DESIGN AND IMPLEMENTATION OF WSRF-BASED GIS SERVICE IN SPATIAL DATA GRID

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The integration of services in heterogeneous, distributed Grid environment is dynamic and diverse since the disparate resources within an enterprise or from external resource sharing and service provider relationship. This integration can be technically challenging because of the need to achieve various qualities of service when running on top of different native platforms [1]. So, in a Grid environment, implementations of GIS (Geographic Information System) should not only concern their internal spatial characteristics, but also deal with the Grid resources properties, such as the workload, network capabilities, memory, and job queue, etc. Because the GIS services with requirements of grid resources have dramatic effects on the performance of a grid environment and on the other hand the Grid fulfills the requirements of GIS application with the available resources.

Nowadays, the large-scale Grid applications to integrate resources distributed geographically are promoted in many countries. For example, TeraGrid in the United States integrates resources include more than 100 teraflops of computing capability over 100 high-performance networks [2]. Other similar applications with widely distributed general-purpose software are used only in specific fields, but seldom referred in GIS realm. Though some workgroups made attempts of building the architecture for Grid GIS, for example, the reference [3] proposed that grid computing technologies should serve as the network infrastructure for geo-science applications, they did not develop usable applications, and most researches only utilize the functions of the modules in the Grid rather than combine GIS and Grid environment.

As to GIS applications, the developers and users often require extensive collections of spatial data which are placed randomly and redundantly in different formats or on different platforms, which means that there are different approaches to access data of a particular area. Moreover, in a Spatial Data Grid environment, the GIS services, such as analytic geometry service, are usually dispersed to different Grid nodes and sometimes need to be combined for a complex analysis. So, Grid GIS applications include collaborative visualization of large spatial datasets, distributed computing for computationally demanding the combined analyses, and coupling of GIS platforms with remote computers and archives.

As an example, consider a distributed GIS Spatial Overlay Analysis facility that calculates the distributed and redundant spatial dataset of the Yellow River among two peers, A, B. Unfortunately the peer A we request does not support the analysis function but can provide the result of overlay operation, while the platform of peer B possess a robust facility the peer A needs. So, a reference implementation should be created and hosted in a service execution environment for storing parts of the spatial dataset, retrieving the dataset to form a completed one, computing the data, and analyzing the result of the overlaying on demand. On the other hand, in this process there are much more details need to be considered, such as how to search and locate the most appropriate resources in a dynamic GIS application, how to find other suitable services and delegate the users’ request to them, how to handle the fault tolerance and load balancing of the Grid environment. Consequently, specifying the combination of the spatial dataset and/or the GIS services, the real-time state of involved services, and guaranteeing the scheduling of the services required according to Quality of the service (QoS) properties which are based on the geographic distribution of dataset can help make GIS applications more accurately and efficiently.

Due to the problems discussed above, it is quite necessary to build the architecture for applying the contracts and standards in a Spatial Data Grid based on GIS characteristics. Because, the Grid defines standard mechanisms for creating, naming, and discovering transient Grid service instances; provides location transparency and multiple protocol bindings for service instances; and supports integration with underlying native platform facilities [1], and the implementations of GIS often require the aid of the grid environment, such as the demand of reserved resources, combination of varieties of data formats or service implementations, and independent control and monitoring. This paper proposes a complete architecture for implementing WSRF (Web Service Resource Framework) -based GIS services with both Grid key techniques and software tools. That is to say, our architecture supports local and remote transparency with respect to service location and invocation. It also provides for multiple protocol bindings to facilitate localized optimization of services invocation when the service is
hosted locally with the service requestor, as well as to enable protocol negotiation for network flows. Finally, the GIS services are implemented based on WSRF which provides the ability to model stateful resources, including the spatial data set and/or the Grid properties and the implementation of a particular Grid service may map to native, non-distributed, platform functions and capabilities.

As regard WSRF, it defines a set of conventions and extensions for managing the state of applications which can reliably share dynamical spatial geography data [4], as well as could separate the static binding between services and resources when published and to realize the dynamic binding at runtime, resulting in the improvement of the service virtualization, together with better resource sharing and service performance. As a result, the Grid applications have the possibility of combining the spatial data or the WSRF-based GIS services to perform the combination of spatial analysis or calculation in distributed systems or on various platforms. In spite of the diversity of data format, the decentralization and distribution of software, hardware, and spatial-related resources make it essential that we need to achieve desired QoS, whether measured in terms of common security semantics, distributed workflow and resource management performance, coordinated fail-over, or other metrics such as on resources assembled dynamically from different systems, service provider systems, etc. Therefore, a kind of service should be used to possess the mechanism to build scheduling process in the implementation which hides the complexity of the scheduling process from users and conducts a suitable algorithm which is based on an adaptive QoS scheduling guidance to select the suitable WSRF-based services and best resources deployed over multiple sites in a dynamic Virtual Organization (VO) according to the user-request QoS properties and the resource requirement of specific service providers. Based on the result, dynamic binding to the best-fitted resources will be established, making the service available and transparent to clients.

For this purpose of GIS applications, we brought forward a solution in the architecture which consists of three types of WSRF services: spatial analysis service, computing service, the Qos-based scheduling service.

To construct a spatial data grid environment, using some mature existing software tools is a practical way. With the aid of the Globus Toolkit [5], a community-based, open-architecture, open source set of services and software libraries that support Grids and Grid applications, we can implement grid-based applications and utilize the available GIS services for the integration. Therefore, we build a prototype system with the Version 4 of the Globus Toolkit (GT4). Especially, GT4 includes a complete implementation of the WSRF specification, whose stability and related technologies produce new demands for WSRF-based services scheduling.

Eventually, Our WSRF-based GIS service was implemented in a real Grid system for spatial data browsing, retrieving and operations on spatial data. The efficiency of the system demonstrates our approach satisfies the needs of spatial Grid environment and leads to better spatial resource sharing and significant service performance.

REFERENCES

[1] Ian Foster, Carl Kesselman, Jeffrey M. Nick, Steven Tuecke, “The Physiology of the Grid”,


