Modelling Spatio -Temporal Aspects for Cadastral System in China

Ning ZHANG, China, P. R. and Arbind Man TULADHAR, the Netherlands

Keywords: Cadastral System, Spatio-Temporal, Data Model, Identity-based Change Model

SUMMARY

Due to increasing population, industrialization, and urbanization in China, the demand for land resources has become a major limitation to the sustainable economic and social development of China. Chinese government has realized that an efficient management using modern Geo-Information technology for the land resource is vital both for the present and future use of land. Thus efficient and effective management of Cadastral Management System is one of important priority now in China (Zhang, 2006).

Cadastral system in China currently operates only with current data not historical data. If it has to relate to the temporal aspects of cadastral land parcel with historical data, it then has to provide the capability to trace the spatial and associated changes in time. It can then be used to anticipate the trends for future strategic planning about the use of land.

In this paper, we highlight three main issues. The first issue describes land tenure how Chinese people uses land and deals with land use rights in urban as well as rural areas. The paper then highlights the needs of the Spatio-Temporal Data about the cadastral land objects from the view points of users and land registration in China. Then it describes the Spatio-Temporal Cadastral Data Model (STCDM) using Unified Modelling Language (UML) for static component and Identity-Based Change Model for dynamic part. Finally it concludes that such STCDM is a great demand for Cadastral Information System in Chinese land management (Zhang, 2006).

Modelling Spatio -Temporal Aspects for Cadastral System in China

Ning ZHANG, China and Arbind Man TULADHAR, the Netherlands

1. INTRODUCTION

Cadastral data in China is managed by the Cadastral Management Division under the Cadastral Management Department of the Ministry of Land and Resources (MLR). Cadastral data includes a) spatial data on the location, types, shapes, quality, and size of the land, and b) associated land tenure data such as the owner and ownership rights, user and usership rights and other rights. These cadastral data are of dynamic nature, as they continuously change in space and time for a number of reasons. For example, the rapid urbanization in China is one of the obvious reasons. Many buildings and apartments are built every day on land, and such activities have led Chinese cultivated land becoming less and less. In the mean time, the real estates have always been the most popular instrument for investment in China. That is, every day the property investors buy and sell the real estates. The subdivision and the amalgamation of the land parcels are also frequently taking place according to the zoning plans causing both spatial and non-spatial changes in land use or usership rights. When setting up a mortgage on a land parcel, it also causes changes in the nature of land parcels with a history during daily land transactions at the local land registration offices.

Cadastral data has a great variety of users of which the MLR is one of important stakeholders in China. The MLR regards “protecting cultivated land and promoting the intensive use of land” as the most important task in the management of land and natural resources in China. To support such tasks, the cadastral data is very much needed for the daily works including “temporal data” that concerns the past or historical information. Therefore, it is seen in this paper that the analysis of Chinese Cadastral Information System Behaviours is essential element for the Spatio-Temporal Data Model (STDM) for the cadastral system.

2. LAND TENURE SYSTEM

Land tenure system in China can be distinguished into three types of rights are ownership right, usership right and other rights (Zhang, 2006).

2.1 Ownership

According to the “Land Management Law in China”, the People’s Republic of China practices socialist public ownership of land, namely, either ownership by the people or collective ownership by the working people (Article 2). Thus, there are two kinds of ownership in Chinese Land Tenure System:

- State-owned land: owned by the people, (but ownerships exercised by the State on the behalf of the people), and

- Collective-owned land: owned by collectives (a group of farmers)

Accordingly, almost all land in cities and urban areas of cities are the State-Owned Land (i.e. ownership lies on *State)*, while the land in rural belongs to *Collective.* In other words, in cities and urban areas of cities, the owner name is always 'State' in the books of land registration. But rural areas normally have a variety of owners according to the law. Table.1 below shows the Ownership and its corresponding coverage in detail

Ownership	**Coverage**
State-owned land	- Urban areas of cities; - Rural land not for agriculture use; - Rural and suburban area that is confiscated, requisitioned, expropriated (expect for those portions designated or define as owned by collectives); - Forestland, grassland, hills, wasteland, mineral resources, mountains, unclaimed land, beaches, flood land and other types of land, which the state has not determined to be owned by collectives.
Collective-owned land	- Rural and suburban areas except for those portions, which belong to the State in accordance with the law (Article 8); - Rural land mainly for agriculture; - House sites and private plots of cropland and that of hilly land

Table 1: Ownership and its coverage

2.2. Usership

Usership means that a legal person / organization have the right to use the land. The right to use land may be transferred in accordance with law. In accordance with law the State applies a system of compensation on use of State-owned land.

Since the land in urban area is owned by the state, all organizations including government departments, companies and so on have to obtain the right to use the land. In rural areas, both the ownership and the usership of the land owned by collectives belong to the collectives. Thus, users and owners in rural areas are the same in most cases.

Ways to obtaining the Usership: According to the laws, the ownership in China cannot be bought and sold. But the usership can be sold and bought under some conditions. Since the State itself does not use the land, the usership is separated from the ownership. With regard to the State-owned land, the organizations can obtain the usership rights through *allocation* and *granting.* The land obtained by the way of allocation cannot be transferred (through any acts including sale, exchange, and donation) or mortgaged. But the granted land can be transferred, leased or mortgaged as long as the following conditions are met:

- The certificate for the usership of the state-owned land has been obtained;
- Legal title certificates of buildings and other attachments on the land have been obtained; and
- The contract for granting land-use right has been signed and land-use granting fees have been paid retroactively to the people's governments of relevant cities or counties or payment made with proceeds from land transfer, lease or mortgage.

The differences between granting and allocation are: i) only the land obtained by granting can go into the open market; ii) granting is limited by a certain time period but allocation is limitless.

Type	**Land in cities and towns**	**Land in rural areas**
Ownership	State	Different collective organizations
Usership	Individual organization	Individual collective organization
Way of obtaining Usership	Allocation / Granting	Previous facts of using land
Transfer	Only acts on granted parcels	NO
Way of the ownership change	-	-
Mortgage	Only acts on granted parcels	NO
Lease	Yes, to granted parcels State-owned lands without users can be leased under certain conditions	Yes, under certain conditions

Table 2: Current situations related to Chinese Land Tenure System

2.3 The other Rights

The other rights mean that after confirming to the ownership and usership, there are the other rights on land. Until now, there are two types of other rights i.e. mortgage and lease right.

3. LAND REGISTRATION SYSTEM IN CHINA

Chinese land registration system is a basic system for registering land required by the law in China. The system is divided into two components i.e. initial land registration and change land registration (Xinming, 1998).
Initial land registration, also called overall registration, is the universal land registration covering the complete area in a region. It is carried out region by region. The physical boundaries of land parcel are based on the administrative boundaries. In cities and towns, the boundary units follow the administrative hierarchy from the Country, Province, District, and

City-Street to Block. In rural areas its small units derives from the Country, Province, District, County, Township and Village. In both cases the smallest units is land parcel.

Change land registration is actually land registration that keeps maintaining land registers, and provides the services to the users, owners and persons who have right on land's rights. Any changes on land rights or land use must be registered at local cadastral office in the region according to the "Land Management Law in China (Article 12)".

Change land registration includes all kinds of registration such as:

- Setting up the rights (ownership, usership, other rights) of the parcel;
- Changing the rights (ownership, usership, other rights);
- Changing the name, address, landuse and so forth;
- Termination of land registration of a parcel by issuing new certificate.

The difference between initial land registration and change land registration lies in the following:

- The former covers the complete area in region while the latter refers to several parcels when changes in region.
- The initial land registration is one-time, after initial land registration the change land registration becomes a routine.

4. SPATIO-TEMPORAL ASPECTS : ANALYSIS OF USER REQUIREMENTS

With the rapid economic reform of China, land transaction of land usership rights has been taking place through selling and buying in open land market at a surprisingly fast speed in cities where the economic development is fast.

In Beijing many buildings, apartments, and offices are built every day due to its dynamic nature of economy, and there are many real estate transactions taking place each day and hour. In such situation many land titles and cadastral data are handled by the Local offices of Cadastral Management Division in Beijing.

Land title and cadastral data has a great variety of users or stakeholders such as legal authorities, financial institutions, various other organizations, private sector companies, local government, owners/ users and many others. For their decision making, these organisations need the "Temporal Data" concerning the current and past situation (or the history) of real estates. Currently the cadastral system deletes the old data or stores the latest data, and so it does not allow temporal analysis. The fieldwork made in this research reveals that for the quick and reliable decision making process, the Spatio-temporal information is utmost important and to be incorporated in Cadastral Information System (Zhang, 2006).

In the traditional or current system, the temporal analyses needed by all users could not be performed in rapid and reliable way. The reason is that the traditional land title and cadastral

system are manual and paper-based. Today, the considerable work can be done to carry out temporal analyses by the means of Geographical Information System (GIS). However, the main problem still remains due to lack of a Spatio-Temporal Data Model.

4.1 Spatio-Temporal Aspects in Land Registration and Cadastral Systems

According to land registration in China (both in initial and change land registration), time concept is divided into two situations:

4.1.1 Time during initial land registration

After a land user obtains land usership through the initial land registration, the parcel object is normally given birth with the unique ID. The user acquires the land registration certification from land registered office. Thus, initial state is then established between land user and parcel object. Thus we can say the parcel object has been born on the completion of initial land registration process.

4.1.2 Time during change land registration

When there are changes in land tenure information due to various reasons, it is compulsory to register the changes at local office and then the change land registration process would start. Then new land tenure information will be recorded in the books, and old land tenure record will also be required to keep record in the system. Here we could identify Time in two cases:

4.1.3 Spatial change in land parcel(s)

The unique parcel identifier would be changed including parcel's topology. This time point means that new parcel(s) emerge and old parcel(s). In this case, non-spatial data concerning land tenure will be stored for new parcel(s).

4.1.4 Non-spatial change in land parcel(s)

In this case, parcel's geometry is not changed, only non-spatial attribute values change such as the other rights change, land use changes, etc. Under this circumstance, parcel unique ID isn't changed, but time point as a change point in parcel's life-span.

From the above discussion the workflows of land registration have many steps with time stamps on objects. These time stamps have different temporal dimensions such as real time, transaction time, and procedure time in Chinese Cadastral Information System.

5. SPATIO-TEMPORAL CADASTRAL DATA MODEL

In order to capture the requirements described in section 4 for Digital Cadastral Information System, the Spatio-Temporal Cadastral Data Model (STCDM) would require two main components in the Chinese Cadastral Information System, namely static and dynamic

components. Static component shows the object classes that need to be maintained with time stamps, while the dynamic component provides operations that changes data in databases.

5.1 Static Components of STCDM

Figure 1 illustrates a static component of STCBM in Unified Modelling Language (UML) for Chinese situation as a sample. In this figure, there are two main abstract classes namely *Obligee* and *Chinese Land Parcels* on which all other classes and subclasses are built and new object classes can easily be added.

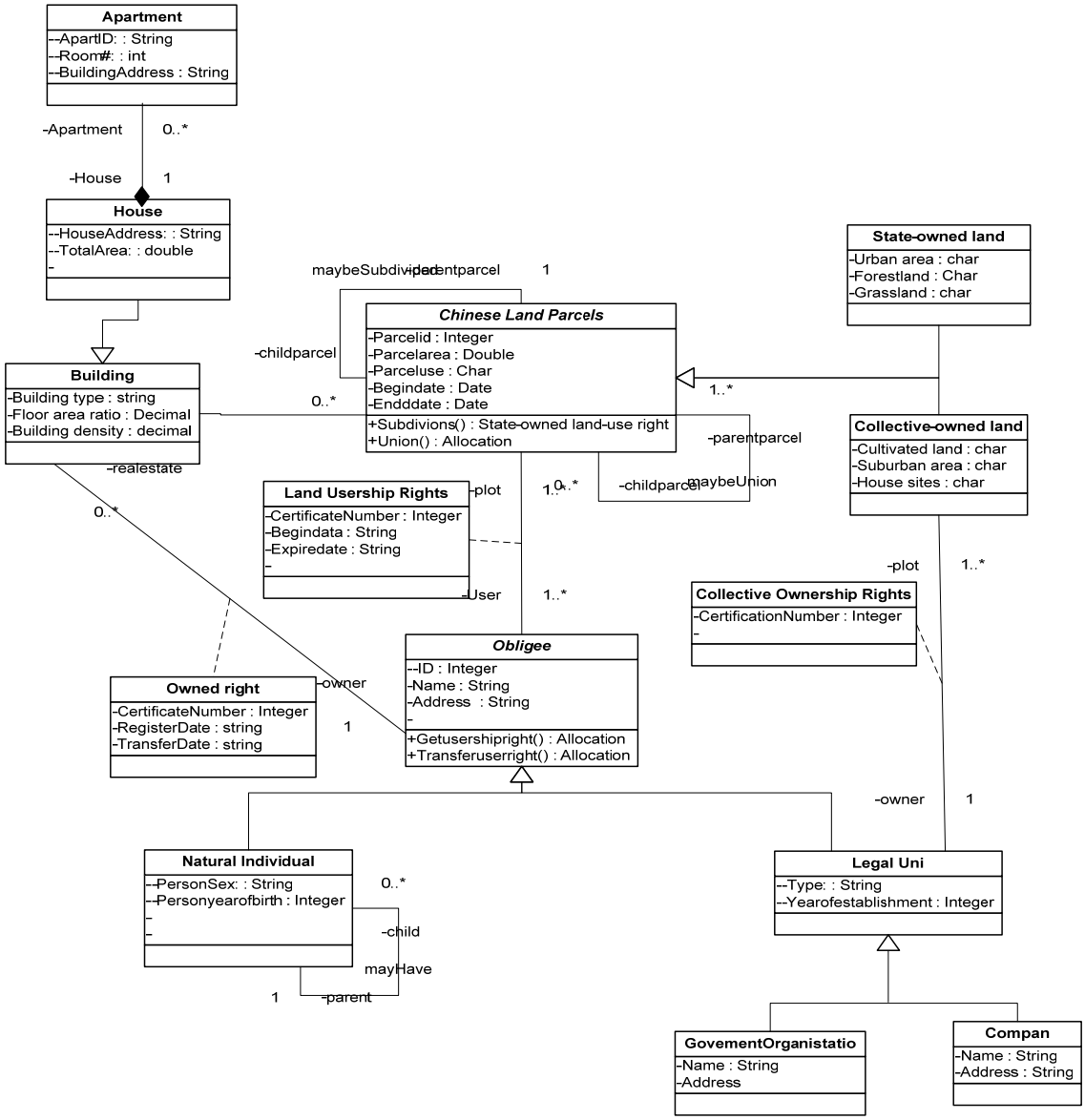

Figure 1: Spatio-Temporal Cadastral Data Model (STCDM) (Zhang, 2006)

Referring to the figure 1, there are two subclasses of the abstract class *obligee* (i.e. natural individual and legal unit). The class *Legal unit* is further specialized into government organizations. Financing agencies or banks are considered in this subclass. There is an association link between *Obligee class* and *Legal unit class*. It shows that an obligee participates as a representative on behalf of that organization. With *Natural individual* class, there is an association link showing that an *obligee* (as Parent) may have zero or more children. In China, this is important for inheriting properties, and similarly a relationship between husband and wife can be defined in *Obligee class*. Another two association link between *Obligee class* and *Chinese Land Parcel class* show that obligee can get land usership right on land, but for Collective-owned land legal unit can get only ownership right on land.

Building rights is regarded as attachment right on land. In China, building is divided into house and apartment that is modelled using association. Therefore, there is a strict composite relationship. A householder has ownership right of the building, so the buildings (house and apartment) are considered as commodities that can be sold, purchased, mortgaged, leased and inherited.

All the legal rights of an obligee are executed through the change land registration. The deeds and titles are represented in documents. The document can be a certificate for ownership or usership with easement and restriction, or registered deeds such as granting, mortgage, or lease contract. In other words, rights of an obligee on a land parcel are realized by several documents associated with an obligee and a land parcel.

5.2 Dynamic Aspects of STCDM based on Identity-based Change Approach

While UML use case and interaction diagrams provide dynamic aspects of the system, it was intentionally chosen to use "Identity-based change approach" in this research work. It argues that it is a powerful tool for representing temporal behaviours with different methods of creating new objects, spatial relations among objects, or properties of objects (Hornsby and Egenhofer, 2000). Further more query about the existence of an object or queries about past or future states of an object can be seen in the model such as:

- Is this object in existence at time *t?*
- Is this object at time *t2* the same object as encountered at time *t1*?
- Has this object always existed?
- What future changes are possible to this object?

5.2.1 Identity-based approach for initial land registration

The parcel information is created through initial land registration. The date will be stored to static database as history data (time is recorded *t*). In other words, an object that is without history is birthed with history. According to Chinese land tenure, four types of rights are represented by identity-based change (Figure 2). It includes State-owned land-use rights A (Figure 2 (a)); Collective ownership right B (Figure 2 (b)); Collective-owned land-use right C (Figure 2 (c)); or other rights D (Figure 2 (d)).

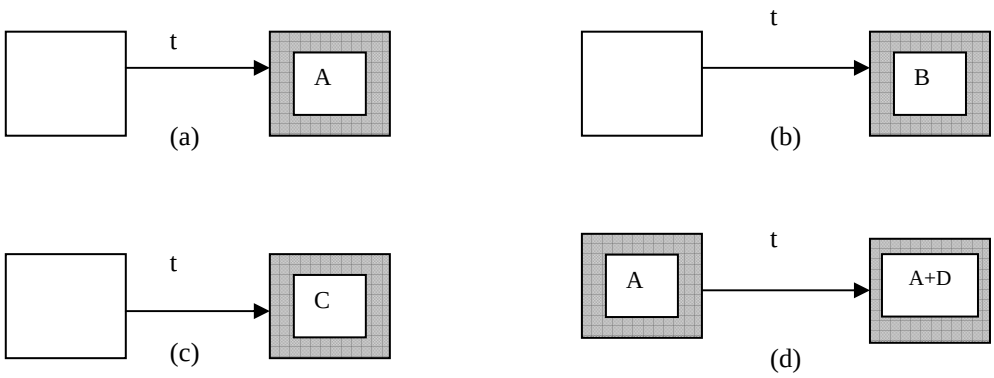

Figure 2: Identity operations creating: (a) State-owned land-use rights A is created, (b) Collective ownership right B is created, (c) Collective-owned land-use right C is created, and (d) other rights D is created on A.

5.2.2 Identity-based change approach for change land registration

The change land registration happens so frequently that immediately any change in the registration book should be updated. For our discussion on temporal change we choose State-owned land usership right as example. Five possible cases namely Split, Aggregate, Compound, Union and Amalgamate are spatial object using identity-based change described below.

5.2.3 Split

Assume the object A is a plot of State-owned land. See the figure 3. After initial land registration it was defined at the time t. Due to spatial changes, the object A is split into four new objects that have different land-use rights A1, A2, A3, and A4 at the time t1, t2, t3 and t4. During the process object A becomes non-existing with its history information, and new four objects are created.

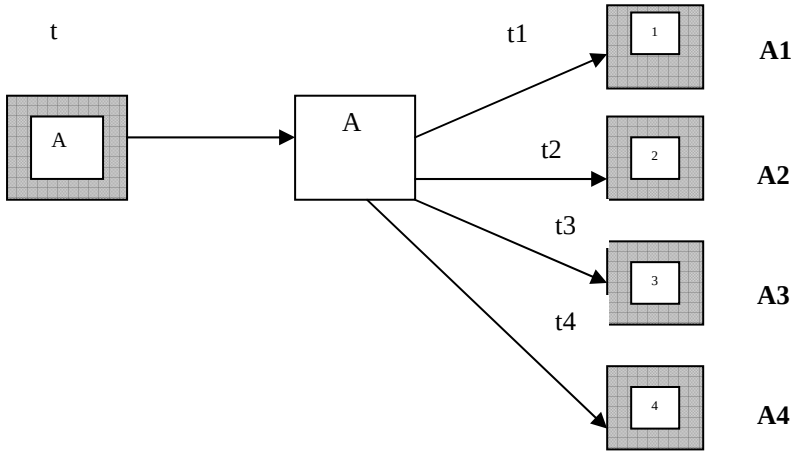

Figure 3: Object A is split to four objects

5.2.4 Aggregate

There are two plots of parcels *A* and *B* through initial land registration at the time ***t***. See the figure 4. According to land use change that object *A* and *B* aggregate to one object *C* at the time ***t1***. It also means that the objects *A* and *B* firstly become non-existing objects with their history. Then an object C is created.

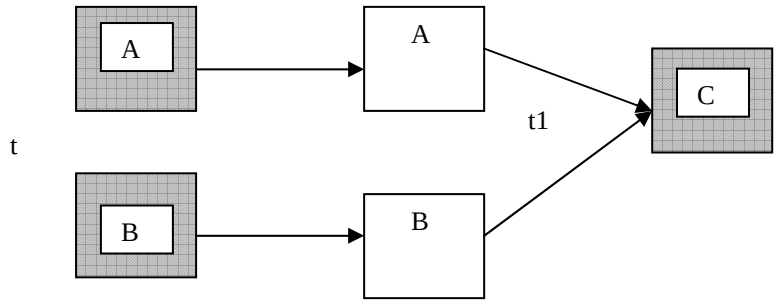

Figure 4: Objects A and object B are aggregated into an object C

5.2.5 Compound

Object *G* consists of objects *A* and *B* through initial land registration at the time ***t***. See the figure 5. Object *C* also is defined by initial land registration at the time ***t'***. Objects *A* and *B* keep existing with non-changing, but object *C* is compounded to object *G*. On the other word, the object *C* becomes non-existing with its history information. However, the new object *H* is created through change land registration that consists of object *A*, *B* and *C* at the time ***t1.***

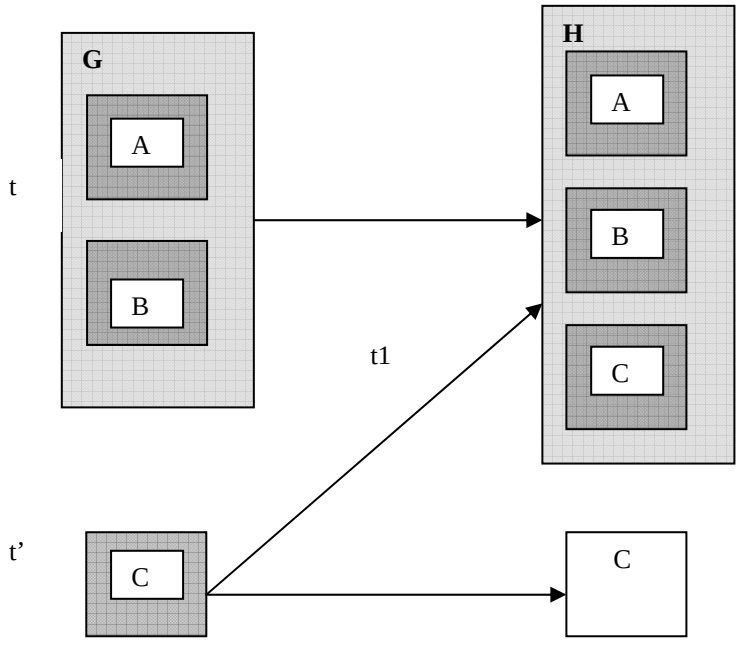

Figure 5: Object G and object C are compounded to object H

5.2.6 Union

Object *G* consists of objects *A* and *B* at the time ***t*** through initial land registration. Object *I* consists of object *C* and *D* at the time ***t'*** through initial land registration. Due to the land use changes that object *G* and object *I* are united into an object *H* through change land registration. But objects *A, B, C* and *D* still exist with their history information. Thus, the new object *H* is defined at the time ***t1*** that consists of objects *A, B, C* and *D* (Figure 6).

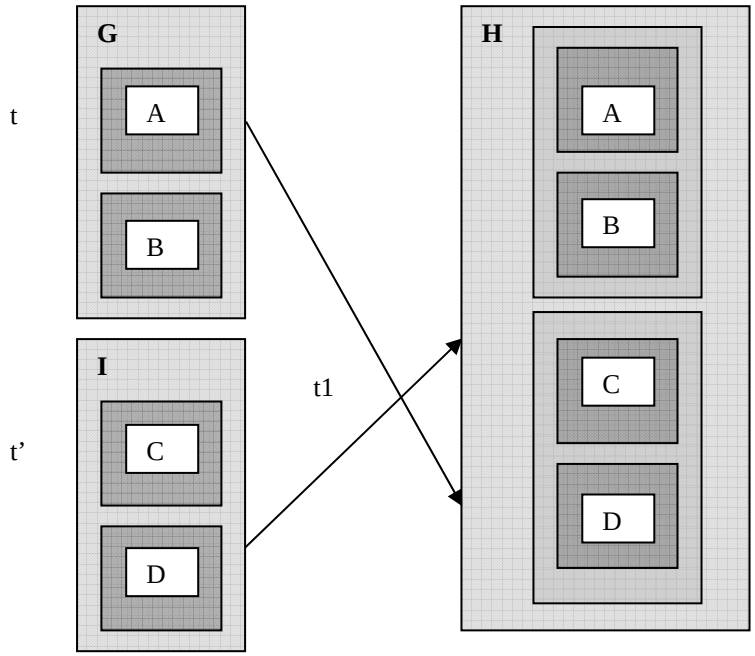

Figure 6: Objects G and I unite into object H

5.2.7 Amalgamate

Object *G* consist of objects *A* and *B* through initial land registration at the time ***t***. Object *I* consist of objects *C* and *D* through initial land registration at the time ***t'***. Due to the land use changes, Objects *A* and *B* are aggregated to new object *E* at the time ***t1***. Object *A* and *B* is non-existing with their history information (object *G* is non-existing). Objects *C* and *D* are aggregated to new object *F* at the time ***t2***. Objects *C* and *D* are non-existing with their history information. After that, the land use again changes, new object *H* consist of objects *E* and *F* at the time ***t3***. The objects *E* and *F* are amalgamated and it means that objects *E* and *F* are non-existing with their history information (Figure 7).

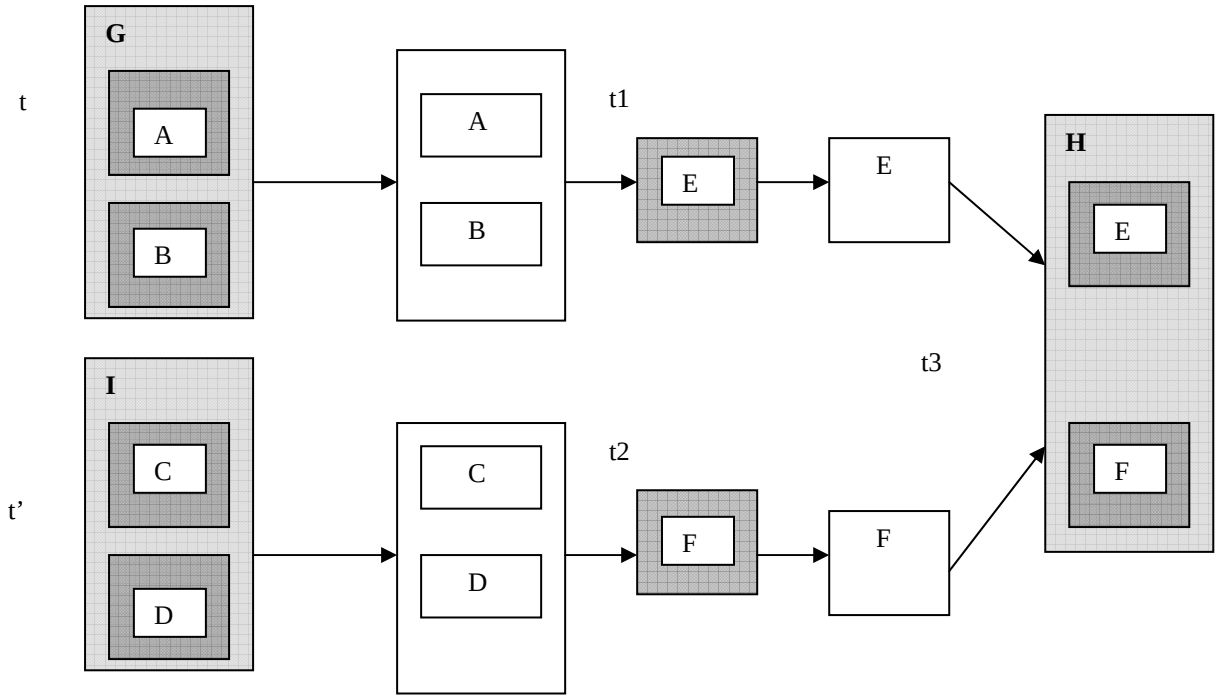

Figure 7: Object G and I amalgamate to object H

6. CONCLUSION

Chinese Cadastral Management deals with two types of land namely State-owned land and Collective-owned land. They can be either allocated or granted through the usership rights to the land users. Due to the rapid economic growth, change land registration is getting important to record the changes in land uses through land transfer process.

In this paper, Spatio-Temporal Cadastral Data Model (STCDM) is presented for cadastral information system in China. Its static part is developed using UML Class diagram, while dynamic part is developed using Identity-based Change Model for processes such as split, aggregate, compound, union and amalgamate that generate temporal data. This exercise shows us that such STCDM is essential for Cadastral Information System.

REFERENCES

.

Hornsby, K. and Egenhofer, M. J., 2000. Identity-based change: a foundation for spatiotemporal knowledge representation. Int. Journal of GI Science,14(3): 207-224.

Langran G.,1989. A Review of Temporal Database Research and It Use in GIS Applications. International Journal of Geographic Information System, Vol. 3, No. 3, 215-232.

Langran G., 1992. Time in Geographic Information Systems, Taylor & Francis, reprint.

Oosterom, P. Van, 2000. Time in Cadastral Maps in Time in GIS: issues in Spatio-Temporal Modeling, Delft, Nederland Commissie voor Geodesie. P 36-45,

Pengde, Li, 1992. Object-Oriented Approach and Expert System for Cadastral Applications, Enshcede, the Netherlands

Xinming T., 1998. Modeling of Spatiotemporal Data and Identification of Relationships and Change Processes for a Cadastral Information System in China, Enschede, the Netherlands.

Zhang, N., 2006**.** Spatio-temporal cadastral data model: geo-information management perspective in China. M.Sc. Thesis, ITC, Enschede, the Netherlands.

BIOGRAPHICAL NOTES

Ms Ning Zhang has Master of Science degree in Geo-Information Science and Earth Science specialising in Geo-Information Management at the International Institute for Geo-information Science and Earth Observation (ITC) in Enschede (NL). She is currently working as project leader in Chinese Land Surveying and Planning Institute, Ministry of Land and Resource, Beijing, China.

Dr. Arbind Man Tuladhar is assistant professor of Land Administration and Geo-Information Science at International Institute for Geo-Information Science and Earth Observation (ITC), the Netherlands. His current research interests focus on land tenure, land management/ administration, cadastral systems, system modelling and development including 3D modelling, and Spatial Data Infrastructure.

CONTACTS

Ms Ning Zhang
Chinese Land Surveying and Planning Institute (CLSPI)
37 guanyingyuan Rd., Xichenqu, Beijing, China
Tel: +86-10-66562973
Fax: +86-10-62156274
E-mail: Zhangning @clspi.gov.cn and supina20042000@yahoo.com

Dr. Arbind Man Tuladhar
International Institute for Geoinformation Science and Earth Observation (ITC)
PO Box 6, 7500 AA Enschede, the Netherlands
tel. +31-53-4874312
fax +31-53-4874575
E-mail: tuladhar@itc.nl
website: www.itc.nl