THE SPATIAL DATA WAREHOUSE OF SEOUL

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ABSTRACT

The Seoul metropolitan government has constructed a Spatial Data Warehouse (SDW) by integrating various kinds of geospatial data since 1995. The objective of its construction is to prevent duplicated creation of spatial information, make data access and acquirement more convenient, establish data registration and standardization, and increase data sharing and joint utilization. The SDW integrates all the spatial and administrative data generated by 13 individual GIS systems separately performing its own specific task and thus enabling more synthetic spatial analysis by combining these numerous data. It also takes a role of a centralized data source to provide spatial data required for each local department and the individual GIS systems. All the departments can access the GIS information of the entire area of Seoul through the Internet data sharing framework created in the SDW. This presentation will describe the integrated models and operational results of the SDW.

1. INTRODUCTION

The Seoul metropolitan government (SMG) constructed various GIS systems individually designed for road management, urban planning, water supply facility management, sewerage management and other municipal affairs, respectively. Since these systems were developed for the individual purposes by each department, the connectivity between them had not been efficiently established, causing the critical problems mainly summarized as follows:

1) Insufficiency of the systematic update of the spatial data of each individual GIS system, causing complex administrative process to share or update the data between the systems.
2) Redundant construction of the spatial data and thus the waste of the budget allocated to their construction, because the contents of the data already constructed and their locations cannot be easily known.
3) Lack of the standard for maintaining the spatial data common to the individual systems, causing inefficiency quality control of the data and difficulty to use the data supplied by the national geographic information system.

To overcome these problems, the SMG was to construct a standard centralized spatial data management system, so called the Seoul Spatial Data Warehouse (SSDW). The purposes of the SSDW construction are as follows:

1) Establishment of the sharing system of the spatial data to save the data construction budges by preventing their redundant construction. In addition, the administrative information is to be efficiently combined to the spatial data.
2) Integrated management of the spatial data common to individual GIS systems to provide the latest updated geographical information promptly to each department.
3) Development of the map viewer program and thematic analysis service based on OLAP tools so that all the city's employees can utilize the geographical information supplied from the SSDW for their administrative tasks.

2. THE PRESENT STATUS OF THE SSDW

2.1 Individual GIS Systems in the SMG

The SMG has constructed digital maps (the scale of 1:1000) of the 147 layers including building, roads, rivers and other geographic objects. It completed the first set in 1998 and the second set from 2001 to 2003. Currently, it is converting them based on Bessel ellipsoid into those based on the world geodetic coordinate system (GRS80).

The SMG is now operating 24 individual GIS systems based on these maps such as a road management system, an urban planning information management system, an aerial photo web search system, an underground facility management system and other systems. In terms of their application fields, the GIS systems are categorized as shown in Table 1. Besides these systems, the 25 local district offices under the SMG developed the independent GIS systems customized to their situations.

Table 1. Overview of individual GIS systems in the SMG

Field	count	System Category	
		Front Office(Internet Service)	Back Office
Sum	24	7	17
City	7	-	City planning information management, Road management, Airborne image web search, Drainage system management, Waterworks management, Urban ecological information management, Integrated information management of underground facilities
Transportation	4	Information homepage of public transportation system, Data processing system of traffic report	Road sign management, Management of demand for parking classified by block
Disaster prevention	2	-	119 integrated computation information for preventing disasters, Managing the movement of vehicles
Administration	4	Road excavation · restoration management, Land management information system	Spatial data warehouse, New address management
Environment	1	-	Water pollution management
Civil	3	GIS portal service, New address guide, National geographic information circulation system	-
The others	3	-	Circulation system of SDW spatial DB, Ground information management, Digital topographical map (dwg)circulation system

2.2 System Operating Environment

The huge data in the SSDW can be searched and rapidly transmitted via a high-speed intranet so called “e-Seoul Net” connecting the numerous offices under the SMG such as the main office, the 25 local district offices, and several project offices.

The hardware infrastructure of the SSDW consists of the DB servers containing 163 kinds of common spatial data, 8 kinds of administrative data, and metadata, the Web servers providing intranet services, the OLAP servers providing thematic analysis services. The GIS DB servers are based on the Oracle, utilizing ArcSDE 8.3 as the spatial engines. The Web servers are based on ArcIMS 4.0.

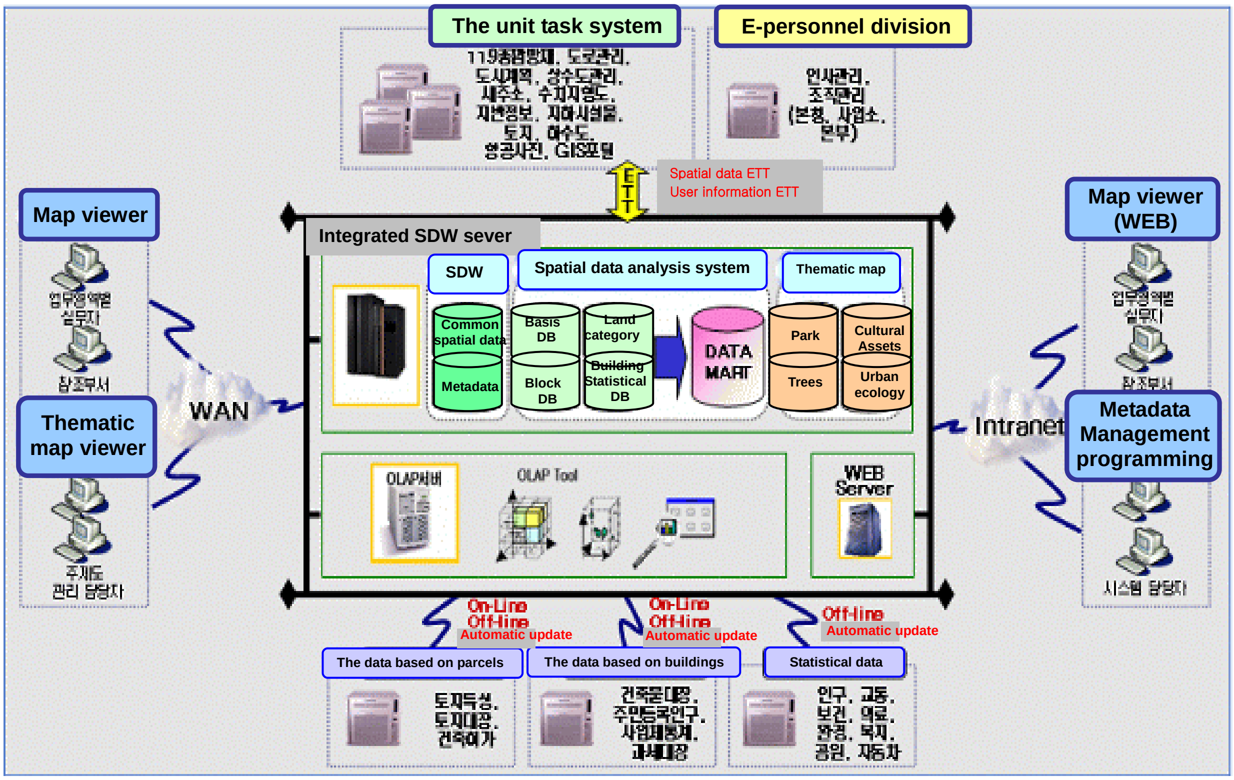

Figure 1. The system architecture of the SSDW

3. THE MAIN COMPONENTS OF SSDW

3.1 Spatial Data Sharing Network

To establish the data sharing network for the SSDW, we selected as the common spatial data the fundamental GIS data provided as the national level so called the *national framework data* systems as well as the data commonly used for the individual GIS. Based on the analysis on the spatial data required by each individual GIS system, we found that 163 layers were required by at least three individual GIS systems and selected them as shown in Table 2. Since the demands of these common spatial data can be changeable due to the change of the task environment, the introduction of a new system, and the social issues, we have been monitoring and satisfying these demands through a geographical information coordination committee.

Table 2. The status of Seoul's Common Spatial Data

Provided System	Common Spatial Data	Count	The period of update
City planning information management system	Uses area, uses district, uses zone, etc.	12	Once in a week
Road management system	Surface of road, road facilities, intersection, etc.	11	Twice in a year
Waterworks management system	Tap water pipeline, fire plug	4	Once in a month
New address computation system	Building, road, etc.	10	Once in a month

Digital topographical map	Contour line, railroad, river etc.	73	As changed
Integrated information system of underground facilities	Communication network, electric pipeline, etc.	28	Quarterly
Land management information system	Editing cadastral	23	Once in a month
Drainage management system	Distribution equipment, draining work zone, etc.	2	Quarterly
Sum		163	

The selected common spatial data are updated using the on-line system facilitated by the SSDW and distributed to each department via the unique window provided by the SSDW. We employed three different methods to share and update these common data such as SDE to SDE, DB to DB and Shape to SDW methods. The SDE to SDE method is used only if the data is managed by the spatial DB engine, ArcSDE so that their versions are properly managed. Since only the data to be updated are transmitted in this case, the network load can be significantly reduced. On the other hand, the DB to DB method is utilized if the data updating period is relatively long and it is difficult to extract only the data to be updated.

In addition to these spatial data, we also linked to the SSDW the general administrative information systems already established as on-line systems. For example, since the visualization of some administrative information based on the spatial data can significantly improve the efficiency of the corresponding administrative tasks, we linked such information to the SSDW. In total, eight kinds of administrative information are categorized in terms of the association with buildings, land pieces, and administrative counties and connected to the SSDW.

3.2 Spatial Data Management Framework

The spatial data management framework was developed to maintain properly the on-line data sharing framework between the common spatial data bases. This framework was implemented by developing the ETT module that maintains the correspondence between spatial data and the metadata management program. The common spatial data originally constructed in each individual GIS system is acquired and archived to the SSDW servers. Since the individual system continuously updates its data, the common data archived in the SSDW can be out of date within a period of time. To solve this problem, the ETT module is designed to update automatically the common data in the SSDW according to the update period of each individual GIS system, as shown in Fig. 2.

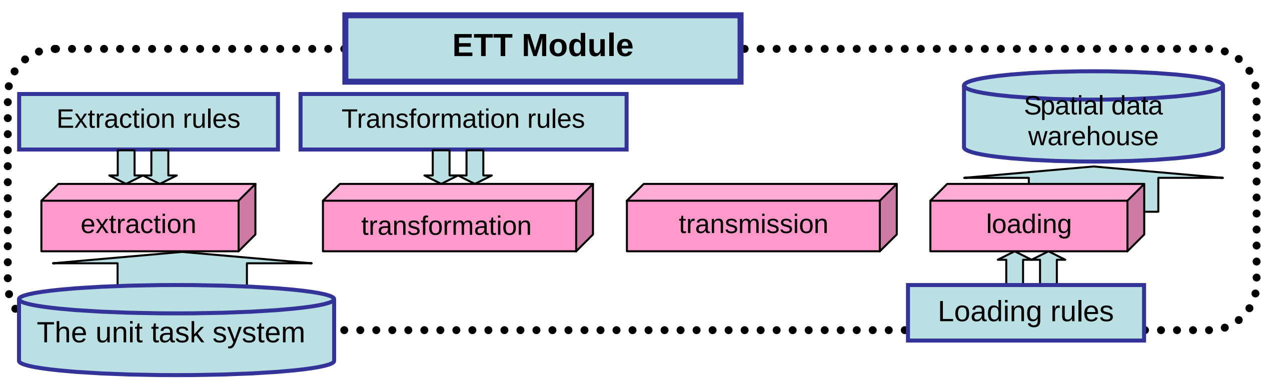

Figure 2. The data update process performed by the ETT module

In addition, the metadata of the spatial data were constructed so that the users can easily search and acquire the spatial data distributed in many different individual GIS systems. The metadata are the standard descriptions about the spatial data themselves and can be effectively used for the search/acquisition process. To define the metadata properly, we reviewed the standards provided by Korean Telecommunication Technology Association (KTTA) and International Organization for Standardization (ISO). In addition to these standards, we added some items to improve the quality control and management efficiency and constructed finally 104 items for the metadata.

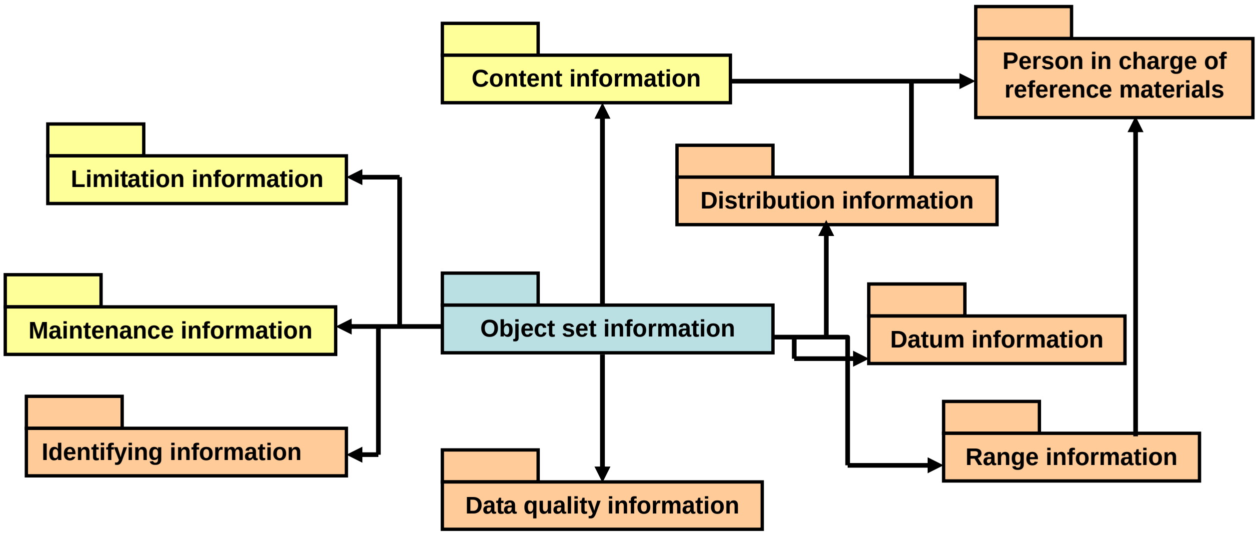

Figure 3. Metadata structures defined in the SSDW

3.3 Spatial Data Application Framework

The spatial data application framework was constructed to effectively utilize the geographical and administrative information shared and linked in the SSDW. To improve the usability and accessibility of the users to the common spatial data DB and various linked DB managed in the SSDW, we developed the map viewer program and the spatial data analysis system to analyze the spatial data linked to the administrative information in multi-dimensional aspects.

The map viewer program based on C/S and Web is developed to search not only the common spatial and administrative data but also the results from their analysis and display them the search results. The main functions are search/display/printing of the spatial, attribute, and meta data, search of spatial data based on the meta and administrative data, search/display of the results from the analysis linked to the individual GIS systems and so on. The web-based version is also facilitated with SSO(Single Sign On) provided by the electronic authorization system through the user authorization management system of the SSDW.

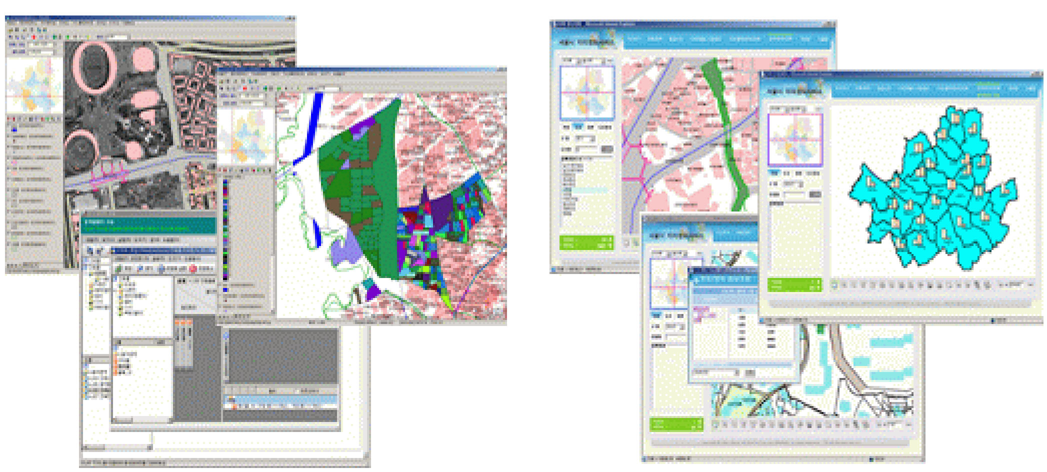

Figure 4. Map viewers of the SSDW based on C/S and Web

The spatial data analysis system based on OLAP tools is developed to perform the spatial analysis that can combine the spatial data, the statistical data, and administrative data. First, we selected 66 analysis themes in eight fields such as urban planning, population, housing, and welfare and constructed a data mart by processing the common spatial data and administrative information associated with the themes. The results from this analysis system are provided to the users via the map viewer based on C/S and web. This system provides the results analyzed and visualized with the map data which can be more understandable to the users. As these results can be also stored in the format of spatial data or a figure, the users can efficiently utilize them in their individual tasks.

4. CONCLUSIONS

The SSDW can prevent the redundant investment on the data acquisition by establishing the data sharing framework and thus contribute to constructing more consistent GIS systems. In addition, this system improves the applicability of the geographical data by linking them to the administrative information so that the local district offices as well as the SMG can apply them to their own administrative tasks.

The benefits from the SSDW's introduction to various municipal tasks can be supposed in terms of three aspects as follows:

First, in terms of strategic aspects, since the consistency, sharing ability, and deterministic properties of the data structures are established, the SSDW can provide an efficient framework to integrate the GIS data, expand the task supporting functions linking the spatial and administrative data, supports the rapid policy decision based on high-level multi-dimensional analysis.

Second, in terms of service aspects, since the geographical data of the entire Seoul city can be provided through a single window equipped with the map viewer program of the SSDW, the number of the data application cases can be significantly increased. There were 60,000 inquiring cases from Sep. 2004 to Mar. 2006, that is, 4,500 per month, as shown in Fig. 5. These inquired data are mainly used for utilizing as base maps, verifying accurate positions, searching details on spatial information, and performing spatial analysis for mainly road digging, facility construction, urban planning and so on.

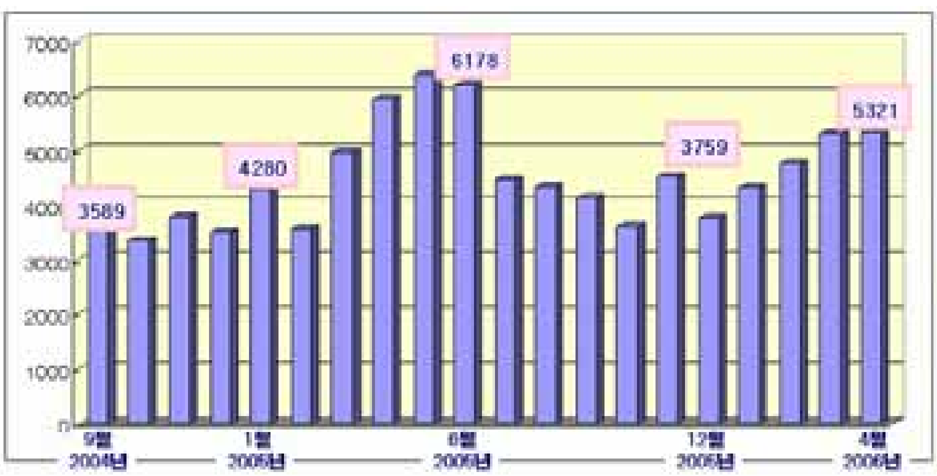

Figure 5. Number of cases using the SSDW (2004.9 – 2006.4)

Third, in terms of economic aspects, the uses of the common spatial data in the SSDW for developing a new GIS system can reduce about 20 thousand dollars from the total construction expenses. When using them for various development planning, 150 thousand dollars per year can be saved.

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