Web GIS Server Using GML

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Abstract: Recently, loosely-coupled systems are widely used for distributed computing environment. We develop a web GIS server who conforms to the international standards developed by the Open GIS Consortium (OGC), such as web feature service (WFS) implementation specification, Geography Markup Language (GML) implementation specification, and the simple features specification for OLE/COM. The web GIS server provides interoperable access of spatial data among data formats in the distributed environment.
Keywords: Web GIS, Open GIS Consortium (OGC), Geography Mark-up Language (GML), Web Feature Server (WFS), Spatial Data.

1. Introduction

The provision of spatial data is a key infrastructural requirement for the promotion of economic growth, environmental quality, social progress, etc. For the purpose of efficient management of spatial data, Geographic Information System (GIS) is emerged. Various GIS that can analyze, process, and manage spatial data have been developed. Because they have their own storage format, integration or conversion of the spatial data consumes a lot of cost and time. Furthermore, interoperability among the spatial data seems infeasible in distributed environment. The Open GIS Consortium (OGC) makes efforts to overcome these problems and develops implementation specifications for interoperability of the spatial data.

In this paper, we propose a web GIS server for interoperability in loosely-coupled distributed environment. In order to provide interoperability and reusability for the spatial data, we adopt international standards for implementation made by the Open GIS Consortium, such as Simple Features Specification (SFS) for OLE/COM, Web Feature Service (WFS) Implementation Specification, and Geography Markup Language (GML) Implementation Specification.

The simple features specification for OLE/COM is used for access database from disk without consideration of its specific storage format. The web feature service implementation specification provides operations to obtain not only spatial data but also metadata about them. In this paper, the operations are limited to the read-only processing, known as basic WFS in the specification. The geography markup language implementation specification is used for uniformed encoding of spatial data for the response when a user request spatial data to the WFS.

2. Geography Markup Language (GML)

GML is an XML encoding for the modeling, transport and storage of geographic information, including both the geometry and properties of geographic features. Using GML, an XML-based language, you can deliver geographic information as distinct features, and then control how they are displayed in a Web browser. Just as XML is helping the Web to clearly separate content from presentation, GML will do the same in the world of geography. GML provides an XML-based encoding of geospatial data; it can be viewed as a basic application framework for handling geographic information in an open and non-proprietary way. [6]. Figure 1 shows example of GML.

Traditional 0, 1 and 2-dimensional geometries defined in a two-dimensional spatial reference system (coordinate reference system in version 3.0) are represented in GML as points, line strings and polygons. GML also allows geometries that are collections of other geometries (either homogeneous, using multi-points, multi-line strings and multi-polygons, or heterogeneous, using geometry collections).

The GML approach is a great improvement over the historical reliance on simple GIF/JPG image maps for the following reasons: better quality maps, works on a browser, custom map styling, editable maps, more sophisticated linking capabilities, better query capability, control over content, service chaining, and so on.

GML 3.0 released in 2003 provides a variety of kinds of objects for describing geography including features, coordinate reference systems, geometry, topology, time, units of measure and generalized values [7]. OGC defines a geographic feature as an abstraction of a real world phenomenon; it is a geographic feature if it is associated with a location relative to the Earth.

```
<Feature typeName="Road">
 <description>
   Georgia Street
 </description>
 <property typeName="numberLanes" type="integer">
    4
 </property>
 <geometricProperty typeName="linearGeometry">
  <LineString srsName="EPSG:4326">
   <coordinates>
      0.0,100.0 100.0,0.0
   </coordinates>
  </LineString>
 </geometricProperty>
</Feature>
```

Fig. 1 Example of GML

3. Design of the Web GIS Server

The proposed web GIS server is designed with adoption of international standards for interoperability as shown in figure 2. It uses the Microsoft Internet Information Server (IIS) as a web server and consists of spatial data configuration tool (SCT), spatial data management component (SDM), and spatial query management component (SQM). Any kind of spatial databases that have data providers conform standard of the simple feature specification for OLE/COM can be used.

1) The Spatial Data Management Component

The spatial data configuration tool (SCT) is an executable file who invokes the spatial data management component at the beginning, reads spatial data to be serviced through data provider from databases or files, and loads them to the allocated main memory using the spatial data management component. An administrator can select data provider that conforms to the simple feature specification for OLE/COM and spatial data which will be served. The configuration information that is set by the administrator can be stored as XML file for reuse in the future. The SCT can be used to show status and logging information of the server.

2) The Spatial Data Management Component

The spatial data management component (SDM) manages spatial data from the SCT in the main memory and fetches spatial data corresponding to user's query with MBR and a list of type names.

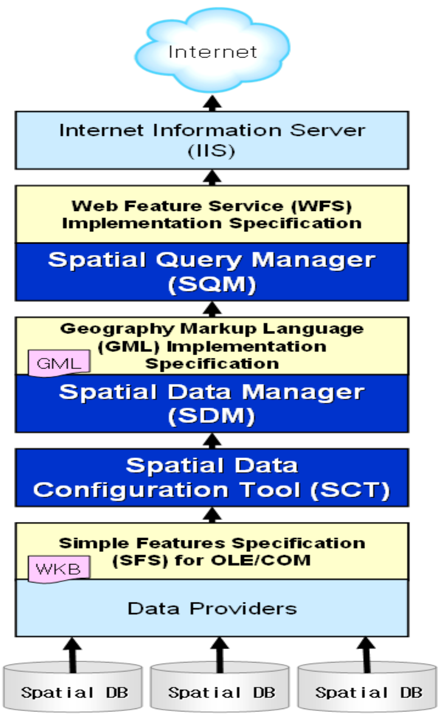

Fig. 2 Architecture and Adopted Standards

The management of spatial data in the main memory gives rapid response by reducing access time from database in disk for each request. The format of spatial data in memory is GML as target data format for reducing conversion time for each request. The spatial data management component is an out-of-process COM server to be shared with other processes, such as the SCT and the SQM.

3) The Spatial Query Management Component

The spatial query management component (SQM) adopts the web feature server specification and invokes methods of the SDM to fetch spatial data. It is an Internet Server Application Programming Interface (ISAPI) extension component which guarantees more efficient service than CGI approach though many clients request the service at the same time. The ISAPI extension is loaded only once by web server when the first service is requested. The component is not loaded more than once but shared when another request is invoked. It minimizes overload of the server and enables rapid service.

The SQM provides basic WFS operations, such as GetCapabilities, DescribeFeatureType, and GetFeature. Because the SDM manages spatial data in the main memory regardless of write-operations, the SQM cannot support transactional operations

4. Implementation of the Web GIS Server

1) Use of Main Memory

We exploit main memory for efficient performance to manage spatial data which can be served. The target GML data is stored in memory with many pointers that refer the offsets of the individual features for spatial index as shown in figure 3. It reduces time-consuming operations such as reading database from disk, conversion from a specific storage format of spatial data to well-known-binary (WKB) in data provider component for unified access among different formats, and conversion from the WKB to the GML.

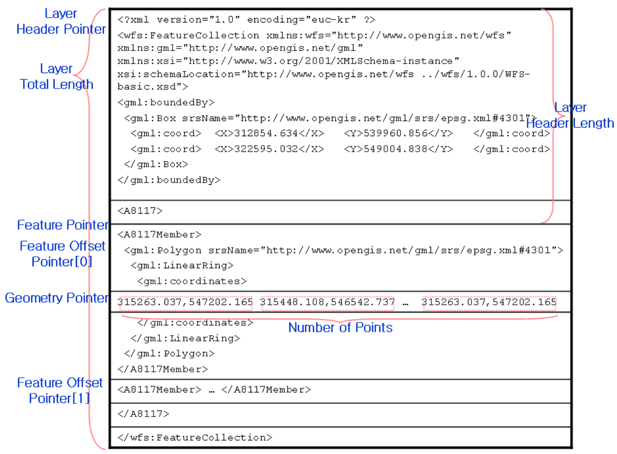

Fig. 3 Management of Main Memory

Because the cost of the main memory has been decreased gradually, content providers who want to support rapid response may willingly increase the main memory for better services. We support up to 64 Gigabytes of physical main memory if they are installed in the server computer. The physical main memory supported by the MS-Windows' kernel guarantees that it is never swapped to the disk by operating system for context switching.

2) Progressive Transmission

The web GIS server processes user request to access spatial data in web environment. We extend it to support progressive transmission for rapid response. The goal of progressive transmission is to reduce latency time by representing only received spatial data. The remainder can be continuously received during representation with multi-threaded process. Once, the client draw already transmitted geometry data, the client should merge remainder part of geometry to the previous data and redraw periodically. More time goes, more detailed spatial data can be displayed as shown in figure 4.

(a) 10% (b) 20% (c) 50% (d) 100%

Fig. 4 Example of Progressive Display

The progressive transmission can be more useful when a user request spatial data in mobile environment through wireless communications.

3) Spatial Data Compression and Encryption

The web GIS server supports compression and encryption for efficiency of transmission and security, respectively. The compression is developed using zlib which can be obtained from http://www.gzip.org/zlib. The encryption uses Crypto API which is provided by Microsoft.

5. Conclusions

In this paper, we proposed a web GIS using GML for interoperability in distributed environment. In order to provide interoperability and reusability for the spatial data, we adopted standards of Open GIS Consortium, such as Simple Features Specification for OLE/COM, Web Feature Service Implementation Specification, and Geography Markup Language (GML) Implementation Specification. The Simple Features Specification for OLE/COM is used for uniformed access of spatial database from disk without consideration of its specific storage format. The web feature service implementation specification provides operations to obtain spatial data and metadata about them. In this paper, the operations of the web GIS server are limited to the read-only processing, known as basic WFS in the specification. The Geography Markup Language Implementation Specification is used for encoding spatial data for the response when a user request spatial data to the WFS. The version of the GML that we implemented is 2.1.2.

We have a plan to implement the latest version 3.0 of the specification and to develop dedicated codec for the GML 3.0 for the future work. Development of a wrapper which uses the web GIS server as back-end for the web services using SOAP (Simple Object Access Protocol) can be a future work.

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