The Research on Geographic Information Services Based on Multi-Agent Architecture

Gao Gang-yi
Zhejiang University of Finance & Economics, Hangzhou 310018, China

Abstract: The progress of information technology and the need for global distribution of geographic information making the GIS community to distribute geographic information services (GI Services) is possible on the Internet. In this paper, the model of GI services based on Multi-Agent architecture is designed after analyses GI services and Agent. At last, the implemental system using GML (Geographic Markup Language) is discussed. This architecture can provide a flexible and scalable architecture for distributing GI services on the Internet.

Key words: GIS, Agent, Geographic Information Services, Geographic Information, GML

1 Introduction

At present, geographic information data and applied software are increased rapidly on the Internet, Internet became a huge resources database; On the other hand, the present mostly GIS (Geographic Information System, GIS) adopts C/S or of B/S structure, and they can’t provide to user more and better GI service on line. Users only acquire the service of map shows generally, and they can’t acquire on-line GI service, such as transform data, the transform of reference system, the analysis of data, etc. Users do not know where the geographic spatial data is, what it is and how to use it. So how to find and use the needed data and services in the enormous data repository is a problem of each user [1].

To solve above those problems, not only to send out a great deal of data to clearing house to handle, but also to consider about distributed processing method. This paper put forward a model of GI services based on Multi-Agent architecture that united GIS with agent techniques. This architecture can provide a flexible and scalable architecture for distributing GI services on the Internet.

2 Geographic Information Services and Agent

2.1 Geographic Information Services

Geographic information service is a service that provides geographic information for user, which includes the service of geographic data and GIS processing function. The key of GI service is realizes the standardization of geographic information and the universalness of geographic information processing function, converting with the geographic data only far share of fall through the information. Only with information sharing that geographic data conversion is not far, only realized systems cooperates mutually on the higher layer, and then can be real to attain the target of GI services. This paper mainly what to discuss is the service of geographic information processing function. GML that is in part 4 can be use to realizes the standardization of geographic information.

On the Internet, GI services should include: search and filter of spatial geographic information, downloading and explanation of geographic data, display of map or data, process and analyses of GIS on-line etc [1][2].
The realization of GI service has two difficult problems. One is how to access the data of the different system (geographic information sharing); two is how to share operation of geographic information (function sharing). The model based on agent architecture can resolve above-mentioned problem effectively.

2.2 Agent

The concept of Agent originated from Distributed Artificial Intelligent (DAI), and is a basic term of DAI. There is no uniform and specific definition yet for Agent until now. Patie Maes, the director of MIT media lab, deems that Agent is “a computer system, which locates in dynamic and complex environment, can automatically sense the environment and act accordingly to complete its tasks or goals”. Agent is a computing entity with four features of autonomy, reactivity, interaction and initiative.

Agent offers a new method for computation and problem solution, which has many advantages as follows [3] [4]: Agent not only can act by itself, but also can react to the environment, and can receive the feedback information of the environment, and it can get feedback information from the environment, and then redirect its activities; Agents can cooperate with each other; Agent system can decrease the cost of software and hardware and offer a quicker method of problem solution etc.

Based on these features of Agent, it is natural to introduce Agent into GIS system where it can be provide with many GI services as follows:

1. Search and filter of spatial geographic information: There is a great deal of geographic information on the Internet, and it is become more and more important that how to acquire information what we need in extensive information ocean. So we can search and filter geographic information using Agent.

2. Downloading and transformation of geographic data: In distributed environment, the isomerous data and system can't communication directly with each other. Agent can download and transform data, and realize geographic data sharing.

3. Cooperation of GI service: The cooperation of multi-agents can better resolve the cooperation problem of geographic spatial information service functions and GIS application on the Internet and improve the capability and efficiency of GIS service.

4. System integration: Agent can be use repeatedly. User can convenient construct GIS system, and realize the code sharing to a large extent.

3 The Model of GI Services Based on Multi-Agent Architecture

The system of GI service is a many Multi-Agent system, which contains a set of software Agents that may run on one computer, and may be distributed on different computers on the web.

To complete the GIS task, Agent needs to communicate and cooperate with other participants (such as users, other Agents or data sources). In the system, different Agents act as different characters, having different functions and tasks.

The overall architecture of GI service based on Multi-Agent is shown in Fig.1
Spatial metadata database (SMDB) is a database of saving spatial metadata. With the development of network, metadata is already extend from a method of data description and index to a powerful tool or method that including data detection, data conversion, data management and data using in the whole information process. Spatial metadata provided to the multi-layer index management of the geographic spatial data, and locate position of data for user quickly [5].

3.1 Interface Agent

User interface is a bridge of user and GIS. Interface is designed according to the task of user, and a fitly interface is usually very important to system [6]. In this model, interface Agent is designed to achieve the interaction between system and users. It realized the generality of user interface.

The main functions of interface Agent include: 1. Help user to describing searching request in some kind of fixed format; 2. Support vague-searching through communication with KDB (Knowledge DataBase); 3. Communicating with task Agent (such as query Agent, map display Agent etc.), submitting the searching request and returning the resulting data to user; 4. When user gives an incorrect request description (such as syntax errors), interface Agent will display error information and prompt user to correct it.

The problem description of user’s can be easily described by GeoScript language, which is a kind of interpretative program development language, and is itself a distributed computing platform. It has unexampled advantages in integrating operating systems that are written by different languages and are distributed in different computers. But one of its disadvantages is slowness. In addition, script need to be extended depending on its specific application, for example, GeoScript language in GIS field.

3.2 Administrator Agent

Administrator Agent manages the whole system, process the complex communication between the inside and outside of system. It is unique in the system. The main functions of administrator Agent include: 1. The interface of system with other systems or Agent systems; 2. Administrate the table of Agent registers; 3. Cooperate the interaction of Agents which inside of system; 4. Administrate all the active Agent instance, including the status and life cycles of active Agents; 5. record the related information of other Agent systems, convenient for communication with each other.

The Agent register table includes all information that identifies the Agent, besides its ID, address, name, etc. It is an important part that records the specific method and the service function of the cooperation of Agents. According to this register table, administrator Agent creates Agent instances and uses them.

3.3 Cooperation Agent

Cooperation Agent also is unique in the system, it is responsible for Agents communication each other inside of the system, creates the Agent instance, and carries on the distributed control to the system. The main function of the cooperation Agent
include: 1. Analysis the request of interface Agent; 2. Seek the Agent class by accessing the register information of the administrator Agent; 3. Create the Agent instance; 4. balance the system burden by some arithmetic; 5. Process the communication of Agents [6].

In GIS system, the network burden is a more important problem, because: 1. The data transmission of geographic spatial information is huge; 2. The cost of the communication between Agents is too high. Hence, to reduce the network burden, we must: 3. Try to reduce the inter-network communication, especially the communication with large amount of data. A solution is to put the return data in the local database, if there is a similar request later, just returns the data to users by accessing the local database; 4. Try to reduce the amount of communication data among agents (this should be taken into account when designing the system);

3.4 Task Agent

Task Agent is the Agent that is carry out one GIS task in system. Such as the search Agent, the information filters Agent, map display Agent and the analysis Agent etc…

The creates process of the task Agent to is divided into following few steps: 1. the interface Agent sends the user’s request to cooperation Agent; 2. cooperation Agent searches the Agent that needs to be created according to the description of the request; 3. coordination Agent creates the instance of GIS Agent.

According to different system demand, we can flexibly design different kinds of GIS Agent to complete specific missions. System can be extended flexibly based on the specific requirement.

4 Implementation by mean of GML

Based on the model of Multi-Agent system architecture above, we proposed a construction method of the model system, and implemented a simple prototype system. Its architecture is shown in Fig.2.

GML (the Geographic Markup Language) [7] standard is adopted in data transmission between tiers. GML, which is an extension of XML, is proposed by OGC (OpenGIS Consortium) to solve the interoperability problem.

![Fig.2 the model of Multi-Agent system architecture](image)

Wrapper is an important part of server. It is in charge of the format transformation between geographic spatial data and GML so that is can make full use of the advantages of GML. Developed by Java Server, Wrapper accesses database (such as SQL Server and Oracle) through JDBC-ODBC Bridge or Oracle JDBC [8].

If the database is not supports spatial data (such as SQL Server), we need to read out spatial data from the database and append into the GML file (tree); If the database is supports spatial data, the process is easy to do. Oracle is a widely used and object-relation database. It allows users to store and retrieve geographic objects such as point, line and area. At the same time, Oracle provides spatial data access method (R-tree). Searching and analysis of spatial data are supported, and the result of user’s request is returned in the form of GML document.

Now most sharing forms of geographic information are the map and the display of geographic information data that mostly adopts vector-graphics. Since GML separates the content of geographic data from the display of graphics, there are many tools to interpret its content, such as SVG (Scalable Vector Graphics) which is widely supported by many products. The GML data display of OGC actually adopts SVG to display the map information. According to the Map Style Sheet of GML data display processing, SVG, using XSLT (XMSL Transformations) criterion, transformed GML data into SVG format and displayed it.
Nowadays most of the browsers such as Internet Explorer (IE) support SVG.

5 Conclusion

GI service on the Internet is a new direction for GIS. However, Agent technology gives us a brand new method to solve the problem. After analyzing geographic information and Agent, this paper proposed a model of GI service based on multi-Agent architecture and discussed the system construction by means of GML. The prototype system with this architecture has the following features and advantages: reduce the complexity and construction difficulty of GIS; resolve the cooperation problem of GIS application; improve the capability and efficiency of GIS service.

Because of the limitation of system design and implementing method, the prototype system still needs to be improved. What is more, it needs further research for Multi-Agent system to be applied in practice. Such as, MA system lack of a standard of system architecture and organization, and efficient methods to construct and evaluate MA system. We will keep the research on these aspects.

References