Web-based Knowledge Management Methods for Collaborative Product Development

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SYNOPSIS

As the use of web-centric technology matures, one of the most widely used data exchange formats is XML (Extensible Markup Language). This is due to the fact that XML-wrapped data can be used and understood by any application that is XML-enabled. This paper reports the application of XML for web-based knowledge management in Collaborative Product Development between design and manufacturing functions. Another aspect of this paper is to emphasise the implementations of a "Manufacturing Knowledge Know-how System" as opposed to a "Design Knowledge-Based System" in product development.

1. INTRODUCTION

In today's highly competitive industrial environment, the design and analysis of manufacturing and process plans for complex products requires a very high degree of 'know-how' **(1), (2)**. Suitable tools are required to store this vital information, and make it available for re-use on a company-wide basis. Effective management of this knowledge from discipline to discipline is a requirement to realize the expected cost, schedule, and quality benefits. During the course of this research, several problems and technology shortcomings have been identified. Firstly, there is lack of use of modern technologies in the early design and manufacturing phases. Secondly, there is low of efficiency in information distribution to support product development activities despite the fact that manufacturing knowledge is recognised as one of the greatest assets for a company involved in product development. However, little progress has been made towards using it in a distributed and collaborative product development process. There have been a number of researchers whose aim was to develop knowledge-based process planning systems to improve the product development process **(3), (4)**. None of the systems, however, are currently exploiting advanced tools such as a Web-centric PLM system for storing the appropriate manufacturing 'know-how' to support process planning by utilizing Web-based technologies such as XML. The main

challenge of the research reported in this paper is to develop a knowledge-based system which utilizes web-based technology to support the early product development phases. The success of this development does not just provide a significant improvement in communication; it can also be used to support manufacturing operations by providing an open source environment for information sharing and retrieval.

2. APPLICATION OF WEB-BASED TECHNOLOGIES AND DISPARATE TOOLS

The software tools used to develop a prototype software system to explore the feasibility of operational improvement are XML, the CAPABLE Aggregate Process Planning System **(5)** and a PLM system. The functionality of each software component is described in this section.

2.1 XML in Manufacturing Knowledge Representation

XML is the universal format for structured documents and data on the World-Wide-Web **(6)**. The XML specification describes XML *documents*; a class of data objects stored in computers, and partially describes the behaviour of XML processor programs used to read such documents as well as provides access to their content and structure. XML documents are composed of *entities*, which are storage units containing text and/or binary data. Text is composed of character streams that form both the document character data and the document markup. *Markup* describes the document's storage layout and logical structure. An example of the work describes here for representing knowledge statements is shown as follows:

```
<?xml version="1.0" encoding="utf-8" ?>
<!DOCTYPE document (View Source for full doctype...)>
- <document>
- <Knowhow>
<Date_Prepared date="30/02/2003" />
<SubjectType subject="GasWelding" />
<FPR>Processes</FPR>
<Probability_Factor>0.5</Probability_Factor>
<Knowledge_Type knowledgetype="Best Practice" />
<Organization_Name organization="Mabey and Johnson" />
<Owner_of_Knowhow ownerknowhow="JD Salinger" />
<Qualitative_KS_Type>Agile Manufacturers</Qualitative_KS_Type>
<Qualitative_Knowledge_Statements qualitativeKS="Ensure all safety procedures
    are followed accordingly" />
- <Knowhow>
```

2.2 The Manufacturing System and the Aggregate Process Planning Concept

The proposed system consists of a Manufacturing Domain and a Design Domain which are being developed as part of a collaborate research project. The Design Domain is under development at Cranfield University **(7)**. Whilst the Manufacturing Domain, it is being developed at the University of Durham which consists of the CAPABLE Aggregate Process Planning system and a manufacturing knowledge-based system. Aggregate Process Planning is a methodology, developed at the University of Durham, for the selection of the most appropriate processes and resources and the automatic creation of “rough-cut” processing information from early feature-based product models. The purpose of Aggregate Process

Planning is to allow alternative process plans (containing information) for custom parts to be generated, evaluated and improved based upon estimated *manufacturability* before committing to a fully specified product model and supplier base. CAPABLE/Space **(5)** is a software implementation of Knowledge-Enriched Aggregate Process Planning which utilises intelligent, "data-resistant" planning algorithms to automatically explore process and resource alternatives from the enterprise model, seeking a process plan which results in near-optimal manufacturability as determined by quality, cost, lead time and knowledge (QCD+K) criteria. This research seeks to enhance CAPABLE/Space's functionality by providing a PDM-based methodology for knowledge management within a distributed and collaborative environment.

2.3 The PLM Environment

PLM can be seen as an integration tool **(8)**, **(9)**, **(10)**, connecting many different areas of product development, which ensures that the right information is available to the right person at the right time and in the right form. In general, the PLM systems were developed based on a set of functions that include an electronic vault or database, utility and user functions. The foundation of a PLM system is the data vault or database engine, which can be considered as a repository for all kinds of product information. Since the emerging of Internet technology in the mid 90's the concept of PLM technology has evolved and most of the current PLM systems encompass web-based collaborative and e-Integration functionality such as the PTC Windchill PLM system **(11)**. In practice, PLM systems are used by various personnel in different locations from design to manufacturing, its core capabilities enabling users to collaboratively develop and share data in a controlled environment. From the research, the following question emerges, "What would happen if the system can be used not only disperse product-related information, but also can be used to distribute knowledge in design and manufacturing issues to support product development?". Hence, one of the objectives of this paper is to report the way to utilize the PLM system to disperse 'knowledge' to be used by a third party software system.

2.4 Implementation of the Knowledge-Based System

The Knowledge-Based System (KBS) is constructed using an integrated software tool, Protégé **(12)** which supports by XML. The instances captured in the KBS are being saved into XML format. The XML file is then being stored into a Windchill PDM Cabinet **(11).** Hence, this allows the knowledge to be shared and reused by the CAPABLE Aggregate Process Planning System and other third party software. A KBS for capturing manufacturing know-how has been developed. This has a hierarchical data structure known as "Organisation Knowledge Know-how". It was constructed using the UML Rational Rose Object Modelling Tool in a class diagram representation. The class diagram was transferred into a XMI formatted file using Rational Rose UML 1.3 XMI function, and subsequently imported into the Protégé KBS Editor to create the ontology of a knowledge based system for further implementations. The KBS was then populated with instances of manufacturing knowledge shown in Figure 1. Each of the instances represents a set of attributes which captures the information in terms of *Type_of_Manufacturing_Knowhow*, *Dated_Prepared*, *Owner_of_Knowhow*, the *Knowledge_Statement_Type* and the *Knowledge_Statement* itself and so on. The Design knowledge-based system was also developed using the same approach but with a different kind of web-based data exchange format. However, one of the advantages of using Protégé is that the information can be converted between formats using a native function provided in the software system, which can eliminate the process of manually implementing of data exchange mappings. One of the reasons for using data exchange

mappings is that the CAPABLE Aggregate Process Planning System is able to reuse the design and manufacturing knowledge to produce "knowledge-enriched" aggregate process plans. Therefore, the data captured within the KBS must be XML-enabled.

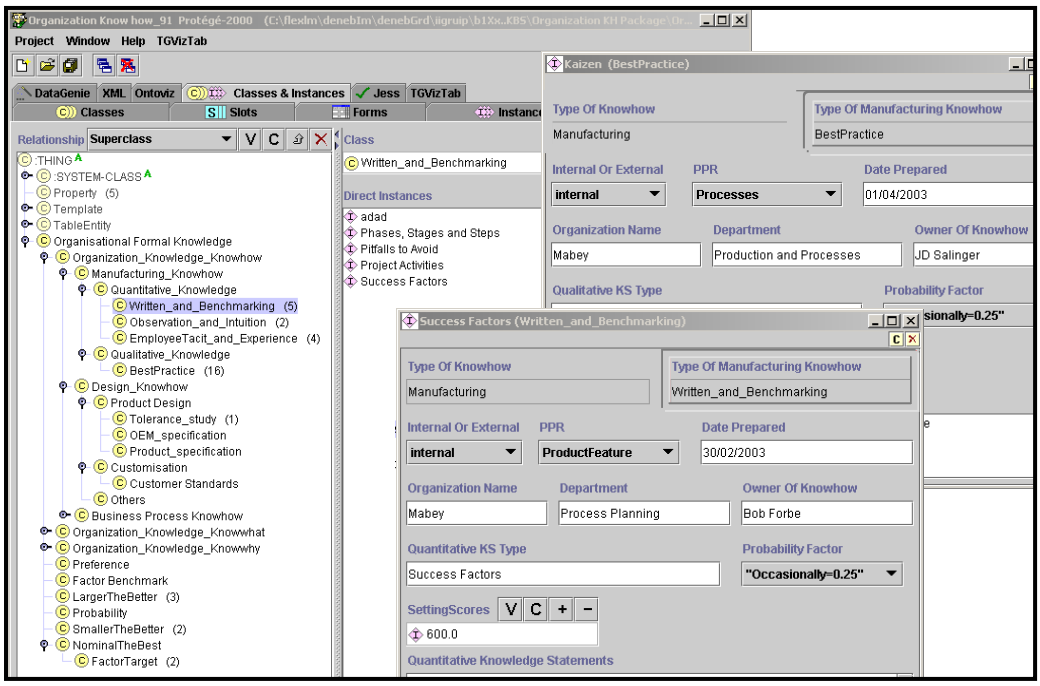

Figure 1. The Knowledge-based System

3. INTERACTIONS OF KNOWLEDGE-ENRICHED PLM SYSTEM DURING EARLY PROCESS PLANNING

Figure 2 depicts the example of web-based data interoperability between the knowledge-based system, PLM system and process planning system. The figure shows that the captured knowledge will be saved and stored as an XML file in a Windchill PDM Cabinet. The big advantage of XML formatted file is that, there are a whole range of generic XML tools available to create an XML parser for extracting the right information and turning it into the required format of a proprietary tool to re-use. In this case, the XML Parser has been created for transferring the stored knowledge to the CAPABLE Aggregate Process Planning System. One important aspect in creating the XML Parser is that the developer must, understand the interface provided by the XML Parser used **(13)**. The figure also shows a representation of the Java-Based XML Parsers' intend methods that are used to read and extract the right information of data type string and translate it into the CAPABLE Aggregate Process Planning System's local database. Figure 3 illustrates some example knowledge statements relating to a specific object termed Robot_Cell_0 which belong to a cell of a factory. Once the XML Parser is called, the knowledge statements are attached to this particular group of machines within CAPABLE Aggregate Process Planning System's internal resource model and can be used for further analysis to enhance the planning process of a product.

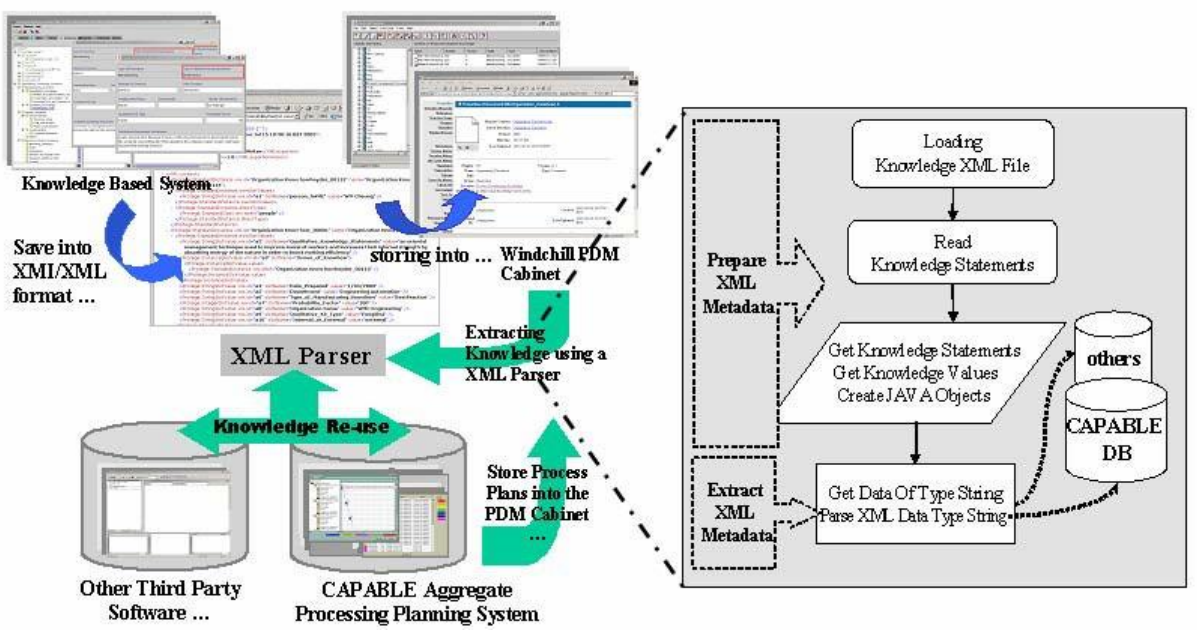

Figure 2. Web-based data interoperability

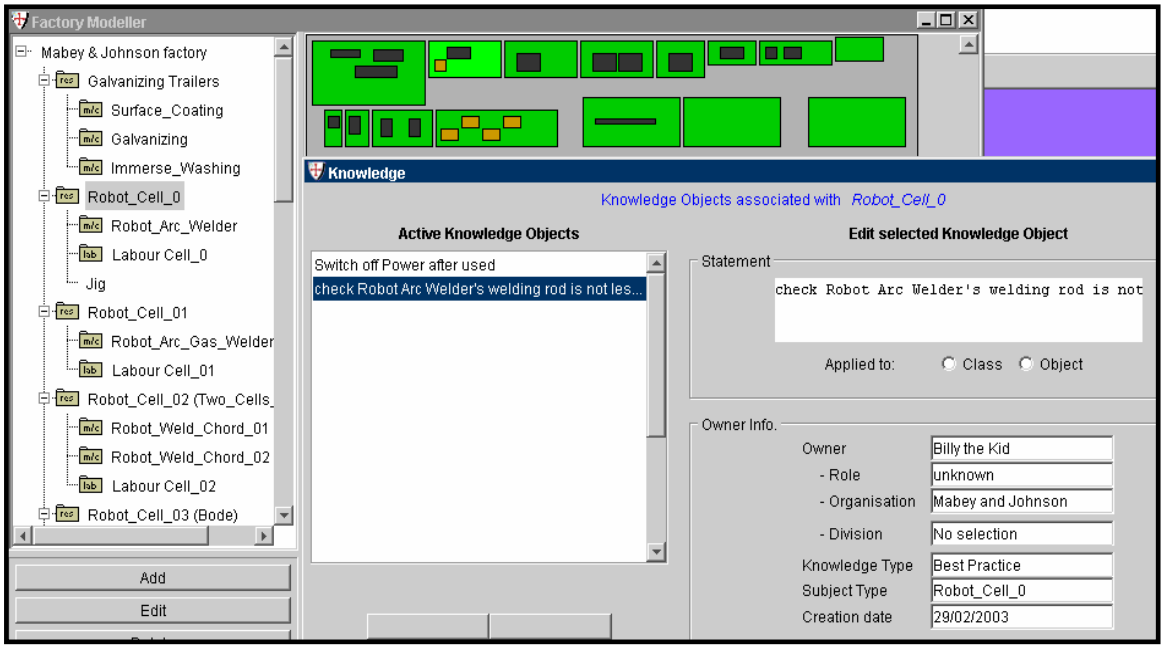

Figure 3. Knowledge Statements related to a specific object

4. CONCLUSIONS

There is no single management tool and data exchange format that can overcome all the obstacles involved in a product development process. However, the proper application of web-based technologies, PLM technologies and other proprietary tools are a means of bridging the gap between the design and manufacturing departments for improving the

product development process **(14)**, **(15)**. This paper described a prototype computer system and has attempted to fulfil the above objectives and outlined the links that must be created between PLM and a third party in-house software systems by utilizing web-based technologies. The significance of using XML parser to support systems interoperability and data exchange has been demonstrated. This paper has also described and implemented a method of capturing and reusing manufacturing know-how opposed to dealing with design know-how to support process planning.

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