Developing a Virtual Disaster Information Management and Analysis System in Internet for Chi-Chi Earthquake

S. M. Wang[1], C. H. Loh[2] and T. H. Huang[3]
ryan@email.ncree.gov.tw
++ 886 – 2 – 27326607 ext 402

Abstract

This paper presents the development of a virtual disaster information management and analysis system in Internet for Chi-Chi earthquake. This system was developed by National Center for Research on Earthquake Engineering (NCREE) in Taiwan after Chi-Chi earthquake. The initiative of this system is to provide a virtual environment that can be used to display both spatial and feature information of the aftermath damage investigation results. It is also developed to provide related government agencies, academic and private sectors the functions of on-line disaster information management, query and analysis to the reconnaissance database compiled by NCREE. Furthermore, general publics and students can also be benefited form using this system in their distance learning activities for knowing the damage caused by Chi-Chi earthquake.

The developing concept of this system is to follow the concept of Digital Earth Initiative (DEI) that integrates advanced information and network technologies, database management system and GIS technologies in Internet environment for applications development. The system was designed and implemented under the DEI concept by using Java Script Language, Microsoft SQL Server Database Management System, Cold Fusion Application Server and Autodesk Mapguide Web GIS Server. This system includes two sub-systems: 1) Disaster Information System and 2) Earthquake Reconnaissance Database Management and Analysis System. The first sub-system provides functions to general publics to derive abstract Chi-Chi Earthquake disaster information. The second sub-system was developed to provide spatial, statistical and cross-reference analysis functions to users from government agencies, academic and private sectors to acquire full contents of reconnaissance information for decision support needed by earthquake recovery activities as well as

[1] Associate Researcher, National Center for Research of Earthquake Engineering, Taiwan; Assistant Professor, Department of Computer Science, Chinese Cultural University, Taiwan
[2] Director, National Center for Research of Earthquake Engineering, Taiwan; Professor, Department of Civil Engineering, National Taiwan University
[3] Head of Department, Department of Civil Engineering, National Taiwan University

earthquake related researches. Database management mechanisms are also developed in the second sub-system to provide functions for on-line data uploading and downloading. Fast prototyping method had been used to develop the system. The first version of this system had been developed and can be accessed by http://gisdb.ncree.gov.tw/. More complicated analysis functions are still being developed and will be integrated in the next version of the system. The possibility and methods will also be evaluated for expanding the system with functions of near real time earthquake loss estimation and decision support to earthquake emergency response in future.

Keywords: Chi-Chi Earthquake, Information Technology, Database Management, Virtual Environment, Internet, Web GIS

I. Introductions

A magnitude 7.3 earthquake hit central Taiwan on 1:47 am, September 21, 1999. It caused severely damaged in the Central part of Taiwan, especially in Natou county and Taichung city. According to the official report, this earthquake caused 2274 people death, 8457 buildings whole collapsed, 6204 building partially collapsed. It also caused large-scale landslide in mountain areas. This earthquake is manifested essentially by Chelungpu thrust fault. The surface rupture length of more than 105 km was observed along the Chelungpu fault. The largest vertical offset reaches about 11 m, while the maximum left-lateral offset is about 7 m. It experienced maximum horizontal shaking of more than 1g. In general, the peak ground acceleration is higher than 0.5g along the Chelungpu fault area. More than twenty thousand aftershocks took place after the major shock. There were ten aftershocks greater than Richter magnitude 6 [5]. These aftershocks, which some of them with the measure of M_L = 6.8 and M_L = 5.3, caused further collapses of bridges and buildings which their structures were already damaged in the major shock.

After the earthquake, the National Center for Research on Earthquake Engineering was assigned by the National Science Council to organize the aftermath reconnaissance activities. There were 9 groups of data collecting task force, shown in table 1, being organized for establishing reconnaissance database by the field survey results. Meanwhile, a data processing task force, shown in table 2, was also organized by the information system research group of NAHPM (National Science and Technology Program for Hazards Mitigation). The data processing task force prepared maps and coordinated information for aftermath emergency response and reconnaissance activities using the techniques of Geographic Information System (GIS) and Remote Sensing (RS).

1. Geology (Active Fault)	6. Lifelines System
2. Strong Ground Motion	7. Hydraulic Facilities
3.Geotechnics	8. Industry and Hospital
4.Building Damage	9. Social Economics
5. Transportation and Bridge System	

Table 1 The 9 Groups of the Data Collecting Task Force for Chi-Chi Earthquake

1. Data Integration Team	5. Disaster Information Compilation Team
2. Aerial Photography Interpretation Team	6. Map-making Team
3. Secondary Damage Analysis Team	7. Disaster Prevention Application System Development Team
4. Post-earthquake Reconstruction Team	

Table 2 The 7 Teams of the Data Processing Task Force for Chi-Chi Earthquake

Furthermore, the information system group of NCREE used GIS techniques to integrate the spatial and feature data comes from both the data collecting and data processing task force and compiled the reconnaissance database of Chi-Chi Earthquake. The database tables were created based on the investigation and questionnaires designed by each field survey groups. Totally, there are around 18,000 data items with around 150 Megabyte of data volume being compiled in the Chi-Chi earthquake reconnaissance database. There are approximately 5 Gigabyte of data if the database included 2-4 pictures of each survey point taken form the field survey and approximately 30 Gigabyte if the database included the data processing result of the data processing task force which contains aerial photos, SPOT image, basic dataset of disaster area, DTM, digital maps..etc (Figure 1).

Figure 1 An Example of Chi-Chi Earthquake Reconnaissance Database

II. Database Sharing Mechanism – Introduce of Digital Earth Concepts

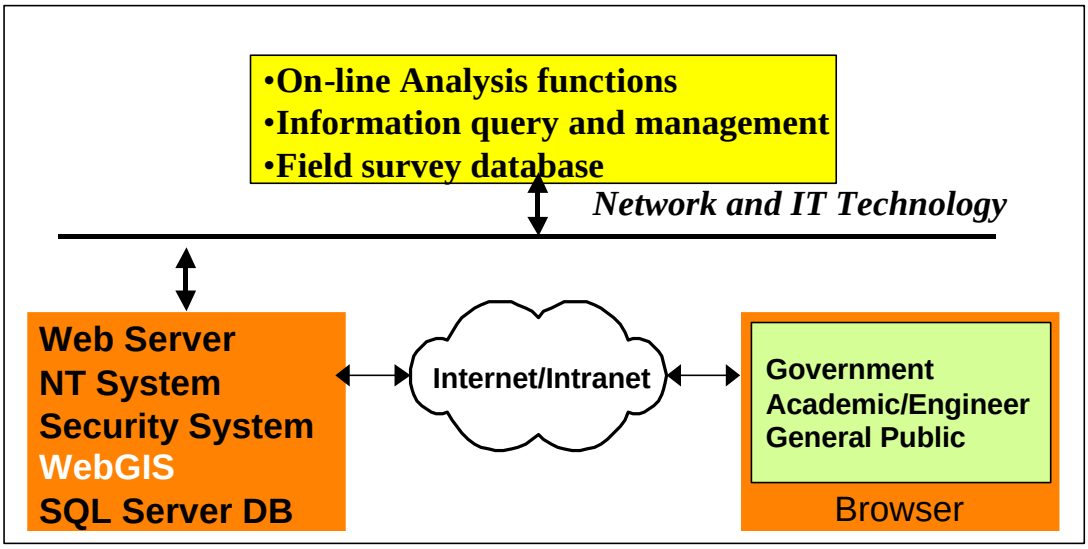

Figure 2 The Conceptual Diagram of Developing Virtual Disaster Information Management and Analysis System in Internet for Chi-Chi Earthquake

The task for compiling Chi-Chi Earthquake Reconnaissance Database was coordinated by the National Science Council and implemented by the NCREE. The task was set up for the following objectives:

1. To collect the disaster information of Chi-Chi Earthquake, so that related government agencies can use the information for emergency response and future reconstruction activities.
2. To record the damage caused by Chi-Chi Earthquake, so that the database can be used by academic researchers for their research activities on earthquake, construction engineering and social economics impact caused by Chi-Chi Earthquake.
3. To provide an educational mechanism to general publics and students by exploring the Chi-Chi Earthquake information complied by this task.
4. To preserve the history of Chi-Chi Earthquake.

Since the Chi-Chi Earthquake Reconnaissance Database should be opened and used in different purpose, a practical system should be designed and developed to establish the database sharing mechanism and to fulfill the requirements of various users. Hence, the development of the virtual disaster information management and analysis system for Chi-Chi Earthquake had been proposed by NCREE. Originally, the integration of the concept of virtual reality with the applications of Internet and geographic information system has been planned for developing the system. After reviewing the paper of Michael F. Goodchild – Implementing Digital Earth: A

Research Agenda, mentions that the Digital Earth Initiative (DEI) proposed by the U.S. Vice-President, Al Gore provides the vision for future development and integration of virtual reality concepts and Internet applications, especially in the database sharing aspect of geosciences. In DEI, he describes an immersed environment that would allow its users to explore and learn about the Earth and its human and physical environment [1]. Hence, the concept of Digital Earth has been introduced in establishing the database sharing mechanism by developing the virtual disaster information management and analysis system in Internet for Chi-Chi Earthquake. The conceptual diagram for the system is shown in Figure 2.

III. System Analysis, Design and Implementation

In order to provide dynamic access to the reconnaissance database over Intranet and Internet, the system has been analyzed and designed to fulfill the following requirements:

1. To establish the mechanism for compiling and managing the reconnaissance database: The system is essential to have a database management system for data classification, query, analysis, and related functions. Moreover, it is necessary to provide on-line data upload and download functions to reduce the load of the system.
2. To provide on-line analysis functions that can use to show the feature and spatial information of the reconnaissance database: Basically, the damage caused by earthquake is related to the location of investigation points. Hence, not only the details of damage status should be surveyed, the spatial information of the investigation point should also be recorded. Traditionally, we can perform quantitative statistical analysis and qualitative querying analysis using the attribute data stored in the database. In order to developing the functions to display associate spatial information of above analysis results, advanced IT, network, and WebGIS technologies should be used in the development of the system.
3. To provide on-line cross-reference analysis functions that can be used for analyzing the data collected by different groups of data collecting task force: Cross-reference analysis functions, such as functions for analyzing the relationships between strong ground motion information and building damage is essential for earthquake engineering research.
4. To develop tools as well as functions for near real time disaster information collection, analysis, and management for future earthquakes: The user interface for non-professional people should be designed for them to report the disaster information using Internet. Meanwhile, the user interface for

professional people should also be designed for rapid evaluation of the information report from various sources.

In order to fulfill the above requirements and to ensure the stability of the system operating in Internet, the system was designed with three major features: Data Analysis, Information Query and System Administration; as shown in the diagram of system analysis and design result in figure 3.

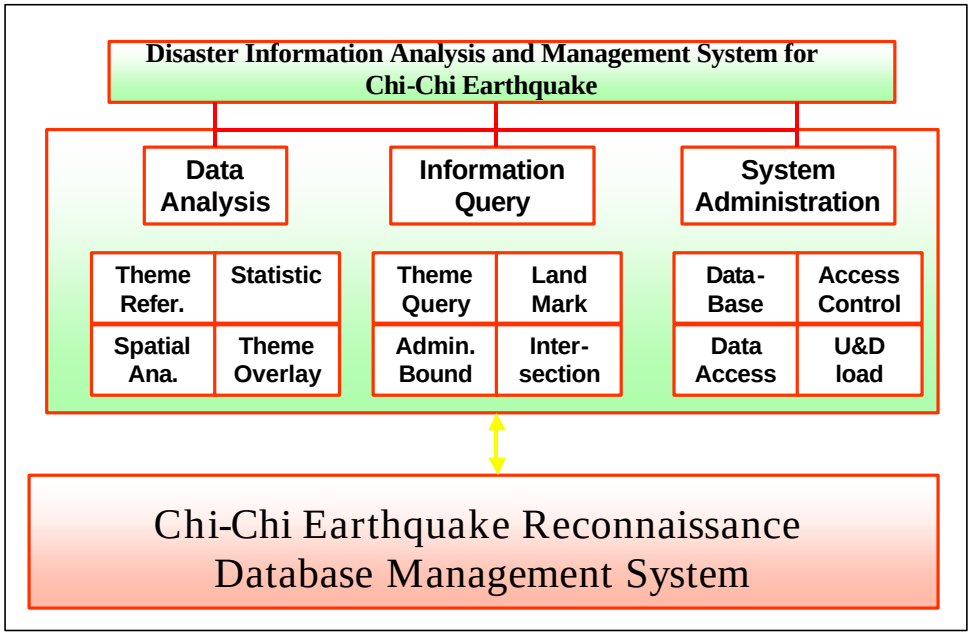

Figure 3 The Diagram of System Analysis and Design Result for the Virtual Disaster Information Management and Analysis System for Chi-Chi Earthquake

The details of these features are described as following:

1. Data Analysis: This feature is designed for using by government agencies, academics, and engineers to perform on-line analyses via Internet or Intranet. It contains the functions for performing on-line statistic analysis and for thematic reference and overlay analysis, spatial analysis and using WebGIS techniques.
2. Information Query: This feature is designed for using by all users to access disaster information in a more efficient way. In order to speed up the querying process, it provides four query methods – thematic map, administrative boundary, landmark location, and road intersection points.
3. System Administration: This feature is designed for using by system administrator to maintain the system as well as the reconnaissance database. It provides methods for administrator to perform the access control to the system and database in Internet environment.

In addition to the system analysis and design that were shown above, the following hardware and software had been used for the implementation of the system (table3).

Web server	Pentium III 450 dual CPU's with 512 MB RAM, and 60 GB disk
Operating system	Microsoft Window NT Server 4.0
WebGIS software	MapGuide Server and Author version 4.0
Database software	Microsoft SQL Server version 7.0
Interface and application development	Java Scripts and Applet ColdFusion version 4.0

Table 3 The hardware and software used for the implementation of the the Virtual Disaster Information Management and Analysis System for Chi-Chi Earthquake

IV. System Development Results

The Virtual Disaster Information Management and Analysis System for Chi-Chi Earthquake had been developed by the information system group of NCREE using fast prototyping method. The first version of the system has been finished and can be accessed by *http://gisdb.ncree.gov.tw/* as shown in Figure 4.

Figure 4 The Homepage of The Virtual Disaster Information Management and Analysis System for Chi-Chi Earthquake (*http://gisdb.ncree.gov.tw*)

The first version of the system is further divided into two major sub-systems: Disaster Information System and Reconnaissance Database Management and Analysis System.

1. Disaster Information System: This sub-system is intended to provide disaster information to general publics, especially non-professional users. There is no access control to the system. But users of the system can derive only abstract disaster information. Meanwhile, only information query but no the on-line data analysis functions are provided in this system. The WebGIS techniques had been used in this sub-system to provide the spatial information. The development result of this sub-system is shown in figure 5.

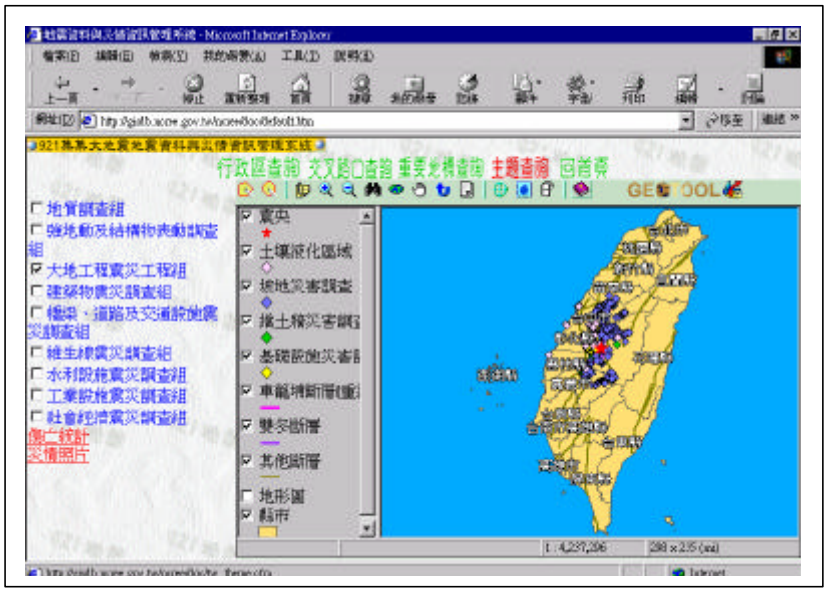

Figure 4 The Webpage of Disaster Information System

2. Reconnaissance Database Management and Analysis System: This sub-system is intended to provide data analysis functions to academic for their research and to related government agencies for their decision support and reconstruction activities. Since the full content of the reconnaissance database can be accessed using this system, it is access controlled for avoiding misuse of the system and the data analysis results. The users of this system should have basic knowledge on earthquake engineering, civil engineering or building and architecture. Complicated on-line analysis functions are provided in this system. Users can use this system to perform various analysis, such as thematic map overlay and building damage analyses which are shown figure 5. Users can also use this system to perform on-line statistical analysis that will show the result in graphic as shown in figure 6. Furthermore, users can apply to the system administrator for using the interface provided by this system to upload data, which includes the spatial information of the data to the database or download data

from the database (figure 6). The uploaded data will be stored in a temporary space for checking by system administrator before it is put into the reconnaissance database.

Figure 5 The Thematic Map Overlay and Building Damage Analyses Functions Provided by the Reconnaissance Database Management and Analysis System

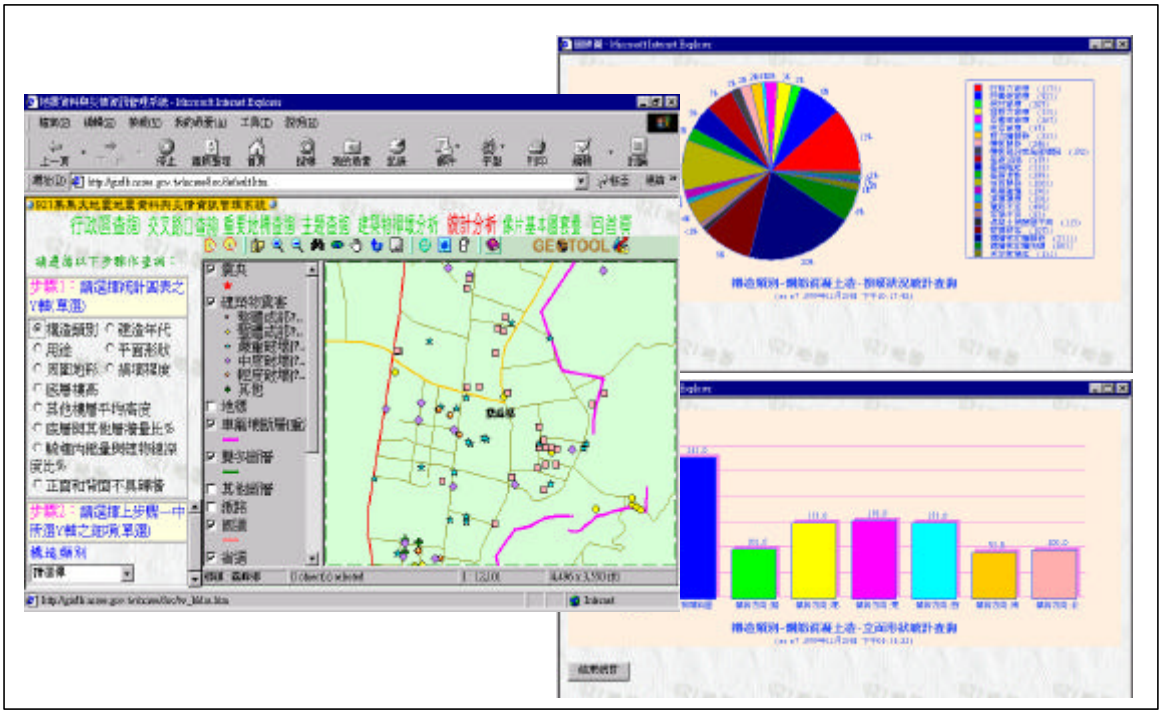

Figure 6 The On-line Statistical Analysis Functions Provided by the Reconnaissance Database Management and Analysis System

Figure 6 The Data Uploading Functions Provided by the Reconnaissance Database Management and Analysis System

V. Conclusions and Future Works

The development of a practical system that uses the concept of Digital Earth Initiative to integrate advanced information and network technologies, database management system and WebGIS technologies for Chi-Chi Earthquake has been presented in this paper. The associate reconnaissance database compiled by NCREE and the first version of the Virtual Disaster Information Management and Analysis System for Chi-Chi Earthquake has been transferred and used by the Chi-Chi Earthquake Reconstruction Committee for aftermath reconstruction works. Future development plans of the system are proposed as follow:

1. To modulize the functions of the system so that the system can be expanded in other application areas.
2. To modify the system according to the requirements of Chi-Chi Earthquake Reconstruction Committee for long-term reconstruction activities.
3. To develop the English version of the system for international access. The disaster information system will be opened to general publics, but the Reconnaissance Database Management and Analysis System will be only opened to the participant of International Collaborate project with NCREE.

4. To evaluated methods for integrating this system with the functions of near real time earthquake loss estimation and decision support to earthquake emergency response.

Finally, the task for verifying the quality of Chi-Chi Earthquake Reconnaissance Database should be done by the collaboration of NCREE, Chi-Chi Earthquake Reconstruction Committee, and related government agencies. It is also very important to include large-scale dataset compiled by government agencies or private sectors, such as the 1:500 scaled map produced by Chung-Hwa Telecom, within this system for supporting the aftermath reconstruction activities using this system.

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