THE DEVELOPMENT OF WEB MAPPING APPLICATION USING OPEN SOURCE GIS SOLUTION

Xianfeng Song, Yasuyuki Kono, and Mamoru Shibayama

Center for Southeast Asian Studies, Kyoto University

46 Shimoadachi-cho, Yoshida, Sakyo-ku, Kyoto 606-8501, Japan

E-mail: song@cseas.kyoto-u.ac.jp

ABSTRACT

The Open Source GIS Software is growing in popularity within geo-informatics community. The software with a strong momentum, such as Minnesota Mapserver, PostgreSQL/PostGIS, GRASS GIS, and GDAL/OGR packages, have begun offering a technically competitive and open-source alternative solution to the proprietary software. This paper illustrates such an Open Source solution to web mapping service, by which the data preprocess and the construction of prototype system both used merely open source GIS software. Although this system serves Environment Cambodia on the Web, the methodology can be applied elsewhere for similar processes.

1. INTRODUCTION

The open source license guarantees the freedom to read, redistribute, modify and use the software freely (OSI). This license plays an important role in breaking down barriers where the cost limits the use of public spatial data and the access to GIS tools. With an effort, the open source GIS has grown its popularity in geo-informatics community.

This paper illustrates an open source GIS solution to web mapping services by means of the development of an online prototype system - Environment Cambodia. To be open and interoperable, the prototype system was designed to be compatible with OGC WMS specification. The data preprocessing and the construction of web mapping system both used merely open source GIS software (see http://aris.cseas.kyoto-u.ac.jp/khmer/).

The development of such an open source system clearly illustrates the logistics of open system architecture, the orchestration of the interaction between open source softwares, the performance of integrated system, and a matter of concern to function limitations or bugs. As the geographic datasets used in this work contain a huge volume of collections, this, to some extent, is also an experiment that examines the capability of open source GIS solutions in building a large-scale GIS system.

2 OPEN SOURCE WEB MAPPING SOLUTION

2.1 Prototype System

The prototype system of Environment Cambodia adopts a solution that has a lightweight client and a heavyweight backend-processing server, in order to speed up processing a huge volume of GIS datasets. The system has a multiple-layer architecture consisting of three parts – browser, map server and database server (Figure 1).

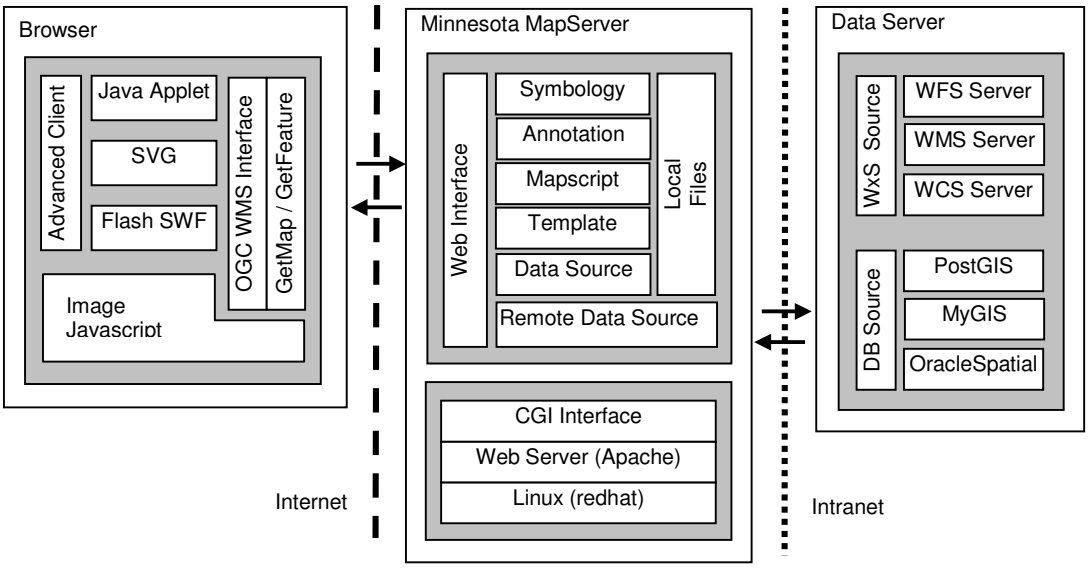


Figure 1. Open source prototype system for web mapping.

The main component – map server for constructing our web mapping service is based on Minnesota (UMN) Mapserver. It runs on the stable open source platforms – Redhat Linux OS and Apache Web Server, which are two popular and powerful platforms, providing a secure, efficient and extensible support to their child programs.

The database system we used to store the large volume of GIS dataset is the postgreSQL platform, whose spatial data engine – postGIS speeds up data access to spatial databases using spatial index technology.

The map clients in browser deploy multi-media graphic technologies: Java applet – jBox, SVG, and Flash SWF. The interoperation between mapclient and mapserver is implemented in both the Mapserver CGI interface and the OGC WMS Interface, but the advanced clients we programmed access map and retrieve attribute only via the WMS interface. All of clients serve web users an impressive look-and-feel.

2.2 OGC WxS Specification

OGC Web Map Service defines a set of open standard interfaces for web-based client/map-server interactions. It mandates communication parameters to access a WMS-compliant server and solves the interoperability problem among Web clients and servers on basis of HTTP. Thus, the advantage the web provides for broad access is taken again to enable the isolated spatial sources of this network to be connected.

The WMS specification work enables web-mapping applications to work cooperatively and to operate reciprocally without need to understand the details of the backend implementation. This greatly promotes the interoperation between web map servers on Internet. The WMS is not single, but there is Web Feature Server (WFS) for vector correspondingly. Moreover, the Web Coverage Server (WCS) is also under development. The irreversible movement to standards is leading to one big spatial web (McKee, 2001).

2.3 Open Source Map Server

There are several open source map servers with broad deployment and advanced functionality, for example, Minnesota Mapserver, GeoServer and Deegree. All of them have strong momentum and are able to be viable alternatives to proprietary map servers.

According to the declaration of supporting OGC WFS/WMS specification, all servers are compatible with OGC WMS interface; GeoServer and Deegree fully implement OGC WFS supporting additional transaction operations of GIS database– insert, update and delete, while Mapserver only supports basic WFS functions. The Environment Cambodia currently focuses on the application of WMS on map browse and geographic feature query. We chose Mapserver, other than GeoServer or Deegree, because it has an excellent performance of functionality and speed on processing large volume datasets.

The Mapserver is not a full-featured GIS system, but provides enough core functionality to support a wide variety of web applications. It is primarily written in C/C++, but it supports as well the scripting access to the Mapserver C API via popular script languages such as PHP, Perl, Python Java etc. This cross-platform development environment eases developing spatially enabled Internet applications (Raghavan, V., Santitamont, P., Masumoto, S., and Honda, K., 2002).

3 OPTIMIZING SERVERSIDE GEOPROCESSING

3.1 Dataset Used

The data sources used include the free copy of 1:1,000,000 Vmap0 (formerly known as Digital Chart of the World)), the open source Landsat MSS and TM/ETM scenes at Global Land Cover Facility, the 1:500,000 Cambodian geology maps, the 1:100,000 Cambodian topographic maps and Land Use maps. Among the above, the Landsat MSS and TM/ETM data is in either GeoTiff or HDF4 format, Vmap0 is VPF, and others are Arcinfo coverage data.

The Mapserver can support the above formats directly or via spatial components. Nevertheless, the data preprocessing mentioned in section 3.2 and 3.3 still needs to improve the Mapserver performance, especially, in database access and satellite image visualization.

3.2 Spatial Indexing Large GIS Database

All the vector datasets were converted into the postGIS/postgreSQL database using OGR plus OGDI driver, because the spatial index greatly speeds up GIS data access as the indexes on normal fields do. We had an experiment in comparing the system performance where the Mapserver was fed shape files and postGIS data source respectively. The tested dataset is Vmap0, a global database with four CDs.

The Vmap0 was converted into Shape format and imported into postGIS respectively, and then, the quadtree spatial indexing for shape files and the spatial index (GiST) were built correspondingly. The result showed that the use of spatial index of postGIS/postgreSQL was about 8-10 times faster than the quardtree-based spatial index of shape files. The examination also indicated the change of quadtree depth had no significantly improvement in server performance, perhaps because the volume of Vmap0 shape files was too large.

3.3 Image Preprocessing

3.3.1 *Image Composite*

The Landsat satellite scene is stored in a separate band. To enable the Mapserver to render a pseudo-color image to web users, all single bands were merged into one multi-bands image and saved in GeoTiff format. The composite processing used GDAL, GRASS and LibGeoTiff toolkits. The HDF4 bands were converted into GeoTiff using GDAL with HDF4 support, and then, single band GeoTiff files were supposed to be composited as follows:

GeoTiff ---(r.in.gdal)--->GRASS --- (r.out.erdas) ---> ERDAS --- (gdal_translate) ---> GeoTiff

However, the ERDAS (.lan) exported by GRASS (version 5.3) was not compatible with GDAL, although the documents indicate they should be so with each other. We extensively tested a successful conversion as follows:

GeoTiff ---(r.in.gdal)--->GRASS --- (r.out.ppm3) ---> PPM --- (gdal_translate) ---> TIFF
|
GeoTiff ---(listgeo)--->GeoTag --- (geotifcp) ---> GeoTiff

This conversion requires all bands should have the same spatial extent and the same number of pixels in width and height. Otherwise, the bands would not match each other.

3.3.2 *Tile Indexing and On-the-Fly Raster Resampling*

The Mapserver with GDAL support gives a high-performance read access to remote sensing images. The high performance is achieved particularly though GDAL library, GDAL utility and GDAL supported raster files.

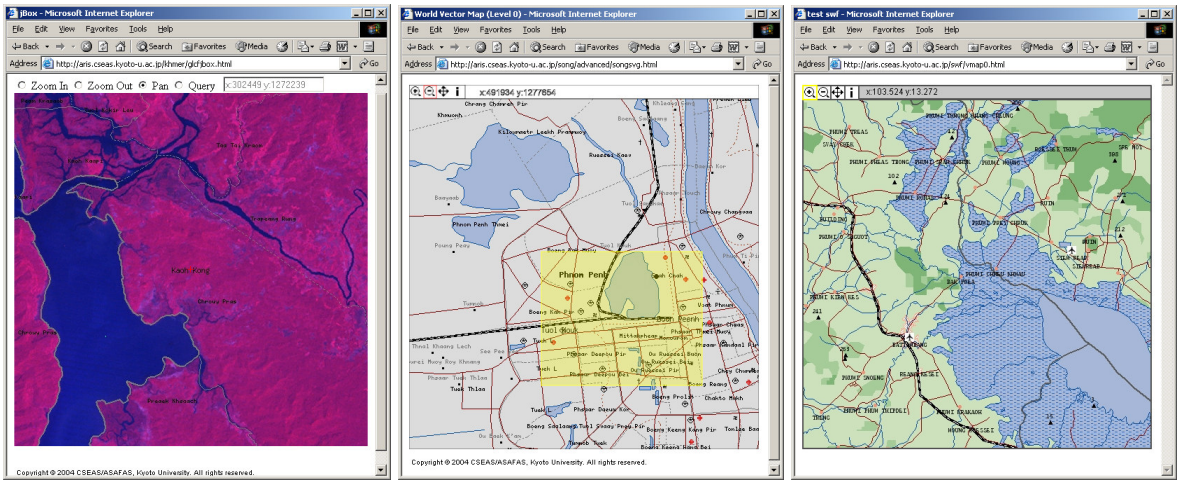
The Cambodia territory occupies 18 Landsat MSS scenes. If mosaicing these images, the system performance would be significantly slowed down. Fortunately, the Mapserver uses 'TILEINDEX' to control displaying images that just overlap the current map windows. This tile index actually is a shape file that stores the name and map extent of each tile image files. In case of handling a very large volume scene such as Landsat ETM+, it is also convenient and has higher performance to split one scene into a number of small tiles.

The on-the-fly resample process would also slow down the Mapserver performance, particularly in case of displaying multiple scenes simultaneously. There are two ways to overcome this problem. One is scale control and the other is pre-built overview. The former requires resampling a satellite image into multiple-resolution copies and uses MAXSCALE / MINSCALE in mapscript to control displaying the copy with an appropriate resolution. The later uses GDAL utility – gadaladdo to generate pre-built overviews for a satellite image and use GDAL in support of the Mapserver to access the image with pre-built overviews. In this work, we used the GeoTiff with built-in overviews to improve the performance of image rendering.

4 ADVANCED MULTIMEDIA MAP CLIENTS IN WEB BROWSERS

To expand the universe of accessing spatial data on Web, a lightweight WMS mapclient embed in browser is often used to help web users to automate the interaction with mapservers. Conducting such a client must revolve around the full compliance with its host system, great user interactivity, and impressive data representation.

In this study, we deployed three advanced multimedia clients to operate our OGC WMS compliant map server. They are Java Applet – jBox, SVG and Flash SWF, and each gives a deep impression on enhancing user interactivity and map presentation (Figure 2). Their development considered two basic functions - auxiliary graphic user interfaces for interactively operating maps and automatic HTTP request processors corresponding to map operation.



(a) Java Applet – jBox (b) SVG (c) Flash SWF

Figure 2. Advanced WMS clients – Java Applet (jBox), SVG and Flash SWF.

4.1 Java Applet - jBox

The jBox (formerly called "Mapplet") is an elegant open source Java applet. It is initially developed to enhance user interactivity of CGI Minnesota Mapserver. In this practice, the jBox was configured as a smart WMS client.

When using jBox as a OGC WMS compliant client, a particular attention should be paid to a bug in jBox's setimage() method. That is the jBox displays map in a wrong position when it operates maps in image swapping style. This is because the setimage() method forgets to set zero two variables ('ix' and 'iy') – the 'x' and 'y' direction's displacements between the event 'mousedown' and 'mouseup', although it already re-initialises the cursor positions of event 'mousedown' and 'mouseup'.

4.2 Scalable Vector Graphics

SVG is XML graphics for the Web. The SVG fulfills the very specific requirements for dynamic GIS mapping. Compared with traditional graphic formats, it is incredibly versatile and is revolutionizing how spatial data are graphically presented on the Internet.

The strong industrial support makes SVG never tied to one particular implementation or vendor. We used SVG as a common web-mapping platform upon which to build graphically rich GIS applications and user interface. The demo results showed that the WMS SVG client we developed enabled enhanced graphics and sophisticated interactivity, in comparison with the jBox.

4.3 Flash SWF

The Macromedia Flash file format (SWF) specification is designed to deliver graphics, animation and sound over the Internet. It is licensed to Macromedia Flash, but there are no access or deployment fees required to use the specification. The Macromedia Flash compliant player may be the most pervasive graphic platform on the web, and it has become an industry standard to some extent.

We developed a Flash WMS client using open source tools – libMing, ActionScript and PHP scripting language. The libMing is a free SWF output library that defines a set of Flash Movie objects. The ActionScript is similar to ECMAScript and JavaScript, helping to create sophisticated interactive SWF function. With PHP support, we created a WMS compliant Flash client using Ming functions and ActionScript. The client performance came as a shock.

When using libMing Flash for an interoperable web mapping, the developers have to be ware of some limitations. That is, libMing can only deal with JPEG baseline ("standard") at this point, no baseline optimised or progressive scan jpegs. Therefore, the output format of UMN Mapserver WMS server should be configured to support the standard baseline JPEG.

5 CONCLUTIONS

This paper highlights an open source prototype system for web mapping. The map service is a WMS compliant map server that uses a technically competitive solution to serve a large-scale GIS database on the Web. The map clients are lightweight cross-browser spatial wares - Flash SWF, SVG and Java applet, which enable enhanced graphics and sophisticated interactivity. This successful development shows us once more how the Open Source solution benefits users, particularly those working in education, research, and in developing countries.

The techniques and system source code in this research work can be applied freely as a laboratory excise or a course curriculum. As Ramsey (2002) mentioned wherever people had problems to solve and a willingness to share their solutions with others, open source would continue to flourish. We hope the dissemination of this development could contribute to the geo-informatics community.

6 ACKNOWLEDGEMENTS

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