GML-Based Interoperable Geographical Databases

Chuanrong Zhang
Department of Geography, University of Wisconsin-Milwaukee, Milwaukee, WI 53201-0413
czhang@uwm.edu

Zhong-Ren Peng
Department of Urban Planning, University of Wisconsin-Milwaukee, Milwaukee, WI 53201-0413
zpeng@uwm.edu

Weidong Li
Computer Programs, Marquette University, Milwaukee, WI 53201 wli@mscs.mu.edu

Micheal J. Day
Department of Geography, University of Wisconsin-Milwaukee, Milwaukee, WI 53201-0413
mickday@uwm.edu

ABSTRACT

Many geographical databases have been developed by different programs and applications, but data acquisition and data sharing are still a big problem because no interoperability exists among these different databases. This study presents a GML (Geography Markup Language) approach to build a geographical database in order to enable interoperability. As an open, non-proprietary industry standard, GML overcomes the problems of current GIS software proprietary data models and database structures. Compared with other standards, such as Geographic Data File (GDF) and Spatial Data Transfer Standard (SDTS), GML approach has the advantage of enabling on-line data exchange. GML holds promise in providing a standard way to share and use the existing spatial data over the Web. A GML-based interoperable geographical database for the conservation of the Stone Forest Landscape is implemented as a case study. It shows that the public can access and use the GML-based spatial database through a user-friendly interface and that GML can deliver high quality vector data on the Web.

INTRODUCTION

With the rapid development in GIS (Geographic Information System) and its applications, more and more geographical databases have been developed by different programs and applications, but data sharing and acquisition is still a big problem for the development of GIS applications. Not that data are not available, there is a huge amount of geographical data stored in different places and in different formats, but data reuse for new applications and data sharing are daunting tasks because of the heterogeneity of existing systems in terms of data modeling concepts, data encoding techniques and storage structures, etc. (Devogele *et al*, 1998).

Currently, several commercial desktop GIS software systems dominate the geographical information (GI) industry, such as ESRI ArcInfo and ArcView, Smallworld GIS, Intergraph GeoMedia, MapInfo professional, Clark Lab Idrisi, etc. It is unlikely that all GIS applications will use the same software (Tarnoff, 1998). Different vendors have their own proprietary software designs, data models and database storage structures. Thus, geographical databases based on these designs cannot communicate without data conversion. In order to exchange information and share computational geo-database resources among heterogeneous systems, conversion tools have to be developed to transfer data from one format into another. Furthermore, these diverse desktop GIS database structures make remote data exchange and sharing more difficult because of limited accessibility and required data conversion.

The development of the World Wide Web creates a unique environment for sharing geospatial data. Users can use the World Wide Web to download data for viewing, analysis or manipulation. Many of commercial Internet GIS programs, such as ESRI's MapObject IMS and ArcIMS, AutoDesk's MapGuide, Intergraph's Geomedia WebMap, MapInfo's MapXtreme, GE SmallWorld's Intenet Application Server and ER Mapper's Image Web Server, are developed to offer better tools for data sharing over the Web. But like the desktop GIS software these Internet GIS programs also have the problems of proprietary software designs, data models and database storage structures.

Sharing of data, facilitated by the advances in network technologies, is hampered by the incompatibility of the variety of data models and formats used at different sites (Choicki, 1999).

In addition, two other problems result directly from non-interoperability of databases. One is about data precision. This includes coordinate precision, errors of omission, missing or wrong attribute names, and incorrect topology, after data are converted from one format to another (Noronha, 2000). The other problem is that a lot of money and time have been wasted on data conversion or developing data conversion tools. Most investments by today's GIS users lie in three areas: data conversion, development of application specific extensions to general purpose GIS products, and the learning of applications of software and data to enhance productivity. Among these three areas data exchange and conversion account for a very high percentage (Siki, 1999).

Interoperability is *the ability of a system, or components of a system, to provide information portability and inter-application cooperative process control* (Bordie, 1992). Two kinds of interoperability can be distinguished. For a program, data interoperability means the ability to utilize a range of data formats. For a data set, program interoperability means that it can be used by different types of programs (Laurini, 1998). An interoperable database refers to the data level interoperability. It can be used by different types of programs and applications. With interoperable databases users can request and integrate data easily no matter whether the databases are stored locally or remotely. The interoperability of data from heterogeneous sources is extremely important in the context of geographical applications, because there exist large amounts of spatial data of different geographical formats and there are increased demands for re-use of these existing spatial data.

How to realize the goal of data interoperability? There are two approaches to data interoperability—database integration and standardization (Devogele *et al*, 1998). Database integration is the most sophisticated approach. A very first basic approach is to provide users with a global catalogue of accessible information sources, where each source is described by associated metadata, including representation mode, scale, last update date, and data quality level, etc. (Stephan *et al*, 1993; Uitermark, 1996). Current database integration has evident drawbacks related to lack of scalability, consistency and duplication (Devogele *et al*, 1998). The second approach to interoperability is through standardization. The definition of standard data modeling and manipulation features provide a reference point which facilitates data exchange among heterogeneous systems (Devogele *et al*, 1998).

In the past, several useful standards have been developed to facilitate data exchange. Among them, Geographic Data File (GDF) and the Spatial Data Transfer Standard (SDTS) are widely used and accepted. GDF is specifically designed for spatial data exchange for ITS. It defines a set of spatial features, attributes and relationships that are particularly relevant to ITS applications, and specifies a set of useful data structures and data formats. This makes it readily usable for off-line data exchange. SDTS is a general purpose standard that is flexible and adaptive (NIST, 1994). With anticipated extensions and refinements, SDTS was expected to become an important data format for ITS spatial data transfer or a neutral format for data archiving (Arctur *et al*, 1998). But several barriers block the popularity of SDTS. These barriers include the complexity of SDTS, slowness in the development of practical SDTS profiles, restriction of each SDTS dataset to a single profile, lack of a clear definition of geospatial features in SDTS, and ambiguity in the means of specifying cardinality of relationships in a data model (Arctur *et al*, 1998). Currently both GDF and SDTS were not so widely used as originally anticipated. The creation of a new standard data exchange format--Geography Markup Language (GML)--represents another important step taken by the geospatial community towards data interoperability. The GML is *an XML grammar written in XML Schema for the modeling, transport, and storage of geographic information including both the spatial and non-spatial properties of geographic features* (OGC, 2003) It is developed as Data Exchange Standards Interface by Open GIS Consortium (OGC) to achieve data interoperability and reduce costly geographic data conversions between different systems. In the OGC spirit, interoperability is achieved by means of common specifications that programs and data must follow (Buehler and McKee, 1996). OGC takes a new spatial interoperability approach, which is not based on a common format, but based on open and common software interfaces. The interface specification largely eliminates the need for data format standards and costly batch data conversion. With the development of the World Wide Web Consortium's XML (Extensible Markup Language), the creation of Geography Markup Language Implementation Specification by OGC represents a significant step in the development of interoperable architectures for the use of spatial information between different applications. GML holds promise to support mapping from a wide variety of sources and enable sharing of geospatial data for on-line information exchanges.

Unlike current proprietary commercial Internet GIS programs, the OpenGIS GML specification is a public open standard for coding and sharing spatial data. GML is a good alternative to expensive, proprietary web-based mapping solution: (1) GML is an open source standard. Users can use it for free. But for other commercial Internet GIS programs, users have to buy. For example ESRI ArcIMS Internet software is so expensive that many users cannot afford it. But they need provide online spatial data services. GML is a good alternative for these users. With GML they can provide the online spatial data services without buying these proprietary software. (2) GML data are stored in text format, which is a universal format. Thus it is easy to integrate GML data into other data across a variety of platforms and devices. (3) As a standard data exchange format GML reduces the costly conversion processes among different format databases. (4) Although GML specifications take the standardization approach to data interoperability as do GDF and SDTS, it goes further and supports interoperable solutions that geo-enable the Web. While GDF and SDTS are useful for off-line data exchange, GML is capable of facilitating real-time data sharing and exchange on the Web because it uses XML grammar which is widely supported on the Web. GML can enable an accessible Geo-Web (Lake, 2002; Peng and Tsou, 2003; Shekhar *et al*, 2001).

In addition, GML can deliver vector data over the Internet by styling the data into Scalable Vector Graphics (SVG) format. Most current Internet GIS programs deliver spatial data through transmission of raster images such as GIF and JPEG formats over the World Wide Web. There are several advantages for delivering SVG vector GIS data over the Web compared with raster GIS data: (1) Compatibility. SVG also uses text-based XML format, which is compatible with other formats. It can seamlessly integrated with current Web technologies, such as HTML, JavaScript, JSP, ASP, JPEG, GIF, etc. (2) Graphic quality. SVG format graphics are scalable and resolution-independent. This kind of data can be scaled without loss of quality across different platforms and devices. But coarse raster images are low quality because of a low resolution. Especially when users zoom in too many times, images will become blurred and pixelated. However, a raster image with high resolution usually has a larger file size since it needs to store information as finer pixels. The speed of delivering such large files over the Web becomes slow, so it is not practical to use high-resolution images for Internet GIS. The need for delivering high quality vector graphic maps over the Internet is becoming pressing as data availability and global sharing increases (Bertolotto and Egenhofer, 2001). (3) SVG vector data can be accessed in a more interactive and dynamic way. Some dynamic functions can be integrated into SVG documents so that the SVG graphics are animated on the Web. For example, a SVG graphic can interact with users by mouse over if a mouserover() function is added in the SVG document. By combining SVG with other web technologies like HTML, JavaScript, JSP or ASP, GML-based database can provide users an extremely rich interactive graphic interface.

In general, GML-based databases have many advantages compared with other alternatives. Firstly GML-based databases can be easily shared and reused. They have no proprietary data models and database structures. Because of the proprietary software design, databases created by current commercial GIS software are difficult to be shared. To share data among such databases, many data conversion processes are necessary. Since GML-based databases are text format, they can be easily integrated with other format data across varieties of platforms. Secondly GML-based databases can be shared and exchanged online in real time. But databases based on other standards, such as GDF and SDTS, only can be shared and exchanged off-line. Although current Internet GIS programs can let users share spatial data online, they have the aforementioned proprietary data model and database structure problems. Thirdly, GML-based databases can let users exchange data at feature level, while current commercial Internet GIS programs cannot. For example, from a big GML-based database, users can just query and download one feature such as a specific road, while from other alternatives users have to download the whole data set. Sharing and exchanging data at feature level in real time are especially important for emergency services, they can greatly reduce the time spending on data-acquiring processes. Fourthly, by styling GML data into SVG, GML-based databases can provide users a more sophisticated interactive graphic interface and deliver higher quality graphic maps over the Web than most other online alternatives. Fifthly, GML is more flexible than other alternatives. It only defines a basic geographical feature schema and geometry schema, which are convenient for users to use. Based on these schemas users can define their own specific schemas for their spatial data documents.

It has been widely recognized that GML will play an important role as a future Web data exchange standard (Clemens, 2002; Lake, 1999; Meneghello, 2001; Murray and Chow, 2002; Smith *et al*, 2002). This paper will talk about what mechanisms of GML lead to data interoperability and provide a real application of a GML-based database by building a GML-based interoperable geographical database for the conservation of the Stone Forest Landscape.

MECHANISMS OF GML FOR DATA INTEROPERABILITY

As mentioned previously, GML specification is an important step taken by the geospatial community towards the vision of widespread spatial data interoperability. GML-based geographical databases can communicate with each other. The mechanisms of GML for data interoperability are given as following:

1. GML provides a common schema framework for encoding geo-spatial features. GML uses the W3C XML Schema Definition Language to define and constrain the contents of its XML documents. The GML v2.0 Specification provides two basic XML Schemas: the GML Feature Schema (feature.xsd) and GML Geometry Schema (geometry.xsd). Users can develop their own application schemas according to GML v2.0 Specification conformance requirements. GML schemas reconcile the need for standardization with the need for diversity by providing a standard means of extending the GML format. The direct consequence of applying schemas with GML is that it becomes possible for organizations to define formats to suit their needs and exchange geographic information without the need to involve software developers to create translators for that format. This has impacts on both the cost and risk of exchanging data (Curtis, 2003).

2. While GML builds on XML Schema, it provides a more constrained model. GML is based on a common abstract model of geography (OGC Abstract Specification), which describes the world in terms of features. A geographic feature is an abstraction of a real world phenomenon; it is a geographic feature if it is associated with a location relative to the Earth (OGC Abstract Specification, 2001) A feature has both simple properties and geometry properties. Simple properties refer to the usual name, type and value description. Geometry properties are composed of points, curve (linestring) and surface (polygon). By looking at feature schemas and properties, one can readily compare features and integrate data.

3. GML is based on an XML standard. XML is a universal format for structured documents and data on the Web. XML is easy to transform. Using XSLT or almost any other programming language (VB, VBScript, Java, C++, Javascript), users can transform XML from one form to another. By adhering to an open, non-proprietary standard, GML documents can be manipulated, transformed and presented in the same flexible way as XML contents.

4. GML provides XLink and XPointer mechanisms as does XML. The linking mechanism of HTML (one web page linking to another), is one of the key foundations of the Web. GML goes further by providing a mechanism for linking multiple distributed resources into a complex association. As HTML is important to the Internet as a linked collection of web pages, GML can enable the development of a Geo-Web as a linked collection of geo-spatial features. Through XLink and Xpointer, different features and feature collections, which may be located remotely, can be associated together at the feature level (Peng, 2003). XLink and XPointer hold great promise for building complex and distributed geographic data sets (Lake, 1999). They make it possible to access and seamlessly integrate data from different departments, cities, states and countries.

5. GML provides a means to transport geospatial data over the Web. With the help of Web Feature Server (WFS), spatial databases with different formats can transparently communicate with each other by being converted to GML-format data on the fly. Figure 1 illustrates that GML geo-enables the Web by transporting and re-using geospatial data with different formats using GML. As XML is an important Internet data transport technology, GML makes it possible for real-time data access and transport in the Internet environment at feature level. When the GML-marked geospatial data are transported, all the markup elements that describe every spatial and non-spatial features, geometry and spatial reference systems of the data are also transported to the recipient (Peng, 2003).

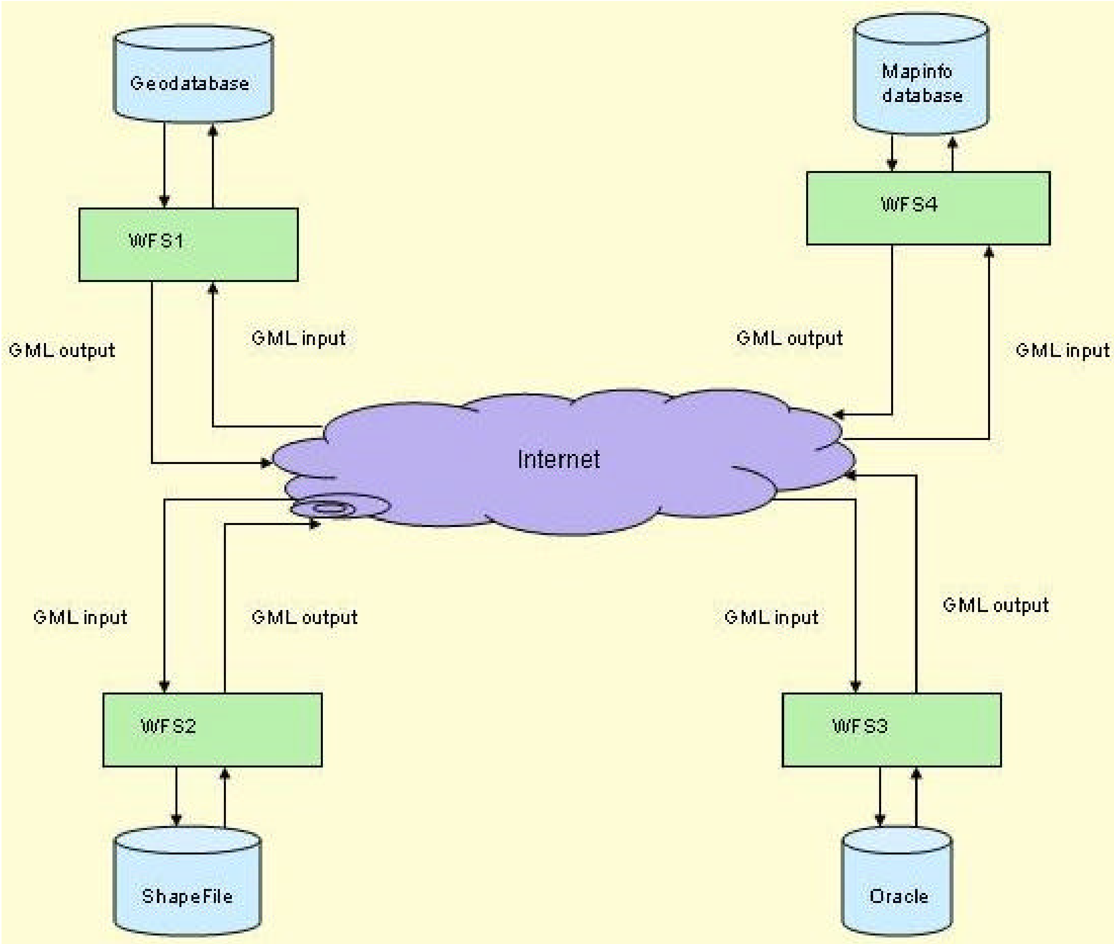

Figure 1. *Geo-enabling the Web by transporting and sharing different format geospatial data using GML*

6. GML data are stored in plain text. Text is vendor-neutral, so information stored in GML is not locked into a proprietary binary format. Since GML is text-based, it can readily integrate geospatial data with a wide variety of non-spatial data types including text, business transactions, graphics, audio, voice and more. This capability would greatly enhance the value and accessibility of geospatial information. For example, users can easily insert a map in a financial report, or vice versa (Peng and Tsou, 2003). In addition, as a text format, GML can be easily transmitted across a variety of platforms over the Internet. Thus GML enables disparate systems to share information easily.

GML mechanisms allows users to build a large, global map stored and processed in a scalable and redundant distributed architecture. GML makes it possible that all spatial data in the whole world can be integrated into one map (Misund and Johnsen, 2003). The inherent transformability and accessibility of GML opens a new domain for the geo-community (Lake, 1999). The following section gives a case study of building such an interoperable geographical database using GML. Because of the above mechanisms of GML, this database can be easily shared and used by different programs.

A CASE STUDY—A GML-BASED INTEROPERABLE GEOGRAPHICAL DATABASE FOR CONSERVATION OF THE LUNAN STONE FOREST LANDSCAPE

Objectives

The first objective of this case study is to implement an interoperable database with GML for the conservation of the Lunan Stone Forest Landscape that allows for the database to be easily shared and re-used in the future. The second objective is to illustrate that GML plays an important role as a vector feature distribution format and that GML-based interoperable databases can serve better quality maps through delivering SVG vector data over the Internet. The third objective is to show that the GML-based interoperable database offers a user-friendly interface, thus the public can easily access and use the existing spatial data to do GIS analyses. The fourth objective is to illustrate that the interoperable database can be accessed and queried at the feature level from the Web Feature Service (WFS) server over the Internet.

There are several reasons for building the GML-based interoperable geographical database. First, such a database can be easily re-used in the future. Second, data developed on a local scale can be readily integrated into those on a regional or global scale in the future. Third, data developed for one application could be readily integrated with data developed for another application. Any other GML-based database can communicate with this database. Finally, the interoperable database can let other departments and application programs easily share and integrate the data. It can also supply the public and the decision makers with the data resources in real-time for the conservation of the Lunan Stone Forest Landscape.

Background

Stone Forest is a forest of intensively corroded limestone pinnacles up to some ten meters high. The Lunan Stone Forest is one of three unique landscapes in China, and is a very special type of karst landform in the world. It has a total area of 350 square km and by far is the largest area of pinnacle karst in the world. It is currently under the consideration for UNESCO World Heritage designation. It is now attracting 1,500,000 visitors each year (Song, 1997).

As a karst landscape, the Lunan Stone Forest is inherently fragile (Huntoon, 1992, 1993). Stone Forest Landscape conservation is a very complex problem. The conservation of the landscape involves many factors, such as geomorphology, geology, soil, vegetation, hydrology, population, tourism and the economy. To effectively protect the landscape various data are required, which come from different government departments. An interoperable database can enable convenient sharing and re-use these spatial data.

Spatial heterogeneity is the most fundamental characteristic of all landscapes, and scale multiplicity is inherent in spatial heterogeneity. Multi-scale analysis is imperative for understanding the structure, function and dynamics of landscapes. A GML-based database can easily integrate different scale data (Lake, 1999). Thus, a GML-based interoperable database will play an important role to comprehensive study of landscape conservation problems.

The conservation program of the Stone Forest Landscape has created large quantities of data and involves a range of different departments, many that may need or already have their own different databases. Thus, data sharing between these departments is very necessary. Since GML-based databases are interoperable, such a database not only supplies a model for the involved departments to develop their own databases so as to better share data, but also provide a common database to share among them. Any other GML-based databases can also communicate with this database.

Public participation will play an important role in the conservation of the Stone Forest Landscape. A web-enabled geo-database can supply the public and the decision makers with the data resources in real-time. This will create for the public the conditions of attending data analyses and expressing their opinions for the conservation program through the Internet.

Database Construction

Figure 2 illustrates the procedure for building a GML-based interoperable geographical database. The first step is to collect and prepare the spatial data for the conservation of the Stone Forest Landscape. The data collected for this case study include a Stone Forest distribution map, a river map, a lake map, a village distribution map, a geology map and a geomorphology map. The format of these data is ArcView Shapefile.

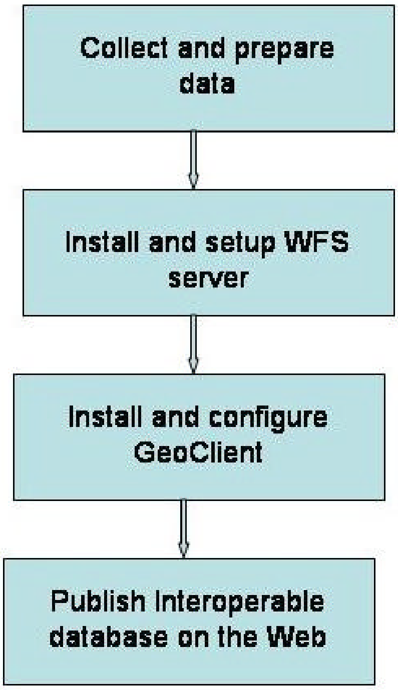

Figure 2. *Procedure of building a GML-based interoperable geographical database*

The second step is to install and setup the Web Feature Service (WFS) server to support the database. Currently there are several commercial WFS software programs available. We chose the GeoServerLite (http://www.mycgiserver.com/~amri/), which is a simple WFS server based on the Open GIS Consortium standard. The GeoServerLite is open-source software with a graphic client. All supporting software can be downloaded for free. GeoServerLite is written in the broadly available PHP scripting language and is based on the MySQL database. To setup GeoServerLite, we need first to select and setup a HTTP Web Server. In this case study the Apache HTTP Web Server (http://httpd.apache.org/), currently a popular web server on the Internet, is used. To completely set up GeoServerLite, we also need to install and setup the PHP scripting language environment and MySQL database.

The third step is to install and configure a client interface. We chose the GeoClient (http://www.mycgiserver.com/~amri/), which is a graphic interface for accessing and querying GML data over the Internet. GeoClient is written in Scaleable Vector Graphics (SVG) and ECMAscript/JavaScript, and can run natively in a web browser if SVG support is available. Currently it needs support of the Adobe SVG Viewer Plug-in.

The final step is to build the interoperable database. Two methods are used in this study (Figure 3). The first one is using ToWKT, an extension of ArcView developed by the Geoclient project. ToWKT can export Shapefile data into a MySQL database in text format. It can also transform Shapefile data into GML data format or SVG data format. The PHP-based GeoServerLite can be connected to the MySQL database. The feature level data required by users can be extracted from the MySQL database and then transferred into GML format on the fly by the GeoServerLite. The GML format data are delivered out through Internet to clients. On the client side, the data are further dynamically transferred to SVG maps by client browsers. This method can serve feature level data in real-time, and is easier to implement without changing existing databases. The second method is using the FME software plus some customized Visual Basic code to first convert Shapefile data into GML data. The GML data are then converted into SVG files with the help of the XSLT processor and style sheet. The GeoServerLite directly serves users the SVG data. This method is more flexible but can not serve data at the feature level.

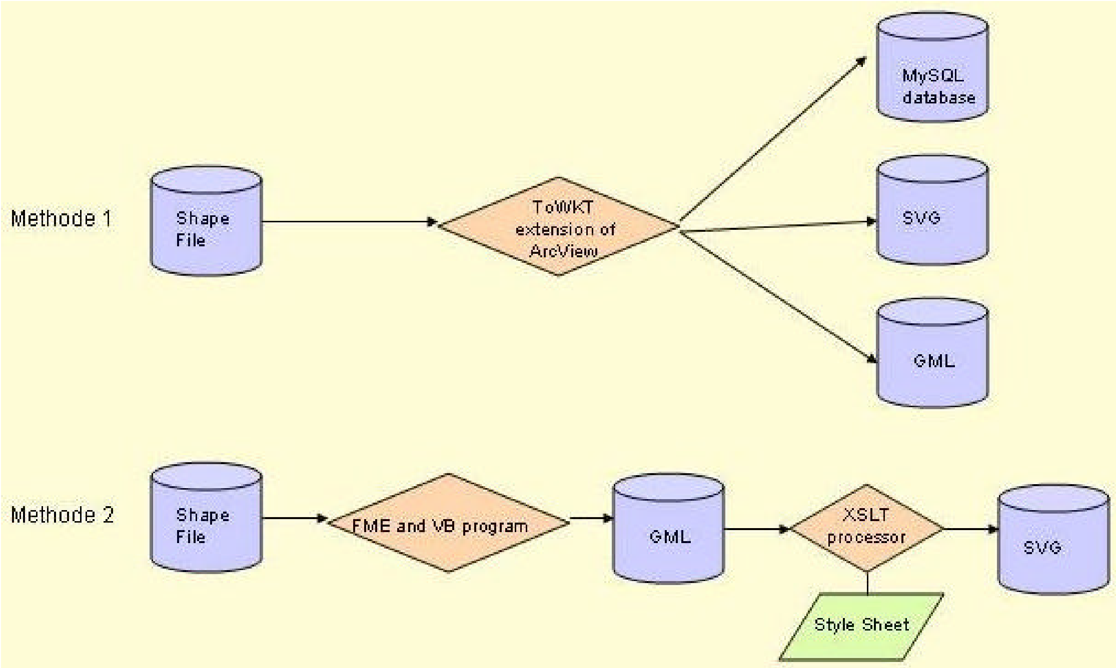

Figure 3. *The two methods for building interoperable database*

To browse SVG maps on the Internet, users need to download and install the Adobe SVG Viewer Plug-in. This is a free browser Plug-in (http://www.adobe.com/svg/). There are also a number of stand-alone SVG viewers available.

Results

Based on the above procedure, a GML-based interoperable database for the conservation of the Lunan Stone Forest Landscape was constructed. Figure 4 shows a user-friendly interface provided by the GeoClient for the GML-based interoperable database. It can be accessed and queried at the feature level in real time from the WFS server over the Internet. Such a GML-based database is interoperable and different programs on various platforms can use it remotely through the Internet. Other geo-databases that can accept GML formatted data, can communicate with the GML-based database. Of course the GML-based database can also be re-used easily in the future for other purposes.

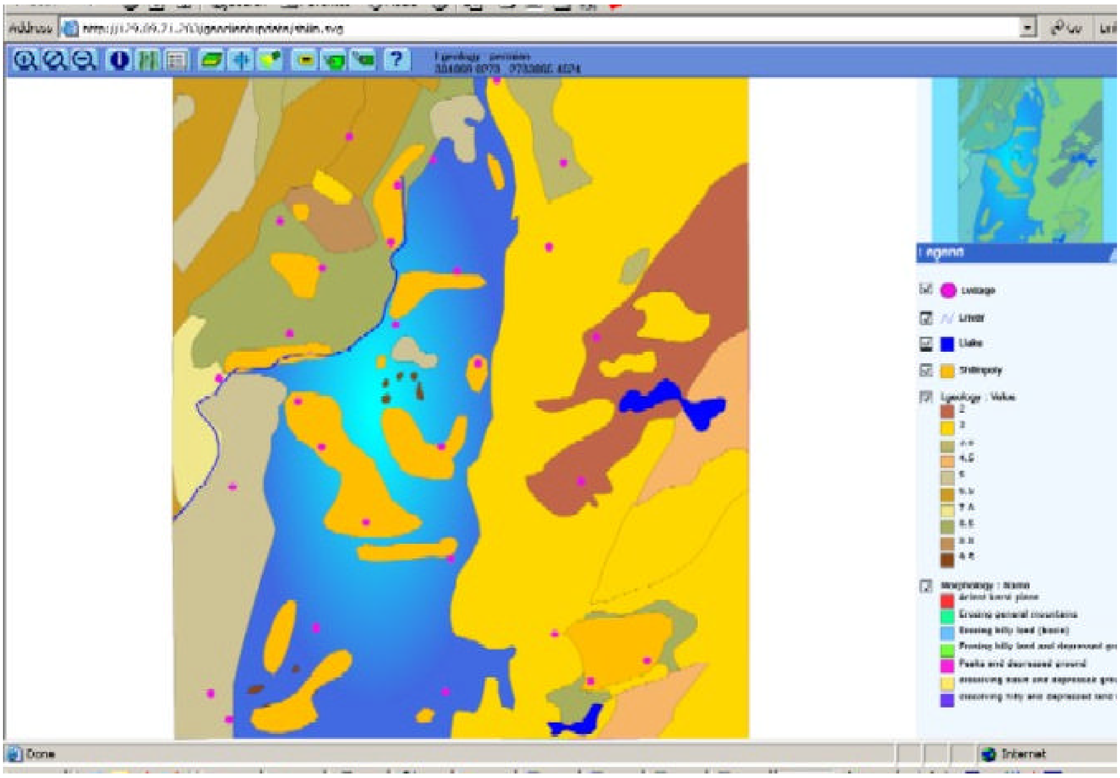

Figure 4. *Interface of the GML-based interoperable database*

Currently the GeoClient software can only provide some basic GIS functions for the GML-based database on the Web. X and Y coordinates can be viewed by the moving mouse over a map. The map can be labeled automatically through the graphic interface (Figure 5). Users can zoom in, zoom out, pan and query the map. When users click on a feature the interface will bring out an attribute table for the feature (Figure 5). Because the development of Geoclient software is just in its initial stage, other GIS analysis functions like buffer analysis, are not supported and need to be added in the near futures.

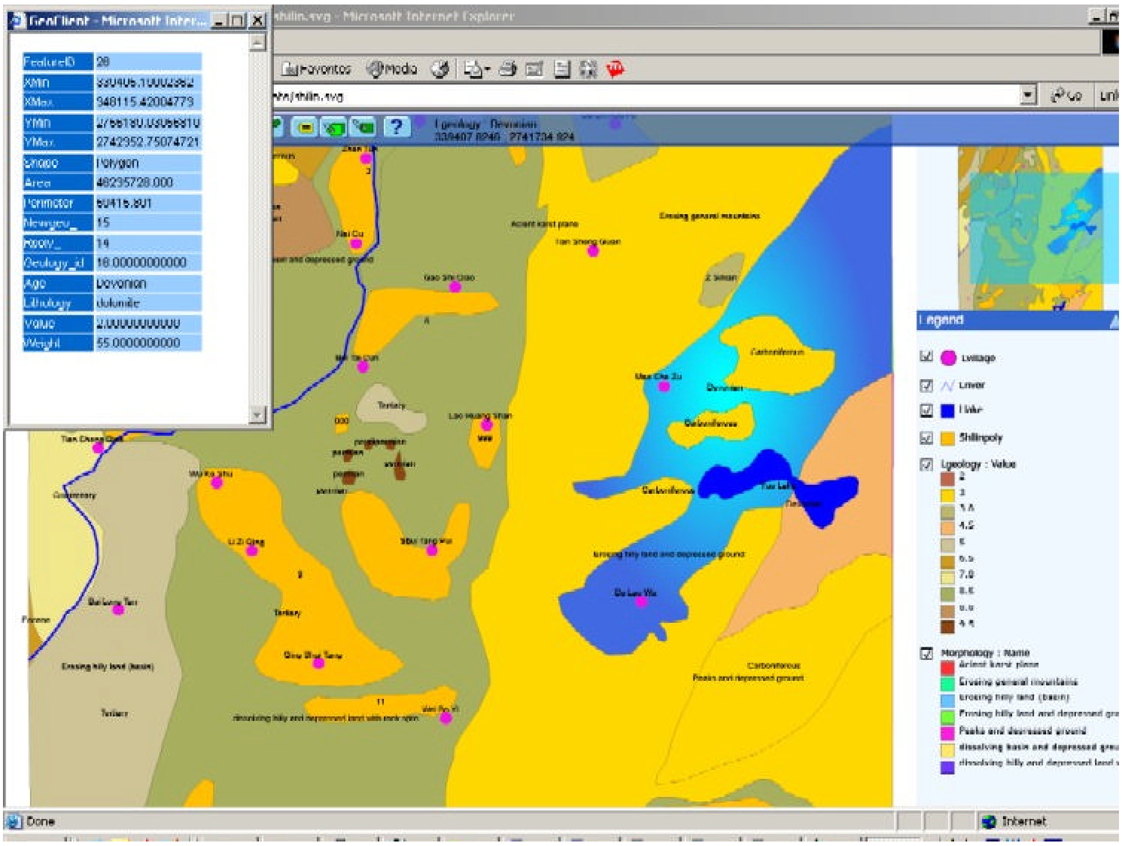

Figure 5. *Labeling and Querying the map*

The case study also shows that the GML-based interoperable database can serve scalable and high quality maps through delivering SVG vector data over the Internet. To make maps from GML data, the eXtensible Stylesheet Language Transformations (XSLT) processor was used to style the GML data into a SVG graphical format. As a vector format, SVG can let users zoom in on any portion of the GML data without any degradation in the quality of maps. The SVG vector data maps can be printed with very high quality at any scales. No matter how many times of zooming in, a resolution-independent high quality map can always be provided. Of course, the quantity of information is still restricted by the original data But the vector maps from the database never have *staircase* effects as users see when printing enlarged pixel-based GIF and JPEG image. So this has solved the blur problem of raster image maps when scale is changed (especially amplified). Further, like XML, GML separates content from presentation. GML only concerns the content of geographic data. How to present the map data is decided by users. This is the advantage of GML. This case study indicates that users can control how the data are displayed in a Web browser by changing the symbols of features using the Geoclient graphic interface. By delivering vector data over the Internet, GML give users the capability to publish higher quality spatial maps quickly, dynamically and economically. Any changes to the GML data can be instantly reflected in the SVG maps. But since the GeoClient software is still premature, in our case study the advantages of GML-based databases can not fully displayed.

Effective conservation of the Stone Forest Landscape requires knowledge of local ecosystems on different temporal and spatial scales. Further research is needed to use GML to effectively store temporal data so as to build a 4-dimensional GML-based database for the conservation of the Stone Forest Landscape.

CONCLUSION

This paper introduces the issues of data interoperability, advantages of GML, and its mechanism for data interoperability. A simple GML-based database is designed and constructed as a case study to demonstrate the interoperability of GML-based databases. The GeoClient software, which is the only one we can find currently on the Internet for free, is used to serve as an graphic interface for the GML-based database. The case study shows that the GML-based interoperable database can be displayed as a SVG map, which is very high quality, scalable and resolution-independent, on a user-friendly interface provided by the GeoClient. The database can be accessed and queried at the feature level in real time from the WFS server over the Internet. The information can be accessed by a range of programs on different platforms via the Internet. Basic GIS functions provided by the GeoClient, such as zooming, panning, labeling and quering, can be performed using the database on the Web. The GML-based database can serve high quality maps through delivering SVG vector data over the Internet. It can be shared and re-used easily in the future.

As an interoperability standard, GML allows us to bridge the gaps among different data sources, vendors, databases and formats. The database built in the case study can communicate with other databases through converting ArcView Shapefiles into GML data. GML can give users the capability to easily and dynamically publish and exchange data in an open, non-proprietary industry-standard format on the Web, thus maximizing the re-use of geospatial data, eliminating time-consuming data conversion and reducing associated costs. The high quality and colorful SVG map transformed from the GML-based database shows a very nice interface to users, which can improve the public accessibility to existing data. GML holds promise to lead an exciting interoperable future via online interactive Web maps and spatial Web services. But because the development of support software systems for GML-based databases are still at its beginning stage, the advantages of GML-based databases can not fully displayed in our case study.

As a new interoperability approach, GML still has some limitations. GML is not intended to solve all geo-processing interoperability problems. It still can not fully solve the problem of semantic interoperability. For example, GML provides users the ability to create application schemas to model their data, but different users (i.e., data providers) may use different names to represent the same feature, e.g., one user may decide to create a GML schema with a *building* feature while another user may use a *house* feature for essentially the same entities. Thus the second user must know the schema created by the first user in order to integrate the data from the first user into his. Without knowledge of these schemas users cannot fully understand what the GML represents. The real data interoperability is to provide seamless communication between remote GIS databases without having prior knowledge of their underlying semantics. A real interoperable GIS database should provide transparent communications at data model and application semantics level (Bishr, 1998).

Further research needs to be done for a GML-based database becoming a real interoperable GIS database.

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