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Data Exchange between Cadastre and Physical Planning by Database Coupling

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Abstract

The information in physical planning field shows the socio-economic potentials of land resources while cadastral data does the physical and legal realities of the land. The two domains commonly deal with land information but have different views. Cadastre has to evolved to the multi-purpose ones which provide value-added information and support a wide spectrum of decision makers by mixing their own information with other spatial/non-spatial databases. In this context, the demands of data exchange between the two domains is growing up but this cannot be done without resolving the heterogeneity between the two information applications. Both of either discipline sees the reality within its own scope, which means each has a unique way to abstract real world phenomena to the database. The heterogeneity problem emerges when an GIS is autonomously and independently established. It causes considerable communication difficulties since heterogeneity of representations forms unique data semantics for each database. The semantic heterogeneity obviously creates an obstacle to data exchange but, at the same time, it can be a key to solve the problems too. Therefore, the study focuses on facilitating data sharing between the fields of cadastre and physical planning by resolving the semantic heterogeneity. The core job is developing a conversion mechanism of cadastral data into the information for the physical planning by DB coupling techniques.

Keywords : data exchange, DB heterogeneity, data semantics, cadastre, physical planning

1. Introduction

Information in the field of physical planning shows the socio-economic potentials of lands surface while cadastral data describes the physical and legal realities of the limited resource. They commonly deal with the information created from lands even though the two domains have different views on lands from each other. Physical planning aims at optimally distributing spatial objects, functions, and activities within a certain area. The cadastre has evolved to be a multi-purpose system to meet growing demands by providing value-added information to a wide spectrum of users and levels of decision makers.

The methodologies to develop land use plans are divided into two different ways, top-down and bottom-up planning. The bottom-up methodology is more effective for detailed physical planning. However, it requires considerable amount of information about the present status of the land. Cadastre is one of the best information providers in this context in combination with building registers that show the type, area, use of a structure built on the earth. The building register database does not include graphic data in Korea but the graphic data can be extracted from large-scale topographic maps(Fig. 1).

Therefore, the study focuses on developing a prototype to provide real time information for detailed physical planning by designing a federated database system between the two database systems. Prerequisite of the data sharing is the complete resolution of the semantic heterogeneity

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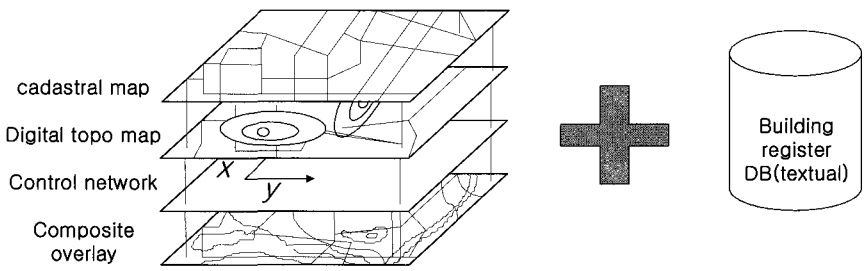


Fig. 1. Data Sharing between Cadastre, Topography and Building Registry

between the two databases. The job is done by developing a small conversion mechanism of semantics and embedding it into the federated schema.

2. Domains Concerned

Among a variety of information required in the domain of physical planning, land use situation is provided by the cadastral information system, called Korea Land Information System, and building information by Building Register System. Digital topographic maps of 1:1,000 scale are used to supply essential graphic data - building maps - and are combined with the textual data of Building Register System.

2.1 Physical Planning

The ultimate objective of physical planning is to optimally distribute spatial objects, functions, and human activities in a certain extent of area to provide citizens with the spaces in which they can enjoy safe and convenient lives. The basic factors should be considered such as population, economy, environment, land use, infrastructure and facilities (Kaiser et al, 1995) of the target area when a physical plan is developed. The types and number of factors, of course, can be deviated according to the situation of the area.

2.1.1 Current Situation

Korean physical planning pursues balanced, characteristic and competitive regional development at the national level. Balancing has some meaning because she has been rapidly industrialized and urbanized since 1970's, which has influenced on the communities in urban and rural areas in a different manner. As a result, people in urban areas presently enjoy higher income, better educational environments and broader cultural opportunities than those in rural regions do. Therefore, balancing means redistribution of the fruits among the communities in addition to balanced development of the territory as a whole.

The bodies in chare of land use planning are municipal, provincial and central governments. Each municipality and province sets up physical plans within the boundary of jurisdiction and administers space related affairs as planned. The central government is responsible for designing national-level comprehensive planning and plays a role in arbitrating between the authorities concerned where a regional plan is to be established over two or more geopolitical bodies and conflicts arise among them.

2.1.2 Physical planning

The hierarchy of Korean physical plans shows National Comprehensive Plan at the top which gives an overall view that the future Korean territory looks alike. It encompasses the guidelines and directions hypo-plans should follow. Provincial and Municipal Plans are developed and established according to the guidelines of national plans. Inter-provincial and inter-municipal plans can be set up under the supervision and mediation of the central government.

The means for land use planning are bottom-up and top-down approaches. The top-down methodology has been applied to most Korean spatial plans because of its nature of convenience and time saving. Governments have mostly employed a top-down methodology regardless of the level and scale. The conventional way saved time and promoted efficiency to develop a plan but it revealed deficiency in effectiveness. The top-down approach uses relatively rough information and less deliberates the local conditions of districts, villages and communities.

2.1.3 Zone Unit Plan

As mentioned above, the top-down approach hardly considers local conditions and results in unbalanced physical development and cause of conflicts among localities. In the past decade, the people in charge of physical planning did not have sufficient information about the planning area. If any, they could not access to the databases because adequate institutional arrangements were absent.

Census data, economic statistics, environmental information, land use situation altogether facilitate appropriate design of physical plans. A bottom-up approach makes use of the information for setting up a plan from the smallest planning. The plans of smallest units aggregate and form a bigger plan.

The governments recently employed the bottom-up methodology what is called the zone unit planning. The definition of the zone unit is a tract of land assigned to a homogeneous land use which includes several to dozens of neighbouring blocks specifically in urban areas. The adoption of zone unit planning purposes to construct environment- friendly cities and to facilitate sustainable development.

The zone unit planning applies to the areas of intensively developed or expected to be developed. Buildings and public facilities in the areas designated as a kind of zone unit are strictly restricted in shape, colour, height, building coverage/land ratio and volume/land ratio to improve the function and appearance of cities, which, in turn, makes the residents supplied with sufficient civilised and environmental services.

2.2 Cadastral Information

The records kept in the Korean cadastral system consist of maps and books. The cadastral map delineates parcel boundaries and has the legal consequence when disputes arise on the boundaries. The cadastral book contains attribute data such as parcel-id, address, acreage, land use, owner-related information and tax grade.

2.2.1 Cadastral Map

The map scales vary 1:500 to 1:6,000 and adopt Gauss conformal double projection to reduce geodetic positions to a plane coordinate system. The maps of 1:500 and 1:1,000 have been made according to the amendment of the Cadastral Act in 1975 and boundary corners are described by a pair of coordinates. Among the rest of maps, urban or arable land was mapped 1:600, 1:1,200 or 1:2,400 scales for while mountainous or waste land has 1:3,000 or 1:6,000 scales. The maps of 1:3,000 and 1:6,000 are especially called the Forest Maps. The different mapping scales generally represent the economic importance of each mapping area. In other words, areas of more importance were mapped with larger scales. The plane table method was adopted for surveying and mapping except less than 5% of the whole land.

Figure 2 depicts a typical digital cadastral map of 1:1,200 scale in agricultural areas. The parcel boundaries, parcel numbers, land use and control points are the information found in a cadastral map. Cadastral maps do not show buildings, infrastructure and public facilities

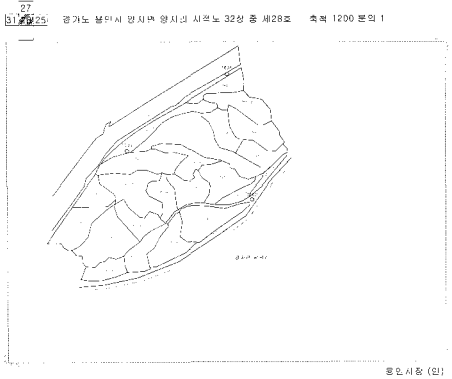


Fig. 2. Typical Cadastral Map of 1:1200 scale

which are essential information to design a physical plan. The newest amendment of Cadastral Act allows the registration of buildings on the maps but it seems difficult to register all the buildings in near future because it requires tremendous working time and expenses. Land use information on the maps is identical with that in the books and is explained in the next section.

2.2.2 Cadastral Book

The cadastral book contains textual information such as parcel identifier, address, acreage, land use, owner-related information and tax grade. A parcel identifier is for linking textual data of a parcel to map data and consists of a 19-digit number, which does not coincide with any identifiers of 36 million parcels in the cadastral database. The first 10 digits are assigned to the administrative divisions in which the parcel locates. The endmost 8 digits are for the parcel number. One digit between the two parties indicates whether the parcel is registered in a cadastral map or a forest map.

The acreage represents the area of a parcel in metric terms. Legal consequence resides in the areas recorded in the cadastral books other than any records, calculations or measurements.

The land use data shows the present land use of a parcel. The meaning of 'land category' in the cadastral field differs from that in the planning discipline in some degree. Korean Cadastral Act defines 28 land use categories into which any land parcel should be classified according to the present type of use. Short descriptions about the major categories and their coverage are as follows:

- dry field: land for cultivating cereal crops, sapling plants, medicinal herbs and other species not much dependent on irrigated water 8%
- paddy field: watery land for growing rice, lotus root, dropwort, etc 12%
- forest and waste land: land for forestry, marshy and waste land 65%
- building site: land for permanent buildings used for residential, commercial, museum, theater, gallery and attached gardens and/or facilities 2.5%
- road: land for transportation of pedestrians and/or vehicles, and attached facilities 2.5%
- river: land for natural water flows 2.8%
- ditch: land for natural water flows in smaller scales or for irrigation uses 1.8%

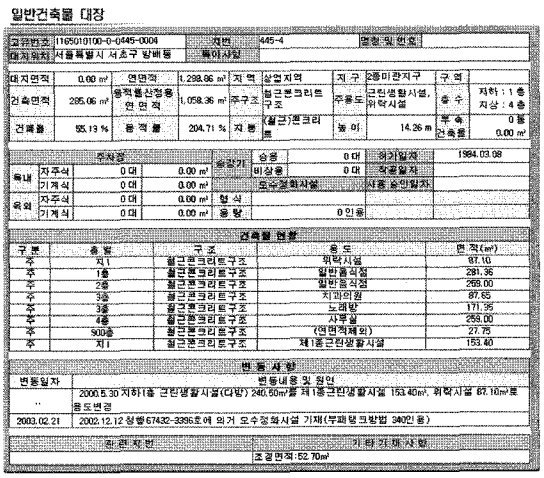
2.3 Building Register

Building Registry is maintained by municipalities. Building Act binds every building to be registered by the completion time of construction. Figure 3 shows that a building register contains textual information such as building identifier, building area, zoning information, structure, main use, use per floor, number of car parks and lifts.

2.3.1 Building Identifier

The building identifier, the 19-digit number shown at the second row of figure 3, is identical with the parcel identifier except 1 digit in the middle with which one can recognise whether an id number is for a parcel or a building. For example, 1165010100-0-0445 -0004 is an id for a building while 1165010100-1-0445-0004 is for a parcel in which the building is located. It means the building identifier is the key to link the building register database to the cadastral information system.

If a parcel has several buildings, the main building


일반건축물 대장

고유번호	1165010100-0-0445-0004	지번	445-4	명칭 및 번호	
대지위치	서울특별시 서초구 방배동	특이사항			

대지면적	0.00 ㎡	연면적	1,298.86 ㎡	지역	상업지역	지구	2종미관지구	구역	
건축면적	285.06 ㎡	용적률산정용 연면적	1,058.36 ㎡	주구조	철근콘크리트 구조	주용도	근린생활시설, 위락시설	총수	지하 : 1 층 지상 : 4 층
건폐율	55.13 %	용적률	204.71 %	지붕	(철근)콘크리트	높이	14.26 m	부속 건축물	0 동 0.00 ㎡

주차장			승강기	승용	0 대	허가일자	1984.03.08
옥내	자주식	0 대	0.00 ㎡	비상용	0 대	착공일자	
	기계식	0 대	0.00 ㎡	오수정화시설		사용승인일자	
옥외	자주식	0 대	0.00 ㎡	형 식			
	기계식	0 대	0.00 ㎡	용 량	0 인용		

건축물 현황

구분	층별	구조	용도	면적(㎡)
주	지1	철근콘크리트구조	위락시설	87.10
주	1층	철근콘크리트구조	일반음식점	281.36
주	2층	철근콘크리트구조	일반음식점	269.00
주	3층	철근콘크리트구조	지하이원	87.65
주	3층	철근콘크리트구조	노래방	171.95
주	4층	철근콘크리트구조	사무실	268.00
주	옥탑층	철근콘크리트구조	(면적제외)	27.75
주	지1	철근콘크리트구조	제1종근린생활시설	153.40

변동 사항

변동일자	변동내용 및 원인
"	2000.5.30 지하1층 근린생활시설(다방) 240.50㎡를 제1종근린생활시설 153.40㎡, 위락시설 87.10㎡로 용도변경
2003.02.21	2002.12.12 청방67432-3396호에 의거 오수정화시설 기재(부패탱크방법 340인 용)

이전 지번	기타 기재 사항
	조경면적:52.70㎡

Fig. 3. Information in Building Register System

has an id number. The rests are considered as annexes and no ids are given. A building on several parcels has an id related to the main parcel. Thus, no normalisation procedure is needed for linking the two databases.

2.3.2 Acquisition of Graphic Data

As mentioned above, Building Register System provides pure textual information. Lack of graphic data requires developing appropriate means of data acquisition from other spatial databases.

Digital topographic maps with 1:1,000 scale depict the buildings in urban areas. The maps are produced by the photogrammetric procedures with 1:5,000 aerial photos. Spaghetti model is applied to delineate the buildings and other topographic features. It is necessary to process the building layer of the maps for creating polygon topology and to add a procedure for linking the created building polygons to the textual data of Building Register System. It may be a tedious and time-consuming job to manually give an identifier to every building polygon.

However, the problem can be solved by a simple GIS process like overlaying the topographic map layer on the cadastral map layer. Details on this issue are described in the next chapter.

3. Prototyping

The issues are addressed by previous chapters such as the information stored in building register database, that in cadastre, and the substance and form of information specifically required by the discipline of physical planning. They are discussed to establish background knowledge to develop a prototype for facilitating data sharing between the information systems concerned. This chapter presents descriptions about employed techniques, used tools, hardware/ software architecture as well as functionality of each component of the prototype.

3.1 Creation of Graphic Building DB

The first stage of prototyping is to create a graphic building database by making building polygons because the features including buildings shown in the digital topographic maps do not employ a topological model. Identifiers are then assigned to the polygons. Following steps are taken for the polygonising and id numbering for buildings;

1) Extraction of the building layer from the digital topographic map
2) Retouch of the building layer to ensure building lines enclosed
3) Transformation of spaghetti to topological to create building polygons
4) Overlay of the building layer on the cadastral map to assign a parcel-id to each building
5) Revision of the assigned parcel-ids to form building ids as shown in figure 4 (i.e. 1165010100-1-0445-0004 to 1165010100-0-0445-0004)
6) Elimination of cadastral data invaded with overlay process from the database for reducing the data quantity handled by Building Register system

3.2 Federation with Building Register DB

Database federation is a tight-coupling technique to facilitate data sharing between different databases. The federated database system employs a federated (global) schema on the sharable data of the participating local database servers as shown in figure 5. These local servers provide schematically homogeneous data to the federation server but the heterogeneity may still exist semantically. In order to cope with these semantic conflicts within a heterogeneous FGIS, each member of the federation

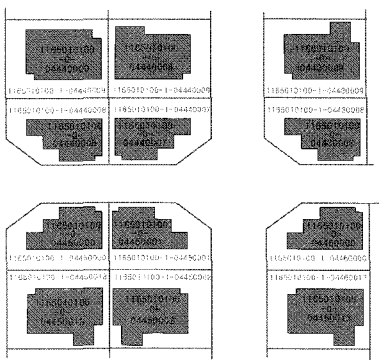


Fig. 4. Assignment of Building Ids

should equip itself with semantic translation mechanism that reconciles its own data semantics with those of the other members.

The created graphic database has building ids as the only attribute of entity 'building' at this moment. This is the minimum limitation of the physical planning office. In other words, it is necessary to link to the textual database of Building Register System by means of the 'building identifier' which commonly plays the role of the identifier in each database.

Figure 6 partly shows the federated schema and the mechanism of the linkage using the identifier. The hardware/software configuration has relatively simple appearance. The user interface locates at the side of graphic (building map) database which is connected to Building Register System through the network. It may require the employment of ODBC drivers to resolve the potential heterogeneity caused by different hardware/ software configurations. The person in charge of analyzing the land use situation can query and manipulate whatever he or she wants to do with building information for physical planning.

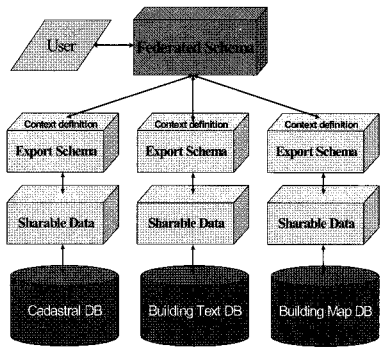


Fig. 5. Database Federation

3.3 Federation with Cadastral DB

Cadastral information system supplies parcel-wise data, which is the largest scale among the presently available spatial datasets. The spatial and socio-economic information pertaining to terrain such as land use, owner, value, products, geography of a parcel provides a good basis where bottom-up planning technique is applied. Urban designers become capable to extract the essential information for building zone, block and lot unit plans from the integrated database created by linking the cadastral information with the building register data.

It is necessary to define the domain of sharable datasets of the cadastral and building register databases, and then to design the export schema (Bishr, 1997) in order to realize the proposed system (Fig. 7). The semantic heterogeneity emerges out between the participating databases because the context view of a system differs from the other. For example, the 'area' or 'acreage' only represents the parcel area in cadastre while it means several such

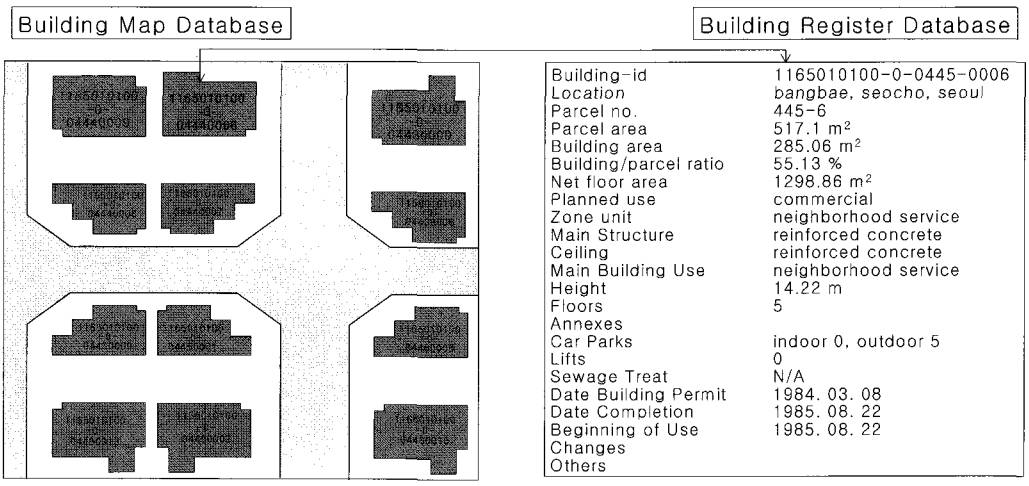


Fig. 6. Linkage Mechanism between Graphic and Textual Building Databases

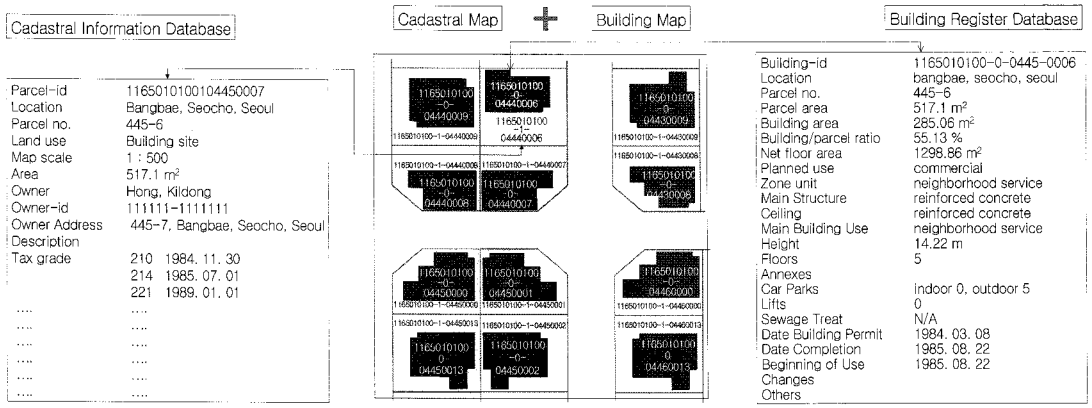


Fig. 7. Link of Cadastral DB and Building Register DB using DB Federation

as parcel area, floor area, net floor area in Building Register System. The heterogeneity should be resolved when the export schema is designed (Goh et al, 1994 ; Bressan et al, 1997).

4. Conclusions

The research focuses upon data sharing to provide the discipline of physical planning with appropriate and up-to-date information about land use by applying federated database techniques to cadastral and building information systems.

In this research, the whole data in each database is defined as the sharable datasets. The federated schema is designed to direct queries to the cadastral database to acquire parcel information and to send queries to Building Register Database to get building information. The map data of buildings are imported from topographic maps and processed to have topology, which creates Building Map Database. A building identifier is then assigned to each building polygon by overlaying of cadastral maps upon the created building maps. The textual data of Building Register System are linked to the building polygon of Building Map Database with the mediation of building identifier. The cadastral information system participates in the database federation using the close similarity between parcel and building identifiers. Users can access the federation through the export schema or the export schema of Building Map Database and get information they need.

Further research is recommended to proceed on coupling other information systems with the proposed database federation such as census data, environment, infra-structure. Diverse resources make that the federation can provide rich information and users can make choice of adoption or rejection, which eventually leads decisions made appropriately and accurately.

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