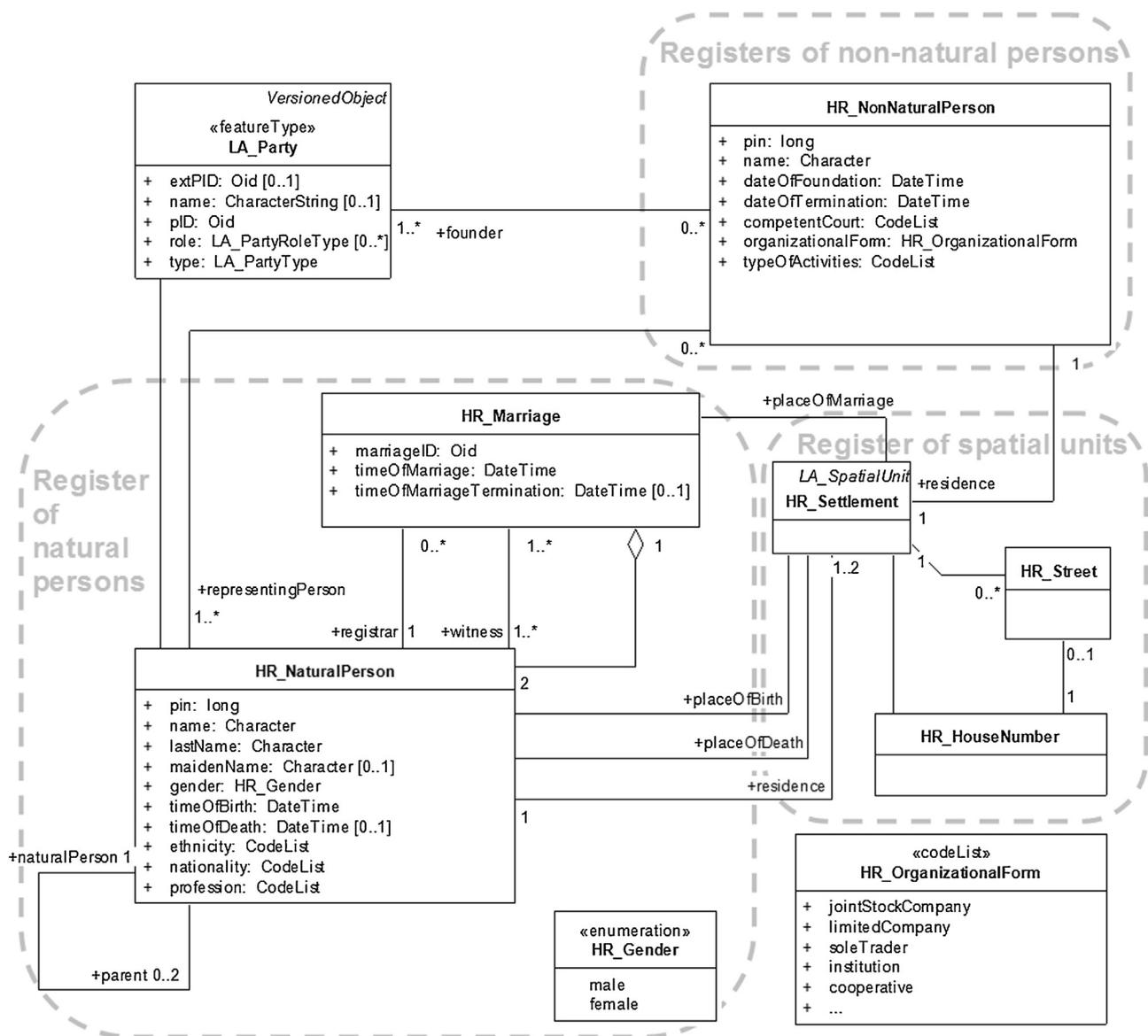


Fig. 6. Natural and non-natural persons.

Cadastre is the register of real properties. The Register of spatial units keeps data about names, territories and boundaries of administrative and technical spatial units such as counties, cities, districts, local self-government units, settlements, cadastral municipalities, statistical and census districts, streets and house numbers. Utility cadastre keeps data about power lines, water systems, sewerage systems, gas pipelines, thermal pipelines and other utilities together with associated facilities, as technical information only.

Compliance analysis

Analysis of official registers data compliance with the LADM was based on a comparison with the classes of three packages (Administrative package, Party package, Spatial Unit package) and one subpackage (Surveying and Representation package).

The Administrative package contains 8 classes with a total number of 20 attributes. Table 2 shows the LADM attributes and official registers in which they were identified. Attributes of the Administrative package have been found in analyzed registers in a large

amount. Cases in which a particular attribute of the Administrative package is identified in more than one official register are a certain indicator of redundancy.

The Party package contains 3 classes with a total number of 8 attributes. Table 3 contains the results of the comparison that indicates an extremely high level of redundancy in the field of some personal data.

The Spatial Unit package contains 6 classes with a total number of 24 attributes. Table 4 contains all identified attributes. A smaller number of identified attributes points to the fact that spatial data in the official registers are not yet at the level required by the LADM, regarding the diversity of collected spatial data and the way in which they are organized in official registers. For instance, the LADM supports 3D data. On the other hand, the obligation for 3D data does not yet exist in the Republic of Croatia. Therefore attribute *volume* could not be identified by any attribute of official registers. Traces of redundancy are also present here.

The Surveying and Representation package contains 4 classes with a total number of 17 attributes. Table 5 contains all identified

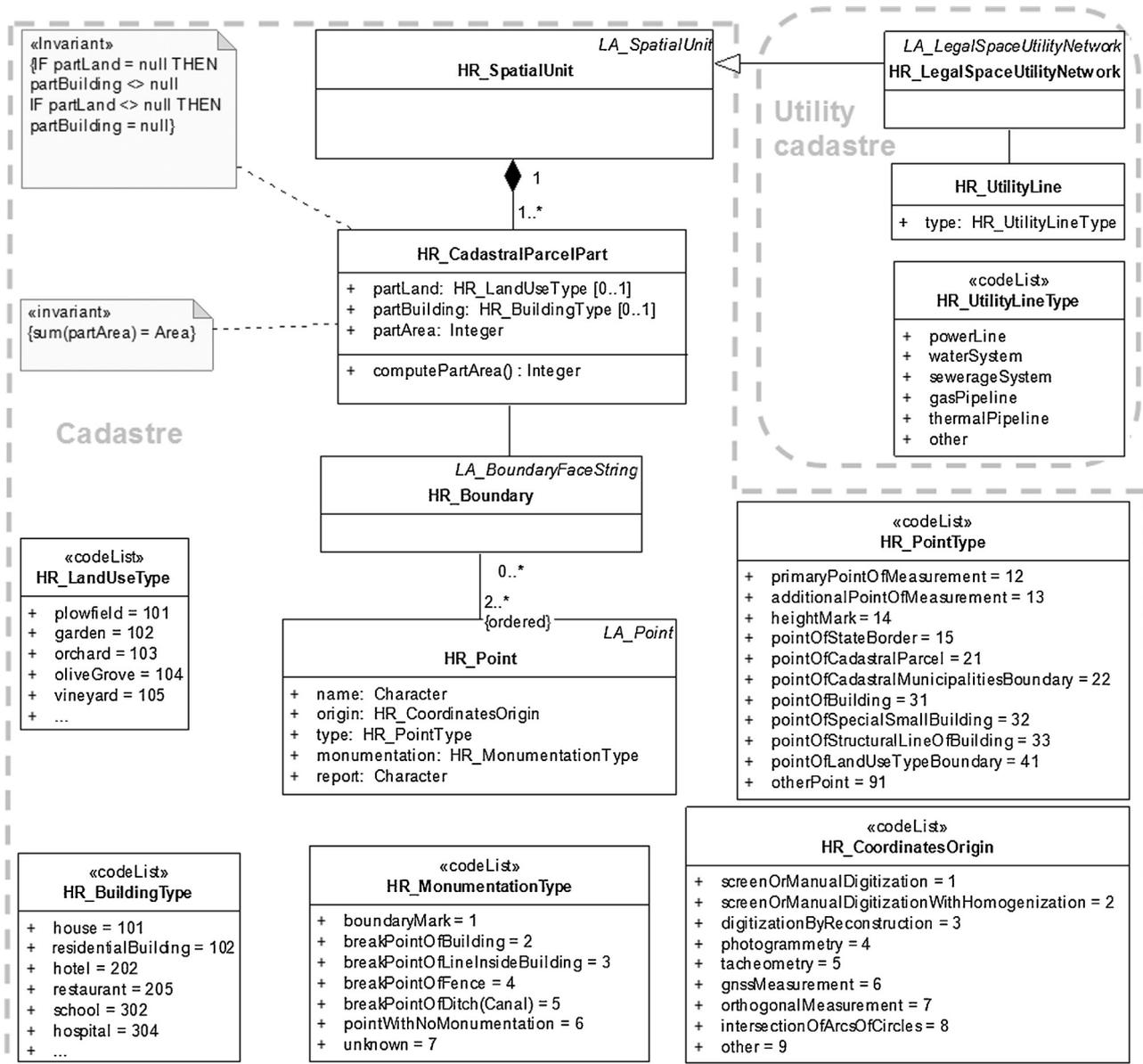


Fig. 8. Cadastral parcels and utilities.

thus producing redundancy. At the time when analogue technologies were used for data maintenance, such copying of data was the only available method to have additional relevant information about a recorded item originating from other registers, all in one place. However, later when electronic technologies emerged, such practice continued to be used as a result of the retained analogue logic and the analogue way of thinking in the newly established electronic environment. The largest redundancy was found in data related to natural and non-natural persons. This is not surprising if one takes into account the fact that almost every other register uses those data while there is no systematic solution for linking registers on a data level. The personal identification number provided by Tax administration, has systematically been introduced into the system of registers. Therefore we consider that the most appropriate way to deal with the redundancy in data related to natural and non-natural persons would be to include personal identification numbers while implementing the linkage with other parts of the national system of registers.

More surprising is the fact that a certain degree of redundancy exists when the level of individual public authorities responsible

for governing multiple registers is analyzed (Fig. 5). In the registers which are under the jurisdiction of the State geodetic administration a total of 66 attributes was discovered. Analysis revealed 10 attributes that appear on 2 or more occasions, which is a significant redundancy of 15%. In the registers which are under the jurisdiction of Ministry of public administration a total of 32 attributes was discovered. Analysis revealed 7 attributes that appear on 2 or more occasions, which is a significant redundancy of 22%. In the registers which are under the jurisdiction of the Judicial authority the total of 46 attributes was discovered. Analysis revealed 4 attributes that appear on 2 or more occasions, which is also a significant redundancy of 9%.

Especially situations like this should not occur because the public authority responsible for more than one register has an unrestricted access to all of the data, is fully familiar with the underlying data models, and thereby should be able to find simpler solutions for data sharing than those when data is kept under different jurisdictions. This type of redundancy also originates from the analogue era but nowadays there are no technical or administrative reasons for its existence. Additional analysis of the results presented by the

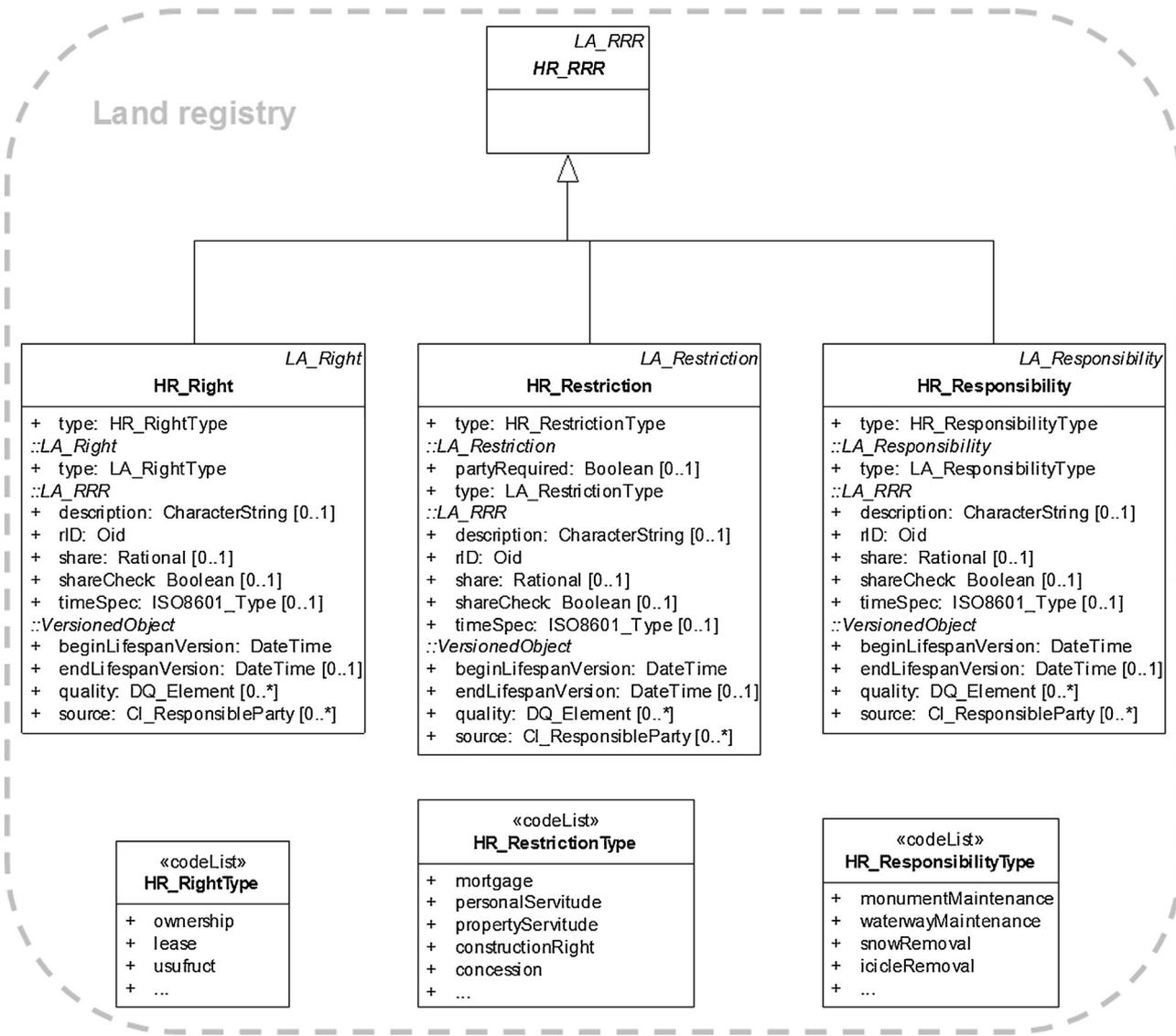


Fig. 9. Interests over the real properties.

previous figure shows that a significant amount of this redundant data is natively maintained by the individual public authority, thus confirming that the problem is caused by non-existing linkage, not only at the level of different jurisdictions but also at the level of individual public authorities. The following table shows the data maintained in the register which is native for it, but also in other registers of the same authority (Table 6).

Model of linking the analyzed registers

The model of linking the official registers was created using the standard Unified Modelling Language (UML) diagrams. It has been done by extending the LADM in parts which are outside its scope. Parts of each diagram bounded by dashed lines are the ones that can be recognized as parts of current official registers. The first diagram shows the extension of the LADM regarding the natural and non-natural persons (Fig. 6).

Detailed information on persons is outside the scope of the LADM so an extension has been made by classes HR.NaturalPerson and HR.NonNaturalPerson, which are included into the model by associating them with class LA.Party. By separating natural and non-natural persons into two separate specialization classes, their specific attributes were also separated. Such a separation is in

accordance with the divided jurisdiction over the data on persons. Class HR.NaturalPerson, together with class HR.Marriage represents the Register of births, Register of wedded and Register of deceased, which are all parts of one Register of natural persons.

The Register of spatial units keeps data about spatial units shown below (Fig. 7). Those data can be easily integrated with the LADM by associating them with the two basic classes of the Spatial Unit package: LA.SpatialUnit and LA.SpatialUnitGroup. Relationships of classes that represent spatial units are mostly series of aggregations resulting from their positional and hierarchical relationship in nature.

The basic registration unit of Cadastre is a cadastral parcel. Its spatial component is represented by class HR.SpatialUnit (Fig. 8). Although it is a basic unit of registration, a cadastral parcel can consist of even smaller parts which are differentiated according to the way of land use and cannot be registered individually, but only as a part of the basic administrative unit. Those parts are represented by class HR.CadastralParcelPart which may refer to land or a building (land beneath the building). Land use types and building types are presented by appropriate code lists. The HR.SpatialUnit class is a specialization of LA.SpatialUnit which represents the spatial component of all spatial units in the LADM. Its specialization HR.LegalSpaceUtilityNetwork is associated with

Table 6
Insight into redundancy of data maintained natively by public authorities.

Public authority	Attribute	Register
State geodetic administration	cadastral municipality identification number	Cadastr Register of spatial units
	cadastral municipality name	Cadastr Register of spatial units Utility cadastre
	cadastral municipality border	Cadastr Register of spatial units
	street/square name	Cadastr Register of spatial units Utility cadastre
	type of building	Cadastr Register of spatial units
Ministry of public administration	house number	Register of spatial units Utility cadastre
	name and surname of natural person	as explained earlier Register of natural persons, actually consists of three registers in which redundant existence of listed attributes was identified
Judicial authority	date and time of birth place of birth nationality	
	name of non-natural person	Registers of non-natural persons Land registry
	address of non-natural person	Registers of non-natural persons Land registry

class `HR.UtilityLine`, which is a class for utility data registration. Boundaries of spatial objects are defined by points measured in the field and are represented by class `HR.Point`.

Interests that can be established on the real properties are subjects of the Land registry. Based on registration in the Land registry those interests can be gained, lost or transferred between different persons. Registration of interests is entirely within the scope of the LADM and is represented by one of the main classes of the Administrative package, `LA.RRR`, i.e. its specialization `HR.RRR` (Fig. 9). It is an abstract class, so it gives no instances. Instances of its subclasses represent interests and can be recognized as real property rights, restrictions and responsibilities defined by civil law and incorporated as the most important part of the Land registry.

Conclusion

In this paper we presented our research on analysis of the state of redundancy within the (potentially) key registers of the Croatian system of land administration-related registers, accompanied by the proposal for implementing an effective linkage thereof. The analysis was executed using the schema matching techniques which are known from the database research domain. The proposed linkages were created by extending the UML models of the LADM.

By conducting our research we accomplished two objectives, which represent the main contributions of the work. Firstly, we produced a sound and justifiable overview of the status of the redundancy within the Croatian official land administration related registers, followed by suggestions as to how its effectiveness can be increased by introducing a linking. We concluded that it would be advisable to use personal identification numbers provided by Tax administration for the implementation of linking regarding the data about natural and non-natural persons which are outside the scope of the LADM.

This together can, and in our opinion should, present a starting point when creating a strategy for improving effectiveness of

the overall system of registers. The idea to use the LADM as a fixed central point of the analysis proved to be a sound and efficient approach. The stability and the maturity of the LADM make it an excellent anchor for analysing redundancy within the land administration related registers.

Furthermore, by using schema matching techniques to conduct the actual analysis we have shown its applicability to the domain of redundancy of the official registers. A simple manual schema matching approach proved to be appropriate for the extent of the data we wanted to cover within this research.

In future, we plan to investigate the applicability of more automated methods for schema matching and to include a wider spread of the registers into the analysis.

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