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A Study on the Design of LADM-based Cadastral Data Model for Mongolia*

LADM 기반의 몽골 지적 데이터 모델 설계에 관한 연구

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Abstract

The paper reviews the adoption of ISO 19152, Land Administration Domain Model (LADM) for the enhancement of the current Mongolian cadastral system. It can be said that the current cadastral system is developed for the pure purpose of land registration. There is a need for a comprehensive data model for not only this reason but also reflecting the current problems in the Mongolian cadastral system. The LADM was published by the International Organization for Standardization later in 2012 as an International Standard for modeling cadastral and land administration information for the purpose of providing a common vocabulary(ontology) and efficient system development. This study examined possibilities of adopting the LADM to the cadastral system for Mongolia focused on Land Manager system. Data model of the Land Manager was examined against the corresponding LADM classes and as a result, gaps between each data model have been drawn. Lastly we proposed the LADM-based new data model for Mongolian cadastral system ensuring that the current problems be reflected.

Keywords: LADM, Mongolian Cadastral System, Land Manager, Cadastral Data Modeling

1. Introduction

FIG(1995) defines cadastre as a parcel based and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities).

However the extension of new property rights and restrictions will change the traditional

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cadastral concept to the future cadastre due to the macro-environment drivers such as a political and legal, environmental, technological and socio-economic. Future cadastre concept includes the characteristics of survey-accuracy, object-oriented design, 3D/4D arrangements, real-time information, global and organic cadastre(Bennett et al., 2011).

For the implementation tool of the future cadastre in terms of the object-oriented design, 3D and global cadastre International Organization of Standardization(ISO) established "ISO 19152 Land Administration Domain Model(LADM)" international standard later in 2012.

A number of countries considered the adoption of LADM standard into their local needs. LADM compliant land information systems (Elia et al., 2013; Tjia and Coetzee, 2013; Lee et al., 2014; Alkan and Polat, 2017) and cadastral systems(Kim et al., 2013, Psomadaki et al., 2016, Kim et al., 2018) were developed and 3D cadastre (Lee et al., 2015; Janečka and Souček, 2017; Radulović et al., 2017) was implemented. Thus an application of the LADM could be various depending on a specific country's needs. Munkhbaatar et al.(2018) derived a country profile for Mongolia showing the possibility of LADM application. This study can be said as a successive study of the former, however, it is more focused on a specific application of the LADM.

Therefore the aim of this study is to propose LADM-based cadastral data model for the current cadastral system to ensure that the current problems in the Mongolian cadastre including data duplication, data exchange, standardization and quality aspects to be reflected.

In order to achieve the goal of study, the paper is structured as follows. Section 1 introduces the background and purpose of this study. Section 2 describes current cadastral system and its data model in Mongolia. Section 3 describes the mapping of the LADM and the Mongolian cadastral system. Section 4 presents the design of LADM-based cadastral data model. Finally, section 5 discusses the conclusion and further works.

2. Cadastral System in Mongolia

Cadastral systems can be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (FIG, 1995).

Mongolia has a cadastral system supporting the both legal(e.g. land tenure) and fiscal purposes(e.g. taxation) for multipurpose cadastre. The authority responsible for the management of cadastre is the Agency for Land Administration, Geodesy and Cartography (ALAGaC).

ALAGaC implemented several projects and initiatives to establish cadastral system in Mongolia. One of those that influenced the most is "Cadastral Survey and Land Registration Project" which introduced the first digital cadastral database in Mongolia earlier in the 2000s(ADB, 2010).

However cadastral systems were operated separately until Jo(2013) integrated existing separate systems into one. Systems were namely "UBGIS" for graphical data (e.g. cadastral map), "LPIS" for ownership, "LandUK" for land possession and land use right, and "LandFee" for land tax. A new inte-

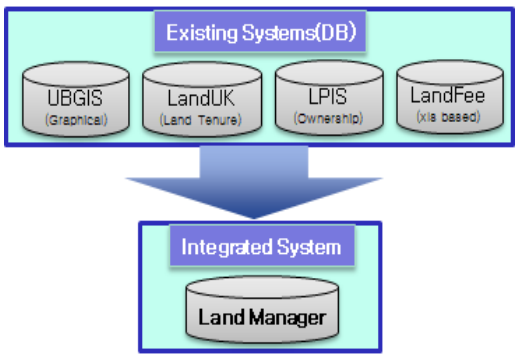

Figure 1. New integrated cadastral system.

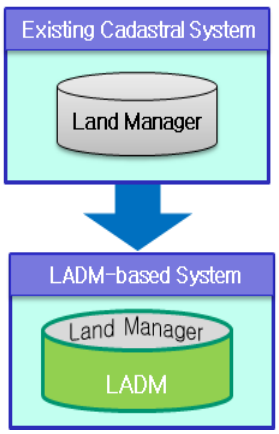

Figure 2. LADM-based cadastral system.

grated system named "Land Manager" (Figure 1).

ALAGaC is now on its way to disseminate the system all over the country not only to use in the capital city of Ulaanbaatar, Mongolia.

This study is focused on the "Land Manager" cadastral system and proposes to develop a new data model based on the LADM (Figure 2).

In order to achieve the goal of the study current data model of the system needs to be investigated.

Jo (2013) presented an Entity Relationship Diagram (ERD) based logical data model of the integrated system. This study uses a data model presented by the previous study. However, directly using the logical model has a restriction since the LADM uses an Unified Modeling Language(UML) based conceptual data model. Therefore logical data model has been converted to a conceptual data model and restructuring of the database was needed for the purpose of the study. Also proper english class names and attribute names were given.

The current data model of Land Manager consists of 3 main groups including land permission management, land tax management and land registration management. The group of land permission management consists of two main classes which are land register(book) and land (registration) permission application. The group of land tax management includes land tax bill as a core class while the group land registration management includes cadastral map as a core class. Figure 3 presents core classes and their relationship within groups of Land Manager. Figure 4 illustrates core data model of the Land Manager without relation to groups. Table 1 shows class description of the core data model. Figure 5 illustrates a class diagram of the core data model.

3. Mapping Land Manager to LADM

LADM provides an abstract, conceptual schema with three basic packages including parties (such as people and organizations), administrative (rights, responsibilities and restrictions), and spatial units (such as parcels, buildings and networks) with the one sub-package: surveying and representation

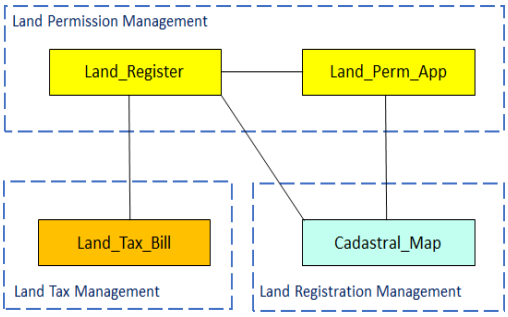

Figure 3. Core classes and their relationship.

(ISO, 2012).

The purpose of the LADM is that it provides a reference model which will serve for two goals: to provide an extensible basis for the development and refinement of efficient and effective land administration systems based on Model Driven Architecture(MDA) and to enable communication within one country and between different countries by involved parties based on the shared vocabulary (e.g. ontology), implied by the model (ISO, 2012).

In order to model an existing cadastral system to the LADM requires examination of corresponding classes between each data model. The first step to migrate from existing cadastres to LADM is to map data models to each other and identify corresponding elements in each data model in terms of bridging gap (Kalantari et al., 2013). The mapping of the Land Manager basic classes to the corresponding LADM classes is described in Table 2.

Though most of the classes of Land Manager could successfully mapped to the LADM corresponding classes there are some discussion that were identified in the process of mapping.

LA_RRR cannot be identified fully in the current system. A right as a holder by party can be identified.

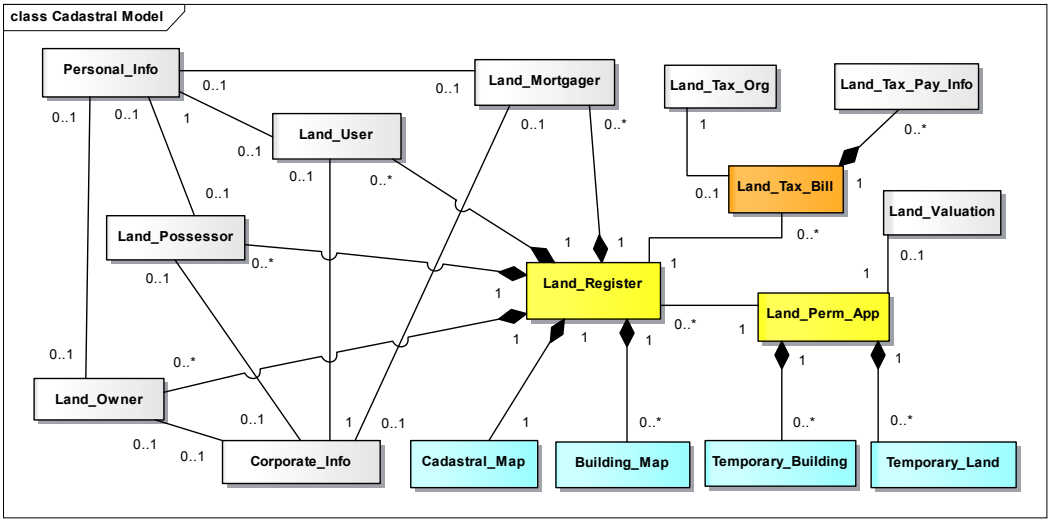

Figure 4. Core data model of the Land Manager.

Table 1. Class description of the core data model.

Group	Class	Description
Land permission management	Personal_Info	Local or foreign nationality involved in land permission
	Corporate_Info	Local or foreign company involved in land permission
	Land_Owner	Information about (common) land owner
	Land_Possessor	Information about (common) land possessor
	Land_Tenant	Information about land tenant/user
	Land_Mortgager	Information about land mortgagor
	Land_Perm_App	Application for land permission registration
	Land_Valuation	Land valuation information for land permission
	Tech _Advice_Council	Technical advice council responsible for land permission
	Land_Register	Registered or permitted land based on the application
Land registration management	Temporary_Land	Cadastral map for land permission (application)
	Temporary_Building	Building map included in a cadastral map for land permission
	Cadastral_Map	Cadastral map for permitted land registered on a land register
	Building_Map	Building map for permitted land
Land tax management	Land_Tax_Bill	Information about land tax claim after land registration
	Land_Tax_Pay_Info	Information about land tax payment
	Land_Tax_Org	Land tax claim organization issued land tax bill
	Land_Tax_Dec	Land tax/fee decision document

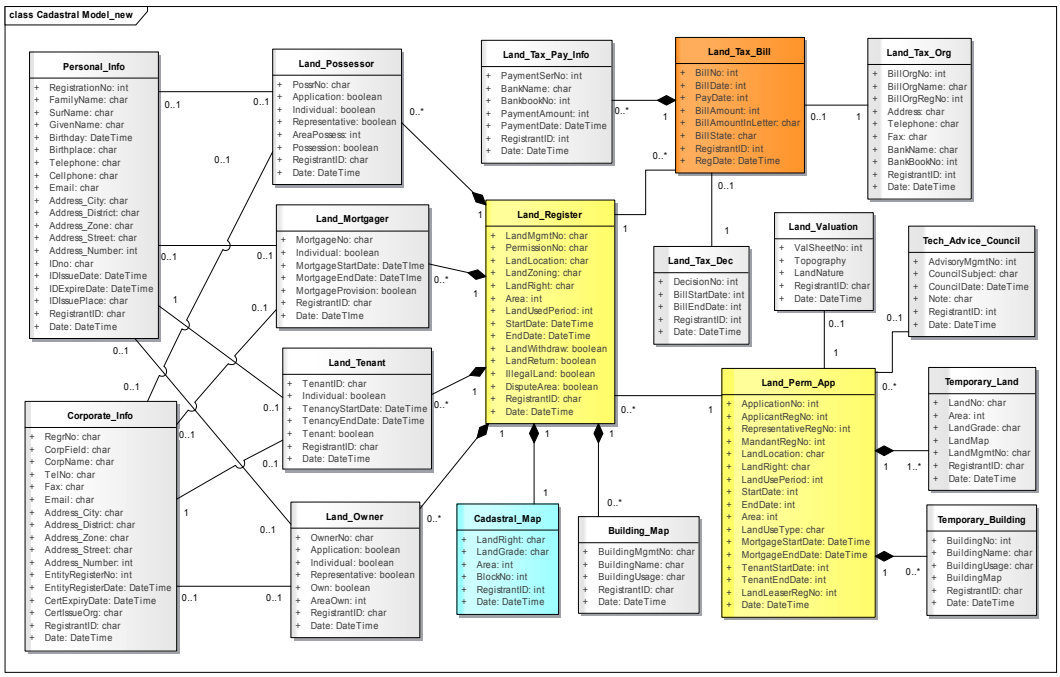

Figure 5. Class diagram of the core data model.

Table 2. Mapping of LADM classes with Mongolian Land Manager basic classes.

LADM	Land Manager
PARTY PACKAGE	
LA_Party A Party is a person or an organization who participates in land administration.	**Personal_Info, Corporate_Info, Land_Tax_Org, Tech_Advice_Council** Personal and corporate information can correspond to LA_Party since these classes indicates the identity of a party. Land tax (claim) organization and technical advice council can exist as a role type of a party.
ADMINISTRATIVE PACKAGE	
LA_Right Right is a formal or informal entitlement to own or to do something.	**Land_Owner, Land_Possessor, Land_Tenant** Land owner holds ownership, land possessor holds possession right and land tenant has an use right. Thus ownership, possession and tenancy can correspond to LA_Right.
LA_Restriction Restriction is to refrain from doing something.	**Land_Mortgagor** Restriction can exist as land mortgagor as a right type of land mortgage and it is restricted by ownership.
LA_BAUnit BAunit is abbreviation of Basic Administrative unit consisting of zero or more spatial units (parcels) with one or more unique and homogeneous rights (e.g. ownership), responsibilities or restrictions.	**Land_Register** Land register describes parcel with one unique right. It consists of one spatial unit as a cadastral map.
LA_AdministrativeSource Administrative source shall be associated to one or more parties and may describe the objects of the right, restriction or responsibility.	**Land_Perm_App, Temporary_Land, Temporary_Building** Land permission application is associated to a party as an applicant and describes its interests in land. Temporary land and building describe land of the right spatially before registration.
SPATIAL UNIT PACKAGE	
LA_SpatialUnit A spatial unit can be associated to zero or more BAUnit. Also it can be used to describe the extension part of BAUnit.	**Cadastral_Map, Building_Map** One cadastral map and building map(inside cadastral map) are used to describe BAUnit(as a parcel) as a spatial unit. Thus these classes can correspond to LA_SpatialUnit.
EXTERNAL CLASSES	
LA_ExtAddress ExtAddress is for an external registration of addresses.	**Personal_Info, Corporate_Info** Address information from personal and corporate may correspond with ExtAddress separately.
LA_ExtValuation ExtValuation is for the external registration of valuation data and is associated to BAUnit.	**Land_Valuation** Land valuation information may correspond with ExtValuation.
LA_ExtTaxation ExtTaxation is for the external registration of taxation data and is associated to BAUnit.	**Land_Tax_Bill** Land taxation information may correspond with ExtTaxation.

LA_Right can be identified as a right ownership, possession and tenancy(use right) not by a holder.

LA_Restriction only corresponds to Land_Mortgagor, however according to land privatization law of Mongolia, servitude as a restriction can be identified (Munkhbaatar et al., 2018).

LA_Responsibility can also be identified as a responsibility e.g. protecting surveying point within one's land (parcel) according to the law (Munkhbaatar et al., 2018).

LA_BAunit can be identified as Land_Register class. Land_Register describes parcel information with rights. On the other hand, LA_SpatialUnit can be identified as Cadastral_Map as it describes geometric(spatial) information about parcel (Land_Register).

The Spatial Unit package has one Surveying and Representation subpackage with classes LA_SpatialSource for surveying data acquisition, LA_Point for either spatial point or surveying point, LA_BoundaryFaceString for spatial line and LA_BoundaryFace for spatial polygon.

However the Land Manager does not support spatial part of the cadastre since it focused mostly on the land registration. Therefore classes that describe a data about cadastral surveying in the system is needed. Besides these, common part of the two model is model supports temporal management of a data.

4. Design of LADM-based Mongolian cadastral system

LADM-based cadastral data modeling is done based on the mapping of the LADM to the Land Manager. "MG_" prefix standing for Mongolia is used to differentiate the proposed data model from other country profiles. For all proposed model, overlapping class attributes between the LADM and Land Manager were excluded in order to provide coherent and consistent modeling.

4.1. Party package

Classes of Personal_Info and Corporate_Info can be modeled to the LA_Party class. Proper class names were given to Personal_Info as MG_NaturalPerson and Corporate_Info as MG_Legal Entity. In relation with association, these classes can be subclasses inheriting from the LA_Party class.

However address related information from both Personal_Info and Corporate_Info class should be converted to external class of the LADM.

Therefore address related attributes of Personal_Info and Corporate_Info are mapped to ExtAddress class which is for an external registration of addresses (an address being a direction for finding a location). The advantage of ExtAddress class is that historical data management is available provided by generalized VersionedObject class.

MG_GroupParty which consists of two or more parties can be modeled as an inheriting class of MG_Party since two or more parties holding ownership is possible in Mongolia. Figure 6 shows the proposed data model of the Mongolian cadastral system with content of the corresponding classes of party package and associations with other classes including code lists.

The proposed code list of party package are

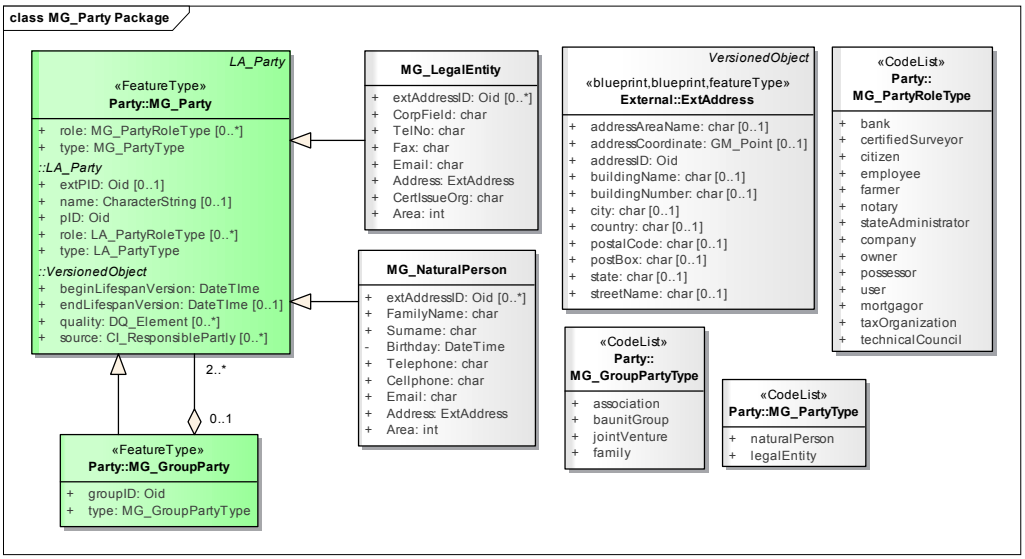

Figure 6. Proposed data model of the Mongolian cadastral system based on party package.

MG_PartyRoleType, MG_PartyType and MG_GroupPartyType. A few more attributes added to these code lists considering characteristic of the current cadastral system respectively. For instance, MG_PartyType includes two attributes natural Person and legal Entity.

4.2. Administrative package

The most of the classes from the Land Manager corresponds to the administrative package. Classes of Land_Owner, Land_Possessor and Land_Tenant could correspond with LA_Right. Thus these classes named as MG_Ownership, MG_Possession and MG_LandUseRight. In relation with association, these classes can be subclass of the LA_Right. However these classes should be directed to define land as a right of use unit rather than holder of land to be compliant with the LADM.

Land_Mortgagor can be corresponded to LA_Mortgage class as a subclass of LA_Restriction. Land_Mortgagor renamed properly as MG_Land Mortgage and relevant code lists are added respectively.

Land_Register may correspond with LA_BAUnit since it contains information about land right type, location, and land grade. New code lists for this class are added respectively.

Land_Perm_App could correspond with LA_AdministrativeSource as this class contains information about an applicant and interests in land. Whilst Temporary_Land and Temporary_Building may correspond to LA_Administrative Source as these classes describe spatial component of land permission application.

Figure 7 illustrates the proposed data model of the Mongolian cadastral system with content of the corresponding administrative package classes and associations with other classes including code lists.

The proposed code list of the administrative package includes MG_RightType, MG_Responsibility Type, MG_RestrictionType, MG_BAUnitType, MG_MortgageType, MG_MortgagePurposeType, MG_AvailabilityStatusType, MG_AdministrativeSource Type, ExtTaxType, ExtValuationType, MG_Land RightType, MG_LandUseType and MG_LandGrade Type. Basically all types of administrative package code lists are applicable to the cadastral system and some new code lists and attributes were added considering the Mongolian cadastre.

4.3. Spatial unit package

Cadastral_Map and Building_Map correspond to LA_SpatialUnit. These classes describe cadastral parcel registered in the Land_Register(BAUnit) as a spatial component.

A spatial unit can form part of other spatial unit and includes zero or more other spatial units (ISO, 2012). Building_Map is included in the Cadastral_Map in 2D form. Therefore the included form of spatial unit can be created between Cadastral_Map and Building_Map.

Furthermore spatial units can be further specialized into building units as LA_LegalSpaceBuilding Unit and utility networks as LA_LegalSpaceUtility Network. However these classes cannot be modelled to the current system since the Land Manager mostly focused on the land registration process. LA_SpatialUnitGroup and LA_Level classes can be considered for systematic land registration. Though current system does not support these kind of classes, it is possible to be considered for the future system.

Spatial unit class can be associated to zero or more spatial sources. LA_SpatialSource class defines observation and measurement process of points (ISO, 2012). However the Land Manager does not support information about cadastral surveying. In order to overcome the current shortcomings of Land Manager, Surveying and Representation subpackage needs to be considered in the modeling. Therefore, to be able to process information about cadastral surveying, MG_Point and MG_Spatial Source classes should be modeled for the Land Manager.

Figure 8 shows the proposed data model of the Mongolian cadastral system with the content of the corresponding classes of spatial unit package with its subpackage including code lists.

The proposed code lists of spatial unit package includes MG_RegisterType, MG_LevelContentType, MG_StructureType, MG_AreaType, MG_Dimension Type, MG_SurfaceRelationType, MG_Interpolation Type, MG_MonumentationType, MG_PointType and MG_SpatialSourceType. Basically the most types of spatial unit package code lists are applicable to the Mongolian cadastral system and some new code lists and attributes are added or eliminated considering local needs.

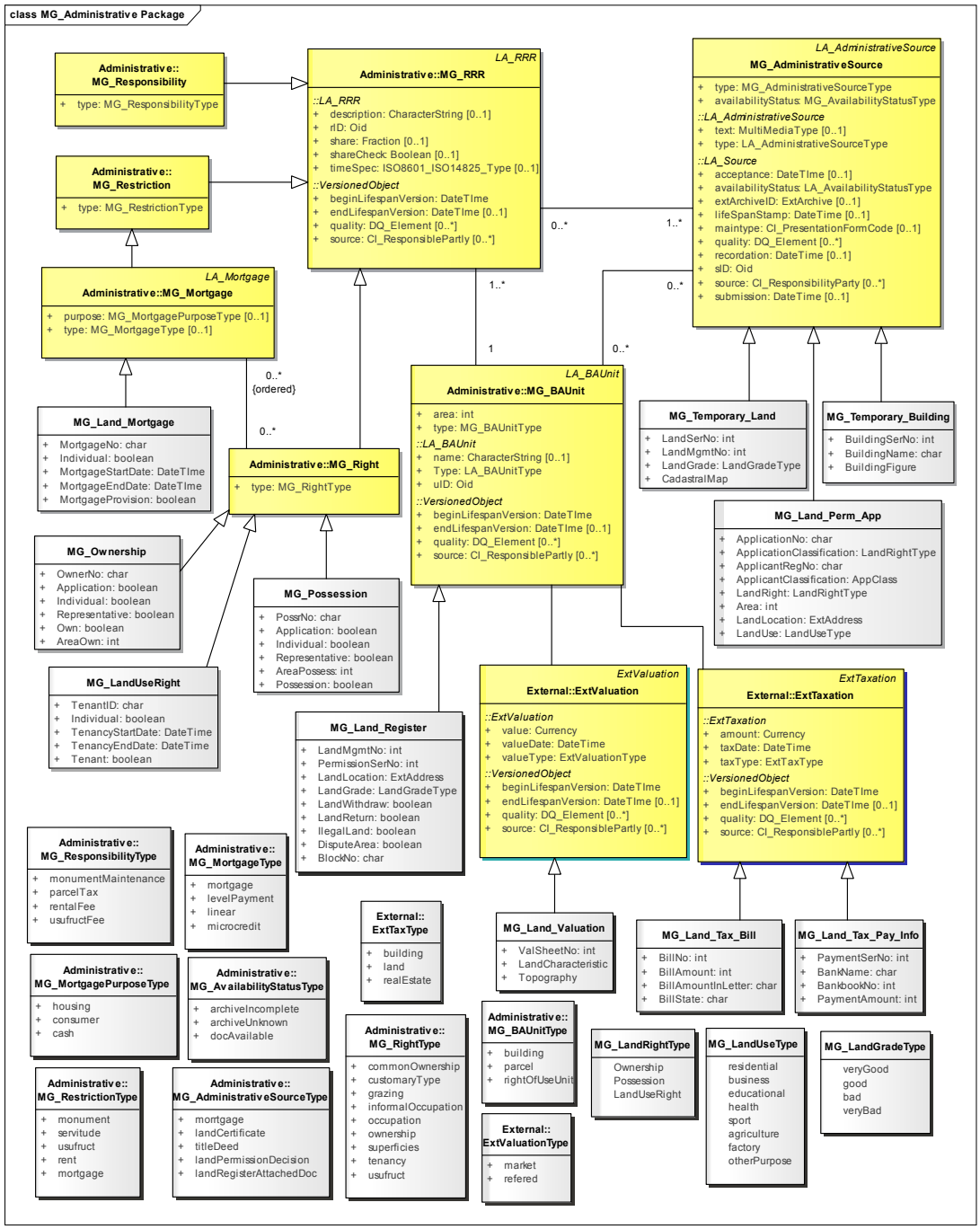

Figure 7. Proposed data model of the Mongolian cadastral system based on Administrative package.

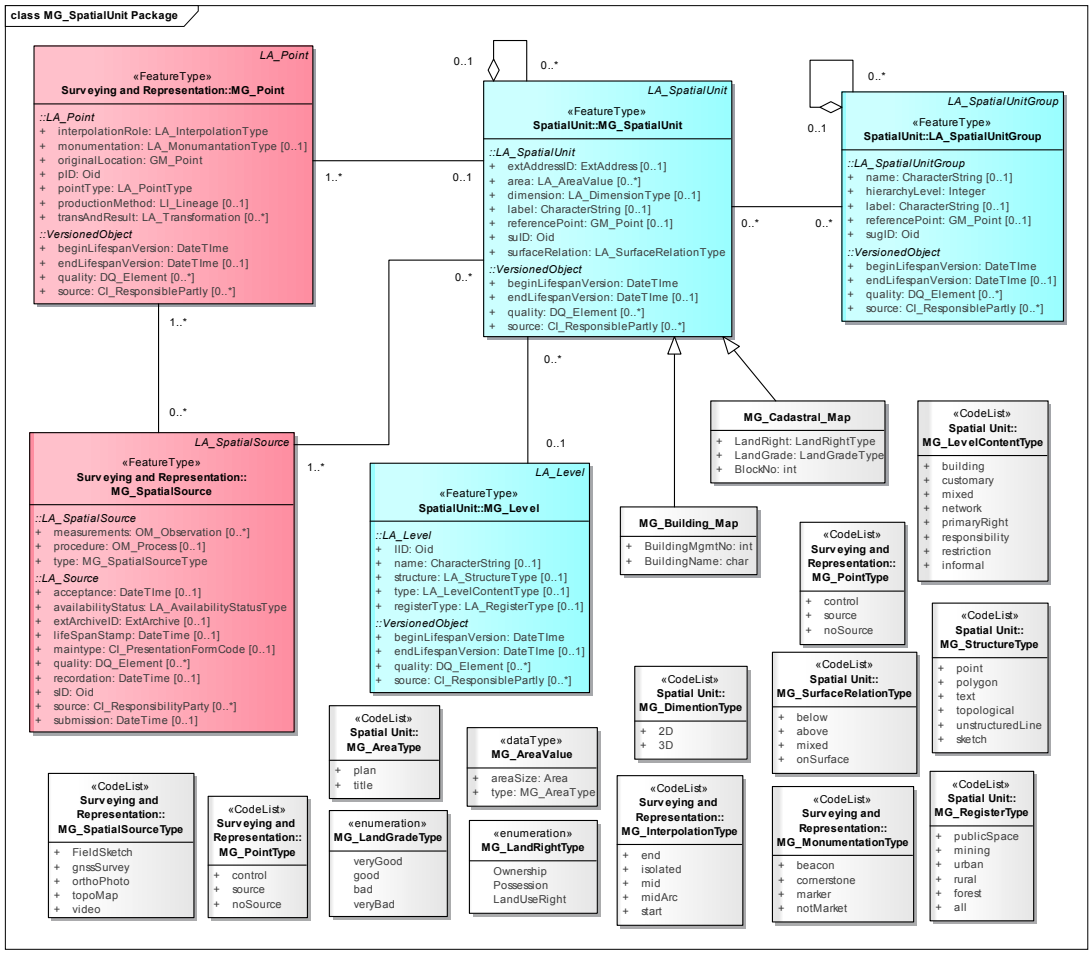

Figure 8. Proposed data model of the Mongolian cadastral system based on spatial unit package.

4.4 External class

Though classes of Land_Valuation, Land_Tax_Bill and Land_Tax_Pay_Info can correspond to LA_AdministrativeSource, these classes can rather be converted to the LADM external classes. ExtTaxation and ExtValuation are classes for the external registration of taxation and valuation data that is associated to BAUnit. External classes are added in the administrative package accordingly.

5. Conclusion

The introduction of a new data model is inevitable to enhance the existing system and to facilitate efficient data management. Using LADM will not only provide interoperability and standardization but also international experience better service users by providing more accurate data in a time stamp.

We designed and proposed a LADM-based domain model for the Mongolian cadastral system.

The Land Manager fits into the LADM without losing any important information. A comparison of the Land Manager classes with LADM classes showed that there is compatibility between the two models and the LADM can be used as the reference model for the extension of the Land Manager.

The conclusion of this examination is that the adoption of LADM to the Mongolian cadastral system is an absolute necessity not only to introduce an ISO standard model, but also improving the problems such as data duplication, inefficiency and non interoperability that exist in the current cadastral system. Thus ALAGaC must consider adopting the LADM as a reference model to the current Mongolian cadastre as a data model enhancement based on the Land Manager. Also the Land Manager must include surveying information in order to provide not only accurate and reliable information but also to support integrated information.

The future work should include further modeling of spatial package and surveying and representation subpackage. LA_LegalSpaceBuilding Unit and LA_LegalSpaceUtilityNetwork should be considered when connecting the current system to the building or real estate system and utility network system.

LA_Point, LA_Boundary Face String and LA_BoundaryFace classes should be considered to enable the current system spatially manageable. Also further modeling of LA_Spatial Unit and LA_SpatialUnitGroup should be considered to create and manage BAUnit(as a parcel) spatially and efficiently.

The proposed data model can be realized in the real situation by system or web development as prototype for some pilot region.

Furthermore, LADM enables transition from 2D to 3D cadastre. In the future, the proposed data model can be used as a basis for 3D cadastre, however, further consideration to the modeling must be included.

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초 록

본 연구는 현존하는 몽골 지적 시스템의 개선을 위해서 ISO 19152, 토지행정도메인모델(LADM)의 채택을 검토하였다. 현재의 몽골 지적시스템은 토지등록만을 위해 개발되었다고 할 수 있다. 따라서 이러한 점을 보완할 수 있고 현재의 문제점을 개선할 수 있는 새롭고 포괄적인 시스템이 필요한 실정이다. LADM은 국제표준으로서 2012년도 후반에 국제표준화기구(ISO)에 의해 제정되었으며, 지적 및 토지행정정보의 모델링을 통해 효율적이고 효과적인 지적시스템 개발과 지적의 공통어(온톨로지)를 제공하는 것을 목적으로 하였다. 본 연구에서는 몽골의 지적시스템인 Land Manager에 초점을 맞추어 몽골의 지적시스템에 LADM의 적용가능성을 검토하였다. 또한, Land Manager의 데이터 모델을 LADM의 해당되는 클래스별로 분석하여 각 모델간의 차이점에 의한 데이터 모델링을 수행하였다. 마지막으로 LADM 기반의 현재 문제점을 반영할 수 있는 새로운 몽골 지적시스템의 데이터 모델을 제시하였다.

주요어 : LADM, 몽골지적시스템, Land Manager, 지적 데이터 모델링