Study on GML Spatial Interoperability based on Web Service

Abstract

As the deeply and broadly applying GIS, GIS has turned into the main technology of management of spatial information as well as integrated platform carried with spatial information, and gradually melted into mainstream of IT. However, due to the content and source diversity of spatial data and the platform difference of GIS software, GIS application is still a “black box” which leads to difficulties of data and functions sharing between GIS applications. Hence, both study on interoperability technology of GIS and solution on interoperability bottleneck between GIS applications have become the most valuable research in GIS domain.

Based on Web service and OWS model of OGC, this paper built Application Integration Layer, Web Application Manager Layer, Service Registry Layer, and GML Spatial Data Storage Layer for GML Spatial Interoperability Framework. This paper established SOAP generation mechanism, WSDL description mechanism and UDDI service registry mechanism for GML Spatial Service, and provided templates for Spatial Web Service Interoperability.

Key Words: GML, Spatial Interoperability, Web Service, SOAP, UDDI, WSDL

1 Introduction

Interoperability is the ability of communication, executing programs and exchanging data between functional cells (such objects or services) in the case of that user know little or even nothing about characteristic of these functional cells. Two components X and Y (see Figure 1) can interoperate (are interoperable), if X can send requests R for services to Y, based on a mutual understanding of R by X and Y, and if Y can similarly return mutually understandable responses S to X.

Figure 1 Interoperability (from OGC)

“Geographic interoperability” is the ability of information systems to 1) freely exchange all kinds of spatial information about the Earth and about the objects and phenomena on, above, and below the Earth’s surface; and 2) cooperatively, over networks, run software capable of manipulating such information.

2 OGC Web Service Interoperability Model

2.1 Basic interoperability of service

Based on OpenGIS® Service model of OGC, OGC developed Interoperability Program Service Model (IPSM), which aimed at description of how to embed spatial software service into interoperability infrastructure and extent diversified, loose data and service resource[2][3]. IPSM pay close attention to existed technology, platform and mechanism about the implement of interoperability service, according to OGC Abstract Specification Topic 12(Service Architecture). On OGC’s opinion: application shall be dynamically integrated and configured by service finding. Since the diversity of methods of creating service, IPSM only described interoperability mechanism without associated implementation. In IPSM, Web Architecture is a distributed compute model based on process element (service), connect element (connector) and data element (resource), which defined discern resource and methods to access and operate these resource.

2.2 OGC Web Service Interoperability Model

OGC service interoperability is implemented by interaction. Service Interoperability Model includes Service (service type), operation (operation type),
interface (interface type), Message (message type) and binding [2]. As shown in figure 2.

Figure 2 OGC Web Service interoperability model (from OGC)

1. Service is a representation mode of integrity system, subsystem, component, module, processing stream and database etc; it is also a distributed and management unit of deployed system. Service shall be customized by multiple types. Type is a suit of qualification and restriction for service classification and evaluation.

2. Action inside and outside the service is called Operation. Operation implemented information exchange between services, defined roles of service and its reason of communication; it is an action when an interface communicates with one or multiple services and its environment.

3. Service Communication is implemented by interfaces. The interface connects service of system to provide capability of information exchanging. Binding connects different interfaces to implement interaction of distributed service in system. Interface type defined semantics of service action and status associated with other services.

4. Binding is a sort of mechanism that connect more than two interfaces to implement interoperability. Services interact with each other by interfaces. To connect two or more interfaces, services must understand identifiers of all interfaces by binding.

5. Operation is an abstract, nomenclative specification of a transformation or query that an object may be called to execute. It has a name, a list of Input message (parameters) and Output message (results). Operation is processed by interfaces, and one operation shall be applied to multiple interfaces, though operation with different interfaces has different semantics.

6. Message is the aggregation of character string that composed of text and numbers to record actions and events, and it may contain any geospatial description (reference) of fixed or mobile features and object in the real world. Message is the information format and content exchanged between services, and processing object of interaction.

3 Interoperable Mechanism of GIFW (GML Interoperability Framework Based Web Service)

3.1 GIFW Functional System and Interoperable Mechanism

GIFW Functional System as shown in Figure 3.
GIFW Functional System consists with four parts: GML Client based on browser, Web application server, GML application server and GML registry center.

(1) GML Client

Data Search: client is used for sending request to background service or data service over Internet, and search GML or other data that needed to be processed or interoperated. Data search is the basic of processing data on client, which implement generating of communication link.

SVG Display: to display SVG data transferred from background service. Operation on SVG shall implement “fat client”, which guarantee direct operation of spatial vector data on browser.

Map Display: to implement “thin client”, map displaying is to display image passed from background service (WMS operation) such as JPEG and so on, and implement view operation such as Zoom in, Zoom out, Cruise, Full Screen etc.

Data Query: to query features in image, find out further relative information (such as area, length, name etc.). Query process is executed mainly according to feature processing specification of WFS.

Data Edit: to provide functions of deleting features, altering attributes and editing symbols and so on, its operation mainly according to WFS and SLD.

Data Extract: to Save GML data of query result, and generate corresponding GML file on client.
Map Service Integration: to implement integration of WMS from different software such as ArcIMS and MapXtreme, and to access data from different GIS platforms.

(2) Web Application Server
Web application Server is an extension of commercial application server, such as Microsoft IIS. It includes several parts as follows:
- Request Classifier: to classify HTTP requests of client, requests are classified to data request; basic view request; interoperability request.
- SOAP Packer: to encapsulate relative request according to request classifier by SOAP format.
- SOAP Analyzer: to parse response and send result to client, according to SOAP response of background service.

(3) GML Application Server
- SOAP Analyzer: to parse request according to Web application server’s SOAP request, and send response result to corresponding components of application server to be processed.
- Data Search: to response data request from client, and implement data service search on GML service registry center. Register on registry center is required.
- Aggregation of View Operation: to implement basic view operation of GML, such as Zoom in, Zoom out, Cruise, Full Screen etc. These operations depend on WMS and WFS on application server. Register on registry center is required.
- WMS Operation: to provide base for view operation, each Zoom in and Zoom out operation need to submit request to WMS service. WMS operation uses cascade mechanism to realize the link to WMS from commercial software such as ArcIMS, which guarantee the integration capability of Web Map of client. Register on registry center is required.
- WFS Operation: to support querying and processing feature on browsers as well as basic editing feature. Register on registry center is required.
- GML Data Conversion: to implement data conversion between GML and other data source (such as E00, SHP, MIF) registered on registry center. These data with different format shall be interoperated by GIFW. Register on registry center is required.
- Service Register: to provide service description and registry mechanism to components that needed to register on registry center.

(4) GML Registry center
GML Registry center is mainly to provide functions of implement service register to service providers that want to implement data and functional interoperability using GIFW framework. It includes several parts as follows:
- Service Search: to implement data and function service search, according to search request of GML application server.
- Service Register: to provide WSDL description for spatial service and service register and storage mechanism.
- Cancel Service: service provider may cancel registered service by cancel service function.
- Description Distribution: response for exterior request for search.

Besides four functional systems mentioned above, GIFW can implement integration and interoperability with exterior service, which process still depends on SOAP request to implement binding and activation of service.

3.2 Spatial Service Description Based on WSDL
Spatial Web Service that accord with Web service standard must contain a WSDL file, Spatial Web service provider describe interface of Web service through WSDL, and register this WSDL document on UDDI. Client obtain
WSDL of spatial service by searching service registered on UDDI, which implement binding of web service, and call or activate associated spatial service by WSDL interface description mechanism, finally implement transparent spatial interoperability.

Spatial service of GIFW is mainly implemented by WMS, WFS based on GML and data conversion of GML, spatial interoperability based on GML is implemented by encapsulating Web service of associated function on application server.

WMS and WFS servers of GML are actually components on GML application servers, and they completely satisfy OGC WMS and WFS interoperability specification and implement corresponding interfaces based on GML. GML WMS not only implement three common interfaces: GetCapabilities, GetMap and GetFeatureInfo, but also extend some other operation interfaces aimed at WMS operation, such as Zoom In and Zoom Out, which would make it easy to operate it when client program call GML WMS. Besides GetCapabilities, DescribeFeature and GetFeature interfaces, GML WFS build linkage mechanism between WFS and WMS, which would integrate WFS and WMS. For example, when it comes to query by rectangle on WMS, FLD of WFS would be used to extract attribute information. The two functions are separated by traditional approach of implementing WMS and WFS.

This paper would take WSDL of WMS and WFS for example to demonstrate WSDL approach aimed at these two spatial services. As shown in figure 4 and figure 5.

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**Figure 4 WSDL of WMS of GML**

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**Figure 5 WSDL of WFS of GML**
WSDL description of WMS and WFS of GML composed of four parts, Operations: to describe exterior interface of WMS of GML; PortTypes: to define abstract aggregation that operating interfaces; Bindgins: to define request and response mechanism of service, it connect with corresponding SOAP, it is also instance of PortTypes; Services: to define location of service. Other description information such as Types and Messages has the same effect with what WSDL defined. The graphic structure mentioned above may be generated by XML Spy of Altova Co. It is actually generated by WSDL document of WMS and WFS.

3.3 Spatial Service Register Based on UDDI

Spatial Service Register Based on UDDI is implemented by GML service registry center which realized search and distribution mechanism of GML spatial service. Spatial service distribution of GML provides description of service provider and function of building tModel. As shown in figure 6.

Service registered on GML service registry center includes WMS and WFS of commercial software for example ArcIMS, GML processing service and GML data conversion service, they are provided respectively by three providers: “ArcIMS Web Service”, “UDDIServer” and “Shuliang zhang”. These providers respectively hosted on host computer connected with GML service registry center over Internet. They mainly provide registry service to service providers which service can establish mechanism for description process of spatial service. For example, service access point information, service classification architecture and service binding etc. As shown in figure 7 is description of service access point information.

One service provider can register many spatial services, but one spatial service can correspond to only one tModel which is used to binding concrete spatial service WSDL. In addition, entire register of a GML spatial service can be implemented by tModel of service provider. As shown in Figure 8 is the implementation of binding of spatial service description of service provider and tModel technology specification.
Figure 7 Binding of spatial service description of service provider and tModel technology specification.

Current GML service registry center is a private UDDI which based on Windows2003 Server Microsoft Co. When it comes to implementation of distribution of spatial service of GML service registry center over Internet, such UDDI may be registered on UDDI node of Microsoft Co.

3.4 GIFW Application System

GIFW application system composed of client system of GML map and feature processing, GML service registry center, system of GML spatial service finding, system of GML spatial data conversion service, the main interface of the system would be seen in Figure 9, Figure 10, Figure 11, Figure 12, Figure 13 and Figure 14.
4Conclusion

As kernel interoperability criterion of OGC, GML plays a role of “bond” in the interoperability framework, which promotes the development of interoperability. GML is not only outstanding on storage and conversion of spatial data but also on spatial interoperability, in virtue of its advantage of open and concise spatial data expression.

Spatial Service Registry Center based on GML and its corresponding registry mechanism provided consistent interfaces for supply and registry of spatial service, it also provided standard interface for queries of spatial service, consequently avoided shortage of traditional spatial interoperability which can’t resolve the problems of search for data and functions. Spatial Service Description Schema based on WSDL separated interface and implementation of service, thereby ensured transparency of user service call.

Spatial request and response based on SOAP transparentized request process and ensured loose coupling of spatial service call, hence simplified service call protocol mechanism between service caller and provider, realized “distribution” of service request and response.

Spatial Interoperability Framework for GML based on Web service technology dose not only expands cognition extent of spatial interoperability, but also provides new ideas and methods for research on spatial interoperability. This paper develops prototype system for GML interoperability by .NET technology and implements distribution of system service based on private UDDI. Experiment proved that interoperability framework and interactive mechanism proposed by this paper can largely enhance data interoperability, function interoperability and semantic interoperability of GIS.

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