Introducing a framework for Cost Effective Web-GIS solutions for Sri Lanka

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Abstract— **Sri Lanka is still in its infancy of adoption of GIS solutions and not yet experiencing the use of web-GIS. The main reasons behind not adopting such are the high cost of proprietary web-GIS technologies and technical unawareness. These prevent the application of web-GIS for the betterment of developing countries including Sri Lanka. This application proposed a framework for the adoption of open source solutions for web based GIS applications with the use of existing digital datasets of Sri Lanka. The technology selected includes the *UMN MapServer,* map server *PosrgreSQL/PostGIS* databases and *Apache* web server, all are FOSS tools. A prototype is developed for land usage analyzing application for Sri Lanka . The other possible directions for adoption of the same architecture for web-GIS solutions in the context of Sri Lanka are analyzed.**

Keywords – **web-GIS, FOSS, mapping in Sri Lanka**

1. INTRODUCTION

The history of mapping in Sri Lanka runs to several centuries back. The Survey Department of Sri Lanka which started its work in year 1880 lead the main role of creating maps required for country's different purposes, starting with land use titling[1]. It started adopting computerized systems to digitize aerial photographs and preparation of digital spatial data around 1990's and introduced GIS to the country. GIS is a "*computer based information system that enables capture, modeling manipulating, retrieval and presentation of geographically referenced data*" [2].

Most of the high level decisions as well as common information requirements of human beings are based on geographical location. GIS provides a means not only to creating spatial data but visualizing large volumes of such data in easily understandable manner. It provides facilities to analyze spatial data based on different criteria, integrating them with non spatial data including vital socio, economic data [3].

Urban Development Authority of Sri Lanka which has adopted GIS techniques with support from World Bank around 1999 now plays the leading role in providing GIS solutions to the Government and commercial users [4]. The services it provides include road planning, land usage mapping, new urban area planning and temporal data analysis related to environment and urbanization [5]. Road Development Authority is using GIS systems for analyzing effects of land slides on road network. There are few other organizations using GIS applications but usage is limited to highly technical people involved in little specific areas. All service providers are resides in Colombo, capital city and for distribution of visualized information manual means are being adopted by all of them. Overall the GIS in Sri Lanka is still in its infancy.

With the rapid development of web services, GIS has incorporated into web based systems where accessing to geography related data through web is becoming a big consumer attraction worldwide. These applications are very much new to Sri Lanka.

This work is an attempt to propose web-GIS solutions in the context of Sri Lanka, to provide timely and easily accessible information for decision makers and the general public for their information requirements. The study does not cover preparation of digital data for such an application and assumes t the use of existing data sets available within the country.

2. WEB GIS ARCHITECTURE

A web GIS application is a "*system that makes geographic information available on the web through geographic representations and often allows map interactions such as zoom, pan (movement) access to descriptive information related to maps etc"* [6].

A typical web GIS system will consist of map handling servers, web servers, several databases including spatially enabled databases, web clients and supporting hardware. The core of a web map application is the map server, which communicate with the web server and database/files and response to client's requests as processed map data. Data of a web GIS application can be resides in a file system or a database which support spatial data. A minimal component of such, which can be adopted in the context of Sri Lanka, where multiple web mapping servers or use of different databases are not applicable at present is illustrated in *Fig1*.

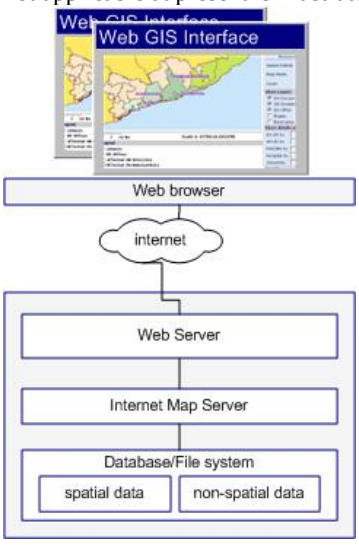

Figure 1. Architecture of a typical web-GIS Application

A key feature of any GIS application is dealing with large amount of data to produce a map. In web-GIS, several

techniques are used to handle this. One option is the passing of the map related data in vector form to the browser and generate the image on clients machine (thick client).Other option is to generate the map according to the user requirements in the server it self and pass the map to the client (thin client). Passing data in vector form is much faster than passing the rendered image where request of each map mean passing a separate raster image [7]. Another technology allows user to download a rendering machine and all maps are generated in the client machine, which is the fastest way in this context but needs faster hardware than just using a standard web browser in a low end machine. (eg GoogleEarth)

A true web GIS system provides facilities to generate dynamic maps interactively while providing interface for information retrieval through a map and means much more than a static "image map". The distribution of GIS data for information requirements in different fields become easy and user oriented with web-GIS. Common web-GIS based applications include disaster relief support systems [8], town information systems, city guides, and urban planning [9] , which are having impact on community as a whole.

3. EXISTING SYSTEMS IN SRI LANKA

Few attempts on web-GIS applications of Sri Lanka is done on the field of disaster management. Soon after the Tsunami disaster in December 2004, Cornel University has attempted to provide a web-GIS tool to highlight damaged hospitals of Sri Lanka [10]. It has minimal capabilities of a web-GIS but failed to provide usage it intended to have. The technology used is Manifold GIS, a commercial web mapping software tool. Department of Graphics and Multimedia of SLIIT has earlier proposed FOSS based technology for post disaster recovery management with web-GIS support [11].

4. PROBLEMS RELATED TO ADOPTING WEB GIS SOLUTIONS IN SRI LANKA

All stand alone GIS systems used in Sri Lanka are commercial ones. Due to the high cost of them, in many cases they are adopted with support from various grants and technical support. Examples are GIS units in UDA, Survey Department and Agrarian Development Board [12]. The costs of commercial web-GIS technologies which are usually provide as extension to existing stand alone applications are very costly and questionable worth spending for a country such as Sri Lanka The GIS community in Sri Lanka is not much aware of exiting FOSS technologies for GIS including web-GIS. This technical unawareness leads to holding of distribution of benefits of web mapping applications to the country through cost effective FOSS based solutions.

Web-GIS itself cannot provide much meaningful solution and it has to be incorporated with a data intensive web based information system. The data required to provide sufficient information visually including both spatial and non spatial data need much consideration. In Sri Lanka the collaboration of spatial data with socio-economic data is rare and available spatial datasets have no or few related information.

The internet infrastructure of the country also has to be considered when adopting web-GIS solutions. It is advisable to use vector data processing rather than raster data processing where common internet bandwidth of the country is only 56kbps.

5. PROPOSED TECHNOLOGY

There are many proprietary and open source web-GIS tools exits, especially internet map servers. *ArcIMS* by *ESRI*, the industry leader dominates the proprietary GIS software market. *ArcIMS*, is meant as an extension to *ArcView* [13], stand alone application. The end user need to have Java enabled web browser. The cost of the technology is in millions of rupees. There are very few databases which support spatial data handling; Oracle spatial extension is the leading commercial tool.

FOSS tools for web mapping applications are well developed as commercial tools while providing interoperability, access to source code and compatibility with common GIS data standards [14]. These include database support, map servers and projection and spatial data processing support tools.

UMNMapserver(http://mapserver.gis.umn.edu/), *MapBender*(http://www.mapbender.org/), *MapBuilder*(http://www.mapbuilder.net/) and *Geoserver*(http://docs.codehaus.org/display/GEOS/Home)are some well accepted map servers, which are compliance with Open Geographic Consortium standards [15]. When selecting a map handling server, map processing type (thin client/thick client) ,support for existing data formats, query processing, easy deployment and compatibility with other supporting software were analyzed. *UMN MapServer* which is considered as the world's leading open source open source web mapping tool is selected as the map server. The key features of *UMN MapServer* which make the deployment suitable for Sri Lanka are as follows.

- Acquisition cost of the software is minimal
- Thin Client approach for web mapping is used. Users are not required to have any other additional tool than a standard web browser. This provides a effective mechanism as the user is completely free to use any browser and need not install any software or be familiar with any web or web -mapping technologies.
- There is no binding to any specific language; many other tools (Eg:ArcIMS,) are bound to Java, though it's not a disadvantage.
- The user can interact with the map and retrieve information as a map and /or as normal text based information.
- Additional tools for easy deployment and testing of the work are provided including direct support for *shape* file format which is the most common vector file format used in GIS and support for other vector file formats through the *GDL* library. Similarly support for *Geotiff* raster file format is directly available and other file formats can be supported through the *GDL* library.

- Compliant to the *OGC* Specification, Web Map server and Web Feature Services support; data residing in different web map servers can be accessible.
- Support for database access; *PostGIS* support is directly incorporated but can extend to support popular and well established other web database systems such as *MySql* and *Oracle Spatial Extension*.

The *Apache* web server was selected as the web server. It is considered as the best open source web server which is used worldwide successfully. *MapServer* can work with the Windows *IIS* server as well but as then it will be bound to Windows environment.

For simple applications with limited analysis, data resides in flat files can be used for internet mapping. When it comes to sophisticated mapping and query processing, support of a database is desirable; flat file systems does not provide any of the capabilities of a database .Therefore, the possibility of using a FOSS database is investigated.

MySql is not meant to be a spatial support DBMS but geometry information can be handled in two separate numeric columns and can be accessed via *MapServer*[16]. But the spatial support of *MySql* is limited and on revision *PostgrSQL* database, a FOSS database has most features present in large commercial databases such as triggers, views, foreign key referential integrity, sophisticated locking and features which they are not having such as user defined types [17]. It support spatial data management through *PostGIS* database which runs top of *PostgreSQL.UMN MapServer* directly support retrieving data thorough *PostgreSQL / PostGIS*. It provides a mean to add spatial indexing to speed up the query processing.

GIS data are available mostly in standard *shape* file format. The dumping of data to *PostgreSQL* can be handled trough "*shp2pgsql*" utility, which runs on command line and effectively creates table schemas based on shape files and populate the spatial database with them.

The basic mechanism UMN *Mapserver* uses for interactive mapping is passing CGI variables through *HTML* forms. It supports more sophisticated means such as *phpMapscript*, java support through *Kamap*. The structure of the map is given by native file format *.map*, which is used by *UMN MapServer* to communicate with the web browser. *UMN MapServer* handle complicated queries through *.map* file to retrieve data in useful form (report) to present in a web page through same *.map* file. The process is supported by *HTML* based template file.

Therefore ,the selected framework consists of U*MN MapServer* ver 4.8.3 ,*Apache* web server ver 2.0.58 ,*PostgreSQL* ORDBMS (ver 8.1.4), *PostGIS* RDBMS (ver1.2.1) , Software on the Server Side. The selected technology is illustrated in *Fig.2*.

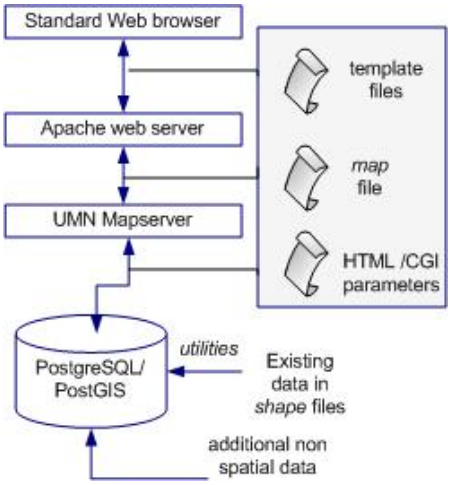

Figure 2. Proposed Architecture for a FOSS based web-GIS Application

6. LAND USE MAPPING OF URBAN AREAS OF SRI LANKA

UDA is the governing body handling land usage in urban areas of Sri Lanka. Once an area is declared as urban area, the land usage of that area is planned by UDA and users who want to involved with development of such area work closely with UDA to identify suitable lands for different constructions. Temporal analysis of land usage is important to identify the trends in urbanization and proper planning.

7. APPLICATION

The application is an attempt to demonstrate the use of selected technology for temporal analysis of land usage in Colombo municipal council area of Sri Lanka. The selected area is changing fast with urbanization.

System provides web interface with facilities to analyze land usage based on time, property type, value, and possible expansion directions. For an example an investor can acess the urbanization pattern and identify the locations for allowed construction types in different areas through web-map interface. Standard features such as zooming, panning printing maps and map based querying facility are incorporated.

The potential users of the system would be investors, valuation officers, property holders of that areas and officials in UDA and other regulatory bodies of Sri Lanka governing land usage decisions.

All data raw data were in shape file format and are in 1:5000 scales. Data sets for year 1996,200 and 2005 are used. PC having configurations Pentium 4, 3GHz CPU, 512MB RAM, 80 GB HDD, Fast Ethernet NIC, 52X CD ROM drive, Graphics card with 128MB VRAM is acted as the server for the prototype application. All servers and database resides in this PC. *MS4W -2* bundles with, *Apache 2.0.58* is used as this assists easy configuration of both servers.

Fig3. shows a comparison of land usage in two years. It clearly shows, new apartments, banks and reduction of shanties around Beire Lake at the heart of Colombo, Sri Lanka.*Fig4.* shows a query result , retrieved by clicking a building.

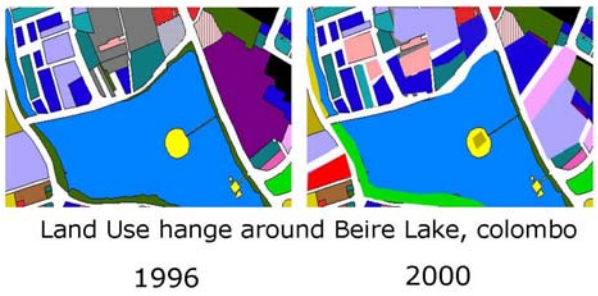

Figure 3. Land use Change (year 1998/2004) , commercial property

Data as at year	1996	2000
Location Type:	Vacant Land	Comercial Area
Area:	200 sqm	225 sqm
Land Location ID:	CMC5045	CMC5045
Is building ?	Y	Y
Type:	D3	B 12
Floor Area:	100 sqm	25600 sqm
No of Floors:	1	8
Entrance:	5m	10m
Main Road:	Baybrook Lane	Baybrook Lane
Width of Main Road:	20m	20m
Description:	no occcupants, damaged building only	occupied by JetAir, SeaMarketing,

Figure 4. Spatial Query Result

8. DISCUSSION

Being a third world country with GDP of Rs. 2365 billion [18] where 4.1% is spent on ICT [19], spending huge amount of foreign currency on software which are essential for distributing benefits of IT to community of the country is a challenging task. Sri Lankan IT sector is matured enough to provide the expertise knowledge required to deal with FOSS. This paper proposed a technical frame work based on FOSS to adopt web GIS applications to Sri Lanka with successful case study with existing digital data of Colombo Metropolitan area. The prototype application uses only basic features of the technology adopted. The same can be enhanced and can be applied to assist in providing low cost solutions to different fields, where location based information is vital for decision makers and such can be provided through a web based system. These involved on-line route planning, web based tourist information systems dealing with interactive maps, environmental mapping and pre - disaster awareness planning. There is an ongoing project on road network analysis by same authors.

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REFERENCES

[1] History of Mapping and GIS in Sri Lanka [online]. Available from: <www.ucsc.cmb.ac.lk/gis/gis_mapping_history.html >[Accessed on 05.07.2006]

[2] Worboys M. GIS:A Computing Perspective ,:Taylor and Frances,1995

[3] What is GIS? [online].Available from: <http://www.gis.com/whatisgis/whatisgis.pdf >[Accessed on 15.05.2006]

[4] Anon. Colombo Metropolitan Regional Structure Plan,Study of Colombo Central Business District, UDA, Ministry of housing and Urban Development, 1998

[5] Gamage P. GIS in urban Planning, Msc Lecture series, University of Peradeniya, 2005

[6] Alameh N, "Chaining Geographic Information Web Services," IEEE Internet Computing, vol. 07, no. 5, pp. 22-29, , 2003.

[7] Robert I. Dunfey, Bruce M. Gittings and James K. Batcheller Towards an open architecture for vector GIS Computers & Geosciences pg - 4 , Volume 32, Issue 10, December 2006, Pages 1720-1732

[8] A. Mansouriana, A. Rajabifardb,_, M.J. Valadan Zoeja, I. Williamso. Using SDI and web-based system to facilitate disaster management Computers & Geosciences, Volume 32, Issue 3, April 2006, Pages 303-315

[9] Culshaw MG, Nathanail CP, Leeks GJ, Alker S, Bridge D, Duffy T, Fowler D, Packman JC, Swetnam R, Wadsworth R, Wyatt BSci Total Environ.The role of web-based environmental information in urban planning--the environmental information system for planners.2006 May 1;360(1-3):233-45. Epub 2005 Oct 20.

[10] Tsunami website of damage locations[online].Available from:<http://polarbear.css.cornell.edu/srilanka/>[Accessed 17.08.2006]

[11] N, Fernando N,Widyasekara.S,Dias D, A System based on Web–GIS for Post-DisasterRecovery Management, IEEE ICIA 2006 conference proceedings,Colombo, Accepted for publication

[12] ArcNews Online : Sri Lanka Uses GIS for Planning and Management of Irrigation Systems [online] Available from: http://www.esri.com/news/arcnews/winter0304articles/sri-lanka.html [Accessed 05.08.2006]

[13] Product overview [online]. Available from: <http://www.esri.com/products.html> >[Accessed on 01.08.2006]

[14] Cavalini P.Open Source and free GIS: a way out? [online]. Available from:<http://www.gisdevelopment.net/technology/gis/techgis_004pdf.htm>[Accessed 08.04.2006]

[15] OpenGIS® Specifications (Standards) [online]. Available from: < http://www.opengeospatial.org/standards> >[Accessed 02.05.2006]

[16] OGR Direct Connection to MySQL [online]. Available from: http://mapserver.gis.umn.edu/docs/howto/ogrmysql/?searchterm=MySql [Accessed 25.06.2006]

[17] How does POSTGRESQL compare to other DBMS's? [online]. Available from : <http://www.postgresql.org/files/documentation/books/aw_pgsql/node193.html#SECTION00296140000000000000000>[Accessed 25.06.2006]

[18] Annual report 2005 central Bank [online]. Available from:http://www.centralbanklanka.org/AR2005data/Key-Econ-Indi.pdf [Accessed 20.08.2006]

[19] ICT at a glance-Sri Lanka [online] Available from: <http://devdata.worldbank.org/ict/lka_ict.pdf > >[Accessed 15.08.2006]