Conceptual Modeling and File Encoding of Provincial Cadastre System in Anhui Province, China

Chen WANG∗, Yan-lan WU, Ming LIANG and Xiao-jun ZHU
Anhui University, LiGong F 313, 111 Jiulong Road, Hefei, China
*Corresponding author

Keywords: Cadastre, Conceptual modeling, CityGML, LADM.

Abstract. This paper reports the design, encoding, and validation of a cadastre conceptual model for the unified registration of immovable properties in Anhui Province, China. First, a TF-IDF method was employed to extract all the fundamental concepts from a large amount of cadastre related regulations. Then, ISO 19152 LADM was extended with these concepts, creating an Anhui provincial cadastre conceptual model. Finally, CityGML Application Domain Extension and its encoding mechanism were employed for model encoding. A preliminary validation with case studies in Anhui Province, China demonstrates the expressiveness of this conceptual cadastre model and the compatibility with a series of OGC and ISO standards of its encoding files. The application of this model in the cadastre education also demonstrates its advantages compared with existing cadastre knowledge framework. The work described in this paper extends existing efforts of China’s cadastre conceptual modeling and is beneficial for both cadastre researchers, administrators, and system developers in China.

Introduction

Cadastre is the information system that registers the space on, above, and beneath the earth surface and the right, responsibility, and restriction connected to it [1,2]. It is a key for property security, transfer, and management. In China, the cadastre was maintained and used by different administration ministry according to its location (urban, rural) and its subject (land, sea, forest). Now, a unified cadastre registration is installing at both state and province level, aiming to simplify the cadastre registration process and to improve the data integrity [3]. In such circumstance, data standardization is the center of fusing existing heterogeneous data from different ministry and applying unified register. Thus, Ministry of Land and Resources of the Peoples Republic of China has enacted a series of regulation on unified cadastre registration including: “Interim Regulations on Real Estate Registration”, “Implementation details of Interim Regulations on Real Estate Registration”, “Real Estate Database Interim Standard” and so on. These regulations are either from the legal aspect or for detailed technical implementation. However, the conceptual model, which is critical to knowledge synthesis, system development, and interoperation between systems, is still missing. A conceptual model is especially beneficial to the design and implementation of cadastre system, which is dealing with multi-source heterogeneous spatial and non-spatial data [4] and is rich in semantic content [5].

This article describes an ongoing research project that aims to create a conceptual cadastre model at a provincial level to facilitate unified registration of the provincial immovable property in cadastre system. The conceptual model is based on ISO 19152 LADM Land Administration Domain Model standards. Compared with existing research carried out by Yu [3] and Zhou [6], this conceptual model embeds the latest unified registration regulations at both state and provincial level. Based on this conceptual model, the model-driven workflow from multi-source cadastre data to unified cadastre data encoding is also tested by case studies in Anhui Province China. The preliminary result demonstrates the expressiveness of this conceptual model and the effectiveness of conceptual model-based data construction. The conceptual model built in this work supports the
related data fusion, analysis, and system construction for unified registration of immovable properties in China.

**Conceptual Model Design**

**Concept Collection**

Although the latest cadastre unification effort has made clear the definition of some of the core cadastre concepts, a large amount of the concepts is still dispersed in different laws, regulations, and administration statements [3]. They were defined by different ministries and aiming for diverging objectives. To find relevant concepts, all these related laws and regulations in both state and provincial level are collected and coded. They include Property Law, Grassland Law, Anhui Urban Real Estate Transaction Regulation and so on. Then, the keywords are extracted with TF-IDF methods and are manually verified. Two types of disparity have been spotted: first, the same term may have different meanings in different application circumstances; second, multiple terms may denote the same concept. The solution could be either introducing new terms to distinguish different concept in each of the sub-domain or constructing a general concept to represent terms with the same meaning. We also compared the final selection set of concepts with existing unified registration regulations to eliminate possible conflicts.

**Extension of ISO 19152 LADM**

ISO 19152 Land Administration Domain Model (LADM) is a comprehensively discussed, extensively tested, and widely accepted conceptual model in Cadastre domain [7]. It is based on a series of existing ISO/TC 211 standards and largely object-oriented modeling, which describes the concept by using classes and their connections. LADM provides a common concept bundles that could be shared by different countries, provinces, ministries, and cadastre system developers. It could also be modified and extended according to specific administrative requirements while maintaining interoperability.

The features of LADM make it an ideal framework for a provincial conceptual model of cadastre. The general rule of the extension is to maintain the LADM class as many as possible and to extend it with new classes only when necessary. There are three methods to extend LADM class: adding new class properties, adding new sub-classes, and adding new standalone classes. For example, firstly, current “LA_PartyGroup” in China’s regulation could be further extended with properties of “ShareType”, a concept used in China’s cadastre for shared properties ownership. Secondly, “Natural Person”, “NonHumanParty”, and ”Delegate” are added to the conceptual model as sub-classes of “LA_Party”. Thirdly, the class “LawEnforcement” should be added standalone to describe the three conditions of property: pre-right, when the property has not yet been established; dissent, when the ownership of the property is questionable; and close-down, when the property is forbidden for transfer.

**The Anhui Cadastre Conceptual Model**

Based on concept collection and LADM extension, the Anhui cadastre conceptual model has been designed. Similar to LADM, the Anhui model has three packages and one sub-package: 1. Party package, the concepts of cadastre party and their relationships. 2. Administration package, the concepts of right, restriction, responsibility and their relationships. 3. Spatial Unit package, the concepts concerning spatial entities. 4. Surveying and representation sub-package. Figure 1 shows the content of Spatial Unit package.

**CityGML Encoding**

The rich semantic nature and the geospatial content in cadastre make the encoding with GML (Geographic Markup Language) more applicable compared with other model encoding choices. More specifically, this work uses OGC (Open Geospatial Consortium) CityGML (City Geographic Markup Language) encoding specification, an urban application extension of GML, to encode the semantic information defined in Anhui cadastre conceptual model. Since CityGML contains a
different conceptual model, the first step is to fuse concepts in CityGML with those in Anhui cadastre conceptual model. The fusion could be centered on either Cadastre conceptual model or CityGML model [8]. In this work, the latter method is employed and an Anhui cadastre Application Domain Extension (ADE) of CityGML is created. In this ADE, the “_CityObject” class in CityGML is extended with “SpatialUnit” class in Anhui cadastre conceptual model. This inheritance guarantee that all spatial unit objects could be spatially registered. The building in cadastre denotes legal spaces, which may not in accord with its physical counterpart [9]. To properly model the relationship between legal objects with their physical counterparts, Anhui Cadastre ADE establishes the connection between class “AbstractBuilding” in CityGML and the class “AbstractBuilding” in Anhui cadastre model.

With the conceptual fusion of Anhui cadastre model and CityGML model, the CityGML encoding mechanism (GML 3.1 specification) could thus be leveraged to project conceptual model to XML schema (XSD), naming Anhui Cadastre XSD here. A data construction pipeline from original multi-sourced cadastre data to unified registration data could then be established. The CityGML core, building module, land module, appearance module and Anhui cadastre ADE are all encoded. An ETL tool is constructed to regulate the pipeline from original cadastre data to the destination GML file following the Anhui Cadastre XSD schema.

![Figure 1. Spatial Unit Package of the provincial cadastre conceptual model.](image)

**Model Validation**

The conceptual model is validated with multiple urban cadastre cases in Anhui Province. The evaluation criteria include first if this conceptual model and the following encoding data could support the registration, storage, and query of cadastre related spatial and non-spatial information and second if this conceptual model could be encoded in a form that is compatible with current GML specification and then supported by multiple geospatial information systems.

A preliminary evaluation with cadastre related data from multiple domains and interim unified registration databased proves the effectiveness of data producing process, and there are few information losses. Moreover, the compatibility test demonstrates that the data encoding meets the
requirements of OGC GML3.1, ISO19152, and ISO19136. Thus, the data processing, managing, and visualization could use current OGC and ISO/TC211 compatible platform with minimum extension. Compatibility with standards also guarantees the interoperability between systems.

A conceptual model, if well designed, could also sharpen the epistemology of a particular domain. A quick application of this conceptual cadastre model in the education process with undergraduate students indicates its advantages compared with the current way of cadastre related knowledge synthesis, which is fragmentized, dispersed, and contains a lot of conceptual conflicts.

**Conclusion**

This paper reports an ongoing development of the conceptual model for China’s provincial cadastre unified registration to advance the fusion of cadastre data maintained by different ministries and facilitate related system development and interoperation. Key cadastre concepts are extracted from existing laws and regulations by TF-IDF methods, ISO 19152 LADM model is extended, and a CityGML implementation is carried out at the end. A preliminary evaluation of the conceptual model proves its expressiveness for provincial cadastre information registration, its effectiveness of data encoding, and its advantages in cadastre education compared with current knowledge schema. The conceptual model development is still at an early stage. Further discussion and evaluation by other domain experts from different ministry and application domain are indispensable. In future, the model could be improved on its topology integrity, the legal and physical object connection, and the semantic query method.

**Acknowledgement**

This research was financially supported by the University Science Research Key Project of Anhui Province (KJ2017A038), University Science Research Key Project of Anhui Province (KJ2017A039), Science and Technology Research Project of Anhui Department of Land and Resource (2016-K-12), Anhui Innovation Support Project for overseas returnee.

**Reference**


