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SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

Low Cost GIS Data Base Solution for Water Utility Network in Sri Lanka

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In 1999 National Water Supply and Drainage Board (NWSDB) commenced developing a Water Utility GIS for the Greater Colombo(GC) area with the objective of improving its operations and maintenance activities. National Survey Department of Sri Lanka was contracted out to produce 1:1000 scale 3D digital base maps from Air Photographs. Available water utility maps were digitized using Autocad Map GIS and updated using Global Positioning Systems and other survey methods. Due to voluminous nature of base maps and utility data it is impractical to store them as a one seamless coverage. Storing these data as separate map tiles leads to several practical constraints such as updating difficulties, searching delays and data retrieval problems. Therefore it is required to develop a Geo-database to efficiently manage these data. It is not feasible to utilize available commercial Geo-databases for this purpose due to their high purchasing and maintenance costs. As a solution PostgreSql, a free Open Source Object Relational Database Management System(ORDBMS) was selected. PostgreSql has a module called PostGIS which handles spatial data and is used by hundreds of similar organization around the world. The software successfully runs on Linux Operating System, which also is a freeware. Geo-database was established in PostgreSQL ORDBMS with necessary table structures, relations etc., to store and manage geometric/attribute data of water features including 3D basemap data. A user friendly interface was developed within Autocad Map GIS to handle data uploading and retrievals. All necessary procedures were introduced to the organization for the efficient management of the Geo-database. Further, an Intranet Web Map Browser was developed to browse the data. Currently the system has 18 themes with total objects of around 800,000 and successfully used by all Water Manager Regions in GC area for their day-to-day activities. This implemented solution provides an excellent platform for the NWSDB to do advance geo data management for low cost.

Introduction

National Water Supply and Drainage Board(NWSDB) is the leading organization responsible for supplying drinking water in Sri Lanka. One of the largest water supply network maintained by NWSDB is the Greater Colombo (GC) water network which is in the Western Province of the country (See Figure 01). Extent of the GC area is around 412 sq. km. and it consists of five water manager zones. Presently there are around 400,000 water consumers in this highly urbanized area and this number is increasing rapidly. Efficient management of this large water network is essential for providing water to the consumers without disturbances. Large scale maps of water network and base map details are extremely useful in this connection. NWSDB has produced first set of the water features and base map details in 1983. These paper maps are well known as NORPLAN maps and they were used by NWSDB as well as many other organizations for their planning purposes during past two decades. However, due to large scale urbanization process in the Western Province water supply network was expanded and these maps were outdated.

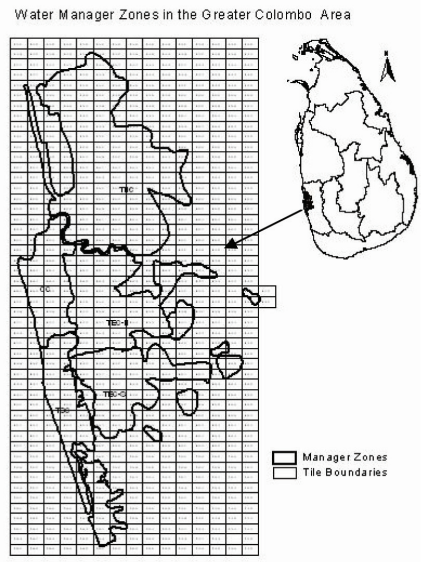

Figure 1. Water Manager Zones of Greater Colombo Area

In 1999 Mapping Section of NWSDB started a project to develop a Water Utility GIS for the GC area with the objective of improving its operational and maintenance activities. This project had several components. Preparation of 1:1000 scale 3D base maps for the GC area was the first task. This was contracted out to National Survey Department of Sri Lanka. Air photographs were taken in the GC area at the scale of 1:8,000 and 3D digital base maps were produced. These base map tiles were developed using Microstaion Software (DGN format) and had 30 data layers. Secondly, using new basemap details as background information, water features from geo-referenced Norplan maps were digitized into AutocadMap. Later these details were ground checked and updated using Global Positioning Systems (and other survey methods) to produce up-to-date set of water utility maps.

Next major task was to store and manage these digital base maps and water utility data systematically in order to extract necessary data sets for GIS applications. It was impractical to keep these maps as separate tiles due to several reasons such as water features cross over the map boundaries, difficulties in querying, updating problems, data volumes etc. leaving only possible solution as to store and manage these data in a geo-database. Even though the project had planned to install a commercial database system for this task, these plans were abandoned due to high purchasing and maintenance costs. Therefore selection and implementing a feasible geo- database solution had become a major challenge for the project.

Methodology

Open source software solution

There was a immense need in the project to find a low cost efficient database management software to manage its spatial datasets. As a solution, consultants suggested to explore possibilities of using available Open Source Software. Such software has been developed by volunteers over many years and become a competitive alternative to the commercial databases. It was found from the internet that more and more companies migrating to these cheaper systems and specifically moderate size organizations are successfully utilizing them. As the need was to find a data base which can be used to store spatial features, PostgreSQL an Object Relational Data Base Management System (ORDBMS) was selected as a solution. PostgreSQL has a separate module called PostGIS which has GIS functionality and facilities to handle spatial objects, both geometry and attribute data. Postgre/PostGIS successfully runs in Linux Redhat 7.0 Operating System which also is a free software.

Development of the database

A Dell PowerEdge 2400 computer with a SCSI RAID5 system, 140 GB of disk was selected as the server. Redhat Linux 7.0 was installed as the operating system. Postgre and PostGIS software were downloaded from the internet and installed as the database server. All database table structures were created to store geometric and attribute properties of water features as well as 3D base map data. These tables contain a special field to store x, y, z coordinates of the spatial features(See Table 1). In addition indexes, metadata tables, relations, stored procedures etc were developed as required. Further all user groups and users were created with necessary privileges to ensure data security.

On the client side AutoCad Map was used as the GIS Software in Windows 2000 (or in Windows XP) environment. An user interface was developed using AutoCad Map Visual Basic for Applications(VBA), which can communicate with the database via Postgre sql Open Data Base Connectivity (ODBC) Driver (See Figure 2). This advance user friendly interface basically handles data uploads i.e. from Autocad Map data to the data base and downloads i.e. from database to Autocad Map.

Table 2. Water pipeline table structure

Fields	Type	Sample value
gid	integer	1002
digi_from	character	oth
diameter	integer	63
map_number	character	66-04-04
proj_name	character	TSC
class	character	d
diam_units	character	mm
material	character	pvc
type	character	dist
status	character	tv
laid_on	character	1983
period	character	23
file_num	character	10/25/97/3260
cement_lin	character	y
Year_lin	character	1990
geom	geometry	LINESTRING (402356 493909,402383 493901,402172 493015)

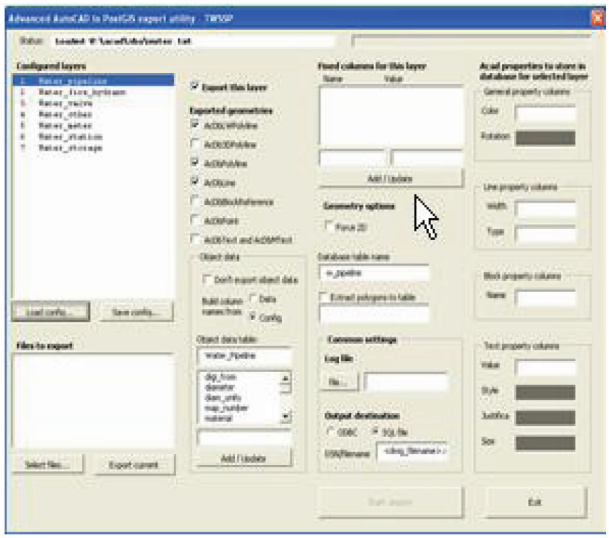

Figure 2a. VBA Interfaces for data upload/download

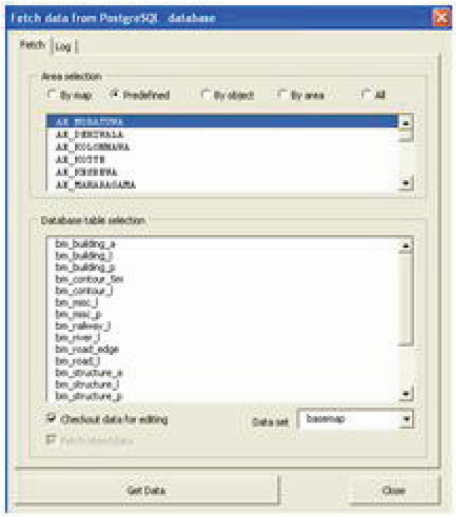

Figure 2b. VBA Interfaces for data upload/download

To administrate the database from the client side Postgresql has a module called pgadmin. This is also a user friendly software and most of the database administrative tasks could be accomplished without difficulty. Also the connectivity of windows and Linux is established with 'samba' software, which is also available freely.

Once the database settings and interface was tested for their accuracy all AutocadMap tiles were quality checked and uploaded to the data base using the developed interface. A set of procedures and guidelines were introduced to the operational staff to ensure correct usage of interfaces and the database. This was an essential step for maintaining an error free efficient database.

Web Map Browser

In order to browse the data stored in the database an open source Minnoseta Internet Map Server software was installed in the server. This map browser fetches data online from the data base and displays in map form. Also the browser has facilities to query attribute data.

Decentralization and data updating mechanism

As there are five water manager zones in the GC area, a read only copy of the database and the web map browser were provided to each zone for their usage. For continuous updating of water features a data set for each manager zone is extracted from geo-database using the interface and provided in Autocad Map format. Manager office staff is supposed to update this Autocad Map dataset and send it back to the Mapping Section for updating the master database.

This dataset is quality checked at the map section and uploaded to the database. Then new dataset is fetched from the database and send it back to the manager office for updating and references. This method ensures regular database updating mechanism.

Results and discussion

Currently the system has 18 themes with total objects of around 800,000 and successfully used by all water manager zones in the GC area for their day-to-day activities. Planned updating routines are functioning well at all manager offices. Datasets are being fetched from database directly to the ArcGIS, AutocadMap format etc for GIS applications (See Figure 3).

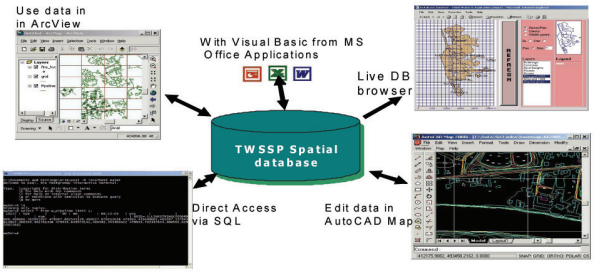

Figure 3. VBA Interfaces for data upload/download

This spatial database can be further utilized to extract statistical data of water supply network, such as obtaining total pipe length of water supply network under a user specified criteria.

Also the database has facilities to link external databases (eg. Oracle). Few attempts made to link consumer database maintained at the commercial section of NWSDB to the map database (Postgre/PostGIS) showed promising results.

The solution adapted for the development of the system was an integrated approach with two main software types. They are low cost commercial GIS software and cost free open source software. Since most of the installed database software are open source, there is a very little cost involve-

ment for the database implementation. As these software are being continuously developed by group of volunteers, future versions are also available with more functionality.

Costs involved directly with the database solution is hardware costs for the server installation. In future required hardware upgrades will be necessary on the server side as well as on the client computers. Another cost is related to training of employees and keeping their knowledge within the organization. Since it is often impossible to keep IT specialists many years, the management has to take necessary measures to ensure that required knowledge is documented. Therefore the systems and routines were well documented to ensure sustainability of the current system.

Conclusion

To manage base map details and water utility data NWSDB has successfully utilized an integrated solution which included low cost commercial GIS software and open source database management system. This system is currently operational covering five water manager zones in the GC area. Implemented solutions provide an excellent platform and give a good start in implementing advance geo-database solutions to support their activities for low cost. This method can be easily adopted to established geo-database for organizations in developing countries

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