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Architecture Design of the Cladding Part Modeling System

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Abstract
The cladding part is a new type of layered heterogeneous material part with three layers of the substrate, the interface and the clad. According to the part unique material composition and structural characteristic, the software architecture design of the cladding part modeling system was researched based on the hierarchical modeling method. Using UML (Unified Modeling Language) and the software Rational Rose, the use cases, static logic, dynamic logic and physical deployment of the modeling system were described with the use case diagram, class diagrams, communication diagrams, components diagram and deployment diagram. The research results can guide the developed process of the cladding part modeling system with high stability and reliability.

Keywords: cladding part modeling system, architecture design, UML, Rose

1. Introduction

The cladding part is a new type of layered heterogeneous material part with excellent properties, which has been widely used in automobile, machinery and other industrial fields. It consists of three layers of the substrate, the interface and the clad [1, 2]. Among them, the substrate layer and cladding layer are homogeneous materials, the interface layer is located between the substrate and the clad, and it is the functionally gradient material along the part thickness direction.

According to the unique material composition and structural characteristics of the cladding part, a hierarchical modeling method relatively consistent with the part actual structure and performance has been studied in detail in the references [3, 4]. The hierarchical modeling method means that the clad, interface and substrate are firstly modeled respectively, then they are glued together, meanwhile the bonding strength is considered [4]. In order to develop 3D digital modeling system of the part, based on the hierarchical modeling method [4], the architecture design of the part modeling system based on the software of SINOVATION is studied in the paper. The architecture describes each part of the modeling system of the cladding part and their collaborative work mode on the whole, which can guide the development process of the entire software system. This system architecture can not only make the development of the cladding part modeling system be more reasonable, but also ensure the developed modeling system to operate more stably and reliably.

In the paper, using the unified modeling language (UML) [5-8] and the tool of software Rational Rose [9-11], the overall architecture of the cladding part modeling system is firstly established, and then the use cases, static logic, dynamic logic and physical deployment for the modeling system are described with the use case diagram, the class diagram, the communication diagram, the component diagram and the deployment diagram respectively.
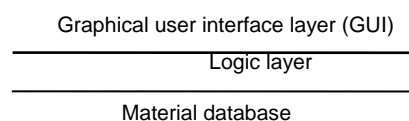
Graphical user interface layer (GUI)

Logic layer

Material database

Figure 1. Overall Architecture of the Cladding Part Modeling System

2. Overall Architecture of the Modeling System

The user interface and the logic part of the cladding part modeling system are independent with each other. The system overall structure is divided into three layers. They are the graphical user interface layer (GUI), the logic layer and the material database, as shown in Figure 1, where, the graphical user interface layer (GUI) is mainly the dialog box for the cladding part modeling, the logic layer mainly deals with the logical part of the processing command, and the material database storages the material information for the use of the cladding part modeling.

2.1. Use Case Description of the System

According to the hierarchical modeling method [4], the cladding part modeling system mainly include the following functions: the substrate material definition, the clad material definition, the material database update function, the basic modeling function of the interface layer, the element refinement function of the interface layer, the element material query and modify functions of the interface layer, the clad layer modeling function, the adhesion function, the difference operation function for heterogeneous body, the fillet function for heterogeneous body, the chamfer function for heterogeneous body, the "and" operation function of the interface layer. These functions are completed by the cladding part modeling system and SINOVATION. The functions of the cladding part modeling system are described with the use case diagram as shown in Figure 2.
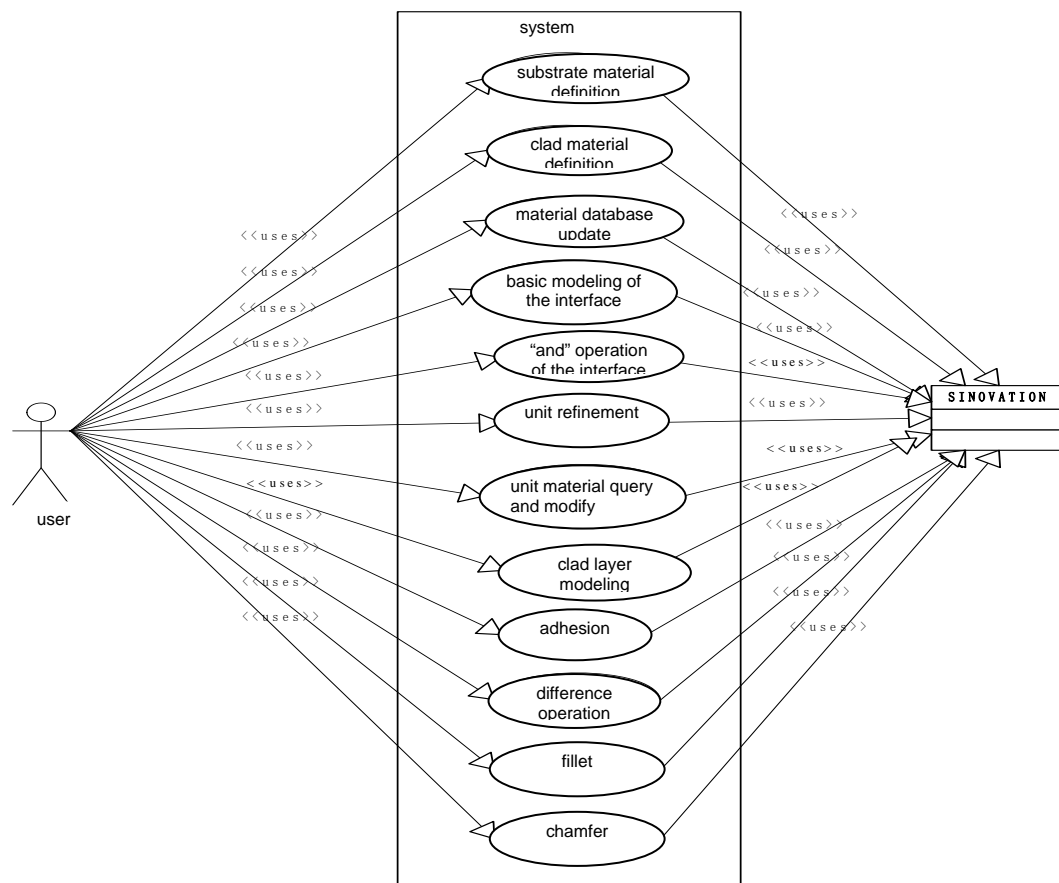

Figure 2. Use Case Diagram for the Cladding Part Modeling

2.2. Static and Logic Description of the System

The class diagram is often used to show the static structure of the software system, it is the most commonly used view in the object-oriented system model, and it describes the

relationship between one class and the other class in the system [6]. In the paper, the class diagram is used to describe the static and logic model of the cladding part modeling system.

For the development of the cladding part modeling system, the V7 command in SINOVATION software development method is used in the paper. The V7 command mainly includes four types: the command body class Cmd, the command parameter class CmdPrm, the command dialogue frame class CmdDlg, and the command logic class CmdCmp. The suffixes of Cmd, Prm, Dlg and Cmp are used to represent these four class names respectively. For each V7 command, the relationships among the four classes are shown in Figure 3. It can be seen from the figure that the parameter class CmdPrm is the association class between the command dialogue frame class and the command logic class, however, both the dialogue frame class and logic class depend on the command body class. Among them, the inheritance relationship between the command dialogue frame class and command logic class in the cladding part modeling system is shown in Figure 4. In addition, the cladding part modeling system also includes some common logical and entity classes, for example, the interface layer geometry modeling logic class IntfGemBuild and the substrate class Base, but their names haven't the unified suffixes.
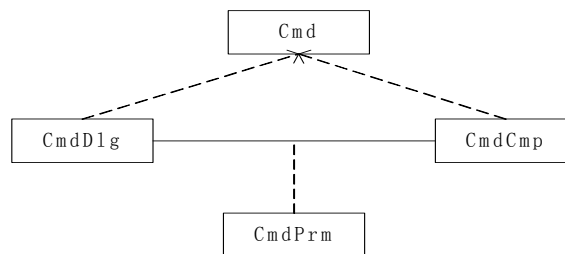
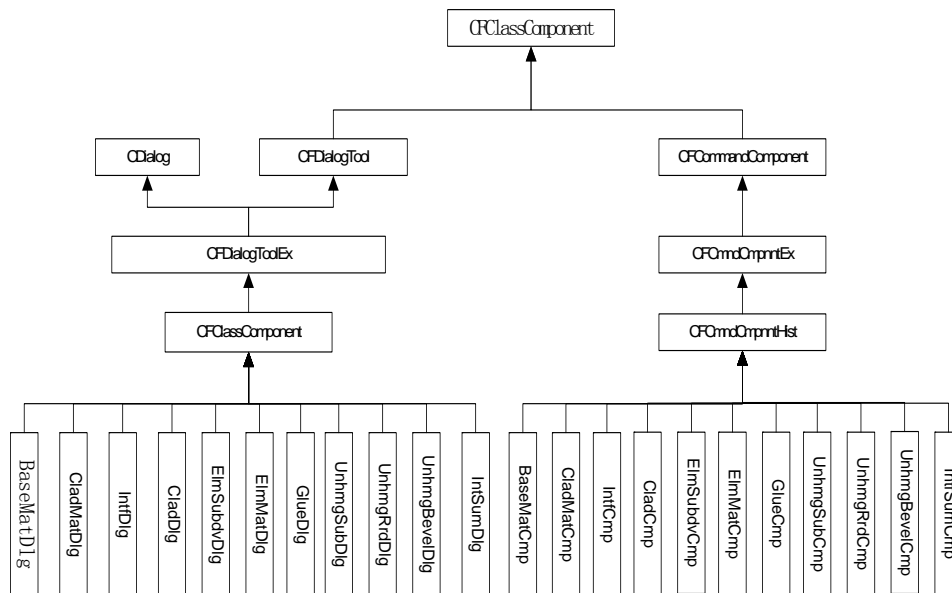Figure 3. Relationships between Classes in V7 command

Figure 4. Inheritance Relationship between Command Dialogue Frame Class and Command Logic Class

Considering all of the above classes, the overall class diagram for the cladding part modeling system is shown in Figure 5. Where, the class CFDialog ToolHist, the class CFCmnd CmpnntHist, the above classes and the inheritance relationship between these classes have been described in Figure4, they are not listed in Figure 5.

Figure 5. Overall Class Diagram for the Cladding Part Modeling System

2.3. Dynamic and logic description of the system
        In the system to be developed, the objects are not isolated. They interact with each other by message passing. The interaction diagram is used to describe the dynamic interactions among objects [12]. Each interaction diagram corresponds to a use case scenarios, which is

used to display the flow of the scenarios events, it mainly includes the objects needed in the event flow, how to send messages between objects, what role to start the event flow, and in what order to send messages. The communication diagram is used to describe the dynamic logic in the cladding part modeling system in the paper.

There are many use cases and scenarios in the cladding part modeling system. In the paper, the interface layer basic modeling is taken as an example of the use case, the communication diagrams corresponding to two use cases of using the single and composite surfaces as the initial surfaces of the interface layer respectively are established.

In the scene of using a single surface as the interface layer initial surface, according to the different element mesh ways, the scene can be divided into three sub scenes of the layer mesh, tetrahedron mesh and hexahedron mesh. The only difference among these three sub scenes is that, during the process of the interface layer material modeling, the called element mesh functions of the interface layer are different, they are LayerMesh(), TetrahedralMesh() and HexahedralMesh() respectively. The communication diagram corresponding to the scene of using a single surface as the interface layer initial surface with the tetrahedron mesh way is described in detail in Figure 6.
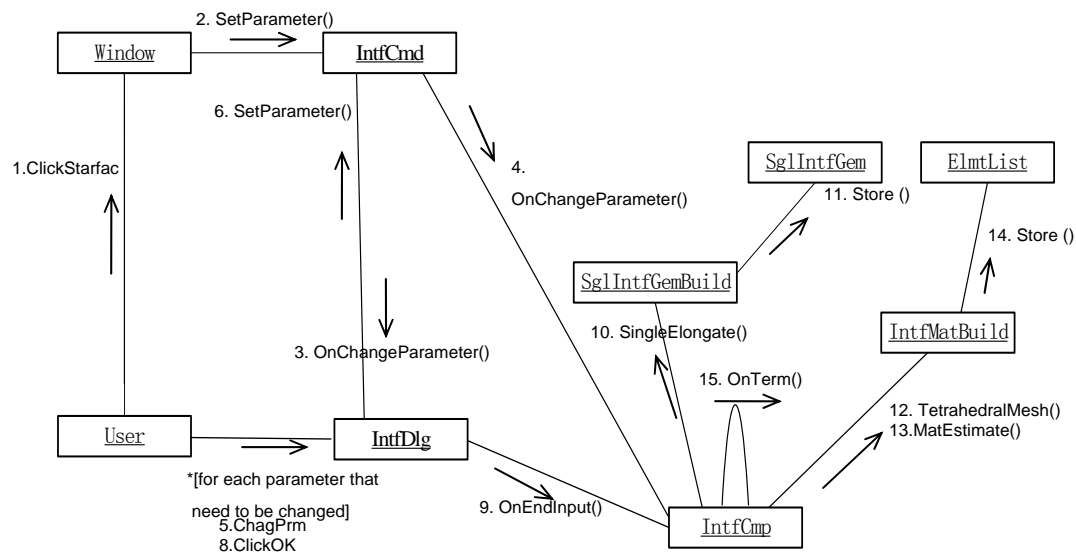

Figure 6. A Single Initial Surface Interface Layer Modeling Scene Communication Diagram

From the communication diagrams, it can be seen that, in the scene of using a single surface as the interface layer initial surface with the tetrahedron mesh way, the basic interface layer modeling proceeding is as the following.
(1) Users click the substrate layer surface to be added the interface layer in the view.
(2) The view receives the message from the mouse click, and then notifies the command body IntfCmd to change the parameters.
(3, 4) The command body IntfCmd notifies command dialogue IntfDlg to change the corresponding parameter display, and notifies the command logic box IntfCmp to change the parameters.
(5) For every command parameter need to change the value in the dialog box, the user changes the corresponding parameter in the command dialog box IntfDlg.
(6) Command dialogue box IntfDlg notifies the parameter change to the command body IntfCmd.
(7) The command body IntfCmd notifies the command logic IntfCmp to change the parameters.
(8) After the parameter setting, the user clicks the "OK" button.

(9)   The command dialogue box IntfDlg notifies the command logic IntfCmp to the end of the parameter inputs.
(10) The command logic IntfCmp notifies the single initial surface interface layer geometry modeling logic SglIntfGemBuild to establish the geometric model of the interface layer to from a single initial surface.
(11) The geometric model of the interface layer from a single initial surface established by SglIntfGemBuild is stored in the command of the single initial surface interface layer geometry SglIntfGem.
(12) The command logic IntfCmp notifies the interface layer material modeling logic IntfMatBuild to mesh the established interface layer geometry model with the tetrahedron element.
(13) The command logic IntfCmp calls the element material calculation function MatEstimate() in the IntfMatBuild to calculate the material composition for each element.
(14) The material composition information is stored in the element list ElmtList.
(15) The command logic IntfCmp calls itself function OnTerm() to end the command logic.

For the communication diagram corresponding to the scene of the use case of using the composite surface as the initial surface to model the interface layer, according to different element meshing way, the scene also can be divided into three sub scenes of the layer mesh, the tetrahedron mesh and the hexahedron mesh, and its scene communication diagram is similar to that corresponding to the use case of using the single surface as the initial surface to model the interface layer except some changes, for example, change SglIntfGemBuild and 10.SingleElongate() in Figure 6 to be CmpIntfGemBuild and 10. CompositeElongate() respectively, then the communication diagram corresponding to the sub scene of using the composite surface as the initial surface to model the interface layer with the tetrahedron element mesh way can be obtained.

2.4. Physical Description of the System
The physical modeling for a software system mainly includes the component diagram and the deployment diagram. The component diagram is used to show the physical structure of the components in the system, and the deployment diagram is used to show the topological structure of the system.

2.4.1. Component Diagram
Components are the replaceable physical parts of the system. They encapsulate the implementation and provide a sent of interface [12]. Component diagram can be used to show the relationship among components in the software system. In the cladding part modeling system, all of the boundary classes and control classes are encapsulated into components respectively, and the entity classes are located in the database of SINOVATION and managed unifiedly by the database.

The executable program of the cladding part modeling system is modeled, the established component diagram is shown in Figure 7, where, the dotted arrow indicates a dependent relationship. Dependence is the only existing relationships between components, which means that some classes in the components at the end of the dotted line depend on the class that the arrow points to.

It can be seen from Figure 7 that the components for the cladding part modeling system include the main program of SINOVATION, the cladding part modeling components and the material database. Among them, the main program of SINOVATION is represented by the center box with the letter "A" nearby. Each command body component to realize the cladding part modeling function manages the corresponding dialog component and command logic component, and the command body components are represented by the box with the letter "B" nearby, such as the IntfCmd component. The component of the command dialogue box represented by the box with the letter "C" nearby mainly contains the corresponding dialogue box class, for example, the component of IntfDialog contains the dialogue box class IntfDlg. The command logic component represented by the box with the letter "D" nearby contains the command logic class counterparts, and some command logic components depend on some other logic components to help to finish the corresponding modeling function, for example, the component of IntfLogic contains the command logic class IntfCmp and the command parameter class IntfPrm, at the same time, it depends on the component of SglIntfGemBuild, the component of   CmpIntfGemBuild and the component of IntfMatBuild. The component

represented by the box with the letter "D" nearby is the material database including material list class of MatList and the material item class of MatItem. The other components in the Figure7 are the ordinary logic components. In addition, the other entity classes are stored in the database of SINOVATION as entity objects.
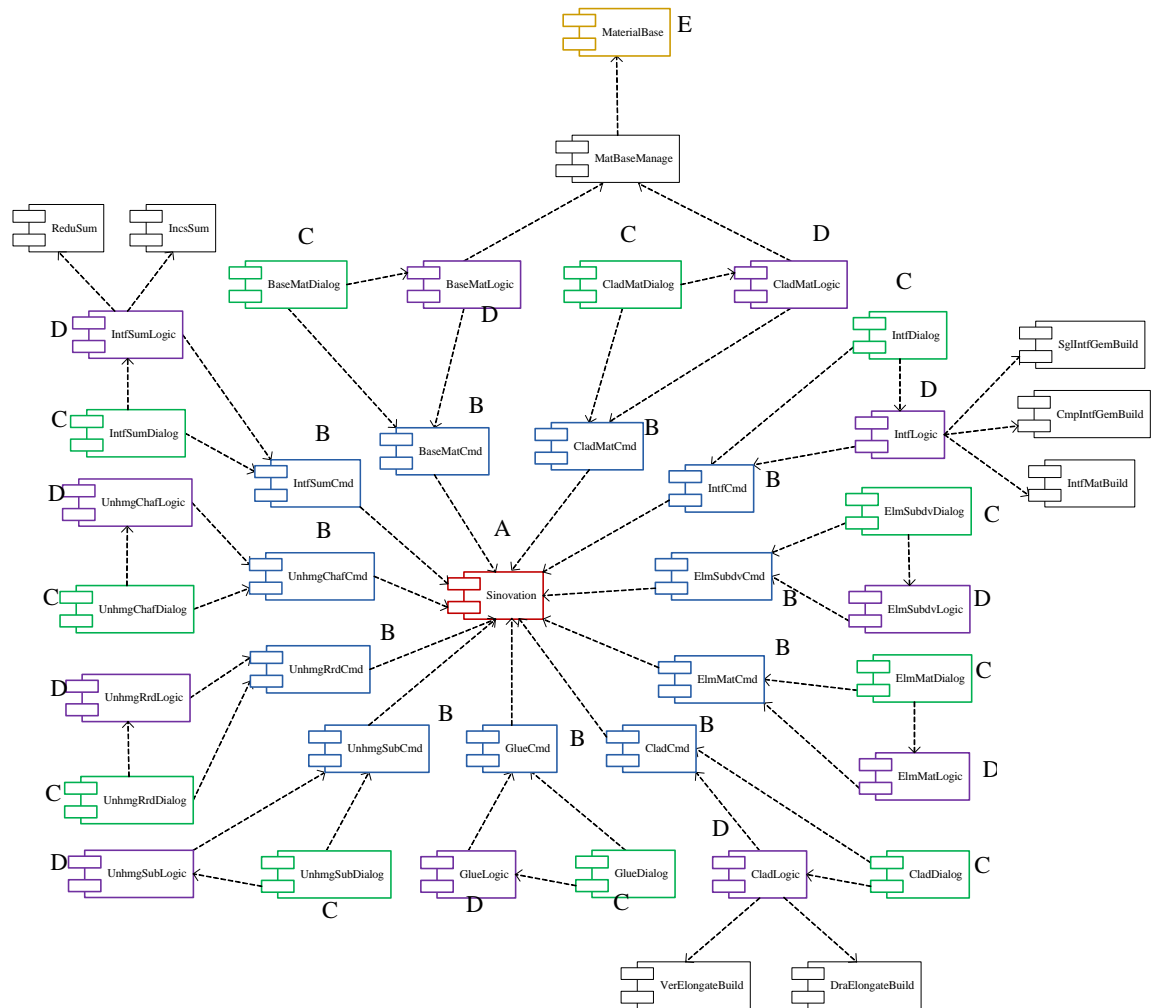

Figure 7. Component Diagram for the Cladding Part Modeling System

2.4.2, Deployment Diagram

The cladding part modeling system designed in the paper is as a plug-in of SINOVATION software. Both display interface and database of the cladding part modeling system will use those existing in the SINOVATION platform. The deployment diagram to describe the overall relationship between the cladding part modeling system and SINOVATION is shown in Figure 8.
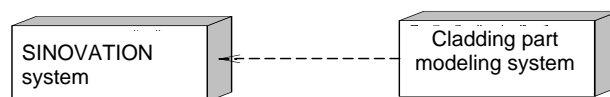

Figure 8. Deployment Diagram of the Cladding Part Modeling System

3. Conclusion

Based on the hierarchical modeling method for the cladding part in the reference [4], the architecture design of the part modeling system based on SINOVATION is studied. Using the unified modeling language UML and the software Rational Rose, firstly, the overall architecture of the cladding part modeling system is established, and then the use cases, the static logic, the dynamic logic and the physical deployment of the cladding part modeling system are described with the use case diagram, the class diagram, the communication diagram, the component diagram and the deployment diagram respectively. According to the designed architecture, the modeling system prototype for the part has been designed in the reference [4]. The designed architecture describes every part of the cladding part modeling system and their collaborative work mode, which can not only guide the development process of the total cladding part modeling system to be more reasonable, but also ensure the developed modeling system to operate more stably and reliably.

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