SPATIAL DATA SHARING AND INTEROPERABILITY BASED ON WEB SPATIAL DATA SERVICE AND GML

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ABSTRACT:

In recent years, China made great progress in the field of Spatial Data Infrastructure. But spatial data sharing and interoperability was not taken into inadequate consideration. In this paper, three methods of spatial data sharing and interoperability are discussed, especially data sharing based on Web spatial data service and Geography Markup Language (GML). At last, this paper proposes that the construction of entity- oriented spatial database and the rule design of spatial data collection are also important factors to implement spatial data sharing and interoperability.

1. INTRODUCTION

Since Spatial Data Infrastructure (SDI) was issued by Canada in the 80's of 20th century, SDI has been taken seriously by all countries government. America, England, Netherlands, Australia, Malaysia, India began to establish the National Spatial Data Infrastructure (NSDI) in succession.

The importance of spatial data and necessity of Spatial Data Infrastructure have spread in public. In the high-speed developing information era, the key of whether the government and other organization can make prompt and exact reaction to the every kind of natural disaster, environmental pollution and other similar incidents is the rapid acquirement of necessary information, especially the acquirement of spatial information. This exposes two problems. The first one is the emergency of establishment of Spatial Data Infrastructure at different level. The last one is the importance of implementation of spatial data sharing and interoperability using appropriate technique.

In recent years, China made great progress in the field of Spatial Data Infrastructure. But the focus of research and application were the theoretical modeling, framework design, data collection and method of spatial database construction. But spatial data sharing and interoperability was not taken into inadequate consideration. This resulted in the contradictory that on the one hand the huge funds was spent and the large volume of spatial data was produced, on the other hand proper or usable data was scarce or data could not be shared or interoperated because of data itself.

In this paper, three methods of spatial data sharing and interoperability are discussed, especially data sharing based on Web spatial data service and Geography Markup Language (GML). At last, this paper proposes that the construction of entity- oriented spatial database and the rule design of spatial data collection are also important factors to implement spatial data sharing and interoperability.

2. THE TECHNICAL IMPLEMENTATION OF SPATIAL DATA SHARING AND INTEROPERABILITY

Spatial data sharing and interoperability is to use appropriate software tool and technique to exchange and transform spatial data so that the users can make full advantage of the function of Geographic Information System (GIS) software.

At present, the technical implementation of spatial data sharing and interoperability include three methods, namely data format exchange method, direct data access method and the Open Geo-data Interoperability Specification (OGIS) -based method. These three technical methods are in the different application field respectively and are improved constantly.

2.1 Data Format Exchange Method

Data format exchange method is to turn certain other data format into internal data format through transform. The method is mainly based on external data exchange file or the Spatial Data Transform Standard (SDTS). Data transform function is implemented by the commercial GIS software. In the recent years, the special software tools are developed to solve spatial data transform, for example, Feature Manipulation Engine (FME), the software product of Safe Company. It supports transform among nearly one hundred kinds of data format, including geometry data and attribute data. The users can define new data format to exchange with other data format. FME can batch the data transform, thus improving work efficiency.

Data format exchange method is very useful in the field of data processing before importing data into spatial database and providing digital map products according to the requirement of the users. This method is considered as one kind of data sharing from the viewpoint of data transform. But it is only file-based sharing and can not implement real-time data sharing at the feature level. So it can not be considered as true data interoperability.

2.2 Direct Data Access Method

Direct data access method is to directly access to other platform data format on one GIS information platform. Direct data access method avoids the complicated data transformation and provides one kind of applied multi-sources data integration pattern. One example is the research and application of spatial data sharing based on Oracle Spatial. Most GIS software can store spatial data and attribute data into Oracle database. Oracle Spatial is gradually accepted as the spatial data management pattern. But Oracle Spatial provides open data structure and only describes the structure of spatial data field. It does not limit spatial data type codes and coordinate sequence. Thus, different GIS software has different methods to describe the spatial object, for example, MapInfo, AutoDesk Map and ArcSDE. Though these software store spatial data into the Oracle Spatial, the storage rules are different and data can not be accessed by other GIS software.

To implement mutual access to the heterogeneous data in the Oracle Spatial, data storage rule, namely spatial data structure established by different GIS software, must be transformed. It is mainly processed and transformed on the spatial data tables according to the corresponding GIS software. Thus spatial data tables can be read and written by different software and the aim of heterogeneous database is achieved.

Direct data access method also has inevitable problems. Spatial data sharing based on Oracle Spatial is not exception. One problem is that the upgrade of any platform will influence other platforms concerned and make them lose the function of access to the spatial data. Another problem is some data management characteristics owned by every GIS platform will be lost in the processing of data sharing, for example, topology structure and version management in the ArcGIS, heterogeneous geometry collections in the MapInfo and etc.

Direct data access method is considered to implement spatial data sharing and interoperability through a local intranet.

2.3 Open Geo-data Interoperability Specification -Based Method

In 1996, Open GIS Consortium (OGC) was founded to specify the method, pattern and protocol of geographic information system interoperability in America. OGC mainly researched and founded Open Geo-data Interoperability Specification (OGIS). Its aim was to transparently get geographic data needed by end users in a heterogeneous distributed environment.

Web Service and XML have become mainstream technique to construct platform-spanned heterogeneous application and data exchange. On the basis of Web Service and XML, OGC and ISO/TC211 issued Web spatial data service specification and Geography Markup Language (GML), the language of spatial data transportation and exchange. Web spatial data service and GML is the most important technique of spatial data sharing and interoperability.

3. WEB SPATIAL DATA SERVICE AND GML

The basis of Web spatial data service and GML are Web service and XML. So the principle of Web service and XML is adaptable to the Web spatial data service and GML.

3.1 Web Service and XML

Web Service is a kind of distributed computing technique based on object/component model. It is a self-contained, self-described and modularized application program. This application program can be published, located and called dynamically through Web. As soon as one Web Service is being configured, other application program, including other Web Service can discover and call this Web Service. Web Service can be considered as an extension of component model over the Internet because Web Service is a logical application unit that can be called over the Internet.

The technical framework of Web Service is composed of a set of associated standards and protocols. Fig.1 illustrates the whole technique framework. The basis of Web Service is XML and Simple Object Access Protocol (SOAP) locating on the XML. The basic principle of Web Service is that the client and server wrap the request and data result in SOAP and transfer them in the form of HTTP. Web Service Description Language (WSDL) is used to describe the necessary concrete information. Web Service is registered and discovered through Universal Description Discovery and Integration (UDDI).

SOAP is a simple protocol used to exchange information in a distributed environment. It uses the SOAP envelop to describe the sender, receiver, processing method of message and message content. XML is used as normal data transfer format in SOAP. So SOAP can span heterogeneous system and implement inter-associated system.

WSDL is used to describe Web Service based on XML. The Client decides how to access Web Service according to the description to the Web Service in the WSDL.

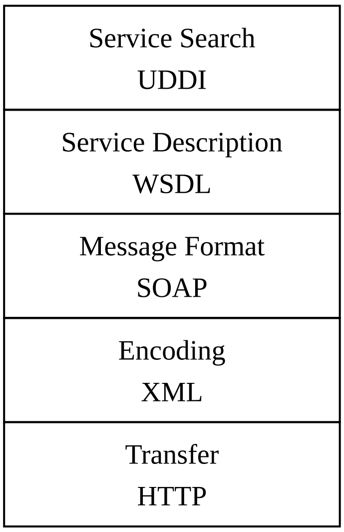


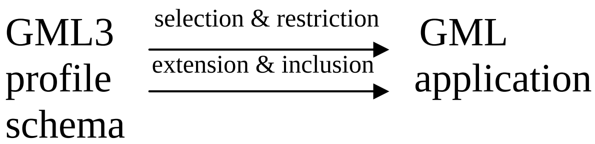
Figure 1. Technical framework of Web Service

UDDI provides three important supports for Web Service at technical level, namely the normalized, transparent and Web Service –described specially mechanism, the sample mechanism calling for Web Service and the accessible Web Service registration center. In registration center, Web Service is defined by tModel, Including WSDL document illustrating SOAP interface.

3.2 Geography Markup Language (GML)

The Geography Markup Language (GML) is an XML encoding for the modeling, transport and storage of geographic information including both the spatial and non-spatial properties of geographic features. GML provides an open, vendor-neutral spatial data modeling framework for the GIS development companies and users and increase the ability of organizations to share spatial information. GML3.1.0 was issued by OGC in February, 2004.

One whole GML document is composed of three parts, GML profile, GML application schema and GML instance document. GML profile and GML application schema describe the structure of GML instance document. GML is a complex specification and includes 29 base schemas. In general, an application need not exploit the entire specification, but may employ a subset of constructs corresponding to specific relevant requirements. This subset is called as GML profile. The application schema creates new types and elements by extension and inclusion based on GML profile.



GML instance document provides every kind of data of geographic object. GML schema document is an abstract definition of elements and structures of the instance document. As a brand-new open spatial data encode standard, GML is very important for the spatial data sharing because of its internal accessibility and transferability.

3.3 Web Spatial Data Service

OGC established Web geographic service framework in the basis of Web Service. The services relevant to the spatial data include: Web Map Service (WMS), Web Feature Service (WFS) and Web Coverage Service (WCS).

A Web Map Service (WMS) produces maps of spatially referenced data dynamically from geographic information. This International Standard defines a "map" to be a portrayal of geographic information as a digital image file suitable for display on a computer screen. A map is not the data itself. WMS-produced maps are generally rendered in a pictorial format such as PNG, GIF or JPEG, or occasionally as vector-based graphical elements in Scalable Vector Graphics (SVG) or Web Computer Graphics Metafile (WebCGM) formats.

The OGC Web Feature Service allows a client to retrieve and update geospatial data encoded in GML from multiple Web Feature Services. The WFS operations support INSERT, UPDATE, DELETE, LOCK, QUERY and DISCOVERY operations on geographic features using HTTP as the distributed computing platform.

The Web Coverage Service (WCS) supports electronic interchange of geospatial data as "coverages" – that is, digital geospatial information representing space-varying phenomena.

4. THE ARCHITECTURE BASED ON WEB SPATIAL DATA SERVICE AND GML

The architecture based on Web spatial data service and GML is composed of presentation layer, business logical layer, service layer and UDDI registration center. FIG.2 illustrates the whole architecture.
The work flow is as follows based on WFS: Spatial data service platform register WFS to the UDDI registration center. WFS is described by the WSDL. The client application program or Internet Explorer queries the WFS via UDDI registration center. Then it submits binding request to the application server and gets the description and interface information of WFS. At last, the client application program or Internet Explorer requests spatial data, data server reads spatial object from spatial database, transforms spatial data into data stream described by the GML and provides GML data to the client. Thus data client can get and query real-time spatial object data and achieve the aim of real-time on-line spatial data sharing and interoperability.

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4.1 Service Layer

Service Layer mainly provides data or function service for business logical layer, for instance, storing the processing results of business logical layer, returning data results and function service requested by the business logical layer and masking the change of data sources, thus achieving heterogeneous spatial data sharing.

The implementation of service layer is the creation of application program implementing the interface described by OGC specification. For example, ArcIMS is the solution of ESRI. The ArcIMS Image Service can be used to implement Web Service to provide the GetCapabilities and GetMap interface in accord with OGC WMS specification.

WMS, WFS and WCS are used as network spatial data on-line service, in addition to a heterogeneous data sources on the Internet embodied into GIS application system.

4.2 Business Logical Layer

Business logical layer is the core of the pattern of spatial data sharing, including Web server and application server. It is responsible for processing the requests of the clients, linking to the service layer, executing computing task of business logic and returning processing results to the clients. Furthermore, it is also responsible for the network resources, threads and etc.

4.3 Presentation Layer

Presentation Layer, the client, may be Internet Explorer or application program. It is the unique interactive point to the end users. Presentation Layer submits the request and the relevant parameters to Web server through HTTP, presents data results to the end users and executes basic operation.

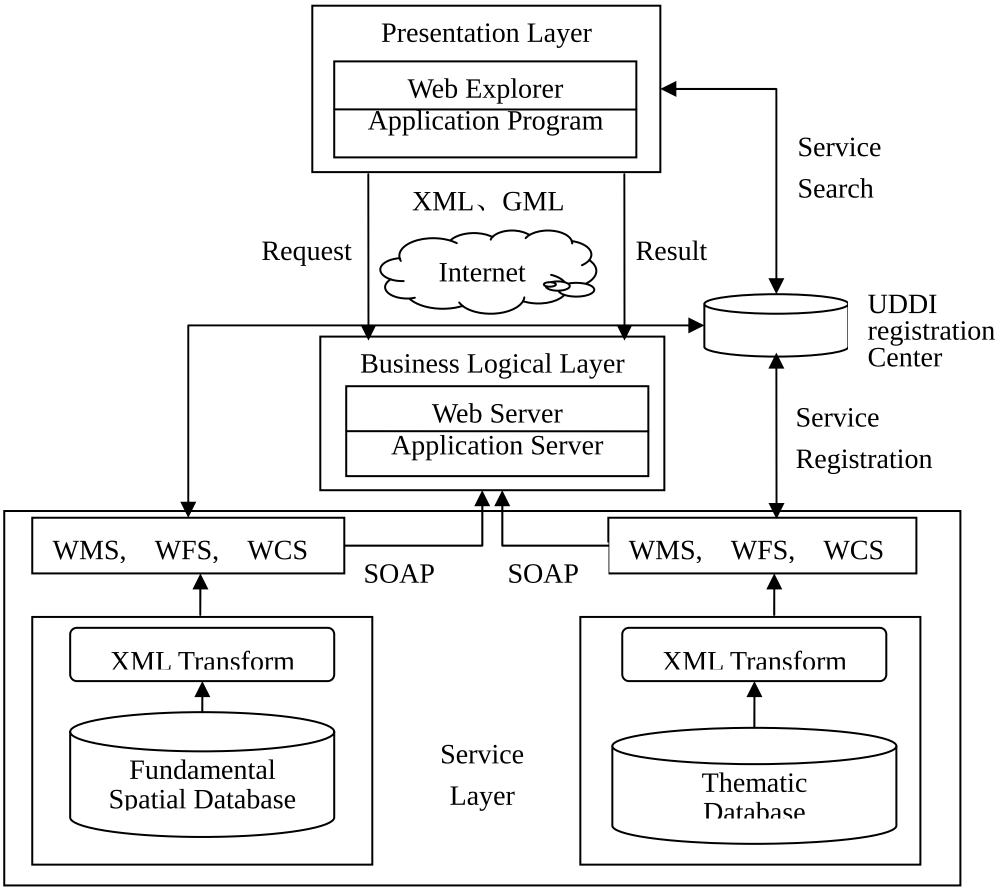

Figure 2. Data sharing architecture based on Web spatial data service and GML

Because the current explorer can not display spatial data described in the GML instance document at the form of graphics, SVG is used to visualize the GML spatial data. SVG was issued by World Wide Web Consortium (W3C) to display and transfer vector graphics. FIG.3 illustrates GML data visualization based on SVG.

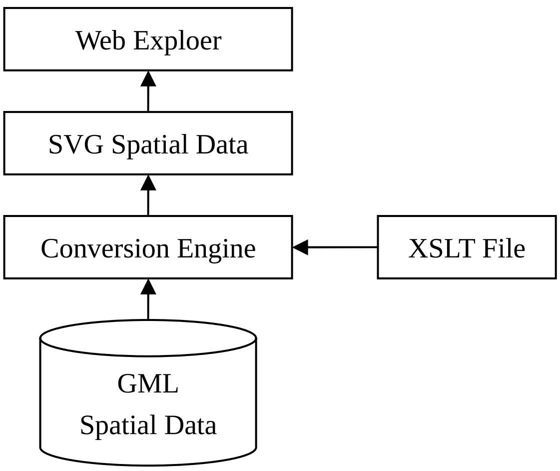

Figure 3. GML data visualization base on SVG

Because GML is described at the form of Text, large volume of GML data is not suitable for transferring over the Internet. Usually GML file can be compressed firstly and transferred from the server to the clients. The compression ratio is 5 to 7.

4.4 UDDI Registration Center

Web spatial data service can be registered to the current registration center, for example, the registration center of IBM or Microsoft. But these commercial centers provide help for the whole world of Web Service. Although it is a good choice to register these spatial data services to the UDDI registration center for the sake of enlarging the application field of spatial data service, the description about service does not meet the need of spatial data service in the UDDI registration center.

One private registration center can be created to support the calling of service requester. It provides more flexibility for the register of spatial data service. Not only do the information of WCS, WFS and WCS need to be registered, but metadata information of the dataset relevant to the service need to be registered.

5. THE PROBLEM OF SPATIAL DATA IN THE SHARING

According to the discussion above, it is feasible to implement spatial data sharing and interoperability based on Web spatial data service and GML from the viewpoint of technique. At least, spatial data can be transferred to the end users. But we can not guarantee that it is convenient for end users to integrate their thematic data with fundamental geographic information data.

End users using fundamental geographic information data are divided into two types. The first type is that the fundamental geographic information data is used as geographic base map. It is relatively easy. The second type is that end users' thematic data need to be linked with the geographic feature. But the confusion of spatial data collection rules makes it very different.

Last year, new specification for feature classification and codes of fundamental geographic information and data dictionary for fundamental geographic information features of 1:5000 1:10000 scale were issued in China. But these standards only solved the problem of which geographic features need to be collected, but did not solve how to collect these geographic features.

According to the experience of some developed countries, an ideal pattern to solve above problems is to construct entity-oriented spatial database, introduce geographic feature –based data model, and provide a unique identifier for every feature. This identifier is a key for end users to link their thematic data to the fundamental geographic information data. At the same time, it can be used as track mechanism of data update and the linkage among the features at the different resolution.

The key to achieve above object is determined by the extent of geographic entity information encoding in the special departments, for example, transportation department, hydrological department.

Of course, surveying and mapping department need to change the pattern of producing and storing spatial data based on "map sheet" and renovate the whole technical system of producing geographic data. This needs large volume of investment and long time.

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