IMPLEMENTING WEB-GIS AND DEVELOPING SPATIAL DATA INFRASTRUCTURES USING OPEN SOURCE SOFTWARE

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ABSTRACT

Spatial databases offer a means to build and deliver geographically referenced information over computer networks. There are already several Open Source Software packages available that could be tailored to develop Spatial Data Infrastructures. In the present paper we describe the salient features of a spatial database system that was developed by integrating the Open Source GRASS GIS and PostgreSQL Object-Relational database into a Web based client/server environment. The system can facilitate easy and rapid collection and dissemination of spatial information. Since the system is independent of any proprietary software, it is easily in a distributed spatial database environment at low overall cost. Further, the system can serve as a platform for rapid implementation of spatial data infrastructures through collective participation and also serve as a means for standardizing data collection. We also present our ongoing efforts to improve the interoperability and adapting the system to meet the widely accepted Web Map Server specifications.

1. INTRODUCTION

Internet based geographical data services involve management spatial and non-spatial (attribute) data. Geographic Information System (GIS) has come to be an indispensable tool for analyzing and managing spatial data. Data pertaining to spatial attributes can be efficiently managed using Relational Database Management System (RDBMS). The development of a Web-based system by integrating GIS and RDBMS would serve two crucial purposes. Firstly it would allow the user to operate the system without having to grapple with the underlying intricacies of GIS and RDBMS technology. Secondly, it would allow sharing of information and technical expertise among a wide range of users. In the present paper we describe the salient features of spatial database that was developed by integrating the Open Source Software (OSS) GRASS GIS and PostgreSQL Object-Relational database into a Web based client/server environment. The system described in this paper aims at providing a web-based platform for collaboration and data sharing between specialists, planning agencies, citizens, and private entities.

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In order to access the spatial database, the user need only have a Web browser and access to the Internet. The system can be used to readily build and manage spatial databases pertaining to landslides (Raghavan *et al.* 2001) and is presently being adapted to suit other applications such as a Water Infrastructure Inventory System (Raghavan, Herath and Dutta, 2001). Since the system is developed using OSS, it can be easily implemented in a distributed spatial database environment at a low overall cost. In this presentation we discuss salient features of an online system that offers public access to landslide information related to Japan (Japan Society of Landslides, 1996). The basic framework of the system is shown in Figure 1. Further, we also present an overview of our ongoing efforts to improve the interoperability and compliance with the OpenGIS Consortium (OGIS) Web Map Server (WMS) specifications.

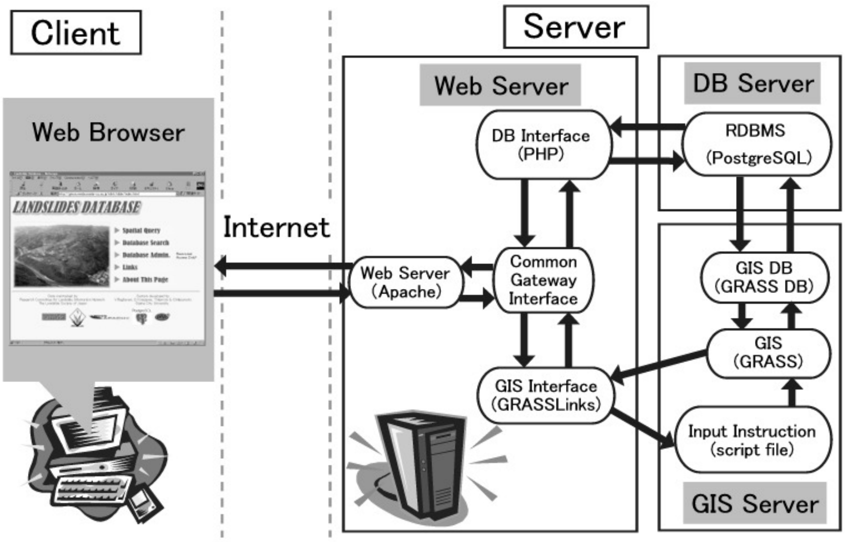


Figure 1: Components and Information Flow within the Prototype System

2 SYSTEM FEATURES

An online demonstration of the basic features is available at http://gisws.media.osaka-cu.ac.jp/slink/. "*Spatial Query*" option allows the user to retrieve attribute data from the RDBMS table by selecting a location on the raster image displayed on the web browser. The user selects the GRASS data layers from an interactive menu based on which the GRASS raster layer is displayed on the web-browser. The user can also select vector maps and site data as overlays for raster map layer (Figure 2). Interactive zoom/pan capability allows the user to view the displayed maps in greater details or to choose different areas for display. Once the desired area is displayed on the web-browser, the user is allowed to view the attribute table by "clicking" on respective site. The relation database is queried based on the geographical location (Figure 3a) of the "clicked" site. Attribute data is displayed in two stages. Firstly, a brief summary (Figure 3b) of the attribute information is presented. The summary table also includes a hypertext link, which can be followed to view more detailed information including figures and field photographs is also provided (Figure 4).

"*Database Search*" option allows the user to retrieve attribute information by keyword searching (Figure 5a). Search fields include name, location and date. In addition full-text searching is also provided. The results of the text based searching are the same as those shown in Figure 3b and Figure 4.

"*Database Administration*" option allows registered user to insert new attribute information into the RDBMS table. User can select the option (Figure 5b) to upload data by clicking a location on the basemap or directly input the location coordinates into the data upload form (Figure 6). This module also allows direct uploading of binary files such as images, sketches etc. from the client's computer to the database server.

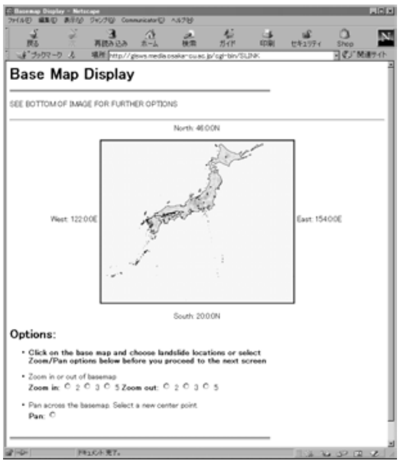


Figure 2: Query basemap.

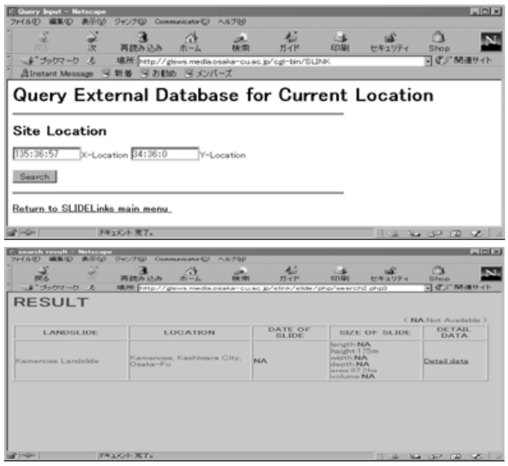


Figure 3: (a) Location (b) Query results.

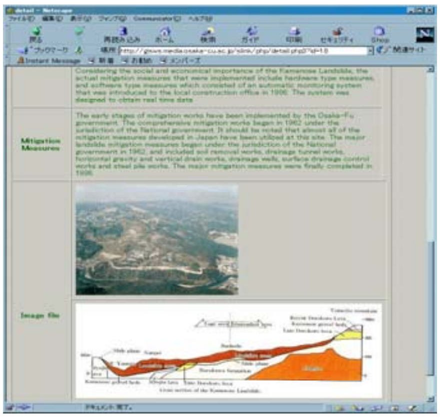


Figure 4: Attribute information.

Figure 5: (a) Keyword Search (b) Data Upload.

3D visualization through the use of Virtual Reality Modeling Language (VRML) is currently possible within the system's framework. VRML models can be interactively generated and view on the client browser. In addition, the GRASS GIS now incorporates advanced visualization called the "nviz". "nviz" allows users to realistically render multiple surfaces in a 3D space. Options for using thematic coloring, vector/site data overlay and rendering of animation sequences are also supported. The Figure 7 is an example of digital elevation model rendered using "nviz".

Figure 6: Database update form.

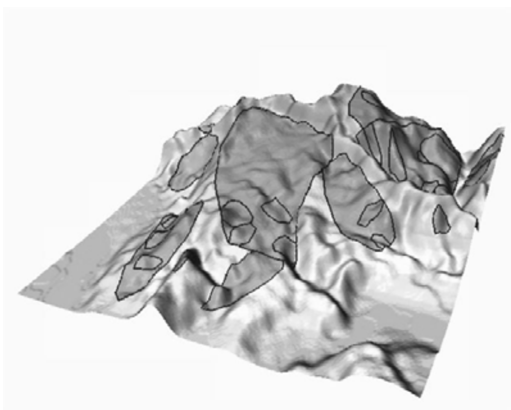


Figure 7: 3D visualized using "nviz".

3 INTEROPERABILITY AND COMPLIANCE TO STANDARDS

Apparently, one of the main limitations of the present system is the interoperability and non-compliance with widely accepted Web mapping standards. In using the system described above, access to spatial data requires the information to be stored in the GRASS GIS format and the GRASS GIS needs to be installed on the server in order to get the system running. The advantage in having a full fledged backend GIS running on the server would be the ability to implement online systems with spatial analytical capabilities rather than providing visualization or portrayal capabilities alone as are commonly available in other Web GIS applications. Such online systems for 3D online geological modeling have been demonstrated in our earlier research (Raghavan *et al.*, 2000). However, in most general situation of providing seamless access to spatial data, the advantages of adopting approach wherein issues such as interoperability and compliance to *de facto* global standards far outweigh any other consideration. The OpenGIS Consortium (OGC) in cooperation with GIS experts and leading software vendors has evolved advanced open system standards for spatial data and related information technologies. The WMS specifications have emerged within the OGC for the design of interoperable systems for spatial data sharing amongst users with only map reading skills.

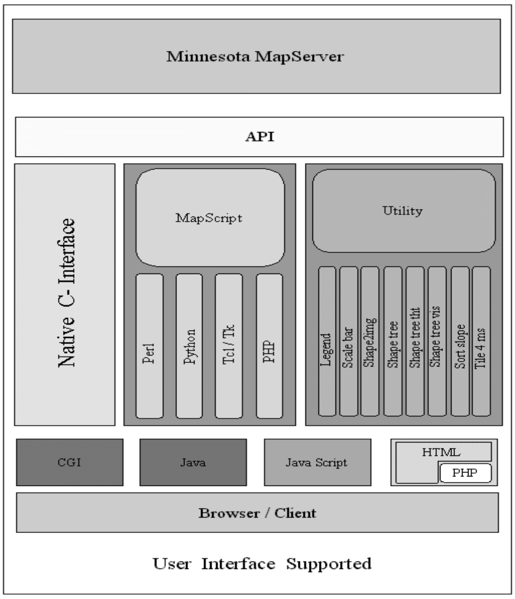


Figure 8: MapServer development tools.

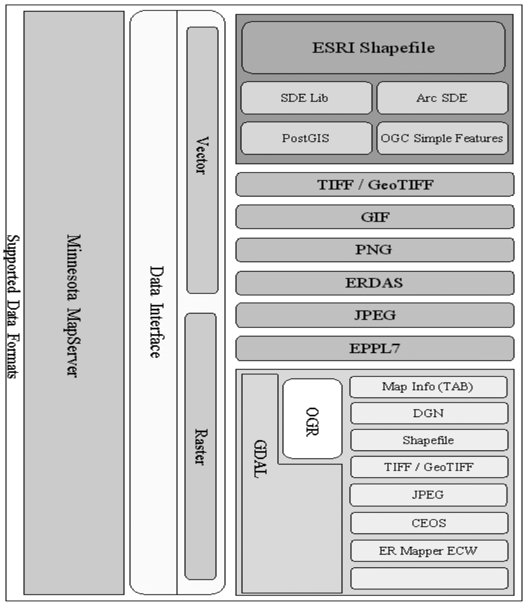
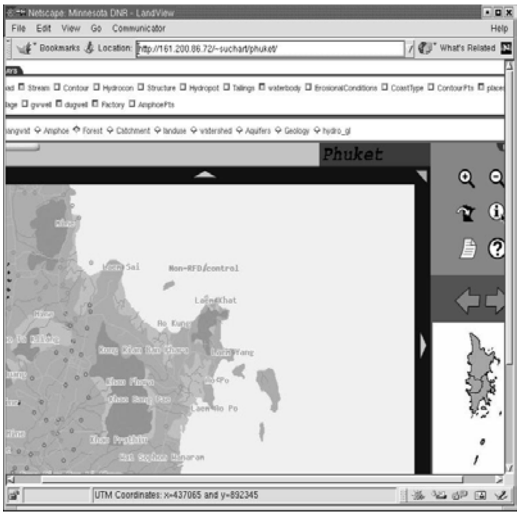


Figure 9: Data format supported in MapServer.

Open Source MapServer project (http://mapserver.gis.umn.edu/) affords the development and deployment of OGC compliant WMS. MapServer provides a cross-platform development environment for building spatially enabled Internet applications. Fig. 8 shows the various programming tools available for development of MapServer based applications. MapServer relies on numerous other free software to convert vector to raster, draw true-type fonts, or create images. In addition to the built-in support for several spatial data formats, the MapServer can also be coupled with the Open Source GDAL (Geospatial Data Abstraction Library; http://www.remotesensing.org/gdal/) that functions as a translator library for raster spatial data formats. As a library, GDAL presents a single abstract data model to the calling application for all supported formats (Figure 9). The related OGR Simple Features Library (http://gdal.velocet.ca/ projects/opengis/) provides read (and sometimes write) access to a variety of vector file formats. Figure outlines various data formats supported by MapServer. Integration with PROJ4 (EVENDEN, 1990; http://www.remotesensing.org/proj4) enables support for over 120 different map projections. Software to transform raster, vector and site data between differently projected locations is also available.



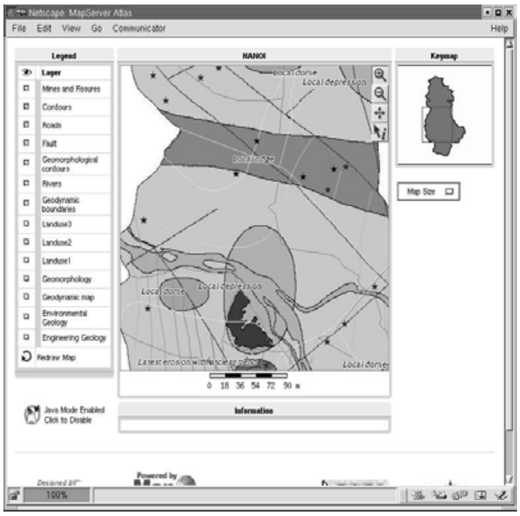


Figure. 10: Phuket Island, Thailand

Figure 11: Hanoi City, Vietnam

Considering the obvious advantages of providing standardized data access and portrayal services, we are now in the process of enhancing the features of the present the spatial database system using the MapServer toolkit. In this regard, we have developed several applications using existing spatial data that are available through regional initiatives (e.g. (DCGM III Working Group, 2001). Some example of the MapServer implementation using the data from Phuket, Thailand (Fig. 10) and Hanoi City, Vietnam (Fig. 11) have already been developed. Ongoing development is focused on integration an RDBMS interface to support better management of attribute information including multimedia contents. Further, efforts are also being made to examine data compression techniques to enhance speedy access to spatial and attribute information and also incorporate metadata search system to aid in information retrieval.

4 CONCLUSIONS

The prototype system described in this presentation affords easy and rapid collection and dissemination of spatial information. Since system has been developed using OSS, it is easily adapted in a distributed database environment. The system provides the basic components for generation and delivery of spatial information at very affordable costs and would be greatly beneficial to small organizations that might neither have the financial resources nor range of expertise needed to implement proprietary solutions. The system can provide a platform for developing Spatial Data Infrastructures (SDI) through collective participation and could also serve as a means for standardizing data collection. Such efforts will help coordinate better strategies for environmental assessments, hazard mitigation and resource evaluation in the future. The ongoing work is focused at adapting to global standards for data access and portrayal services and tighter integration between the GIS and RDBMS component. With these added functionality, the system could not only afford an efficient mechanism for the generation and delivery value-added spatial information but also help in extending the concept of SDI by providing the means to analyze the data that are being made available through regional initiatives.

Our experience in using OSS suggests that many basic tools for building SDI are already available while others are undergoing rapid development. Existing OSS projects have the potential to provide necessary information and communication technology services for SDI initiatives. Widespread use of Open Source Software in SDI implementations could stimulate further developments of OSS projects that could benefit a vast user community.

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