https://doi.org/10.4233/uuid:2926040b-19a0-4633-816b-c605d9da4146

Temporal Perspective Towards the Design of Cadastral Database in Taiwan

Sin-Yi Ho and Jung-Hong Hong, Taiwan

Key words: land administration, ISO 19152, 3D Cadastre, time perspective, LADM

SUMMARY

Regardless of whether explicitly recorded, every geographic data has various aspects about time. Especially for integrated applications, the temporal aspects of geographic data from different stakeholders play an extremely critical role. Ignorance of the temporal difference or valid time of the datasets may easily lead to unexpected and even unpredictable mistakes. It is hence the responsibility for data designers to cautiously consider the demanded temporal information during schema design and correctly convey unambiguous meanings of the temporal information to users. It is also the responsibility of users to correctly interpret the temporal information before making any decision. Cadastre is governments' system developed to facilitate the management of lands and buildings, so as to protect citizens' property and drive the growth of economy. The massive volume of real estate transactions makes the management of cadaster systems a big challenge that involves both spatial and temporal aspects. From the interoperable application perspective, the ultimate goal of the cadastre system is to ensure every piece of information is based on the precise and coherent spatio-temporal modeling results, such that every decision can be made without ambiguity. It is therefore necessary to have a thorough examination on the spatio-temporal characteristics of the various types of cadastral data, as well as their relationships with the cadastre operations.

This research mainly focuses on the temporal modelling issue, especially in the valid time and semantics of temporal information. The Land Administration Domain Model (LADM) from ISO/TC211 (International Organization for Standardization/ Technical Committee 211) is chosen as the reference model in this study because it offers a whole package of standardized classes specifically designed for land administration purpose. As LADM is endorsed by international organizations like FIG and already adopted by many countries for developing national profiles for their cadastre systems, we believe the research results are not only beneficial to the digital cadastre systems of Taiwan, but also contribute to the guidelines for designing temporal information for domain data. Thie preliminary result shows the feasibility of introducing LADM to model the various temporal characteristics for the current cadastral data in Taiwan, but additional guidelines for designing temporal information with semantics to fulfill the needs required by related laws are also necessary. It would be even advantageous such standardized vocabularies can be unambiguously defined and extensively used in cross-domain integrated applications to improve the interoperability of temporal information.

Temporal Perspective Towards the Design of Cadastral Database in Taiwan

Sin-Yi Ho and Jung-Hong Hong, Taiwan

1. INTRODUCTION

The successful operation of Geographic Information System (GIS) heavily relies on the integration of various themes of data to "model" the reality. From the perspective of "modelling", every data represents the status of earth phenomena at a specific time, therefore all geographic data naturally has a temporal aspect and such information serve as an extremely important role while integrating data independently collected by different domains. Failure to recognize and address the temporal issues may cause serious problems, while users may never notice, e.g., overlaying two datasets referring to two different time together and use it as a map for decision. Unfortunately, the importance of temporal information is often overlooked by both domain data designers and users such that we are often dealing with data only with spatial consideration. This may become a even more risky issue when the data sharing becomes easier with the fast growing volume of worldwide open data.

Cadastral data is one of the core datasets of the National Geographic Information System (NGIS) in Taiwan even since it was launched in 1989. The operation of cadastre system in Taiwan can be dated back to the early 1900s, while both cadastral maps and registration data were recorded on papers. The development of digital land database began 1991 and continuously evolved over last 30 years (Ministry of the Interior, 2007). The current registration data includes six types of data, namely, related rights of land and building, identification of land and building, registration information, information of subjects, transaction index, and historical data. The map data includes cadastral maps, building survey map, etc. All cadastral data is updated and maintained according to the real estate transactions or government land reform projects. Since the cadastral data is specifically handled by cadastre agencies, the temporal status of any type of cadastral data should be able to be unambiguously determined. The challenges are to determine the best way for modelling each type of data according to their distinguished spatio-temporal characteristics and develop effective mechanism to correctly integrate different data for intended applications.

The temporal description framework developed in this research intends to address the modelling of various aspects of time information from a semantic and standardized perspective. The Land Administration Domain Model (LADM) is an international standard (ISO19152) designed to serve as the common conceptual model of land-related administration requirements, such that related parties can communicate data based on a set of a shared vocabulary with unambiguous semantics. Since the design of the LADM is based on the "common" characteristics of land administration models, it is neither intended to be a complete package, nor a specific model for an individual country system (Hong, 2016). Each country can design profile specifically according to the distinguished needs of their cadastral systems following the common conceptual schema from LADM. Countries that have developed LADM profile widely cover different continents, e.g., South Korea, Croatia, the

Netherlands, Malaysia, Singapore, etc (Polat, Z. A., & Alkan, 2018), which indicates the standardization of cadastre system is clearly a common challenge to all he countires.

The first version of the LADM framework was published in 2002 (Van Oosterom et. al, 2013), Lemmen and van Oosterom (2006) later argued the attributes of this model should considerthe time aspect and proposed to start a 4D cadastral study (Döner, F. et. al, 2010). We would particularly pay special attention to the temporality issue of Taiwan Cadaste. The proposed model intends to ensure the consistency of time information in cadastral management and cross-domain applications. The correct spatial-temporal record can be introduced as the constraints all data must rigorously follow. Furthermore, the standardized processing of data can improve the efficiency of data use, remove errors and conflicts and enable the correct interpretation to enhance the quality of decision-making.

2. TEMPORAL ISSUES IN LAND MANAGEMENT

2.1. Temporal Characteristics of Cadastral Data

Since our living world is not static, every recorded data should by default have a time information to indicate the status is valid at the specified time. Being used in various legal scenarios, this is also true for the cadastral data. One of the important issues of cadastral data is its timeliness. As the content of the cadastral data may change for various reasons, the design of any type of data should take the time factor into consideration. In order to establish the correct and dynamic relationship between different thematic data from the temporal and spatial perspective, Van Oosterom et.al. (2006) proposed three types of time in the cadastral database, namely, database time, legal event time, and variation of the right with time.

The database time is the time when the data was input to the system or database; the legal event time is the time for the events with legally valid status in law, e.g., the transaction dates and times related to ownership and other rights, the time for land division and consolidation; finally, the time period of various types of rights, such as leases, rights that will be effective in the future, and those that take effect on regular basis rights (grazing rights). Polat and Alkan (2021) argued that many users in Turkey (such as legal institutions, local governments, banks, and owners) not only need current cadastral data, but also historical data from the past. Therefore, land models must effectively address the management of data at different stages.

Moreover, environmental protection may also require consideration of cadastral time. For example, Unger et al. (2019) proposed the LA-DRM model (Land Administration-Disaster Risk Management) for integrating land administration and DRM activities to prepare, prevent, mitigate and respond to natural disasters more adequately, in which the validity period of land use rights needs to be traced. The above discussion shows that the temporal issue is an essential element in cadastre, and while countries begin to develop cadastral profiles to manage more complex land use, time will play an indispensable role in the schema design and related operations (Babalola et.al, 2015).

2.2. Standardization of Cadastral Data

The Land Administration Domain Model (LADM) is an international standard (ISO19152) designed to serve as the common conceptual model of land related administration issues, such

that related stakeholders can communicate with each other based on the same model and a set of shared vocabulary. The purpose of LADM is to provide a more comprehensive conceptual schema and offer a standardized description to remove the heterogeneity and enable the development of interoperable applications. As for the temporal issue, the class of VersionedObject is a class specifically designed to manage the modelling of time in the LADM standard.

The major three packages and one subpackage in LADM are designed to inherit from the class of VersionedObject, shown as Figure 1 (except the class of AdministrativeSource and SpatialSource), such that the time information for each class by default include the time it starts and ends, respectively defined by the name of beginlifespanversion and endlifespanversion. Becasue the start time is a mandatory attribute, it implies the start time of every described phenomenon is always available, while whether the value of the end time is recorded depends on the data itself. For example, when an instance of data is replaced by a new version of the same instance, the value of the attribue of endlifespanversion for the current version must be specified to indicate the time this instance is outdated and the new version of data must be given a DateTime value as the beginlifespanversion, which is the same value as the "end" stamp of the old version. (Inan, 2010). In addition, these classes also "automatically" inherit attribute information such as time, quality, and source. Since the management of start time and end time of the state described in the cadastral data is the responsibility of the land administration agency, in principle, all the changes to the database can be fully controlled, including all the historical versions (Hong et al., 2016).

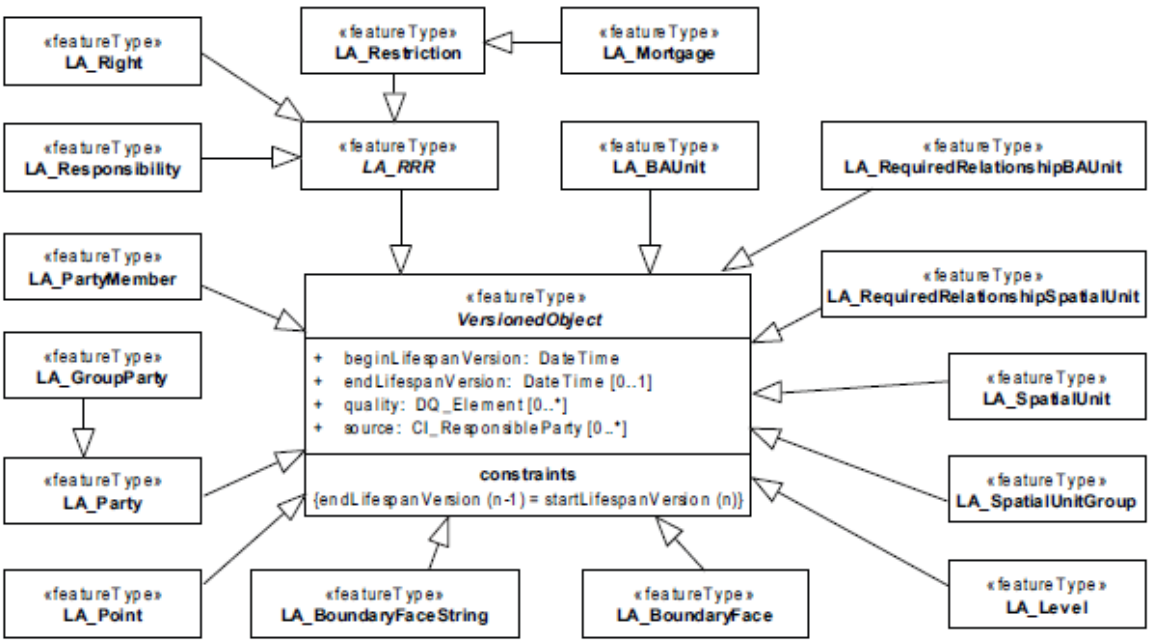

Figure 1. Inheritance diagram of VersionedObject class

Two issues require further consideration. One is the interpretation of time stamp or time period can only be inferred depending on if the end time is recorded. If only the start time is recorded, the time of the phenomena is interpreted as a time stamp; while if the time of the phenomena has an end time, it will be interpreted as a time period. The challenge is to

determine the status for described phenomena that has yet to have a end time. The other issue is while the class of VersionedObject uses the same design, the start and end time, to record time information, the semantics of such concept for different classes are different. For example, the start time of a person shall be his or her birthday, while the same attribute for the ownership shall be interpreted as the time of transaction or the time of registration. It is therefore necessary to consider how the time issues are appropriately modelled in the cadastre systems and provide the data to the users in a meaningful way without semantic ambiguity.

3. CADASTRE DEVELOPMENT IN TAIWAN

3.1. Land/ Building Registration in Taiwan

The current land registration system in Taiwan adopts the characteristics of both the German right registration system and the Torrens registration system, that is, when accepting the case from the citizen, it should be reviewed immediately, and the liability for damages should be attached (Land registration system after Restoration, 2020). Major properties of the cadastre systems include:

- For the change of land rights, registration is necessary. The so-called compulsory registration requires the registration for each land. All the registration information is managed by databases.
- The registration adopts the substantive examination doctrine. The concept is to carry out a detailed review from the substantive law. If it is found to be defective, it will be rejected or corrected within a time limit, and registration will not be granted.
- Registration has absolute effect. The so-called absolute effect means that entrust the registered items with absolute truthfulness and credibility, and the registered rights are consistent with actual rights.
- The register is in order of parcel number or building number.
- Anyone can apply for a transcript of the register to understand the contents of the register.
- After the ownership or other rights are registered, a certificate of ownership or a certificate of other rights shall be issued as a certificate of the right to facilitate the exercise of the right.
- If the real right holder suffers damage due to registration errors, omissions or hypocrisy, the land administration agency shall be liable for damages, but when the land administration agency proves that the cause is attributable to the victim, the victim shall be responsible for it.

3.2. Temporal issues in Taiwan Cadastral Database

Since Taiwan's cadastral system has two major characteristics: compulsory registration and absolute validity of registration, the people's property is based on the right to the possession of the right certificates issued by the government. The content of the land or building rights certificate consists of three major sections: the land/building description, the land/building ownership, and the other rights of land/building. Land/building description records the identification and basic information of the land/building, such as the parcel number, address, and area. Land/building ownership records the information of the owners and their ownership. The other rights of the Land/building records the other types of rights related to the land/building, such as the superficies, easement, mortgage, etc. Moreover, the digital cadastral

map records the identification and geometry information of parcels and their associated boundary points.

In Taiwan, cadastral data is maintained by the government, therefore, it must include a description of the start time. This is rather different from the situation of natural phenomena because we can seldom determine when a phenomena starts. From the point of view of valid status, the time record of cadastral data include three types of choices (Figure 2): (1) Time stamp: the state of the event is only guaranteed at the moment specified, for example, the construction complete date, the registration date. (2) Time period: this usually used for modelling a historical status continued for a period of time. For example, the validation of ownership or other rights. (3) Should be record both begin time and end time, and the phenomenon is not changed for a long time, so the end time will not record usually.

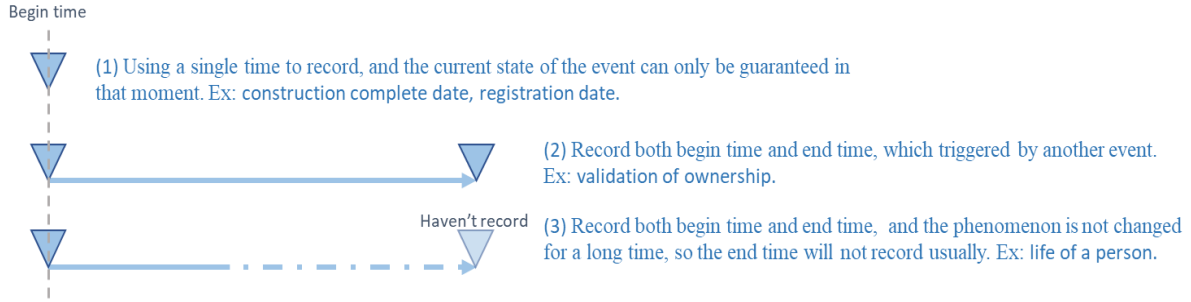

Figure 2. Three kinds of time recording types

In addition to above the standardized temporal information offered by the LADM, sometimes temporal information with specific semantics is required to supply additional explanation. For example, the data set metadata standard specifications formulated by the National Development Council of Taiwan requires to provide metadata about the start collection date, end collection date, launch date, metadata update time and data resource update time of the distributed open data (National Development Council, 2018). This type of information helps users to establish an understanding about the acquired data. These "standardized" temporal metadata elements are designed to provide distinguished time information for the data from the semantic perspective. Users can hence interpret the data and determine their fitness for use in a consistent way. Even if the importance of time information is well recognized, the ”standardized design” of temporal information to address different application needs is rather limited, such that different vocabularies are used for similar scenarios.

A pilot study for introducing LADM to model the Taiwan cadastre data was conducted in 2016. By choosing the building registraton as the target, Figure 3 shows the preliminary research results. The design basically follows the classes designed by LADM. The core classes are Party, RRR, BAUnit and SpatialUnit. The TW_Party, TW_Right, TW_BAUnit and TW_SpatialUnit classes are designed in consideration of the characteristics of the cadastre systems through inheritance from LADM classes and expansion of attributes. The related description classes of the surveying and representation sub package are mainly represented by the LA_BoundaryFace, LA_BoundaryFaceString, and LA_Point classes are designed by LADM. Related reference documents such as the building plan are represented by the class ofTW_SpatialSource, and the building ownership certificates are represented by the LA_AdministrativeSource class.

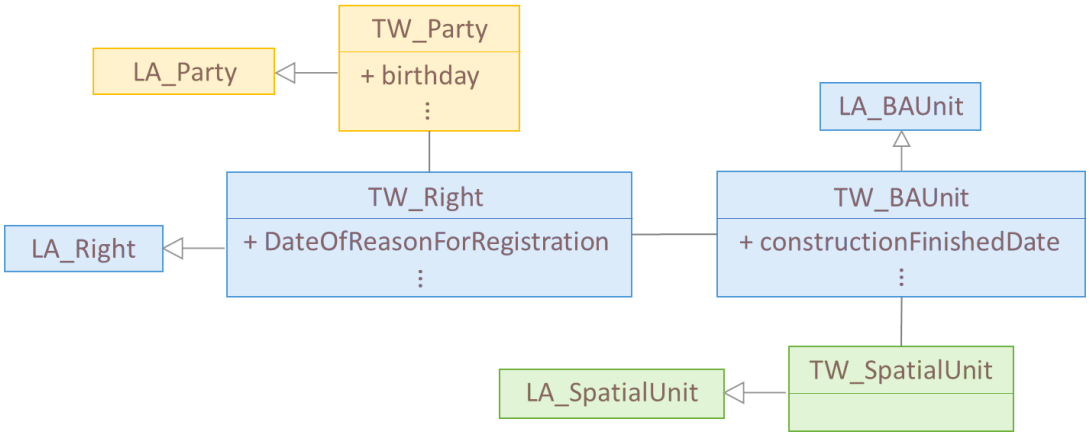

Figure 3. Taiwan LADM profile preliminary plan (core part of the temporal attributes)

TW_Party added birthday attribute to record the owner's date of birth, TW_BAUnit class added constructionFinishedDate attribute to record the completion date of the building, and TW_Right added DateOfReasonForRegistration attribute to separate the date of occurrence and registration of the cause date, because the effective time of rights is the registration time, this time is not equal to the time that the event that caused the change of rights occurred. For example, the transfer of land ownership is caused by the act of buying and selling, but the actual effective time of the transfer of ownership is not the time of buying and selling, so the land transcript will record the date of registration and the date of the cause (the date of signing the sale and purchase agreement).

The land or building rights certificate combines multiple information from various classes in LADM Taiwan Project into one document containing all the information most needed in Taiwan.

Table 1. Land/ building rights certificate combines various classes in LADM Taiwan Project

Time record	Directions	Taiwan Project Class
Land Description Part		
Registration time	The date of the latest registration of the land or building.	TW_SpatialUnit/ TW_BAUnit
Land Ownership Part		
Registration time	The date of registration after the change in ownership of the land or building.	TW_SpatialUnit/ TW_BAUnit
Reason happening time	The date of the cause of the change in the ownership of the land or building.	TW_Right
Current Declaration of the Land Value time	The declaration land price at the time of registration.	TW_BAUnit
Last transaction value or Assessment of land value time	The land value at the time of the previous land ownership transfer or when the land was first transferred, the original prescribed land value.	TW_BAUnit
Date of birth	Date of birth of the owner of the land or building	TW_Party

Land of Other Rights Part		
Submission time	The date of the submission of the application for the other right.	TW_RRR/ TW_Right
Registration time	The date of the other right register.	TW_RRR/ TW_Right
Duration	Duration of other rights.	TW_RRR/ TW_Right

4. TEMPORAL CONSIDERATION OF CADASTRAL DATABASE IN TAIWAN

4.1. Conceptual Design

There are two main strategies for the design of time attributes. One is to follow the versionedObject architecture, and the other is to expand the attributes with specific semantics. Three major requirements include the connection with international standards, the time semantics that effectively represents the specific meaning of Taiwan, and the clear display of the effective status of the phenomena for users to make correct judgments.

Based on LADM standard, the classes and attributes are expanded and modified to meet the application of Taiwan cadastral database. Continuing the four major packages designed by LADM, describing the relationship between people, parcels, and rights, and connecting them to the measurement. Use the VersionedObject class to record part of cadastral time such as the period of ownership, birth time of natural person, etc. However, when two types of data are overlapped, we must determine the effective time period to explain the state of the phenomenon. A common problem is only recording the event at the start time, we don't know how long its status lasts, so that we can't compare it with other data. Another problem stems from not understanding the meaning behind the concept of time. In order to deal with the different data recorded by each temporal model, we should develop the temporal semantic issue. The land ownership certificate contains various dates, which I mentioned in section 3.2. Because the lack of background, we do not know the meaning of each date, and we can't realize when the state recorded on the certificate begins and when it finishes. Regarding the registration time, it is found in the identification part, the ownership part and other rights part. They all use the same word: "registration time" but it is obvious that they represent different meanings (See Table 1).

To enrich the semantics of the distributed data, the expanded design of temporal attributes adopts the concept of the CI_DateTypeCode of ISO 19115-1 (Table 2). ISO 19115:2003 standard defines the schema required for describing geographical information and services. It provides information related to the identification, extent, quality, spatial and temporal schema, spatial reference, and distribution of digital geographical data. Although we have our own metadata profile called TWSMP (Taiwan Spatial Metadata Profile), there is a lack of time regulations, focusing on other quality assessments. In our study, we add the temporal semantic such as: release time, confirmation time, validity time, termination time, production time, update time, transaction time, etc., among which validityBegins and validityExpires are specifically designated according to Taiwan cadastral requirements, which have legal meanings. Each semantic meaning has its own characteristics. Although data from different sources may choose to use different attribute names, their concepts can be attributed to one of

the semantics listed in Table 2. Finally, the valid status of the event can hence be determined through the description of the temporal semantics. For example, the code of ”examined” is used to indicate that the data status has been determined and will not change after that time point, therefore, the status is valid from the time of recording. The code of ”lastUpdate” indicates the last time the data is updated. As the database can only be maintained by the governments, for some types of data, this information can be interpreted as the status remain valid from the time of recording till now.

Table 2. Temporal semantic vocabularies

Name	Definition	Example
creation	Data creation time.	Boundary points determine date, GPS station deploy date
publication	Date publication or announced time.	Upload time, announcement time
examined	Data verification or deadline.	Data approval time, verification date, modification time.
update	The time of re-recording the state, data may not change its value.	Update time
lastUpdate	The time when the information was last updated, and value may be different from the current status.	Update time
validityBegins	The time at which the phenomena began to be in a valid state.	Contract establishment time
validityExpires	The time when the phenomena is no longer activated.	Registration of deletion time
transaction	The status of the data changes, and the record of this time is triggered for some reason, which is different from the previous version.	land division、land consolidation, Date of occurrence of cause registration
representative	Use a certain point in time to represent the ongoing phenomenon.	Demographic time in May、satellite image photography time
begin	The time when the phenomenon occurred.	Date of birth, date of announcement
end	The end time when the phenomenon occurred.	Construction completion date, closing date, announcement expiry date, overdue date/time
execute	The time of occurrence of events related to various specialized domains that are not beginning and ending.	Correction time, retest time, survey time, application time, receipt time, request time

4.2. Logical Design

The logical design of the correct temporal record method at least includes name, time, and semantic. It can be further subdivided into sub-elements necessary for each element record, such as time must specify its reference system. Therefore, the design of the database is subdivided into three main categories (Figure 4), namely, time identification, time description and time scope. Time identification is the basic information describing the event, and the validity of the version must be explained; the time description category is the main time

record, such as the clock, how long it lasts, the update frequency, etc. In this part, the time attribute specified by VersionedObject is mainly retained, and other attributes are additionally extended to determine which type of the data belongs to; the time scope category describes for applications where time is applicable, users must pay attention to the description of the scope of time when comparing two types of data to avoid making wrong decisions.

- **Identification:** The attributes in this part include versionID, lastVersionID, nextVersionID, validityState, and timeName. The purpose is to link the previous and next version with the identifiers. We also record the validity state of the event to understand the effectiveness of the duration such as contract establishment time and registration time, so that we can clearly know when the situation of the data starts and end.
- **Description:** This part is designed to record time information.In addition to the beginlifespanversion and endlifespanversion included in the VresionedObject from ISO19152, four attributes, periodlifespan, updateSituation, updateFrequency, and approximateTime are added. Recording format follows ISO 8601- date and time format. ISO 8601 standardizes the universal time recording format throughout the world. Because it is an international standard, the content is planned and designed in the way of international time recording standards: A.D. and UTC. The format is based on year, month and day (YYYMMDD) plus hour, minute and second (hhmmss).
- **Scope:** This part explains the scope of applications, including the basic descripitive elements such as reference system, resolution, primitive, quality, and semantics. Except for quality information, all attributes are recorded by respective code lists, such as reference system（TW_ calendarReference Type, TW_ timeReference Type）, resolution （ TW_ resolutionType ）, primitive （ TW_ primitiveType ）, semantic （ TW_ semanticType）. The above code lists are all formulated according to our country's needs. For example, TW_calendarReference Type includes the Republic of China commonly used in Taiwan, and the lunar calendar (Chinese calendar) is added to accommodate the unique 24 solar terms in our country.

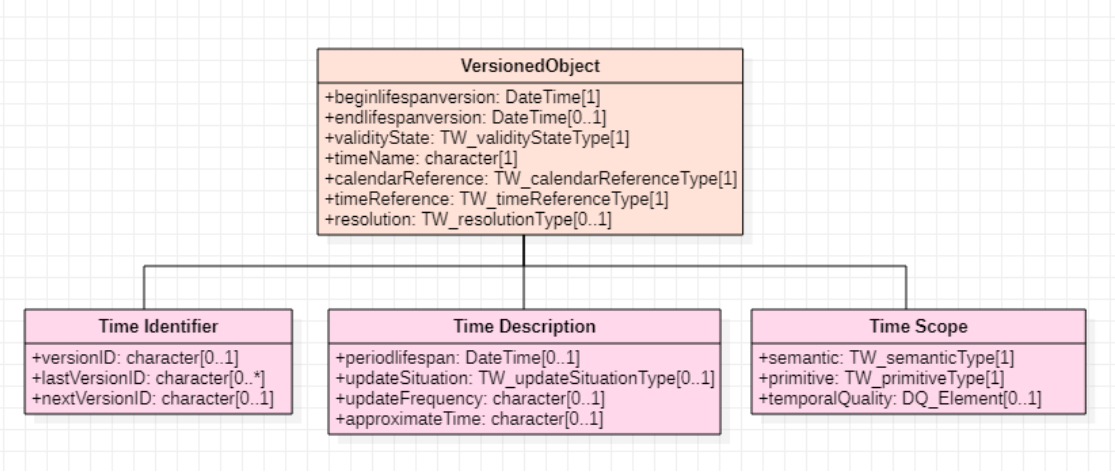

Figure 4. Standardized temporal schema

Respond to the Chapter 3.2, we can distinguish three kinds of situations from the standardized temporal schema we proposed, summarized as Figure 3. In addition to record the begin and end time, we also rely on the primitive to explain if the end time of the phenomena should be record or not. If the primitive is time period and the end time haven't been recorded, it implies

the described status remains the current status. On the other hand, if primitive is time stamp, meaning that the phenomena is a moment situation.

Table 3. Land/ building rights certificate combines various classes in LADM Taiwan Project

Time record	Belong group	How to record
Land Description Part		
Registration time	(3). Should record both begin and end time, but the end time will not record usually.	Primitive= period；beginlifespanversion
Land Ownership Part		
Registration time	(2) or (3). The start and end time should be recorded, unless the phenomenon has ended, the end time will not be recorded.	Primitive= period；beginlifespanversion；(endlifespanversion)
Reason happening time	(1). Using a single time to record, indicates the completion of the action.	Primitive= time stamp
Current Declaration of the Land Value time	(3). Should record both begin and end time, and the phenomenon but the end time will not record usually.	Primitive= period；beginlifespanversion
Last transaction value or Assessment of land value time	(2). Record both begin time and end time.	Primitive= period；beginlifespanversion；(endlifespanversion)
Date of birth	(3) Should record both begin and end time, and the phenomenon but the end time will not record usually.	Primitive= period
Land of Other Rights Part		
Submission time	(1). Using a single time to record, indicates the completion of the action.	Primitive= time stamp
Registration time	(2) or (3). The start and end time should be recorded, unless the phenomenon has ended, the end time will not be recorded.	Primitive= period；beginlifespanversion；(endlifespanversion)
Duration	(2) or (3). The start and end time should be recorded, unless the phenomenon has ended, the end time will not be recorded.	Primitive= period；beginlifespanversion；(endlifespanversion)

5. TEST ANALYSIS

Take the land register in Taiwan as an example, shown as Figure 5, and we can summarize it into Table 4. In the land register includes various time information which may cause the user to confuse to read and make it difficult to use. However, through the temporal semantic proposed in this paper, the required registration information can be record by one of semantic vocabularies, which consequently clear to understand the meaning of each recording name.

What's more, combine the primitive and time recording, we can solve the problem that LADM does not know whether the event is over or not.

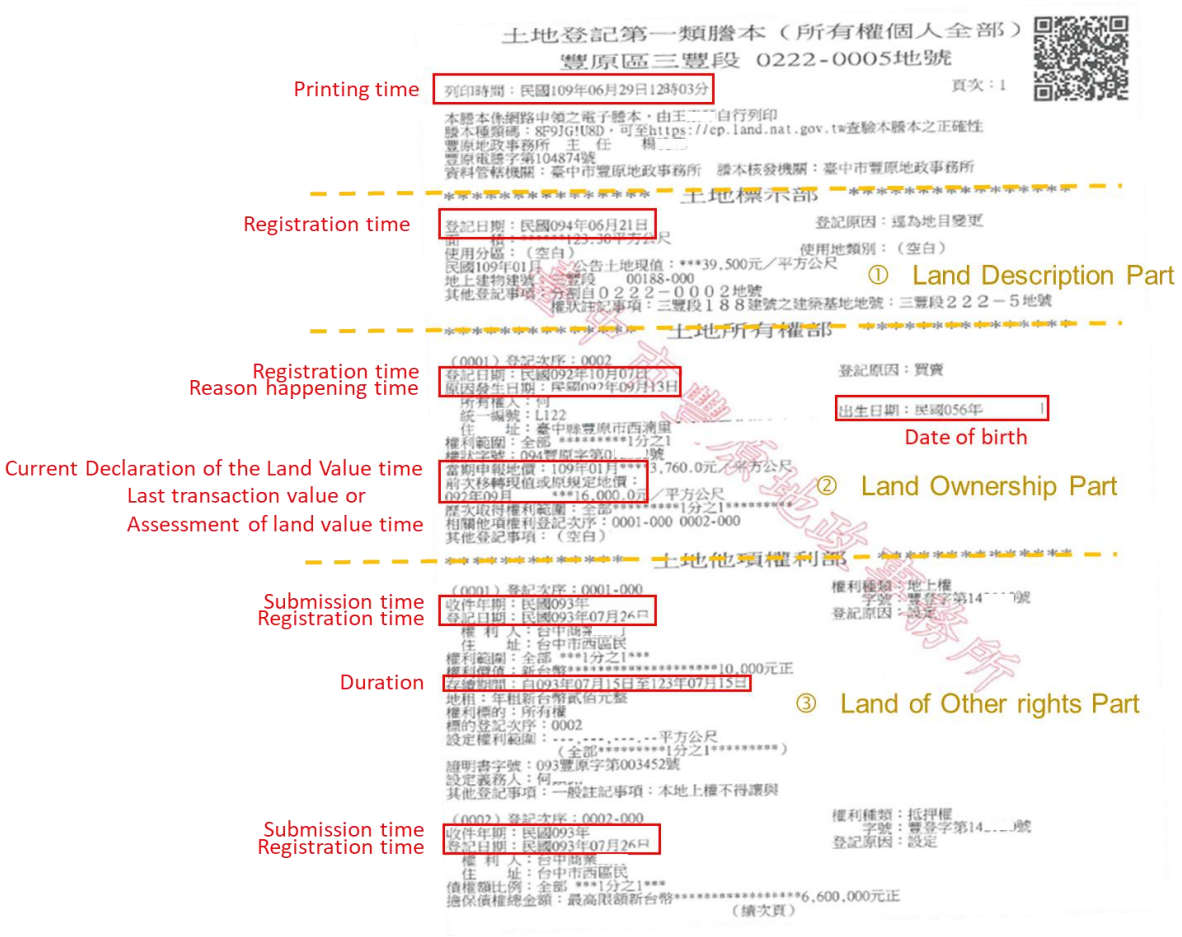

Figure 5. Land Register

Table 4. Recording terminology

#	Name	primitive	beginlifespanspan	Endlifespan version	Semantic vocabulary
1	Printing time	Time stamp	2020.06.29 12:03		creation
Land Description Part					
2	Registration time	Time period	2005.06.21		validityBegins
Land Ownership Part					
3	Registration time	Time period	2003.10.07		validityBegins
4	Reason happening time	Time stamp	2003.09.13		transaction
5	Current Declaration of the Land Value time	Time period	2010.01		publication
6	Last transaction value or Assessment of land value time	Time period	2003.09		lastUpdate

7	Date of birth	Time period	1967.08.06		begin
Land of Other rights Part					
8	Submission time	Time stamp	2004		execute
9	Registration time	Time period	2004.07.26		validityBegins
10	Duration	Time period	2004.07.15	2034.07.15	validityBegins / validityExpires

When we want to retrieve the history of all events in the life cycle of the land:
First, we can check whether each event is finished or not. Number 1, 4, 8 events are time stamp recording types, so they don't need to record the end time any longer. Except for them, the rest are time period recording types, and those who didn't record the end time means haven't been finished.

From the recommend semantic vocabularies in Table 2, we can know which time points are of legal characteristics, showing validBegins and validExpires. According to the meaning of the recorded data, users can easily understand the time when the ownership is transferred and legally takes effect, which should be based on the registration time. And in the setting of other rights, it is obvious to rely on Registration time. In addition, the concept of last update displayed in Last transaction value or Assessment of land value time indicates that the status of this phenomenon has version information, and the information is the current latest version. This concept can remind users to find the latest version when checking the information.

6. CONCLUSIONS

To evaluate the feasibility of the proposed temporal model, digital cadastre based on LADM (ISO19152) is chosen as the research target. The analysis respectively examines the temporal aspects of every LADM package and proposes appropriate time attributes according to the regulations of Taiwan cadastral database. The result intends to serve as the basis for future development of LADM Taiwan profile. The following lists the major findings in the research:

- The class of VersionredObject in LADM can be used to present the valid temporal status of the described phenomena. However, additional temporal attributes are still required in developing Taiwan profile. Through the proposed temporal semantic code list, the temporal aspect of all the analysed cadastral data can be represented by one of the twelve scenarios, and each scenario has a specific meaning of valid situation for modelling its distinguished temporal characteristics.
- Following the standardized temporal LADM profile, the correct management of historical cadastral data can be tremendously improved, especially the temporal consistency among the multiple versions of cadastral data. The proposed model can be used to unambiguously describe the temporal relationship between events and status.
- As the geographical data sharing between the platforms can be described in a standardized way, effective data exchange can be carried out between various domains. When web services are provided, users can correctly interpret the time information and determine its

use and limitation. Temporal information of data from the different domains can be explicitly recorded by the standardized rule to enhance the cross-domain applications and improve the interoperability between heterogeneous geodata.

REFERENCES

Babalola, S. O., Rahmanb, A. A., & Choonc, T. L. (2015). A brief review of land administration domain model and its temporal dimension. Journal of advanced review on scientific research, 6(1), 1-15.

Döner, F., Thompson, R., Stoter, J., Lemmen, C., Ploeger, H., van Oosterom, P., & Zlatanova, S. (2010). 4D cadastres: First analysis of legal, organizational, and technical impact—With a case study on utility networks. Land use policy, 27(4), 1068-1081.

Halil Ibrahim Inan, Valentina Sagris, Wim Devos, Pavel Milenov, Peter van Oosterom, Jaap Zevenbergen, 2010. Data model for the collaboration between land administration systems and agricultural land parcel identification systems.

Inan, H. I., Sagris, V., Devos, W., Milenov, P., van Oosterom, P., & Zevenbergen, J. (2010). Data model for the collaboration between land administration systems and agricultural land parcel identification systems. Journal of environmental management, 91(12), 2440-2454.

Jung-Hong, Hong, Hun-Qin, Jiang, Yu-Ting, Su (2016): A New Perspective on Land Management - The Development of LADM. Promote forward-looking map management and services, 97(11), p.42.

Land registration system after Restoration. Retrieved September 15, 2020, from https://emuseum.land.gov.taipei/Item/DetailDiscover/%E5%85%89%E5%BE%A9%E5%BE%8C%E5%9C%9F%E5%9C%B0%E7%99%BB%E8%A8%98%E5%88%B6%E5%BA%A6?businessType=%E5%88%B6%E5%BA%A6&discoverType=%E5%9C%9F%E5%9C%B0%E7%99%BB%E8%A8%98.

National Development Council, 2018. Data Set MetaData Standard Specification Second Edition.

Polat, Z. A., & Alkan, M. (2018). Design and implementation of a LADM-based external archive data model for land registry and cadastre transactions in Turkey: A case study of municipality. Land use policy, 77, 249-266.

Polat, Z. A., & Alkan, M. (2021). Associating land registry and cadastre transactions with LADM-based external archive data model: a case study of Turkey. Survey Review, 1-15.

Sin-Yi, Ho (2020). A Standardization Perspective towards the Interoperability of Temporal Information – An Example of Land Administration Domain Model. Masters Dissertation.

Unger, E. M., Zevenbergen, J., Bennett, R., & Lemmen, C. (2019). Application of LADM for disaster prone areas and communities. Land use policy, 80, 118-126.

Van Oosterom, P. J. M., Ploeger, H. D., Stoter, J. E., Thompson, R., & Lemmen, C. (2006). Aspects of a 4D cadastre: a first exploration. In FIG 2006: Proceedings of the conference: Shaping the change, XXXIII FIG congress, Munich, Germany, 8-13 October 2006. Frederiksberg: International Federation of Surveyors (FIG), 2006. ISBN 87-90907-52-3. 23 p.. International Federation of Surveyors (FIG).

Van Oosterom, P., Lemmen, C., & Uitermark, H. (2013). ISO 19152: 2012, land administration domain model published by ISO. FIG Working Week 2013 in Nigeria–Environment for Sustainability, Abuja, Nigeria, 6–10 May 2013.

BIOGRAPHICAL NOTES

Sin-Yi, Ho is a Ph.D. student in the Geomatics Departments at the University of National Cheng Kung University. Her research interests focus on the standardization perspective towards the interoperability of temporal information.

Dr. Jung-Hong Hong serves as the professor of the Dept. of Geomatics, National Cheng Kung University of Taiwan. He is also the head of the information division of the National Science and Technology Center for Disaster Reduction. He has been the leader of the national project for GIS standardization of Taiwan and involve various research topics including 3D GIS, SDI, standardization and data quality.

CONTACTS

Sin-Yi Ho
Department of Geomatics, National Cheng Kung University
1, Daxue Rd., East Dist., Tainan City 701401, Taiwan (R.O.C.)
Tainan
TAIWAN
Phone: + 886-935349809
E-mail: f64041208@gmail.com

Sin-Yi Ho / Jung-Hong Hong
Department of Geomatics, National Cheng Kung University
1, Daxue Rd., East Dist., Tainan City 701401, Taiwan (R.O.C.)
Tainan
TAIWAN
Phone: + 886-939682845
E-mail: junghong@mail.ncku.edu.tw