Integration Model Design Strategy for Cadastral Information System: Case Study of a Cadastral Management System in Korea

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Abstract

For the cadastral management advancement, South Korea has upgraded its system through digitization of cadastral map. Recently, due to the computerization of the cadastral management system, various work systems have been developed and operate in cadastral fields for cadastral book information services, cadastral map information services, and real estate services. Especially brand-new information systems have been developed as part of a cadastral resurvey project. Although the operation of diversified systems has no problem in independent work areas, the inefficiency of operation such as data non-coincidence and compatibility issues between system databases has been incurred in mutual utilization and provision of cadastral information. In order to resolve these issues, this study suggests an integration model design strategy of cadastral information systems.

Keywords: Cadastral information system, Cadastral book information, Cadastral map information, Cadastral resurvey project

1. Introduction

The Korean cadastral management system has been transferred and developed from an analog cadastral management system based on analog maps to a digital cadastral management system based on digital maps. The analog cadastral management system has limitations in accurate management due to various problems such as new construction, damage, and deformation of the analog map. The Korean government has computerized the cadastral book information (parcels registered for site and parcels registered for forest areas) from 1982 to 1990 to advance the cadastral information management system. After that, domestic cadastral map computerization began in 1999 and was completed in 2003 [1]. In addition, The Korean government has developed and operates a CAS (Cadastral Administration System) as a cadastral book application system along with KLIS (Korea Land Information System) to manage and provide cadastral map information. The development of a cadastral book and map management system improves the work process efficiency in various cadastral fields including cadastral surveying.

Recently, an integrated real estate record system has been being developed for integrated and unified services in real estate study [2]. The government is also carrying forward a cadastral resurvey project for accurate cadastral information management by resolving cadastral non-coincidence between actual and registered boundaries. The cadastral resurvey project will be implemented from 2012 to 2030, and other separate information systems will be developed for the project [3].

As above, new information systems are being established and operated in Korea. These systems do not generate any significant problems in independent work areas, but facilitate
efficient operation. However, issues such as non-coincidence of data, compatibility of systems, and inefficiency of operation may be generated in integrated information services.

The government is developing diverse technologies for integrated spatial information services, including cadastral information service and also trying to provide integrated information for spatial information industry promotion in the cadastral field and effective land information provision based on cadastral information. However, cadastral information in various fields, including spatial information, has not been provided smoothly, as many issues occur due to diversified operation of cadastral information in integrating, processing, and handling data for user purposes. Thus, new strategies are required to efficiently integrate cadastral-related information systems to ensure spatial information industry promotion and an integrated cadastral information service.

As relevant research, work process improvement research [4] through the integration of land-related civil affairs administration tasks and development & establishment research for the cadastral document integrated management system [5] have been carried out. Research related to system data errors and integration include analysis and maintenance research for cadastral information logical errors (attributes) [6], architecture improvement planning research for KLIS middleware performance enhancement [7], and research for integrated CAS and KLIS system establishment [8]. Regarding the standardization of cadastral information integration, the establishment of a standard cadastral information system has been suggested and studied, including spatial cadastral information, common reference standard, and standards by spatial cadastral information data [9].

Likewise, much research has been conducted so far for the integration of cadastral information. Studies for cadastral information system analysis and integrated management are as yet insufficient, however. This study analyzes the current operating status and condition of domestic cadastral information systems and suggests integration model design strategies for cadastral information.

2. Current Operation of Cadastral-related Information System

2.1. KLIS

KLIS refers to a system developed for cadastral data management & operation and the mutual utilization of cadastral land information based on GIS (Geographic Information System). This system was established by integrating PBLIS (Parcel Based Land Information System) and LMIS (Land Management Information System) for the prevention of duplicated data and the mutual utilization of land-related information. KLIS is composed such that independent systems are installed in individual cities, counties, and boroughs. Common relevant programs are installed on 1st and 2nd-level servers and then the KLIS (previous LMIS server, the 2nd-level server of city, county, and borough, and newly introduced server) is mounted on the KLIS server. Each local government produces and maintains KLIS data and the central government stores and controls such. This was led by the central government in the initial stage of the information management project, but has begun to be controlled by local governments.

Pertaining to cadastral work, KLIS comprises the cadastral record management system, the cadastral surveying result map making system, the serial and editing map management system, the land civil applications issuance system, KAIS (Korea Address Information System), the DB management system, and related items. KLIS usually controls cadastral map information. When simultaneous use of cadastral map information and cadastral book information (parcels registered for site and forest areas) is required, middleware is used to
connect with administrative information systems (the cadastral administration system) in the relevant city, county, or borough [10].

![Figure 1. Structure of KLIS [10]](image)

**Table 1. Operation System of KLIS [2]**

<table>
<thead>
<tr>
<th>Application system</th>
<th>Language</th>
<th>DB</th>
<th>O/S</th>
<th>Middleware</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cadastral Record Management System</td>
<td></td>
<td>ORACLE</td>
<td>AIX, windows2000, HPUX, Solaris</td>
<td>CORBA</td>
</tr>
<tr>
<td>Cadastral Surveying Result Map Making System</td>
<td>Visual C++</td>
<td>ORACLE</td>
<td>AIX, windows2000, HPUX, Solaris</td>
<td>CORBA</td>
</tr>
<tr>
<td>Serial/Editing Map Management System</td>
<td></td>
<td>ORACLE</td>
<td>AIX, windows2000, HPUX, Solaris</td>
<td>CORBA</td>
</tr>
<tr>
<td>Land Use Regulation Management System</td>
<td></td>
<td>ORACLE</td>
<td>AIX, windows2000, HPUX, Solaris</td>
<td>CORBA</td>
</tr>
<tr>
<td>Land Administration Support system</td>
<td>OZ (Java script)</td>
<td>ORACLE</td>
<td>AIX, windows2000, HPUX, Solaris</td>
<td>CORBA</td>
</tr>
<tr>
<td>Topographic Map Management System</td>
<td>C++, JSP</td>
<td>ORACLE</td>
<td>AIX, windows2000, HPUX, Solaris</td>
<td>CORBA</td>
</tr>
<tr>
<td>Mobile Field Support System</td>
<td>VB</td>
<td>ORACLE</td>
<td>AIX, windows2000, HPUX, Solaris</td>
<td>CORBA</td>
</tr>
<tr>
<td>Land Information Searching(Intranet)</td>
<td>Java script, java</td>
<td>ORACLE</td>
<td>AIX, windows2000, HPUX, Solaris</td>
<td>CORBA</td>
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</table>
2.2. Cadastral Administration System for City, County, and Borough

The cadastral administration system controls cadastral records (land/parcels registered for forest areas, joint signature books of public land, and site rights records) investigated and surveyed for land-related information after registration by computer. It has been established and operating as a part of city, county, and borough administrative information systems under the Saeol administration system, which is an integrated electronic government network. This system was established to increase work efficiency and the applicability of cadastral information through computational processing of cadastral book information (attribute information). As the major function of the system, it supports various kinds of cadastral work such as land alteration management, ownership changing management, cadastral work, civil affair management, policy task, etc. This system incorporates the central government, city/province, and city/community/borough's systems [11].

Each city, county, and borough has different computational operation environments for the cadastral administration system, as there are a considerable number of self-governing bodies such as early NT, HP (HPUX), and IBM (AIX) transferred to other fields due to auto-upgrade business.

<table>
<thead>
<tr>
<th>Table 2. Operation System of Cadastral Administration System [2]</th>
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<tr>
<td><strong>Language</strong></td>
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<tr>
<td>DELPHI/Pro C</td>
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</tbody>
</table>

The RPC and DLL methods are used as connection means with exterior systems. RPC directly calls Entera middleware (RPC) for exclusive connection use for the mutual cadastral information utilization and DLL retrieves cadastral information by calling the DLL provided from the cadastral administration.

2.3. Integrated Real Estate Record System

The real estate integrated record system refers to a system established to solve diverse administrative needs and provided problems generated due to dual, separated, or severed operation in 18 kinds of records, including cadastral records. Its detailed plan is to integrate 11 kinds of records (parcel registrations for site & forest areas, site right records, joint public land signature books, cadastral maps, forest maps, numerical terriers, building management records, and the like) by 2012. 15 kinds of records will be integrated by integrating the four records comprising individual public land price confirmation, housing price confirmation, apartment housing price confirmation, and land use planning confirmation by 2013.
Afterwards, 18 kinds of records will be integrated into one by integrating three records including ground, building, and aggregate building registration from 2014 on [2].

The purpose for system establishment is to improve public confidence in real estate administration and protect the people's property rights through real estate administrative information maintenance and reorganization, integrated real estate records establishment and maintenance, and real estate civil and administrative process optimization. Beyond this, the automated registry office system, public land price management system, and land use regulation management system are included.

Besides which, the cadastral surveying institute (Korea Cadastral Survey Corporation) has developed and operates various systems such as TOSS(Total Survey System), SIP(Survey Information Processing System), COS(Cadastral survey One-stop service System), MOS(cadastral survey Management & apprOval sign System) and SIMC(Survey Information Management System) for cadastral surveying tasks and cadastral survey data management.

3. Actual Operation Issues of Cadastral-related Information System

The current representative cadastral-related information systems include the cadastral administration system, the Korean land information system, and the real estate integrated record system mentioned above. The automated registry office system, the public land price management system, the land use regulation management system, and other cadastral survey related systems developed and used by the Korean Cadastral Survey Corporation are included as well. Also, a new cadastral resurvey system will be developed through the cadastral resurvey project. His diversified system operation raises such problems as data duplication and non-coincidence between systems. Moreover, operational inefficiency is being caused, including the compatibility issue between systems due to insufficient standards systems.

As an example, different software must be installed to operate the cadastral administration system (located in city, county, and borough servers) and the cadastral record management system (located in the KLIS server), and their operating systems are varied, including NT (Windows 2000 Server), SUN (Solaris), IBM (AIX), HP (HPUX), and so on. DBMS for the storage of graphic and attribute information other than coordinate information comprises Oracle (8i-10g) and UniSQL, and the GIS engine applied to graphic information includes SDE from America’s ESRI, ZEUS from Korea’s Data Communications Corporation, GOTHIC from the UK’s Laser Scan, and so on. After the KLIS upgrade project in 2008, only two GIS engines, SDE and ZEU GOTHIC, are being used. The middleware has a complicated structure comprising web-based WMS (Web Map Service), WFS (Web Feature Service), CORBA-based EA (Edit Agent), and DP (Data Provider), so that it becomes a hindrance to system performance and process improvement [8].

For data error issues between information systems, 170 types of errors (error in record, error between records, work information errors, etc.) have been found, based on comparison and analysis results of interactive system data errors for cadastral maps, forest maps, parcels registered for site & forest areas, public land prices, land use planning confirmations, and building a cadastral management book as a part of a real estate administration information integration pilot service [2].
The cadastral-related information systems diversification issue can be found in the standardization problem. To create various spatial information industries and provide cadastral information for the government or private sector, the standard system of cadastral information is necessary for smooth provision and utilization in user areas. Although there is no difficulty in using such in cadastral administration areas for now, because the cadastral information standard system is not yet prepared, limitations appear with real-time provision or use in the relevant industries or organizations.

Therefore, an effective connection and integration plan for cadastral-related information systems is required to solve the above issues. Also, standard model development of cadastral information is necessary to reinforce smooth system operation, new attributes, and the utilization of information provision after integration.

4. Design Strategy of Integrated Cadastral Information System Model

4.1. Base System Establishment for Integration

One of the most important factors in the integration of cadastral-related information systems is in matching errors between data controlled by the diversified systems. These errors should be preferentially fixed for system integration. When an integrated database is established after completion of error repair, DBs are required to continuously update the data controlled by relevant systems to the latest data. Also, a base system is necessary to integrate in a unified system in the long-term.

The cadastral resurvey project is in the process of registering land information through nationwide land investigations and surveys in Korea from 2012 to 2030. For this reason, a
A cadastral resurvey system is being established to efficiently manage the collected and registered data. Most accurate data will be collected and stored by nationwide land information investigations and surveys through the cadastral resurvey system. Thus a cadastral resurvey system should be established, taking the following factors into consideration, since it should be used as a base system for the integration and update of cadastral-related information systems. Requirements for establishment are as follows.

An initial stage cadastral resurvey system should be established such that the databases of relevant systems can be updated based on accurate spatial data collected through independent establishment. As well, international standards should be considered in constructing a cadastral resurvey system. It is crucial to maximize the compatibility and sharing of cadastral information and smoothly provision the fields requiring the information and ensure its ease of use.

The cadastral resurvey system should be established based on GIS, as GIS is the most effective system for storing, analyzing, and updating the spatial data [12-13]. The other reason is that an efficient large spatial data management system is necessary to integrate cadastral-related information systems over the long-term. In particular, TS survey data angle, distance, mapping (point, line, and polygon), GPS RTK mapping (point, line, and polygon), and offset surveying distance (line) should be recorded for the collected spatial data and stored during the cadastral resurvey project as graphic data. In addition, it should be constructed based on GIS, which can control and handle the spatial database efficiently as thematic maps such as digital topographic maps and road name data as along with image data like aerial photograph images, high-resolution satellite images, and 3-D building objects, should be recorded and saved.

![Figure 3. Acquisition and Input Data in Cadastral Resurvey Project](image)

The cadastral administration system, Korea land information system, and real estate integrated record system, along with connectivity with systems used by cadastral surveying institutes should be considered as well. This is for the real-time update of data saved in the relevant systems with regard to newly collected cadastral information. Data whose errors are
fixed should be preferentially used in the cadastral resurvey project of course, for integrated real estate record system establishment.

4.2. Cadastral-related Information System and DB Integration Model

In this study, the connection and integration model design of a cadastral information management system is divided into two stages. The first stage is the integration of physically integrative systems. It seems difficult to physically integrate such into a unified system, as the current cadastral information management systems and organizations are varied. Thus, for smooth integration, it would be a practical plan to integrate physically integrative systems first, and then unify other systems through database connection. In the long-term, however, cadastral-related information systems should be integrated based on the cadastral resurvey system.

The cadastral administration system and the Korea land information system respectively control cadastral book information and cadastral map information, and are included in physically integrative systems. Physical integration seems to be possible for attribute information controlled by the cadastral administration system as the management organization (Ministry of Land, Infrastructure and Transport) is identical. In the second stage, relevant systems are connected and integrated using databases. The Korea land information system DB, the cadastral administration system DB, the real estate registry DB, the public and land price DB, and the land use regulation DB are available for integration. If a cadastral resurvey system and integrated real estate record system are established later, their DB will be applicable as well. After connecting and integrating databases, the unification of management and provision systems should be implemented by collecting and processing the data in the common server of the Ministry of Land, Infrastructure and Transport, by unifying the information management and provision channels, and then providing the information to government organizations or relevant institutes.

Figure 4. Integration Model Design of Cadastral Information System
Furthermore, channels that can be used to provide cadastral information (including processed cadastral information) to private companies and civil petitioners should be retained by securing a web-common server as well as the common server.

4.3. Data Error Maintenance and Update Model

Data error maintenance and continual updates are the most significant factors in the DB connection and integration. Regarding error maintenance all connected and integrated DBs should be recorded in the integrated cadastral information database, primarily through the maintenance of graphic and attribute errors. Relevant DBs should be continuously updated with the latest data, based on information recorded in the newly constructed cadastral resurvey system. Thus, the cadastral resurvey system should be constructed in a central management oriented manner. A system should be established that collects, controls, and provides data for the central government, by transferring the data collected from local city, county, and borough headquarters to the cadastral departments of city and province, and then transferring from city and province to the Ministry of Land, Infrastructure, and Transport. This structure will facilitate the establishment of efficient data update system and enable smooth information provision to relevant fields or institutes.

4.4. Standard Cadastral Information Model

In cadastral information management, the standard model should be defined to effectively connect and integrate systems, share information, and smoothly provide information to diverse fields. In Korea, cadastral-related information systems are used by primary action departments thus far, after their design and establishments is completed, and standard data models are not considered in advance in system establishment. In the spatial information field (or geographical information), international standard criteria have already been established and many nations using them based on the standardization of cadastral information. Therefore, a data standards model should be constructed for cadastral information in Korea.

OGC and ISO/TC211 are international standards organizations related to spatial information [14]. ISO 19152 (Land Administration Domain Model) [15] which is most similar in standards, can be referred to for cadastral information. According to the enactment of LADA implemented by the International Organization for Spatial Standards, many nations
are applying the cadastral standard model to LADM standard documents. The Korean cadastral profile has been applied to the final LADM version in Korea. The following figure shows the Korea cadastral profile included in LADM [16].

Figure 6. Cadastral Profile of Korea included LADM [16]

Beyond this, the range of information to be added, reference models to externally be referred to, conformance and testing, spatial schema for cadastral information DB establishment, temporal schema, and the introduction of spatial referencing by coordinate & spatial referencing with geographic identifiers for international coordinate system reference, should be reviewed. In addition, standards system establishment and application are necessary for encoding methods facilitating information exchange between a cadastral-related information system, procedures and regulations required for service, and so on.
5. Conclusion

In this study, the current operating status and condition of cadastral-related information systems which are diversely established and operated in Korea have been analyzed and integrated model design strategies for systems integration have been suggested based on the analysis results. The study results are as follows.

According to the operating condition analysis results of cadastral-related information systems variously constructed and operated these days, inefficiency of operation such as data error issues (duplication and non-coincidence) between systems, and information compatibility issues between systems due to insufficient standard systems have been determined. As a solution of these issues, the integration model, including primary integration for physically integrative systems (CAS and KLIS) and the database connection method for other systems have been suggested. In addition, the use of a cadastral resurvey system in DBs has been proposed for effective data updates and long-term system unification strategies. Finally, a standard cadastral information model establishment plan using ISO 19152 (LADM) has been suggested for efficient connection & integration between systems, information sharing, and smooth provision to various fields as cadastral information management.

References
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Sungeon Hong received the Ph.D. degrees in GIS from the INHA University of Incheon at Korea, in 2002 and 2005, respectively. He is a Professor in the Department of Land Management at Cheongju University at Cheongju Korea. His current research interest cadastral information system and its application, GIS, SMCDM, cadastral surveying. He has published 40 journal papers, 30 conference papers, and several undergraduate textbooks.