Design and Implementation of Service-Oriented Spatial Information Sharing Framework in Digital City

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Abstract  This paper proposes a theoretical framework of spatial information sharing in a digital city, and analyzes its technical characteristics. According to the service-oriented architecture (SOA) framework, a geospatial information sharing platform is put forward. The spatial information sharing model based on SOA is designed. A prototype platform realizing multiple-source spatial information sharing based on ArcGIS Server is developed.

Keywords  digital city; Web services; service-oriented architecture (SOA); spatial information sharing

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Introduction

In order to obtain geographic information timely, process it automatically, and then provide network services and social application, we need to implement real-time acquisition and automatic processing. Furthermore, we should share the spatial information to serve economic construction and bring it to everyone’s daily life.

Service-oriented architecture (SOA) is a type of architecture modeling that carries out the distributed deployment, combination and use on the loose coupling and coarse-grained application components through network according to the demand. The services layer, which is the basis of SOA, can be called directly by an application. Consequently, the artificial dependence during the intercommunication between systems and the application agent can be effectively controlled. The key of SOA is the concept of “Services”, which is defined by W3C as “Service providers perform a set of tasks in order to provide final result to service customers. The final result may change the status of customers or providers or both.” The paper design a geospatial information sharing platform based on SOA framework in a digital city.

The research on geospatial data sharing started earlier abroad. In 1957, the International Council for Science (ICSU) founded the World Data Center (WDC), promoted scientific data sharing, and established the Geosphere and Biosphere plan[1,2]. Created in 1966, Committee on Data (CODATA) for science and technology coordinates the global various areas of the data construction and sharing service, in which China joined in 1984. In 1922, Japan proposed the plan of Global Mapping, and established International
Steering Committee for Global Mapping (ISCGM) in 1996, which studies and promotes global mapping in order to acquire global uniform basic geographic data [3,4]. In 1993 and 1994, The United States proposed the plan of national information infrastructure and national spatial data infrastructure[5], and proposed the strategic plan of Digital Earth in 1998. All of these international organizations and cooperation plans were established to complete the gathering of global basic geographic data and achieve global spatial data sharing.

Service-oriented sharing framework is generated in such a public demand. Table 1 shows the comparison of the spatial data-oriented sharing and service-oriented spatial information sharing.

Service-oriented architecture is a software system structure that achieves interoperability by packaging the program unit which can accomplish the given task. It originates from the distributed computing model which is based on a software component, promoted by OMG (object management group) and IONA, and which has been accepted as a standard widely.

Service-oriented integration (SOI) integrates the traditional objects with highly flexible Web services. SOI provides an abstract interface. Systems are able to communicate with each other by this interface, instead of using low-layer protocols and self-defined programming interfaces to prescribe how to communicate with other systems. The system only need to appear in a form of service, select the interactive system, make a simple discovery and bind with this service at runtime or in design.

### Table 1  A comparison of data-oriented spatial information sharing and service-oriented spatial information sharing

| Comparative item                  | Data-oriented spatial information sharing | Service-oriented spatial information sharing |
|-----------------------------------|-----------------------------------------|---------------------------------------------|
| Outcome form                      | Data of various scales                   | Different granularity service                |
| Invocation interface              | Data interface                          | Standardized service protocol                |
| The method data updates           | Periodic renewing                       | Dynamic, continuous, popular renewing as need |
| Sharing framework                 | By converting the format of data         | Use the different granularity service        |
| Requirements on operator          | Professional, experienced personnel      | Professionals and public                     |
| Security                          | Data security protocol or data encryption| Provide service contents, service form, service quality on agreement |
| Flexibility of using              | Passivity of data searching              | Registrability and detectability             |
| Integration and interopera-bility | Difficult in interoperation              | Can realize interoperation between CORBA, DCOM and EJB with the standard protocol |

SOA is a loose coupling software system structure. In this structure, the functions of the system consist of services which are respectively independent and reusable. These services publish clearly-defined interfaces, and call these interfaces to realize the software development. The system structure shown in Fig.1.

Mainly, there are three kinds of roles in a service-oriented architecture:

1. Services consumers, which use application services or other services, bind with services and perform the function of services according to the information of interfaces and use of some kind of transfer protocol, after querying from services in the registration centre.

2. Services provider is the entity of services creation, which can take in the request of services consumer and perform the requested services remotely, releases the information services.

3. Services registration centre, where the service consumer can find interested services of interface information by way of querying the registration centre.
which has stored services information database, is the centre position which can provide the function of display services.

The system based on SOA may set up some service by object oriented architecture, but the whole design is service-oriented. Considering the objects in the system, service-oriented Architecture is based on object and is not object-oriented. The key difference is interface. The representative instance of SOA is common object request broker architecture (CORBA), the definition of which is similar with SOA.

SOA may change nowadays, because it relies on some development based on eXtensible Markup Language (XML). Interface can be described by Web services definition language (WSDL) based upon XML, so that the services will make the system more dynamic and more flexible, which the interface definition language (IDL) of CORBA cannot achieve.

Web service is not the only implement of SOA. The forenamed CORBA is another implement, which can set up the system based on message-oriented middleware, as an example of MQseries in IBM. In constructing the architecture model, it is not only service description but also the definition of how to perform workflow among services in the whole application that is a necessary condition. Especially, the breaking point between operation of mission and software must be found. Accordingly, the business process and technical process of mission should be connected by SOA, as well as the relationship between them. For example, the operation of pay the Suppliers is a business process, and updating part database is a technical process. Thus, workflow plays an important role in the design of SOA.

Furthermore, the workflow of dynamic mission consists of the operation among inner departments and work with uncontrol exterior partners. To improve the efficiency, the policy of how to receive the relationship in services must be regulated. It is usually formed as a service level agreement and operation policy.

Ultimately, all of these must be put in a trustful and reliable surrounding and be performed in the stipulation. Therefore, it has an important role in SOA as a safe, trustful and reliable mode of information transfers.

1 Design of service-oriented spatial information sharing framework in a digital city

This paper designs a service-oriented spatial information sharing framework in a digital city, as shown in Fig.2.
The service-oriented spatial information sharing framework is a distributed system deployed on several different computers, and a sharing framework of spatial information based on the B/S pattern. Its server-side has 3 layers: Web Server layer, GIS application server layer and database layer, in which the database layer manages spatial data. GIS application server layer manages the services of spatial data.

2 The characteristics of service-oriented spatial information sharing framework in digital city

SOA contains a series of interactive services, which can provide access to its function library. As a whole, SOA is designed and implemented as a set of interactive services. In this method, the application system implements every business function as a service, which can enhance the flexibility of the whole system, and in this way, the system can finish evolution through adding new services.

SOA defines the services which compose the whole system, and describes the interaction behaviors between services. At the same time, SOA is also responsible for mapping every service to one or more concrete technical implementations. In general, SOA’s advantages focus on its high reusability and flexibility, as well as, preferable expandability and usability. Service encapsulates business function. In order to implement the interaction and communication among services, some communication media must be involved. Because services may be implemented in a single PC or in a LAN, when we use the Internet as its communication mechanism, it is just fashionable Web service. Web services represent a kind of SOA implementation, which are new Web applications characterized as self-containing, self-describing, and modular, and we can release, search and use it through the website. Web services can serve for responding to a simple client request or a complex work flow. Once a web service has been configured, it can be found and used by other applications or services.

In view of external users, Web services are a kind of object/components deployed on the web, which contain several characteristics as follows:

(1) Good encapsulation. Web services as objects deployed on the web, naturally process object’s encapsulation. As a user, we are able to see the function list provided by this object.

(2) Loose-coupling. This feature is also derived from object/component technology. When a change of a web service’s implementation happens, users have no need to see its details. In their views, as long as the interface has no change, the variation of its implementation is transparent to them. Even if the implementation platform of one web service transfers from J2EE to .NET, or vice-versa, the users need not acknowledge this change. In order to realize this loose-coupling of web service on the Internet, we need an information exchange protocol suited to the environment of the Internet. XML/SOAP is just the appropriate one currently.

(3) Using standard specification. As a web service, its common treaty must use an openly standard protocol which is responsible for the description, transformation, and exchange of data. These standard protocols contain a serial specification which we can get freely if we plan to implement them. In general, most of these specifications were finally released by W3C or OASIS.

(4) High integration. Owing to the adoption of a simple and intelligible standard web protocol as the specification of describing the component interface, web services can shield the diversion between different software platforms. CORBA, DCOM, and EJB are all able to accomplish interoperation with each other through this protocol, which can achieve the highest integration in current circumstances.

3 Test platform of service-oriented spatial information sharing framework in a digital city

Taking the ArcGIS Server as a platform, with the Nanning City data as an example, this paper achieves the sharing of image data, basic electronic map data and thematic data. The sharing experiment research is
carried out for different geographical locations. The software environment involved includes the following 4 aspects:

1. Windows 2003 Server x64 is taken for server operating system, Windows 2000 or Windows XP is taken for the client operating system.
2. ArcSDE9.2 is taken as a database management software.
3. ArcGIS Server9.2 is taken as the server of the geographic information platform’s spatial data editing, processing and sharing.
4. Microsoft Visual Studio .NET 2005 is taken for system development environment.

On the database management of spatial data, the GIS Server manages spatial data service, and posts the database’s spatial data to the GIS Server. For GIS Server, Web Server calls the service of GIS Server, and is the client of GIS Server. On calling the service of GIS Server, Web Server achieves function by implementing a service operation, and provides the service to the user by browser ultimately. The work process is shown in Fig.3.

The experimental system is a three-tier architecture which contains the database layer, GIS Server layer and Web Server layer. It is deployed in different servers. The database server and Web Server each occupy a server, and GIS Servers occupy multiple servers, which has something to do with the capacity of the system load and server process.

For thematic data, because of the involvement of different departments, it can deploy and maintain them physically separate. The individual server object manager (SOM) is used for logical management, as shown in Fig.4.

According to the different congruent relationships of meta-data and corresponding spatial data, different storage strategies can be chosen. One strategy is to take the distributed way, another strategy is to take the centralized way. Distributed storage is based on datasets and each data set matches one meta-data file. Centralized storage is based on the whole database. Each database matches one meta-data file, each record in the file matches one data set.

The experimental system integrates aviation data and remote sensing data together, and it provides various browser ways to users, as shown in Fig.5.

For basic geospatial data, open access is shown in Fig.6. To share geospatial data of different themes,
according to the current situation of which information and data of different themes are separately stored, and data sharing between different parts refers to the problem of access rights and security, this experiment system uses a SOM to manage several distributedly deployed sever object container (SOC) as a solution. Each SOC Server can be deployed at a different place which is different from others. Users request services by SOM, and SOM assigns different SOC to supply data access services and analysis functions. It is not necessary for geographical data to centralize the storage and management, but only register to the service and management center. Fig.7 shows the service and management center.

The system uses XML configuration files to control the access rights of services. Access control is set up according to user group, which takes charge of user and services match with user group. Users who have enough rights are able to access the thematic data when needed, which is illustrated in Fig.8.

4 Conclusion

The information sharing system designed in this paper sets the service-oriented Web Service as the bottom data organization and chooses a B/S distributed system framework. The authors put forward a digital city sharing platform architecture based on SOA. GIS functions are packed to services. Interfaces of services are described in a standard way; implementations of services are transparent to users. Based on the spatial information data of Nanning City in Guangxi Province, the experimental sharing platform can provide convenient, quick and transparent services to users with multiple-section data. Further studies include improving spatial data services, developing related information services, implementing the one-to-one relationship between task and service type, further classification of geo-spatial services according to task demands and semantic granularity, and improving metadata service system.

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