An Open Source Web GIS based Infrastructure and Environmental Planning for Universities

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***Abstract*— *Abstract*—GIS and remote sensing is an eminent technology for representing geographical properties and used to store, retrieve, and visualizing geographical data in a useful manner. This paper implements a GIS and web based Navigation system to represent geospatial information linked to environmental and infrastructure resources of Universities. The proposed system is framed for the University of Calicut, Kerala, so as to support the University administration for the planning and development processes. This system uses two different types of layers: base layers and overlay layers. Base layers such as OSM maps are used for mapping and Overlays are used for representing infrastructure facilities including University buildings, roads inside the campus, water pipelines, electrical cables, OFC, locations of the biometric punching machines and the environmental resources such as water bodies, vegetation, soil and rock. The open source GIS tools are used for the implementation of this work. It also discusses the potential of the open source tools and how it is used in web GIS application development. The proposed system also capable to display different geographical object parameters such as name, area, content, longitude and latitude values of the special and non-special resources within the University campus. As this web GIS application is built on a generic frame work, it could systematically support and solve many geospatial related decision making issues currently faced by many of the Indian Universities.**

Keywords-FOSS; Web GIS; Geospatial data; GPS; georeference; overlays; baselayer;

I. INTRODUCTION

A Geographic Information System (GIS) is a computer-based tool for mapping and analysing geographic phenomenon that exist, and events that occur, on earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies. Map making and geographic analysis are not new, but a GIS performs these tasks faster and with more sophistication than do traditional manual methods. It provides an electronic representation of geographical information is called spatial data, about the earth's natural and man-made features.

A GIS references these real-world spatial data elements to a coordinate system. These features can be separated into different layers. A GIS system stores each category of information in a separate layer. Layers can represent terrain characteristics, census data, environmental and ecological data, roads, land use, river drainage and flood plains. Different applications create and use different layers. A GIS can also store attribute data, which is descriptive information of the map features. GIS systems are dynamic and permit rapid updating, analysis, and display. They use data from many diverse sources such as satellite imagery, aerial photos, maps, and global positioning systems (GPS). There are two types of data types in GIS that are spatial data and attribute data.

Spatial data: Traditionally spatial data has been stored and presented in the form of a map. Three basic types of spatial data models have evolved for storing geographic data digitally. In this paper base layer as a raster format and overlays as vector data format. These are referred to as of geographic features.

Attribute data: A separate data model is used to store and maintain attribute data for GIS software. These data models may exist internally within the GIS software, or may be reflected in external commercial Database Management Software (DBMS). A variety of different data models exist for the storage and management of attribute data.

- Tabular
- Hierarchical
- Network
- Relational
- Object Oriented

This paper mainly intended to implement a web based geographical information system which helps the University administration in infrastructure and environmental planning. The study is performed at University of Calicut, Kerala and currently the University has no such geographical information system based applications. There for a printed map is followed for solving various planning related issues which require the assistance of geospatial information. The main problem with the manual map is that most of the cases it will not have precise information recorded and the map is not geo-referenced. The other problem is that spatial information related to the University which are at present recorded in manual maps

cannot be accessed through internet by the planners or by the public. We identified many difficulties faced by the engineers and the technical staff in the University associated with the construction and maintenance of the buildings, laying optical fiber cables, electrical and water pipe lines, biometric punching systems etc., due to the lack of a proper geospatial monitoring system. Similar problems are also faced in environmental resource planning such as crop stress identification in plantations, maintaining botanical garden, University park and proper utilization of water resources in the campus etc. The University administration also finds major difficulties in decision making and planning due to the lack of systematic geospatial related information in infrastructure and environmental resources. This paper proposes a solution to support infrastructure and environmental panning for Universities which uses open source web based GIS. The rest of the paper is organized as follows. In section II, related works are presented. Section III describes the proposed web GIS framework. Section IV illustrates the development and implementation of the application and finally Section V concludes the work and provides future directions.

II. RELATED WORKS

Many works have been reported in the literature related to open source web GIS based applications and hardly a few are specifically address the problems related to the Indian Universities [1][2][3][4]. Puyam S. Singh et al. describes how an GIS based information system can be implemented for managing spatial natural resources using effective open source software and standards [5]. This paper discusses some of the features of a GIS, the general trends in this field and the technology behind it. It also describes the advantages of using multimedia to implement a GIS by extending its capabilities of presenting geographic and other information. In another work, Fang YIN and Min Feng discusses how to instrument open source tools in web GIS [6]. They described about the open source technology are using in the current scenario. Web GISs have been developed and used extensively in real-world applications with the development of GIS and Internet technology. They are conclude that, sharing and interoperability of large volumes of geospatial data in such a complex web-based systembecome a challenge.

III. PROPOSED FRAMEWORK

This section describes the source of data used in this work and proposed application framework in detail. A wide variety of data sources exist for both spatial and attribute data. In this work we used data from hardcopy map, satellite imaginary and GPS. The data and map analysis are performed using the open source tools including geoserver [9], GeoExt [10] and OpenLayer [11] and postgis PostgreSQL. The vector and raster analysis are performed with the open source tools QGIS and grass. The proposed application uses Open Geospatial Consortium (OGC), Web Coverage Service (WCS), Web Feature Service (WFS) standards to publish geographical data in GeoServer. For storing metadata we used geoserver as mapserver, ExtJS is used for data web visualization and JDK was the basic environment. Figure 1 shows the generic framework of a web based GIS.

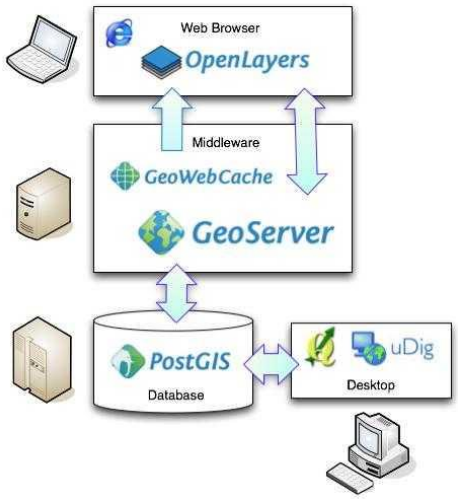

Figure 1: A general web GIS framework.

Normally, a typical GIS framework provides three layers including data management layer, data storage layer, and data application layer. Data management layer handles spatial query operations such as create, delete, update, and rename. These layers also helps vector and raster data analysis. This study used point, polygon and line as vector data analysis. For example the University Department buildings can be considered as polygon. Road, water pipe lines and optical fiber cables, electrical cable etc. can be considered as line. Water bodies, entry and exit gates, biometric punching machine locations are considered as points. PostGIS is used to handle vector and raster data query analysis.

In this study, we used another open source tool Qgis to create vector overlays layers [9]. Figure 2 shows a Qgis interface for vector data. It is a most familiar open source geographical information tools licensed under the GNU general public license. This open source tools help to georeference (WGS 84/ UTM 44 N Zone) from manual map and toposheet.

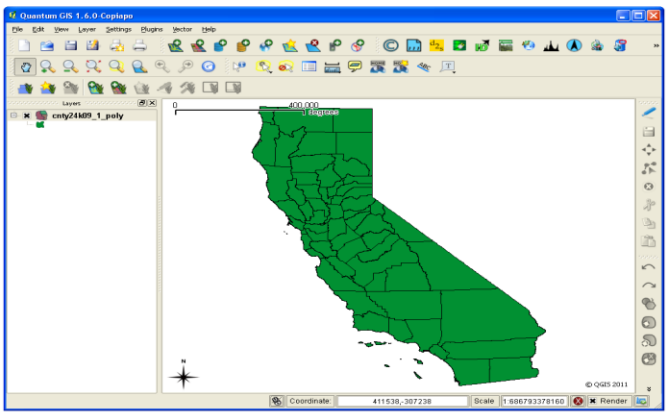

Figure 2: Qgis interface for vector data

Data storage layer is used to store spatial and nonspatial information about the resources in the University. For example, the Deaprtment\Branch name, area of the building, length of road, thikness of cable, etc. are considered as the attribute of the corresponding overlays layer. They are represnetd in differenct file formats as shape format (.shp), shape index format (.shx), attribute format (.dbf), projection format (.prj) and then they are converted in to sql format using PostGIS, and then the data are stored by using a local server.

In this study Apache Tomcat act as a local servar and Geoserver act as geographical server. Geoserver suport different input format such as ArcSDE, shape file, geotif, db2,and out put format suport Esri shape file, KML, JPEG, SVG, PNG. GeoServer aims to operate as a node within a free and open spatial data infrastructure. Just as the Apache HTTP Server has offered a free and open web server to publish HTML, GeoServer aims to do the same for geospatial data. Figure 3 shows the components of GeoServer.

Figure 3: GeoServer components

Application layers provides a user interaction frame work, using tools such as ExtJS and OpenLayer. This tools used for web based map creator and web based visualizer. Map visualization using different ways such as 2D vector (WFS), 2D map (WMS), 3D map (KML). The overlay layers are interacted with OpenStreetMap (OSM) [12] by the use of WMS service. Open Layer provides many JavaScript library exclusively for displaying map data in web browsers. It also provides a Java API for building rich web-based geographic applications similar to OSM Maps. In this work, all the overlays are interact with the OSM layer. The library includes components from the Rico JavaScript library and the Prototype JavaScript Framework

Here we implemented all the user interfaces using GeoExt. It is a pure JavaScript application framework for building interactive web applications using techniques such as Ajax, DHTML and DOM scripting. Originally built as an add-on library extension of YUI by Jack Slocum, GeoExt includes interoperability with jQuery and Prototype.

IV. APPLICATION DEVELOPMENT

We have developed user interfaces that help to access spatial data from GeoServer with the help of any web browser. We also provided different tools for user interaction with map layout such as zoom panel, scale, pan tools, zoom in zoom out tools, longitude, latitude, visible tools, base layer and overlays layer tools. The developed application provides two type of layer information that is base layers and overlays. In the application, base layer is divided into three layers based on the user choice to access spatial data that are OSM maps. Overlays layers designed and developed for this application have different layers that gives geographical information of the following infrastructure components of the University.

- Buildings
- Boundary walls
- Entry and exit gates
- Roads
- Water pipelines
- OFC\Electrical cables
- Biometric punching locations
- Water bodies

The overlays layer gives different spatial information about the above mentioned components of the University. For example, name, area, location, size, length of different spatial objects Figure 4 shows the map layout of GeoExt taken from OSM maps indicating University boundary information.

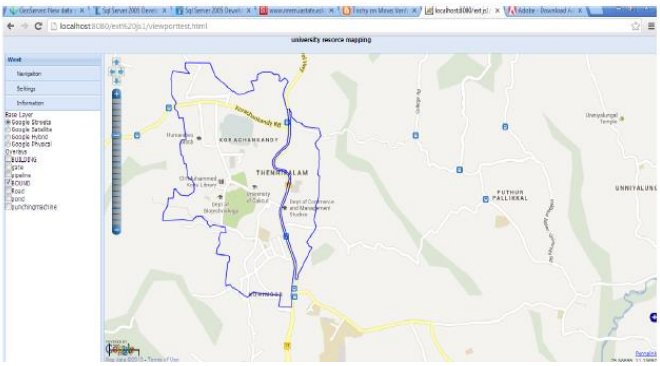

Figure 4: OSM with University boundary information.

Figure 5 shows the location details of all the Departments in the University. It also displays name, locations and other attributes of the selected building.

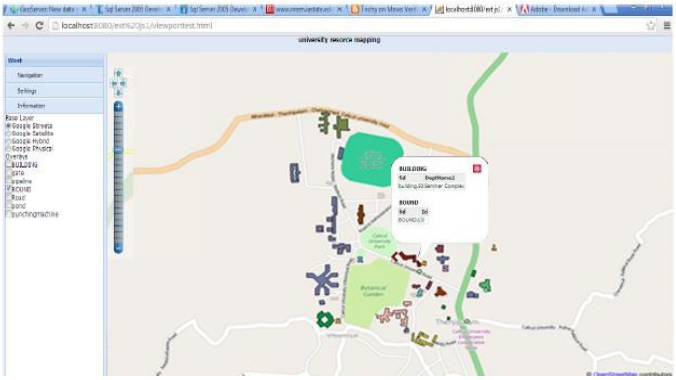

Figure 5: OSM layer with University buildings with details

Figure 6 shows the snap shot of the application indicating the location of water pipelines and other cable locations and its details.

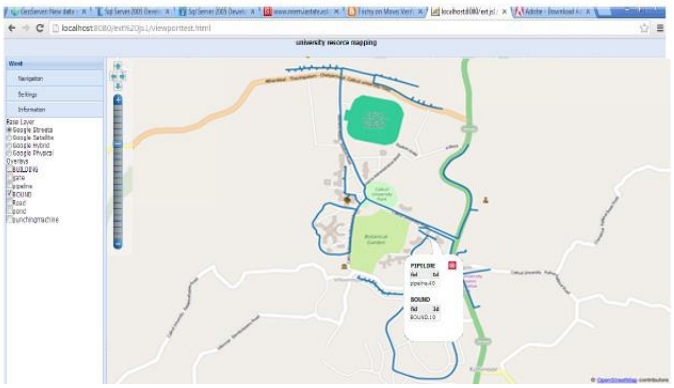

Figure 6: OSM layer with water pipelines with details

V. CONCLUSIONS AND FEATURE WORK

This paper implemented an open source web GIS application combined with current technology for infrastructure and environmental planning for Universities. It is a low cost geographic problem solving system. This system provides public sharing and assessing options for various users. The paper addresses many geographical information based monitoring and maintenance areas in the Universities with a special reference to the University of Calicut, Kerala. The proposed framework, the development and implementation of the application are discussed in detail. This study clearly underlines the high potential of open source technologies to establish new web-based geo data visualisation services that can be effectively used in various planning and developmental processes in Indian Universities. The next stage of this project would be focusing to develop a complete web based open GIS solution by incorporating different geographical layers to extract soil information, waterbody content information, to find variations of vegetation and climate variation etc. with a mobile version of it. The feasibility of developing a decision support module for the web GIS that helps in infrastructure and environmental planning will also be studied.

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AUTHORS PROFILE

Abhilash K.G. earned his Masters in Computer Science from the University of Calicut in 2013. Presently he is working towards his MPhil Degree in Computer Science with a specialization in Remote Sensing and GIS. He is an active research scholar working in the area of Web GIS for infrastructure and environmental planning and decision making under the supervision of Dr.Lajish.V.L.

Dr. Lajish.V.L has been associated with University of Calicut, Kerala, INDIA as Head of the Department of Computer Science. He has worked as Scientist R&D in TCS Innovation Labs, Tata Consultancy Services Ltd. Mumbai, prior to joining the University. His prime areas of research include Digital Speech and Image Processing, Pattern Recognition algorithms, Indian language script technology solutions for mobile devices and remote sensing and Web GIS applications. He has more than forty research publications in journals and peer-reviewed international and national conferences to his credit. He is a senior life member of International Association of Computer Science and Information Technology.