Easily Accessible GML-based Geographic Information System for Multiple Data Server over the Web

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Abstract: This paper has proposed GML-GIS, which is a prototype system for geographic information service over the Web based on GML (Geography Markup Language). This system generates geographic information into GML document by user requests through URL and provides them with various styles applied to the document on the Web browser. This proposed system converts geographic information of a spatial database into GML documents for interoperability of diverse GIS engine. The architecture of this system is composed of User Interface Module, CGI/Script Module, Application Schema Generator, GML Translator, XML Analyzer, and Documents Pool. By the usage of this system, general users can access easily geographic information of multiple data server with different data type by Web browser

1. Introduction

The rapid popularization of the Internet and the expansion of the information society have requested for integrated data forms to aggregate distributed heterogeneous data dispersed throughout various environments. And Web pages contain a great deal of information included geographic data. The Internet mapping of geographic data has provided URL access on the Web and is increasingly gaining popularity. However, data as well as software are proprietary and completely controlled by individual GIS (Geographic Information System) engine. It is very difficult for general users to integrated search result from different system or with other application [Ga00, ZG01, Zj00, Ss01]. Accordingly, the OGC (Open GIS Consortium) has proposed GML specifications that laid the basis on advantage of XML which can integrates distributed diverse documents on the Web. GML specifications are such standards for developing interoperable web based GIS and the encoding mechanisms and grammars of XML for storing and transmitting geographic data that include the geometry and properties of geographic features [OGC02, W3C98a]. Related works for interoperable Web GIS system based on advantage of GML have proposed [OGC98a, OGC00, ZG01, Ss01]. But explanation of detailed description and converting method of the system is lack in the previous studies.

In this paper[1] the detailed design and implementation of GML-GIS, which integrates distributed heterogeneous geographic information based on the GML have discussed and the converting method between spatial database and GML documents, which is applied to the GML-GIS has described. The advantage of this system provides an integrated service from the different data server with various data type to the Web users using general Web browsers without running of individual applications.
The rest of this paper is organized as follows. Section 2 introduces the GML and XML schema that form the bases of our research. Section 3 explains the architecture of the GML-GIS, which is a prototype system for geographic information service over the Web based on GML. And section 4 tests the actual implementation of the system in a Web environment, and Section 5 discusses the conclusions and future work of this study.

2. Related Studies

2.1 GML

GML is an XML encoding for the transport and storage of geographic information, including both the spatial data and non-spatial properties of geographic features [OGC02, W3C98b, W3C01].
The GML specifications are based on Simple Feature and offer three types of schemas for geometry, feature, and xlink to represent geographic information. The geometry.xsd replaces geometry.dtd, which used to indicate geometrical elements, such as dots, lines, and surfaces in GML 1.0 specifications. It provides geometry elements related to Point, LineString, LinearRing, Polygon, MultiPoint, MultiLineString, MultiPolygon, and MultiGeometry classes consistent with the OGC Simple Features Model [OGC98b]. The feature.xsd defines Feature Collection model used in GML 2.0, and xlink.xsd provides Link Attributes that is used to create links between resources [W3C00].
The user makes an application schema on the basis of these three schemas. An application schema is a XML Schema document that is defined by user to represent geographic information of user specified object or domain into GML documents. A GML document is created of referencing this application schema.

2.2 XML Schema

The XML schema specifications have proposed by the W3C (World Wide Web Consortium) to substitute for DTD [W3C01]. The schema gives higher flexibility and more data types than DTD, and provides backward compatibility with elements, characteristics and data type definitions of DTD. Moreover, as DTD, it can create a mechanism that limits the structure of documents, and is written in XML-based syntax. Therefore, with the XML schema it is also possible to make use of tools such as XML parser and DOM (Document Object Model), which are used to create and operate XML documents [W3C98b].

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3. GML-GIS: GML-based Geographic Information System

In this section, we have proposed the prototype system, GML-GIS that is supporting geographic information service for multiple data server over the Web based on GML.

3.1 The System Architecture of the GML-GIS

The overall architecture of the GML-GIS is shown in Fig. 3.1. The system adopts a tree-tier architecture that is composed of User Interface Module, CGI/SCRIPT Module, Application Schema Generator, GML Translator, XML Analyzer and Documents Pool.
The description of the function, detailed structure, role of each module is as following.

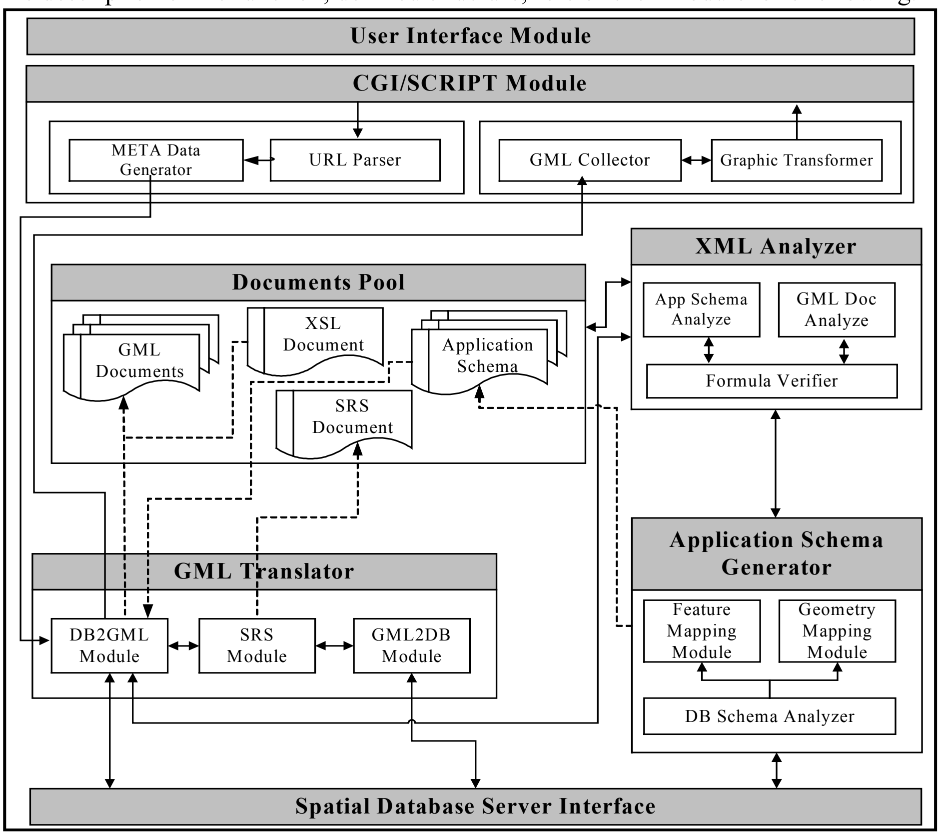

Fig. 3.1 System architecture of the GML-GIS

- User Interface Module

The User Interface Module offers interface with specific user like DBA by utility. The utilities of User Interface Module are composed of to create application schema documents and to store GML documents' data in specified spatial databases. Also, it provides the interface that creating GML documents by user request of SQL like.

- CGI/ SCRIPT Module

The CGI/SCRIPT Module obtains a request made by a user through URL on the Web browser, sends it to the GML translator. Also it receives GML documents as the result for the request and displays it on the Web browser of the user. CGI/SCRIPT Module is composed of URL parser, META Data Generator, GML Collector, and Graphic Transformer. The URL parser parses the URL-style request sent from a user, and the META Data Generator creates the meta data necessary to make SQL inquiries that request data corresponding to the spatial database, such as layer data and MBR (Minimum Bounding Rectangle) domain data. These inquiries are then sent to the GML Translator. The results of the inquiries are transmitted in GML documents, which are collected and integrated by the GML Collector using XLink [W3C00]. The Graphic Transformer uses VML (Microsoft Vector Markup Language) and SVG (W3G Scalable Vector Graphics) to transform the GML documents into graphic map formats readable over Web browsers.

- Application Schema Generator

The Application Schema Generator automatically creates application schemas referenced when a GML documents are made. The Application Schema Generator is composed of Feature Mapping Module, Geometry Mapping Module, and DB Schema Analyzer. The Feature Mapping Module maps feature of the spatial database's geographic information into GML-specified feature, and the Geometry Mapping Module maps spatial database's data forms into GML geometry. The DB Schema Analyzer creates the application schemas relevant to the request by analyzing spatial database schemas, and referencing Geometry and Feature schemas.

The application schema is made for each layer, and a layer's FeatureType is a user-defined by field name and type, which in turn is defined by the ComplexType composed of spatial types and aspatial types. As for annotated information of spatial data, because it does not contain GML-specified types, we have defined new AnnotextTypes with user-defined types. The AnnotextType is defined by the PointType of Geometry to represent the annotation's position, and by the ComplexType that includes the corresponding label information. Fig. 3.2 shows definitions of the AnnotextType of representing the layers of a building.

```
<xsd:complexType name="BuildingType">
    <xsd:complexContent>
        <xsd:extension base="gml:AbstractFeatureType">
            <xsd:sequence>
            <xsd:element name="ANNOTATION" type="dblab:Annotext Type "/>
            </xsd:sequence>
        </xsd:extension>
    </xsd:complexContent>
</xsd:complexType>
<xsd:complexType name="dblab:AnnotextType">
    <xsd:complexContent>
        <xsd:sequence>
            <xsd:elementname="ANNOTATES" type="gml:PointProperty"/>
```

```
            <xsd:element name="ID" type="integer" />
            <xsd:element name="LABEL" type="string" />
        </xsd:sequence>
    </xsd:complexContent>
</xsd:complexType>
```

Fig. 3.2 AnnotextType definitions for annotated information of spatial data

- GML Translator

The GML Translator creates GML documents according to the data requested by the user and transmits them in CGI/SCRIPT module. The GML Translator is composed of DB2GML Module, GML2DB Module, SRS Module.

The DB2GML module transforms user requested data into SQL inquiry forms using parsed information for URL-type requests sent from CGI/SCRIPT module. The transformed SQL inquiries are transmitted to the spatial database and answered by result data for the corresponding layers. Result data from the spatial database is divided into spatial data and aspatial data. Data type of the spatial data is mapping to the geometry model of GML. Data type of the aspatial data is mapping to primary type in XML. In order to change the result data into GML documents, the application schemas which is created by Application Schema Generator, are analyzed through the DOM interface. On the basis of each element and type's information generated by this analysis, GML documents are created. The GML documents' structure includes the layer's MBR domain information, field elements, and field data values.

As a module that stores data from GML documents in spatial database, the GML2DB module receives GML document inputs from user interface modules. In that case, the GML document includes table information, stored data description and the conditions for restriction, and its efficiency is tested in accordance with the provided DTD or XML schemas. Fig. 3.3 shows a GML document for the information of a river layer. Such GML documents provide ease of data exchange between two heterogeneous spatial databases.

```
<ogc-sfsql-table>
    <table-definition>
        <name> lakes </name>
        <column-definition>
            <name>fid</name>
            <type>INTEGER</type>
                <constraint>NOT NULL</constraint>
                <constraint>PRIMARY KEY</constraint>
        </column-definition>
        …
```

```
        <column-definition>
            <name>shore</name>
            <type>POLYGON</type>
        </column-definition>
    </table-definition>
        <row-value>
        <column-value>
            <name>fid</name>
            <value>101</value>
        </column-value>
        …
        <column-value>
            <name>shore</name>
            <value>POLYGON((52 18, 66 23, 73 9, 48 6, 52 18), 59 18, 67 18, 67 13,
59 13, 59 18))</value>
        </column-value>
        </row-value>
</ogc-sfsql-table>
```

Fig. 3.3 GML for the storing of a river layer

The SRS (Spatial Reference System) module is a coordinate conversion system that matches coordinates on the map with actual global positions. The coordinates of the geometry specify SRS information that each set of coordinates uses for criterion. This information is defined as srsName attributes inside the GML documents.

- XML Analyzer

The XML analyzer is a module that uses the XML parser to carry out well-formed tests, and efficiency tests and analyses. The GML documents created by a user's requests and for the user's data inputs, go through structural and efficiency tests on XML analyzer-consulted DTD or schemas.

- Documents Pool

To manage the newly created GML, XSL, SRS and application schema documents, directories are set as environmental variables at the beginning of the system installation. The XSL (eXtensible Stylesheet Language) documents are automatically created when the application schema generator makes the application schema. They are used to create the styles that describe how the data inside XML are represented to the users through the Web.

3.2 Implementation of the GML-GIS

We implemented a GML-based geographic information service system on the Web capable of transforming heterogeneous spatial data into GML documents to provide the end users with maps in graphic forms, and also capable of storing data from user-generated

GML documents in the spatial database. As for the spatial database engine, the GMS[2] (GEOMania Millennium Server) [Lh00, Kj01] have used as basis, and for the XML parser to check validation, MSXML (Microsoft), which supports DOM level 1, was employed.

Fig. 3.4 shows the creation of an application schema for referencing when an Application Schema Generator is transformed into a GML document. The application schema corresponding to each layer creates the layers by choosing desired ones in the entire layer list after connecting to the DB through a utility of User Interface Module.

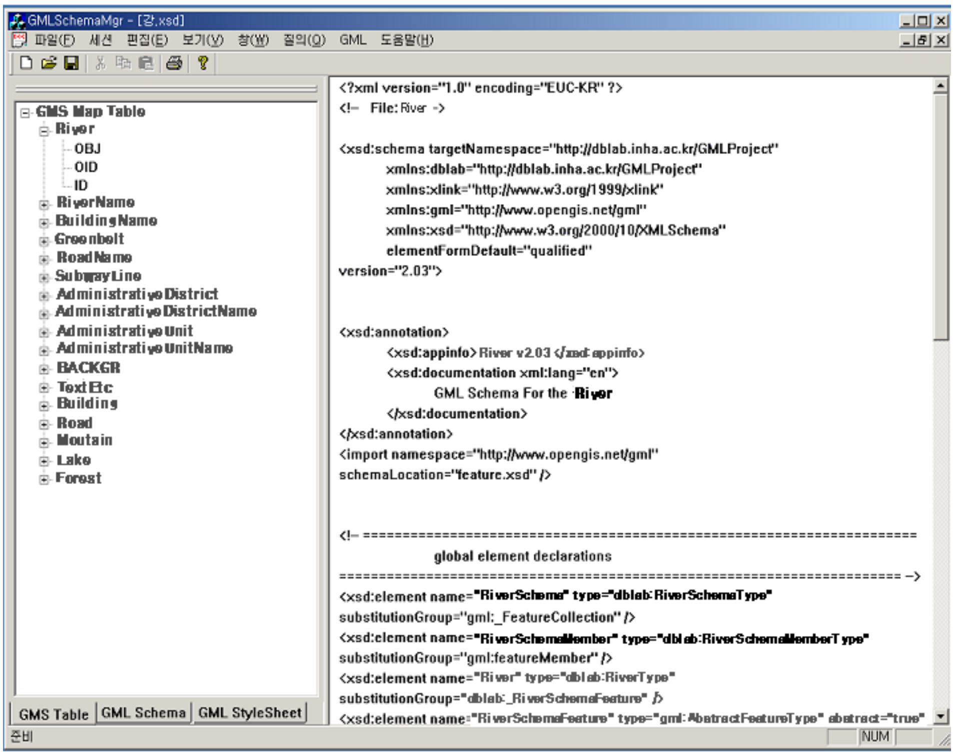

Fig. 3.4 Creation of an Application Schema

Fig. 3.5 represents a request in a URL form sent in CGI/SCRIPT module.

VERSION=1.0&REQUEST=GetMap&SRS=NONE&STYLES=Default&WIDTH=500&HEIGHT=400 &FORMAT=text&LAYERS=River,Greenbelt,Road,SubwayLine,AdministrativeDistrict,Administrative Unit&BBOX=196575,435629,208821,448117

Fig. 3.5 Request Syntax in URL Form

URL formed requests are parsed by the URL parser with CGI/SCRIPT module, and the Metadata Generator creates metadata, such as layer and MBR information for GML

[2] Client/Server Spatial DBMS Engine of GEOMania Co., Ltd. (http://www.GEOMania.com)

document creation, to transmit them in DB2GML module of GML translator.
The DB2GML module creates SQL requests based on received information to send them to the spatial database. The results corresponding to the requests are created into GML documents by referring to the application schema definition for the layers and these GML documents are integrated one document by the CGI/SCRIPT module's GML Collector. The integrated document is transmitted to the Graphic Transformer and then transformed into graphic format to be represented in Web browser. Fig. 3.6 represents the output on a screen that shows a Web browser representing a VML result for a URL form request automatically created into GML document. GML documents can be applied and provided into various styles according to the user's environment.

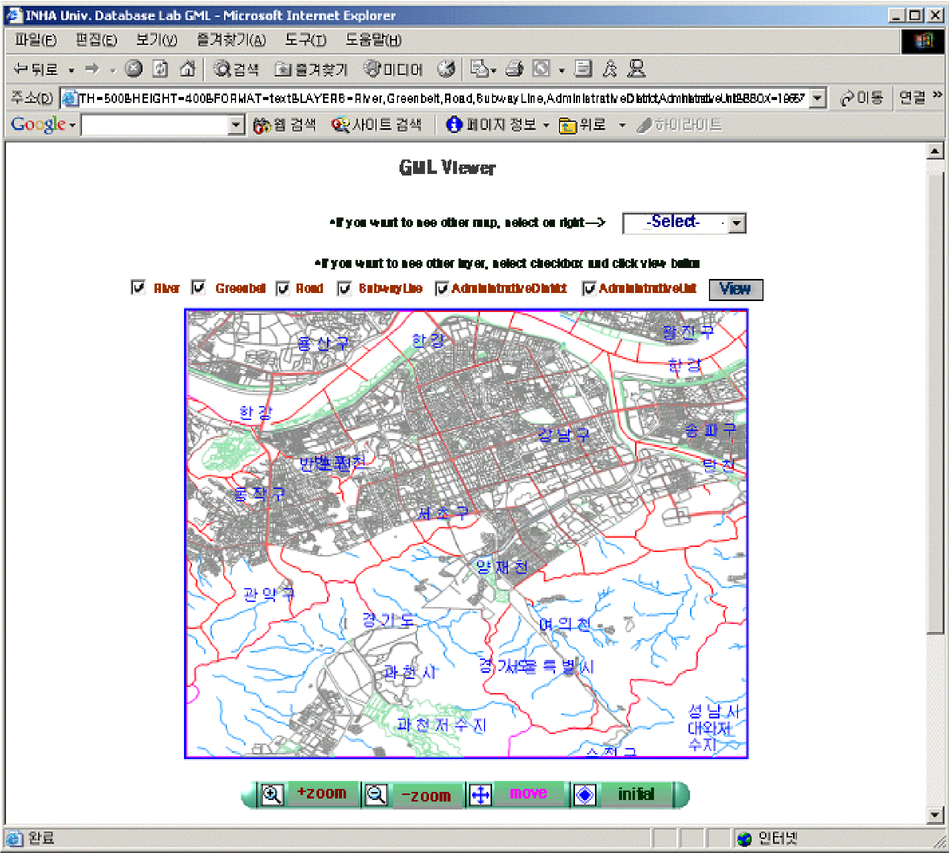

Fig. 3.6 GML Output for a URL request on the Web Browser

4. Conclusions and Future Works

The diffusion of the Internet and the development of the information society have affect the geographic information system and demanded for standards to operate geographic data dispersed over heterogeneous environments. Accordingly, the OGC proposed GML specifications that take advantage of XML to apply to geographic information sharing. In

this paper, a GML-based geographic information service system has proposed based on such GML specification and implemented in the Web environment.
Presently, the OGC is working on the standardization of GML 3.0 operable on LBS (Location Based Service) basis. In the light of such trends, future studies demands for finding the methods to effectively apply and operate geographic information and the compaction technique of GML data for wireless devices and providing a service system that suits to the new mobile environments.

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