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Internet Web-based information system for scrap vehicle disposal in Taiwan

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The scrap vehicle recycling program was formally initiated in 1995 when the illegal dumping issues of scrap tires and cars turn out to be intolerable in the society of Taiwan. The inherent complexity of such a recycling program, however, by integrating many public and private sectors that functions as a whole from the collection, storage, transport, treatment, and the disposal of scrape vehicles, makes the entire managerial efficiency hard to be maintained. Therefore, the state-of-the-art information technology via the use of the "Internet" platform becomes an indispensable tool to present a good communication mechanism, to provide the essential information sharing between all users and agencies, and to end up with improving the overall managerial efficiency. The idea using advanced web database along with geographical information system to help general public to dump their scrap vehicles smoothly and to make governmental agency control the disposal procedure easily could be one of the best solutions from the long-term environmental management perspective. This paper, representing contemporary progress of environmental management skill performed by the "Foundation for Reduction, Reuse and Recovery", sponsored by the Environmental Protection Administration (EPA) in Taiwan, is designed to illustrate how to build up such a system, as named by the "Scrap Vehicles Recycling Program Information System" (SVRPIMS) in order to meet the requirement from both supply and demand sides of scrap vehicles disposal. Experience gained in this study indicates that the SVRPIMS successfully integrates the Coldfusion® and Mapguide® software engineering technologies on the World Wide Web (WWW) platform. After actual implementation in 1999, it proved that communication between users and agencies at various levels in the recycling program became much easier through instant information retrieval and analysis via such a system. Besides, SVRPIMS also provides two decision-support functionalities to assist in automatic search for the most appropriate dumping site for the users and to perform possible trading of spare parts for the recyclers through a logistic optimization analysis.

Keywords: scrap vehicle, resource recycling, internet, management information system, geographic information system, decision support system, solid waste management

1. Introduction

The rapid economic growth in the last two decades motivates the tremendous consumption of various types of vehicles. According to a statistical report [1], there were 15,000,000 vehicles, including cars and motorcycles, registered in use until April 1998 in Taiwan. Although the increase in the total amount of vehicles implies the wealth of society, the dumping of scrap vehicles may result in a big environmental impact that requires applying advanced environmental management skills. It inevitably becomes one of the most important waste management issues in modern society.

Prior to 1995, most of the scrap vehicle recycling activities were performed by unregulated private sectors that were in charge of all the work of collection, storage, transport, decomposition, and disposal via a profitable basis in Taiwan. Recycling industries handling scrap vehicles and scrap tires have recently been booming due to the incentives created by the governmental subsidiary program. To properly control the recycling business, a task force, "Foundation for Reduction, Reuse and Recovery (3R Foundation)", sponsored by the Environmental Protection Administration (EPA) in Taiwan was then organized to administer all aspects of the scrap vehicle recycling program. Figure 1 shows the configuration of this program [2]. At the highest level, it identifies all the sources of scrap vehicles, no matter whether they are domestically manufactured or imported from overseas countries, they have to experience a consumption process and end up in a disposal system eventually. The scrap vehicles may experience a recycling process once they are reported by the owners of the vehicles or verified by the local authorities as abandoned vehicles after a legitimate process. An officially installed toll-free telephone number provides additional convenience to ease such a process. After passing through the initial verification procedure, the haulers may either ship those scrap vehicles to their own storage sites waiting for further notice from the privately owned small-scale decomposition factories when the treatment capacity is available or directly send those scrap vehicles to the designated publicly-owned large-scale decomposition factories in a region. An audit team has to be organized by the 3R foundation annually to monitor the scrap vehicle collection, hauling, and decomposition process as well as to guarantee an efficient use of governmental subsidy. Before the decomposition process takes place, final verification of the Department of Vehicle Management (DVM) is required in order to modify the corresponding database in the computers and to avoid accidental decomposition of vehicles that are still in use. But it normally takes a lot of time to handle those arbitrarily abandoned vehicles. After decomposition is performed, the scrap tires, leaded batteries and lubricant taken out from the scrap vehicles have to be shipped to other re-

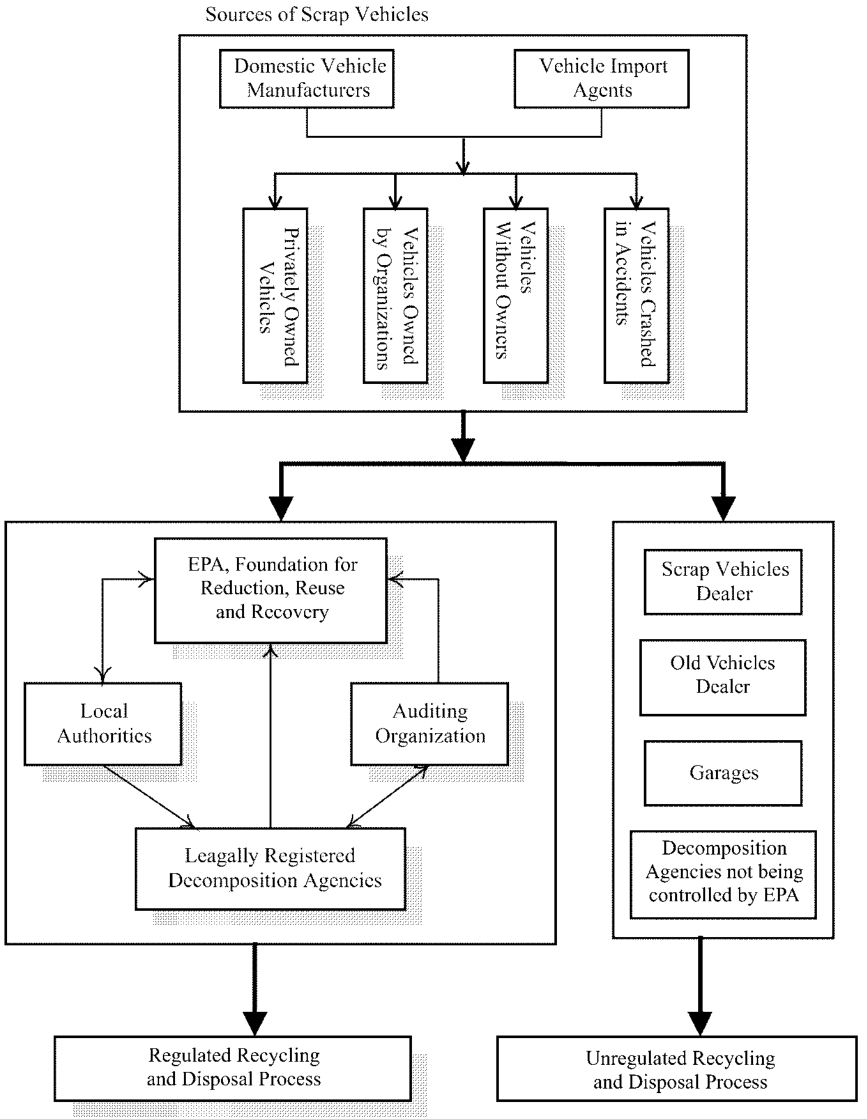

Figure 1. The configuration of scrap vehicles recycling system in Taiwan.

cyclers to ensure a complete recovery and reuse. The 3R Foundation is in charge of supervising all the auditing organizations and decomposition factories. However, it runs as an open system when part of the recyclers choose to stay outside the recycling system because of the lack of incentives. Mandatory requirement to reshape such a system into a closed system integrating all the unregulated agencies as a whole is anticipated in the future. That will include all scrap vehicle dealers, private garages involved in this business, and privately-owned small-scale decomposition factories.

2. Problems and solutions

The experience gained in the period between 1996 and 1998 shows that the performance of scrap vehicles recycling program in Taiwan is far behind its original expectation. Communication inefficiency arises in some recycling channels that causes abnormal accumulation of scrap vehicles in the shipping process and deteriorates environmental quality indirectly. There are many people who don't know how to declare their own scrap vehicles or who just feel inconvenient or reluctant to use such a process. These problems have resulted in difficulty when shipping the scrap vehicles to the designated recycling channel. On the other hand, the number of private sectors that are willing to participate in the public recycling system is always smaller than that of those that are not. Although mandated regulations or laws could improve managerial efficiency, soft approaches are encouraged in the initial stage. By establishing a more convenient and accessible mechanism than the existing one, it is believed that the efficiency of using the designed recycling channel as shown in figure 1 could be significantly enhanced. The idea of using advanced web database along with geographical information system to help the general public to dump their scrap vehicles smoothly and to make a governmental agency control the disposal procedure easily, could be one of the total solutions in the long-term environmental management perspective.

The usage of information technology in a Wide Area Network (WAN) to enhance or improve the managerial efficiency is not a unique approach described in the literature. Previous studies, however, mainly employ Local Area Network (LAN) to achieve such goals. Chang and Lin [4] did the early-stage planning of a nation-wide solid waste management information system via an integration of hardware equipment, software programs, and networking options among various levels of governmental agencies. With the aid of a client–server framework and a frame relay backbone, it is possible to transform the regular official reports and the statistic figures into digital format promptly in each local office in order to share the information flows for centralized decision-making and thus increase the efficiency for solid waste management. Besides, Loh et al. [5] addressed the needs of international collaboration for information management and exchanges for sustainable development. Using the current information services on the Internet, an advanced system called GIME has been outlined to simplify a user's access to information resources and facilitate decision support.

For scrap vehicles recycling, however, the application of information technology can facilitate the collection duty, share the information between storage sites and decomposition factories, and even provide various types of statistical analyses and decision support with respect to particular management scenarios or policies via simulation or optimization techniques for governmental agency. Besides the obvious functionalities that help to collect the scrap vehicles more easily through the Internet system, information sharing can play an active role in improving the operation of decomposition factories. It will be required to provide the capacity of Electronic Data Interchange (EDI) to enhance the trading potentials of secondary parts collected during the decomposition of various types of scrape vehicles, and, therefore, will increase the incentives of those private sectors to join such a public recycling program. From management perspective, information system could also provide instant browsing of relevant regulations and laws with regard to both supply and demand sides. Extended evaluation of cost/benefit analysis for various sizes of recycling programs, collection routing and scheduling for shipping scrap vehicles is also anticipated.

3. Internet technologies and WWW platform

Internet technology started in the early 1970s when the need of connecting different intranets to aid in national defense program in the United States was recognized. Advanced Research Projects Agency Network (ARPANET) was the prototype of the Internet system that integrated the networks in the Department of Defense, supporting contractors, and the Intranet at major research-oriented universities. Thanks to the success of running the ARPANET as a new communication media, the National Science Foundation (NSF) in the U.S. initiated the National Science Foundation Network (NSFNET) in 1986 using the Transmission Control Protocol/Internet Protocol (TCP/IP) as the typical communication protocol for extended applications worldwide, which connects various Intranets in different countries to perform basic functionalities of Email, File Transfer, Telnet, Netnews, Internet Relay Chat, Gopher, Bulletin Board Systems and Archie, etc. [6].

In 1989, World Wide Web (WWW), another application of the Internet was developed in the European Laboratory of Particle Physics, which was capable of integrating text and various multimedia resources (such as pictures, sounds, and movies) within an open architecture. This invention pushed the Internet applications to a higher level. Via the Internet, using a simple browser users can easily search online databases and retrieve hypermedia information supplied by various WWW servers all over the world. This technology not only may dramatically increase the amenity between remote users but also fulfill the anticipation of processing multimedia data in a simple and convenient way [7]. The WWW is evolving as a major component for information storage, sharing, and retrieval in many academic research and business development programs. Besides providing the multimedia display, WWW also has the following characteristics:

1. Using the hyperlink concept: When the user is browsing through a web page, he/she can use the mouse to click on pre-set words or pictures on the document. Following the arranged links among different web pages they can easily get required information.
2. Interacting with the users: In most broadcast media, information providers send out one-way communications that only present messages to the general public. In contrast, the WWW allows the receiver to give feedback to the information supplier by sending back information that users post onto the browser via the Internet. This system provides an efficient communication mechanism for both the information receiver and the supplier.
3. Executing external programs: Although WWW servers can support many file format displays, it cannot process data of all formats. To overcome this restriction, WWW servers provide an interface called CGI (Common Gateway Interface) for running external programs or gateways that may facilitate the response of various information requests and can act as a gateway for returning the appropriate Hypertext Markup Language (HTML) document for reading via the browser.
4. Using the client–server architecture: WWW uses a client–server architecture, which is often seen in the information industry. This means that the Internet servers supply information whenever there are demands from clients. On the client end they use the given program along with certain networking communication protocols for requesting services from the servers. Users only need to learn the basic WWW browser system that may allow them to explore and surf through the endless treasure-filled Internet world.

While access to information of common interest can be a huge benefit from a Web-enabled database, there can be even bigger advantages. The ability of a Web server to communicate with a database opens an incredible array of possibilities. Perhaps, the most useful WWW application is the ability to publish information to the general public [9]. In earlier developments, publishing data on static Web pages required tremendous effort to keep the information up to date for sites larger than a few HTML pages. For example, changes in contact information to decomposition factories had to be manually transcribed from the corresponding database to the HTML pages in the catalog. This would be great if the constantly updated data were automatically reflected in the catalog's HTML pages and if the agencies belonging to the same organization could update and manipulate the selected data. To ensure this, it is desirable to generate dynamic data and maintain live data while performing applications. Fortunately, the development of the Internet technology made it possible to implement the client–server database system on the WWW, which produced the era of dynamic live data.

Many public systems were developed for environmental management based on the WWW platform. As Boston described, a WWW service provided by the Australian Environmental Resources Information Network (ERIN) may support people to easily access key environmental information for various applications in Australia [8]. Moreover, William et al. designed a Web Group Decision Support System (GDSS) for planning an urban water supply system [10]. Bhargava and Tettelbach implemented a decision support system, installed on a Web server, for waste disposal and recycling [11]. This study also tries to integrate several existing and separate databases in the WWW platform. The WWW along with Web-database connectivity offers far greater flexibility for integrating different databases. Users who hope to dump their vehicles can access data via the Internet through a Web server to announce their willingness with no geographical limitations. Local authorities, the auditing organization in different branch offices, the decomposition factories, and anyone else who is given permission can use the same pool of information. All they need is a Web browser and an Internet connection.

To connect a database to the Web, some types of connectors are needed so that the Web server can be used to make calls to the database. Examples of connectors include ColdFusion®, Active Server Pages® (ASP), PHP®, Java®, and Perl®. Clients invoke a CGI process on the Web server, which links them to a Relational Database Management System (RDBMS), such as Oracle®, Sybase®, Access®, Microsoft SQL® Server, and so on. The connector can then help to access the database via Open Database Connectivity (ODBC) or Active Data Object Data Base (ADODB) technologies, supported by most commercial databases. Once the connector receives the data from the database, the connector can process the data, format it, and return it to the user as an HTML document. In order to retrieve the information from the databases, connector must manipulate a query language so that the RDBMS can understand the required work. One of the most popular one is Structured Query Language (SQL), which allows users to describe the data the user wishes to see and also allows users to define the data in a database and manipulate that data.

4. Internet GIS

Due to the complexity of the scrap vehicle recycling program, geographic data management is also considered to be a key factor to the recycling program. One of the critical issues is how to effectively distribute information around those sites applicable for scrap vehicles recycling in a designated region. Given the assumption that people can easily acquire the locations of decomposition factories through the Internet, for convenience, they will be willing to declare scrap vehicles to the designated agencies via exploiting geographic data on the web pages. Additional benefits, such as efficient routing in search of the optimal choice among decomposition factories can be acquired.

Traditionally, most geographic data is communicated visually via maps, which save the trouble of long descriptions. Before the 1960s, the first Geographic Information System (GIS) was implemented in Canada using digitized geographic data. This led to the application of spatial information into the computer management age. Generally, a complete set of GIS must have hardware, software, a database, people, an organization and a management environment. The structure and functions should include data key-in, data storage, data management, data exchange, and display [12]. The spatial analysis capability in GIS has made traditional planning processes more accurate and efficient. Various applications can be found in different domains, such as environmental impact assessment [13], wetland protection [14], vehicle routing [15], and groundwater investigation [16]. Meanwhile, GIS can also be connected with people's daily life to facilitate specific search for spatial objects, such as scenery spots, entertainment sites, and public service stations.

Fortunately, the advantages and characters of the WWW make up for what traditional GIS lacks. GIS research has been heading towards integrating Internet technology and GIS technology and developing what is called Internet GIS [17–19]. It solves the problem of how to provide access to geographic data without burdening end users with complicated and expensive software. It is convenient for people to use Web browsers as tools to query, manipulate, analyze, and display spatial information, which links to the geographic data located on Web servers via the Internet. Currently many companies, the government and academic units have joined Internet GIS research. The relevant information is summarized in table 1.

There are two basic approaches to deploying GIS on the Internet: server-side or client-side applications. Figure 2 describes the server-side connectivity and the software configuration that most of the Internet GIS systems are adopting. On the client end, the user has the option to manipulate the

Table 1
The investigation of Internet GIS software.

Developer	Product	Web link	Architecture
Environmental System Research Institute (ESRI)	ArcView Internet Map Server	http://www.esri.com/software/arcview/extensions/imsext.html	Server-side
	MapObjects IMS	http://www.esri.com/software/mapobjects/ims/index.html	Server-side
Intergraph	GeoMedia	http://www.intergraph.com/geomedia/	Client-side
Xerox	PAARC Map Server	http://www.xerox.com/map	Server-side
MapQuest	Interactive Atlas	http://www.mapquest.com/	Server-side
Autodesk	MapGuide	http://www.mapguide.com/	Client-side
Berkeley University	Grasslink	http://www.regis.berkeley.edu/grasslinks/	Server-side
Purdue University	Grassway	http://ingis.can.purdue.edu/	Server-side

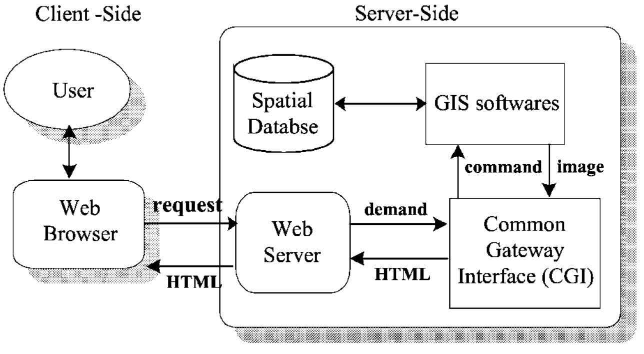

Figure 2. Internet GIS with server-side connection.

browser, i.e., zoom out or in, turn a layer on or off, and drag a map layer using the interface created by HTML in the Web browser. These requests will first be transferred to a Web server through Hypertext Transfer Protocol (HTTP). The server will then respond by calling upon the certain CGI for connecting application programs, like Arc/View® or GRASS® (Geographic Resources Analysis Support System), etc. The GIS software executes the commands passed from the client to extract information from the spatial database. The geographic data display on the GIS would then be captured as an image file and send back to CGI. CGI would pack this image file into an instantly created HTML file and send it back to the client side via the Web server. The user can read the geographic data displayed as a static image using a Web browser.

The major concept of the client-side Internet GIS is to move some of the GIS functionality on the server to the client. The client receives enhanced GIS operation support through the augmenting the Web browser with Plug-Ins, Java, or ActiveX, which users must download and install before the maps can be accessed. To take full advantage of client-side connectivity, vector data, sent from the Web server to the client, is used directly for core GIS operations without retransmitting a request to the server. The use of vector data generates real graphic objects, such as points, lines, polygons, for the client, which allows a higher degree of user's interaction. For example, when a user moves the mouse over graphic objects, they light up and the coordination can also be shown.

There are pros and cons for both applications. The major advantages of server-side applications include no additional software required, platform/browser independent, and implementation ease. On the other hand, the connectivity creates many requests that cause substantial network overhead and a heavy burden on the server. Meanwhile, no viable vector formats cause the problems of low user interaction, limited Graphic User Interface (GUI) performance, and low graphic quality. The advantages of the client-side applications are excellent performance, less Internet traffic, and real graphic objects using vector data. The drawbacks include additional software required, platform/browser incompatibility, and long initial download time for large databases. After carefully comparing the functionality of various products, the choice of Internet GIS should primarily depend on the application requirements in this paper.

5. Designing and building SVRPIMS

One of the key factors in building any information system is the initial planning and design. Screening design requirements and creating a manageable framework for the project are crucial [20]. The information technologies introduced earlier would form a viable base for designing and developing the Scrap Vehicle Recycling Program Information System (SVRPIMS). The overall goal of building the SVRPIMS system is to improve coordination and communication between the 3R Foundation, the DVM, local authorities, decomposition factories, an auditing organization, haulers, and owners of scrap vehicles. The following guidelines are essential for use in the design phase.

1. To provide rapid and accurate information for inquiry of the latest dynamic information, regulation, and technical reports with respect to pollution control for the relevant agencies in the recycling program.

2. To supply the basic information required for the statistics and analysis procedures of the 3R Foundation and to support the decisions toward better recycling policies and regulations.

3. To develop an automated mechanism to replace an inefficient paper-based process so that the information would be updated in real-time and shared among various agencies.

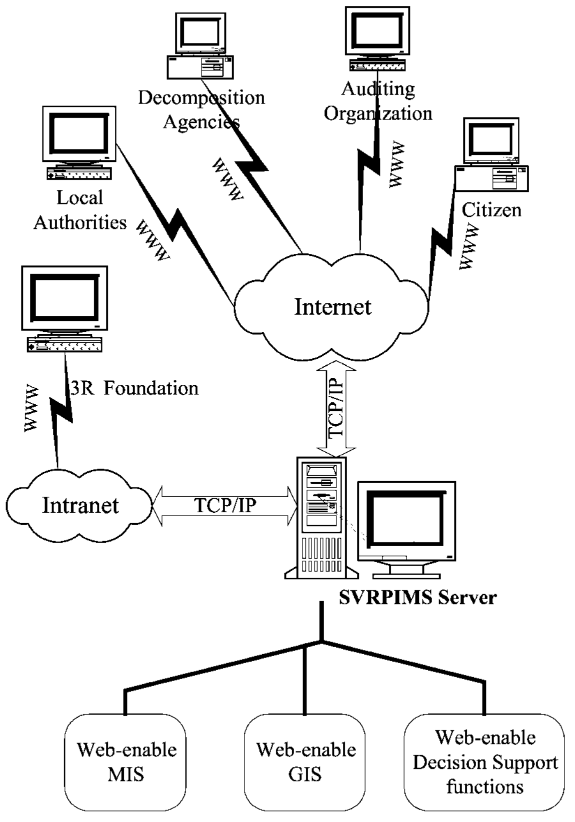

Figure 3. The schematic diagram of the SVRPIMS.

4. To digitize the geographic data, to display the spatial information and to provide spatial inquiry service via WWW in a GIS environment.

The potential impediments to the development of an information system are the current system and the users themselves. The desired goals of a SVRPIMS that tries to integrate many governmental agencies may not be fully achievable due to the inherent reluctance and resistance embedded in different administrative systems. The major dilemma is that external users are currently not allowed to access the vehicle database classified and controlled by the DVM. Unless this issue can be resolved, the potential of the SVRPIMS might be limited. The other obstacles include how to unify different favorite data formats in various spreadsheet software packages used in different agencies and how to design a user-friendly GUI to meet the practical needs at different levels.

Figure 3 shows the schematic diagram of the SVRPIMS. The SVRPIMS integrates MIS (Management Information Systems) as well as GIS to fully meet the needs of all users involved in the scrap vehicles recycling program. The ColdFusion® software technology is used as a connector between remote users and the server under Windows browsing environment. The essential data of scrap vehicles recycling program was customized and housed in a Microsoft SQL Server database that connects with the Web server, which is the Microsoft Internet Information Server (IIS), via ODBC or ADODB. The AutoDesk MapGuide® was chosen to implement the spatial analysis via a client-side Internet GIS framework to reduce the server load. Basic information sharing between agencies becomes possible via EDI channel. The decision support functionalities cover the application of shortest path model to find the nearest way from users to storage site or decomposition factory.

To illustrate the basic framework of SVRPIMS clearly, figure 4 displays the systematic configuration that shows a Web-enabled system may mingle normal HTML tags with those ColdFusion Markup Language® (CFML) for querying databases and outputting texts, and interacting with other Web services. These files end with the .cfm extension that tells the ColdFusion® server to parse the pages and extract the information from the MS SQL server via ODBC or ADODB before sending the results to the Web server. To successfully display the spatial information, the digitized geographic data prepared by the GIS software package Mapinfo® was first transferred to the format of Spatial Data File (SDF) as required by the MapGuide®. Then, MapGuide Author® was utilized to design the Map Window File (MWF), which defines in advance how the geographic data can be displayed. When users make a request to the MapGuide® server through the IIS framework for sending and downloading the MWF, the MapGuide® Plug-In program for the browser may be activated to display the vector data. The graphic objects displayed on the browser are also linked to the attribute databases, which are manipulated by the Microsoft SQL® Server and can be accessed via ODBC or ADODB. Therefore, both spatial information and the associated attribute data are applicable for users when facing a spatial query. Using the Visual Basic® programming language, the shortest path calculation was implemented as a Dynamic Linking Library (DDL) which would call MapGuide® Server to input geographic data and perform the output display.

Reviewing the previous work and interviewing the potential end-users further enhance the functionalities of the SVRPIMS system. Figure 5 describes that the entire system is divided into five sub-systems, including the document inquiry sub-system, recycling information report sub-system, database inquiry sub-system, database maintenance sub-system and the statistics and analysis sub-system. The databases to support the operation of the proposed sub-systems include: vehicle data associated with these rather domestically manufactured or imported from foreign countries, decomposition factories, recycling agencies, disposal agencies, scrap vehicles declaration, citizens' reports with regard to abandoned vehicles, auditing information, declaring and towing information, spare parts information, and related regulations and technologies. Among them, additional spatial information of decomposition factories, recycling agencies and disposal agencies are stored and linked with their associated attribute data. To facilitate effective searches by these agencies, several geographic map layers are compiled as base maps for use, which include the information of roads, rivers, and important landmarks consistent with the scale of 1/25000. The detailed functionalities of each sub-system are explained below.

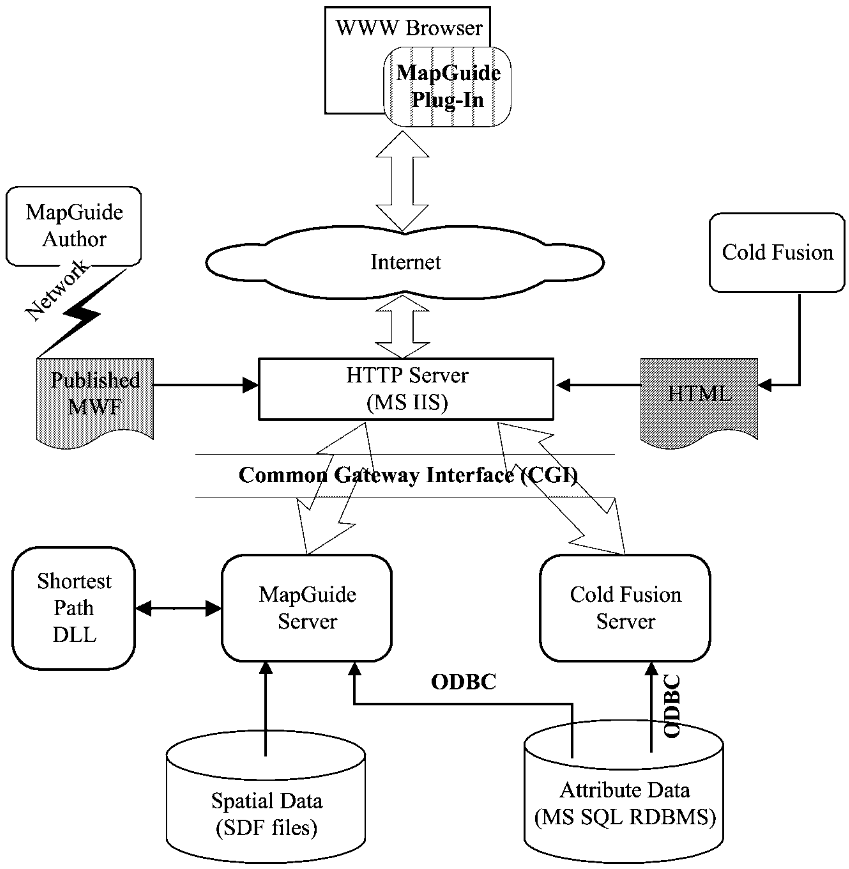

Figure 4. Software configuration of the SVRPIMS.

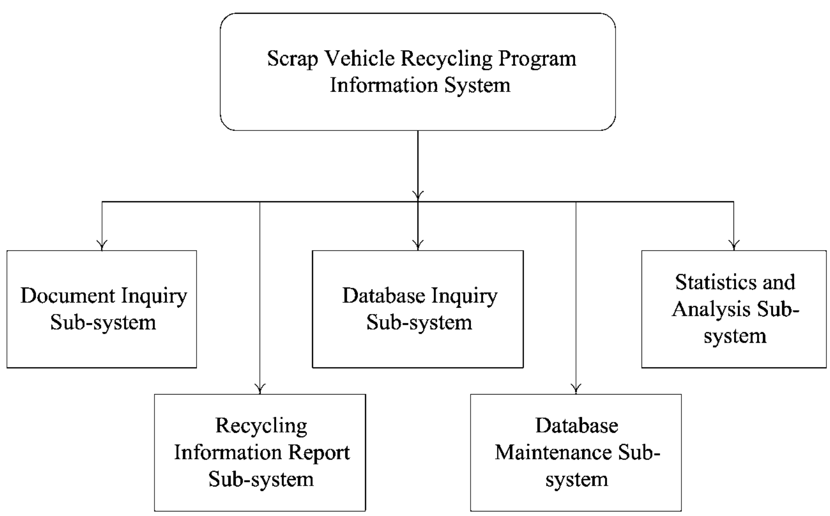

Figure 5. Functional framework of the SVRPIMS.

5.1. Document inquiry sub-system

The sub-system collects the up-to-date information to perform as a digital library so as to present users the technical documents, operational reports, and essential regulation and laws via the Internet. The documents are divided into several categories including the policies and regulations for scrap vehicle recycling, decomposition technology, recycling technology, as well as the related information of ISO14001 environmental management system. These documents are expressed by the HTML or Microsoft Word formats at the present time. There is index search function available in the system. When a user inputs a key word, the system will automatically sort out all the documents containing that key word to enable the user to obtain the relevant information easily. With the rapid increase of information nowadays, the content of the digital library has to be reorganized from time to time.

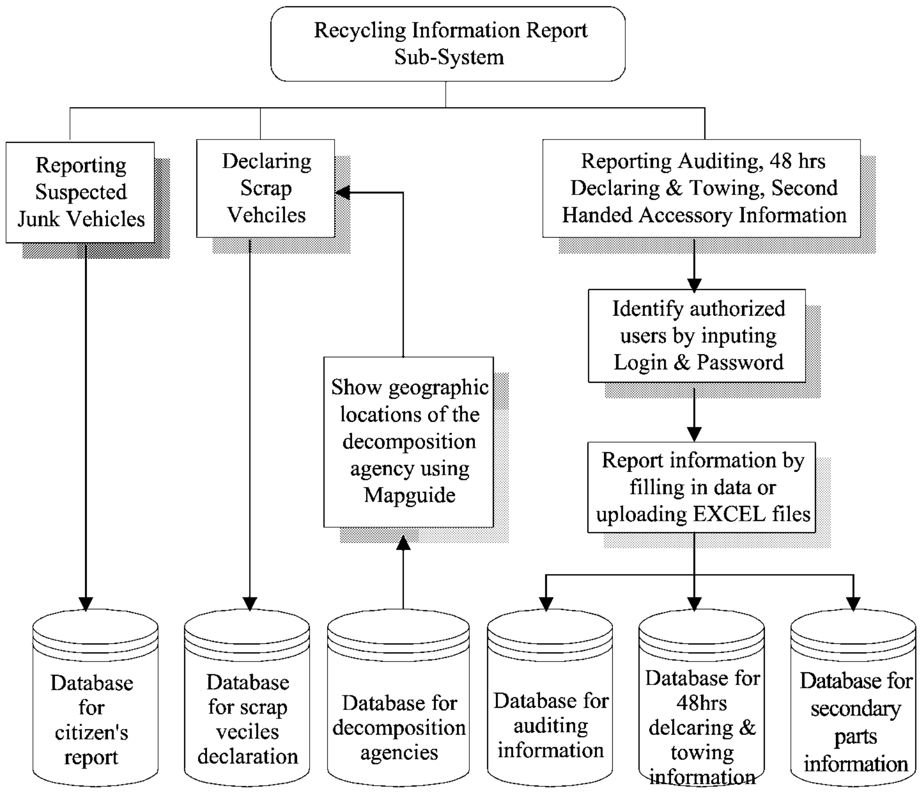

Figure 6. Framework of recycling information reporting sub-system.

5.2. Recycling information sub-system

This sub-system is designed as a public utility to provide an easy search by citizens, auditing groups, local authorities, and the decomposition factories via the Internet. This system can replace or supplement the existing mode of reporting procedure via toll-free telephones and paper work. It will be beneficial for time and cost saving in the long run. Figure 6 displays the framework of this sub-system.

Using this sub-system to declare and hand over scrap vehicles, a citizen would first be asked to input some basic information. The system would then automatically sort out the decomposition factories near the citizen's location and display the spot on a map via the Web browser. While the user browses the map and pinpoint his or her own location on the GIS interface, he/she can select any decomposition factory by double clicking on the graphic object on the map. In response to the mouse click, the associated attribute data, such as name of the director, telephone number and its performance evaluated routinely by the 3R Foundation will be presented to the user step by step. Figure 7 exhibits a typical snapshot. Based on the user's preference, final decomposition factory may be chosen for subsequent operation. With the guidance of the map on the computer screen, the user may drive his or her vehicle to the factory and dump it there. Otherwise, the selected factory, upon receipt of a notice from the system administrator, would contact the citizen consulting for scrap vehicle collection, transport, decomposition, and disposal. On the other hand, to report the abandoned vehicles via Internet instead of conventional paper work would also provide additional convenience in the dumping operation.

Classified users, such as the auditing organization, the local authorities, and the decomposition factories may update the associated databases via the Internet system. The security of the system can be maintained using preset login names and passwords. Two approaches for reporting information are available. The first approach utilizes a similar method as described for dumping scrap vehicles before in which the system prompts the user with an active Web page to fill in all the necessary data. The second approach allows the authorized users to upload a file with the Microsoft Excel® format. The system would automatically extract the content in the file and store the information in the database accordingly. To accommodate those users who have different data with inconsistent format, the SVRPIMS provides an additional "translator" to allow heterogeneous information to be converted into the required one. This would save extra data entry time in the way to build the database. Such a system earns a comparative advantage in business operation. It would improve the recycling performance when the dumping procedure is dramatically simplified.

The sub-system also allows the auditing group to submit their regular reports via Internet, which contain the monthly statistics. This would urge the 3R Foundation to be fully aware of the scrap vehicles recycling conditions, island-wide on a monthly basis. The auditing information will be stored in the digital format, which will facilitate the staffs in the 3R Foundation to further process the information for decision-making. Meanwhile, the local authorities can also report

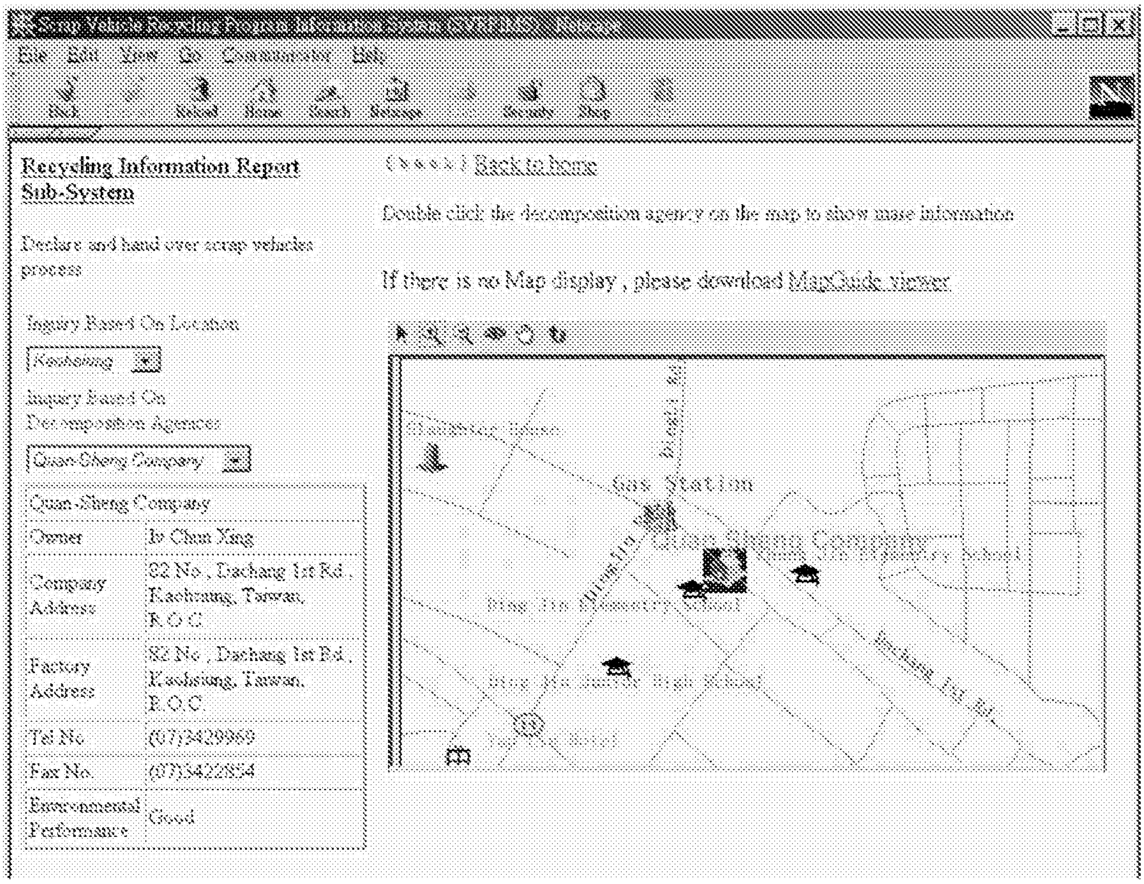

Figure 7. Geographic and attribute information for a selected decomposition agency.

their declaration and towing information using this system, and each decomposition factory can update on-line information of the current stock of secondary parts via Intranet system.

5.3. Database inquiry sub-system

Particular users can be authorized to search for the databases of the SVRPIMS. Figure 8 delineates the framework of this sub-system. Users with higher rank, such as the staffs of the 3R Foundation, can access classified databases while general users can only query one or two relevant databases. Either to browse the whole list of databases or set up some query criteria based on one or several conditions may achieve the query. For example, while the staffs of the 3R Foundation need to evaluate the performance of a local authority in Taipei during the period of March, the user can issue a searching criteria by selecting Taipei from the drop-down list and typing in the time period required. Figure 9 shows the result of such query for the time period of March 2000. Once the query is finished, the user may select the button "Convert to EXCEL" to transform the data into an EXCEL file for further analysis and processing. In addition to use the search command in text mode, users can also access the data through GIS graphic interface.

To promote the trading possibility of spare parts, users are welcomed to manipulate the well-designed inquiry function in search of the databases with respect to the types of vehicles and specific manufacturing features. The system can easily find the decomposition factories where the desired parts are available in stock. To ease the trading process, contact information for the target factories will be provided immediately on the screen. It may perform as sort of electronic-commerce via the supply chain management.

5.4. Database maintenance sub-system

The goal of this sub-system is to maintain all of the databases created by the SVRPIMS in an active basis. Major operations of this sub-system include adding, modifying, and deleting the entry data in the database. The authorized users may conduct regular database updates, and the system administrator can modify updated database in case the information is incorrect. Figure 10 displays the framework of this sub-system. As shown in figure 11, graphic user interface may the help user fill in the blank fields via a simple way of selecting the "Add" button after typing the information on the textbox. The system will then store the new data entry into the database. In addition to the maintenance of attribute data, there is also a need to edit the geographical data due to some special occasions, such as adding a new decomposition factory on a map layer that is digitized using the GIS digitizer during the system implementation stage. In particular, this sub-system provides an easy way for updating digitized geographical data without using any professional

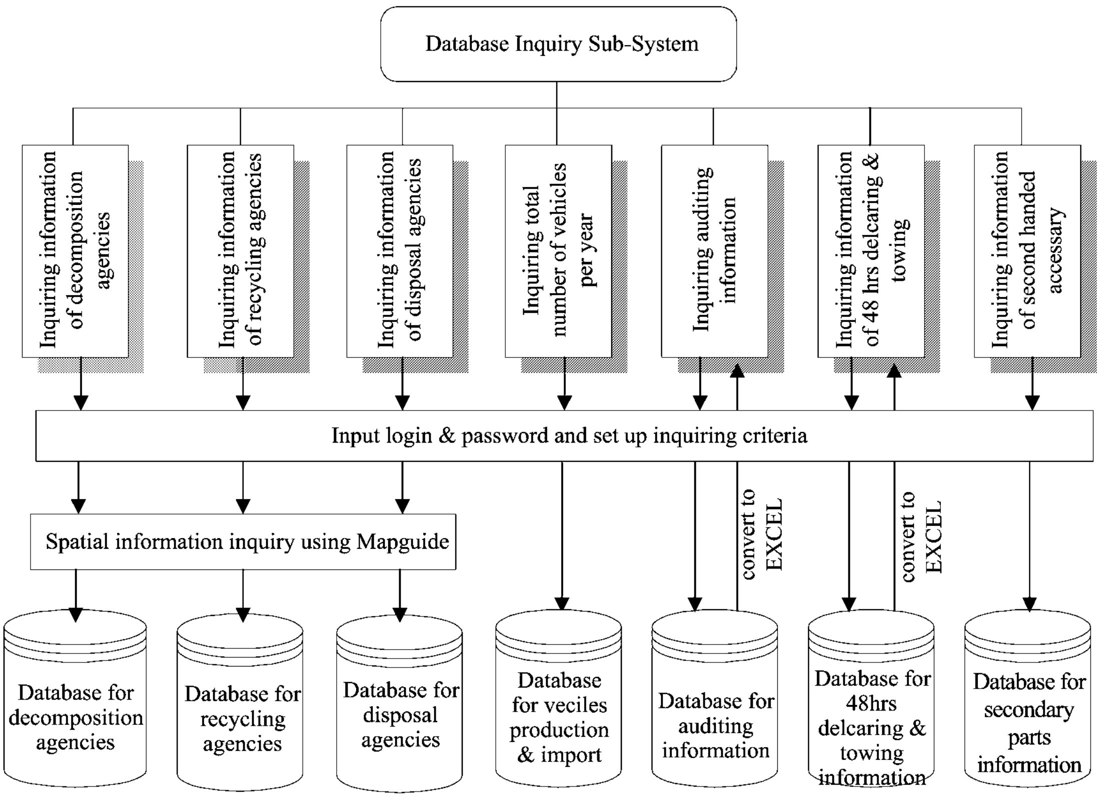

Figure 8. Framework of the database inquiry sub-system.

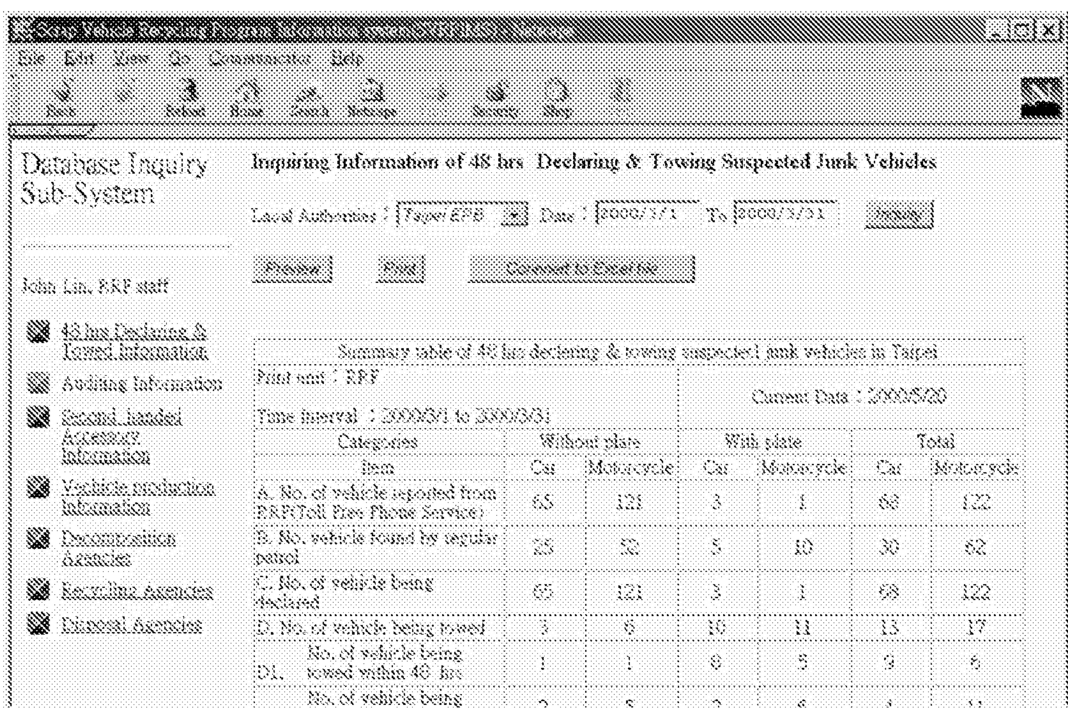

Figure 9. Results of querying 48 hrs declaring & towing information.

GIS software. The user can perform this operation directly on the Web browser by adding, modifying, and deleting the coordination of the site if he is authorized to do so. Correct display of spatial information by the system can therefore be assured.

5.5. Statistics and spatial analysis sub-system

This sub-system primarily concerns about specific decision support by incorporating the statistical procedures and analytical models. To fully exploit these mathematical tools, complete data collection is needed. Currently, due to data limitation, the SVRPIMS can only provide two decision support functionalities. They include the statistical analysis in relation to summarizing the vehicle growth rate and the shortest path analysis in order to guide users to find out the nearest route for dumping their vehicles. The former would help figure out a reasonable level subsidy and associated policy. The latter would integrate all the related facilities in an area that are available for dumping. The network of roads and the algorithm make the system perform correct spatial analysis based on the well-known Dijkstra's algorithm. Figure 12 presents a snapshot of the typical spatial analysis. It may point out the related driving distance for the users when making a decision.

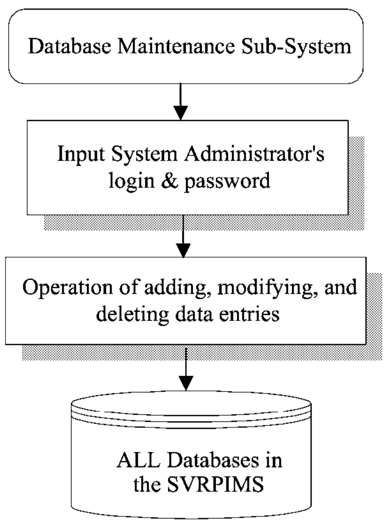

Figure 10. Framework of the database maintenance sub-system.

Overall, this SVRPIMS was designed to improve the managerial efficiency of the current scrap vehicles recycling program in Taiwan. This Web-enabled decision support system incorporates RDBMS, GIS along with some modeling analysis capability based on the Internet architecture to accommodate various information flows among system components. The integration of web-site database and GIS successfully facilitates the information collection, sharing, analysis, and presentation via the use of a Web browser. With a growing amount of data accumulated in the future, more analytical models can be applied for particular decision support.

6. Conclusion

The recycling of scrap vehicles is of significance in a sustainable society. Performing systematic recycling, recovery and reuse of all secondary materials in the decomposition process would be consistent with the requirements of resources conservation and greenhouse gas emissions reduction simultaneously. However, it is a great challenge for us to integrate so many recycling channels and overcome such management complexity via an integrated recycling program. This study unambiguously indicates that proper use of advanced information technologies would reshape the system configuration and smooth out the complexity to a great extent. SVRPIMS is verified helpful in controlling all the information flows and materials on the Internet platform. It demonstrates how to utilize the state-of-the-art Internet GIS and website database to perform various customized query and manipulation. With the help of such an integrated system, it is expected to facilitate specific decision support functionalities in terms of particular management goals. Users

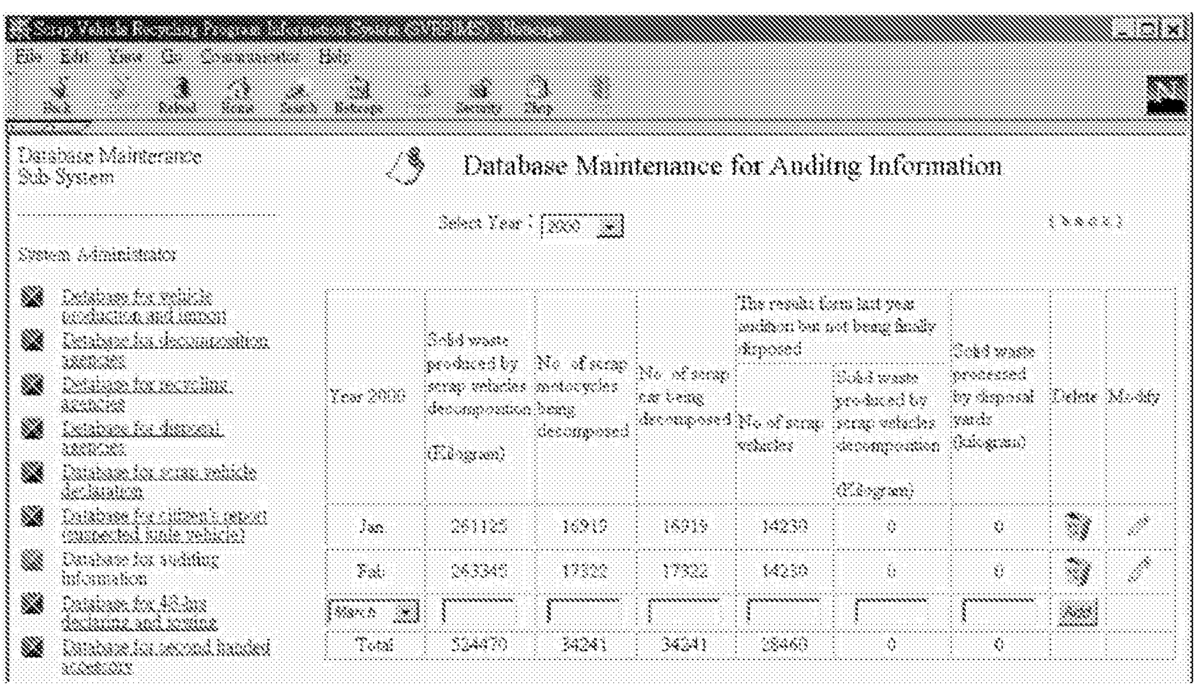

Figure 11. Database maintenance operations.

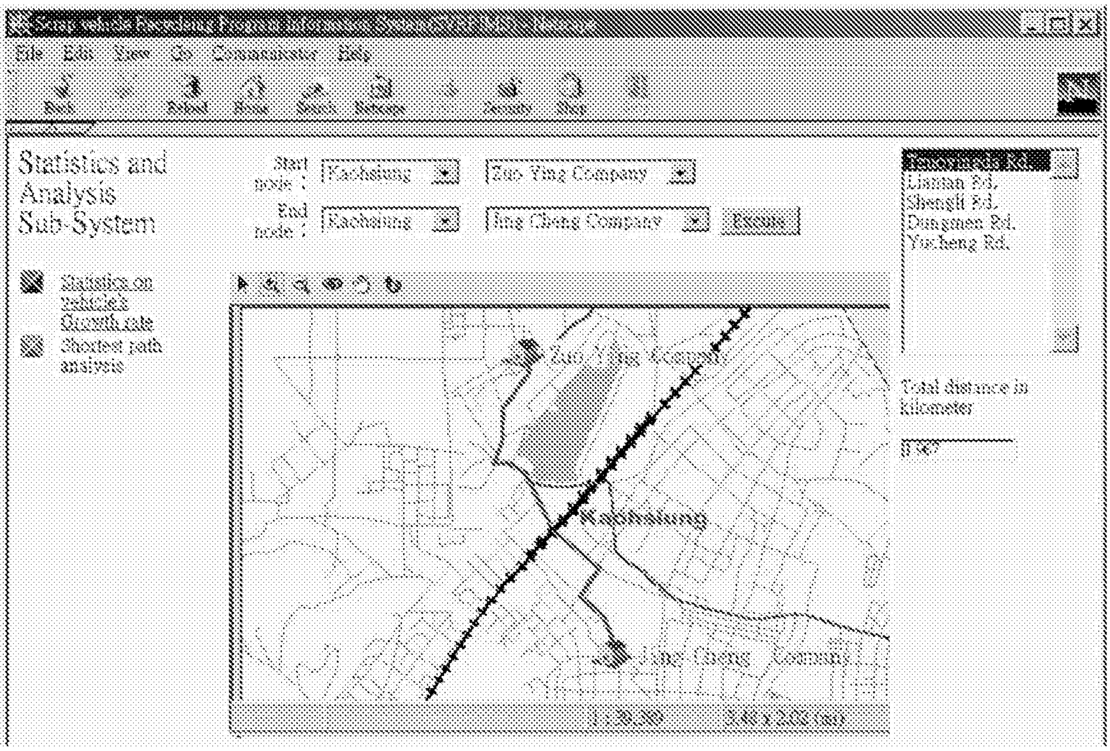

Figure 12. Shortest path analysis results.

in all levels will be beneficial for handling their individual piecework that is relevant to scrap vehicles recycling in the system.

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