Studying on Data Integration Mechanism of Virtual Assembly System

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Abstract—During the course of aircraft manufacturing, there are large volumes of data which has complex relationships. In order to ensure the rationality of the assembly process, to reduce assembly costs and to improve assembly efficiency, centering on aircraft digital assembly process system, we studied in-depth the data conversion and integration method of aircraft assembly process system. To transfer model data from CAD system to integrated virtual assembly environment, information extraction & model conversion method is put forward. Based on XML, the conversion among various types of aircraft assembly process data model are implemented, the basis for following tasks of digital assembly of aircraft is provided. We developed the assembly process system of aircraft, and the system can be integrated with PDM system. The application indicated that the method was feasible and the effectiveness of data transformation was validated.

Keywords-Virtual Assembly; Data Integration; Information extraction; Model conversion; Aircraft

I. INTRODUCTION

During the course of aircraft manufacturing, there are large volumes of data which has complex relationships. Aircraft assembly data, which account for more than half of the cycle time of the entire aircraft manufacturing, is the key to the development of the entire aircraft. In order to ensure the rationality of the assembly process, to reduce assembly costs and to improve assembly efficiency, those who can find the problem in advance, will play the more and more important role in modern aircraft design and manufacture. Data source is an important basis of aircraft digital assembly process design, so it is the key part to ensure the aircraft technology design quality that the data source import in bulk to digital assembly process system accuracy and efficiency, and that the data source changing timely response to the design of aircraft digital assembly process. In this paper, taken the instance of data reception of assembly process system as extension, the method of aircraft digital data conversion and integration between the assembly process systems and other enterprise application systems is studied to transfer model data from Computer Aided Design(CAD) system to integrated assembly environment, to realize automatic conversion of different data models and importing data in bulk, to solve the accuracy of the data transmission and to improve data import efficiency.

Data conversion technology from the CAD system to the assembly environment has already been studied by many people at home and abroad. These researches combined with virtual assembly, can be mainly divided into two types: ① Making use of neutral file(Initial Graphics exchange Specification (IGS), STandard for the exchange of Product model data(STP), STereo Lithography interface specification(STL) or virtual reality modeling language (VRML), etc.), VADE system uses STP as a medium to transmit information[1]. This method is simple and straightforward but there are obvious shortcomings, they are: first, to the neutral file, sometimes the models are simplified and approximate, some information, especially required information is easily lost; second, and sometimes the models contain more redundant information, data conversion efficiency is not high. ② Making use of CAD system developed by themselves, the CAD design system and virtual assembly system together share the underlying database, such as: Concept Dynamics, CODY from German [2], VAVAS from Zhejiang University [3]. These methods can be implemented in system assembly modeling and virtual assembly without data conversion, but it is difficult to integrate with mainstream CAD systems.

Traditional assembly models are mainly: relation model [4], hierarchical model and the virtual link model[5]. These models are proposed on the basis of traditional CAD environment based on WIMP interface. However the operating of WIMP interface environment is process-oriented, so, they contain only static structures representation information without reflecting the interaction of the dynamic assembly process. At present, because the direct operation and multi-channel interactive approach in virtual assembly system is task-oriented, the corresponding assembly models should not only describe the static structure, but also reflect the dynamic process of assembly interactions [6-10]. Centering on the data model of the aircraft assembly process, the data integration mechanism among various types of aircraft assembly process data model should be studied.

II. DATA TRANSFERRING PROCESS BETWEEN AIRCRAFT ASSEMBLY SYSTEM

The system takes the assembly process design of C919 type aircraft as an example. The workflow is shown in Fig .1. Digital assembly process system obtains product engineering data (EBOM data) and 3D digital model from enterprise PDM system; through data acception module, imports product engineering data (EBOM data) and 3D digital model into digital assembly system, through the visualization process planning module, divides product engineering data (EBOM data) into the initial product manufacturing data (MBOM data) and generates a process structured data. On the basis of process structural data, through detailed process design process module and process simulation module, process engineers generate 3D AO document to guide product assembly, and through the file upload module, uploads them to enterprise PDM to carry on process management.

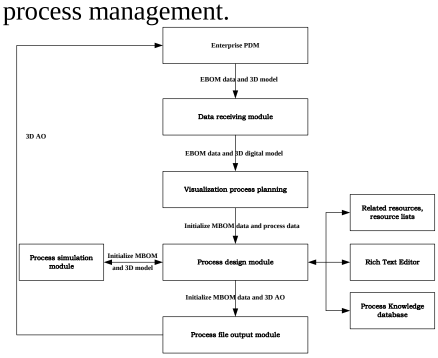

Figure 1. Running data flowchat

III. CONVERSION BETWEEN CAD SYSTEM AND ASSEMBLY SYSTEM

To effectively transfer model data from CAD system to integrated assembly environment, information extraction & model conversion method was put forward. In this method, the process of assembly model transformation was divided into two processes: information extraction and model conversion and importing them into VE. The method not only retains the advantages of merely using neutral file, makes up for its shortcomings, but also easily integrates with mainstream CAD systems (such as UniGraphics and Pro/Engineer, etc.) At the same time, in this method, the data is accurate and reliable, and the information is comprehensive and complete. Fig .2 is the schematic of information extraction model transferring method.

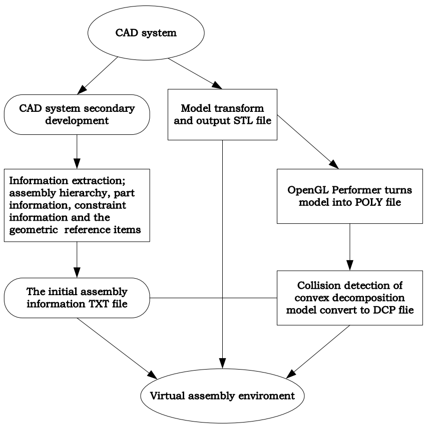

Figure 2. The schematic of information extraction model transferring method

A. Information extraction

By the secondary development of CAD system, internal data of CAD models can be directly accessed, and then to export the hierarchical structure, part information and constraint information of assembly models. Fig .3 shows the data conversion process, by traversing the assembly model tree, all the part and assembly hierarchy model information can be obtained; traversing the assembly tree again, the constraint information can be obtained, and geometric reference item information can be filled with the relevant part models. The model data rules of IVAE virtual assembly system can convert the information and write the initial assembly information files. The recursive traversal method is suit for complex assembly hierarchical structure. The function of extraction part information is the conversion of CAD product model from assembly information to VE information, so that the model data from IVAE environment is accurate, reliable, comprehensive and complete.

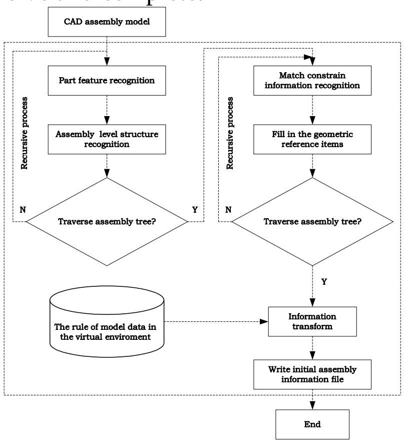

Figure 3. Assembly information extraction flowchart

B. Model conversion

The assembly models in the integrated virtual assembly environment can quickly render and collision detection, so, not only those models imported into IVAE VE must have accurate information on topology and geometric information, but also the assembly constraint information is defined in the exact model. In IVAE virtual assembly environment, the facet model and the collision detection model are used to represent a part model. The function of model transformation module is to display products, to carry on fast rendering and to make interaction operation and real-time collision detection by virtual reality devices in VE, so that the position constraint solving and optimization of assembly path can be completed in virtual assembly environment.

The conversation of facet model exports STL model through the model conversion interface which the CAD systems have themselves. Once the parametric solid models become facet models, they can directly be import into the virtualization assembly environment. Conversation of collision models is indirectly generated by facet model. In terms of graphical support system, STL model will first carry on middle geometric conversation to become POLYgonfacet (POLY) format model, and then the convex is decomposed into the body for collision detection

(DeCom Poser, DCP) model, DCP model can be integrated directly into the virtualization assembly environment.

IV. CONVERSION SCHEME OF DATA MODEL

The data in the digital assembly process system is divided into product, process and resources. On the basis of three parts, according to the different requirements of enterprises or projects, corresponding template is customized as PTS, which determines the template data attribution, hierarchy relationship, displays structure and other various of information. This paper only takes the data receiver from PDM to EBOM as an example, takes the definition of the product data model and its automatic conversion as the description, and the other data processing in the assembly process and so on.

A. Integration with PDM system

Enterprise data is managed by the PDM system, therefore, the digital process system must integrate PDM to obtain the data, and to get BOM data from the PDM. In this paper, the integration between the application systems is indirect, that is, data transmission between PDM and DPE is completed by the middle file: BOM table in XML format. During the course of data transferring, sending messages between application systems is completed by Soap protocol, therefore, the integrated approach between heterogeneous systems is the system integration based on XML and Soap protocol. There are 4 steps as shown in Fig .4.

Step 1: Digital assembly process system sends a request to the PDM system, and passes the number of EBOM which user import to the PDM system, and then waits for PDM system response.

Step 2: Once PDM system receives the request, immediately turns the number of EBOM and sub-EBOM data into a common XML format EBOM data which is send in a shared folder on the system.

Step 3: After the data transmission is finished, PDM system will send "Data transmission complete" message to digital assembly process system.

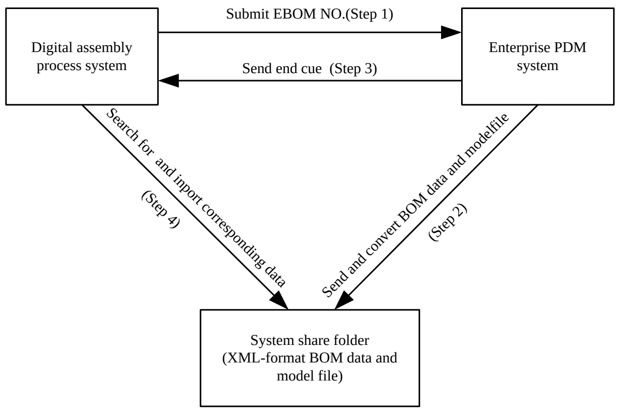

Figure 4. Integration diagram between digital assembly process system and PDM system

Step 4: After the digital assembly process System receives "Data transmission complete" message, it will find the corresponding EBOM data and sub-EBOM data and associated model file in the share folder designated by system, and then bulk import the data as shown in Fig .5.

B. Traversal algorithm and importing data

After EBOM table is transferred to the system shared folder, the data of EBOM table should be traversed, and the appropriate hierarchy tree is establish in DPE. Typical traversal algorithm usually consists of recursive algorithm and hierarchical algorithms.

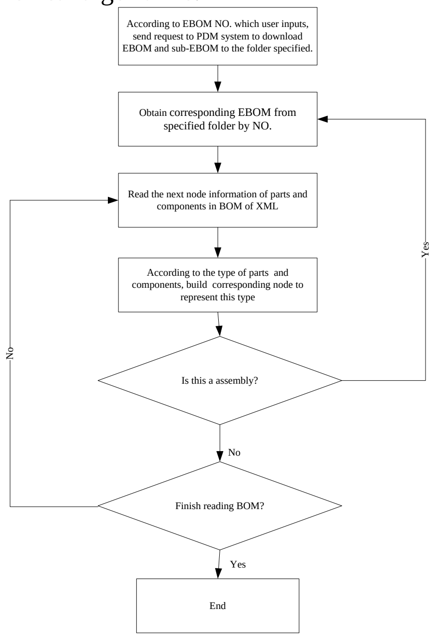

Figure 5. Flowchart of importing BOM in bulk

Recursive algorithm, which makes use of depth-first search approach, takes the product structure tree parts having sub-items or not as the recursive conditions, fully demonstrates the level of relations between parts and the BOM tree structure. The algorithm has the advantage of simple procedures, but because it is a recursive call and is involved with the operation of the stack, the system resource consumption will be great when making deep traversal.

Hierarchical algorithm is adopted the way of breadth-first search, it first visits the root which the number of level is 0, and then visits all nodes which the number of level is 1, and then traverses down layer by layer until finishing visit all the nodes on the final layer.

Because the list of BOM data in the enterprise is more project and less layers (typically 3 to 4 layers), this paper uses a recursive traversal algorithm, which implements traversal and imports feature through establishing sub-function writedata(). Values corresponding to parts attribute can be obtained by the function, getElementsByTagName ("Property Code") provided by DOM. The function can operate XML. According to the attribute value of the nodes from parts in XML form, the appropriate type of nodes are established in DPE, and the corresponding value is added for this node attributes, that is, the value of other property in the label. In DPE, nodes are created by interface functions Data.CreateComponent (), and its nodes attribute value is added by using its interface functions Data.SetAttributebyId (). If parts type is the component of assembly parts, the traversal function can be used to recursive, to read sub EBOM table, to establish child nodes under assembly node, until all the entire EBOM data is imported completely.

The key code of this part as follows:

```
Sub writedata()
……
   Set elemlist=
      xmldoc.getElementsByTagName("Category")
For i = 0  To elemlist.length-1
……
      If elemlist.Item(i).text = "assembly component" Then
Call writedata()      'recursive
  End if
Next
……
End Sub
```

C. Update data

Data update is similar to data bulk import, but the trigger program executes in different ways. Bulk import the data is manually triggered by process engineer on-demand, while data updating process is automatically triggered as soon as process engineers open process nodes to edit. And it is automatically triggered as soon as process engineers have detected related nodes to carry on process design. Schematic diagram of its implementation is shown in Fig .6. When the PDM system's data is changed, it will send modification information to the shared folder designated by system. When process engineers have detected related nodes to carry on process design, the digital assembly process system will automatically search for the latest modification which is relevant to editing process nodes from specified shared folder by system, and if so, it will prompt the process engineers to update the relevant data.

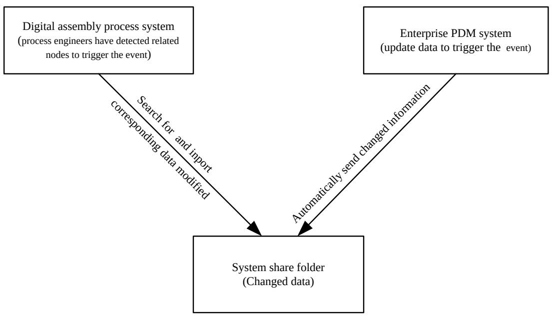

Figure 6. Implementation diagram of data modification

V. MAIN DATA TRANSFERRING PROCESS WITHIN SYTEM

Within the system, there are upload and download 3D models, import EBOM, export documents, and other functions. The following will introduce them.

A. Upload three-dimentional model

Before design process, PDM system should have the necessary 3D CAD models of the number of product parts and components, otherwise, the required number of modules should firstly be uploaded to enterprise PDM system, the upload process is completed by the Java program (program flowchart shown in Fig .7). To realize the function, firstly, we should prepare Excel files with digital model information, then run the PDM system shell and input the relevant commands and parameters in the command line. After the commands executed, in accordance with Excel file information (including number, name, file location, etc.) created in the PDM system, the program calls a function which PDM system provide for the corresponding parts to import CAD documents and to create relationship between parts and CAD documents, so to achieve uploading 3D data model.

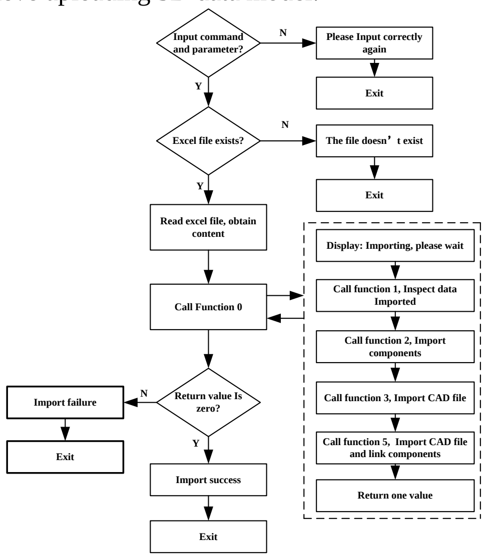

Figure 7. Flowchart of uploading 3D models

B. Import EBOM

During process deign, the data required by process design should be imported from the enterprise PDM system to process design system. They are mainly products EBOM and 3D CAD model files.

The function module should achieve integration between process design system and PDM systems. The integration of the two different systems often implements through BOM table in XML format, which can be divided into two steps. Step 1: download the data model from the PDM system to the system shared folder and form EBOM data tables in XML format (program flowchat is shown as Fig .8); step 2: according to XML format EBOM data table, import data files in bulk from shared folders to the corresponding product nodes in the process planning system (program flowchat is as shown in Fig .9.)

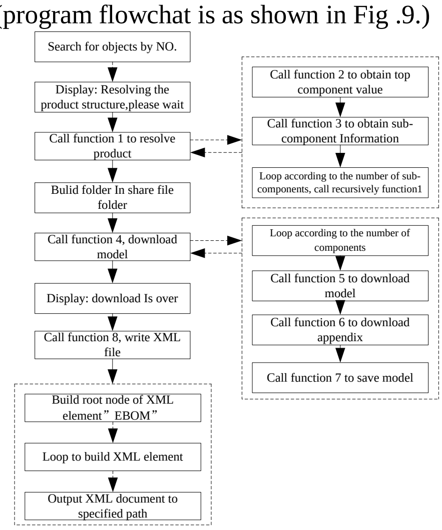

Figure 8. Flowchart of downloading 3D models

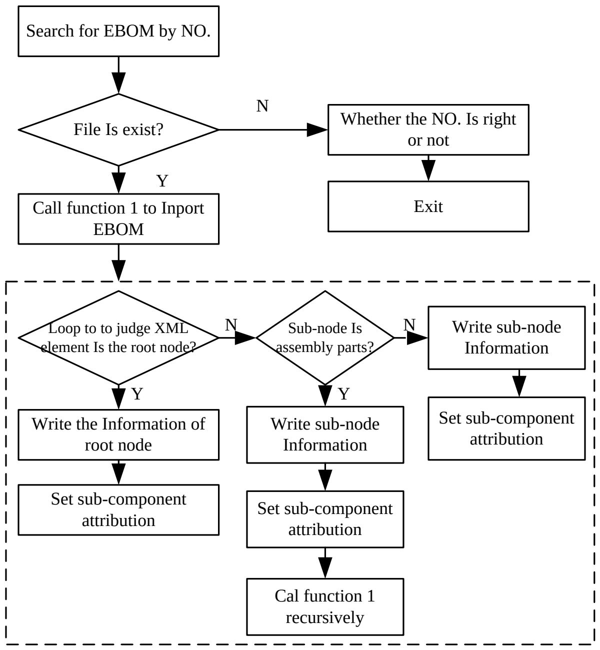

Figure 9. Flowchart of importing EBOM

C. *Process file export*

The function realization process flowchart is shown in Fig .10, the program will package the process file in XML format and the 3D scene simulation file as an appendix into a zip file, then call the function in the format of byte stream to write to the database, and then update or create process documents in the PDM system,.

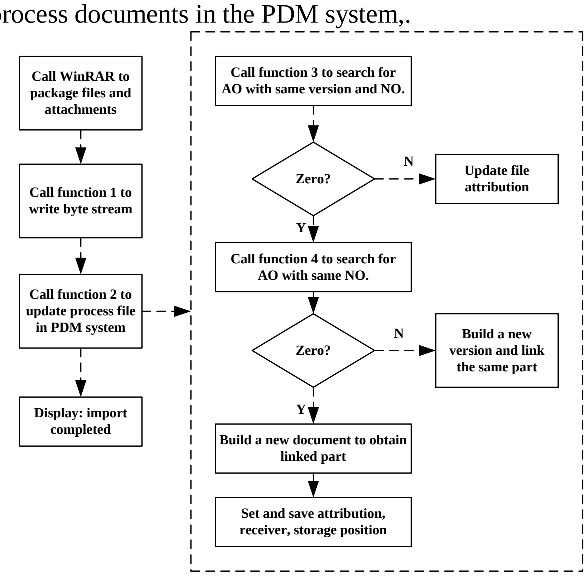

Figure 10. Flowchart of exportting process file

VI. CONCLUSION

In this paper, centering on aircraft digital assembly process system, we studied in-depth the data conversion and integration method of aircraft assembly process system, we mainly do the following works.

(1)To transfer model data from CAD system to integrated virtual assembly environment, we put forward information extraction & model conversion method. In this method, the process of assembly model transformation was divided into two processes, information extraction and model conversion. Model data information was transferred into the VE by secondary development of CAD system and model conversion. The application indicated that the method was feasible and the effectiveness of data transformation was validated.

(2)According to the characteristics of the aircraft assembly process, the hierarchical PPR data model of aircraft assembly process is defined. Based on XML, the conversion among various types of aircraft assembly process data model are implemented, the basis for following tasks of digital assembly of aircraft is provided.

(3)We developed the assembly process system of aircraft， and the system can be integrated with PDM system.

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