WEB-GIS solution for rice cultivation management in Taiwan

Jo-Yu Liu, Chung-Chi Chang, Ying-Hui Chang, Fu-Jen Chien, T.Y Chou

Abstract

Paddy/dry land rotation and non-cultivation period finance distribution is a reward policy that the Taiwanese government offers. The historical cultivated status is used as the criterion to decide if the applicant is qualified for finance distribution. On a yearly basis, the cultivation data were established by investigation through aerial survey and analyzed. However, the colossal volumes of data accumulated result in wastage of resources on data verification and organization.

To efficiently handle such situations, computerized techniques such as GIS, internet, large-sized database (Oracle), and spatial database engine (ArcSDE) are employed to develop a Web-based GIS platform that serves as a tool for query and analysis. This application system can not only query decades of information in few minutes, but also analyze the changes between 2 time periods using online spatial analysis functionalities. Thus, using a GIS approach, the system facilitates enhancing the efficiency of the cultivation management.

1. Preface

On a yearly basis, cultivation data are collected through aerial survey and analysis. Technologies such as remote sensing, GIS and agricultural models are employed to create colossal volumes of digital data. All of these data are used to analyze crop production, and the results are used as reference for agricultural policy making.

Farmers in Taiwan can apply for subsidies if they followed the "paddy/dry land rotation and non-cultivation period" rules established by the government. The local governments reference the cultivation history and check the qualifications of the applicants. The historical cultivation data must have been tracked for the past 20 periods from 1994 to 2003. The quantities of applicants and the users, i.e. the basic level local governments are too numerous, and the historical data too much to manage efficiently.

Meanwhile, it takes much time to retrieve useful information from considerable quantities of paper information and unorganized digital data. On the other hand, the cultivation data are based on the cadastres which may change the land registration as time goes by. It becomes harder to check the same location history with different attributes. When the MIS is maturely established over a long time, cultivation data need GIS to deal with the spatial problems which are difficult to be solved by MIS alone.

In this project, colossal volumes of data were stored and managed in the Oracle

through the spatial database engine (ArcSDE). Periodical cultivation maps and attributes were managed in Oracle, relevant digital information was connected through Sybase, and map and query results were displayed on the GIS platform. The application system used the concept of design pattern and the standard of DCOM/ActiveX to build up the distributed object framework of Web-GIS. The advantage is to enhance the execution efficiency and the load balance. The system applied MapObject to implement the spatial query and analysis on-line, and saving time on secondary development.

2. System Environment

The existing MIS application system used Sybase as its database. To carry out collocation and to cooperate with the existing system, the application needs to directly connect Sybase and retrieve information based on users query. First of all, the information regarding user identification will be sent to Sybase by single-sign on. Afterward, the Web-GIS displays the querying location and historical maps with relevant cultivation data retrieved from Sybase.

To assure information security, 3-tier Internet architecture is the main system framework. The web server is independent from the database server, and placed in a different domain. The encryption mechanism is started when the user's ID is sent from the Sybase to the Web-GIS. As to the developing technologies, the DHTML Viewer is applied to develop the alternative for numerous users and the demand for viewing both large amounts of vector and raster data. Clients do not have to install the plug-in by using the Web-GIS directly, simplifying the process for using this web application system.
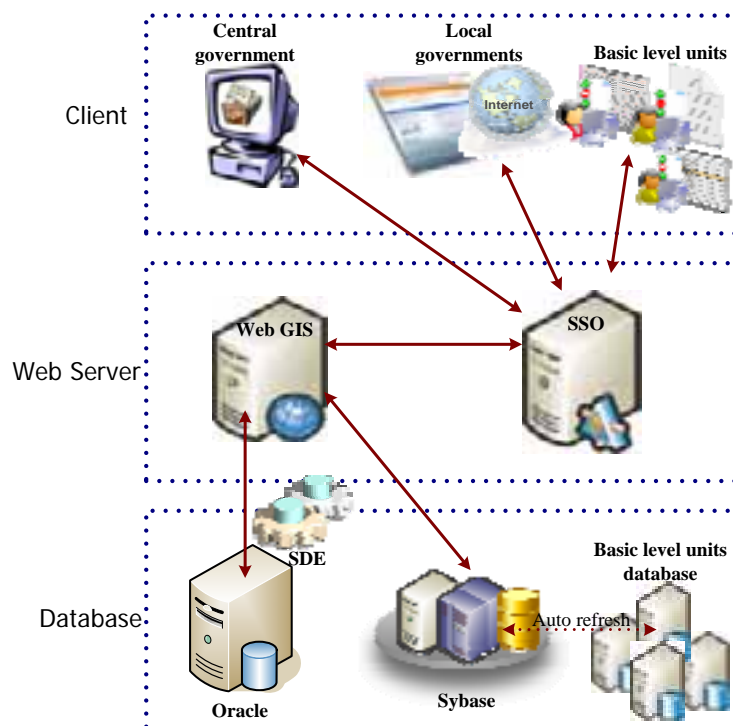

Fig.1 System Environment

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2.1 Map platform technologies

Microsoft FrontPage 2000 and Dreamweaver 2004MX were used to design the user interface. DHTML, JavaScript and ASP were employed to develop the web-viewer. Meanwhile, Microsoft Visual Basic 6.0 was used to develop COM/COM+ and ActiveX Control objects. Objects were integrated by Windows DNA and DCOM to develop the map server. When users send requests from the viewer, the application mechanism will access the database through the web server, and SDE. The application mechanism can access the oracle and the image files at the same time, and overlay both vector and raster data.

The web-viewer offers a convenient, simple and friendly query interface for users to access the database and display the results in the viewer through the map server via electronic map and Internet technologies.
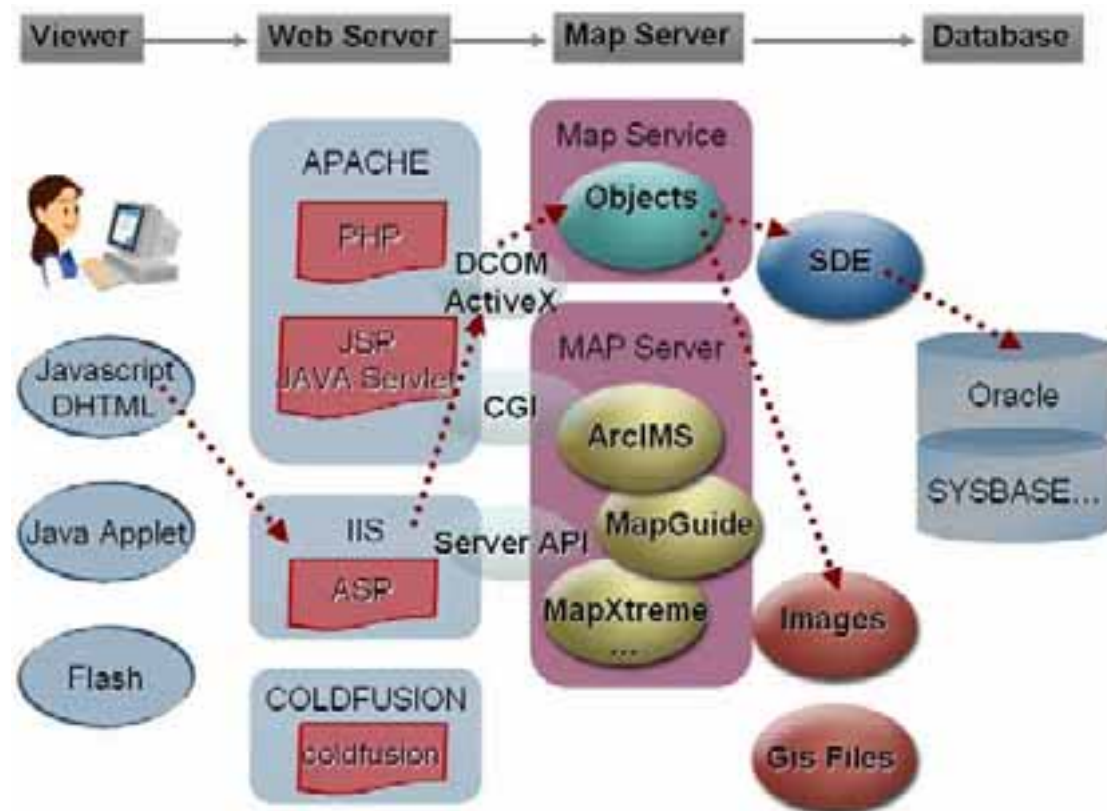

Fig.2 Framework of map platform

2.2 Load Balance

In this case, the Windows DNA framework is used to perform the load balance. Windows DNA is an N-tiers framework. It includes the presentation service layer for front-tier viewer, the business service layer for logical proceeding objects and the data service layer for storing data and storage objects. The client can communicate with the medium through uniform interface and protocol. On the other hand, the business service layer shares the load of single server.

2.3 MapObject

The ESRI MapObject provides spatial analysis functions which help to analyzed 2 periods of cultivation data by spatial location in this case. The functions include the difference, intersect and union, and the function intersect is mostly applied in this case. The spatial data and attributes are stored in Oracle, and MaoObject analyzes the intersection area by the same attributes in the same spatial area. The application mechanism will transmit the image to the viewer, and the user can see the result in their web-viewer.
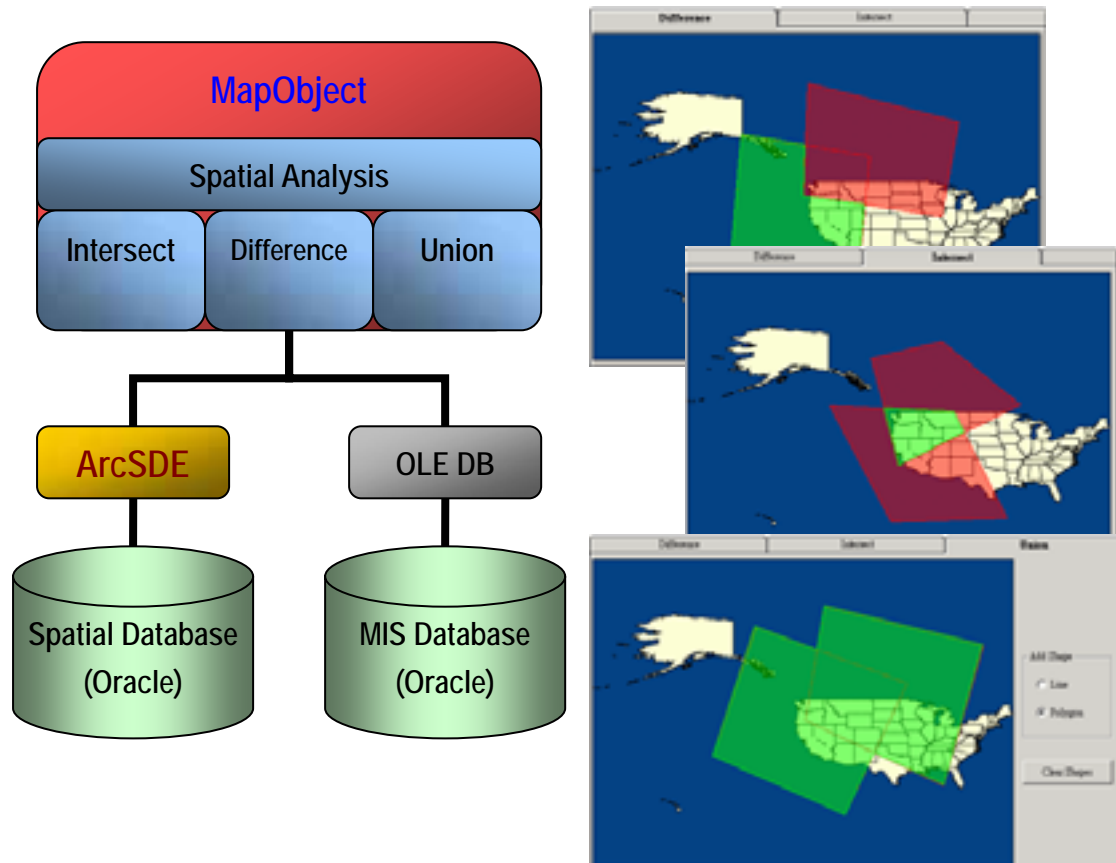

Fig.3 Structure of information analysis platform and the spatial analysis function provided by MapObject

3. Data storage

In this case, there are 3 different kinds of data in 2 different databases:

3.1 Sybase

The majority of cultivation data are stored in Sybase as the database of the MIS system. Sybase includes the land information, paddy/dry land rotation, non-cultivation period information, and users' identification information to access the system.

When Web-GIS receives a request from a user, it will retrieve the historical cultivation data in Sybase as part of its source data. Basically, Sybase is allowed to be read but not edited.

3.2 Oracle

Periodic cultivation maps are digitalized based on digital cadastral maps and aerial photos. Cartographers overlay the cadastral maps and aerial photos to fill in cultivated status attributes twice a year. The original data format is Shapefile which imports to Oracle by SDE. Therefore, Oracle contains spatial information and basic cultivated status attributes for each period. The territories of each period cover all cultivation areas in Taiwan which is a huge volume of data that is produced. Each period of maps contains at least 2 to 6 million records, and each record may include multiple types of information so a post process must be carried out after importing to Oracle. There are already 25 periods of layers stored in Oracle, and 2 periods of new layers will be added every year.

Other kinds of spatial data stored in Oracle are the electronic maps which are the fundmental information for location identification. They are shown on the viewer to help users recognize the real world environment.

ArcSDE is applied as the medium between Oracle and the application. ArcMap and ArcCatalog also cooperate to transfer Shapefile into Oracle database.

4. Spatial cultivation information query system

The functions of the querying system are developed according to the business demands. The main goal of this system is to look up spatial historical information, not only the attributes but also the historical maps are overlapped for display and analysis. The function and the characteristics are as follows:

4.1 Historical information query

The sequence of historical information query is as follows:

(1) Send a request for land section and number.

(2) Search the latest cadastral map and show the location and basic attribute in the viewer.

(3) Send request for historical overlapping information and maps.

(4) Retrieve the last 20 periods of cultivation data from 1994 to 2003, which overlap with the object ID boundary (inherited from step 2).

(5) Draw the overlapping area with unique value by cultivated status and show the historical attributes which are mapped to object IDs.

The historical information query retrieves not only from the attributes of the same land section and land number, but also from the spatial intersection parcels of location boundary. Otherwise, due to the multiple types of information in each parcel, the query must also check for matches in multiple information areas. The results show the spatial parcel and cultivated status changes for each year at the same location, the yearly attributes and the maps with different symbols.

Fig. 4 Historical information query

4.2 Customized query

The map platform is based on the electronic maps, and this web-GIS system provides the functions that query the land parcel and cultivation data via the known spatial coordination or known landmarks. Users can input the coordination or select the landmark, and the system will automatically overlap the cadastral maps to show the location information. Users can all carry out advanced query.

Fig. 5 Query using nearby landmarks

The other kind of customized query is to offer SQL query on-line. Users can retrieve the information by inputting SQL, and the system can return the information not accessed by default query function.

Fig.6 SQL query

4.3 On-line spatial analysis

Spatial analysis emphasizes cultivated status changes between 2 years/periods. It calculates the intersection amount of parcels and areas with defined cultivated status. The area may be analyzed by one land section or by user-defined area. Users can easily manipulate spatial analysis through the web and obtain the analysis results from complex operations.

In addition, analysis of large areas is time consuming. Thus, the booking mechanism was developed as an alternative. When users send a request of spatial analysis of a large area, the system will receive the request and execute the command in the off-peak period. It will send the analysis results and distribution map back to the users via email the next day. This helps to reduce the load on the server and increase performance for other users.

Fig.6 Spatial analysis result sent by email

4.4 Heterogeneous database query
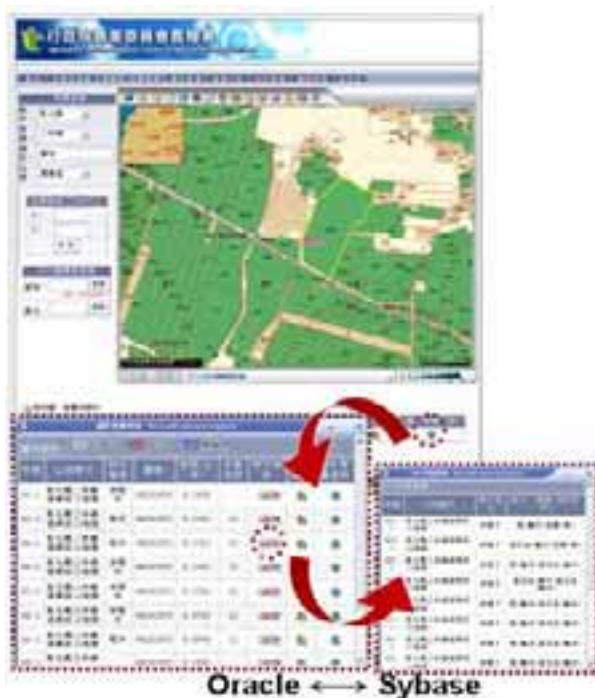
Oracle ⟷ Sybase

Two different kinds of data are stored in 2 heterogeneous databases: Sybase and Oracle. Land owners' information and farmers' information are maintained in Sybase, and cultivated status and map data are stored in Oracle. The application mechanism can query the land parcel information by farmers' ID or name. The land parcel information will be retrieved from Sybase while the maps and the cultivated status information will simultaneously be retrieved from Oracle.

Fig.7 Information exchange between 2 databases

4.5 Layout

The layout contains the map viewer and legends. Users can edit the statement text and define the page size when printing. The layout is the same size as the printed page, so the user may manipulate the print function.

Fig. 8 Layout

4.6 Management

System administrator can manipulate the attribute modification and the users' responses in the management module. It helps the administrators to modify attribution directly through the web to save time and reduce risk when editing enormous amounts of data on a PC.

Logs are stored when users manipulate the system, and the administrator can detect the log-in condition or analyze the system performance via the log. The system helps the administrator to decide if the hardware needs to be upgraded or to provide assistance when use frequency is abnormal.

Fig.9 Log in frequency statistics

5. Conclusion

In this project, spatial analysis and data were retrieved from colossal volumes of data to enhance agricultural management. Manipulation of Oracle and customized map platform composed an efficient web-GIS tool for relevant agriculture units in Taiwan. The customized web-GIS overcome the limitation of web-GIS package, and attemps to reach the following goals:

(1) OGC

The data exchange mechanism should follow the OGC standard and share the information with other government units.

(2) E-GIS to M-GIS

Wireless and mobile devices can be combined with this project to provide more flexible usage for cultivation management. Spot investigation, real time data access, and relevant application can be implemented to extend the usage through communication technologies.

(3) Advanced application

Some cultivation or agriculture research includes mathematical models or other analysis models, which may be integrated with AI (Artificial Intelligence) or DSS (Decision Support System) to implement more advanced application for cultivation management.

(4) 3D management

Virtual reality management is a trend in GIS. The DEM, aerial photos, and 3D models may integrate with digital maps to show the real world. This may provide administrators and general users more "real world" information when making policies or decisions.

Author Information

Primary Author

Jo-Yu Liu

Project manager, GIS Research Center, Feng-Chia University

No.100 Wenhwa Rd. Taichung, Taiwan, R.O.C

886-4-24516669#580, 886-4-24519278

katt@gis.tw

Co-Author

Chung-Chi Chang

Division Chief, Information Center, M.O.I

No.4, Lane 469, Songjiang Rd., Jhongshan District, Taipei City , Taiwan, R.O.C.

886-2-25132233, 886-2-25132244

open@rdec.gov.tw.

Ying-Hui Chang

Division manager, GIS Research Center, Feng-Chia University

No.100 Wenhwa Rd. Taichung, Taiwan, R.O.C

886-4-24516669#500, 886-4-24519278

cindy@gis.tw.

Fu-Jen Chien

Project manager, GIS Research Center, Feng-Chia University

No.100 Wenhwa Rd. Taichung, Taiwan, R.O.C

886-4-24516669#506, 886-4-24519278

jeffrey@gis.tw.

T.Y Chou

Director, GIS Research Center, Feng-Chia University

No.100 Wenhwa Rd. Taichung, Taiwan, R.O.C

886-4-24516669#100, 886-4-24519278

jimmy@gis.tw.