

# Web Based Spatial Query System for Decision Making

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## Abstract:

GIS is becoming essential to understand what is happening and what will happen-in geographic space. This project web based geographic information system (GIS) lets us visualize, question, analyze, and interpret data to understand relationships, patterns, and trends online. Most of the geo-portals which are web based primarily provide display of geo-data/ satellite images. But analysis of geographical data to solve the problem of real nature on the move is very limited. The proposed project work envisages development of a prototype for carrying out multilayer GIS queries online using geo processing techniques and WPS. The development of this prototype is aimed at providing support in decision making to the users online. Through this model, users can query information of specific geographical area of interest from data spanning multiple layers. The query result will be retrieved by making use of geo-processing techniques, and Open Geo Consortium (OGC) compliant services such as Web Processing Service (WPS) and Web Map Service (WMS) etc. Spatial queries are also performed on the resultant output obtained by spatial queries performed earlier, thus forming a chain of web of processing services.

**Keywords:** GIS, OpenLayers, Web Processing Services, Shapefiles.

## Introduction:

Geospatial data is the information describing the location and names of features beneath, on or above the earth's surface. Use of geospatial data has been increasing rapidly over years as it supports a wide range of business, government and community activities. The use and reuse of this information has significant productivity related benefits. Traditionally, there are two broad methods used to store data in a GIS for both kinds of abstractions mapping references: raster images and vector. Points, lines, and polygons are the stuff of mapped location attribute references. Web GIS, is the combination of the Web and geographic information systems or science (GIS), has grown into a rapidly developing discipline since its inception in 1993. GIS has turned into a compelling Internet application that has prompted many people to take advantage of the Web.

The map data or the GIS data is available in many formats. The shape file format is a popular geospatial vector data format for geographic information system (GIS) software. It is developed and regulated by Esri(**Environmental Systems Research Institute**) as a (mostly) open specification for data

interoperability among Esri and other GIS software products. The shapefile format can spatially describe vector features: points, lines, and polygons, representing, for example, water wells, rivers, and lakes. The shapefile of a particular area when downloaded and un-zipped consists of four files, they are:

- **.dbf file** - The .dbf file extension represents the dBASE database file. It represents attribute format, columnar attributes for each shape, in dBase IV format.
- **.prj file** - It is a generic file extension for a project file used with many applications. PRJ stands for Project. It consists of projection format, the coordinate system and projection information, a plain text file describing the projection using well-known text format.
- **.shp file** - shape format, the feature geometry itself.
- **.shx file** - shape index format, a positional index of the feature geometry to allow seeking forwards and backwards quickly.

The Open Geospatial Consortium (OGC) is an international industry consortium of **507** companies, government agencies and universities participating in a consensus process to develop publicly available

interface standards. OGC Standards support interoperable solutions that "geo-enable" the Web, wireless and location-based services and mainstream IT. The standards empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications.

GeoServer can be defined as a reference implementation of the OGC standards. GeoServer is an open source software server written in Java that allows users to share and edit geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards. Open Layers, a free mapping library, is integrated into GeoServer, making map generation quick and easy. GeoServer includes several types of OGC services like:

**Web Coverage Service (WCS):** WCS offers multi-dimensional coverage data for access over the Internet. It defines Web-based retrieval of coverage's that is, digital geospatial information representing space/time-varying phenomena. A WCS provides access to coverage data in forms that are useful for client-side rendering, as input into scientific models, and for other clients.

**Web Map Services (WMS):** WMS is used for serving geo-referenced map images over the Internet that are generated by a map server using data from a GIS database. A WMS server usually serves the map in a bitmap format, e.g. PNG, GIF or JPEG. In addition, vector graphics can be included: such as points, lines, curves and text, expressed in SVG or WebCGM format.

**Web Feature Service (WFS):** WFS provides an interface allowing requests for geographical features across the web using platform-independent calls. One can think of geographical features as the "source code" behind a map.

**Web Processing Service (WPS):** WPS standard defines how a client can request the execution of a process, and how the output from the process is handled. It defines an interface that facilitates the publishing of geospatial processes and clients discovery of and binding to those processes.

**WPS Processes** can include all the algorithms, calculations or models that operates on spatially referenced data. The data required by the WPS can be delivered across a network or they can be available at the server. There are three mandatory operations that must be performed by a WPS, namely-

- **GetCapabilities** send back an XML document describing the service capabilities.
- **DescribeProcess** returns a description of a process including its inputs and output.

- **ExecuteProcess** returns the outputs of a process.

OpenLayers is a pure JavaScript library displaying map data in most modern web browsers, with no server-side dependencies. It implements a JavaScript API for building rich web-based geographic applications. In OpenLayers, a map is a collection of layers and various controls for dealing with user interaction. A map is generated with three basic elements: markup, style declarations, and map initialization code. Geoserver is used to display the maps that are generated using openlayers.

**PostgreSQL**, often simply "**Postgres**", can also be defined as an object-relational database management system(ORDBMS) with an emphasis on extensibility and standards-compliance. PostgreSQL handles complex SQL queries using many indexing methods that are not available in other databases, has updateable views and materialized views, triggers, foreign keys, supports functions and stored procedures, and other expandability, and has a large number of extensions written by third parties.

Spatial databases store and manipulate spatial objects like any other object in the database. **PostGIS** is a spatial database extender for PostgreSQL object-relational database. It adds support for geographic objects allowing location queries to be run in SQL. Spatial data types refer to shapes such as point, line, and polygon. Multi-dimensional spatial indexing is used for efficient processing of spatial operations. Spatial functions, posed in *SQL*, are for querying of spatial properties and relationships.

**Thematic Maps:** A thematic map is a type of map especially designed to show a particular theme connected with a specific geographic area. These maps "can portray physical, social, political, cultural, economic, sociological, agricultural, or any other aspects of a city, state, region, nation, or continent".

#### Dynamic layering of thematic maps:

The dynamic layering of thematic maps is a process in which thematic maps of the area of interest available are added to the base map. To generate dynamic maps on a browser an open source javascript library "**OpenLayers**" is used. OpenLayers Map stores information about the default projection, extents, units, and so on of the map.

To use OpenLayers the version of it compatible with geoserver installed version should be downloaded and placed in the doc folder of tomcat/webapps. Building an OpenLayers viewer requires crafting HTML in which your viewer will be seen.

```

<Script type="text/javascript">
var map = new OpenLayers.Map('map',
    {controls :
      [
        new OpenLayers.Control.PanZoom(),
        new OpenLayers.Control.Navigation
      ]});
var wms = new OpenLayers.Layer.WMS("Layer1",
  "http://localhost:8080/geoserver/alfi/wms",{
    layers:"boundary",
    isBaseLayer:true
  });
map.addLayer(wms);
map.zoomToMaxExtent();

```

**Fig:** Code for creating a map viewer and a base map

The above figure shows the code in which a viewer is created named map and WMS is the base layer displayed in that viewer. The thematic layers are created same as the base layer using **OpenLayers.Layer.WMS** constructor but the property **"isBaseLayer"** of the thematic layers is set to false, which makes these layers transparent. These transparent thematic layers can be added to the base layer either statically or dynamically.

### Using WPS processes to perform GIS calculations on the layered thematic maps:

There are around 92 Web Processing Services(WPS) that are available to GeoServer. To perform an operation of any of the WPS processes on the thematic layer using GeoServer a WPS client is to be created to specify the server. Creation of the WPS client is as shown in the below figure.

```

//creating WPS Client
var client= new OpenLayers.WPSClient({
  servers:{
    local:"http://localhost:8080/geoserver/wps";
  }
});

```

**Fig:** Creating a WPS client

As the result of the execution of WPS Process should be added to the thematic layer on which the execute operation of the WPS process is to be performed a transparent vector layer is to be created. The creation of the transparent vector layer is as shown in the below figure:

```

//Create the layer that will hold the result
trans_layer=new OpenLayers.Layer.Vector();

```

**Fig:** Creating a transparent Layer

Now to use a WPS process to perform GIS calculations on any thematic layer the layer should be a WFS (Web Feature Service) layer. As WMS layer only displays the map on which no operations can be performed, so it is important to render the map as a WFS layer to access the features of the thematic map and to perform GIS calculations using WPS processes. The WFS standard defines operations that enable clients to:

- **GetCapabilities:** Discover which feature collections are available.
- **DescribeFeatureType:** Describe the attribute fields available for features.
- **GetFeature:** Query a collection for a subset of features based on a provided filter.
- **Transaction:** Add, edit or delete features.

Adding of a WFS layer to the code is shown in the below figure. In the parameters of the WFS layer the **featurePrefix** specifies the workspace name, **featureType** specifies the name of the WMS layers whose WFS layer is being created.

```

var roadswfs = new OpenLayers.Protocol.WFS({
  url:"http://localhost:8080/geoserver/wfs",
  request:"GetFeature",
  featurePrefix: "alfi",
  featureType: "roads",
  featureNS:"http://alfisha/khan",
  geometryName : "the_geom"
});

```

**Fig:** Adding a WFS layer

Each and every WPS process has its own input and output names which act as variables to store the inputs and the outputs, these names should not be changed. To perform this GIS Operation the WPS process **"gs:BufferFeatureCollection"** is used. The inputs to perform this operation are the **features** of the WFS layer that is the roads and the **distance** in kilometres that determines to which extent the roads should be buffered. The output of the execute operation of this WPS process is **result**.

To display or show the result of the execute operation performed on the WPS process the features of the result are to be added to the transparent and this transparent layer is to be added to the viewer that is created to display the maps.

### WPS Process Chaining:

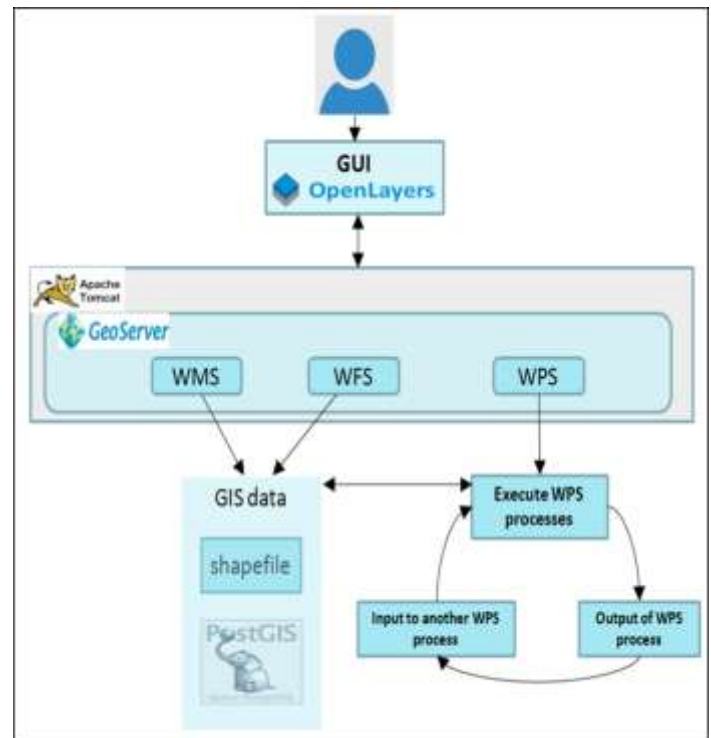
A WPS process is normally an atomic function that performs a specific geospatial calculation. Chaining of WPS processes facilitates the creation of repeatable

workflows. A service chain is a sequence of services where, for each adjacent pair of services, occurrences of the first action are necessary for the occurrence of the second action. When no single service can be used for the requirement, we should combine several services together to do the work. As the central concept of SOA (Service Oriented Architecture) framework, compositing services chain can solve complex problems. There are three possible ways that can be used to chain WPS processes, they are:

- BPEL
- WPS Interface
- Simple cascading service chains

Using WPS Interface to design a sequence of web services:

The WPS interface standardizes the way processes and their inputs/outputs are described, how a client can request the execution of a process, and how the output from a process is handled. WPS uses standard HTTP and XML as a mechanism for describing processes and the data to be exchanged. In principle there are no restrictions on what can be implemented using the WPS interface.



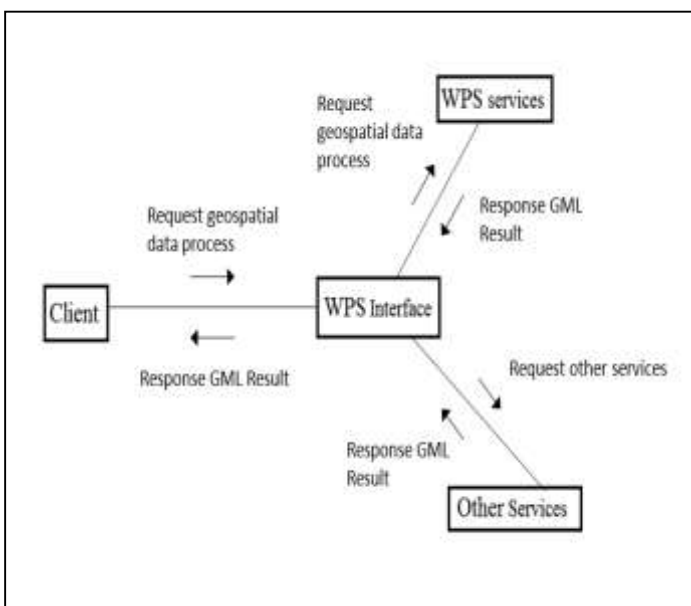
**Fig:** Architecture of “Web Based Spatial Query System for Decision Making”.

**Dynamic chaining of these WPS processes:**

Dynamic chaining is a very complicated, as the output of any geospatial operation listed in the web page should be provided as input to any other geospatial operation present and this processes of providing output of one process as input to another process may continue infinite number of times. That is the dynamic chaining of WPS processes is done using two global temporary variables (temp1, temp2) and a stack (st).

The **steps of dynamic chaining** are as follows -

1. Whenever a layer is added to the basemap then the features of that map are retrieved using " **OpenLayers.Protocol.WFS** " .
2. The retrieved features of the map that are in the form of an array are pushed on to the stack, if more thematic layers are added the same thing happens with them also.
3. The aim of this project states that any operation is to be performed on the layer that is last added to the base map i.e. the layer present on the top of all the layers added to the base map.
4. As per the aim of the project, the features of the layer that are last added to the stack are present on the top of the stack. These features are popped out of the stack and this array of features are stored in one of the temporary variables and the geospatial operation using WPS processes is performed on that temporary



**Fig:** Using WPS interface to orchestrate a services chain

**Architecture of the project:**

The architecture of the project tries to convey that the GUI of the Project is designed using the functions of the OpenLayers, GeoServer that does all the processing is integrated inside tomcat.

variable. The result obtained is pushed on to the stack.

5. In case of Multi-layer operations whenever a WPS process requires two input layers to perform a geospatial operation, so the features of the topmost layer present on the stack are popped out and placed in the temporary variable temp1 and the features of the layer next to the top layer are popped out and placed in the temporary variable temp2 and the multilayer geospatial operation is performed on these two variables.
6. The result of the multi-layer operation is added to the stack and this result now is the top of the stack.

### **Conclusion:**

This is project "Web based Spatial Query System for Decision Making" is subjected to provide online support to the clients to perform Geospatial operations on the geographical thematic maps online. It can be used by a client or a user who has complete knowledge about geographic operations and spatial queries and also by a non-technical person .The user can chain the operations without any limit on the number of operations to be chained. Web Based Spatial Query System for Decision making consists of a query shell where a user can enter an English type query or use the buttons given below to perform geospatial operations and get the result displayed on the base map. There is also a log box present in this web application that shows or lists the operations or the things performed by the client or the user.

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