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Service-based Geometry Modeling Framework for Large-scale Information Visualization

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***Abstract*—Web-based Information visualization is one of the key technologies for product development and cooperative work in the enterprises. But existence of heterogeneous systems make geometry modeling a heavy task especially in the narrow-band network condition. Thus, a geometry modeling framework is built based on service-based architecture. On the aided of X3D component, a basic geometric data structure is built firstly. Then referred to operational semantic of geometry component, geometry modeling services are generated by service composition based on legacy CAD interfaces or geometry engine encapsulation. Lastly, A software prototype is also proposed based on an open geometry engine CASCADE. And it is shows that the framework provides an effective approach for large-scale information visualization.**

***Index Terms*—Geometry modeling; X3D component; information visualization; web-based computer graphics**

I. Introduction

With the popularization and development of web services computing technology, distributed systems with weak function on the heterogeneous platform can be combined together through formally unified way of services computing to finish complex work. Geometry modeling, which is key technology of information visualization, allows users to define and modify the parameters and geometric features through the way of visual interaction, and complete the complex distributed collaborative work in the way of three dimension graph.

Some researches concern about encapsulating interfaces into web-services so as to provide standard 3D modeling services. The Collaboration Graphic Design System (CGDS) based on Web Service [1] adopts communication mode of SOAP protocol to implement collaboration with graphic design in the internet environment. The Distributed Collaboration CAD System [2] based on web service communicates with clients through web service and selects concrete operations based on the input parameters. The combination of the dynamic tasks scheduling and the web service of the distributed-computing collaborative CAD system prototype [3] can not only support distributed collaborative CAD very well, but also make the system easier to extend and update because of its component-based architecture. After 2005, the complete concept of service technology is introduced into the distributed visualization system such as SOA and RESTful services. Document-driven design process [4] provides a feature-based modeling mechanism to enable batch mode geometry construction for distributed CAD systems.

Most current researches have realized the possibility and necessity to use web-service technology in the system for information visualization. But most of the existed finished systems are just with single access entrance. The client can only run the concrete operations through the specified input parameters, which cause the tight coupling between client and supporting-side. Therefore, we propose a framework of Geometry Modeling Integrated Platform based on Services (GMIPS) so as to realize the interactive manipulation between 3D geometry data and system specific application.

II. Framework of Service-based Information Visualization

In order to build an open, highly efficient, large-scale information visualization supporting platform, we should mainly consider the function, the data and the architecture. The key point of function is that the platform should be implemented with standard and open interfaces to access and invoke, and thus we plan to build service encapsulation of functions based on the web service.

In the aspect of function, considering web service which is based on HTTP protocol and SOAP message, X3D can adapt to the complex web environment as a standard distributed computing model. Through service encapsulation of geometry modeling functions of the heterogeneous systems, the foundation of the distributed 3D graphic operation supporting environment is established.

In the aspect of data, in order to reduce the transferring quantity of the 3D data and the frequency of the interaction, we plan to build a hierarchical 3D representation model and an operation structure, and then construct a kind of general data model form to realize the data exchange of the scenes. The X3D technology adopts

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XML encoding and introduces the component-based structure, which makes it extensible and has a light weighted kernel [5]. We plan to use the X3D component to represent 3D geometric resource, and the ontology is used to describe the relationship of resource so as to build an open X3D-based 3D geometry supporting environment.

In the aspect of service architecture [6], service-based distributed 3D application has a wide range of prospects. Compared with the traditional geometry modeling system, the development and deployment of service-based distributed 3D application are easier and more convenient because of the open and standard feature of service. The geometry modeling services can be provided by different service providers, the common geometry modeling operations can be encapsulated into services so as to be reused. Therefore based on the analysis above, the main ideas for building the 3D geometric supporting environment for large-scale information visualization is shown as Figure 1

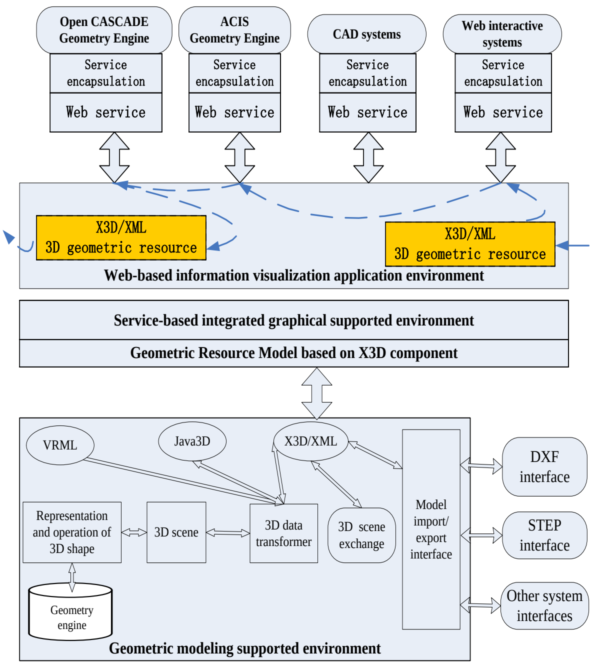

Figure 1. framework of service-based information visualization environment

The establishment and the management of the 3D geometric resource model are the basic of the whole information visualization platform construction. In order to describe relationship and properties of 3D geometric resources, X3D/XML is taken as the basic data structure for representation and exchange. Both of the models from the 3D geometry engine generation or other existing CAD systems are transformed into X3D-based 3D geometric resource model. There are three main points in building the service environment on 3D geometric resources:

(1) The data representation and operation function are separated. Therefore, the capture and management of the geometric resource can be attained, and the geometric services can be encapsulated from legacy systems or developed from geometry engine directly. Thus the architecture adapts to the real heterogeneous complex environment in the web.

(2) The invocation of geometric service focuses mainly on the form of resource matching service pattern. Resources have work state property, but the requests for the resources are stateless. Services of different granularity could be generated according to the requirement. According to this workflow, geometric services is organized and managed on the base of domain ontology.

(3) The interact pattern of resource and service is a process that resources array flow among the group services instead of services invoke resource individually in a disordered pattern. Based on geometric data resources, external application is encapsulated into different services, which are organized and managed according to the disposing flow. Thus the resources can flow in order among the services instead of the traditional disorder invocation of the resources by the services. Since open geometry modeling services are based on the disposing process flow, thus it provides not only an integrated platform of heterogeneous systems, but also an open environment.

III. SERVICE-BASED GEOMETRY PLATFORM MODELING

A. Geomethy Resource model based on X3D component

In order to realize modeling, the data structure must be in a kind of general data format which is easy to be characterized and exchanged. Based on X3D, we plan to establish the geometric shape structure and encapsulate it into the high level information format which is called the Geometry Resource Model here.

The Geometry Resource Model is used to record the complete modeling process, as well as the surface structure for display. And common information should also be involved to connect disposing and displaying information, thus the Geometry Resource Model is defined as the following triples:

Definition 1 Geometry Resource Model (GRM) is the basic shape unit of 3D scene, which is described as:

$$GRMObject = \{CV, CM, Ts, Es, Rs, IOps, Xs, PSs\}$$

CV expresses the Computation View, which is the BRep expression of GRM model. CV is used for rapid computation for 3D scene displaying utility. It is a shape expression model, which contains a variety of instances of shape elements, such as apex, edge, boundary, surface, shell, body and so on. It also contains descriptions of the process model and topological relationships between the shape elements.

CM is Common Model which expresses the common information. It contains the semantic information and the attribute description and so on.

Ts is Types of shape set which expresses the type of GRM. Ts expresses different type of shape element in modeling process model. The set of types contains a variety of shapes, such as spheroid, cone and so on, and other concepts used to describe the shapes like material, color, texture and so on.

Es is Element sets, which expresses the elements in a GRM. Every modeling element must be an instance of the shape type in Ts.

Rs is the Relationships sets which is used to connect elements in a GRM. Rs consists of three types: Part-of, Kind-of, and Attribute-of. Part-of expresses the inter-types relationship between the part and the whole, for example the aggregation relationship between shapes. Kind-of expresses the inter-types inheritance relationship, like the ellipsoid is a kind of spheroid. Attribute-of expresses that a type is an attribute of another type, for example the material is the attribute of shape.

IOps is Inner Operations sets which includes a variety of modeling operations related to different shape types. Operations in IOps accept modeling elements as parameters and return the result.

Xs expresses the sets of rules, namely the rules and the constraints in the process of creating shapes. These rules can be described formally with First-Order Logic (FOL) or Description Logic (DL).

PSs expresses the sets of state of extern process. It is defined just for recording the status of GRMObject in extern disposing process.

In fact, GRM is a hierarchy mixed model which combines the CSG/ BRep expression of the shape and the X3D standard into a mixed geometric model. The expression includes the following aspects:

(1) The extended CSG process tree: It records the operations history in tree structure and concludes three kinds of nodes: (a) CSG Root node: The foundation of the entire CSG tree part, non-null; (b) Non-leaf node: In the extended CSG tree, non-leaf node Oi expresses the geometric operation to the basic shape. It can be the Boolean operation such as intersection, union and subtraction, or some operations like lofting, skinning, or some feature modification operations like blending, shelling and so on. For each node, Oi can be the concrete modeling operation related to a special shape type. (c) Leaf node: Leaf node Li is used to simplify the GRM model in the extended CSG model. In this extended CSG process tree, leaf node Li can be the basic shape such as the basic entity, basic curve, and basic curved surface and so on. It can also be the reference point to other entities.

(2) The common description: It contains the public information of GRM, including attribute and semantic information. In fact, it is also the kernel to connect CSG parts and surface parts.

(3) The surface lists: For the entity represented by the root node of this CSG process tree, the model contains the BRep expression of this entity. The BRep expression is used for the rapid operation of 3D scene and generation of the surface expression. Each FaceList (FL) relates to a component Li of extended CSG tree, in another word, each FL has a certain relation with a component Li.

(4) The X3D surfaces expression: The surface expression is transmitted progressively in X3D format from the services-supporting side to the client side. The client displays the shape according to the surface information, and it can specify the LoD (Level of Detail) model which generates the surface document.

In the service-supporting side, the model mixes the use of extended CSG and BRep expression. The extended CSG model can be used in the modeling process. When replacing the provider of the Web service, it can be used to rebuild the model. The BRep model is easy to be computed so as to support rapid 3D model display and rapid user response.

B. Services construction based on resource operations

On the aim of management and utility, GRM model is grouped according to the similar features related to geometry modeling process. Therefore, domain ontology which includes GRM model and operations is built. Based on domain ontology, conception relationships for resources organization and utility are then built, and operational semantic information related to GRM model is also included.

Definition 2 Geometry Modeling Service (GMS) is expressed as a five parameters group as:

$$GMS = \{BD, IOPEs, CPs, ORef, OpS\}$$

In the expression, the element

BD represents Basic Description of service, which includes service name, description, type and other basic information.

IOPEs describes interface and function of service. IO describes interface defined with input/output parameters, which include parameter number, parameter type and so on. PE describes service function which defines pre-condition and effect of service execution. Pre-condition describes run environment for service execution, and Effect describes services execution effect to the environment.

CPs describes non-business features of service which includes service cost, reply time and so on. There are related descriptions about CPs and other conceptions in the domain ontology.

ORef represents the invocation of domain ontology.

OpS describes the Operations Set to carry out concrete geometry modeling operations related to the service. These operations could be mapped from the IOps in GRM model, in fact, each operation in OpS have a original instance from IOps. The operation could be found in the common operation set. In fact, these operations also make a ground for service composition based on simple services. And single operation will be defined in detail in the next definition.

OpS of GMS service concludes a set of operations. In order to carry out the concrete operations of the service, the simple operation of GRMObject should be defined.

Refer to common operations of different shape types, the service encapsulation related to different shape types could be carried out. Table 1 lists some services established by encapsulating the basic entity modeling operation in the service system. Three kinds of service, Construction services, Modeling services, and Support services are listed as follows.

TABLE I. GEOMETRY MODELING SERVICES FRAMEWORK

Service Type	***Type of operation***	***Operation***
Construction	Basic shape	Establish the basic shape such as the basic entity, basic curve, basic curved surface
Modeling	Curved face Construction	Skinning, Sweeping, Covering, Lofting
	Assembly operation	Motion, Rotation, Distortion
	Boolean operation	Unite, Intersection, Subtraction
	Solid modeling	Skinning, Lofting, Sweeping, Sheet thicken
	Feature Modify operation	Blending, Shelling, Plane taper, Offset, Hole
Support services	Import shape	Import the extensible CSG document to rebuild the complex shape.
	Export shape	Export the extensible CSG process tree, BRep document , LOD model.

Ⅳ. IMPLEMATATION

A prototype system is implemented. Java is used to invoke modeling functions so as to generate geometry modeling services. These modeling services are published in Axis2, and are deployed on JBoss application server. The Client program is also developed based on Java, and could be embedded into Brower in Java Applet. With the support of system framework, web-based distributed CAD system could be implemented. The platform could be shown as figure 2, which is divided into five parts.

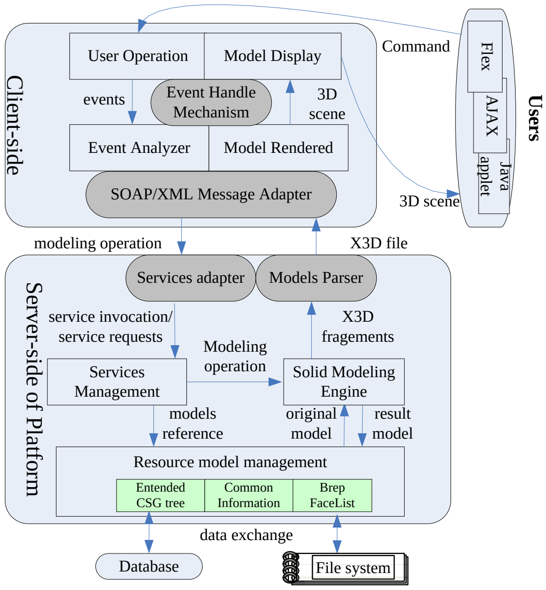

Figure 2. Interactive process Scenario of modeling service

(1) Event Handle Mechanism: Event Handle is divided into two parts: modeling operation and change shape model. User interface transforms user command into modeling operation. Event Handle Mechanism then invokes corresponding services. When Client gets the X3D fragment from service-side, model maintenance modifies local X3D model and the Change shape model event is triggered, Event Handle Mechanism thus sends message to render the 3D scene for user.

(2) SOAP/XML Message Adapter: It is used to encapsulate service requests into SOAP messages, or analyze the model content from SOAP messages.

(3) Services Adapter: It is used to get and analyze services requests. Services Adapter uses model Reference to locate the GRMobject, and to send modeling operation to modeling engine and CSG database. Modeling engine carries out concrete modeling operation on the GRMobject, and database maintains operations history tree data.

(4) Models Parser: It is used to generate X3D file for displaying 3D scene based on LOD technology. On the purpose of reducing data quantity transferring on the network, model data is always divided into several parts and details adjustment operation is carried out.

(5) GRM model: This model is the core of resource model management, which consists of three parts: extended CSG tree, common information, and Brep surface lists.

The general working process of client-side solid modeling services is as follows: (a) Search modeling services in service registry center; (b) According to the description of service especially IOPEs and CPs, select services to satisfy the requirements. (c) Compose the basic services into a composed service if necessary. (d) Push the service to the server so that the service can be invoked as native codes. (e)Display the results of service execution to finish the command from user.

Ⅵ. CONCLUSIONS

The framework of GMIPS is an exposition for research and application for large-scale Information Visualization on the network. There are still lots of work left to do. Future works about the framework will focus on the aspects of service preference and complex services composition.

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