

Using hybrid GIS for environmental management and monitoring

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Abstract

To manage and monitor diverse environment situations in Taiwan, a hybrid GIS is developed to meet the needs of different users and objectives. Various kinds of data includes multi-scale raster data, vector data and alphanumeric data from SDE, single files or other database can be displayed via one portal . AJAX, XML, web service and mashups are involved to develop the map platform. The paper presents a new approach for integrating heterogeneous data into a hybrid GIS environment from different data providers by self-invented map service framework. Furthermore, some practical cases will be demonstrated, and an enhancement strategy with additional hybrid GIS development for environmental management and monitoring will be addressed for future improvement.

1. Foreword

The two thirds of the territory in Taiwan are the mountainous and hilly areas that can't be highly developed. In recent years, the ecological environment is losing balance due to the land usage overload and the rapid urban sprawl. The fragile and sensitive environment experienced many hazards caused by typhoons and torrential rain, and it took serious loss of lives and properties. Therefore the slopeland monitoring is the desperately important issue to manage.

To deal with the environmental issue in a more effective way, it is necessary to employ the multidiscipline technologies like GIS, RS, GPS, communication, and etc. to handle these problems with the concept of spatial management.

Abundant and correct spatial information is the essential of spatial management. However, it is difficult to integrate diverse data from different data providers with various data formats. In view of this, this project develops a uniform communication interface to integrate heterogeneous data from various units.

2. Introduction

2.1 Environmental Issue

[Environmental Monitoring]

Some authorities in Taiwan apply the theory of natural hazard management proposed by FEMA on hazard management. The theory is focus on the 4 phases of hazard management life cycle including preparation, mitigation, response and recovery. This concept is applied on environmental management with 2 aspects includes "environmental monitoring" and "environmental management".

Environmental monitoring is a qualification, quantification, and systematic analysis on environmental characteristics via technical means. It is used to grasp the information of environmental variation or movement in quantity or quality.

The fixed spot monitoring is mostly applied on specific key areas such like environmental sensitive areas or debris flow-prone streams in Taiwan. The monitoring equipments like CCD, wire sensor, rain gauge, water level meter, and geophone are setup on spot to observe and retrieve the environmental information in hazard potential areas for analysis and early warning for those disasters. The collected data will transmit to the central data control center, and the control center will send the alerts previously when the on-site data reach the warning threshold.

However, all these data come from different competent authorities with different data format. There are administrative and technical problems when retrieving all these information into one portal and serving all sorts of population.

[Environmental Management]

The allowed-developed land resources in Taiwan are limited, and that's why the competent authority must have comprehensive management measures for construction application and illegal restriction management. In the past, all of these management measures were paper works which was lack of sufficient references for decision making or policy making. Due to the development of GIS and RS (Remote Sensing), the concept and tools of spatial management are involved to assist the decision making and management in environmental management. It is necessary to enhance the correctness on filed investigation by considering the physical environmental factors during the management process.

2.2 Heterogeneous data

The spatial factors are numerous and complicated. There are many units building GIS relevant data through the years. Because of the different business objectives and system architectures, the low interoperability and compatibility become a serious problem when comprehensive information needed to be composed for advanced analysis. The heterogeneous data means the data may come from different coordination systems, GIS data format, database format, source providers, and etc. Therefore, a hybrid GIS is one of the solutions to be the portal for sharing the information based on the unified standards.

2.3 Different user demands

During the process the PC GIS becoming the Web-GIS, the users demands is also expanding. People want something more flexible, free and friendly for GIS concept products when it comes to the most powerful free software called Google Earth and Google Map. Google not only provides the easy and free GIS concept products for everyone to retrieving information anywhere on earth, but also share the APIs for users to create user-defined mashup GIS. Users in each level need different scalable GIS functions. That's why the GIS applications have to break the limitation of present package software and try to cooperate with the other resources to meet the various levels of users' demands.

3. Material and Methods

3.1 Web Service

Web service is an object deployed in Web. W3C(World Wide Web Consortium) defines as "a software system designed to support interoperable Machine to Machine interaction over a network." Web services are frequently Web APIs that can be accessed over a network, such as the Internet, and executed on a remote system hosting the requested services. Web services can communicate with each other in a heterogeneous environment based on industrial standards.

3.2 OGC &WMS

The Open GeoSpatial Consortium, Inc (OGC) is an international industry consortium of companies, government agencies and universities participating in a consensus process to develop publicly available interface specifications. OGC provides the shared architecture for software and data providers to achieve the development of interoperable spatial data and systems. In these years, OGC emphasizes on the

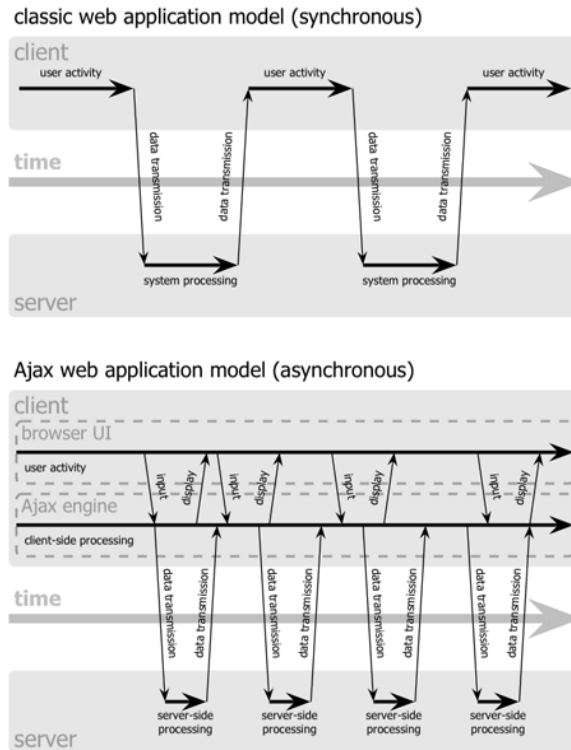
standardized activities to fit in with international requirements. For example, the Web Map Service Interface (WMS) of OGC becomes one of the international standards for GIS commercial usage. WMS is an image generator of geospatial features. WMS can transfer the vector or raster data into readable image format for general browser. Therefore, GIS features from different sources can be overlaid and displayed real time without letting users realize what the original data format is.

3.3 Technique

3.3.1 AJAX

AJAX is the abbreviation for Asynchronous JavaScript and XML. The content of AJAX is similar with DHML, and the main purpose of AJAX is to enhance the interactivity, speed and usability of homepages. AJAX is combined by XHTML and CSS for display the data, and manipulates the data storage and retrieval process by DOM and JavaScript. It is bundled by JavaScript and proceeds the asynchronous data exchange with remote web server by XMLHttpRequest.

Fig.1 Comparison between classic web application and Ajax web application model in system processing



3.3.2 Feature Service

Feature service is a kind of service to read the geographic features. This service provides an interface for the system programs calling. For now, the WFS1.1 of OGC is the most important open standard. In Web-GIS, we may take these geographical features as map source code, and the feature service is to retrieve or manipulate the source code. Many spatial analyses or editing applications may be derived from feature services.

Compare the Web-GIS software package with the Google map, the reason why the WMS-oriented Web-GIS is slower than the Google Map when display the maps is that the Web-GIS transmits the images to the users' browser after dynamically generate the maps while the Google shows the images which previously generated. Those tiling images are stored in server and displayed in the users' browser immediately through AJAX without the duration of generating maps dynamically.

However, the Web-GIS provide lots of spatial analysis functions while the Google Map is more focus on the displaying functions. In view of this, developing the Google-based Web-GIS platform to offer spatial analysis functions with high speed in displaying maps is the main purpose of this paper.

3.4 Mashup

In technology, a mashup is a web application that combines data from more than one source into a single integrated tool; an example is the use of cartographic data from Google Maps to add location information to real-estate data from Craigslist, thereby creating a new and distinct web service that was not originally provided by either source. There are two styles of mashups: Web-based and server-based. Whereas Web-based mashups typically use the user's Web browser to combine and reformat the data, server-based mashups analyze and reformat the data on a remote server and transmit the data to the user's browser in its final form. (Wikipedia)

The Service-oriented Architectures (SOA) is one kind of mashups. It integrates disparate data by making this data available as discrete Web services. Web services provide open, standardized protocols to offer a unified means of accessing spatial information from diverse platforms. These kinds of web services can be reused or even combined to a new service within and across organizations to provide business flexibilities.

4. Practice

Hybrid GIS may refer to the data hybrid or the system hybrid. No matter which kind of hybrid is, it is built for reinforcing the GIS capability by integrating the foreign aids.

4.1 Data Hybrid

It is a portal to receive monitoring data from all sorts of on-site instruments and rainfall data from Central Weather Bureau. The on-site instrument data is formulated by the OGC standard, and the rainfall data is released by web service. In this system, the rainfall value can be estimated by interpolation of relevant values derived from nearby rain gauge stations.



Fig.2 Demonstration platform shows all data from on-site instruments



Fig.3 Calculation of rainfall by interpolation from nearby rain gauge stations

In another system, the platform gets the real time uploaded shapefiles and displays immediately on the Web-GIS by receiving the WMS from heterogeneous data from other providers. Many different data can be overlaid as the WMS layers from diverse sources.

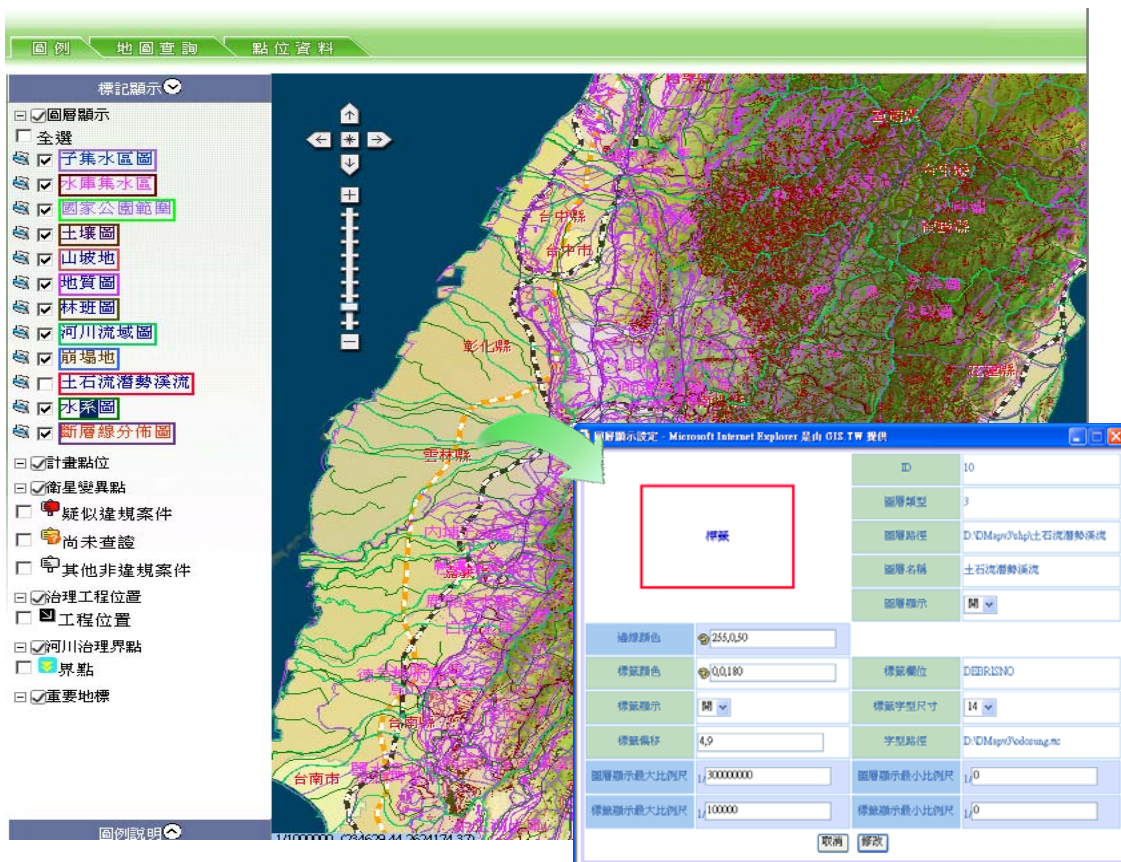


Fig.4 Editing symbol of uploaded shapefile on line

4.2 Service Hybrid

The OGC Web Processing Service (WPS) is an advanced application of hybrid GIS. WPS is designed to standardize the way that GIS calculations are made available to the Internet. WPS can describe any calculation (i.e. process) including all of its inputs and outputs, and trigger its execution as a Web Service.(Wikipedia) In this system, the local government apply NGIS service platform to integrate and compose the services published by other department including the shortest path service, sensor data and the stockpiles allocation.



Fig.5 Combination of services provided from different authorities

4.3 Mashup with GE

One of the mashup with GE is to generate the cadastral map to the KMZ and overlay with Google Earth. It is the most common mashup by transforming the data format and providing 2 kinds of platforms for viewing the land cadastre information. The administrative authorities may use the Web-GIS to make the management decision by reviewing the cadastral maps and land use limitation and restriction via Web-GIS. Meanwhile, the general users may check the Google-based platform to confirm their land parcel location and simple information.

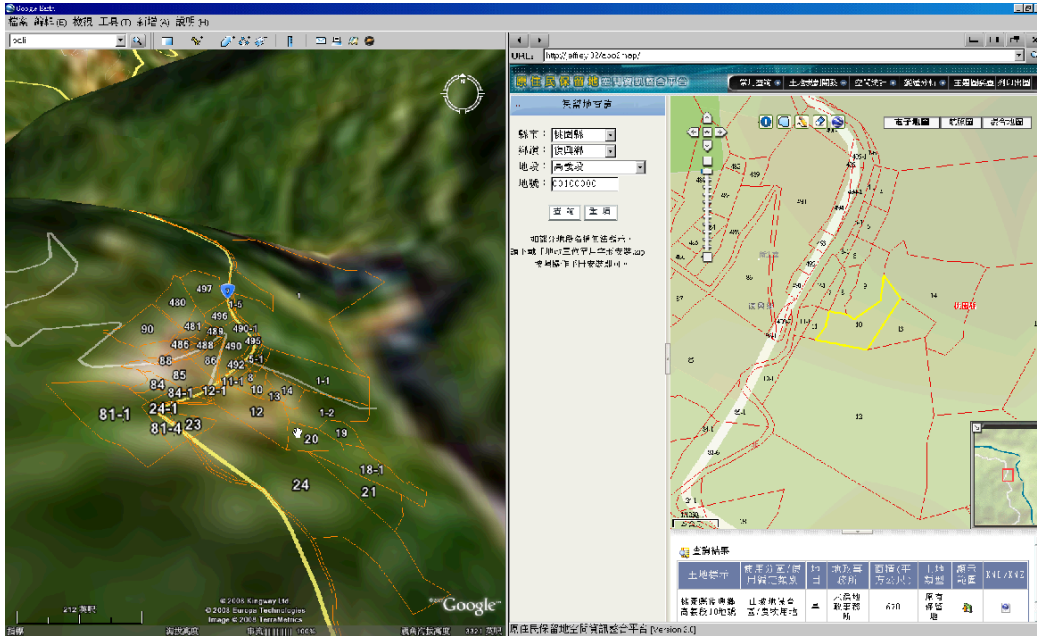


Fig.6 Convert the cadastral maps to KMZ and overlay in GE

The other enhancement practice is to convert the DTM and aerial photo to KMZ. One of the advantages is to increase the accuracy of partial terrain data with high resolution aerial photos. Both of these are providing a more clear vision for users.

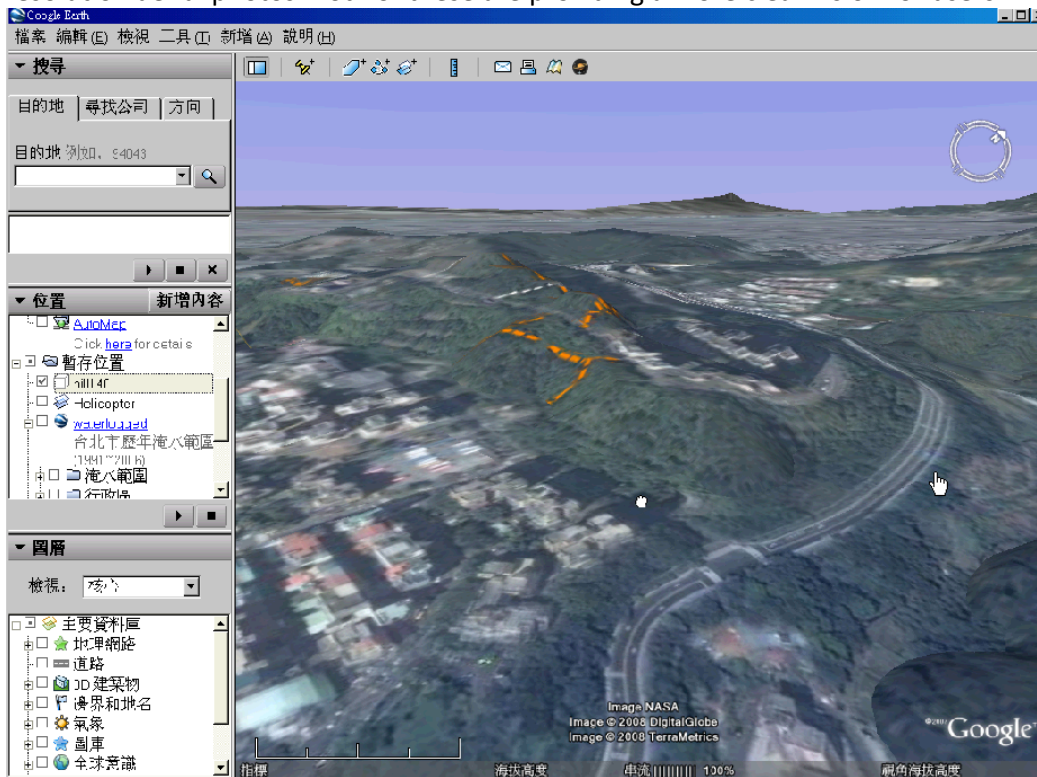


Fig.7 Convert the DTM and aerial photos to KMZ and displayed in GE

When it comes to environmental monitoring, the mobile monitoring vehicle becomes the most important tools to retrieve on-site data. It is very useful to

combine the Web-GIS with the Google Earth to return the real time dispatching route. The vehicle transmits the location to the server every 10 seconds. The vehicle moving route is not only displayed on the Web-GIS, but also can be converted to the KMZ and show the moving path on Google Earth.

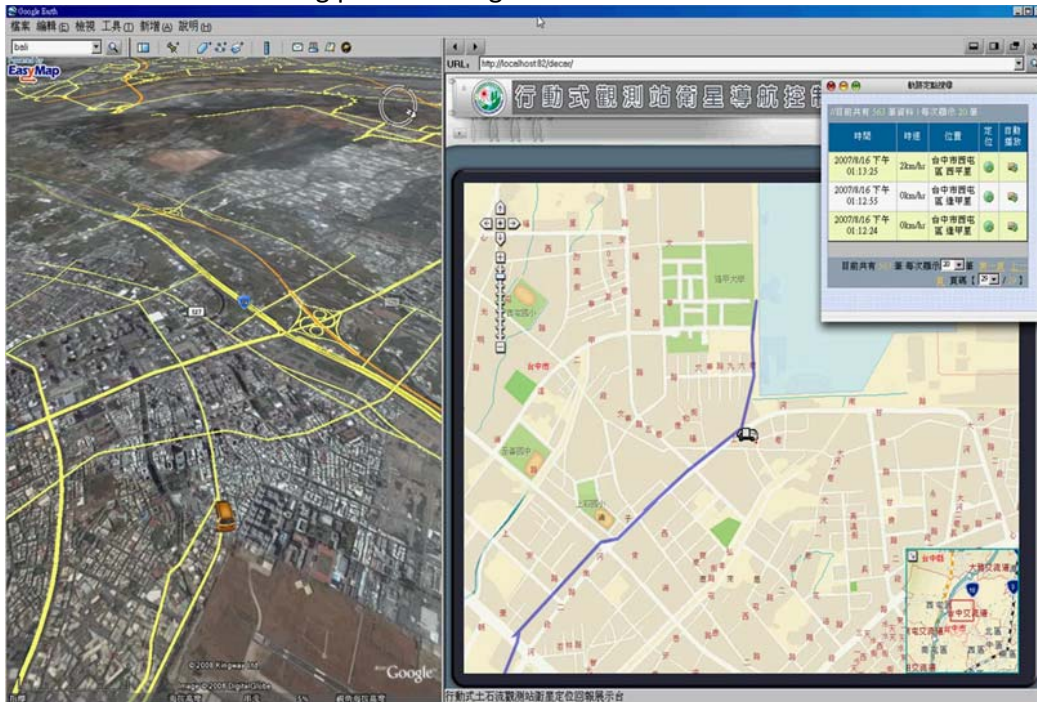


Fig.8 Vehicle moving path displayed by mashup with GE

4. Conclusion

All the subjects like SOA, OGC and SWE are about to unify the standard for sharing the data, providing services, and establishing interoperability mechanism. The hybrid GIS is born to bring up the concepts like web 2.0 or the mashups because of the growing demands from no matter marketing, academic, or governments. Cooperation is one way to make GIS stronger, and it is also the trend to step toward the interoperability for GIS development.

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