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Web-GIS based Framework for Solid Waste Complaint Management for Sustainable and Smart City

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Abstract Geographical information system (GIS), data management and digital technology play a key role in the development of sustainable city. These technologies help administrator and planner to increase performance, utilize resources efficiently, reduce cost and engage the citizen in the system, which makes the city smarter. Basic infrastructure component that makes the city smarter include transport, energy, healthcare, water and waste management. The present study is aimed to develop Web-GIS based framework for the lodging complaint, visualization and monitoring for solid waste in an urban area. A Web-GIS based framework is presented that uses free open-source software (FOSS) such as open layer, Javascript, Apache tomcat, Geoserver and PostgreSQL/PostGIS for visualization and monitoring of geospatial data. Using this framework a Geo-locator tool is developed to find the locations of facility (bins) to end user for reporting and lodging complain etc. It also develops automatic report for municipal officers to quickly respond to the complaints.
Keywords *MSW; Geoserver; Open Layer; Open Source; PostGIS; WebGIS*

1. Introduction

Web-GIS is also known as Internet GIS, which is the combination of Internet and GIS. It is a conventional GIS which uses the Internet as a basic information infrastructure for spatial data dissemination. Internet GIS is regarded as an interactive, distributed, dynamic, cross-platform and client/server computing system which has the capability to access various forms of GIS data and functions in an interoperatable environment [1].

There has been many WebGIS based system and decision support system for geospatial mapping for map visualization [1], assessment of health [2, 3], transportation [4] and for decision making that include the public participation [5].

GIS and Internet technology are useful in monitoring the urban system. GIS improves the monitoring and visualization experience and makes possible to monitor and visualize the city in spatial context.

With the help of GIS, it has become possible to visualize the physical entities in a virtual environment using different models.

The basic goals of smart cities are efficient organization, recycling and reuse of already developed solutions, better and quick decision making, easier to contact the governing organization (eg. Municipality, Nagar Nigam etc.) and improve the participation of citizen for longer sustainable environment.

In the present study web-GIS based has been developed that works as information system as well as used for monitoring the solid waste complaint. Free open source softwares have been used in development of system.

2. Architecture of WebGIS based Framework

Web-GIS based architecture and used software in each phase is shown in Figure 1, which is based on client-server architecture. A generalized Web-GIS architecture includes three basic components: client layer, server layer, and data layer. For developing a WebGIS based framework html, openlayer, javascript and Java server page (JSP) are used at client layer. Apache tomcat and Geoserver is used as server layer and PostgreSQL with PostGIS are used as database for data storage and management.
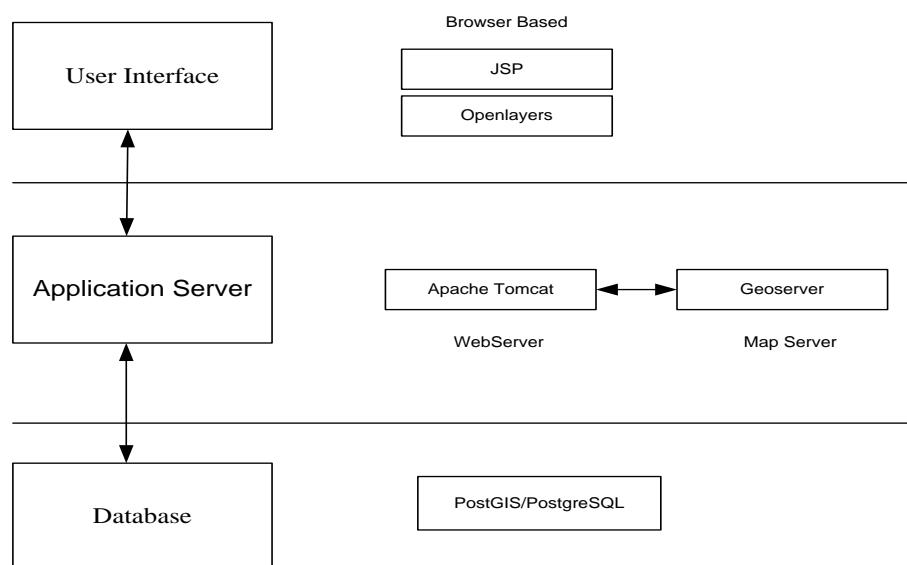

Figure 1: WebGIS Framework Architecture

Descriptions of open source software used in developed framework are as follows:

2.1. OpenLayers

Open Layers is an open-source JavaScript library for displaying map data in web browsers. It provides an API for building rich web-based geographic applications similar to Google Maps and Bing Maps. The library was originally based on the prototype JavaScript Framework [7]. Openlayers support GeoRSS, Keyhole markup language (KML), geography markup language (GML), GeoJSON and map data from any source using OGC standards as Web Map Services(WMS) or Web Feature service(WFS).

2.2. Apache Tomcat

Apache Tomcat software is an open source implementation of the Java Servlet and Java Server Pages technologies [8]. It is a web server and servlet container

2.3. GeoServer

Geoserver is an open source server for sharing geospatial data which provide the interoperability. It publishes data from any major spatial data source using open standards. GeoServer can access a variety of spatially enabled databases such as Oracle Spatial, ArcSDE and PostGIS [2]. GeoServer also publish data from many sources such as PostGIS, shapefile, java property file as vector data sources ArcGrid, GeoTIFF, Gtopo30, Image Mosaic and World Image as Raster data sources and other. Geoserver can deliver these data to different formats such as GIF, GeoTIFF, JPEG, KML, PDF, PNG and OpenLayer [9].

2.4. PostGIS/PostgreSQL

PostgreSQL database coupled with the additional PostGIS package are OGC (open geospatial consortium) compliant and open source software [10]. Postgres is an enterprise class relational database system. PostGIS is a spatial add-on for Postgres [6]. PostGIS spatially enables the Postgres database by adding support for geographic objects, allowing it to understand coordinate systems, projections, transformations, etc. PostGIS is the most common data store used with GeoServer because both are open source applications as well as being OGC standards compliant [2].

3. Development of Framework

Web-GIS based framework is developed for visualization of geospatial data, named as Web GIS based Framework for Management and Monitoring of Municipal Solid Waste (WGFMM-MSW). Figure 2 gives the framework of proposed system. It includes three modules namely pubic, ward level administrator and city administrator. Modules are further subdivided into sub modules as shown in Figure 2.

In public module main concern is to lodge complain regarding the solid waste location with the help of geo-locator. It shows the latitude, longitude and closing matching address.

The Ward level admin module is divided into three sub modules as given below:

1) To assign jobs to employee based on lodged complaint about unattended garbage bins by waste collection agency/system.
2) To update the status based on served complaints by the employees.
3) To generate the ward wise report based on solid waste complaint.

The third module is 'Admin module' for the management authority of the city whose responsibility is to monitor the status of solid waste management of the entire city. System helps the authority to visualize entire city data at one place and to generate reports accordingly. This helps administrator to assess the solid waste efficiency of entire city which may be used for further planning and improving the system with time.
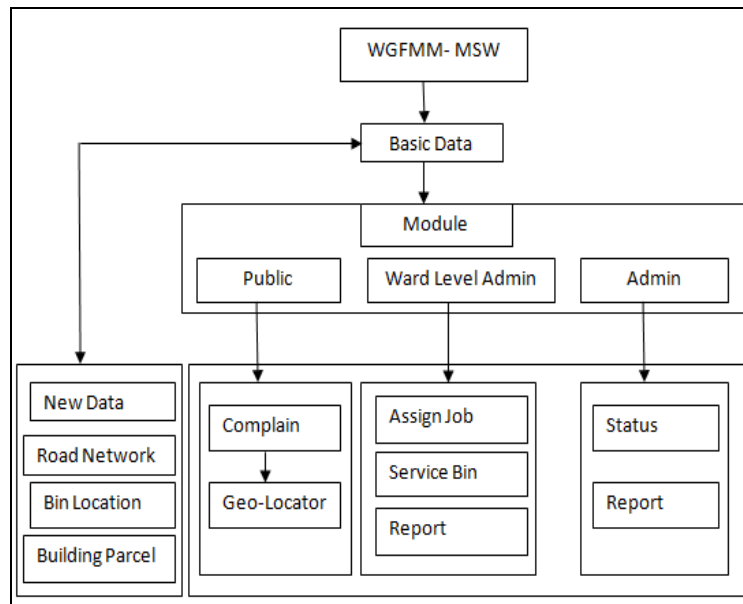
Figure 2: Framework for WGFMM-MSW

4. Implementation of Framework

Proposed Web GIS based framework has been implemented for complaint monitoring and management of municipal solid waste. For implementing the framework study area is Allahabad city. Basic data that have been used in system are road network and point vector data of bins location. The road network is created on survey of India (SOI) toposheet of scale 1:50000 using ArcGIS software. Bins location has been collected by field survey using the GPS receiver and then plotted in ArcGIS software. These data have been exported in PostGres/PostGIS database using the pgShapeLoader graphical interface. Publish these layers in GeoServer from PostGIS. These published layers are shown in Figure 3 and 4 respectively.
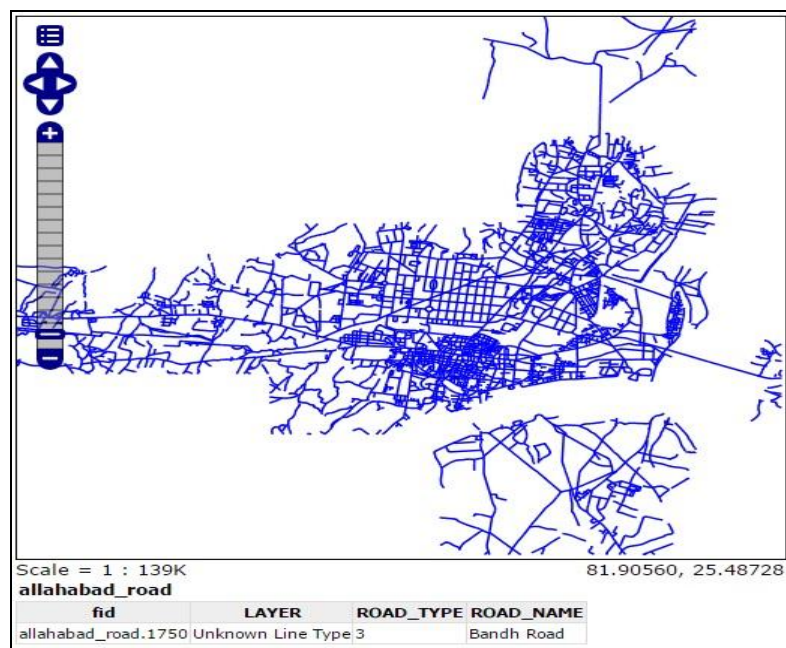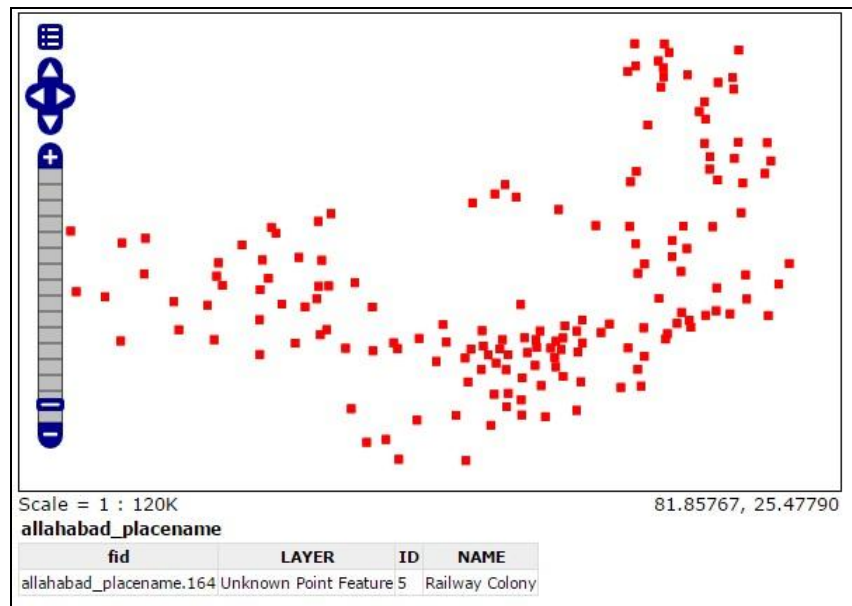

Figure 3: Road network of Allahabad

Figure 4: *Bins location published in Geoserver*

These layers are meaningful when the base layers are added in web application and overlaid these layers on the base map. Base layer can be added using the Open street map or Google map. Visualization of map and features with base layer provide the realistic view of environment. Google map is used as a base layer in application. A snapshot of home page is shown in Figure 5 to explain the implemented framework. Home page consists of the module links as indicated in Figure 2.

Figure 5: *Home page of implemented Framework*

First module for lodging the complaint by user is named as Geo-locator. Geo-locator tool is developed for public participation and feedback. It shows the Geo-locator status, location in form of longitude and latitude and close matching address across the roads. Figure 6 shows the location and close matching address of the user who lodged the complaint about the unattended solid waste bins or unestimated garbage generated at any location due to activities such as demolition, public events etc. Geo-locator

works when it moves with mouse point and it shows the status of attributes. Marker status attribute is at drag ended it shows the correct information about attributes. This information is used by the end user to lodge complaint by clicking on submit button as shown in Figure 6.
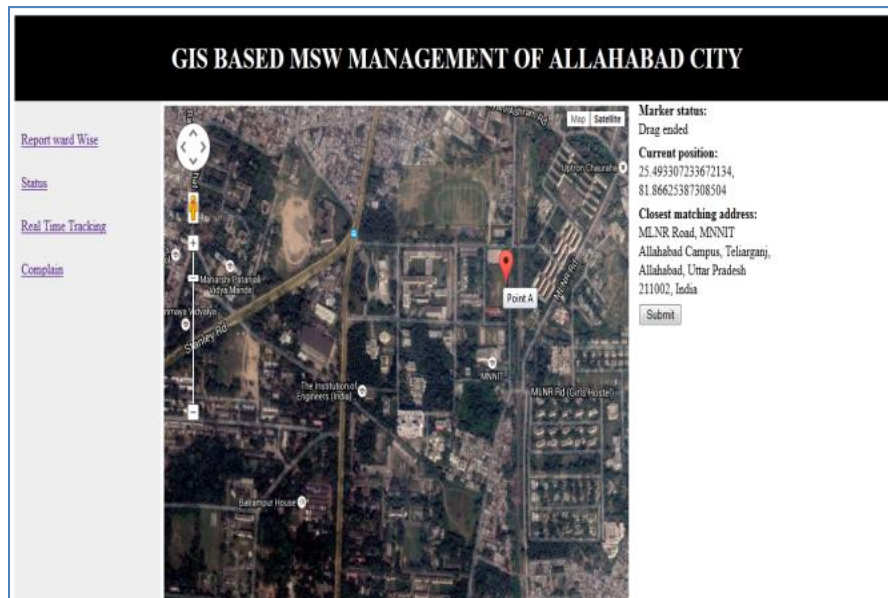

Figure 6: Geo-locator tool for citizen to report and lodge complain of solid waste

Geo-locator for administrator works when address is put in textbox and then clicked on Geo-code button; it generates the marker on the map at given address. Figure 7 shows the location of complaints to the administrator on the map. This may be helpful to the administrator when complains about solid waste are lodged through telephone or from other communicated system. This information is used by the administrator for providing the service to the end user by communicating address to employee who is serving at that location.
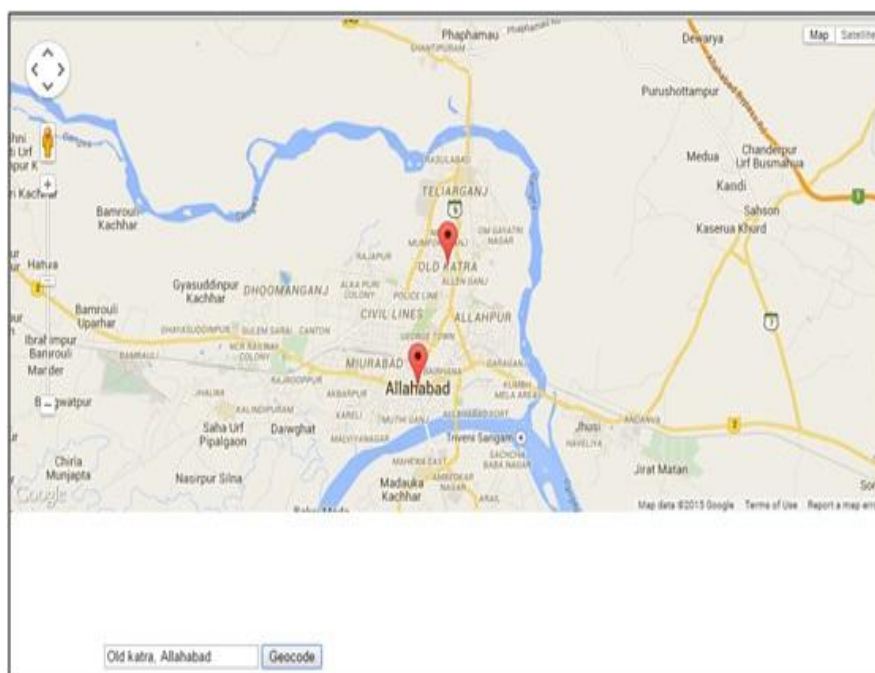

Figure 7: Geo-Locator for Administrator to know Position on Map

These lodged complaints are saved in database which is used by administrator at different levels to monitor the system. Ward level admin responsibility is to distribute the jobs to employee based on lodged complaints. At the end of the day status is updated based on attended complaints by employee. This updated information is saved in the database and used by city administrator to check the status of entire city and can generates the report accordingly.

5. Conclusions

In this paper WebGIS based framework is introduced for solid waste complaint monitoring and management. For public participation to easily lodged complaints online with help of GIS tool a Geo-locator marker is developed. Geo-locator marker helps the user to easily find the exact location with close matching address for lodging complaints. This lodged complaint is saved in a central database and this helps the different levels of administrator to see the status of city on map to improve the decision making capability of administrator. With the help of this tool, collection of solid waste becomes easy and the service level and satisfaction of citizen is improved. This may also helpful in finding the waste generation in city.

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