RESEARCH ON THE GRID SERVICES COMPOSITON MODEL BASED ON THE 3D GEOSPATIAL INFORMATION APPLICATION

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ABSTRACT:

In 3D geospatial information grid, single service can not meet the complex application demands of geospatial information. It needs different granularity services composition and coordination mechanism. This paper put emphasis upon a kind of grid services composition model of 3D geospatial information application based on Petri Net theory, which was able to complete complex 3D geospatial information application through grid services composition. Firstly, based on Petri Net theory, the formal definition and graphic description were proposed for grid services and their composition. The element mapping process was also illustrated. Then an algorithm was proposed to construct the Petri Net model for the grid services composition. Secondly, this paper gave an example of 3D geospatial analysis grid services composition, the reachability, safeness, boundedness and liveness of the model were validated. Finally, combined with the subject study, the prototype system GridVRMap of 3D geospatial information grid application was established, the feasibility of grid services composition model based on Petri Net was further verified.

1. INTRODUCTION

The technology of grid brings not only opportunities, but also challenges to geospatial information science. The traditional geospatial information system has a serious problem, which failed to solve the effective sharing and utilization of geospatial resources fully, while the grid emphasizes is fully sharing of resources and integrative management of resources sharing [Foster I, Kesselman C,Nick J,Tuecke S ., 2002, Foster I. And Kesselman C., 2004]. In order to fully share and utilize the information of grid, the fast searching service, services composition and others of grid should be touched upon.

Targeting at 3D geospatial information application, this paper presents to improve the environment of 3D geospatial share and application by grid technology. The services-based application mode provided 3D geospatial information application services and services composition for users transparently. There exits lots of grid services of all kinds in 3D geospatial information application grid environment, such as 3D visualization service, 3D spatial analysis service, etc. How to find grid service satisfying its requirement (service discovery) is very important research issue. In addition, the single service sometimes can't fulfill a complex geospatial grid application all by itself and needs different granularity services composition and coordination mechanism [Jin Baoxuan, Bian Fuling., 2006]. Therefore, this paper puts emphasis upon a kind of grid services composition model of 3D geospatial information application based on Petri Net theory, which is able to complete complex 3D geospatial information application through grid services composition. With these services composition, geospatial information share and interoperability can be implemented. It is also convenient for heterogeneous environment integration and application of heterogeneous system, and can serve for the construction of digital city better.

2. THE GRID SERVICES COMPOSITION MODEL BASED ON PETRI NET

First mentioned by a German, C. A. Petri, in 1960s, Petri Net was developed dramatically and has enjoyed a wide acceptance in many fields. Petri Net is a sound method of process modeling. A Petri Net is a two-way diagram of orientation connection, in which the nodes are symbols of Place and Transition [Milanovic N, Malek M., 2004]. Petri Net strictly based on mathematics offers a sort of operable semantics, qualitative and quantitative analysis, which can be used extensively in describing and researching the information system with concurrency, asynchrony, paralleling, nondeterminancy and randomness [Srini Narayanan, Sheila McIlraith., 2003].

2.1 The Definition of Grid Service Based on Petri Net

In order to modeling analyze grid service by Petri Net, the elements of Petri Net and those of grid service should be corresponded with each other to describe in form easily grid services composition by Petri Net. The definition of grid service based on Petri Net is mainly from the Petri Net format of grid service [R Hamadi, B Benatallah, 2003]. Followings are the details:

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Definition 1. Definition of grid service
A Grid Service S defines as five groups:
$S = (Sid, Sname, Sdesc, Surl, Soper)$, among which:

1. Sid: the only identification of grid service.
2. Sname: the name of grid service.
3. Sdesc: the description of grid service.
4. Surl: the transfer URL of grid service.
5. Soper: the operation assembly of grid service.

Definition 2. Definition of service net
A Service Net SN defines as five groups to model the dynamic action of service: $SN = (P, T, F, i, o)$, among which:

P: assembly of finite Place, stands for the status of grid service, P={p1,p2,p3,…,pn}.

T: assembly of finite Transition, stands for the operation of service and among services, T={t_1,t_2,t_3,…,t_n}.

F: $\subseteq (P \times T) \cup (T \times P)$, is assembly with Connection, to show the relationship between status of service and operation.

i: input Place, $i = \{x \in P \cup T \mid (x, i) \in W\} = \varnothing$.

o: output Place,
$o = \{x \in P \cup T \mid (o, x) \in W\} = \varnothing$.

Token i is regarded as the initial identification of service S. Execute service S, when there is a Token in Place i. Service is regarded as been stopped when there is a Token in Place o. Use the identified function to show the status of system, plus describe the process of evolution of status of system, so as to comprehensively model the static and dynamic character of grid service composition system. The description of the dynamic process of evolution of system and the rule of execution of Petri Net are corresponding:

1. $t \in T$ in identification M can be triggered when and only when for any $p \in P$, $M(p) \geq I(p,t)$.

2. If $t \in T$ can be triggered under Identification M, M^1 will be generated according to trigger rule, M(p)= M^1 (p)+F(p,t)-F(t,p). M^1 is regarded as reachable identification of M0 of M when and only when above running rule. There is a transferable sequence t1,t2,t3,…,tn to make model identification M_0 transform into M, and M_0 's reachable identification is named reachable assembly of Petri Net.

2.2 Algebra Description of Grid Service Composition

Components of grid services composition is composed of atomic service and control structure. Control structures are: ordering, choosing, cycling, paralleling, etc. This paper uses Petri Net to describe precisely the control flow. Based on Definition 1 and 2, grid services composition can be defined by the symbols of BNF Model [R Hamadi, B Benatallah, 2003, Zhang Peiyun, Huang Bo, Shun Yaming., 2007]. The grammar of operation mark of algebra is the following:

$S ::= Ns \mid S1 \odot S2 \mid S1 \oplus S2 \mid mS \mid S1 \parallel S2$

1. Ns stands for an atomic service or empty service (namely a service without executing any operation).

2. $S1 \odot S2$ stands for a service of composition is formed after executing S1 and S2 sequentially.

3. $S1 \oplus S2$ stands for a service of composition is formed after executing S1 or S2 (can not coinstantaneous or).

4. mS stands for a service of composition is the result of S executing m times cyclically.

5. $S1 \parallel S2$ stands for a service of composition is formed after S1 and S2 execute simultaneously, and there maybe correspondence between two services.

Composed service of grid can be gained by the algebra above.

Definition 3. Model of services composition is reasonable, which must meet the following basic demands:

1. Each model has an input Place i and an output Place o.

2. Each transferred Place is in the path from input Place i to output Place o.

3. Service composition can terminate finally in any situation. Except output Place, there is no Token existing in any other Place when terminated.

4. There is no extinct composition in model of composition. That is to say, every composition is executable.

According to the four demands above, we give the Fig. 's of the models of composition. When modeling by Petri Net, the operation of designate service is transfer, the status of service is Place, and the minimum composed unit of modeling method of grid service based on Petri Net is atomic service. Regard the operation of atomic service as event (Transition) and the operation execution of Service S1 and S2 changes the status of service (Place). A service may be in the following status anytime: status of un-instance, ready status, running status, suspend status and finished status. The service, which is in Ready, of the service composition in this paper is composed, while the service in finished is composed successfully.

1. the Petri Net Figure of the service of composition $S1 \odot S2$ is Figure. 1.

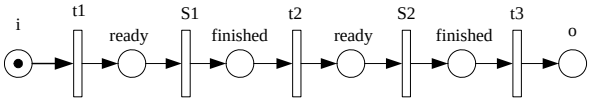

Figure 1. Services composition $S1 \odot S2$

2. the Petri Net Figure of the service of composition $S1 \oplus S2$ is Figure. 2.

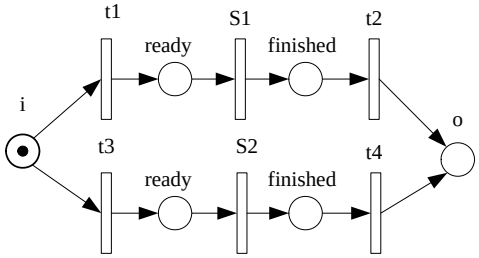

Figure. 2 Services composition $S1 \oplus S2$

3. the Petri Net Figure of the service of composition mS is Figure. 3

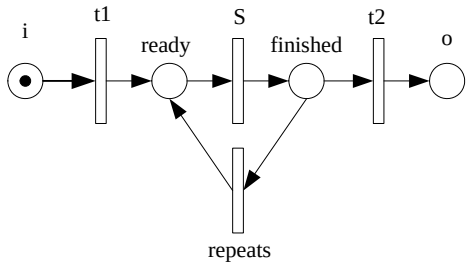

Figure. 3 Services composition mS

4. the Petri Net Figure of the service of composition $S1 \parallel S2$ is Figure. 4.

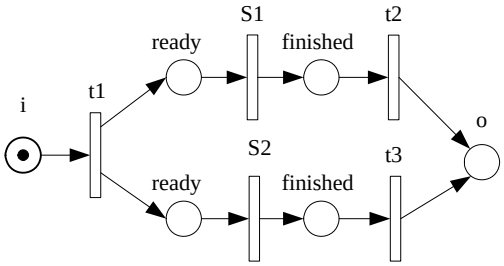

Figure. 4 Services composition $S1 \parallel S2$

2.3 the Description of Generation Algorithm of Petri Net

The descriptions of generation algorithm Arithmetic of Petri Net are followings:

step 1. Make sure the number of awaited composed grid, operations of each service and controlling flow.

step 2. Generate an initial status of operation, and plus a mark, as the initial branch Net.

step 3. for i=1 to m.

There are operation modules as the number of i in awaited composed services.

Choose an operation module according to controlling flow.

Assign a random time to each operation, and time of operation meet the demands of distribution of probability of distribution of index.

Link the operation to the existed branch grid.

step 4. End.

step 5. Establish corresponding position for each kind of service status.

step 6. Use the following methods to add service status to operation.

Choose a position of service status.

Assign the status to corresponding service operation according to controlling flow, in which link the input Transition of the status position and operation position through input Connection, and link the output Transition of status and operation position through output Connection.

Repeat step 6 until all operation has been assigned to service status according to controlling flow.

In the realization of process, the result of algorithm program is the generated model of Petri Net of service composition.

2.4 Verification for Grid Service Composition

Each branch service of composed service may be established and published by different supplier, while they must interact with each other as coupling relationship, thus service composition may generate unexpected effectiveness afterwards, which will affect using. In order to avoid this, the verification before publishing is necessary. This paper proposes verification of reachable tree method. The basic idea of this is to construct a tree in which regards the reachable identification as node, transferred trigger as Connection. Our algorithm is to realize the verification for flow model in the process of constructing the tree through verify the status of service composition and the number of its Place [Zhang Peiyun, Huang Bo, Shun Yaming., 2007].

It is important for the timely end of grid service composition to composed service. Through verifying the liveness and boundedness by Petri Net to decide whether service terminate regularly, to verify the correctness of grid service composition through inspecting whether it has entire reachability, integrity and proceeding[Jiang Changjun, 2003].

Definition 4. Reachability

If a transfer sequence will be triggered to generate identification M_r from initial identification M_0, it means M_r is reachable from M_0. All the assemblies of reachable identification from M_0 are named Assembly of Reachable Identification or Reachable Assembly, marked as R (M_0).

Definition 5. Boundedness

PN and its reachable assembly $R(M_0)$ are specified, for position $p \in P$, if $\forall m \in R(M_0): M(p) \le k$, it is said that p is bounded k, k is positive integer here, if all the position of Petri Net is bounded k, Petri Net is bounded k.

Definition 6. Liveness

For a Transition $t \in T$, if there is one Transition sequence under any identification $M \in R$, the trigger of this Transition sequence makes this Transition live. If all the Transitions of one Petri Net are live, the Petri Net is live.

Definition 7. Integrity

All the status of Petri Net is reachable.

Definition 8. Proceeding

Each trigger will make efforts to the end, and there is no closed-end loop in Reachable Tree.

The Petri Net with all the five characters cannot be a standstill. The status in execution and the awaited information is limited, in which deadlock cannot be ensued.

3. INSTANCE ANALYSIS FOR 3D GEOSPATIAL INFORMATION GRID SERVICES COMPOSITION APPLICATION BASED ON PETRI NET

Different sorts of grid services are involved in the 3D geospatial information grid, such as 3D data service, 3D modeling service (terrain modeling, building modeling, complex feature modeling etc.), 3D visualization services and 3D geospatial analysis services and so on. When carry out a complicated 3D application service, several grid services (branch services)

should be composed to finish a business process. Thus, correctness and effectiveness of serial composed services must be guaranteed at the phase of design. The followings are gotten down to the composition of 3D geospatial analysis service business process modeling and related services. An abstract expression of service composition is Figure. 5.

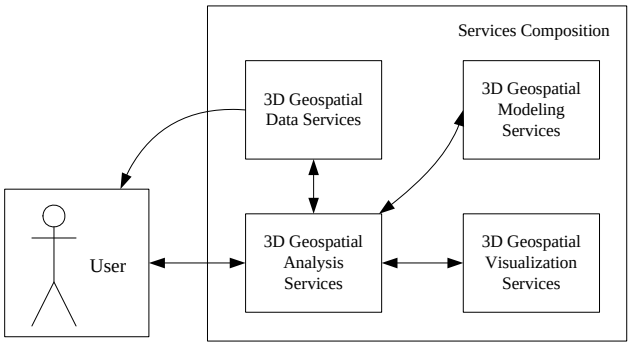

Figure. 5 Abstract expression of services composition

3D geospatial analysis services accept requests of geospatial analysis types. Invoke geospatial data services to gain 3D geospatial data within geospatial analysis data touched by users. If the geospatial data of analysis range exists, information for confirmation will be send to users, and then related 3D modeling services will be invoked for constructing 3D models of scene for users. When modeling was accomplished, 3D visualization services will be invoked to render the scene. At last complete the task of geospatial analysis, and then return the result to users. Concrete model of service composition is like Figure. 6.

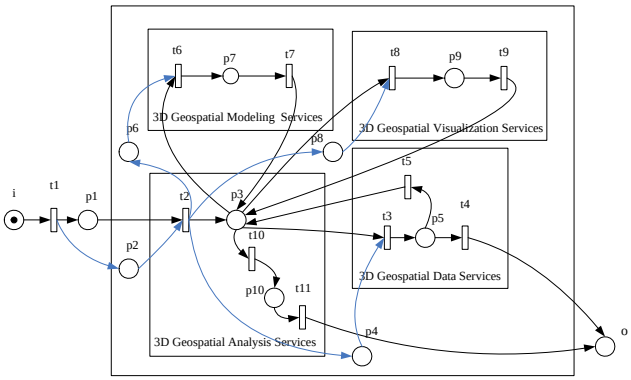

Figure. 6 Instance analysis of grid services composition

Adopting Petri Net, this service composition instance modeling is involved in ordering, choosing, cycling etc. and other such composed structures. The meaning of Place and Transition of this Petri Net is described as: i is the initial identification of grid service; t1 is required operation for starting users; p1 is status of successful request for starting by users; p2 is compounding assistant status of services; t2 is executive operation of 3D geospatial analysis services; p3 is executive status of 3D geospatial analysis services; p4 is compounding assistant status of services; t3 is the range of geospatial analysis and matching data operation; p5 is accomplished status of services of gaining 3D data; t4 is the failure of geospatial data matching, meaning composition is over; t5 is successful gaining of geospatial data, returning to the result; p6 is service compounding assistant status; t6 is operation of executing 3D modeling; p7 is accomplished status of 3D modeling service; t7 is success of 3D modeling service, returning to the result; p8 is service compounding assistant status; t8 is computing operation of starting data analysis and visualization; p9 is accomplished status of 3D visualization service; t9 is success of visualization service, returning to the result; t10 is operation of extracting parameter of geospatial analysis service; p10 is accomplished status of service of executing 3D geospatial analysis; t11 is success of 3D geospatial analysis execution, returning to the result; o is the end of grid service.

Figure. 7 shows adopt Reachable Tree generating algorithm to construct Reachable Tree based on assemble models of Petri Net generating algorithm. Among them, M_i = (i ,p1,p2,p3,p4,p5,p6,p7,p8,p9,p10,o).

The followings are analysis of reachability, boundedness, liveness, integrity and proceeding of Reachable Tree:

1. This composed service is totally reachable. Reachable assembly of status from M_0 $R(M_0)$={ M_0 ,M_1,M_2,M_3 ,M_4,M_5 ,M_6, M_7,M_8, M_9 M_{10}, M_{11}}. Assembly of status MS={ M_0 ,M_1,M_2,M_3 ,M_4,M_5 ,M_6, M_7,M_8, M_9 M_{10}, M_{11}}. From above, for any mark $M_i \in$ MS, $M_i \in R(M_0)$ is existing, that is to say any status in this composed service is reachable from M_0.

2. This composed service is boundedness. In Reachable Tree, Token tree in each position is no more that 1. This composed service is safe.

3. This composed service is liveness. It can be seen in Reachable Tree, from M0 $\forall Ti \in T$ (T is Transition assembly) at least can be triggered once by triggered sequence from M_0. It is clear that the Petri Net of this composed service is live.

4. This composed service is integrity. Every status of composed service is reachable from M_0, and can be triggered to transfer to end status M_{11}.

5. This composed service is proceeding. It is can be known from Reachable Tree that there is no any meaningless circle among random status.

Above all, 3D geospatial analysis services composition meets the demand of correctness, and composed model is correct.

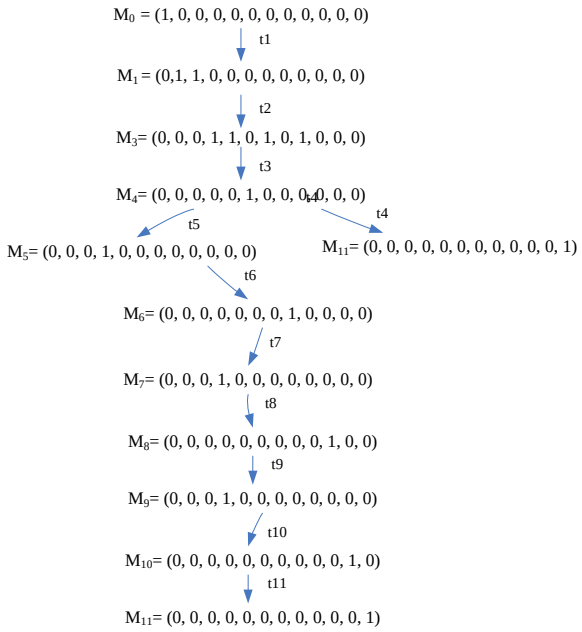

Figure. 7 Reachable tree of services composition

4. ESTABLISHMENT OF THE PROTOTYPE SYSTEM OF 3D GEOSPATIAL INFORMATION APPLICATION GRID

The prototype system of 3d geospatial information application grid based on grid computing, GridVRMap, whose main purpose is to establish a gateway of 3D geospatial information application, to offer 3D geospatial information application service to users, to realize the operation by users themselves, and to complete the functions user need. In prototype system, referred to the grid service composition of 3D application complicated functions, the realization of system function verified the feasibility of service composition modeling based on Petri Net.

4.1 the Framework of the Environment of Prototype System Operation

As the registration centre, metadata centre and geospatial database server (storing vector data mainly), the server with the address of IP 192.168.1.165 is installed the software RedHat Linux9.0, Globus Toolkit3.2.1 and J2SDK1.4.2, ArcSde9.1, Oracle9i mainly. Only as the server of Web, the server with the address of IP 192.168.1.189 stores DEM data and texture data mainly. The main software Windows 2000 Server, Apache Tomcat4.1.29, J2SDK1.4.2，Globus Toolkit 3.2.1, Java3D1.3.1 (OpenGL Edition) and OGSA-DAI4.0 are installed in the serve of Web with the address of IP 192.168.1.190. The client machine with the address of IP 192.168.1.188 is application client, in which the main software installed are Windows XP Professional, Globus Toolkit 3.2.1, J2SDK1.4.2 and so on.

4.2 the Logic Structure of Prototype System

Figure. 8 is the logic structure of GridVRMap system. This system offers two kinds of application. One is multilayer system based on B/S structure, in which the client is mainly expressed by web pages, adopting Servlet or JSP to be the client of grid service to execute related service and service composition transfer, then returning to clients. The other is the application of C/S structure. Ordinary Java application process transfers service and service composition as the client of grid service to complete the reference function, in order to realize the integrating with external system.

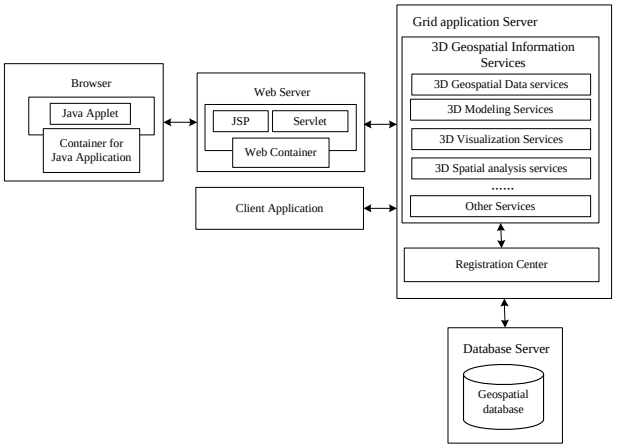

Figure.8 the Logic Structure of GridVRMap System

4.3 the Instance of Application

The query of building attribute (Figure.9) and the geospatial distance measurement (Figure.10) based on grid service composition.

Figure. 9 the Query of building attribute

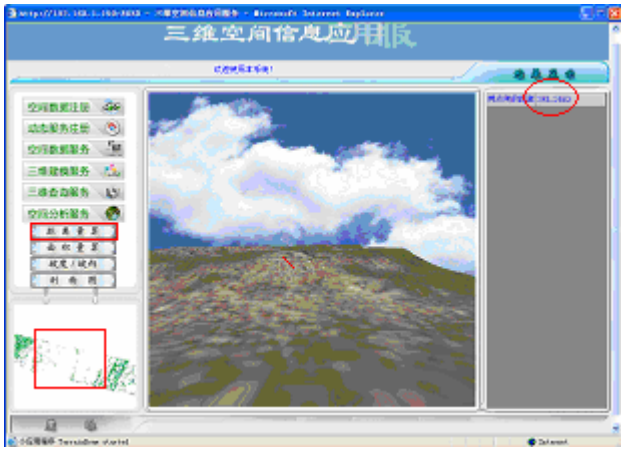

Figure. 10 the Geospatial distance measurement

5. CONCLUSIONS

In geospatial information grid, single service can not meet the application demands of geospatial information. Therefore, grid services composition is an important study course. The definition of grid service, algebra Description of Grid Services Composition, the generating algorithm of services composition and verification were mainly discussed in this paper combined with Petri theory within the application of 3D geospatial information. Moreover, aiming at the application of 3D geospatial information grid, this paper presented the discussion in detail and feasibility analysis of 3D geospatial analysis service composition. At the end of this paper, combined with the subject study, the prototype system GridVRMap of 3D geospatial information grid application was established, the instances such as the inquiry of building attribute based on grid service composition and the geospatial distance measurement were offered, and the feasibility of grid services composition modeling based on Petri Net was further verified. The further task is to continue to complete the tools of models and enrich the functions of prototype systems.

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