A WebGIS Platform Design and Implementation Based on Open-Source GIS Middleware

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Abstract-In recent years, with the rapid development of networks and computer technology, WebGIS has changed the traditional GIS Application mode, becoming more and more popular. At the same time, the Open Source GIS software projects and open technical standards have been developed rapidly. During the informatization process in different fields, most managers uses commercial GIS software platform or some Open Source GIS software that has had a long history and sophisticated framework to build their information management and service system. Based on the analysis of Open Source GIS technology, a new WebGIS design scheme based on Open Source GIS middleware technology was put forward. And then A Tourism Resources Information System was used as an example to verify the feasibility of this blue print.

Keywords-WebGIS; Open Source; Middleware; Spatial Database

I. INTRODUCTION

GIS has been developing for nearly fifty years. Many GIS organizations, companies, and research institutes have gathered a lot of experience in software development. Different industries and sectors have accumulated plenty of practical experience. A great number of WebGIS solutions have emerged during the past two decades. Online map services and data resources, especially Google Maps and Baidu Maps, have been used widely. They released their own open-source API and data format to interoperate geospatial data, making WebGIS applications popular and of greater diversity.

Recent years, open-source GIS software are making extraordinary progress in desktop GIS application, database, Spatial Data Engine, and map server. Open-source GIS software is a highly-developed system with flexibility that covers various application architecture and programming language[1-2].

The development of open-source software invigorates the global software industry, put forward a challenge to the reorganization of the industry, and also provides opportunities for the development of software industry in China. Making full use of open-source information technology and resources can help to break through the technology barier and promote the development of geographic information systems in China[3].

This paper designs and implements a WebGIS platform based on open-source GIS middle-ware, expounds on the work flow of each middle-ware and how to make these middle-ware work collaboratively in detail, and finally verifies the platform with practical work.

II. WEBGIS ENGINE AND MLDDLEWARE

A. WebGIS Engine

The WebGIS[4] engine is the core of geographic information systems. A good map engine is crucial in improving the response ability of WebGIS. Online maps communicate through the Internet which inevitably influenced by network transmission speed. Meanwhile, huge amounts of data in GIS often results in display delay in client page. Real-time data display is one of the key factors in WebGIS.

Any one of the major online map publishing platforms now can meet the end users' need, reduce the workload for developers and improve the deployment efficiency. However, these platforms are highly encapsulated, making it difficult to find out the internal implementation mechanism for the average developers.

B. MiddleWare technology

GIS middle-ware is a kind of reusable software block. By providing pre-defined interfaces to the users, they encapsulate various of GIS services, so that users can focus on integrating middle-ware into their applications with powerful and flexible means instead of implementing the very basic functions[3]. GIS middle-ware here is a code library, a toolkit. It provides standard means to manipulate the geographic spatial data and perform topological analysis.

GIS expert Zhou Chenghu once said, "In the age of knowledge economy and globalization, geospatial information is the strategic information resources in the modern society, geospatial information industry has become an important part of modern knowledge economy. The development of open-source GIS accelerates the independent innovation in spatial information technology."

Using GIS middle-ware in scientific research, teaching and other fields can not only cultivate students' interest, but also allows them to have a better understanding of the GIS workflow. Therefore, research on GIS middle-ware based application is a very meaningful work.

III. THE DESIGN OF WEBGIS BASED ON OPEN-SOURCE GIS MLDDLEWARE

In this chapter, a design of a WebGIS publishing platform based on open-source GIS middle-ware is presented[4]. The work flow of each middle-ware and how to make these middle-ware work collaboratively is illustrated in detail. With the convenience in extension, this design can meet the needs of

small and medium-sized enterprises. The most important aspect is that developers can become familiar with the development environment, the internal implementation mechanism, and the communication principle between different components.

A. Design Principles

WebGIS is the Geographic Information System that publishes geographic information on the web using Internet technology. Users can browse the spatial data, make thematic maps, carry out spatial retrieval and spatial analysis on the WebGIS site. The principles of WebGIS are as shown in Figure 1. From the graph, it can be found that the WebGIS application consists of three parts: the database server (data layer), the application server (application layer), and browser (map presentation layer). The data layer includes the thematic database and GIS database, application layer includes Web server, GIS server and their service extension programs, the client layer is a standard Web browser.

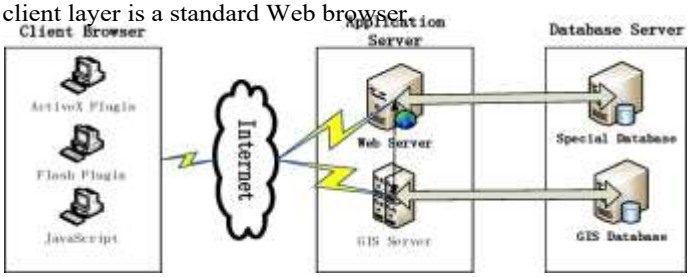

Figure I. Data flow of Mobile map tile application

The client layer is the map presentation part. However, current browsers do not support the GIS data type directly. There are two common ways to achieve client map display function. One of them need to load specific plug-ins, such as ActiveX, Flex etc to control the display of the map data; the other one uses JavaScript map library to process the interactions between the client browser and the application server and display the request result. Plug-ins implementation requests the client to download a specific plug-in program while the JavaScript map library technology does not have this limitation. Currently, JavaScript map library is the mainstream technology of WebGIS map display.

B. Architecture Design

This paper designs and implements a WebGIS publishing platform based on open-source GIS middleware according to WebGIS principles. Figure 2 is the technical architecture. Client map display uses the mature, open-source script library OpenLayers[5]. Application layer uses TF.NET[6] and FDO[7] function library as the main GIS analysis library. Data layer includes basic map data, thematic data, grid (slice) map data, and vector data of other GIS format. Basic map data is provided by Google as two-dimensional image data, three-dimensional model data; thematic data contains some GIS data stored in SQL Server 2005 Express; tile data is generated by custom map segmentation program; other GIS data is managed by the FDO function library and can interact with thematic data in certain way.

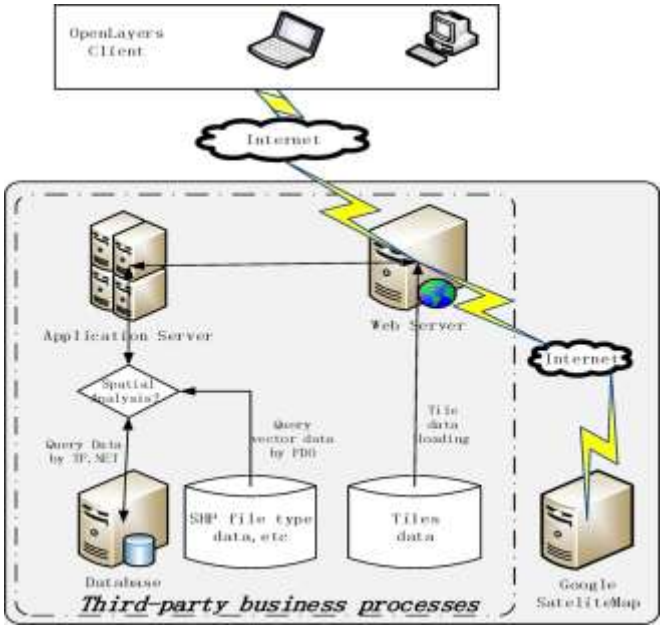

Figure 2. The WebGIS technology architecture based on middleware

C. Function Design

According to the design principles and architecture design, the system can be divided into three layers in structure, the browser, application server, and database server. Correspondingly, its function is divided into 3 parts: client map presentation layer, application service layer, and data service layer. The following is the technical architecture design of the three basic function module.

1) Map Presentation Layer based on Ajax

(1) Ajax and WebGIS

Ajax is the abbreviation of "Asynchronous JavaScript and XML", it is a Web application development method that uses client script to exchange data with Web server. In this way, the Web page can update dynamically without interrupting the interaction processes. WebGIS has the basic characteristics of developing in Ajax: the need for real-time interaction response and large, frequent communication with server to transmit data. Ajax is competent to implement the client development and enhance the user experience.

It is appropriate to adopt Ajax in the WebGIS client that meet the OGC specifications. One obvious advantage is that it naturally achieves a common client need in spatial information sharing. People can acquire spatial information from the Internet without installing additional program. The system development can be focused on improving server performance.

(2) The client map display based on OpenLayers

Along with the expansion of the online map market, the number of the client JavaScript class library based on Map Tile and Ajax Technique is increasing. OpenLayers, MapEasy and MapBuilder are popular ones among them. Making good use of these class libraries can significantly reduce the technical

threshold and accelerate the system development. OpenLayers is one of the most used frameworks by developers.

All functions of OpenLayers that access geospatial data are in line with industry standards, such as the WMS and WFS of OpenGIS. OpenLayers uses a pure object-oriented JavaScript development method and shares some components of the Prototype framework and Rico library. Using OpenLayers as the client could avoid the dependency on the browser. OpenLayers supports many data formats such XML, GML, GeoJSON, GeoRSS, JSON, KML, WFS, and WKT. It has a wide range of map data resources, such as WMS, WFS, Google Maps, Virtual Earth, World Wind, MapGuide and so on, providing more choices to users. Also, it could use a simple image as the map source.

2) Application Service Layer based on .NET

The application service layer is the layer located in the middle, mainly includes Web server, GIS server and application extensions. GIS server deals with complex data analysis such as editing, building of topological relations, automatic maintenance of object relations and charting. The Web server obtains two-dimensional POI data and attributes data via ASP.NET and returns them to the client after interactively processing with GIS server.

The design in this paper is mainly for small and medium-sized application system and the realization of GIS application server mentioned in the paper uses GIS middle-ware. The base map uses pre-treated tiled map data and online map data like Google Maps rather than taking the way like ArcServer.

The process is: receiving a client request, converting to standard query statement, constructing spatial object, interacting with database and returning result set, processing result set to demanded format, returning fmal result to client. The flow chart is as shown in Figure 3.

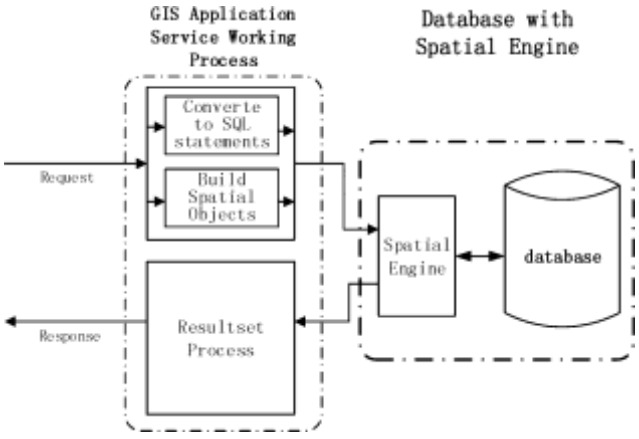

Figure 3. The Workflow of GIS Application Service Layer

3) Spatial Data Access Service Layer based on multi-source spatial data

GIS database is the core of the whole design in this paper. Unlike the integrated database such as MySQL, It is a light weight spatial database, which is independent design and implementation as well as being extended based on the relational database. In this part, we mainly study the spatial data engine, GIS topology library, spatial database access library, and three modules of the spatial database based on these previous parts.

(I) Theory of spatial data access engine

Spatial data access engine[8-IO] is the core component of spatial database for the management of the spatial data, of which the implementation is based on the spatial database techniques of relation database. The application layer such as GIS are all using this core component for the interaction between middle layer and relational databases, such as ArcSDE, PostGIS, MsSQLSpatial. Thus, we can consider spatial database as the mixture of traditional relation database and spatial data engine. The working theory of spatial data engine is illustrated in Figure 4.

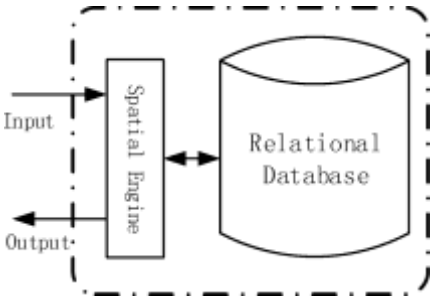

Figure 4. Spatial Data Engine schematic diagram

(2) GIS topology library and spatial data access library

Spatial search is completely different from the search in the traditional relation database, which contains not only the related information, but also its topology information. During the spatial search, it may relate to the spatial computation and spatial analysis, both of which are the central part of spatial data engine. Here the spatial computation includes spatial buffering, spatial distance and others, and the spatial analysis is mainly the topology analysis, including plane inclusion, intersection of space, etc.

Considering the fact that it needs to interact with other GIS database like ShapeFile, function library that could access multi-source spatial data is needed.

In order to reduce the workload of development, we use TF.NET and FDO middle-ware as the topological function library and spatial data access library respectively.

(3) Design of spatial data engine

In this paper, we do the design of spatial data engine according to the Figure 5. Meanwhile, we implement and realize a program for a particular engine based on TF.NET and FDO. Here, the relation database SQL Server 2005 Express from Microsoft is used, which can coordinate with the document-type GIS database.

In the spatial data engine, TF.NET is used to filter the geo-data and FDO to access other GIS format data. The structure of

the engine is shown in Figure 5. Firstly, the query parameters are analyzed, and then SQL statements and ADO.NET are used to get a SqlDataReader result set, lastly the topological function is used to analyze the result set until a matched result is found. When the parameters contain the FDO keywords, the FDO API should be used to read related GIS data, and then convert to TF.NET spatial object set, finally, TF.NET combines the spatial object set and the passed object set to complete the data access of the relational database.

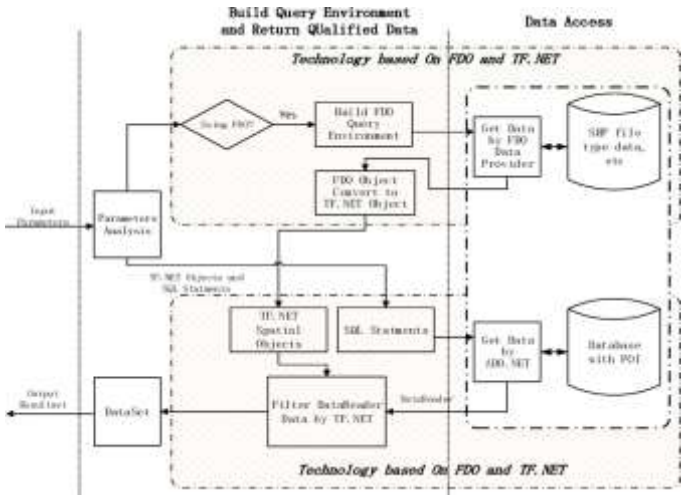

Figure 5. Spatial Data Engine architecture diagram

Spatial data engine in this paper relies on the Microsoft.NET environment. You can use C#, VB.NET to develop database application and extend your own system.

```
private DataTable Query (string mysql, List<Polygon> ps, int pageIndex, int pageSize, int total)

    sql = mysql.Substring (0, mysql.ToLower () .IndexOf ("where") ) ;
    sql += " where 1=2";
    DataTable dt = DbHelperSQL.Query (sql) .Tables[O];
    SqIDataReader dr DbHelperSQL.ExecuteReader (mysqI) ;
    int index = O,endIndex;
    if (pageIndex == -1)
    { pageSize = 10000;11 }
    if (pageIndex + pageSize > total)
      endIndex = total;
    else{ endIndex = pageIndex + pageSize;}
    int added_C = 0;
    while (dr.Read () )
    if (ps.Count > 0)

      IGeometry g = GeometryHelper.BuildPoint
          dr["LocationX"].ToString ()
          dr["LocationY"].ToString () ) ;II
      if (this.Contains (ps, g) )
        continue;

      if (pageIndex <= index && index < endIndex)
      {... }
      if (added_C >= pageSize II index >= endIndex)
      { break; }
      index++;

    dr.Close ()
    return dt;

private bool Contains (List<Polygon> ps, IGeometry g)

    bool c = false;
    foreach (Polygon p in ps)

      if (p.Contains (g) )
      {c = true; break;}

    return c;
```

IV. IMPLEMENTATION

Based on relative technologies and the study of demanding investigation, we try to construct a new system releasing the tourism resource based on the open source middleware. Here we will adopt the distributed multi-layer structure and mainly use the Asp.Net 4.0 technology. In this new system, we take the OpenLayer as the map-display frame as client and use Asp.Net Ajax to realize the demonstration of information without refreshing. More specifically, in the new system, after the client sends the request to the server through lIS, it will analyze the received parameters on WebForm or WebService, carry out the related computations using middleware and ADO.NET techniques, and then send the results back to client for display.

This new system is an Ajax application with B/S structure. Here the GIS application is based on the design based on the

open source middleware proposed in the previous section. Therefore, it is install free, and only requires a web browser. The practical implementation of the system is shown in the following figure.

Figure 6. Query results with Regional Scope tool

The runtime environment for the server and client is shown as below:

TABLE T. RUNTrME ENVIRONMENT

Configuration			Software
2 = = 5:- (3)	Client	Browser	IE8.0+, Firefox, Chrome
	Server	OS	Windows Server 2008R2..
		Web Server	liS 7.5
		Database	Sal Server 2005
		Other	.NET Framework4.0, Asp.Net Ajax

CONCLUSIONS

In this paper, we primarily made an investigation on the theory, design, and implementation of the open-source- middleware-based platform for online mapping, and proposed an initial WebGIS program that has basic functions, such as map operation, map search, path regional analysis and spatial data engine. This open-source-GIS-middleware-based WebGIS program has the advantages of easy implementation, simple configuration, installation-free, and high efficiency, which has been verified on a tourism resource system. Of course, this program is not perfect yet, and further work such as coordination among the components of GIS middleware and others will be considered in the future.

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