

## **A unified modeling method of manufacturing products**

**Hao Zhang**

*Qinggong College,  
North China University of Science and Technology,  
Tangshan 063000, Hebei, China*

**Qun Wei**

*College of Science,  
North China University of Science and Technology,  
Tangshan 063000, Hebei, China*

**Qihong Fan**

*College of Science,  
North China University of Science and Technology,  
Tangshan 063000, Hebei, China*

**He Li**

*Qinggong College,  
North China University of Science and Technology,  
Tangshan 063000, Hebei, China*

### **Abstract**

The manufacturing of products are related to all aspects in national construction, the formation of global information and marketing makes competition in manufacturing market become fierce increasingly, in the networking manufacturing environment, there are a large number of heterogeneous information sharing and exchange between enterprises. Web technology provides effective means to the products information integration. Product information modeling is a key supporting technology in manufacturing, reasonable product model has the vital significance to the product development and enterprise survival. How to solve the interoperability is a worldwide problem, this paper studies oriented enterprise interoperability of UPM (Unified Product Modeling) modeling framework, proposes a based on XML data, provides a universal, standard, neutral modeling mechanism for different types of products, and establishes a unified data model for development of product in the whole life cycle on STEP international standard .

Key words: INTEROPERABILITY, UPM, STEP, PRODUCT MODELING, MAPPING

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## Introduction

Countries all over the world are more and more economically interdependent, cannot leave the globalization of the market and independent from the development of the national economy, and must be in line with international standards [1-2], make full use of international market information, capital, resources, technology, goods and services, cooperate and benefit mutually and together based on the equal competition. Therefore, the modern enterprise is no longer a single concept, the modern enterprise also includes cooperation partners, suppliers and customers. If you want to achieve the extended enterprise integration, enterprise architecture must involve partners, suppliers and customers in addition to the internal business units, so the interoperability has become the key technologies in the design of the business architecture [3].

In order to make a rapid response to market demand, these expanding enterprises need new system, new tools and techniques to manage the whole process of the product development cycle, which includes customers' need enterprises to explain how to meet their needs, to meet the requirements of the product design, plan about product manufacturing, tools used in the manufacture of components, pre-testing product, manufacturing and the product finally delivered to the customer or to market [4-6]. It need to fully meet the needs of users and minimize the intermediate test and manufacturing cost, various kinds of interests chain and industry chain drive enterprise to find the unified product modeling standard .Therefore, building a kind of product model, as well as how to build a product model to achieve the distributed and networked manufacturing collaborative environment requirements, becomes a research hotspot.

### Summary of product data modeling and mapping based on STEP

Product information model's content: information model of product in simple terms is to reflect the situation of the whole life cycle of

information system products, is the abstract understanding and representation of the product shape, function, performance, technology, manufacturing and management information.

Product information model proposed in this paper is based on information theory and computer technology, with the guide of the modern design methodology, definite and describe product data contents, process data link and an information model in the development of design, performance analysis, process planning, manufacturing, assembly, inspection maintenance sales until the product die throughout the whole life cycle with certain data model. Focused on the overall product design stage to consider the product performance, build CAD/CAE/CAM universal product performance information model, achieve product design information, information analysis, experimental test of information and information sharing and interaction, and give full play to the role of product information model.

With the rapid development of computer application, the modern network manufacturing put forward higher requirements for interoperability between enterprises, reflected in the system within the enterprise as well as the exchange and sharing of information. But the diversification of enterprises and their products caused by differences in product data model of product data management system of each enterprise, between PDM [7-8] systems of different enterprises unable to exchange and share the product data design. In order to solve the above problem, need to establish a unified product information model, this paper proposes a STEP based on UPM (Unified Product Modeling) unified modeling method, provides the basis and guarantee for the realization of enterprise interoperability. The model is used as the database structure, to achieve product information management by using the PB software development tools and SQL SERVER database, in order to verify the proposed UPM model is effective and reasonable.

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### **Product information model is described in EXPRESS and EXPRESS-G diagram**

In recent years, in order to realize the rapid manufacturing, manufacturing conducted extensive research to support the traditional product modeling technology, but not the modeling method to support distributed manufacturing environment in the exchange and sharing of information, this will lead to many problems such as the loss of information, the data format is not compatible and product development process inefficient, then generate integration bottleneck. The unified product model (UPM) can solve these problems effectively, which is based on STEP, consists of four basic components: EDM (EXPRESS data model), modeling environment, the six steps of STEP modeling method and the method of sharing data exchange based on EDM four. Practice has proved that, UPM is compatible, comprehensive, flexible and support the exchange of information sharing. The UPM method based on STEP, can be used to describe the different types of products in different stages of the product development process. The output of the UPM is described in various stages of development of the data model, product data of different types by UPM method can get product information model.

The UPM framework is shown in Figure 1, the whole framework consists of four functional modules:

EXPRESS data model (EXPRESS Data Model, EDM).

Product modeling environment based on STEP.

Six steps product modeling method.

Exchange and sharing of data with EDM.

The four function blocks according to the standard of STEP, the modeling of product resources, protocols and realization method to construct a product modeling environment based on STEP, the STEP environment based on UPM

can be used for modeling, description separately as follows:

1) EDM is the core part of the UPM framework, it defines the data structure of a complete set of products, and by using the standard data format. The EDM module consists of 11 defined EXPRESS schema and STEP AP203. Each schema is defined using the STEP resources or defined by the users themselves are compatible with STEP resources to specific types of product information modeling.

2) Based on the modeling environment using STEP modeling language EXPRESS and graphical description method of EXPRESS EXPRESS-G to the modeling of product structure. Using STEP universal resource modeling STEP definition of product information, and use STEP AP203 to simulate the product geometry information. The modeling environment can also be used in modeling new resources to the definition of STEP product information modeling non.

3) The "six steps" modeling method is EDM support module. This module defines a formal approach to the modeling process of logic programming to complete the task of building EDM.

4) In UPM, there are four methods can realize the data exchange and data sharing EDM, respectively is the exchange of documents, spreadsheets, database and XML file. The exchange of product model users can use any one of those ways to complete the definition of UPM and sharing. The four methods can easily with other application software are integrated together, the product model makes it easy for users to use the application to handle the definition of UPM.

The UPM modeling framework [9-10] provides product unified modeling method, this section uses this framework to computer products, for example, established product development lifecycle based on STEP data model and modeling method is described, the

model can be used for the management of its product development process.

On the relationship between product data in product structure is the most important, because they reflect the basic structure of information products and components. The assembly relationship between products can be a variety of product data organization, the user can conveniently along component parts of the product line access to the needed data. In addition, in the product data management (PDM) system and the traditional CAD system is mostly to the assembly relation of product as the core

content of product structure management. Therefore, the product structure as the main line, the configuration management of product information for the point, the formation of a reflection of product structure information (only including data management, not including the geometric data) the assembly tree, can realize the information integration and information of CAD system and PDM system, PDM system and PDM system sharing.

For illustration, the product information is divided into seven modules, as shown in Figure 1, including:

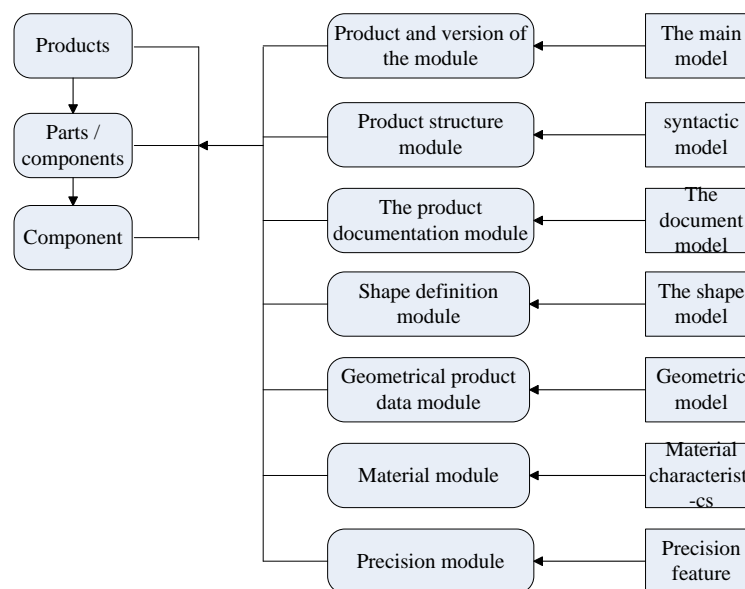


Figure 1. Model library of UPM

Product structure model, the document management features: description model.

Shape defined representation model, geometric model geometric features: description of the project.

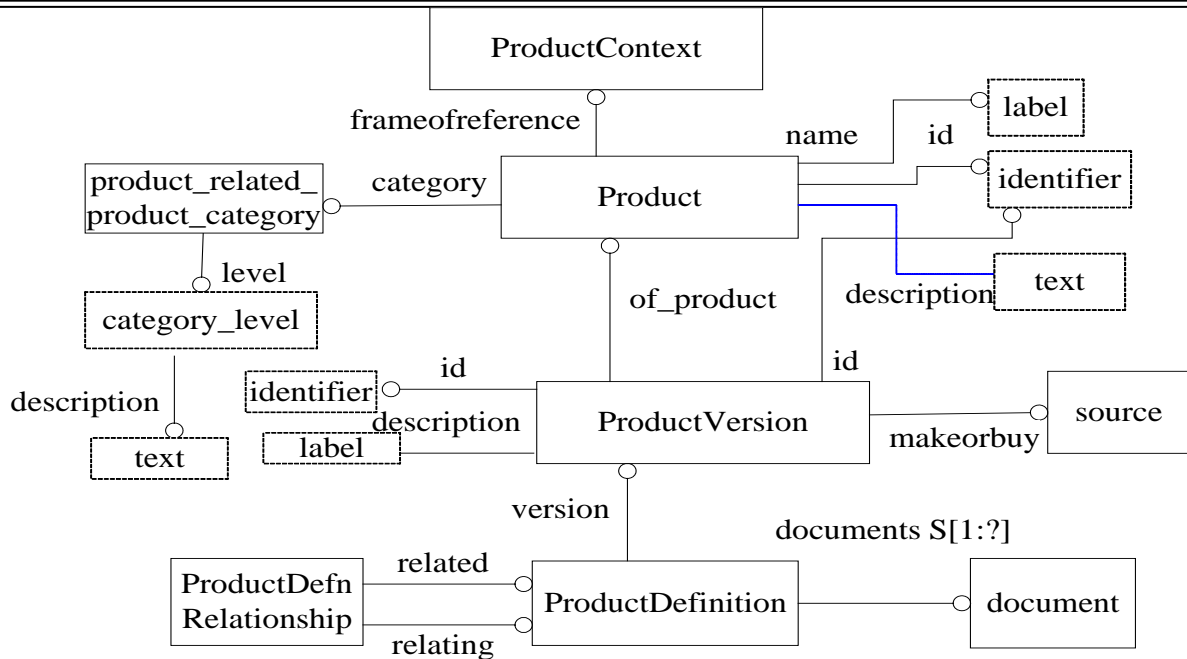
Tolerance model: description precision feature.

Physics and material feature model to describe the physical characteristics.

Each model graph to higher levels of abstraction and simplification of semantic expression and contact data objects with EXPRESS-G[11], said at the same time, gives the corresponding EXPRESS, which the EXPRESS-G map into the form of computer is

easy to handle, can form processing strictly to express the same meaning of the computer information system. (Note: the following EXPRESS-G graph is given in the seven module, product model each graph to have multiple related entities, inheritance and reference to the relationship between description, solid frame representation STEP solid, dashed box for STEP entity attribute types, solid line represents the inheritance relationship between the parent class, subclass entity and entity component reference the relationship between entities, or between the thin solid line represents an attribute and each entity has one or more attributes).

**Products and product version model**



Product and version model, basic information to describe the product, as shown in Figure 2, the model includes:

**Figure 2.** Model of product and version

1) The product model:

The product model to describe the general information, the name of the entity Product, attributes including ID, name, description, frameofreference and category, ID is the product identifier, unique; name is the name of the product; description for a brief description of product features, these three attributes are the string data type. Category points out that the product in the assembly level, described by level and description two properties, is the enumeration type, its value can be one of the assembly parts, components or parts. Frameofreference points out that the application area of the products, such as electronics, machinery, building, data type ProductContext. Description the EXPRESS part of it as follows:

```
ENTITY Product;
product_id:identifier;
name:label;
description:OPTIONAL text;
frameofreference:SET[1:?] OF product_context;
category:product_related_product_category;
UNIQUE UR1:unique_product_id;
END_ENTITY;
ENTITY ProductContext;
```

```
SUBTYPE OF (application_context_element) ;
Discipline_type:label;
END_ENTITY
```

2) the version of the product model:

The version of the product model to describe the version information of the same product in the process of changing, the name of the entity ProductVersion, the main properties of version\_id, description and of\_product, version\_id is the version identifier, unique; description the brief description of the product version; makeorbuy points out that the product version is homemade or purchased parts; of\_product points out that this version belong to which object. A product can have multiple versions, so the associated with multiple class ProductVersion phase. Description the EXPRESS part of it as follows:

```
ENTITY ProductVersion;
version_id:identifier;
description:OPTIONAL text;
of_product:Product;
make_or_buy:source;
UNIQUE
UNIQUE UR1:unique_product_version_id:id;
END_ENTITY;
```

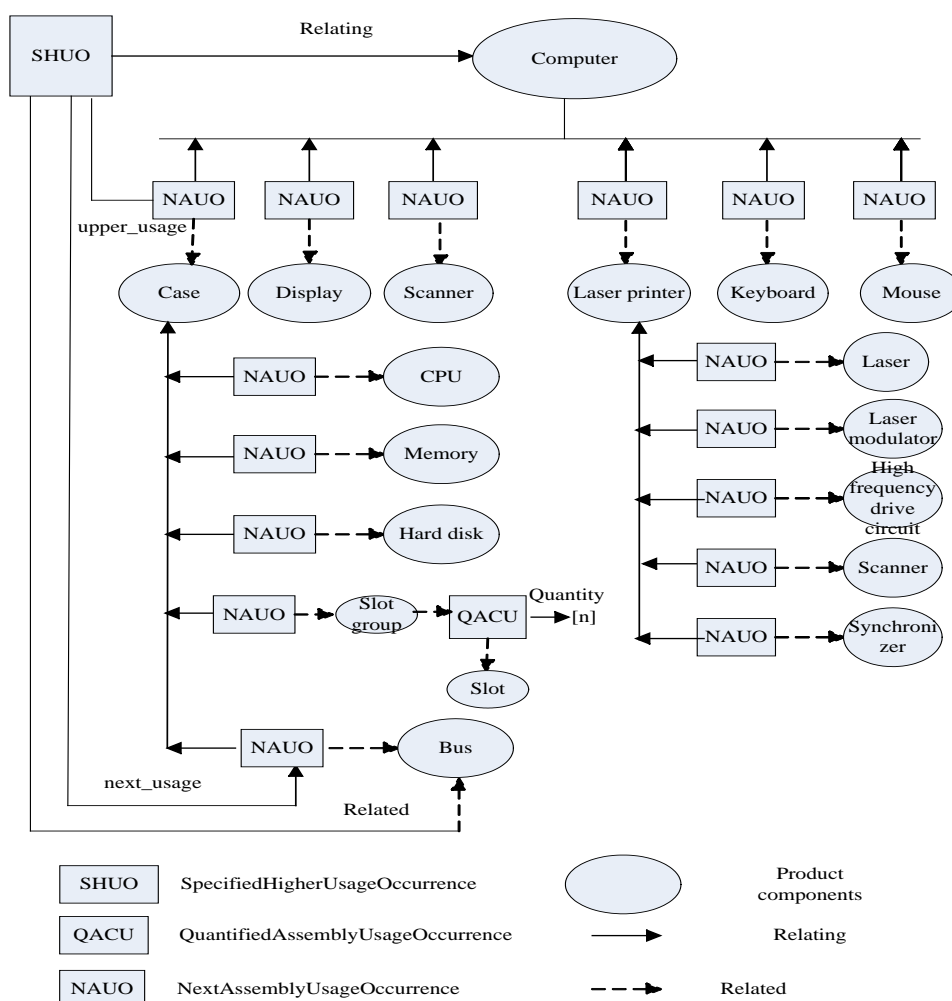


Figure 3. Relationships of computer product

The final product relationship (abbreviated as SHUO), the description of the direct relationship between a component and its ultimate parent product, it is also from the super class ProductDefnRelationship inherits the properties of relating and related, meaning. In addition, the class also has two proprietary property of upper\_usage and next\_usage, upper\_usage relating specified in the ProductDefinition instance is associated with a NextAssemblyUsageOccurrence, a NextAssemblyUsageOccurrence next\_usage related specified in the ProductDefinition instance associated. As shown in Figure 3, the bus master component is directly connected with the computer through the SHUO, upper\_usage corresponding to the NAUO instance is the assembly relationship bus and computer,

next\_usage corresponding to the NAUO instance is associated with a host of assembly relationship bus.

### UPM relationship between relational database tables

UPM product information model and EXPRESS model, each entity has multiple attributes, at the same time between each entity has all kinds of constraints. The mapping process in the UPM product model to relational database, need to be constrained entity attributes and entities are reflected in the database table and the relationship between, method:

- 1 The EXPRESS entity and its attribute mapping to the database table;
- 2 The mapping relationship between different EXPRESS entities to the corresponding data tables in the database.

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For the first kind of mapping, physical properties are mapped into the field of database table, the name and data type field is completed by defining the mapping properties, second kinds of mapping is described by the primary key, foreign key between database tables. As shown in figure 4, Using the above two rules can be based on the establishment of a description language in EXPRESS product information model in relational database. Such as product

structure information model entities Assembly Component Usage and Make\_From\_Usage\_Option is mapped to a database of products corresponding description of the product form relation database table, two physical properties are mapped to the corresponding fields of a database table, the relationship between two entities are mapped into the relationship between database tables.

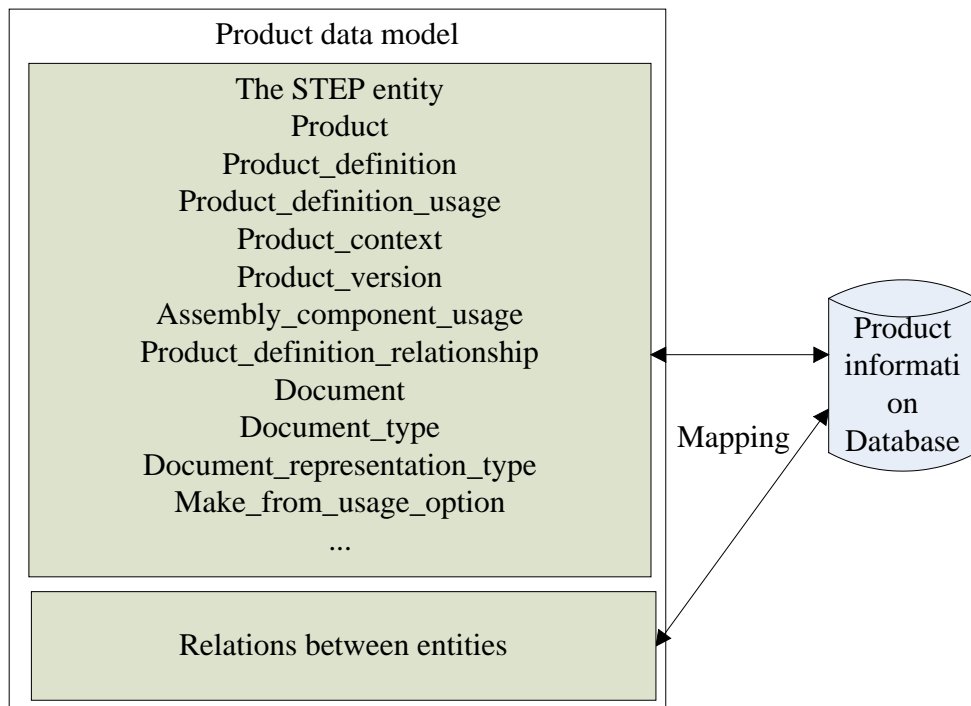


Figure 4. Mapping between product information model and database

In the design of relational database, a work of the most important is how the data elements will be assigned to each relation data table. Upon completion of the classification of the data elements, the relationship between the operation of the data will depend on these data table, through these relationships, that data can be a meaningful way together. For example, a product product information may correspond to multiple products constitute relation record, using two data relationships between tables, can also display the product more manufacturing or assembly relationship, creating product structure tree. If a data sheet is based on relational

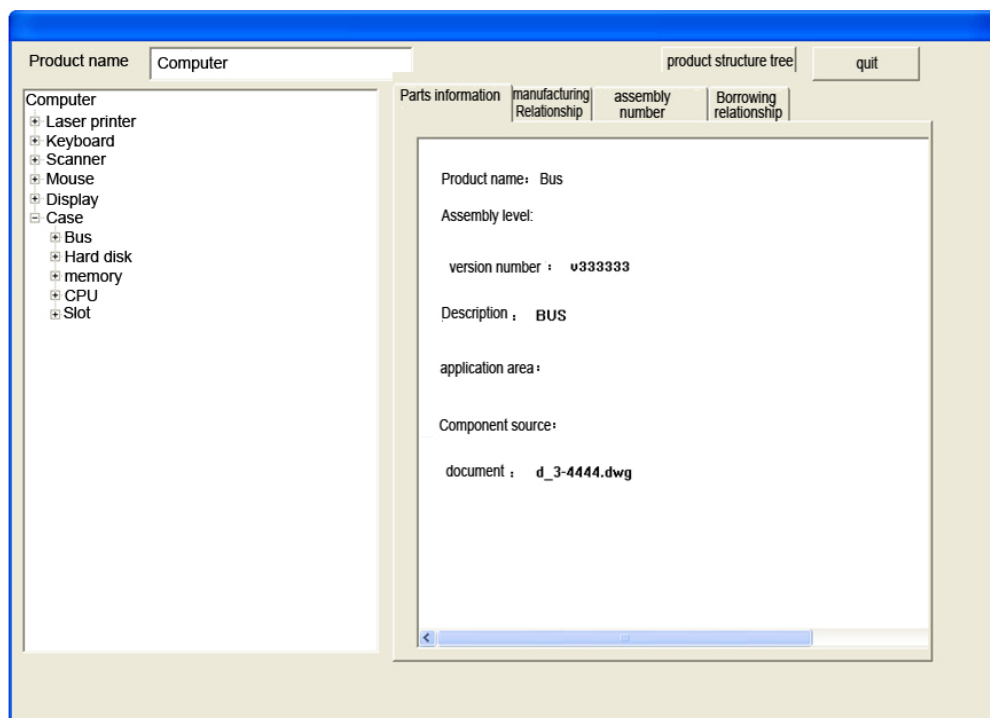
database of words, so the relationship between the data table is the cornerstone of the basic.

### XML document mapping

Product structure browser is to show the product structure based on product structure tree form, so that more intuitive, clear understanding of the product. If the sequence from bottom to top, a group of components interconnected according to the assembly relation of specific assembly is components, parts and components of a series of assembly together constitute the product; in sequence from top to bottom, the products in accordance with the component decomposition, components are further decomposed into the component and parts, until

parts, resulting in a hierarchical tree structure, called product structure (tree), product structure tree is a reflection of the hierarchical model. The product structure tree, managers can be stratified branch of intuitively find their required data, regardless of its physical location. The product structure tree each node represents one product or one of those parts, each node has the various

parts of the corresponding properties. Through the product structure tree, all kinds of data related to the product (such as product attributes, manufacturing information, assembly information and information etc.) organically linked together, so that the organization and management of data becomes very easy, data relationship more clear.



**Figure 5.** Operation interface for users

Implementation of the main menu in the "product structure browser" menu, open the product structure browser window, the program interface as shown in figure 5. First in the product name input field enter the product name, and then click "display product structure tree" button, the left side of the data window will display the product structure tree. If you want to display detailed information on a tree node, with the left mouse button click on the node in the tree structure, data window displays detailed information of the node tree structure at the same time, the four data window on the right side of the tab page also shows the node part master information, production information, assembly information and information the window around each other, information control, can more clearly,

to display the product structure tree information and detailed information.

### **XML mapping file to import:**

Export this operation is performed and the XML mapping file instead of the operation, the product information is the data bus type computer host part of, with data transmission function. According to the database structure of the above product information, including four kinds of information, are the main information products, manufacturing information, assembly information and information, corresponding to the four XML files, file names are the nodes of the product ID + "\_product.xml", the node of the product identification + "\_manu.xml", the node of the products ID + "\_assem.xml" and the node product ID + "\_use.xml", at the same time four

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XML file corresponding to the four XSD files, the contents of the XSD file with the same file content, respectively:

Product main information contents of the XML file as follows:

```
xml version="1.0" encoding="gb2312"
standalone="no" ?>
<data
xmlns:xsi=http://www.w3.org/2001/XMLSchema
a-instance xsi:noNamespaceSchemaLocation="3-
4444-2_product.xsd">
```

```
<data_row>
<product_id>3-4444-2</product_id>
<name>data bus</name>
<product_product_description> Bus to transfer
data
</product_product_description>
<product_version_id>v333333</product_versio
n_id>
<product_document>d_888888.dwg</product_d
ocument>
```

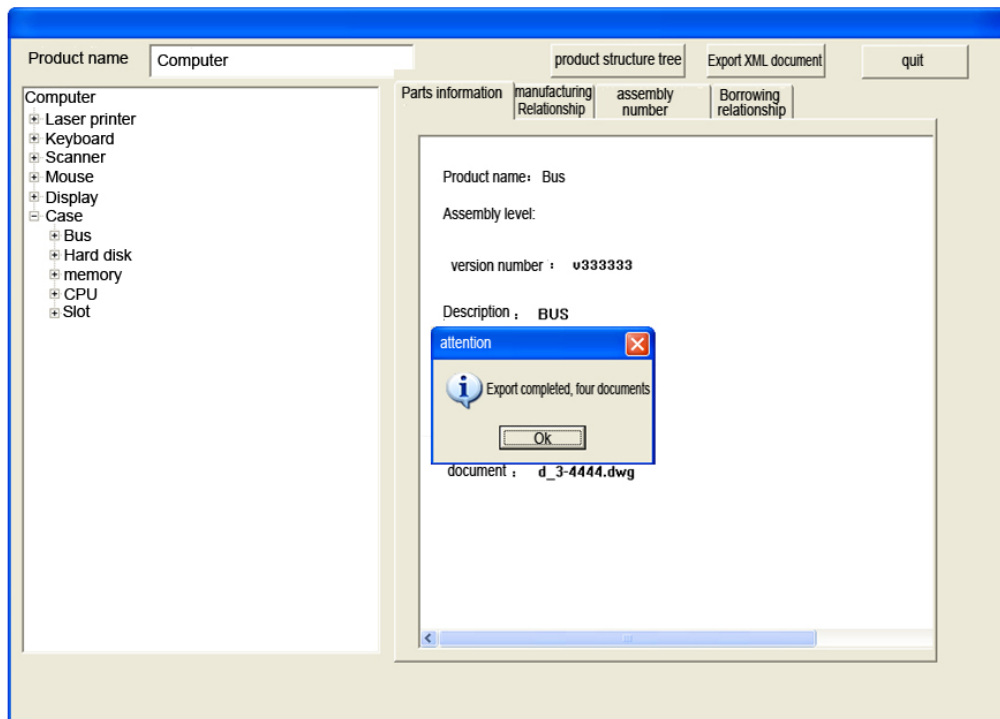


Figure 6. XML file deriving

## Conclusions

In order to achieve the enterprise interoperability between member enterprises, product data sharing and exchange is the basis. However, the model structure among the members of each are not identical, the format of the conflict will lead to the exchange and sharing of data is not sufficient, the useful data will be lost, so the product model is not compatible with the collaboration between enterprises become the obstacles to development of new modeling method to establish a unified product model is highly compatible. Therefore, this

paper studies a kind of unified modeling method of UPM based on STEP, the establishment of product information model for enterprises.

In the product after the establishment of the model, but also some processing in data storage and exchange. In the aspect of data storage, based on the STEP model has the features of object oriented, the information management system for better and other manufacturing industries (such as ERP, CAx etc.) of the underlying database integration, this paper will describe the UPM product information model based on EXPRESS language into relational data

model. At the same time, in the exchange of data in the network, for better sharing and exchange of product data model, the information model mapping has been transformed into the relational model XML. This paper implements the relational database as the storage method, data management method in XML format for data exchange medium.

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