Algorithm analysis for the pipeline computing in Grid GIS

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Abstract。Grid GIS is a new technology which integrates the Grid with GIS. The analysis and application of geospatial information based on WebGIS now has new contents and application approaches based on Grid GIS, so the assignment and realization of computation tasks are more complex. The algorithm Com-Pool which is applied in Grid GIS can realize the task scheduling for its simple and practical characters, but it also has restriction on resource utilization. The task analysis and scheduling for geospatial information can be realized by using the Analyse–X algorithm based on stream computing effectively.

Key words：Grid GIS，computing pool，pipeline computing，task assignment

Introduction

It is significant to integrate Grid technique with GIS, and those are correlated and belong to two different technical fields. Grid GIS is to integrate Grid with GIS to fulfill GIS' computing task based on WebGIS. And the assignment of task is to decompose a series of data to get several organic data sets and to assign the task to a computing resource, or to decompose the task to some current computing tasks, any one of which is responsible for a special segment, to finish all tasks. Therefore, it is worth studying how many tasks Grid GIS includes, how to assign a task to a computing unit and decompose the task during the current assignment, which system should be assigned and how much processing resource should be shared.

1 GridGIS

1.1 Grid technique and GIS one

Grid is an integrated conditions for computation and resources or a Com-Pool by a general sense in reference[1], which absorbs all computation resources and turns them into an convenient, reliable, standard, efficient computation capability. However, by a narrow sense, Grid is often called Computation Grid and chiefly used to resolve some problems for the scientific computation. That is, Grid can cooperate with some distributed computers to deal with some complex problems about scientific or engineering computation and the Grid resources mainly refer to the computer ones. And Grid can be classified as computing grid, data grid, service grid[3] with different functions and algorithms, which processes the dense data tasks, scientific computing problems, geographic environmental problems respectively. The keys of the grid technology include the grid node, broadband network system, resources management and tasks assignment tools, monitoring tools, visual tools for the users and so on, which can be broadly applied to all social working fields.

Now, a plenty of international research projects for Grid springs up such as American Globus, Legion, Condor and IPG, European GERN DataGrid, UNICORE, MOL, Australian Nimrod/G, EcoGrid, Japanese Ninf, Bricks. The integrated GIS are described in details and the top integrated system from the elementary soft program is considered be a great progress in reference [2]. And all geographic elements with their properties in the spatial geographic environment are more precisely defined, the organization of geographic information and the application of data analyses, based on database management model, are schemed exhaustively, too. In additional, the code descriptions of geographic characteristic elements, the management based on metadata, model establishment, analyses and application belong to their studying objects.

1.2 Grid GIS

Grid GIS, which is GIS research and realization under the grid computing conditions, is a new technology field and a contemporary hot research issue. And Grid GIS is a spatial information infrastructure which compiles and shares the spatial information resources, organizes and processes the integration data, services according to the requirements. Therefore, the construction and application of Grid GIS will supply a powerful platform for spatial data management and information process, support the users to access, share, visit, analyze and process the spatial information. In additional, Grid GIS adopts the W3C criterion, truly achieves the platform freeness, owns friendly interface, which can use the HTTP identification model and supports the SSL.

Now, the research of Grid GIS primarily focus on the architectural structure, the standardization of geographic information, the operational semantics of GIS, the service frame of grid map, the middleware technique of Grid GIS, real realization process according to real task by different algorithm.

2 Task definition of Grid GIS

2.1 Task computation of WebGIS

Comparing with Grid GIS, WebGIS has the following problems such as interchanging heterogeneous spatial data, operating among different platforms, programming, debugging and maintaining itself. And the technical frame of the WebGIS realization is to let users apply and obtain the data with their simple analyses and application from web page by the internet conditions based on the database management system. Actually, WebGIS is an internet GIS which adopts the Internet/Intranet technical standard and communication protocol. From any node of the Internet/Intranet, any user can browses the special information and attribute, inquires and analyzes spatial information (reference [5]). The task primarily depends on the asking and response of HTTP for the operations of server and database is invisible to users, which is divided into three levels as Fig.1 (reference [4]). Therefore, the clients communicate with related servers through the inquiry and response of HTTP and the apply server with the database server through the SQL language and result sets.

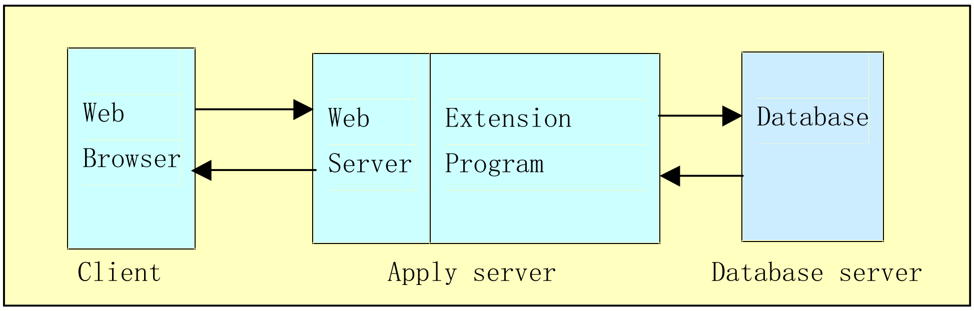

Fig.1 WebGIS structure model

The method of implementation mainly includes CGI, Plug-in, API, Java, ActiveX and so forth (reference [4]).

2.2 Task computation of Grid GIS

The comprehensive analysis under the grid conditions not only deals with the spatial data ordinarily but also analyses the many-dimensions data (reference [10]). Over vast domain, the task T of all spatial analysis is primarily as follow:

（1）Task T_1 of distribution analysis

（2）Task T_2 of buffer analysis

（3）Task T_3 of net analysis

（4）Task T_4 of joint analysis

（5）Task T_5 of overlapping analysis

Definition of the task computation for the primarily spatial data in Grid GIS:

Assuming that the amount of parallel systems in Grid is n , the grid computing resources are $G_R=\{R_1, R_2, \ldots, R_n\}$; the amount of tasks in the serial composition pipeline is k, which are able to be expressed as $T=\{T_1, T_2, \ldots, T_k\}$, for example, the above-mentioned task is composed of T_1, T_2, T_3, T_4, T_5; We define the task assignment A by

$$A: T_i \rightarrow R_j, \quad T_i \in T, \quad R_j \in G_R \cup \{R_{none}\}$$

Here the parameter R_{none} denotes that no resources have been assigned to T. And the algorithm based on task assignment is to assign the task to the corresponding computing unit, get right processor and implement the task computation.

3 Task algorithm of Grid GIS

3.1 Design of Com-Pool algorithm

The Com-Pool algorithm is to connect some separated high capability computers together by high speed internet and join them by professional middleware soft organically, by which the web interface can receive the computing request from any place and assign it to an appropriate node to run. And the Com-Pool algorithm not only improves the service quality and efficiency of the resources but also averts the inefficiency and complication from the divided application program in different place, which is able to put into practice under today's conditions.

The fundamental idea of the Com-Pool algorithm is to try its best to assign a computing unit for a task and not to decompose the task, which simplifies the complication of the internet computation. However, the rightful decomposition of task is still at the phase of study and experiment, and not in practice in the world nowadays. For instance, the SF Express of military imitation in vast region or the Cactus of simulation of the black hole running into each other demands very high speed and vast capacity computing resources. Why? Because it is often difficult to decompose a task into some subtasks which never or seldom communicate one another, and the communication bandwidth or delay among the distant supercomputers from the distant transition or the TCP/IP protocol are not better than the supercomputer's bus or the SAN of system area internet by faster internet speed if the supercomputers communicate each other frequently. Therefore, the above-mentioned simulation proposes an extreme high requirement for the integration or schedule of the system resources. That is, it is not ideal for the contemporary internet technique to implement the computing tasks distributed in different node, and the Com-Pool algorithm is an alternative transitional method to implement the required computing tasks although the dispatch and application of the method is not very efficient.

The procedure of the Com-Pool algorithm is

(1) The computing resources are shared and N high capability computers are joined in the system together from native or different places.

(2) A task is only arranged to run by a suitable machine among the system and the task is not required to be decomposed N subtask, which avoids the complication of decomposing the task or the ability descent from the frequent communication between different subtask modules. However, the method of P2P is better than Grid if the communication is not required among the subtask modules.

(3) It is very easy for the users to visit the high level computers because of referring to a task or looking over the result by web. And the following algorithm from reference [6] has some pragmatic qualities.

Assume that there are N idle supercomputers of the Com-Pool named S with computing abilities P1,P2,…PN, respectively, at time label t. The Com-Pool will assign number i supercomputer but not too several for a task A with computing capabilities MA according to some principles if a user refers to the task A, which make

$$Pi*T \geqslant MA,$$

where T is the acceptable time by the user.

In view of the above-mentioned task series $T_1 \rightarrow T_5$, assuming that: (1) Every computer owns equal computing ability, that means, P1=P2= =PN; (2) The arrival patterns obey a Poisson process, the service times are independent random variables with the same exponential distribution, the mean interval of the task arrival is $1/\lambda_1$ and the mean service time is $1/\mu_1$, we can get that the task series will become a normal M/M/5 queue dispatching system, the speed of response for the users will be prompter and the quality of service better if the amount of the computers in the Com-Pool is larger.

3.2 Pipelined computing from task dispatch

The fundamental thinking of Com-Pool algorithm is to share the computing resources without task decomposition and the dispatching unit is a task. The algorithm implementation is simple but inefficient and can not take advantage of the grid computing resources completely. However, the pipelined computing algorithm from the task dispatch can decompose a task into several subtasks so that the cooperation and dispatch is consistent.

An task assignment algorithm of X-max-min in the reference[7] is: (1) A task assignment includes which parallel system is included and how many buffers should be allocated; (2) The task should be parallelizable and the computing cost of the parallel system is not an invariable but the function of the processor amount; (3) Communication cost is part of the task response time which depends on the assigning result of other tasks; (4) The response time of a task depends on other tasks' circumstance and it can not be determined until the task assignment is finished.

From the above-mentioned technical idea, the pipelined assignment algorithm of Analyse-X can be established under the grid conditions :

```
(1) initialize (A); count=k;
(2) while (count<>0)
      { f_i (A ⊕ A(T_i))=max-min({f_j (A)|A(T_j)=R_none, ∀ T_j ∈ T});
        A=A ⊕ A(T_i);
        update({T_j (A)|A(T_j)= R_none, ∀ T_j ∈ T})
        count=count-1;
      }
```

where A、k、T_i、T_j are defined as segment 2.2。And f is constructed by the following rule:

(1) $f_i^{exec}(A)+ f_{i\rightarrow 2}^{comm}(A)$ i=1

(2) $f_{i-1\rightarrow i}^{comm}(A)+ f_i^{exec}(A)+f_{i\rightarrow i+1}^{comm}$ $i\in(1,k)$

(3) $f_{k-1\rightarrow k}^{comm}(A)+f_k^{exec}(A)$ i=k,

where $f_i^{exec}(A)$ is the computing cost of T_i, $f_{i\rightarrow i+1}^{comm}(A)$ denotes the communicating cost from T_i to T_{i+1}, $f_i(A)$ is the response time of T_i.

Now Xi'an Jiaotong University has established a experimental grid condition which is composed of three kinds of computer group. And the Rs6000 computer group has four POWER3 nodes, SUN group owned four SPARC nodes and the Intel group only two P4 nodes. Let R_1, R_2, R_3, denote RS6000, SUN, Intel, respectively, and the bandwidths of every connection are showed as Tab. 1.

Tab.1 The bandwidth of every internet joints

Bandwidth / $Mb \cdot s^{-1}$					
$L(R_1\text{-}R_1)$	$L(R_2\text{-}R_2)$	$L(R_3\text{-}R_3)$	$L(R_1\text{-}R_2)$	$L(R_2\text{-}R_3)$	$L(R_1\text{-}R_3)$
170.0	8.8	90.7	7.2	7.3	4.4

The experiment shows the multitasks assignment for spatial information analyses can be realized, when a computing node only participates a subtask computation in a assembly tasks without repetition. And the computing costs the tasks is correlated with their communicating cost and correlation difference depends on the different task.

4 Conclusion

(1) The concept of Grid GIS is introduced, which is a perfect combination of the internet technique with GIS.

(2) The task computation of Grid GIS from WebGIS is analyzed and the content of spatial geographic information analysis with application task computation under Grid GIS conditions is proposed.

(3) The algorithm of task computation under Grid GIS is analyzed and two different realization methods are importantly discussed. And the different character of the two methods to different tasks is presented.

(4) The task assignment algorithms of the grid computation are not perfectly resolved nowadays. The discussion of the paper is under the assumption that the grid resources are the general designation of parallel system, the obtaining the identification of parallel system is part of assigning an assembly task. and how many processing resources should be assigned for the multitask process. Therefore, the algorithm needs refining further.

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Biography:

ZhangDong birthday of Jan. 1967, vice-researcher, In 1988, I graduated from Xi'an Jiaotong University and got my bachelor of computer science and engineer. Then I got my master's degree for map cartography and GIS engineer in 1999. Now I study in Xi'an Jiaotong University for doctor degree of computer system. I have finished about ten scientific research tasks and some of them have gotten award and been used in cartographic researches and applications. The main research tasks include: (1) Map Electronic Publishing System; (2) Digital Map System for Navigation and Position; (3) Data Distribute and Metadata Technology. I have finished 20 papers in journal and conference. My main interesting fields are network application, electronic publishing system, RIP series processors, network publishing and GIS applications.