Product Data Quality Control for Collaborative Product Development

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ABSTRACT
Since the rapid development of information technology and the trend of business globalization, product development independently performed by an enterprise becomes more difficult to meet the market demand. Therefore, the enterprise begins to develop new products collaboratively with partners in the supply chain to improve productivity. In this kind of environment, various data types may cause problems of data access and transformation. As a result, research works focused on product data quality are gradually paid attention. To solve the above problem, this paper proposes a framework of controlling product data quality for collaborative product development. A prototype is tested in a hand tools company located in central Taiwan to examine its product data quality control during the product development process.

Keywords: Product data quality, collaborative, product development

1.0 Introduction

The business competition between industries becomes more severe due to the globalization and broad application of information technology. It is not sufficient for an enterprise to use independent product development procedures to meet the changing environment. Therefore, the enterprise begins to develop products collaboratively with partners in the supply chain to enhance production capability. In a collaborative product development environment, product data shared by various partners include documents, drawings and files with different formats. In addition to security problems during data access, product data quality is also an important issue required to pay more attention. For example, product data transfer between different CAD tools usually generates the problem of incorrect data interpretation which causes delay of product development. Other problems resulted in product data quality in collaborative environment can be found in product data inconsistency and data loss. In this situation, more time and cost are wasted due to poor product data quality.

To solve the above mentioned product data quality problem, a framework of controlling product data quality is presented in this research. This framework is composed of 1) original data model, 2) exchange data platform, 3) product data family, and 4) function repository. Product data transformation in a collaborative product development environment is examined to check the process of product data quality assurance. When product data is transformed between enterprises based on required collaboration, definition of product data quality is first generated by the system and used as the criteria for the following tests. Match of original product data and that after exchange is then triggered to assure the completeness of product data transformation. Product data is treated as an "information product" to trace the process flow. XML format is applied to represent the required specification of product data transformation. A flexible product data quality control system can be reached through this representation scheme and the proposed framework. The advantage of this approach is to improve product data quality for collaborative product development without consideration of software tools. An interface for collaboration is also developed in a web-based system to motivate the commitment of system users to ensure product data quality. A hand-tools company located in central Taiwan is used as a case study to examine the product data quality control. In this paper, the background of the case study is initially introduced. Product data types and related product data quality (PDQ) issues are discussed before describing the proposed product data quality control system. As a conclusion, suggestion based on current development is presented.

2.0 Background of the case study

The case company, anonymously indicated by "K Group" in this paper, was founded in 1984. It produces professional tools and D.I.Y. tools with its well-known brand name throughout the tool industry. In 1998, K Company received the Certificate of ISO 9002 followed by an effort of receiving the Certificate of ISO 9001(2000) in 2004. To offer better service and understand the international customer's needs, this company operates its branch offices in France, Germany, Mexico and China. In recent years, K Company continuously reengineers its business processes through business alliance and series of acquisition to form as the K Group for expanding its market shares. Currently, the K Group has four subsidiary companies and joins a business alliance through investment in relevant business. As the enterprise rapidly grows, problems of product development occur simultaneously. Since each subsidiary company has its own R&D division, integration of product development process is required. In addition to market analysis, inventory level of subsidiary companies and partners in business alliance should be considered during the process of new product development (NPD). Starting from 2005, the K Group initiates a plan of integrating NPD throughout the enterprise for its human factor hand tools series. An integrated enterprise information system is the ultimate goal of this plan. However, it's beyond the scope of this paper. This paper focuses on the issue of product data quality control in this case study. In particular, collaborative design during NPD process is the major concern and product data transformation is used as an example to illustrate the proposed framework.

3.0 Literature review

Collaborative NPD is a growing research area of discussing the issue of product development process integration among various R&D divisions. It contributes rapid and flexible NPD to the enterprise. The concept of collaborative engineering actually contains both supplier integration and the communication mechanism to deal with the NPD process. Collaboration is defined as the concept of reaching the pre-defined and common goal and solving problems through the cooperation of all involved partners [Kvan, 2000]. Kvan [2000] also presented two collaborative models: close coupled and loosely coupled such as those shown in figure 1 and 2. From the perspective of time and location, four types of collaborative models are presented by [Anumba, et al., 2002] as follows: face to face, synchronous distributed, asynchronous and asynchronous distributed. In similar, another three types of collaboration are defined as mutual, exclusive and dictator collaboration [Maher, Cicognani and Simoff, 1998]. Types of parallel and sequential collaborative models based on operation time are also discussed by [Zhang, et al., 2002] where the former model belongs to on-line collaboration and the latter one shows the off-line collaboration.

Types of product data frequently exchanged in collaborative engineering activities can be identified as: project planning data, design data, notes/documentation, communication data, analysis/performance data, verification data and scientific data [Bergman and Baker, 2000]. Research efforts related to product data can be found in data modeling, data management and data security. For example, a security model for distributed product data is presented in [Leong, Yu and Lee, 2003] to discuss data security in a manufacturing enterprise where large amounts of interaction are performed between systems and different users located everywhere.

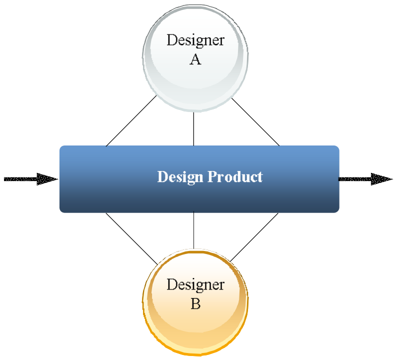

Figure 1: Close coupled collaboration

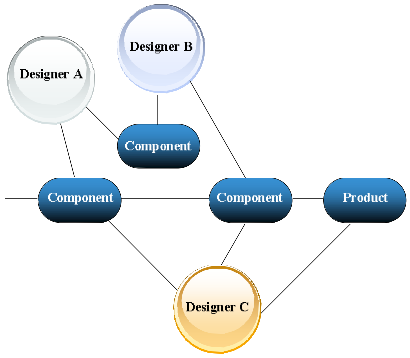

Figure 2: Loosely coupled collaboration

Environmental issue is also paid attention recently in product data management (PDM). Green product for environmental impact evaluation is discussed in [Park and Seo, 2006] in a collaborative design environment using a knowledge-based approximate life cycle assessment system. To deal with PDQ, data quality definition should be defined. Phelps [1999] defines PDQ as a measure of the accuracy and appropriateness of product data with timeliness concern to data users. Data quality in software engineering is another aspect of defining PDQ such as accuracy, completeness and consistency. Social and cultural views of data quality are discussed in [Shanks and Corbitt, 1999] combined with other data levels of structure, meaning and usage. A simple definition of data quality is "fitness for use" based on actual use of data [Wand and Wang, 1996]. To discuss data quality management, the information product map (IPMAP) is used to evaluate data quality by completeness and information is defines as "a product" to discuss quality. [Shankaranarayanan and Cai, 2006]. Contero, Company, Vila and Aleixos [2002] survey the impact of product data quality within an extend enterprise and present a linguistic mode for use in collaborative engineering. Example is given in automotive industry where product data quality standards are defined in VDA 4955 which also adopted in many other industries. Product family is another area of PDQ research. It is important to define hierarchies of product families for mass production, and UML is used as a data modeling language [Pels, 2006] to model classification hierarchies. For specific industries such as the automotive industry, particular product data quality is paid attention to diagnose the data problem for collaborative e-engineering. For example, EXPRES-X based on the standard for the exchange of product data (STEP) is used to create the data quality diagnostic criteria for geometric errors [Tanaka and Kishinami, 2006]. In this paper, problems of PDQ found in the case study are access right conflict, data inconsistency and data incompleteness. Since there are many related works in data access control to solve conflict problem such as RBAC, this problem is not discussed in this paper.

4.0 Collaborative Product Data Quality Control

The framework proposed in this paper is initially developed to solve the data inconsistency and data incompleteness problem caused by data format during transformation in the NPD process. In terms of product data neutral format, ISO 10303 (STEP) [ISO, 1994, 2002] is considered as major standard widely used in industries. However, due to the complex features provided by commercial CAD systems, users are not surely familiar with the STEP standard. In addition to functions offered by CAD systems, a mechanism of ensuring accurate data transformation is the main purpose of the proposed framework. This framework, shown in figure 3, is composed of 1) original data model, 2) exchange data platform, 3) product data family, and 4) function repository. The original data type is collected by users from primitive product data files stored in the enterprise's R&D division. During data transformation between systems, original data type is retrieved based on product data attribute requested by users and then passed to the exchange data platform.

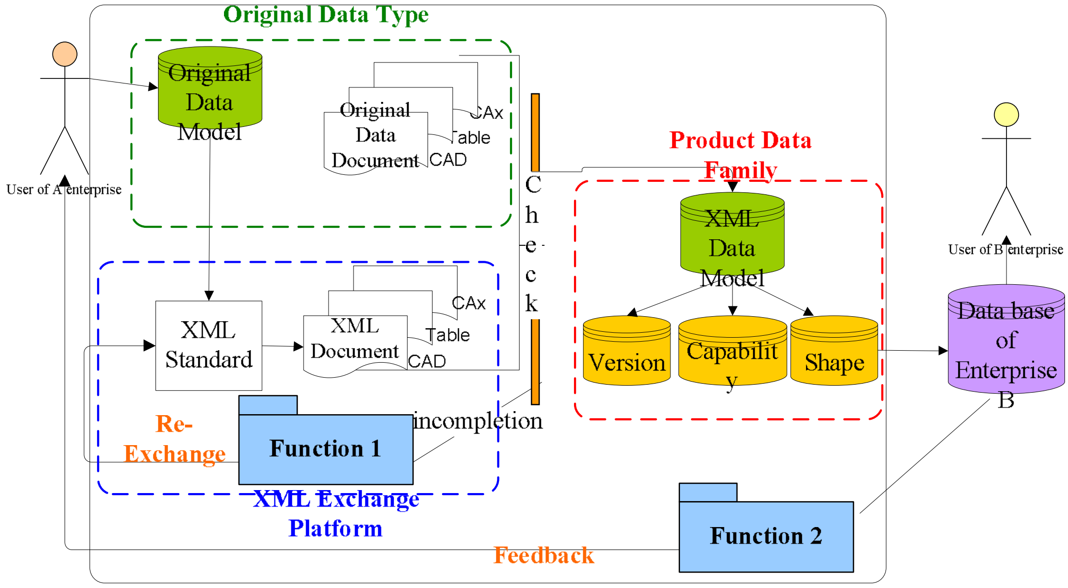

Figure 3: The framework of collaborative product data quality control

The major function of the exchange data platform is to translate original data type into XML format that is compared with original data type at later stage. If the result of above comparison is correct and confirmed, product data is classified and introduced into the product data family. Otherwise, the system triggers function I embedded in the function repository to re-translate original product data. Other users located in different R&D divisions can access translated product data simply through product data family. Supposes that the product data accessed from product data family is unsatisfactory, function II in the repository is then used to recall users who generate the original product data for further discussion and review. Product data family is categorized by version, shape (feature) and capability. Since product data is changing and dynamic in nature between systems, it is insufficient for the user's need and ensuring data quality if the system merely offers transformation function. The proposed framework therefore uses the concept of product data family in which rapid product data access is feasible.

In the exchange data platform, XML data model is responsible for managing translated product data which with XML format including databases of shape, version and capability. The shape database classifies product data based on features in similarity. The version database stores various versions and differences of product data collected from different R&D divisions, while the capability database gathers product data with similar function defined in original data. The whole XML model applies XML language to express the exchange standard since the structured and cross-platform characteristics it owns. Based on product data classification, this research discusses the interaction between users and product data to provide rapid response to the user's data access demand. The system is able to flexibly adjust the product data control if the status of data requirement and product data is changed. A sample of XML data model description is shown in figure 4.

There are two functions embedded in the function repository. During the process of introducing translated product data into XML data model through the exchange data platform, the system will trigger Function I to re-translate original product data if the format comparison is failed. The information regarding data format inconsistency is recorded and stored in the database whenever error message is published. The function II is used to deal with communication between users to recall or inform users of the status of product data access.
Using the function repository, users in different R&D divisions are closely linked to ensure product data quality of data consistency and completeness.

```
<?xml version="1.0" encoding="Big5"?>
  <!DOCTYPE XMLdataModel SYSTEM
                    "user.dtd">
<XMLdataModel>
   <VersionDatabase>
      <Name>Version</Name>
   </VersionDatabase>
   <Company>
      <name>K Company</name>
      <department>R&D</department>
   </ Company >
    <Version>
      <filename>Product Data_1</filename>
      <edition>1.0</edition>
   </Version>
</ XMLdataModel >
```

Figure 4: XML data model

5.0 Experience of the case study

In the background of case study described in section 2, the K Group faces the major PDQ problems of data inconsistency and incompleteness due to various product data types used in its subsidiary companies. The proposed framework is currently developed and cooperated with programmers of the centralized IT Division under the K Group. Since the product lines are complicated and duplicated within four subsidiary companies, the human factor hand tools series is chose as the initial NPD for experiments. The process of integrating CAD systems and the exchange data platform is underdevelopment. Comfortingly, the progress of cooperating with programmers is smooth and successful. However, the prototype system introduction to R&D divisions is impeded by the unfamiliarity with using XML data model. Engineers respond to pressure of additional learning and show their unwillingness to use the system even if data inconsistency is indicated. After intensive discussion with programmers and engineers, the system is adjusted through modifying the user interface which assists engineers in learning XML data model. It is done by adding a simple Blog-like communication module for engineers to share their experiences. Ongoing development shows a positive result for the adjustment. The experience of this case study demonstrates the advantage of using the product data family as an approach to rapidly retrieve accurate product data for various users. However, the following problems require more research efforts: inclusion of information about inventory level of each subsidiary company, unification of coding product family and integration of NPD strategy.

6.0 Conclusions

Due to the trend of global economics and changing customer's demand, the enterprise adopts the process of collaborative NPD to improve its productivity and expand market shares. During the collaborative NPD, various product data transformation is executed throughout the enterprise. Since quality of product data is one of the elements in product lifecycle management, PDQ control becomes an important issue which is worthy of receiving more attention. Using the case study as an experiment, the ongoing research effort emphasizes on building a prototype of product data quality control for collaborative product development. The proposed framework is underdeveloped and tested in the subsidiary company of the case study. It is still far from the full introduction into the enterprise. Nevertheless, the result so far is inspiring and more closely cooperation with IT staff and engineers will be expected. In addition to standard adopted by industries like ISO 10303 for the manufacturing sector, the research provides a supplement to the existing standard to ensure product data quality.

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Author's Background

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