Architecture Of The Geodata Service Composition Web Application

K.Priyadarshini[1], G.Guru Brahmam[2]

[1]*Student, Computer Science and Engineering Department, Prakasam Engineering College, Andhra Pradesh, India,* ***priyadarshinikalvakuri2@gmail.com***

[2]*Asociate Professor, Computer Science and Engineering Department, Prakasam Engineering College, Andhra Pradesh, India,* ***madalaguru@gmail.com***

Abstract

Service composition has emerged to allow multiple functions, fine granularity, and fast access to applications. service composition can be invoked any time on the web so as to facilitate easier, faster, and much more cost-effective rebuilding. In the environment of service-oriented architecture, geodata web applications may be offered as services for geodata sharing and interoperability. Hence, there is a need for the development of a geodata service composition web application. To ensure smooth and efficient implementation. Petri nets are employed to model the geodata service composition, and its structural analysis techniques are used to verify deadlock. Finally, the proposal and the implementation of the architecture for the geodata service composition web application are described. This project offers compliant support for structural integrity in the geosciences from the design phase to the implementation phase.

Index Terms: *Service oriented Architecture, Petrinets, geodata,* service source, service structure, and service context.

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1. INTRODUCTION

Previously geodata applications focused on technology for improving discovery, performance, and work_ows only. Now, for geodata sharing and interoperability with the advent of service-oriented architecture (SOA), geodata applications can be considered in SOA environments as services. To enable interoperability between geodata web applications and accessibility of execution of geodata web service composition, the Open Geospatial Consortium (OGC) has developed a number of specifications for geodata and services. One such data specification is Geography Markup Language (GML).

Many other data specifications have been developed based on this specification, such as GeoScience Markup Language (GeoSciML) for geological objects and City Geography Markup Language (CityGML) for the exchange of 3D city models. Service specifiations developed include Web Feature Service (WFS), Web Map Service, and Web Processing Service (WPS), which are provided by OGC.

In SOA environments, a geodata service can be thought of as a software product that offers a solution to satisfy the customer's needs. However, service composition associated with a geodata application, which is emerging to provide multiple functions by dynamically orchestrating individual distributed services to work together, introduces new concerns. A question that may be asked is why a particular geodata application should be built as a geodata service composition (as we have done) instead of as a geodata service. One answer is that with its multiple functions and handling of fine granularity, a geodata service composition that can be invoked any time on the web can facilitate easier, faster, and much more cost-effective rebuilding than can a geodata service. Additionally, properties of a geodata web application supported by service composition include flexibility, reusability, and ease of deployment because in SOA environments, the components of a geodata service composition are independent of the platform and can be flexibly reassembled for other business processes. By employing web services, users can find the service they want and read Web Services Description Language (WSDL) tags to find the functions they need without the involvement of a third party. The _exibility and reusability of a geodata service composition can reduce the cost and time needed for system rebuilding and redeployment. To achieve ease of deployment, geodata service compositions composed using standards interoperate with other services to achieve a common goal. Standardization for business process management and execution includes Simple Object Access Protocol (SOAP) and WSDL.

In view of the above related work conducted on geodata services, there are two main phases in building a geodata service composition web application: the design phase and the implementation phase. The former phase focuses on the modeling and analysis of the geodata service composition; the latter phase focuses on the implementation of the geodata service composition web application. To ensure smooth and efficient implementation, structural integrity is essential.

2. METHODOLOGY

In this paper, we model and analyze geodata service composition based on service semantics and Petri nets with strict mathematical definitions, which offer a concise process modeling tool. Petri nets can be used to provide modelling approaches for concurrent, parallel, and distributed systems. In addition, many validation methods have been proposed based on theory and tools of Petri nets. Petri nets can provide not only representation but also abundant analysis capability to support the solid veri_cation of service composition. In this paper, service processes are modeled as service nets using Petri nets. Composite service processes can be modeled as service composition nets.

A. SERVICE DESCRIPTION

A ``basic service" has been described comprehensively as shown in Fig. 1.

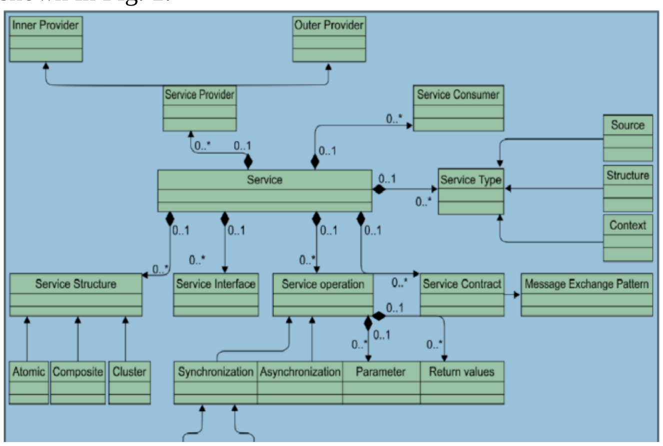

FIGURE 1. Basic service semantics description.

Fig. 1 shows the basic service semantics used in this study. The properties of basic service are defined as follows:

- A service is an entity that has a life cycle. It is also a software solution that can solve business and technology problems and that coexists with other software assets.
- A consumer is an acquirer that participates in service interactions and is one of the participants. It cannot provide a service itself, but it acquires the service from peer services. The consumer interface is one of the service interfaces.
- A provider is a user that participates in service interactionand is also a participant. The provider interface is also one of the service interfaces.
- Service types can be classi_ed into three categories: service source, service structure, and service context.
- Service structures can be classi_ed into three basic service categories: atomic, composite, and cluster.
- Service interfaces de_ne how the operations provided by the service are executed. They can be classi_ed into simple and collaborating interfaces.
- A service contract provides many speci_cations to describe services and is more complex than a service interface. Services communicate with each other in accordance with the contracts, which contain all the information for serving the providers and consumers.
- Messages are the information exchanged when services interact.
- Participants are the entities that participate in service interactions including people, systems, and application. The functions provided by a service to consumers are contained in the service operation, which are implemented via request and response messages. Services can be collaborated into business processes.

B. DEFINITION OF SERVICE COMPOSITION NET

We use Petri nets as an underlying formalism in our work. Models based on Petri nets facilitate comprehension, definition, and analysis of composition behaviour in the preliminary and first steps of their design. Service processes can be modeled as service nets; composite service processes can be modeled as service composition nets. Petri nets and logic expressions are reviewed briefly below.

*Definition 1:*A typical Petri net (*PN*) is a tuple (*P, T, I, O, F, M*), in which

- P denotes a set of n places, $P = P_1 \cup P_2 \cup .... \cup P_n$;
- T denotes a set of n transitions, $T = T1 \cup T2 \cup .... \cup T_n$;
- I denotes the initial state of the process;
- O denotes the end state of the process;
- F denotes a set of arcs, $F \subseteq (P\ X\ T\ ) \cup (T\ X\ P)$; where

P X T denotes a flow relationship from P to T and T X P denotes a flow relationship from T to P;

- M is the marking of PN, which describes the distribution of resources.

3. DESIGNING A GEODATA SERVICE COMPOSITION WEB APPLICATION

A. GEODATA WEB APPLICATION BACKGROUND

A geological model, or geomodel, is an abstract representation of a geological situation. Such models in 3D subsurface space have been extensively applied in the petroleum and mining exploration industry, geological surveys, and academic science. With the increase in the number of geological modeling methods, the possibility of creating detailed geomodels brings new, specific needs for geodata management as well as new opportunities for visualization and analysis of geodata using a web application. The matters of data access and management through the web for 3D geological modeling have been resolved.

Cutting of the geomodel to achieve visualization and analysis is a very common operation. Here, we describe a geomodel web-based cutting application as an illustrative example of a geodata application that is utilized over the web. The process carried out by our geodata application is illustrated in Fig. 2 and is as follows:

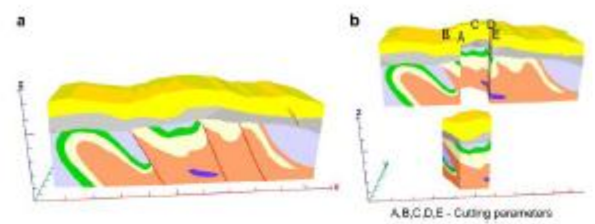

FIGURE 2. (a) An original geomodel. (b) Cutting parameters and cutting results.

- First, geological model data are acquired in XML.
- Next, cutting parameters are defined.
- Finally, the process is executed and cutting, analysis, and visualization operations are carried out.

This application is normally implemented in a specific environment using a speci_c technology, so rebuilding and giving distributed access to such an application is not a trivial task and is also very expensive. In the SOA environment, however, a geodata web application can be offered as a service. Moreover, our geodata application, which provides multiple functions such as cutting, analysis, and visualization, can be built as a service composition (as opposed to an atomic service) that can be invoked at any time on the web for fine granularity. End users can use it to obtain detailed geology characteristics and inner components not only for analysis but also to facilitate working with geodata.

B. ARCHITECTURE

The implementation architecture of our geodata service composition web application is an adaptation of architecture proposed by Arsanjani. The architecture comprises five layers as depicted in Fig. 3.

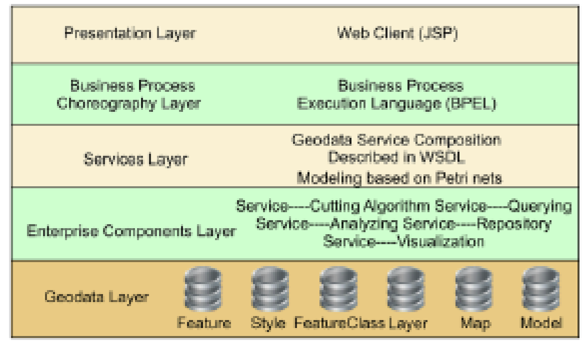

FIGURE 3. Implementation architecture of geodata service composition web application.

Layer 1: The first layer, called the geodata layer, gathers geodata service repositories and other data sources containing geodata standards. Fig. 4 presents the geodata standards. The basic elements of geodata, such as point, line, surface, and body, follow uni_ed standards and can be processed by the geodata service composition application. Finally, users' requests to access the data sources are transformed into a format accessible to the enterprise components.

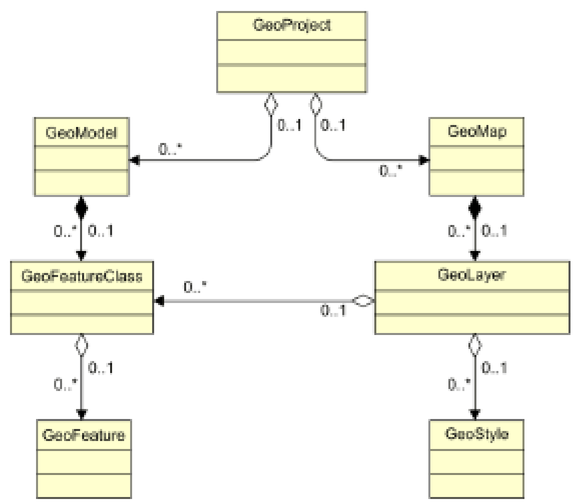

FIGURE 4. Geodata standards.

Layer 2: The second layer, called the enterprise components layer, consists of components that are in charge of the quality of service that the third layer provides. This layer comprises one component for connecting to the data sources repository, another for wrapping the geomodel cutting algorithm, a third for wrapping and visualizing the geomodel, and a fourth for querying and analyzing the geomodel.

In our implementation, all the results are programmed in CCC except for the web service, which is written in Java and is implemented on an Apache Tomcat application server.

Layer 3: The third layer, the services layer, exposes the geodata service composition designed. The functions provided by the service composition can be consumed by the user application. The geodata service composition can be invoked by many geosciences information systems. Services in the service composition can be described in Web Services Description Language (WSDL), which specifies the root element in the format <wsdl:definitions>. Other tags include <wsdl:import>, which specifies importation of one WSDL document to another; <wsdl:types>, which specifies the message type; <wsdl:message>, which specifies the message data element; <wsdl:portType> and <wsdl:operation>, which specify the operation sets; <wsdl:binding>, which specifies the protocols; and <wsdl:service>, which specifies the overall service. A sample of a geodata service composition is specified in WSDL. Simple Object Access Protocol (SOAP) is used as the speci_cation for the exchange of messages encoded in XML between the services; it can facilitate data interoperation.

Layer 4: The fourth layer is called the business process layer. The geodata service composition can be executed using Business Process Executable Language (BPEL). Designing the service and analyzing how it integrates with its partner service, we build a service description and modeling service composition based on Petri nets..

Layer 5: The _fth layer is called the presentation layer. This layer can be accessed by clients.

3. IMPLEMENTATION DETAILS

The input of the geodata service composition is managed in a format consisting of GeoFeature, GeoStyle, GeoFeatureClass, GeoLayer, GeoModel, and GeoMap. The geodata service composition provides operations such as GetAllProjects, GetProject, GetProjectFileData, GetProjectMetaData, and GetCutProject. Finally, the outputs of the geodata service composition are presented.

Operations

The service composition offers the following operations:

- GetAllProjects: This operation obtains all information surrounding the project.
- GetProject: This operation obtains all the information about the project.
- GetProjectFileData: This operation obtains project loading path and file name information.
- GetProjectMetaData: This operation returns all project metadata information, including version.
- GetCutProject: This operation generates all the information about the project that is cut.

Repository

The service composition repository stores all the data that facilitate the operations of the service composition.
The service composition repository includes the following geodata:

- GeoFeature Table: This table stores the basic geological feature data, including the typical four: GeoUnit, Fault, Fold, and Contact. It is the core of the data model.
- GeoFeatureClass Table: This table contains the sets of the GeoFeature, with a one-to-many relationship between the GeoFeatureClass and the GeoFeature.
- GeoModel Table: This table gathers the sets of the GeoFeatureClass, with a one-to-many relationship between the GeoModel and the GeoFeatureClass.
- GeoLayer Table: This table manifests the position attributes of the GeoFeatureClass.
- GeoMap Table: This table contains the sets of the GeoLayer, with a one-to-many relationship between the GeoMap and the GeoLayer.
- GeoProject Table: This table comprises both the GeoModel table and the GeoMap table.

4. CONCLUSION

Service composition has emerged to allow multiple functions, fine granularity, and fast access to applications. In addition, service composition can be invoked any time on the web so as to facilitate easier, faster, and much more cost-effective rebuilding. Hence, a need emerged for the development of a geodata service composition web application.

The main contribution of our paper is to describe the design and implementation of a geodata service composition web application based on service-oriented architecture. Service semantics is used for describing geodata service composition to align the technology environment with its business process. Service processes can be modeled as service nets using Petri nets; thus Petri nets were chosen to model the geodata service composition, and its structural analysis techniques were used to verify deadlock. Finally, the implementation architecture of a geodata service composition web application has been proposed and implemented.

We believe that this contribution is theoretically and practically relevant because of the advantages offered by service composition web applications for geodata applications, including cost effectiveness, ease of use, flexibility, reusability, and ease of deployment.

Although existing technologies and techniques such as service composition and Petri nets have been used, this work offers compliant support for the geosciences of structural integrity from the design phase to the implementation phase. In addition, this work extends the challenging area of geomodeling by introducing service-oriented architecture resources. It offers a simplified approach to and handling of geodata in the form of services available via the Internet.

In future work, we plan to continue this work and extend the results, increasing the experiments by complex geological model to show the advantages of the presented approach. We also plan to undertake the challenging task of service composition model optimization using cloud computing.

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