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A method for transformation of engineering bill of materials to maintenance bill of materials

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ABSTRACT

In order to solve the transformation problem of Bill of Materials (BOM) from engineering BOM to maintenance BOM for Maintenance, Repair and Overhaul (MRO) systems, a formal transformation model of BOM view is proposed. In this model, the intermediate component, inherited component, virtual component are defined in the specific maintenance management domain, and the transformation process from engineering BOM to maintenance BOM is discussed through feature recognition methods and rules. The proposed transformation model has been developed and deployed in an MRO system for a steel manufacturing enterprise.

1. Introduction

Nowadays, enterprises are confronted by challenges arising from continuous innovations, global collaborations, and complex risk management. Companies strive for technological innovation and more efficient management methods to improve production efficiency and reduce production costs. For example, in the steel manufacturing industry, a variety of large-scale steel-making equipment needs maintenance, repair and overhaul (MRO) for ensuring the production process, and many kinds of important data and MRO service activities need to be recorded. Therefore, MRO management systems have been developed to manage equipment, MRO service activities and data [1].

During the past few decades, the manufacturing processes have been becoming more and more intelligent and the manufacturing equipment has been more complicated, many information systems have been introduced into enterprise management process, such as Enterprise Resource Planning (ERP),Supply Chain Management (SCM),Computer Aided Design, Manufacturing, Assembly(CAX), Product Lifecycle Management (PLM), and MRO [2,3]. In the above systems, the Bill of Material (BOM) is an important structure of product. It can integrate product data through the product life-cycle, and it has been used as a hub of product data for product design, production planning, procurement, maintenance and repair [4].

For the maintenance, repair and overhaul of the manufacturing equipment, the product manufacturers can choose different MRO service providers and the various parts of the equipment may be sent to the different MRO service providers for maintenance. In the equipment maintenance process, the MRO system is able to monitor and record the maintenance procedures of all parts and help manufacturers to make better decisions for production planning, equipment maintenance and repair. Moreover, many maintenance data files should be added into BOM to record the maintenance activities throughout the product lifecycle [5], in which the Engineering BOM (the engineering BOM is constructed by the design department) or the Manufacturing BOM (the manufacturing BOM is developed for the manufacturing process by production department) should be transformed into a MBOM (BOM for product Maintenance designed by the maintenance department). Therefore, the MBOM and maintenance service activities corresponding a physical part are the most important parts of serving equipment in the maintenance process.

Usually, this transforming process from EBOM to MBOM is very complex and time consuming, and is not fully automated because each maintenance worker and the concrete maintenance operating conditions should not only be known early, but also the track parts and non-track parts logically determined by the maintenance workers should be differentiated into the inherited parts, the intermediate parts, and the virtual parts stored in MRO system before transformation. However, The MBOM can be achieved by transforming from the Engineering BOM using some transformation methods and rules under help of some human-computer interaction process.

In this paper, we propose a formal transformation model of BOM and some transformation methods and rules from Engineering BOM

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(EBOM) to Maintenance BOM (MBOM) for MRO Systems. The remainder of the paper is organized as follows. Section 2 presents a brief research literature review; Section 3 describes the proposed BOM transformation method; Section 4 discusses in details the transformation of EBOM into MBOM using feature recognition methods and rules; Section 5 presents a case study; Section 6 summarizes the contributions of this work and outlines some future research issues.

2. Literature review

With the increasing application of ERP systems in China, BOM has been playing a more and more important role in the manufacturing enterprises [6]. The transformation and maintenance of BOM will have the most direct impact on the operation of manufacturing enterprises. BOM has also become a key factor to improve the competitiveness of enterprises. Companies also recognize that BOM research gradually separated from the ERP and accurately completed enterprise product data information collection, summary statistics, analysis and output [7,8].

There have been a number of studies on the method of BOM transformation and BOM view converting. Liu et al.[9] developed a method of BOM transformation based on feature identification to transform engineering BOM to manufacturing BOM, but this method did not resolved the transformation between engineering BOM and maintenance BOM. Wang and Si [10] solved the maintenance BOM problems for complex equipment by building the network structure model of maintenance BOM based on the maintenance structural factors information. Lee et al. [11] discussed rules of transformation based on a clear analysis of the relationship between engineering BOM and manufacturing BOM. Zhang et al. [12] described the characteristics of maintenance BOM and proposed an integration method based on XML technologies, but their study only focused on maintenance BOM without engineering BOM or the process of converting engineering BOM to maintenance BOM. Geng et al. [13] developed a metric method for the BOM similarity.

According to the actual requirements of the manufacturing enterprises and the state-of-the-art of the BOM research, the following two important issues need to be addressed:

(1) BOM multi-view mapping tool. Due to the different needs of the different departments of the BOM, there are a number of BOM types, including design BOM, engineering BOM, manufacturing BOM, and maintenance BOM. The links between these BOMs and their views lack enough studies, and the existing software tools cannot meet the business needs [14].
(2) BOM validity and consistency. A variety of different BOM views are used in enterprises. Maintaining consistency of these views is a major challenge and needs to be addressed.

3. BOM transformation framework in MRO

Bill of materials (BOM) is the product structure data file which computers can recognize and link all the business processes of an enterprise [15]. BOM forms the fundamental data of the PDM/MRO systems and other information systems. BOM structure has a significant impact on the performance of these systems. Therefore, it is very important to establish a reasonable and valid BOM framework.

BOM views are different in different application systems, including Design BOM in CAD, EBOM (Engineering BOM) in PDM, MBOM (Maintenance BOM) in MRO. EBOM is used to represent the structure of the product at the design stage. Production department of an enterprise uses EBOM to manage bills of materials to launch a new production. EBOM extracts the relative data from design drawings, including product name, product structure and relationships between parts of the assembly properties. Fig. 1 shows the EBOM with three levels. In rectangle shape, the component name is represented by the letter, and the number denotes the number of the sub-assemblies or sub-parts. M as the root node is made up with one A, one B, one C, one D, one E, one F, and one G. A/1 represents one A, B/1 represents one B, etc. one B is made up with one B_1, one B_2, and one B_3. B_1/1 represents one B_1. B_3 is made up with two b_1 and three b_2. B_1 and F_1 are virtual components. B_2, G_1 and G_2 are intermediate components.

MBOM is applied for the management of equipment maintenance by the maintenance department in an enterprise. MBOM is mainly based on the EBOM. It reflects the products and equipment maintenance business logic. However, MBOM is more complex than EBOM, because the relationships of equipment maintenance processes should be added up to the structural relationships of the parts [13]. Fig. 2 shows the MBOM, which is constructed according to the EBOM as shown in Fig. 1. Part D and part E are the inherit components, and H is the intermediate component.

There is some fundamental difference between EBOM and MBOM: EBOM is a kind of technical design BOM, and MBOM is a kind of management BOM. In addition, the hierarchy relationship of parts and components in MBOM must be the reflection of the actual maintenance processes, and therefore transformation from EBOM to MBOM is important and necessary.

MBOM in the MRO system is divided into Neutral BOM and Physical BOM as shown in Fig. 3. This figure is made up with five modules which are also the main modules of an MRO system. The first module is the Neutral BOM which is the key to the transformation framework. This module comprises of the part relationships and the defined attribute types. The Physical BOM module, which comprises of same part relationships and the concrete attributes, is generated from the Neutral BOM. History Record Module is used to record all the detail maintenance information when parts are offline or online. The Service Management

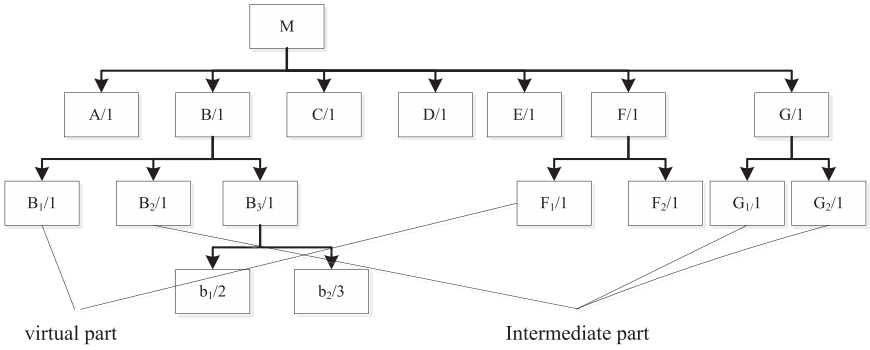

Fig. 1. EBOM.