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PRODUCT STRUCTURE DIGITAL MODEL

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Research results of representation of product structure made by means of CADDS5 computer-aided design (CAD) system, Product Data Management Optegra (PDM) system and Product Life Cycle Management Windchill system (PLM), are examined in this work. Analysis of structure component development and its storage in various systems is carried out. Algorithms of structure transformation required for correct representation of the structure are considered. Management analysis of electronic mockup presentation of the product structure is carried out for Windchill system.

Introduction

Requirements of quality improvement, as well as development acceleration of a complex technical product (such as a ship, a plane, an automobile), have resulted in wide use of information technologies. One of the basic criteria of information technologies application usage is a new information object development. Such new information objects may be referred as electronic data objects of any kind. First of all, automation of product designing processes has resulted in usage of CAD systems. CAD systems were the pioneers of the electronic product definition development. Product geometrical mock-up consists of part models and assembly structure models. Each of the models is presented as electronic data. Being used in science-intensive and complicated projects, these models require ordering and control. Data obtained from CAD-systems must be stored and coordinated. To utilize the data, access rules must be determined for the users. Enumerated tasks are carried out by means of the Optegra PDM system and similar systems. Enlargement of an electronic product definition compound demands wider spectrum of EPD-objects modification control and accountability. Information objects require support and control of modification. CAD system data become a segment of the electronic information objects. A decision of an integration task is obtained with the systems like Windchill PLM.

Problem statement

The aim of the research is:
– to determine specificity of assembly structures developed within CADDS5/Optegra/Windchill systems;
– to develop algorithms of structure presentation and transformation providing adequacy of the structures.

Electronic model of a Product

A product's mockup provides a new kind of a product model presentation. New objects are added. Electronic media (EM) are used as information-carrying media. Design work results are presented as electronic design documents. The documents are a structured dataset [1].

This dataset consists of property part, data content and electronic digital signature (signatures). The documents can be processed, stored, transferred and used both in them hardcopy and digital media.
Electronic technical document structure consists of property part and data content (table).

Electronic technical document structure

<table>
<tr><td colspan="2"><HEADER>
<Attribute 1>: Value
<Attribute 2>: Value
…
<Attribute 3>: Value
<Digital Signature>
</HEADER></td><td>Section: Properties
Identification and authentication attributes</td></tr>
<tr><td>Information Unit 1</td><td><DATA>
<HEADER>
…
</HEADER>
<DATA>
</DATA>
</DATA></td><td rowspan="4">Section: Content
Information Unit described electronic technical document</td></tr>
<tr><td>Information Unit 2</td><td><DATA>
<HEADER>
…
</HEADER>
<DATA>
</DATA>
</DATA></td></tr>
<tr><td></td><td>…</td></tr>
<tr><td>Information Unit n</td><td><DATA>
<HEADER>
…
</HEADER>
<DATA>
</DATA>
</DATA></td></tr>
</table>

Mandatory attribute of the ETD property part is a digital signature (DS) providing legitimacy of the document.

Assembly structure digital model

Electronic model of a part designed in CAD system is an electronic design document. Data content of the document determines the part geometry as well as production and control requirement.

Two objects of electronic definition determine an assembly. Assembly model is a structured dataset. The assembly is determined completely and unequivocally with the dataset.

"Specification" component of a model is supplemented with an electronic product structure. The later is an electronic design document which data content reflects the product structure in a tree graph form. A top node of the graph corresponds to the product. The intermediate nodes correspond to the product assemblies, their complexes and/or kits. The bottom nodes of the graph correspond to the product parts and, finally, the graph edges determine connections of compound parts hierarchy.

Assembly structure made in CADDS5/Optegra environment

Assembly structure made in CADDS5 [2, p. 1-10] environment is presented as a graph (not containing reference assemblies).

Designation of the graph vertex (root component) corresponds to the designation of the assembly. The components corresponding to the assembly parts are placed at the graph nodes. Depending on the simulation requirement development of assembly unit structure of two kinds is possible. These structures may be divided into single-level (fig. 1, *a*) and multilevel (fig. 1, *b*) according to subordination.

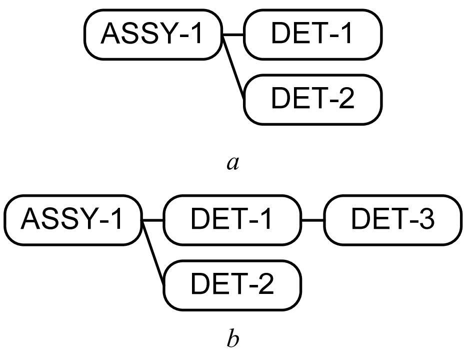

Fig. 1. Single-level (*a*) and multilevel assemblies (*b*)

Multilevel assembly use provides possibility to manipulate mutual allocation of parts in space.

The whole information of part (component) mutual orientation, as well as their interconnection and their quantity is stored in the same information object. This object is an assembly. Aforementioned is independent from the kind of component hierarchy in the assembly. An assembly (CADDS/CAMU data type) is an electronic object describing both electronic mockup and electronic structure. Information storage, as well as its change, is carried out by means of a single file editing. The only part models are external (i.e. these models are independent from the point of view of structure change).

Data management provided with the Optegra system is implemented at information object level (i.e. at file level). Assembly structure is presented as a single information object describing each of incoming components (except reference assemblies). It means that a part is not an object, which affects to the product structure.

The assembly determines the last one even if no part is included into the assembly.

Assembly structure made in Windchill environment

Windchill system [3, p. 214] is based upon management of each object describing a product. Root component of assembly and part components are joined by links (fig. 2).

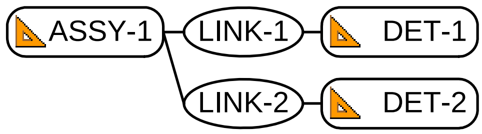

Fig. 2. CAD data structure presented in Windchill system

Windchill graph edge is evolved into a single object unlike the Optegra system. From the point of view of the user, the edge, as an object, is invisible. But it is the edge that determines object interconnection.

CAD data are presented as EPMDocument (fig. 3).

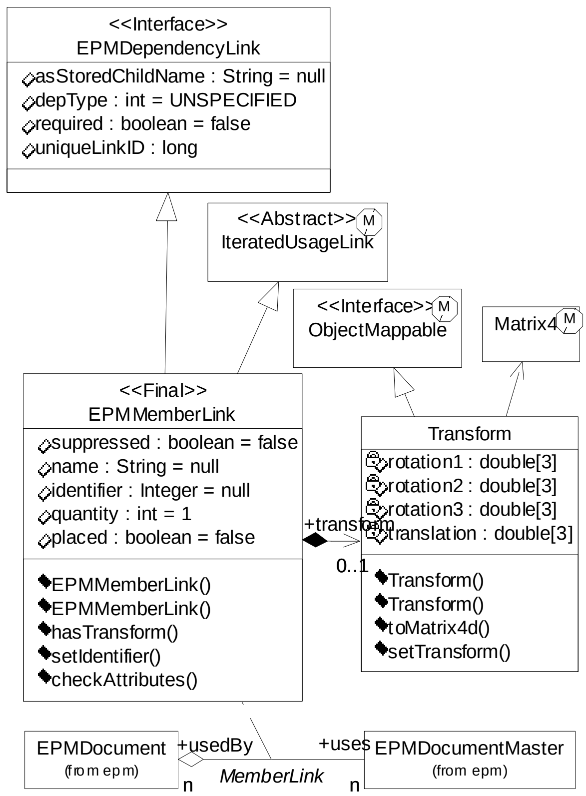

Fig. 3. UML-notation of EPMDocument link model

Variety of CAD data types does not lead to the Windchill data types variety development. CAD data type became one of the EPMDocument attributes. This means

CAMU = EPMDocument (type = assembly)

Part = EPMDocument (type = part)

The structure developed within the Windchill system corresponding to that shown in fig. 2, means availability of EPMDocuments ASSY-1:

DET-1

DET-2

And edges as well. The latter ones are described with EPMMemberLink objects:

LINK-1 (ASSY-1 == DET-1)

LINK-2 (ASSY-1 == DET-2)

Neither EPMDocument assignments, nor their names indicate availability of any interconnection between the objects. The interconnection availability may be determined by means of "parent" and "child" attributes of EPMMemberLink-objects describing the edges.

Mapping of various system structures

A part is an indivisible element of a structure. Part's development with CAD-system, as well as its storage within PDM-system, and information transfer to PLM-system, do not require any manipulations from the point of view of the structure developer.

A single-level structure (fig. 4, *a*) transfer will result in creation of the following objects:

ASSY-1

DET-1

DET-2

DET-4

LINK-1 (ASSY-1 == DET-1)

LINK-2 (ASSY-1 == DET-2)

LINK-3 (ASSY-1 == DET-4)

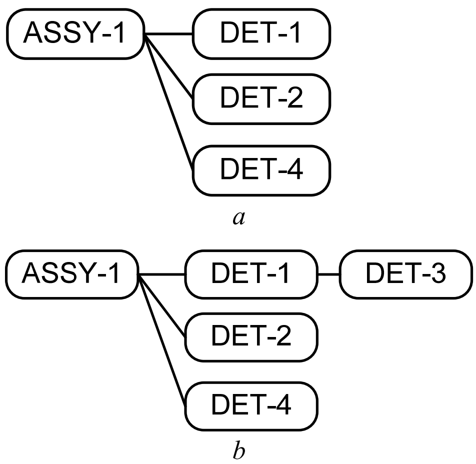

Fig. 4. A single-level (*a*) and multilevel (*b*) assembly structures transferred to the Windchill system

When the structure graph is displayed, the system indicates a tree, which properties and a view comply with fig. 4, *a*. We can see the result for this tree in fig. 5, *a*.

If we have a source multilevel structure (fig. 4, *b*) with addition component, the result of transformation to the Windchill system of this structure will look like fig. 5, *b*.

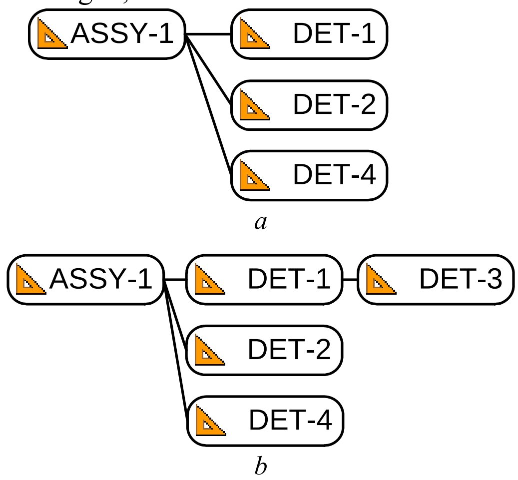

Fig. 5. The Windchill system assembles graph according to a single-level (*a*) multilevel (*b*) assembly structures

There are no differences in the graph structure. And this is quite right. The mistake is in assembly structures, which will be developed in the Windchill system later. The structures will include the objects previously developed. This means that two EPMDocuments (DET-1 and DET-3) are already interconnected. The interconnection is determined for the project in whole, not for any assembly.

The subsequent publication of the assembly type (fig. 6) into the Windchill system will yield other results.

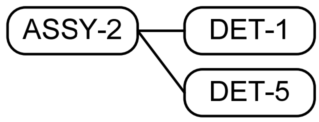

Fig. 6. Assembly structure which includes an existing part

Such representation of the assembly structure (fig. 7) is incorrect.

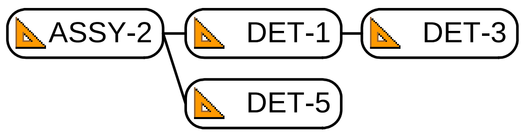

Fig. 7. Assembly structure in the Windchill system, containing already existing part

Because in the Windchill environment two object DET-1 and DET-3 are linked forever. Development of algorithms of assembly adequate representation is required.

Transformation algorithm

Aforementioned research results have lead to the structure transformation necessity.

The algorithm (fig. 8) given below provides treatment of those assembly structures, which have been developed in CADDS5/Optegra environment [4, p. 7–18] previously (i.e. before the structures were placed in Windchill environment).

Series of subroutines have been developed on the basis of the given algorithm.

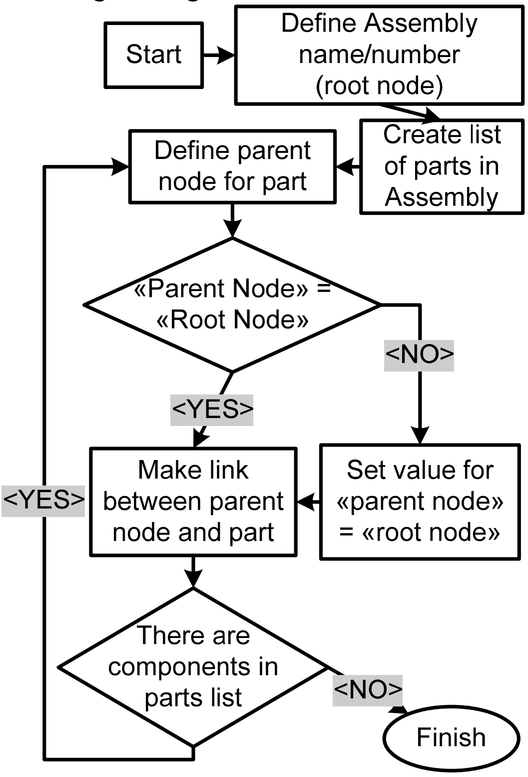

Fig. 8. Algorithm of assembly structure treatment

The subroutines allow processing of such kind transformations at publication of CADDS5/Optgera data in the Windchill environment. Using this algorithm, the structure shown in fig. 4, *b* will look like the assembly shown in fig. 9. The assembly parts membership is preserved by application of the algorithm.

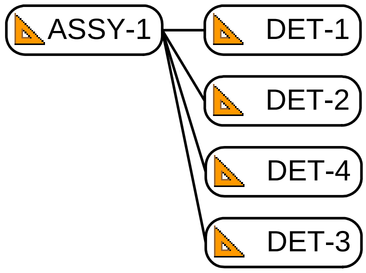

Fig. 9. The Windchill system assembly graph produced with the transformation algorithm

Conclusion

Necessity of state-of-the-art PLM system implementation is a result of enlargement of the EPD information objects' list. Data developed with CAD- and maintained with PDM-systems, are integrated to the PLM-system. Methods of assembly structure representation in the various systems have been obtained during integrating works. Recommendations and algorithms of assembly structure transformation have been developed for data publication. This work has permitted to carry out assembly structure integration in the Windchill system.

Literature

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Електронна модель структури виробу

Розглянуто результати дослідження подання структури виробу (складальних одиниць) у системі САПР (CAD) CADDS5, системі керування проектними даними (PDM) Optegra, системі супроводу життєвого циклу виробів (PLM) Windchill. Проведено аналіз створення й зберігання компонентів структур у різних системах. Наведено алгоритми перетворення структур для їхнього правильного подання. Дано аналіз керування поданням електронної моделі структури виробу в системі Windchill.

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Электронная модель структуры изделия

Рассмотрены результаты исследования представления структуры изделия (сборочных единиц) в системе САПР(CAD) CADDS5, системе управления проектными данными (PDM) Optegra, системе сопровождения жизненного цикла изделий (PLM) Windchill. Проведен анализ создания и хранения компонентов структур в различных системах. Приведены алгоритмы преобразования структур для их правильного представления. Дан анализ управления представлением электронной модели структуры изделия в системе Windchill.