Exchange of Product Structure Data between CAD and PDM

Yongjun Jiang
Inner Mongolia University of Science & Technology, Baotou, China, 014010
Email: jxxjyj@imust.cn, address: 7# Areding St., Kun District, Baotou, Inner Mongolia, P.R.China

Abstract: The product data exchange between heterogeneous CAD and PDM systems is a crucial issue for the integration of product development systems. STEP offers an efficient mechanism of product data exchange between heterogeneous systems. This paper introduces a UML-based mapping methodology for the product data models. The suggested mapping method has been applied to exchange the product structure data between a CAD system and a PDM system. Based on the STEP methods, we developed an interface module.

Keywords: Product data exchange; STEP; system

1 Introduction

Manufacturing industry today faces challenges. In order to meet the competition in the market, the information technology has become one of the significant factors [1]. Early introduction of information technology applied computers to tasks previously carried out manually. For example, computer systems such as CAD (computer aided design), CAE (computer aided engineering), and CAM (computer aided manufacturing) have been successfully introduced and increased the productivity. However, the models of these computer systems are heterogeneous because they have been developed independently. The product data exchange between these automation systems becomes a crucial issue for the integration of product development systems. Recently the PDM (product data management) system is being used to integrate these systems into a common environment throughout the product lifecycle. The PDM system also has the problem of exchanging product data with legacy systems, especially with the CAD system that generates the product data. The interface between CAD and PDM systems is considered as an enabling technology for CE (concurrent engineering), CALS (commerce at light speed), and CIM (computer integrated manufacturing).

To integrate a CAD system with a PDM system, we need to develop a data translator. The mapping between the internal models of each system must be defined first. There are four different solutions for the data exchange problem; the manual re-input of data, direct translation, neutral format translation, and shared product database. Each approach has its own pros and cons. Direct translation is the simple and accurate solution, but the number of translators increases exponentially with the number of systems involved. The last two solutions are reasonable, flexible, and adaptable. The product data exchange in this paper is based on STEP (standard for the exchange of product model data).

2 Integration of CAD and PDM systems

PDM is a tool that helps engineers manage both the engineering data and the product development process throughout the product lifecycle. The main functions of a PDM system are the data vault management, the process management, the product structure management, the classification, and the program management [2]. As PDM systems are widely used to reduce the product development time, they need to exchange product data with CAD systems.

It is necessary to integrate CAD and PDM systems, because the CAD system generates the product data and the PDM system manages the product data. The CAD system generates not only geometry data but also product structure data. The management of product structure data is the main function of a PDM system. Without the integration of CAD and PDM systems, engineers would have to re-input the product structure data into the PDM system and update the data whenever it changes.

There are several types of integration between CAD and PDM systems according to the level of integration. The factors that decide the types of integration are as follows.

2.1 Data integration

• Manually re-input the data
• Data exchange using file
• Stand-alone databases but the data is updated automatically.
• Shared database

2.2 User interface integration

• PDM system recognizes CAD files and can launch the CAD system.
• Some PDM functions are available via the CAD menu.
• A new interface independent from CAD and PDM systems.
• Fully integrated interface.

The level of integration depends on the data and the user interface. Figure 1 shows the integration plane of CAD and PDM systems, where the x-axis is the level of data integration and the y-axis is the level of user interface integration. In addition, the openness of the integration system is decided by whether it adopts the standards. Usually a PDM system supports a specific CAD system. If the integration is based on standards, it is possible to integrate with all the systems support those standards.

CIMdata defines three types of integration between a PDM system and an application, which are integration, interface, and encapsulation [3]. Integration provides full, automatic exchange of product data and all the PDM functions are available within the application (or vice-versa). Interface means that the PDM and the application can exchange files without user intervention, and PDM functions are available as the application's menus (or vice-versa). Encapsulation is that PDM recognizes application's files and can launch the application. These three types of integration are also placed on the integration plane of CAD and PDM systems. In Fig. 1, the STEP interface is an interface based on STEP standards. The IMI (IDEAS Metaphase Interface) is a commercial interface between IDEAS CAD system and Metaphase PDM system. If the systems are more tightly integrated, they are easier to use but it costs more. Which level of integration is appropriate should be decided considering the cost, the organization, and user requirements.

2.3 Exchanging product data based on STEP

This section describes how a CAD system and a PDM system can exchange the product structure data based on the STEP standards. Many CAD vendors have implemented the STEP interfaces that exchange AP203 data, but only a few PDM vendors support STEP interfaces according to STEPnet [5] and PDMnet [6] which are the STEP interoperability test bed. To transfer the product structure data created in a CAD system into a PDM system, the following steps are needed. First, the assembly model from a CAD system is converted into a STEP physical file by the pre-processor. This STEP file is then converted into the product structure data of a PDM system by the post-processor. We need the schema mapping between STEP entities and PDM classes on the conceptual level, and the data translator on the implementation level.

2.4 Mapping product structure data using UML mapping diagram

To exchange the product data between a CAD system and a PDM system, the schema mapping on the conceptual level must be considered. In this paper, SDRC Metaphase system is used as a PDM system. Its PSM (product structure manager) module manages the product structure and the BOM (bill of materials). Metaphase is composed of classes. Assembly and Component are the part identification class, and AssmStrc is the relation class of product structure [7]. Fig. 2 shows the mapping between STEP entities and PDM classes of Metaphase based on UML mapping diagrams. The identifier and label attributes of the STEP’s product entity map respectively to the Part Number and Nomenclature at-
tributes of the Metaphase's Assembly or Component class. The relating_product_definition attribute of the STEP's next_assembly_usage_occurrence entity maps to the left attribute of the Metaphase's AssmStrc class for the representation of a parent part. The related_product_definition attribute of the STEP's next_assembly_usage_occurrence entity maps to the right attribute of the Metaphase's AssmStrc class for the representation of a child part.

3 An implementation

3.1 The problem

Recently customized Metaphase PDM system for the implementation of a concurrent engineering environment. Problems were identified as it was launched into the production line. One of the problems is the manual re-input of product data into the PDM system because the CAD system cannot transfer the data. In addition, the data in the PDM system must be updated manually whenever the CAD model changes. To solve this problem, DHI has a plan to introduce the IMI (IDEAS Metaphase Interface) module. It is a commercial tool to transfer the IDEAS's TDM (Team Data Manager) data to Metaphase.

The problems prefers the direct translation such as IMI. It is a simple solution for the specific case, but has two unsolved problems. One is the interface between Metaphase and other CAD systems such as AutoCAD, Catia, Pro/E, and UG. The other is the exchange of product data between Metaphase and other PDM systems. The second problem occurs when a company has two different PDM systems or parts suppliers use different PDM systems. Fig. 3 shows three problems. One is the data exchange between the different CAD systems. Another is the data exchange between CAD and PDM systems. The other is the data exchange between the different PDM systems. Fig. 3 also shows the STEP based solutions. The data exchange between different CAD systems can be solved using STEP AP203, and the data exchange between different PDM systems can be solved using the STEP PDM Schema. The data exchange between CAD and PDM systems can be solved using the STEP based interface, which will be presented in the following sections.

3.2 An experimental exchange of product structure data

According to the mapping between STEP and PDM models, we have developed a data translator which converts a STEP model into the Metaphase PSM instances. The translator has been developed as a Metaphase client program based on the Metaphase API (Application Programmer's Interface) [7]. The STEP assembly model of Fig. 4 generated by AutoCAD is used for the test. This model is borrowed from the CAD data exchange test of STEPnet [5]. The translator reads the STEP file and constructs the product structure according to the local PDM classes.

Figure 3. The problems of DHI and STEP-based solution.

3.3 The STEP based interface

According to the integration plane of Fig. 1, the STEP based interface between CAD and PDM systems uses the independent user interface and exchanges data using files. Fig. 11 shows the architecture of the STEP based interface. CAD models are translated into STEP physical files using the STEP pre-processor provided by the CAD vendor. Then the STEP data is converted into the PDM data using the Metaphase client program we developed. The main functions of this interface are login, check in/out, update, and STEP file input/output. These functions have been implemented using ST-Developer [8] and Metaphase API [7].
Fig. 6 shows the integrated model of the STEP based interface. It consists of a STEP AP203 model, a Metaphase model, and a mapping model between STEP and Metaphase. The mapping model is described in UML mapping diagram. The conceptual models are modeled in EXPRESS and OMT (Object Modeling Technique). The physical data is stored in STEP physical files or the Oracle database.

4 Conclusion

In this paper, we explained how the product structure data of STEP can be exchanged between CAD and PDM systems.

We suggested a UML-based mapping methodology for the mapping between heterogeneous product models. The UML-based mapping methodology has strong points in that it is suitable for any object-oriented modeling language. Also it is easy to use and easy to read because it is a graphical notation. The weak point is that it is not yet computer interpretable, so it needs human interpretation. The computer interpretable syntax must be defined in the future. The choice of mapping language is dependent on the project. EXPRESS-X is suitable for the mapping between EXPRESS models such as the ARM to AIM mapping and the mapping between different APs. On the other hand, the UML-based mapping methodology of this paper is suitable for the mapping between any legacy system and a STEP model.

For the data exchange between CAD and PDM systems, the suggested UML-based mapping methodology has been applied to real data. The various types of integration besides the STEP based interface have been investigated through the integration plane. Integrating a CAD system with a PDM system would be a step forward from the geometry-centered CAD systems. Finally, the STEP based interface has been implemented and applied to the product development environment of systems. The STEP based interface is an open solution for the system integration, so it can be applied to the various CAD and PDM systems.

References