STREAM ECOLOGICAL ENGINEERING ASSESSMENT USING JAVA PHONES, JSP AND GIS

Walter W. Chen
Associate Professor, Department of Civil Engineering
National Taipei University of Technology
1, Sec. 3, Chung-Hsiao E. Rd., Taipei, Taiwan,
Tel: +886-2-2771-2171 ext 2628 Fax: +886-2-2781-4518
E-mail: waltchen@ntut.edu.tw
Tai-I Chen

Former Graduate Student, Department of Civil Engineering
National Taipei University of Technology

KEY WORDS: Ecological Engineering, Java-enabled phones, SMS

ABSTRACT: Ecological engineering is a new multi-discipline engineering and design practice that emphasizes the stream restoration, slope stabilization, road construction, and soil and water conservation in an ecological perspective. The ecological engineering development has progressed rapidly in the recent years in Taiwan. Among the public-works projects undertaken in Taiwan, most were related to stream restorations, which include the stabilization of river banks, the construction of retaining structures (gabions), the use of vegetation to increase riparian habitats, and the application of soil bio-engineering to control erosion and surface runoff. Although the projects were viewed as successes, very little monitoring was conducted after the projects were completed for follow-up evaluation and assessment. To improve this situation, this study developed a stream eco-engineering monitoring and assessment system. Based on a geographic information system, this system uses Javaenabled phones and digital cameras to conduct field investigations, and transmit the collected data back to the office via the Internet, 3G networks, or short message services (SMS) in real time. The results could then be accessed by manual browsing or a querying mechanism using JavaServer Pages (JSP) technology to generate simple and fast dynamic web contents. The potential use of the system is to provide system-based planning and decision support to officials in charge of public engineering projects based on continuous monitoring and an accumulated database.

1. INTRODUCTION

Ecological engineering is a new multi-discipline engineering and design practice that emphasizes the stream restoration, slope stabilization, road construction, and soil and water conservation in an ecological perspective. The ecological engineering development has progressed rapidly in the recent years in Taiwan. In the past, Taiwan's river-management efforts were usually coordinated with flood control/disaster prevention projects (Chen and Lin, 2004; Chen and Lin, 2005). Therefore, most engineering structures in the streams and rivers were designed using reinforced concrete to be durable and capable of withstanding the force exerted by floods. It was not until 1998, under the gradual influence of Europe, Japan, and the US, that the engineering community and the government began to embrace the practice of natural river restoration (Chen and Lin, 2004). This practice later extended to become ecological engineering practices, and the same practice was applied to almost all civil engineering disciplines such as slope stabilization, road construction, and soil and water conservation. Today, ecological engineering is used to solve a wide range of problems in Taiwan. Lots of progress was made in a very short amount of time. Nevertheless, among the public-works projects undertaken in Taiwan, most were still related to stream restorations, which include the stabilization of river banks, the construction of retaining structures (gabions), the use of vegetation to increase riparian habitats, and the application of soil bio-engineering to control erosion and surface runoff. Although the projects were viewed as successes, very little monitoring was conducted after the projects were completed for follow-up evaluation and assessment. To improve this situation, this study developed a stream eco-engineering monitoring and assessment system (SEEMAS) to assist the investigators benchmarking the river conditions. The system could also be used by residents of local communities to encourage them to participate in the protection of the environment. The local awareness would lead to a form of active engagement in applying ecological engineering principles to construction practices to achieve the goal of sustainable development.

2. ISC BENCHMARKING

The index of stream condition (ISC), varying between 0 and 50, is a measure of the stream quality from an ecological perspective (http://www.vicwaterdata.net/isc/intro1.html). It is composed of 19 key indicators grouped into five sub-indices, which are hydrology, physical form, streamside zone, water quality, and aquatic life. The indexing method was first developed in Australia and applied to the entire State of Victoria (18,000 km of rivers). As an important tool for catchment management, the ISC was also adapted by researchers in Taiwan to assess the river conditions and is the rating system used in the SEEMAS.

3. SYSTEM ARCHITECTURE

The purpose of this study is to develop a stream eco-engineering monitoring and assessment system (SEEMAS). Based on a geographic information system, this system should allow users to collect data at various geographical locations and upload the data to the central database easily and quickly. The data should be linked to the stream restoration projects that are either going on or have been completed. Furthermore, the data in the database should allow users to query and analyze in an organized fashion. Given the limited technology available at the time, attempts were made to develop the SEEMAS system and application programs on PDAs and laptops in an earlier design. The users would carry their PDAs, laptops, or ultra mobile PCs to the field to conduct field investigations, and the PDAs/laptops/UMPCs would be brought back to the office to be hot-synced after the field trips. However, some engineering projects were in remote locations and it might take days to complete the field work. Past experience with custom-programmed PDAs to collect pipeline damage data showed high probability of data loss due to hardware malfunction as a result of the harsh environment where they were put to use. Therefore, the earlier design has severe limitations. Fortunately, the fast and widespread establishment of cell towers and the GPRS network recently in Taiwan provides a better solution. Real-time transmission of data is now available even in remote locations, and the software development task becomes easier as it could be done on the server side rather than the client side. Our final system (SEEMAS) thus integrates the use of PDAs, laptops, Java-enabled phones and digital cameras to conduct field investigations, and transmit the collected data back to the office via the Internet, the GPRS network, the PHS (Personal Handy-phone System) network, the 3G (WCDMA) network, or the short message services (SMS) in real time. The system architecture and data flow is shown in Figure 1.

3.1 The Database Subsystem

The SEEMAS uses a 3-tier architecture, which includes the front layer (presentation tier), the middle layer (application tier), and the back layer (data tier). The data tier was designed with an entity-relationship model and implemented using a relational database management system (RDBMS). The entities used in the RDBMS included the investigators, engineering projects, engineering structures, streams, ISCs, plants and animals, each with specified data properties and data relationships. Primary keys and foreign keys were also specified to connect related records held in different tables. Although the SEEMAS has different presentation tiers for different clients, they all connect and share the same database for data consistency.

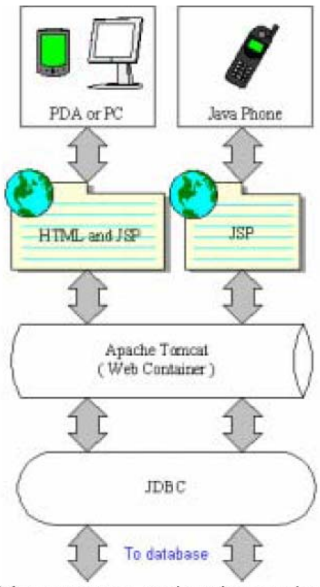

Figure 1. System design of the stream eco-engineering monitoring and assessment system (SEEMAS)

3.2 The Data Collection Subsystem

The data collection subsystem is a part of the presentation tier that also includes the data presentation subsystem (see below). The SEEMAS provides three different methods for field data collection—PDAs/laptops, Java phones, and short message services (SMS). When an investigator uses a PDA or laptop in the field, he can interact with the dynamic web pages generated by HTML and JSP. The historic data are brought to the PDAs/laptops and the collected data are sent back to the server and database in real time. When carrying a laptop to the field is not practical, the investigator can then use a Java phone uploaded with the custom SEEMAS Java program instead. The custom Java program provides the interactivity similar to JSP in the PDA/laptop example. However, the data do not flow between the user and the server until the data are ready to be submitted. Then, the data will be sent back to the server and posted to the database in a batch. The last method to collect field data is to use an ordinary cell phone with the SMS function. The user needs to text the data message in a special format and sends it

3.4 The Data Transmission Subsystem

Together with the application logic, the data transmission subsystem forms the middle layer. It provides connectivity between the data collection subsystem and the central server, and allows the information to be sent back and forth between the users and the database. Using the Java phone interface as an example, Figure 4 shows a sequence of screen shots that demonstrate the integrated process of data collection and transmission: (a) starting the Java program, (b) displaying the menu items, (c) displaying the login screen, (d) adding a new engineering structure, (e) inputting detailed information, (f) transmitting the data back to the server via SMS, (g) transmitting the data back to the server via JSP, (h) storing the data in the Java phone, and (i) completing the task.

(a) the starting screen (b) menu of functions (c) login screen
(d) adding structures (e) adding structure info (f) transmitting data
(g) connecting JSP (h) storing data (i) completion

Figure 4. Demonstration of recording and sending data to backend server using a Java phone (system implemented in traditional Chinese)

4. CONCLUSION

Many stream restoration projects were completed and viewed as successes in Taiwan, but very little monitoring was conducted after the projects were completed for follow-up evaluation and assessment. To improve this situation, a stream eco-engineering monitoring and assessment system (SEEMAS) was designed and implemented in this study. Based on a geographic information system, this system uses Java-enabled phones and digital cameras to conduct field investigations, and transmit the collected data back to the office via the Internet, 3G networks, or short message services (SMS) in real time. The data are stored in a relational database for SQL-based querying and analysis with a user friendly interface. The potential use of the system is to provide system-based planning and decision support to officials in charge of public engineering projects based on continuous monitoring and an accumulated database.

5. ACKNOWLEDGEMENT

This work was supported in part by the National Science Council under the Grants 94-2211-E- 027-008, 95-2221-E-027-032 and 96-2218-E-027-005.

6. REFERENCES

[1] Chen, W. W. and Lin, J.-Y., 2004. Development of ecotechnology in Taiwan. In: *Proceedings of the 2004 Sino-German on Advance in Hydroscience,* National Cheng Kung University, Taiwan, April 28.

[2] Chen, W. W. and Lin, J.-Y., 2005. Ecological engineering development in Taiwan. In: *proceedings of the 2005 AWRA Summer Specialty Conference, Institutions for Sustainable Watershed Management: Reconciling Physical and Management Ecology in the Asia- Pacific,* Honolulu, Hawaii, June 27-29.