Updating processes with work flow for cadastral survey records to support LIS in Korea

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우리나라 LIS 지원을 위한 지적측량기록 갱신과정에 관한 연구

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국문요약 : 지적정보는 국토계획 및 개발, 그리고 소유권 보호를 위해 제공되는 중요한 의미를 가지고 있다. 그러나 지난 20여 년 동안, 빠른 사회변화에 지적조직은 적절히 대응하지 못하고 있는 실정이다. 최신의 지리정보통신기술은 지적조직의 변화를 떠미는 현상에 있고, 다양한 사용자의 요구에 지적조직은 끌려가는 형태이다. 이러한 의미에서 지적조직은 토지정책, GIS 시장, 데이터 표준 등과 같은 사회적인 환경요인에 따라 적절히 대응할 필요가 있고, 지적조직에 맞는 비전과 전략을 준비하여야 할 것이며, 품질경영에 따른 고급화된 상품과 서비스를 사용자에게 제공해 주어야만 한다. 일반적으로 지적기관은 지적데이터 이용을 정해진 법규에 따라 엄격하게 통제하고 있으며, 체계화된 절차에 따라 일정한 작업순서를 가지고 있다.

본 연구는 최신의 국제 지적시스템의 흐름 분석 및 법적, 기술적, 재정적 영향이 국내에 미치는 영향을 파악하였으며, 시스템개발을 위한 객체지향 모델링 도구인 통합모델링 언어를 사용하여 지적기관 안에서 이루어지는 지적측량기록의 관리 및 갱신을 일련의 워크플로워를 바탕으로 모델링하였다. 이 워크플로워는 최신 GIS 관리방법인 버전(Version)을 바탕으로 지적측량기록을 단계별로 처리과정을 표현하였다. 그 결과 제안한 객관적 업무처리는 향후의 지적조직 간에 보다 간편하고 단순하게 자료를 공유할 수 있으며, 지적측량기록의 관리 및 갱신을 위한 통합된 처리공정을 체계화할 수 있었다.

Key words : 지리정보통신기술, 핵심지적모델, 지리정보인프라, 통합모델링언어

Geo-ICT, Core Cadastral Model, GDI, Unified Modelling Language

Ⅰ. Introduction

1. Background

The maintenance and management of the cadastral information in the cadastral organizations is a very important issue for the implementation of surveying and mapping. Many activities, such as land conveyancing, taxation, and legal protection for the land tenure are based on this cadastral information.

The survey records have specific information to recognize the location of boundaries of parcels. Many countries have made the inclusion of a document called the field sketch to be archived as a compulsory part of the parcel based land information system for reconstruction of boundaries. Surveying practice in Korea doesn't include archiving of the original field observations as source documents containing not only survey data but also legal observations. Even for newly produced maps in new developing areas, the original information of field observation, such as control points, fences and fixed points are not maintained and managed. This mean that survey results made after original cadastral survey activity imply original survey observations. However current survey system cannot store and manage this kind of an important survey information, they only store and manage a final cadastral map. In this result mostly a cadastral survey is not based on prior survey results but depend on his experience and field situation with cadastral map itself, cadastral information in many cases are not consistent.

This research focuses on the development of a new workflow emphasizing a cadastral data model to integrate survey record information into the digital cadastral features so that newly produced maps are directly related to new survey information collected in developing areas. This enables access and data provision of reliable and consistent cadastral information to the future stakeholder.

2. Research problems

A cadastral database may be described as part of a Land Information System (LIS), which stores spatially defined cadastral and related information in a database such as the ownership, value. Cadastral survey system provides land-related information, to support certainty of ownership and rights to land, to give legal protection for land tenure, and to facilitate the land conveyancing (Cheng and Conrad, 2002). Thus, the cadastral system is primarily based on the accurate individual cadastral survey and plans built from original survey activities (Williamson, 1996).

Although detailed descriptions of parcel boundaries are needed to enable the extent of each property to be recorded for legal and fiscal purposes and to enable the limits of each property to be re-established in case of dispute over land (Dale, 1976), the organizations in South Korea didn't archived the original survey observations but only keep the original cadastral maps. As a consequence of this approach, most cadastral surveyors are not able to show the original boundary to the customer because the original observations are not available as well as the cadastral map is not accurate enough to be used as a source for reconstruction of coordinates in case of disputes. The traditional process of cadastral survey has caused the following performance problems:

- Cadastral survey records is not consistent (different results)
- Cadastral surveyors largely depend on personal experience than prior surveys
- Poor management of original survey data and related legal descriptions
- Customers are dissatisfied with survey results and want more reliable survey customers are nearly to pay for this

3. Scope of this research

There are two main objects dealing with in this research. Firstly, an analysis of the core cadastral domain model (van Oosterom et al., 2003) is reviewed as standardization for the developing of the information system. Secondly, a Updating System is designed in order to implement parts of the distributed set of information systems for supporting the maintenance activities and the information supply of parts of the land information systems as well as for improving digital cadastral spatial information in South Korea. In this thesis the proposed approach is to use the Unified Modelling Language (UML) which is one of the most powerful object-oriented modelling tools for system development. The diagram below shows the scope of this research.

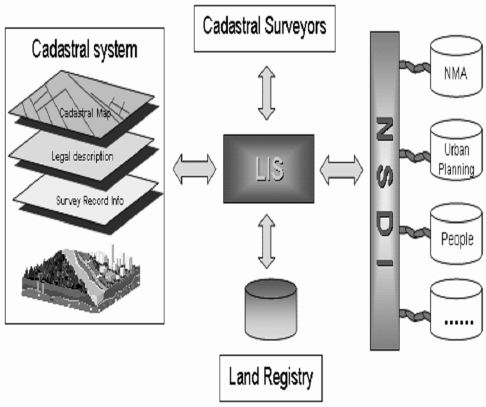

Figure 1.1 Scope of this research

4. Research objectives

The main objective of this research is to develop improved updating processes with workflow between the cadastral survey records and the digital cadastral map based on a new designed cadastral mapping process in GIS environment. Tasks to be accomplished include:

- To identify the information requirements for updating processes in LIS
- To develop the updating processes using a workflow based on versions

5. Research methodologies

The methodology for the study will be conducted in several research phases designed to address formulated research questions.

Task 1. Literature review

- To investigate trends in modern land information systems as maintenance and management aspects
- To review which standardization in cadastral domain model is necessary to implement the improved cadastral surveying system in South Korea

Task 2. Analysis of the existing system

- Analysis of the relationships between resources and existing work processes
- Impact of the proposed system on the current organizations in terms of legal, institutional, technical aspects

Task 3. Designing the conceptual cadastral data model

- This phase proposes a conceptual cadastral data model using UML. Necessary components and their roles in the system are identified.

Ⅱ. Challenges of cadastral survey system to support LIS

The maintenance and management of cadastral information in cadastral organizations is a very important issue for the implementation of surveying and mapping. Many activities, such as land conveyancing, taxation and legal protection for land tenure are based on this cadastral information. The objectives of this part is to investigate trends in maintenance and management of LIS and to identify challenges for the change of cadastral survey systems and to describe the cadastral model.

1. Modern trends of maintenance and management of LIS

The management of an up-to-date land administration system inevitably involves the use of modern information technology. Conventional solutions may no longer apply and the new system may involve the fundamental restructuring of the existing cadastral services and the security and analysis of every part of the system (UN/ECE/WPLA, 1996). Modern trends of land information system such as maintenance and management aspects can improve the data integration and sharing. Modern comprehensive and complete cadastral systems use Information and Communication Technology (ICT).

1.1 Enterprise GIS for automatic proceeding of information between different organizations

Observing developments of information systems in many countries during the last few decades, cadastral organizations can be recognized the integrated products and services from governments, agencies, provinces and municipalities to citizens and business (van der Molen, 1998). Business goals for establishing an enterprise GIS are to implement business process solutions utilizing GIS as a core component for interoperability between different organizations. Applications that have GIS built into the core enable the user base for GIS to expand to the greatest portion of the organization. The aims of the automation were to integrate all survey and title processes, to provide them in digital form, to reduce the costs of both provision and compliance, to utilize technological development, and to meet the growing community demand for improved quality and delivery (Bevin, 2002). The Figure 2.1 shows an automatic proceeding view of how GIS and business applications may be integrated to maximize the use of GIS.

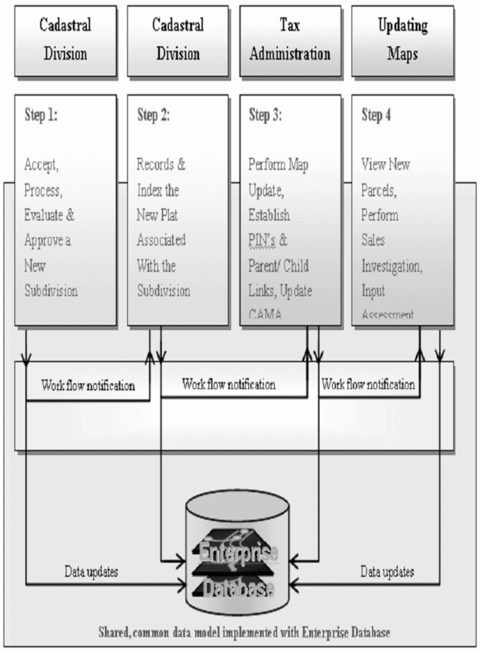

Figure 2.1 Business process to establish new parcels within Enterprise GIS (NovaLIS, 2003)

GIS provides the framework for an integrated work flow for creating and updating the cadastral information that can be easily shared both within and between organizations. Although GIS applications have been used to manage individual aspects of land records management for decades, the real benefits of GIS use can only be fully realized through applying GIS across the land records work flow.

1.2 Renewal of information systems and technologies

Current cadastral organizations are to support core data for land information system. In the years behind, the system is frequently modified and new functionality is added. However existing systems didn't always fit in the existing requirements to increased technical possibilities and developing customer demands (Mba, 2003). Many cadastral organizations rapidly tried to change IT/IS environments because of changes in requirements over recent years. In FIG (2003), two major strategies are introduced and elaborated for the renewal process of the IT environment in cadastre and land registration.

Step by step approach

The step by step approach is very complex and time consuming. A new system will be built up in parts in a new environment while the old system must be synchronized until it can be phased out. In this approach, the availability and continuity of the ICT systems at least at the current level is guaranteed. This step by step approach has examples in cadastres and land registrations: the Netherlands, Norway, Austria, England and Wales, and Sweden.

Big-bang approach

The big-bang approach means designing and building the new system as a whole. This approach may be a faster and less costly strategy for developed country. But this step has the risks which can be found in the time short after the implementation of the new system. Therefore it is highly recommended to develop a very careful planning and preparation of the big-bang event. This big-bang approach has examples in cadastres and land registrations: Czech Rep, Finland, Scotland, Slovenia, and Germany.

2. Challenges for the change of cadastral survey system

A common characteristic of Land Administration organizations is the great deal of effort they devote to the determination, registration and dissemination of information pertaining to the ownership, value and use of land (van der Molen, 2003). In this section the important factors forcing changes in cadastral survey system and challenges that cadastral organizations are facing with are identified.

2.1 Key driver to change

The organizations are now increasingly confronted with rapid development in the technology, a technology push: internet, database, modelling standard, open systems, GIS, as well as a growing demand for new services, a market pull: enhanced user requirements, E-governance, E-conveyance, integration of public data and systems (FIG, 2003).

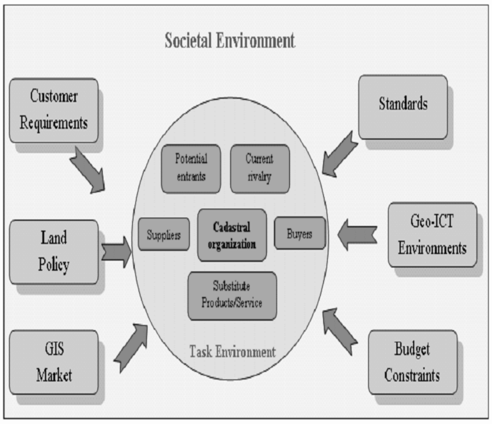

Figure 2.2 Key drivers to change for cadastral organizations

In particular, in case of implementation of competitive and effective organizations it is essential to include the elements of the customer satisfaction as a part of the organizational strategies. In careful listening to customer requirements, it is important to take into account and to understand the customer's background and values, map customer's problems and opportunities, and to notice unspoken concerns. On the other hand the suppliers always needs to keep informing all newly changes in the products and services including the customer's roles, the suppliers continuously gets feedbacks on the products and services (Tuladhar and van der Molen, 2003). Figure2.2 gives the context of key drivers for the changes of cadastral organizations in South Korea.

3. The cadastral domain model

A cadastre usually includes a geometric description of land parcels linked to other records describing the nature of the interests, and ownership or control of those interests, and often the value of the parcel and its improvements. In this result, cadastral system can support diverse stakeholders for an efficient service to share and distribute cadastral data in Geo-ICT environments. The cadastral domain model for improvement of cadastral system is analyzed concept and standard for spatial cadastral data and investigated activities for standardization in the following section.

3.1 Concept of the cadastral domain model

Current GIS process are time consuming and it may be difficult to find the data, the data model of the source may be very different from the model implemented by the local system, the supported exchange formats of source and destination are different (van Oosterom and Lemmen, 2002).

The main reason for constructing the cadastral domain model is to describe the different parts of real property information, including real property rights, and especially the relations between the different kinds of real property information. Many organizations are looking even more deeply at application specific data models. Also vendors, companies, schools, government agencies, and standard organizations are developing data models aimed at specific disciplines. Data models are structures into which data is placed and can detail everything from field names, the number of attributes for each geographic feature (Schutzberg, 2003).

3.2 Standardization for the cadastral domain model

Standardization activities can often seem complex or even impenetrable. Worldwide many efforts can be recognized related to standardization in the cadastral domain model. In this section, an overview is given of some standardization for the cadastral domain model.

1) Importance of standardization

Official standards have always been important in production operations, with many originating in military activity. Standards are becoming increasingly important for cadastral organizations (Greenway, 2002). Greenway introduced turning to benefit of standard by recent research (http://www.din.de/set/aktuelles/benefit.html) are followed:

- The benefit to the German economy from standardization amounts to more than US$ 15 billion per year
- Standards contribute more to economic growth than patents and licenses
- Companies that participate actively in standards work have a head start on their competitors in adapting to market demands and new technologies
- Transaction costs are lower when European and International Standards are used
- Research risks and development costs are reduced for companies contributing to the standardization process.

2) International cadastral domain model by FIG

The core cadastral domain model by a task for FIG Commission 7 - Cadastre and Land Management is given to the development of Land Administration standards in the context of appropriate ICT support for modern land administration and land management. Every cadastral system is keeping the contents of relationship between persons and land, via rights up-to-date (based on legal transactions) and providing information on this registration (Lemmen et al., 2003). The importance of the use of the cadastre to support land management has steadily increased. The cadastral organization is based on the systematic determination of land rights based on a state wide cadastral system.

The core of the cadastral domain model is relationship between real estate objects and persons via rights is the foundation of every land administrations. The cadastral domain model contains both legal/administrative like persons, rights and objects and the geographic description of real estate objects maintained by different organizations that have their own responsibilities in data maintenance and supply and have to communicate on the basis of standardized processes. The core cadastral domain model is structured into different 'packages' or aspects:

- The real core: The Person- Right-RealEstate structure
- The legal/ administrative aspects
- The real estate object specializations
- The geometric/ topological aspects

Ⅲ. Analysis of the impact of the proposed system in South Korea

Cadastral information is a basic pillar used in relation to all aspects of the real estate. Managing cadastral information is of great importance, regardless of the stage of development within each particular jurisdiction. The Korean cadastral organization manages all cadastral survey activities and cadastral data by a well-suited system in the future. The improved updating processes are proposed to support efficient and effective management of cadastral information through integration of digital survey records and spatial features in Information System. With this concept the supply of more credible quality to the customer within reality environments will be possible. In this section, the technical, legal, and financial impacts are analysed respectively.

1. Technical impact

The proposed system is to support the current cadastral survey system in South Korea. In order to manage efficiency in handling all kinds of spatial data, the cadastral organization must carefully consider the introduction of a survey work process based on modern Geo-ICT. Geo-ICT development has, over recent decades, an increasing influence on the business of land information and on the evolution of cadastre. The ICT has created a new and rapidly changing environment for further developments. In this section changing into GIS environments and cadastral infrastructure issues are addressed.

1.1 Changing into GIS environments

The Land Information Systems (LIS) provides integrated data to facilitate all processes in the areas of acquisition, management and distribution of spatial information. In order to support a progressive LIS, the cadastral system should supply improved data quality in the GIS environment for the user. On the other hand, the cadastral surveying system can also provide a seamless data flow between field and office, providing the quality of survey measurements into the GIS world. Modern cadastral system has changed legacy system into GIS environments, divided in three parts: manage survey records, improving the spatial quality of cadastral data, and historical database.

1.2 Cadastral infrastructure

In most cases existing systems do not satisfy the growing needs for cadastral information required for planning, development and management of land resources (Jerzy, 1998). Precisely, the United Nations and the FIG (FIG, 1996) defined the cadastral view as "develop modern cadastral infrastructures that facilitate efficient land and property markets, protect the land rights of all, and support long term sustainable development and land management".

Cadastral systems is a subset of National Spatial Data Infrastructure (NSDI) and cadastral data are some specific spatial data with a large component of attribute data describing cadastral objects in relation to cadastral subjects (Jerzy, 1998).

2. Legal impact

From a legal perspective, the cadastral organizations can supply improved cadastral quality to the user for protecting ownership and security based on a sustainable cadastral system. This section investigates the legal impacts in South Korea. In this section quality assurance and land dispute issues are addressed.

2.1 Quality assurance

Since the cadastral data have very serious legal consequences, adequate methods and checking systems should be implemented in the whole process of acquisition, subsequent processing, maintaining, storing and issuing the data to achieve reliability needed. Historically, cadastral surveying has applied surveying technology, and cadastral surveying processes include the provision of written property descriptions of land parcels and boundaries. In many countries, the methods used to perform cadastral surveys have remained relatively static for the past one century.

As most of the current cadastral maps have been made about one hundred years ago, the accuracy of maps has dropped. Furthermore, cadastral surveying is mostly done by graphic surveying using a plane table. Original survey records are not stored and managed till now. It means that systematically, it is impossible to use the precise original surveying results which people demand. With the growing land market, changes such as subdivisions,

merging and change in land categories happen frequently; but the consequent adjustments the cadastral records are not made in due time. This causes disparity between the cadastral records and real situation.
For the reason of lacking historical survey data, the cadastral surveyor cannot guarantee his result to the customer and cadastral organizations need to maintain and manage survey record information and need to provide reliable cadastral data to surveyors and customers on this basis.

Quality is the key to a successful business, whether it is a profession, a service industry or in manufacturing. The quality of goods and services is now recognized as a prerequisite to commercial success. It is a management approach that aims to achieve continuous improvement in all process, goods and services through the creative involvement of all people. The present system of licensing should be replaced by quality assurance so that companies as well as individuals can undertake all forms of cadastral work, including boundary surveys and spatial data management. Quality assurance should be backed by professional indemnity insurance.
The purpose of a profession is to provide a quality service, not only for its clients, but to the public at large. Cadastral organizations included surveyors are taken part in this service. This will be to the benefit of cadastral organizations as well as the status of the profession.

2.2. Land dispute

The number of land boundary disputes in South Korea increased till now because the cadastral data are not in accordance to the category, boundaries, size, and ownership of parcels in reality. Furthermore errors in control points propagate in the cadastral spatial data. There are many example of errors in control points. The land disputes are also caused by the errors of cadastral surveying and boundary reconstruct surveying. Thus, land owner and neighbour apply for survey claim to the surveyor and do not rely on the results of cadastral survey any more. Table 3.1 shows claims of cadastral survey for the KCSC during 1984 ~ 2002.
In table 3.1 the simple cases are not included. This table shows only claims of cadastral surveys in case of complex problems for surveyor as well as cadastral organizations. Because customers who have experience of survey claim don't rely on cadastral survey service any more. This means serious problems in the near future. Thus cadastral organizations could be better prepared for this in supplying better services to the customer using modern Information Techniques.

Nowadays cadastral organizations recognized land disputes as a problem. They created a department of a customer service in order to reduce the number of land disputes. However, current cadastral system is not sufficient to solve land disputes. Management of survey records and methods could provide more transparency cadastral information to the

Table 3.1 Big claims of the cadastral survey for the KCSC (Lee, 2004)

Type	Number of survey claims	Claim amount	Compensation	Year
Total	138	4,108	1,296	
Mutual agreement	122	1,361	1,105	Number: 1997 ~ 2002 Amount: 1984 ~ 2002
Lawsuit	16	2,747	191	1993 ~ 2002

- Unit: 1,000 Euro

user. The survey records information will be used in cases where there are disputes over the land. The legal position as shown in the records must be related to the evidence on the ground. In many systems the evidence on the ground is considered paramount.

3. Financial impact

Obviously, the development of a cadastral system is essential to establish law and order in relation to land resources as well as to form real estate markets. A technical infrastructure stemming based on computers and telecommunication is able to observe, record, store, retrieve and analyze cadastral data. However, converting these opportunities into reality depends on detailed analysis of cognitive processes to achieve higher levels of automation. This need for automation led the Korea economy to develop and maintain large data sets in modern cadastral systems. This section investigates the financial impacts of improving the cadastral survey system and reviews the cost recovery and GIS market of operating cadastral organizations.

3.1 The cost recovery

Economic development and economic depression can be of fundamental importance for evolving institutional and organizational infrastructures in accordance to national strategies focusing on reduction of government inefficiency and duplicated tasks. Budgeting systems of cadastral organizations are based on annual plans for the expenditure and revenue of government agencies. Van der Molen (2003) highlighted that the 'cost recovery' is the maintenance of the equity as specified in the balance sheet within a certain range, irrespective of any developments of relevance to the equity in the market. When trying to see around the corner and look into the future, therefore, it is quite obvious that national mapping organization, the national cadastre and other GIS sectors in GDI environments will share much from developments in the forthcoming years, and definitely more than in the past.

From government perspective, establishment of the cadastre for a public task and services of general interest has been financed by the state or local government by fiscal resources. Therefore there is no cost recovery. However, maintenance of the geodetic reference system and updating records for the cadastre is financed by the state or local government in general.

By to the benefit charging fees for the services performed that correspond to the benefits gained by the surveyors and the customers, enough funds for active development the cadastral system as a whole can be generated. Thus, it is possible to provide services to the whole society and across the whole jurisdiction. The fees paid actually go back into the infrastructure, and to the further improvement of services.

3.2 GIS market

The information contained in various cadastral and legal land registers, utility registers and map databases is a key infrastructural component carrying immense capital value, both in the public and private sectors of a nation's economy. A well-functioning land administration system (including maps) is one of the essential bricks in a market economy. The demand for land registration services and associated data is increasing year by year. Also increasing is a need for systems, such as GIS, that can be used to efficiently manage the considerable volumes of data involved and make this available to a wide range of users and uses: local authority survey and mapping organizations, real property formation, production of cadastral maps, public utility mapping, surveying and mapping companies, property tax assessment and related valuation, national, regional and local planners.

Entering the 21st Century, Korea has comprehensive plans to achieve a world-class level deployment of information technology (IT) with its governmental organizations taking the lead. In particular, GIS will play a central role in the Korean government's environmental monitoring and land management programs. GIS market has been growing steadily, and it is estimated that it will grow annually at a very robust rate of 30 percent year through 2005. The total size of the GIS market in 2001 was $363.1 million.

For many operations, private or public, the knowledge that many customers now have means that they require much more from the different kinds of services they make use of. If we look at the pattern of geographic information and land administration, this increased interest in digital information means that there will be less focus on traditional activities such as analogue mapping and registration. It is the information that these "production operations" generate that is of interest and that will be in focus. It is essential to realize that this is not only a political mantra but also a true customer demand that must be dealt with.

Cadastral information in Korea has been captured and provided by the public sector (including surveying and mapping) with a lot of personnel and fiscal for a governmental budget. Although cadastral information is provided for a basis for the different basic data, the opinion prevails that these data should not be put into the economic cycle free of charge. The cadastral information will support a main geo-source representing the first link of a value chain in the GIS market. Because of the high economic value, the government regards its public cadastral information as a protect-worth, but marketable product, which can contribute to a refinancing of the production and maintaining costs.

Ⅳ. Information requirements

In the analysis of user requirements, the developed model should be maintained and manage original survey records based on a well structured cadastral model. In this section, information requirements are explained with components of the proposed system. the Unified Modelling Language (UML).

1. Components of the proposed system

In this research, the proposed system focuses on improving cadastral surveying system in South Korea. The system for management and maintenance of cadastral survey records should be changed to a well-structured system to support LIS. This provides the framework for an integrated work flow for managing and updating the survey records that can be easily shared between cadastral organizations such as cadastral survey offices and cadastral departments.

● Toward more accurate survey records

Although the national cadastral system is survey based, cadastral records for the users, such as public sector, cadastral surveyors, and customers frequently have not been based on highly accurate spatial data. This information can not support purposes by other departments such as the urban planning and land use management department. Therefore an improved survey system should be made to make it possible for cadastral organizations to incrementally improve the accuracy of existing as well as new spatial data.

● Streamline work flows

Using GIS for managing and updating of cadastral data, work flows can be streamlined related to an enterprise database. Maintaining cadastral survey records in GIS environments saves money and time by automating maintenance of cadastral information, speeding the enrolment of new survey records. The purpose of this system improves survey records management by reducing data duplication and promotes distribution and easy access to survey records via cadastral infrastructure.

2. Unified Modelling Language (UML)

A cadastral system is a complex system, which consists of many subsystems with many sets of activities or processes and supporting data bases located at different geographical locations. It has to deal with institutional, legal, economical and technical issues (Tuladhar, 2002). UML modes can be used to describe and implement various components and their links with cadastre and survey system within the scope of a management framework for developing the information systems and their business processes (Tuladhar, 2004). Therefore, modelling for developing systems or business processes using UML can be as straightforward as drawing a flowchart listing the steps carried out by an application. The system developer can focus more easily on the smaller parts of a system and then understand the "big picture."

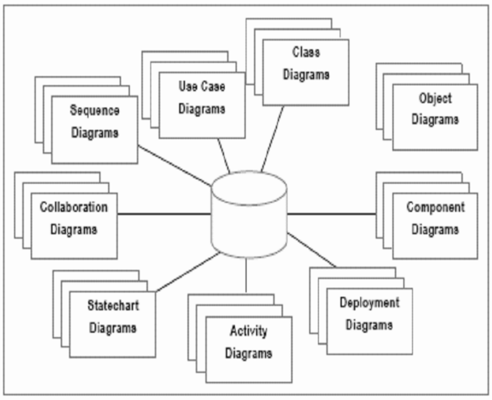

Figure 4.1 The type of UML diagram

The Unified Modelling Language (UML)is the language that can be used to model systems and make them readable. This essentially means that UML provides the ability to capture the characteristics of a system by using notations. UML provides a wide array of simple, easy to understand notations for documenting systems based on the object-oriented design principles. These notations are called the nine diagrams of UML. The UML unifies the design principles of each of these methodologies into a single, standard, language that can be easily applied across the board for all object-oriented systems. The UML is made up of nine types of diagrams that can be used to model a system at different points of time in the software life cycle of a system.

Ⅴ. Updating processes with workflow based on versions

In most cadastral organizations the use of cadastral survey data is often strictly regulated by laws, regulations and instructions and its processing must follow a work flow based on a set processes and routines. Cadastral survey projects also go through a prescribed or regulated set of stages that require legal approval before proceeding to the next stage. When sharing survey data in cadastral organizations, the cadastral record manager can grant many database users storing and editing privileges for the data in the survey record management system based on predefined work flow.

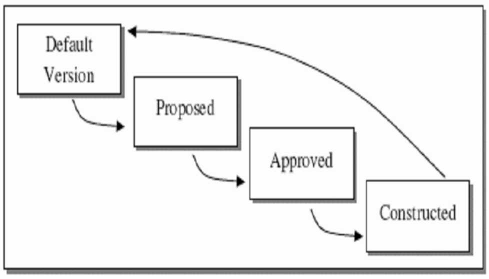

Figure 5.1 Cyclical work flow (Zeiler, 1999)

A work flow based on versions represents each stage of this process. Updating processes (Figure 5.1) can be used as a basis for the design at each stage, and when the last stage is reached and finished, the final updating result can be posted directly to the default version, which represents the nominal state of the database.

1. Models for updating processes

In the enterprise geo-database, the proposed system offers an environment in which multiple users can simultaneously edit the same set of the cadastral data set by creating so called versions of the geo-database. Conflicts between different versions of the same data set are easily detected, reconciled, and posted. Updating processes based on versions are explained as use-case, sequence, and activity model in this section.

1.1 Use case model

When updating or sharing survey data in cadastral organizations, the cadastral record manager, who is responsible in his or her role to manage the cadastral database, can grant many users for storing and editing privileges of the same data in the SurveyRecordSet. Once they have these privileges, each user creates and uses its survey projects based on an editing version. The survey records in the cadastral database could be enforced to protection from edits by other users to use same survey data sets because a survey project contains the control points published by a national cadastral and topographic organization. The control points in the surveyproject can be used by any other survey project in the SurveyRecordSet, but they can only be edited by the cadastral manager responsible for maintaining control points.

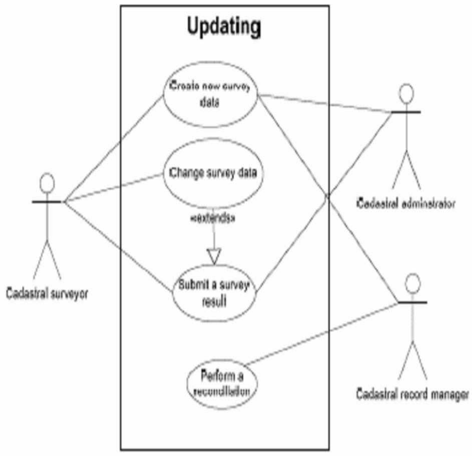

Figure 5.2 Use case for updating processes

In the use case model, Figure 5.2 shows updating processes of cadastral survey records with work flow based on versions within cadastral organizations. There are four use-cases such as 'Create new survey data', 'Change survey data', 'Submit a survey result', 'Perform a reconciliation'. In this use-case, a cadastral surveyor working in a local cadastral survey office represents to request survey records to the cadastral department in municipality, a cadastral administrator represents responsible roles for checking and approving of the survey results, and a cadastral record manager represents responsible roles of the data management for updating survey records in regional cadastral department.

Use-Cases of data update of survey records in the updating system are identified as work flow for cadastral data updating through request survey records by a cadastral surveyor.

a. Create new survey data

Cadastral surveyor requests survey records for the cadastral department. Cadastral record manager creates new survey data based on default version.

b. Change survey data

The cadastral surveyor starts editing the new version derived from the default version in the cadastral survey database. At this time, cadastral surveyors calculate survey measurements, and modify feature.

c. Submit a survey result

This use-case is extended by Change survey data. Cadastral surveyor has completed the survey data and submits a survey result based on an editing version to the cadastral department.

d. Perform a reconciliation

As a new survey data is completed by cadastral surveyor, cadastral record manager must be posted to the cadastral database. Cadastral record manager performs a reconciliation with the default version and updated version, resolve any conflicts if necessary, and post to the cadastral database.

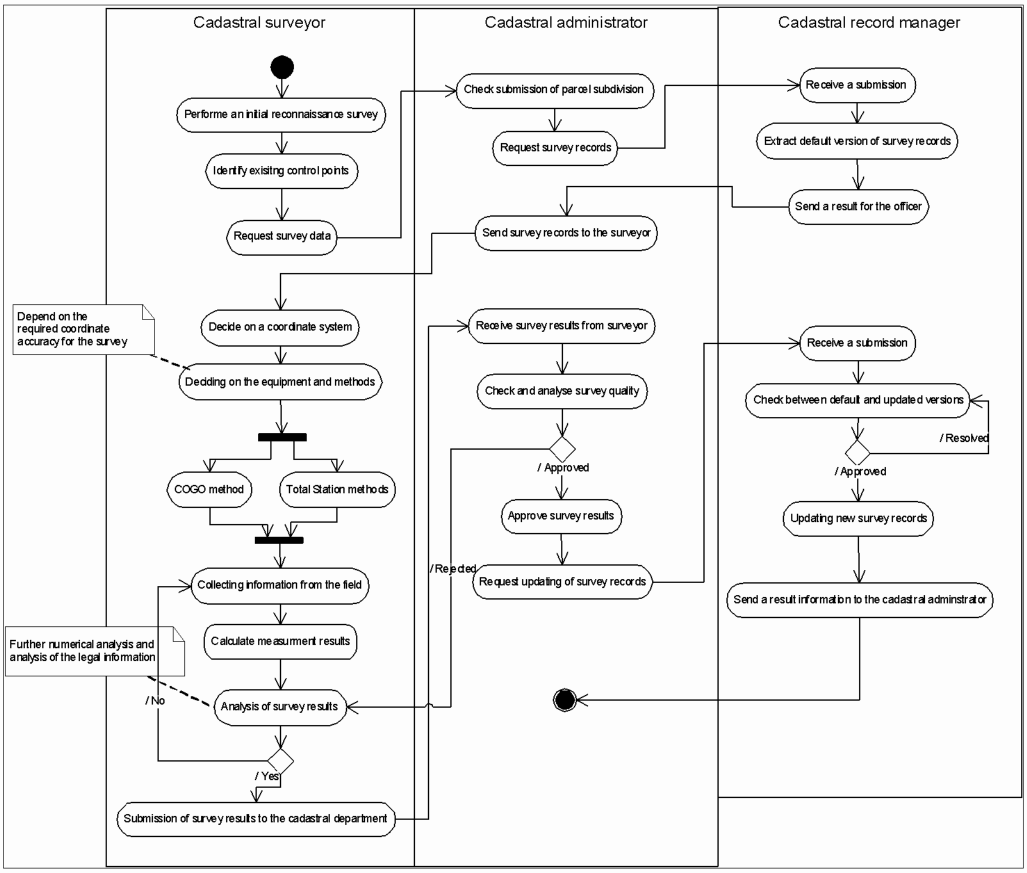

Figure 5.3 Activity diagram of updating processes

1.2 Work flow activities: Activity diagram

Before identifying business objects it is desired to draw activity diagram showing workflow of a use case. In this research swimlanes in an activity diagram represent business workers who are responsible for activities in cadastral surveying system. The activity diagram of Submit a survey result within updating processes use cases is shown in Figure 5.3. In this section, the 'Submit a survey result' use-case (Figure 5.2) is chosen for the further modelling. This model handles cadastral surveyors who want to get survey measurements including original records. The final goal of this use-case is to send information of the updated survey result to the cadastral administrator and more detailed work flows are followed as steps in alternatives.

Step 1. Cadastral surveyor performs an initial reconnaissance survey

Step 2. Cadastral surveyor requests survey data to the cadastral administrator in the regional cadastral department

Step 3. Cadastral administrator checks a submission and requests a new version to the cadastral record manager. Cadastral record manager supplies a new version containing survey records to the cadastral surveyor

Step 4. Cadastral surveyor decides on a coordinate system and methods for the required accuracy in the field survey

Step 5. Cadastral surveyor collects survey measurements and legal observations from the field. Cadastral surveyor computes survey points using survey measurements based on an editing version and creates a survey result

Step 6. Cadastral surveyor submits a survey result and proposes an editing version of survey records to the cadastral department in municipality

Step 7. Cadastral administrator checks and analyses a quality of the survey result

Step 8. Cadastral administrator approves a survey result and requests updating of the survey records based on an updated version to the cadastral record manager

Step 9. Cadastral record manager checks an updated version and posts this to the default version

Alternative 4. Cadastral surveyor decides survey methods of the required accuracy such as urban or rural area as well as instrument types such as Total Station or COGO method

Alternative 5. During computation of survey measurements, cadastral surveyor needs further numerical analysis of measurements and analysis of the legal information. If this process happens to problems, cadastral surveyor should be collected survey information from the field again.

Alternative 7. Cadastral administrator

checks quality of the survey results. If this is not satisfied quality according to current regulations, cadastral administrator demands for a resurvey to the cadastral surveyor

Alternative 9. Cadastral record manager receives and checks an updated version. If this data contains changed information, a cadastral record manager goes back Step 9 and resolves conflicts between default and an updated version.

1.3 Class diagram of updating processes

The cadastral data based on versions define a variety of representations in the enterprise database. Cadastral users can create versions for doing analysis with a series of alternate proposals. The main purpose of version data is to update the default version with the most current and best representation of the cadastral database. Instead of being the subjects of quality control through multiple versions, survey objects are used as indicators of the quality control for the geometry of the cadastral features on the default version.

Figure 5.4 shows a class diagram of 'Perform a reconciliation' among updating processes use cases. For requesting survey records by a cadastral surveyor, a cadastral record manager extracts a new version from the cadastral database and sends it to the cadastral surveyor. The cadastral surveyor can change the name of the new version and start editing of the cadastral feature and survey data. To finish editing version, a cadastral surveyor sends

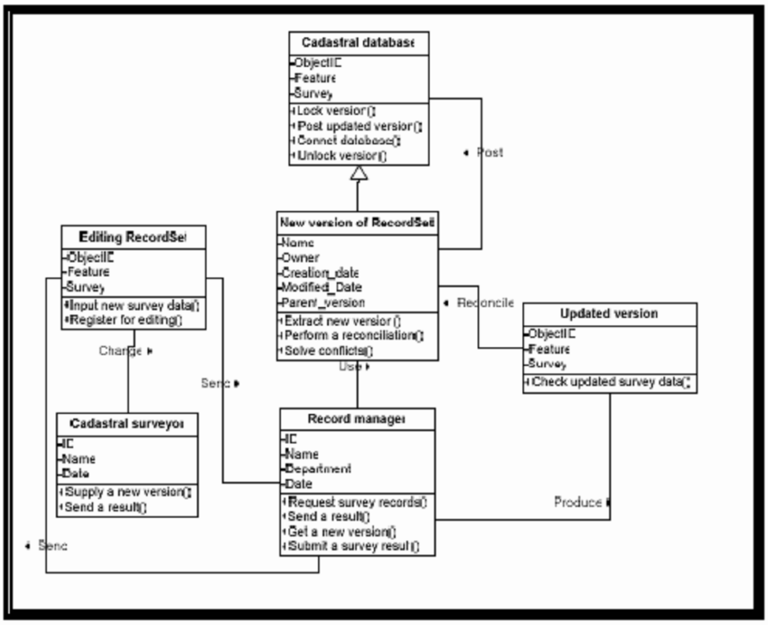

Figure 5.4 Class diagram of Perform a reconciliation use case

survey results to the cadastral record manager. Before posting the updated version into a cadastral database, a reconciliation process is required to change an editing version into an updated version. Conflicts of the cadastral data including the survey data are resolved and an updated version is posted to the default version in the cadastral database finally.

1.4 Sequence diagram of updating processes

A use case is more precisely described and explained by showing the interaction between participating objects in the use case. In a sequence diagram, all objects and their relationships to each other can be identified and modelled. A workflow based on versions provides improved updating processes with advanced data storage techniques. The cadastral data is centrally located in one corporate database and there is never a need to extract units of the cadastral data like a traditional disconnecting environment. Figure 5.5 shows the sequence diagram of Perform a reconciliation use case.

A cadastral record in the cadastral department is initially generated and assigned to the cadastral surveyor, then modified over time as it progresses from stage to stage, and finally the changes are posted an updated version. To implement updating processes, versions can be created corresponding with each stage of the work flow process.

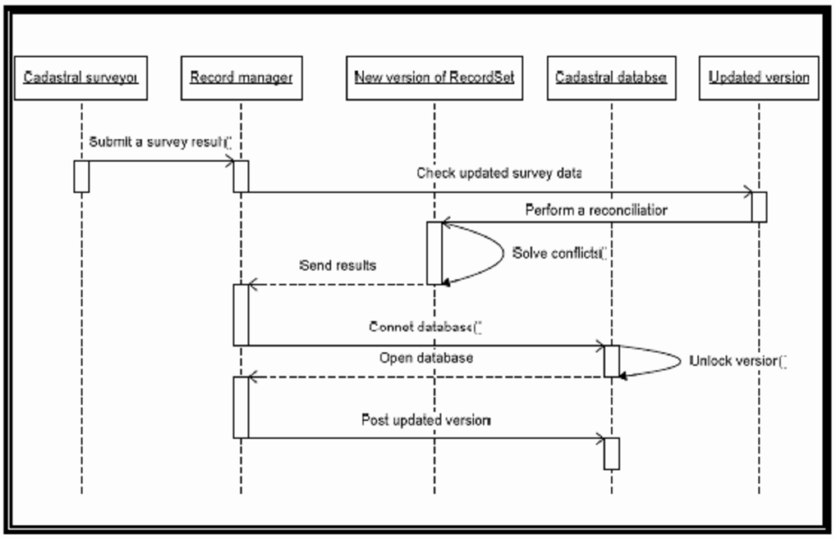

Figure 5.5 Sequence diagram of Perform a reconciliation use case

Ⅵ. Conclusions

The UML was used to design a survey record management system that provides cadastral surveyors with the ability to manage survey objects, to produce field notes and to use different survey equipments for terrestrial activities. For achieve objectives of the proposed system, survey record components have been discussed as updating processes. An activity, class, and sequence models were used for the design of updating processes of the survey records between cadastral organizations. Although newly produced maps have been stored a digital format, the traditional systems have been managed paper types in case of survey results in the archive office or scanned field sketches in separate databases Thus, it can be concluded that the proposed system can supply improved survey information to the cadastral user in which the user can access and check survey quality as well as the original survey records within GIS environments.

Based on proposed updating processes, the cadastral organizations can manage and maintain the survey data in GIS environments as well as update new data using workflow based on versions. This system was developed to manage and maintain as well as to analyze and deliver the survey records (including original records) using Geo-ICT. The designed system offers a good starting point to the current cadastral organizations for an effective cadastral survey system in the future.

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