The Design and Implementation of GIS applications Based on SOA

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1. Introduction

GIS systems (Geographic Information System) utilize multiple ground surface information, e.g. DEM or geography location information, to provide geographers, relevant domain experts and the public geography functions such as navigation, spatial analysis and location retrieval. GIS has tight relationship with computer technology and the progress of computer technology will certainly promote the development of GIS. Traditional GIS systems, which focus on providing functions to professionals, are always made up of closed, stand-alone and single-machine software. With the development of computer technology and network, GIS turns to be open, distributed and multi-machine, and the public starts to use GIS systems as daily tools. However, many features of GIS make it difficult for people when designing and implementing a useful and flexible GIS system.

First, most GIS systems have to face mass geography data problem. Geography data refers to the basic data that GIS systems rely on when providing geography relevant functions. Common geography data includes map data, geography entity data and DEM data. With the integration among GIS, RS and GPS, people get more and more geography data nowadays and the quantity of the geography data we get every day is about TB level. As a result, in order to develop GIS in network environment, the first problem we should address is the mass geography data. Traditional GIS systems prefer to define their own data formats, meaning that different modules from different GIS systems should translate the data in the uniform format between them before communication, because mass quantity and heterogeneous format make it harder to share and update geography data. As a result, many GIS systems own a copy of the same data which is a waste of resource.

Second, with the rapid progress of web services and technologies, more and more GIS products and personalized GIS services arise over the Internet. Besides, the public has been the user of GIS systems. However, not only the quality of service and data provided by various producers are not consistent, but also the services' interfaces are quite different. Mainly by these reasons, most of the GIS services over the Internet are tentative, simple and small that cannot reach users' requirements. How to unify the interface of the services and integrate these small services to form a more useful GIS system is a difficult problem.

Third, as the development of GIS over Internet, various GIS data and GIS services make up the new GIS systems which are more complicated than before. How to coordinate these data and services to let GIS systems easy-to-use for the public is a new problem for GIS architect.

In summary, the development and popularization of GIS system today is constrained by the problems mentioned above. For one thing, GIS systems should mask the professional characteristics of geography and provide simple service interface for the users to assemble personalized service; for the other thing, when facing special professional requirements, say geography modeling and such like, GIS systems should provide the ability to share and reuse various geography data and professional functions or execute geography computations more efficiently. To achieve these aims, we should consider the design and composition of GIS systems from the view of software and network architecture. As a new enterprise level distributed software architecture concept, SOA may help us on how to construct a rational GIS system.

2. Using SOA in GIS

As GIS becoming open and networked, modules or data of a GIS system are always deployed on different nodes in the distributed environment. At the same time, SOA is a methodology of constructing a distributed software system, so the combination between GIS and SOA may bring us some new ideas and designs.

2.1 Active Effects of SOA to GIS

The active effects of SOA to GIS can be summarized from two aspects: firstly, using standard interface and visiting channel to provide various functions in GIS systems, which can be called module encapsulation; secondly, using combination technologies to integrate different modules in GIS systems based on geography signification, which can be called module combination.

(1) Module Encapsulation

Module encapsulation makes different modules from different GIS systems communicate with each other more freely despite these modules having different visiting channels, running on different platforms or using different data formats. Encapsulation provides us a well-formed interface which can be considered as the basis of module reuse. SOA uses service to explain interface and a service usually means an instance of a meaningful module. When using web services to encapsulate modules, the web service description document (using WSDL) is the interface of the service. The service interface defines the location, parameter and visiting channel of the service. With the information defined in service interface, service invoker can make a standard service call instead of invoking concrete service method and naturally, the invocation of the service is cross-platform and cross-language.

Module Encapsulation brings two conveniences for GIS: module reuse and data sharing.

Module Reuse. Most GIS systems cover some common functions, such as map printing, data format transformation, spatial location computation and so on. These common functions are always tight-coupled with the design of the whole GIS system which means that one should always re-program these functions when implementing a new GIS system. If we could extract the common modules from the systems and encapsulate them well, we would reuse them and manage them more easily.

Geography Data Sharing. The geography data used by different enterprises and GIS systems are always heterogeneous, so how to share them in different systems is a big problem. There are three methods in SOA to address this problem: 1. Using SDO (Service Data Object) to encapsulate structured geography data. By this way, different modules will transmit SDO as parameter instead of quantities of geography data. 2. Based on GML proposed by OGC, people designed a lot of service-oriented data sharing method, such as WMS (Web Map Service), WFS (Web Feature Service) and WCS (Web Coverage Service). 3. By using ESB concept (Enterprise Service Bus), we can design concrete data transmission protocol and data transformation program for different modules that connected to the GIS service bus.

(2) Module Combination

Module combination depicts the process when assembling small and stand-alone modules to form a bigger and meaningful module in the distributed environment. Module combination brings the flexibility to software, because different modules' combination stands for different business logic. There are mainly three technologies in SOA to realize combination, they are: SCA (Service Component

Architecture), BPEL (Business Process Execution Language) and MD (Message Driven). SCA is a coarse-grained service integration method. The components of a SCA module, which are implemented in different languages or on different platforms, can be deployed on different nodes in the network. BPEL is a kind of process integration method which focuses on how to assemble various services together as a service chain. MD uses message transmission pattern and message transmission middleware to construct a loose-coupled environment for the upper software layer.

Different module combination manners provide different methods for constructing GIS systems:

Combination based on Geography Signification. In GIS systems, several functions in fact contain a series of other functions or they may have close association with each other. For example, when browsing a map, one may zoom or move the map; when taking map search, one may need the functions like nearby information retrieval, POI retrieval and route retrieval. These small functions are all independent but having geography association with each other. In these cases, we can use SCA to assemble different modules together to provide a uniform interface. SCA supports the integration of heterogeneous modules which are cross-platform and cross-language. So when we extract modules from GIS systems based on geography signification, SCA will help us combine them and encapsulate them as standard web services.

Combination based on Geography Process. Geography process describes the execution process of geography functions in steps. Geography process is very common in GIS systems, for example, when retrieving route, firstly, GIS system should query the coordinates of the start position and the destination according to the user's input; then, uses a fixed route computation algorithm to calculate the route based on the road topological data; finally, prints the route on the map and returns it to the user. Geography process is a series of independent services or modules, in other words, it's a service chain or an orchestration of services or modules. In these cases, BPEL is a quite convenient manner for assembling different services or modules as a meaningful process. Furthermore, user can also use BPEL to integrate the services provided by GIS systems to form a more personalized geography service according to their requirements.

Combination based on Geography Event. In many GIS relevant systems, e.g. spatial analysis or geography model simulation, geography events usually trigger the start of some functions or processes. The event producer is always independent from the event consumer, but in traditional GIS systems, they are tight-coupled. MD will make the modules in the GIS systems loose-coupled and therefore, different modules in the systems can be developed independently. MD mainly depends on message transmission pattern and message transmission middleware.

2.2 Problems SOA cannot addressed for GIS

SOA is designed for the construction of enterprise level distributed software, so there are still many GIS specific problems that SOA can not address. These problems are:

Transmission of Mass Geography Data. SOA can help us share and encapsulate data, but in some situation, e.g. spatial analysis or spatial interpolation calculation, we have to transmit mass geography data over the network. In these cases, SOA is not an efficient choice.

Status of Geography Process. In some time-simulation relevant GIS systems, the execution process of the systems have to save some intermediate results as status. Services in SOA are always stateless; as a result, one should consider the status problem when designing services in such systems.

QoS. Till now, SOA is not suitable for some efficiency critical or security critical environments.

2.3 Present Research on Using SOA in GIS

With the development and popularization of SOA, more and more research focuses on how to associate SOA with GIS. The research can be divided into two aspects:

Focusing on how to use web services in GIS. This kind of research always uses the structure of web services technology, which is comprised of service provider, service register center and service consumer, to interpret how to use web services in GIS systems. However, SOA is not web services, so their research does not really introduce SOA into GIS.

Focusing on how to design the architecture of large GIS systems. This kind of research tries to use some key concepts of SOA, e.g. service classification or ESB, to design the macroscopic architecture of the whole GIS system. Most of the research is lack of details or implementation, still at descriptive and conceptual level. In the following sections, we will design and implement a mini campus GIS system. With this case, we will discuss how to realize several SOA key technologies in GIS.

3. A GIS application based on SOA— Mini Campus Map Service

In order to provide the detailed information of Peking University to visitors or students and teachers, we developed a PKU-oriented mini campus map service – PKUMAP. PKUMAP is a light weighted web GIS application, implementing with the techniques of SOA. The main architecture is shown in Figure.1.

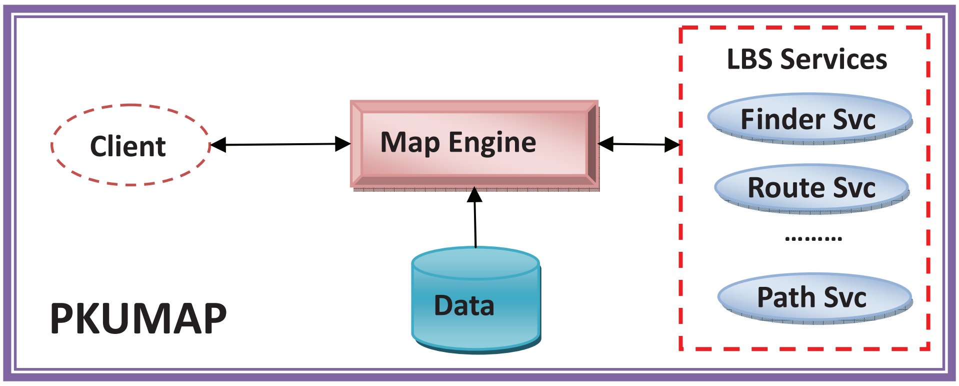

Figure 1. The Architecture of PKUMAP

As Figure 1 shows, PKUMAP consists of Client, Map Engine, related GIS data and a series of LBS services. It can provide users with the basic map operations, such as moving, zooming and so on. Besides, it can provide two LBS services – POI Finder Service and Router Service.

4. Conclusion

In this paper, we discussed how to apply several SOA technologies in GIS. And with a case of a mini campus GIS, we displayed the implementation of SOA in GIS. SOA is a methodology of constructing enterprise level software and it brings enterprises flexible distributed software architecture. With the development of GIS in distributed environment, GIS could also benefit from SOA concepts. More and more GIS modules turn to be reusable and flexible, and the architecture of GIS system is also progressing greatly. However, because of some features of GIS, SOA is not completely suitable for GIS systems. So in some situations, we have to extend the ability of SOA to let it be more helpful in constructing GIS systems.

5. References

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