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A Conceptual Model of Intelligent Program Management Information Systems (iPMIS) for Urban Renewal Mega Projects in Korea

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Abstract

This paper is about intelligent Program Management Information System (iPMIS) to support decision-making and management of urban renewal mega projects over their life cycle in Korea. Program management focuses on soft issues i.e. benefits, stakeholders, and governance. A challenge is the diversity of urban renewal projects in terms of process and organization structure. The authors clarify the general requirements of systems to support program management while coping with diversity as follows: openness, clearness, convenience and consistency. As solutions, the authors present a conceptual model for iPMIS featuring the following characteristics: a web-based platform in which general modules and external integrated Geographic Information System (GIS) with decision support logical models are operated; interfaces; cooperative operating IT and IS in urban planning and construction; and a protocol for managing data cooperatively at the level of nation, district, project and facility. Two main unique features are: a user-created ontological process map that provides the operation scenario and menus of the iPMIS; and plug & play techniques by which modules are selected and then operated immediately. These core concepts have been implemented as a prototype system and have been applied to a real construction project. The evaluation result shows that this technique can reduce systems implementation time by 90%.

Keywords: information systems (IS); program management; urban renewal; Korea

1. Introduction

Like other leading developing countries, Korea is experiencing, paradigm shifts in urban renewal and maintenance. More attention has been given to enhancements of living quality and the influences of socio-economic and environmental aspects. However, aspects of conventional on-site housing redevelopments with an increased number of units for financial benefits have caused problems i.e. insufficient public spaces, worse traffic conditions, environmental problems etc. This type of project has been led by communities since the 1990s. (Lee, 2000) A new approach to planning and developing a district including several blocks of houses in marginal conditions has gained popularity since 2002. (Kim, 2007) This type of renewal is called 'New Town construction in Korea. Relevant regulations and codes have been amended to facilitate district or town level urban renewal as these are believed to balance public and private land usage under a master plan for enhancing regional living, socio-economic and environmental conditions. Renewal of old commercial zones follows this trend as well.

As a consequence, the size of urban renewal projects has been enlarged and the clients side organization becomes more complicated than ever before. (Kim, 2007) Urban renewal mega projects in terms of size and the number of stakeholders involved have appeared. In these projects, social, economic and political activities are embedded. (McCarthy, 2007)

From administrative and managerial perspectives, the clients and their representative should introduce different approach and methods compared to those for single or multiple projects. In order to manage those, information systems for reaching consensus among participants and consistent information management are necessary. Cooperated Geographic Information System (GIS) with decision support logical models are likely to enhance understanding (Yaakup *et al*., 2005). Relevant theories and applications of integrated urban planning and management systems are presented in various research papers (Yaakup *et al*., 2005; Stevens

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et .al., 2006; Crêt-Regamey *et al*., 2007).

However, in the Korean context, like other countries, it is difficult to standardize the process and thus a systematic approach to planning and management of urban renewal projects from the initial phase requires further consideration. Most of all, management information systems for urban renewal mega projects should be able to cope with the diversity of the process and organizational structure. In addition, they should support soft aspects of the program management i.e. benefits, stakeholders and governance. Technically, next generation urban planning and management systems should harness the evolution of IT in urban planning and construction, and thus make practical life cycle management possible.

The Korean government funded USD 150 million on an 8-years research and development (R & D) project to develop an approach, models and applications for urban renewal. This was launched in 2007. The R & D project consists of 41 sub projects and one of those is "Development of iPMIS (intelligent Program Management Information Systems)". The iPMIS aims to support decision-making and information management for urban renewal mega projects over their life cycle.

This paper focuses on the background, conceptual development and prototype systems of the iPMIS.

2. Urban Renewal Mega Projects in Korea

Lee (2000) summarizes the evolution of urban renewal in Korea as: i) state-led shanty clearance and relocation in the 1950s and 1960s; ii) citizen apartment building program in the 1970s; iii) public-private partnership in property-led urban renewal in the 1980s; and iv) community-led urban renewal in the 1990s. In the 2000s, a considerable increase in the size of urban renewal projects has been observed. Between 2000, when the "Urban Planning Law" was amended to facilitate a holistic approach for urban renewal and 2004, 59 sectors of 2,546 million m^2 had been approved as "The Urban Poor's Housing Environment Improvement" projects (Kim, 2007). The area of a single project has been enlarged by 240% from 23.3 million m^2 in 2001 to 55.6 million m^2 in 2005. The main reason is that district or town renewal has been planned instead of on-site housing redevelopment or rehabilitation. For instance, in Seoul, 25 new town projects have been in progress since 2002. Partnership between the public and private sectors is likely to be increased due to the financial risks (Kim, 2007).

Massive commercial and business district construction projects have been undertaken as part of urban renewal. These projects show the characteristics of mega projects.

Three major urban renewal mega projects that have been undergone in 2008 are presented in Table 1. The Sewoon project is under construction and the other two are in the planning phase.

Table 1. Examples of Urban Renewal Mega Projects in Korea

Project Name	Area (m^2)	Budget (USD)
Sewoon 4th Commercial Block	132,000	1,900 M
Yongsan Business District	566,610	28,000 M
Haeundae Resort	49,830	1,500 M

Fig.1. shows the main features of urban renewal mega projects. Various functions such as residential, commercial and public spaces are allocated vertically as well as horizontally. The complicated organization of the client side is also a considerable aspect. Since the 1990s, the public and private sectors have cooperated. For instance, use of an SPC (Special Purpose Company), 3rd temporary sector, has been preferred to minimize financial risks. This trend causes conflicts within the client side.

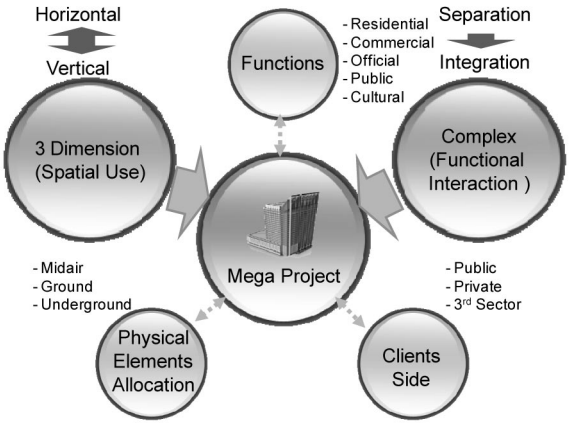

Fig.1. Characteristics of Urban Renewal Mega Projects

It has been observed that conflicts among participants, especially in terms of economic interests, have hindered the progress of projects (Kim *et al*., 2006, McCarthy, 2007). For instance, central and local governments are concerned with publicity and operation and maintenance of the territory. On the contrary, private participants are keen on the financial benefits.

For this reason, functions to support integration and coordination of values among participants should be considered when developing information management systems for urban renewal mega projects. However, in the Korean context, the processes vary according to the project types and region. As a result, the process cannot be provided as a single model, and thus, a unified framework for managing various types of urban renewal mega projects has not previously existed. This makes it harder for central and local governments to share information needed for decision-making and to manage the process consistently.

The scope of these managerial activities is wider than the conventional project management of single or multiple projects and it can be empowered under the "program management" scheme.

2.1 Program Management in Mega Projects

A program is "a group of projects managed in

a coordinated way to obtain benefits not available from managing them individually" (Yamada and Tanabe, 2005). Urban renewal mega projects consist of sub projects such as residential, commercial and public facilities construction projects. As sequences, stakeholders with various purposes are involved. For this reason, program management should be introduced for successful management.

Yamada and Tanabe (2005) define program management as "a concept to deal with huge and complex business activities from social, economical, cultural and environmental points of view and increase their value for client and society." They present the five major elements of a program as business value, stakeholders, project portfolio, business environment and risks. e-Builder (2008) categorizes it similarly as follows: i) benefit management - activity and technology to maintain justice and maximize benefit or value by program; ii) stakeholder management - activity to manage the individual or team in the early stages which is influenced by the output of program and iii) program governance - process to develop policy, procedure and team structure relating to the program and to guarantee communication, action, and monitoring of those involved.

2.2 Scope of Program Management

Program management is more than the combination of single or multiple facility construction projects. In this context, it should cover the urban renewal projects process as a whole, and thus naturally includes the sub-process at the level of a single facility construction project.

The general process of any single facility construction project can be defined as follows: i) pre-design (PD) in which the decision maker from the client side thinks of the project and evaluates the fesibility; ii) schematic design (SD); iii) detailed design (DD); iv) construction documentation (CD); v) construction (CO); and vi) operation/maintenance (OM). Only the client can be involved in the entire process and other professional participants join in the project as required. A problem is that the sequence of participation varies according to the procurement path and is mainly determined by the interests of and constraints imposed by of the client. As a result, the responsibility and scope for managing projects are not consistent from project to project. Due to the diversity of procurement paths and organization structures, consistent information management remains challenges. Given that important decisions are made in the earlier phases, i.e. PD phase, especially, modules to support decision-making at this stage are necessary. To this end, systems should provide information for decision-making (Jaafari and Manivong, 1998) and simulate future results according to each decision.

The urban renewal process includes the major phases of construction, but it is far wider than the latter. The authors define the urban renewal process at the higher level as: i) conception; ii) planning and feasibility; iii) preparation; iv) execution; and v) operation/maintenance. In general, the conception phase is initiated according to a national and provincial master plan. Local governments conduct an initial survey and the results feed into the plans at the district or regional level. The plans are approved according to social, economical, environmental and financial criteria in the feasibility study phase. In the preparation phase, client representatives, i.e. developers, are appointed and detailed planning permissions are sought.

The main interconnection between programs for urban renewal and the construction of each facility within the project occur at the execution phase as described in Fig.2. Conventional construction phases from schematic design to construction are a part of the execution phase of urban renewal project.

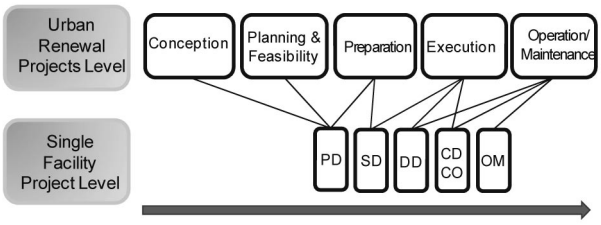

Fig.2. Scope of Program Management

Given that data and information from the urban renewal project level are referred to each single facility project level after a time delay, systems should be implemented that enables information flows across the phases. In addition, the systems should provide functions for oversight management so that the status of each single facility project can be monitored at the upper level for management.

The operation and maintenance of next generation cities, i.e. ubiquitous cities, requires more detailed data that represents as-built facilities as accurately as possible. A system enabling coordination and integration of information across levels can be implemented by introducing state-of-the-art IT and IS in urban planning and construction.

3. IT and IS in Urban Planning and Construction

Briassoulis (1999) explained information perspectives in urban planning as: i) the need for as much scientific and technical information as possible to analyze comprehensive planning problems; ii) the use of scientific analysis and mathematical models to design optimal solutions; and iii) the primacy of technical and technological solutions to these problems. (Yaakup *et al.*, 2005) Research and practices in the field of information processing and management in urban planning has two broad directions: spatial information processing (i.e. Stevens *et al.*, 2006) and decision support (i.e. Charkrabarty, 2005; Crêt-Regamey *et al*., 2007). GIS has been regarded as a tool for visualization of spatial information in urban

planning (Stevens *et al.*, 2006). Integrated GIS with decision support models can contribute to a clearer understanding of real planning problems as well as prescriptive planning scenarios to enhance the quality of urban planning and management (Ayeni, 1997; Yaakup, *et al.*, 2005). They emphasize the role of this incorporation system as "to forecast and determine future development strategies and policies by integrating physical, environmental and socio-economic aspects of planning especially regarding the spatial context."

Considering the importance of GIS, the Korean government launched a research and development project to develop a next generation GIS at the national level. The National Geographical Information Systems (NGIS) is a system that stores the location and characteristics of natural elements (i.e. sea, mountains, rivers, land, etc.) and man-made materials (buildings, roads, railroads, etc.) in computers and inter-links all inputted information to help in various planning, decision-makings, and industrial activities. NGIS will be used further for operations and maintenance at the regional level utilizing information on topographical, cadastral, land usage, road, water line and other underground facilities (MLTM Korea, 2008).

In addition to spatial information management, decision support modules and process-based information management functions are required. Reviews of approach, methods and techniques in PMIS (Project Management Information Systems) can provide a direction for implementing management information systems for urban renewal mega projects.

Traditionally, construction projects produce enormous amounts of information related to cost, schedule, and administration through all phases of the project lifecycle. The fundamentals of any PMIS are to control project cost, schedule and scope in one integrated suite. (e-Builder, 2008) As a project is undertaken, changes to the project plan are inevitable. Proper systems enable participants to manage changes. In short, PMIS has been developed to provide functions to manage changes, minimize risk and decrease the planning, development and construction life cycle (e-Builder, 2008). These can be achieved by streamlining, automating and standardizing processes and, communications providing a central access point for all project information.

The evolution of PMIS follows the trend of IT in construction. The future of PMIS can be predicted by reviewing the paradigm shifts of IT in construction. The trends in IT for construction can be classified into three eras. In the first era, most construction IT historically focused on developing stand-alone tools to assist with specific tasks. Examples are CAD, structural analysis tools, estimating, scheduling, and general business applications. In the second era, in the mid 1990s, the trend in construction IT focused on computer aided communications i.e. email, the world wide web, document management systems etc. This is also the moment when concepts on CIC (Computer Integrated Construction) were first established. Finally, in the third era, there has been a big shift towards implementing an integrated way to create, save, and reuse data. The fundamental concept is that all participants can share information on product and process based on an integrated building information model and relevant DB. The product is defined as objects and combinations of those objects and is partly merged into the process (Van Leeuwen and van Der Zee, 2005).

Since most decisions involve collaborative working of practitioners from different disciplines such as designers, project managers, cost estimators, structural analysts, schedulers, and MEP(mechanical, electrical, and piping) experts, it is certain that there is an increasing amount of electronic information generated by each disciplines. In order to reduce the data-handling load while enhancing the efficiency of communication among practitioners and electronic data exchange, researchers have presented a practical project information model during this era. The model is called BIM (Building Information Model). Research on an integrated project information model for collaboration (Plume and Mitchell, 2007) and decision support cooperated with 4D simulation (Fisher, 2000; Chau *et al.*, 2005) are examples of how to implement the approach. As stated above, management systems for urban renewal mega projects would harness state-of-the-art IT in construction as well. However, it does not mean that the system can make decisions on behalf of the human specialists. The role of systems is to aid decision-making at the program level with intelligent functions and information that is provided in a timely fashion.

4. General Requirements for the iPMIS

The intelligent Program Management Information System (iPMIS) means that the system can facilitate the integrated data and information management environment and then support the participants in obtaining proper information in a timely fashion for decision-making through the life cycle of urban renewal mega projects focusing on the program as well as on single facility project management.

Fig.3. shows the scope of the iPMIS for urban renewal projects. Conventional PMIS aims to support the construction process of single facility or multiple facilities projects. The narrow use of the system is partly derived from the responsibility for implementing and operating the system rather than technical feasibility. Unless the client has in-house PMIS, the system may be purchased or implemented after a project manager (PM) is appointed. Considering diversity in terms of process and organization structure,

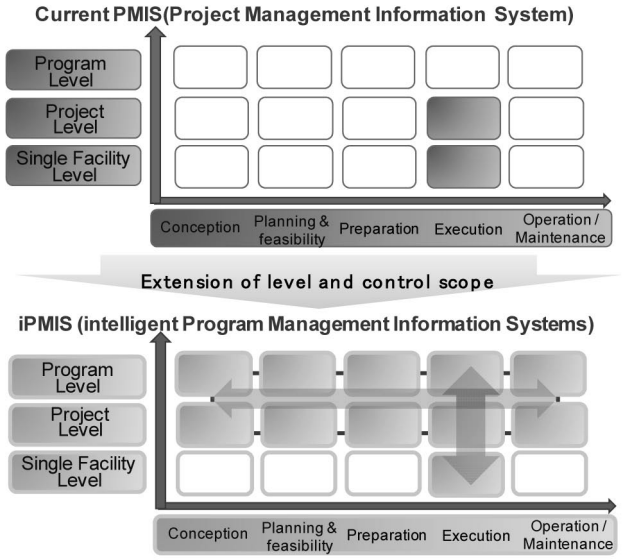

Fig.3. Scope of the iPMIS

the concept for information systems for urban renewal mega projects should be redefined.

Regarding reviews presented in previous sections, features and solutions for the iPMIS are summarized in Table 2.

Table 2. Major Features and Solutions for the iPMIS

Features	Solutions
Soft aspects of program management	Open and consistent information management supported by simulation
Diverse process of urban renewal projects	Ontological process map
Abnormal modules according to project types	Plug & Play
Oversight management	Cooperated visualization of BIM data
Communication among diverse participants	Web-portal platform
Standard data exchange protocol	XML-base data exchange

As mentioned in Table 2., the fundamental functions of the iPMIS are to support decisions relevant to the soft aspects of program management. Open and consistent information management should be facilitated. In order to achieve this, the operating environment is designed as a web-portal platform in which participants and stakeholders can have an overview of the plan, simulated results and project process irrespective of time and location.

Regarding unpredictable organization structures, the time lag between participants involvement and never-consistent responsibility, the system should be flexible. To this end, the system is planned to provide functions enabling the participants to design a tailored process map. Criteria for decision-making and input and output data fields are presented according to this map. This is called the "ontological process map." At the lower level of the process map, functions and data flows are predefined for electronic data management. The users select the upper level of process elements and those become the menus. These menus will be operated immediately after becoming part of the system. This mechanism is called "plug & play". This concept will be explained in detail in the next section.

The iPMIS should include fundamental modules i.e. oversight management and change management. Data on products and process (i.e. cost, schedule) can be provided from the database that is designed for interfacing with project management information systems. The data from the level of individual facility projects are summarized and reported for program management.

For consistent data management over life cycle, data exchange protocol is required. XML has been selected as the standard data exchange protocol to enhance flexibility. Reports for human users can be created by processing data saved in XML format.

Once the iPMIS is developed by regarding the features and solutions in Table 2., it will have the following characteristics: openness, convenience, and consistency as described in Fig.4.

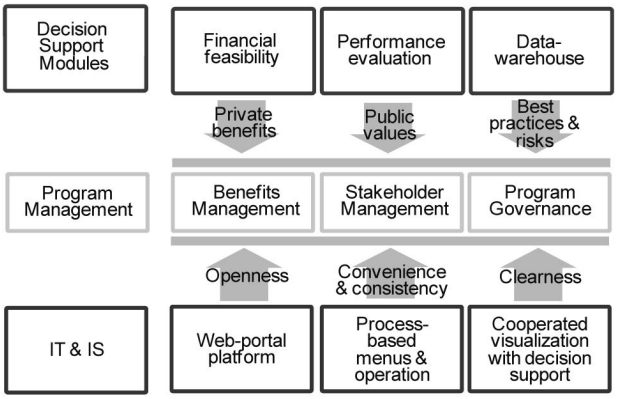

Fig.4. The Role of iPMIS in Program Management

The web-portal platform provides openness, visualization functions enabling participants to understand the problems and future scenarios in urban planning clearly, and the ontological process map guide for the proper governance. Logical models to support decisions will be merged into these modules. For proper use of those, decision criteria based on performance evaluation and the timely feed of data and information from the external database are essential. Data warehousing will play that role.

4.1 Systems Analysis and Design of iPMIS

The authors conducted a survey to analyze the needs for decision-making support modules of the iPMIS between February and May 2008. 28 public and private client representatives are asked about the necessary functions of the iPMIS through face-to-face interviews. The RFP (Request for Proposals) for the iPMIS development R & D project that was issued by

Table 3. Decision Support Modules of the iPMIS

Modules	Description
Land usage zoning and simulation	Simulating public and private space zones and allocating facilities according to it
Constricts checking	Checking code and other constricts of alternative zoning and facilities plans
Transportation condition simulation	Simulating traffic capacity
Financial feasibility simulation	Predicting the budget and selecting a proper financial model
Performance simulation	Providing criteria and evaluating the results

MLTM Korea was analyzed as well. Modules that are frequently selected are presented in Table 3.

General requirements such as "enhanced visualization" and "oversight management" are excluded in Table 3. as those are already mentioned in the previous section and will be embedded into the fundamental features of the iPMIS.

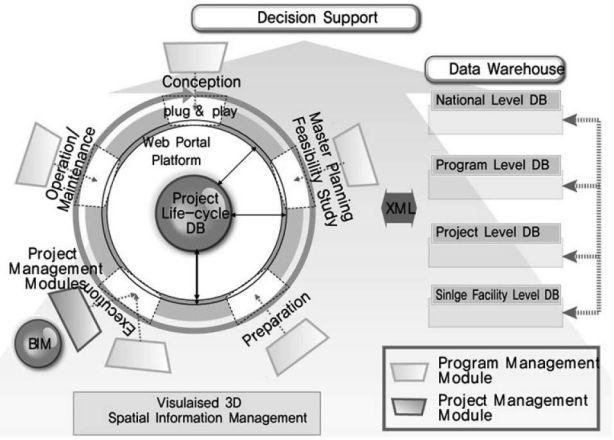

Fig.5. A Physical Structure of the iPMIS

The authors present a physical structure of the iPMIS as shown in Fig.5. The principles are open architecture to cope with the diversity of urban renewal projects. Operation scenarios and the menus of the web portal platform follow the user-created process map. Pre-dveloped moduels are operated using the plug & play concept.

The national level database provides spatial data, statistics of cities and districts, regulations and codes etc. These will be referred to or used in the master planning and feasibility study phases. As the project is undertaken, admistrative information and decisions at the higher level are accumulated in the program database. Detailed data on products are manged in the BIM database externally. As required, data from it will be fed into the iPMIS.

The iPMIS consists of the following 3 layers in terms of operation scenarios and main functions as described in Fig.6.: i) the first layer is the national urban renewal portal; ii) the second layer is the web platform for individual urban renewal projects; iii) the third layer contains decision support modules and interfaces with the project management information system for single or multiple facilities construction.

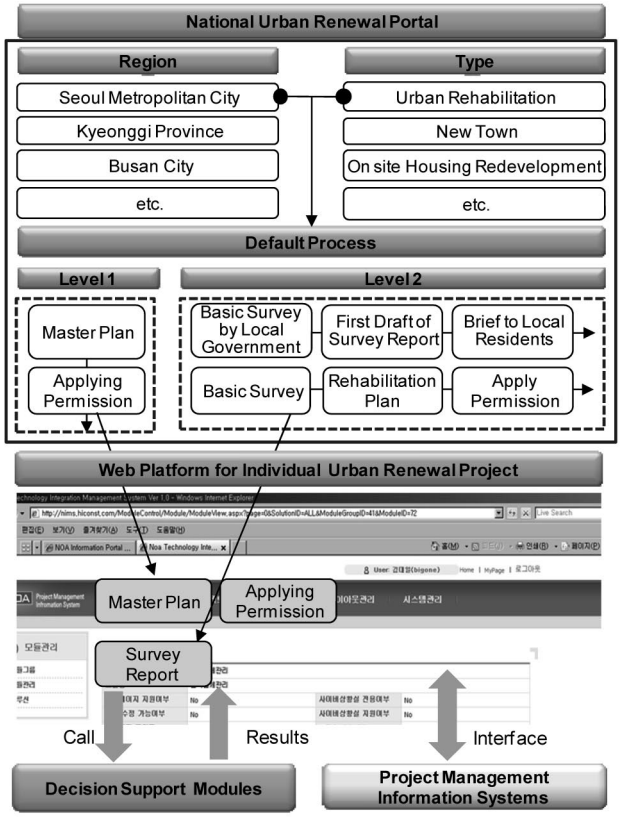

Fig.6. Layers and Operation Scenarios of the iPMIS

The first layer is operated by the Korean government or a public agency. The second layer is operated by local government until the plan is approved and the client s side appoints project representatives (or developers). As required, stand-alone decision support modules will be operated and the results will be uploaded onto the web platform in the second layer. The iPMIS does not include conventional PMIS operated by main contractors. Instead, the interface will be developed by which the data for oversight management can be accumulated and fed into the iPMIS.

A unique feature of the iPMIS is that the menus of the web platform for individual urban renewal projects are created by combining the process elements as shown in Fig.7. Given that the process for urban renewal projects is mainly determined by region and project type, a default process can be provided by combination. In addition, the iPMIS provides ontological tools to customize the process by selecting process elements at the lower level as described in Fig.7.

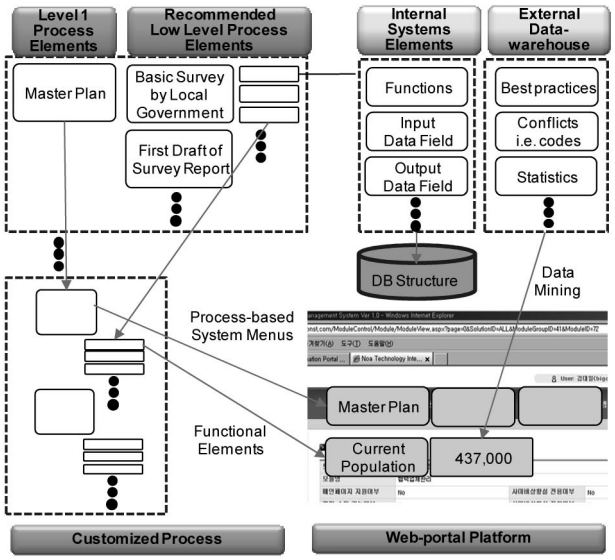

Fig.7. Ontology in the iPMIS

The functions, data and information can be pre-defined at the lowest level of process elements that are described as the functional elements in Fig.7. Users can design a group of functional elements into the upper level of process elements. By doing this, a process map for human users and data structure for information system can be defined.

Decision-making can be supported by stand-alone applications that are linked to the web platform. For instance, an external application for visual allocation of facilities with geographical information is shown in Fig.8.

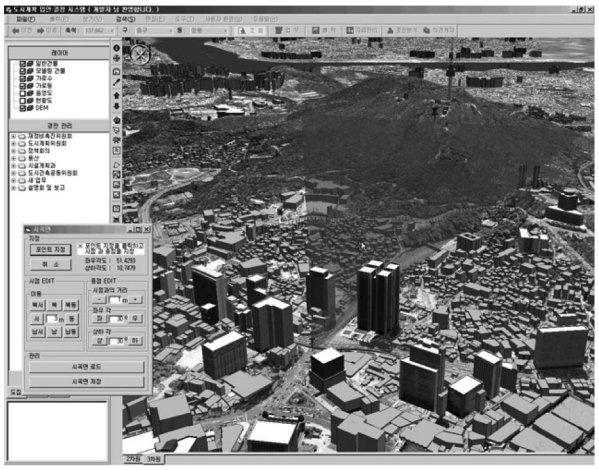

Fig.8. Example to External Module for GIS Spatial Data Visualization

Various decision modules that work in cooperation with visualized functions have been developed in Korea. Fig.9. is an example that is developed by a research team including the authors. The purpose of the example is code-checking focusing on the height limit in the central zone of Seoul. Modules for evaluating public and private space allocation, simulating budget according to the type and size of individual facilities

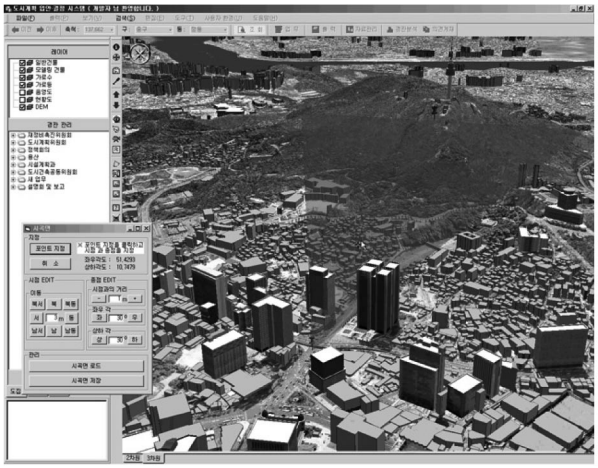

Fig.9. Example to External Module for Visualized Code Checking

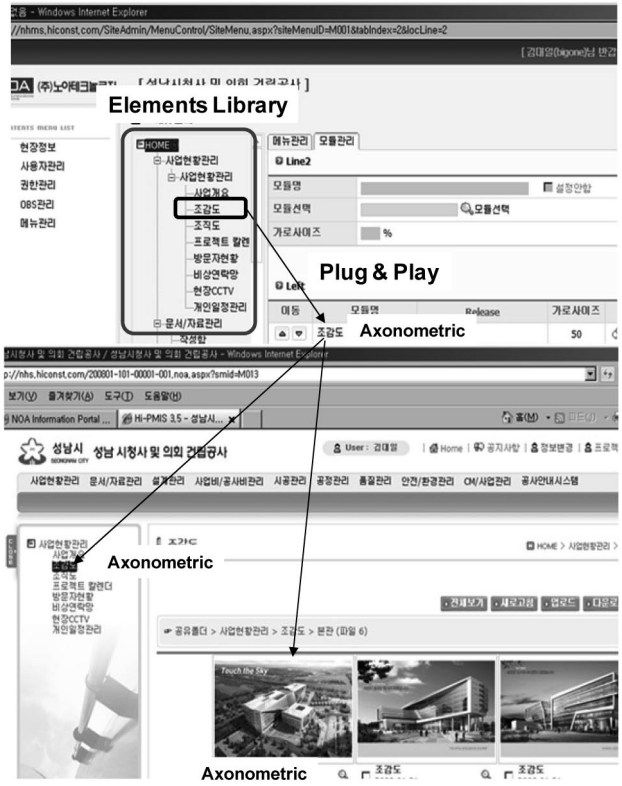

Fig.10. Plug & Play Concept Implemented in Prototype System

and others have been developed by the research team.

4.2. Prototype Systems and Evaluation

The research team including the authors developed a prototype system implementing plug & play concept as described in Fig.10. Once the functional elements that are defined from the ontological process map are selected, these will become the menus of iPMIS. In the figure, for example, a functional element "axonometric" is selected and it will become a part of the web portal. Currently, the technical feasibility of such plug & play is being proved.

The developed plug & play concept was applied into a real project in January 2008. With this method, 90%

of web portal platform development time was saved.

5. Conclusion

Only few practical applications are available to support program management of urban renewal mega projects over their life cycle. iPMIS aims to support decision-making and information management at the program management level. The system should enable the participants from various sectors to harmonize the conflicts in terms of economic benefits, stakeholders and governance. In addition, the diversity of process and organization structure of urban renewal projects in Korea should be coped with. To this end, openness, enhanced clearness, convenience and consistency should be implemented.

As solutions, the authors presented a conceptual model of iPMIS with the following features: a web based platform in which the main and sub functions are defined according to a user-created ontological process map; various general modules are operated immediately by means of plug & play and external decision support modules can be linked. The information on process and decisions can be updated and shared among participants and stakeholders, and thus open consensus making is available.

The plug & play concept is implemented as a prototype system and it has been applied to a real project. The evaluation results show that this technique can reduce systems development time by 90%.

Further considerations should be given to the authority for accessing information and technical feasibility for interface with urban and building spatial data.

Acknowledgement

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