DEVELOPMENT OF THE KNOWLEDGE-SHARING SHEET SYSTEM FOR LANDSCAPE DESIGN MANAGEMENT

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Abstract. In a public design, such as a landscape, it is important that the information on the design process be shared among the planners, the administration, and the citizens, and to continue the design work with consensus. A landscape design proposal cannot be reasonably evaluated from only the result of a design since the decision-making process would not be sufficiently explained. Therefore, designers are required to record and store several design documents during the design process. The development of a knowledge management technique is desirable in order to facilitate the sharing of the project information in the designer's group. The authors have researched knowledge management in a landscape design process, developed a heuristic knowledge-sharing tool that aids decision-making by consensus in a design process. This tool is a sheet system based on XML (extensible markup language). It allows the user to retrieve knowledge from a similar design project, and to customize the formats of a sheet according to the design process.

1. Introduction

In recent years, for projects of a large-scale facility such as skyscrapers, power stations, and airport buildings, planners are expected to arrive at a consensus decision with the public with respect to landscape preservation. Conventionally, in order to explain the design to the residents and obtain their feedback, the planners have presented only a model of the finished landscape.

The authors have been researching the process of executing a landscape design project by the design team, in cooperation with the construction department of an electric company. We observed the process of landscape design in actual projects

of large-scale facilities. As a result, we have enumerated the following points with reference to the problem of information sharing:

1. A forum where the participants can exchange information on the design and review the design proposal is lacking. Several organizations hold various meetings, and hence a number of related documents, such as the meeting agenda and the reports of the decisions taken lie dispersed among organizations. Moreover, it is difficult to develop a system of sharing information among the organizations.
2. A record of the process followed for the decisionmaking and the minutes of the discussions is not maintained. Although the design team generates a report at each stage of the design process, the entire content of these reports may not be made available to all members. Moreover, because the report often records only the result of a review, it is unclear as to how the design proposal was agreed upon at each stage.
3. A design-team member learns neither the technique of prediction and evaluation of landscape nor the method of sufficiently employing the various tools. For landscape design, the techniques and tools employed vary with each case. Therefore, an inexperienced member is unable to select an appropriate technique. If neither the technique nor information on the tool is shared, group work becomes inefficient.
4. For a new project, a member cannot sufficiently reuse information from a past case. Neither a detail of the problem nor a method of executing the actual task is specified although past cases are reported in documents. Moreover, because the report is not available to the public as digital data, data cannot be recycled.

In the actual business of landscape design, the solution to these problems of sharing knowledge is required. To support the design project within a team, it is necessary to develop systems that manage the knowledge of landscape design in accordance with the design process.

Several researches concerning a method to help design a landscape with public involvement, and a data sharing system with network communication technology have been conducted. (McCullough and Hoinkes, 1995; Dazhong, 1999; Fukuda. et. al., 2002; Lou. et. al., 2002; Peng, 2003). However, studies on an information sharing system with respect to the design decision process are insufficient. On the other hand, research related to knowledge management includes researches for structurizing design information or researches on the technique of data mining (Ciftcioglu and Durmisevic, 2001; Turk. et. al., 2001; Rafi and Karboulonis, 2002; Chen, 2002). Although these studies focus on developing the design knowledge, these do not discuss a practical technique for externalizing individual knowledge.

The purpose of this research is to adopt knowledge management in a landscape design process and to develop a heuristic knowledge-sharing tool for consensus

decision-making in a design process. This tool is an XML-based sheet system. It allows the user to retrieve knowledge from a similar design project and to customize the formats of a sheet according to the design process. The created data sheet is available on the internet.

2. Tacit Knowledge and Explicit Knowledge

Knowledge management in a team involves managing a dynamic process wherein participants execute the project while exchanging knowledge. Individual knowledge is tacit knowledge and is not externalized. On the other hand, knowledge that is externalized with language is assumed to be explicit within the team. It is necessary to convert tacit knowledge into explicit knowledge in order to create the process whereby knowledge is developed for the organization. The authors have defined knowledge management in the team by three stages.

1. Stage of tacit knowledge:
   Tacit knowledge is individual knowledge. Also, it is not conveyed to the other members. Therefore, the team iterates inefficient knowledge management. At this stage, information and proposals from the members are digitalized. However, the knowledge is a result of discrete information from various individuals and is not a result of collective input from the team.
2. Stage of explicit knowledge:
   Converting tacit knowledge into explicit knowledge requires disseminating knowledge. As a result, the team accumulates knowledge and can share it. The team should systematize knowledge according to the process of the project at that stage. The systematized template executes the accumulation of efficient knowledge regardless of individual ability.
3. Stage of sharing knowledge:
   Integrating and managing knowledge using XML notation results in the knowledge of the project team becoming public knowledge. Using XML facilitates the retrieval and editing of information.

Team knowledge is created by repeating these three stages in spirals. We have shown that the following conditions are necessary to convert tacit knowledge into wisdom and to create wisdom at an organizational level. These are also the concepts of the system development.

1. Recording discrete information, wisdom, and know-how
2. Storing heterogeneous documents
3. Inputting the information into the template of the task
4. Understanding the entire design process
5. Laying out the information graphically

6. Using the data for presentation and printing
7. A keyword- or full-text enabled search function
8. Providing common space on the network
9. Confirming the progress of the project
10. Sharing problems
11. Using the information as a reference for the next project
12. Capturing information¡¡according to the requirements of the user
13. Guaranteeing security.

3. Define the Knowledge Structure in Actual Projects

In a large-scale construction project, the landscape is designed simultaneously considering the main building and the circumference environment. In order to ensure harmony between the building and the surrounding landscape, designers consider the arrangement, shape, and color of the building as well as planting trees. The landscape design processes in actual large-scale building projects were reviewed from the viewpoint of information. As a result, the entire design process was expressed in four stages.

Stage A: Agreement on the purpose and method of a design process
Stage B: Survey and analysis of the geographic information of the area covered under the project
Stage C: Creation and presentation of a design proposal
Stage D: Evaluation and modification of a design proposal, examination of an alternative

Minutes of meetings held, at each step in the design process for both the construction and the landscape, should be maintained. The authors analyzed the documentation and classified them according to the project schedule, design technique, tool, and format. The authors then defined the matrix of the knowledge structure, which described all documents in accordance with the design process. This can express the entire landscape design project.

Here, the information that should be shared in designing the landscape of large-scale facilities has been extracted. Table 1 shows the information classified into four stages.

4. Development of a Knowledge-sharing Sheet System

4.1. CONCEPT OF A KNOWLEDGE-SHARING SHEET

A knowledge-sharing system is a developing system, which consists of well-

TABLE 1. Four stages in the landscape design process.

STAGE_A	Aim and Goal, Task Flow, Regulation documents, Client profile Interview to residents, Site Map, Site Information, Minutes
STAGE_B	Tourism Leaflet, Site Analysis, Similar Facilities Survey, Law and Regulation of Landscape, Environmental Assessments, Analysis by GIS _iVisibility, Viewpoints Selection_j Resident's Opinion by Questionnaire, Minutes
STAGE_C	Design Concept, Landscape Design Concept, List of Space, Block plan Reference case, Alternative Proposal, Perspective, Minutes
STAGE_D	Design Condition, Process of Design, Volume examination State of Reference Case, Photographs, Construction Drawing by CAD Rendering Image by Computer Graphics _iPhotomontage and Animation_j, Result of Assessments for Design, Flow of Design Process

formatted sheet groups. The sheet describes one decision result as one unit in a design process. It is formatted with XML, which enables perusal, modification, and printing. The sheet system consists of four categories of sheet groups, which are (*i*) building design sheet "D," (*ii*) landscape design sheet "L," (*iii*) related method and tools instructions "M," and (*iv*) related document sheet "R." The matrix number in each category and the four stages of a design process govern each sheet. Each sheet is expressed in terms of the following expressions.

building design sheet:	(*STAGE , SHEET_NUM)*	**D** *VERSION_NUM*
landscape design sheet:	(*STAGE , SHEET_NUM)*	**L** *VERSION_NUM*
related method and tools instructions:		**M** *VERSION_NUM*
related document sheet:		**A** *VERSION_NUM*

Figure 1 shows the structure of knowledge-sharing sheet in the system. It is the matrix structure according to the four design processes and the four sheet categories. Each sheet is linked to essential tools and the past cases of similar projects. In addition, we have prepared the management sheet to manage the entire design project. This management sheet contains an index of all sheets, a progress report, and a present problem. The index sheet contains the retrieval page, and it enables a full-text search by a keyword.

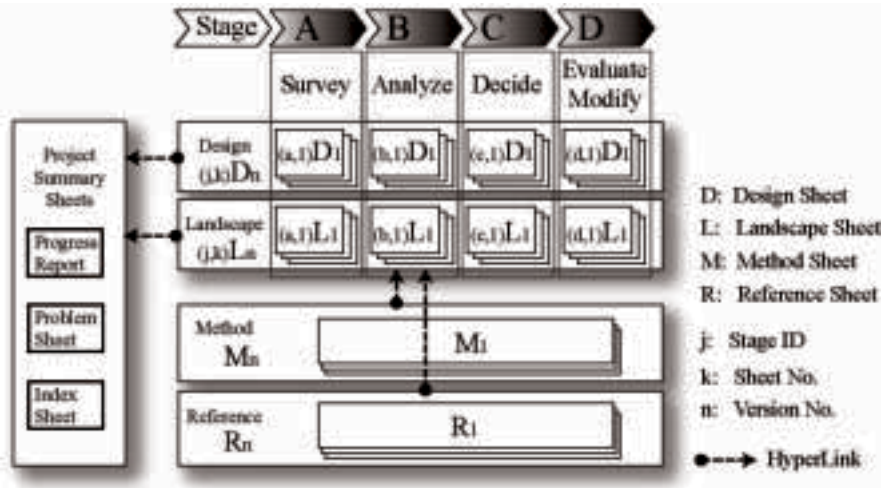


Figure 1. Structure of the knowledge-sharing sheet.

4.2. CONFIGURATION OF A SHEET

Each sheet is composed of elements, which are retrieved from the base XML file. The sheet includes the multimedia metadata, such as the image file (JPG, GIF), video file (MPG), CAD file (DWG, DWF, DXF), and map file (SVG). The SVG, in particular, is an XML grammar for describing two-dimensional graphics, which includes elements of vector graphic, raster images, animation, and text. It enables a user to magnify and reduce the image on the sheet.

A design-team member should always update the information on the project in terms of the external factor (change in the demand condition) or time.

On updation of the information on the sheet, the XML file is automatically updated, and updating time is recorded as the editing history. In addition, a problem faced while executing a task can be described on the sheet. Both the editing history and the problem summary are shared with the design-team through the management sheet. Figure 2 shows the updating process of the sheet.

5. Dynamic Data Structure by XML

5.1. XML NOTATION FOR LANDSCAPE DESIGN

Thus far, the author has developed a project management system that uses RDB (Relational Database) (Homma. et. al., 1998, 1999). Although the system was developed using an RDB at the initial stage, we finally used an original XML scheme with a more flexible data structure. XML can facilitate storage, integration,

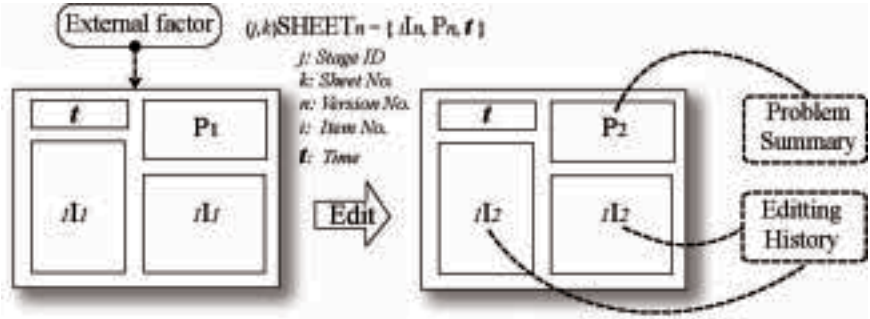


Figure 2. Updating process of the sheet.

assessment, and rapid digitization of a very large tree-like data structure containing heterogeneous information used in scientific investigation (Korolczuk and Szewczyk, 2002). It enables meaningful, content-oriented data notation, providing the means for building several hierarchies for the data. All tasks of the landscape design process were structured and all elements for each task expressed as a tag in XML1.0 syntax. One Base-XML file contains the data of all sheets. The following XML scheme is an example of the sheets of "stage A":

```
<stageA id="A">
<process id="title of the sheet">
    <header>
        <sheet_symbol>A01</ sheet_ symbol >
        <title_of_sheet> title of the sheet </title_of_sheet>
        <problem> Description of problem</problem>
        <Workflow>
            <Create_Date > Create Date </ Create_Date >
            <Edit_Time > Edit Date </ Edit_Time >
        </Workflow>
    </header>
    <body>
        <cntent_1>
            <item1> text description </item1>
            <item2> text description </item2>
        </cntent_1>
        <content_2> text description </content_2>
        <content_3> text description </content_3>
        <image_list>
            <image id="1">
```

link path to the image file
</image id="**1**">
</image_list>
</process>
</stageA>

5.2. THE FUNCTION OF A KNOWLEDGE-SHARING SHEET SYSTEM

The knowledge-sharing sheet system is the web-based tool, which runs with Internet Information Server on Windows platform. Therefore, team member needs only a web browser to manage the knowledge in a team.

There are four major functions of the knowledge-sharing sheet system to provide to the user. First, a user can access and browse each sheet from the index sheet with the problems of each sheet consolidated. Secondly, the full_|text search function is contained in the index sheet. When a user input a specific keyword or sentence, the sheet with the keyword is displayed. Thirdly, a new sheet can be created from the same formatted existing sheet. When the content of the sheet is edited, Base-XML file is updated automatically. Fourthly, the user can upload graphic data on the sheet. The file name will be changed on the server side automatically. Figure 3 shows data transaction in the knowledge-sharing sheet system.

6. Case Study and System Evaluation

As a case study, the developed system was applied to the actual design project and the system was evaluated. In order to assess the system with respect to a large-scale wind power station, one of the Japanese electric company used the sheet in their project. Finally, 104 decisions and 141 graphical data were recorded in 38 formatted sheets.

Figure 4 is an example of a sheet used in each design stage. The system enabled the designer to take decisions efficiently in this case. Further, the knowledge regarding design determination was shared between the designer and the citizen. This knowledge system can describe a design process in a general project.

7. Conclusion and Future Study

We have structured the practical task and externalized the tacit knowledge of a team member in the landscape design process and described the knowledge using an original XML scheme. In addition, we have developed the system that enables the sharing of the described knowledge by the template sheets. As a case study, the system was actually applied to the landscape design project of the wind farm.

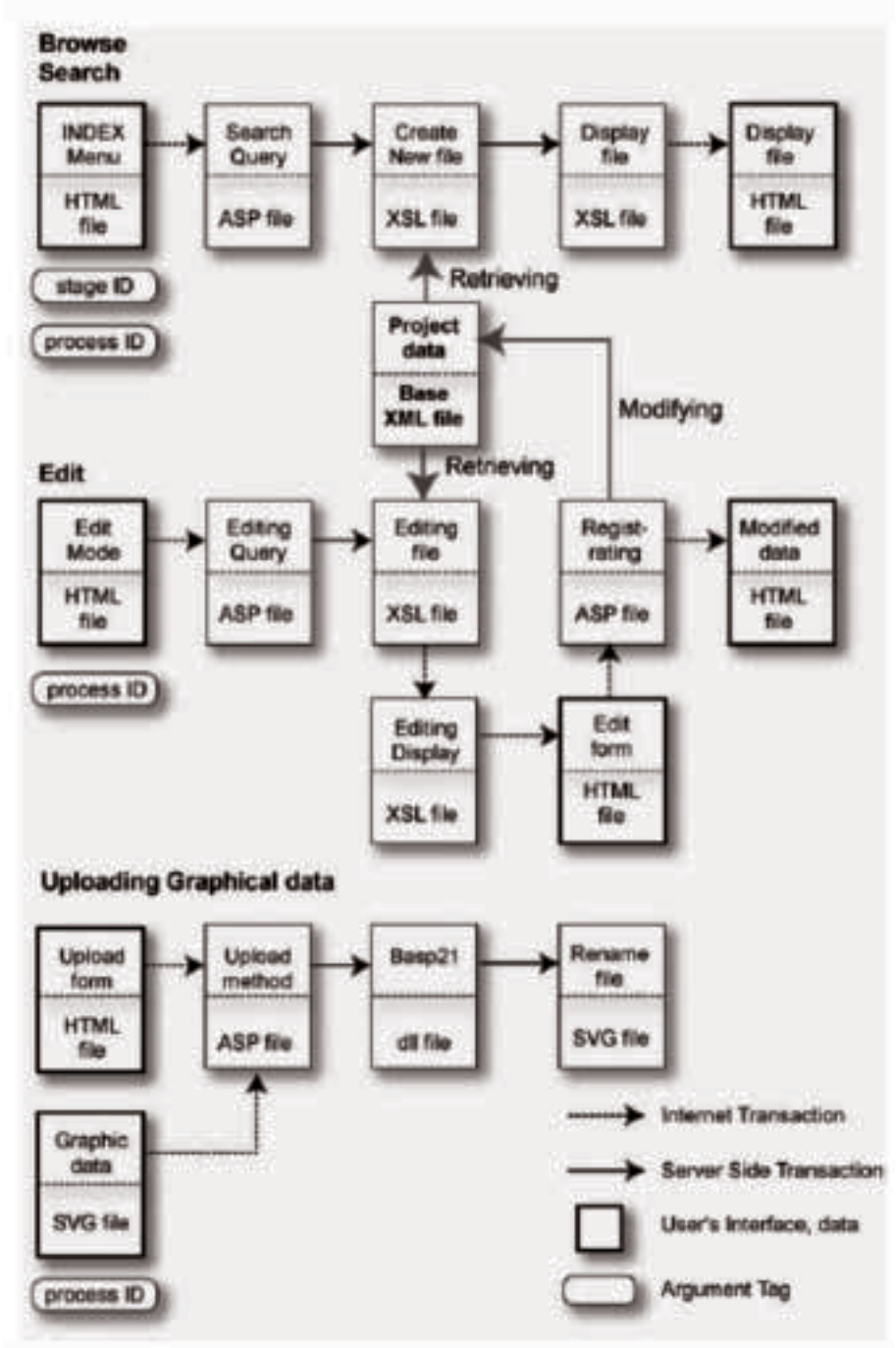
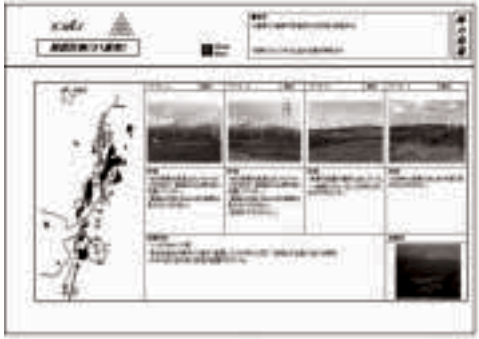


Figure 3. Data transaction in the system.

Sheet Number: *(A,1) L1*
Category=*Landscape*
Stage ID=*A*
Process ID=*Outline*
Sheet Name=*A01*
Title of sheet=
Project Outline
Image ID=*1-2*

Sheet Number: *(B,2) L1*
Category=*Landscape*
Stage ID=*B*
Process ID= *map*
Sheet Name=*B02*
Title of sheet=
Map in large area
Image ID=*1 Map*



Sheet Number: *(C,6) L1*
Category=*Landscape*
Stage ID=*C*
Process ID=*Alternative*
Sheet Name=*C06*
Title of sheet=
Comparison of designs
Image ID=*1 - 6*

Sheet Number: *(D,1) L3*
Category=*Landscape*
Stage ID=*D*
Process ID=*montage*
Sheet Name=*D01*
Title of sheet=
Photo Montage
Image ID=*1-3*

Figure 4. Sheet images of each design stage.

Subsequently, the result was reported to the design team. Using this system promotes rationalization of design work, it controls quality of design, and achieves collaborative work more creatively. Furthermore, this system can reflect the opinion of a citizen in the design process.

Future developments will initially focus on enhancing connectivity with the geographical information system and architectural CAD data format. In order to ensure interoperability, it is necessary to develop the XML scheme that is compatible with DesignXML, LandXML, LandGML, and G-XML. The interface of the sheet system will then be improved by incorporating an application such as Macromedia Flash that will make the sheet system further content-rich. This will enable the user to access the elements freely on a web browser and to print them.

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