地理学报(英文版) 2001年第11卷第5期

Towards distributed e-map service

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This paper explores a new approach towards the distributed e-map service with CORBA. The architecture of a distribute d e-map service model is described. This model mainly contains a distributed map database, a database connection laye r, an application service layer and a client layer. For the sake of convenient transmission of map data, a combinatio n of CORBA and GML method is introduced. Furthermore, in order to keep the loading balance among distributed servers

Towards distributed e-map service ZHANG Yan1, WANG Yuxiang2 (1. Institute of Geographic Sciences and Natural Resource s Research, CAS, Beijing 100101, China; 2. Institute of Remote Sensing Applications, CAS, Beijing 100101, China) Abst ract: This paper explores a new approach towards the distributed e-map service with CORBA. The architecture of a dist ributed e-map service model is described. This model mainly contains a distributed map database, a database connectio n layer, an application service layer and a client layer. For the sake of convenient transmission of map data, a comb ination of CORBA and GML method is introduced. Furthermore, in order to keep the loading balance among distributed se rvers, object migration is implemented among servers and security is considered. Key words: distributed e-map servic e; CORBA; ORB; map data CLC number: P283 1 Introduction Map is an efficient language for describing geographic object s. Electronic maps (e-map) have come into being with the development of computer technology. Internet makes it easy f or the public to explore maps and retrieve geographic information remotely. In our traditional browser/server archite cture, map data are usually maintained in a single centralized map database, although map information covers the whol e earth's surface. The characteristics of such wide-spread map information can be better preserved in terms of distr ibuted map databases. For this reason, a distributed e-map service based on the concept of distributed map databases is developed. The distributed e-map service contains a number of functions ranging from map query, remote map generat ion to map analysis for users in a distributed networked computing environment. It helps to enhance the ability of sh aring maps on different servers and integrate the geometry data with attribute data in a whole distributed database. Users can retrieve map data from the nearest map database. With the development of distributed computing technology a nd application of Internet, distributed map service will replace the centralized map service. The distributed e-map s ervice is the combination of distributed computing technology and geographic information system technology. Currentl y, the main distributed object computing technologies are CORBA (Common Object Request Broker Architecture), COM/DCO M (Component Object Model/Distributed Component Object Model) and EJB (Enterprise JavaBeans). CORBA is a standard obj ect-oriented application specification by OMG (Object Management Group). It is independent of operating systems and p rogramming languages. Established objects can be reused in various situations. Therefore, CORBA serves as an ideal di stributed object computing technology among different operating systems. COM/DCOM and EJB distributed computing techn ologies in Windows operating system by Microsoft Corporation and in Java language based on RMI (Remote Method Interfa ce) respectively. 2 A brief description of CORBA CORBA is made up of Object Request Brokers (ORBs) that can communica te with each other via the General Inter-ORB Protocol (GIOP) and the Internet Inter-ORB (IIOP) Protocol (Orfali/Harke y, 1998). CORBA facilitates a middle-tier, object-to-object infrastructure that allows one to encapsulate data from m ultiple sources. The language and compiler used to create the server objects, the location of distributed CORBA objec ts and the operating system they execute on are completely transparent to clients. CORBA therefore provides an ideal mechanism for creating 3-tier (or n-tier) distributed applications beyond the simple interoperability (Orfali/Harke y, 1998). CORBA provides the ability to perform dynamic discovery of objects and services as CORBA objects are self-d escribing and introspective. CORBA's dynamic facilities, including Dynamic Invocation Interface (DII) and the Interf ace Repository, are able to create particularly flexible systems that allow run-time discovery and late-binding (Orfali/Harkey, 1998). This is especially useful in the Web environment where a user desires to discover new services and then makes use of them transparently. 3 Distributed e-map service model with CORBA The distributed e-map service model mainly includes a distributed map database, a database connection layer, an application service layer and a client layer. Figure 1 shows the whole structure of our distributed e-map service. A distributed map database is for storing and retrieving map data. By means of the ODBC (Open DataBase Connectivity) function of API (Application Programming Interface), CORBA objects can be connected to many commercial databases such as Oracle, Sybase, SQL (Structured Query Language) server, Access, and so on. The distributed e-map service is encapsulated into CORBA objects. They are map projection service, data format exchange service, map query service and application service (Figure 2). The CORBA objects are located and managed by a Naming Service or Interface Repository. The naming service locates data objects by name. Each data object, for example, a digital map or a remote sensing image, has a descriptive, recognizable name used for query. The naming service maps the name into the address and the reference of the object. Clients can access map server remotely and concurrently by IIOP protocol. The distributed e-map service is based on the technique of a distributed map database which is growing with the development of computer architecture and database technique. In distributed systems the client/server architecture is widely used (Berson, 1996). The technique of distributed relational database based on relational data model has been applied successfully in commercial data processing (Kenyatta, 1998). However, many large database management systems have difficulties in distributed processing of data with complicated spatial relationship, such as geographic information (Laurini, 1994). GIS based on Internet, known as WebGIS, presents potentials in on-line dissemination of map information, but it has some difficulties in the realization of distributed real-time processing, spatial analysis and map data update (Yuan, 1999). The cadastral data has both spatially distributed characteristics and large quantities of non-spatial attributes. Taking the cadastral data processing as an example, we put forward a method of realizing distributed processing with the aid of distributed relational database. The distributed processing of map data can be implemented by integrating maps including their attributes and the technique of distributed system based on a relational data model. The distributed map database includes geometries of map features, their attributes and corresponding map symbols. The geometry types of map features are defined according to the Open GeoData Interoperability Specification (OGIS) (Figure 2). For the retrieval of map data, special access modes which rely on spatial index are necessary. Hitherto, R-tree and Quad-tree are two main spatial indexing methods. R-trees are a direct extension of B-trees in k-dimensions. The data structure is a height-balanced tree which consists of intermediate and leaf nodes. Data objects are stored in leaf nodes and intermediate nodes are built by grouping rectangles at lower levels. Each intermediate node is associated with some rectangle, which completely encloses all rectangles corresponding to lower level nodes. Considering the performance of R-tree searching, the concepts of coverage and overlap are important. Coverage of a level of an R-tree is defined as the total area of all the rectangles associated with the nodes of that level. Overlap of a level of an R-tree is defined as the total area contained within two or more nodes. Obviously, an efficient R-tree searching demands that both overlap and coverage be minimized. A minimal coverage reduces the amount of dead space (i.e. empty space) covered by the nodes and a minimal overlap is even more crucial than the minimal coverage. Figure 1 Architecture of the distributed e-map service Figure 2 Geometry types according to OGIS 3.1 Map projection service According to the concept of spatial reference system of geodata model, attributes are tied with map features by coordinate. The spatial reference system is a function which associates locations in geospace with coordinate tuple in mathematical space, usually a real valued coordinate vector space. The projection transform service provides the operation of coordinate transformation and allows points to be transformed between any ellipsoid coordinate system and a plan coordinate system such as Gauss-Krueger and UTM. It provides a “domain of validity” for each coordinate system transformation, as most transformations are valid only over a portion of the Earth. Exceptions are raised when a transformation is invoked beyond its domain of validity. 3.2 Map data format exchange service Maps have been digitized since more than 30 years ago. Map data formats tend to be more complicated than other kinds of digital data formats due to the large scope of information they must be able to represent. Usually, the intrinsic complexity of the underlying digital format defined by a particular software application or acquisition method is incremented by the complexity of higher level descriptions, conventions and rules imposed by individuals, organizations or disciplines using the software. Often spatial data exist in a wide range of incompatible and vendor-proprietary formats, while geographic information systems (GIS) usually exist in organizations as isolated collections of data, software and user expertise. To make the data usable, the format transformation service ORB including interface for exchanging diverse map data is developed. With the help of this service, applications can access remote spatial databases and spatial processing resources in real-time. 3.3 Map query service In SQL 1999, the logical building blocks of a database are tables (relations). SQL 1999 allows to use a User-Defined Type (UDT) as the type of a table column (relation attribute). A UDT is basically an object class. In SQL/MM, a set of UDTs have been defined for structuring spatial features. A natural approach is to represent maps as tables. In the object-relational map database, a map relation can take the form R (F; A0; A1; … ; An) where R is the name of the map, F is an attribute whose type is a spatial UDT, A0, A1…. An are attributes, with A0 as the column for identifying numbers. A relation tuple represents the position of a map feature. Some main map query functions are listed in Table 1. Table 1 Map query method for distributed e-map service Map buffering is frequently used in map spatial analysis. Figure 3 shows a map buffering example in our system. Since query in a distributed e-map service involves a large number of spatial operations, it is more complicated than query in a normal distributed related database. For this reason, data distribution and transformation costs must be considered when remote data are queried. 3.4 Application service Application object is the kernel of the distributed e-map service. The principal analytical functions that are implemented with the help of application objects can be divided into two groups. One is the general application group including map data visualization and map annotation and symbolization, the other contains domain-dependent functions. For example, the environment administration needs different functions from those that are useful for land use. Figure 3 Line buffer example In our system, all sites have identical structures in the sense that each has a query server and an ORB with several service objects that provide common services including naming services, persistence services, query services and so on. As users may request data stored at remote sites, the query is distributed to multiple sites to execute. The query service is also responsible for initiating execution of the query. The ORB provides mechanisms for inter- and intra-site communications between objects. The naming service is used to locate any named objects. The persistence service objects provide an object-oriented interface for the data persistently stored in the local service. 3.5 Integration of GML (Geographic Makeup Language) and CORBA The emerging set of XML Standards is gaining widespread support from enterprises in content management, delivery and presentation at the web-based front end of today ' s Enterprise Systems. As map data will be encoded in an GML form and sent across the internet, there is a need for native processing of GML data under CORBA. Integrating CORBA and GML allows: (1) GML data received from web-based systems to be efficiently processed by CORBA systems that provide data access and query services to the web; (2) GML data to be sent back to web systems; and (3) CORBA Objects to be accessed through XML-based Messaging protocols. The Integration of CORBA and GML constitutes the base of the overall solution to share the Enterprise Map service for today ' s emerging web-based GIS. In our system, the GML process is implemented by using a Java ORB client embedded in the Web Browser, with a Java ORB server processing the received document and generating an GML-encoded receipt which then returns to the ORB client. Both the sent and received documents are serialized into text before they are sent or received. 4 Load balance and security Object migration is the process of terminating an object implementation on one host, and then starting it on another host. Object migration can be used to provide load balancing by moving objects from overloaded hosts to hosts that have more resources or processing power (there is no load balancing between servers registered with different ORB servers). Object migration can also be used to keep objects available when a host has to be shut down for hardware or software maintenance. The migration of objects that do not maintain the state is transparent to the client program. If a client is connected to an object implementation that has migrated, the ORB service will detect the loss of the connection and transparently reconnect the client to the new object on the new host. When a distributed e-map service based on CORBA is deployed over the Internet or Intranet, many security restrictions can apply to the system, including the following: (1) Java sandbox security prevents unsigned Java applets from communicating with servers other than the ones running on the host machine from which the applets were downloaded; (2) server-side firewalls can prevent the client from accessing certain hosts; and (3) client-side firewalls can prevent incoming connections or prohibit protocols other than HTTP. When certain restrictions prevent the clients from connecting directly to the server, the client can choose to connect to the gateway if the server object reference has the necessary information. The clients can send messages to the gateway and the gateway will then forward the messages to the server. When certain restrictions prevent the server from connecting back to the client to do callbacks, the server can choose to connect to the gateway if the callback object reference has the necessary information. The server can send callback messages to the gateway and the gateway will forward the messages to the client. 5 Conclusion A distributed e-map service is quite different from a stand-alone GIS. For the sake of interoperability, the new map service has to conform the specification of OpenGIS, which means that the spatial reference system and spatial data interchange are necessary. Spatial query and map data retrieve are essential for many space-related domain applications. While GML is a promising method for spatial data storage, the integration of CORBA and GML allows users to enjoy the distributed e-map service.

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关键词： distributed e-map service; CORBA; ORB; map data