Web-Based Information System Development for Building Demolition Management

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Abstract: The demolition of buildings produces enormous amounts of waste materials that are hardly reused or recycled and therefore result in significant waste streams to landfills. This research aims to develop a Web-based information system for promoting management methodologies for demolition projects. Instead of the waste materials exchange in current online waste material management systems, this research aims to explore the possibility of exchange of demolition projects, by which the utilization of demolished materials may be ascertained before the demolition action is actually produced. With reference of the needs and difficulties of online drawing acquisition in architecture and building discipline, an online multimedia data acquisition tool is developed to collect the drawing data of a project to be demolished. Following the introduction for developing a Web-based distributed database system, a prototyped information system is demonstrated in detail through the system environment, structure and functions.

Keywords: data acquisition, distributed database, demolition, information system, Internet

1. INTRODUCTION

The increasing pressure of waste disposal has recently challenged various industries worldwide. Most industrialised countries have achieved high levels of consumption and correspondingly high levels of waste disposal. For example, in Australia that is the second highest domestic waste production per capital among all member nations of the Organization for Economic Co-operation and Development (New South Wales Environment Protection Authority 2003), nearly one tonne of solid waste is sent to landfill per person each year as the whole country's waste stream is about 14 million tonne, of which about 30-40% is construction and demolition waste (Australian Bureau of Statistics 2003). The demolition of building structures produces enormous amounts of waste materials that in most countries result in significant waste streams. The construction industry, particularly in the demolition of constructed facilities, is the top contributor among all industry sectors. On the other hand, due to the lack of supply of usable second-hand materials on the market, new and high quality materials are used in construction projects whose design

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standards can be fitted by the secondary or used materials.

Waste-exchange system development is an increasingly widespread solution to the waste material exchange problem (Chen et al. 2003, Liu and Pun 2004). For example, a resource exchange information system was developed for the regional exchange operators by the Global Presence (2003). However, the information flow natures of the current waste-exchange systems and the present demolition procedure are inefficient to achieve the goal of waste reduction. A system approach is therefore needed to involve the generation stage of waste materials. The recently created concept of deconstruction rather than destruction for demolishing a constructed facility fails to achieve widespread understanding or acceptance due to various practical limitations (Liu et al. 2003). Information technologies were demonstrated to be able to drive the development of deconstruction planning so that a shift in building demolition will be promoted from destruction to deconstruction (Liu et al. 2004). On the other hand, an information system approach, in particular based on the Internet, may also envisage the implementation of deconstruction in practice and promote the cascading usages of materials with more construction and demolition loops.

The paper is organised as follows: the next section points out the weaknesses of current waste material exchange systems. Then, a web-based data acquisition toolkit is demonstrated to collect drawing data of a project to be demolished. Furthermore, the techniques are demonstrated in developing a Web-based distributed database for demolition project material management. The development and implementation of a prototype system are described in detail through the system environment, structure and functions. The research conclusions are stated in the final section.

2. NEEDS OF A NEW DEMOLITION MATERIAL MANAGEMENT SYSTEM

The impracticalness and inefficiency of the current waste-exchange systems are caused by the fact that there is no communication before the waste is actually created. Because the site of demolition activity is very likely to be cleaned up due to the preparation of new construction project, waste materials can only be kept in the site for a short period. It is certainly hard for both the waste material producer and demander to find each other in a narrow time span. Furthermore, the waste materials are likely to be reworked to satisfy the potential demander because there are no negotiations before the demolition project and thus no requirement to comply. Instead of information exchange happening after the waste materials are produced, information can be delivered before the waste is actually produced (Liu and Pun 2003). As a result, negotiations are enabled between the demolition material producer and the material demander. This gives great flexibility and time to both parties. They therefore can change their plans to suit the situation of each other, and produce detailed specification on waste materials. With longer time to prepare and plan, demolition project, construction project and transportation can be adjusted to connect to each other tightly (Pun and Liu 2003).

To virtually release a demolition project through an online information system, the demolition material producer however has to estimate the amount and classification of the waste produced before the project is undertaken. This imposes some difficulties to the material producers who do not have an engineering background. The proposed system will therefore address this problem with the assistance of intelligent application and other aided technology.

The material producer should only be asked to provide simple information regarding to the project, including the dimension of the building and the material used. The material producer then gets estimated data on the material the project produces. This data also provide the basic information for visualising the demolition process and products (Pun and Liu 2004).

There are some common and specific features in the proposed demolition materials management system (DMMS). Same as other waste-exchange systems, this system is built on the Internet using the form of interactive web page. Online transaction is not provided due to numerous flexibilities and possibilities during the information exchange process. On the other hand, different from most conventional waste management systems, DMMS deals with both construction and demolition waste. Instead of the conventional second-hand construction material exchange, DMMS aims at the generation, exchange and disposal of demolition materials. The providers of demolition materials may seek the potential demanders of second-hand materials and the construction projects before the implementation of demolition so that the demanders may involve in the demolition activities and the demolition may be oriented to reuse or recycling of demolition materials. In addition, DMMS supports the information exchange of demolition projects and construction projects for a long term so that a demolition project may be scheduled in consideration with the construction projects which need demolition materials and vice versa. Figure 1 describes the main participants in the proposed system, including demolition project providers, demolition materials demanders, and general web visitors as well as the system managers. For the purpose of information accuracy, membership is required before providing demolition supply or demand information. General web visitors may participate in the systems positively such as navigating the education module, discussing on visiting board, or browsing system information. The current URL for demonstration of DMMS is: http://www.deakin.edu.au/~skp/dmms/.

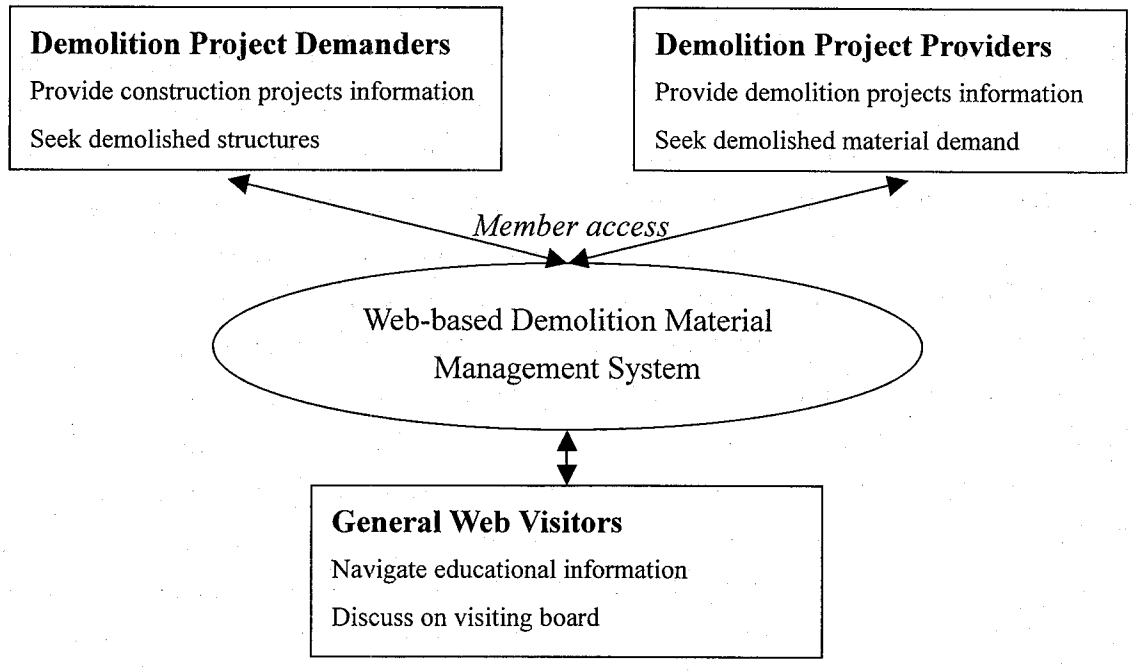

Figure 1: Functionality Requirement and Design

3. DEVELOPMENT OF DATA ACQUISITION TOOLKIT IN DMMS

The logical design of DMMS is developed using the three-tier client-server architecture (Goscinski and Zhou 1999). The techniques in developing a multimedia data acquisition toolbar are related to the three areas, which are the web server side, the web client side, and the communication to link these two sides. Figure 2 briefly describes the client-server architecture, and the main components and required techniques in each of these three tiers. The client tier provides the user interface running on the user's computer. The middle tier runs on the application server and functions for data processing. The server tier is actually runs on the database server to store the data required by the middle tier. The specific functions and implementation of each tier is detailed in the following.

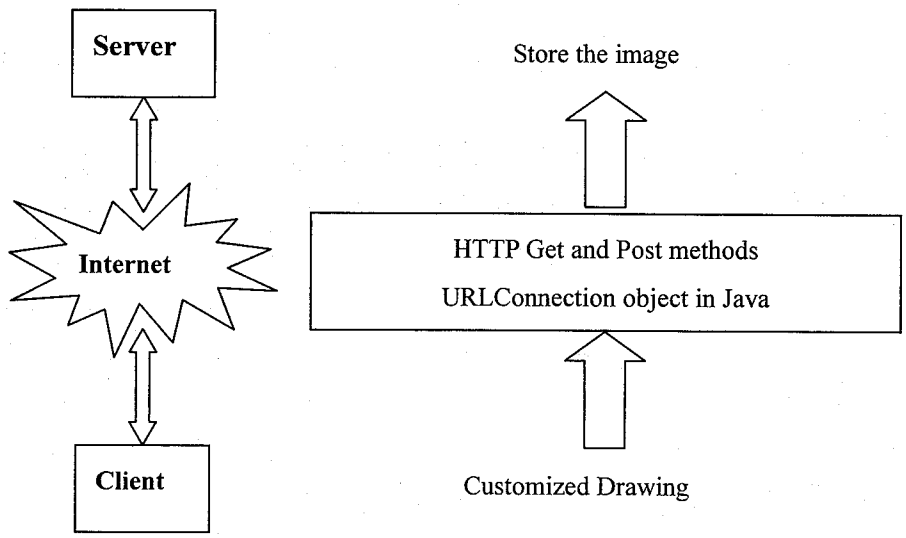

Figure 2: The Architecture of Drawing Toolkit

3.1 Server Component

The web server acts as both a client and a server. The HyperText Preprocessor (PHP) is a part of the web server. It gives the privileges of retrieval, modification, insertion and deletion of database items by the system program. It generates HTML codes for the client side according to the results from the database. The web server acts as a client when it requests service from the database server, which is to access the data. On the other hand, it acts as a server when it sends back the web page to the client side.

PHP code is embedded directly into HTML documents. It is supported by a number of web servers. While a HTTP request is received in a web server machine using PHP, PHP acts as a script. Different with Java Script or VB Script, PHP runs in the server and sufficient privileges are given to access files or databases. PHP written in a web database program generally consists of two parts. The first part is to access a database and retrieve its records. The widespread usage of PHP in the database system mainly comes from its excellent support of a range of database products. The second part of the PHP program is to generate HTML codes according to the records retrieved from a database. These two parts give the web page a really dynamic and interactive information access facility. The web page shown to the user is

not static or prepared in advance, but dynamically generated as requested by the user.

While the HTML form is insufficient to describe the object to be submitted to the Web server, Java Applet performs an important role. It provides genuine graphical user interfaces to users contrasting a raw HTML form. It is also dynamic in one single Web page without the need to refresh the page. More importantly, supporting of standard protocol allows Java Applet retrieval information from the server side script program, and transmits information user inputs at the client side back to the server side script program (Moller and Schwartzbach 2002). This feature is very useful while the system needs users to draw simple sketches of their buildings to be demolished. The characteristics of the drawn object are sent to the server, and the whole drawing is saved in the server as an image file. This customer drawing approach will help the users to gain the knowledge of the building that is retrieved from the database.

3.2 Client Component

A client side program is required to run inside the web browser that is the most available tool to access the Internet (Kurose and Ross 2003). Its application entities include HTML, Java Script and Java Applet. HTML gives the appearance and formation of the web page, while Java Script helps in the formation of the web page and validating the data inputted by the user. These two elements communicate to the server using Get and Post methods from the HTTP protocol, and form the main application parts of database access.

Java is used to construct the client component of the distributed drawing toolkit. Java is a relatively new language but it has been rapidly developed all the time. Java is naturally distributed and is ideal for developing the Internet-based application. Its other features such as object-oriented, dynamic, robust and secure make the language popularly supported, especially by most web browsers. Java Script is mainly used to control the HTML form. While it is running on the client side, Java Script has the strong ability to access the form elements in the web page. Java Script is able to access the value of form elements and control the form submission. Moreover, there is a facility that allows Java Script to call the function of a Java Applet. This gives the substantial flexibility to the communication between the server and the client. Finally, Java Script is always used in formation and appearance improvement of the web page.

The main functionalities of the toolkit are to draw the graphics, save back to the server and analyse the graphics. Among these processes, drawing on a board runs on the client side only. Java provides rich Application Programming Interface (API) to support graphics processing (Moller and Schwartzbach 2003). It includes drawing lines, rectangles, circles and other customized shapes. It is relatively simple to develop a tool that allows users to draw simple lines and shapes on the screen.

3.3 Communication between Client and Server

The HTTP protocol supports both Get and Post methods to transmit information back to server from the client side. The Get method is simply placing the names of variables and their values in the end of the URL. It is less secure because all values are shown to the user. Moreover, information cannot be too long due to the limited length of URL. The Post method is sending a message through a byte stream between client and server and it is transparent to the client. In this case,

the size of the message could be much bigger. Because the image is drawn on the client side and saved on the server side, the content of the image needs to be sent back to the server. Therefore, a relatively larger amount of message transmission is unavoidable, and the Post method must be chosen for transferring the image.

The support of the HTTP protocol in Java is comprehensive. Using a URL Connection class, output streams can be built to a server and byte transfers to a server are enabled. This scenario is exactly the same as the HTTP Post method. A file upload activity using a HTTP form can be simulated exactly. The content of the file is retrieved from the file system, then transferred into a byte stream and finally sent to the server. The server gets the bytes through the stream and reassembles them into a temporary file. This file can then be moved to the desired place using a desired name. In the case of using JAVA as the client interface instead of the HTTP form, no actual file is read from the local file system. The graphics drawn on the screen are coded and sent to the server directly. The server does the same activity to reassemble received bytes into a file. Different with using the HTTP form submission, the web page shown in the client's web browser does not need to be refreshed. However, for completeness of the whole system, the server side script program is constructed so that it gives feed back to the client to indicate the necessary messages such as the completion of the file transmission.

In another point of view, the requirement might need the page to be refreshed as usual in web-based systems. Saving the file to the server can be seen as a single part of the whole HTTP form submission. This can be achieved using Java Script. Even though Java Script is only a subset of Java language, there are mechanisms that allow communication between these two languages. Java Script language can invoke the function in the Java Applet object, and it can also get the returned value from the function. Therefore Java Script can request the saving graphics on the server by invoking specified function defined in Java Applet. Java Script has the fill ability of HTTP form control and saving graphics can therefore be set to act just before the form action. Java has another advantage to enable saving graphics efficiently.

Graphics, represented in computer by image files, have lots of format. The primitive format, which is Bitmap, records colour for every single point inside the image. It takes huge space to store the image and thus much longer time to transfer. Java provides a group of classes that enable JPEG coding of the graphics (Moller and Schwartzbach 2003). JPEG is a well-known and widely used image format because of its high compression of the image. Since the JPEG coding is happened in the client side, less time for transferring the image to the server is needed. Selectively shifting computation load to a client machine is a trend of client-server computing. Efforts have been made in researching about process or program migration such as intelligent agents (Anumba et al 2002).

4. DEVELOPMENT OF WEB-BASED DISTRIBUTED DATABASE

Database is the core of a system to provide a convenient and transparent way to access raw data. As shown in Figure 3, data are mainly divided into four tables. The user table is used to store the authentication information for users. As users are registered with their contact information, the contact information is also stored in the user table.

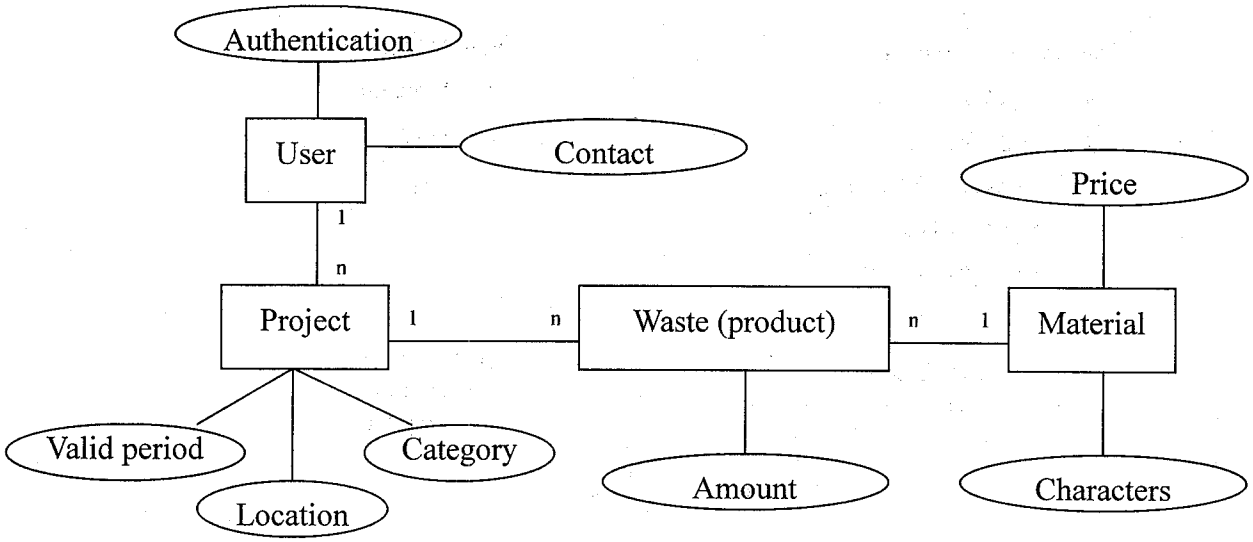

Figure 3: Database Entity-Relationship Diagram

One user can hold multiple projects, and a project table is used to hold the project information of type, available time span and location. A project table also holds the data related to the project itself such as the dimension and structural type of a building. A demolition project provides multiple kinds of materials, and a type of material can appear in multiple projects. As a result, a new table called product is generated that keeps references to both project table and material table, and the amount of the materials in a particular project. With the practical implementation of the system, the database grows to more complex. A project has many child tables because different data are held representing different type of project, while they are still sharing some attributes such as location and available date.

The system will allow users to upload multiple photos to help describe the project, and thus the photo table is needed to store the information of filename and directory of the image file related to a particular project. Among these tables, the material table are predefined and maintained from the system administrator according to the market information. Information in other tables, such as project and product, are generated during the practical use of the system.

There are several types of data flow processes. A database table describing the features of all kinds of materials is predefined in database server and accessible only to system administrator. Other tables are accumulated from the operation of the system. Because conventional web page form submission can only transfer simple text-based information or existing file to the server (Strahl 2002), a web-based drawing tool is developed to allow users to draw graphics and submit to server. The needed information is acquired, and the graphics drawn is saved in server that can be viewed by other people in the future.

Figure 4 shows the information flows implemented in DMMS. The information retrieved from the graphics can be the dimension of the building to be demolished and the structural features of the building. After obtaining all physical dimensional characters and descriptive engineering characters, all information is put into an intelligent and knowledge aided calculation component.

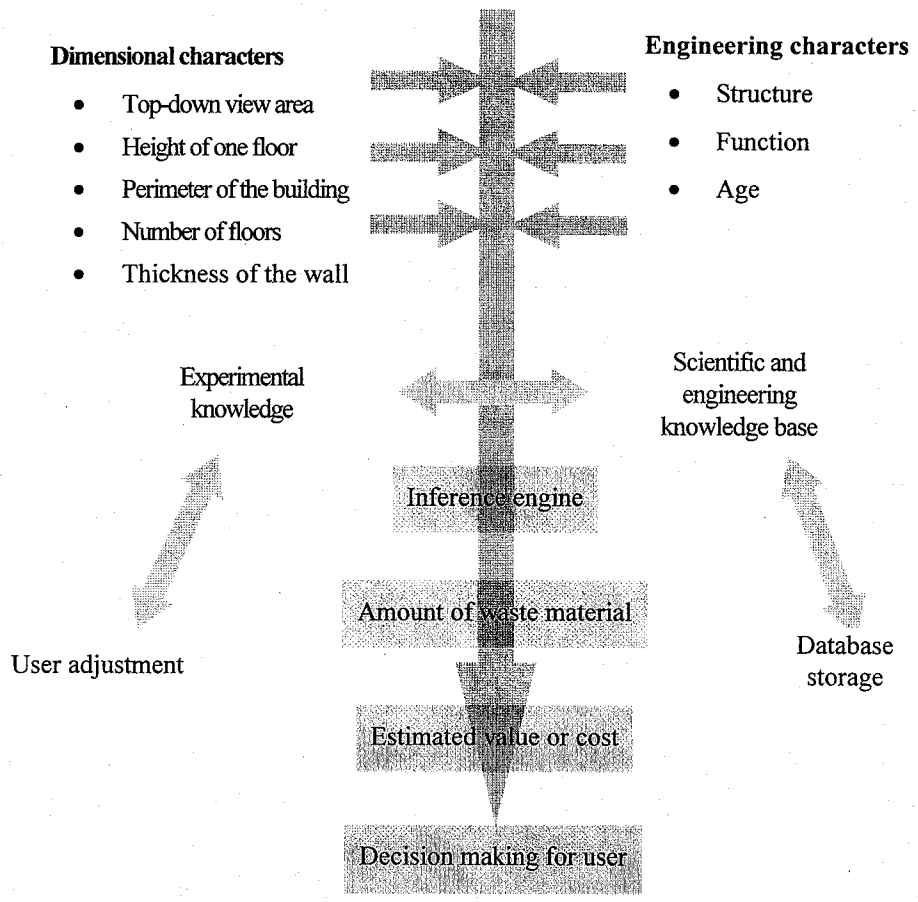

Figure 4: Information Flow Diagram

The additional parameters used in the intelligent and knowledge aided calculation component might be gained from past experience and scientific calculation. This system then outputs all the volumes of all kinds of materials. Volumes are then transferred into weights according to physical features of the particular material. Unit values, including unit price for new material and suggested unit price for used material, are used to produce the economic value of the materials, both categorized and summarized. Information about the values is shown on web page. This enables user to make selling and purchase decision based on the value. Information about products, which is the amount that a particular material will produce in each project, is saved in the database for supporting the search and list activities.

5. DEVELOPMENT OF A PROTOTYPED SYSTEM

The selections of tools, systems and programming languages are based on the currently available circumstances. PHP, which is a mature programming language for server side, is chosen for the development of the server component of the system. The database is stored in an Oracle database server. The Java Applet is developed in Java Developer Kit (JDK) 1.4.

The Web page is divided into three frames. Upper frame does not carry any actual function. It gives the title banner to the page. The left side frame is main menu area. Content regarding to particular menu item appears in right side frame. The first and default menu item is notice board. It gives up-to-date information about the change of the Web page to the users. The member area is the

core of the system and main source of database. If user has not logged into the system, the login screen will be showed to authenticate member by username and password. User also has the choice of register as a member, which needs contact information. After logging into the system, submenu items are shown. Changing profile and changing password allow member to change personal contact information and password. Adding project provides a wizard style procedure to members, allows them to add a project into database step by step.

The data needed for the process includes the type of the project, the location of the project, the earliest available start date and the latest, photos that help to describe the demolition project, the dimensional features and structure features of the project and a user custom drawing tool, which allows user to draw lines and shapes to further describe the project.

Figure 5 shows the interfaces when a user provides information of a demolition or construction project into the developed demolition material management system. After all necessary data in the text, photo and drawing media are collected, potential materials produced or needed are categorized, quantified and listed. These numbers are available to modification from the user, considering user is able to gain more precise data through other mechanisms. The data are then stored into a database. A user is able to remove projects from his or her list in case that the material exchange is completed and further materials are not available any longer. User can also modify the quantity for a particular item or items from the list.

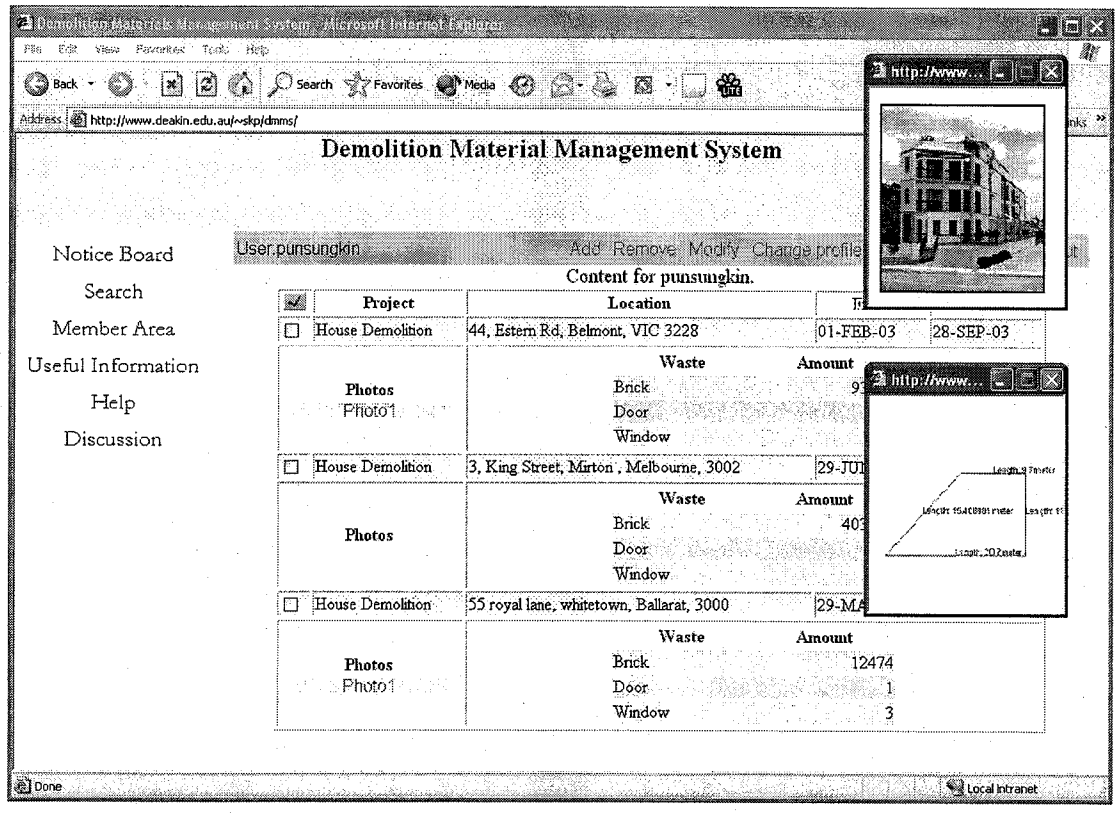

Figure 5: Interface of Demolition Project Information Acquisition

The search function is also an important part of any information system. In DMMS, it is given a specific consideration so that both the system users and the community can benefit from their search. As shown in Figure 6, users can search the catalogue using a single or several combined criteria, including project type, date, location, the type and amount of materials, and so on. There are also predefined categories for a quick access. The result of a search enquiry returns as a list of projects. Users are able to browse the details of an individual project, including the photo that the project owner uploaded and the draft that the owner drew. The member who has logged into the system is able to obtain the contact information regarding to every project from the search results. This enables the communication to be made outside the system through the conventional channels such as phone and facsimile. Moreover, the communication manner is available through electronic emails.

A useful information broadcasting section gives all users, both members and non-members, educational information such as on building deconstruction and environment protection. One of the reasons that general construction practitioners do not want to be actively involved in waste material reuse and recycle is that people are lacking the necessary motivation and for doing so. Information and knowledge on both natural environmental and the Internet are ideal for the education of general users. Finally, a discussion board is constructed to allow users to discuss issues, in particular on the construction material reuse and recycle. It also provides a communication channel for system manager to answer general questions from users.

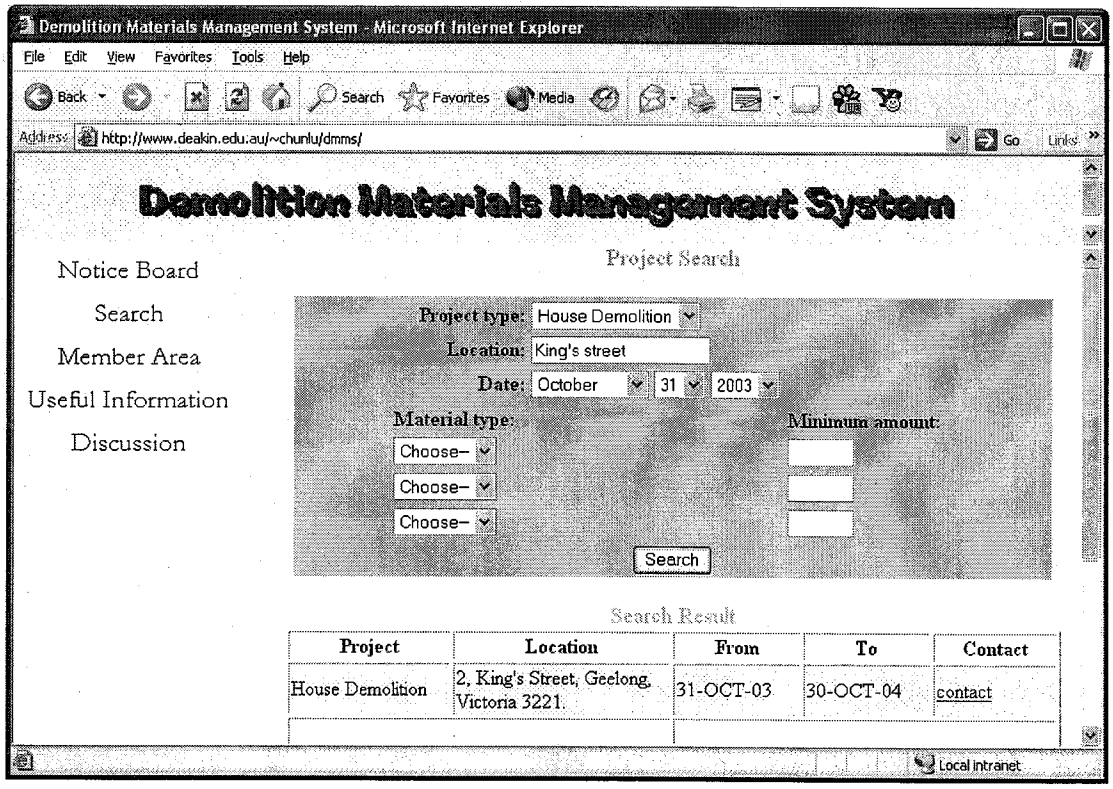

Figure 6: Screen Shot of Search Component

6. CONCLUDING SUMMARY

This paper presents the development of a Web-based information system for the exchange of building demolition materials. Different from the existing waste material management systems, this new system enable users to provide and receive the demolition information before the demolition waste materials are actually produced. The conclusions can be stated as follows:

(1) An online multimedia data acquisition toolkit was developed so that it is made possible to collect the drawing data of a project to be demolished.

(2) A Web-based distributed database system was presented for implementing material management of demolition projects.

(3) A prototyped information system was demonstrated to identify the components of the new demolition material management system, and the crucial techniques to develop such a system.

The utilization of mature Web technology in demolition material management enables efficient communication among stakeholders of the demolition project, especially the owner and demanders of the waste materials. The distributed computing environment is ideal to be applied in construction industry since the industry always involves in multiple parties located in different places. Furthermore, the knowledge database helps users who are not professionals in demolition area but involved in demolition process to determine technical issues and accordingly make decision. As a result, an information system that merges practical late information technologies and proper management approaches achieves the goal of waste exchange for demolition project.

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