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The Data Transmission Network and Computing Environment of Spatial Information Grid

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Abstract

Studied the foundation of SIG (Spatial Information Grid) computing environment, this article first designed a data transmission network which is based on SIG. And then, it described the topological structure and communication link of data transmission network. Next, it discussed the status quo of spatial computing resources and the resources deployment of spatial information grid which made a support to the finding and calling of resources. Finally, it studied the resources finding and sharing of spatial information grid in VO (Visual Organization) and the VO form in SIG. It then proposed the resources finding mechanism and the sharing process.

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Keywords: spatial information grid, data transmission network, computing environment, resources deployment;

Introduction

With the spread of internet, quick development of web technology and the extensive application of remote sensing and other earth spatial data acquisition technologies, the magnanimity, isomerism and distribution feather of spatial data is becoming increasingly evident which made the contradiction sharper between the distributed storage of spatial information and centralized processing. Traditional data integration cannot meet the application needs. SIG (Spatial Information Grid) is a kind of spatial information services infrastructure which tries to collect and sharing geographically distributed massive spatial information and let them integrated organizing and cooperative processing according to needs.

SIG is a distributed network environment which can connect and combine spatial data resources, computing resources, storage resources, processing tools and software and user to complete spatial information applications and services. In this environment, the user can call a variety of data and process them. The system will also call for resources, such as geographically distributed data, computing, networking and software, to correspond to more than one user's request.

SIG is at the core of spatial information, which will provide technical support for spatial information user who wants to share, access, analyze and process spatial data. SIG also afford a powerful, fast and

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flexible capabilities to organize, control and process spatial information. With the growing processing demand of spatial data, the demand for spatial calculating resource will also be increasing. As constrained by processing capacity and low efficiency, the current processing capacity is far from meeting the needs of SIG. so how to build an efficient, widely distributed and dynamic computing environment to provide large-scale computing centres, E-mail services, network services, shared databases, collaboration messaging is the main research of SIG.

1. Data Transmission Network of SIG

1.1. Network Topology and Link Analysis

SIG is a broadband IP network which connects various spacecrafts, ground support systems and application systems. SIG can achieve a seamless, organic connection for space power. Comparing with the two-dimensional topology of ground, the topology of SIG is a complex, wide-area, three-dimensional, dynamic structure. The topology and link structure of SIG is the basement of network protocols and applications which directly determines SIG communication performance.

- Network topology

Communication networks of SIG including space and ground networks. Space network includes satellite network consisted with GEO, MEO and LEO; ground network consists with ground support systems and application systems.

- Link analysis

The communication of ground network can use wired IP network. For it is relatively mature, this paper does not talk about it. According to different link direction between satellites, the link has three types: ISLs（Inter-Satellite Links）, IOLs（Inter-Orbital Links） and UDLs（User Data Links）. SIG builds a three-dimensional, spatial communication network through the link among layers and inter-layer of satellite. All applications can access and exit SIG through user's links.

As a wireless communication link, the ISLs of SIG can be divided into microwave, millimetre-wave and laser link according to different communication frequency. As SIG high-speed application node of communication link, microwave link can be used to communicate among high-speed satellites and between satellites and targets on ground, sea and air. Laser link can conduct main link for stable position communication in SIG. Millimetre-wave link, which is between microwave and laser, can be used as main link in SIG. For the features of good spread in air and unconstraint by power density, millimetre-wave is paying more attention. Their equipments can be large capacity and small size.

1.2. The Analysis of SIG Data Communication Networking Protocol

The ground applications' network can use the traditional internet protocols (such as TCP / IP, UDP, FTP) as main network protocol which can afford the ground end to end capabilities, high-level protocol function and standardization capabilities. But space environment is different from ground, when we design protocols for data network and communication, the problems of transmission delay, signal level feebleness, interchannel noise, movement of Doppler frequency and frequently interruption of air-ground communication signals should be take into account. Now the international standards of spatial data transmission were SCPS（Space Communication Protocol Specialization）made by CCSDS (Consultative Committee for Space Data Systems). The research of SCPS was in charge of DOD (Department of Defense of the United States) and NASA (National Aeronautics and Space Administration) and adopted as international standards by ISO. It can be SID data transmission standards.

SCPS is designed to: support efficient, reliable spatial data transmission; adapt to the requirements that the developing multi-node network task call for routing configuration function; provide a variety of routing patterns to increase flooding addressing mode; enhance information grid compatibility and interoperability;

increase collaboration and interoperability between tasks, agencies and countries; significantly reduce operating costs.

2. SIG Computing Resource Deployment

Data transmission network build a broadband, efficient network platform for SIG computing environment. In order to achieving virtualization of spatial computing resource, computing resources requires to make planning and distribution which will take a support to the discovery and scheduling of computing resources.

In SIG, computing resources is distributed in the information processing, reception centres and base stations. The processing capacity on satellite is weak, and the sharing and collaboration of processing capacity is hard to achieve in a short time. So this paper just focuses on the sharing of ground computing resources. In ground computing resources, the centres and the base station computing resources are relatively independent which are viewed as autonomous systems (administrative domain). For the affiliation between the centres and the base stations is a superior-inferior relationship, so the distribution of ground computing resources likes internet which can be organized like cell hierarchy and built a two level management environment for computing resources[1].

The resources deployment which based on the two level management environment can divide spatial computing environment into several resources management domains which unites are the centres and the base stations. Every management domain will connect with one or several management domains to form a distributed resource structure. In order to meet the standard and adaptable requirements, management domains are further divides into two parts: Internal Domain and External Domain. Every management domains are connected through the External Domain and access each other the services in domains through standard mode. The internal domains are not directly accessible.SIG resources deployment shown in Figure 1.

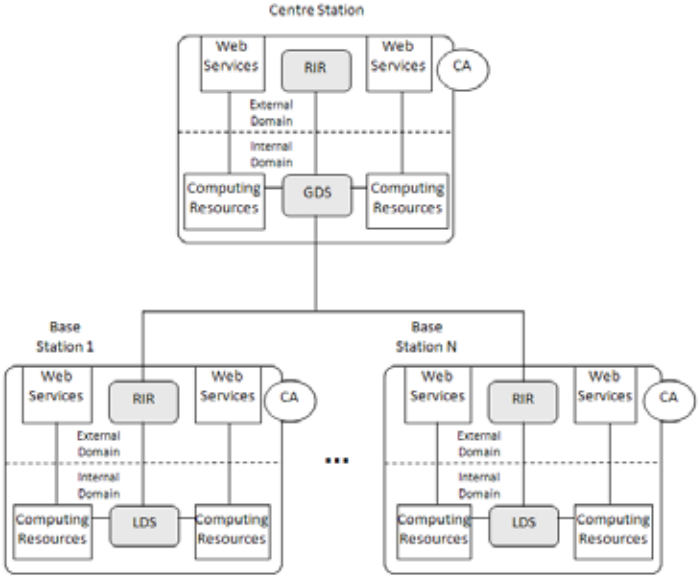

Figure1. SIG resources deployment model

In figure 1, the main entities within each management domain include: LDS（Local Directory Server）, GDS（Global Directory Server）, RIR（Resource Information Router）, Web services and computing resources. In the level of base station management domains, resources are provided through web services. And the information about description of web service, resources attributes and constrained

strategies are issued to LDS. The external domain of each management domain is set up a RIR which can access the LDS in same domain. In the centre management domain, there is a whole center GDS. Through GDS the catalogue resources services is provide, RIR is set and other base station LDS can be accessed.

The organizational structure in domains is set to adopt resource information. Every external domain also is set a CA (Client Agent) to simplify the client work and support client calculation. The only thing clients need to do is to send a demand to CA and explain the type and quality of service. CA will send those information to other management domains through RIR to get the matching resources information and find the most appropriate service. And then, clients can ask for this service through CA.

3. Resources Finding and Sharing of SIG Computing

As a large-scale, wide-area distributed computing environment, the SIG computing environment needs a resource finding and control mechanism which is independent on central control, distributed, scalable, adaptable to dynamic changes of resources and good for positioning.

3.1. The Relationship of Resources

There are some principles in SIG which formulate what kind of resources can be shared, who can share those resources and what is the condition of sharing. Those individuals and institutions defined by those principles are what we called VO (Virtual Organization).VO based on the real organization (the resources of centrals and base stations) includes the computing resources of real organization, GDS/LDS, RIR and CA. through the web linked and wide-area distributed spatial information resources, VO can organize the spatial information resources which belonged to different autonomous systems and management domains to make large computing and problem solving.

3.2. Finding Mechanism

- Request for resources

Principles for SIG resources finding [2]: first, try to use the local resources and reduce unnecessary communication overhead among remote resources; second, if local resources cannot meet the requirements, try to call for the local VO resources and reduce the cross among VO which is conductive to integrated processing tasks and enhance efficiency of SIG resources. Steps of SIG resources finding include:

①Clients send service requests to LDS/GDS. If there is local resources that meet the requirements, LDS/GDS will send back the result to clients. Otherwise, step to ②;

②LDS/GDS call for resources from RIR;

③RIR will adopt appropriate algorithm to spread the information according to the scale of the node in local VO. If it is failed to find the resources, RIR will use appropriate strategy to send the resources requests to other RIR. Then, step to ④;

④RIR received the service requests will adopt appropriate strategy to spread the service requests to other VO's node according to the scale of the node in local VO.

⑤VO's node will check whether the requests are timeout. If not, LDS/GDS will search services in local VO. When find the resources meet the requests, VO's node will respond to the requests.

- Resources requests matching

Resources providers and users will express their respectively demands through RID (Recourse Information Descriptor) and CRD (Client Request Descriptor). When RIR received the resources requests, it will make a match between RID and CRD and send back the matched demands.

RIR select XQuery based on XML as requests matching mechanism of SIG. XQuery is a kind of normative XML query language developed by W3C which is simple, easy to implement, accurately defined and easy to understand query language. The input and output of query are XML document elements which is coincide with XPath 2.0 standard and can be dynamically extracted from external data

sources [3]. Each query in XQuery is expressed as a expression which is executed on a tree data structure and any query that can use SQL to express can expressed by XQuery.

RIR uses XQuery as a matching mechanism, and CA will receive the XQuery query generated from requests. When RIR received the query, RIR will make a match and then put the matched resource information as input data of resource scheduling process.

- Response to resources request

At present, six kinds of response models exist in peer-to-peer network: indirect response, directly response without invitation, directly response with invitation, indirect meta-data response, directly response without meta-data invitation and directly response with meta-data invitation.

In SIG, CA is introduced into the resource management system that simplified the clients. Compared with download files, the data amount of request and response of resource finding are usually small. So response protocols of resource request can use indirect response and directly response without invitation other than meta-data response and invited response. When request was sent out, CA can specify the model of response protocols. If the select strategy for apropos result is very simple, such as optimal cost performance or minimum cost, it should be appropriate to use indirect response model to send back the first or several forward results.RIR can use simply choose strategy to match the response time received from different RIR and select the most appropriate result which will save network resources; if the strategy is complicated or needs clients participate, directly response without invitation should be selected as response protocols of resource request, and it should be more appropriate to let client choose from all the matching results.

3.3. Sharing Process Analysis

Sharing process of SIG include finding of local resources, discovery of VO resources, discovery among different VO resources and the selection and scheduling to discovered resources. The procedure of using a single task as an example to analyze the process of resources finding and scheduling is as followed:

- Ask for resources: according to task demands, clients submit resources requests from local resource scheduler.
- Find resources list: local resources scheduler will try to find appropriated resources according to the resources requests in base station and return the results;
- Send resources requests to close resources holder in VO: the VO resources scheduler will check useful resources from all resources holders in VO.
- Resources provider send information which meet the conditions back to resources scheduler;
- VO resources scheduler send information which meet the conditions back to resources request scheduler;
- If there does not have suitable resources, the resources request scheduler will send request information to wide-area resources schedule network which will send resources request information to other VO.
- Other VO resources provider will match the request information with their resources. If it matched, the other VO resources provider will send the matched information back to wide-area resources scheduler;
- Wide-area resources scheduler will send the matched information back to resources request scheduler;
- Resources request scheduler will select resources according to local strategy;
- Resources request scheduler will offer useful resources information to clients;
- Clients share tasks and data;
- Resources request scheduler allots tasks and data to the selected computing resources;
- All computing resources send back the results to resources request scheduler;
- Resources request scheduler combines all the results according to tasks, return it to clients and end the resources schedule;
- Renew the resources information of all computing resources that performed the tasks.

4. Summary

Computing environment based on grid technology connects all the geographically wide-spread, heterogeneous and dynamic resources to achieve high degree sharing and integration of resources through internet or private network; through resources virtualization, SIG computing environment realize the sharing and collaboration of resources with VO's model to provide clients with high-performance computing, management and service. Computing environment based on grid technology is the most important solution to solve the low efficient utilization of spatial computing resources.

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