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Data model for the collaboration between land administration systems and agricultural land parcel identification systems

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ABSTRACT

The Common Agricultural Policy (CAP) of the European Union (EU) has dramatically changed after 1992, and from then on the CAP focused on the management of direct income subsidies instead of production-based subsidies. For this focus, Member States (MS) are expected to establish Integrated Administration and Control System (IACS), including a Land Parcel Identification System (LPIS) as the spatial part of IACS. Different MS have chosen different solutions for their LPIS. Currently, some MS based their IACS/LPIS on data from their Land Administration Systems (LAS), and many others use purpose built special systems for their IACS/LPIS. The issue with these different IACS/LPIS is that they do not have standardized structures; rather, each represents a unique design in each MS, both in the case of LAS based or special systems. In this study, we aim at designing a core data model for those IACS/LPIS based on LAS. For this purpose, we make use of the ongoing standardization initiatives for LAS (Land Administration Domain Model: LADM) and IACS/LPIS (LPIS Core Model: LCM). The data model we propose in this study implies the collaboration between LADM and LCM and includes some extensions. Some basic issues with the collaboration model are discussed within this study: registration of farmers, land use rights and farming limitations, geometry/topology, temporal data management etc. For further explanation of the model structure, sample instance level diagrams illustrating some typical situations are also included.

1. Introduction

The European Common Agricultural Policy (CAP) has changed substantially since 1992. The CAP has focused on the subsidies (direct aids) for the implementation of Market Policy and Rural Development Policy, and an integrated system is required for the management of these subsidies. This integrated system is called as Integrated Administration and Control System (IACS). Member States (MS) in the European Union (EU) have been using IACS in order to administer agricultural subsidies since 1992 (Krugh, 2000; Delince, 2001; van der Molen, 2002). Over time, IACS experienced some major changes triggering the use of concrete spatial reference systems. In this context, Land Parcel Identification Systems (LPIS) emerged in order mainly to spatially represent the activities of farmers on their land (JRC, 2001; Kay, 2002).

The LPIS as a concept was developed already in 1992 (Council Reg. No 3508/1992), when the need for identification of the agricultural parcels to support IACS had emerged. At that time, there was no restricting regulation and so the data model in many MS was purely alphanumerical without any spatial reference. It was in the Council Reg. No 1593/2000 that the spatial LPIS based on Geographic Information System (GIS) was first promoted. The 2003 CAP Reform (Council Reg. No 1782/2003 replaced by No 73/2009) forced the MS to establish LPIS in digital and geo-referenced format by December 1st 2005. As a result, the first year of an operational GIS-based LPIS was 2005 (Sagris et al., 2008).

Although the regulatory requirements are uniform across the sector (IACS/LPIS), the particular implementations were subject to MS subsidiarity. Some of the MS used their Land Administration System (LAS:[1] Land Registry and Cadastre) data, as starting point for the creation of the new registers (LPIS) required by the CAP, others made use of dedicated production block (farmer's block,

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[1] Note that LAS represents a modern Land Registry and Cadastre System.

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physical block) system (Milenov and Kay, 2006; Sagris et al., 2008). In fact, during the development stages of different LPIS in different MS, the use of LAS data as well as large-scale topographic mapping data were on the agenda for a considerable while; see Section 2.2.2. To date, different LPIS in different MS greatly differ in concepts and models of representation and spatially identification of the agricultural land use unit (Sagris et al., 2008). For these different LPIS, main spatial unit may be Cadastral Parcels (CP), Agricultural Parcels (AP), Farmer Blocks (FB) and Physical Blocks (PB) (see Section 2.2.2 and Section 2.2.3) depending on the LPIS design in different MS. These four different kinds of spatial units have different characteristics, yet all of them may be used as Reference Parcels (RP) of the LPIS. Even so, each LPIS can function properly to meet the needs for the management of agricultural subsidies. However, they are lacking of a standardized structure. Different IACS/LPIS structures even in different regions within the same country will definitely hamper implementations of National Geographic Information Infrastructure (GII) for each MS. Data interoperability at the EU level will definitely be another aspect of this issue in the future.

The aim of this study is to design a data model which is mainly based on LAS and which can also enable the management of agricultural subsidies as in the case of IACS/LPIS. This model does not cover all different types of IACS/LPIS implementations in the MS. In fact, it is useful only for the MS having adequately organized LAS, which reflects the current real world land use situation quite closely. Germany, Netherlands, France, Spain and Italy may be examples of having well organized LASs. Yet, current structures of LASs may not be adequate and new advances may be needed for a robust implementation of the data model introduced with this study. So, the aim of this study is to provide a common data model for the implementation of IACS/LPIS based on CPs within LAS. The model implies the development of both current LAS and also IACS/LPIS for the implementation of the model. It is based on previous standardization efforts both in the area of LAS and IACS/LPIS – ISO 19152 Land Administration Domain Model (LADM) (ISO/CD 19152, 2009) and LPIS Core Model (LCM) (Sagris and Devos, 2008a, b). A second objective is to investigate the efficiency and the quality of the model for the implementation of IACS/LPIS. For this purpose, only relevant parts/functionalities of LADM and LCM are discussed. In the following sections, you can find some information on LADM and LCM (Section 2), the data model for the collaboration, main issues and sample instance level diagrams for better understanding (Section 3), and some notes on the implementation of the model and other concluding remarks as the last section. The appendix contains a complete diagram showing the proposed model as a whole with its basic components.

In this study, the figures are presented in Unified Modeling Language (UML) Class Diagrams. UML was introduced by Object Management Group as an international standard for application structure, behavior, and architecture, but also business process and data structure (see, www.uml.org). UML has largely been used by professionals and also by scientists (see, Page-Jones, 2002; ISO/IEC, 2005; OMG, 2009).

2. Background

In this section, background information on LADM, LCM and their history of development are presented.

2.1. Land administration domain model (LADM)

2.1.1. Different land administration systems (LAS) throughout the EU

The scope of LAS, both the legal/administrative and the geographic components, differs throughout the EU and depends on the history and the social structure of different countries. Some systems primarily aim at fiscal purposes (cadastres), and some others aim at legal security (land registries). Satisfying those two aims is often, but not always, coordinated, but only in a few (but growing number of) cases combined in one organization. In several countries, additional (environmental landscape or planning) aims are also served by the LAS. The different set-ups per country are usually treasured, and seem outside of the scope of the EU's authority (article 295 of the Treaty Establishing the European Community). So, initiatives as EULIS (Ploeger and van Loenen, 2005) aim at one access portal, leaving the underlying systems as they are (for further understanding, see Zevenbergen et al., 2007). For the short term, aiming to deliver legal (administrative) data is the current goal. However, for the long term, it should be considered also including spatial data in such initiatives. At the moment, the INSPIRE drafting team and the different thematic working groups (see INSPIRE Directive, 2007) are working on the harmonization of 34 themes, including cadastral parcels (INSPIRE DT DS, 2008 and INSPIRE TWG CP, 2008) between the 27 member countries of the EU.

2.1.2. LADM as an initiative for an international standard

LADM was initially developed under the name of the Core Cadastral Domain Model (CCDM). It was first discussed in a number of scientific meetings. Several versions of CCDM were published; among these are van Oosterom et al. (2006) and Lemmen and van Oosterom (2006). In early 2008, the International Federation of Surveyors (FIG) submitted LADM to ISO/TC 211 as a new work item proposal for an international standard. It was accepted and has been under development as an international standard (ISO/CD 19152, 2009). As a contribution to these efforts, LCM/LADM collaboration model proposed by this study is planned to be an annex of the ISO19152 – LADM.

2.1.3. Basics of LADM

LADM covers all basic information-related components of land administration. It provides a terminology for land administration, based on various national and international systems, that is as simple as possible in order to be useful in practice. The terminology allows a shared description of different formal or informal practices and procedures in various jurisdictions (ISO/CD 19152, 2009). All internal classes of LADM have the prefix "LA_" to be distinguished from the collaborating classes originally outside of LADM. The core of LADM is based on the four basic classes (Fig. 1):

1. LA_SpatialUnit: An instance of a subclass of LA_SpatialUnit (e.g. parcel, building, or network) is defined as a single area of land or, more specifically, a volume of space, under a unique and homogeneous (bundle of) right(s) (e.g. a property right, a land use right); definition based on UN-ECE (2004) and WG-CPI (2006).
2. LA_LAUnit: An instance of it is a unit recognized as a legal unit for land administration, and subject to registration (by law), or recordation (by informal right, or customary right, or another social tenure relationship) (ISO/CD 19152, 2009). This class is associated with spatial units (including cadastral parcels) via the super class LA_SpatialUnit.
3. LA_RRR (Right, Restriction, Responsibility): It is an abstract class (it has no instances). An instance of a subclass of LA_RRR might be a right, a restriction, or a responsibility.
4. LA_Party: It represents natural, non-natural and group of persons. It may also represent an instance of LA_LAUnit as a party (see Fig. 1).

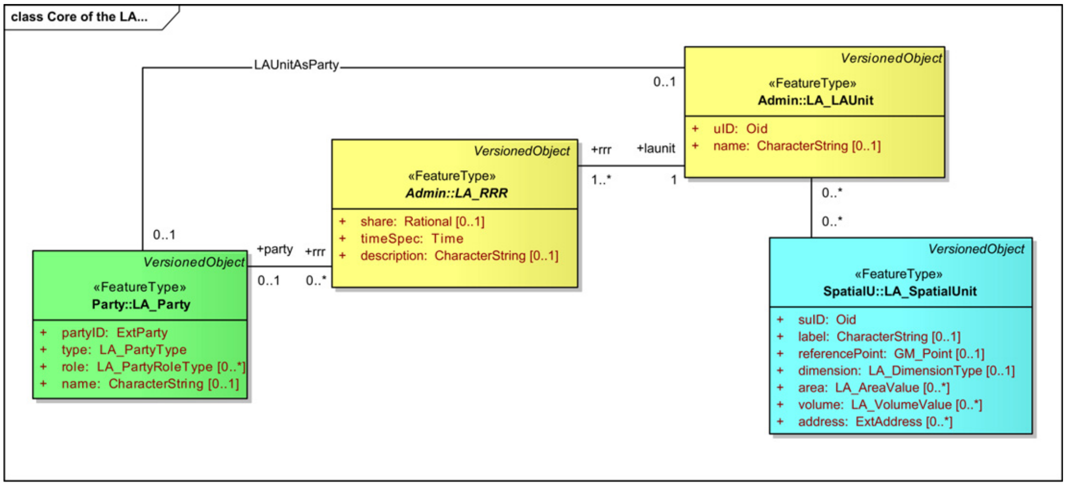

Fig. 1. The core (classes) of land administration domain model.

The model supports the temporal aspects of the involved classes: LA_Party, LA_RRR, LA_LAUnit, and LA_SpatialUnit and other basic classes all inherit from Versioned Object (with temporal attributes based on ISO 19108; see Section 3.3.3). The model offers three basic types of Spatial Unit representation: 2D, liminal and 3D. For the 2D data, the model supports topologically structured, polygon, unstructured, or simply point or textual descriptions (ISO/CD 19152, 2009) (see Section 3.3.2).

The class LA_SpatialUnit is one of the core classes of LADM. It is an abstract class, which represents all types of spatial objects and, also real estates in association with the class LA_LAUnit. Different types of spatial unit classes (LA_Parcel, LA_Building and LA_Network) are designed as specializations of LA_SpatialUnit, and so, they inherit all properties of this class. This class also associates with the class LA_SpatialUnitSet that is to represent different hierarchical levels of administrative boundaries. Out of all these spatial units, our LCM/LADM collaboration model concentrates only on the class LA_Parcel, which represents cadastral parcels (see Section 3.1).

LADM contains administrative object classes for persons (parties) (LA_Party, LA_GroupParty) and for the representation of property rights (LA_RRR as a generalization and LA_Right, LA_Restriction, LA_Responsibility as specializations). It also includes the classes to represent geographic description (LA_SpatialUnit) of real estate objects (LA_LAUnit) (see Appendix). The structure of the model supports data maintenance by different (but cooperating) organizations. The model can be implemented in a distributed set of (geo-) information systems, each supporting the maintenance activities and the information supply of parts of the data sets represented in this model (diagram), thereby using parts of the model. The model can also be implemented by one or more maintenance organization(s) operating at national, regional or local level. This underlines the relevance of the model: different organizations have their own responsibilities in data maintenance and supply, but can communicate on the basis of standardized legal, administrative and technical information exchange (ISO/CD 19152, 2009).

2.2. LPIS core model (LCM)

2.2.1. Systems for administration and control of agricultural subsidies in the EU member states

The geo-informatics aspect of the administration and control of agricultural area-based subsidies in the EU MS is relatively young, if we compare it to that of the traditional LAS which were established much earlier and operate through stable and formalized procedures. Although the idea of the LPIS systems dates back to the 90s, the systems only became a compulsory part of the IACS since 2005. In recent years, the agricultural sector has recorded a large amount of geo-information concerning the use of farmer's fields. Nowadays LPIS systems are expanding their scope towards the so-called CAP second pillar – sustainable rural development, which respects environmental and societal needs. However, the domain is not well-known for the general geo-information public, there are only a few scientific publications covering geo-informatics aspects in this sector (Milenov and Kay, 2006; Sagris et al., 2008). One of the

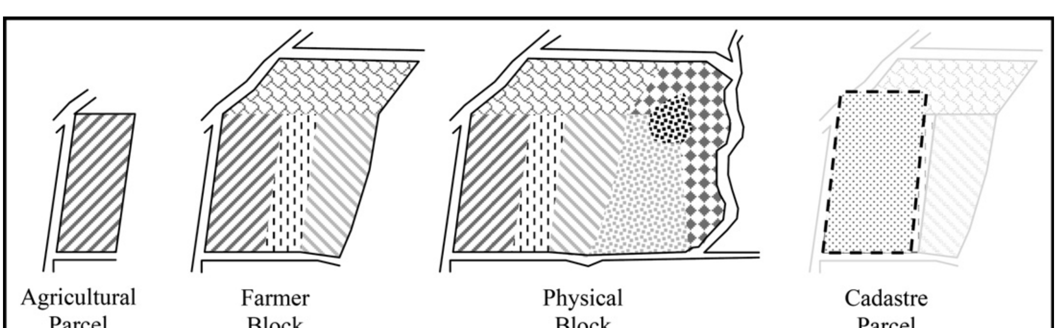

Fig. 2. Different reference parcel types used for IACS/LPIS applications and their relation (adopted and elaborated after JRC, 2001).

Table 1
Different type of reference parcel and their main properties (from Sagris et al., 2008).

	Agricultural parcel (AP)	<Farmer block (FB)	<Physical block (PB)	Cadastral parcel (CP)
Land use for aid scheme	One single crop group	One or several crop groups	One or several crop groups	Does not match agricultural pattern
Applicants	Single farmer	Single farmer	One or several farmers	One or several farmers
Temporal aspect	Annual	Multi – annual	Semi – permanent	Land tenure cycle
Main data source	Farmers' application	Farmers' survey	Administration survey	Land Register/Cadastre

unique advantages of the domain, underlined by these authors, is that it has a single legal basis and common set of requirements laid down by the EU regulations, which can be considered as a good precondition for standardization.

The central concept connecting all stakeholders in the domain is the farmer's single application. The farmer lodges a single yearly application for all aid into the IACS operated by the paying agency, which is established in each MS. Among other data, the farmer's single application shall mention (Commission Reg. No 1122/2009): (a) the identity of the farmer; (b) the aid scheme(s) concerned; (c) the identification of payment entitlements; (d) particulars permitting identification of agricultural parcels on holding and their area. In plain words, each farmer registered to the system shall activate his entitlements, which gives him the right to benefit from one or several EU payment schemes. Entitlements were allotted to farmers actively farming at the date each MS introduced the Single Payment Scheme (SPS) based on the reference amounts they received previously (amounts of direct payments each farmer received in the three-year period individually or per region). Note that so-called new MS had the option to implement a simplified scheme without entitlements (Single Area Payment Scheme: SAPS) where all eligible hectares represent the same financial value.

Additionally, in order to receive aid in the form of direct payments, farmers must fulfill cross-compliance conditions. Cross-compliance is a concept for ensuring that agricultural activities by farmers are undertaken with respect for rural sustainability, environmental and sanitary requirements. Failure by farmers to respect these conditions can result in deductions from, or complete cancellation of, payments. Areas of cross-compliance cover the EU policies established by European Directives and Regulations relating to the protection of environment, public, animal and plant health, and animal welfare (the Statutory Management Requirements). The MS should also ensure that all agricultural land is maintained in Good Agricultural and Environmental Conditions and should establish national or regional measures for these purposes under a common European framework. A considerable part of the cross-compliance requirements involves geographic components (e.g. location inside a protected zone or topographic elements such as slopes prone to erosion). These requirements call for special practices on the land, often named farming limitations or farming restrictions.

2.2.2. *Spatial concepts of the IACS/LPIS*

AP is a key spatial concept applied in relation to area-based payments, which determines the subject of the aid application, its geographic location and the extent (area) of the agricultural activity. It represents the land over which payment entitlements may be activated and for which payment may be claimed. In addition to being the subject of the payment calculation, AP is also a subject of administrative crosschecks and control procedures established in IACS. Due to the dynamic nature of agricultural activities, AP can be unstable over time and space (crop rotation, out of use, aggregation or subdivision of fields, different extent of use, conditions for eligibility for payments etc.). Therefore, Article 6 of the Commission Reg. No 1122/2009 stipulates that, for the purpose of identification of the AP referred in Article 17 of the Council Reg. No 73/2009, Reference Parcel (RP) should be the basic unit of the LPIS. No aid can thus be claimed outside an RP of the LPIS. The regulation also indicates that an RP could operate as a cadastral parcel or as a production block (FB, PB) (see Fig. 2). RP may contain one or many AP declared for aid by one or several farmers and shall have a unique identifier at national (in some countries regional) level.

A small number of MS decided to record the LPIS data for each AP (in this case AP functions as RP). Thus, this type of RP is also addressed as Agricultural Parcel (spatial AP further in our model; see Fig. 2), which often cause confusion with the concept of the declared AP. The advantage of this approach is that each field declared by a farmer can easily be measured and identified in GIS and therefore other registers can directly query them. On the other hand, it requires an annual and costly revision of the whole database.

Countries, which opted for a block system, made use of two approaches: adjacent AP of a single farmer create (1) an FB based on production pattern or (2) a PB according to physical (topographic) boundaries of a continuous stretch of agricultural land. Block-based systems are much more stable over time, but involve control procedures that are more sophisticated.

Finally, some of the MS chose cadastral parcel as RP. Fig. 2 contains graphical representations of different types of RP and Table 1 gives their main properties. The choice of the RP is an example of subsidiarity in the adoption of the EU regulations in order to find the most appropriate solutions for the agricultural pattern of each country. A more detailed overview on different types of RP can be found at Milenov and Kay (2006) and Sagris et al. (2008).

The spatial units (RP) and the classification of land use/cover are the two central issues, which require standardization (Sagris et al., 2008; Sagris and Devos, 2008a, b). However, the problem of the standardization of the RP inside the complete domain is out of the scope of this study. Our efforts have been concentrated indeed on only one particular case; cadastre-based LPIS systems. The overview of approaches adopted by the EU MS based on surveys from 2006 to 2008 indicated that only a few of the EU countries opted for the use of the cadastral parcel for their LPIS (Milenov and Kay, 2006; Zielinski and Sagris, 2008). According to the latter survey, Austria, Poland, Italy, Spain, and Cyprus are these

Table 2
Examples of different land use/cover classes stored in LPIS data sets (from Sagris et al., 2008).

Country	Type of land use recorded	Type of RP
DK, UK-NI	None	PB
HU	Eligible; Non-eligible	PB
SE	Agricultural land	PB
LT	Agricultural blocks; Build-up blocks; Miscellaneous blocks; Grassland blocks; Orchard blocks; Non-subsidized area blocks	PB
DE-Bavaria	Farmland; Permanent grassland, Permanent orchard; Vineyard	FB
FI	Field; Forest; Pasture	FB
IE	Forage; Arable; Set-aside; Forestry; Other	AP

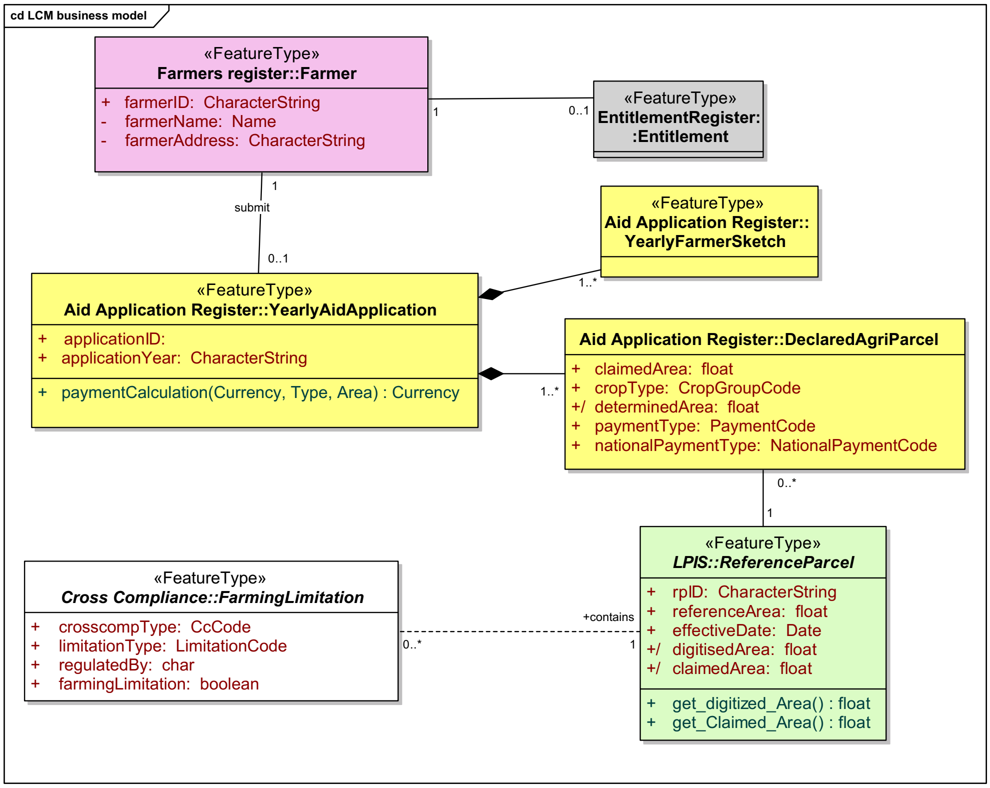

Fig. 3. The core classes of LCM.

countries. There are several reasons for this. Firstly, as mentioned by the survey authors, cadastre-based systems have a different philosophy of the spatial unit (cadastral parcel) which is primarily based on ownership, compared to the other types of RP based on land cover/use. The main difficulty of the cadastral parcel as RP, in contrast to other systems, is that it may contain both agricultural and non-agricultural land. So, the area eligible for the CAP payments cannot be directly quantified. In addition, those boundaries of agricultural activity are in general out of the LAS scope and their maintenance via the cadastral update cycle is very complicated.

For CP, AP as well as block-based systems (based on FB or PB) there is often a mixture of concepts of land cover and land use applied for the representation of agricultural land. Several countries store purely land cover information such as arable land, grassland, permanent crops. Others make use of detailed land use classifications where all possible crops are recorded. For comparison, the land cover class arable land can be used for growing for example wheat, rye, or barley. Encoding of the land cover/land use is also very variable depending of the particular situation in the MS (Sagris et al., 2008). Examples of different types of land cover/land use can be seen in Table 2.

2.2.3. *Basics of LPIS core model (LCM)*

LCM has been developed by the MARS unit of the Institute for Protection and Security of the Citizen of the European Commission Joint Research Centre. The first version of LCM was available for discussion among domain experts from January 2008 and published at the outset by Sagris and Devos (2008a, b) and this version of LCM is still under discussion, fine-tuning and testing in the MS. Contrary to domain models in general, the intention of this LCM is not to propose an extensive rigid model that covers every aspect of the implementation; it is rather intended as a base whose boundaries may be extended by domain experts for national implementation needs through further analysis and development.

Fig. 3 represents the main concepts (core classes) of the IACS/LPIS system. In order to manage data of farmers' applications, IACS should (Council Reg. No 73/2009, Art. 17) contain the following components: (1) a computerized database; (2) an identification system for agricultural parcels also known as LPIS; (3) a system for identification of entitlements; (4) register for aid applications; (5) an integrated control system; and (6) identification system for farmers. In short, it is an information system containing several inter-related components of register, one of them has geographic/spatial content (LPIS, in green[2] on the Fig. 3) and the others are alphanumerical components of the information system. For the purpose of this study, all LCM administrative classes are, in this section, presented in their original colors, later (as of Section 3) for the collaboration model, they are presented in grey[2] – these are further incorporated and elaborated by collaboration model in one IACS/LPIS administrative package. In LCM, in fact, they belong to different packages corresponding to different IACS registers (see Fig. 3). In addition, the names of key classes differ slightly from what can be found in previous publications. This is done in order to better illustrate the relations between LCM and LADM for the collaboration model.

The key concept farmer's single application is represented in the model as YearlyAidApplication class. The Farmer, registered in IACS via farmers' register combines all claims for aid from different support schemes such as area-based crop payments, livestock payment, rural development, etc. in one single application form. The Farmer can submit 0 or 1 applications each year. In order to do this, the farmer should have payment entitlements which are the

[2] See the online version.

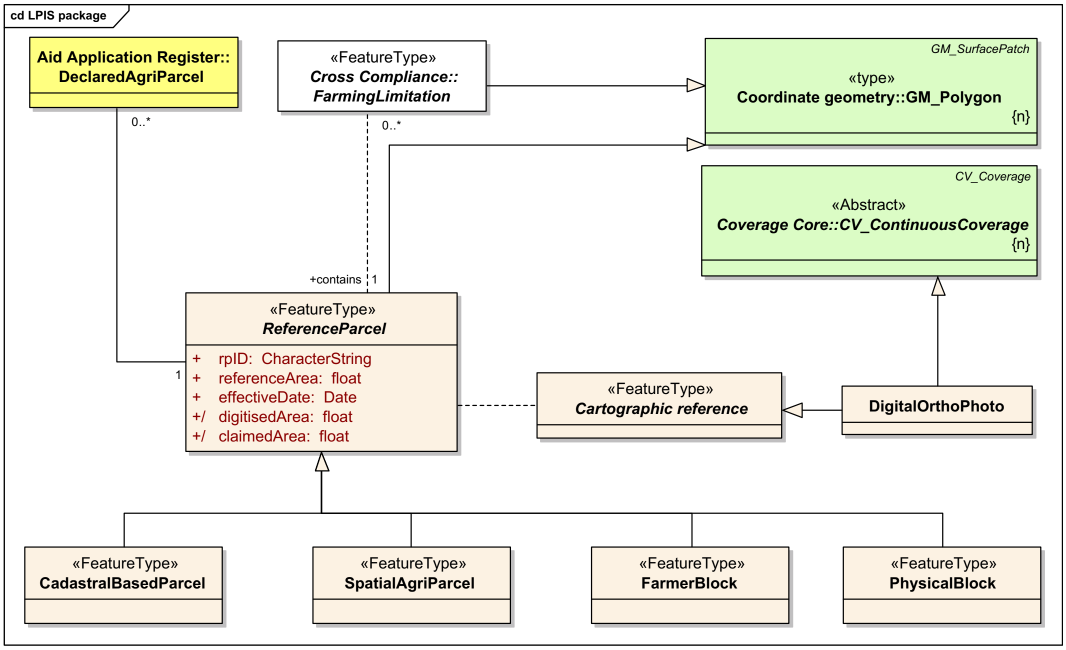

Fig. 4. Spatial features of LCM.

basis for his claim – class Entitlement in the model. Among other information, the YearlyAidApplication contains records on agricultural parcels the farmer cultivates and has on his holding parcel and farmer's sketch where he or she indicates the location of farming activity – classes AgriculturalParcel and FarmerScketch correspondently.

Each AP (DeclaredAgriParcel class in Fig. 4) declared by the farmer in his application documents shall refer via identifier to one of the RP of LPIS. Each AP shall be located inside of one of RP of the LPIS, but on the other hand each RP can contain none, one or several declared AP. The ReferenceParcel class has four specializations (Fig. 4) – one per RP type. In LCM, class ReferenceParcel is an abstract class. It has attributes, which are mandatory to all its specializations: they are rpID, referenceArea and effectiveDate. Furthermore, each RP can have none, one or several farming limitations from cross-compliance requirements and standards. They are combined under abstract class FarmingLimitation, which can have specializations according to the type of cross-compliance. Only farming limitations which have a spatial distribution and can be presented by spatial data layers are included in LCM. The class FarmingLimitation may entirely include or overlap with the ReferenceParcel. Both classes are spatial features and therefore use the coordinate geometry data type Polygon as defined in ISO 19107 (Spatial Schema). However, there may be point or line features as farming limitations. These cases are currently excluded by LCM.

3. Model design

In this section the details of the design of LCM and LADM Collaboration Model are presented. For the presentation, UML class diagrams are used. Spatial and administrative classes, their basic interactions and some special issues raised during the design process are presented in different sub-sections. In the diagrams (figures) of this section, administrative classes that originate from LCM are shown in grey[3]; classes originating from LADM retain their default colors.[3]

[3] see the online version.

3.1. Spatial classes

LCM/LADM collaboration model proposed with this study concentrates on the cadastral parcel, which is represented in the model by LA_Parcel as a specialization of the super class LA_SpatialUnit (see Fig. 5). With the spatial classes of the collaboration model, our primary aim is to use cadastral parcels as spatial basis for identification of the reference parcel for the agricultural (CAP) application. Here we have introduced an idea of a sub-parcel (see SubParcel class in Fig. 5), which represents different agricultural land cover classes within the cadastral parcel. In the spatial part of the collaboration model, the SubParcel is the only new class, which is originally not a part of LADM (the idea of sub-parcel is simply introduced in LADM without any attributes) nor of LCM, and which is developed as an extension for LCM/LADM collaboration model. The land cover classification (through SubParcel class) within the cadastral parcel (see Section 3.1.1 and Fig. 6) is proposed considering the particular requirements of the CAP regulations and common practices used by the MS (see Section 2.2.2).

3.1.1. SubParcel class as delineation of agricultural activity extend within cadastral parcel

As a specialization of LCM class ReferenceParcel, the SubParcel class inherits all the former's attributes in order to support IACS functionality. There is no need for separate date attribute as the SubParcel is a VersionedObject in LCM/LADM collaboration model (see Section 3.3.3). With the inherited attribute coordinateGeometry, the structure is limited to polygon (data type GM_Polygon) in the current design. Further, we introduced the typeSubParcel attribute, to hold information on the land cover inside particular sub-parcel. This attribute is crucial for identifying spatial objects, which contain land eligible for agricultural subsidies. Initially, the land cover classes included only three main classes (cultivated, planted and non-Agricultural) in order not to cause complexity in the applications (see Inan et al., 2008). Afterwards, the classification has been extended considering the IACS/LPIS applications in the MS (see Section 2.2.2). From the mixture of land cover/land use classifications, we opted clearly for land cover approach. The advantage here is that land cover

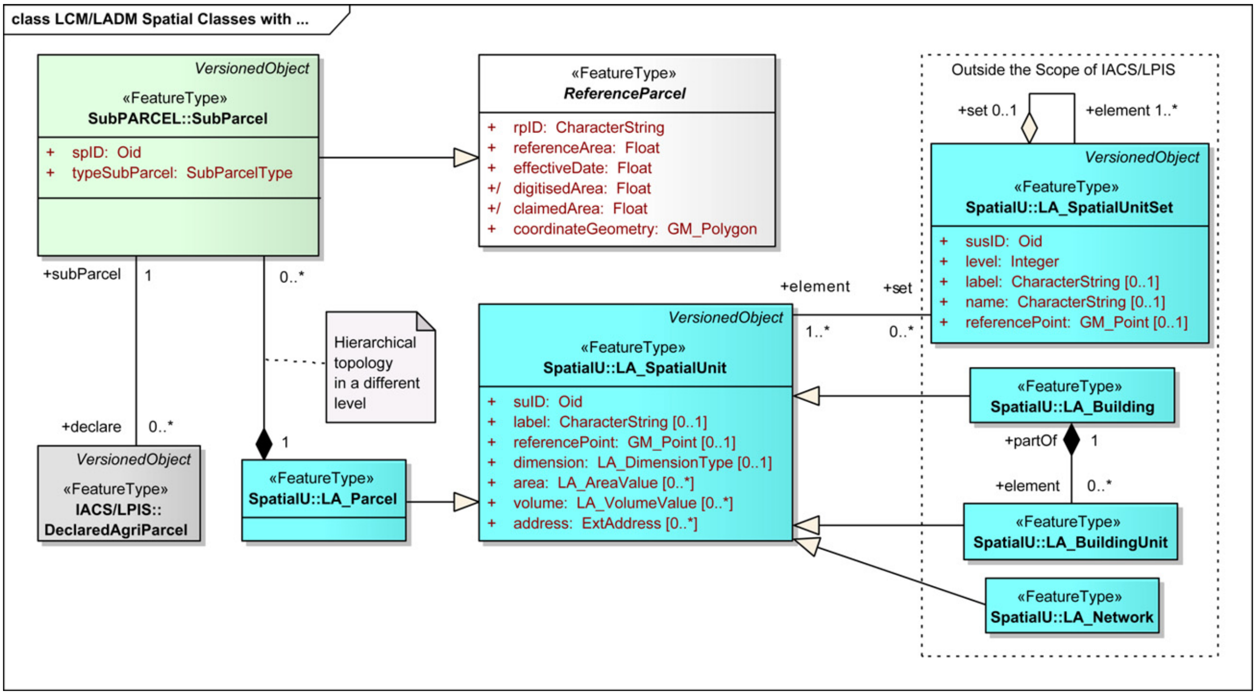

Fig. 5. Spatial classes in LCM/LADM collaboration model.

represents a notion, which is relatively stable over time compared to land use and which is unambiguous (e.g. arable land can be used for growing different cereals or crops). The land cover approach should yield that less effort will be needed for updating the databases and changes of eligibility conditions will not necessarily trigger an LPIS spatial data upgrade. We have also examined the CAP regulations in order to fine-tune the proposed classification and to ensure that it reflects the requirements of the subsidies practice. The final classification proposal is presented in Fig. 6 (see code list SubParcelType).

3.1.2. Cadastral parcel as frame for reference parcel and functionality of SubParcel class

The SubParcel class is designed as part of LA_Parcel. This design implies that all instances of SubParcel associated with one instance of LA_Parcel must also be spatially related. This calls for topology relation in the design (Fig. 5, see the note attached the association between SubParcel and LA_Parcel). So, it can be said that the two classes (SubParcel and LA_Parcel) are spatially/topologically dependant. This dependency has a crucial role in the model for the association between IACS/LPIS data and LAS data.

The relation between administrative classes of LCM, in particular DeclaredAgriParcel class and LA_Parcel class, is established through the SubParcel class. The model needs to offer a standardized land cover classification within cadastral parcels, and for this, the class SubParcel functions as a standardized land cover classification (see Section 3.1.1) and as a mediator between Cadastral Parcel and Agricultural Parcel concepts. Through this class, it is possible to establish a clear association between farmer declarations (DeclaredAgriParcel) and different types of agricultural activities taking place within a cadastral parcel.

The LA_Parcel class is designed as a composition of SubParcel class. This means that instances of SubParcel class cannot stand without an associated instance of LA_Parcel. In other words, instances of SubParcel are dependent on instances of LA_Parcel. On the other hand, LA_Parcel (through LA_SpatialUnit) has

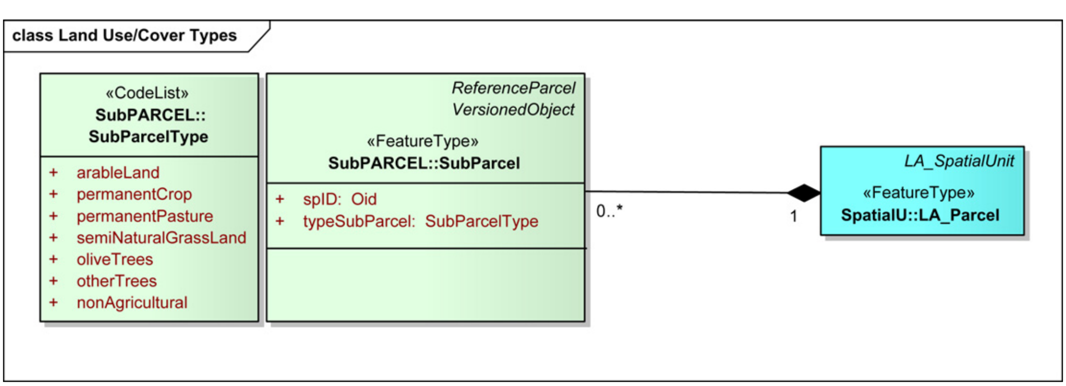

Fig. 6. Basic land cover classification with the spatial class SubParcel.

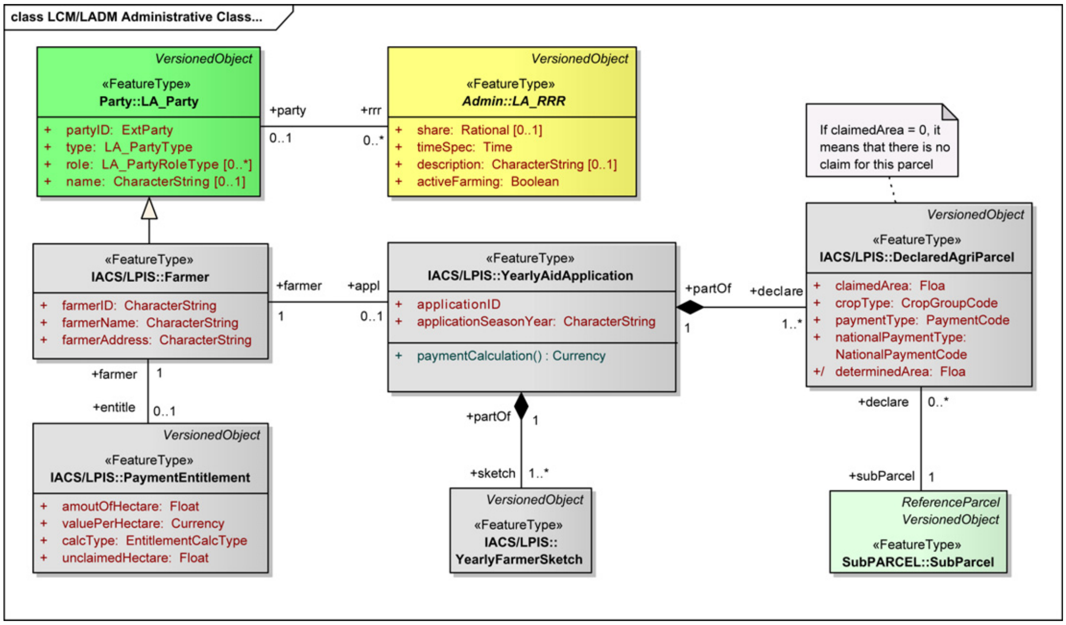

Fig. 7. Administrative classes for LCM/LADM collaboration model.

association to LA_LAUnit. As a result, all Rights-Restrictions-Responsibilities (LA_RRR) associated with LA_LAUnit and thus with the LA_SpatialUnit are also applicable for SubParcel (see Section 3.3.4). It should also be considered that, according to the current CAP regulation, the right of a farmer to benefit from agricultural subsidies (his activation of an entitlement) is not directly connected to the land, but it is associated with the farmer. The relation between payment entitlement and agricultural land needs to be re-established every year through the process of farmer's application.

3.2. Administrative classes

Fig. 7 presents the basic classes designed to manage administrative data in the collaboration model. LA_Party (person) and LA_RRR are two core classes coming from LADM. Classes Farmer, YearlyAidApplication, DeclaredAgriParcel, YearlyFarmerSketch originate from LCM. They are included in the collaboration model with some modifications/adaptations (for the original LCM classes, see Section 2.2.3). For AidApplication and FarmerSketch classes, the prefix 'yearly' is added in order to underline temporal aspects of these classes in the system (see Fig. 7). The attributes of these classes were reviewed and redefined during discussions with domain experts and their code lists were added (see Fig. 8).

The Farmer class is designed as a specialization of LA_Party class in order to handle the attributes specific to farmers. To handle the application information of farmers, YearlyAidApplication class is adapted from LCM. To represent the entitlement they possess, the PaymentEntitlement class is also adapted from LCM and further developed for the collaboration model. A farmer's declaration is represented by DeclaredAgriParcel in the model. It is designed as a part of the YearlyAidApplication class because this class cannot exist without any aid application. In the case of multiple pieces of land (as determined by the cropType in the DeclaredAgriParcel) claimed in an aid application, this

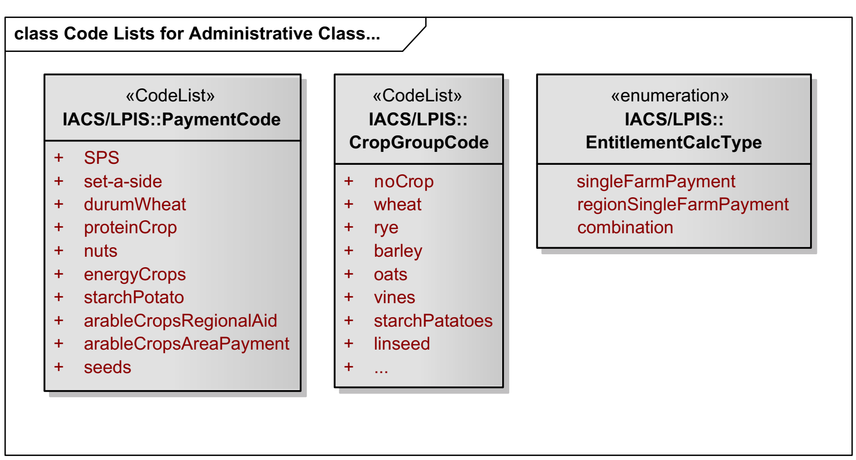

Fig. 8. Code lists for the attributes of administrative classes.

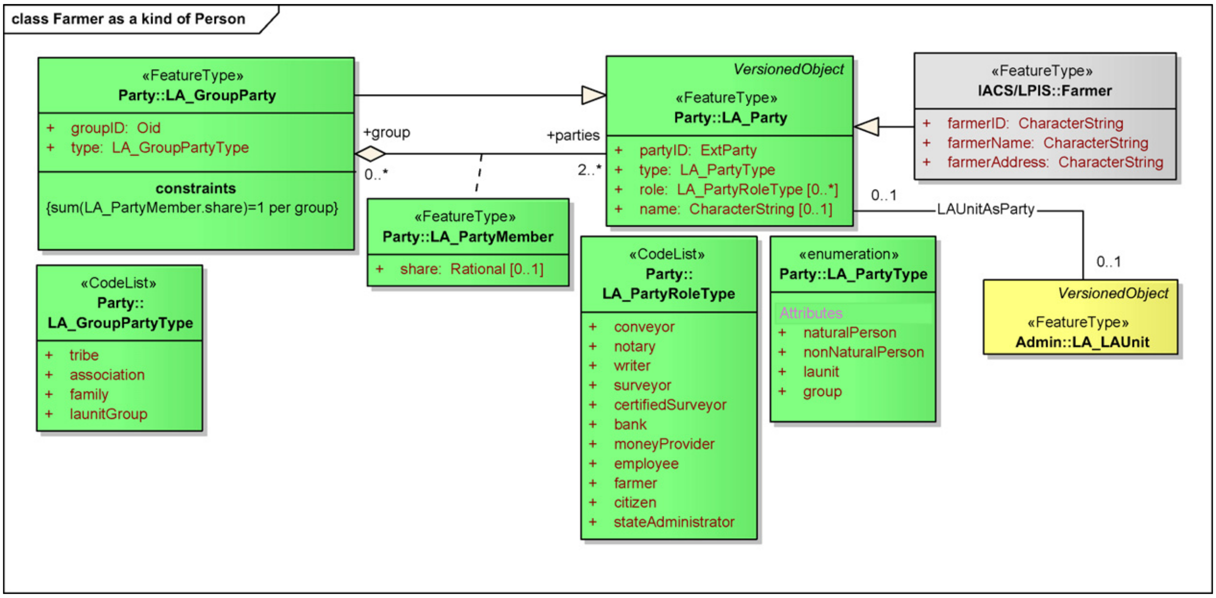

Fig. 9. LA_Party, LA_GroupParty and Farmer.

application must include an individual declaration for each piece. So, in this case, each piece of land is represented by one instance of DeclaredAgriParcel class. The Farmer class includes three basic attributes farmerID, farmerName and farmerAddress. This class will function to populate up-to-date information about farmers (e.g. their address information). For aid applications, farmers have to provide up-to-date personal information before their application. Other attributes may be added to the Farmer class depending on the need in specific countries as well as personal information facilitating control, communication and payment, e.g. bank account of the farmer or farmers' association.

The PaymentEntitlement class has currently four attributes. The attribute amountOfHectare represents the total area (in hectares) for which a farmer can get subsidy when activated during the application process. The attribute valuePerHectare, is calculated by dividing a reference amount (the total amount of subsidy during a reference period) by a reference area (of land). For this attribute, there are three basic calculation types – historic, regional and hybrid (DG Agri., 2009). The attribute calcType is designed to represent these calculation types (see Fig. 8 for the enumeration class of EntitlementCalcTypes). The attribute unclaimedHectare represents the amount of land (amountOfHectare) not claimed, but declared in the current season (see Fig. 7).

YearlyAidApplication is the main class for the registration of aid applications and related information. It has two attributes. One is applicationID (e.g. farmerID + year), which is designed to associate all other related information with the application process. The attribute applicationYear is designed to indicate the time period for which the application is valid. YearlyFarmerSkecth and DeclaredAgriParcel classes are parts (composition) of this main class. These two classes have no meaning without the association with YearlyAidApplication class.

The DeclaredAgriParcel class is designed to store all declaration information from farmers. Farmers do not have to do all the work to re-declare their land and agricultural activities separately every year if there is no change in their land. The Paying Agency is

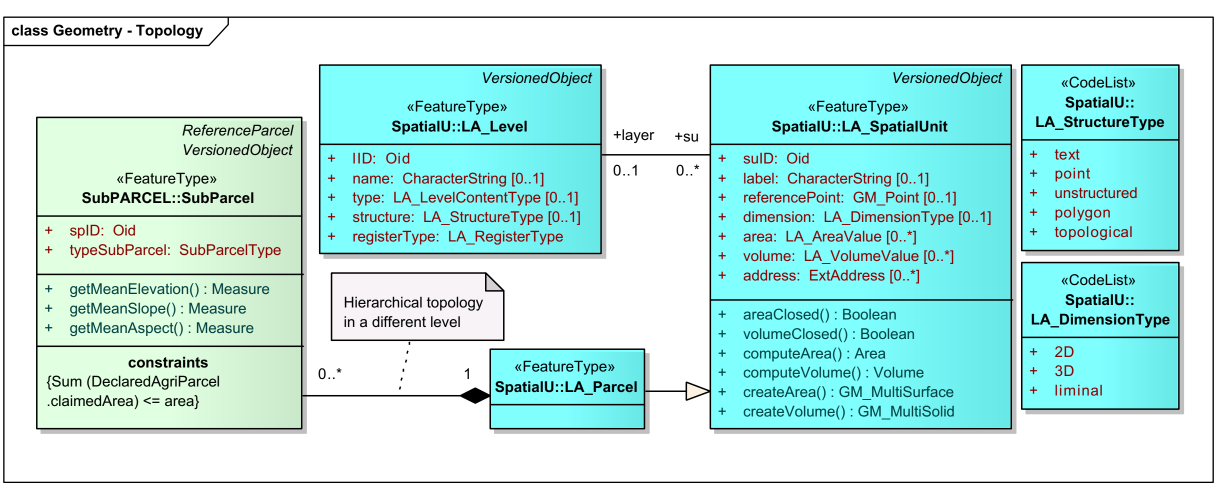

Fig. 10. Topology rules for spatial data.

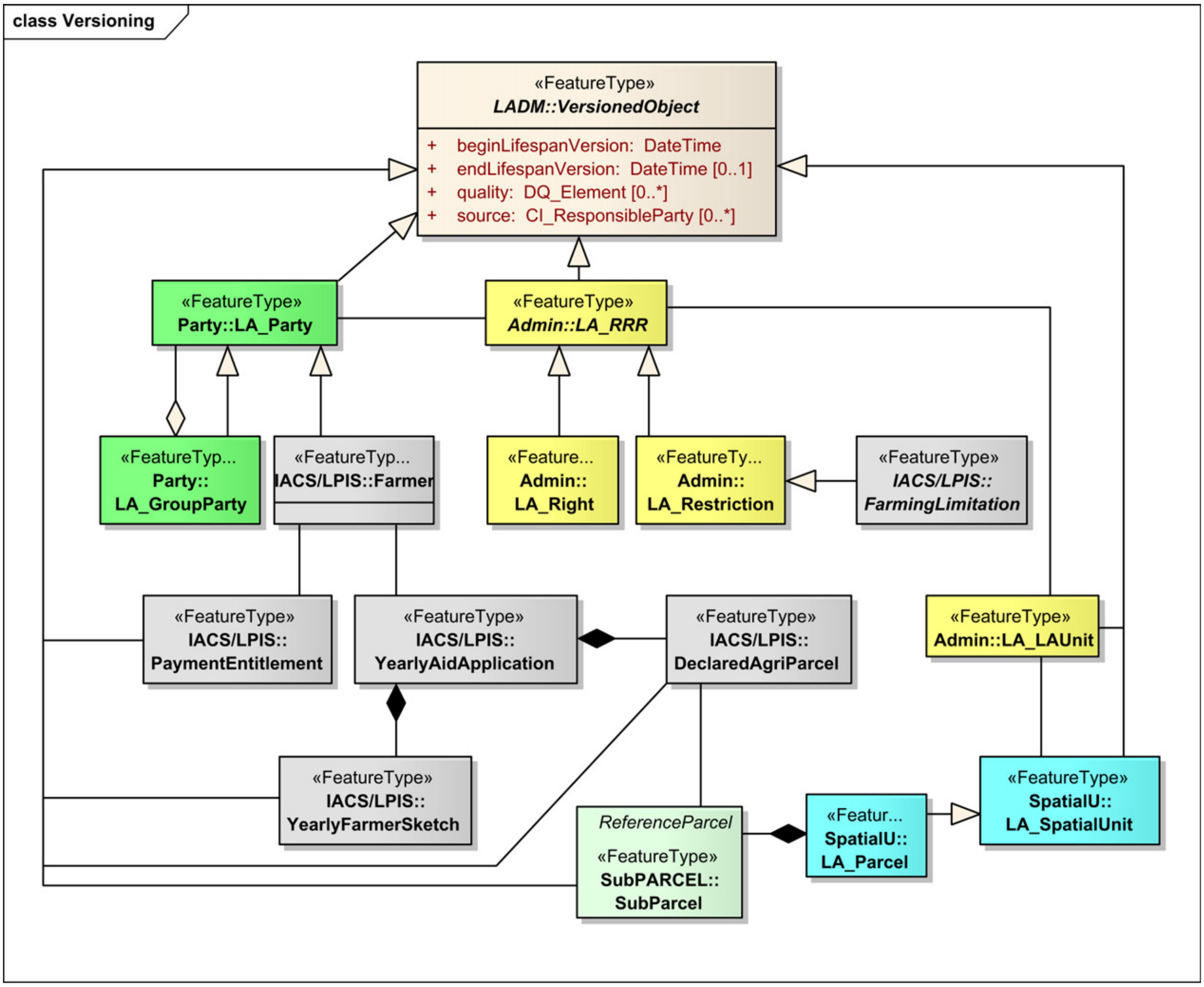

Fig. 11. Versioning and special class names.

obliged to pre-print their previous year's claimed and determined area, and farmers can simply confirm that the previous situation remained unchanged for a specific piece of land (DeclaredAgriParcel). Some changes in the attributes of the previously registered DeclaredAgriParcel are also possible instead of full re-declaration. Storing different versions of objects (instances of DeclaredAgriParcel) is proposed in the model to provide this functionality (see Section 3.3.3). The composition association between YearlyAidApplication and DeclaredAgriParcel classes requires versioning of DeclaredAgriParcel instances in a yearly basis even in the case of no change in attributes. For completely different objects (pieces of land), farmers have to make new declarations (DeclaredAgriParcel) to complete the application process. The attribute claimedArea represents the area for which the farmer asks community aid (subsidies). A farmer is obliged to declare all agricultural land on his holding. If there is no claim for agricultural (or agri-environmental) aid or no DeclaredAgriParcel for some land, its claimedArea should be zero, although this does not mean that the physical area of that land is zero. The attribute determinedArea, on the other hand, represents the area approved by the related authority after control processes. The attribute cropType represents certain types of crop groups to be treated differently in the application/payment procedure (see Fig. 8, for the code list of CropGroupCode). So, each crop group should be declared differently (as different instances of DeclaredAgriParcel). The attribute nationalPaymentType is designed to have the functionality of implementing some agricultural subsidy regimes specific to different MS.

3.3. *Main issues for the collaboration of LADM and LCM*

During this study, some important concerns were raised and feasible solutions were designed and explored. The main concerns are introduced and discussed in the following sub-sections.

3.3.1. *Farmer as a specialization of LA_Party*

Farmer is defined in Article 2 of the Council Reg. No 73/2009 as a natural or legal person or a group of natural or legal persons. This definition of farmer can be represented by LA_Party classes of LADM. In Fig. 9, the classes in green[4] are LADM party classes. LA_Party is the main class which represents natural person and non-natural person, and also groups of natural and non-natural persons via LA_GroupParty class. So, LADM LA_Party classes have the functionality of representing farmers as all kinds of persons. However, a new class Farmer is designed to add the attributes which are specific only to farmers.

[4] see the online version.

All IACS/LPIS farmers form the farmers' register, which explicitly required by the CAP regulation (see Section 2.2.3). Currently, there is no legal requirement to store or link information on land ownership or use rights in the farmers' register. In Section 3.3.4 we discuss how both systems may contribute from this link and how it can be technically done by using collaboration model.

3.3.2. Geometry/topology issues

LADM implies that cadastral parcels (represented by LA_Parcel) on which RPs (represented by SubParcel) are dependent may be in 2D, liminal and 3D data structures (for more information see ISO/CD 19152, 2009). However, our collaboration model is intended only for 2D structure. For the 2D data, LADM supports topologically structured, polygons, unstructured, or simply point or textual descriptions (ISO/CD 19152, 2009; see the code list LA_StructureType in Fig. 10). However, the proposed collaboration model is intended primarily for topologically structured objects and also for polygon based objects because topology rules defined by ISO 19107 apply with these choices. With these options can the hierarchical topology rule between SubParcel and LA_Parcel be implemented (see the note in Fig. 10).

3.3.3. Temporal issues, versioning and class names

Temporal data management within the classes of the model is proposed to be implemented by versioned classes. All classes in the model inherit from VersionedObject class (Fig. 11). This class provides all inheriting classes with a "begin" and an "end" DateTime stamp. Every instance of inheriting classes has a DateTime value as the "begin" stamp when they are first created. When an instance is replaced with a new version of the same instance, the old one must set a DateTime value as the "end" stamp, and the new one must set a DateTime value as the "begin" stamp, which is the same value as the "end" stamp of the old version. This type of versioning is useful when some attributes of object are changed (e.g. value of a real estate, declared area of an agricultural parcel) due to corrections or routine update procedures, and the object remains the same. In the proposed model the YearlyAidApplication inherits from LA_SourceDocument (which inherits from VersionedObject) and also provides other important date/time attributes such as submission, registration and acceptance dates. In the model, the prefix "Yearly" is used for the class instances which are expected to be valid only for a year. These special classes are YearlyAidApplication and YearlyFarmerSketch (see Fig. 11).

3.3.4. Registration of farming rights/restrictions and their relation with aid applications

There has been a common understanding that the LPIS deals with farmers (users of land) and cadastres deals with owners (Perez, 2003; JRC, 2001), and they may not be the same person (Perez, 2003). It is a fact that cadastres as current legacy systems are not always capable of administering all kinds of land related rights, restrictions and responsibilities. But multipurpose cadastre or LAS, as it described by the Cadastre 2014 report (see Kaufmann and Steudler, 1998; for more information see also UN-ECE, 1996, 2005; UN-FIG, 1999), can deal with a wide range of information related to land including ownership, land use rights (right holders of registered properties), farming rights, restrictions, responsibilities etc.

In fact, a farmer is a person who undertakes an agricultural activity (growing crops, raising livestock or keeping land in Good Agricultural and Environmental Condition) and that inevitably uses some piece of land. Farmers may own some of that land, but may lease and/or get some kind of consent from others for another piece of land. However, the registration of farming rights could serve for many invaluable functionalities for a variety of users as well as users or administrators of IACS/LPIS. In this study, in order to introduce the idea of registering farming rights in the collaboration data model, farming rights are designed as part of LAS with a few extensions in attributes of some LADM classes (see highlighted attributes in Fig. 12).

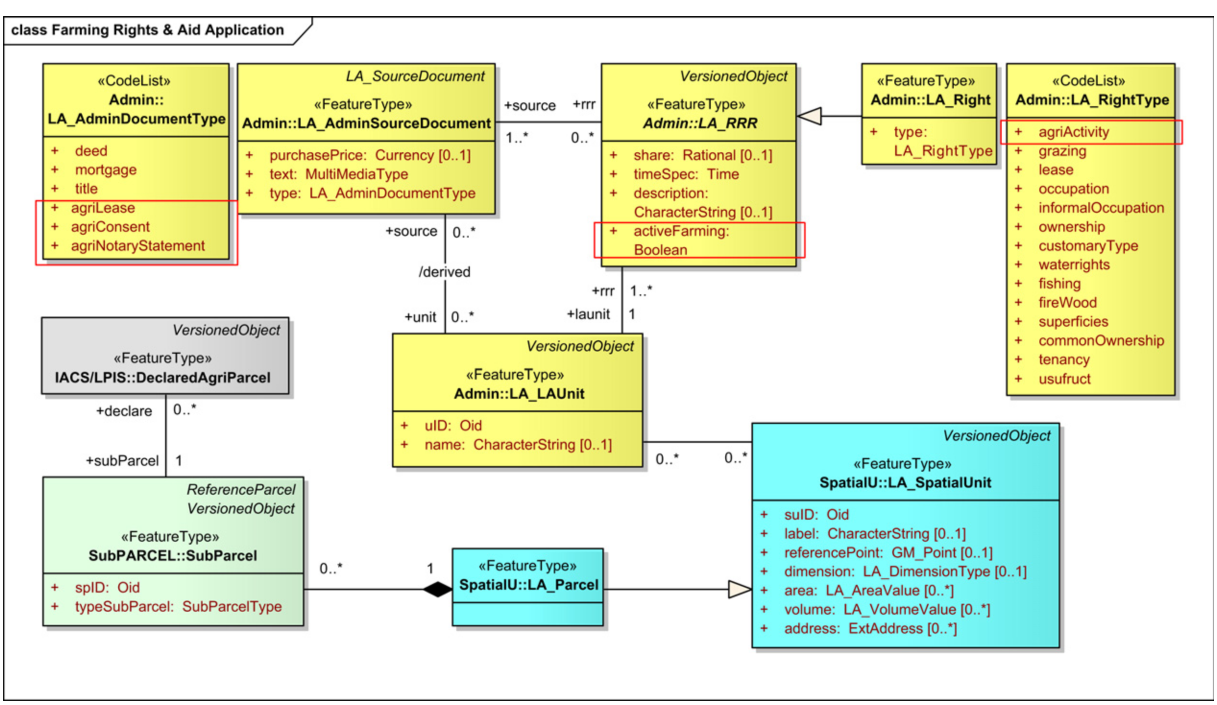

Fig. 12. Registration of farming rights with LADM classes.

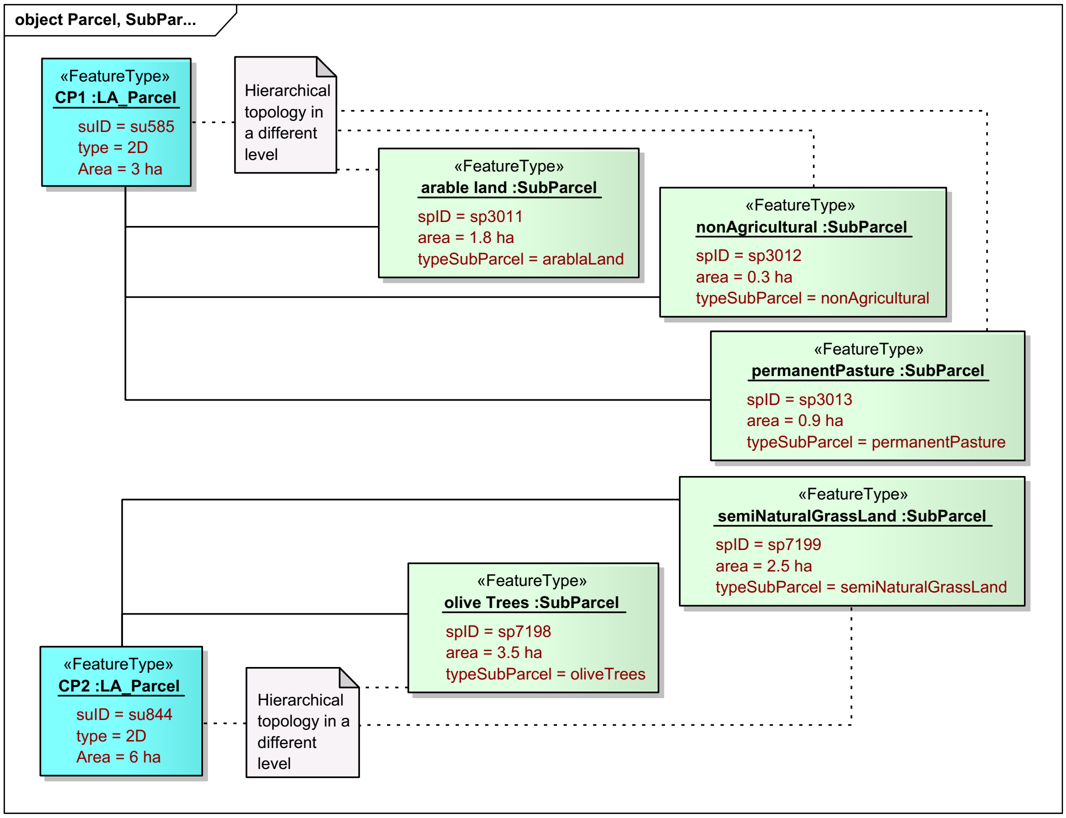

Fig. 13. Recorded objects, associated cadastral parcels and sub parcels.

All the classes, which are involved in land use rights, come from LADM. Among them, the LA_Right class has a type attribute to store LA_RightType. The right types (see the code list LA_RightType in Fig. 12) such as ownership and lease are very common ones, yet, occupation of abandoned or state land or having only the right for agricultural activity is also possible. This list may be further extended depending on the needs in the future because code lists are flexible/extendible lists in the model. However, these rights should be registered somewhere in LAS for securing the right. For this, LA_AdminSourceDocument class is designed and associated with the LA_RRR (LA_Right) to provide the proof. There may be different types of legal documents. So, the attribute type (of legal document) in the LA_AdminSourceDocument class represents different types of legal documents (LA_AdminDocumentType). These document types may differ even for the same right type. For example, deed or title for ownership right, and agriLease, agriDeedOfConsent or even agriNotaryStatement may be possible for agriActivity right.

In the model, the LA_Right class is designed as a specialization of the abstract class LA_RRR. This means that it inherits all the attributes of this abstract class. The type (of right), the share of the associated real property, the time spectrum for the associated right, and also an indication information if there is any agricultural activity are encoded in the right class through the attributes type, share, timeSpec and activeFarming (designed for the collaboration model) respectively. Ownership, lease, occupation or agriActivity rights do not necessarily mean that associated land is used for agricultural purposes. So, if required, this information should be handled separately via activeFarming attribute. This attribute may function when the association between farmer declarations in the IACS/LPIS system and the LAS is established appropriately or it may be optional.

3.4. Sample instance level diagrams

In this section, sample instance level diagrams representing two cadastral parcels and associated sub parcels (Fig. 13), and an aid application submitted by a farmer for his agricultural activities on sub parcels (Fig. 14) are presented.

In the first part (see Fig. 13), the associations between cadastral parcels (instances of LA_Parcel) and sub parcels are shown. Basic properties (IDs, areas) of presented objects are also presented. Note that, CP1 comprises of three sub parcels one of which is non-Agricultural.

In the second part (see Fig. 14), a scenario of aid application is presented. The farmer having agricultural activity rights on CP1 and CP2 applies for the 2009 aid. He has a total of 10 ha entitlement right. He provides two sketches describing the spatial locations of six different agricultural parcels. Remember that SubParcels arable land, non-Agricultural and permanentPasture are all associated with CP1 (see Fig. 13), and suppose that the farmer has a share of 1/2 on this CP (not specified in the diagrams), and this ratio applies also for sub parcels. So, the farmer claims less than half area of each sub-parcel except for the non-Agricultural one. Also note that agricultural parcels (APs) are drawn spatially on farmer sketches, but they are non-spatial administrative objects, yet they are associated with spatial sub-parcel objects. For example, AP1, AP2 and AP3 are administrative objects associated with the same sub-parcel (arable land) object, and AP4, AP5 and AP6 are associated with different sub parcels (see Fig. 14).

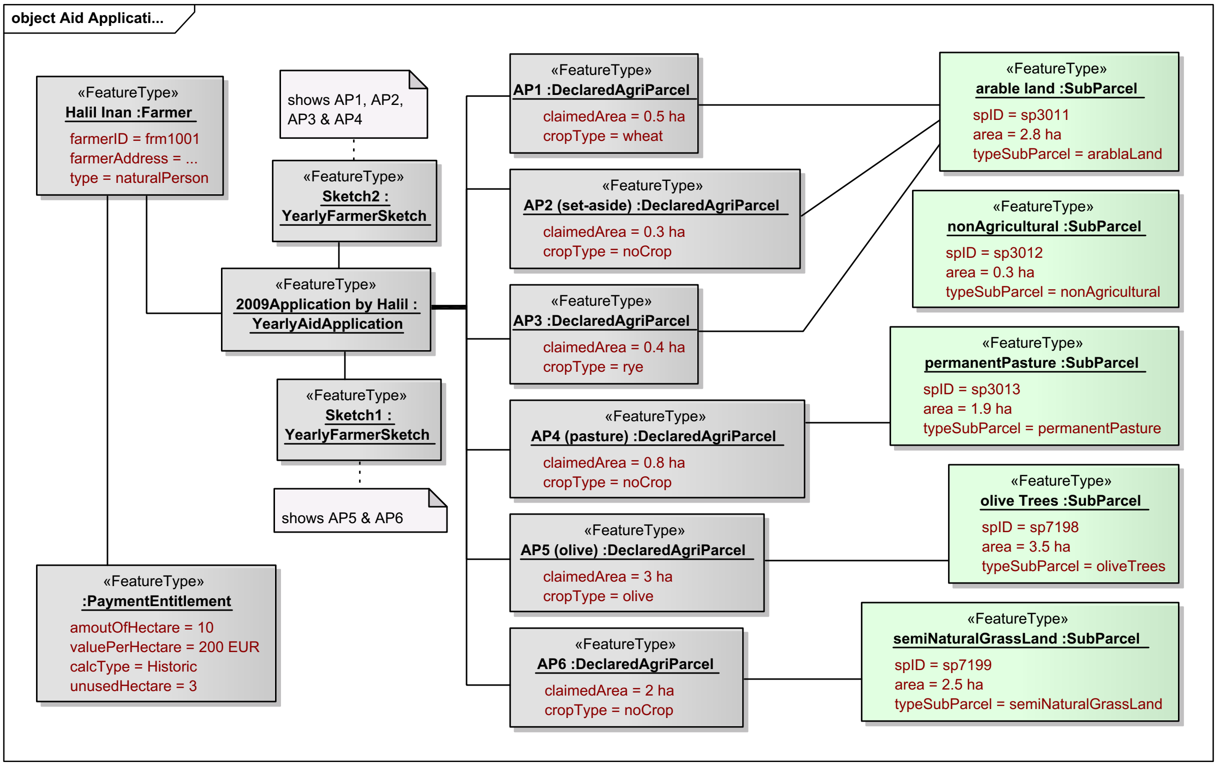

Fig. 14. Aid application, declared APs and their association with sub parcels.

4. Conclusion

In this study, we proposed a collaboration data model, which provides the concept to manage IACS/LPIS application based on LAS. The concept of the model covers only one type of IACS/LPIS application in terms of basic spatial unit – Cadastral Parcel. However, the model includes more sophisticated functionalities (originally provided by LADM) than a simple cadastral parcel. It offers the use of topologically structured spatial units. Depending on further study, it also offers the use of groups (having a legal meaning in LAS) of cadastral parcels with homogeneous rights.

The implementation of such a model might be non-trivial firstly because LAS data which represent legal, formal and documented aspects of land does not always fit well with real world land use/cover data. In countries where this gap is big (and no improvement is expected in the near future) one can conclude that cadastral parcel layer in LAS are of little use as basis for reference parcels in IACS/LPIS. Such cases indicate that the LAS would be re-organized/updated such that the legal situation corresponds to the terrain reality for any practical LAS application. An important consideration is that the maintenance of the SubParcel boundaries is out of scope of conventional LAS and update procedure is an additional task requiring additional capacity. So, the proposed model may only be implemented in the countries ready or willing (by taking the necessary measures to improve their LAS if needed) to use their LAS for this purpose (and for other applications).

Different LAS set-ups in different MS have adversely affected the establishment of functional IACS/LPIS based on LAS. Rather, MS have resolved the problem by finding alternative solutions which are not primarily based on LAS. As a result, there are only few MS having an IACS/LPIS based on their LAS and many others with special solutions (by using different types of RPs). In many MS, LAS are not adequately structured and organized and they need further development in different aspects for the establishment and maintenance of IACS/LPIS. On the other hand, IACS/LPIS set-ups in all MS have different characteristics although they function similarly for the management of agricultural subsidies. They only have some common basic features imposed by related IACS regulations. So, LADM and LCM as standardization initiatives in both domains may be regarded as a good common point for the two domains. These initiatives are supposed to contribute to the advancement of both LAS and IACS/LPIS set-ups. In this respect, LCM/LADM collaboration model we proposed with this study will further support their development and advancement especially in a harmonized way.

The proposed collaboration data model is a generic model and may need refinement to be adapted to a specific country. It could support an integrated management of rural land in the future. The implementation process of the model may require relatively serious investment of fund and time depending on the MS. With the implementation, some advancement are supposed to be experienced in the areas of data comparability among different IACS/LPIS, generation of common statistics, data sharing between organizations, prevention of data redundancy, land use/cover classification for rural areas, data consistency for National GIIs and integrity of rural land administration/management applications.

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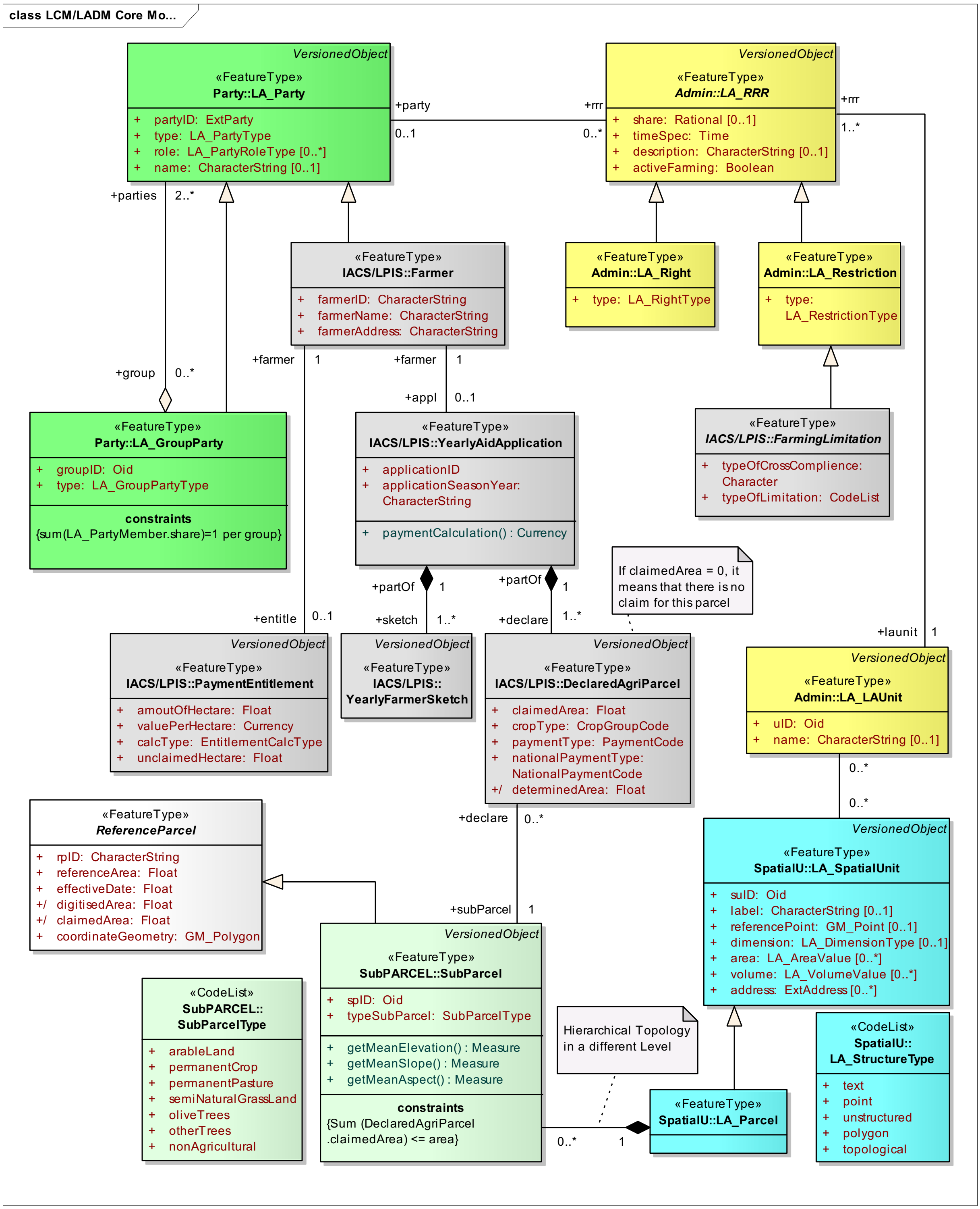
Appendix. UML Diagram of the LCM/LADM collaboration model as a whole.



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